CITY OF
WICHITA

**Department of Public Works**

January 30, 2012

Attention Development Community;

The Interim Approved Wichita/Sedgwick County Stormwater Manual has been revised to include the following modifications to the requirements for Downstream Channel Protection Volume – Section 3.5:

1. The City of Wichita Stormwater Management Division shall create and maintain the ***Map of Downstream Protection Volume Watersheds and Channels***. Downstream long-term channel protection shall be provided for applicable developments and redevelopments in watersheds delineated on this map prior to discharge from the new/redevelopment site in accordance with the downstream stabilization standards and criteria provided in the Storm Water Manual.
2. The requirement to design and provide **Downstream Channel Protection Volume** shall be required for new developments and redevelopments that will create or add five acres or greater of disturbed area including projects that have less than five acres in disturbed area that are part of a larger common plan of development or sale that will result in five acres or greater of disturbed area.

The Stormwater Advisory Board is currently reviewing the Wichita/Sedgwick County Stormwater Manual. Other modifications or revisions may be forthcoming as recommendations are made and approved by the Director of Public Works & Utilities. Once the Stormwater Advisory Board is satisfied with the changes to the Interim Wichita/Sedgwick County Stormwater Manual, the City plans to modify the Stormwater Manual to incorporate the approved changes.

Alan King 1/30/12

Alan King, Director of Public Works & Utilities

**Office of the Director**

City Hall • Eighth Floor • 455 North Main • Wichita, Kansas 67202-1685

**T** 316.268.4422 **F** 316.337.9027

Public Works & Utilities – Stormwater Management Division

**TO:** Alan King, Director of Public Works & Utilities

**FROM:** Scott Lindebak, Support Staff on behalf of the Stormwater Advisory Board

**SUBJECT:** Proposed Modification to Section 3.5 of the Wichita/Sedgwick County Storm Water Manual

**DATE:** January 30, 2012

The Stormwater Advisory Board recommends your approval for modification to the requirements for Downstream Channel Protection Volume – Section 3.5 of the Wichita/Sedgwick County Stormwater Manual as indicated below:

1. The City of Wichita Stormwater Division shall create and maintain the ***Map of Downstream Protection Volume Watersheds and Channels***. Downstream long-term channel protection shall be provided for applicable developments and redevelopments in watersheds delineated on this map prior to discharge from the new/redevelopment site in accordance with the downstream stabilization standards and criteria provided in the Storm Water Manual.
2. The requirement to design and provide **Downstream Channel Protection Volume** shall be required for new developments and redevelopments that will create or add five acres or greater of disturbed area including projects that have less than five acres in disturbed area that are part of a larger common plan of development or sale that will result in five acres or greater of disturbed area.

Upon your approval, the requested changes will supersede the Downstream Channel Protection Volume requirements in the Wichita/Sedgwick County Stormwater Manual. The manual will be revised in the future upon a complete and thorough review by the Stormwater Advisory Board.

Alan King

Alan King, Director of Public Works & Utilities

1/30/12

Date

SWAB/cas

## 3.5 Offsite BMP Program[1]

Section 3.5 is written specifically for developers and owners of properties within the City that are subject to the 80% Total Suspended Solids (TSS) Removal performance standard and want to learn more about the Offsite Best Management Practice (BMP) Program to potentially avoid the construction of TSS Removal facilities onsite. This section is not intended for property owners who wish to implement TSS Removal BMPs on their land in order to provide sediment reductions.

More detailed information on the framework, costs and BMPs that comprise the Offsite BMP Program is provided in a technical report on the topic developed by Kansas State University and Vireo, entitled *Consultant Services for an Offsite BMP Evaluation Plan, Final Report to the Wichita Stormwater Advisory Board*. This technical report is available on the City's website: http://www.wichita.gov/Government/Departments/PWU/Pages/Stormwater.aspx.

### 3.5.1 Introduction

The Offsite BMP Program is a voluntary stormwater quality compliance alternative for developments in the City of Wichita that must meet the 80% TSS Removal performance standard. Owners of properties that participate in the Program elect to fund stormwater quality treatment offsite by paying a fee to support offsite BMPs that reduce sediment pollution instead of constructing onsite BMPs to the required standard. For the City, the goal of the Program is to maximize the economic efficiency by which the City meets its National Pollutant Discharge Elimination System (NDPES) stormwater permitting requirements while protecting water quality in the Little Arkansas River, the Arkansas River and other priority streams. For property owners, this program provides substantial flexibility to comply with the City's NPDES permit-mandated stormwater quality requirements.

Sediment is a significant pollutant in the City's rivers and streams. As a result, the City's post-construction stormwater quality control program focuses on the reduction of sediment via the indicator pollutant, TSS, through the implementation of the 80% TSS Removal performance standard that is described in Volume 2 of this Manual. Similarly, sediment serves as the basis of the Offsite BMP Program thus ensuring that the Program is a viable stormwater quality compliance alternative to the 80% TSS Removal standard.

Properties registered in the Program are not required to have onsite facilities to meet the 80% TSS Removal standard. Rather, the owner of these properties must purchase sediment "reductions" which provide continuous financial support for the implementation of offsite sediment removal or sedimentation prevention BMPs. Located in a priority watershed, these offsite BMPs control sediment by preventing sediment discharges to a priority river or stream, thus compensating for the absence of onsite BMPs. The advantage of the Offsite BMP Program to participating property owners is the ease of implementation. Namely, ***property owners are required only to register their***

[1] Portions of text for section 3.5 were adapted from Moore et al, June 11th 2015.

***property(s) and pay the fee in perpetuity. They are NOT responsible for locating, designing, constructing, operating and maintaining TSS Removal BMPs either onsite or offsite.***

### 3.5.2 Key Definitions and Acronyms

The following definitions are provided to help readers understand the basic framework of the Offsite BMP Program.

**Existing development** means a developed property that was designed and constructed after January 1, 2011 and therefore is subject to the City's post-construction water quality control requirements (i.e., section 16.32.091 of the City's stormwater management ordinance), namely, meeting the 80% TSS Removal performance standard. An existing development will have a construction plan that was approved by the City after January 1, 2011, which is the date when the City's post-construction water quality control requirements came into effect.

**KDHE** is an acronym for the Kansas Department of Health & Environment.

**New development** – See City Ordinance 16.32.

**Offsite BMP Program** means the voluntary stormwater quality compliance alternative for developments in the City of Wichita which allows owners of properties to provide stormwater quality treatment by paying a fee that will support the administration, operation and maintenance of sediment reduction BMPs located offsite and in a priority watershed.

**Offsite BMP Program fee** means the on-going financial compensation that owners of Registered Properties pay to participate in the Offsite BMP Program instead of implementing onsite controls to meet the 80% TSS Removal standard. Payment of the fee as compensation for the lack of onsite controls will occur in perpetuity or until it is shown that the Registered Property meets the 80% TSS Removal performance standard using BMPs installed onsite. Payment of the fee is the responsibility of the owner of the Registered Property. When the Registered Property is transferred, the fee becomes the responsibility of the subsequent property owner(s).

**Registered Property** means a new development, redevelopment or existing development located within the City of Wichita that is subject to the 80% TSS Removal performance standard, is (or will be) relying on the purchase of sediment reductions to comply with City stormwater quality requirements, and is (or will be) registered by the City in the Offsite BMP Program.

**Redevelopment** – See City Ordinance 16.32

**Sediment reduction** means the annual amount of sediment removed or retained by a sediment reduction BMP, in annual tons of sediment retained.

**Sediment reduction BMP** means a facility that is constructed, operated and maintained to reduce or remove TSS and is enrolled by WRAPS in the Offsite BMP Program, thus providing sediment reductions for one or more Registered Properties.

**TSS** is an acronym for Total Suspended Solids. When considering pollutant loads or concentrations, TSS is often used as an indicator or substitute for sediment.

**WRAPS** is an acronym for the Kansas Watershed Restoration and Protection Strategy. The WRAPS program is assisting the City with the administration and implementation of the Offsite BMP Program.

### 3.5.3 Program Roles and Responsibilities

The four entities that participate in the Offsite BMP Program are listed below. A summary of the responsibilities of the different entities that play a role in the Offsite BMP Program are shown in Table 3-12.

1. The **Owner of the Registered Property** is the property owner of a new development, redevelopment or existing development that is subject to the 80% TSS Removal performance standard, but is (or will be) relying on the purchase of sediment reductions to meet the City's stormwater quality requirements. For new developments, the owner of the Registered Property may be a developer.

2. The **City of Wichita** holds the NPDES permit for which the Offsite BMP Program is established. The City's administers the Program (with WRAPs), primarily overseeing the portion of the Program that deals with Registered Properties.

3. The **Owner of the Sediment Reduction BMP** is the owner of the sediment reduction (i.e., offsite) BMPs that are implemented, and have been enrolled by WRAPS, to provide sediment reductions for Registered Properties in the City. Typically, this will be the owner of the land where the BMP is located.

4. The **Kansas WRAPS program** and Kansas State University (KSU) partner with the City to administer the Offsite BMP Program, primarily overseeing the portion of the Program that deals with sediment reduction BMPs.

**Table 3-1. Responsibilities of Offsite BMP Program Entities**

| |
|---|
| **Owner of the Registered Property (this may be the developer of a new development)**<br>• Notify City of intent to participate in the Offsite BMP Program and provide documentation of the area(s) within the property to be registered as required in Section 3.5.4 of this Manual.<br>• Pay Offsite BMP Program fee, as required by Chapter 16.32 of City code. |
| **The City of Wichita**<br>• Review the information provided by the property owner/developer for the Registered Property. Use this information to calculate the required sediment reduction and the fee.<br>• Bill and collect the fee from the owner of the Registered Property.<br>• Transfer payments to WRAPS to fund their role in the administration, implementation, operation, maintenance, documentation and reporting of the Offsite BMP Program. |
| **WRAPS Program**<br>• Identify, prioritize and enroll Sediment Reduction Properties for participation in the Offsite BMP Program. Work with owners of Sediment Reduction Properties to implement sediment removal or sediment prevention BMPs.<br>• Conduct field checks to ensure that sediment reduction BMPs are maintained and enroll replacement BMPs as needed.<br>• Maintain sediment reduction/BMP database and sediment reductions benefits calculation.<br>• Provide the City the required NPDES permit documentation for permit reporting. |
| **Owner of the Sediment Reduction Property**<br>• Implement, operate, protect and maintain offsite sediment removal or retention BMPs in accordance with the terms of their enrollment with the WRAPS program. |

### 3.5.4 Registering for the Program

#### 3.5.4.1 Eligibility

Any property in the City of Wichita is eligible to become a Registered Property in the Offsite BMP Program. The Program primarily targets new developments, redevelopments or existing developments that are subject to the City's 80% TSS Removal performance standard as required by Chapter 16.32 of City code.

It is important to note that participation in the Offsite BMP Program ***does not*** relieve the owner of the Registered Property from compliance with post-construction water quantity control requirements outlined in City Ordinance 16.32 (i.e., peak discharge control of the 2-, 5-, 10-, 25- and 100-year return frequency, 24-hour duration storm events).

#### 3.5.4.2 Registration

**New Developments and Redevelopments:** Property owners of new developments or redevelopments who wish to register their property (or portions of their property) in the

Offsite BMP Program shall indicate this intent on the Drainage Plan Cover Sheet with a note stating that the property owner elects to participate in the offsite BMP program.

**Existing Developments:** Property owners, or their acting agent, of existing developments who wish to register their property (or portions of their property) in the Offsite BMP Program shall contact the City Stormwater Management Utility for enrollment.

### 3.5.5 The Offsite BMP Program Fee

The Offsite BMP Program fee supports the administration, operation and maintenance of sediment reduction BMPs, thus ensuring an overall reduction in sediment loading within the watershed. The fee is used to compensate the Kansas WRAPS program, which serves as the primary administrative entity for the offsite BMP and sediment reduction balancing portions of the Program.

#### 3.5.5.1 Billing and Payment

In accordance with City Ordinance 16.32, participation in the Offsite BMP Program requires payment of an Offsite BMP Program fee in perpetuity. The fee is billed and collected as a separate line item on the standard utility bill for the Registered Property. Failure to pay the fee will result in payment collections and/or enforcement actions as provided for in the ordinance. Enforcement may include removal from the Offsite BMP Program and retrofitting of the site with appropriate stormwater quality controls to meet City stormwater quality performance standards.

The responsibility for payment of the fee lies with the owner of the Registered Property. However actual payment can be made by someone other than the owner, such as the person(s) typically responsible for utility bill payment (e.g., an occupant or lessee). The fee transfers with the property and therefore becomes the responsibility of the subsequent property owner(s) or designee(s) after a property transfer.

#### 3.5.5.2 Fee Changes or Elimination

Once a property is registered, the Offsite BMP Program fee calculated by the City is established within the billing system. The amount of the fee remains fixed unless or until:

- the fee is no longer valid for the property as the result of installation of onsite TSS Removal BMPs that meet the performance standards of City Ordinance 16.32, thus eliminating the need for continued purchase of sediment reductions;
- the fee requires recalculation as a result of property redevelopment, grading or other modifications that result in drainage area changes, potentially changing the amount of sediment reduction that must be purchased.

While the City may become aware of either of the above situations through the City's normal land development process, changes on a Registered Property that warrant elimination or recalculation of the fee could occur without the City's knowledge. Therefore, **it is the responsibility of the owner of the Registered Property to advise the City of conditions that may be cause to recalculate or eliminate the Offsite BMP Program fee**. The City will not reimburse overpayments by the owner of a Registered Property who has failed to advise the City of the need for fee modification or elimination.

Alternately, the City may examine the validity of an Offsite BMP Program fee for any Registered Property at any time to ensure the property conditions remain valid for the established fee.

Requests for fee recalculation or elimination by the owner of a Registered Property must be provided to the City Stormwater Management Utility in writing. The following supporting documentation must accompany the written request:

- A narrative describing the need for recalculation or elimination of the fee;
- *For fee recalculation requests*, submit an engineering drawing to scale that shows the contributing area from the Registered Property that drains into the City's MS4 permit area.
- *For fee elimination requests*, provide engineering drawings (to scale) and associated specifications and calculations which show that the City's stormwater quality management requirements are being met on the property. The fee will not be eliminated until the property is in compliance with these requirements.

### 3.5.5.3 Fee Calculation

The City will calculate the Offsite BMP Program fee for the Registered Property based on information provided in the drainage plan (described below) and will advise the Registered Property owner of the fee amount. Owners of Registered Properties are encouraged to contact the City's Stormwater Management Utility if additional information is needed to understand the fee calculation.

**New Developments and Existing Developments:** The Offsite BMP Program fee for new developments and existing developments shall be calculated using the *total contributing area* of the Registered Property. The *total contributing area* shall be determined by adding 100% of the pervious area and 100% of the impervious area on the Property that discharges into the City's MS4 permit area.

**Redevelopments:** The Offsite BMP Program fee for redevelopments shall be calculated using the *redeveloped contributing area* of the Registered Property. The *redeveloped contributing area* shall be determined by adding 100% of the pervious area, 30% of the existing impervious area and 100% of the new impervious area of the Property that discharges into the City's MS4 permit area.

### 3.5.6 Program Coordination and Administration

The City and the Kansas WRAPS program have established a partnership to administer the Offsite BMP Program. This partnership greatly enhances the Program as a viable option to developers and property owners that are subject to City stormwater quality requirements because WRAPS alleviates the responsibilities of design, construction and maintenance of 80% TSS Removal facilities, while the City provides an easy property registration and fee payment process. From the perspective of the owner of the Registered Property, the City's land development process is nearly the same, with no adverse impact on the time or effort it takes to produce, submit and review drainage plans.

The partnership between the City and WRAPS is organized in a manner that eliminates the need for interaction between the owner or developer of the Registered Property and the owner of the sediment reduction BMP. On one hand, The City routinely interacts with developers and property owners through its land development process, therefore it administers the program for Registered Properties. On the other hand, WRAPS is uniquely suited for communication and networking with large landowners who can potentially implement BMPs. With the involvement of both the City and WRAPs, the owners of Registered Properties typically will not have knowledge of the sediment reduction BMPs that are being used to compensate for the lack of TSS removal controls at their property. Similarly, BMP owners typically will not know the Registered Properties for which their BMPs provide reductions.

The primary role of the WRAPS program is to establish, operate and maintain a sufficient bank of sediment reductions from BMPs to exceed the demand for reductions by owners of Registered Properties in Wichita. This role supports the City in meeting the compliance requirements of KDHE for the Offsite BMP Program. WRAPS typically does not interact with Registered Property owners. Rather, services provided by the WRAPS include building and maintaining a "front-loaded" sediment reduction bank, enrolling and coordinating sediment reduction BMP owners and BMPs, inspecting BMP operation and management, and providing reporting and documentation activities to meet the City's permit requirements. WRAPS is paid by the City for these services through funds obtained from the Offsite BMP Program fee.

# City of Wichita/Sedgwick County

## Stormwater Manual Errata Sheet

Current Manual version is dated 03/16/2011

| Volume | Section | Erratum | Approval Date |
|---|---|---|---|
| 1 | 3.5.1 | Modified section is entitled *Downstream Stabilization Standard.*<br>Text added to identify the policy of the City of Wichita to create and maintain a *Map of Downstream Protection Volume Watersheds and Channels*, to be provided in Volume 1, Appendix G. | 02/06/13 |
| 1 | Appendices | Added Appendix G entitled *Map of Downstream Protection Volume Watersheds and Streams*. Policies associated with the use of these maps are presented in Volume 1, Chapter 3, Section 3.5.1 and on the maps themselves. | 02/06/13 |
| 2 | 3.2.2 | Section 3.2.2 is entitled *Extended Dry Detention Pond*. The modified section is entitled *Inlet and Outlet Structures.*<br><br>2nd bullet - Text added to clarify the design criteria for the extended detention of the $WQ_v$. Specifically, 90% of the $WQ_v$ must be detained for not less than 24 hours, and then must be released over the reasonable time period (e.g., 2 to 4 days).<br><br>3rd bullet - Text added to clarify the design criteria for the extended detention of the $CP_v$. Specifically, the outlet structure must have an orifice capable of detaining the $CP_v$ for a minimum of 24 hours, and then discharging the $CP_v$ within a reasonable timeframe (e.g., 2 to 4 days). | 02/06/13 |
| 2 | 4.13.1 | Example Problem 2 added on page 4-43, entitled *Calculating the WQv for a Redevelopment*. | 02/06/13 |
| 2 | 4.13.3 | Modified section is entitled *Water Quality Volume Extended Detention*.<br><br>1st paragraph and Step 4 - Text modified and added to clarify the requirement for the extended detention time for the $WQ_v$ to be detained for not less than 24 hours, and then must be released over the reasonable time period (e.g., 2 to 4 days). | 02/06/13 |
| 2 | 4.15.1 | Modified section is entitled *Channel Protection Volume*.<br><br>2nd paragraph - Text modified and added to clarify the requirement for the extended detention time for the $CP_v$ to be detained for not less than 24 hours, and then drained over the reasonable time period (e.g., 2 to 4 days). | 02/06/13 |
| 2 | 4.15.2 | Modified section is entitled *Channel Protection Volume Extended Detention – Centroid Method*.<br><br>Step 5 - Text modified and added to clarify the requirement for the extended detention time for the $CP_v$ to be detained for not less than 24 hours, and then drained over the reasonable time period (e.g., 2 to 4 days). | 02/06/13 |
| 2 | 4.15.2 | Example Problem added on page 4-53, entitled *CPv Outlet Sizing Using the Centroid Method*. | 02/06/13 |

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# City of Wichita/Sedgwick County

## Stormwater Manual Errata Sheet

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| 1 | Appendices | Added Appendix G entitled *Map of Downstream Protection Volume Watersheds and Streams*. Policies associated with the use of these maps are presented in Volume 1, Chapter 3, Section 3.5.1 and on the maps themselves. | 02/06/13 |
| 2 | 3.2.2 | Section 3.2.2 is entitled *Extended Dry Detention Pond*. The modified section is entitled *Inlet and Outlet Structures.*<br><br>2nd bullet - Text added to clarify the design criteria for the extended detention of the $WQ_v$. Specifically, 90% of the $WQ_v$ must be detained for not less than 24 hours, and then must be released over the reasonable time period (e.g., 2 to 4 days).<br><br>3rd bullet - Text added to clarify the design criteria for the extended detention of the $CP_v$. Specifically, the outlet structure must have an orifice capable of detaining the $CP_v$ for a minimum of 24 hours, and then discharging the $CP_v$ within a reasonable timeframe (e.g., 2 to 4 days). | 02/06/13 |
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| 2 | 4.15.2 | Modified section is entitled *Channel Protection Volume Extended Detention – Centroid Method*.<br><br>Step 5 - Text modified and added to clarify the requirement for the extended detention time for the $CP_v$ to be detained for not less than 24 hours, and then drained over the reasonable time period (e.g., 2 to 4 days). | 02/06/13 |
| 2 | 4.15.2 | Example Problem added on page 4-53, entitled *CPv Outlet Sizing Using the Centroid Method*. | 02/06/13 |

| Volume | Section(s) | Erratum | Approval Date |
|---|---|---|---|
| 2 | 4.2<br>4.4<br>4.6.4<br>4.15.3 | Section 4.2 - The narrative and Table 4-1 were revised to provide point rainfall depths determined from data provided by the Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2.0 and the Precipitation Frequency Data Server (PFDS) from the Hydrometeorological Design Studies Center.<br><br>Section 4.4 – Data for $P_2$ in Equation 4-5 was changed based on the updated precipitation data provided in Table 4-1 (described above).<br><br>Sections 4.6.4 and 4.15.3 – The example problem in each section was revised based on updated precipitation data provided in Table 4-1 (described above). | 11/06/13 |
| 2 | Appendix B | Revised the Rainfall Intensity table (Table 1) and the associated Figure entitled *Sedgwick County IDF Curves* were modified to reflect updated data based on rainfall data provided by the Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2.0 and the Precipitation Frequency Data Server (PFDS) from the Hydrometeorological Design Studies Center. | 11/06/13 |
| 2 | Appendix B | Added General Rainfall Equation Constants table (Table 2). Constants were developed by a regression analysis of the rainfall data provided by the Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2.0 and the Precipitation Frequency Data Server (PFDS) from the Hydrometeorological Design Studies Center. | 11/14/13 |

# Wichita/Sedgwick County Stormwater Permit

For Authorization to Discharge Stormwater Runoff from Construction Activities
In Accordance with the Kansas Water Pollution Control General Permit
Under the National Pollution Discharge Elimination System (NPDES)

Submission of this Permit application constitutes notice that the identified parties in the "OWNER OPERATOR" Section of this form have requested and received a copy of a signed NOTICE OF INTENT (NOI) from the Kansas Department of Health and Environment (KDHE). Becoming a permittee within the Wichita/Sedgwick County region obligates the discharger to comply with the terms and conditions of the general permit as well as all local regulations and ordinances. Completion of this Permit application does not provide automatic coverage under the general permit. City of Wichita Engineering or Sedgwick County Stormwater Management will notify owners or operators and or agents of such, when Stormwater permit application and supporting documentation is incomplete, deficient, or denied.

**Submit completed forms to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202 or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

**Please Type or Print**

☐ **Owner** ☐ **Operator**

Name: ____________________

E-Mail Address: ____________________

Area of site disturbance (acres) ____________________

**Project Information & Location**

Project Name: ____________________

Project Address: ____________________

Impervious Area Before Construction :(sq ft) ____________

Impervious Area Post Construction: (sq ft) ____________

☐ **Unincorporated Sedgwick County**

☐ **City of Wichita**

**Below is a list of Supporting documentation required to be supplied for this Permit application:**

Signed copy of State (NOI) Must be Attached. Ks Permit No. ____________ Federal Permit No. ____________

*Copy of submitted (NOI) ok to start plan review process, KDHE approved front page of (NOI) required before this permit will be issued.*

**Items listed below will need to be submitted in electronic pdf, as well as two hard copies of ½ scale prints.**

- ☐ On File ☐ Attached — Subdivision drainage plan for site.
- ☐ On File ☐ Attached — Private Project Drainage (PPD) construction plans (City Only) & or Public Drainage Improvements.
- ☐ Yes ☐ No — PPD Plan Review Fee Paid. (City Only)
- ☐ On File ☐ Attached — Stormwater Pollution Prevention Plan. (SWPPP)
- ☐ On File ☐ Attached — Draft of Operation & Maintenance (O & M) Plan for Stormwater Management Facility.
- ☐ On File ☐ Attached — ERU plan sheet. (City Only)
- ☐ On File ☐ Attached — Project narrative.
- ☐ On File ☐ Attached — Engineer Project certification statement, & supplemental drainage calculations.

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

# Wichita/Sedgwick County Stormwater Permit

## OWNER/OPERATOR STORMWATER QUALITY COMPLIANCE STATEMENT

The undersigned, being the owner of a facility that has applied to the City of Wichita or Sedgwick County, Kansas, for a storm sewer tap/discharge/ stormwater permit, hereby acknowledges the requirements of Section 16.32 of the Wichita City Code, and/or Sedgwick County resolution #196-10, which states that only stormwater can be discharged into the municipal storm sewer system, with the following exceptions:

1. A discharge authorized by, and in full compliance with, a federal or state NPDES permit.
2. A discharge from emergency fire fighting.
3. A discharge from water line flushing.
4. A discharge from lawn watering, landscape irrigation, or other irrigation water.
5. A discharge or flow from a diverted stream flow or natural spring.
6. A discharge or flow from uncontaminated ground water or rising groundwater.
7. Uncontaminated groundwater infiltration.
8. Uncontaminated flow from a foundation drain, crawl space pump, footing drain, or sump pump (no discharge onto street per City Code 10.04.060 City only).
9. A discharge from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container.
10. A flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant.
11. Flows from individual residential car washing.
12. A flow from a riparich habitat, wetland, or natural spring.
13. Storm water runoff from a roof that is not contaminated by any runoff from an emissions scrubber or filter or any other source of pollutant.
14. Residential heat pump discharges.
15. Swimming pool water, excluding filter backwash, that has been de-chlorinated so it contains no harmful quantity of chlorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning.
16. Contaminated groundwater if authorized by KDHE and approved the County. (County Only)
17. Street wash water.(excluding street sweepings which have been removed from the street) (County Only)
18. Discharges specified in writing by the Director as necessary to protect public health and safety. (County only)

I further understand that allowing any other discharge will subject me to the penalties provided in said City Section 16.32, and or Sedgwick County Stormwater Management Resolution #196-10, as well as other federal and state penalties.

Owner or Operator Signature: ______________________________ Date: ____________________________

Name typed or printed: __________________________________Title: ____________________________

**Upon completion of construction for this project, a copy of the certified as-built stormwater plans as well as the final O & M Plan shall be filed with City of Wichita Engineering or the Sedgwick County Stormwater office (depending on project location, City or County). The final O & M Plan shall be recorded with the Sedgwick County Registrar of Deeds. Proof of this filing shall also be submitted to the appropriate City/County office prior to the Owner or Operator receiving a full use Occupancy Certificate.**

| | | |
|---|---|---|
| Reviewer Name ________________________ | City project No. ________________ | SW ID No. ______________ |
| Date Packet Received: __________ | Date Approved: ___________ | Date Recorded Final O & M Plans Received: ______________ |

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
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## Volume 1 – Stormwater Policy

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# FORWARD

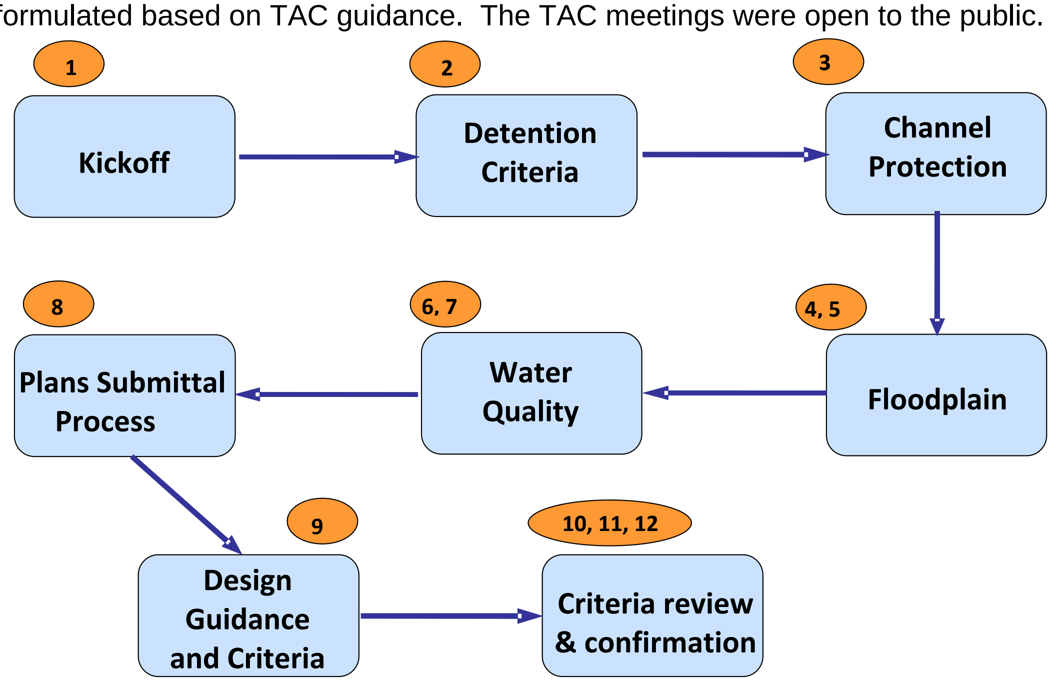
## Preface

The recognition that a regional approach is needed to address regional stormwater issues led the City of Wichita and Sedgwick County to create the Stormwater Manual. A pressing need to manage both stormwater quantity and quality became apparent with the requirements from the National Pollutant Discharge Elimination System (NPDES) municipal and industrial permits, Total Maximum Daily Loads (TMDL) reduction targets, watershed assessments, as well as the desire to protect human life, property, aquatic habitats and the quality of life in our communities. To do this, it will be important that the citizens, land owners and business owners in the region view stormwater not as a waste that requires disposal, but as an important resource and opportunity for enhancement of our region.

A primary goal of the Stormwater Manual is to provide the policies and technical standards to implement a consistent and effective approach for stormwater management in the City of Wichita and Sedgwick County. In support of this goal, the Manual provides a comprehensive approach to stormwater management that integrates drainage design (i.e., the movement of stormwater over land) and the control of both stormwater quantity and quality.

## Acknowledgements

The Stormwater Manual was developed in a collaborative effort between the City of Wichita and Sedgwick County. Over the course of ten meetings held in 2008 and 2009, a Technical Advisory Committee (TAC) followed the meeting "roadmap" presented in the following graphic in order to understand the stormwater management issues that face this region, and to make recommendations on regional stormwater regulations and policies. An additional two TAC meetings were held as the writing of the manual progressed to confirm the stormwater criteria being formulated based on TAC guidance. The TAC meetings were open to the public.



After the work of the TAC was completed, the completion and publication of the Manual hinged on the adoption of stormwater management regulations by both the City of Wichita and Sedgwick County. The Manual was written to provide policies and design criteria and guidance to support these regulations, therefore Wichita and Sedgwick County staff believed it prudent to delay publication of the manual until the regulations were in their final form and were adopted. A draft stormwater management ordinance for the City was discussed and modified over the course of a twelve month period, during which the City held a charette-style meeting with local stakeholders and engaged in numerous discussions with members of the local development community, most notably the Wichita Area Builders Association (WABA) and representatives of the local Certified Commercial Investment Member (CCIM) group. Both the City's Stormwater Management Ordinance (Chapter 16.32) and the County's Stormwater Management Resolution (Resolution 196-10) were adopted in November 2010.

Thank you to the many people who provided input on regional stormwater management during the TAC process. The TAC Team Members that dedicated their time and advice to this process are listed below.

| | |
|---|---|
| Dave Barber | Wichita/Sedgwick County MAPD |
| Richard Basore | Kansas Department of Health & Environment |
| Tim Boese | Groundwater Management District #2 |
| Chris Bohm | Ruggles and Bohm PA |
| Clement Dickerson | SMAB member |
| Susan Erlenwein | Environmental Resources |
| Phil Frasier | Professional Engineering Consultants |
| Brian Glenn | Baughman Company PA |
| Trevor Kurth | Baughman Company PA |
| Scott Lindebak | Wichita Public Works & Utilities |
| Jim Putman | U.S. Geological Survey |
| Christy Rodriguez | Wichita-Sedgwick County MAPD |
| Nadine Stannard | Associated Material & Supply Company |
| Rob Stutzman | NRCS |
| Jim Weber | Sedgwick County Public Works |

Although this manual was developed to provide specific information for stormwater management and property development in the City of Wichita and Sedgwick County, useful policies, guidance and concepts from the *Georgia Stormwater Management Manual* (Atlanta Regional Commission, 2001) have been used, suitably modified to meet state and local stormwater management objectives and the needs of the City and County stormwater programs. This paragraph serves as an acknowledgement of the use of text and concepts from the *Georgia Stormwater Management Manual*, and shall be considered as a general reference.

# INTRODUCTION AND PURPOSE

## Objective of the Manual

The objective of the Stormwater Manual (the Manual) is to provide a consistent set of policies and technical standards for the management of stormwater runoff on and from new developments and redevelopments. The policies and standards presented in this Manual are consistent with, and were developed in support of, the stormwater management and floodplain ordinances adopted by the City of Wichita (City) and Sedgwick County (the County). Toward this end, the Manual addresses drainage design, water quantity controls (i.e., detention facilities), structural (i.e., constructed) and non-structural (i.e., planning) controls for water quality, and regulatory controls on development in floodplains.

The Manual is not intended to address regional flood control initiatives such as watershed comprehensive master plans and the local flood control infrastructure and levee system. The focus of the Manual is on the management of stormwater runoff from new developments and redevelopments.

## Organization of the Manual

The Stormwater Manual is organized as a three volume set:

Volume 1 - Policy

Volume 2 - Technical Guidance

Volume 3 – Plan Preparation Guidance

**Volume 1** provides a basic understanding of the regional stormwater management issues and needs and the regulations that drive the need for a consistent and comprehensive management approach. This volume also provides policy statements to support and further clarify the regulatory language contained in the City and County stormwater management and floodplain ordinances. Policy statements included in Volume 1 address stormwater design, detention, water quality control, channel protection, site design practices, and floodplain management.

**Volume 2** provides the technical design standards, criteria and calculation methods to be used to implement the design, inspection and maintenance of stormwater management controls. The information provided in Volume 2 is guidance that is provided in support of City and County stormwater management and floodplain ordinances and the policies presented in Volume 1, and therefore must be used in order to comply with local stormwater management requirements.

**Volume 3** provides the administrative procedures that must be followed during the design, construction and maintenance of a development or redevelopment. Process flow charts and checklists are provided to aid the developer and designer throughout the process.

Figure 1, located on the following page, provides a navigational aides for the use of this manual during the City and County land development processes. This aide is provided again in Volumes 2 and 3.

## Regulatory Status of the Manual

The Stormwater Manual will be used by the City of Wichita and Sedgwick County as a tool to help manage and regulate stormwater and floodplains within these jurisdictions. The manual can be applied in a regulatory capacity through:

- laws and rules established by the City of Wichita and/or Sedgwick County;
- applicable permits and other authorizations issued by local, state and federal agencies.

## How to Get Printed Copies of the Manual

Printed copies of the Stormwater Manual, or CD copies, can be purchased at:

Kansas Blue Print Co., Inc.
700 S. Broadway
Wichita, KS 67211
(316) 264-9344

## How to Find the Manual on the Internet

The Stormwater Manual is available in Adobe Acrobat PDF document format for download at the following Internet address:

http://www.wichita.gov/stormwatermanual

## Contact Information

The City of Wichita's Stormwater Management website is provided below. The website includes contact information and an email link for the City Stormwater Engineer.

http://www.wichita.gov/stormwater/

In Sedgwick County, please use the following email address to gain more information on stormwater topics: info@sedgwickstormwater.com.

| | Stormwater Approval Process | Applicable Stormwater Manual Sections |
|---|---|---|
| | Pre-Design Conference, Drainage ConceptSubmittal/Approval | Vol. 2, Chapters 2 & 3<br>Vol. 3, Sections 2, 3, 5 & 6<br>Vol. 3, Appendices B & C |
| | Stormwater Regulatory and Policy Review | Vol. 1, Chapters 2 & 3<br>Vol. 1, Appendices A, B, C & D |
| | Engineering Design of Site Stormwater System | Vol. 2, All Chapters |
| *Subdivision Platting Process* | Drainage Plan Submittal & Approval, Master Grading Plan Submittal | Vol. 2, All Chapters<br>Vol. 3, Sections 3 & 5<br>Vol. 3, Appendix D |
| *Subdivision Platting Process* | Stormwater Covenants Execution | Vol. 3, Appendix E |
| *Construction Approval Process* | Construction Plan Submittal & Approval: Stormwater Permit, Stormwater Design Plan, Operations & Maintenance Plan, SWPPP | Vol. 2, All Chapters<br>Vol. 3, Sections 4 & 7<br>Vol. 3, Appendices F, G, H, I & J |
| *Construction Approval Process* | Stormwater System Construction, Construction Inspection | Vol. 1, Chapter 4<br>Vol. 1, Appendices A & B |
| *Construction Approval Process* | As-Built Drawings and Final Acceptance by the City of Wichita<br>O&M Plan recorded w/ Register of Deeds | Vol. 3, Sections 4 & 7<br>Vol. 3, Appendices H & K |
| | Post-Construction Stormwater Facility Inspection and Maintenance<br>(In-Perpetuity) | Vol. 1, Chapter 4<br>Vol. 1, Appendices A & B<br>Vol. 2, Chapter 3, Section 5 |

**Figure 1-1 Stormwater Manual Navigational Aide for the Land Development Process**

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CHAPTER

1

# THE NEED FOR INTEGRATED STORMWATER MANAGEMENT

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CHAPTER

1

# THE NEED FOR INTEGRATED STORMWATER MANAGEMENT

## 1.1 Impacts of Development and Stormwater Runoff

Land development changes not only the physical conditions, but can also change the chemical and biological conditions of streams, lakes and other receiving waters. This chapter describes the changes in our local receiving waters that can occur due to development and stormwater runoff, and the potential impacts.

### 1.1.1 Development Changes Land and Runoff

When land is developed the natural water cycle is altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens terrain and fills in natural depressions that slow and provide temporary storage for rainfall. The topsoil and sponge-like layers of humus are scraped and the remaining subsoil is compacted. Rainfall that once seeped into the ground is made to run off the surface. The addition of buildings, roadways, parking lots and other impervious surfaces further reduces infiltration and increases runoff. Figure 1-1 is an example of the changes that take place as land is developed.

**Figure 1-1 Typical Changes in Land Surface for a Commercial Site**

Depending on the magnitude of changes to the land surface, the percentage of rainfall that becomes stormwater runoff can increase dramatically. These changes not only increase stormwater runoff, but also accelerate the rate at which runoff flows across the land. This effect is further exacerbated by drainage systems such as gutters, storm sewers and lined channels that are designed to quickly carry runoff to rivers and streams. Development and impervious surfaces also reduce the amount of water that infiltrates into the soil and groundwater, thus reducing the amount of water that recharges aquifers and feeds stream flow during periods of dry weather. The changes in hydrology and runoff that can result from land development are illustrated in Figure 1-2.

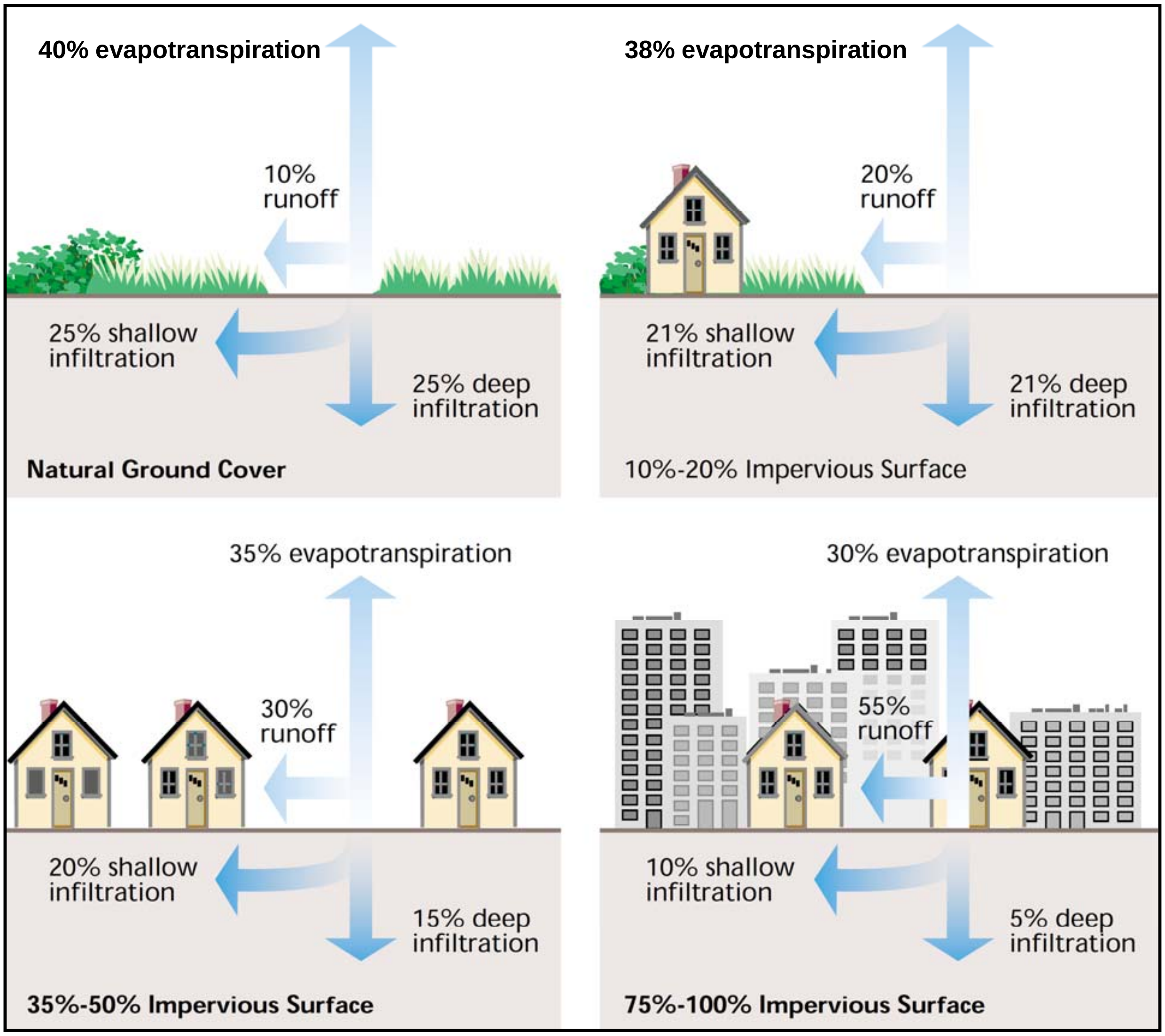



**Figure 1-2 Changes in Hydrology and Runoff Due to Development**
Adapted from “Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the FISRWG."

Finally, development and urbanization affect not only the quantity of stormwater runoff, but also its quality. Development can increase both the concentration and types of pollutants carried by runoff. As it runs over rooftops and lawns, parking lots and commercial sites, stormwater picks up and transports a variety of pollutants to downstream waterbodies. The loss of the original topsoil and vegetation removes a valuable filtering mechanism for stormwater runoff.

**Figure 1-3 Impervious Cover Increases Stormwater Runoff and Transports Pollutants to Local Waterways**

The cumulative impact of development and urban activities, and the resultant changes to both stormwater quantity and quality in the land area that drains to a stream, river, or lake determines the conditions of the waterbody. This land area that drains to the waterbody is known as its watershed. Urban development within a watershed has a direct impact on downstream waters. The impacts of development on watersheds can be placed into four interrelated categories which are described over the next several pages:

- changes to stream flow;
- changes to stream geometry;
- degradation of aquatic habitat; and,
- water quality impacts.

## 1.1.2 Changes to Stream Flow

Urban development alters the hydrology of watersheds and streams by disrupting the water cycle that existed prior to development. This results in:

- Increased Runoff Volumes: Land surface changes can dramatically increase the total volume of runoff generated in a developed watershed.
- Increased Peak Runoff Discharges: Increased peak discharges for a developed watershed can be much greater than those for an undisturbed watershed.
- Greater Runoff Velocities: Impervious surfaces and compacted soils, as well as improvements to the drainage system such as storm drains, pipes and ditches, increase the speed at which rainfall runs off land surfaces within a watershed.
- Timing: As runoff velocities increase, it takes less time for water to run off the land and reach a stream or other waterbody. This changes the timing of flows downstream, which can lead to increased flooding.
- Increased Frequency of Bankfull and Near Bankfull Events: Increased runoff volumes and peak flows increase the frequency and duration of smaller bankfull and near bankfull events. Bankfull indicates the stage of the stream that just fills the channel. These medium-sized storms are the primary channel-forming events.
- Increased Flooding: Increased runoff volumes and peaks also increase the frequency, duration and severity of out-of-bank flooding.
- Lower Dry Weather Flows (Baseflow): Reduced infiltration of stormwater runoff reduces the amount of rainfall recharging groundwater and may cause streams to have less baseflow during dry weather periods.


**Figure 1-4 Increased Runoff Peaks and Volumes Increase Stream Flows and Flooding**
Main Street during 1904 flood and Hyatt building as seen from the Lewis Street bridge during 1998 flood

Streams in developed areas are often characterized as "flashy" because of the increased volume of stormwater runoff, greater peak flows, and quicker hydrologic response to storms. This characterization translates into increased size of the unregulated post-development hydrograph as illustrated in Figure 1-5. This diagram shows the hydrograph for a typical 30-acre residential site during a 10-year storm event.

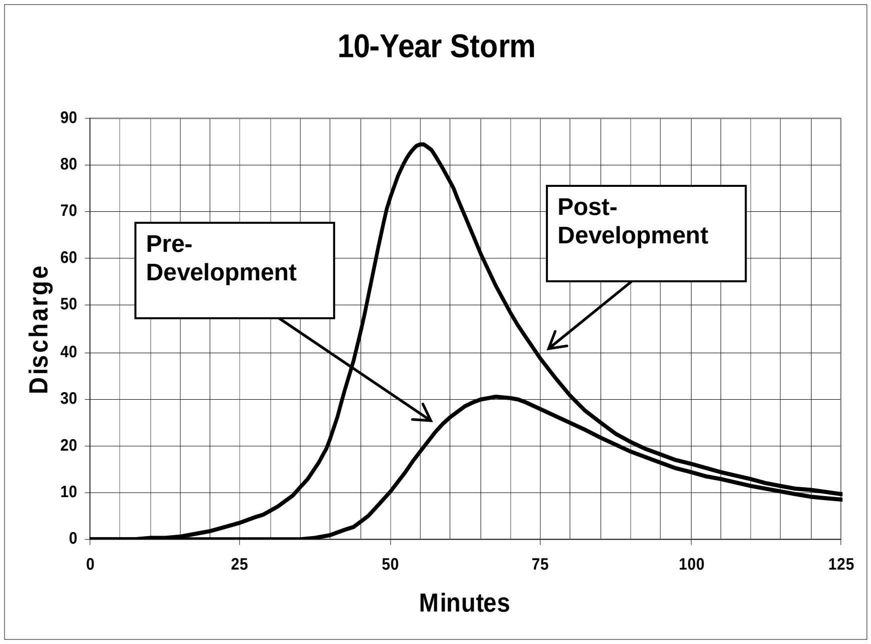



**Figure 1-5 Hydrograph under Pre- and Post Development Conditions**

### 1.1.3 Changes to Stream Geometry

Changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of streams and rivers. An example of the progression of the impacts due to urban development is shown in Figure 1-6.

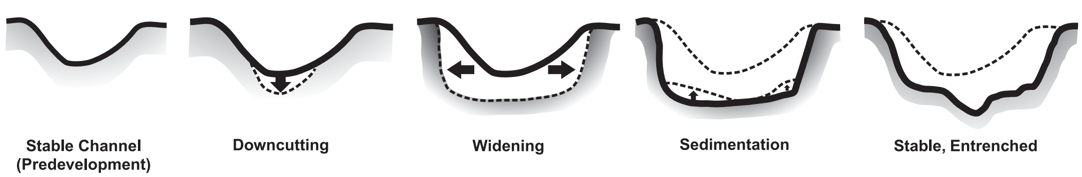



**Figure 1-6 Changes to a Stream's Physical Character Due to Urban Development**

These urban impacts are described as follows:

- Stream Widening and Bank Erosion: Stream channels widen to accommodate and convey the increased runoff and higher stream flows from developed areas. Frequent small and moderate runoff events undercut and scour the lower parts of the streambank, causing the steeper banks to slump and collapse during larger storms. Higher flow velocities further increase streambank erosion rates. A stream can widen to many times its original size due to increased post-development runoff.

- Stream Downcutting: Another way that streams accommodate higher flows is by down-cutting their streambed. This may cause instability in the stream profile, triggering further channel erosion both upstream and downstream.
- Loss of Riparian Tree Canopy: As streambanks are gradually undercut and slump into the channel, the trees that may be protecting the banks are exposed at the roots. This leaves them more likely to be uprooted during major storms, further weakening bank structure.
- Changes in the Channel Bed Due to Sedimentation: Due to channel erosion (Figure 1-7) and other sources upstream, sediments may be deposited in the stream as sandbars and other features, covering the channel bed, or substrate, with shifting deposits of mud, silt and sand.
- Increase in the Floodplain Elevation: To accommodate the higher peak flow rate, a stream's floodplain elevation typically increases following development in a watershed due to higher peak flows. This problem can be compounded by building and filling in floodplain areas, which cause flood heights to rise even further. Property and structures that had not previously been subject to flooding may now be at risk.


**Figure 1-7 Example of Stream Channel Bank Erosion**
Photo courtesy of Kansas State Conservation Commission

### 1.1.4 Degradation of Aquatic Habitat

Along with changes in stream hydrology and morphology, the habitat value of streams diminishes due to development in a watershed. Impacts on habitat may include:

- Degradation of Habitat Structure: Higher and faster flows due to development can scour channels and wash away entire biological communities. Streambank erosion and the loss of riparian vegetation reduce habitat for many fish species and other aquatic life, while sediment deposits can smother bottom-dwelling organisms and aquatic habitat.

- Loss of Pool-Riffle Structure: Streams draining undeveloped watersheds often contain pools of deeper, more slowly flowing water that alternate with “riffles” or shoals of shallower, faster flowing water. These pools and riffles provide valuable habitat for fish and aquatic insects. As a result of the increased flows and sediment loads from urban watersheds, the pools and riffles may disappear and be replaced with more uniform, and often shallower, streambeds that provide less varied aquatic habitat.
- Reduce Baseflows: Reduced baseflows due to increased impervious cover in a watershed and the loss of rainfall infiltration into the soil and water table adversely affect in-stream habitats, especially during periods of drought.
- Increased Stream Temperature: Runoff from warm impervious areas, storage in impoundments, loss of riparian vegetation and shallow channels can all cause an increase in temperature in urban streams. Increased temperatures can reduce dissolved oxygen levels and disrupt the food chain. Certain aquatic species can only survive within a narrow temperature range.
- Decline in Abundance and Biodiversity: When there is a reduction in various habitats and habitat quality, both the number and the variety, or diversity, of organisms (wetland plants, fish, macroinvertebrates, etc.) is also reduced. Sensitive fish species and other life forms disappear and are replaced by those organisms that are better adapted to the poorer conditions. The diversity and composition of the benthic, or streambed, community have frequently been used to evaluate the quality of urban streams. Aquatic insects are a useful environmental indicator as they form the base of the stream food chain.


**Figure 1-8 Impacts to Aquatic Habitat**
Litter and Sediments in Spring Creek

Fish and other aquatic organisms are impacted not only by the habitat changes brought on by increased stormwater runoff quantity, but are often also adversely affected by water quality changes due to development and resultant land use activities in a watershed. These impacts are discussed below.

### 1.1.5 Water Quality Impacts

Nonpoint source pollution, which is the primary cause of polluted stormwater runoff and water quality impairment, comes from many diffuse or scattered sources—many of which are the result of human activities within a watershed. Development concentrates and increases the amount of these nonpoint source pollutants. As stormwater runoff moves across the land surface, it picks up and carries away both natural and manmade pollutants, depositing them into streams, rivers, lakes, wetlands, marshes and aquifers.

Water quality degradation in urbanizing watersheds starts when development begins. Poorly controlled erosion from construction sites and other disturbed areas can contribute large amounts of sediment to streams. As construction and development proceed, impervious surfaces replace the natural land cover, and pollutants from human activities begin to accumulate on these surfaces. During storm events, these pollutants are then washed off into the streams. Although the stormwater system and the sanitary sewer system are separate conveyance systems in Wichita, discharges from sewer overflows and overflows from septic tanks can also contribute to the pollution load. There are a number of other causes of nonpoint source pollution in urban areas that are not specifically related to wet weather events including leaking sewer pipes, septic tanks or waste lagoons, sanitary sewage spills, and illicit discharge of commercial/industrial wastewater and wash waters to storm drains.

Stormwater runoff into lakes and reservoirs can have some unique negative effects. A notable impact of urban runoff can be the filling in of lakes and reservoirs with sediment. Another significant water quality impact on waterbodies related to stormwater runoff is nutrient enrichment. This can result in the undesirable excessive growth of algae and aquatic plants. Lakes do not flush pollutants as quickly as streams and act as sinks for nutrients, metals and sediments. This means that lakes can take longer to recover from pollution.

Due to the magnitude of the problem, it is important to understand the nature and sources of urban stormwater pollution. Table 1-1 summarizes the major stormwater pollutants and their effects.

**Table 1-1  Summary of Major Stormwater Pollutants**

| Constituents | Effects |
|---|---|
| Sediments—Suspended Solids, Dissolved Solids, Turbidity | Stream turbidity<br>Habitat changes<br>Recreation/aesthetic loss<br>Contaminant transport<br>Filling of lakes and reservoirs |
| Nutrients—Nitrate, Nitrite, Ammonia, Organic Nitrogen, Phosphate, Total Phosphorus | Algae blooms<br>Eutrophication<br>Ammonia and nitrate toxicity<br>Recreation/aesthetic loss |
| Microbes—Total and Fecal Coliforms, Fecal Streptococci Viruses, E.Coli, Enterocci | Ear/Intestinal infections<br>Recreation/aesthetic loss |
| Organic Matter—Vegetation, Sewage, Other Oxygen Demanding Materials | Dissolved oxygen depletion<br>Odors<br>Fish kills |
| Toxic Pollutants—Heavy Metals (cadmium, copper, lead, zinc), Organics, Hydrocarbons, Pesticides/Herbicides | Toxicity to humans & aquatic organisms<br>Bioaccumulation in the food chain |
| Thermal Pollution | Dissolved oxygen depletion<br>Habitat degradation |
| Trash and debris | Recreation/aesthetic loss |

Some of the most frequently occurring pollution impacts and their sources for urban streams are:

- <u>Reduced Oxygen in Streams:</u> The decomposition of organic matter uses up dissolved oxygen (DO) in the water, which is essential to fish and other aquatic life. As organic matter is washed off by stormwater, dissolved oxygen levels in receiving waters can be rapidly depleted. If the DO deficit is severe enough, fish kills may occur and stream life can weaken and die. In addition, oxygen depletion can affect the release of toxic chemicals and nutrients from sediments deposited in a waterway. All forms of organic matter in urban stormwater runoff such as leaves, grass clippings and pet waste contribute to the problem. In addition, non-stormwater discharges of organic matter to surface waters, such as sanitary sewer leakage and septic tanks leaching, can also cause reduced oxygen levels.

- <u>Nutrient Enrichment:</u> Runoff from urban watersheds contains increased levels of nutrients such as nitrogen and phosphorus. Increased nutrient levels are a problem as they promote a condition known as eutrophication, which encourages excessive weed and algae growth in water bodies. An example of eutrophication in the Dell is shown in Figure 1-9. Algae blooms block sunlight from reaching underwater grasses and deplete oxygen in bottom waters. In addition, nitrification of ammonia by microorganisms can consume dissolved oxygen, while nitrates can contaminate groundwater. Typical sources of nutrients in the urban environment include washoff of fertilizers and vegetative litter, animal wastes, sewer overflows and leaks, septic tank seepage, detergents, and the dry and wet fallout of materials in the atmosphere.


**Figure 1-9 Eutrophication in the Dell**

- Microbial Contamination: The level of bacteria, viruses and other microbes found in urban stormwater runoff can exceed public health standards for water contact recreation such as swimming and wading. The main sources of these contaminants are sewer overflows, septic tanks, pet waste, and urban wildlife such as pigeons, waterfowl, squirrels and raccoons.
- Hydrocarbons: Oils, greases and gasoline contain a wide array of hydrocarbon compounds, some of which have been shown to be carcinogenic, tumorigenic and mutagenic in certain species of fish. In addition, large quantities of oil can impact drinking water supplies and affect recreational use of waters. Oils and other hydrocarbons are washed off roads and parking lots, primarily due to engine leakage from vehicles. Other sources include the improper disposal of motor oil in storm drains and streams, spills at fueling stations and restaurant grease traps.
- Toxic Materials: Besides oils and greases, urban stormwater runoff can contain a wide variety of other toxicants and compounds including heavy metals such as lead, zinc, copper, and cadmium, and organic pollutants such as pesticides, PCBs and phenols. These contaminants are of concern because they are toxic to aquatic organisms and can bioaccumulate in the food chain. In addition, they may also impair drinking water sources and human health. Many of these toxicants accumulate in the sediments of streams and lakes. Sources of these contaminants include industrial and commercial sites, urban surfaces such as rooftops and painted areas, vehicles and other machinery, improperly disposed household chemicals, landfills, hazardous waste sites and atmospheric deposition.
- Sedimentation: Eroded soils are a common component of urban stormwater and are a pollutant in their own right. Excessive sediment can be detrimental to aquatic life by

interfering with photosynthesis, respiration, growth and reproduction. Sediment particles transport other pollutants that are attached to their surfaces including nutrients, trace metals and hydrocarbons. High turbidity due to sediment may increase the cost of treating drinking water and reduce the value of surface waters for industrial and recreational use. Sediment also fills ditches and small streams and clogs storm sewers and pipes, and can cause flooding and property damage. Sedimentation can reduce the capacity of channels, reservoirs and lakes. Erosion from construction sites, exposed soils, street runoff, agriculture and streambanks are the primary sources of sediment in urban runoff.

- Higher Water Temperatures: As runoff flows over impervious surfaces such as asphalt and concrete, it may increase in temperature before reaching a stream or reservoir. Water temperatures are also increased due to shallow ponds and impoundments along a watercourse as well as the reduction of trees along streams, which provide shade to the stream. Since warm water can hold less dissolved oxygen than cold water, this "thermal pollution" further reduces oxygen levels in depleted urban streams. Temperature changes can severely disrupt aquatic species that can survive only within a narrow temperature range.

- Trash and Debris: Considerable quantities of trash and other debris are washed into gutters, down banks, and through storm drain systems into water bodies. Debris can cause blockage of a channel, which can result in localized flooding and erosion as shown in Figure 1-10. The debris blocking flow under the Harry Street Bridge contributed to the flooding of Harry Street.

**Figure 1-10 Trash and Debris at a Bridge**
Harry Street Bridge

### 1.1.6 Stormwater Hotspots

Stormwater hotspots are areas of the urban landscape that often produce higher concentrations of certain pollutants, such as hydrocarbons or heavy metals, than are normally found in urban runoff. These areas merit special management and the use of specific pollution prevention activities and/or structural stormwater controls. Examples of stormwater hotspots include:

- Gas / fueling stations;
- Vehicle maintenance areas;
- Vehicle washing/steam cleaning;
- Auto recycling facilities;
- Outdoor material storage areas;
- Loading and transfer areas;
- Landfills;
- Construction sites;
- Industrial sites; and,
- Industrial rooftops.

Figure 1-11 shows examples of potential stormwater hotspots.


**Figure 1-11 Examples of Potential Stormwater Hotspots**

Filling Station at Lewis and Broadway (ca 1930) and Fleet Storage Area on South Meridian Avenue during 1998 Flood

## 1.2 Social and Economic Impacts of Uncontrolled Stormwater

The effects of urban stormwater runoff are not only environmental, but also have very real social and economic impacts on the City and County. These impacts are described below.

### 1.2.1 Human Welfare

The first concern of local governments is that of public safety. Increased runoff peak flows and volumes due to development can potentially overwhelm stormwater drainage facilities, structural controls and downstream conveyances, putting human welfare at risk. Floodwaters can cause driving hazards by overtopping roadways and washing out bridges, as well as carrying sediment and debris onto streets and highways.

Since 1877, there have been 16 “notable” flood events, two of which were presidentially declared disasters. Surface waters historically prone to flooding include: Arkansas River, Little Arkansas River, Ninnescah River, Jester Creek, Big Slough Creek, Chisholm Creek, Cowskin Creek, Dry Creek, Gypsum Creek, Wildcat Creek, Clearwater Creek, Spring Creek and Sand Creek. Areas of Sedgwick County prone to flooding are shown on the 2001 Flood Insurance Rate Map (FIRM) panels. A composite of the panels is shown in Figure 1-12, with cities displayed in green and blue, and flood prone areas displayed in gray. The October 1, 1973 flood peak was the largest on record and closely approximates the 100-year flood frequency.

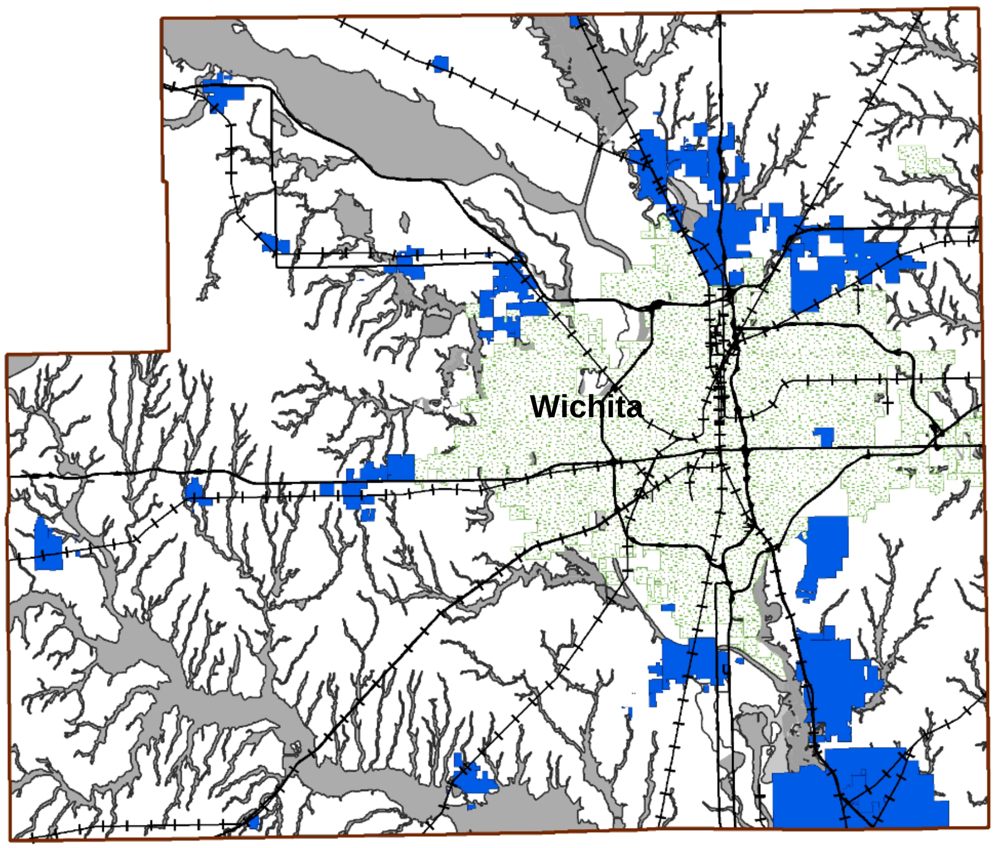



**Figure 1-12 Composite of Sedgwick County Flood Panels**

Floods on the Little Arkansas River exceed channel capacity on the average of once a year. The U.S. Army Corps of Engineer (USACE) Wichita and Valley Center Local Protection Project (completed in 1959) is the largest mitigation constructed to provide protection to the City of Wichita. The project comprises a system of control structures and levees and is designed to intercept the excess flow of Chisholm Creek, the Little Arkansas River, the Arkansas River, Big Slough Creek and Cowskin Creek, among other streams. The amount of investment in these flood control structures demonstrates the importance of flood protection in Wichita and Sedgwick County.

### 1.2.2 Property and Structural Damage Due to Flooding

Due to upstream development, properties that were previously outside the 100-year floodplain may now find themselves subject to flood damage. Areas that previously flooded only once every 10 years may flood more frequently and with more severity due to upstream development. Increased property and infrastructure damage can also result from stream channel widening, undersized runoff storage and conveyance facilities, and development in the floodplain. Figure 1-13 includes photos from two local flooding events.

**Figure 1-13 Flooding Endangers Human Life and Property**
Cowskin Branch during 1998 Flood and Truck Stranded on South Meridian Street during May 2006 Flood

### 1.2.3 Impairment of Drinking Water Supplies (Surface and Groundwater)

Water quality degradation from polluted stormwater runoff can contaminate both surface and groundwater drinking water supplies and potentially make them unfit for a community's use. Sedgwick County is particularly susceptible to contamination of the drinking water aquifer due to the shallow nature of the Equus beds that local drinking water is drawn from.

### 1.2.4 Increased Cost of Treating Drinking Water

Even if a drinking water supply remains viable, heavy concentrations of contaminants such as sediment and bacteria can increase the costs of water treatment to a community and water customers.

### 1.2.5 Loss of Recreational Opportunities on Streams, Rivers, and Lakes

Turbidity from sediment, odors, floating trash, toxic pollutants and microbial contamination from stormwater runoff all reduce the viability of waterbodies for recreational activities such as swimming, boating and fishing. In addition, the aesthetic loss along these waterways also reduces the experience for noncontact recreation such as picnicking, jogging, biking, camping and hunting.

### 1.2.6 Increased Litigation

Increased legal action can result against local governments that have not adequately addressed stormwater runoff drainage and water quality problems. Communities risk lengthy and expensive court proceedings when community groups take action to force modernization of stormwater policies.

### 1.2.7 Quality of Life

Stormwater quantity and quality impacts can affect the overall quality of life in a community. The public life of Wichita is closely linked to the streams and rivers that flow through it. Examples of how residents enjoy the Arkansas River can be found in the yearly Riverfest and heavy use of the River Walk. Significant investment has occurred around surface water bodies within the County, so that public use and private property values are closely linked to water.


**Figure 1-14 Water Quality Problems have the Potential to Impact Key Local Events like Riverfest**

Many people believe that stormwater pollution affects the appearance and quality of downstream waterbodies, influencing the desirability of working at, traveling to, living in, or owning property near the water.

For a number of reasons - including public health and safety, environmental, economic, legal liability, regulatory responsibility and improved quality of life - the City and County have a vested interest and need to effectively deal with the effects of development and stormwater runoff. Beyond these reasons, the City and County are required by Federal and State law to implement effective local stormwater regulations and guidance. The following section outlines the regulations that require local governments to control stormwater, and how these regulations affect land development at the City and County level.

**Figure 1-15 Waterfronts are an Important Resource for Residents and Visitors**
View of the Wichita Riverwalk at Sunset

## 1.3 Addressing Runoff Impacts through Stormwater Management

### 1.3.1 The City of Wichita and Sedgwick County Stormwater Management History

Flooding problems in the 1940s and 1950s led to the creation of major flood control works to protect the city. Local flooding problems were also a concern, as streets were often swamped by stormwater runoff. These local flooding problems led to the creation of design guidance on storm sewer pipe sizing and inlet design sizing. Continued flooding during the 1970s and 1980s pointed to the role of increased stormwater peak flows and volumes due to urbanization. Stormwater detention guidance was published in 1981 in an attempt to combat flooding due to urbanization.

The late 1980s and 1990s saw a growing recognition of urban impacts on water quality as well as water quantity. The Clean Water Act (CWA) began permitting municipalities as nonpoint dischargers under the Municipal Separate Storm Sewer System (MS4) program. Wichita was permitted in 1987, and Sedgwick County in 2004. Both of these entities have made great strides in creating overall stormwater management programs to control the detrimental effects of uncontrolled stormwater on local citizens and the effects land use on water quality. Figure 1-16 outlines the progress of local stormwater policy.

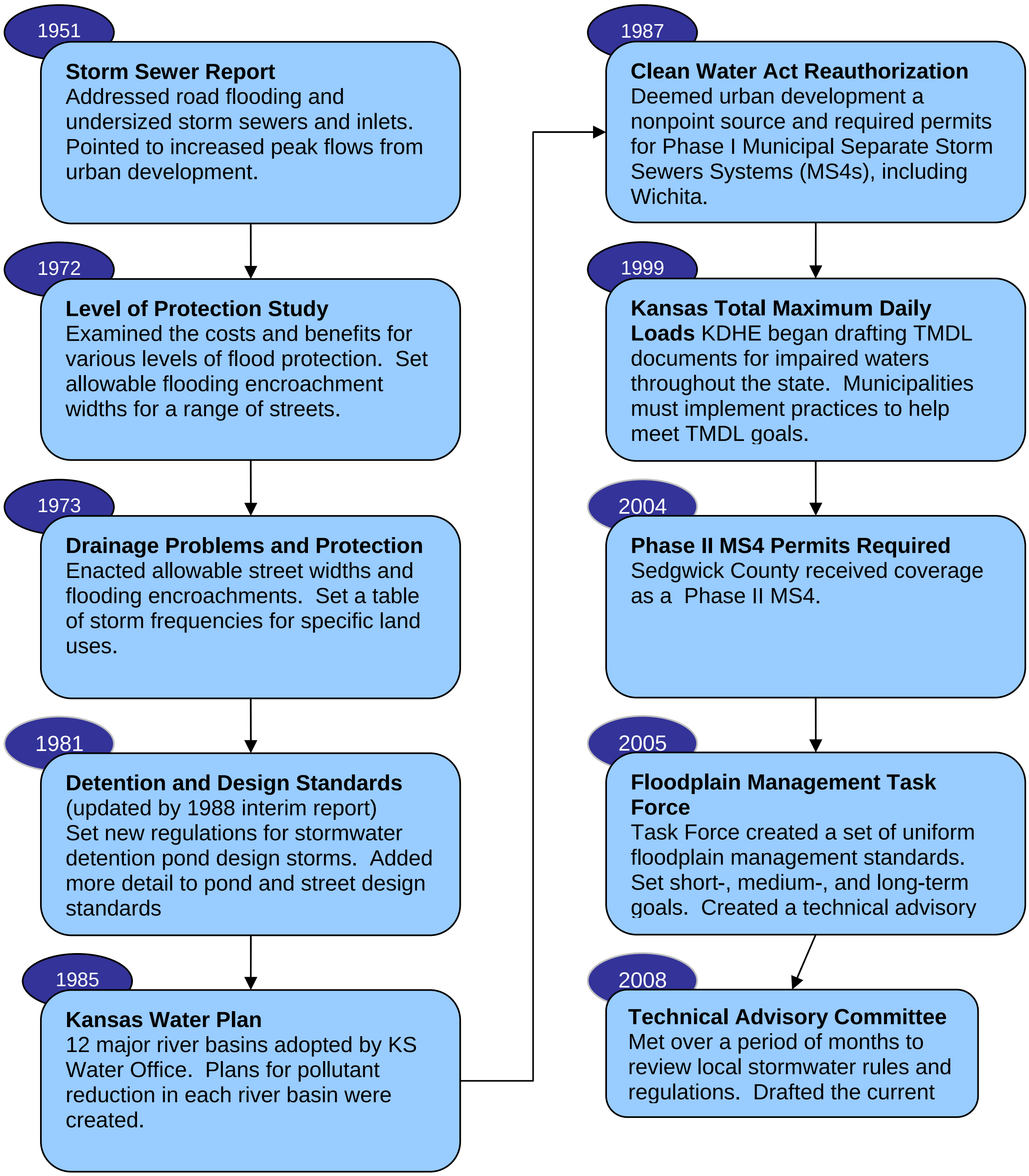



**Figure 1-16 History of Policy Development**

### 1.3.2 Moving Forward with a Comprehensive Stormwater Management Approach

Through the creation of the Stormwater Manual and associated local stormwater management regulations, and the revisions to the floodplain regulations, the City of Wichita and Sedgwick County have continued to move forward with a consistent approach to deal with the impacts of development on stormwater runoff.

Effective stormwater management involves both the prevention and mitigation of stormwater runoff quantity and quality impacts through a variety of methods and mechanisms. In general, stormwater management can be broken down into the following six areas:

**Watershed Planning:** Using the watershed as the framework for managing land use and developing large scale solutions to regional stormwater quantity and quality problems.

**Development Requirements:** Addressing the stormwater impacts of new development and redevelopment through stormwater management requirements and minimum standards.

**Erosion and Sediment Control:** Controlling erosion and soil loss from construction areas and resultant downstream sedimentation.

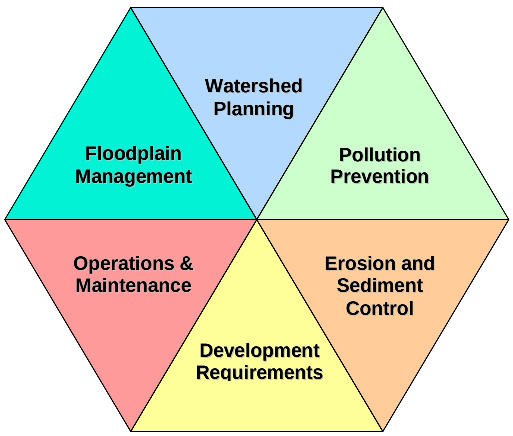
**Floodplain Management:** Preserving the function of floodplain areas to reduce flood hazards, minimize risks to human welfare and property, reduce modifications to streams and protect water quality.

**Operations and Maintenance:** Ensuring that stormwater management systems and structural controls work as designed and constructed; includes the retrofitting of existing problem areas and streambank stabilization activities.

**Pollution Prevention:** Preventing stormwater from coming into contact with contaminants and becoming polluted through a number of management measures.

Together these six categories create the "umbrella" of comprehensive stormwater management as shown in Figure 1-17.

**Figure 1-17 The "Umbrella" of Comprehensive Stormwater Management**



The focus of the Stormwater Manual is effective water quality and quantity management for new developments and redevelopments. Stormwater management involves both the prevention and mitigation of stormwater runoff quantity and quality impacts through a variety of methods and mechanisms.

The Stormwater Manual provides requirements, policies, and guidance for developers to effectively implement water quality management controls on-site to address the potential impacts of new development and redevelopment, and both prevent and mitigate problems associated with stormwater runoff. This is accomplished by:

- Developing land in a way that minimizes its impact on a watershed by reducing both the amount of runoff and the pollutants generated (i.e., optional Preferred Site Design practices);
- Controlling stormwater to prevent or reduce downstream streambank channel erosion;
- Treating stormwater runoff before it is discharged to a waterway; and,
- Implementing pollution prevention practices to prevent stormwater from becoming contaminated in the first place.

### 1.3.3 Comprehensive Stormwater Management Planning

Minimum standards and performance requirements for treating and/or controlling runoff from development are critical to addressing the impacts of urban stormwater and are required of the local jurisdictions in order to comply with the National Pollutant Discharge Elimination System (NPDES) stormwater regulations. Minimum stormwater management standards must also be supported by a set of design and management tools and an integrated design approach for implementing both structural and nonstructural stormwater facilities. The major elements of the stormwater management program implemented by the City of Wichita and Sedgwick County are:

- <u>Incentives for Stormwater Preferred Site Design:</u> The first step in addressing water quality management begins with the site planning and design process. The goals of preferred site development design are to reduce the amount of runoff and pollutants that are generated from a development site and provide for some nonstructural on-site treatment and control of runoff by implementing a combination of approaches collectively known as stormwater preferred site design practices. These optional (recommended but not required) practices include maximizing the protection of natural features and resources on a site, developing a site design that minimizes impact, reducing the overall site imperviousness, and utilizing natural systems for water quality management.
- <u>Water Quality Reductions for Preferred Site Design:</u> The Stormwater Manual establishes a set of optional water quality protection volume "reductions" that can be used to provide developers and site designers' incentives to implement preferred site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. While reducing stormwater impacts, the reduction system can also translate directly into cost savings to the developer by reducing the size of structural water quality management

and conveyance facilities. Specific technical guidance on the water quality reductions offered is presented in Chapter 2 of Volume 2.

- Stormwater Quality Treatment: Stormwater that runs off from a new development or redevelopment shall be treated to remove pollutants prior to discharge from the development or redevelopment site. Stormwater management systems shall be designed to remove 80% of the post-development total suspended solids (TSS) load, based on the 85th percentile storm event, and be able to meet any other additional watershed or site-specific water quality requirements, as determined by the local jurisdiction. Design criteria and equations are presented in Chapter 3 of Volume 2. It is presumed that a stormwater management system complies with this performance standard if:
    - appropriate structural stormwater controls are selected, designed, constructed, and maintained according to the specific criteria in the Stormwater Manual, and
    - runoff from hotspot land uses and activities is adequately treated and addressed through the use of appropriate structural stormwater controls and pollution prevention practices.
- Downstream Channel Erosion Protection: Local streams are susceptible to long-term erosion and degradation due to increased flows and flow durations resulting from upstream development and urbanization. Protection of stream channels shall be provided through the capture and extended detention of the runoff volume from the 1-year return frequency, 24-hour duration storm event. Channel protection requirements are presented in Volume 1 and Chapter 4 of Volume 2.
- Downstream Impact Analysis (e.g. the 10% rule): The potential for a new development or redevelopment to increase flooding downstream is managed by requiring a hydrologic analysis to extend from the property boundary to a point downstream where the development area is 10% or less of the total drainage area. Measures must be taken to ensure that the project does not increase flooding for the 2, 5, 10, 25 and 100-year, 24-hour rainfall events. Downstream impact analysis requirements are presented in Volume 1 and Chapter 4 of Volume 2.
- Guidance on Structural Stormwater Management Facilities: Volume 2 of the Manual provides requirements and specifications for a set of structural water quality management facilities that can be used to meet the water quality and flood control management goals.

### 1.3.4 Summary of Integrated Site Design

The design criteria and specifications in the Stormwater Manual communicate the regional approach to address potential adverse impacts of stormwater runoff for new developments and redevelopments. The purpose of the design criteria is to provide a framework for design of a development site's stormwater management system in order to reduce stormwater runoff pollutants; control peak flows, runoff volumes and velocities, and prevent long-term downstream streambank and channel erosion.

Volume 2 of the Manual presents the Integrated Site Design (ISD) approach to site-level stormwater management. The ISD approach takes advantage of the fact that the design criteria for water quality, channel protection, and flood protection can often be blended together. This enables the sizing and design of structural stormwater facilities in conjunction with each other to address the overall stormwater impacts from a development site. When stormwater design criteria are considered as a set, the site designer can control the range of design events, from the smallest amounts of runoff that are treated for water quality, to events requiring extreme flood protection, such as the 100-year storm. Figure 1-18 graphically illustrates the relative volume requirements of the various stormwater controls and demonstrates that, in some cases, the controls can be nested within one-another (i.e., the flood protection volume requirement also contains the channel protection volume and the water quality treatment volume).

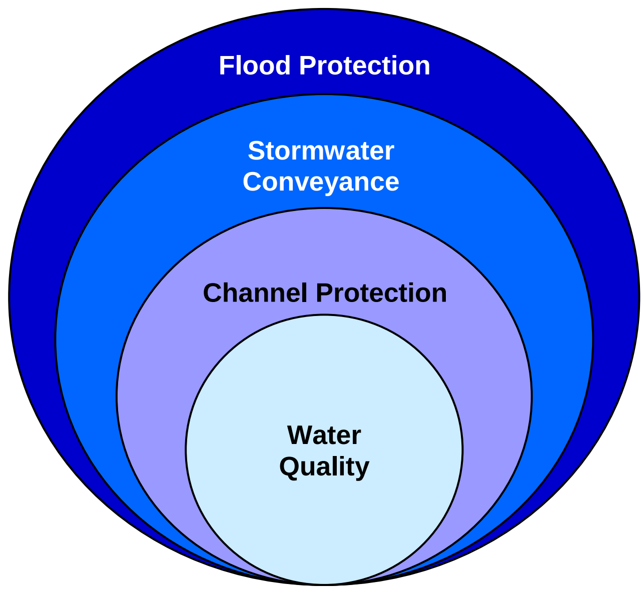



**Figure 1-18 Design Volume "Nesting" of Stormwater Criteria**

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CHAPTER

2

# OVERVIEW OF INTEGRATED SITE DESIGN

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CHAPTER

2

# APPLICABLE REGULATIONS AND INITIATIVES

## 2.1 Overview

As a result of the need to address the potential negative impacts of development and stormwater runoff, a number of federal, state, and regional regulations have been created to regulate stormwater runoff and manage floodplains. The purpose of this section is to provide a brief overview of the regulations and programs that can impact new developments and redevelopments.

## 2.2 Federal Regulations

### 2.2.1 National Flood Insurance Program

Established under the National Flood Insurance Act of 1968 and broadened with the passage of the Flood Disaster Protection Act of 1973, the National Flood Insurance Program (NFIP) provides federally supported flood insurance to residents in communities that voluntarily adopt and enforce regulations to reduce future flood damage. As part of the program, the Federal Emergency Management Agency (FEMA) defines minimum standards for land development in floodplain areas. The City of Wichita and Sedgwick County participate in the NFIP and have adopted floodplain development standards as part of this program. Floodplain development requirements and policies for the City and County can be found in each jurisdictions local floodplain regulations and in this manual.

**Error! Reference source not found.** provides a general guide to indicate regulations, programs and initiatives that are relevant to land development.

As this is not intended to be a detailed analysis of each requirement, site designers are advised to obtain a copy of the specific administrative rules for each program from the appropriate regulatory agency.

**Table 2-1 Regulatory Framework for Local Stormwater Management in Kansas**

| Basis of Regulation | Quantity Based Regulations | | Quality Based Regulations | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Area of Regulation | Flood Control | Dam Safety | Municipal Stormwater | Construction Stormwater | Water Quality Standards | Water Supply Protection | Groundwater Protection | Stream and River Protection | Wetland Protection |
| Objective | Flood prevention and property protection | Protect the safety of Kansas residents | Management of municipal stormwater | Control of stormwater (erosion and sedimentation) from construction sites | Control of point and nonpoint loads so that quality standards are met | Protection of municipal drinking water supplies | Protection of municipal groundwater aquifers | Protect water quality, control of erosion, reduction of flood hazards | Protection of wetlands and waters |
| Federal Legislation | Flood Insurance & Floodplain Management Program (1) | National Dam Inspection Act of 1972 | Clean Water Act | | | Safe Drinking Water Act | | NA | Clean Water Act; Rivers and Harbors Act |
| State Legislation | NA | Dam Safety Program | Kansas Rules and Regulations | | | Kansas Statues for Public Water Supply | Groundwater Exploration and Protection Act | Kansas Rules and Regulations; Kansas Environmental Coordination Act | |
| Enforcement Agency(s) | Local agencies that issue building permits | Kansas Department of Agriculture | Local MS4 and Kansas Department of Health and Environment (2) | | | Groundwater Management Districts and Kansas Department of Health and Environment (2) | | Kansas Department of Agriculture - Division of Water Resources | |
| Enforcement Mechanism | Local floodplain regulations | Permits for dam construction and inspections | NPDES Phase I and II Municipal Stormwater Permits | NPDES Permits for construction sites, SWPPP | NPDES Permits for industrial activities and watershed assessment req'ts; TMDLs (3) | Water supply watershed regulations; SWAP program (4) | Groundwater recharge area criteria; Wellhead Protection program | Section 401/404 Permits (5) | |

Notes:
1) Broadened and modified with passage of the Flood Disaster Act of 1973 and National Flood Insurance Act of 1994
2) Final enforcement authority for federal laws under the Clean Water Act and Safe Drinking Water Act rests with the U.S. EPA
3) Refers to the federal and state Total Maximum Daily Load (TMDL) initiative
4) Refers to the federal and state Source Water Assessment Program (SWAP)
5) Section 401 deals with water quality certifications intended to assure that the permitted activity will not result in a violation of Kansas water quality standards. 404 Permits authorize the U.S. Army Corps of Engineers to administer a program of permitting the discharge of dredge and fill material to the nation's waterways.

## 2.2.2 Waters of the U.S./Wetlands – Federal Section 404 Permits

The U.S. Army Corps of Engineers administers a permit program for activities in, on, or around waters of the United States. Regulated activities include excavating or depositing fill materials in waters of the United States. Waters of the United States include all surface waters, such as navigable inland waters, lakes, rivers, streams, and their tributaries; interstate waters and their tributaries; wetlands adjacent to the above (e.g. swamps, marshes, bogs, or other land areas); and isolated wetlands and lakes, intermittent streams, and other waters where degradation could affect interstate commerce.

Section 404 permits are required for stormwater activities that may impact waters of the United States, including natural wetlands. Section 10 permits (Section 10 Rivers and Harbors Act) are also required for navigable waters of the United States.

The Kansas Department of Health and Environment (KDHE) is responsible for conducting water quality certification reviews for 404 permits in Kansas. The certification reviews are required by Section 401 of the Clean Water Act. Water quality protection plans may required by KDHE to ensure that proposed projects comply with state water quality standards.

### 2.2.3 National Environmental Policy Act, Council on Environmental Quality

Congress established the Council on Environmental Quality within the Executive Office of the President as part of the National Environmental Policy Act of 1969 (NEPA). NEPA establishes the Federal government's environmental policy to help public officials make decisions based on an understanding of the environmental consequences of their actions, and to take actions that protect, restore, and enhance the environment. NEPA requires Federal agencies to prepare written assessments that describe the environmental consequences of a proposed project, reasonable alternatives to avoid environmental impacts, and any mitigation measures necessary to minimize an unavoidable impact.

If a project is either directly or indirectly funded by a federal source, then the agency providing funds to the project owner is responsible for seeing that the appropriate level of environmental assessment is performed. There are three levels of analysis depending on whether or not an undertaking could significantly affect the environment. These three levels include: categorical exclusion determination; preparation of an environmental assessment/finding of no significant impact (EA/FONSI); and preparation of an environmental impact statement (EIS).

EPA Region VII staff is the first point of contact for NEPA reviews in Kansas.

### 2.2.4 Endangered Species Act

The mission of the U.S. Fish and Wildlife Service (USFWS) is to conserve, protect, and enhance fish and wildlife, and their habitats for the continuing benefit of the American people. USFWS activities affecting land development include enforcing the federal Endangered Species Act (ESA) and insuring compliance with the National Environmental Policy Act (NEPA).

The Kansas Department of Wildlife and Parks (KDWP) coordinate closely with USFWS to administer the Endangered Species Act within Kansas. KDWP staff has mapped areas of critical habitat for threatened and endangered species throughout the state. Any action which will impact threatened/endangered species or their critical habitats and is totally or partially funded with public money or requires a permit from a state or federal agency must be permitted through KDWP.

## 2.3 State of Kansas Regulations and Programs

### 2.3.1 KDHE MS4 Stormwater Permit Program (Phase I and II)

The National Pollutant Discharge Elimination System (NPDES) was originally established by the Clean Water Act of 1972 to control wastewater discharges from various industries and wastewater treatment plants known as "point" sources. Congress amended the Clean Water Act with the Water Quality Act of 1987 to expand the NPDES permit program to address "nonpoint" source pollution through schedules for permitting municipal stormwater discharges. The Municipal Separate Storm Sewer System (MS4) stormwater discharge permit establishes requirements for municipalities to minimize pollutants in stormwater runoff to the "maximum extent practicable."

KDHE is the authority that administers the NPDES program. Under the KDHE MS4 permit program, local governments and public entities in regulated areas are required to establish and implement a comprehensive Stormwater Management Program (SWMP) to control potential pollutants in stormwater runoff discharging to Waters of the State to the maximum extent practicable and to eliminate non-stormwater discharges entering the stormwater system.

KDHE has two active MS4 general permits, one for rural areas (G-UNA-0604-S001) and one for urbanized areas (G-UA-0604-S001). There are six elements, termed "minimum control measures" that each SWMP must address for the MS4's coverage under the state general permit. The measures are as follows:

1. Public Education and Outreach;
2. Public Involvement and Participation;
3. Illicit Discharge Detection and Elimination;
4. Construction Site Stormwater Runoff Control;
5. Post-Construction Stormwater Management in New Development and Redevelopment Projects; and,
6. Pollution Prevention/Good Housekeeping for Municipal Operations.

For the City of Wichita and Sedgwick County compliance with the MS4 permit is accomplished through a stormwater program which includes the implementation of structural and non-structural stormwater practices to protect stormwater quality. Local stormwater management, erosion and sediment control and other development-related regulations provide enforcement authority and criteria for controlling significant components of the SWMP. This Stormwater Manual is a part of the overall SWMPs for the City and County. This Manual was created through public involvement (#2), helps to prevent illicit discharges (#3), gives some guidance on construction runoff control (#4) and sets enforceable standards for post-construction stormwater management (#5).

### 2.3.2 KDHE Stormwater Permits for Construction Activities

The KDHE State General Permit for Construction Activities is directed toward controlling the quality of stormwater runoff from construction. The permit requires the preparation of a construction Stormwater Pollution Prevention Plan (SWPPP) that emphasizes the application of BMPs to control erosion and sedimentation processes during the construction phase of development. Construction site waste must also be addressed in the SWPPP.

Operators of construction sites disturbing one acre or greater are required to obtain coverage under the General Permit by developing a SWPPP and filing a Notice of Intent (NOI) and other supporting documents. KDHE will review the SWPPP and provide a Notice of Coverage (NOC) to the land disturber once any deficiencies in the SWPPP have been corrected. The NOC must be obtained prior to initiating construction activities. A copy of the SWPPP and NOC must be submitted to the local jurisdiction prior to construction.

Permittees on sites with a NOC are further required to submit a Notice of Termination (NOT) to KDHE when final stabilization has been achieved on all portions of the site. Refer to KDHE Bureau of Water General Permit No. S-MCST-0701-1 for specific permit requirements.

### 2.3.3 KDHE Total Maximum Daily Load (TMDL) Program

Under Section 303(d) of the Clean Water Act, the State of Kansas is required to develop a list of impaired waters that do not meet water quality standards. KDHE must then establish priority rankings for waters on the list and develop Total Maximum Daily Loads (TMDLs) for listed waters. The TMDL specifies the maximum amount of a specific pollutant of concern that a stream segment can receive and still meet water quality standards. The TMDL also allocates pollutant loadings among point and nonpoint pollutant sources, including stormwater runoff. If a TMDL has been established for a water body, the impact of new point and nonpoint sources must be assessed prior to KDHE approval of new or amended discharge or stormwater permits.

The TMDL program has a broad impact on the City of Wichita and Sedgwick County, because nonpoint sources of pollutants must be addressed at the local level. The following local waters are on the 303(d) impairment list:

**Table 2-2 TMDL Regulated Parameters for Sedgwick County in 2010**

| TMDL Regulated Parameter | Associated Stream or Lake |
|---|---|
| Phosphorus | Little Arkansas River, Cowskin Creek, Cheney Lake & Afton Lake |
| Nitrate | Little Arkansas River & Cowskin Creek |
| Ammonia | Little Arkansas River & Cowskin Creek |
| Biochemical Oxygen Demand Pollutants | Little Arkansas River & Cowskin Creek |
| Suspended Solids (Sediment) | Little Arkansas River, Cowskin Creek & Cheney Lake |
| Fecal Coliform Bacteria | Arkansas River, Whitewater River & Little Arkansas River |
| Nitrogen | Lake Afton |

For each pollutant identified, a TMDL implementation plan has been developed. The implementation plans provide a list of actions or management measures needed to reduce the pollutant, a schedule for implementing controls or measures, milestones for implementation, and a monitoring program to measure progress. MS4s are considered a point discharger. KDHE ensures MS4 cooperation with the TMDL implementation through adding requirements to the MS4's permit. For example, the City of Wichita is required to implement at least one stormwater management facility for each of the TMDL regulated pollutants found in **Error! Reference source not found.**. Controls and management measures need to be in place two years after the plan is developed.

**Table 2-3 TMDL Regulated Parameters for the City of Wichita in 2010**

| TMDL Regulated Parameter | Associated Stream or Lake |
|---|---|
| Total Phosphorus | Little Arkansas River & Cowskin Creek |
| Total Nitrogen | Little Arkansas River & Cowskin Creek |
| Biochemical Oxygen Demand Pollutants | Little Arkansas River & Cowskin Creek |
| Suspended Solids (Sediment) | Little Arkansas River & Cowskin Creek |
| Bacteria | Little Arkansas River & Cowskin Creek & Arkansas River & Whitewater River |

### 2.3.4 KDHE Industrial Stormwater Permit Program

KDHE requires that the discharge of stormwater from certain types of industrial facilities be covered under the State General Permit (S-ISWA-0507-1) for Industrial Stormwater. Industrial stormwater is defined as water discharged from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant. Currently, eleven categories of industrial facilities identified in the State's General Permit are required to have an NPDES permit for their stormwater discharge.

Regulated industrial facilities are required to develop a SWPPP and submit a NOI for permit coverage under the KDHE General Permit. Components of the SWPPP include identification and elimination of potential sources of stormwater contamination, stormwater monitoring at each stormwater outfall, employee training, and other stormwater protection activities.

### 2.3.5 KDHE Confined Animal Feeding Operations

The Livestock Waste Management Section of KDHE Bureau of Water administers laws regarding livestock waste. Any confined animal feeding operation (CAFO) with more than 1,000 animal units must write a nutrient management plan to protect state waters from nutrient enrichment. KDHE issues Livestock Waste Management Permits after the nutrient management plan is approved. Annual reports and permit renewals are required to keep the permit active.

### 2.3.6 Water Well Program

The purpose of the Water Well Program is to provide for the exploration and protection of groundwater through the licensing and regulation of water well contractors in Kansas and to protect the health and general welfare of the citizens of Kansas. The program oversees the proper construction, reconstruction, treatment and plugging of water wells and to provide data on potential water supplies in Kansas. This is done by requiring well logs for all water well construction, reconstruction, and plugging of wells within the state. Any landowner wishing to install a well must work through the water well program to permit and properly construct a well.

### 2.3.7 KDA Water Structures Program

The Kansas Department of Agriculture (KDA) Division of Water Resources (DWR) regulates a number of in-stream and near-stream structures under the Water Structures Program. This program regulates manmade activities affecting the flow and overflow of any stream by ensuring that such activities are properly planned, constructed, operated and maintained for their authorized purpose without adversely affecting the environment, public health and welfare, and public and private property.

Examples of activities regulated by the Water Structures program include:

- bridges, culverts;
- weirs;
- low-water crossings;
- dams;
- intake/outfall structures;
- boat ramps;
- pipeline/cable crossings;
- grassed waterways;
- channel modifications;
- levees;
- placement of fill within the floodplain; and,
- gravel/sand dredging.

Levee construction in Kansas is regulated by the provisions of The Levee Law. The law states that no entity or individual shall lawfully construct or maintain any levee or any such improvement on, along, or near any stream in the state that is subject to floods, freshets or overflows, so as to control, regulate or otherwise change the flood waters of that stream without first obtaining approval of plans by the chief engineer of the division of water resources.

Stream channel protection in Kansas in the form of a vegetated buffer is regulated by Water Structures Statutes and Regulations, specifically K.A.R. 5-41-6. This regulation is enforced by the Kansas Department of Agriculture (KDA).

The construction of dams in Kansas that are 25 feet high and greater, or 6 feet high or greater and impound 50 acre-feet or more of water, requires approval from the KDA Division of Water Resources. Plans and specifications are required for KDA review. The KDA also has the authority to inspect existing dams, and if necessary, require unsafe dams to be upgraded or removed. The Dam Safety Program is administered under the KDA Division of Water Resources.

### 2.3.8 Kansas Historical Society

The Kansas Historical Society (KHS) is the state agency for historic preservation. KHS staff consults with citizens and organizations to preserve Kansas's architectural, archaeological, and cultural landmarks. The agency maintains the Kansas Historic Resources Inventory (KHRI), a directory of historic records, and the Register of Historic Kansas Places. Projects that include the disturbance of existing features such as buildings or other manmade structures should include a search of the KHS databases to screen for potential historic significance. Projects that include ground disturbance, such as new construction or pipeline installation, should include an assessment of the potential for disturbance of archaeological or other culturally significant sites.

## 2.4 City and County Regulations and Programs

### 2.4.1 Local Stormwater Management Regulation

The stormwater management regulations for the City of Wichita and Sedgwick County are provided in Appendix A of Volume 1 of this manual. (The user of this Manual should check with the City of Wichita and Sedgwick County to ensure that the user has the latest version of this regulation since the version included in this manual may not reflect more recent revisions.) The regulations regulate the design and construction of storm drainage facilities for purposes of water quality and quantity control. The regulations strive to limit the dangers of personal injury, and/or property or environmental damage that may be caused by stormwater runoff.

### 2.4.2 Floodplain Regulation

The floodplain regulations for the City of Wichita and Sedgwick County are provided in Appendix A of Volume 1 of this manual. (The user of this Manual should check with the City of Wichita and Sedgwick County to ensure that the user has the latest version of these regulations since the versions included in this manual may not reflect more recent revisions.) The regulations regulate development in and around Special Flood Hazard Areas, as designated by the Federal Emergency Management Agency (FEMA), in the City and County for general purposes of floodplain management and flood damage prevention and the protection of life, health, commerce, property and public funds that can be impacted by flooding. The regulations were developed in accordance with the minimum standards required of communities that participate in the NFIP.

### 2.4.3 Local and Regional Watershed Plans

Stormwater master planning is an important tool used to assess and prioritize both existing and potential future stormwater problems and to consider alternative stormwater management solutions. Stormwater master plans are prepared to consider, in detail, what stormwater management practices and measures are to be provided for an urban drainage area or a large development project.

Stormwater master plans are most often used to address specific single functions such as drainage provision, flood mitigation, cost/benefit analysis, or risk assessment. These plans prescribe specific management alternatives and practices. Multi-objective stormwater master planning broadens this traditional definition to potentially include land use planning and zoning, water quality, habitat, recreation, and aesthetic considerations.

The City of Wichita has several stormwater master plans providing detailed guidance on required stormwater management practices for individual watersheds. Those required practices may differ from the general standard put forth in this manual. Those watershed-specific standards must be followed for developments occurring in master-planned areas. This is also true if and when similar master plans are developed for other communities, such as Sedgwick County.

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CHAPTER

3

# STORMWATER POLICIES

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CHAPTER

3

# STORMWATER POLICIES

## 3.1 General Policies

The following general policies shall apply to new developments or redevelopments for which stormwater management controls are required:

- A waiver for compliance with any of the stormwater management standards must be requested of the local jurisdiction in writing at the time of, or prior to, the submittal of stormwater design information for the new development or redevelopment. The local jurisdiction will notify the person(s) requesting the waiver in writing at the time of, or prior to, approval or denial of the stormwater design information.
- Design computations shall be performed in accordance with the calculation guidance provided in this Manual, or other criteria that the local jurisdiction establishes based on scientific and engineering information to supplement or supersede this guidance.
- Stormwater runoff resulting from developed conditions on a site must be routed at appropriately small time intervals through water quality and quantity controls using either hand calculations or computer software/models that are approved by the City of Wichita and Sedgwick County. Acceptable computer software/models are presented in Volume 2 of this Manual.
- All calculations utilized in the design of stormwater controls must be prepared by an engineer that is proficient in the field of hydrology and hydraulics and licensed to practice in the State of Kansas.
- The boundaries and elevations of the floodplain and floodway shall be depicted on stormwater design plans using site specific topography.
- The local jurisdiction may require the stormwater management facility(s) that serve the development or new development to be placed in a reserve and/or a drainage easement that is suitable for access by maintenance equipment. The need for reserves/drainage easements for stormwater facilities will be determined by the local jurisdiction during their review of the drainage plan for the site. In general, water quality volume reduction areas, open channels, creeks, flood hazard areas, dry detention ponds, extended detention ponds, and wet ponds shall be located in a reserve.

## 3.2 Water Quality Treatment

### 3.2.1 Summary of Local Regulatory Language

The requirements for water quality treatment for new development and redevelopment that are stated in the local stormwater management regulations differ slightly, as summarized in the box below. Note: the requirements stated in the regulations are only summarized here. Readers should refer to the actual stormwater management regulations for the specific and correct wording of these requirements.

**Water Quality Treatment Requirement for New Developments**

Stormwater runoff must be treated for water quality prior in accordance with the standards and criteria presented in this section of the Stormwater Manual.

**Water Quality Treatment Requirement for Redevelopments**

Property owners must adhere to one of the following options in order to comply with the water quality treatment requirement for redevelopments.

1. A 20% reduction in impervious area on the property;
2. Stormwater runoff from at least thirty percent (30%) of the site's existing impervious cover and for one-hundred percent (100%) of the impervious cover for any newly disturbed area must be treated for water quality prior in accordance with the standards and criteria presented in this section of the Stormwater Manual;
3. Equivalent water quality controls must be provided at an alternative location in the same watershed as the proposed redevelopment;
4. One or more known downstream water quality or channel erosion issues located within the same watershed as the proposed redevelopment must be addressed through stream restoration and/or other off-site remedies.
5. Payment of a fee in-lieu-of water quality control and channel protection control facilities.
6. Any combination of (1) through (5).

The Water Quality Treatment Standard that is referred to in the requirement for new developments and in options 1, 2 and 3 for redevelopments is presented in this section. Note that policies that are specific to design calculations for different stormwater management facilities are included in Volume 2 of this Manual, where facility design specifications are presented.

### 3.2.2 Stormwater Treatment Standards and Criteria

The following policies comprise the stormwater *quality* treatment standards and criteria for the City of Wichita and Sedgwick County.

- Water quality treatment facilities shall be designed to remove, at a minimum, 80% of the average annual total suspended solids (TSS) load for typical urban runoff (after-development) from the stormwater volume required for water quality treatment. This stormwater volume shall henceforth be called the "water quality treatment volume" ($WQ_v$). This standard is also referred to in this Manual as the "80% TSS removal standard".

- The 80% TSS removal standard shall be applied to the 85th percentile storm event for the Wichita area, which is equal to 1.2 inches of rainfall. The 85th percentile storm event is defined as the storm depth for which 85 percent of all storms are smaller.
- The $WQ_v$ and % TSS removal shall be calculated for the development or redevelopment in accordance with the policies and calculation guidance provided in Volumes 1 and 2 this Manual. In order to comply with the 80% TSS removal standard, the result of the % TSS removal calculations for the entire development or redevelopment must be no less than 80%.
- It is presumed that a stormwater management facility (or system of facilities) complies with the Water Quality Treatment Standard if the structural water quality controls are selected, designed, constructed and maintained in accordance with the design criteria specified in this manual and whose calculated TSS removal % for the entire development or redevelopment is equal to or greater than 80% TSS. Because this is a presumptive standard, analytical monitoring (i.e., sample collection and analysis of stormwater runoff) upstream or downstream of structural water quality controls is not required.
- Only those structural facilities that are included in this Manual are permitted for use as a water quality treatment facility. Other facilities are prohibited, unless their performance has been verified and they are approved by the local jurisdiction. This list of controls has sufficient flexibility and variation to fit most site development situations.
- The structural facilities (and variations thereof as described in Volume 2 Chapter 3) that are acceptable for use in the City of Wichita and Sedgwick County to attain the Water Quality Treatment Standard are presented in Table 3-1.

**Table 3-1 % TSS Removal for $WQ_v$ Treatment Structural Facilities**

| Structural Facility | % TSS Removal |
|---|---|
| Stormwater Pond | 80 |
| Dry Extended Detention Pond | 60 |
| Enhanced Swale | 90 |
| Grass Channel | 50 |
| Infiltration Trench | 90 |
| Soakage Trench | 90 |
| Vegetative Filter Strip | 50 |
| Surface Sand Filter | 80 |
| Underground Sand Filter | 80 |
| Organic Filter | 80 |
| Bioretention Area | 85 |
| Stormwater Wetland | 75 |
| Proprietary Manufactured Device | device-specific |
| Gravity Oil/Water Separator | device-specific |
| Alum Treatment | 90 |
| Green Roof | installation-specific |

Table 3-1 also presents the % TSS removal value that is assigned to each structural facility type. Only this value shall be used to calculate the total weighted % TSS removal for the development site.

- Innovative technologies that are not included in this Manual are encouraged provided that such methods, designs or technologies will meet or exceed the stormwater treatment standards set forth by local regulation and this Manual. It is the responsibility of the property owner and/or the site design engineer to provide adequate proof of the effectiveness of such methods, designs, or technologies in meeting local requirements.

### 3.2.3 Obtaining a Waiver

The requirements for water quality treatment may be waived by the local jurisdiction if it is determined by the local jurisdiction that the pollutants of concern from the new development or redevelopment are not those identified in the Manual and would be best treated using an alternative approach than that defined by the Manual.

### 3.2.4 Water Quality Treatment Controls for Special Circumstances

The local jurisdiction may require additional water quality treatment criteria or controls to conform to State and/or Federal regulatory requirements, and/or to address watershed or site-specific water quality requirements, or on land uses that have the potential to discharge pollutants in higher amounts or that would not be adequately treated using the structural facilities identified in this manual. For example, additional treatment criteria may be required if the new development or redevelopment will have a land use or on-site activities that have the potential to generate highly polluted runoff, with concentrations of pollutants in excess of those typically found in stormwater. Examples of such land uses might include operations producing concrete or asphalt, auto repair shops, auto supply shops, large commercial parking areas, or restaurants. Examples of additional controls for such lands uses could include installation of specialized structural facilities such as oil/water separators for petroleum based pollutants, or the implementation of pollution prevention practices, such as employee training programs on chemical handling/application. The implementation of any additional controls are the responsibility of the property owner and/or business/activity operator.

General policies for structural facilities and pollution prevention activities at land uses that are often identified as having a higher than normal pollutant potential are presented in the following paragraphs.

**Gas stations, vehicle maintenance, washing or storage facilities.** Gas stations, vehicle storage and/or maintenance facilities shall address the potential for pollutant discharges from petroleum-based products, oils and other fluids in the following manner:

- Oil/water separators or other separation or absorbent devices that target removal of gasoline, petroleum based products, oils and other fluids commonly associated with motor vehicles (e.g., anti-freeze) shall be installed to reduce or eliminate the potential for such pollutants to be discharged into stormwater runoff.

- Gas pump areas and vehicle maintenance areas shall be covered and not exposed to rainfall and stormwater runoff. Floor drains in these areas shall not be connected to the stormwater system. Wash water from these areas should be prevented from discharging to the stormwater drainage system.
- Discharges of wash water resulting from the hosing or cleaning of vehicles, equipment and/or facilities is considered an illegal non-stormwater discharge. Therefore, wash water must be prevented from entering the stormwater system. These activities could include blocking the stormwater system or diverting the wash water into a pre-treatment measure and then into the sanitary sewer system. Floor drains in vehicle wash areas shall not be connected to the stormwater system. It is preferred that these areas be covered and therefore not exposed to rainfall and stormwater runoff.
- Pollution prevention activities for vehicle maintenance, washing, or storage land uses shall be employed as appropriate, focusing on:
  - spill prevention and cleanup;
  - oil and other fluid and material recycling;
  - staff education on proper pollution prevention techniques; and,
  - customer education about repair and maintenance activities that are or are not acceptable on the premises.
- For businesses where vehicles will be stored, pollution prevention activities must also include routine inspection of the vehicles for leaks or discharges. Drip pans must be used to capture leaks and discharges until the vehicle can be maintained or fluids should be drained completely from vehicles that will remain unused.

**Recycling and salvage yard facilities.** Where the land use is a business that recycles or salvages vehicles or other equipment, the pollution prevention practices for that site must include draining the equipment of all fluids before storage. If the storage area is uncovered, pre-treatment controls are required to treat additional pollutants that could result from the storage or deterioration of the equipment or vehicles before the runoff discharges to structural stormwater controls.

**Restaurants, grocery stores, and other food service facilities.** Grease, trash and organic pollutants are pollutants that are typically encountered around restaurants, grocery stores, and other food service facilities. Pre-treatment to remove such pollutants prior to discharging to structural stormwater facilities is required, in order to prevent clogging of downstream BMPs and the stormwater system. Grease traps are required for all sinks and floor drains. Dumpsters shall be covered at all times, and leakage from dumpsters shall not be allowed to discharge to the stormwater system. As well, wash water from equipment and/or facility cleaning activities must either be discharged to the sanitary sewer or be pre-treated prior to discharging to a stormwater facility. Litter and other wastes shall be picked-up on a regular basis to prevent them from entering the stormwater system. Parking lots shall be swept/cleaned on a regular basis to remove gross solids. Wastes gathered during litter collection and parking lot cleaning activities shall be disposed of properly.

**Facilities that temporarily or permanently house animals outside (non-agricultural).** Animal housing facilities, such as veterinary clinics, boarding facilities, recreational (i.e., non-agricultural) livestock stables, and animal shelters have the potential to deliver higher than normal bacterial loadings to the stormwater system. High counts of bacteria in streams and rivers can cause water quality impairments, but can also cause illnesses in people. Pollution prevention practices for these types of facilities shall include pet waste management practices, such as collecting and properly disposing of pet waste at landfills or wastewater treatment facilities. Soiled animal bedding shall be removed and properly disposed. Wood shavings or chips shall not be allowed to migrate into the stormwater system.

## 3.3 Water Quality Control using Non-Structural Preferred Site Design Practices

Non-structural stormwater control practices (also called “Preferred Site Design” practices) are increasingly recognized as a useful tool in site design because they result in the generation of less stormwater runoff from a development site than what would be generated in a more conventional site design. As compared to conventional site designs, a Preferred Site Design approach attempts to adapt a development design to the existing site conditions, and therefore preserve the topography, vegetative cover and hydrologic and environmental features of a site to the maximum extent practicable. This results in less clearing and grading, less use of impervious areas, and therefore less stormwater runoff and dependency on stormwater infrastructure. Relevant to the stormwater management requirements contained in local stormwater management regulations and in this Manual, the use of Preferred Site Design practices in a site design can have the effect of reducing the runoff volumes and peak flows, and therefore the size of the stormwater management facilities and conveyance appurtenances that are needed to control stormwater on the site. Preferred Site Design practices are discussed in detail in Chapter 2 of Volume 2.

<u>Uses of Preferred Site Design practices are included in the Stormwater Manual as an option, not as a requirement</u>. As an incentive, a set of $WQ_v$ “reductions” has been developed to quantitatively recognize the benefits of certain practices to further reduce the volume of stormwater that must be treated for pollutants, and therefore reduce the size of the structural stormwater facility needed for water quality treatment.

General policies pertaining to $WQ_v$ reductions are as follows:

- The amount of $WQ_v$ reduction obtained for a site will be determined in accordance with the reduction guidance presented in Volume 2 of this Manual.
- $WQ_v$ reductions can only be claimed if the area or practices for which the reduction is requested conforms to all of the required minimum design criteria and conditions stated in Volume 2 of this Manual. Full or partial reductions will not be given to areas or practices that do not conform to all of the criteria and conditions. The intent of this policy is to avoid situations that could lead to a reduction being granted without the corresponding decrease in pollution attributable to an effective Preferred Site Design practice.

- $WQ_v$ reductions cannot be claimed twice for an identical area of the site (e.g., a reduction for stream buffers cannot be claimed if that area has already received a reduction for disconnecting impervious areas).
- General Preferred Site Design practices and techniques performed without regard to the criteria and conditions stated in this Manual will not be awarded WQv reductions. However, these practices reduce the overall impervious and disturbed area of a development. This land use change reduces the total amount of stormwater runoff generated by a site, and thus the required WQv, because the calculation of WQv is dependant upon site imperviousness. That is, the higher a site's impervious area, the higher the WQv, and vice versa

## 3.4 Ground Water Protection

It is the intent of the City of Wichita and Sedgwick County to minimize the risk of contaminating groundwater by stormwater runoff discharged from new developments and redevelopments. The design guidance in Volume 2 of this manual requires minimum separation between the bottom of certain stormwater management facilities (wet ponds, infiltration trenches, soakage trenches, sand filters, organic filters, bioretention areas and wetlands) and the historical high groundwater table. These measures are intended to minimize the risk of contaminating groundwater with stormwater runoff. However, in all cases, more restrictive regulations invoked by local, State or Federal authorities, or adopted local, State or regional groundwater programs shall apply.

For areas where the historically high groundwater table is within 5 feet of the bottom of the stormwater facility, stormwater runoff from a new development or redevelopment may be discharged into one of the facilities identified in the paragraph above only after the runoff has met the Water Quality Treatment Standard, as defined in the local stormwater management regulations and in this Manual. This separation distance may be reduced to 2 feet if additional measures such as lining or underdrains are installed per the guidance found in Volume 2 of this manual. The local jurisdiction may waive this requirement if engineering studies determine that installing the required water quality treatment practices are unnecessary to protect groundwater quality, human health and the environment.

Any discharge of stormwater runoff directly to groundwater must meet all applicable local, State and Federal requirements, permits, plans and programs. The person(s) responsible for the new development or redevelopment are also responsible for all local, State and Federal permits that may be applicable to the site.

## 3.5 Downstream Stabilization Standard

### 3.5.1 Standards and Criteria

The following policies comprise the downstream stabilization standard for the City of Wichita and Sedgwick County. Implementation of this standard is intended to minimize the effects of development on long-term downstream channel erosion and the delivery of sediment to local waterbodies.

The downstream stabilization shall be provided for developments that:

- will create or add five (5) acres or greater of impervious cover, including projects that have less than five acres of impervious cover but are part of a larger common plan of development or sale that will result in five acres or greater of impervious cover; and,

- are located in watersheds or on streams that are designated by the City and/or the County as a Downstream Stabilization Protection Volume Watershed or Stream.

When required, downstream stabilization shall be provided in one of the following ways:

1. the runoff volume from the new development that results from the 1-year frequency, 24-hour storm event shall be detained for not less than 24 hours; or

2. the volume difference between the pre-development and post-development runoff from the development that results from the 1-year frequency, 24-hour storm event must be infiltrated, reused or evaporated.

The City of Wichita Stormwater Management Division shall create and maintain the ***Map of Downstream Protection Volume Watersheds and Streams***, provided in Appendix G. This map will contain the watersheds and streams where downstream long-term channel protection is required.

Calculation methods that must be used to meet the downstream stabilization standard are presented in Volume 2 of the Manual. There are no additional policies associated with downstream channel erosion protection in this volume.

### 3.5.2 Obtaining a Waiver

The requirement for downstream stabilization may be waived by the local jurisdiction if engineering studies show that the stormwater conveyance channels located downstream of the new development or redevelopment are capable for resisting long-term erosion. Engineering studies must be reviewed and approved by the local jurisdiction in order to obtain the waiver.

## 3.6 Stormwater Quantity Management (Peak Discharge Analysis and Control)

Local stormwater management regulations require that stormwater runoff peak discharge analysis and control be implemented in accordance with the stormwater quantity standards and criteria provided in the Stormwater Manual. Policies associated with the peak discharge control standard are listed below.

### 3.6.1 Peak Discharge Control Design Standard

Applicable new developments and redevelopments (as defined by the local regulation) shall adhere to the following peak discharge control standard:

- The calculated peak discharge of stormwater runoff at each site stormwater outfall resulting from the 2-year, 5-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events shall be no greater after development or redevelopment of the site than that which would result from the same 2-year, 5-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events on the same site prior to development or redevelopment.
- For redevelopment sites, peak discharge controls shall be sized using the existing developed land use as the baseline condition, not the land use that existed prior to the original development of the site.
- Peak discharge analyses should be performed after any Preferred Site Design practices have been included in the design. The use of Preferred Site Design practices will inherently reduce runoff volumes and potentially reduce post-development peak discharges, both on-site and downstream of the site.

### 3.6.2 Downstream Hydrologic Analysis (The 10% Rule)

Downstream hydrologic analysis shall be performed for all applicable new developments and redevelopments (as defined by the local regulation) in accordance with the following policies:

- <u>Sites with Off-Line Stormwater Management Facilities</u>. A downstream hydrologic analysis to determine if the new development or redevelopment causes an increase in peak discharges and velocities compared to pre-development peak discharges and velocities for the same site shall be performed for the 2-year, 5-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events. Peak discharges and velocities shall be evaluated at the location(s) of the stormwater outfall(s) from the new development or redevelopment and at each downstream tributary junction, bridge, culvert, weir or dam to the next junction, bridge, culvert, weir or dam (whichever is encountered first) beyond the ten-percent (10%) point(s). If increases in the peak discharge or velocity are identified at any point in the analysis area as defined in this paragraph, the stormwater management facilities at the new development or redevelopment shall be re-designed to eliminate such peak discharge and velocity increases.
- <u>Sites with On-Line Stormwater Management Facilities</u>. A downstream hydrologic analysis to determine if the new development or redevelopment causes an increase in peak discharges and velocities as compared to pre-development peak discharges and velocities for the same site shall be performed for the 2-year, 5-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events. Peak discharges and velocities shall be evaluated at the location(s) of the stormwater outfall(s) from the new development or redevelopment and at each downstream tributary junction, bridge, culvert, weir or dam to the ten-percent (10%) point(s), or to the point(s) where the peak discharge and velocity

are no longer increased, whichever is further downstream. If increases in the peak discharge or velocity are identified at any point in the analysis area as defined in this paragraph, the stormwater management facilities at the new development or redevelopment shall be re-designed to eliminate such peak discharge and velocity increases. Peak discharge control evaluations showing full routing calculations and supporting documentation shall be submitted with the drainage plan, in the manner described in Volume 2 of this Manual.

### 3.6.3 Obtaining a Waiver

The requirement for peak discharge control may be waived if it is demonstrated by an engineering study that:

1. the new development or redevelopment does not cause an increase in peak discharges from pre-developed conditions for the required storm events; or,
2. increased peak discharges are adequately handled by the existing downstream channel without adverse impacts as defined in the Manual.

Engineering studies must be reviewed and approved by the local jurisdiction in order to obtain the waiver.

### 3.6.4 Stormwater Conveyance Design

It is the intent of the local jurisdiction to ensure that stormwater control infrastructure is capable of safely and efficiently conveying the applicable design flows; that the infrastructure is durable and maintainable; and that structures are protected against flood damage even when the infrastructure experiences runoff events greater than the design flows, up to the 100-year flood occurrence. The specific requirements are detailed in local floodplain regulations, and the design procedures for achieving those requirements are provided in Volume 2 of the Manual. There are no additional policies associated with downstream channel erosion protection in this volume.

## 3.7 Floodplain Management

The local jurisdiction's primary floodplain management requirements are contained in their floodplain management and/or flood damage prevention regulations (Wichita Code of Ordinances # 27.06 and Sedgwick County Code Chapter 13). However, these regulations address only those requirements for areas that are designated by the Federal Emergency Management Agency (FEMA) as special flood hazard areas and are included on the Wichita or Sedgwick County Flood Insurance Rate Maps (FIRMs). Additional floodplain management requirements are contained in local stormwater management regulations, which address both special flood hazard areas and floodplains and flood-prone areas that are not included on FIRMs.

Specific policies to support local jurisdiction floodplain management requirements are as follows:

- Watershed analysis and planning efforts have indicated that the flood potential in specific drainage basins within each jurisdiction is especially sensitive to changes in floodplain storage volumes. In short, a loss of floodplain storage volume in such basins may significantly raise the flood potential for habitable structures in the basin. In an effort to eliminate the loss of floodplain storage in volume sensitive basins, the local jurisdictions have included a requirement in their stormwater management regulations and/or floodplain management regulations to provide compensatory storage when development or other encroachments occur in the floodplains of volume sensitive basins. Policies associated with this requirement are as follows.

  Volume sensitive basins shall be defined by the local jurisdiction. Maps indicating volume sensitive basins in the City of Wichita may be obtained from the City. The location and magnitude of compensatory excavations shall be provided with the stormwater design information that is incorporated into the construction plan, and must be approved by the local jurisdiction prior to excavation activities.

- The property owner performing compensatory excavations is responsible for obtaining all applicable local, State and Federal permits.

## 3.8 Residential 1 & 2 Family Exterior Storm Drain Piping/Lines

The purpose of this policy is to outline minimum installation guidelines and related City permitting requirements for both aboveground and underground stormwater or sump pump piping/discharge for 1 and 2 family residential structures. This policy is developed with respect to the requirements set forth in City of Wichita Code Title 10 (Streets and Sidewalks), Title 16 (Sewers, Sewage Disposal and Drains), and Title 18 (Building Code).

This policy affects 1 and 2 family construction only. The procedures for commercial exterior storm drain piping/lines (or any construction other than 1 and 2 family residential) are not affected by this policy.

The policy is as follows:

1. City permits are NOT required for the following outdoor stormwater or uncontaminated sump pump piping/discharges for 1 & 2 family residential construction or use:

   - Any drain pipe/discharge that is not placed or located within seven and a half (7.5) feet of a public sidewalk;
   - If no public sidewalk exists, any drain pipe/discharge that does not abut or lie within a public street right-of-way, and which is not closer than ten (10) feet to the back of any public street curb;
   - Any drain pipe/discharge that is not placed or located within five (5) feet of a rear private property line;
   - Any drain pipe/discharge that is not placed or located within two (2) feet of a side private property line and does not project discharged water across a property line;

- Any drain pipe/discharge that is not connected to a public storm sewer line, inlet or box;
- Any drain pipe/discharge that is not placed or located in a publicly maintained drainage way, ditch or culvert. NOTE: the installation of private storm drainage lines within a public easement (except to use the utility) is discouraged so as not to encumber the easement. Installation of such private drain lines, sprinkler heads, fences, flower beds, rock gardens, etc., within a public easement is subject to removal at the property owner's expense in the event a public utility repair or replacement is necessary.

2. City permits shall be required for the following:

   - If a stormwater drain pipe/discharge extends through a public street curb (sump pump pipe/discharge is not permitted), but not directly into a City storm sewer line, drain, inlet or box, a "Curb Cut Permit" must be obtained from the local jurisdiction. A City of Wichita licensed cement contractor must obtain such curb cut permit and pay the associated fee (set by the local jurisdiction). The contractor must submit a drawing or site plan with the request for the permit.
   - If a stormwater drain pipe/discharge extends to and connects to a City storm line, drain, inlet or box, a Storm Sewer Permit, issued to a licensed drain layer or plumber, must be obtained from the local jurisdiction. In this circumstance, the local jurisdiction will obtain any required drawings for the permit review/issuance, and will route the permit application for reviews and approvals to the appropriate agencies, departments and/or divisions, and will also request/obtain a Compliance Certificate.

     Because a Storm Sewer Permit must be obtained in this circumstance, local jurisdiction inspection staff will inspect the piping and connections for installation and code compliance.

     If this connection to the stormwater inlet is in public right-of-way, the contractor will be required to obtain a "Dirt or Pavement Cut" permit and pay the associated fee. If sidewalk or pavement is required to be removed during installation of pipe, a pavement cut permit is required to be obtained, and the City's contractor will make the permanent repair with the costs being billed to the plumbing/sewer contractor.

CHAPTER

4

# STORMWATER FACILITY INSPECTION AND MAINTENANCE

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CHAPTER

4

# STORMWATER FACILITY INSPECTION AND MAINTENANCE

The purpose of this chapter is to establish general policies for maintenance of stormwater management systems in the City of Wichita and Sedgwick County, and to define the maintenance responsibilities of the local jurisdiction and the responsibilities of private property owners.

## 4.1 Inspection and Maintenance During Construction

### 4.1.1 Property Owner Responsibilities

This section provides further clarity on this requirement by describing the differing responsibilities of the developer or property owner and the local jurisdiction to perform inspections and maintenance during active construction.

While the construction site is active, the property owner (or the person holding the building permit, or the property owner's designee) must conduct inspections on all components of the stormwater system within the development. The inspection should document the functionality of each component, including the component's ability to convey or treat runoff, as well as any maintenance needs. It is recommended that the stormwater system be inspected after every rainfall event that produces stormwater runoff to assess the functionality of the system.

The property owner is also responsible for performing maintenance on erosion prevention and sediment control practices and the portions of the stormwater system that have been installed. Maintenance includes, but is not limited to, removing blockages, removing accumulated sediment, replacing stone, repairing silt fence, and cleaning sediment out of catch basins, pipes, and check dams. Maintenance activities should focus on maintaining the functionality of each component as well as preventing pollutants from being discharged from the development site.

Finally, the importance of properly functioning erosion prevention and sediment control practices to the future performance and operation of the site's stormwater system must not be overlooked. Therefore, the property owner is responsible for conducting and documenting stormwater system inspections and maintenance, in accordance with the local stormwater management regulation and the Kansas General Permit for Stormwater Discharges at Construction Sites. Erosion control practices must function properly during construction to ensure that uncontrolled sediment does not impact the future functionality of stormwater conveyance components, stormwater management facilities, and preferred site design and $WQ_v$ reduction areas.

### 4.1.2 Local Jurisdiction Authority and Responsibilities

Each jurisdictions stormwater management regulation gives them the authority and right to enter private property to inspect for compliance with approved plans. During the normal course of the property development process, this is a common occurrence. Local jurisdiction inspectors will document activities at the site and note any corrective actions needed at the site. The property owner (or his/her designee) may be required to provide the inspector with copies of inspection reports and permit documentation to verify that inspections and maintenance are being performed as necessary. In the event that a maintenance need or concern is identified during an inspection by the local jurisdiction, the property owner will be required to perform the maintenance activity and will establish a completion date in writing. Failure to perform the maintenance by the completion date set by the local jurisdiction could result in further enforcement action.

## 4.2 Inspection and Maintenance <u>After</u> Construction

This section provides further clarity on this requirement by describing the differing responsibilities of the developer, property owner and the local jurisdiction to perform inspections and maintenance after active construction.

Proper maintenance of stormwater management facilities after construction is complete is one of the most important factors in the long-term performance and effectiveness of a stormwater management plan. Effective, long-term operation and maintenance of stormwater management facilities requires a three-phased approach on the parts of the developer, property owner and local jurisdiction. These three phases are as follows:

1. <u>Site Developer:</u> In an effort to reduce maintenance requirements for each development, the developer or site designer should consider the maintenance requirements for each structural stormwater management facility (or the non-structural Preferred Site Design practices) when designing a development. To this end, the City of Wichita and Sedgwick County encourage site designers to utilize Preferred Site Design practices to the maximum degree practicable and thereby minimize the degree of stormwater maintenance that will be required for the property after construction. Non-structural controls, which are discussed in detail in Volume 2, generally require very little (and often no) maintenance and can result in the need for a smaller structural facility needed to treat stormwater runoff quality. The developer and site designer should then choose, design and construct structural stormwater facilities that can meet all water quality, channel protection and flood control requirements while having comparatively low long-term maintenance requirements based upon the site constraints.

   The site designer will also have the responsibility of developing the plats, drainage plans, Operations and Maintenance Plan, and the As-Built Plan, as originally described in Chapter 3 of this volume.

2. Property Owner: After construction, the property owner is responsible for ensuring the long-term proper operation and maintenance of all stormwater management facilities and the appropriate long-term maintenance of Water Quality Volume ($WQ_v$) reduction areas. For stormwater management facilities, this requires that the property owner perform regular inspections and necessary maintenance activities. For $WQ_v$ reduction areas, such as natural areas, this might simply mean ensuring that the area is left alone and not cleared or developed for another purpose. For many property owners, these activities might be done by a third party such as a capable landscape maintenance business, facility manager or site superintendent. For more information on structural stormwater management facility inspection content, frequency and documentation, and on $WQ_v$ reduction areas, refer to Volume 2 of this Manual.

3. Local Jurisdiction: The local stormwater management regulation gives each jurisdiction the authority to perform periodic inspections of stormwater management facilities and $WQ_v$ reduction areas during and after construction, and to order corrective actions when needed. Specifically, the local jurisdictions will be inspecting for conformance of the facility with local regulations and policies. The reader is referred to the jurisdiction's stormwater management regulations for more information on jurisdictional authority and penalties if corrective actions are warranted.

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# APPENDIX A

City of Wichita Stormwater Management Ordinance – Chapter 16.32

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## CHAPTER 16.32. STORMWATER POLLUTION PREVENTION

### Sec. 16.32.010. General provisions.

A. Purposes. The purpose and objective of this chapter are as follows:

   1. To maintain and improve the quality of surface water and groundwater within the city;
   2. To attenuate the discharge of contaminated storm water runoff from industrial, commercial, residential, and construction sites into the municipal separate storm sewer system (MS4) and natural waters within the city;
   3. To promote public awareness of the hazards involved in the improper discharge of hazardous substances, petroleum products, household hazardous waste, industrial waste, sediment from construction sites, pesticides, herbicides, fertilizers, and other contaminants into the storm sewers of the city;
   4. To encourage recycling of used motor oil and safe disposal of other hazardous consumer products;
   5. To facilitate compliance with state and federal standards and permits by owners of industrial and construction sites within the city;
   6. To enable the city to comply with all federal and state laws and regulations applicable to its NPDES permit for storm water discharges;
   7. To regulate the management of storm water for purposes of public safety, welfare and quality of life;
   8. To manage and maintain local floodplains;
   9. To facilitate compliance with city standards and permits by owners of developed, redeveloped and undeveloped properties within the city;

B. Administration. Except as otherwise provided herein, the director, or his appointed representative, shall administer, implement, and enforce the provisions of this chapter.

C. Authority. The Director may develop additional policies, criteria, specifications and standards in a Storm Water Manual and/or in other policy, master plans, watershed plans or guidance documents as necessary to effectively implement the requirements of this chapter. The policies, criteria and requirements of the Storm Water Manual and/or other policy, plans or guidance documents may be implemented and amended by the Director, are referenced in this chapter when required, and shall be enforceable, consistent with the provisions contained in this chapter. A public meeting shall be held bi-annually to allow public comment on this chapter and the Storm Water Manual.

   In the event that a violation of any provision of this chapter has occurred, or that work does not have a required plan or permit, or that work does not comply with an approved plan or permit, the city may issue a Notice of Violation to the permittee, plan holder or property owner and/or any other person or entity having responsibility for the property or properties where the violation occurred under the provisions of subsection .100 B. of this chapter.

   In the spirit of the purposes defined above for this chapter and in the administration of these requirements, the Director may consider the cost-effectiveness of storm water management controls provided that such controls meet the water quality, channel erosion protection and flood protection requirements of this chapter or are waived or exempted in accordance with the criteria defined in this chapter.

D. Regulatory or legal conflicts. This chapter is not intended to repeal, abrogate, or impair any existing easements, covenants, deed restrictions, or existing ordinances and regulations, except as specifically noted in this chapter. However, where the provisions of this ordinance and another regulation conflict or overlap, that provision which is more restrictive or imposes higher standards or requirements shall prevail.

E. Abbreviations. The following abbreviations when used in this chapter shall have the designated meanings:

| | | |
|---|---|---|
| BMP | - | Best Management Practices |
| CFR | - | Code of Federal Regulations |
| CLOMR | - | Conditional Letter of Map Revision |
| EPA | - | U.S. Environmental Protection Agency |
| FEMA | - | Federal Emergency Management Agency |
| HHW | - | Hazardous Household Waste |
| KAR | - | Kansas Administrative Regulations |
| KSA | - | Kansas Statutes Annotated |
| LOMR | - | Letter of Map Revision |
| mg/l | - | Milligrams per liter |
| MS4 | - | Municipal Separate Storm Sewer System |
| NOI | - | Notice of Intent |
| NOT | - | Notice of Termination |
| NPDES | - | National Pollutant Discharge Elimination System |
| OCI | - | Office of Central Inspection |
| PST | - | Petroleum Storage Tank |
| SWP3 | - | Storm Water Pollution Prevention Plan |
| TMDL | - | Total Maximum Daily Load |
| USC | - | United States Code |

F. Definitions. Unless a provision explicitly states otherwise, the following terms and phrases, as used in this chapter, shall have the meanings hereinafter designated.

1. "As-built plan" means a drawing showing the actual state of permanent storm water facilities as installed.

2. "Best management practices (BMP)" means schedule of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States or the city's MS4. Best management practices also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage areas. The BMPs required in this chapter will be sufficient to prevent or reduce the likelihood of pollutants entering storm sewers, ditches, or ponds.

3. "City" means the City of Wichita.

4. "Commencement of construction" means the disturbance of soils associated with clearing, grading, or excavating activities or other construction activities.

5. "Commercial" means pertaining to any business, trade, industry or other activity engaged in for profit.

6. "Construction general permit" refers to the *Kansas General Permit for Stormwater Discharges from Construction Sites*.

7. "Contractor" means any person or firm performing construction work at a construction site, including any general contractor and subcontractors. Also includes, but is not limited to, earthwork, paving, building, plumbing, mechanical, electrical, landscaping contractors, and material suppliers delivering materials to the site.

8. "Development" or "new development" means undisturbed property where improvements are planned or intended that will result in land disturbance activities or impervious areas either during or after construction.

9. “Director” means the person appointed to the position of Public Works and Utilities Director by the City Manager of the City, or his/her duly authorized representative. Authorized representatives can include, but are not limited to, the City Engineer, the Storm Water Engineer, and others, as so authorized.
10. “Discharge” means any addition or introduction of any pollutant, storm water, or any other substance whatsoever into the municipal separate storm sewer system (MS4) or into waters of the United States.
11. “Discharger” means any person who causes, allows, permits, or is otherwise responsible for a discharge, including without limitation any owner of a construction site or industrial facility.
12. “Domestic sewage” means human excrement, gray water (From home clothes washing, bathing, showers, dishwashing, and food preparation), other wastewater from household drains, and waterborne waste normally discharged from the sanitary conveniences of dwellings (including apartment houses and hotels), office buildings, factories, and institutions, that is free from industrial waste.
13. “Drainage plan” refers to the detailed water quantity and quality calculations and plan that are required for final plat approval or for issuance of a building permit.
14. “Earthwork” means the disturbance of soils on a site associated with clearing, grading, or excavation activities.
15. “Environmental Protection Agency (EPA)” means the United States Environmental Protection Agency, the regional office thereof, any federal department, agency or commission that may succeed to the authority of the EPA, and any duly authorized official of EPA or such successor agency.
16. “Extremely hazardous substance” means any substance listed in the appendices to 40 CFR Part 355, Emergency Planning and Notification.
17. “Facility” means any building, structure, installation, process, or activity from which there is or may be discharge of a pollutant.
18. “Fertilizer” means a substance or compound that contains an essential plant nutrient element in a form available to plants and is used primarily for its essential plant nutrient element content in promoting or stimulating growth of a plant or improving the quality of a crop, or a mixture of two or more fertilizers.
19. “Final stabilization” means the status when all soil disturbing activities at a site have been completed. This would establish a uniform perennial vegetative cover with a density of seventy percent coverage for unpaved areas and those not covered by permanent structures or equivalent permanent stabilization measures (by employing riprap, gabions, or geotextiles).
20. “Fire protection water” means any water, and any substances or materials contained therein, used by any person to control or extinguish a fire, or to inspect or test fire equipment.
21. “Garbage” means putrescible animal and vegetable waste materials from the handling, preparation, cooking, or consumption of food, including waste materials from markets, storage facilities, and the handling and sale of produce and other food products.
22. “Harmful quantity” means the amount of any substance that will cause a violation of a State Water Quality Standard or any adverse impact to the city’s drainage system.
23. “Hazardous household waste (HHW)” means any material generated in a household (including single and multiple residences) by a consumer which, except for the exclusion provided in 40 CFR Section 261.4(b)(1), would be classified as a hazardous waster under 40 CFR Part 261.

24. “Hazardous substance” means any substance listed in Table 302.4 of 40 CFR Part 302.

25. “Hazardous waste” means any substance identified or listed as a hazardous waste by the EPA pursuant to 40 CFR Part 261.

26. “Hazardous waste treatment, disposal, and recovery facility” means all contiguous land, and structures, other appurtenances and improvements on the land used for the treatment, disposal, or recovery of hazardous waste.

27. “Impervious area” or “impervious cover” means the number of square feet of hard surface areas which either prevent or retard the entry of water into soil mantle, as it entered under natural conditions as undisturbed property, and/or causes water to run off the surface in greater quantities or at an increased rate of flow from that present under natural conditions as undisturbed property, including, but not limited to, roofs, roof extensions, patios, porches, driveways, sidewalks, pavement, athletic courts, and compacted dirt or graveled areas.

28. “Individual building sites” means and includes sites of building construction or earthwork activities that are not a part of a new subdivision development and any individual lot within a newly developing subdivision.

29. Industrial General Permit. See “Kansas General Permit for Stormwater Discharges Associated with Industrial Activity.”

30. “Industrial waste” means any waterborne liquid or solid substance that results from any process of industry, manufacturing, mining, production, trade or business.

31. “Industry” means and includes: (a) municipal landfills; (b) hazardous waste treatment, disposal, and recovery facilities; (c) industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42, U.S.C. Section 11023; industrial facilities required to obtain NPDES stormwater discharge permits due to their Standard Industrial Classification or narrative description; and (d) industrial facilities that the director determines are contributing a substantial pollutant loading to the MS4, which are sources of stormwater discharges associated with industrial activity.

32. “Kansas General Permit for Stormwater Discharges Associated with Industrial Activity (or industrial general permit)” means the industrial general permit issued by KDHE and any subsequent modifications or amendments thereto, including group permits.

33. “Kansas General Permit for Stormwater Discharges from Construction Sites (or construction general permit)” means the construction general permit issued by KDHE and any subsequent modifications on amendments thereto, including group permits.

34. “Land disturbance” means the disturbance of soils on a site associated with clearing, grading, excavation, new development or redevelopment activities.

35. “Landfill” means an area of land or an excavation in which municipal solid waste is placed for permanent disposal, and which is not a land treatment facility, a surface impoundment, or an injection well.

36. “Municipal separate storm sewer system (MS4)” means the system of conveyances, (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by the city and designed or used for collecting or conveying stormwater, and which is not used for collecting or conveying sewage.

37. “Municipal solid waste” means solid waste resulting from or incidental to municipal, community, commercial, institutional, or recreational activities, and includes garbage, rubbish, ashes, street cleanings, dead animals, abandoned automobiles, and other solid waste other than industrial waste.

38. “NPDES permit” means for the purpose of this chapter, this is a permit issued by EPA or the state of Kansas that authorizes the discharge of stormwater pollutants to waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis

39. “Nonpoint source” means the source of any discharge of a pollutant that is not a point source.

40. “Notice of intent (NOI)” means the notice of intent that is required by either the industrial general permit or the construction general permit.

41. “Notice of termination (NOT)” means the notice of termination that is required by either the industrial general permit or the construction general permit.

42. “Notice of violation” means a written notice provided to the owner or contractor detailing any violations of this chapter and any clean-up action expected of the violators.

43. “OCI” means office of central inspection and includes its superintendent and his or her authorized representatives.

44. “Oil” means any kind of oil in any form, including, but not limited to: petroleum, fuel oil, crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure, sludge, oil refuse, and oil mixed with waste.

45. “Outfall” or “storm water outfall” means the terminus of the storm water system for a development or redevelopment where the storm water runoff is released into a larger public or private storm water management system, or into a stream, waters of the United States or other water body.

46. “Owner” means the person who owns a facility, part of a facility, or land.

47. “Person” means any individual, partnership, copartnership, firm, company, corporation, association, joint stock company, trust, estate, government entity, or any other legal entity; or their legal representatives, agents, or assigns, including all federal, state, and local government entities.

48. “Pesticide” means a substance or mixture of substances intended to prevent, destroy, repel, or migrate any pest, or substances intended for use as a plant regulator, defoliant, or desiccant.

49. “Petroleum product” means a petroleum product that is obtained from distilling and processing crude oil and that is capable of being used as a fuel for the propulsion of a motor vehicle, or aircraft, including motor gasoline, gasohol, other alcohol blended fuels, aviation gasoline, kerosene, distillate fuel oil, and #1 and #2 diesel.

50. “Petroleum storage tank (PST)” means any one or combination of aboveground or underground storage tanks that contain petroleum product and any connecting underground pipes.

51. “Point source” means any discernable, confined, and discrete conveyance including, but not limited to: any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

52. “Pollutant” means dredged spoil, spoil waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical waste, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, soil, yard waste, hazardous household wastes, used motor oil, anti-freeze, litter, and industrial, municipal, and agricultural waste discharged into water.

53. “Pollution” means the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property, or public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

54. “Qualified personnel” means persons who possess the required certification, license, or appropriate competence, skills, and ability as demonstrated by sufficient education, training, and/or experience to perform a specific activity in a timely and complete manner consistent with the regulatory requirements and generally accepted industry standards for such activity.

55. “Redevelopment” or “redevelopment site” means a change to previously existing improved property, including but not limited to the demolition or building structures, filling, grading, paving, or excavating.

56. “Release” means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the municipal separate storm sewer system (MS4) or the waters of the United States.

57. “Reportable quantity (RQ)” means, for any hazardous substance, the quantity established and listed in Table 302.4 of 40 CFR Part 302; for any extremely hazardous substance, the quantity established in 40 CFR Part 355.

58. “Rubbish” means nonputrescible solid waste, excluding ashes, that consist of: (a) combustible waste materials, including paper, rags, cartons, wood, excelsior, furniture, rubber, plastics, yard trimmings, leaves, and similar materials; and (b) noncombustible waste materials, including grass, crockery, tin cans, aluminum cans, metal furniture, and similar materials that do not burn at ordinary incinerator temperatures (one thousand six hundred to one thousand eight hundred degrees Fahrenheit).

59. “Sanitary sewer” means the system of pipes, conduits, and other conveyances which carry industrial waste and domestic sewage from residential dwellings, commercial buildings, industrial and manufacturing facilities, and institutions, whether treated or untreated, to the city sewage treatment plant (and to which stormwater, surface water, and groundwater are not intentionally admitted).

60. “Septic tank waste” means any domestic sewage from holding tanks such as vessels, chemical toilets, campers, trailers, and septic tanks.

61. “Service station” means any retail establishment engaged in the business of selling fuel for motor vehicles that is dispensed from pumps.

62. “Sewage”, means the domestic sewage mid and/or industrial waste that is discharged into the city sanitary sewer system and passes through the sanitary sewer system to the city sewage treatment plant for treatment.

63. “Site” means the land or water area where any facility or activity is physically located or conducted, including adjacent land used in connection with the facility or activity.

64. “Solid waste” means any garbage, rubbish, refuse, sludge from a waste treatment plait, water supply treatment plant, or air pollution control facility, and other discarded material including: solid, liquid, semi-solid, or contained gaseous material resulting from industrial, municipal, commercial, mining, agricultural operations, and community and institutional activities.

65. “State” means the state of Kansas.

66. “Stormwater” means stormwater runoff, snow melt runoff, and surface runoff and drainage.

67. “Stormwater discharge associated with industrial activity” means the discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant which is listed as one of the categories of facilities in 40 CFR Section 122.26(b)(14), and which is not excluded from EPA’s definition of the same term.

68. “Storm water management facility” or “storm water control” means any structure or installation used to manage storm water quality, flow rate, or volume.

69. “Storm Water Manual” refers to the latest version, as amended, of the document on file with the Director of Public Works entitled City of Wichita/Sedgwick County Storm Water Manual.

70. “Stomwater pollution prevention Plan (SWP3).” Means a plan required by an NPDES stormwater permit and which describes and ensures the implementation of practices that are to be used to reduce the pollutants in stormwater discharges associated with construction or other industrial activity.

71. “Subdivision development” means and includes activities associated with the platting of any parcel of land into two or more lots and includes all construction taking place thereon.

72. "Undisturbed property" means real property which has not been altered from its natural condition so that the entrance of water into the soil mantle is prevented or retarded through changes to the topography or soils.

73. “Used oil (or used motor oil)” means any oil that has been refined from crude oil a synthetic oil that, as a result of use, storage, or handling; has become unsuitable for its original purpose because of impurities or the loss of original properties.

74. “Water of the state (or water)” means any groundwater, percolating or otherwise, lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, inside the territorial limits of the state, and all other bodies of surface water, natural or artificial, navigable or non-navigable, and including the beds and banks of all water courses and bodies of surface water, that are wholly or partially inside or bordering the state or inside the jurisdiction of the state.

75. “Water quality standard” means the designation of a body or segment of surface water in the state for desirable uses and the narrative an numerical criteria deemed by the state to be necessary to protect those uses.

76. “Waters of the United States” means all waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and the flow of the tide; all interstate waters, including interstate wetlands; all other waters the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce; all impoundments of waters otherwise defined as waters of the United States under this definition; all tributaries of waters identified in this definition; all wetlands adjacent to waters identified in this definition; and any water within the federal definition of “waters of the United States” at 40 CFR Section 122.2; but not including any waste treatment systems, treatment ponds, or lagoons designed to meet the requirements of the Federal Clean Water Act.

77. “Watershed” means the cumulative area that drains to a common point.

78. “Watershed plan” means an engineering and planning study for the drainage system and/or land areas of a watershed that may include a plan for storm water management in the watershed. Watershed plans can include, but are not limited to, the analysis of flooding problems, water quality problems, potential storm water

capital improvements, land use patterns, and regulatory issues for existing and potential future land use conditions and address solutions to these problems.

79. "Wetland" means any area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
80. "Yard waste" means leaves, grass clippings, yard and garden debris, and brush that results from landscaping maintenance and land-clearing operations.

(Ord. No. 44-123 § 1)

**Sec. 16.32.020. General prohibition.**

A. No person shall introduce or cause to be introduced into the municipal separate storm sewer system (MS4) any discharge that is not composed entirely of stormwater, except as allowed in subsection B.

B. The following nonstormwater discharges are deemed acceptable and not a violation of this section:

1. A discharge authorized by, and in full compliance with, an NPDES permit (other than the NPDES permit for discharges from the MS4);
2. A discharge or flow resulting from emergency fire fighting;
3. A discharge or flow of fire protection water that does not contain oil or hazardous substances or materials;
4. A discharge from water line flushing;
5. A discharge or flow from lawn watering, landscape irrigation, or other irrigation water;
6. A discharge or flow from a diverted stream flow or natural spring;
7. A discharge or flow from uncontaminated pumped groundwater or rising groundwater;
8. Uncontaminated groundwater infiltrations;
9. Uncontaminated discharge or flow from a foundation drain, crawl space pump, footing drain, or sump pump;
10. A discharge or flow from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container;
11. A discharge or flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant;
12. A discharge or flow from individual residential car washing;
13. A discharge of flow from a riparian habitat or wetland or natural spring;
14. A discharge of flow from water used in street washing that is not contaminated with any soap, detergent, degreaser, solvent, emulsifier, dispersant, or any other harmful cleaning substance;
15. Stormwater runoff from a roof that is not contaminated by any runoff or discharge from an emissions scrubber or filter or any other source of pollutant;

16. Swimming pool water, excluding filter backwash; that has been dechlorinated so that it contains no harmful quantity of chorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning.

17. Heat pump discharge waters (residential only).

C. Notwithstanding the provisions of subsection B of this section, any discharge shall be prohibited by the section if the discharge in question has been determined by the director to be a source of a pollutants to the waters of the United States or to the MS4, written notice of such determination has been provided to the discharger, and the discharge has occurred more than ten days beyond such notice.

(Ord. No. 44-123 § 2)

**Sec. 16.32.030. Specific prohibitions and requirements.**

A. The specific prohibitions and requirements in this section are not necessarily inclusive of all the discharges prohibited by the general prohibition in Section 16.32.020.

B. No person shall introduce or cause to be introduced into the MS4 any discharge that causes or contributes to causing the city to violate a KDHE water quality standard, the city's NPDES stormwater permit, or any state-issued discharge permit for discharges from its MS4.

C. No person shall dump, spill, leak, pump, pour, emit, empty, discharge, leach, dispose, or otherwise introduce or cause, allow, or permit to be introduced the following substances into the MS4:

1. Any used motor oil, antifreeze or any other petroleum product or waste;
2. A harmful quantity of industrial waste;
3. Any hazardous waste, including household hazardous waste;
4. Any domestic sewage or septic tank waste, grease trap waste, or grit trap waste;
5. Any garbage, rubbish, or yard waste;
6. Wastewater that contains a harmful quantity of soap, detergent, degreaser, solvent, or surfactant based cleaner from a commercial carwash facility; from any vehicle washing, cleaning, or maintenance at any new or used automobile or other vehicle dealership, rental agency, body shop, repair shop, or maintenance facility; or from any washing, cleaning, or maintenance of any business or commercial or public service vehicle, including a truck, bus, or heavy equipment, by a business or public entity that operates more than five such vehicles.
7. Wastewater from the washing, cleaning, de-icing, or other maintenance of aircraft;
8. Wastewater from a commercial mobile power washer or from the washing or other cleaning of a building exterior that contains any harmful quantity of soap, detergent, degreaser, solvent, or any surfactant based cleaner.
9. Any wastewater from commercial floor, rug, or carpet cleaning;
10. Any wastewater from the washdown or other cleaning of pavement that contains any harmful quantity of soap, detergent solvent, degreaser, emulsifier, dispersant, or any other harmful cleaning substance; or any wastewater from the wash-down or other cleaning of any pavement where any spill, leak, or other release of oil, motor fuel, or other petroleum or hazardous substance has occurred, unless all harmful quantities of such released material have been previously removed;
11. Any effluent from a cooling tower, condenser, compressor, emissions scrubber, emission filter, or the blowdown from a boiler;

12. Any ready-mixed concrete, mortar, ceramic, asphalt base material or hydromulch material, or discharge resulting from the cleaning of vehicles or equipment containing or used in transporting or applying such material;
13. Any runoff, washdown water or waste from any animal pen, kennel, fowl or livestock containment area;
14. Any filter backwash from a swimming pool or fountain;
15. Any swimming pool water containing a harmful level of chlorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning;
16. Any discharge from water line disinfection by super chlorination if it contains a harmful level of chlorine at the point of entry into the MS4 or waters of the United States;
17. Any water from a water curtain in a spray room used for painting vehicles or equipment;
18. Any contaminated runoff from a vehicle wrecking yard;
19. Any substance or material that will damage, block, or clop the MS4;
20. Any release from a petroleum storage tank (PST), or any leachate or runoff from soil contaminated by leaking PST; or any discharge of pumped, confined, or treated wastewater from the remediation of any such PST release, unless the discharge has received an NPDES permit from the state.

D. No person shall introduce or cause to be introduced into the MS4 any harmful quantity of sediment, silt, earth, soil, or other material associated with clearing, grading, excavation or other construction activities in excess of what could be retained on site or captured by employing sediment and erosion control measures to the maximum extent practicable under prevailing circumstances.

E. No person shall connect a line conveying sanitary sewage, domestic or industrial, to the MS4, or allow such a connection to continue.

F. Regulation of Pesticides and Fertilizers.

1. No person hall use or cause to be used any pesticide or fertilizer in any manner that the person knows, or reasonably should know, is likely to cause, or does cause, a harmful quantity of the pesticide or fertilizer to enter the MS4 or waters of the United States.
2. No person shall dispose of, discard, store, or transport a pesticide or fertilizer, or its container, in a manner that the person knows, or reasonably should know, is likely to cause, or does cause, a harmful quantity of the pesticide or fertilizer to enter the MS4 or waters of the United States.

G. Used Oil Regulation.

1. No person shall discharge used oil into the MS4 or a sewer, drainage system, septic tank, surface water, groundwater, or water course.

H. Cleanup. Should it be determined by the director that any person or business has allowed any pollutant into the MS4 or waters of the United States, immediate measures will be taken by the responsible party to remove the pollutants. If the pollutants are not removed within the time period specified by the director, the city may remove the pollutants and assess the cost thereof to the responsible party. The city may use any legal means to collect said cost, should the responsible party fail to pay said cost within forty-five days.

(Ord. No. 44-123 §4)

**Sec. 16.32.040. Release reporting and cleanup.**

A. Any person responsible for any release of any hazardous material that may flow, leach, enter, or otherwise be introduced into the MS4 or waters of the United States shall comply with all state, federal, and any other local law requiring reporting, clean-up, containment, and any other appropriate remedial action in response to the release.

B. Within thirty days following such release, the Wichita fire department shall submit a written report to the public works department detailing spill information and the methods used to remedy the problem.

(Ord. No. 44-123 §4)

**Sec. 16.32.050. Stormwater discharges from construction activities.**

A. General Requirements (All Sites).

1. The owners of construction sites shall ensure that best management practices are used to control and reduce the discharge of pollutants into the MS4 and waters of the United States to the maximum extent possible under the circumstances.
2. Qualified personnel (provided by the owner of the construction site) shall inspect disturbed areas that have not been finally stabilized, areas used for storage of materials that are exposed to precipitation, structural control measurers, and location where vehicles enter or exit the site, at least once every seven calendar days and within twenty-four hours of the end of a storm that is one-half inch or greater. All erosion and sediment control measures and other identified best management practices shall be observed in order to ensure that they are operating correctly and are effective in preventing significant impacts to receiving waters and the MS4. Based on the results of the inspection, the best management practices shall be revised as appropriate as soon as practicable. These inspections, along with a description of revisions, will be documented in writing and available for inspection by the director and OCI upon request.
3. Should it be found that soil or pollutants have already or may be carried into the MS4 or waters of the United States, immediate measures will be taken by the owner to remedy the violation and/or remove the pollutants. If the owner fails to remove pollutants within the time period prescribed in the notice of violation from the city, the city may remove the pollutants and assess the cost thereof to the responsible owner. Failure of the owner to pay said costs will be grounds for the denial of further approvals or the withholding of occupancy certificates.
4. When determined to be necessary for the effective implementation of this section, the director may require any plans and specification that are prepared for the construction of the site improvements to illustrate and describe the best management practices required by subsection A.1 of this section above that will be implemented at the construction site. Should the proper BMP's not be installed or if they BMP's are ineffective, upon reasonable notice to the owner, the city may deny approval of any building permit, grading permit, subdivision plat, site development plan, or any other city approval necessary to commence or continue construction, or to assume occupancy.
5. The owner of a site of construction activity is responsible for compliance with the requirements in this subsection. In the case of new subdivisions, builders on individual lots can operate under the developers NPDES permit if the developer's SWP3 deals with individual lots and the contractors certification has been signed.

6. Any contractor on a construction site will also be required to use best management practices so as to minimize pollutants that enter into the MS4.

7. All persons shall avoid damaging BMP devices once in place. Any person damaging a BMP device shall be responsible for the repair of the damaged BMP device. Malicious destruction of a BMP device or failure of such responsible person to repair BMP device will be deemed a violation of this chapter.

B. Sites Requiring Federal and/or State NPDES Stormwater Discharge Permits. All owners of and contractors on sites of construction activity, that require a federal or state NPDES stormwater discharge permit, or that are part of a common plan of development or sale requiring said permit(s), shall comply with the following requirements (in addition to those in subsection A):

1. Any owner who intends to obtain coverage for stormwater discharges from a construction site under the Kansas General Permit for Stormwater Discharges From Construction Sites ("the construction general permit") shall submit a signed copy of its notice of intent (NOI) to OCI when a building permit application is made. If the construction activity is already underway upon the effective date of this chapter,* the NOI shall be submitted within thirty days. When ownership of the construction site changes, a revised NOI shall be submitted within fifteen days of the change in ownership.

***Editor's note:** Ordinance 44-123, which enacted Chapter 16.32, is effective on January 1, 1999.

2. A stormwater pollution prevention plan (SWP3) shall be prepared and implemented in accordance with the requirements of the construction general permit or any individual or group NPDES permit issued for stormwater discharges from the construction site, and with any additional requirement imposed by or under this chapter and any other city ordinance.

3. The SWP3 shall be prepared by a qualified person and shall comply with State NPDES requirements. The signature of the preparer shall constitute his/her attestation that the SWP3 fully complies with the requirements of the permit issued.

4. The SWP3 shall be completed prior to the submittal of the NOI to OCI and for new construction, prior to the commencement of construction activities. The SWP3 shall be updated and modified as appropriate and as required by the NPDES permit.

5. The director and/or OCI may require any owner who is required by subsection B.2 of this section to prepare a SWP3, to submit the SWP3, and any modifications thereto, to the Director and/or OCI for review at any time.

6. Upon the director's review of the SWP3 and any site inspection that he/she may conduct, if the SWP3 is not being fully implemented, the director may upon reasonable notice to the owner, deny approval of any building permit, grading permit, site development plan, final occupancy certificate, or any other city approval necessary to commence or continue construction. A stop work order may also be issued.

7. All contractors working on a site subject to an NPDES permit shall sign a copy of the following certification statement before beginning work on the site:

I certify under penalty of law that I understand the terms and conditions of the National Pollutant Discharge Elimination System (NPDES) permit that authorizes the stormwater discharges associated with construction activity from the construction site identified as part of this certification and with the Stormwater Pollution Prevention Plan Chapter of the city, and I agree to implement and follow the provisions of the Stormwater Pollution Prevention Plan (SWP3) for the construction site;

The certification must include the name and title of the person providing the signature; the name, address, and telephone number of the contracting firm; the address (or other identifying description) of the site; and the date the certification is made.

All contractors will be responsible for their own activities to ensure that they comply with the owners' SWP3. Failure to comply with the SWP3 or malicious destruction of BMP devices is hereby deemed to be a violation of this chapter.

8. The SWP3 and the certifications of contractors required by subsection B.7 of this section, and with any modifications attached, shall be retained at the construction site or at a local office in Wichita from the date of construction commencement through the date of final stabilization.

9. The director may notify the owner at any time that the SWP3 does not meet the requirements of the NPDES permit issued or any additional requirement imposed by or under this chapter. Such notification shall identify those provisions of the permit or chapter which are not being met by the SWP3, and identify which provisions of the SWP3 require modification in order to meet such requirements. Within thirty days of such notification from the director, the owner shall make the required changes to the SWP3 and shall submit to the director a written certification from the owner that the requested changes have been made.

10. The owner shall amend the SWP3 whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to the MS4 or to the waters of the United States, and which has not otherwise been addressed in the SWP3, or if the SWP3 proves to be ineffective in eliminating or significantly minimizing pollutants, or in otherwise achieving the general objective of controlling pollutants in stormwater discharges.

11. Qualified personnel (provided by the owner of the construction site) shall inspect disturbed areas that have not been finally stabilized, areas used for storage of materials that are exposed to precipitation, structural control measures, and locations where vehicles enter or exit the site, at least once every seven calendar days and within twenty-four hours of the end of the storm that is one-half inch or greater. Disturbed areas and areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures identified in the SWP3 shall be observed to ensure that they are operating correctly. Where discharge locations or points are accessible, they shall be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to receiving waters or the MS4. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site sediment tracking.

12. Based on the results of the inspections required by subsection B.11 of this section, the pollution prevention measures identified in the SWP3 shall be revised as appropriate. Such modifications shall provide for timely implementation of any changes to the SWP3 within ten calendar days following the inspection.

13. A report summarizing the scope of any inspection required by subsection B.11 of this section, and the names(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the SWP3, and actions taken in accordance with subsection B.12 of this section above shall be made and refined on site or at a local office in Wichita as part of the SWP3. Such report shall identify any incidence of noncompliance. Where a report does not identify any incidence of noncompliance, the report shall contain a certification that the facility is in compliance with the SWP3, the facility's NPDES permit, and this

chapter. The report shall be certified and signed by the person responsible for making it.

14. The owner shall retain copies of any SWP3 and all reports required by this chapter or by the NPDES permit for the site, and records of all data used to complete the NOI for a period of at least three years from the date that the site is finally stabilized.

15. Upon final stabilization of the construction site, the owner shall submit written certification to the director and OCI that the site has been finally stabilized. The city may withhold the final occupancy or use permit for any premises constructed on the site until such certification of final stabilization has been filed and the director has determined, following any appropriate inspection, that the final stabilization has occurred and that any required permanent structural controls have been completed.

(Ord. No. 44-123 § 5)

**Sec. 16.32.060. Stormwater discharges associated with industrial activity.**

A. All operators of: (1) municipal landfills; (2) hazardous waste treatment, disposal, and recovery facilities; (3) industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42, U.S.C. Section 11023; industrial facilities required to obtain NPDES stormwater discharge permits due to their Standard Industrial Classification or narrative description; and (4) industrial facilities that the director determines are contributing a substantial pollutant loading to the MS4, which are sources of stormwater discharges associated with industrial activity, shall comply with the following requirements:

1. Any owner who intends, after the effective date of this chapter,* to obtain coverage for a stormwater discharge associated with industrial activity under the Kansas General Permit for Stormwater Discharges Associated With Industrial Activity ("the industrial general permit") shall submit a signed copy of its notice of intent (NOI) to the director.

***Editors note:** Ordinance 44-123, which enacted Chapter 16.32, is effective on January 1, 1999.

2. When required by their NPDES permit, all industries listed in this section shall prepare a stormwater pollution prevention plan (SWP3) and implement said plan in accordance with the requirements of their state or federal NPDES permit.

3. The SWP3, when required shall be prepared and signed by a qualified individual and will comply with all state NPDES requirements. The signature of the preparer shall constitute his/her attestation that the SWP3 fully complies with the requirements of the NPDES permit.

4. The SWP3, when required, shall be updated and modified as appropriate and as required by the NPDES permit and this chapter.

5. A copy of any NOI that is required by subsection A.1 of this section shall be submitted to the city in conjunction with any application for a permit or any other city approval necessary to commence or continue operation of the industrial facility.

6. The Director may require any operator who is required by subsection A.2 of this section to prepare a SWP3, to submit the SWP3, and any modifications thereto, to the director for review.

7. Upon the director's review of the SWP3 and any site inspection that he/she may conduct, the director may upon reasonable notice to the owner deny approval necessary to commence or continue operation of the facility, on the grounds that the

SWP3 does not comply with the requirements of the NPDES permit, or any additional requirement imposed by or under this chapter. Also if at any time the director determines that the SWP3 is not being fully implemented, upon reasonable notice to the owner, he/she may deny approval of any application for a permit or other city approval necessary to commence or continue operation of the facility.

8. The SWP3, if required, with any modifications attached, shall be retained at the industrial facility from the date of commencement of operations until all stormwater discharges associated with industrial activity at the facility are eliminated and the required notice of termination (NOT) has been submitted.

9. The director may notify the owner at any time that the SWP3 does not meet the requirements of the NPDES permit, or any additional requirement imposed by or under this chapter. Such notification shall identify those provisions of the permit or chapter which are not being met by the SWP3, and identify which provisions require modification in order to meet such requirements. Upon thirty days of such notification from the director, the owner shall submit to the director a written certification that the requested changes have been made.

10. The owner shall amend the SWP3, if required, whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to the MS4 or to the waters of the United States, or if the SWP3 proves to be ineffective in eliminating or significantly minimizing pollutants, or in otherwise achieving the general objective of controlling pollutants in stormwater discharges.

11. As may be required by the facilities NPDES permit, qualified personnel (provided by the owner) shall inspect equipment and areas of the facility specified in the SWP3 at appropriate intervals or as may be specified in their NPDES permit. A set of tracking or follow up procedures shall be used to ensure that appropriate actions are taken in response to the inspections. Records of inspection shall be maintained.

12. Industrial facilities will implement a sampling and testing program as required by their individual NPDES permits. The director may require written reports of any such monitoring and testing to be submitted to him/her.

13. The owner shall retain the SWP3 and all sampling and testing reports until at least one year after stormwater discharges associated with industrial activity at the facility are eliminated, or the operator is no longer operating the facility, and a notice of termination (NOT) has been submitted.

14. For discharges subject to the semi-annual or annual monitoring requirements of the industrial general permit, in addition to the records-retention requirements of the paragraph above, owners are required to retain for six year period from the date of sample collection, records of all sampling and testing information collected. Owners must submit such monitoring results, and/or a summary thereof, to the director upon his/her request.

15. After the effective date of this chapter,* no stormwater discharge shall contain any hazardous metals in a concentration that would result in the violation of any Kansas Surface Water Quality Standard.

(Ord. No. 44-123 § 6)

***Editor's note:** Ordinance 44-123, which enacted Chapter 16.32, is effective on January 1, 1999.

**Sec. 16.32.070. Ditches and ponds.**

A. Duty to Maintain. The owner of any private drainage ditch or pond that empties into the city's MS4 or the waters of the Unit States has a duty to use BMP's on the ditches or pond to minimize the pollutant levels downstream. Such BMP's include, but are not limited to, removing excessive build-up of silt, repairing bank erosion, maintaining vegetative cover, the cleaning of inlet and outlet works, and the like.

B. Inspection and Notice by City. The city will periodically inspect these privately owned ditches and ponds. Should conditions be found that because the pollution of downstream receiving waters, the director shall so notify the owners, and state what actions are expected by the owners to remedy the problem.

C. Failure to Repair. Should the owners fail to make the necessary repair within one hundred twenty days after notice, the city is authorized to do the repairs at the expense of the owner. Should the owner fail to reimburse the city for the cost of the repairs upon demand, the city may assess the cost thereof to the owner and initiate any collection proceedings authorized by law.

(Ord. No. 44-123 § 7)

**Sec. 16.32.080. Compliance monitoring.**

A. Right of Entry. The director, OCI, and the city-county health department, or their authorized representatives, shall have the right to enter the premises of any person discharging stormwater to the municipal separate storm sewer system (MS4) or to waters of the United States at any reasonable time to determine if the discharger is complying with all requirements of this chapter, and with any state or federal discharge permit, limitation, or requirement. Dischargers shall allow the inspectors ready access to all parts of the premises for the purposes of inspection, sampling, records examination and copying, and for the performance of any additional duties.

B. Records. Subject to the requirements of subsection A, dischargers shall make available, upon request, any SWP3's, modifications thereto, self-inspection reports, monitoring records, compliance evaluations, notice of intent, and any other records, reports, and other documents related to compliance with this chapter and with any state or federal discharge permit.

C. Sampling. The director shall have the right to set up on the discharger's property such devices that are necessary to conduct sampling of stormwater discharges.

(Ord. No. 44-123 § 8)

**Sec. 16.32.090. Subdivision development.**

A. The developer of any subdivision requiring a federal or state NPDES stormwater discharge permit will be responsible for obtaining the required permit and developing and implementing an overall SWP3 for the subdivision. Said SWP3 shall include BMP's to be used on individual lot building sites.

B. City contractors installing public streets; water sanitary sewer, storm sewer lines; and/or sidewalks will be required to comply with the developers SWP3's and sign the appropriate contractor certification statement. For work in public right-of-way or easements requiring a federal or state NPDES stormwater discharge permit, the city shall be responsible for obtaining the required permit and preparing and implementing the required SWP3's.

C. Any utility company installing utilities within a new subdivision will also be required to comply with the developers SWP3's and sign the appropriate contractor certification statement. For work in public rights-of-way or easements requiring a federal or state NPDES stormwater discharge permit, the utility company shall be responsible for obtaining the required permit and preparing and implementing the required SWP3's.

D. The purchasers or individual lots within the subdivision for construction purposes shall comply with the developers SWP3 and shall sign a certification statement agreeing to do so.

(Ord. No. 44-123 § 9)

**Sec. 16.32.091. Storm Water Quality Management Standards**

A. Applicability.

1. Water quality treatment and downstream channel protection shall be required of owners of new developments and redevelopments that cause a land disturbance greater than or equal to one (1) acre, including projects that cause a land disturbance less than one (1) acre that are part of a larger common plan of development or sale.

2. The requirements of 16.32.091 shall not apply to:

i. new developments or redevelopments that have a construction plan approved by January 1, 2011 and will have completed construction of all storm water management facilities within 90 days of January 1, 2011. This does not exempt such new developments from water quality management regulations that may be required in the future by EPA or KDHE; or,

ii. redevelopment projects that consist solely of ordinary maintenance activities, remodeling of buildings on the existing foundation, resurfacing (milling and overlay) of existing paved areas, and exterior changes or improvements.

B. Water Quality Treatment Standard for New Developments. Storm water runoff from applicable new developments must be treated for water quality prior to discharge from the development site in accordance with the storm water treatment standards and criteria provided in the Storm Water Manual.

C. Water Quality Treatment Standard for Redevelopments. Owners of applicable redevelopments must adhere to one of the following requirements.

1. The total impervious cover of the property after redevelopment shall be reduced by at least twenty-percent (20%) from the total impervious cover of the property prior to the proposed redevelopment.

2. Storm water runoff from at least thirty percent (30%) of the site's existing impervious cover and for one-hundred percent (100%) of any new land disturbance that will result from the proposed redevelopment shall be treated for water quality prior to discharge from the redevelopment site in accordance with the storm water treatment standards and criteria provided in the Storm Water Manual.

3. The owner shall provide storm water controls at an alternative location in the same watershed as the proposed redevelopment. The level of storm water control provided shall be equivalent to what would have been provided at the proposed redevelopment for either requirement 1 or 2 above, at a minimum.

4. In agreement and partnership with the City of Wichita, the owner shall provide engineering design and/or construction activities to address one or more known downstream water quality or channel erosion issues located within the same watershed as the proposed redevelopment, through stream restoration and/or other off-site remedies approved by the Director.

5. The owner shall pay a fee in-lieu-of water quality control and channel protection control, in an amount to be determined by the city in accordance with the in-lieu-of fee schedule as adopted by the City Council of the City of Wichita per the watershed plan which covers the redevelopment.

6. Any combination of (1) through (5) above may be acceptable to the City of Wichita or other solution(s) approved by the Director that meets the intent of this chapter.

D. Downstream Stabilization Standard. Downstream long-term channel protection shall be provided for applicable new developments and redevelopments prior to discharge from the new/redevelopment site in accordance with the downstream stabilization standards and criteria provided in the Storm Water Manual.

**Sec. 16.32.092. Storm Water Quantity Management Standards**

A. Applicability. Storm water runoff peak discharge analysis and control shall be required for new developments and redevelopments that will create or add one (1) acre or greater of impervious cover, including projects that have less than one (1) acre in impervious cover that are part of a larger common plan of development or sale that will result in one (1) acre or greater of impervious cover.

B. Water Quantity Management Standard. Storm water runoff peak discharge analysis and control shall be required for applicable new developments or redevelopments in accordance with the storm water quantity standards and criteria provided in the Storm Water Manual.

**Sec. 16.32.093. Other Storm Water Management Requirements**

A. Applicability. Section 16.32.093 is applicable to new developments and redevelopments that are required to comply with section 16.32.091 and/or section 16.32.092.

B. Alternative Standards for Individual Watersheds. Alternative storm water management standards, either lesser or greater than those specified in this chapter, may be required by the Director in those areas or watersheds where water quality, flooding or erosion problems are known to exist, or in individual watersheds where a watershed plan or storm water master plan, approved by the City Council of the City of Wichita, specifies such alternative standards.

C. Other Requirements for Storm Water Discharges.

   1. Storm water discharges shall be managed in consideration of the erosion control measures detailed in the Storm Water Manual.

   2. Any discharge of storm water runoff to groundwater must meet all applicable local, State and Federal requirements, permits, plans and programs. The owner is responsible for complying with all local State and Federal permits that are applicable to the site.

D. Requirement to Stabilize Banks. Banks of all streams, channels, ditches and other earthen storm water conveyances shall be left in a stabilized condition upon completion of the new development or redevelopment. No actively eroding, bare or unstable vertical banks shall remain after completion of construction.

E. Requirement to Use the Storm Water Manual. All storm water facilities and systems, including those designed and constructed for water quality treatment, downstream channel stabilization, and peak discharge control shall be designed, constructed and maintained in accordance with the criteria, standards, and specifications presented in this chapter and in the Storm Water Manual. The standards for water quality treatment, downstream channel stabilization and peak discharge analysis and control shall be achieved through the use of one or more storm water quality management facilities that are designed and constructed in accordance with the design criteria, guidance, and specifications provided in the Storm Water Manual. Methods, designs or technologies for storm water quality management facilities that are not provided in the Storm Water Manual may be submitted for approval by the city if it is proven that such methods, designs or technologies will meet or exceed the storm water treatment standards set forth in the Storm Water Manual and this ordinance. Proof of such methods, designs, or technologies must meet the minimum testing criteria set forth in the Storm Water Manual.

F. Storm Water Facilities on Public Property. Storm water management facilities shall not be installed within public rights-of-way or on public property unless a permit has been issued by the city engineer.

**Sec. 16.32.094. Waivers and Exemptions from Storm Water Management Standards for New Developments**

A. Exemptions. Owners of properties where the following activities are undertaken are exempt from the requirements of sections 16.32.091, 16.32.092, 16.32.093 and 16.32.094 of this chapter.

1. Minor land disturbing activities at individual locations, such as gardening, building or grounds maintenance and landscaping, provided that the activity does not result in equal to or greater than one (1) acre of land disturbance;
2. Individual utility service connections, unless such activity is carried-out in conjunction with the clearing, grading, excavating, transporting, or filling of a lot or lots for which a grading permit would otherwise be required by regulation;
3. Installation, maintenance or repair of individual septic tank lines or drainage fields, unless such activity is carried out in conjunction with the clearing, grading, excavating, transporting, or filling of a lot or lots for which a grading permit would otherwise be required by the regulation;
4. Installation of posts or poles;
5. Farming activities;
6. Unplanned emergency work and emergency repairs necessary to protect life or property.

B. Waivers. All or some of the storm water management standards required in section 16.32.091 and/or 16.32.092 of this chapter may be waived by the Director under the following circumstances.

1. Existing Downstream Facilities. A waiver may be provided for one or more storm water management standards if the waived standard(s) are met by discharging the storm water runoff to an existing storm water management facility, whether public or private, that is:
   i. provided in accordance with an existing watershed plan that is approved by the city; and,
   ii. already in existence, or will be in existence at the time of construction of the new development or redevelopment; and,
   iii. designed, constructed and maintained to provide a level of storm water control that is equal or greater than that which would be afforded by on-site storm water management facilities.
   iv. If a waiver is provided for this reason, the owner of the new development or redevelopment will be required to pay a fee in-lieu-of water quality control, downstream channel stabilization and peak discharge control, in an amount to be determined by the city in accordance with an adopted in-lieu-of fee schedule as adopted by the City Council of the City of Wichita per the watershed plan which covers the new development or redevelopment.
2. Adverse Impact. A waiver may be provided if engineering studies determine that installing a storm water management facility in order to meet the storm water management standard being considered for waiver will cause adverse impact to water quality, or cause increased channel erosion, or downstream flooding.

3. Technical Criterion. A waiver may be provided if the technical criterion required to waive the storm water management standard, as presented in the Storm Water Manual, is met. In any case, a waiver is subject to satisfaction of the following requirements, which shall be shown in drainage plans submitted for the new development or redevelopment:

   i. the waiver applicant shall provide an engineering study, as defined in 16.32.094.C that proves the adequacy of downstream or shared off-site storm water management facilities to offer equivalent or greater protection than the standard(s) for which a waiver is requested; and,

   ii. the waiver applicant obtains any necessary CLOMR prior to construction, and a LOMR upon completion of construction; and,

   iii. the waiver applicant obtains all State and Federal permits that may be applicable to the site.

C. Engineering Study Required. In the event that a waiver from storm water management control requirements is requested, the adequacy of downstream or shared off-site storm water management facilities to control storm water runoff shall be determined, reviewed and approved by an engineering study that is performed in accordance with the calculation methods presented in the Storm Water Manual. The engineering studies shall be performed at the expense of the owner(s) of the proposed new development or redevelopment, unless a study has already been or is being performed by the city as part of a watershed plan or other land use plan.

**Sec. 16.32.095. General Requirements for Storm Water Design Plans**

A. Storm water design information shall be submitted as part of the preliminary plat, final plat and construction plans, in accordance with the site development process established by the city.

B. A building permit shall not be issued for the land development activity until the required storm water design information and corresponding plans are approved by the city.

C. At a minimum, the storm water design information submitted at each stage of the city development process shall include the specific required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies, guidance and calculation methods (unless equivalent methods are pre-approved by the city) presented in the Storm Water Manual. Additional storm water design information may be required as necessary to allow an adequate review of the existing or proposed site conditions.

D. The submittal of storm water design information shall be subject to the requirements set forth in the minimum subdivision regulations, zoning ordinance, or other city regulations.

E. Storm water design information shall be prepared under the supervision of and stamped by a professional engineer licensed to practice in the State of Kansas.

F. The portions of the new development or redevelopment on which storm water management facilities and systems are located shall be shown on the preliminary and final plats for all residential subdivisions and recorded with the plat as permanent reserves or easements consistent with the policies stated in the Storm Water Manual. Non-residential plats and/or subdivisions having a total area less than or equal to fifteen (15) acres shall be required to demonstrate the viability of proposed storm water management facilities and systems. In such cases, the Director is authorized to allow contingent dedications for storm water facilities providing that the owner/developer enters into an agreement with the City guaranteeing the construction of the said facilities in accordance with a schedule approved in the said agreement.

G. Conformity to the Approved Plans.

1. Grading designs shown on approved master grading plans and the design of storm water facilities and controls shown on approved design plans shall be adhered to during grading and construction activities. Under no circumstance is the owner or operator of land development activities allowed to deviate from the approved plans without prior approval of a plan amendment by the city.

2. Grading and storm water design plans shall be amended to meet all local ordinances and standards if the proposed site conditions change after plan approval is obtained, or if it is determined by the city during the course of grading or construction that the approved plan is inadequate.

H. Duty to Provide an Operations and Maintenance Plan.

1. An Operations and Maintenance Plan shall be included with the storm water design information submitted with the construction plan. The Operations and Maintenance Plan shall include the required operation and maintenance provisions for each storm water management facility and water quality volume reduction area that is serving, or will serve, the development or redevelopment. The Operations and Maintenance Plan shall include all of the required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies and guidance provided in the Storm Water Manual.

2. The Operations and Maintenance Plan shall include an executed legal document entitled "Restrictive Covenants for Storm Water Facilities" (Covenants). The property owner shall record the Covenants with the deed for the property. The location of the storm water management facility(s) and water quality volume reduction areas, the recorded location of the Covenants document, and inspection and maintenance guidance outlining the property owner's responsibility shall be shown on a plat that is recorded for the property.

I. Duty to Provide Storm Water Construction Information on As-Built Drawings.

1. Prior to the release of the performance bond, complete As-Built Drawings shall be provided to the Director, and shall include sufficient design information to show that the storm water facilities will operate as designed under the approved drainage plan.

2. The As-Built Drawings shall include the required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies and guidance provided in the Storm Water Manual.

3. The As-Built Drawings shall be prepared and stamped by a professional engineer licensed to practice in the State of Kansas.

**Sec. 16.32.096. Maintenance and Inspection of Storm Water Drainage Paths and Controls.**

A. Duty to Inspect and Maintain Storm Water Systems and Controls. Property owners shall at all times properly maintain and shall at intervals in accordance with the Operations and Maintenance Plan inspect all storm water facilities, systems, conveyances, pipes, channels, ditches, swales, inlets, catchbasins, water quality volume credit areas, and other facilities and systems of storm water treatment and control (and related appurtenances) so that they operate at their full function. Maintenance and inspection of privately-owned storm water management facilities, systems, conveyances, pipes, channels, ditches, swales, inlets, catchbasins, water quality volume credit areas, and other facilities and systems of storm water treatment and control (and related appurtenances) shall be performed at the expense of the owner(s) of such facilities.

B. Duty to provide inspection reports. After construction of each storm water management facility on the property is complete, property owners shall provide to the Director on a bi-annual basis a completed and signed copy of the inspection report for each storm water management facility that is included with the Operations and Maintenance Plan for the property. The inspection report is due every two years no later than the date (month and day) of approval of the as-built plan for the property.

C. Duty to Preserve Approved Grading Designs. Re-grading an individual lot or lots, or portions of a lot or lots, in a manner that is not in accordance the approved master grading plan, such that the direction(s) of storm water runoff is altered from the direction that would occur under the approved master grading plan, shall be considered a violation of this chapter.

D. Duty to Preserve Existing Drainage Paths. Blockage of a channel, ditch, stream or any other drainage path or storm water system appurtenance that is located in a storm water easement or drainage easement shall be considered a violation of this chapter.

E. Pollutant Removal for Maintenance. The removal of pollutants, sediment and/or other debris for the purpose of maintenance of storm water management facilities shall be performed in accordance with all city, State, and Federal laws.

F. Inspection During Grading or Construction.

    1. During grading or construction, the property owner or his/her appointed designee shall conduct site inspections in accordance with the requirements stated in the Kansas General Permit for Storm Water Discharges from Construction Sites. The property owner will also ensure construction conformance with the approved drainage and construction plans. More stringent inspection requirements may be imposed as necessary for purposes of water quality protection and public safety and to pursue total conformance of the site with the approved plans.

    2. The following areas and items must be inspected throughout grading and construction to ensure that land disturbance activities do not cause adverse impacts to the performance of storm water management facilities and/or water quality volume reduction areas:

        i. all unstabilized areas that drain to a permanent storm water facility or water quality volume reduction area;

        ii. temporary and permanent storm water management facilities; and,

        iii. all erosion prevention and sediment control measures.

G. Inspection After Construction. Once the site has been stabilized and construction has ceased, the property owner or his/her appointed designee shall conduct routine inspections for the storm water management facilities and water quality reduction areas, based on the guidance provided in the Operations and Maintenance Plan and the requirements of the "Restrictive Covenants for Storm Water Facilities" for the property, as set forth in section 16.32.095.H.2. of this ordinance.

H. Inspection Records. Property owners shall make available upon request any self-inspection reports, monitoring/maintenance records, compliance evaluations, notices of intent, and any other records, reports, receipts, and other documents related to compliance with this chapter and with any related local, State or Federal permit.

I. Right-of-Entry. The Director or his/her designee shall have the right to enter the premises of any person discharging storm water to the MS4 or to waters of the United States at any reasonable time to determine if the discharger is complying with all requirements of this chapter, and with any State or Federal discharge permit, limitation, or requirement. Dischargers shall allow the Director or his/her designee ready access to all parts of the premises for the purposes of inspection, sampling, records examination and copying, and for the performance of any additional duties. Failure of a property owner to allow entry onto a property for the purposes set forth in this section shall be cause for the issuance of a stop work order, withholding of a certificate of occupancy, and/or civil penalties and/or damage assessments in accordance with the enforcement provisions of this chapter.

J. Inspection and Notice by City. The city may periodically inspect these privately owned storm water controls. If the facility is not operating as shown in the approved As-Built Drawing, or should conditions be found that cause or may cause the pollution of downstream receiving waters or the erosion of downstream channels or the flooding of adjacent or downstream properties, the Director may issue a notice of violation in accordance with the enforcement provisions stated in this chapter and shall notify the property owner(s) of the potential violation(s). The Director may order the property owner(s) to perform corrective actions as are necessary to facilitate the proper operation of these facilities for the purposes of flood prevention, downstream channel stabilization, water quality treatment and/or public safety, and/or to ensure compliance with jurisdictional regulatory conditions.

K. Failure to Perform Corrective Actions. If property owner(s) fail to make the necessary corrective actions in the timeframe specified in the enforcement provisions of this chapter, the city is authorized to perform the corrective actions at the expense of the owner(s). If the owner(s) fail to reimburse the city for the corrective actions upon demand, the city may assess the cost of the corrective actions to the owner and initiate any collection proceedings authorized by law.

L. Access to Adjacent Properties. This ordinance does not authorize access by a property owner or site operator to private property adjacent to or downstream of the owner's property. Arrangements concerning removal of sediment or pollutants on adjoining property must be settled by the owner or operator with the adjoining landowner.

**Sec. 16.32.097. Special Provisions for Open Channels.**

A. No structure or land shall hereafter be developed, redeveloped, located, extended, converted, or structurally altered without full compliance with the terms of this section, the City of Wichita Floodplain Management Ordinance (Chapter 27.06) and other applicable local, state or federal regulations.

B. Requirements for vegetative buffer zones or maintenance access areas that have been established in approved and adopted watershed plans have priority over the provisions of this section.

C. Closure of open channels. Existing or proposed open channels may be enclosed if a maintenance plan approved by the City is provided; if the closed conduit conforms to the design criteria set in the Storm Water Manual.

D. Access Easement Required. All open channels must have a minimum twenty (20) foot wide maintenance access on each side of the stream as measured from the top-of-bank on each side of the stream, except as required by KSA 24-126 as amended, and KAR 5-45-12 as amended for "streams" defined in KAR 5-45-1 as amended.

**Sec. 16.32.100. Enforcement actions.**

A. The discharge of, or potential discharge of, any pollutant to the MS4 or waters of the United States and/or the failure to comply with the provisions of this chapter and/or the failure to comply with and directive, citation, or order issued under this chapter; are violations of this chapter for which enforcement action may be taken.

B. Prior to taking any enforcement action as specified in this section, a violator will be issued a notice of violation except when, in the opinion of the Director, an owner or contractor has repeatedly ignored the requirements of this chapter and has not made any reasonable intent to comply with these provisions. When issued, the notice of violation will detail the nature of the violation, actions to be taken to remedy the violation, actions to be taken to clean-up any pollutants, and any specific time periods within which to accomplish said actions. Failure to successfully comply with the notice of violation may result in enforcement action.

C. The enforcement actions to be taken under this chapter, as provided in Section 16.32.110 are as follows:

1. Criminal Penalty. Any person violating any provision of this chapter is guilty of a misdemeanor and upon conviction thereof shall be punished by a fine of not more than one thousand dollars. Each and every day during which any violation of any provision of this chapter is committed, continue, or permitted is a separate violation.

2. Stop Work Order. Notwithstanding other penalties provided by this chapter, whenever the Director or OCI, or their designees, finds that any owner or contractor on a construction site has violated, or continues to violate, any provision of this chapter or any order issued thereunder, the director or OCI may after reasonable notice to the owner or contractor issue a stop work order to the owner and contractors by posting such order at the construction site. Said order shall also be distributed to all city departments and divisions whose decisions may affect any activity at the site. Unless express written exception is made, the stop work order shall prohibit any further construction activity at building permit, grading permit, site development plan approval, or any other approval necessary to commence or to continue construction or to assume occupancy at the site. Issuance of a stop work order shall not be a bar against, or a prerequisite for, taking any other action against the violator. Failure to comply with the requirements of any stop work order is a violation of this chapter.

3. Administrative Penalty Process.

    a. When the director finds that any stormwater discharger has violated or continues to violate the provisions set forth in this chapter, or the discharger’s NPDES permit or any order issued thereunder, the director may issue an order for compliance to the discharger. Such orders may contain any requirements as might be reasonably necessary and appropriate to address noncompliance including, but not limited to, the installation of best management practices, additional self-monitoring, and/or disconnection from the MS4.

    b. The director is empowered to enter into consent orders, assurances of voluntary compliance, or other similar documents establishing an agreement with any industrial discharger responsible for noncompliance. Such orders shall include specific action to be taken by the discharger to correct the noncompliance within a time period specified by the order.

    c. Notwithstanding any other remedies or procedures available to the city, any discharger who is found to have violated any provision of this chapter, or any NPDES permit or any order issued under this chapter, may be assessed an administrative penalty as follows:

        1. The minimum administrative penalty for any violation shall be no less than five hundred dollars ($500) per day the violation is maintained and not more than two thousand five hundred dollars ($2,500) per day for each day the violation is maintained;

        2. Failure to obtain required NPDES permit: up to two thousand five hundred dollars per violation;

        3. Failure to prepare stormwater pollution prevention plan: up to two thousand dollars per violation;

        4. Failure to install best management practices: up to one thousand eight hundred dollars per violation;

        5. Failure to maintain best management practices: up to one thousand dollars per violation;

6. Failure to perform required sampling and testing or provide testing reports: up to one thousand dollars per violation;
7. Commencement of construction without an approved drainage plan: up to two thousand five hundred dollars ($2,500) per day of noncompliance;
8. Failure to comply with approved drainage plan: up to two thousand five hundred dollars ($2,500) per day of noncompliance;
9. Failure to maintain storm water management facilities: up to two thousand five hundred dollars ($2,500) per day of noncompliance.

d. Each day on which noncompliance shall occur or continue shall be deemed a separate and distinct violation.

e. Separate but multiple violations (except for violations under subsection C.3.d) by the same person(s) on one or more sites within any period of twelve consecutive months shall be cause to double the amount of penalty assessed under section C.3.c above for each violation after the first.

f. Upon assessment of any administrative penalty, the city will bill the violator for said charge and the Director shall have such collection remedies as are available at law. (Ord. No. 44-123 § 10)

**Sec. 16.32.110. Applicability of enforcement actions.**

A. Illegal dumping will be subject to criminal penalties process.

B. Illegal connections will be subject to either the criminal or administrative penalty processes.

C. Industrial violations will be subject to the administrative penalty process.

D. Individual building sites not requiring a federal or state NPDES permit will be subject to the criminal penalty and the stop work order processes; however, any owner or contractor of such site found guilty of multiple violations of this chapter will also be subject to the administrative penalty process.

E. Individual building sites requiring a federal or state NPDES permit will be subject to the administrative penalty process.

F. Subdivision developers in subdivisions not requiring a federal or state NPDES permit will be subject to the criminal penalty and stop work order processes; however, any such developer found guilty of multiple violations of this chapter will also be subject to the administrative penalty process.

G. Subdivision developers of subdivisions requiring a federal or state NPDES permit will be subject to the administrative penalty process.

H. City contractors and utility companies working on projects not requiring a federal or State NPDES permit will be subject to the criminal penalty process.

I. City contractors and utility companies working on projects requiring federal or state NPDES permit will be subject to the administrative penalty process.

J. Property owners, subdivision developers, commercial and industrial developers, and city contractors working on new developments and redevelopments requiring compliance with the City of Wichita storm water quality or quantity management standards will be subject to the criminal penalty, stop work order and administrative penalty processes.

K. Owners of storm water management facilities and systems that are required to be maintained in accordance with an approved Operations and Maintenance Plan will be subject to the criminal penalty and administrative penalty processes.

(Ord. No. 44-123 § 11)

**Sec. 16. 32.120. Hearing and appeal.**

A. Persons who desire to appeal an administrative requirement, violation or penalty invoked under this chapter may request a hearing and appeal as follows:

1. Any party affected by a penalty, order, directive or determination issued or made, pursuant to this chapter may, within fourteen days of the issuance of such penalty, order, directive, or determination request a hearing before the Director to show cause why such should be modified or made to not apply to such person. Such request shall be in writing and addressed to the Director of Public Works at 455 North Main Street, Wichita, Kansas, 67202. The Director or his designee shall hold the requested hearing as soon as practical after receiving the request, at which time the person affected shall have an opportunity to be heard. At the conclusion of the hearing, the Director shall issue a written response to the person requesting the hearing affirming, modifying, or rescinding the penalty, order, directive, or determination issued or made.

2. Any party aggrieved by the decision of the Director may appeal such decision to the City Council within fourteen days of receipt of the decision by filing notice of appeal with the city clerk. Upon hearing, the City Council may affirm, modify, or reverse the decision of the Director.

**Sec. 16.32.130. Enforcement personnel authorized.**

A. The following personnel employed by the city shall have the power to issue notices of violations, criminal citations and implement other enforcement actions under this chapter:

1. All deputies under the supervision of the superintendent of the office of central inspections;
2. All authorized personnel under the supervision of the director of public works;
3. All authorized personnel under the supervision of the City Health Officer.

(Ord. No. 44-123 § 13)

**Sec. 16.32.140. Other legal actions.**

Notwithstanding any other remedies or procedures available to the city, if any person discharges into the MS4 in a manner that is contrary to the provisions of this chapter, or any NPDES permit or order issued hereunder, the city attorney may commence an action for appropriate legal and equitable relief including damages and costs in the district court of Sedgwick County. The city attorney may seek a preliminary or permanent injunction or both which restrains or compels the activities on the part of the discharger.

(Ord. No. 44-123 § 14)

**Sec. 16.32.150. Falsifying information.**

Falsifying information is a separate offense and deemed a misdemeanor. Any person who knowingly makes false statements, representation or certification in any application, record, report, plan or other document filed or required to be maintained pursuant to this chapter or any NPDES permit, or who falsifies, or tampers with any monitoring device or method required under this chapter shall, upon conviction, be punished by a fine or not more than one thousand dollars or by imprisonment for not than six months, or by both.

(Ord. No. 44-123 § 15)

**Sec. 16.32.160. Supplemental enforcement actions.**

A. Performance Bonds. Where necessary for the reasonable implementation of this chapter, the director may, by written notice, order any owner of a source of stormwater discharge associated with construction or industrial activity effected by this chapter to file a satisfactory bond, payable to the city, in a sum not to exceed a value determined by the director to be necessary to achieve consistent compliance with this chapter. The city may deny approval of any building permit, grading permit, subdivision plat, site development plan, or any other city permit or approval necessary to commence or continue construction or industrial activity at the site, or to assume occupancy, until such a performance bond has been filed.

B. Liability Insurance. Where necessary for the reasonable implementation of this chapter, the director may, by written notice, order any owner of a source of stormwater discharge associated with construction or industrial activity effected by this chapter to submit proof that it has obtained liability insurance, or other financial assurance, in an amount not to exceed a value reasonably determined by the director, that is sufficient to remediate, restore, and abate any damage to the MS4, the waters of the United States, or any other aspect of the environment that is caused by the discharge.

(Ord. No. 44-123 § 16)

**Sec. 16.32.170. Severability.**

If any provision of this chapter is invalidated by any court of competent jurisdiction, the remaining provisions shall not be affected and shall remain in full force and effect.

(Ord. No. 44-123 § 17)

# APPENDIX B

City of Wichita Floodplain Ordinance – Chapter 27.06

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# CHAPTER 27.06. FLOODPLAIN MANAGEMENT

## Sec. 27.06.010. Statement of purpose.

It is the purpose of this chapter to promote the public health, safety, and general welfare; to minimize those losses described in Article 1, Section B(1); to establish or maintain the community's eligibility for participation in the National Flood Insurance Program (NFIP) as defined in 44 Code of Federal Regulations (CFR) 59.22(a)(3); and to meet the requirements of 44 CFR 60.3(d) and K.A.R. 5-44-4 by applying the provisions of this chapter to:

1. Restrict or prohibit uses that are dangerous to health, safety, or property in times of flooding or cause undue increases in flood heights or velocities;

2. Require uses vulnerable to floods, including public facilities that serve such uses, be provided with flood protection at the time of initial construction; and

3. Protect individuals from buying lands that are unsuitable for the intended development purposes due to the flood hazard.

(Ord. No. 47-346, § 1, 2-13-07)

## Sec. 27.06.020. Definitions.

Unless specifically defined below, words or phrases used in this chapter shall be interpreted so as to give them the same meaning they have in common usage and to give this chapter its most reasonable application.

"100-year Flood." See "base flood."

"Accessory structure" means the same as "appurtenant structure."

"Actuarial rates." See "risk premium rates."

"Administrator" means the Federal Insurance Administrator.

"Agency" means the Federal Emergency Management Agency (FEMA).

"Appeal" means a request for review of the Floodplain Administrator's interpretation of any provision of this chapter or a request for a variance.

"Appurtenant structure" means a structure that is on the same parcel of property as the principle structure to be insured and the use of which is incidental to the use of the principal structure.

"Area of shallow flooding" means a designated AO or AH zone on a community's Flood Insurance Rate Map (FIRM) with a one percent or greater annual chance of flooding to an average depth of one (1) to three (3) feet where a clearly defined channel does not exist, where the path of flooding is unpredictable and where velocity flow may be evident. Such flooding is characterized by ponding or sheet flow.

"Area of special flood hazard" is the land in the floodplain within a community subject to a one percent or greater chance of flooding in any given year.

"Base flood" means the flood having a one percent chance of being equaled or exceeded in any given year.

"Basement" means any area of the structure having its floor subgrade (below ground level) on all sides.

“Building.” See structure.”

"Chief Engineer" means the Chief Engineer of the Division of Water Resources, Kansas Department of Agriculture.

"Chief Executive Officer" or "Chief Elected Official" means the official of the community who is charged with the authority to implement and administer laws, ordinances, and regulations for that community.

"Community" means any State or area or political subdivision thereof, which has authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

"Development" means any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, levees, levee systems, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of equipment or materials.

"Elevated building" means for insurance purposes, a non-basement building which has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns.

"Eligible community" or "participating community" means a community for which the Administrator has authorized the sale of flood insurance under the National Flood Insurance Program (NFIP).

"Existing Construction" means for the purposes of determining rates, structures for which the "start of construction" commenced before the effective date of the FIRM or before January 1, 1975, for FIRMs effective before that date. "Existing construction" may also be referred to as "existing structures."

"Existing manufactured home park or subdivision" means a manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed before the effective date of the floodplain management regulations adopted by a community.

"Expansion to an existing manufactured home park or subdivision" means the preparation of additional sites by the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads).

"Flood" or "flooding" means a general and temporary condition of partial or complete inundation of normally dry land areas from: (1) the overflow of inland waters; (2) the unusual and rapid accumulation or runoff of surface waters from any source; and (3) the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood, or by some similarly unusual and unforeseeable event which results in flooding as defined above in item (1).

"Flood elevation determination" means a determination by the Administrator of the water surface elevations of the base flood, that is, the flood level that has a one percent or greater chance of occurrence in any given year.

"Flood Elevation Study" means an examination, evaluation and determination of flood hazards.

"Flood fringe" means the area outside the floodway encroachment lines, but still subject to inundation by the regulatory flood.

"Flood Insurance Rate Map (FIRM)" means an official map of a community, on which the Administrator has delineated both the special flood hazard areas and the risk premium zones applicable to the community.

“Flood Insurance Study (FIS)" means an examination, evaluation and determination of flood hazards and, if appropriate, corresponding water surface elevations.

"Floodplain" or "flood-prone area" means any land area susceptible to being inundated by water from any source (see "flooding").

“Floodplain management" means the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, and floodplain management regulations.

"Floodplain management regulations" means zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain and grading ordinances) and other applications of police power. The term describes such state or local regulations, in any combination thereof, that provide standards for the purpose of flood damage prevention and reduction.

"Floodproofing" means any combination of structural and nonstructural additions, changes, or adjustments to structures that reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, or structures and their contents.

"Floodway" or "regulatory floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

"Floodway encroachment lines" means the lines marking the limits of floodways on Federal, State and local floodplain maps.

"Freeboard" means a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as bridge openings and the hydrological effect of urbanization of the watershed.

"Functionally dependent use" means a use that cannot perform its intended purpose unless it is located or carried out in close proximity to water. This term includes only docking facilities and facilities that are necessary for the loading and unloading of cargo or passengers, but does not include long-term storage or related manufacturing facilities.

"Highest adjacent grade" means the highest natural elevation of the ground surface prior to construction next to the proposed walls of a structure.

"Historic structure" means any structure that is (a) listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register; (b) certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district; (c) individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or (d) individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either (1) by an approved state program as determined by the Secretary of the Interior or (2) directly by the Secretary of the Interior in states without approved programs.

"Lowest floor" means the lowest floor of the lowest enclosed area, including basement. An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage, in an area other than a basement area, is not considered a building's lowest floor, provided that such enclosure is not built so as to render the structure in violation of the applicable floodproofing design requirements of this ordinance.

"Manufactured home" means a structure, transportable in one or more sections, that is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle."

"Manufactured home park or subdivision" means a parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.

"Map" means the Flood Hazard Boundary Map (FHBM), Flood Insurance Rate Map (FIRM), or the Flood Boundary and Floodway Map (FBFM) for a community issued by the Federal Emergency Management Agency (FEMA).

"Market value" or "fair market value" means an estimate of what is fair, economic, just and equitable value under normal local market conditions.

"Mean sea level" means, for purposes of the National Flood Insurance Program (NFIP), the National Geodetic Vertical Datum (NGVD) of 1929 or other datum, to which base flood elevations shown on a community's Flood Insurance Rate Map (FIRM) are referenced.

"New construction" means, for the purposes of determining insurance rates, structures for which the "start of construction" commenced on or after the effective date of an initial FIRM or after December 31, 1974, whichever is later, and includes any subsequent improvements to such structures. For floodplain management purposes, "new construction" means structures for which the "start of construction" commenced on or after the effective date of the floodplain management regulations adopted by a community and includes any subsequent improvements to such structures.

"New manufactured home park or subdivision" means a manufactured home park or subdivision for which the construction of facilities for servicing the lot on which the manufactured homes are to be affixed (including at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed on or after the effective date of floodplain management regulations adopted by the community.

"(NFIP)" means the National Flood Insurance Program (NFIP).

"Participating community" also known as an "eligible community," means a community in which the Administrator has authorized the sale of flood insurance.

"Permit" means a signed document from a designated community official authorizing development in a floodplain, including all necessary supporting documentation such as: (1) the site plan; (2) an elevation certificate; and (3) any other necessary or applicable approvals or authorizations from local, state or federal authorities.

"Person" includes any individual or group of individuals, corporation, partnership, association, or any other entity, including Federal, State, and local governments and agencies.

"Principally above ground" means that at least 51 percent of the actual cash value of the structure, less land value, is above ground.

"Reasonably safe from flooding" means base flood waters will not inundate the land or damage structures to be removed from the SFHA and that any subsurface waters related to the base flood will not damage existing or proposed buildings.

"Recreational vehicle" means a vehicle which is (a) built on a single chassis; (b) 400 square feet or less when measured at the largest horizontal projections; (c) designed to be self-propelled or permanently able to be towed by a light-duty truck; and (d) designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use.

"Remedy a violation" means to bring the structure or other development into compliance with Federal, State, or local floodplain management regulations; or, if this is not possible, to reduce the impacts of its noncompliance.

"Risk premium rates" means those rates established by the Administrator pursuant to individual community studies and investigations, which are undertaken to provide flood insurance in accordance with Section 1307 of the National Flood Disaster Protection Act of 1973 and the accepted actuarial principles. "Risk premium rates" include provisions for operating costs and allowances.

"Special flood hazard area." See "area of special flood hazard."

"Special hazard area" means an area having special flood hazards and shown on an FHBM, FIRM or FBFM as zones (unnumbered or numbered) A, AO, AE, or AH.

"Start of construction" includes substantial improvements, and means the date the building permit was issued, provided the actual start of construction, repair, reconstruction, rehabilitation, addition placement, or other improvements were within 180 days of the permit date. The "actual start" means either the first placement of permanent construction of a structure on a site, such as the pouring of slabs or footings, the installation of piles, the construction of columns, any work beyond the stage of excavation, or the placement of a manufactured home on a foundation. Permanent construction does not include land preparation, such as clearing, grading and filling, the installation of streets and/or walkways, excavation for a basement, footings, piers, foundations, the erection of temporary forms, nor installation on the property of accessory structures, such as garages or sheds not occupied as dwelling units or not part of the main structure. For a substantial improvements, the "actual start of construction" means the first alteration of any wall, ceiling, floor, or other structural part of a building, whether or not that alteration affects the external dimensions of the building.

"State coordinating agency" means the Division of Water Resources, Kansas Department of Agriculture, or other office designated by the governor of the state or by state statute at the request of the Administrator to assist in the implementation of the National Flood Insurance Program (NFIP) in that state.

"Structure" means, for floodplain management purposes, a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home. "Structure" for insurance purposes, means a walled and roofed building, other than a gas or liquid storage tank that is principally above ground and affixed to a permanent site, as well as a manufactured home on a permanent foundation. For the latter purpose, the term includes a building while in the course of construction, alteration or repair, but does not include building materials or supplies intended for use in such construction, alteration or repair, unless such materials or supplies are within an enclosed building on the premises.

"Substantial damage" means damage of any origin sustained by a structure whereby the cost of restoring the structure to pre-damaged condition would equal or exceed fifty (50) percent of the market value of the structure before the damage occurred.

"Substantial improvement" means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before "start of construction" of the improvement. This term includes structures, which have incurred "substantial-damage," regardless of the actual repair work performed. The term does not, however, include either (1) any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications that have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions, or (2) any alteration of a "historic structure," provided that the alteration will not preclude the structure's continued designation as a "historic structure."

"Variance" means a grant of relief by the community from the terms of a floodplain management regulation. Flood insurance requirements remain in place for any varied use or structure and cannot be varied by the community.

"Violation" means the failure of a structure or other development to be fully compliant with the community's floodplain management regulations. A structure or other development without the elevation certificate, other certifications, or other evidence of compliance required by this chapter is presumed to be in violation until such time as that documentation is provided.

"Water surface elevation" means the height, in relation to the National Geodetic Vertical Datum (NGVD) of 1929 (or other datum where specified) of floods of various magnitudes and frequencies in the floodplain.

(Ord. No. 47-346, § 2, 2-13-07)

### Sec. 27.06.030. Applicability.

This chapter shall apply to all lands within the City of Wichita identified as numbered and unnumbered A Zones, AE, AO, and AH Zones, on the Index Map dated February 2, 2007 of the Flood Insurance Rate Map (FIRM) as amended, and any future revisions thereto. In all areas covered by this ordinance, no development shall be permitted except through the issuance of a floodplain development permit, granted by the City Council or its duly designated representative under such safeguards and restrictions as the City Council or the designated representative may reasonably impose for the promotion and maintenance of the general welfare, health of the inhabitants of the community, and as specifically noted in Article 4.

(Ord. No. 47-346, § 3, 2-13-07)

### Sec. 27.06.040. Compliance.

No development located within the special flood hazard areas of this community shall be located, extended, converted, or structurally altered without full compliance with the terms of this chapter and other applicable regulations.

(Ord. No. 47-346, § 4, 2-13-07)

### Sec. 27.06.050. Abrogation and greater restrictions.

It is not intended by this ordinance to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this chapter imposes greater restrictions, the provisions of this chapter shall prevail. All other ordinances inconsistent with this chapter are hereby repealed to the extent of the inconsistency only.

(Ord. No. 47-346, § 5, 2-13-07)

### Sec. 27.06.060. Interpretation.

In their interpretation and application, the provisions of this ordinance shall be held to be minimum requirements, shall be liberally construed in favor of the governing body, and shall not be deemed a limitation or repeal of any other powers granted by Kansas statutes.

(Ord. No. 47-346, § 6, 2-13-07)

### Sec. 27.06.070. Warning and disclaimer of liability.

The degree of flood protection required by this chapter is considered reasonable for regulatory purposes and is based on engineering and scientific methods of study. Larger floods may occur on rare occasions or the flood heights may be increased by man-made or natural causes, such as ice jams and bridge openings restricted by debris. This chapter does not imply that areas outside the floodway and flood fringe or land uses permitted within such areas will be free from flooding or flood damage. This chapter shall not create a liability on the part of the City of Wichita, any officer or employee thereof, for any flood damages that may result from reliance on this chapter or any administrative decision lawfully made there under.

(Ord. No. 47-346, § 7, 2-13-07)

## Sec. 27.06.080. Designation of floodplain administrator; duties and responsibilities.

(a) The Superintendent of the Office of Central Inspection is hereby appointed to administer and implement the provisions of this ordinance.

(b) Duties of the Floodplain Administrator shall include, but not be limited to:

(1) Review of all applications for floodplain development permits to assure that sites are reasonably safe from flooding and that the floodplain development permit requirements of this ordinance have been satisfied;

(2) Review of all applicaions for floodplain development permits for proposed development to assure that all necessary permits have been obtained from Federal, State, or local governmental agencies from which prior approval is required by Federal, State, or local law;

(3) Review all subdivision proposals and other proposed new development, including manufactured home parks or subdivisions, to determine whether such proposals will be reasonably safe from flooding;

(4) Issue floodplain development permits for all approved applications;

(5) Notify adjacent communities and the Division of Water Resources, Kansas Department of Agriculture, prior to any alteration or relocation of a watercourse, and submit evidence of such notification to the Federal Emergency Management Agency (FEMA);

(6) Assure that the flood-carrying capacity is not diminished and shall be maintained within the altered or relocated portion of any watercourse; and

(7) Verify and maintain a record of the actual elevation (in relation to mean sea level) of the lowest floor, including basement, of all new or substantially improved structures;

(8) Verify and maintain a record of the actual elevation (in relation to mean sea level) that the new or substantially improved non-residential structures have been floodproofed;

(9) When floodproofing techniques are utilized for a particular non-residential structure, the floodplain administrator shall require certification from a registered professional engineer or architect;

(10) Where interpretation is needed as to the exact location of the boundaries of the areas of special flood hazards (for example, where there appears to be a conflict between a mapped boundary and actual field conditions), the city engineer shall make the necessary interpretation.

(Ord. No. 47-346, § 8, 2-13-07)

## Sec. 27.06.090. Floodplain development permit.

A floodplain development permit shall be required for all proposed construction or other development, including the placement of manufactured homes, in the areas described in section 27.06.030. No person, firm, corporation, or unit of government shall initiate any development or substantial improvements or cause the same to be done without first obtaining a separate floodplain development permit for each structure or other development.

(Ord. No. 47-346, § 9, 2-13-07)

### Sec. 27.06.100. Application for floodplain development permit.

To obtain a floodplain development permit, the applicant shall first file an application in writing on a form furnished for that purpose. Every floodplain development permit application shall:

1. Describe the land on which the proposed work is to be done by lot, block and tract, house and street address, or similar description that will readily identify and specifically locate the proposed structure or work;

2. Identify and describe the work to be covered by the floodplain development permit;

3. Indicate the use or occupancy for which the proposed work is intended;

4. Indicate the assessed value of the structure and the fair market value of the improvement;

5. Specify whether development is located in designated flood fringe or floodway

6. Identify the existing base flood elevation and the elevation of the proposed development;

7. Give such other information as reasonably may be required by the floodplain administrator;

8. Be accompanied by plans and specifications for proposed construction; and

9. Be signed by the permittee or his authorized agent who may be required to submit evidence to indicate such authority.

(Ord. No. 47-346, § 10, 2-13-07)

### Sec. 27.06.110. Recording of minimum pad elevation information.

For every development permit issued hereunder, the Administrator shall cause an affidavit to be filed and recorded with the register of deeds of Sedgwick County, Kansas, which affidavit shall contain the following information:

1. The legal description of the subject land;

2. Elevation in relation to mean sea level of the lowest floor (including basement) of all structures;

3. Elevation in relation to mean sea level to which any nonresidential structure is to be floodproofed; and

4. The name or names of the record owners of the subject land.

The cost of recording of such affidavit shall be at the expense of the applicant for the development permit.

(Ord. No. 47-346, § 11, 2-13-07)

### Sec. 27.06.120. General standards.

(a) No permit for floodplain development shall be granted for new construction, substantial improvement, and other improvements, including the placement of manufactured homes, within any numbered or unnumbered A zones, AE, AO, and AH zones, unless the conditions of this section are satisfied.

(b) All areas identified as unnumbered A zones on the FIRM are subject to inundation of the 100-year flood; however, the base flood elevation is not provided. Development within unnumbered A zones is subject to all provisions of this ordinance. If Flood Insurance Study data is not available, the community shall obtain, review, and reasonably utilize any base flood elevation or floodway data currently available from Federal, State, or other sources.

(c) Until a floodway is designated, no new construction, substantial improvement, or other development, including fill, shall be permitted within any unnumbered or numbered A zones, or AE zones on the FIRM, unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.

(d) All new construction, subdivision proposals, substantial improvement, prefabricated structures, placement of manufactured homes, and other developments shall require:

(i) Design or adequate anchorage to prevent floatation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy;

(ii) Construction with materials resistant to flood damage;

(iii) Utilization of methods and practices that minimize flood damages;

(iv) All electrical, heating, ventilation, plumbing, air-conditioning equipment, and other service facilities be designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding;

(v) New or replacement water supply systems and/or sanitary sewage systems be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters, and on-site waste disposal systems be located so as to avoid impairment or contamination; and

(vi) Subdivision proposals and other proposed new development, including manufactured home parks or subdivisions, located within special flood hazard areas are required to assure that:

(aa) All such proposals are consistent with the need to minimize flood damage;

(bb) All public utilties and facilities, such as sewer, gas electrical, and water systems are located and constructed to minimize or eliminate flood damage;

(cc) Adequate drainage is provided so as to reduce exposure to flood hazards; and

(dd) Alll proposals for development, including proposals for manufactured home parks and subdivisions, of five (5) acres or fifty (50) lots, whichever is lesser, include within such proposals base flood elevation data.

(Ord. No. 47-346, § 12, 2-13-07)

## Sec. 27.06.130. Storage of material and equipment.

The storage or processing of materials within the special flood hazard area that are in time of flooding buoyant, flammable, explosive, or could be injurious to human, animal, or plant life is prohibited. Storage of other material or equipment may be allowed if not subject to major damage by floods, if firmly anchored to prevent flotation, or if readily removable from the area within the time available after a flood warning.

(Ord. No. 47-346, § 13, 2-13-07)

## Sec. 27.06.140. Nonconforming uses.

A structure, or the use of a structure or premises that was lawful before the passage or amendment of the ordinance, but which is not in conformity with the provisions of this chapter, may be continued subject to the following conditions:

1. If such structure, use, or utility service is discontinued for twenty-four (24) consecutive months, any future use of the building shall conform to this ordinance.

2. If any nonconforming use or structure is destroyed by any means, including flood, it shall not be reconstructed if the cost is more than fifty (50) percent of the pre-damaged market value of the structure. This limitation does not include the cost of any alteration to comply with existing state or local health, sanitary, building, safety codes, regulations or the cost of any alteration of a structure listed on the National Register of Historic Places, the State Inventory of Historic Places, or local inventory of historic places upon determination.

3. Uses or adjuncts thereof which are or become nuisances shall not be entitled to continue as nonconforming uses."

(Ord. No. 47-346, § 14, 2-13-07)

## Sec. 27.06.150. Specific standards.

In all areas identified as numbered and unnumbered A zones, AE, and AH zones, where base flood elevation data have been provided, as set forth in Article 4, Section A(2), the following provisions are required:

(a) New construction or substantial improvements of any residential structures, including manufactured homes, shall have the lowest floor, including basement, elevated a minimum of two (2) feet above base flood elevation. The elevation of the lowest floor shall be certified by a licensed land surveyor.

(b) New construction or substantial improvements of any commercial, industrial, or other non-residential structures, including manufactured homes, shall have the lowest floor, including basement, elevated a minimum of two (2) feet above the base flood elevation or, together with attendant utility and sanitary facilities, be floodproofed so that below the base flood elevation the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. A registered professional engineer or architect shall certify that the standards of this subsection are satisfied. The elevation of the lowest floor shall be certified by a licensed land surveyor. Such certification shall be provided to the floodplain administrator as set forth in section 27.06.080(b)(7,)(8), and (9).

(c) For all new construction and substantial improvement of fully enclosed areas below lowest floor which are used solely for parking of vehicles, building access, or storage in an area other than a basement and that are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of flood waters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria:

(1) A minimum of two (2) openings having a total net area of not less than one

(1) square inch for every square foot of enclosed area subject to flooding shall be provided; and

(2) The bottom of all opening shall be no higher than one (1) foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of flood waters."

(Ord. No. 47-346, § 15, 2-13-07)

## Sec. 27.06.160. Manufactured homes.

(a) All manufactured homes to be placed within all unnumbered and numbered A zones, AE, and AH zones, on the community's FIRM shall be required to be installed using methods and practices that minimize flood damage. For the purposes of this requirement, manufactured homes must be elevated and anchored to resist flotation, collapse, or lateral movement. Methods of anchoring may include, but are not limited to, use of over-the-top or frame ties to ground anchors

(b) All manufactured homes that are placed or substantially improved within unnumbered or numbered A zones, AE, and AH zones, on the community's FIRM on sites (1) outside of a manufactured home park or subdivision; (2) in a new manufactured home park or subdivision; (3) in an expansion to and existing manufactured home park or subdivision; or (4) in an existing manufactured home park or subdivision in which a manufactured home has incurred substantial damage as the result of a flood, shall be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated a minimum of two (2) feet above the base flood elevation and be securely attached to an adequately anchored foundation system to resist flotation, collapse, and lateral movement. The elevation of the lowest floor shall be certified by a licensed land surveyor.

(c) All manufactured homes that are placed or substantially improved on sites in an existing manufactured home park or subdivision within all unnumbered and numbered A zones, AE and AH zones, on the community's FIRM that are not subject to the provisions of subparagraph (b) herein shall be elevated so that either:

(1) The lowest floor of the manufactured home is a minimum of two (2) feet above the base flood level; or

(2) The chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than thirty-six (36) inches in height above grade and that are securely attached to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

The elevation of the lowest floor shall be certified by a licensed land surveyor.

(Ord. No. 47-346, § 16, 2-13-07)

## Sec. 27.06.170. Areas of shallow flooding (AO and AH zones).

Located within the areas of special flood hazard as described herein are areas designated as AO zones and AH zones. These areas have special flood hazards associated with base flood depths of one (1) to three (3) feet where a clearly defined channel does not exist and where the path of flooding is unpredictable and indeterminate. The following provisions apply:

(a) *In AO Zones.*

(1) All new construction and substantial improvements of residential structures,

including manufactured homes, shall have the lowest floor, inducing basement, elevated above the highest adjacent grade at least two (2) feet above the depth number specified in feet on the community's FIRM (at least three (3) feet if no depth number is specified).

(2) All new construction and substantial improvements of any commercial, industrial, or other non-residential structures, including manufactured homes, shall have the lowest floor, including basement, elevated above the highest adjacent grade at least as high as two (2) feet above the depth number specified in feet on the community FIRM (at least three (3) feet if no depth number is specified) or together with attendant utilities and sanitary facilities be completely floodproofed to that so that the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

(3) Adequate drainage paths shall be required around structures on slopes, in order to guide floodwaters around and away from proposed structures.

(b) *In AH Zones.*

(1) The specific standards for all areas of special flood hazard where base flood elevation has been provided shall be required as set forth in section 27.06.150.

(2) Adequate drainage paths shall be required around structures on slopes, in order to guide floodwaters around and away from proposed structures."

(Ord. No. 47-346, § 17, 2-13-07)

## Sec. 27.06.180. Floodway.

Located within areas of special flood hazard as defined herein are areas designated as floodways. Since the floodway is an extremely hazardous area due to the velocity of floodwaters that carry debris and potential projectiles, the following provisions shall apply:

(a) The community shall select and adopt a regulatory floodway based on the principle that the areas chosen for the regulatory floodway must be designed to carry the waters of the base flood without increasing the water surface elevation of that flood more than one (1) foot at any point.

(b) The community shall prohibit any encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge.

(c) All new construction and substantial improvements shall comply with all applicable flood hazard reduction provisions contained herein.

(d) In unnumbered A zones, the community shall obtain, review, and reasonably utilize any base flood elevation or floodway data currently available from Federal, State, or other sources as set forth herein".

(Ord. No. 47-346, § 18, 2-13-07)

## Sec. 27.06.190. Recreational vehicles.

Recreational vehicles placed on sites within all unnumbered and numbered A Zones, AE, AH, and AO Zones on the FIRM shall either:

(1) Be on the site for fewer than 180 consecutive days, or

(2) Be fully licensed and ready for highway use; or

(3) Meet the permitting, elevation, and anchoring requirements for manufactured homes as set forth herein.

A recreational vehicle is ready for highway use if it is on its wheels or jacking system, is attached to the site only by quick-disconnect type utilities and security devices, and has no permanently attached additions.

(Ord. No. 47-346, § 19, 2-13-07)

## Sec. 27.06.200. Variance procedures.

(a) The Floodplain Administrator shall hear and decide appeals and requests for variances from the floodplain management requirements of this ordinance. Applications for variance shall be in writing and on forms provided by the Administrator. A nonrefundable processing fee of one hundred dollars shall be paid to the Administrator at the time of the filing of a request for variance.

(b) The subdivision committee of the Metropolitan Area Planning Commission, the first Appeal Board shall hear appeals from any decision or determination made by the Administrator in the enforcement or administration of this chapter. Such appeals shall be in writing and shall specify the grounds for appeal. Such appeals shall be filed with the secretary of the Metropolitan Area Planning Commission within thirty days of the decision or determination appealed from. The secretary of the Metropolitan Area Planning Commission shall fix a reasonable time for the hearing of appeals, giving notice to the appealing party or parties at least fifteen days prior to such hearing. Appeals shall be decided within a reasonable time. At appeal hearings, any party may appear in person, by agent or by attorney. The subdivision committee may reverse or affirm, in whole or in part or modify the decision or determination appealed from and may make such order, requirement, decision or determination as may be appropriate under the circumstances.

(c) Any person aggrieved by the decision or determination of the subdivision committee may appeal such decision or determination to the Metropolitan Area Planning Commission, the second Appeal Board. The procedure for such appeals shall be as set forth above in subsection (a) for appeals from decisions by the Floodplain Administor.

(d) Any person aggrieved by the decision or determination of the Metropolitan Area Planning Commission may appeal such decision or determination to the city council, the third Appeal Board. The city council will review such decision or determination in the manner provided above for appeals from decisions by the Administrator, except that such appeals shall be filed with the city clerk and the notice to the appealing party or parties shall be provided at least five days prior to such hearing.

(e) In passing upon such applications for variances, the Administrator and Appeal Boards shall consider all technical data and evaluations, all relevant factors, standards specified in other sections of this ordinance, and the following criteria:

(1) Danger to life and property due to flood damage and erosion damage;

(2) Danger that materials may be swept onto other lands to the injury of others;

(3) Susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual owner;

(4) Importance of the services provided by the proposed facility to the community;

(5) Necessity of the facility of a waterfront location, where applicable;

(6) Availability of alternative locations, not subject to flood damage, for the proposed use;

(7) Compatibility of the proposed use with existing and anticipated development;

(8) Relationship of the proposed use to the comprehensive plan and floodplain management program for that area;

(9) Safety of access to the property in times of flood for ordinary and emergency vehicles;

(10) Expected heights, velocity, duration, rate of rise and sediment transport of the flood water, if applicable, expected at the site; and,

(11) Costs of providing governmental services during and after flood conditions, including maintenance and repair of public utilities and facilities such as sewer, gas, electrical, and water systems; streets; and bridges;

(f) Variances may be issued for new construction and substantial improvement to be erected on a lot of one-half acre or less in size contiguous to and surrounded by lots with existing structures constructed below the base flood level, providing items two (2) through six (6) below have been fully considered. As the lot size increases beyond the one-half acre, the technical justification required for issuing the variance increases.

Variances may be issued for the reconstruction, rehabilitation, or restoration of structures listed on the National Register of Historic Places, the State Inventory of Historic Places, or local inventory of historic places upon determination, provide the proposed activity will not preclude the structure's continued historic designation.

Variances shall not be issued within any designated floodway if any significant increase in flood discharge would result.

Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief.

Variances shall only be issued upon: (1) showing of good and sufficient cause, (2) determination that failure to grant the variance would result in exceptional hardship to the applicant, and (3) determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, cause fraud on or victimization of the public, or conflict with existing local laws or ordinances.

(Ord. No. 47-346, § 20, 2-13-07)

## Sec. 27.06.210. Penalties.

Violation of the provisions of this chapter or failure to comply with any of its requirements (including violations of conditions and safeguards established in connection with granting of variances) shall constitute a misdemeanor. Any person who violates this chapter or fails to comply with any of its requirements shall, upon conviction thereof, be fined not more than $500.00 for each such violation. Each day any such violation continues, shall be considered a separate offense. Nothing herein contained shall prevent the City of Wichita or other appropriate authority from taking such other lawful action as is necessary to prevent or remedy any violation of this chapter.

(Ord. No. 47-346, § 21, 2-13-07)

# APPENDIX C

Sedgwick County Stormwater Management Resolution – Resolution 196-10

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RESOLUTION 196-10

## SEDGWICK COUNTY STORM WATER MANAGEMENT CODE

**WHEREAS**, Sedgwick County is regulated under the Kansas Water Pollution Control General MS4 Permit (MS4 Permit) and Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES); and

**WHEREAS,** the MS4 Permit requires Sedgwick County to implement best management practices associated with the MS4 Permit's six minimum control measures; and

**WHEREAS,** the MS4 Permit requires Sedgwick County to implement best management practices to attenuate the discharge of each total maximum daily load regulated parameter identified in the MS4 Permit; and

**WHEREAS**, the conditions of the MS4 Permit broadly apply to activities, such as the permitting and inspections of development, the adoption and enforcement of relevant regulations, the detection and elimination of non-storm water discharges, the maintenance and operations of County facilities and other activities, that are conducted by Sedgwick County and which have been identified by the United States Environmental Protection Agency and the Kansas Department of Health and Environment as relevant to pollutants that may be discharged to the Sedgwick County Municipal Separate Storm Sewer System; and

**WHEREAS,** the Board of County Commissioners finds it necessary to adopt the Sedgwick County Storm Water Management Code in order to comply with the MS4 Permit.

**NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS OF SEDGWICK COUNTY, KANSAS, THAT THE SEDGWICK COUNTY STORM WATER MANAGEMENT CODE BE AND IS HEREBY ADOPTED.**

## SECTION I. THE SEDGWICK COUNTY STORMWATER MANAGEMENT CODE.

## ARTICLE I. IN GENERAL

### Sec. 1. Acronyms.

The following abbreviations, when used in this Code, shall have the designated meaning:

| | | |
|---|---|---|
| BMP | - | Best Management Practices |
| CFR | - | Code of Federal Regulations |
| CLOMR | - | Conditional Letter of Map Revision |
| EPA | - | U.S. Environmental Protection Agency |
| HHW | - | Hazardous Household Waste |
| ILC | - | Individual Lot Certification |

KAR - Kansas Administrative Regulations
KDHE - Kansas Department of Health and Environment
KSA - Kansas Statutes Annotated
KS-CGP - Kansas General Permit for Storm water Discharges from Construction Sites or Construction General Permit
LOMR - Letter of Map Revision
MS4 - Municipal Separate Storm Sewer System
NOI - Notice of Intent
NOTO - Notice of Transfer of Ownership
NOV - Notice of Violation
NPDES - National Pollutant Discharge Elimination
SWPPP - System Storm Water Pollution Prevention Plan
TMDL - Total Maximum Daily Load
USC - United States Code

**Sec. 2. Definitions.**

Unless otherwise expressly stated or unless the context clearly indicates a different intention, the following terms shall, for the purposes of this Code, have the meanings indicated in this section:

(1) As-built plan means a drawing showing the actual state of permanent storm water facilities as installed.

(2) Best management practices (BMPs) means schedules of activities, prohibitions of practices, general good house keeping practices, pollution prevention and educational practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to storm water, receiving waters, or storm water conveyance systems. BMPs also include treatment practices, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

(3) Clean Water Act means the federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.), and any subsequent amendments thereto.

(4) Commercial means pertaining to any business, trade, industry or other activity engaged in for profit.

(5) Construction activity means any construction practices or work including, but not limited to, clearing, grubbing, grading, and excavation which disturbs one (1.0) acre or more; or which is part of a larger common plan of development or sale which disturbs a cumulative total area of one (1.0) acre or more during the life of the project.

(6) Construction general permit (KS-CGP) refers to the Kansas General Permit for Storm water Discharges from Construction Sites.

(7) Construction related waste means waste that is generated through construction, land development and land-disturbing activities that may cause adverse impacts to water quality. Construction related waste includes, but is not limited to, discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site.

(8) Contractor means any person or firm performing construction work at a construction site, including any general contractor and subcontractors. Also includes, but is not limited to, earthwork, paving, building, plumbing, mechanical, electrical, landscaping contractors, and material suppliers delivering materials to the site.

(9) County means Sedgwick County, Kansas.

(10) Development means undisturbed property where improvements are planned or intended that will result in land disturbance activities or impervious areas either during or after construction.

(11) Director means the person appointed to the position of the Director of the Sedgwick County Department of Environmental Resources or his/her duly authorized representative.

(12) Discharge means any addition or introduction of any pollutant, storm water, or any other substance whatsoever into the municipal separate storm sewer system (MS4) or into waters of the United States.

(13) Discharger means any person who causes, allows, permits, or is otherwise responsible for a discharge, including without limitation any owner of a construction site or industrial facility.

(14) Drainage plan refers to the detailed water quantity and quality calculations and plan that are required for final plat approval or for issuance of a building permit.

(15) Earthwork means the disturbance of soils on a site associated with clearing, grading, or excavation activities.

(16) Facility means any building, structure, installation, process, or activity from which there is or may be discharge of a pollutant.

(17) Fertilizer means a substance or compound that contains an essential plant nutrient element in a form available to plants and is used primarily for its essential plant nutrient element content in promoting or stimulating growth of a plant of improving the quality of a crop, or a mixture of two or more fertilizers.

(18) Final stabilization means all soil disturbing activities at the site have been completed and a uniform perennial vegetative cover with a density of 70% of the cover which is typical for undisturbed areas, unpaved areas, or areas not covered by permanent structures, in the geographic location of the construction site, has been established, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

(19) Garbage means putrescible animal and vegetable waste materials from the handling, preparation, cooking, or consumption of food, including waste materials from markets, storage facilities, and the handling and sale of produce and other food products.

(20) Hazardous household waste (HHW) means any material generated in a household (including single and multiple residences) by a consumer which, except for the exclusion provided in 40 CFR Section 261.4(b)(1), would be classified as a hazardous waste under 40 CFR Part 261.

(21) Hazardous material means any substance identified or listed as a hazardous waste by the EPA pursuant to 40 CFR Part 261.

(22) Impervious area or impervious cover means the number of square feet of hard surface areas which either prevent or retard the entry of water into soil mantle, as it entered under natural conditions as undisturbed property, and/or causes water to run off the surface in greater quantities or at an increased rate of flow from that present under natural conditions as undisturbed property, including, but not limited to, roofs, roof extensions, patios, porches, driveways, sidewalks, pavement, athletic courts, and compacted dirt or graveled areas.

(23) Illegal discharge means any direct or indirect non-storm water discharge to the storm drain system, except as exempted in Article III of this Code.

(24) Illicit connection is defined as either of the following:

a. Any drain or conveyance, whether on the surface or subsurface, which allows an illegal discharge to enter the MS4 including but not limited to any conveyances which allow any non-storm water discharge including sewage, process wastewater, and wash water to enter the storm drain system and any connections to the storm drain system from indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by Sedgwick County; or,
b. any drain or conveyance connected from a commercial or industrial land use to the storm drain system which has not been documented in plans, maps, or equivalent records and approved in writing by Sedgwick County.

(25) Individual Lot Certification (ILC) means the Individual Lot Certification that is required by the KS-CGP to be completed when the permittee transfers ownership of a lot or a portion of the overall construction activity that is covered under the KS-CGP.

(26) Industrial activity: Activities subject to NPDES Industrial Permits as defined in 40 CFR, Section 122.26 (b) (14).

(27) Industry means and includes: (a) municipal landfills; (b) hazardous waste treatment, disposal, and recovery facilities; (c) industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42, U.S.C. Section 11023; industrial facilities required to obtain NPDES storm water discharge permits due to their Standard Industrial Classification or narrative description; and (d) industrial facilities that the director determines are contributing a substantial pollutant loading to the MS4, which are sources of storm water discharges associated with industrial activity.

(28) Kansas Construction General Permit (KS-CGP) means the Kansas Water Pollution Control General Permit and Authorization to Discharge Storm Water Runoff from Construction Activities under the National Pollutant Discharge Elimination System, State of Kansas General Permit No. S-MCST-0701-1.

(29) Kansas Industrial General Permit means the industrial general permit issued by KDHE and any subsequent modifications or amendments thereto, including group permits.

(30) Land disturbance means the disturbance of soils on a site associated with clearing, grading, excavation, new development or redevelopment activities.

(31) Municipal separate storm sewer system (MS4) (also storm water drainage system) means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that are owned or operated by Sedgwick County, Kansas which is designed or used for collecting or conveying stormwater.

(32) MS4 Permit means the Kansas Water Pollution Control General MS4 Permit and Authorization to Discharge Under the National Pollutant Discharge Elimination System, Kansas Permit No. M-AR94-SU01 and General Permit No. G-UA-0604-SO01.

(33) National Pollutant Discharge Elimination System (NPDES) means the national system for the issuance of permits under 42 USC Section 1342 and includes any state or interstate program which has been approved by the USEPA Director, in whole or in part, pursuant to 42 USC Section 1342.

(34) Non-storm water discharge means any discharge to the MS4 or to surface waters directly that is not composed entirely of storm water.

(35) Notice of Intent (NOI) means the notice of intent that is required by either the Kansas Industrial General Permit or the KS-CGP.

(36) Notice of Transfer of Ownership (NOTO) means the notice of transfer of ownership required by the KS-CGP.

(37) Notice of Violation (NOV) means a written notice provided by the Director to the owner or contractor detailing any violations of this Code and any corrective action expected of the violators.

(38) Oil means any kind of oil in any form, including, but not limited to: petroleum, fuel oil, crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure, sludge, oil refuse, and oil mixed with waste.

(39) Owner(s) or operator(s) means the party or parties that either individually or taken together meet the following two criteria: 1) they have operational control over the site specifications; 2) they have the day-to-day operational control of those activities at the construction site necessary to ensure compliance. For a typical commercial construction site, the owner or general contractor is herein defined to be the "owner or operator". For a typical residential development (subdivision), the owner or an authorized representative is herein defined to be the "owner or operator". Each owner or operator who individually does not engage in construction activity of greater than one (1.0) acre must apply when the construction activity is part of a larger common plan of development.

(40) Person or person(s) means any individual or group of individuals, association, organization, partnership, firm, corporation or other entity recognized by law and acting as either the owner or as the owner's agent.

(41) Pesticide means a substance or mixture of substances intended to prevent, destroy, repel, or migrate any pest, or substances intended for use as a plant regulator, defoliant, or desiccant.

(42) Petroleum product means a petroleum product that is obtained from distilling and processing crude oil and that is capable of being used as a fuel for the propulsion of a motor vehicle, or aircraft, including motor gasoline, gasohol, other alcohol blended fuels, aviation gasoline, kerosene, distillate fuel oil, and #1 and #2 diesel.

(43) Pollutant means anything which causes or contributes to pollution. Pollutants may include, but are not limited to dredged spoil, spoil waste, incinerator residue, sewage, sewage sludge, garbage, refuse, rubbish, litter, munitions, chemical waste, biological materials, radioactive materials, heat, wrecked or discarded equipment,

rock, sand, soil, yard waste, paints, varnishes, hazardous household wastes, used motor oil, anti-freeze, animal waste, floatables, pesticides, herbicides, fertilizers, and industrial, municipal, and agricultural waste discharged into water and/or any substance, debris, matter that may be carried downstream by storm water runoff, and/or any substance or matter that may be dissolved in storm water runoff.

(44) Pollution means the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property, or public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

(45) Premises means any building, lot, parcel of land, or portion of land whether improved or unimproved including adjacent sidewalks and parking strips.

(46) Qualified personnel means persons who possess the required certification, license, or appropriate competence, skills, and ability as demonstrated by sufficient education, training, and/or experience to perform a specific activity in a timely and complete manner consistent with the regulatory requirements and generally accepted industry standards for such activity.

(47) Redevelopment or redevelopment site means a change to previously existing improved property, including but not limited to the demolition or building of structures, filling, grading, paving, or excavating.

(48) Release means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the municipal separate storm sewer system (MS4) or the waters of the United States.

(49) Rubbish means nonputrescible solid waste, excluding ashes, that consist of: (a) combustible waste materials, including paper, rags, cartons, wood, excelsior, furniture, rubber, plastics, yard trimmings, leaves, and similar materials; and (b) noncombustible waste materials, including grass, crockery, tin cans, aluminum cans, metal furniture, and similar materials that do not burn at ordinary incinerator temperatures (one thousand six hundred to one thousand eight hundred degrees Fahrenheit).

(50) Sewage means the domestic sewage mid and/or industrial waste that is discharged into the city sanitary sewer system and passes through the sanitary sewer system to the city sewage treatment plant for treatment.

(51) Site means the land or water area where development or redevelopment is physically located or being conducted, including lands adjacent to the development that is not subject to land disturbing activities but that is used as a staging area or for other uses in connection with the new development or redevelopment.

(52) Storm water means storm water runoff induced by atmospheric precipitation, including snow melt runoff and surface runoff and drainage.

(53) Storm water drainage connection means any drain or conveyance, whether on the surface or subsurface, which was constructed or is intended to allow discharges of storm water runoff to enter the MS4 or to surface waters directly, regardless of whether said drain or conveyance had been previously allowed, permitted, or approved by Sedgwick County.

(54) Storm water drainage system. See the definition for municipal separate storm sewer system (MS4).

(55) Storm water management facility or storm water control facility means any structure or installation used to manage storm water quality, flow rate, or volume.

(56) Storm Water Manual refers to the latest version, as amended, of the document on file with the Director entitled *City of Wichita/Sedgwick County Storm Water Manual*.

(57) Storm Water Pollution Prevention Plan (SWPPP) means a document required by KDHE and/or Sedgwick County which describes and ensures the implementation of practices that are to be used to reduce the pollutants in storm water discharges associated with construction activity.

(58) Subdivision development means and includes activities associated with the platting of any parcel of land into two or more lots and includes all construction taking place thereon.

(59) Surface water (or surface waters) means all of the following:
(a) streams, including rivers, creeks, brooks, sloughs, draws, arroyos, canals, springs, seeps and cavern streams, and any alluvial aquifers associated with these surface waters; and,
(b) lakes, including oxbow lakes and other natural lakes and man-made reservoirs, lakes and ponds; and,
(c) wetlands, including water bodies meeting the technical definition for jurisdictional wetlands given in the "corps of engineers wetlands delineation manual," as published in January 1987; and,
(d) surface waters of the state means all surface waters occurring within the borders of the state of Kansas or forming a part of the border between Kansas and one of the adjoining states.

(60) Undisturbed property means real property which has not been altered from its natural condition so that the entrance of water into the soil mantle is prevented or retarded through changes to the topography or soils.

(61) United States Environmental Protection Agency (USEPA) means the United States Environmental Protection Agency, the regional office thereof, any federal department, agency or commission that may succeed to the authority of the EPA, and any duly authorized official of EPA or such successor agency.

(62) Water quality standard means the designation of a body or segment of surface water in the state for desirable uses and the narrative and numerical criteria deemed by the state to be necessary to protect those uses.

(63) Waters of the state (or water) means any groundwater, percolating or otherwise, lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, inside the territorial limits of the state, and all other bodies of surface water, natural or artificial, navigable or non-navigable, and including the beds and banks of all water courses and bodies of surface water, that are wholly or partially inside or bordering the state or inside the jurisdiction of the state.

(64) Waters of the United States means all waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and the flow of the tide; all interstate waters, including interstate wetlands; all other waters the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce; all impoundments of waters otherwise defined as waters of the United States under this definition; all tributaries of waters identified in this definition; all wetlands adjacent to waters identified in this definition; and any water within the federal definition of "waters of the United States" at 40 CFR Section 122.2; but not including any waste treatment systems, treatment ponds, or lagoons designed to meet the requirements of the Federal Clean Water Act.

(65) Watershed means the cumulative area that drains to a common point.

(66) Watershed plan means an engineering and planning study for the drainage system and/or land areas of a watershed that may include a plan for storm water management in the watershed. Watershed plans can include, but are not limited to, the analysis of flooding problems, water quality problems, potential storm water capital improvements, land use patterns, and regulatory issues for existing and potential future land use conditions and address solutions to these problems.

(67) Wetland means any area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

(68) Wastewater: means any water or other liquid, other than uncontaminated storm water, discharged from a facility.

(69) Yard waste means leaves, grass clippings, yard and garden debris, and brush that results from landscaping maintenance and land-clearing operations.

**Sec. 3. Findings of Fact.**

(a) The surface waters of Sedgwick County are subject to the discharge of pollutants, both through inappropriate non-storm water discharges into the MS4 or the surface waters directly, and through the wash off and transport of sediment, wastes, and other pollutants found on the land and built surfaces by storm water runoff occurring as a result of atmospheric precipitation events.

(b) Further, such discharge of pollutants may lead to increased risks of disease and harm to individuals, particularly children, who come into contact with the water; may degrade the quality of such water for human uses, such as drinking, irrigation, recreation, and industry; and may damage the natural ecosystems of rivers, streams, lakes and wetlands, leading to a decline in the diversity and abundance of plants and animals.

(c) Further, this Code will promote public awareness of the hazards involved in the improper discharge of trash, yard waste, lawn chemicals, pet waste, wastewater, oil, petroleum products, cleaning products, paint products, hazardous waste, sediment and other pollutants into the storm drainage system.

(d) Further, such discharges are inconsistent with the provisions and goals of the Clean Water Act, the United States Federal and State of Kansas NPDES programs, and other Federal and state requirements for water quality and environmental preservation.

(e) Further, a reasonable establishment of restrictions and regulations on activities within Sedgwick County is necessary to eliminate or minimize such discharges of pollutants, to protect the health and safety of citizens, to preserve economic and ecological value of existing water resources within the County and within downstream communities, and to comply with the provisions of the County's responsibilities under the Clean Water Act, the NPDES program and the Kansas MS4 Permit.

**Sec. 4. Purpose of Code.**

It is the purpose of this Code to promote the public health, safety, and general welfare and to minimize public and private losses due to the discharge of pollutants into the MS4 or the surface waters directly by provisions designed to:

(1) regulate the contribution of pollutants to the Sedgwick County MS4 or to the surface waters directly, as required by the Kansas MS4 Permit;

(2) establish methods for controlling the introduction of pollutants into the MS4 in order to comply with the requirements of the MS4 permit, including but not limited to:

   (1) prohibiting illegal connections and non-storm water discharges to the MS4 or to surface waters directly;
   (2) prohibiting the discharge of sediment and other construction related waste to the MS4 or to surface waters directly from construction activities;
   (3) facilitating compliance with county standards and permits by owners of developed, redeveloped and undeveloped properties within the unincorporated area;
   (4) regulating the design, construction and maintenance of best management practices that are implemented to reduce pollutants in storm water runoff from new developments and redevelopments; and,
   (5) establishing the legal authority to carry out the plan reviews, inspections, surveillance and monitoring procedures necessary to ensure compliance with this Code;

(3) minimize the potential for expenditure of public money for the costly clean-up of polluted surface waters; and,

(4) ensure that those who are responsible for non-storm water discharges into the Sedgwick County MS4 or into surface waters directly assume responsibility for their actions.

**Sec. 5. Applicability of Code.**

The provisions of this Code shall apply to all unincorporated areas of Sedgwick County, Kansas, except when and where otherwise stated in this Code.

**Sec. 6. Interpretation of Code.**

The provisions of this Code are not intended to repeal, abrogate, or impair any other code, chapter, rule, regulation or other provision of law. However, where the provisions of this Code conflict or overlap with such code, chapter, rule, regulation or other provision of law, whichever provision is more restrictive or imposes higher protective standards for human health or the environment shall control. In the interpretation and application of the provisions of this Code, all provisions shall be:

(1) considered as minimum requirements;
(2) liberally construed in favor of the governing body; and,
(3) deemed neither to limit or repeal any other powers granted under state statute.

**Sec. 7. Warning and disclaimer of liability.**

(a) The standards set forth herein and promulgated pursuant to this Code are minimum standards; therefore this Code does not intend nor imply that compliance by any person will ensure that there will be no contamination, pollution, nor unauthorized discharge of pollutants.

(b) The provisions of this Code shall not create liability on the part of Sedgwick County, or any officer or employee thereof, for any pollution that results from reliance on the provisions of this Code or any administrative decision lawfully made thereunder.

**Sec. 8. Injunctive relief.**

It shall be unlawful for any person to violate any provision or fail to comply with any of the requirements of this Code. If a person has violated or continues to violate the provisions of this Code, the Director may petition for a preliminary or permanent injunction, within a court of proper jurisdiction, restraining the person from activities which would create further violations or compelling the person to perform abatement or remediation of the violation.

**Sec. 9. Severability.**

The provisions of this Code are hereby declared to be severable. If any provision, clause, sentence, or paragraph of this Code or the application thereof to any person, establishment, or circumstances shall be held invalid, such invalidity shall not affect the other provisions or application of this Code.

**Sec. 10. Saving clause.**

All rights and remedies of Sedgwick County, and the property owners and residents thereof, are expressly saved as to any and all violations of the Sedgwick County Code, or any prior resolution that have accrued at the time of the effective resolution. Sedgwick County shall have all the powers that existed prior to the effective date of this resolution as to all such accrued violations.

**Secs. 11 to 29. Reserved.**

## ARTICLE II. ADMINISTRATION AND ENFORCEMENT

**Sec. 30. Designation and duties of the Director**

The Director of the Sedgwick County Department of Environmental Resources shall administer, implement, and enforce the provisions of this Code. Any powers granted or duties imposed upon the Director by this Code may be delegated by the Director to persons or entities acting in accordance with this Code and in the beneficial interest of or in the employ of Sedgwick County.

**Sec. 31. Compliance monitoring.**

(a) Right of entry. The Director shall have the right to enter the premises of any person discharging storm water to the MS4 or to surface waters directly at any reasonable time to determine if the discharger/discharge is in compliance with all requirements of this Code, and/or with any state or federal discharge permit, limitation or requirement. Dischargers shall allow the Director ready access to all parts of the premises for purposes of inspection, sampling, records examination and copying, and for the performance of any additional duties related to the determination, correction or elimination of the discharge in question.

(b) Records. Subject to the requirements of Section 31(a), dischargers shall make available upon request any SWPPPs and modifications thereto, permits, design and construction documents, self-inspection reports, monitoring records, compliance evaluations, notices of intent, and any other records, reports, and other documents related to compliance with this Code and with any other state or federal discharge permit.

(c) Sampling. The Director shall have the right to install and operate on the discharger's property such devices that are necessary to conduct sampling of storm water discharges.

**Sec. 32. Unlawful acts.**

The discharge of, or potential discharge of, any pollutant to the MS4 or waters of the United States; the failure to comply with the provisions of this Code; the failure to comply with any SWPPP or plan developed as required by this Code; or the failure to comply with any directive, citation, or order issued under this Code are violations of this Code for which notice of violations may be issued and enforcement action may be taken.

**Sec. 33. Notice of violation and order to comply.**

(a) Whenever the Director or his/her authorized designee under this Code has probable cause to believe that a person, owner, operator, firm or corporation is committing or has committed a violation of any provision of this Code, the Director or such authorized designee may first cause a notice of violation and order to comply to be served upon said person, owner, operator, firm or corporation responsible therefore. Such notice shall:

(1) be in writing;
(2) include a description of the real estate and/or street address sufficient for identification;
(3) specify the violation(s) that exists and the corrective action(s) required;
(4) allow a reasonable time for the performance of any act it requires to correct the said violation;
(5) state the amount of fines or penalties associated with each violation.

(b) Notice of violations shall be served upon the person(s) or owner(s) or operator(s) deemed responsible for such violations; provided that such notice shall be deemed to be properly served upon such person(s) or owner(s) or operator(s) if a copy thereof is delivered to him or her personally or if not found, by leaving a copy thereof at the place of business, residence, construction activity or property where the violation(s) occurred, or at his or her usual place of abode, with a person of suitable age and discretion who shall be informed of the contents thereof, or by sending a copy thereof by mail to his or her last known address, or if the envelope with the copy is returned showing it has not been delivered to him or her, by posting a copy thereof in a conspicuous place in or about the area of violation.

Such notice may require without limitation:

(1) the performance of monitoring, analyses, and reporting;
(2) the elimination of illegal discharges and/or illicit connections;
(3) the revision and/or resubmission and approval of development or construction plans, including but not limited to SWPPPs;
(4) that violating discharges, practices, or operations causing or the source of such discharges or potential discharges of pollutants shall cease and desist;
(5) the abatement or remediation of storm water pollution or contamination hazards and the restoration of any affected property; and,
(6) payment of any associated fine or penalty to cover administrative and remediation costs; and
(7) the implementation or redesign/repair of source control or treatment BMPs.

(c) Prosecution of violations. In case any notice of violation and order to correct is not promptly complied with, the Director may request the County Counselor to institute an appropriate action or proceeding against any person, owner, operator, firm and/or corporation responsible for the violation:

(1) Stop Work Order. To restrain, correct or remove the violation or to compel such person, owner, operator, firm or corporation to refrain from any further execution of work;
(2) Cease and Desist Order. To restrain from performing the activity(s) not in compliance with the provisions hereof, or in violation of a plan or specification under which an approval, permit or certificate was issued;
(3) Requirement for Corrective Action. To correct the construction, installation, alteration, removal, demolition, use or maintenance of best management practices and storm water management facilities;
(4) Withholding Certificate of Occupancy. To prevent from occupying or using the structure(s) or development(s) or any part thereof erected, constructed, installed or altered in violation of, or not in compliance with the provisions hereof, or in violation of a plan or specification under which an approval, permit or certificate was issued;
(5) Compliance Order. To comply with the plan(s) approved by the Director under this Code or any directive, citation, or order issued under this Code;
(6) Compliance Order. To comply with the provisions of this Code.
(7) Fines and Penalties. Additionally, or in the alternative, the Director may proceed with fines and penalties section hereof.

**Sec. 34. Violation penalties.**

(a) Whenever the Director or his/her authorized designee under this Code has probable cause to believe that a person, owner, operator, firm or corporation is committing or has committed a violation of any provision of this Code, the Director or such authorized designee may serve upon such accused person a uniform complaint and notice to appear, or in the alternative, may sign a complaint against the accused person and cause a notice to appear to be issued according to the provisions of KSA 19-1401, et seq., the Code for enforcement of County codes and resolutions. Pursuant to KSA 19-101d, prosecution for any such violation shall be conducted in the manner provided by law in the district court under the code for the enforcement of County codes and resolutions as provided by KSA 19-4701, et seq. Writs or processes necessary for the prosecution of such violations shall be substantially in the form of writs and process as shown in KSA 19-4738. The County shall provide all necessary supplies, forms and records at its own expense.

(b) If the violation has not been corrected pursuant to the requirements set forth in the notice of violation, or, in the event of an appeal, within three (3) days of the decision upholding the decision of the Director, then the Director shall enter upon the subject private property and is authorized to take any and all measures necessary to abate the violation and/or restore the property. It shall be unlawful for any person, owner, agent or person in possession of any premises to refuse to allow the Director or his/her designated contractor to enter upon the premises for the purposes set forth above.

(c) The owner of subject private property shall reimburse Sedgwick County for its direct and related expenses required to abate the violation and/or restore the property. Within 15 days after abatement of the violation, the owner of the property will be notified of the cost of abatement, including administrative costs. The property owner may file a written protest objecting to the amount of the assessment within 15 days. If the amount due is not paid within a timely manner as determined by the Director or by the expiration of the time in which to file an appeal, the charges shall become a special assessment against the property and shall constitute a lien on the property for the amount of the assessment. Any person violating any of the provisions of this section shall become liable to Sedgwick County by reason of such violation. The liability shall be paid in not more than twelve (12) equal payments. Interest at the rate of 10 percent (10%) per annum shall be assessed on the balance beginning on the 1st day following discovery of the violation.

**Sec. 35. Violations deemed a public nuisance.**

In addition to the enforcement processes and penalties provided, any condition caused or permitted to exist in violation of any of the provisions of this Code is a threat to public health, safety, and welfare, and is declared and deemed a nuisance, and may be summarily abated in accordance with Chapter 19 of the Sedgwick County Code.

**Sec. 36. Remedies not exclusive.**

The remedies listed in this Code are not exclusive of any other remedies available under any applicable federal, state or local law and it is within the discretion of the Director to seek cumulative remedies.

**Sec. 37. Procedures.**

Procedures for prosecution of violations of this Code shall be pursuant to Chapter 8 of the Sedgwick County Code, with the exception of Section 8-5.

**Sec. 38. Classification of violations and schedule of fines.**

The following schedule of fines for violations of this Code is established. Such fines are payable in accordance with K.S.A. 19-4716. The minimum fine for any violation shall be no less than two hundred and fifty dollars ($250) per day the violation for each day is maintained and not more than two thousand five hundred ($2,500) per day for each day the violation is maintained.

| | Convictions for Violations Which Occur Within 12-month period | | |
|---|---|---|---|
| Violation Description | First | Second | Third |
| Failure to obtain required NDPES permit from KDHE | $250 | $500 | $1000 |
| Failure to prepare or comply with a SWPPP | $250 | $500 | $1000 |
| Failure to maintain BMPs | $250 | $500 | $1000 |
| Illegal discharges or dumping | $250 | $1000 | $2500 |
| Failure to comply with an approved drainage plan | $250 | $1000 | $2500 |
| Failure to inspect storm water control facilities | $50 | $250 | $500 |
| Failure to maintain storm water control facilities | $250 | $500 | $1000 |
| All other violations | $250 | $500 | $1000 |

**Sec. 39. Separate offense.**

Each day that any violation of this Code occurs after the passage of the reasonable time for performance of any act required by a notice of violation(s) and order(s) to comply has been served in accordance with the terms and provisions hereof shall constitute a separate offense and shall be punishable as a separate violation. Provided, however, that if any person, owner, operator, firm or corporation is found guilty of a violation hereunder and it shall appear to the Court that the violation complained of as prescribed in this Code is continuing, then in addition to the penalty as set forth, the Court may enter such order as it deems appropriate to cause the violation to be abated.

**Sec. 40. Effect of plan approval.**

The approval of a SWPPP or any other plan or specification required under this Code shall not be deemed or construed to be a permit for, or an approval of, any violation of any of the provisions of the Sedgwick County Building Code or of this Code. No plan approval presuming to give authority to violate or cancel the provisions hereof shall be valid, except insofar as the work or use which it authorized is lawful. The approval of a SWPPP or any other plan or specification shall not prevent the Director from thereafter requiring the correction of errors in said plans and specifications or from preventing construction operations being carried on thereunder when in violation of this Code or of any other County code or resolution or from revoking any certificate of approval when issued in error.

**Sec. 41. Procedures for appeals from the requirements of this Code.**

(a) The Director shall hear and decide appeals from the requirements of this Code.

(b) The Storm Water Appeals Board shall hear appeals from any decision or determination made by the Director in the enforcement or administration of this Code. Such appeals shall be in writing and shall specify the grounds for appeal. Such appeals shall be filed with the Director within thirty (30) days of the decision or determination appealed from. The Director shall notify the Storm Water Appeals Board that an appeal has been filed. A nonrefundable processing fee of $300.00 shall be paid to the Department of Environmental Resources at the time of the filing of an appeal. The Storm Water Appeals Board shall fix a reasonable time for the appeals, giving notice to the appealing party or parties at least fifteen (15) days prior to such hearing. Appeals shall be decided within a reasonable time. At appeal hearings, any party may appear in person, by agent or by attorney. The Storm Water Appeals Board may reverse or affirm, in whole or in part, or modify the decision or determination appealed from and may make such order, requirement, decision or determination as may be appropriate under the circumstances;

(c) Any person aggrieved by the decision or determination of the Storm Water Appeals Board may appeal such decision or determination to the Board of County Commissioners. The Board of County Commissioners will review such decision or determination in the manner provided above for appeals from decisions by the Director; except that such appeals shall be filed with the County Clerk and the notice to the appealing party or parties shall be provided at least five (5) days prior to such hearings.

**Sec. 42. Construction Site Inspection Fees.**

Amount. Construction site inspection fees shall be assessed for construction and land disturbing activities that require submittal of a SWPPP in accordance with the provisions of this Code as set forth below. All fees provided for herein are for regulatory purposes, and shall be payable to the Sedgwick County Treasurer and deposited in and credited to the County general fund.

| Construction Activity Size | Fee<br>(Base Fee = $75) |
| --- | --- |

| | |
|---|---|
| 1 acre or less | Base Fee |
| Greater than 1 acre | Base Fee + $15 per acre |

**Secs. 43 to 49. Reserved.**

## ARTICLE III. GENERAL

**Sec. 50. Surface water protection.**

Every person owning property through which a surface water passes or is partially or fully located, or such person's lessee, shall keep and maintain that part of the surface water within the property free of trash, debris, excessive or obstructive vegetation (including fallen timber), and other obstacles that would pollute, contaminate, or significantly obstruct or retard the flow of water through the surface water. In addition, the owner or lessee shall maintain existing privately owned structures within or adjacent to surface water, so that such structures will not become a hazard to the use, function, or physical integrity of the surface water.

**Sec. 51. Existing eroding areas.**

(a) Upon written notification from the Director, the owner of a property which exhibits unstable, exposed or eroding soil conditions less than one (1) acre in size shall correct the problem within a thirty (30) calendar day period. This period may be extended upon request if conditions warrant.

(b) Minimum correction measures shall include soil stabilization and revegetation of all exposed soil surfaces and otherwise engaging in vegetative erosion prevention and sediment control BMPs. Before commencing corrective measures, the owner may consult with the Director to determine an acceptable method of correction.

(c) This section does not apply to:
(1) exposed soil caused by farming activities; and,
(2) minor land disturbing activities at individual locations, such as gardening, the installation of septic tanks, posts or poles, building or grounds maintenance and landscaping, are exempt from this provision, provided that the activity does not result in prolonged or permanent soil exposure and the exposed area is not equal to or greater than one (1) acre.

**Secs. 52 to 59. Reserved.**

## ARTICLE IV. ILLEGAL DISCHARGES

**Sec. 60. Discharge prohibitions.**

(a) No person shall dump, litter, discharge or cause to be discharged into the MS4 or surface waters directly any solid, liquid or other discharge that is not composed entirely of storm water, except as allowed in subsection (b). Discharges to the MS4 or surface waters that are not excepted in subsection (b) are in violation of this Code.

(b) The following non-storm water discharges are deemed acceptable and not a violation of this Code:

(1) water line flushing;
(2) diverted stream flow;
(3) rising groundwaters;
(4) uncontaminated groundwater infiltration as defined under 40 CFR 35.2005 (20) to separate storm sewers;
(5) uncontaminated pumped groundwater;
(6) contaminated groundwater if authorized by KDHE and approved by the County;
(7) discharges from potable water sources;
(8) foundation drains;
(9) air conditioning condensate;
(10) irrigation waters
(11) springs;
(12) water from crawl space pumps;
(13) footing drains;
(14) individual residential car washing;
(15) flows from riparian habitats and wetlands;
(16) de-chlorinated swimming pool discharges excluding filter backwash;
(17) street wash water (excluding street sweepings which have been removed from the street);
(18) discharges or flows from emergency fire fighting activities;
(19) heat pump discharge waters (residential only);
(20) treated wastewater meeting requirements of a NPDES permit;
(21) other discharges determined not to be a significant source of pollutants to waters of the United States, a public health hazard or a nuisance; and,
(22) discharges specified in writing by the Director as being necessary to protect public health and safety.

(c) The prohibition shall not apply to any non-storm water discharge permitted under an NPDES permit, waiver, or waste discharge order issued to the discharger and administered under the authority of the USEPA and/or KDHE, provided that the discharger is in full compliance with all requirements of the permit, waiver, or order and other applicable laws and regulations, and provided that written approval has been granted by the Director for any discharge to the storm drain system.

(d) The construction, use, maintenance or continued existence of illicit connections to the MS4 or to surface waters directly is prohibited. This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection. A person is considered to be in violation of this Code if the person connects a line conveying sewage to the MS4 or to surface waters directly, or allows such a connection to continue.

**Sec. 61. Illegal dumping.**

It shall be illegal for any person to intentionally dump liquids or solids that are hazardous material or are considered by KDHE to be TMDL regulated parameters in Sedgwick County on the ground where there is potential exposure to rain or storm water and potential for the pollutant to reach the MS4.

**Sec. 62. Suspension of MS4 Access.**

(a) Suspension due to Illicit Discharges in Emergency Situations. The Director may, without prior notice, suspend storm water drainage connection(s) to the MS4 or to surface waters directly to a person, owner or operator when such suspension is necessary to stop an actual or threatened discharge which presents or may present imminent and substantial danger to the environment, or to the health or welfare of persons, or to the MS4 or surface waters. If the discharger fails to comply with a suspension order issued in an emergency, the Director may take such steps as deemed necessary to prevent or minimize damage to the MS4 or Waters of the United States, or to minimize danger to persons.

(b) Suspension due to the Detection of Illicit Discharge. Any person, owner or operator discharging to the MS4 or to surface waters directly in violation of this Code may have their storm water drainage connection(s) to the MS4 or to surface waters terminated if such termination would abate or reduce an illegal discharge. The Director will notify the violator of the proposed termination of its MS4 access. The violator may petition Sedgwick County for a reconsideration and hearing. It is a violation of this Code to reinstate a storm water drainage connection(s) to the premises that has been terminated pursuant to this Article, without the prior approval of the Director.

**Sec. 63. Hazardous material discharges.**

(a) Any person(s), owner or operator responsible for any release of hazardous material that may leach, flow, enter or otherwise be introduced into the MS4 or to surface waters directly shall comply with all state, federal, and any other local law requiring reporting, clean-up, containment, and any other appropriate remedial action in response to the release.

(b) Notwithstanding other requirements of law, as soon as any person responsible for a facility or operation, or responsible for emergency response for a facility or operation has information of any known or suspected release of materials which are resulting or may result in illegal discharges or pollutants discharging into storm water, the MS4, or surface waters directly said person shall take all necessary steps to ensure the discovery, containment, and cleanup of such release.

(c) In the event of such a release of hazardous material said person shall immediately notify emergency response agencies of the occurrence via emergency dispatch services. In the event of a release of non-hazardous material, said person shall notify the Director in person or by phone or facsimile no later than the next business day. Notifications in person or by phone shall be confirmed by written notice addressed and mailed to the Director within three business days of the phone notice. If the discharge of prohibited materials emanates from a commercial or industrial establishment, the owner or operator of such establishment shall also retain an on-site written record of the discharge and the actions taken to prevent its recurrence. Such records shall be retained for at least three years.

**Sec. 64. Industrial or construction activity discharges.**

(a) Any person, owner or operator subject to an industrial or construction activity NPDES storm water discharge permit shall comply with all provisions of such permit. Proof of compliance with said permit may be required in a form acceptable to the Director prior to the allowing of discharges to the MS4.

(b) The owner or operator of commercial or industrial establishments or construction activities shall provide, at their own expense, reasonable protection from accidental discharge of prohibited materials or other wastes into the MS4 or to surface waters directly through the use of best management practices. Further, any person responsible for a property or premise, which is, or may be, the source of an illegal discharge, may be required to implement, at said person's expense, additional BMPs to prevent the further discharge of pollutants.

(c) Compliance with all terms and conditions of a valid NPDES permit authorizing the discharge of storm water associated with industrial activity, to the extent practicable, shall be deemed compliance with the provisions of this section.

**Secs. 65 to 69. Reserved.**

## ARTICLE V. STORM WATER RUNOFF MANAGEMENT FOR CONSTRUCTION ACTIVITIES

**Sec. 70. General prohibition.**

Adequate erosion prevention and sediment control BMPs shall be employed for all land disturbing activities of any size. Land disturbing or construction activities of any size that the discharge of sediment or sediment-laden storm water runoff to the MS4, to surface waters directly discharges or onto adjacent properties are a violation of this Code.

**Sec. 71. Applicability.**

(a) All owners or operators of construction activities as described below that discharge storm water runoff to the MS4 or to surface waters directly shall comply with this Code:

(1) Construction activities for which an NPDES permit from KDHE is required.

(2) Construction activities for new developments or redevelopments which disturb less than one (<1.0) acre and which are not part of a larger common plan of development or sale if, in the opinion of the Director, the potential for water quality impact warrants consideration.

(b) Article V of this Code is not applicable to construction activities that are located on a farm property unless such activities require a Sedgwick County building permit and disturb less than one (<1.0) acre.

**Sec. 72. Requirement for SWPPP.**

(a) Submittal of a SWPPP to the Director is required for all applicable construction activities, as defined in Section 71.

(b) No construction activities shall commence until:
(1) the SWPPP for the construction site has been approved by the Director; and,
(2) the Director has received a copy of the NOI for the construction activity that indicates approval by KDHE; and,
(3) a Floodplain Development Permit is obtained, if applicable.

**Sec. 73. General criteria.**

The following general criteria are minimum requirements for the control of pollutants from applicable construction activities, as defined in Section 71. All erosion prevention and sediment control BMPs shall conform to the requirements of this section. The erosion prevention and sediment control BMPs shall apply to all features of the development site including street, utility installations, drainage facilities and other temporary and permanent improvements.

(a) Owners or operators of construction activities shall implement appropriate erosion prevention and sediment control BMPs as required by and in accordance with the KS-CGP, the Storm Water Manual and this Code. BMPs shall be installed, maintained and repaired by the owner or operator, at his/her expense, as required by the KS-CGP and/or as often as necessary to ensure continual compliance with the approved SWPPP and this Code. BMPs shall be installed and maintained in proper working condition during all stages of any land-disturbing activity.

(b) Owners or operators of construction activities shall control construction related waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste in a manner that eliminates the potential for litter or discharge of the construction related waste via storm water runoff, wind, improper handling and/or disposal or other means to the MS4 or to surface waters directly.

(c) The planning, phasing, and stabilization of all construction activities, related to erosion prevention and sediment control, shall be performed in accordance with the requirements of the KS-CGP and the approved SWPPP.

(d) The design, installation and maintenance of BMPs for construction related waste and for erosion prevention and sediment control shall be performed in accordance with criteria and requirements stated in the KS-CGP, except where more stringent criteria are set forth in this Code or are required by the Director. All BMPs must be properly selected, installed, and maintained in accordance with the manufacturer's specifications (where applicable) and good engineering practices. Measures selected for erosion prevention and sediment control must be able to slow runoff so that rill and gully formation is prevented. When steep slopes and/or fine particle soils are present at the site, additional physical or chemical treatment of stormwater runoff may be required, and must be fully described on the SWPPP if required.

(e) If periodic inspections or other information indicate that a BMP has been used inappropriately, or incorrectly, the owner or operator must replace or modify said BMP for relevant site situations at his/her expense.

(f) The Director may require more stringent standards or BMPs than those required by the KS-CGP or shown in the approved SWPPP where and when deemed necessary to reduce the potential for pollution impacts to streams, public property or adjacent property from sediment-laden stormwater runoff or discharges of other construction related waste. Such BMPs, if required, shall be installed by the owner or operator at his/her expense.

(g) Stripping of vegetation, re-grading, and other development activities shall be conducted so as to minimize erosion. Clearing and grubbing must be held to the minimum necessary. Construction must be sequenced to minimize the exposure time of cleared surface areas.

(h) If ownership of a construction activity is transferred, the owner or operator shall provide the Director with a signed copy of the NOTO that is submitted to KDHE.

(i) If ownership of a lot or portion of a construction activity is transferred, the owner or operator shall provide the Director with a signed copy of the ILC upon request.

**Sec. 74. Required SWPPP components.**

(a) SWPPPs submitted to the Director shall be prepared in accordance with the requirements of the KS-CGP and the plan preparation guidance provided by Volume 3 of the Storm Water Manual. The Director may request that additional information be submitted as necessary to allow a thorough review of the site conditions and BMPs proposed in the SWPPP. Omission of any required items shall render the SWPPP incomplete and the SWPPP will be returned to the owner or operator prior to review by the Director.

(b) SWPPPs shall be developed and prepared under the supervision of an engineer, geologist, architect, landscape architect or a Certified Professional in Erosion and Sediment Control.

(c) Amendments to SWPPP plans shall be prepared under the supervision of an engineer, geologist, architect, landscape architect or a Certified Professional in Erosion and Sediment Control and shall be made in accordance with the KS-CGP.

**Sec. 75. Inspection and documentation requirements.**

(a) Qualified personnel provided by the owner of the construction site shall inspect disturbed areas that have not been finally stabilized, areas used for storage of materials that are exposed to precipitation, BMPs, and locations where vehicles enter or exit the site (construction entrances), at least once every seven (7) calendar days and within twenty-four (24) hours of the end of the storm that is one-half inch or greater. Disturbed areas and areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the storm water drainage system. Erosion and sediment control measures identified in the SWPPP shall be inspected to ensure that they are maintained and operating correctly. Locations where the construction site discharges storm water to the MS4 or to surface waters directly shall be inspected to ascertain whether erosion control measures are effective in preventing sediment from discharging off-site. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site sediment tracking.

(b) The owner or operator shall prepare and maintain records and documentation for all inspections performed and for any changes to the approved SWPPP during construction and after final stabilization has been achieved. Records and documentation shall be kept in accordance with requirements of the KS-CGP and shall be provided to the Director upon request.

**Sec. 76. Requirements at the time of project completion.**

(a) Upon final stabilization of the construction activity, as defined in this Code, the owner shall submit written certification to the Director that the construction activity has been finally stabilized. The Director may coordinate with other County departments to withhold the final occupancy or use permit for any premises constructed as a result of the construction activity until such certification of final stabilization has been filed and the Director has determined, following any appropriate inspection, that the final stabilization has occurred and that any required permanent structural controls have been completed.

(b) The owner or operator shall remove and dispose of all temporary erosion prevention and sediment control BMPs within 30 days after final stabilization of the entire construction site is achieved, unless otherwise authorized by the Director. Trapped sediment and other disturbed areas resulting from the disposition of temporary measures shall be properly disposed of and/or permanently stabilized to prevent further erosion and sedimentation. BMP removal and disposal shall be performed at the expense of the owner or operator. BMPs located in the public right-of-way and not disposed by the owner or operator within 30 days after final stabilization are a violation of this Code.

**Secs. 77 to 99. Reserved.**

## ARTICLE VI. STORM WATER RUNOFF MANAGEMENT FOR NEW DEVELOPMENTS AND REDEVELOPMENTS

**Sec. 100. Storm Water Quality Management Standards**

(a) Applicability.

(1) Water quality treatment and downstream channel protection shall be required of owners of new developments and redevelopments that causes a land disturbance greater than or equal to one (1) acre, including projects that cause a land disturbance less than one (1) acre that are part of a larger common plan of development or sale.

(2) The requirements of Article VI of this chapter shall not apply to:

i. new developments or redevelopments that have a construction plan approved by January 1, 2011 and will have completed construction of all storm water management facilities within 90 days of January 1, 2011. This does not exempt such new developments from water quality management regulations that may be required in the future by EPA or KDHE; or,

ii. redevelopment projects that consist solely of ordinary maintenance activities, remodeling of buildings on the existing foundation, resurfacing (milling and overlay) of existing paved areas, and exterior changes or improvements.

(b) Water Quality Treatment Standard for New Developments. Storm water runoff from applicable new developments must be treated for water quality prior to discharge from the development site in accordance with the storm water treatment standards and criteria provided in the Storm Water Manual.

(c) Water Quality Treatment Standard for Redevelopments. Owners of applicable redevelopments must adhere to one of the following requirements.

(1) The total impervious cover of the property after redevelopment shall be reduced by at least twenty-percent (20%) from the total impervious cover of the property prior to the proposed redevelopment.

(2) Storm water runoff from at least thirty percent (30%) of the site's existing impervious cover and for one-hundred percent (100%) of any new land disturbance that will result from the proposed redevelopment shall be treated for water quality prior to discharge from the redevelopment site in accordance

with the storm water treatment standards and criteria provided in the Storm Water Manual.

(3) The owner shall provide storm water controls at an alternative location in the same watershed as the proposed redevelopment. The level of storm water control provided shall be equivalent to what would have been provided at the proposed redevelopment for either requirement 1 or 2 above, at a minimum.

(4) In agreement and partnership with Sedgwick County, the owner shall provide engineering design and/or construction activities to address one or more known downstream water quality or channel erosion issues located within the same watershed as the proposed redevelopment, through stream restoration and/or other off-site remedies approved by the Director.

(5) The owner shall pay a fee in-lieu-of water quality control and channel protection control, in an amount to be determined by the County in accordance with the in-lieu-of fee schedule as adopted by the County Commission of Sedgwick County Kansas per the watershed plan which covers the redevelopment.

(6) Any combination of (1) through (5) above may be acceptable to the Sedgwick or other solution(s) approved by the Director that meets the intent of this chapter.

(d) Downstream Stabilization Standard. Downstream long-term channel protection shall be provided for applicable new developments and redevelopments prior to discharge from the new/redevelopment site in accordance with the downstream stabilization standards and criteria provided in the Storm Water Manual.

**Sec. 101. Storm Water Quantity Management Standards**

(a) Applicability. Storm water runoff peak discharge analysis and control shall be required for new developments and redevelopments that will create or add one (1) acre or greater of impervious cover, including projects that have less than one (1) acre in impervious cover that are part of a larger common plan of development or sale that will result in one (1) acre or greater of impervious cover.

(b) Water Quantity Management Standard. Storm water runoff peak discharge analysis and control shall be required for applicable new developments or redevelopments in accordance with the storm water quantity standards and criteria provided in the Storm Water Manual.

**Sec. 102. Other Storm Water Management Requirements**

(a) Applicability. Section 102 is applicable to new developments and redevelopments that are required to comply with Section 100 and/or Section 101 of this chapter.

(b) Alternative Standards for Individual Watersheds. Alternative storm water management standards, either lesser or greater than those specified in this chapter, may be required by the Director in those areas or watersheds where water quality, flooding or erosion problems are known to exist, or in individual watersheds where a watershed plan or storm water master plan, approved by the County Commission of Sedgwick County, specifies such alternative standards.

(c) Other Requirements for Storm Water Discharges.

(1) Storm water discharges shall be managed in consideration of the erosion control measures detailed in the Storm Water Manual.

(2) Any discharge of storm water runoff to groundwater must meet all applicable local, State and Federal requirements, permits, plans and programs. The owner is responsible for complying with all local State and Federal permits that are applicable to the site.

(d) Requirement to Stabilize Banks. Banks of all streams, channels, ditches and other earthen storm water conveyances shall be left in a stabilized condition upon completion of the new development or redevelopment. No actively eroding, bare or unstable vertical banks shall remain after completion of construction.

(e) Requirement to Use the Storm Water Manual. All storm water facilities and systems, including those designed and constructed for water quality treatment, downstream channel stabilization, and peak discharge control shall be designed, constructed and maintained in accordance with the criteria, standards, and specifications presented in this chapter and in the Storm Water Manual. The standards for water quality treatment, downstream channel stabilization and peak discharge analysis and control shall be achieved through the use of one or more storm water quality management facilities that are designed and constructed in accordance with the design criteria, guidance, and specifications provided in the Storm Water Manual. Methods, designs or technologies for storm water quality management facilities that are not provided in the Storm Water Manual may be submitted for approval by the County if it is proven that such methods, designs or technologies will meet or exceed the storm water treatment standards set forth in the Storm Water Manual and this resolution. Proof of such methods, designs, or technologies must meet the minimum testing criteria set forth in the Storm Water Manual.

(f) Storm Water Facilities on Public Property. Storm water management facilities shall not be installed within public rights-of-way or on public property unless a permit has been issued by the County Engineer.

(g) Access Easement Required. In order to provide access to storm water and/or water quality volume reduction areas by inspection and maintenance personnel, vehicles and equipment, the property owner(s) shall provide an access and maintenance easement in accordance with the requirements and policies presented in the Storm Water Manual.

**Sec. 103. Waivers and Exemptions from Storm Water Management Standards for New Developments**

(a) Exemptions. Owners of properties where the following activities are undertaken are exempt from the requirements of Article IV of this chapter.

(1) Minor land disturbing activities at individual locations, such as gardening, building or grounds maintenance and landscaping, provided that the activity does not result in equal to or greater than one (1) acre of land disturbance;
(2) Individual utility service connections, unless such activity is carried-out in conjunction with the clearing, grading, excavating, transporting, or filling of a lot or lots for which a grading permit would otherwise be required by regulation;
(3) Installation, maintenance or repair of individual septic tank lines or drainage fields, unless such activity is carried out in conjunction with the clearing, grading, excavating, transporting, or filling of a lot or lots for which a grading permit would otherwise be required by the regulation;
(4) Installation of posts or poles;
(5) Farming activities;
(6) Unplanned emergency work and emergency repairs necessary to protect life or property.

(b) Waivers. All or some of the storm water management standards required in Section 100 and/or Section 101 of this chapter may be waived by the Director under the following circumstances.

(1) Existing Downstream Facilities. A waiver may be provided for one or more storm water management standards if the waived standard(s) are met by discharging the storm water runoff to an existing storm water management facility, whether public or private, that is:
   i. provided in accordance with an existing watershed plan that is approved by the County; and,
   ii. already in existence, or will be in existence at the time of construction of the new development or redevelopment; and,
   iii. designed, constructed and maintained to provide a level of storm water control that is equal or greater than that which would be afforded by on-site storm water management facilities.
   iv. If a waiver is provided for this reason, the owner of the new development or redevelopment will be required to pay a fee in-lieu-of water quality control, downstream channel stabilization control and peak discharge control, in an amount to be determined by the County in accordance with an adopted in-lieu-of fee schedule as adopted by the Board of County Commissioners of Sedgwick County per the watershed plan which covers the new development or redevelopment.

(2) Adverse Impact. A waiver may be provided if engineering studies determine that installing a storm water management facility in order to meet the storm water management standard being considered for waiver will cause adverse

impact to water quality, or cause increased channel erosion, or downstream flooding.

(3) Technical Criterion. A waiver may be provided if the technical criterion required to waive the storm water management standard, as presented in the Storm Water Manual, is met. In any case, a waiver is subject to satisfaction of the following requirements, which shall be shown in drainage plans submitted for the new development or redevelopment:

i. the waiver applicant shall provide an engineering study, as defined in Section 103.c that proves the adequacy of downstream or shared off-site storm water management facilities to offer equivalent or greater protection than the standard(s) for which a waiver is requested; and,

ii. the waiver applicant obtains any necessary CLOMR prior to construction, and a LOMR upon completion of construction; and,

iii. the waiver applicant obtains all State and Federal permits that may be applicable to the site.

(c) Engineering Study Required. In the event that a waiver from storm water management control requirements is requested, the adequacy of downstream or shared off-site storm water management facilities to control storm water runoff shall be determined, reviewed and approved by an engineering study that is performed in accordance with the calculation methods presented in the Storm Water Manual. The engineering studies shall be performed at the expense of the owner(s) of the proposed new development or redevelopment, unless a study has already been or is being performed by the County as part of a watershed plan or other land use plan.

**Sec. 104. General Requirements for Storm Water Design Plans**

(a) Storm water design information shall be submitted as part of the preliminary plat, final plat and construction plans, in accordance with the site development process established by the County.

(b) A building permit shall not be issued for the land development activity until the required storm water design information and corresponding plans are approved by the County.

(c) At a minimum, the storm water design information submitted at each stage of the county development process shall include the specific required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies, guidance and calculation methods (unless equivalent methods are pre-approved by the County) presented in the Storm Water Manual. Additional storm water design information may be required as necessary to allow an adequate review of the existing or proposed site conditions.

(d) The submittal of storm water design information shall be subject to the requirements set forth in the minimum subdivision regulations, zoning ordinance, or other County regulations.

(e) Storm water design information shall be prepared under the supervision of and stamped by a professional engineer licensed to practice in the State of Kansas.

(f) The portions of the new development or redevelopment on which storm water management facilities and systems are located shall be shown on the preliminary and final plats for all residential subdivisions and recorded with the plat as permanent reserves or easements consistent with the policies stated in the Storm Water Manual. Non-residential plats and/or subdivisions having a total area less than or equal to fifteen (15) acres shall be required to demonstrate the viability of proposed storm water management facilities and systems. In such cases, the Director is authorized to allow contingent dedications for storm water facilities providing that the owner/developer enters into an agreement with the County guaranteeing the construction of the said facilities in accordance with a schedule approved in the said agreement.

(g) Conformity to the Approved Plans.

(1) Grading designs shown on approved master grading plans and the design of storm water facilities and controls shown on approved design plans shall be adhered to during grading and construction activities. Under no circumstance is the owner or operator of land development activities allowed to deviate from the approved plans without prior approval of a plan amendment by the County.

(2) Grading and storm water design plans shall be amended to meet all local laws and standards if the proposed site conditions change after plan approval is obtained, or if it is determined by the County during the course of grading or construction that the approved plan is inadequate.

(h) Duty to Provide an Operations and Maintenance Plan.

(1) An Operations and Maintenance Plan shall be included with the storm water design information submitted with the construction plan. The Operations and Maintenance Plan shall include the required operation and maintenance provisions for each storm water management facility and water quality volume reduction area that is serving, or will serve, the development or redevelopment. The Operations and Maintenance Plan shall include all of the required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies and guidance provided in the Storm Water Manual.

(2) The Operations and Maintenance Plan shall include an executed legal document entitled "Restrictive Covenants for Storm Water Facilities" (Covenants). The property owner shall record the Covenants with the deed for the property. The location of the storm water management facility(s) and water quality volume reduction areas, the recorded location of the Covenants document, and inspection and maintenance guidance outlining the property

owner's responsibility shall be shown on a plat that is recorded for the property.

(i) Duty to Provide Storm Water Construction Information on As-Built Drawings.
   (1) Complete As-Built Drawings shall be provided to the Director upon completion of construction, and shall include sufficient design information to show that the storm water facilities will operate as designed under the approved drainage plan.
   (2) The As-Built Drawings shall include the required elements that are listed and/or described in the Storm Water Manual, and shall be prepared in accordance with the policies and guidance provided in the Storm Water Manual.
   (3) The As-Built Drawings shall be prepared and stamped by a professional engineer licensed to practice in the State of Kansas.

**Sec. 105. Maintenance and Inspection of Storm Water Drainage Paths and Controls.**

(a) Duty to Inspect and Maintain Storm Water Systems and Controls. Property owners shall at all times properly maintain and shall at intervals in accordance with the Operations and Maintenance Plan inspect all storm water facilities, systems, conveyances, pipes, channels, ditches, swales, inlets, catchbasins, water quality volume credit areas, and other facilities and systems of storm water treatment and control (and related appurtenances) so that they operate at their full function. Maintenance and inspection of privately-owned storm water management facilities, systems, conveyances, pipes, channels, ditches, swales, inlets, catchbasins, water quality volume credit areas, and other facilities and systems of storm water treatment and control (and related appurtenances) shall be performed at the expense of the owner(s) of such facilities.

(b) Duty to provide inspection reports. After construction of each storm water management facility on the property is complete, property owners shall provide to the Director on a bi-annual basis a completed and signed copy of the inspection report for each storm water management facility that is included with the Operations and Maintenance Plan for the property. The inspection report is due every two years no later than the date (month and day) of approval of the as-built plan for the property.

(c) Duty to Preserve Approved Grading Designs. Re-grading an individual lot or lots, or portions of a lot or lots, in a manner that is not in accordance with the approved master grading plan, such that the direction(s) of storm water runoff is altered from the direction that would occur under the approved master grading plan, shall be considered a violation of this chapter.

(d) Duty to Preserve Existing Drainage Paths. Blockage of a channel, ditch, stream or any other drainage path or storm water system appurtenance that is located in a storm water easement or drainage easement shall be considered a violation of this chapter.

(e) Pollutant Removal for Maintenance. The removal of pollutants, sediment and/or other debris for the purpose of maintenance of storm water management facilities shall be performed in accordance with all County, State, and Federal laws.

(f) Inspection of Storm Water Management Facilities During Grading or Construction.

(1) During grading or construction, the property owner or his/her appointed designee shall conduct site inspections in accordance with the requirements stated in the KS-CGP and this chapter. The property owner will also ensure construction conformance with the approved drainage and construction plans. More stringent inspection requirements may be imposed as necessary for purposes of water quality protection and public safety and to pursue total conformance of the site with the approved plans.

(2) The following areas and items must be inspected throughout grading and construction to ensure that land disturbance activities do not cause adverse impacts to the performance of storm water management facilities and/or water quality volume reduction areas:

i. all unstabilized areas that drain to a permanent storm water facility or water quality volume reduction area;
ii. temporary and permanent storm water management facilities; and,
iii. all erosion prevention and sediment control measures.

(g) Inspection After Construction. Once the site has been stabilized and construction has ceased, the property owner or his/her appointed designee shall conduct routine inspections for the storm water management facilities and water quality reduction areas, based on the guidance provided in the Operations and Maintenance Plan and the requirements of the "Restrictive Covenants for Storm Water Facilities" for the property, as set forth in Section 104 of this chapter.

(h) Inspection Records. Property owners shall make available upon request any self-inspection reports, monitoring/maintenance records, compliance evaluations, notices of intent, and any other records, reports, receipts, and other documents related to compliance with this chapter and with any related local, State or Federal permit.

(i) Right-of-Entry. The Director or his/her designee shall have the right to enter the premises of any person discharging storm water to the MS4 or to waters of the United States at any reasonable time to determine if the discharger is complying with all requirements of this chapter, and with any State or Federal discharge permit, limitation, or requirement. Dischargers shall allow the Director or his/her designee ready access to all parts of the premises for the purposes of inspection, sampling, records examination and copying, and for the performance of any additional duties. Failure of a property owner to allow entry onto a property for the purposes set forth in this section shall be cause for the issuance of a stop work order, withholding of a certificate of occupancy, and/or civil penalties and/or damage assessments in accordance with the enforcement provisions of this chapter.

(j) Inspection and Notice by County. The County may periodically inspect these privately owned storm water controls. If the facility is not operating as shown in the approved As-Built Drawing, or should conditions be found that cause or may cause the pollution of downstream receiving waters or the erosion of downstream channels or the flooding of adjacent or downstream properties, the Director may issue a notice of violation in accordance with the enforcement provisions stated in this chapter and shall notify the property owner(s) of the potential violation(s). The Director may order the property owner(s) to perform corrective actions as are necessary to facilitate the proper operation of these facilities for the purposes of flood prevention, downstream channel stabilization, water quality treatment and/or public safety, and/or to ensure compliance with jurisdictional regulatory conditions.

(k) Failure to Perform Corrective Actions. If property owner(s) fail to make the necessary corrective actions in the timeframe specified in the enforcement provisions of this chapter, the County is authorized to perform the corrective actions at the expense of the owner(s). If the owner(s) fail to reimburse the County for the corrective actions upon demand, the County may assess the cost of the corrective actions to the owner and initiate any collection proceedings authorized by law.

(l) Access to Adjacent Properties. This resolution does not authorize access by a property owner or site operator to private property adjacent to or downstream of the owner's property. Arrangements concerning removal of sediment or pollutants on adjoining property must be settled by the owner or operator with the adjoining landowner.

**Sec. 106. Special Provisions for Open Channels.**

(a) No structure or land shall hereafter be developed, redeveloped, located, extended, converted, or structurally altered without full compliance with the terms of this code, the Sedgwick County Floodplain Management Resolution (Chapter 13) and other applicable local, state or federal regulations.

(b) Requirements for vegetative buffer zones or maintenance access areas that have been established in approved and adopted watershed plans have priority over the provisions of this section.

(c) Closure of open channels. Existing or proposed open channels may be enclosed if a maintenance plan approved by the County is provided; if the closed conduit conforms to the design criteria set in the Storm Water Manual.

(d) Access Easement Required. All open channels must have a minimum twenty (20) foot wide maintenance access on each side of the stream as measured from the top-of-bank on each side of the stream, except as required by KSA 24-126 as amended, and KAR 5-45-12 as amended for "streams" defined in KAR 5-45-1 as amended.

**Secs. 107 to 130. Reserved**

**SECTION II. EFFECTIVE DATE.**

This resolution shall be effective on and after January 1, 2011, and after adoption and publication of this resolution in the official county newspaper.

Commissioners present and voting were:

| | |
|---|---|
| DAVID M. UNRUH | Aye |
| TIM R. NORTON | Aye |
| KARL PETERJOHN | Aye |
| KELLY PARKS | No |
| GWEN WELSHIMER | Absent |

Dated this 23rd day of November, 2010.

BOARD OF COUNTY COMMISSIONERS
OF SEDGWICK COUNTY, KANSAS

/s/
KARL PETERJOHN, Chairman
Commissioner, Third District


ATTEST:

/s/
KELLY B. ARNOLD, County Clerk

APPROVED AS TO FORM:

/s/
ROBERT W. PARNACOTT
Assistant County Counselor

# APPENDIX D

Sedgwick County Floodplain Resolution – Resolution 14-2007

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**RESOLUTION # 14-2007**

EFFECTIVE DATE: 01-02-07

**A RESOLUTION AMENDING CHAPTER 13, SEDGWICK COUNTY CODE, RELATING TO FLOODPLAIN MANAGEMENT FOR SEDGWICK COUNTY, KANSAS**

**WHEREAS**, the National Flood Insurance Act of 1968 as amended requires local communities to adopt control measures that regulate land use in areas of special flood hazard within their communities; and

**WHEREAS**: The Board of County Commissioners on October 13, 2004, enacted Sedgwick County Resolution #183-2004, and the enactment of this resolution will rescind Resolution #183-2004 and all previous floodplain resolutions; and

**WHEREAS**, the Board of County Commissioners finds it necessary to amend Chapter 13 of the Sedgwick County Code in order to comply with regulations of the Federal Emergency Management Agency and to adopt new Flood Insurance Rate Maps and Flood Insurance Study; and

**WHEREAS**, the Federal Emergency Management Agency has identified the areas of special flood hazard in Sedgwick County, Kansas; and

**WHEREAS**, the legislature of the State of Kansas has in K.S.A. 19-212 delegated the responsibility to local governmental units to adopt regulations designed to promote the public health, safety, and general welfare to its citizenry; and

**WHEREAS,** this resolution is adopted pursuant to the authority of K.S.A. 12-766.

**NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS OF SEDGWICK COUNTY, KANSAS, THAT CHAPTER 13 OF THE *SEDGWICK COUNTY CODE* ENTITLED "FLOODPLAIN MANAGEMENT," BE AND IS HEREBY AMENDED.**

**SECTION 1: AMENDMENTS TO CHAPTER 13.** Chapter 13 of the Sedgwick County Code is hereby amended in its entirety, and shall read as follows:

## ARTICLE I. IN GENERAL

### Sec. 13-1. Definitions.

Unless otherwise expressly stated or unless the context clearly indicates a different intention, the following terms shall, for the purposes of this chapter, have the meanings indicated in this section:

(1) Administrator is the Director of the Sedgwick County Department of Code Enforcement or the Director's appointee.

(2) Agricultural commodities means agricultural products and livestock.

(3) Agricultural structure means any structure used exclusively in connection with the production, harvesting, storage, drying, or raising of agricultural commodities.

(4) Appeal means a request for review of the administrator's interpretation of any provision of this chapter or a request for a variance.

(5) Areas of Shallow Flooding means a designated AO or AH zone on a community's Flood Insurance Rate Map (FIRM) with a one percent or greater annual chance of flooding to an average depth of one (1) to three (3) feet where a clearly defined channel does not exist, where the path of flooding is unpredictable and where velocity flow may be evident. Such flooding is characterized by ponding or sheet flow.

(6) Base flood means the flood having a one percent chance of being equaled or exceeded in any given year.

(7) Base flood elevation (BFE) means the elevation for which there is a one-percent (1%) chance in any given year that flood levels will equal or exceed it. The BFE is determined by statistical analysis for each local area and designated on the Flood Insurance Rate Maps (FIRM). It is also known as the 100-year flood elevation.

(8) Basement means any area of the structure having its floor subgrade (below ground level) on all sides.

(9) Development means any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, drilling operations, or storage of equipment or materials.

(10) Existing manufactured home park or subdivision means a manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or pouring of concrete pads) is completed before the effective date of the floodplain management regulations adopted by the community.

(11) Expansion to an existing manufactured home park or subdivision means the preparation of additional sites by the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including the installation of utilities, the construction of streets, and either final site grading or pouring of concrete pads).

(12) Flood or Flooding means a general and temporary condition of partial or complete inundation of normally dry land areas from:

(a) The overflow of inland waters.
(b) The unusual and rapid accumulation or runoff of surface waters from any source.

(13) Flood Insurance Rate Map (FIRM) means an official map of a community, on which the Flood Insurance Study has delineated the Flood Hazard Boundaries and zones establishing insurance rates applicable to the community.

(14) Flood Insurance Study (FIS) means an examination, evaluation and determination of flood hazards and, if appropriate, corresponding water surface elevations.

(15) Floodplain or flood prone area means any land area susceptible to being inundated by water from any source (see "flooding").

(16) Floodplain management means the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, and floodplain management regulations.

(17) Floodplain management regulations means zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain and grading ordinances) and other applications of police power. The term describes such state or local regulations, in any combination thereof, which provide standards for the purpose of flood damage prevention and reduction.

(18) Floodproofing means any combination of structural and nonstructural additions, changes, or adjustments to structures that reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, or structures and their contents.

(19) Floodway means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot at any point. (See "regulatory floodway.)

(20) Floodway encroachment lines means the lines marking the limits of floodways on the Flood Insurance Rate Map.

(21) Floodway fringe means the area outside the floodway encroachment lines, but still subject to inundation by the regulatory flood.

(22) Freeboard means a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, clogged bridge openings, and the hydrological effect of urbanization of the watershed.

(23) Highest adjacent grade means the highest natural elevation of the ground surface prior to construction next to the proposed walls of a structure.

(24) Historic structure means any structure that is:

(a) Listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listings on the National Register;

(b) Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;

(c) Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of Interior; or

(d) Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:

1. By an approved state program as determined by the Secretary of the Interior; or
2. Directly by the Secretary of the Interior in states without approved programs.

(25) Lowest floor means the lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor, provided that such enclosure is not built as to render the structure in violation of the applicable floodproofing design requirements of this chapter.

(26) Manufactured home means a structure, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when connected to the required utilities. For floodplain management purposes the term "manufactured home" also includes park trailers, travel trailers, and other similar vehicles placed on a site for greater than 180 consecutive days. For insurance purposes the term "manufactured home" does not include park trailers, travel trailers, and other similar vehicles.

(27) Manufactured home park or subdivision means a parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.

(28) Market value or fair market value means an estimate of what is fair, economic, just and equitable value under normal local market conditions.

(29) Mean sea level means, for purposes of National Flood Insurance Program, the North American Vertical Datum (NAVD) of 1988 or other datum, to which base flood elevations shown on the community's Flood Insurance Rate Map are referenced.

(30) New construction means, for the purpose of determining insurance rates, structures for which the "start of construction" commenced on or after the effective date of June 3, 1986 of the initial FIRM or after December 31, 1974, whichever is later, and includes

any subsequent improvements to such structures. For floodplain management purposes, "new construction" means structures for which the "start of construction" commenced on or after the effective date of a floodplain management regulations adopted by a community and includes any subsequent improvements to such structures.

(31) Person includes any individual or group of individuals, corporation, partnership, association, or any other entity, including Federal, State, and local governments and agencies.

(32) Principally above ground means that at least 51 percent (51%) of the actual cash value of a structure, less land value, is above ground.

(33) Recreational vehicle means a vehicle that is:

(a) Built on a single chassis;
(b) 400 square feet or less when measured at the largest horizontal projections;
(c) Designed to be self-propelled or permanently towable by a light duty truck; and
(d) Designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel or seasonal use.

(34) Regulatory floodway means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot at any point. (See "floodway.)

(35) Start of construction includes substantial improvements, and means the date the building permit was issued, provided the actual start of construction, repair, reconstruction, rehabilitation, addition, placement, or other improvement occurs within 180 days of the permit date. The actual start means the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, of any work beyond the stage of excavation or the placement of a manufactured home on a foundation. Permanent construction does not include land preparation, such as clearing, grading and filling; nor does it include the installation of streets and/or walkways; nor does it include excavation for a basement, footings, piers, or foundations or the erection of temporary forms; nor does it include the installation on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not part of the main structure. For a substantial improvement, the actual start of construction means the first alteration of any wall, ceiling, floor, or other structural part of a building, whether or not that alteration affects the external dimensions of the building.

(36) Structure means a walled and roofed building that is principally above ground, as well as a manufactured home, and a gas or liquid storage tank that is principally above ground.

(37) Substantial damage means damage of any origin sustained by a structure whereby the cost of restoring the structure to its pre-damage condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

(38) Substantial improvement means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage", regardless of the actual repair work performed. The term does not, however, include either (1) any project for improvement of a structure to correct existing violations of state of local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions, or (2) any alteration of a "historic structure", provided that the alteration will not preclude the structure's continued designation as a "historic structure".

(39) Variance is a grant of relief to a person from the requirements of this chapter which permits construction in a manner otherwise prohibited by this chapter where specific enforcement would result in unnecessary hardship.

(40) Violation means the failure of a structure or other development to be fully compliant with the community's floodplain management regulations. A structure or other development without the elevation certificate, other certifications, or other evidence of compliance required by this chapter is presumed to be in violation until such time as that documentation is provided.

(41) Water surface elevation means the height, in relation to the North American Vertical Datum (NAVD) of 1988 (or other datum where specified) of floods of various magnitudes and frequencies in the floodplain.

**Sec. 13-2. Findings of fact.**

(a) The special flood hazard areas of Sedgwick County, Kansas are subject to periodic inundation that results in loss of life, property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare.

(b) These flood losses are caused by the cumulative effect of obstructions in flood plains causing increases in flood heights and velocities, and by the occupancy in flood hazard areas by uses vulnerable to floods or hazards to other lands which are inadequately elevated, floodproofed, or otherwise unprotected from flood damage.

(c) The Flood Insurance Study (FIS) that is the basis of this chapter uses a standard engineering method of analyzing flood hazards which consists of a series of interrelated steps:

(1) Selection of a base flood that is based upon engineering calculations, which permit a consideration of such flood factors as its expected frequency of occurrence, the area inundated, and the depth of inundation. The base flood selected for this chapter is representative of large floods, which are characteristic of what can be expected to occur on the particular streams subject to this chapter. It is in the general order of a flood that

could be expected to have a one percent (1%) chance of occurrence in any one year as delineated on the Federal Insurance Administrator's Flood Insurance Study (FIS), and illustrative materials dated February 2, 2007, as amended, and any future revisions thereto.

(2) Calculation of water surface profiles that are based on a standard hydraulic engineering analysis of the stream channel and overbank areas to convey the regulatory flood.

(3) Computation of a floodway required to convey flood without increasing flood heights more than one (1) foot at any point.

(4) Delineation of floodway encroachment lines within which no development is permitted that would cause any increase in the base flood height.

(5) Delineation of floodway fringe.

**Sec. 13-3. Purpose of chapter.**

It is the purpose of this chapter to promote the public health, safety, and general welfare and to minimize public and private losses due to flood conditions in specific areas by provisions designed to:

(1) Protect human life and health;

(2) Minimize expenditure of public money for costly flood control projects;

(3) Minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;

(4) Minimize prolonged business interruptions;

(5) Minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets and bridges located in floodplains;

(6) Help maintain a stable tax base by providing for the sound use and development of flood prone areas in such a manner as to minimize future flood blight areas;

(7) Ensure that potential home buyers are notified that property is in a flood area; and

(8) Ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

**Sec. 13-4. Applicability of chapter.**

The provisions of this chapter shall apply to all areas of special flood hazard within the unincorporated areas of Sedgwick County, Kansas. Areas of special flood hazard are identified by the Federal Emergency Management Agency through a scientific and engineering report entitled "The Flood Insurance Study, Sedgwick County, Kansas, Unincorporated Areas," dated February 2, 2007, with accompanying Flood Insurance Rate Maps, with any revisions thereto, which are hereby adopted and incorporated by reference. Such study results are on file at the office of the County Clerk, the Department of Code Enforcement of Sedgwick County, Kansas and the Division of Water Resources for the State of Kansas.

**Sec. 13-5. Compliance with chapter; correction of violations.**

(a) Generally. No structure or land shall hereafter be constructed, located, extended, converted, or altered without full compliance herewith, and with other applicable regulations. Notice of violations shall be served upon the owner of record; provided that such notice shall be deemed to be properly served upon such owner if a copy thereof is delivered to him personally or if not found, by leaving a copy thereof at his usual place of abode with a person of suitable age and discretion who shall be informed of the contents thereof, or by sending a copy thereof by mail to his last known address, or if the envelope with the copy is returned showing it has not been delivered to him, by posting a copy thereof in a conspicuous place in or about the structure(s) affected by the notice.

(b) Service of Notice. Whenever the director of code enforcement determines that there has been or is a violation, or that there are reasonable grounds to believe that there has been or is a violation of any provision of this chapter, the Director shall give notice of such violation or alleged violation to the person or persons responsible therefor. Such notice shall:

(1) Be in writing;

(2) Include a description of the real estate sufficient for identification;

(3) Specify the violation that exists and the remedial action required;

(4) Allow a reasonable time for the performance of any act it requires.

(c) Prosecution of violations. In case any notice of violation(s) and order(s) to correct is not promptly complied with, the director may request the county counselor to institute, in the district court, an appropriate action or proceeding at law or in equity against the owner(s) of record and/or any person(s) with any legal interest of record in or responsibility for the structure(s) or development(s) in violation, ordering that such person(s):

(1) Be restrained and/or ordered to correct or remove the violation, or refrain from any further execution of work;

(2) Be restrained and/or ordered to correct the erection, installation, or alteration of such building;

(3) Remove the structure(s) or development(s) in violation and restore the land to its former condition as directed by Federal Emergency Management Agency;

(4) Be prevented from occupying or using the structure(s) or development(s) or any part thereof erected, constructed, installed or altered in violation of, or not in compliance with the provisions hereof, or in violation of a plan or specification under which an approval, permit or certificate was issued; and/or

(5) Comply with the provisions of this chapter.

(6) Additionally, or in the alternative, the director may proceed with the penalties section hereof.

**Sec. 13-6. Violations and penalty.**

(a) This chapter is enforceable under chapter 8. Violations of this chapter are classified as provided in Section 8-5 of the Sedgwick County Code.

(b) Violations of this chapter are punishable as provided in Section 1-8.

(c) Except as otherwise stated, any violation of this chapter shall be a *class H* violation.

**Sec. 13-7. Interpretation of chapter.**

The provisions of this chapter are not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where the provisions of this chapter conflict or overlap with such easements, covenants, or deed restrictions, whichever imposes the more stringent restrictions shall prevail. In the interpretation and application of the provisions of this chapter, all provisions shall be:

(1) Considered as minimum requirements;

(2) Liberally construed in favor of the governing body; and

(3) Deemed neither to limit or repeal any other powers granted under state statute.

**Sec. 13-8. Warning and disclaimer of liability**.

The degree of flood protection required by this chapter is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur on rare occasions. Flood heights may be increased by man-made or natural causes. This chapter does not imply that land outside the areas of special flood hazards or uses permitted in such areas will be free from flooding or flood damages. The provisions of this chapter shall not create liability on the part of the county, or any officer or employee thereof, for any flood damages that result from reliance on the provisions of this chapter or any administrative decision lawfully made thereunder.

**Secs. 13-9 to 13-35. Reserved.**

## ARTICLE II.  ADMINISTRATION AND ENFORCEMENT

**Sec. 13-36.  Designation and duties of administrator and the director of code enforcement.**

(a) The director of the department of code Enforcement or the director's appointee is hereby appointed to administer and implement the provisions of this chapter. The duties of the administrator shall include, but not be limited to:

(1) Review and file all development permits to assure that sites are reasonably safe from flooding and that all necessary permits have been received from those governmental agencies from which approval is required by Federal or State law, including Section 404 of the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1334;

(2) When base flood elevation data has not been provided in accordance with Section 13-4, then the administrator shall obtain, review, and reasonably utilize any flood elevation data available from a Federal, State or other source, in order to administer the provisions of Section 13-66;

(3) Record and maintain certified record of the mean sea level actual elevation of the lowest floor of all new or substantially improved structures;

(4) Record and maintain certified record of the mean sea level actual elevation to which the new or substantially improved structures have been floodproofed;

(5) When floodproofing is utilized for a particular structure the administrator shall file certification from a registered professional engineer or architect;

(6) Assure that maintenance responsibility is provided for within the altered or relocated portion of any watercourse so that the flood carrying capacity is not diminished;

(7) Notify, in riverine situations, adjacent communities and the State of Kansas prior to any alteration or relocation of a watercourse and submit copies of such notifications to the Federal Emergency Management Agency;

(8) Where interpretation is needed as to the exact location of the boundaries of the areas of special flood hazards (for example, where there appears to be a conflict between a mapped boundary and actual field conditions) the administrator shall make the necessary interpretation. The person contesting the location of the boundary shall be given a reasonable opportunity to appeal the interpretation as provided in Section 13-38;

(9) Approve all development permits to assure that sites are reasonably safe from flooding.

(b) The director of the department of code enforcement or the director's appointee is hereby appointed to provide enforcement of these provisions.  The duties of the director shall include, but not be limited to:

(1) Obtain certified record of the mean sea level actual elevation of the lowest floor of all new or substantially improved structures;

(2) Obtain certified record of the mean sea level actual elevation to which the new or substantially improved structures have been floodproofed;

(3) When floodproofing is utilized for a particular structure the Director of Code Enforcement shall obtain certification from a registered professional engineer or architect;

(4) The Director of Code Enforcement shall comment on all variances in writing to the person contesting the location of the flood boundary within 30 days and shall be given a reasonable opportunity to appeal the interpretation as provided in Section 13-38.

(5) Comply with the provisions of Section 13-42.

(6) Hear and decide appeals and requests for variances from these requirements.

(7) Serve as a code enforcement officer of the county in enforcing the provisions of this chapter.

**Sec. 13-37. Permit required**.

A Floodplain Development Permit shall be obtained before construction or development begins within any area of hazard as established in Section 13-4. No person, firm, corporation or unit of government shall initiate any development or substantial improvement or cause the same to be done without first obtaining a separate permit for each development as defined in Section 13-1. The fee assessed for Development Permits in Section 13-43 shall be paid at the time the application for the permit is filed. Applications for a Development Permit shall be made on forms furnished by the administrator and may include, but is not limited to: plans in duplicate drawn to scale showing the nature, location, dimensions, and elevations of the area in question; existing or proposed structures, fill, storage of materials, drainage facilities; and the location of the foregoing. Specifically, the following information is required:

(1) Elevation in relation to mean sea level, of the lowest floor of all structures;

(2) Elevation in relation to mean sea level to which any non-residential structure is to be floodproofed;

(3) Certification from a registered professional engineer or architect that the non-residential floodproofed structure will meet the flood proofing criteria in Section 13-68; and;

(4) Description of the extent to which any watercourse will be altered or relocated as a result of proposed development.

**Sec. 13-38. Variance and appeals procedures.**

(a) The administrator shall hear and decide appeals and requests for variances from the requirements of this chapter. Applications for variances shall be in writing and on a form provided by the department of code enforcement;

(b) The Subdivision Committee of the Metropolitan Area Planning Commission shall hear appeals from any decision or determination made by the director in the enforcement or administration of this chapter. Such appeals shall be in writing and shall specify the grounds for appeal. Such appeals shall be filed with the Secretary of the Metropolitan Area Planning Commission within thirty (30) days of the decision or determination appealed from. A non-refundable processing fee of $100.00 shall be paid to the Metropolitan Area Planning Department at the time of the filing of an appeal with the Secretary of the Metropolitan Area Planning Commission. An additional processing fee will not be required for appeals to either the Metropolitan Area Planning Commission or the Board of County Commissioners. The Secretary of the Metropolitan Area Planning Commission shall fix a reasonable time for the appeals, giving notice to the appealing party or parties at least fifteen (15) days prior to such hearing. Appeals shall be decided within a reasonable time. At appeal hearings, any party may appear in person, by agent or by attorney. The Subdivision Committee may reserve or affirm, in whole or in part, or modify the decision or determination appealed from and may make such order, requirement, decision or determination as may be appropriate under the circumstances;

(c) Any person aggrieved by the decision or determination of the Subdivision Committee may appeal such decision or determination to the Metropolitan Area Planning Commission. The procedure for such appeals shall be as set forth above in subsection (b) for appeals from decisions by the administrator; and,

(d) Any person aggrieved by the decision or determination of the Metropolitan Area Planning Commission may appeal such decision or determination to the Board of County Commissioners. The Board of County Commissioners will review such decision or determination in the manner provided above for appeals from decisions by the administrator; except that such appeals shall be filed with the County Clerk and the notice to the appealing party or parties shall be provided at least five (5) days prior to such hearings.

**Sec. 13-39. Variance guidelines.**

(a) The conditions under which a variance may be granted by the administrator are as follows:

(1) Generally, variances may be issued for new construction and substantial improvements to be erected on a lot of one-half acre or less in size contiguous to and surrounded by lots with existing structures constructed below the base flood level, providing items (2-5) below have been fully considered. As the lot size increases beyond the one-half acre, the technical justification required for issuing the variance increases.

(2) Variances may be issued for the reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic places or the State Inventory of Historic Places, without regard to the procedures as set forth in the remainder of this section.

(3) Variances shall not be issued within any designated floodway if any increase in the base flood elevation during the flood discharge would result anywhere on the subject flooding source.

(4) Variances shall only be issued upon a determination that the variance is the minimum necessary to afford relief, considering the flood hazard, and upon a finding of the following:

a. A showing of good and sufficient cause;

b. A determination that failure to grant the variance would result in exceptional hardship to the applicant; and

(5) A determination that the granting of a variance will not result in an increase in flood height, additional threats to public safety, extraordinary public expense, create nuisances, cause fraud on or victimization of the public, or conflict with existing local laws or regulations.

(6) Any applicant to whom a variance is granted shall be given a written notice that the cost of flood insurance will be commensurate with the increased risk resulting from any reduction in the lowest floor elevation.

(b) The administrator shall have responsibility for receiving, considering, and passing upon applications for variances. In passing upon applications for variances, the administrator shall consider all technical evaluations, all relevant factors, standards specified in other sections of this chapter, and:

(1) The danger that materials may be swept onto other lands to the injury of others;

(2) The danger to life and property due to flooding or erosion damage;

(3) The susceptibility of proposed facility and its contents to flood damage and the effect of such damage on the individual owner;

(4) The importance of the services provided by the proposed facility to the community;

(5) The availability of alternative locations not subject to flooding or erosion damage, for the proposed use;

(6) The compatibility of the proposed use with existing and anticipated development;

(7) The safety of access to the property in times of flood for ordinary and emergency vehicles;

(8) The expected heights, velocity, duration, rate of rise and sediment transport of the flood waters and the effects of wave action, if applicable, expected at the site;

(9) The cost of providing governmental services during and after flood conditions including maintenance and repair of public utilities and facilities such as sewer, gas, electrical, and water systems, and streets and bridges;

(10) All agricultural structures considered for a variance from the floodplain management regulations of this chapter shall demonstrate that the varied structure is located in wide, expansive floodplain areas and no other alternate location outside of the special flood hazard area exists for the agricultural structure. Residential structures, such as farm houses, cannot be considered as agricultural structures;

(11) For any new or substantially damaged agricultural structures, the exterior and interior building components and elements (i.e., foundation, wall framing, exterior and interior finishes, flooring, etc.) below the base flood elevation, must be built with flood-resistant materials in accordance with Section 13-66(2);

(12) The agricultural structures must be adequately anchored to prevent flotation, collapse, or lateral movement of the structures in accordance with Section 12(A) of this chapter. All of the building's structural components must be capable of resisting specific flood-related forces including hydrostatic, buoyancy, and hydrodynamic and debris impact forces;

(13) Any mechanical, electrical, or other utility equipment must be located above the base flood elevation or floodproofed so that they are contained within a watertight, floodproofed enclosure that is capable of resisting damage during flood conditions;

(14) The agricultural structures must meet all National Flood Insurance Program (NFIP) opening requirements. The NFIP requires that enclosure or foundation walls, subject to the 100-year flood, contain openings that will permit the automatic entry and exit of floodwaters in accordance with Section 13-68(3);

(15) The agricultural structures must comply with the floodplain management floodway encroachment provisions of Section 13-69(1). No variance may be issued for agricultural within any designated floodway, if any increase in flood levels would result during the 100-year flood;

(16) Major equipment, machinery, or other contents must be protected from any flood damage;

(17) No disaster relief assistance under any program administered by any Federal agency shall be paid for any repair or restoration costs of the agricultural structures;

(18) A community shall notify the applicant in writing over the signature of a community official that:

a. The issuance of a variance to construct a structure below base flood level will result in increased premium rates for flood insurance up to amounts as high as \$25.00 for \$100.00 of insurance coverage, and,

b. Such construction shall below the base flood level increases risks to life and property. Such notification shall be maintained with the record of all variance actions as required by this chapter; and

(19) Wet-floodproofed construction techniques must be reviewed and approved by the community and a registered professional engineer or architect prior to the issuance of any floodplain development permit for construction.

**Sec. 13-40. Nonconforming use.**

(a) A structure or the use of a structure or premises which was lawful before the passage or amendment of this chapter, but which is not in conformity with the provisions of this chapter may be continued subject to the following conditions:

(1) If such use is discontinued for 24 consecutive months, any future use of the building premises shall conform to this section; and,

(2) Uses or adjuncts thereof which are or become nuisances shall not be entitled to continue as non-conforming uses.

(b) If any non-conforming use or structure is destroyed by any means, including flood, it shall not be reconstructed if the cost is more than 50 percent of the market value of the structure before the damage occurred except that if it is re-constructed in conformity with the provisions of this Chapter. This limitation does not include the cost of any alteration to comply with existing state or local health, sanitary, building, or safety codes or regulations or the cost of any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

**Sec. 13-41. Amendment of chapter.**

The regulations, restrictions and boundaries set forth in this chapter may from time to time be amended, supplemented, changed, or appealed to reflect changes in the National Flood Disaster Protection Act of 1973, provided, however, that no such action may be taken until after a public hearing in relation thereto, at which parties in interest and citizens shall have an opportunity to be heard. At least twenty (20) days notice of the time and place of such hearing shall be published in the official county newspaper of Sedgwick County, Kansas. A copy of such amendments will be provided to the Federal Emergency Management Agency. Changes in the Flood Insurance Rate Map (FIRM) may be made without the necessity of the public hearing and public notice set forth above. The regulations of this chapter are in compliance with the National Flood Insurance Program Regulations as published in Title 44 of the Code of Federal Regulation.

**Sec. 13-42. Recording of elevation certificate information.**

(a) For every Floodplain Development Permit issued hereunder, the administrator shall cause a certificate in the form of an affidavit to be filed and recorded with the Register of Deeds of Sedgwick County, Kansas. Such affidavit shall contain the following information:

(1) The legal description of the subject land;

(2) Elevation in relation to mean sea level of the lowest floor of all structures;

(3) Elevation in relation to mean sea level to which any non-residential structure is to be floodproofed; and,

(4) The name or names of the record owners of the subject land.

(b) An affidavit meeting the requirements of subsection (a) must be filed prior to any framing inspection being performed. The cost of the recording of such affidavit shall be at the expense of the applicant for the Development Permit. A recorded copy of such affidavit shall be submitted to the administrator.

**Sec. 13-43. Fees.**

(a) Amount. Fees shall be assessed in accordance with the provisions of this section as set forth below. All fees provided for herein are for regulatory purposes, and shall be payable to the Sedgwick County Treasurer and deposited in and credited to the County general fund:

(1) *Floodplain Determination*. The administrator, or his or her duly appointed designee, shall be and is hereby authorized, upon request of any person, partnership, association, corporation, Municipal Corporation, political subdivision, or other entity, to certify whether a tract or parcel of real estate is included in or excluded from a Flood Hazard Area in Sedgwick County, Kansas. Requests for any such written floodplain determination by the administrator shall be in writing and shall be assessed a regulatory fee of $50.00, which must be paid prior to or contemporaneously with the issuance of such certification. Written determinations from the administrator will include a statement as where the County believes the structure or property to be, either in or out of the mapped floodplain on the current FIRM, and shall include a copy of the FIRM with the structure or property located and identified thereon.

(2) *Review applications for letter of map revisions based on fill (LOMR-F).* Requests for the administrator to review applications for LOMR-F, and if approved to forward the application to FEMA for review and approval, shall be assessed a fee of $100.00, which must be paid in at the time the LOMR-F application is submitted. The administrator shall check and verify all technical data that is submitted is accurate, and that all necessary data is submitted in order to process the application.

(3) Floodplain Development Permits. Applications for a Development Permit required by Section 13-37 will be reviewed by the administrator, and assessed a fee of $50.00, which must be paid in advance at the time the application is submitted.

(b) Payment of fees. Cash or check may used for the payment of permits and other fees required by this code. In any case where a check issued for payment of permits or other fees required by this code is returned marked “insufficient funds” or “account closed” or otherwise dishonored, the remitter of the check shall be liable for a $30.00 return check service charge, in addition to the permit or other fee. The amount of the returned check, together with the service charge shall constitute a debt due the county, which may be collected by suit or otherwise. Nothing in this subsection shall be construed so as to exclude criminal prosecutions as in other cases involving dishonored checks. A return check shall void and nullify any approval granted by the administrator until such time new permit application are reviewed and approved by the administrator. Payment of those fees shall be either certified check or by cash.

**Secs. 13-44 to 13-65. Reserved.**

## ARTICLE III. PROVISIONS FOR FLOOD HAZARD REDUCTION

**Sec. 13-66. General standards.**

In all areas of special flood hazards (zones A, AE, AO and AH) the following provisions are required:

(1) All new construction including manufactured homes and substantial improvements shall be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy;

(2) All new construction and substantial improvements shall be constructed with materials and utility equipment resistant to flood damage;

(3) All new construction or substantial improvements shall be constructed by methods and practices that minimize flood damage;

(4) All new construction and substantial improvements shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding;

(5) All new and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the system;

(6) No portion of a private wastewater disposal system shall be constructed within the 100-year floodplain of any stream, river or watercourse unless written approval is obtained from the Director of the Department of Code Enforcement. This does not preclude repair of existing systems;

(7) On site waste disposal systems shall be located to avoid impairment to them or contamination from them flooding;

(8) The storage or processing of materials that are in time of flooding buoyant, flammable, explosive, or could be injurious to human, animal or plant life is prohibited;

(9) If otherwise permitted by zoning resolutions of Sedgwick County, storage of other material or equipment may be allowed if not subject to major damage by floods and

firmly anchored to prevent flotation or if readily removable from the area within the time available after flood warning; and,

(10) That until a floodway has been designated, no development, including landfill, may be permitted within any Zone AE on the County's FIRM unless the applicant for the land use has demonstrated that the proposed use, when combined with all other existing and reasonably anticipated uses, will not increase the water surface elevation of the 100-year flood more than one (1) foot on the average cross section of the reach in which the development or land-fill is located as shown on the Flood Insurance Study, Sedgwick County, Kansas, Unincorporated Area, which is incorporated by reference in Section 13-4.

(11) Structures used solely for agricultural purposes in connection with the production, harvesting, storage, drying, or raising of agricultural commodities, including the raising of livestock, may be constructed at-grade and wet-floodproofed provided there is no human habitation or occupancy of the structure; the structure is of single-wall design; there is no permanent retail, wholesale, or manufacturing use included in the structure; a variance has been granted from floodplain management requirements of this chapter; and a floodplain development permit has been issued.

(12) Structures used solely for parking and limited storage purposes, not attached to any other structure on the site, of limited investment value, and not larger than 400 square feet, may, be constructed at- grade and wet-floodproofed provided there is no human habitation or occupancy of the structure; the structure is of single-wall design; a variance has been granted from the standard floodplain management requirements of this chapter; and a floodplain development permit has been issued.

**Sec. 13-67. Standards for proposed subdivisions and new developments.**

In proposed subdivisions, new developments located in any areas of special flood hazard (zones A, AE, AO and AH), the following provisions shall be required:

(1) All proposed subdivisions and other proposed new developments, including manufactured home parks or subdivisions, shall be consistent with the need to minimize flood damage;

(2) All proposed subdivisions shall have public utilities and facilities such as sewer, gas, electrical and water systems located and constructed to minimize flood damage;

(3) All proposed subdivisions shall have adequate drainage provided to reduce exposure to flood hazards; and,

(4) Base flood elevation data shall be provided for proposed subdivisions and other proposed development (including proposed parks for manufactured homes and subdivisions), which is greater than either 50 lots or 5 acres.

**Sec. 13-68. Specific standards.**

(a) In all areas of special flood hazards where base flood elevation data has been provided as set forth in Section 13-4 or Section 13-36, (Zones AE, AH and AO) the following provisions are required:

(1) *Residential construction*. New construction or substantial improvement of any residential structure shall have the lowest floor elevated to at least two (2) feet of freeboard above the base flood elevation;

(2) *Nonresidential construction*. New construction or substantial improvement of any commercial, industrial or other non-residential structure shall either have the lowest floor, including basement, elevated at least two (2) feet of freeboard above the level of the base flood elevation or, together with attendant utility and sanitary facilities, be floodproofed so that below such a level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. A registered professional engineer or architect shall certify that the standards of this subsection are satisfied. Such certification shall be provided to the official as set forth in Section 13-36.

(3) Requirement for all new construction and substantial improvements. That fully enclosed areas below the lowest floor that are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one (1) foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters; and,

(4) *Manufactured homes.*

a. All manufactured homes to be placed within all unnumbered A zones, AE, and AH zones, on the community's FIRM shall be anchored to resist flotation, collapse, or lateral movement. Manufactured homes must be anchored in accordance with State and local building codes and FEMA guidelines. In the event that over-the-top frame ties to ground anchors are used, the following specific requirements (or their equivalent) shall be met:

1. Over-the-top ties shall be provided at each of the four (4) corners of the manufactured home, with two additional ties per side at intermediate locations and manufactured homes less than fifty (50) feet long requiring one additional tie per side;

2. Frame ties shall be provided at each corner of the home with five additional ties per side at intermediate points and manufactured homes less than 50 feet long requiring four (4) additional ties per side;

3. All components of the anchoring system be capable of carrying a force of four thousand eight hundred (4,800) pounds; and

4. Any additions to the manufactured home shall be similarly anchored.

b. All manufactured homes to be placed within zones A, AE, and AH on the community's FIRM on sites:

1. Outside of a manufactured home park or subdivision;

2. In a new expansion to an existing manufactured home park or subdivision;

3. In an expansion to an existing manufactured home park or subdivision; or

4. In an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as the result of a flood, shall be elevated on a permanent foundation such that the lowest floor of the manufactured home will be at least two (2) feet of freeboard above the base flood elevations; and be securely anchored to an adequately anchored foundation system in accordance with the provisions of subsection (4)a.

c. All manufactured homes to be placed or substantially improved on sites in an existing manufactured home park or subdivision within Zones A, AE, AO and AH on the community's FIRM that are not subject to the provisions of subsection (4)b shall be elevated so that either:

1. The lowest floor of the manufactured home will be at least two (2) feet of freeboard above the base flood elevation, or

2. The manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are not less than thirty-six (36) inches in height above the grade, and be securely anchored to an adequately anchored foundation system in accordance with the provisions of subsection (4)a.

(5) Recreational vehicles. It is required that recreational vehicles placed on sites within the identified floodplain on the community's FIRM either:

a. Be on the site for fewer than one hundred eighty (180) consecutive days;

b. Be fully licensed and ready for highway use; or

c. Meet the permit requirements and the elevation and anchoring requirements for manufactured homes contained herein. A recreational vehicle is ready for highway use if it is on its wheels or jacking system, is attached to the site only by quick disconnect type utilities and security devices, and has no permanently attached additions.

(b) In all areas of the special flood hazards where base flood data has not been determined and no high water records are available, other methods to determine the base flood elevation are to be used, such as Managing Floodplain Development in Approximate Zone A Areas, FEMA Publication 265/July 1995, as set forth in Section 13-4 and/or Section 13-36 (Zones A), and the following provisions are required:

(1) *Residential Construction*. New construction or substantial improvements of any residential structure located where there is no detailed study information shall have the lowest floor, including the basement, elevated to at least three (3) feet of freeboard above the estimated base flood elevation together with the attendant utilities and sewer facilities.

(2) *Nonresidential Construction*. New construction or substantial improvement of any commercial, industrial or other non-residential structure where there is no detailed study information shall either have the lowest floor, including basement, elevated to at least three (3) feet of freeboard above the level of the estimated base flood elevation together with the attendant utilities and sewer facilities, or be floodproofed so that below such a level the structure is water tight with walls substantially impermeable to the passage of water and with structure components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. A registered professional engineer or architect shall certify that the standards of this subsection are satisfied. Such certification shall be provided to the administrator as set forth in Section 13-36.

(c) A survey is required on all platted lots or unplatted tracts of land that have a FEMA mapped Zones A, AE, AH or AO floodplain prior to a building permit being issued. The owner/applicant must obtain the services of a licensed land surveyor to complete the following:

(1) Locate and set stakes identifying the limits of the mapped Zones A, AE, AH or AO.

(2) Locate and stake the four (4) corners of the proposed structure site.

(3) Set a reference elevation point (benchmark) for the construction of the proposed structure. The elevation datum is to be NAVD88.

(4) The owner/applicant must submit a certified drawing by the surveyor to Code Enforcement showing the location of the mapped floodplain, proposed structure site, ground elevations, location of reference elevation point (benchmark) and the

proposed elevation of the lowest opening to the structure to be approved before a building permit is issued.

**Sec. 13-69. Regulatory floodways**.

Located within areas of special flood hazard established in Section 13-4 are areas designated as regulatory floodways. Since the regulatory floodway may be an extremely hazardous area due to the velocity of floodwaters which carry debris, potential projectiles and erosion potential, the following provisions shall apply:

(1) Encroachments are prohibited, including fill, new construction, substantial improvements and other developments unless certification by a professional registered engineer or architect is provided demonstrating the encroachments shall not result in any increase in the base flood elevation anywhere on the subject flooding source during occurrence of the base flood discharge;

(2) If subsection (1) of this section is satisfied, all new construction and substantial improvements shall comply with all applicable flood hazard reduction provisions of Sections 13-66, 13-67, and 13-68; and,

(3) In zone A unnumbered, obtain review and reasonably utilize any floodway data available through federal, state or other sources or Section 13-67 in meeting the standards of this section.

**Sec. 13-70. Areas of Shallow Flooding.**

Located within the areas of special flood hazard established in Section 13-4, are areas designated as shallow flooding. These areas have special flood hazards associated with base flood depth of one (1) to three (3) feet where a clearly defined channel does not exist and where the path of flooding is unpredictable and indeterminate; therefore, the following provisions apply:

(1) Within AO Zones;

a. All new construction and substantial improvements of residential structures shall have the lowest floor elevated above the highest adjacent grade at least two (2) feet above the depth number specified in feet on the County's FIRM (at least two feet if no depth number is specified);

b. All new construction and substantial improvements of non-residential structures shall:

1. Have the lowest floor elevated above the highest adjacent grade at least as high as two (2) feet above the depth number specified in feet on the County's FIRM (at least two feet if no depth is specified), or

2. Together with attendant utility and sanitary facilities, be completely floodproofed to or above the level specified in subsection (1)b.1 of this

section, so that any space below that level is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

c. The anchoring requirements for manufactured homes as established in Section 13-68 shall be required.

(2) Within AH Zones;

a. The specific standards for all areas of special flood hazard where base flood elevation data has been provided shall be required as set forth in Section 13-68; and,

b. Adequate drainage paths around structures on slopes shall be required in order to guide floodwaters around and away from proposed structures.

**SECTION 2: SEVERABILITY CLAUSE.**

Should any section, clause or provision of this resolution be declared by any court of competent jurisdiction to be invalid, the same shall not affect the validity of this resolution as a whole, or any part thereof, other than the part so declared to be invalid, and to that end the provisions of this resolution are declared to be severable.

**SECTION 3: RESCISSION OF PRIOR RESOLUTION.**

Resolution Number 183-2004 titled "A Resolution Amending Chapter 13 Sedgwick County Code, Relating Floodplain Management for Sedgwick County, Kansas" dated October 13, 2004, is hereby rescinded by this resolution.

**SECTION 4: SAVING CLAUSE.**

All rights and remedies of Sedgwick County, and the property owners and residents thereof, are expressly saved as to any and all violations of the Sedgwick County Code, Chapter 13, Resolution Nos. 227-1988, 138-1995 and 183-2004, or any prior floodplain management resolution that have accrued at the time of the effective date of this resolution. The county shall have all the powers that existed prior to the effective date of this resolution as to all such accrued violations.

**SECTION 5: EFFECTIVE DATE.**

This resolution shall take effect upon its adoption by the Board of County Commissioners of Sedgwick County, Kansas, which occurred on the ________ day of ____________________, 20____.

**[APPROVALS ON FOLLOWING PAGES]**

# APPENDIX E

Acronym List

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**Table E-1 Acronym List and Respective Definitions.**

| Acronym | Definition |
|---|---|
| AASHTO | American Society of State Highway and Transportation Officials |
| ACI | American Concrete Institute |
| BFE | Base Flood Elevation |
| BMP | Best Management Practices |
| CLOMR | Conditional Letter of Map Revision |
| CWA | Clean Water Act |
| ESA | Endangered Species Act |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| ISD | Integrated Site Design |
| KDA | Kansas Department of Agriculture |
| KDHE | Kansas Department of Health and Environment |
| KDOT | Kansas Department of Transportation |
| KDWP | Kansas Department of Wildlife and Parks |
| KHRI | Kansas Historic Resources Inventory |
| KHS | Kansas Historical Society |
| LOMR | Letter of Map Revision |
| MAPC | Metropolitan Area Planning Commission |
| MS4 | Municipal Separate Storm Sewer System |
| NEPA | National Environmental Policy Act |
| NFIP | National Flood Insurance Program |
| NOAA | National Oceanic and Atmospheric Administration |
| NOC | Notice of Coverage |
| NOI | Notice of Intent |
| NOT | Notice of Termination |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resources Conservation Service (formerly SCS) |
| NWS | National Weather Service |
| O&M | Operations & Maintenance |
| PSD | Preferred Site Design |
| SCS | Soil Conservation Service (Now NRCS) |
| SWMM | Stormwater Management Model |
| SWMP | Stormwater Management Program |
| SWPPP | Stormwater Pollution Prevention Plan |
| TAC | Technical Advisory Committee |
| TMDL | Total Maximum Daily Loads |
| UDFCD | Urban Drainage and Flood Control District |
| USACE | U.S. Army Corps of Engineer |
| USDA | U.S. Department of Agriculture |
| USDOT | U.S. Department of Transportation |
| USFWS | U.S. Fish and Wildlife Service |

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# APPENDIX F

Reference List

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## REFERENCES

Booth, Derek. 1990. Stream channel incision following drainage basin urbanization. Water Resources Bulletin: 26.

Bledsoe, B. and C. Watson. 2001. Effects of urbanization on channel stability. Journal of the American Water Resources Association: 37(2).

Environmental Protection Agency. 1997. Urbanization and Streams: Studies of Hydrologic Impacts. EPA Document: 841-R-97-009.

FISRWG (10/1998). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.

Leopold, L., Wolman, M. and J. Miller. 1964. Fluvial Processes in Geomorphology.

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# APPENDIX G

Map of Downstream Protection Volume Watersheds and Channels

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Appendix G-1

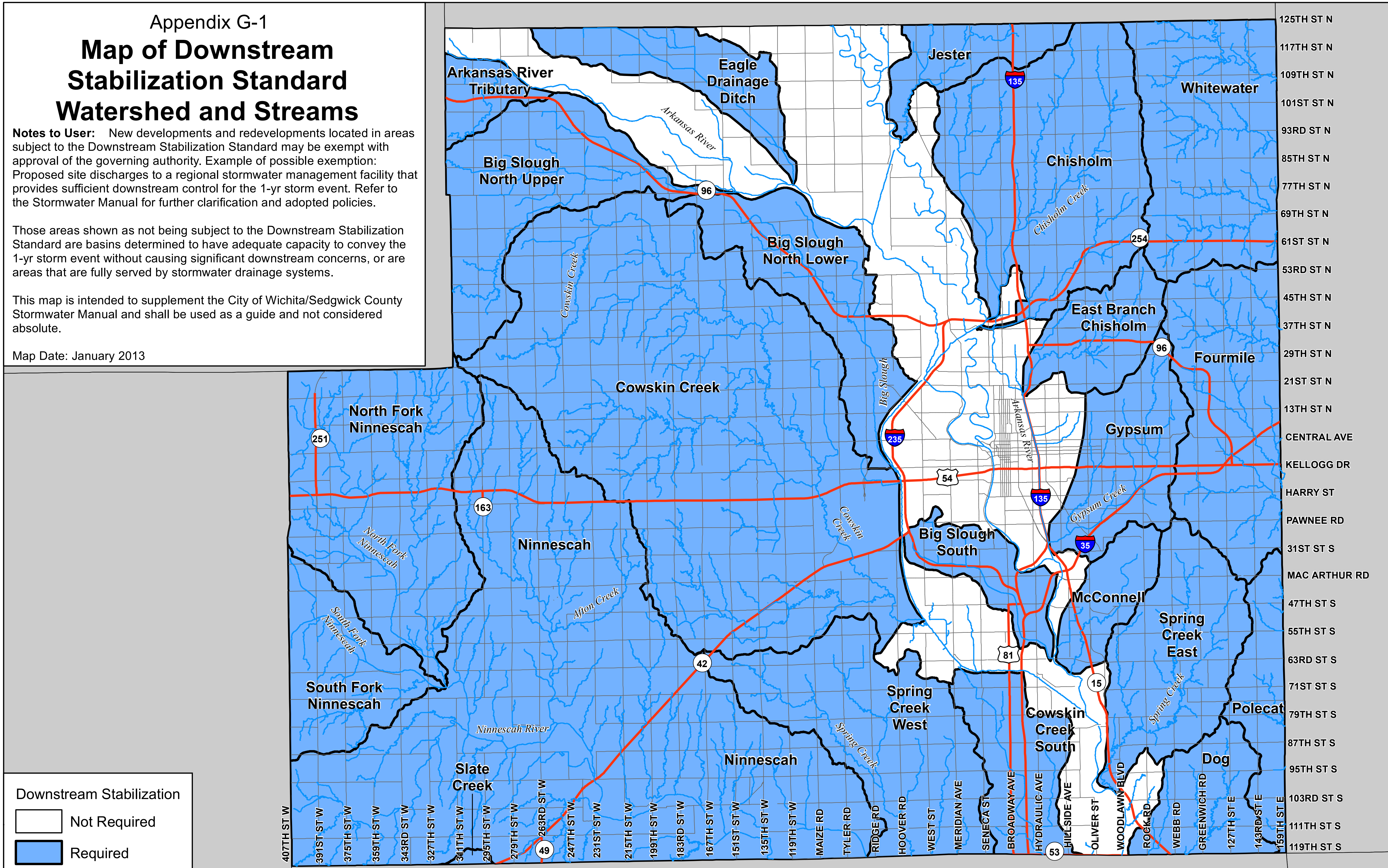
# Map of Downstream Stabilization Standard Watershed and Streams

**Notes to User:** New developments and redevelopments located in areas subject to the Downstream Stabilization Standard may be exempt with approval of the governing authority. Example of possible exemption: Proposed site discharges to a regional stormwater management facility that provides sufficient downstream control for the 1-yr storm event. Refer to the Stormwater Manual for further clarification and adopted policies.

Those areas shown as not being subject to the Downstream Stabilization Standard are basins determined to have adequate capacity to convey the 1-yr storm event without causing significant downstream concerns, or are areas that are fully served by stormwater drainage systems.

This map is intended to supplement the City of Wichita/Sedgwick County Stormwater Manual and shall be used as a guide and not considered absolute.

Map Date: January 2013



Appendix G-2

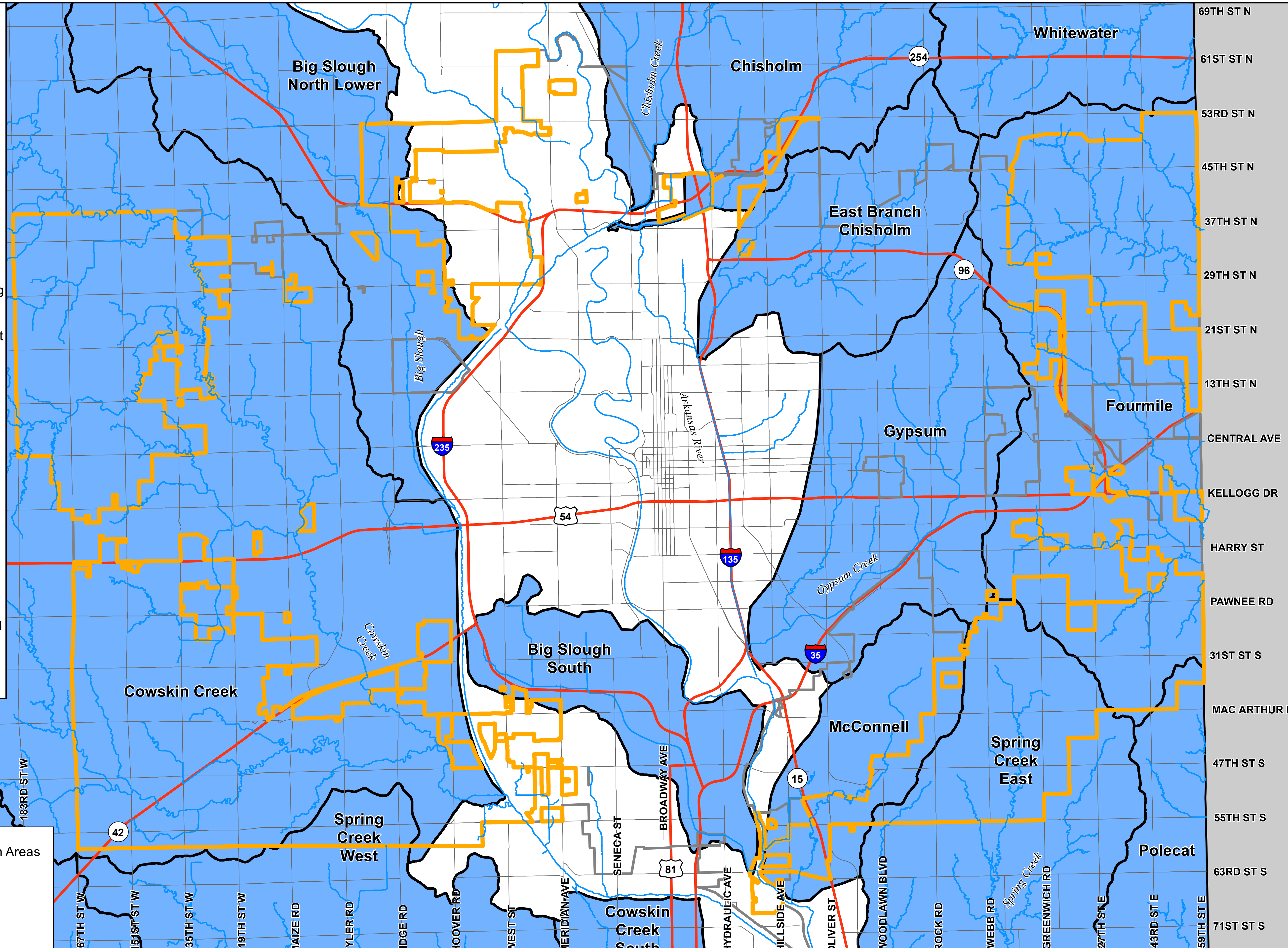
# Map of Downstream Stabilization Standard Watershed and Streams

**Notes to User:** New developments and redevelopments located in areas subject to the Downstream Stabilization Standard may be exempt with approval of the governing authority. Example of possible exemption: Proposed site discharges to a regional stormwater management facility that provides sufficient downstream control for the 1-yr storm event. Refer to the Stormwater Manual for further clarification and adopted policies.

Those areas shown as not being subject to the Downstream Stabilization Standard are basins determined to have adequate capacity to convey the 1-yr storm event without causing significant downstream concerns, or are areas that are fully served by stormwater drainage systems.

This map is intended to supplement the City of Wichita/Sedgwick County Stormwater Manual and shall be used as a guide and not considered absolute.

Map Date: January 2013



Appendix H-1

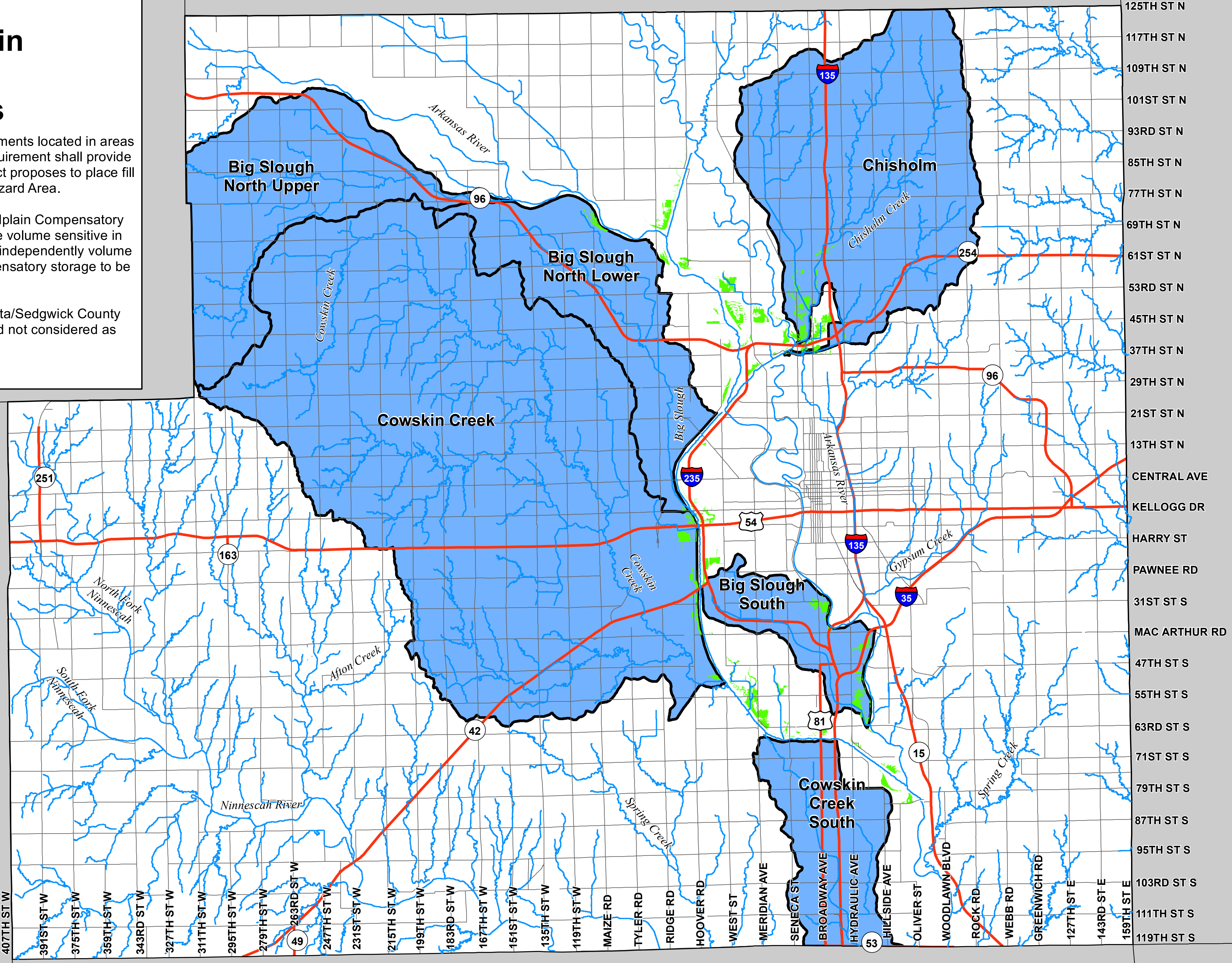
# Map of Floodplain Compensatory Storage Basins

**Notes to User:** New developments and redevelopments located in areas subject to the Floodplain Compensatory Storage requirement shall provide offsetting compensatory storage whenever the project proposes to place fill within a local floodplain or a FEMA Special Flood Hazard Area.

Those areas shown as not being subject to the Floodplain Compensatory Storage requirement have been determined to not be volume sensitive in nature. However, if sub-basins are determined to be independently volume sensitive, the governing authority may require compensatory storage to be provided, regardless of location.

This map is intended to supplement the City of Wichita/Sedgwick County Stormwater Manual and shall be used as a guide and not considered as absolute.

Map Date: January 2013




Requiring Compenstory Storage Due to Levee Ponding Areas

Requiring Floodplain Compensatory Storage

# APPENDIX B

Rainfall Intensity Table for Sedgwick County, Kansas

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Intensity values are based on regression analysis of data obtained from NOAA Atlas 14, Volume 8); Return Periods 1-yr through 10-yr based on Point Precipitation Frequency Estimates (Partial Duration Series); Return Periods 25-yr through 1000-yr based on Point Precipitation Frequency Estimates (Annual Maximum Series). Data values used in the regression analysis were obtained from the NOAA Precipitation Frequency Data Server for Wichita-Mid Continent weather station location.

**Table 1 City of Wichita and Sedgwick County, KS Rainfall Intensity Table (Duration 5 min – 120 min)**

| DURATION in hours | DURATION in | Return Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
| 0.0833 | 5 | 5.07 | 5.43 | 6.79 | 7.82 | 9.14 | 10.16 | 11.17 | 12.16 | 13.45 | 14.44 |
| 0.1000 | 6 | 4.75 | 5.08 | 6.35 | 7.30 | 8.53 | 9.46 | 10.38 | 11.28 | 12.45 | 13.32 |
| 0.1167 | 7 | 4.47 | 4.78 | 5.97 | 6.87 | 8.02 | 8.88 | 9.73 | 10.56 | 11.64 | 12.44 |
| 0.1333 | 8 | 4.22 | 4.52 | 5.65 | 6.49 | 7.58 | 8.39 | 9.18 | 9.96 | 10.97 | 11.71 |
| 0.1500 | 9 | 4.01 | 4.29 | 5.36 | 6.16 | 7.19 | 7.96 | 8.71 | 9.44 | 10.40 | 11.10 |
| 0.1667 | 10 | 3.82 | 4.09 | 5.11 | 5.87 | 6.86 | 7.59 | 8.30 | 9.00 | 9.91 | 10.57 |
| 0.1833 | 11 | 3.65 | 3.90 | 4.88 | 5.62 | 6.56 | 7.26 | 7.94 | 8.61 | 9.48 | 10.12 |
| 0.2000 | 12 | 3.50 | 3.74 | 4.68 | 5.38 | 6.29 | 6.96 | 7.62 | 8.26 | 9.10 | 9.72 |
| 0.2167 | 13 | 3.36 | 3.59 | 4.50 | 5.18 | 6.05 | 6.70 | 7.33 | 7.95 | 8.76 | 9.36 |
| 0.2333 | 14 | 3.23 | 3.46 | 4.33 | 4.99 | 5.83 | 6.46 | 7.07 | 7.67 | 8.46 | 9.04 |
| 0.2500 | 15 | 3.12 | 3.34 | 4.18 | 4.81 | 5.63 | 6.24 | 6.83 | 7.42 | 8.19 | 8.75 |
| 0.2667 | 16 | 3.01 | 3.22 | 4.04 | 4.66 | 5.45 | 6.04 | 6.62 | 7.19 | 7.94 | 8.49 |
| 0.2833 | 17 | 2.92 | 3.12 | 3.92 | 4.51 | 5.28 | 5.86 | 6.42 | 6.98 | 7.71 | 8.25 |
| 0.3000 | 18 | 2.83 | 3.02 | 3.80 | 4.37 | 5.13 | 5.69 | 6.24 | 6.78 | 7.50 | 8.03 |
| 0.3167 | 19 | 2.74 | 2.93 | 3.69 | 4.25 | 4.99 | 5.53 | 6.07 | 6.60 | 7.31 | 7.83 |
| 0.3333 | 20 | 2.67 | 2.85 | 3.58 | 4.13 | 4.85 | 5.38 | 5.91 | 6.43 | 7.13 | 7.64 |
| 0.3500 | 21 | 2.59 | 2.77 | 3.49 | 4.02 | 4.73 | 5.25 | 5.76 | 6.28 | 6.96 | 7.46 |
| 0.3667 | 22 | 2.52 | 2.70 | 3.40 | 3.92 | 4.61 | 5.12 | 5.63 | 6.13 | 6.80 | 7.30 |
| 0.3833 | 23 | 2.46 | 2.63 | 3.32 | 3.83 | 4.50 | 5.00 | 5.50 | 6.00 | 6.65 | 7.14 |
| 0.4000 | 24 | 2.40 | 2.57 | 3.24 | 3.74 | 4.40 | 4.89 | 5.38 | 5.87 | 6.52 | 7.00 |
| 0.4167 | 25 | 2.34 | 2.51 | 3.16 | 3.65 | 4.30 | 4.78 | 5.27 | 5.75 | 6.39 | 6.87 |
| 0.4333 | 26 | 2.29 | 2.45 | 3.09 | 3.57 | 4.21 | 4.68 | 5.16 | 5.63 | 6.26 | 6.74 |
| 0.4500 | 27 | 2.24 | 2.40 | 3.02 | 3.50 | 4.12 | 4.59 | 5.06 | 5.53 | 6.15 | 6.62 |
| 0.4667 | 28 | 2.19 | 2.34 | 2.96 | 3.42 | 4.04 | 4.50 | 4.96 | 5.42 | 6.04 | 6.50 |
| 0.4833 | 29 | 2.15 | 2.30 | 2.90 | 3.35 | 3.96 | 4.42 | 4.87 | 5.33 | 5.94 | 6.39 |
| 0.5000 | 30 | 2.10 | 2.25 | 2.84 | 3.29 | 3.89 | 4.33 | 4.78 | 5.24 | 5.84 | 6.29 |
| 0.5167 | 31 | 2.06 | 2.20 | 2.79 | 3.23 | 3.82 | 4.26 | 4.70 | 5.15 | 5.74 | 6.19 |
| 0.5333 | 32 | 2.02 | 2.16 | 2.74 | 3.17 | 3.75 | 4.18 | 4.62 | 5.06 | 5.65 | 6.10 |
| 0.5500 | 33 | 1.98 | 2.12 | 2.69 | 3.11 | 3.68 | 4.11 | 4.55 | 4.98 | 5.57 | 6.01 |
| 0.5667 | 34 | 1.95 | 2.08 | 2.64 | 3.06 | 3.62 | 4.05 | 4.48 | 4.91 | 5.48 | 5.92 |
| 0.5833 | 35 | 1.91 | 2.05 | 2.59 | 3.01 | 3.56 | 3.98 | 4.41 | 4.83 | 5.40 | 5.84 |
| 0.6000 | 36 | 1.88 | 2.01 | 2.55 | 2.96 | 3.50 | 3.92 | 4.34 | 4.76 | 5.33 | 5.76 |
| 0.6167 | 37 | 1.85 | 1.98 | 2.51 | 2.91 | 3.45 | 3.86 | 4.28 | 4.70 | 5.26 | 5.69 |
| 0.6333 | 38 | 1.82 | 1.94 | 2.47 | 2.86 | 3.40 | 3.80 | 4.22 | 4.63 | 5.19 | 5.61 |
| 0.6500 | 39 | 1.79 | 1.91 | 2.43 | 2.82 | 3.35 | 3.75 | 4.16 | 4.57 | 5.12 | 5.54 |
| 0.6667 | 40 | 1.76 | 1.88 | 2.39 | 2.78 | 3.30 | 3.70 | 4.10 | 4.51 | 5.06 | 5.48 |
| 0.6833 | 41 | 1.73 | 1.85 | 2.36 | 2.74 | 3.25 | 3.65 | 4.05 | 4.45 | 4.99 | 5.41 |
| 0.7000 | 42 | 1.71 | 1.83 | 2.32 | 2.70 | 3.21 | 3.60 | 3.99 | 4.39 | 4.93 | 5.35 |
| 0.7167 | 43 | 1.68 | 1.80 | 2.29 | 2.66 | 3.16 | 3.55 | 3.94 | 4.34 | 4.88 | 5.29 |
| 0.7333 | 44 | 1.66 | 1.77 | 2.26 | 2.62 | 3.12 | 3.51 | 3.89 | 4.29 | 4.82 | 5.23 |
| 0.7500 | 45 | 1.63 | 1.75 | 2.22 | 2.59 | 3.08 | 3.46 | 3.85 | 4.24 | 4.76 | 5.17 |
| 0.7667 | 46 | 1.61 | 1.72 | 2.19 | 2.55 | 3.04 | 3.42 | 3.80 | 4.19 | 4.71 | 5.12 |
| 0.7833 | 47 | 1.59 | 1.70 | 2.17 | 2.52 | 3.00 | 3.38 | 3.76 | 4.14 | 4.66 | 5.07 |
| 0.8000 | 48 | 1.57 | 1.68 | 2.14 | 2.49 | 2.97 | 3.34 | 3.71 | 4.10 | 4.61 | 5.01 |
| 0.8167 | 49 | 1.55 | 1.66 | 2.11 | 2.46 | 2.93 | 3.30 | 3.67 | 4.05 | 4.56 | 4.96 |
| 0.8333 | 50 | 1.53 | 1.63 | 2.08 | 2.43 | 2.90 | 3.26 | 3.63 | 4.01 | 4.52 | 4.92 |
| 0.8500 | 51 | 1.51 | 1.61 | 2.06 | 2.40 | 2.86 | 3.22 | 3.59 | 3.97 | 4.47 | 4.87 |
| 0.8667 | 52 | 1.49 | 1.59 | 2.03 | 2.37 | 2.83 | 3.19 | 3.56 | 3.93 | 4.43 | 4.82 |
| 0.8833 | 53 | 1.47 | 1.57 | 2.01 | 2.34 | 2.80 | 3.16 | 3.52 | 3.89 | 4.39 | 4.78 |
| 0.9000 | 54 | 1.45 | 1.56 | 1.99 | 2.32 | 2.77 | 3.12 | 3.48 | 3.85 | 4.35 | 4.74 |
| 0.9167 | 55 | 1.43 | 1.54 | 1.96 | 2.29 | 2.74 | 3.09 | 3.45 | 3.81 | 4.31 | 4.69 |
| 0.9333 | 56 | 1.42 | 1.52 | 1.94 | 2.27 | 2.71 | 3.06 | 3.41 | 3.78 | 4.27 | 4.65 |
| 0.9500 | 57 | 1.40 | 1.50 | 1.92 | 2.24 | 2.68 | 3.03 | 3.38 | 3.74 | 4.23 | 4.61 |
| 0.9667 | 58 | 1.39 | 1.49 | 1.90 | 2.22 | 2.65 | 3.00 | 3.35 | 3.71 | 4.19 | 4.57 |
| 0.9833 | 59 | 1.37 | 1.47 | 1.88 | 2.19 | 2.63 | 2.97 | 3.32 | 3.67 | 4.16 | 4.54 |

| DURATION in hours | DURATION in | Return Period 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0000 | 60 | 1.36 | 1.45 | 1.86 | 2.17 | 2.60 | 2.94 | 3.29 | 3.64 | 4.12 | 4.50 |
| 1.0167 | 61 | 1.34 | 1.44 | 1.84 | 2.15 | 2.58 | 2.91 | 3.26 | 3.61 | 4.09 | 4.46 |
| 1.0333 | 62 | 1.33 | 1.42 | 1.82 | 2.13 | 2.55 | 2.88 | 3.23 | 3.58 | 4.05 | 4.43 |
| 1.0500 | 63 | 1.31 | 1.41 | 1.80 | 2.11 | 2.53 | 2.86 | 3.20 | 3.55 | 4.02 | 4.39 |
| 1.0667 | 64 | 1.30 | 1.39 | 1.78 | 2.09 | 2.50 | 2.83 | 3.17 | 3.52 | 3.99 | 4.36 |
| 1.0833 | 65 | 1.29 | 1.38 | 1.77 | 2.07 | 2.48 | 2.81 | 3.14 | 3.49 | 3.96 | 4.33 |
| 1.1000 | 66 | 1.27 | 1.36 | 1.75 | 2.05 | 2.46 | 2.78 | 3.12 | 3.46 | 3.93 | 4.30 |
| 1.1167 | 67 | 1.26 | 1.35 | 1.73 | 2.03 | 2.44 | 2.76 | 3.09 | 3.43 | 3.90 | 4.26 |
| 1.1333 | 68 | 1.25 | 1.34 | 1.72 | 2.01 | 2.41 | 2.74 | 3.07 | 3.41 | 3.87 | 4.23 |
| 1.1500 | 69 | 1.24 | 1.33 | 1.70 | 1.99 | 2.39 | 2.71 | 3.04 | 3.38 | 3.84 | 4.20 |
| 1.1667 | 70 | 1.22 | 1.31 | 1.69 | 1.97 | 2.37 | 2.69 | 3.02 | 3.35 | 3.81 | 4.18 |
| 1.1833 | 71 | 1.21 | 1.30 | 1.67 | 1.96 | 2.35 | 2.67 | 2.99 | 3.33 | 3.78 | 4.15 |
| 1.2000 | 72 | 1.20 | 1.29 | 1.65 | 1.94 | 2.33 | 2.65 | 2.97 | 3.30 | 3.76 | 4.12 |
| 1.2167 | 73 | 1.19 | 1.28 | 1.64 | 1.92 | 2.31 | 2.63 | 2.95 | 3.28 | 3.73 | 4.09 |
| 1.2333 | 74 | 1.18 | 1.27 | 1.63 | 1.91 | 2.30 | 2.61 | 2.93 | 3.26 | 3.70 | 4.06 |
| 1.2500 | 75 | 1.17 | 1.25 | 1.61 | 1.89 | 2.28 | 2.59 | 2.91 | 3.23 | 3.68 | 4.04 |
| 1.2667 | 76 | 1.16 | 1.24 | 1.60 | 1.88 | 2.26 | 2.57 | 2.88 | 3.21 | 3.66 | 4.01 |
| 1.2833 | 77 | 1.15 | 1.23 | 1.59 | 1.86 | 2.24 | 2.55 | 2.86 | 3.19 | 3.63 | 3.99 |
| 1.3000 | 78 | 1.14 | 1.22 | 1.57 | 1.85 | 2.22 | 2.53 | 2.84 | 3.17 | 3.61 | 3.96 |
| 1.3167 | 79 | 1.13 | 1.21 | 1.56 | 1.83 | 2.21 | 2.51 | 2.82 | 3.15 | 3.58 | 3.94 |
| 1.3333 | 80 | 1.12 | 1.20 | 1.55 | 1.82 | 2.19 | 2.49 | 2.80 | 3.12 | 3.56 | 3.91 |
| 1.3500 | 81 | 1.11 | 1.19 | 1.53 | 1.80 | 2.17 | 2.47 | 2.78 | 3.10 | 3.54 | 3.89 |
| 1.3667 | 82 | 1.10 | 1.18 | 1.52 | 1.79 | 2.16 | 2.46 | 2.76 | 3.08 | 3.52 | 3.87 |
| 1.3833 | 83 | 1.09 | 1.17 | 1.51 | 1.77 | 2.14 | 2.44 | 2.75 | 3.06 | 3.49 | 3.84 |
| 1.4000 | 84 | 1.08 | 1.16 | 1.50 | 1.76 | 2.13 | 2.42 | 2.73 | 3.04 | 3.47 | 3.82 |
| 1.4167 | 85 | 1.08 | 1.15 | 1.49 | 1.75 | 2.11 | 2.41 | 2.71 | 3.02 | 3.45 | 3.80 |
| 1.4333 | 86 | 1.07 | 1.15 | 1.48 | 1.74 | 2.10 | 2.39 | 2.69 | 3.01 | 3.43 | 3.78 |
| 1.4500 | 87 | 1.06 | 1.14 | 1.47 | 1.72 | 2.08 | 2.37 | 2.68 | 2.99 | 3.41 | 3.76 |
| 1.4667 | 88 | 1.05 | 1.13 | 1.45 | 1.71 | 2.07 | 2.36 | 2.66 | 2.97 | 3.39 | 3.73 |
| 1.4833 | 89 | 1.04 | 1.12 | 1.44 | 1.70 | 2.05 | 2.34 | 2.64 | 2.95 | 3.37 | 3.71 |
| 1.5000 | 90 | 1.04 | 1.11 | 1.43 | 1.69 | 2.04 | 2.33 | 2.63 | 2.93 | 3.35 | 3.69 |
| 1.5167 | 91 | 1.03 | 1.10 | 1.42 | 1.68 | 2.03 | 2.31 | 2.61 | 2.92 | 3.33 | 3.67 |
| 1.5333 | 92 | 1.02 | 1.09 | 1.41 | 1.66 | 2.01 | 2.30 | 2.59 | 2.90 | 3.32 | 3.65 |
| 1.5500 | 93 | 1.01 | 1.09 | 1.40 | 1.65 | 2.00 | 2.28 | 2.58 | 2.88 | 3.30 | 3.64 |
| 1.5667 | 94 | 1.01 | 1.08 | 1.39 | 1.64 | 1.99 | 2.27 | 2.56 | 2.87 | 3.28 | 3.62 |
| 1.5833 | 95 | 1.00 | 1.07 | 1.38 | 1.63 | 1.97 | 2.25 | 2.55 | 2.85 | 3.26 | 3.60 |
| 1.6000 | 96 | 0.99 | 1.06 | 1.37 | 1.62 | 1.96 | 2.24 | 2.53 | 2.83 | 3.25 | 3.58 |
| 1.6167 | 97 | 0.98 | 1.06 | 1.37 | 1.61 | 1.95 | 2.23 | 2.52 | 2.82 | 3.23 | 3.56 |
| 1.6333 | 98 | 0.98 | 1.05 | 1.36 | 1.60 | 1.94 | 2.21 | 2.50 | 2.80 | 3.21 | 3.54 |
| 1.6500 | 99 | 0.97 | 1.04 | 1.35 | 1.59 | 1.93 | 2.20 | 2.49 | 2.79 | 3.19 | 3.53 |
| 1.6667 | 100 | 0.96 | 1.04 | 1.34 | 1.58 | 1.91 | 2.19 | 2.48 | 2.77 | 3.18 | 3.51 |
| 1.6833 | 101 | 0.96 | 1.03 | 1.33 | 1.57 | 1.90 | 2.18 | 2.46 | 2.76 | 3.16 | 3.49 |
| 1.7000 | 102 | 0.95 | 1.02 | 1.32 | 1.56 | 1.89 | 2.16 | 2.45 | 2.74 | 3.15 | 3.48 |
| 1.7167 | 103 | 0.95 | 1.01 | 1.31 | 1.55 | 1.88 | 2.15 | 2.43 | 2.73 | 3.13 | 3.46 |
| 1.7333 | 104 | 0.94 | 1.01 | 1.30 | 1.54 | 1.87 | 2.14 | 2.42 | 2.71 | 3.12 | 3.44 |
| 1.7500 | 105 | 0.93 | 1.00 | 1.30 | 1.53 | 1.86 | 2.13 | 2.41 | 2.70 | 3.10 | 3.43 |
| 1.7667 | 106 | 0.93 | 1.00 | 1.29 | 1.52 | 1.85 | 2.12 | 2.40 | 2.69 | 3.09 | 3.41 |
| 1.7833 | 107 | 0.92 | 0.99 | 1.28 | 1.51 | 1.84 | 2.10 | 2.38 | 2.67 | 3.07 | 3.40 |
| 1.8000 | 108 | 0.92 | 0.98 | 1.27 | 1.50 | 1.83 | 2.09 | 2.37 | 2.66 | 3.06 | 3.38 |
| 1.8167 | 109 | 0.91 | 0.98 | 1.27 | 1.49 | 1.82 | 2.08 | 2.36 | 2.65 | 3.04 | 3.36 |
| 1.8333 | 110 | 0.90 | 0.97 | 1.26 | 1.49 | 1.81 | 2.07 | 2.35 | 2.63 | 3.03 | 3.35 |
| 1.8500 | 111 | 0.90 | 0.96 | 1.25 | 1.48 | 1.80 | 2.06 | 2.33 | 2.62 | 3.01 | 3.34 |
| 1.8667 | 112 | 0.89 | 0.96 | 1.24 | 1.47 | 1.79 | 2.05 | 2.32 | 2.61 | 3.00 | 3.32 |
| 1.8833 | 113 | 0.89 | 0.95 | 1.24 | 1.46 | 1.78 | 2.04 | 2.31 | 2.60 | 2.99 | 3.31 |
| 1.9000 | 114 | 0.88 | 0.95 | 1.23 | 1.45 | 1.77 | 2.03 | 2.30 | 2.58 | 2.97 | 3.29 |
| 1.9167 | 115 | 0.88 | 0.94 | 1.22 | 1.44 | 1.76 | 2.02 | 2.29 | 2.57 | 2.96 | 3.28 |
| 1.9333 | 116 | 0.87 | 0.94 | 1.21 | 1.44 | 1.75 | 2.01 | 2.28 | 2.56 | 2.95 | 3.26 |
| 1.9500 | 117 | 0.87 | 0.93 | 1.21 | 1.43 | 1.74 | 2.00 | 2.27 | 2.55 | 2.93 | 3.25 |
| 1.9667 | 118 | 0.86 | 0.93 | 1.20 | 1.42 | 1.73 | 1.99 | 2.26 | 2.54 | 2.92 | 3.24 |
| 1.9833 | 119 | 0.86 | 0.92 | 1.19 | 1.41 | 1.72 | 1.98 | 2.25 | 2.52 | 2.91 | 3.22 |
| 2.0000 | 120 | 0.85 | 0.92 | 1.19 | 1.41 | 1.71 | 1.97 | 2.23 | 2.51 | 2.90 | 3.21 |

- -

Constants for use in the General Rainfall Intensity Equation are based on regression analysis of data obtained from NOAA Atlas 14, Volume 8); Return Periods 1-yr through 10-yr based on Point Precipitation Frequency Estimates (Partial Duration Series); Return Periods 25-yr through 1000-yr based on Point Precipitation Frequency Estimates (Annual Maximum Series). Data values used in the regression analysis were obtained from the NOAA Precipitation Frequency Data Server for Wichita-Mid Continent weather station location.

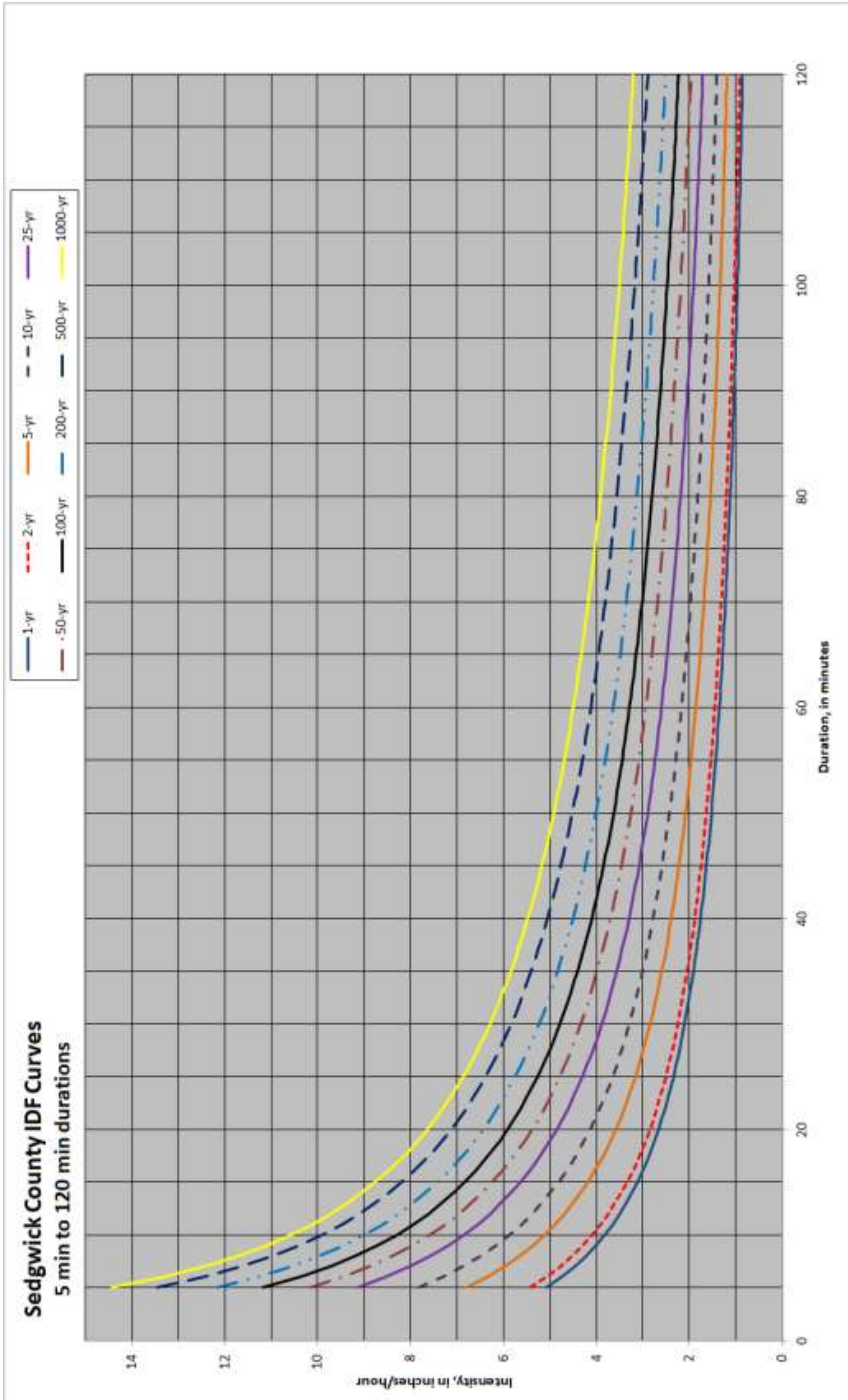
**General Rainfall Intensity Equation**

$$i = \frac{a}{(D+b)^m}$$

*i* = intensity in in/hr
D = Duration of rainfall in minutes
a, b, & m = constants shown in Table 2 below

**Table 2 City of Wichita and Sedgwick County, General Rainfall Intensity Equation Constants (Durations from 5-min to 120 min)**

| | Return Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
| a | 26.462 | 27.843 | 31.881 | 33.778 | 35.588 | 35.372 | 34.955 | 34.688 | 34.486 | 33.743 |
| b | 5.20 | 5.08 | 4.67 | 4.20 | 3.66 | 2.99 | 2.35 | 1.81 | 1.19 | 0.64 |
| m | 0.7113 | 0.7072 | 0.6817 | 0.6593 | 0.6298 | 0.6004 | 0.5721 | 0.5466 | 0.5164 | 0.4908 |


Sedgwick County IDF Curves
5 min to 120 min durations
1-yr
2-yr
5-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
1000-yr
Intensity, in inches/hour
0
2
4
6
8
10
12
14
Duration, in minutes
0
20
40
60
80
100
120

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## Volume 2 – Stormwater Drainage Criteria and Design Manual

CHAPTER

1

# OVERVIEW OF INTEGRATED SITE DESIGN

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## 1.1 Purpose and Scope of the Technical Guidance Manual

The Stormwater Manual for the City of Wichita and Sedgwick County consists of three volumes:

- Volume 1 – Policy Manual
- Volume 2 – Technical Guidance Manual
- Volume 3 – Plan Preparation Guidance Manual

Volume 1 is an overview of the general stormwater policies that form much of the basis for the stormwater and floodplain ordinances, and the criteria and guidelines presented in Volume 2 and Volume 3. Volume 3 is intended to assist the developer and the developer's designers in the plan preparation, review and approval process. The purpose of this Manual (Volume 2 - Technical Guidance Manual) is to provide guidelines and certain criteria to be used in the design and maintenance of stormwater management facilities constructed for new developments or redevelopments. The guidance presented in this volume is intended to be consistent with the stormwater policies adopted by the City of Wichita and Sedgwick County (and presented in Volume 1), and the stormwater management and floodplain regulations for each jurisdiction. Where inconsistencies occur between the Manual and the regulation(s), the latter shall apply.

## 1.2 How to Use this Manual

A graphical stormwater manual navigation aide is provided on the next pages to assist the user in the application of this Manual to the specific local development process. These aides depict the general steps for land development in the City of Wichita and Sedgwick County. The appropriate corresponding chapters/sections/appendices for each development process step are also shown.

## 1.3 Integrated Site Design

This section provides guidance on the Integrated Site Design (ISD) methodology whereby the need to control both the water quality and water quantity impacts of new development are incorporated into a comprehensive, coordinated plan for the development site. Included are specific structural and non-structural controls or practices that may be used to accomplish those requirements. In addition, basic guidelines and criteria for the design of stormwater management infrastructure are included. The rationale behind the use of an integrated site design approach is presented in Volume 1 and therefore is not repeated here.

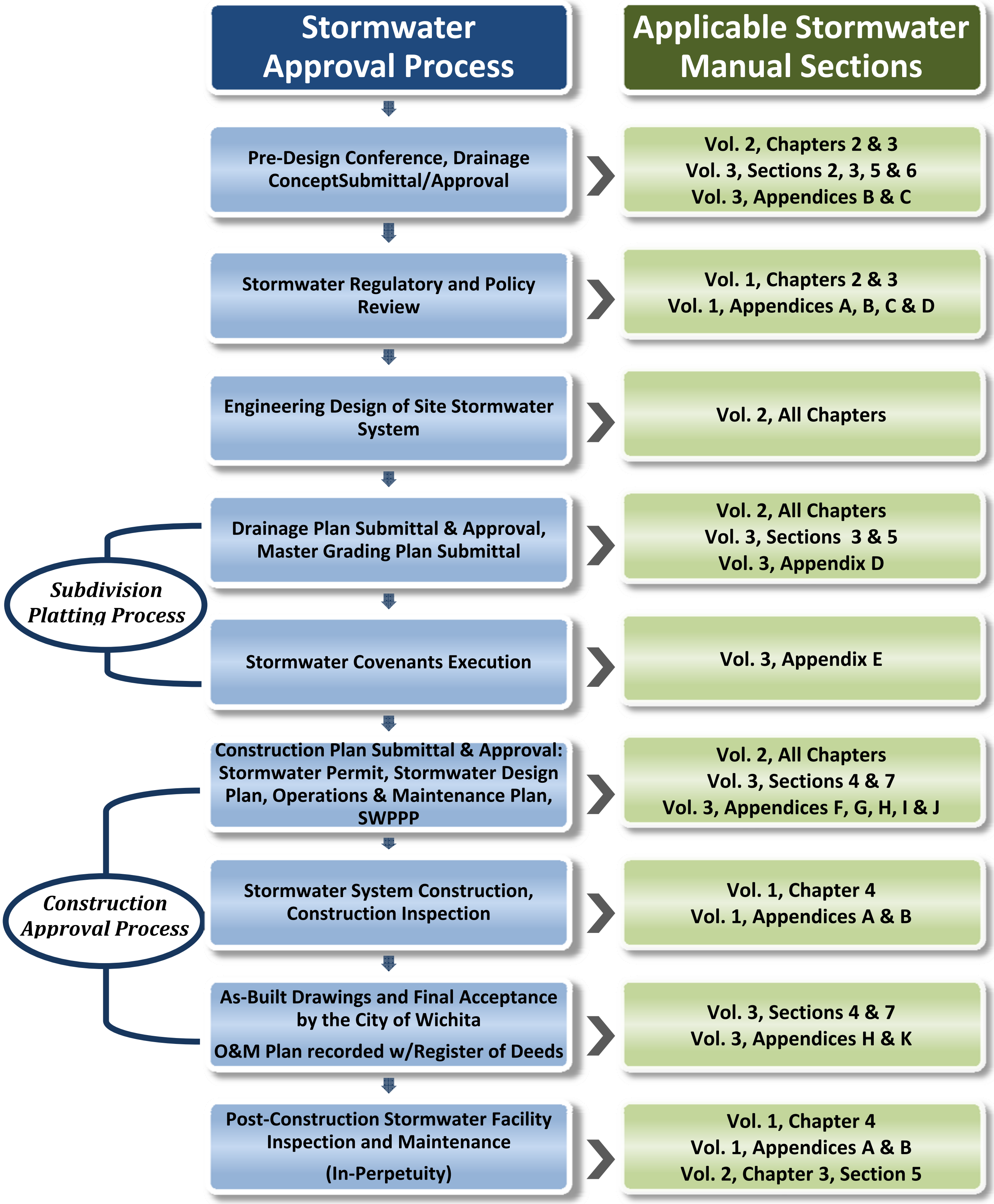


**Figure 1-1 Manual Navigational Aide for the City/County Land Development Process**

### 1.3.1 Goals

The basic goals of integrated site design for stormwater management facilities for new development or redevelopment, as defined in the relevant ordinances, are:

- To the maximum extent practicable, remove pollutants from the stormwater runoff from the development to protect water quality;
- Prevent increases in long-term downstream bank and channel erosion due to the development;
- Safely convey stormwater runoff through the project stormwater control system;
- Safely pass stormwater runoff through the downstream project boundary and control facilities without increasing peak flow rates at the project boundary; and,
- Prevent increases in flooding downstream of the development boundary.

The ISD approach is a coordinated set of design standards used to design stormwater controls to address these goals. Each of the ISD design steps may be used in conjunction with the other steps in the process to address the overall stormwater impacts from a developed site. When used as a set, the ISD approach addresses a wide range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour rain event.

The requirements for achieving the ISD goals are presented in Table 1-1 as steps in the ISD process. Please note that there are some limited exceptions to these requirements. Those exceptions are presented in the ordinances and/or in the detailed discussions of the requirements.

**Table 1-1 Steps for Integrated Site Design**

| Steps | Approach |
|---|---|
| **Step 1:** Water Quality Protection | The Water Quality Protection Volume ($WQ_v$) is the volume of runoff from the development as a result of the $85^{th}$ percentile rain event. In the Wichita and Sedgwick County area, this is the 1.2 inch rain event. Water quality protection must be achieved by treating the $WQ_v$ to remove 80% of the total suspended solids from the development site runoff. |
| **Step 2:** Channel Protection | The Channel Protection Volume ($CP_v$) is the volume of temporary detention required to detain the development site runoff for the 1-year, 24-hour rain event (of 2.8") for a minimum of 24 hours (centroid-to-centroid) to prevent increased long-term downstream channel erosion. Alternatively, the difference in pre- and post-development runoff for the 1-year, 24-hour rain event may be retained on-site and released through evapotranspiration and/or infiltration, or reused. |
| **Step 3:** On-Site Stormwater Conveyance | On-site conveyances must be designed to convey their applicable design rain events (see criteria in Chapter 5) through the project while providing adequate protection from flooding for structures and other critical areas in the development for the 100-year rain event. |

| Steps | Approach |
|---|---|
| **Step 4:** Flood Protection | Principal and emergency stormwater controls must be designed to ensure that the post-development peak discharges for the 2-year through 100-year, 24-hour rain events do not exceed pre-development values at the project boundary, and can be discharged safely from the project. |
| **Step 5:** Downstream Assessment | In conjunction with Step 4, principal and emergency stormwater controls must be designed to ensure that the post-development peak discharges for the 2-year through 100-year, 24-hour rain events do not exceed pre-development values downstream of the project boundary. |

Figure 1-22 conceptually illustrates the relative volume requirements of each of the integrated site design steps and demonstrates that the requirements typically overlay one another. If the assessments for flood control indicate on-site detention is needed to limit the discharge from a development, the volume requirement to achieve the flood protection requirement could also contain the volume needed to provide for channel protection and water conveyance. The appropriate type of detention facility could be designed with outlet controls to address each of the steps of the design approach. Obviously, detention may not be required in all situations; consideration of site design practices and stormwater controls that work together to meet all the requirements is what is important. The following sections describe the integrated site design approach in more detail.

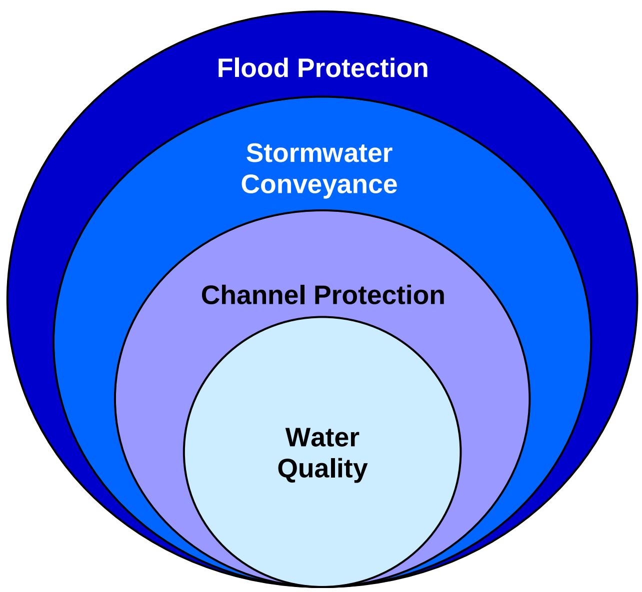


**Figure 1-2 Representation of the Integrated Site Design Approach**

### 1.3.2 Water Quality Protection Volume and 80% TSS Removal

Hydrologic studies show smaller, frequently occurring rain events account for the majority of rain events. Consequently, the runoff from the many smaller events also accounts for a major portion of the annual pollutant loadings. By treating these frequently-occurring, smaller rain events and the initial portion of the stormwater runoff from larger events, it is possible to effectively mitigate the water quality impacts from a developed area.

Studies have shown the 85th percentile rain event (i.e., the storm event that is equal or greater than 85% of the events that occur) is a reasonable target for addressing the majority of smaller, pollutant-laden runoff events. Based on a rainfall analysis, 1.2 inches of rainfall has been identified as the depth corresponding to the 85th percentile storm for the City of Wichita and Sedgwick County (using a 6-hour minimum dry interval to separate “events”). The runoff from these 1.2 inches of rainfall is referred to as the water quality protection volume, henceforth abbreviated as $WQ_v$.

In accordance with the stormwater policies presented in Volume 1, Chapter 3 of this Manual, the $WQ_v$ must be treated to a standard of 80% removal of total suspected solids (TSS). TSS is the parameter chosen as the representative stormwater pollutant for measuring treatment effectiveness for several reasons:

- The standard of using TSS as an “indicator” pollutant is well established;
- suspended sediment and turbidity are directly associated with TSS and are a major source of water quality impairment due to urban development; and,
- a fraction of many other pollutants of concern are removed either along with TSS, or at rates proportional to the TSS removal.

Thus, a stormwater management system designed to meet the requirements for treating the $WQ_v$ will treat the first 1.2 inches of runoff (or less for smaller storms) to the 80% TSS removal standard. Detailed guidance on the calculation of $WQ_v$ and % TSS Removal is presented in Volume 2, Chapter 4, Sections 4.13 and 4.14 respectively.

### 1.3.3 Channel Protection Volume

The increase in the frequency and duration of bankfull flow conditions in stream channels (typically the 1 to 2-year storm events) due to development is a primary cause of accelerated channel erosion and the widening and down-cutting of stream channels. Therefore, the channel protection requirements apply to all development sites for which there is an increase in flow from the 1 to 2-year rainfall events (either volume or rate) to downstream channels, ditches and streams. (This type of channel protection is not to be confused with localized protection against erosion and scour. This type of protection is intended to address long-term channel-forming flows associated with stream geomorphological changes. Localized erosion and scour protection are discussed in Chapter 5, Section 5.7.

Channel protection is achieved by providing 24 hours of extended detention on-site for the post-developed runoff generated by the 1-year, 24-hour rainfall event. The reduction in the frequency and duration of bankfull flows through the controlled release provided by extended detention of the Channel Protection Volume ($CP_v$) will reduce the bank scour rate and severity. An alternative to extended detention of the $CP_v$ is to retain the difference between the 1-year, 24-hour pre-development and post-development runoff volume on-site, and release the volume through evapotranspiration, reuse, and/or infiltration. Detailed guidance on the calculation of $CP_v$ is presented in Volume 2, Chapter 4, Section 4.15.

### 1.3.4 On-Site Conveyance

The on-site stormwater system must be designed to convey the design storm events to provide protection for structures, streets, sidewalks, and other critical areas in the development. On-site conveyance is typically accomplished with a combination of conveyance systems including street and roadway gutters, inlets and drains, storm sewers, culverts, swales and ditches. The presence of other stormwater management facilities may affect the design of these systems. The design storm event criteria associated with the various features, and guidance on stormwater analysis and design, are presented in Volume 2, Chapter 5.

After the initial set of on-site controls are selected for the design storms, the full development build-out 100-year, 24-hour storm (or appropriate duration for intensity-based runoff estimates) shall be applied to the on-site conveyance system and stormwater controls to determine the overall flow paths, velocities and depths for the larger storm. Even though the conveyance systems may be appropriately designed for smaller design storm events per the criteria discussed in Volume 2, Chapter 5, overall the site must be designed to safely pass or temporarily store the resulting flows from the full build-out 100-year storm event without flooding structures or other critical features. Guidance on calculation methods to compute peak flows for use in the on-site conveyance design is presented in detail in Volume 2, Chapter 4.

### 1.3.5 Flood Control

Principal and emergency stormwater controls must be designed to ensure that the post-development peak discharges for the 2-year through 100-year, 24-hour rainfall events do not exceed pre-development values at the project boundary, and can be discharged safely from the project. This is typically accomplished by constructing a stormwater detention pond at or near the downstream project boundary that is designed to control peak flows, and is constructed in such a manner that will permit the flood discharges to pass through and beyond the facility without causing damage to the facility or receiving stream.

The physical characteristics required for detention ponds are reviewed in Volume 2, Chapter 3. The hydrologic procedures for computing flood inflow to detention ponds, and routing those flows through the ponds, are presented in Volume 2, Chapter 4. Note that when multiple flood control facilities are located within the site (not just at the project boundaries), a hydrologic model reflecting the pond network must be used. A discussion of hydraulic analysis and design for energy dissipators/erosion protection, spillways, channels, etc. is presented in Volume 2, Chapter 5.

#### *1.3.5.1 Downstream Assessment*

In conjunction with the basic flood control requirements (above), principal and emergency stormwater controls must be designed to ensure that the post-development peak discharges for the 2-year through 100-year, 24-hour rainfall events do not exceed pre-development values downstream of the project boundary. If pre-development peak discharges are exceeded, then the site design must be modified to eliminate the peak discharge increases. The local jurisdiction's stormwater management regulation in Volume 1, appendices includes a list of limited exceptions to this requirement.

### 1.3.6 Summary of Integrated Site Design Requirements

In summary, the following are required (unless accepted in limited cases under the provisions of the local jurisdiction's stormwater management regulation):

- The runoff from the entire development area (except as adjusted for $WQ_v$ reductions) must be treated to remove at least 80% of TSS for the 85$^{th}$ percentile rainfall of 1.2 inches. (Water Quality)
- The runoff from the entire site (including $WQ_v$ reduction areas) for the 1-year, 24-hour storm event must either be detained for at least 24-hours, or the difference in pre- and post-development runoff volume for that event must be retained on-site. (Channel Protection)
- On-site stormwater conveyances must be designed to convey the peak flows associated with their applicable design rainfall criteria, and must also be capable of conveying the 100-year event without flooding structures or other critical features. (On-Site Conveyance)
- If the project results in an increase in flood peaks at the project boundaries, detention controls must be provided to ensure that post-development flows do not exceed pre-development peak flows at the project boundaries, and that the flows may be safely passed through the detention facilities. (Flood Control)
- Flow conditions in the receiving stream downstream of the project must be evaluated to ensure that the development does not increase peak flows or velocities. (Downstream Assessment)

## 1.4 Preferred Site Design and $WQ_v$ Reductions

The ISD requirements discussed in the previous section are driven by the hydrology of the development site. In the most basic sense, the more runoff generated by a site, the greater the amount of $WQ_v$ that must be treated, the larger the amount of $CP_v$ that must be managed, and the larger the peak flows that must be attenuated for flood control. Therefore, there is a built-in incentive for a development to be designed in a manner that would result in less runoff volume and lower peak flows than would a conventional design that does not consider those effects. This approach is called "Preferred Site Design" (PSD). These "non-structural" practices are not required, but are recommended where practicable and economically viable.

PSD practices are discussed in detail in Volume 2, Chapter 2. In general, these practices consist of site designs that minimize impervious areas, minimize disturbance of site soils, preserve natural areas, and promote infiltration (where permissible). The obvious effect is reduced hydrologic response of the development and a reduction in the amount of pollutants and thus required treatment.

Some of the PSD practices are sufficiently effective at reducing or eliminating pollutants in runoff that they are designated as $WQ_v$ reductions. Runoff from those areas is not required to be treated for water quality protection and thus may be subtracted from the $WQ_v$. Reductions are discussed in detail in Volume 2, Chapter 2.

## 1.5 Structural Stormwater Controls

In some cases, the use of non-structural PSD practices may eliminate the need for constructing any stormwater management facilities (stormwater controls) on a site other than for routine conveyance needs. However, in most cases structural stormwater controls must be used to completely accomplish all of the requirements of integrated site design.

Volume 2, Chapter 3 provides a detailed presentation of the various types of stormwater management facilities permitted for use. In general, the controls consist of detention, filtration, or infiltration facilities that remove TSS from the runoff, and/or detain runoff for quantity control ($CP_v$ and floods). Examples include detention and retention ponds, constructed wetlands, bioretention areas, infiltration trenches, and engineered swales. For each type of control, a design value for the TSS removal rate is provided for use in computing overall TSS removal for the project site. In addition, specific criteria for the facilities are provided to ensure that the controls will achieve the design objectives.

CHAPTER

2

# $WQ_V$ REDUCTIONS AND PREFERRED SITE DESIGN PRACTICES

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## 2.1 Introduction

The first step in stormwater management is the site planning and design process. Development projects can be designed to reduce their impact on watersheds when efforts are made to conserve natural areas, reduce impervious cover, and better integrate stormwater treatment. By implementing a combination of these optional non-structural approaches, referred to herein as "Preferred Site Design" (PSD) practices, it is possible to reduce the amount of runoff and pollutants that are generated from a site and provide for some "non-structural" on-site treatment and control of runoff. The use of some PDSs will allow various $WQ_v$ reductions to be granted. The goals of PSD include:

- Managing stormwater (quantity and quality) as close to the point of origin as possible and minimizing collection and conveyance;
- Preventing stormwater impacts rather than mitigating them;
- Utilizing simple, non-structural methods for stormwater management that are sometimes lower cost and lower maintenance than structural controls;
- Creating a multifunctional landscape;
- Using hydrology as the fundamental design guidance for site designs; and,
- Reducing the peak runoff rates and volumes, therefore, reducing the size and often the cost of drainage infrastructure and structural stormwater controls.

PSD for stormwater management includes a number of site design techniques such as preserving or restoring natural features and resources, effectively laying out the site elements to reduce infrastructure requirements, reducing the amount of impervious surfaces, and utilizing natural features on the site for stormwater management where possible. The objective is to reduce the "footprint" of the site while retaining and often enhancing the owner/developer's purpose and vision for the site. Many of the PSD practices can sometimes reduce the cost of infrastructure while maintaining or even increasing the value of the property.

Reduction of adverse stormwater runoff impacts through the use of PSD practices should be the first consideration of the design engineer. Operationally, aesthetically, and often economically, the use of PSD practices offers significant benefits over treating and controlling runoff downstream. Therefore, opportunities for using these methods should be explored before considering structural stormwater controls. That said, it must be emphasized that the use of PSD practices on a project are entirely optional; they are not required.

The reduction in runoff and pollutants using PSD can reduce the required runoff peak and volumes that need to be conveyed and controlled on a site and, therefore, the size and cost of necessary drainage infrastructure and structural stormwater controls. In some cases, the use of PSD may eliminate the need for structural controls entirely. Hence, PSD practices can be viewed as both a water quantity and water quality management tool.

For some PSD practices various types of $WQ_v$ reductions are granted. Basically, reductions provide a calculated decrease in the volume requirements for water quality protection. Section 0 describes the reduction concept and provides examples of its application.

In addition, other types of PSD practices provide avenues for reducing both hydrologic and water quality management requirements. These practices are discussed in Section 2.3.

The use of stormwater PSD practices also has a number of other ancillary benefits including:

- Possible reduction in construction costs;
- Potential for increased property values;
- More open space for recreation;
- More pedestrian friendly neighbourhoods;
- Protection of natural areas, wetlands, and habitats;
- More aesthetically pleasing and attractive landscape; and,
- Easier compliance with wetland and other resource protection regulations.

During the site planning process, there are several steps involved in site layout and design, each more clearly defining the location and function of the various components of the stormwater management system. The PSD practices can be integrated with this process as shown in Table 2-1.

**Table 2-1 Integration of Preferred Site Design Practices with Site Development Process**

| Site Development Phase | Site Design Practice Activity |
|---|---|
| Feasibility Study | • Determine stormwater management requirements<br>• Identify potential areas for and types of $WQ_v$ reductions |
| Site Analysis | • Identify and delineate natural feature conservation areas |
| Concept Plan | • Preserve natural areas and stream buffers during site layout<br>• Reduce impervious surface area through various techniques<br>• Identify locations for use of vegetated channels and infiltration<br>• Look for areas to disconnect impervious surfaces<br>• Document the use of PSD practices |
| Preliminary and Final Plan | • Perform layout and design of $WQ_v$ reduction areas, integrating them into treatment trains<br>• Ensure appropriate documentation of $WQ_v$ reductions<br>• Develop maintenance requirements and documents |
| Construction | • Ensure protection of key areas<br>• Ensure proper installation |
| Final Inspection | • Ensure long term protection and maintenance<br>• Ensure $WQ_v$ reduction areas are identified on final plan and plat |

## 2.2 $WQ_v$ Reductions

### 2.2.1 Introduction

As discussed in Chapter 1, treatment of the water quality protection volume ($WQ_v$) is required for all new developments or redevelopments with greater than one acre of disturbance. Calculation of the $WQ_v$ is discussed in Chapter 4, Section 4.13. A set of $WQ_v$ reductions is presented to provide developers and site designers with acceptable practices that can reduce the volume of stormwater runoff, including the $WQ_v$, and minimize the pollutant loads from a site.

Site designers are encouraged to utilize as many PSD practices as practicable on a site. Greater reductions in stormwater runoff and pollutant loading can be achieved when practices are combined into multiple systems (i.e., treatment trains). However, volume reduction cannot be claimed twice for the same area of the site.

The basic premise of the system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the $WQ_v$. If a developer incorporates one or more of the methods in the design of the site, the requirement for capture and treatment of the $WQ_v$ will be reduced.

### 2.2.2 Reductions Granted

The PSD practices by which the $WQ_v$ can be reduced are listed in Table 2-2. Site-specific conditions will determine the applicability of each reduction. For example, the stream buffer $WQ_v$ reduction cannot be taken on upland sites that do not contain perennial or intermittent streams. (Perennial streams flow 365 days a year in a normal year. Intermittent streams have periods of time when there is no flow in a normal year but do have periods of flow during the year.)

**Table 2-2 Methods to Reduce the $WQ_v$**

| Practice | Description |
|---|---|
| **Reduction 1:** Natural Area Conservation | Undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. |
| **Reduction 2:** Vegetated Stream Buffers | Stormwater runoff is treated by directing sheet flow runoff through a naturally vegetated or wooded buffer as overland flow. |
| **Reduction 3:** Specially Engineered Vegetated Channels | Engineered vegetated channels are used to provide stormwater treatment. |
| **Reduction 4:** Overland Flow Filtration/Infiltration Zones | Overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from rooftops and other small impervious areas. |
| **Reduction 5:** Environmentally Sensitive Large Lot Subdivisions | A group of site design techniques are applied to low density residential development. |

Due to local constraints, soil conditions, and topography, some of these $WQ_v$ reduction methods may be restricted. Designers are encouraged to consult with the appropriate approval authority to ensure if and when a reduction is applicable and to determine restrictions on non-structural strategies.

The methods by which the $WQ_v$ can be reduced are detailed below. For each $WQ_v$ reduction method, there is a set of criteria and minimum requirements that identify the conditions or circumstances under which the reduction may be applied. The intent of the numeric conditions (e.g., flow length, contributing area, etc.) is to avoid situations that could lead to a $WQ_v$ reduction being granted without the corresponding reduction in pollution.

Reductions are primarily intended to reduce $WQ_v$ requirements by excluding the reduction areas from the $WQ_v$ calculations. However, reductions 1 through 4 also serve as water quality controls with Total Suspended Solids (TSS) removal benefits. Their respective TSS removal efficiencies are provided in the reduction descriptions, below.

It is important to note that site $WQ_v$ and site TSS removal computations, although related, are performed independently. For example, the area draining to a qualifying buffer (reduction 2) is subtracted from the site area for $WQ_v$ calculation purposes, but is still included in the site TSS removal calculation. However, the area that drains to the buffer receives 80% TSS removal in the site TSS calculation.

### $WQ_v$ Reduction #1: Natural Area Conservation

A $WQ_v$ reduction may be taken when undisturbed stable (non-eroding) natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this method, a designer may subtract the conservation areas from the total site area when computing the $WQ_v$. An added benefit is that the post-development peak discharges will be smaller, and hence, $WQ_v$ will be reduced due to lower post-development Curve Numbers or Rational formula “C” values.

**Rule: Subtract conservation areas from total site area when computing $WQ_v$ requirements if the following criteria are met.**

**<u>Criteria:</u>**

- The conservation area cannot be disturbed prior to or during project construction (or must be restored by approved methods if disturbed prior to construction), and must be protected from erosion and from sediment deposition.
- Vegetation should be native and non-invasive.
- The conservation area shall be protected by limits of disturbance clearly shown on all construction drawings.
- The conservation area shall be located within an acceptable reserve that ensures perpetual protection of the proposed area. The reserve must clearly specify how the reduction area will be managed and boundaries will be marked.

Note: Managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management.

- The conservation area shall have a minimum contiguous area requirement of 10,000 square feet.
- The conservation area can be included in the area-weighted Volumetric Runoff Coefficient ($R_v$) calculation.
- The conservation area must have a stable, natural ground cover.
- The conservation area is assigned a 100% TSS removal value.

---

**Example Problem – Residential Subdivision with a Conservation Area $WQ_v$ Reduction**

A = Area = 40 acres
P = $85^{th}$ percentile rainfall = 1.2 inches
Natural Conservation Area = 7 acres
$R_v$ = 0.38 (calculation method presented in Chapter 4, Section 4.13)

**With Reduction:**

Effective drainage area = 40 – 7 = 33 acres

$$WQ_v = \frac{P * R_v * A}{12} = \frac{1.2 * 0.38 * 33}{12} = 1.25 \text{ ac-ft}$$

**Without Reduction:**

$$WQ_v = \frac{1.2 * 0.38 * 40}{12} = 1.52 \text{ ac-ft}$$

Therefore, this method provides an 18% reduction in WQv in addition to the decrease in WQv due to the reduced $R_v$ that would occur based on land use.

---

**$WQ_v$ Reduction #2: Vegetated Stream Buffers**

A reduction for vegetated stream buffers may be taken when a stream buffer is used to treat stormwater runoff. Effective treatment requires overland flow of stormwater runoff through a naturally vegetated or wooded buffer sized in accordance with the criteria stated below. Under this method, the designer may subtract areas draining via overland flow to the buffer from the total site area when computing $WQ_v$ requirements. The area of the buffer itself can also be subtracted if it meets the requirements of Reduction #1. The design of the stream buffer must provide a stable conveyance for flows greater than the annual recurrence (1-yr storm) event in a manner that prevents damage to the buffer.

**Rule: Subtract areas draining via overland flow to the buffer from total site area when computing $WQ_v$ requirements if the following criteria are met.**

**<u>Criteria:</u>**

- The minimum undisturbed buffer width (i.e., perpendicular to the stream) shall be 50 feet from the top of bank.
- The maximum qualifying contributing length (perpendicular to the stream) shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces.
- The average contributing slope shall be 3% maximum unless a flow spreader is used. (See Chapter 5 of Volume 2 for flow spreader design.)
- Runoff shall enter the buffer as overland sheet flow; a flow spreader may be installed to ensure this requirement.
- The buffer shall remain a naturally vegetated area and shall be maintained only through routine debris removal, erosion repairs, or re-planting as necessary.
- Vegetation in the buffer must be native and non-invasive.
- The buffer shall be protected during construction, and the limits of disturbance shall be clearly shown on all construction drawings, and shall be clearly defined on-site using fencing or other means.
- The buffer shall be located within a reserve that ensures perpetual protection of the proposed area. The reserve must clearly specify how the reduction area will be managed and boundaries will be marked.
- The reduction area can be included in the area-weighted $R_v$ calculation.
- The area that drains to the buffer is assigned an 80% TSS removal value.

### Example Problem – Residential Subdivision

A = Area = 40 acres
P = $85^{th}$ percentile rainfall = 1.2 inches
Area draining to buffer = 4 acres
Buffer area meeting Reduction #1 requirements = 1 acre
$R_v$ = 0.38 (calculation method presented in Chapter 4)

**<u>With Reduction:</u>**

Effective drainage area = 40 – 4 – 1 = 35 acres

$$WQ_v = \frac{P * R_v * A}{12} = \frac{1.2 * 0.38 * 35}{12} = 1.33 \text{ ac-ft}$$

**<u>Without Reduction:</u>**

$$WQ_v = \frac{1.2 * 0.38 * 40}{12} = 1.52 \text{ ac-ft}$$

Therefore, this method provides a 13% reduction in $WQ_v$ in addition to the decrease in $WQ_v$ due to the reduced $R_v$ that would occur based on land use.

### $WQ_v$ Reduction #3: Specially Engineered Vegetated Channel

With Reduction #3, the designer may subtract the areas draining to a vegetated (grassed) channel provided it meets the criteria provided below. The area draining to the channel and the area of the channel itself are subtracted from total site area when computing $WQ_v$ requirements. An added benefit is the post-development peak discharges may be lower due to a longer time of concentration for the site.

**Rule: Subtract the areas draining to the engineered channel, and the area of the channel itself, from total site area when computing $WQ_v$ requirements, if the following criteria are met.**

**Criteria:**

- This method is only applicable to moderate or low density residential land uses (3 homes units per acre maximum).
- The maximum flow velocity in the channel for water quality design storm shall be less than or equal to 1.0 feet per second.
- The minimum residence time in the channel for the water quality storm shall be 5 minutes.
- The bottom width shall be a maximum of 6 feet. If a larger channel is needed, a compound cross section is required (see Chapter 5 of Volume 2).
- The side slopes shall be 3:1 (horizontal: vertical) or flatter.
- The channel bottom slope shall be 3 percent or less.
- The area that drains to the engineered channel is assigned an 50% TSS removal value.
- The channel shall be located within a reserve that ensures perpetual protection of the proposed channel. The reserve must clearly specify how the reduction area will be managed and boundaries will be marked.
- The reduction area is included in the area-weighted $R_v$ calculation.

### Example Problem – Residential Subdivision

Area = 40 acres
P = 85$^{th}$ percentile rainfall = 1.2 inches
Area of channel and area draining to channel = 12.5 acres
$R_v$ = 0.38 (calculation method presented in Chapter 4)

**With Reduction:**

Effective drainage area = 40 – 12.5 = 27.5 acres

$$WQ_v = \frac{P * R_v * A}{12} = \frac{1.2 * 0.38 * 27.5}{12} = 1.05 \text{ ac-ft}$$

**Before Reduction:**

$$WQ_v = \frac{1.2 * 0.38 * 40}{12} = 1.52 \text{ ac-ft}$$

Therefore, this method provides a 31% reduction in $WQ_v$ if it is assumed that $R_v$ is the same for both conditions.

---

### $WQ_v$ Reduction #4: Overland Flow Vegetated Filtration Areas (Commercial Developments Only)

Reduction #4 may be taken when overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from small impervious areas (e.g., driveways, small parking lots, etc). This can be achieved by grading the site to promote overland vegetative filtering/infiltration. If impervious areas are adequately disconnected, they can be deducted from total site area when computing the $WQ_v$ requirements. An added benefit is that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

**Rule: If impervious areas are adequately disconnected, they can be deducted from total site area when computing the $WQ_v$ requirements if the following criteria are met.**

**Criteria:**

- Relatively permeable soils (hydrologic soil groups A and B) must be present in the overland flow area.
- Runoff shall not come from a hotspot land use, as defined by the local jurisdiction.
- The maximum contributing impervious flow path length shall be no greater than 75 feet.
- Downspouts shall be located at least 10 feet away from the nearest impervious surface to discourage “re-connections”.
- The disconnection area shall drain continuously overland as sheet flow through a broad grassed area or a vegetated filter strip to the property line or a downstream structural stormwater control.
- The length of the “disconnection” shall be equal to or greater than the contributing length of drainage areas.
- The entire vegetative “disconnection” shall be on a slope less than or equal to 3 percent.
- The surface impervious area draining to any one filtration zone shall not exceed 5,000 square feet.

- For those areas draining directly to a buffer, the $WQ_v$ Reduction can be obtained from either overland flow filtration or stream buffers (See Reduction #2), but not both.
- The area shall be located within a reserve that ensures perpetual protection of the proposed area. The reserve must clearly specify how the reduction area will be managed and boundaries will be marked, and ensure that the disconnection will remain functional.
- The reduction area can be included in the area-weighted $R_v$ calculation.
- Areas draining to these filtration zones are assigned an 80% TSS removal value.

### Example Problem

Area = 3 acres
P = $85^{th}$ percentile rainfall = 1.2 inches
Disconnected Impervious Area = 0.5 acres
$R_v$ = 0.4 (calculation method presented in Chapter 4)

**With Reduction:**

Effective drainage area = 3 – 0.5 = 2.5 acres

$$WQ_v = \frac{P * R_v * A}{12} = \frac{1.2 * 0.4 * 2.5}{12} = 0.10 \text{ ac-ft}$$

**Without Reduction:**

$$WQ_v = \frac{1.2 * 0.4 * 3}{12} = 0.12 \text{ ac-ft}$$

Therefore, this method provides a 17% reduction in $WQ_v$ for the example if it is assumed that $R_v$ is the same for each condition.

### $WQ_v$ Reduction #5: Environmentally Sensitive Large Lot Residential Subdivisions

This reduction can be taken when a group of environmental site design techniques are applied to low density residential development (i.e., 1 dwelling unit per 2 acres or lower density). The use of this method can eliminate the need for structural stormwater controls to treat $WQ_v$ requirements. This method is targeted towards large lot subdivisions.

**Rule: Targeted towards large lot residential subdivisions (2 acre lots and greater). The requirement for structural practices to treat the WQv shall be waived if the following criteria are met.**

**Criteria:**

The following criteria shall be recorded in covenant to ensure perpetual preservation of the features required for the reduction.

**For Single Lot Development:**

- The total site impervious cover for the subdivision must be equal to or less than 12%.
- The lot size for the subdivision shall be at least two acres.
- Rooftop runoff from homes shall be disconnected in accordance with the criteria in Reduction #4.
- Grass channels must be used to convey runoff, versus curb and gutter.

**For Multiple Lots:**

- Total impervious cover footprint shall be less than or equal to 12% of the area, including streets and driveways.
- Lot sizes must be at least 2 acres for each lot, unless clustering is implemented; open space clustered developments shall have a minimum of 25% of the site protected as natural conservation areas and shall have at least a half-acre average individual lot size, as well as meet the subdivision regulations for clustered development.
- Grass channels shall be used to convey runoff rather than curb and gutter.
- Rooftop runoff shall be disconnected in accordance with the criteria in Reduction #4.

## 2.3 Preferred Site Design Practices

### 2.3.1 Overview

This Section provides the developer and/or site engineer with detailed guidance on the use of a number of Preferred Site Design (PSD) practices. While the design practices presented here are encouraged, they are not required. A number of these practices can result in $WQ_v$ reductions along with TSS removal benefits, as discussed previously in this chapter. These practices also reduce the hydrologic impact of a project, and thus may significantly reduce the size and cost of peak flow (flood) control facilities on the site, and may reduce the potential for adverse downstream hydrologic effects.

*Preferred Site Design Practice #1:*
# Preserve Undisturbed Natural Areas

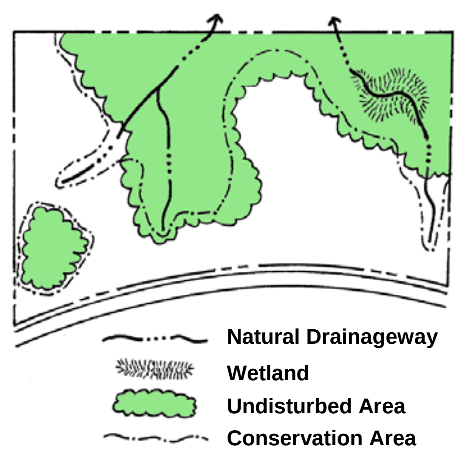
**Description:** Important natural features and areas such as undisturbed natural and vegetated areas, natural drainageways, stream corridors, wetlands and other important site features should be delineated and placed into conservation areas.

| KEY BENEFITS | USING THIS PRACTICE |
| --- | --- |
| • Helps to preserve a portion of the site's natural predevelopment hydrology.<br>• Can be used as non-structural stormwater filtering and infiltration zones.<br>• Helps to preserve the site's natural character and aesthetic features.<br>• A $WQ_v$ reduction can be taken, see Reduction #1. | ☑ Delineate natural areas before performing site layout and design<br>☑ Ensure that conservation areas are protected in an undisturbed state throughout construction and occupancy |

***Discussion***

Preserving natural conservation areas such as undisturbed vegetated areas, natural drainageways, stream corridors and wetlands on a development site helps to preserve the original hydrology of the site and aids in reducing the generation of stormwater runoff and pollutants. Undisturbed vegetated areas also stabilize soils, provide for filtering and infiltration, decreases evaporation, and increases transpiration.

Natural conservation areas are typically identified through a site analysis using maps and aerial/satellite photography, or by conducting a site visit. These areas should be delineated before any site design, clearing or construction begins. When done before the concept plan phase, the planned conservation areas can be used to guide the layout of the site. The figure shows a site map with undisturbed natural areas delineated.




**Delineation of Natural Conservation Areas**

Conservation areas should be incorporated into site plans and clearly marked on all construction and grading plans to ensure equipment is kept out of these areas and native vegetation is kept in an undisturbed state. The boundaries of each conservation area should be clearly flagged so that they are not disturbed during construction.

Once established, natural conservation areas must be protected during construction and managed after occupancy by a responsible party able to maintain the areas in a natural state in perpetuity. Conservation areas are protected by legally enforceable deed restrictions, conservation reserves, and maintenance agreements. Permanent signage is required.

*Preferred Site Design Practice #2:*
# Preserve Riparian Buffers

**Description**: Naturally vegetated buffers should be delineated and preserved along perennial streams, rivers, lakes, and wetlands.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Can be used as non-structural stormwater filtering and infiltration zones.<br>• Pollutant removal.<br>• Keeps structures out of the floodplain and provides a right-of-way for large flood events.<br>• Helps to preserve riparian ecosystems and habitats.<br>• Streambank stabilization.<br>• Aesthetics.<br>• A $WQ_v$ reduction can be taken if allowed by the local review authority per Reduction #2. | ☑ Delineate and preserve naturally vegetated riparian buffers<br>☑ Ensure buffers and native vegetation are protected throughout construction and occupancy |

***Discussion***

A riparian buffer is a special type of natural conservation area along a stream, wetland or shoreline where development is restricted or prohibited. The primary function of buffers is to protect and physically separate a stream, lake or wetland from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management functions, can act as a right-of-way during floods, and can sustain the integrity of stream ecosystems and habitats.

Wooded riparian buffers should be maintained and re-growth should be encouraged where no wooded buffer exists. Proper restoration should include all layers of the plant community, including understory, shrubs and groundcover, not just trees. A riparian buffer can be of fixed or variable width, but should be continuous and not interrupted by impervious areas that would allow stormwater to concentrate and flow into the stream without first flowing through the buffer.

Ideally, riparian buffers should be sized to include the 100-year floodplain as well as steep banks and wetlands. The buffer depth needed to perform properly will depend on the size of the stream and the surrounding conditions. For Wichita and Sedgwick County, a minimum buffer width of 50 feet from top of bank is required in order to receive the buffer water quality reduction.

**Riparian Stream Buffer**

In some areas, specific local, state or federal rules may require stricter buffers than are described here. The buffer widths discussed are not intended to modify or supersede more restrictive buffer requirements already in place.

Generally, the riparian buffer should remain in its natural state. However, some maintenance is periodically necessary, such as planting to minimize concentrated flow, the removal of exotic plant species when these species are detrimental to the vegetated buffer and the removal of diseased or damaged trees.

### *Preferred Site Design Practice #3:*
# Avoid Floodplains

**Description**: Floodplain areas should be avoided for homes and other structures to minimize risk to human life and property damage, and to allow the natural stream corridor to accommodate flood flows.

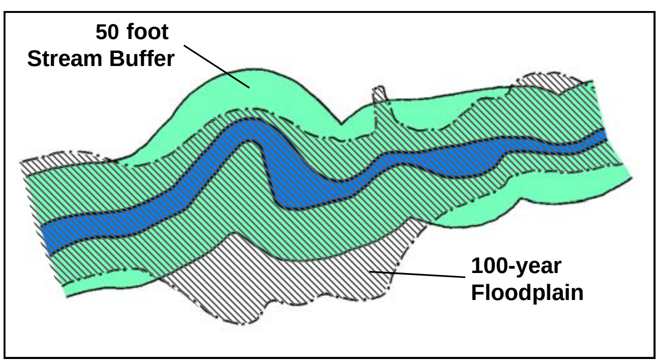
| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Provides a natural right-of-way and temporary storage for large flood events.<br>• Helps to keep people and structures out of harm's way.<br>• Helps to preserve riparian ecosystems and habitats.<br>• Can be combined with riparian buffer protection to create linear greenways. | ☑ Obtain maps of the 100-year floodplain from the local review authority<br>☑ Ensure all development activities do not encroach on the designated floodplain areas |

***Discussion***

Floodplains are the low-lying lands that border streams and rivers. When a stream reaches its capacity and overflows its channel during storm events, the floodplain provides for storage and conveyance of these excess flows. In their natural state they reduce flood velocities and peak flow rates. Floodplains also play an important role in reducing sedimentation by filtering runoff, and provide habitat for both aquatic and terrestrial life. Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. Wichita and Sedgwick County regulate the use of floodplain areas to minimize the risk to human life as well as to avoid flood damage to structures and property.

As such, floodplain areas should be avoided on a development site. Ideally, the entire 100-year full-buildout floodplain should be avoided for clearing, grading or building activities, and should be preserved in a natural undisturbed state where possible. Floodplain protection is complementary to riparian buffer preservation. Both of these PSD practices preserve stream corridors in a natural state and allow for the protection of vegetation and habitat. Depending on the site topography, 100-year floodplain boundaries may lie inside or outside a preserved riparian buffer corridor.

Maps of the 100-year floodplain can be obtained through the local review authority. Developers and builders must also ensure their site designs comply with any other relevant local floodplain and FEMA requirements.




**Floodplain Boundaries in Relation to a Riparian Buffer**

## *Preferred Site Design Practice #4:*
# Minimize Siting on Permeable or Erodible Soils

**Description:** Permeable soils such as sand and gravel provide an opportunity for groundwater recharge of stormwater runoff and should be preserved as a potential stormwater management option. Unstable or easily erodible soils should be avoided due to their greater erosion potential.

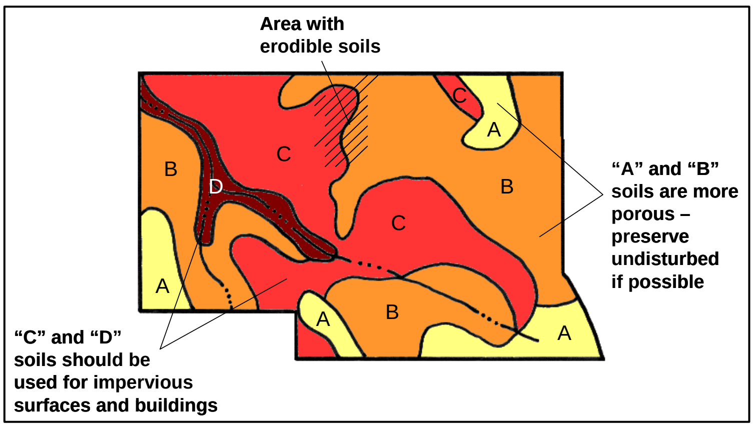
| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Areas with highly permeable soils can be used as non-structural stormwater infiltration zones.<br>• Avoiding highly erodible or unstable soils can prevent erosion and sedimentation problems and water quality degradation. | ☑ Use soil surveys to determine site soil types<br>☑ Leave areas of porous or highly erodible soils as undisturbed conservation areas |

### *Discussion*

Infiltration of stormwater into the soil reduces both the volume and peak discharge of runoff from a given rainfall event, and also provides for water quality treatment and groundwater recharge. Soils with maximum permeabilities (hydrologic soil group A and B soils such as sands and sandy loams) allow for the most infiltration of runoff into the subsoil. Thus, areas of a site with these soils should be conserved as much as possible and these areas should ideally be incorporated into undisturbed natural or open space areas. Conversely, buildings and other impervious surfaces should be located on those portions of the site with the least permeable soils to the extent that soil stability, shrink-swell potential, and other soil characteristics allow.

Similarly, areas on a site with highly erodible or unstable soils should be avoided for land disturbing activities and buildings to prevent erosion and sedimentation problems as well as potential future structural problems. These areas should be left in an undisturbed and vegetated condition.

Soils on a development site should be mapped in order to preserve areas with permeable soils, and to identify those areas with unstable or erodible soils. Soil surveys can provide a considerable amount of information relating to relevant aspects of soils. General soil types should be delineated on concept site plans to guide site layout and the placement of buildings and impervious surfaces.




**Soil Mapping Information can be used to Guide Development**

*Preferred Site Design Practice #5:*

# Locate Development in Less Sensitive Areas

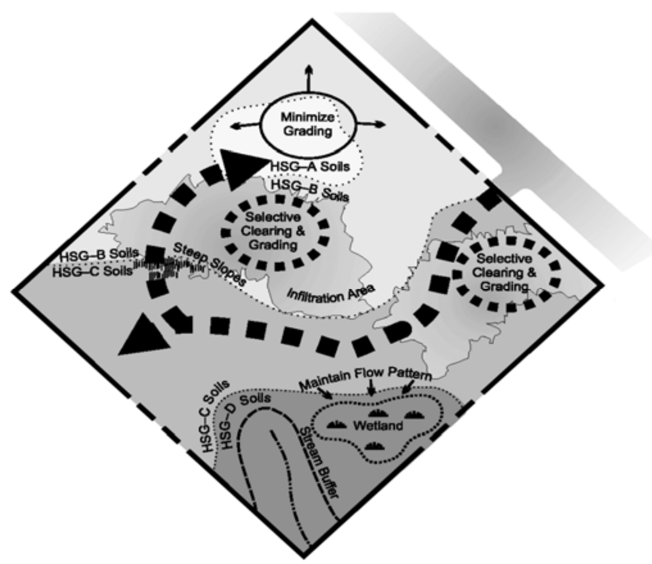
**Description**: To minimize the hydrologic impacts on the existing site land cover, the area of development should be located in areas of the site that are less sensitive to disturbance or have a lower value in terms of hydrologic function.

| KEY BENEFITS | USING THIS PRACTICE |
| --- | --- |
| • Helps to preserve the natural hydrology and drainageways of a site.<br>• Makes most efficient use of natural site features for preventing and mitigating stormwater impacts.<br>• Provides a framework for site design and layout. | ☑ Lay out the site design to minimize the hydrologic impact of structures and impervious surfaces |

***Discussion***

A site layout should be designed so the areas of development are placed in the locations of the site that minimize the hydrologic impact of the project. This is accomplished by steering development to areas of the site that are less sensitive to land disturbance or have a lower value in terms of hydrologic function using the following methods:

- Locate buildings and impervious surfaces away from stream corridors, wetlands and natural drainageways. Use buffers to preserve and protect riparian areas and corridors.
- Areas of the site with permeable soils should be left in an undisturbed condition and/or used as stormwater runoff infiltration zones. Buildings and impervious surfaces should be located in areas with less permeable soils.
- Avoid land disturbing activities or construction on areas with steep slopes or unstable soils.
- Minimize the clearing of areas with tree canopy or thick vegetation, and ideally preserve them as natural conservation areas.
- Ensure natural drainageways and flow paths are preserved, where possible. Avoid the filling or grading of natural depressions and ponding areas.




**Guiding Development to Less Sensitive Areas of a Site**
(Source: Prince George's County, MD, 1999)

The figure above shows a development site where the natural features have been mapped in order to delineate the hydrologically sensitive areas. Through careful site planning, sensitive areas can be set aside as natural open space areas. In many cases, such areas can be used as buffer spaces between land uses on the site or between adjacent sites.

***Preferred Site Design Practice #6:***

# Minimize Limits of Clearing and Grading

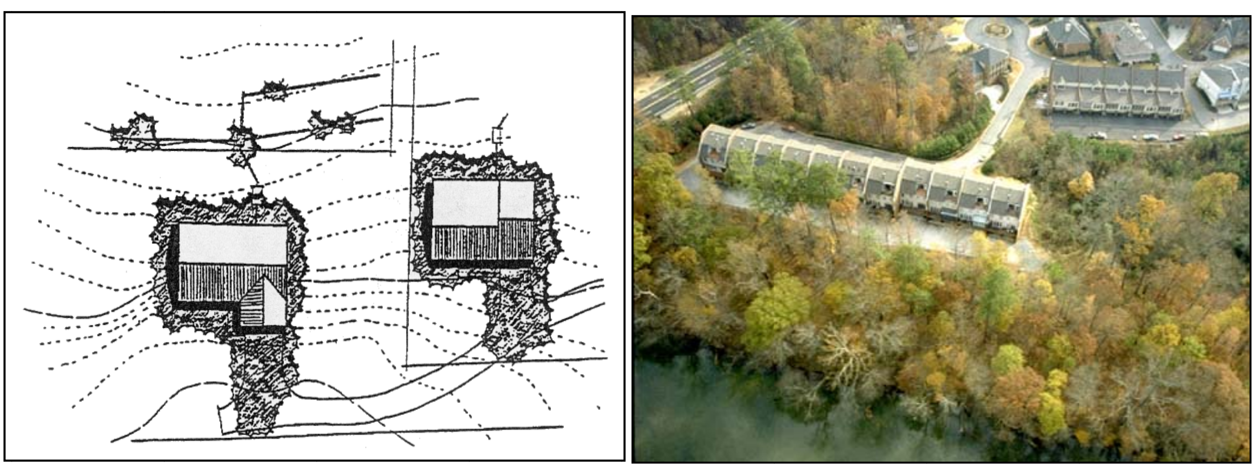
**Description**: Clearing and grading of the site should be limited to the minimum amount needed for the development and road access. Site footprinting should be used to disturb the smallest possible land area on a site.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Preserves more undisturbed natural areas on a development site.<br>• Techniques can be used to help protect natural conservation areas and other site features.<br>• Minimizes runoff volumes and peaks.<br>• | ☑ Establish limits of disturbance for all development activities<br>☑ Use site footprinting to minimize clearing and land disturbance |

***Discussion***

Minimal disturbance methods should be used to limit the amount of clearing and grading that takes place on a development site, preserving more of the undisturbed vegetation and natural hydrology of a site. These methods include:

- Establishing maximum limits of disturbance (LOD). These limits should reflect reasonable construction techniques and equipment needs together with the physical situation of the development site such as slopes or soils.
- Using site "footprinting" by mapping the limits of disturbance to identify the smallest possible land area on a site which requires clearing or land disturbance. Examples of site footprinting are illustrated in the figure below.
- Fitting the site design to the terrain.
- Using special procedures and equipment which reduce land disturbance.



**Examples of Limits of Clearing and Site Footprinting**

*Preferred Site Design Practice #7:*
# Utilize Open Space Development

**Description**: Open space site designs incorporate smaller lot sizes to reduce overall impervious cover while providing more undisturbed open space and protection of water resources.

| KEY BENEFITS | USING THIS PRACTICE |
| --- | --- |
| • Preserves conservation areas on a development site.<br>• Can be used to preserve natural hydrology and drainageways.<br>• Can be used to help protect natural conservation areas and other site features.<br>• Reduces the need for grading and land disturbance.<br>• Reduces infrastructure needs and overall development costs.<br>• Can be used to create natural and pleasing developments.<br>• | ☑ Use a site design which concentrates development and preserves open space and natural areas of the site |

***Discussion***

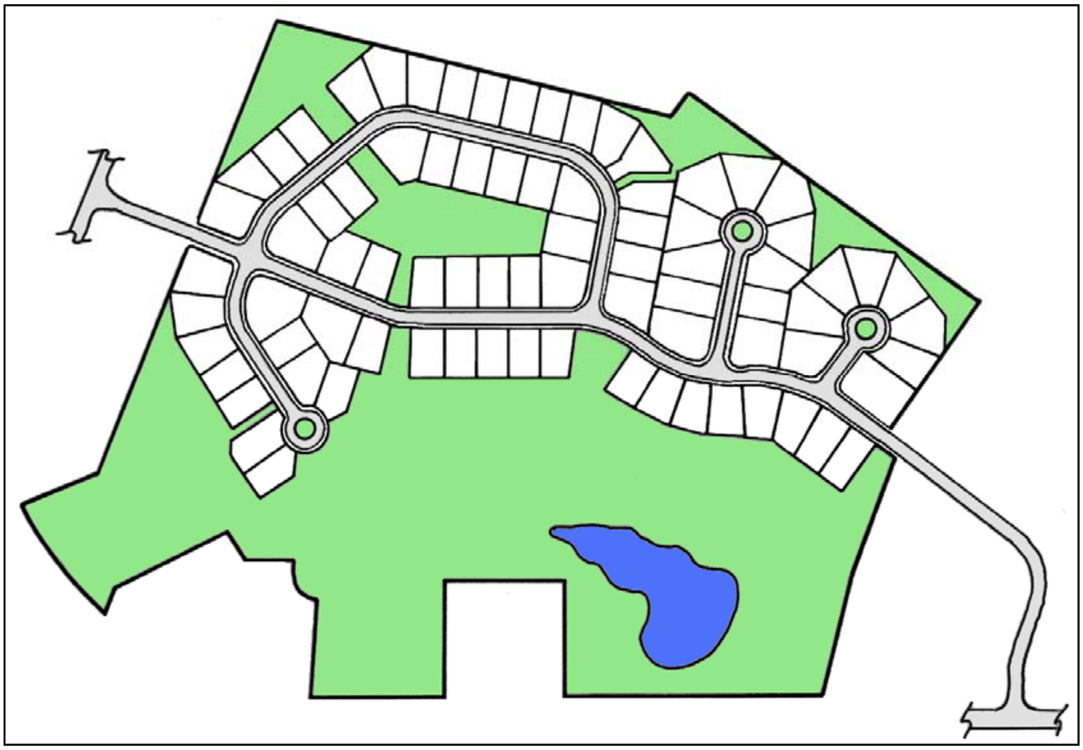
Open space development, also known as conservation development or clustering, is a site design technique that concentrates structures and impervious surfaces in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. Typically, smaller lots and/or non-traditional lot designs are used to cluster development and create more conservation areas on the site.

Open space developments have many benefits compared with conventional commercial developments or residential subdivisions: they can reduce impervious cover, stormwater pollution, construction costs, and the need for grading and landscaping, while providing for the conservation of natural areas. The following figure shows an example of open space developments.

Along with reduced imperviousness, open space designs can provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on conservation and buffer areas because enough open space is usually reserved to accommodate these protection areas. As less land is cleared during the construction process, alteration of the natural hydrology and the potential for soil erosion are also greatly diminished. Perhaps most importantly, open space design may typically reserve 25 to 50 percent of the development site in conservation areas, which would not otherwise be protected.

Open space developments can also be significantly less expensive to build than conventional projects. Most of the cost savings are due to reduced infrastructure cost for roads and stormwater management controls and conveyances. While open space developments are frequently less expensive to build, developers also find these properties often command higher prices than those in more conventional developments. Several studies estimate that residential properties in open space developments garner premiums higher than conventional subdivisions resulting in higher selling or leasing rates.

Once established, common open space and natural conservation areas must be managed by a responsible party to maintain the areas in a natural state in perpetuity. The conservation areas are protected by legally enforceable deed restrictions, reserves, and maintenance agreements.



Open Space Subdivision Site Design Example

### *Preferred Site Design Practice #8:*
# Minimize Roadway Lengths and Widths

**Description**: Roadway lengths and widths should be minimized on a development site where possible to reduce overall imperviousness.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>• Reduces the costs associated with road construction and maintenance.<br>• May contribute to traffic calming. | ☑ Consider different site and road layouts that reduce overall street length<br>☑ Minimize street width by using narrower street designs |

***Discussion***

The use of alternative road layouts that reduce the total linear length of roadways can significantly reduce overall imperviousness of a development site. Site designers are encouraged to analyze different site and roadway layouts to see if they can reduce overall street length.

In addition, residential streets and private streets within commercial and other developments should be designed for the minimum required pavement width needed to support travel lanes, on-street parking, and emergency access. One-way single-lane loop roads are another way to reduce the width of lower traffic streets.

While minimizing impervious surface area is desirable, all designs must meet the minimum requirements of local codes, ordinances and regulations unless waivers are obtained from the local jurisdiction.

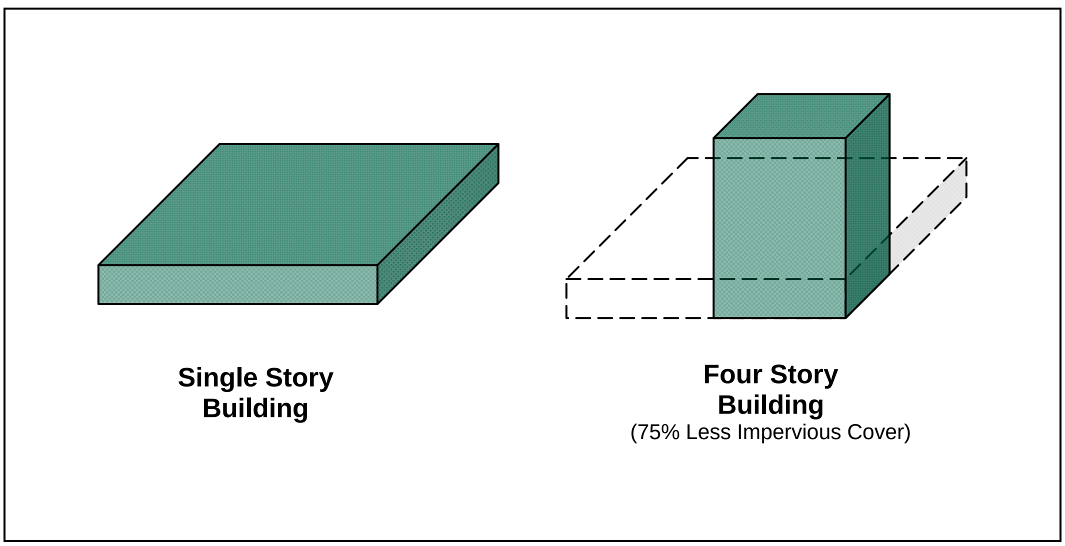
*Preferred Site Design Practice #9:*
# Minimize Building Footprints

**Description**: The impervious footprint of commercial buildings and residences can be reduced by using alternate or taller buildings while maintaining the same floor to area ratio.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>• Can result in more walkable environments.<br>• | ☑ Use alternate or taller building designs to reduce the impervious footprint of buildings |

***Discussion***

In order to reduce the imperviousness associated with the footprint and rooftops of buildings and other structures, alternative and/or vertical (taller) building designs should be considered. The figure shows the reduction in impervious footprint by using a taller building design.




**Building up rather than out can reduce the amount of impervious cover**

*Preferred Site Design Practice #10:*
# Minimize the Parking Footprint

**Description**: Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, parking decks, and using porous paver surfaces or porous concrete in overflow parking areas where feasible and where soils allow for infiltration.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>• Aesthetics.<br>• Allows space for stormwater management and shade trees. | ☑ Reduce the number of parking spaces<br>☑ Minimize stall dimensions<br>☑ Consider parking structures and shared parking<br>☑ Use alternative porous surface for overflow areas |

***Discussion***

Minimizing stall dimensions, using structured parking, encouraging shared parking, minimizing the number of spaces and using alternative porous surfaces can all reduce the overall parking footprint and site imperviousness.

Sometimes parking lot designs result in far more spaces than actually required. This may be caused by a common practice of setting parking ratios to accommodate the highest hourly parking during the peak season. It may be acceptable to adopt a lower number of parking spaces and accommodate most of the demand.

Another technique to reduce the parking footprint is to minimize the dimensions of the parking spaces. This can be accomplished by reducing both the length and width of the parking stall to the minimum acceptable sizes. Parking stall dimensions can be further reduced if compact spaces are provided.

While minimizing impervious surface area is desirable, all designs must meet the minimum requirements of local codes, ordinances and regulations unless waivers are obtained from the local jurisdiction.

Construction of parking decks is one method to significantly reduce the overall parking footprint by minimizing surface parking. The following figure shows a parking deck used for a commercial development.

**Parking Deck**

Shared parking in mixed-use areas can further reduce the conversion of land to impervious cover. A shared parking arrangement could include usage of the same parking lot by an office space that experiences peak parking demand during the weekday with a church that experiences parking demands during the weekends and evenings.

Utilizing alternative surfaces such as porous pavers or porous concrete is an effective way to reduce the amount of runoff generated by parking lots. They can replace conventional asphalt or concrete in both new developments and redevelopment projects. The following figure is an example of porous pavers used at an overflow lot. Alternative pavers can also capture runoff from other site areas. However, porous pavement surfaces are generally more costly to construct and require more maintenance than conventional asphalt or concrete. For more specific information using these alternative surfaces, see the sections in Chapter 3 on porous pavement and modular porous paver systems. These surfaces can only be used if the soils allow for adequate infiltration, or if underdrains are provided.

**Grass Paver Surface Used for Parking**

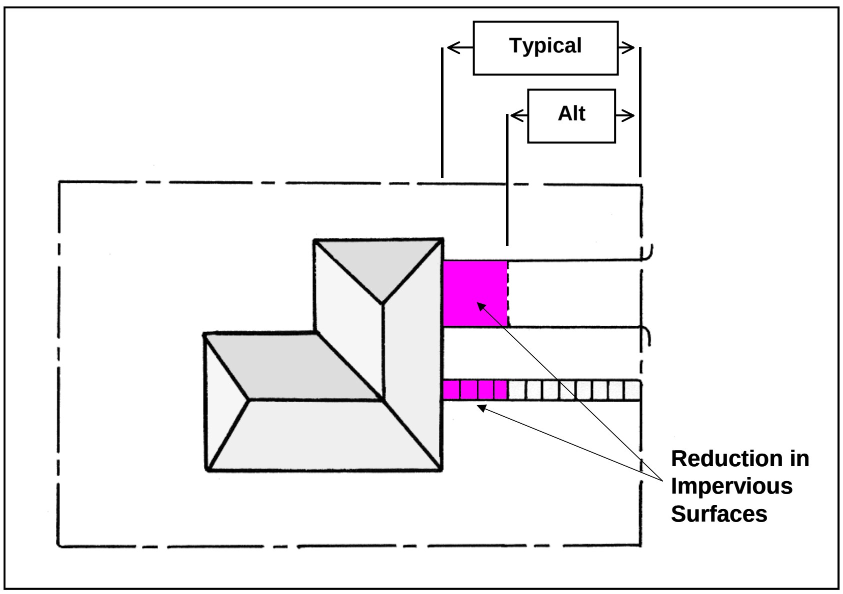
### *Preferred Site Design Practice #11:*
# Minimize Setbacks and Frontages

**Description**: Use smaller front and side setbacks and narrower frontages to reduce total road length and driveway lengths. This would not apply to rear access (i.e. alleys) home developments.

| KEY BENEFITS | USING THIS PRACTICE |
| --- | --- |
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>•<br>•<br>• | ☑ Reduce building and home front and side setbacks<br>☑ Consider narrower frontages |

***Discussion***

Typical building and home setbacks may be shortened (to the extent allowed by local codes, ordinances and regulations) to reduce the amount of impervious cover from driveways and entry walks (see the following figure).

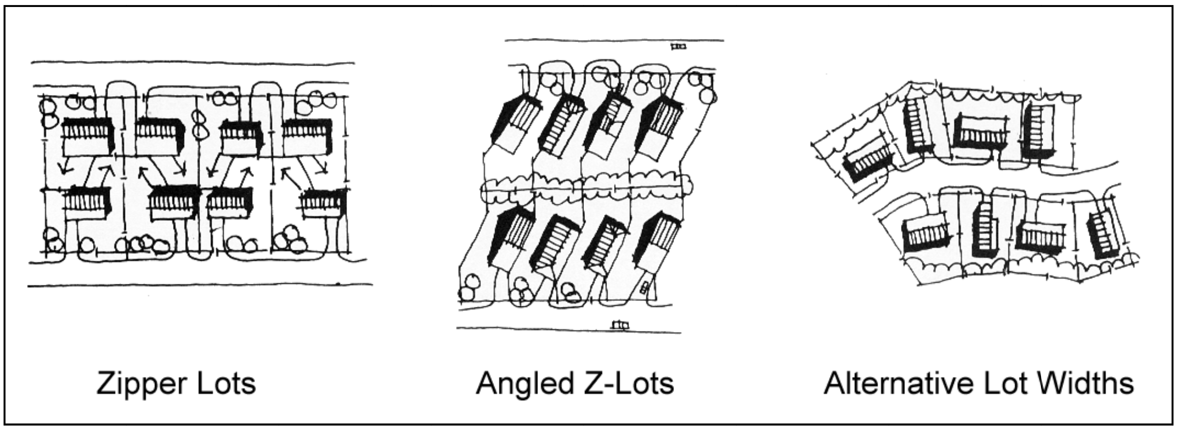



**Reduced Impervious Cover by Using Smaller Setbacks**
(Adapted from: MPCA, 1989)

Likewise, reducing side yard setbacks and using narrower frontages (to the extent allowable) can reduce total street length when the same number of lots are used, especially in cluster and open space designs.

Flexible lot shapes and setback and frontage distances allow site designers to create attractive and unique lots, while allowing for the preservation of natural areas in a residential subdivision. The figure below illustrates various non-traditional lot designs.

Examples of Reduced Frontages and Side Yard Setbacks




**Non-traditional Lot Designs**
(Source: ULI, 1992)

### *Preferred Site Design Practice #12:*
## Use Fewer or Alternative Cul-de-Sacs

**Description**: Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should also be considered.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>• | ☑ Consider alternative cul-de-sac designs |

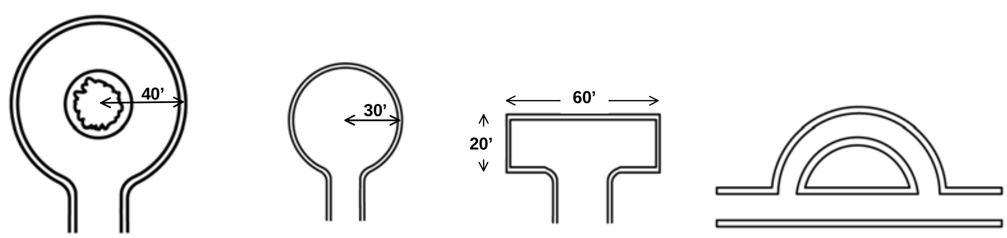
***Discussion***

Alternative turnarounds are designs for end-of-street vehicle turnarounds that replace traditional cul-de-sacs and reduce the amount of impervious cover created in developments. Cul-de-sacs are local access streets with a closed circular end that allows for vehicle turnarounds. From a stormwater perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of runoff. For this reason, reducing the size of cul-de-sacs through the use of alternative turnarounds or eliminating them altogether can reduce the amount of impervious cover created at a site.

Numerous alternatives create less impervious cover than the traditional cul-de-sac. These alternatives include reducing cul-de-sac radius and creating hammerheads, loop roads (eyebrows), and pervious islands in the cul-de-sac center (see the figure below).

Sufficient turnaround area is a significant factor to consider in the design of cul-de-sacs. In particular, the types of vehicles entering into the cul-de-sac should be considered.

While minimizing impervious surface area is desirable, all designs must meet the minimum requirements of local codes, ordinances and regulations unless a waiver is obtained from the local jurisdiction.




**40 ft cul-de-sac with landscaped island** | **30 ft radius cul-de-sac** | **60 by 20 ft T-shaped turnaround** | **Loop road**

**Examples of Turnarounds for Residential Streets**
(Source: Schueler, 1995)

*Preferred Site Design Practice #13:*

# Create Parking Lot Stormwater "Islands"

**Description**: Provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

| KEY BENEFITS | USING THIS PRACTICE |
|---|---|
| • Reduces the amount of impervious cover and associated runoff and pollutants generated.<br>• Provides an opportunity for the siting of structural control facilities.<br>• Trees in parking lots provide shading for cars and are more visually appealing. | ☑ Integrate porous areas such as landscaped islands, swales, filter strips and bioretention areas in a parking lot design. |

***Discussion***

Parking lots should be designed with landscaped stormwater management "islands" which reduce the overall impervious cover of the lot as well as provide for runoff treatment and control in stormwater facilities.

When possible, expanses of parking should be broken up with landscaped islands which include shade trees and shrubs. Fewer large islands will sustain healthy trees better than more numerous very small islands.

Structural control facilities such as filter strips, dry swales and bioretention areas can be incorporated into parking lot islands. Stormwater is directed into these landscaped areas and temporarily detained. The runoff then flows through or filters down through the bed of the facility and is infiltrated into the subsurface or collected for discharge into a stream or another stormwater facility. These facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. For detailed design specifications of filter strips, enhanced swales and bioretention areas, refer to Chapter 3.

**Parking Lot Stormwater "Island"**

***Preferred Site Design Practice #14:***

# Use Vegetated Swales Instead of Curb and Gutter

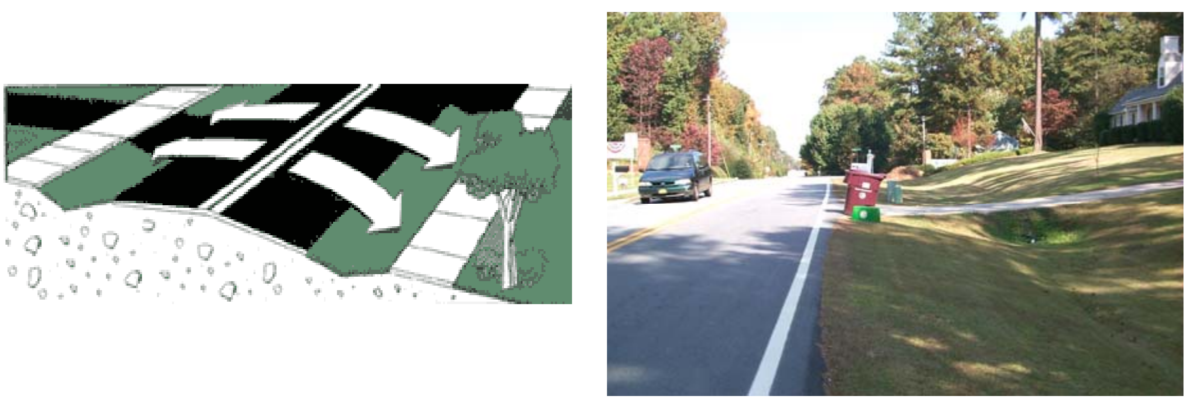
**Description**: Where density, topography, soils, slope, and safety issues permit, vegetated open channels can be used in the street right-of-way to convey and treat stormwater runoff from roadways.

| KEY BENEFITS | USING THIS PRACTICE |
| --- | --- |
| • Reduces the cost of road and storm sewer construction.<br>• Provides for some runoff storage and infiltration, as well as treatment of stormwater.<br>• A $WQ_V$ reduction can be taken if designed appropriately. | ✓ Use vegetated open channels (enhanced swales or grass channels) in place of curb and gutter to convey and treat stormwater runoff |

***Discussion***

Curb and gutter and storm drain systems allow for quicker transport of stormwater from a site to a drainageway, which results in increased peak flow and reduced runoff infiltration. Curb and gutter systems also do not provide treatment of stormwater that is often polluted from vehicle emissions, pet waste, lawn runoff and litter.

Where permitted by local codes, ordinances and regulations, open vegetated channels along a roadway (see the figure below) are effective in removing pollutants by allowing infiltration and filtering to occur, unlike curb and gutter systems which move water with virtually no treatment. Grass channels and enhanced swales are two alternatives that, when properly installed and maintained under the right site conditions, are excellent methods for treating stormwater on-site. In addition, open vegetated channels can be less expensive to install than curb and gutter systems. Further design information and specifications for grass channels/enhanced swales can be found in Chapter 3.



**Using Vegetated Swales instead of Curb and Gutter**

### *Preferred Site Design Practice #15:*
# Drain Runoff to Pervious Areas

**Description**: Where practicable, direct runoff from impervious areas such as rooftops, roadways and parking lots to pervious areas, open channels or vegetated areas to provide for water quality treatment and infiltration. Avoid routing runoff directly to the structural stormwater conveyance system.

| **KEY BENEFITS** | **USING THIS PRACTICE** |
|---|---|
| • Sending runoff to pervious vegetated areas increases overland flow time and reduces peak flows.<br>• Vegetated areas can often filter and infiltrate stormwater runoff.<br>• A $WQ_V$ reduction can be taken if designed appropriately. | ☑ Minimize directly connected impervious areas and drain runoff as sheet flow to pervious vegetated areas |

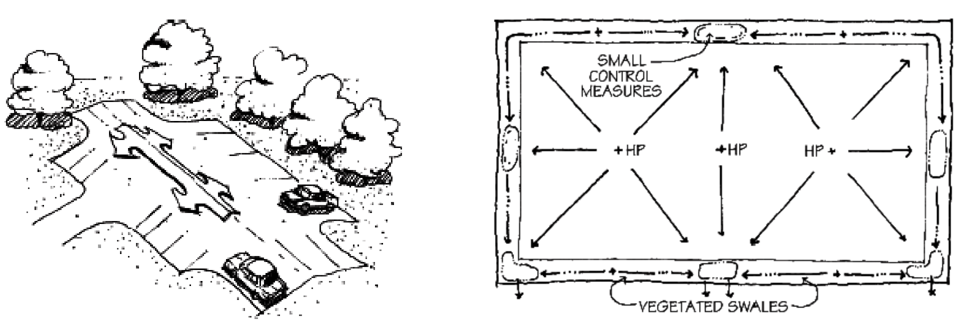
***Discussion***

Stormwater quantity and quality benefits can be achieved by routing the runoff from impervious areas to pervious areas such as lawns, landscaping, filter strips and vegetated channels. Revegetated areas such as lawns and engineered filter strips and vegetated channels can act as biofilters for stormwater runoff and provide for infiltration in relatively pervious (hydrologic group A and B) soils. In this way, the runoff is “disconnected” from a hydraulically efficient structural conveyance such as a curb and gutter or storm drain system.

Some of the methods for disconnecting impervious areas include:

- Designing roof drains to flow to vegetated areas or infiltration areas;
- Directing flow from paved areas (such as driveways) to stabilized vegetated areas;
- Breaking up flow directions from large paved surfaces (see the figure below);
- Carefully locating impervious areas and grading landscaped areas to achieve sheet flow runoff to the vegetated pervious areas.

For maximum benefit, runoff from impervious areas to vegetated areas must occur as sheet flow and the soil must be stabilized. See Chapter 3 for more design information and specifications on filter strips and vegetated channels.




**Design paved surfaces to disperse flow to vegetated areas**

(Source: NCDENR, 1998)

## 2.4 Preferred Site Design Examples

### 2.4.1 Residential Subdivision Example 1

A typical residential subdivision design on a parcel is shown in upper Figure 2-1. The entire parcel except for the subdivision amenity area (clubhouse and tennis courts) is used for lots. The entire site is cleared and mass graded, and no attempt is made to fit the road layout to the existing topography. Because of the clearing and grading, all of the existing natural vegetation and topsoil are removed, dramatically altering both the natural hydrology and drainage of the site. The wide residential streets create unnecessary impervious cover and a curb and gutter system that carries stormwater flows to the storm sewer system. No provision for non-structural stormwater treatment is provided on the subdivision site.

A residential subdivision employing Preferred Site Design (PSD) practices is presented in lower Figure 2-1. This subdivision configuration preserves approximately one-fourth of the property as undisturbed open space and vegetation. The road layout is designed to fit the topography of the parcel, following the high points and ridgelines. The natural drainage patterns of the site are preserved and are utilized to provide natural stormwater treatment and conveyance. Narrower streets reduce impervious cover and grass channels provide for treatment and conveyance of roadway and driveway runoff. Landscaped islands at the ends of cul-de-sacs also reduce impervious cover and provide stormwater treatment functions. Where possible, only the building envelopes of the individual lots are cleared and graded, further preserving the natural hydrology of the site.

### 2.4.2 Residential Subdivision Example 2

Another typical residential subdivision design is shown in upper Figure 2-2. Most of this site is cleared and mass graded, with the exception of a small riparian buffer along the large stream at the right boundary of the property. Almost no buffer was provided along the small stream that runs through the middle of the property. In fact, areas within the 100-year floodplain were cleared and filled for home sites. As is typical in many subdivision designs, this one has wide streets for on-street parking and large cul-de-sacs.

The PSD subdivision can be seen in lower Figure 2-2. This subdivision layout was designed to conform to the natural terrain. The street pattern consists of a wider main thoroughfare, which winds through the subdivision along the ridgeline. Narrower loop roads branch off of the main road and utilize landscaped islands. Large riparian buffers are preserved along both the small and large streams. The total undisturbed conservation area is approximately one-third of the site.

### 2.4.3 Commercial Development Example

Upper Figure 2-3 shows a typical commercial development containing a supermarket, drugstore, smaller shops and a restaurant on an outlot. The majority of the parcel is a concentrated parking lot area. The only pervious area is a small replanted vegetation area acting as a buffer between the shopping center and adjacent land uses. Stormwater quality and quantity control are provided by a wet extended detention pond in the corner of the parcel.

A PSD commercial development can be seen in lower Figure 2-3. Here the retail buildings are dispersed on the property, providing more of an “urban village” feel with pedestrian access between the buildings. The parking is broken up, and bioretention areas for stormwater treatment are built into parking lot islands. A large bioretention area which serves as open green space is located at the main entrance to the shopping center. A larger undisturbed buffer has been preserved on the site. Because the bioretention areas and buffer provide the required water quality treatment, only a dry extended detention basin is needed for water quantity control.

### 2.4.4 Office Park Example

An office park with a conventional design is shown in upper Figure 2-4. Here the site has been graded to fit the building layout and parking area. All of the vegetated areas of this site are replanted areas.

The PSD layout, presented in lower Figure 2-4, preserves undisturbed vegetated buffers and open space areas on the site. Both the parking areas and buildings have been designed to fit the natural terrain of the site. In addition, a modular porous paver system is used for the overflow parking areas.

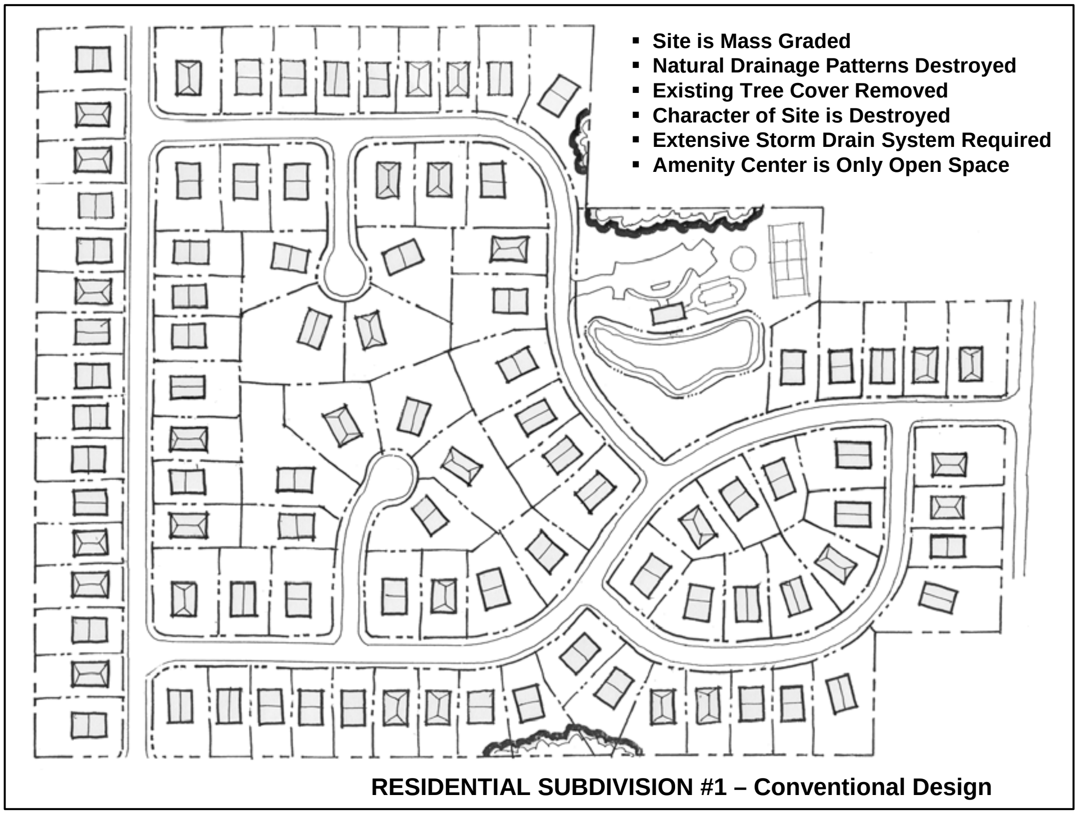



**Figure 2-1 Comparison of a Traditional Residential Subdivision Design (above) with and Innovative Site Plan Developed Using Preferred Site Design Practices (below)**

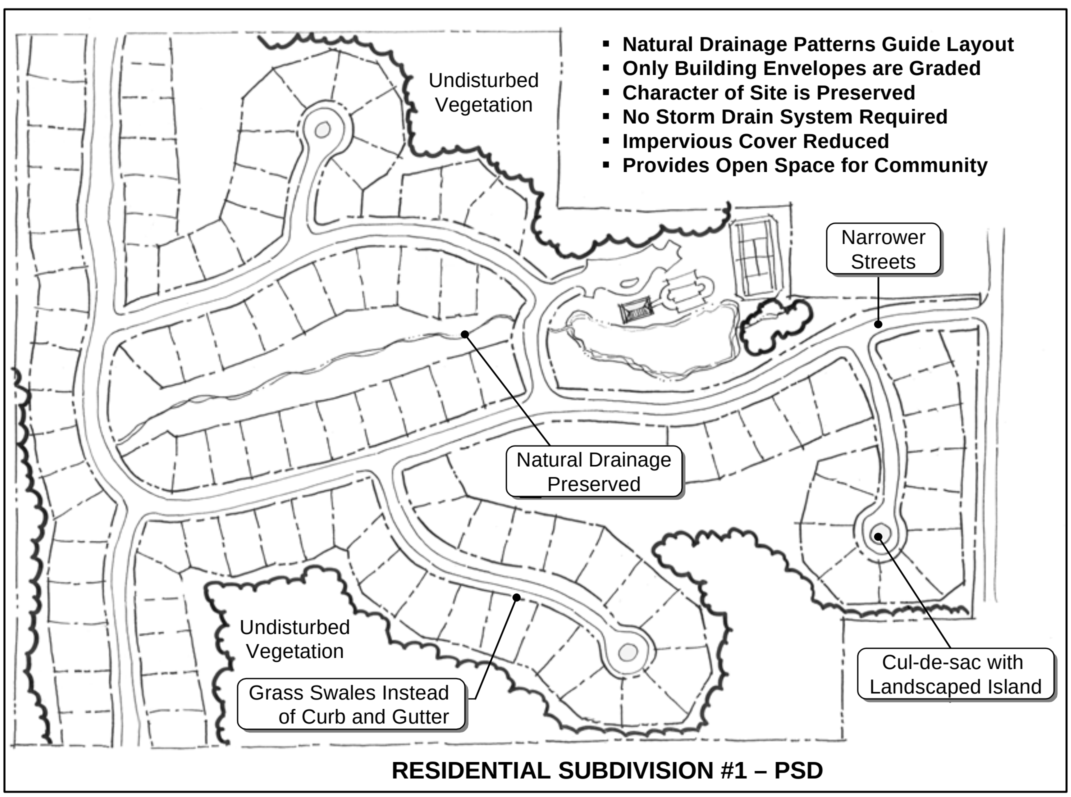
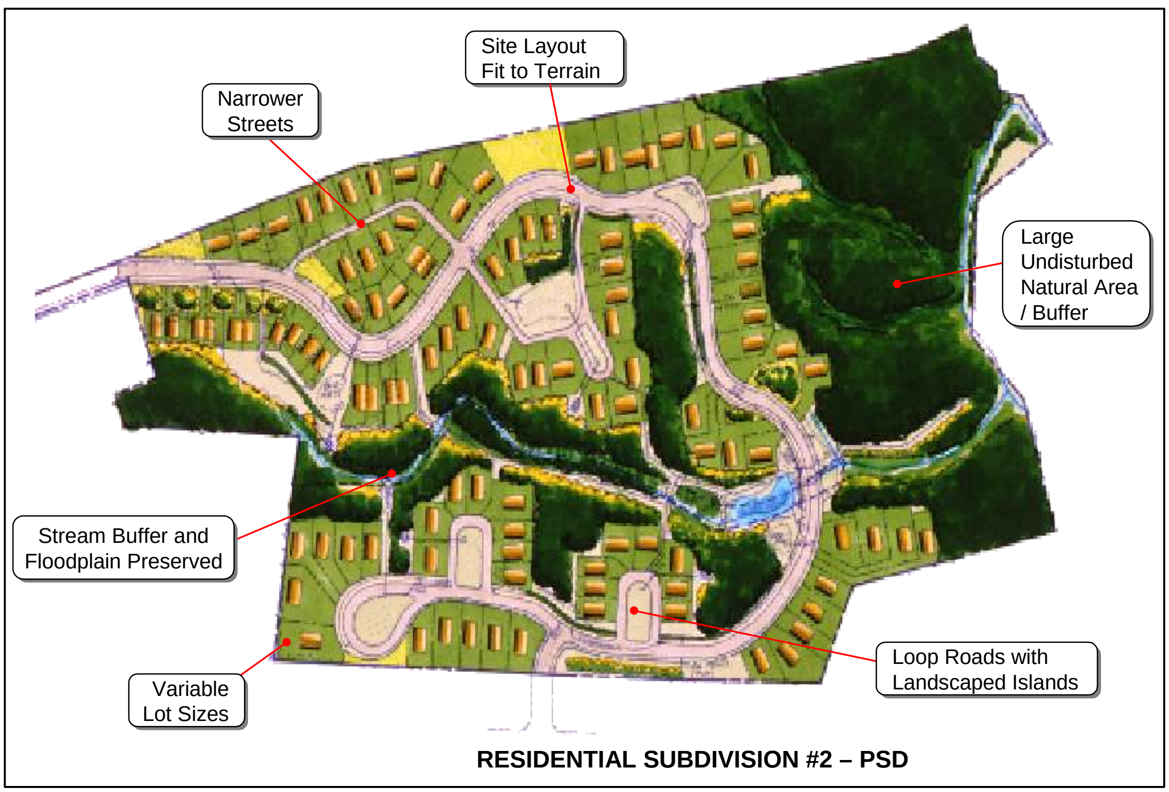



**Figure 2-2 Comparison of a Traditional Residential Subdivision Design (above) with an Innovative Site Plan Developed Using Preferred Site Design Practices (below)**



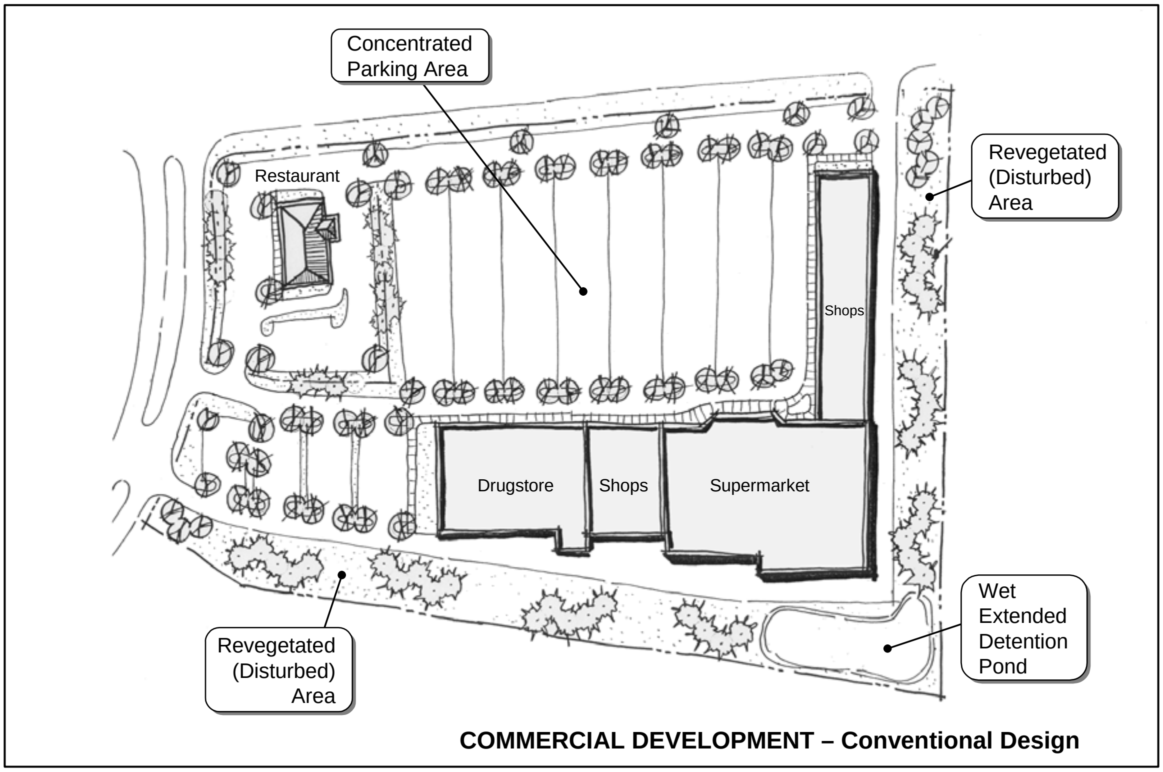
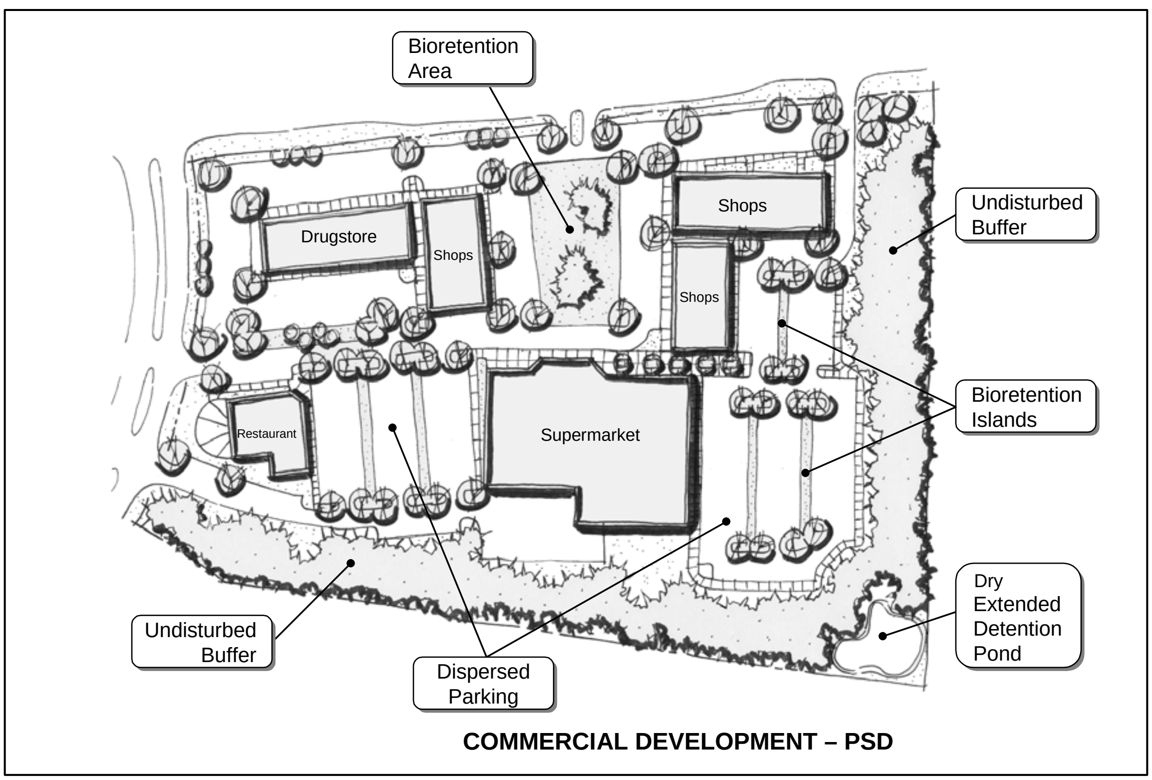



**Figure 2-3 Comparison of a Traditional Commercial Development (above) with an Innovative Site Plan Developed Using Preferred Site Design Practices (below)**



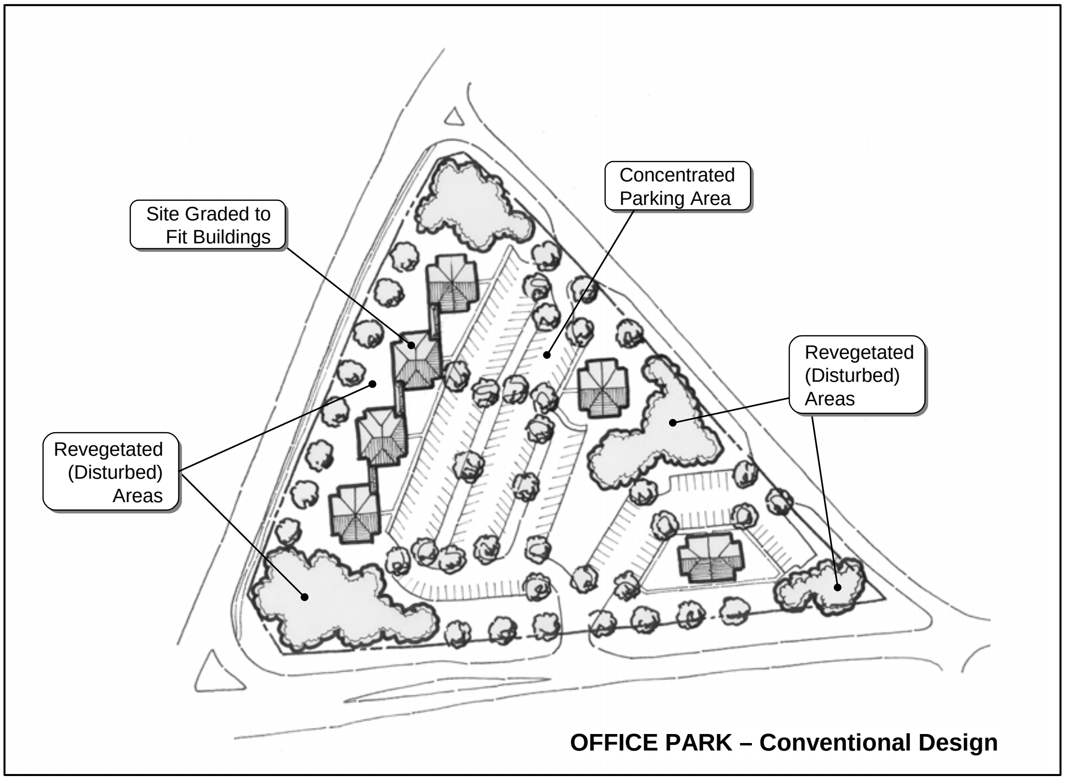
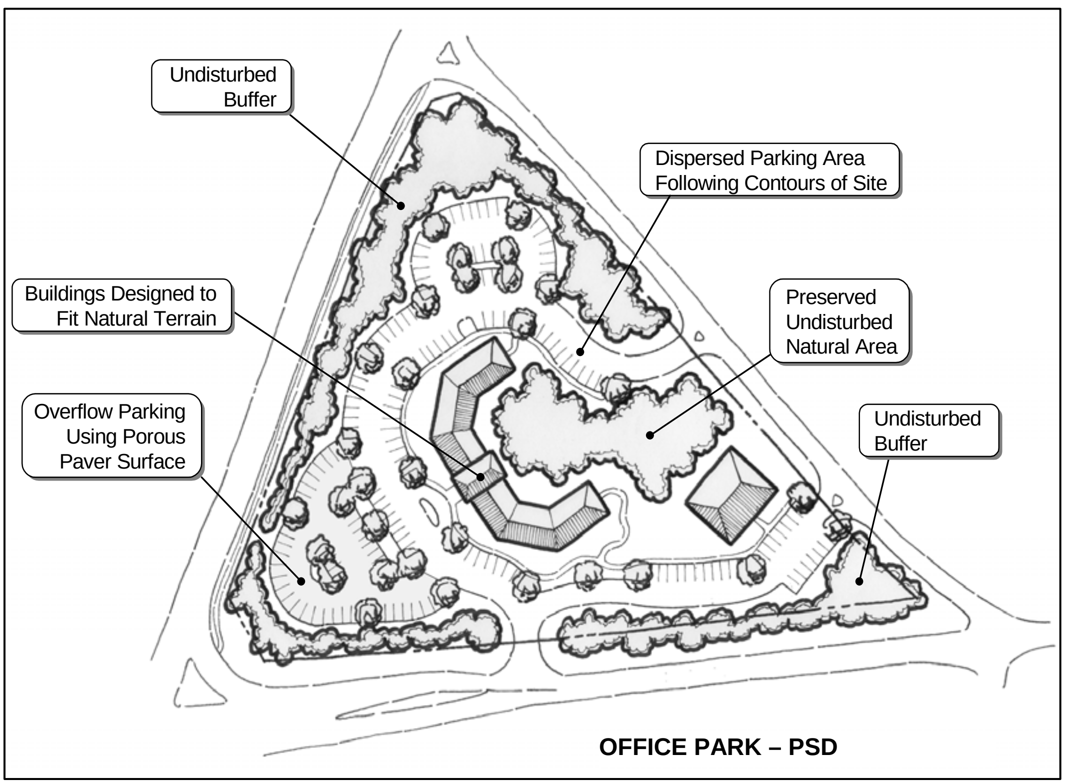



**Figure 2-4 Comparison of a Traditional Office Park Design (above) with an Innovative Site Plan Developed Using Preferred Site Design Practices (below)**



CHAPTER

3

# STORMWATER CONTROLS

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# 3.1 Stormwater Management Controls Overview

## 3.1.1 Stormwater Management Controls - Categories and Applicability

### 3.1.1.1 Introduction

Stormwater management structural controls are engineered facilities intended to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to development. This section provides an overview of structural stormwater controls (also called stormwater management facilities) that can be used to address local stormwater management standards. Many of the structural stormwater controls can be used in an Integrated Site Design (ISD) approach, where a control (or set of controls) are designed and constructed to achieve multiple objectives: 1) water quality control; 2) channel protection; and 3) flood control. More information on the ISD Approach is provided in Volume 2, Chapter 1.

### 3.1.1.2 Control Categories

The stormwater management controls recommended in this Manual vary in their applicability and ability to meet stormwater management goals. These stormwater controls fall into three categories, depending upon their applicability to remove the pollutant of concern for both the City of Wichita and Sedgwick County which is total suspended solids (TSS). The three categories are: primary TSS treatment facilities, secondary TSS treatment facilities, and other stormwater management facilities.

***Primary TSS Treatment Facilities***

Primary TSS treatment facilities are structural controls that have the ability to effectively treat the Water Quality Volume ($WQ_v$) and have been shown to be able to remove up to 90% of the annual average total suspended solids (TSS) load in typical post-development urban runoff when designed, constructed, and maintained in accordance with recommended specifications. These controls are recommended for use with a wide variety of land uses and development types. Several of these controls can also be designed to achieve other ISD approach objectives, that is, downstream channel protection and/or flood control. Primary TSS treatment facilities are recommended for a site wherever feasible and practical.

***Secondary TSS Treatment Facilities***

Secondary TSS treatment facilities are recommended only for limited use or for special site or design conditions. Generally, these practices are: (1) intended to address “hotspot” or specific land use constraints or conditions; and/or, (2) have high or special maintenance requirements that may discourage their use. These types of structural controls are typically used for water quality treatment only. Some of these controls can be used as a pretreatment measure or in series with other structural controls to meet pollutant removal goals.

***Other Stormwater Management Facilities***

Other stormwater management facilities are controls that do not provide TSS treatment and therefore may be used for runoff quantity control only (i.e., peak discharge or volume control). These controls should be used in coordination with primary or secondary TSS treatment facilities. This category also includes the green (or vegetated) roof which is a special control that addresses both water quality and quantity, because it reduces the amount of stormwater runoff.

Table 3-1 lists the all of the structural stormwater control practices included in this Manual. A summary of the suitability, performance, and other considerations applicable to these controls is presented in Appendix E Table E-1 and Table E-2. A detailed discussion of each of the controls, as well as design criteria and other information, is provided in sections 3.2, 3.3 and 3.4. Operations and maintenance checklists are provided in section **Error! Reference source not found.**.

**Table 3-1 Structural Controls**

| Structural Control | Description |
|---|---|
| Stormwater (Wet) Ponds (primary) | **Stormwater ponds** are stormwater retention basins that have a permanent pool (or micropool) of water. All or a portion of runoff from each rain event is detained and treated in the pool. A stormwater pond may incorporate a portion of the $WQ_v$ in extended detention above the permanent pool level. |
| Conventional Dry Detention Pond (other)<br><br>Dry Extended Detention Pond (primary)<br><br>Underground Dry Detention (other) | **Conventional dry detention** ponds are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. **Dry extended detention (ED)** ponds are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts as well as provide water quality treatment. **Underground detention** tanks and vaults are an alternative to conventional surface dry detention for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area. |
| Enhanced Dry Swale (primary)<br><br>Grass Channel (primary) | **Enhanced swales** are vegetated open channels with underdrain provisions that are designed and constructed to capture and treat stormwater runoff within dry cells formed by check dams or other means. **Grass swales or channels** provide “biofiltering” of stormwater runoff as it flows across the grass surface of the conveyance channel. |

| Structural Control | Description |
|---|---|
| Infiltration Trench (primary)<br><br>Soakage Trench (primary) | An **infiltration trench** is an excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench. **Soakage trenches** are a variation of infiltration trenches. Soakage trenches drain through a perforated pipe buried in gravel. They are used in highly impervious areas where conditions do not allow surface infiltration and where pollutant concentrations in runoff are minimal (i.e. non-industrial rooftops). They may be used in conjunction with other stormwater devices, such as downspouts. |
| Filter Strip (primary)<br><br>Surface Sand Filter (primary)<br><br>Underground Sand Filter (secondary)<br><br>Organic Filter (secondary) | **Filter strips** provide “biofiltering” of stormwater runoff as it flows across and through the grassed surface. **Surface sand filters** are structures designed to treat stormwater runoff through filtration, using a sand bed as its primary filter media. Filtered runoff may be returned to the conveyance system, or allowed to partially exfiltrate into the soil. **Underground sand filters** are a design variation of the surface sand filter, where the sand filter chambers and media are located in an underground vault. **Organic filters** are surface sand filters where organic materials such as a leaf compost or peat/sand mixture are used as the filter media. These media may be able to provide enhanced removal of some contaminants, such as heavy metals. Given their potentially high maintenance requirements, they should only be used in environments that warrant their use. |
| Bioretention Area (primary) | **Bioretention areas** are shallow stormwater basins or landscaped areas which utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff may be returned to the conveyance system, or allowed to partially infiltrate into the soil or evaporate. |
| Stormwater Wetland (primary) | **Stormwater wetlands** are constructed wetland systems used for stormwater management. Stormwater wetlands consist of a combination of shallow marsh areas, open water, and semi-wet areas above the permanent water surface. |
| Proprietary Treatment Systems (secondary) | **Proprietary treatment systems** are manufactured structural control systems available from commercial vendors designed to treat stormwater runoff and/or provide water quantity control. Proprietary systems often can be used on small sites and in space-limited areas, as well as in pretreatment applications. However, proprietary systems are often more costly than other alternatives, may have high maintenance requirements, and often lack adequate independent performance data. |
| Gravity Separator (secondary) | **Gravity separator** controls use the movement of stormwater runoff through a specially designed structure to remove target pollutants (such as oil from water). They are typically used on smaller impervious commercial sites and urban hotspots. These controls are typically used as a pretreatment measure and as part of a treatment train approach. |

| Structural Control | Description |
| --- | --- |
| Alum Treatment (secondary) | **Alum treatment** provides for the removal of suspended solids from stormwater runoff entering a wet pond by injecting liquid alum into storm sewer lines on a flow-weighted basis during rain events. Alum treatment should only be considered for large-scale projects where high water quality is desired. |
| Green Roof (other)<br><br>Modular Porous Paver System (other)<br><br>Porous Pavement (other) | A **green roof** uses a small amount of substrate over an impermeable membrane to support a covering of plants. The green roof both detains and consumes (through evapotranspiration) runoff from the otherwise impervious roof surface as well as moderates rooftop temperatures. A green roof can also provide aesthetic or habitat benefits. **Modular porous paver systems** consist of open void paver units laid on a gravel subgrade. **Porous pavement** is a permeable surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. (Porous concrete is the term for a mixture of course aggregate, Portland cement, and water that allows for rapid movement of water through the concrete.) Both porous concrete and porous paver systems have high workmanship and maintenance requirements. |

## 3.1.2 Suitability of Stormwater Controls to Meet the IDS Approach Objectives

### 3.1.2.1 Water Quality

All of the primary and secondary stormwater controls provide some degree of pollutant removal. Pollutant removal capabilities for a given structural stormwater control practice are based on a number of factors including the physical, chemical, and/or biological processes that take place in the structural control and the design and sizing of the facility. In addition, pollutant removal efficiencies for the same structural control type and facility design can vary widely depending on the tributary land use and area, incoming pollutant concentration, flow rate, volume, pollutant loads, rainfall pattern, time of year, maintenance frequency, and numerous other factors.

Table 3-2 provides nominal design removal efficiencies for each of the control practices. It should be noted that these values are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. A structural control design may be capable of exceeding these performances; however the values in the table are minimum reasonable values that can be assumed to be achieved when the structural control is sized, designed, constructed, and maintained in accordance with recommended specifications in this Manual. For some listed controls, pollutant removal rates are not indicated because there is insufficient data for setting those rates, or the removal efficiency is dependent on the design of the specific device or installation. Where the pollutant removal capabilities of an individual structural stormwater control are not sufficient for a given site application, additional controls may be used in series and/or in parallel ("treatment train" approach).

For additional information and data on the range of pollutant removal capabilities for various structural stormwater controls, the reader is referred to the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the International Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

**Table 3-2 Design Pollutant Removal Efficiencies for Stormwater Controls (Percentage)**

| Structural Control | Total Suspended Solids | Total Phosphorus | Total Nitrogen | Metals | Fecal Coliform[g] |
|---|---|---|---|---|---|
| Stormwater Pond | 80 | 55 | 30 | 50 | 70 |
| Conventional Dry Detention Pond | a | a | a | a | a |
| Dry Extended Detention Pond | 60 | 35 | 25 | 25 | b |
| Underground Dry Detention Basin | a | a | a | a | a |
| Enhanced Swale | 90 | 50 | 50 | 40 | b |
| Grass Channel | 50 | 25 | 20 | 30 | b |
| Infiltration Trench | 90 | 60 | 60 | 90 | 90 |
| Soakage Trench | 90 | 60 | 60 | 90 | 90 |
| Vegetative Filter Strip | 50 | 20 | 20 | 40 | b |
| Surface Sand Filter | 80 | 50 | 30 | 50 | 40 |
| Underground Sand Filter | 80 | 50 | 30 | 50 | 40 |
| Organic Filter | 80 | 60 | 40 | 75 | 50 |
| Bioretention Area | 85 | 60 | 50 | 80 | b |
| Stormwater Wetland | 75 | 45 | 30 | 50 | 70 g |
| Proprietary Treatment | c | c | c | c | d |
| Gravity Separator | c | c | c | d | d |
| Alum Treatment | 90 | 80 | 60 | 75 | 90 |
| Green Roof | e | e | e | e | e |
| Modular Porous Paver System | f | 80 | 80 | 90 | f |
| Porous Pavement | f | 80 | 80 | 90 | f |

a for peak flow control only, does not provide appreciable water quality benefit
b insufficient data to assign a pollutant removal value
c removal efficiency depends on specific device
d usually not applicable or determinable
e removal efficiency depends on specific installation
f must not be used to remove TSS due to clogging; use for quantity control only
g Assumes no animal population present to deposit waste in or near the facility

### 3.1.2.2 Channel Protection

Some of the stormwater management controls presented in this Manual have the ability to detain and regulate the discharge of the 1-year, 24-hour storm event and therefore can provide long-term channel protection volume ($CP_v$) control. These include stormwater ponds, detention ponds, stormwater wetlands, porous surface systems, and, to some extent, other runoff-detaining or infiltrating facilities.

#### 3.1.2.3 Flood Control

On-Site**:** Selected stormwater management controls (grassed swales, detention ponds, stormwater ponds, and stormwater wetlands) may be used in conjunction with other drainage controls (storm sewers, channels, curbs and gutters, etc.) to safely convey stormwater through a development in accordance with the stormwater drainage design criteria.

Downstream**:** Selected stormwater management controls (grassed swales, infiltration systems, detention ponds, stormwater ponds, and stormwater wetlands) may be used to retain, detain and otherwise regulate the volume and rates of stormwater discharge from flood events, as determined by the downstream assessment, in accordance with flood control criteria.

### 3.1.3 Selecting Stormwater Management Controls

#### 3.1.3.1 Screening Process

Outlined below is a screening process intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site, and to provide guidance on factors to consider in their physical location.

In general, the following four criteria should be evaluated in order to select the appropriate structural control(s) or group of controls for a development, as summarized in Appendix E, Table E-1:

- Stormwater Management Suitability;
- Relative Water Quality Treatment Performance;
- Site Applicability; and,
- Implementation Considerations.

In addition, for a given site, the following factors should be considered and any specific design criteria or restrictions need to be evaluated, as summarized in Appendix E, Table E-2:

- Physiographic Factors;
- Soils; and,
- Special Considerations.

Finally, environmental and other local, State and federal regulations must be considered as they may influence the location of a structural control on the site, or may require a permit.

The following describes a selection process for comparing and evaluating various structural stormwater controls using a screening matrix and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

***Step 1 - Overall Applicability***

Through the use of the four screening categories in the matrix shown in Appendix E, Table E-1, the site designer evaluates and screens the overall applicability of the full set of structural controls as well as the constraints of the site in question. The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

**Stormwater Management Suitability**

The first category in the matrix examines the capability of each structural control option to provide all or part of water quality treatment, downstream channel protection, and flood control requirements. A blank entry means that the structural control cannot or is not typically used to meet the indicated requirement.

<u>Ability to treat the $WQ_v$:</u> This indicates whether a structural control can be used to treat all or part of the $WQ_v$. The presence of a “P” or an “S” indicates whether the control is a Primary or Secondary control (see Section 3.1.1.2) for meeting the TSS reduction goal.

<u>Ability to provide the $CP_v$:</u> This indicates whether the structural control can be used to provide all or part of the extended detention required for the $CP_v$. The presence of a “P” indicates that the structural control is commonly used. An “S” indicates that the structural control may be used, but the volume provided is usually limited.

<u>Ability to provide Flood Control:</u> This indicates whether a structural control can be used to meet the flood control criteria. The presence of a “P” indicates that the structural control is typically used to provide peak flow reduction of the flood events, including the 100-year storm event. An “S” indicates that the control can be used to reduce the volume and rate of onsite runoff, but is usually not sufficient to provide the majority of flood control.

**Relative Water Quality Treatment Performance**

The second category of the matrix provides an overview of the pollutant removal performance of each structural control option, when designed, constructed, and maintained according to the criteria and specifications in this Manual.

<u>Ability to provide TSS and Sediment Removal:</u> This column indicates the capability of a structural control to remove sediment in runoff. The Primary (“P”) structural controls remove 30% to 90% of the average annual TSS load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment: This column indicates the capability of a structural control to remove nutrients (nitrogen and phosphorus) in runoff.

Ability to provide Bacteria Removal: This column indicates the capability of a structural control to remove bacteria in runoff.

Ability to accept Hotspot Runoff: The last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities which produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning, industrial sites, industrial rooftops, and auto salvage or recycling facilities. A check mark indicates that the structural control may be used for a hotspot site; however, it may have specific design restrictions. Please see the specific design criteria for the structural control for more details. Please note that hotspot treatment must be tailored to the characteristics of the hotspot runoff pollutants to be removed. Designation of a control as suitable for accepting hotspot runoff does not necessarily mean it is the appropriate treatment facility for that particular hotspot condition. Such a designation simply indicates that the facility is commonly used for treatment of some types of hotspot runoff. For example, and oil-water separator is appropriate for runoff containing some types of floatable greases or oils, whereas a surface sand filter would not be suitable.

**Site Applicability**

The third category of the matrix provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits and can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area: This column indicates the approximate minimum or maximum drainage area considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, a variance would be required. Likewise, the minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits, and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or design variations used to maintain a permanent pool (e.g., liners).

Slope: This column identifies general slope restrictions for the specific structural control practice.

Minimum Head: This column provides an estimate of the minimum site elevation difference needed from the inflow to the outflow to allow for gravity operation within the structural control.

Water Table: This column indicates water table or groundwater separation requirements for certain controls.

**Implementation Considerations**

The fourth category in the matrix provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use: This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban: This column identifies those structural controls appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Relative Capital Cost: The structural controls are ranked according to their relative construction cost per impervious acre treated, as determined from cost surveys.

Maintenance Burden: This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. It should be noted that all structural controls require routine inspection and maintenance.

***Step 2 - Specific Criteria***

The last three categories in the screening matrix, shown in Appendix E, Table E-2, provide an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

**Physiographic Factors**

Three key factors to consider are low-relief, high-relief, and karst terrain. Low relief (very flat) areas are common throughout Sedgwick County. High relief (steep and hilly) areas are rare but do exist in limited lot-scale areas. Karst areas (due to dissolution of salt beds) are limited to the northwest part of Sedgwick County. Special geotechnical testing requirements may be needed in karst areas.

- Low relief areas need special consideration because structural controls require a hydraulic head to move stormwater runoff through the facility.
- High relief may limit the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases, high relief may impact dam heights to the point that a structural control becomes infeasible.
- Karst terrain can limit the use of some structural controls as the infiltration of polluted waters directly into underground streams found in karst areas may be prohibited. In addition, ponding areas may not reliably hold water in karst areas.

**Soils**

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

**Special Considerations**

The design of structural stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. In addition, the designer should consult with the appropriate approval authority to determine if the development project is subject to additional or overriding stormwater structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

<u>High Quality (or Potential High Quality) Streams (streams with a watershed impervious cover less than approximately 15%):</u> These streams may also possess high quality cool water or warm water aquatic resources or endangered species. These streams may also be specially designated by local authorities.

<u>Wellhead and Aquifer Protection:</u> Areas that recharge existing water supply wells and aquifers present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of untreated hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to help maintain flow in streams and wells during dry weather.

<u>Reservoir Protection:</u> Watersheds that deliver surface runoff to water supply reservoirs or impoundments are a special concern. Depending on the treatment available, it may be necessary to achieve a greater level of pollutant removal for the pollutants of concern, such as bacteria pathogens, nutrients, sediment, or metals. One particular management concern for reservoirs is ensuring stormwater hotspots are adequately treated so they do not contaminate water supplies.

***Step 3 - Location and Permitting Considerations***

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. The checklist below (Table 3-3) provides a condensed summary of current restrictions as they relate to common site features that may be regulated under local, State, or federal laws and regulations. These restrictions fall into one of three general categories:

- Locating a structural control within an area when expressly prohibited by law.

- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Local, State, and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls located in accordance with local setback requirements.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency or authority is the best strategy.

**Table 3-3 Location and Permitting Checklist**

| Site Feature | Location and Permitting Guidance |
|---|---|
| Jurisdictional Wetland<br>(Waters of the U.S)<br>U.S. Army<br>Corps of Engineers<br>Regulatory Permit | ✓ Jurisdictional wetlands should be delineated prior to siting structural control.<br>✓ Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided.<br>✓ Stormwater should be treated prior to discharge into a natural wetland.<br>✓ Structural controls may also be restricted in local buffer zones. Buffer zones may be utilized as a non-structural filter strip (i.e., accept sheet flow).<br>✓ Should justify that no practical upland preventive treatment alternatives exist.<br>✓ Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands. |
| Stream Channel<br>(Waters of the U.S)<br>U.S. Army<br>Corps of Engineers Section<br>404 Permit | ✓ All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design.<br>✓ Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided.<br>✓ Stormwater should be treated prior to discharge into Waters of the U.S.<br>✓ In-stream ponds for stormwater quality treatment are highly discouraged.<br>✓ Must justify that no practical upland preventive treatment alternatives exist.<br>✓ Temporary runoff storage preferred over permanent pools.<br>✓ Implement measures that reduce downstream warming. |
| Stream and Floodplain Permits<br>Kansas Department of Agriculture | ✓ Kansas Department of Agriculture - Division of Water Resources permits for stream obstruction, channel change, flood plain fill, levee, water appropriations and buffers. |

| Site Feature | Location and Permitting Guidance |
|---|---|
| 100 Year Floodplain<br>Local Stormwater review Authority | ✓ Grading and fill for structural control construction is generally discouraged within the 100 year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps, or more stringent local floodplain maps.<br>✓ Floodplain fill cannot raise the floodplain water surface elevation by more than limits set by the appropriate jurisdiction. |
| Utilities<br>Local Review Authority | ✓ Call appropriate agency to locate existing utilities prior to design.<br>✓ Note the location of proposed utilities to serve development.<br>✓ Structural controls are discouraged within utility easements or rights of way for public or private utilities. |
| Roads | ✓ Consult KDOT for setback requirements from State maintained roads.<br>✓ Consult Wichita or Sedgwick County authority for setback requirements for City or County streets and roads. |
| Structures | ✓ Consult Wichita or Sedgwick County authority for required structural control setbacks from structures. |
| Water Wells | ✓ Consult Wichita or Sedgwick County authority for required minimum setbacks for stormwater infiltration and other structural controls. |

### 3.1.3.2 Example Application

A 15-acre institutional area (e.g., church and associated buildings) is being constructed in a dense urban area. The impervious coverage of the site is 40%. The site drains to an urban stream that is highly impacted from hydrologic alterations (accelerated channel erosion). The stream channel is deeply incised and hydraulically disconnected from the original floodplain; consequently, flooding is not an issue. The channel drains to a larger sediment-laden stream. Low permeability soils limit infiltration practices.

<u>Objective:</u> Avoid additional accelerated erosion to receiving channel and reduce TSS loads to the sediment-laden stream.

<u>Target Removal:</u> Provide stormwater management to mitigate for accelerated channel incision and reduce TSS loadings by 80%.

<u>Activity/Runoff Characteristics:</u> The proposed site is to have large areas of impervious surface in the form of parking and structures. However, there will be a large contiguous portion of turf grass proposed for the front of the parcel that will have a relatively steep slope (approximately 10%) and will drain to the storm drain system associated with the entrance drive. Stormwater runoff from the site is expected to exhibit fairly high sediment.

Table 3-4 lists the results of the selection analysis using the screening matrix described previously. The highlighted rows indicate the controls selected for this example. The X's indicate inadequacies in the control for this site. The ✓'s indicate adequate control capabilities for this site. The process involves moving left to right across the matrix for each control. Note that after a control is excluded, no further evaluation is performed for that control.

While there is a downstream sediment-laden stream to consider, there are no special watershed factors or physiographic factors to preclude the use of any of the practices from the structural control list. Due to the size of the drainage area, most stormwater ponds and wetlands (permanent pools) are removed from consideration. However, an extended detention micropool would be acceptable. In addition, the site's impermeable soils remove infiltration controls from being considered. Other controls are ruled out on the basis of aesthetics, cost and other subjective factors. The micropool can probably be used to achieve channel protection and flood control. If not, a dry extended detention pond (with forebay) may be used.

**Table 3-4 Sample Structural Control Selection Matrix**

| Structural Control Alternative | TSS Removal Suitability | Site Applicability | Implementation Considerations | Physiographic Factors/Soils | Special Considerations | Other Issues OK |
|---|---|---|---|---|---|---|
| Stormwater Pond | ✓ | ✓ ED micropool | ✓ | ✓ | ✓ | ✓ |
| Conventional Dry Detention Pond | X | | | | | |
| Dry Extended Detention Pond | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Underground Dry Detention Basin | X | | | | | |
| Enhanced Dry Swale | ✓ | ✓ | X turf too steep | | | |
| Grass Channel | ✓ | ✓ | X turf too steep | | | |
| Infiltration Trench | ✓ | ✓ | ✓ | X | | |
| Soakage Trench | ✓ | ✓ | ✓ | X | | |
| Filter Strip | ✓ | ✓ | X turf too steep | | | |
| Surface Sand Filter | ✓ | ✓ | ✓ | ✓ | ✓ | Aesthetics and High Cost |
| Underground Sand Filter | ✓ | ✓ | ✓ | ✓ | ✓ | 2 acres max drainage area |
| Organic Filter | ✓ | ✓ | ✓ | ✓ | ✓ | High Cost |

| Structural Control Alternative | TSS Removal Suitability | Site Applicability | Implementation Considerations | Physiographic Factors/Soils | Special Considerations | Other Issues OK |
|---|---|---|---|---|---|---|
| Bioretention Area | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Stormwater Wetland | ✓ | X | | | | |
| Proprietary Treatment | ✓ | ✓ | ✓ | ✓ | ✓ | High Cost |
| Gravity Separator | ✓ | ✓ | ✓ | ✓ | ✓ | High Cost |
| Alum Treatment | ✓ | ✓ | ✓ | ✓ | ✓ | High Cost |
| Green Roof | ✓ | X | | | | |
| Modular Porous Paver System | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Porous Pavement | X | | | | | |

To provide additional pollutant removal capabilities in an attempt to better meet the target removal, bioretention could be used to treat the parking lot and driveway runoff. The bioretention will provide some TSS removal while improving the aesthetics of the site.

The site drainage system could be designed so the bioretention drains to the extended detention micropool pond for additional treatment. If milder sloped turf areas are provided, such as along the sides of the parking lots, vegetated swales and filters could be added to the list of acceptable controls for additional treatment if not restricted by soil permeability.

Finally, modular porous pavers would be a good choice for the occasional overflow parking that a church typically receives during weekly services. The low infiltration rate of site soils could be overcome by adding an underdrain to the pavers.

## 3.1.4 On-Line Versus Off-Line Structural Controls

### 3.1.4.1 Introduction

Structural stormwater controls are designed to be either “on-line” or “off-line.” Figure 3-1 shows an example of an off-line sand filter and an on-line enhanced swale.

On-line facilities may provide treatment of all or part of the $WQ_v$ and may provide control of all or part of the $CP_v$. They may be designed to control flood flows; if not, they are designed to receive and safely pass the entire range of storm flows up to the 100-year discharge.

Off-line facilities are designed to receive only a specified flow rate or volume through the use of a flow regulator (i.e. diversion structure, flow splitter, etc). Flow regulators are typically used to divert all or a portion of the $WQ_v$ to an off-line structural control sized and designed to treat and control that portion of the $WQ_v$. After the design runoff flow has been treated and/or controlled, it is returned to the conveyance system. Flow Regulators

Flow regulation to off-line structural stormwater controls can be achieved by either:

- Diverting the $WQ_V$ or other specific maximum flow rate to an off-line structural stormwater control, or
- Bypassing flows in excess of the design flow rate. The peak water quality flow rate ($Q_{wq}$) is used as a design parameter to calculate the peak flow rate of the $WQ_v$ and is calculated using the procedure found in Chapter 4.

Flow regulators can be flow splitter devices, diversion structures, or overflow structures. Examples are shown in Figures 3-2, 3-3 and 3-4.

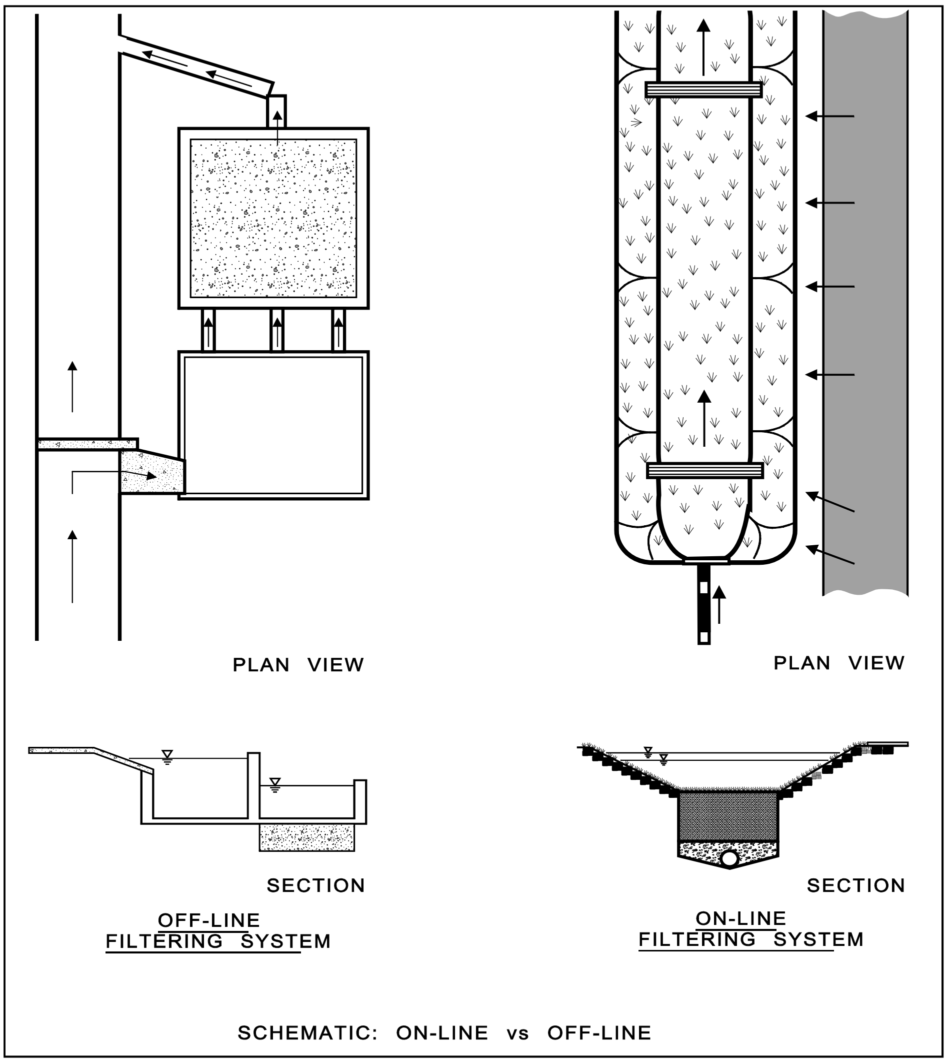


**Figure 3-1 Example of On-Line vs Off-Line Structural Controls**

(Claytor & Schueler, 1996)

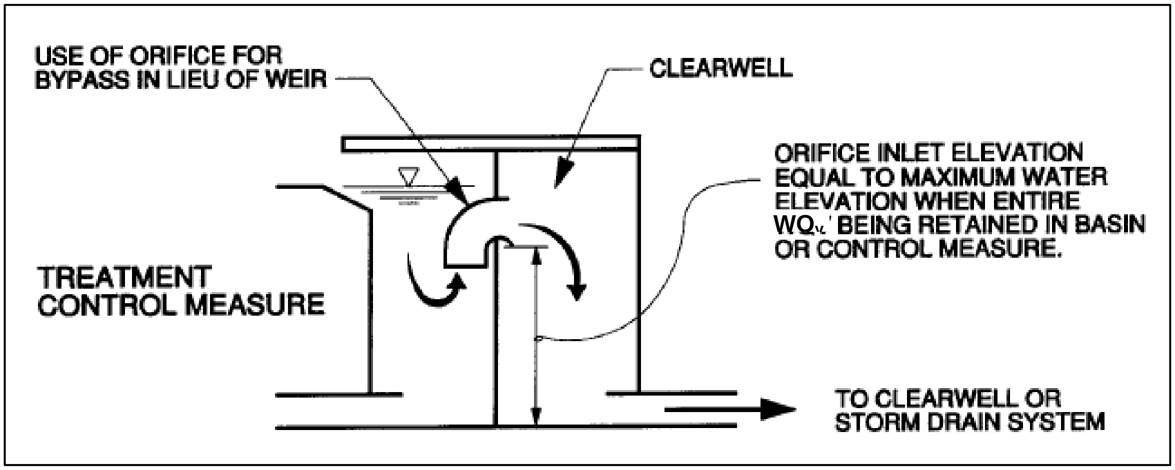


**Figure 3-2  Outlet Flow Regulator**
(Source: City of Sacramento, 2000)

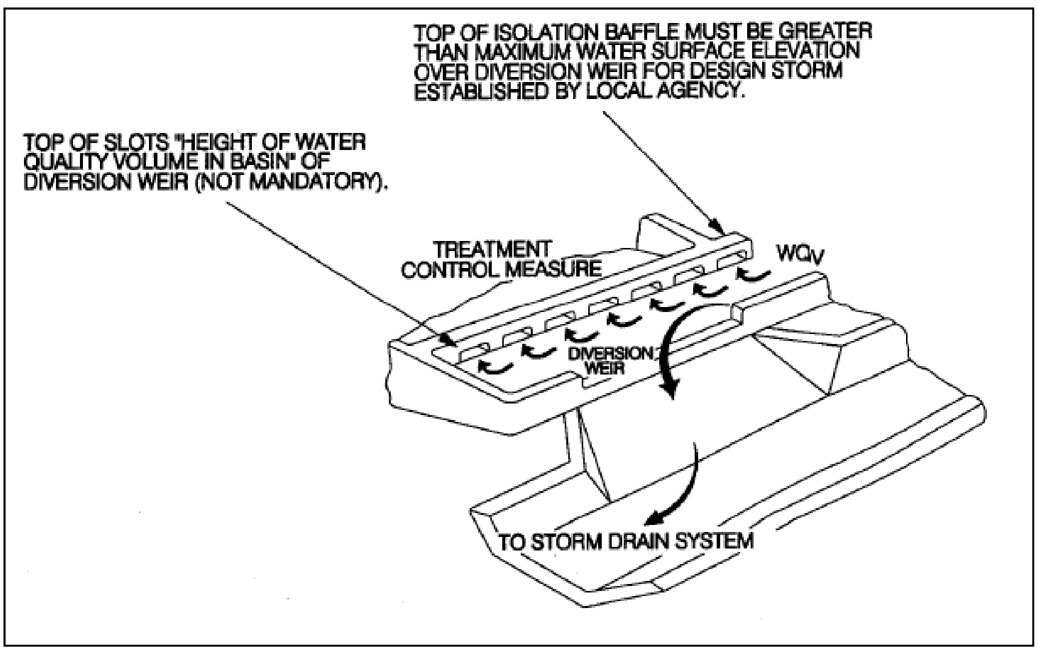


**Figure 3-3  Surface Channel Diversion Structure**
(Source: City of Sacramento, 2000)

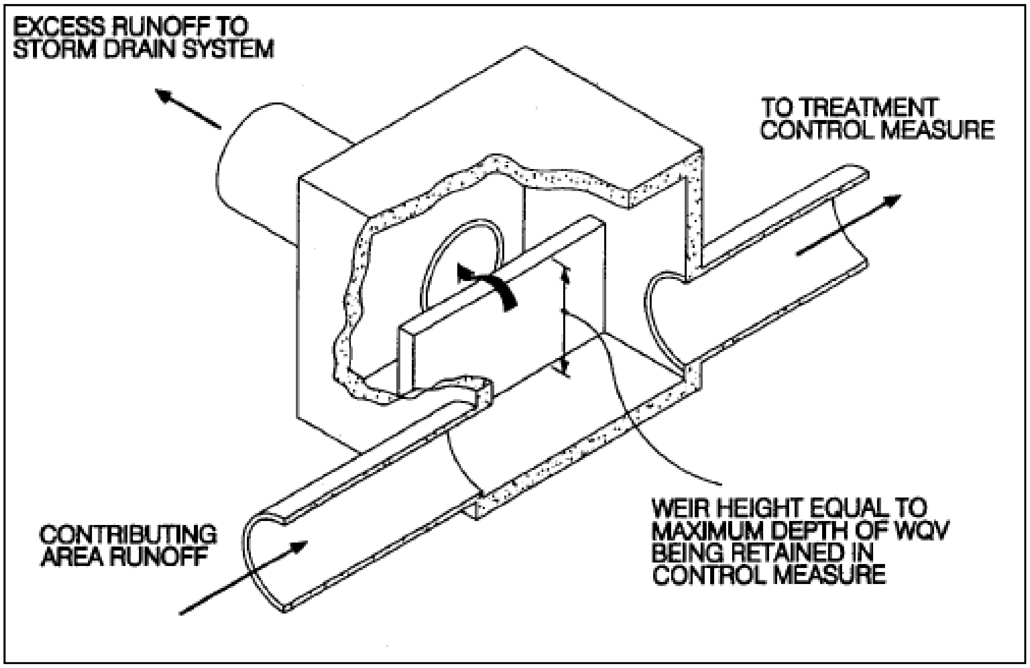


**Figure 3-4 Pipe Interceptor Diversion Structure**
(Source: City of Sacramento, 2000)

## 3.1.5 Regional versus On-Site Stormwater Management

### 3.1.5.1 Introduction

Using individual, on-site structural stormwater controls for each development is the typical approach for controlling stormwater quality and quantity.

A potential alternative approach is for a community to install strategically located regional stormwater controls in a subwatershed rather than require on-site controls (see Figure 3-5). For this Manual, regional stormwater controls are defined as facilities designed to manage stormwater runoff from multiple projects through a local jurisdiction program, where the individual projects may assist in the financing of the facility, and the requirement for on-site controls is either eliminated or reduced. Regional controls are allowed in the City of Wichita and Sedgwick County, provided that such controls can achieve the water quality channel protection and peak discharge standards defined in the local jurisdictions stormwater ordinance and the policies in Volume 1, Chapter 3 of this manual.

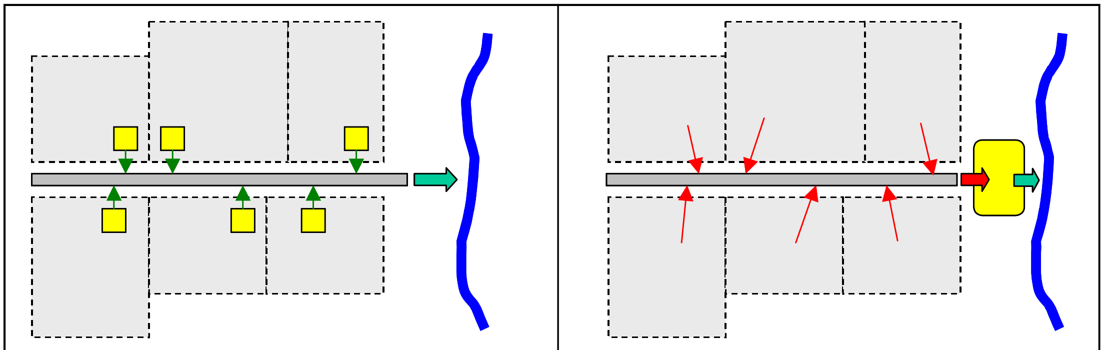


**Figure 3-5 On-Site vs Regional Stormwater Management**

### 3.1.5.2 Advantages and Disadvantages of Regional Stormwater Controls

The use of a regional stormwater facility is not always the best solution and the following "pros" and "cons" should be considered during the decision process.

***Advantages of Regional Stormwater Controls***

Reduced Construction Costs: Design and construction of a single regional stormwater control facility can be more cost-effective than numerous individual on-site structural controls.

Reduced Operation and Maintenance Costs: Rather than multiple owners and associations being responsible for the maintenance of several stormwater facilities on their developments, it is simpler and more cost effective to establish scheduled maintenance of a single regional facility.

Higher Assurance of Maintenance: Regional stormwater facilities are far more likely to be adequately maintained as they are large and have a higher visibility.

Maximum Utilization of Developable Land: Developers would be able to maximize the utilization of the proposed development for the purpose intended by minimizing the land normally set aside for the construction of stormwater structural controls.

Other Benefits: Well-sited regional stormwater facilities often can serve as a community recreational and aesthetic amenity.

***Disadvantages of Regional Stormwater Controls***

Location and Siting: Regional stormwater facilities may be difficult to site, particularly for large facilities or in areas with existing development.

Maintenance: The local government is typically responsible for the operation and maintenance of a regional stormwater facility.

Need for Planning: The implementation of regional stormwater controls requires substantial planning, financing, and permitting. Land acquisition must be in place ahead of future projected growth.

Water Quality and Channel Protection: Without on-site water quality and channel protection, regional controls do not protect smaller streams upstream of the facility from degradation and channel erosion.

Ponding Impacts: Upstream inundation from a regional facility impoundment can eliminate floodplains, wetlands, and other habitat.

#### 3.1.5.3 Important Considerations for the Use of Regional Stormwater Controls

If a regional stormwater control is planned, then it must be ensured that the conveyances between the individual upstream developments and the regional facility can handle the design peak flows and volumes without causing adverse impact or property damage. Siting and designing regional facilities may be done by city of Wichita and/or Sedgwick County as part of watershed master planning efforts. Development and redevelopments will be required to compensate the local jurisdiction for construction of these regional facilities through any equitable and legal system proposed in the watershed master plan. At a minimum, future watershed master plans must provide:

- Protection against water quality impacts to meet the 80% TSS removal standard;
- protection against channel erosion to meet the channel protection requirement; and,
- protection against downstream flooding to meet the peak flow control standard and 10% rule.

Furthermore, unless the system consists of completely man-made conveyances (i.e. storm drains, pipes, constructed channels, etc) on-site structural controls for water quality and downstream channel protection will likely be required for all developments within the regional facility's drainage area. Federal water quality provisions do not allow the degradation of water bodies from untreated stormwater discharges, and it is U.S. EPA policy to not allow regional stormwater controls that would degrade stream quality between the upstream development and the regional facility. Further, without adequate channel protection, aquatic habitats and water quality in the channel network upstream of a regional facility may be degraded by channel erosion if they are not protected from bankfull flows and high velocities.

Based on these concerns, both the EPA and the U.S. Army Corps of Engineers have expressed opposition to in-stream regional stormwater control facilities. In-stream facilities should be avoided if possible and will likely need to be permitted on a case-by-case basis.

## 3.1.6 Using Structural Stormwater Controls in Series

### 3.1.6.1 Stormwater Treatment Trains

The minimum stormwater management standards are an integrated planning and design approach whose components work together to limit the adverse impacts of development on downstream waters and riparian areas. This approach is sometimes called a stormwater "treatment train." When considered comprehensively, a treatment train consists of all the design concepts and nonstructural and structural controls that work to attain water quality and quantity goals. This is illustrated in Figure 3-6.


**Figure 3-6 Generalized Stormwater Treatment Train**

<u>Runoff and Load Generation:</u> The initial part of the "train" is located at the source of runoff and pollutant load generation, and consists of pollution prevention practices and optional "Preferred Site Design" practices that reduce runoff and stormwater pollutants.

<u>Pretreatment:</u> The next step in the treatment train consists of pretreatment measures. These measures typically do not provide sufficient pollutant removal to meet the overall TSS target reduction goal, but do provide calculable water quality benefits that may be applied towards meeting the $WQ_v$ treatment requirement. In addition, pre-treatment may reduce maintenance and/or improve the performance of downstream facilities. These measures include:

- Structural controls that achieve less than the overall TSS target removal rate, but provide pretreatment for sources such as hotspots.
- Pretreatment facilities such as sediment forebays.

<u>Standard Treatment and/or Quantity Control:</u> The last step is standard water quality treatment and/or quantity (channel protection and flood) control. This is achieved through the use of structural controls to achieve overall water quality and quantity goals.

### 3.1.6.2 Use of Multiple Structural Controls in Series

Many combinations of structural controls may be used for a site. The following are descriptions of some examples of how controls and other practices may be combined to achieve the goals of the integrated design approach.

- Stormwater ponds are often used to achieve overall target TSS removal as well as channel protection and flood control, thus meeting <u>all</u> of the requirements of the integrated site design approach in a single facility.

- The other structural controls achieving overall TSS target removal each (bioretention, sand or organic filters, infiltration or soakage trenches, and enhanced swales) are typically used in combination with other water quality controls and with detention flood controls to meet the integrated site design goals. The detention facilities are located downstream from the water quality controls either on-site or combined into a regional or neighborhood facility.
- Where a structural control does not meet the overall TSS target removal criteria, one or more additional downstream controls must be used. For example, urban hotspot land may be fit with devices adjacent to parking or service areas designed to remove petroleum hydrocarbons. These devices may also serve as pretreatment devices removing the coarser fraction of sediment. One or more downstream structural controls are then used to meet the full TSS removal goal, as well as water quantity control.
- An environmentally sensitive large lot subdivision may be designed and developed so as to waive the water quality treatment requirement altogether. However, detention controls may still be required for downstream channel protection and flood control.

$WQ_V$ reductions (See Volume 2, Chapter 2) may be employed to reduce the $WQ_V$ requirement. In this case, for a smaller site, a well designed structural control may provide TSS removal while a dry detention pond provides flood control. Direct discharge to a large stream and local downstream floodplain management practices may eliminate the need for channel protection and flood control storage altogether. (See Volume 2, Chapter 4)

The combinations of structural stormwater controls are limited only by the need to employ measures of proven effectiveness while meeting regulatory and physical site requirements. Figure 3-7 through Figure 3-9 illustrate applications of the treatment train concept to a moderate density residential neighbourhood, a small commercial site, and a large shopping mall site.

In Figure 3-7, runoff from yards and driveways reaches roadside grass channels. Then, all stormwater flows to an extended detention micropool stormwater pond.

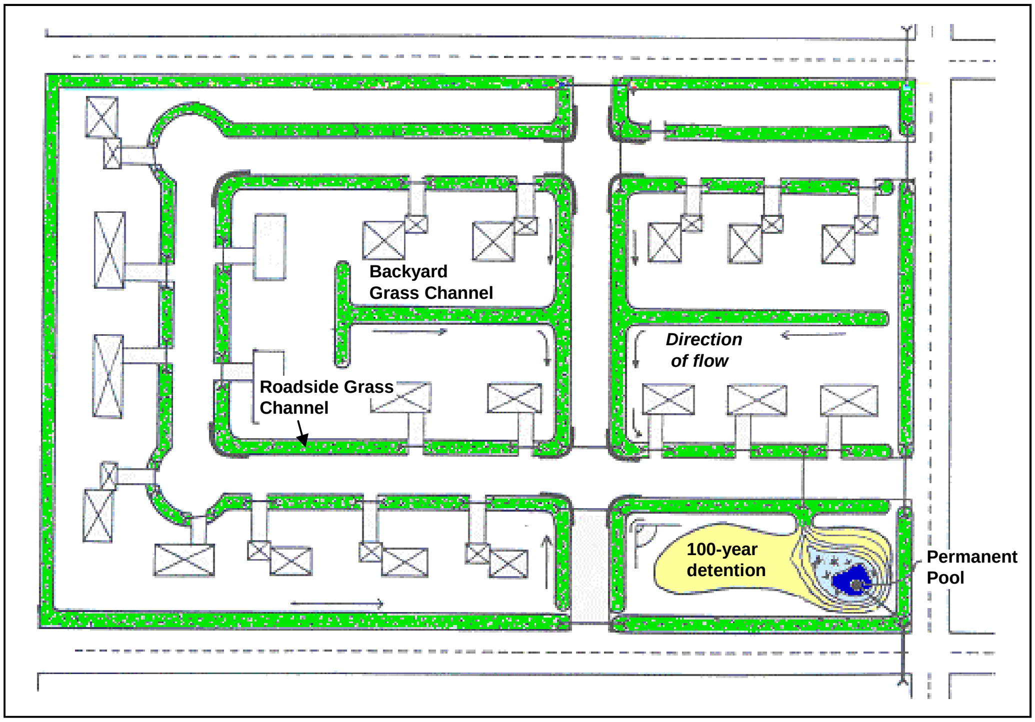


**Figure 3-7 Example Treatment Train – Rural Residential Subdivision**
(Adapted from: NIPC, 2000)

A gas station and convenience store is depicted in Figure 3-8. In this case, the decision was made to intercept hydrocarbons and oils using a commercial gravity (oil-water) separator located on the site prior to draining to a sand filter for removal of finer particles and TSS. No stormwater control for channel protection is required as the system drains to the municipal storm drain pipe system. Flood control is provided by a regional stormwater control downstream.

Figure 3-9 shows an example treatment train for a commercial shopping center. In this case, runoff from rooftops and parking lots drains to depressed parking lot islands, perimeter grass channels, and bioretention areas. Slotted curbs are used at the entrances to these swales to better distribute the flow and to settle out the very coarse particles at the parking lot edge for sweepers to remove. Runoff is then conveyed to an extended detention wet pond for additional pollutant removal and channel protection. Flood control is provided through parking lot detention. (The acceptability of parking lot detention will be determined by the local reviewing authority on a case-by-case basis.)

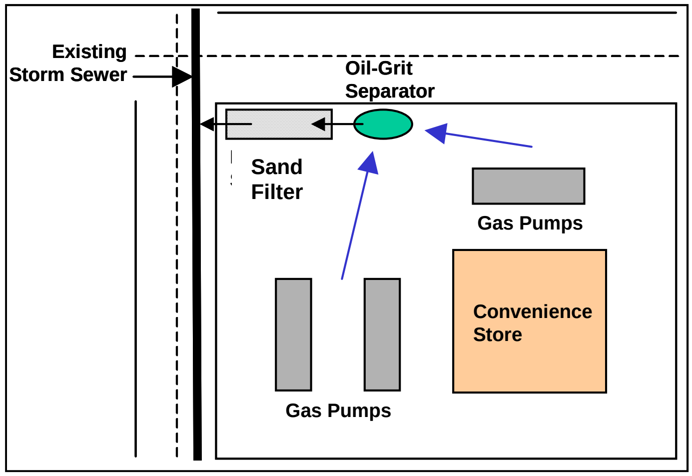


**Figure 3-8  Example Treatment Train – Small Commercial Site**

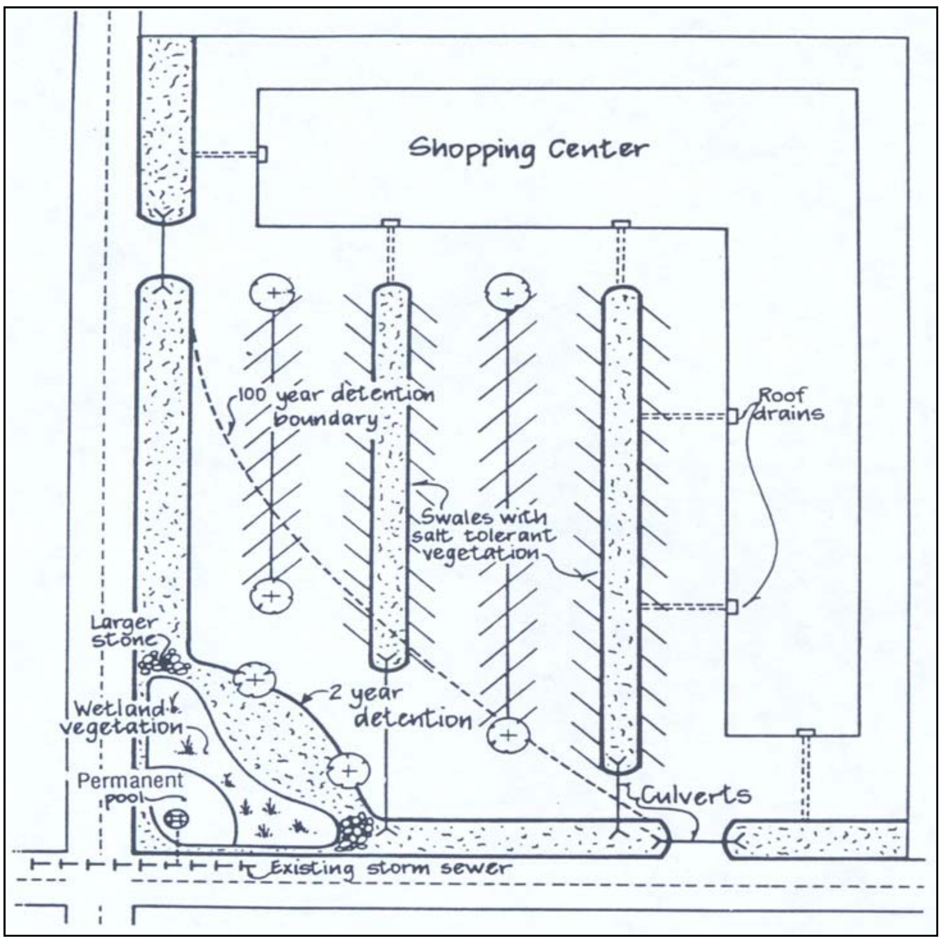


**Figure 3-9  Example Treatment Train – Large Commercial Development**

(Source:  NIPC, 2000)

## 3.2 Primary TSS Treatment Facilities

This section contains design guidelines for the following TSS treatment facilities:

- Stormwater pond
- Extended dry detention pond
- Vegetative filter strip
- Grassed channel
- Enhanced swale
- Infiltration trench
- Soakage trench
- Surface sand filter
- Bioretention areas
- Stormwater wetland

# 3.2.1 Stormwater Pond

**Primary Water Quality Facility**

**Description:** Constructed stormwater retention basin that has a permanent water quality pool (or micropool). Runoff from each water quality rain event displaces all or part of the permanent pool, and is treated in the pool primarily through settling and biological uptake mechanisms.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Minimum contributing drainage area of 25 acres; 10 acres for extended detention micropool pond
- A sediment forebay or equivalent upstream pretreatment must be provided
- Minimum length to width ratio for the pond is 1.5:1
- Pond slopes shall adhere to those found in Figure 3-12

**ADVANTAGES / BENEFITS:**

- Moderate to high removal rate of urban pollutants
- High community acceptance
- Opportunity for wildlife habitat

**DISADVANTAGES / LIMITATIONS:**

- Potential for thermal impacts/downstream warming
- Dam height restrictions for high relief areas
- Pond drainage can be problematic for low relief terrain

**MAINTENANCE REQUIREMENTS:**

- Remove debris from inlet and outlet structures
- Maintain side slopes / remove invasive vegetation
- Monitor sediment accumulation and remove periodically
- Dam inspection and maintenance

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| H | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| ✓ | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| L | **Capital Costs** |
| L | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *10-25 acres min*

**Soils**: *Hydrologic group 'A' and 'B' soils may require pond liners*

**Other Considerations**:

- *Outlet Clogging*
- *Safety Bench*
- *Landscaping*

**L**=Low **M**=Moderate **H**=High

### 3.2.1.1 General Description

Stormwater ponds (also referred to as retention ponds, wet ponds, or wet extended detention ponds) are constructed stormwater retention basins that have a permanent (dead storage) pool of water throughout the year. They can be created by excavation and/or by construction of embankments at an already existing natural depression.

In a stormwater pond, all or a portion of the runoff from each rain event is retained and treated in the pool through gravitational settling and biological uptake until it is displaced by runoff from the next storm. The permanent pool also serves to protect deposited sediments from resuspension. Additional temporary storage (live storage) is provided for extended detention of the 1-year storm for downstream $CP_v$, as well as conventional detention of larger storm events to meet peak flow control requirements. A portion of the $WQ_v$ may also be temporarily stored (detained) above the permanent pool for water quality treatment.

Stormwater ponds are among the most cost-effective and widely used stormwater practices. A well-designed and landscaped pond can be an aesthetic feature on a development site when planned and located properly.

There are several different variations of stormwater pond design, the most common of which include the wet pond, the wet extended detention pond, and the micropool extended detention pond. In addition, multiple stormwater ponds can be placed in series or parallel to increase performance or meet site design constraints. Below are descriptions of each design variation:

<u>Wet Pond:</u> Wet ponds are stormwater basins constructed with a permanent (dead storage) pool of water equal to the $WQ_V$. Stormwater runoff displaces the water already present in the pool. Temporary storage (live storage) can be provided above the permanent pool elevation for $CP_V$ and peak flow control.

<u>Wet Extended Detention (ED) Pond:</u> A wet extended detention pond is a wet pond where the $WQ_V$ is split between the permanent pool and extended detention (ED) storage provided above the permanent pool. During water quality storm events, water is detained above the permanent pool for 24 hours. This design has similar pollutant removal to a traditional wet pond, but consumes less space. Additional temporary storage can be provided above the ED pool for $CP_V$ and peak flow control.

<u>Micropool Extended Detention (ED) Pond:</u> The micropool extended detention pond is a variation of the extended detention wet pond where only a small “micropool” is maintained at the outlet to the pond. The outlet structure is sized to detain the $WQ_V$ for 24 hours. The micropool helps to inhibit resuspension of previously settled sediments and also helps to prevent clogging of the low flow orifice.

<u>Multiple Pond Systems:</u> Multiple pond systems consist of constructed facilities that provide water quality and quantity control volume storage in two or more cells. The additional cells can create longer pollutant removal pathways and improved downstream protection.

Figure 3-10 shows a number of examples of stormwater pond variants. Section 3.2.1.8 provides plan view and profile schematics for the design of a wet pond, a wet extended detention pond, a micropool extended detention pond, and a multiple pond system.

**Wet Pond**

**Wet ED Pond**

**Micropool ED Pond**

**Figure 3-10 Stormwater Pond Examples**

Conventional dry detention basins do not provide a permanent pool and are not acceptable for general use to meet water quality criteria, as they fail to demonstrate an ability to meet the majority of the water quality goals. In addition, dry detention basins are prone to clogging and resuspension of previously settled solids and require a higher frequency of maintenance than most wet ponds if used for untreated stormwater flows. However, these facilities can be used in combination with appropriate water quality controls to provide channel protection and peak flow control. For further discussion please see Section 3.4.1.

### 3.2.1.2 Stormwater Management Suitability

Stormwater ponds may be designed to control both stormwater quantity and quality. Thus, a stormwater pond can be used to address all of the integrated stormwater sizing criteria for a given drainage area.

***Water Quality***

Ponds treat incoming stormwater runoff by physical, biological, and chemical processes. The primary removal mechanism is gravitational settling of particulates, organic matter, metals, bacteria, and organics as stormwater runoff resides in the pond. Another mechanism for pollutant removal is uptake by algae and wetland plants in the permanent pool – particularly of nutrients. Volatilization and chemical activity also work to break down and eliminate a number of other stormwater contaminants such as hydrocarbons.

***Channel Protection***

A portion of the storage volume above the permanent pool in a stormwater pond, or above the water quality ED pool in an extended detention pond, can be used to provide control of the $CP_v$. This is accomplished by detaining the 1-year, 24-hour storm runoff volume for 24 hours.

***On-Site Flood Control***

A stormwater pond located within the development (i.e., not at the project boundary) can provide detention storage for on-site peak flow control, if required.

***Downstream Flood Control***

A stormwater pond can be used to provide detention to control the peak flows at the project boundary and downstream of the project for the 2 through 100-year floods, in accordance with the peak flow control requirements for new developments. In all cases, the pond structure is designed to safely pass extreme storm flows (i.e., the 100-year event).

### 3.2.1.3 Pollutant Removal Capabilities

All of the stormwater pond design variations are presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff when designed, constructed, and maintained in accordance with the specifications discussed herein. Undersized or poorly designed ponds can drastically reduce TSS removal performance.

The following design pollutant removal rates are typical percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 80%
- Total Phosphorus – 55%
- Total Nitrogen – 30%
- Heavy Metals – 50%
- Fecal Coliform – 70% (if no resident waterfowl population present)

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.1.4 Application and Site Feasibility Criteria

Stormwater ponds are generally applicable to most types of development and can be used in both residential and nonresidential areas. The following criteria should be evaluated to ensure the suitability of a stormwater pond for meeting stormwater management objectives on a development site.

***General Feasibility***

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra-Urban Areas – Land requirements may preclude use
- Regional Stormwater Control – YES

***Physical Feasibility - Physical Constraints at Project Site***

<u>Drainage Area:</u> As a guideline, a minimum of 25 acres is needed for a wet pond and an extended detention wet pond to maintain a permanent pool. Ten acres minimum is required for an extended detention micropool pond. Drainage area requirements must be checked with a water balance analysis (See Volume 2, Chapter 4) or other approved method for determining the drainage area necessary to sustain a permanent pool. A smaller drainage area may be acceptable if supported by an approved water balance analysis.

<u>Space Required:</u> Approximately 2 to 5% of the tributary drainage area.

<u>Site Slope:</u> Typically slopes are not more than 15% across the pond.

<u>Minimum Head</u>: Elevation difference needed at a site from the inflow to the outflow: 6 to 8 feet.

<u>Minimum Depth to Water Table:</u> A minimum separation distance of 5 feet is required between the bottom of the pond and the elevation of the historical high water table for unlined ponds, 2 feet for lined ponds.

<u>Soils:</u> Underlying soils of hydrologic group “C” or “D” should be adequate to maintain a permanent pool. Most group “A” soils and some group “B” soils will require a pond liner. Evaluation of soils should be based on an actual subsurface analysis and permeability tests.

***Other Constraints / Considerations***

<u>Local Aquatic Habitat:</u> Consideration should be given to the thermal influence of stormwater pond outflows on downstream local aquatic habitats.

### 3.2.1.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of a stormwater pond facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

**A. LOCATION AND SITING**

- Stormwater ponds should have a minimum contributing drainage area of 25 acres or more for wet pond or extended detention wet pond to maintain a permanent pool. (See previous discussion.) For an extended detention micropool pond, the minimum drainage area is 10 acres. A smaller drainage area can be considered when water availability can be confirmed (such as from a upstream groundwater spring source). In any case, a water balance must be performed to verify a sustainable source of water (See Volume 2, Chapter 4). Ensure that an appropriate anti-clogging device is provided for the pond outlet.
- A stormwater pond should be sited such that the topography allows for maximum runoff storage at minimum excavation or construction costs. Pond siting should also take into account the location and use of other site features such as buffers and undisturbed natural areas and should attempt to aesthetically "fit" the facility into the landscape.
- Stormwater ponds should not be located on steep (>15%) or unstable slopes.
- Ponds cannot be located within a stream or any other navigable waters of the U.S., including wetlands, without obtaining applicable local, state and federal permits.
- No utilities should be located within the reserve boundary for the pond/basin site, if a reserve is required.

**B. GENERAL DESIGN**

- A well-designed stormwater pond consists of:
- Permanent pool of water for water quality treatment,
- Overlying temporary storage zone in which runoff control volumes are detained for quantity control, and
- Shallow littoral zone (aquatic bench) along the edge of the permanent pool that acts as a biological filter and wave-action diffuser.
- To the maximum extent practicable, the long axis of a pond shall be oriented east-west to minimize erosion from wind waves.
- In addition, all stormwater pond designs must include a sediment forebay or equivalent pretreatment at all major inflows to the basin to allow heavier sediments to drop out of suspension before the runoff enters the permanent pool.
- Additional pond design features include a principal spillway, an emergency spillway, maintenance access, safety bench, pond buffer, and appropriate native landscaping.

- Stormwater ponds located in floodplains or backwater areas must perform as specified for peak flow control for any tailwater condition, up to the Base Flood Elevation (BFE). Thepotential for back flow into the pond must be addressed with flap gates or by providing sufficient volume to receive backflow up to the BFE, and still provide peak flow control surcharge volume in the pond (above the BFE).

Figure 3-14 through Figure 3-17 provide plan view and profile schematics for the design of a wet pond, extended detention wet pond, extended detention micropool pond and a multiple pond system.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

In general, pond designs are unique for each site and application. However, there are number of geometric ratios and limiting depths for pond design that must be observed for adequate pollutant removal, ease of maintenance, and improved safety.

- Permanent pool volume is typically sized as follows:
  - Standard wet ponds: 100% of the water quality treatment volume (1.0 $WQ_v$);
  - Extended detention wet ponds: 50% of the water quality treatment volume (0.5 $WQ_v$) with the remaining 50% in the extended detention above the permanent pool;
  - Extended detention micropool ponds: Approximately 0.1 acre-inch per impervious acre, with the balance of $WQ_v$ in the extended detention.
- Proper geometric design is essential to prevent hydraulic short-circuiting (unequal distribution of inflow), which results in the failure of the pond to achieve adequate levels of pollutant removal. The minimum length-to-width ratio for the permanent pool shape is 1.5:1, and should ideally be greater than 3:1 to avoid short-circuiting. In addition, ponds should be wedge-shaped when possible so that flow enters the pond and gradually spreads out, improving the sedimentation process. Baffles, pond shaping or islands can be added within the permanent pool to increase the flow path.

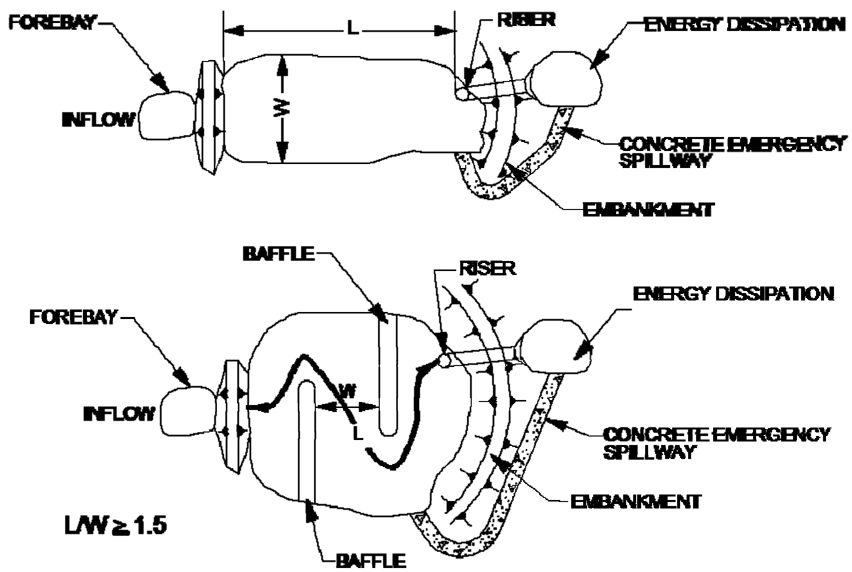


**Figure 3-11 Permanent Pool Length to Width Ratio**

- Minimum depth for the pond bottom shall be 3 to 4 feet, though a minimum depth of 10 feet is recommended for ponds where fish habitat is desired. Deeper areas near the outlet will yield cooler bottom water discharges that may mitigate potential downstream thermal effects.
- Side slopes to the pond may not exceed 5:1 (h:v) unless a safety bench is provided, and in no case shall exceed 3:1 (see Figure 3-12). All side slopes should be verified with a geotechnical evaluation to ensure slope stability.
- Safety benches shall have a maximum slope of 10:1, and a minimum width of 10'.
- The perimeter of all deep pool areas (3 feet or greater in depth) shall be surrounded by an aquatic bench. The aquatic bench shall extend inward from the normal pool edge 10-15 feet on average and have a maximum depth of 18 inches below the normal pool water surface elevation (see Figure 3-12).
- The pond edge shall have turf reinforcing mesh or riprap covering the area from 2 feet above the normal pool to 2 feet below the normal pool to protect areas of the pond that will be exposed to wave action. Appendix D provides wind roses for Wichita during each month of the year to aid in locating areas that will require reinforcement. Local winds are most pronounced coming from the north and south directions.
- The contours and shape of the permanent pool should be irregular to provide a natural landscape effect.

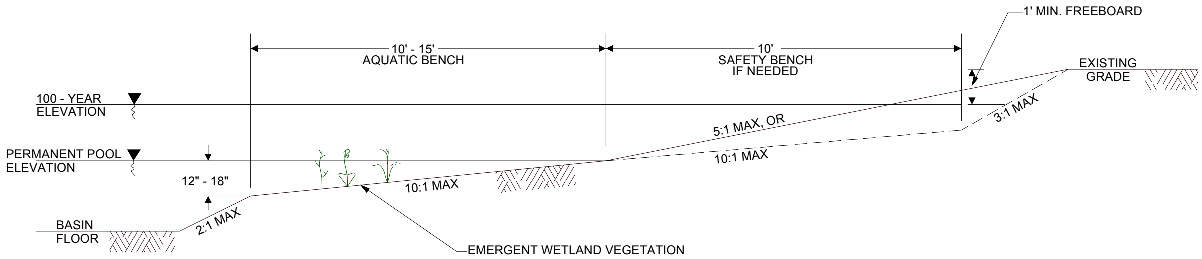


**Figure 3-12 Typical Stormwater Pond Geometry Criteria**

### D. PRETREATMENT / INLETS

- Each pond shall have a sediment forebay or equivalent upstream pre-treatment at each inlet. A sediment forebay is designed to remove incoming larger sediment from the stormwater flow prior to dispersal in the larger permanent pool. Pretreatment consists of a separate cell, formed by an acceptable barrier between the forebay and pond. A forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. In some design configurations, the pretreatment volume may be located within the permanent pool.
- A forebay must be sized to contain 0.1 acre-inch per impervious acre of contributing drainage and should be 4 to 6 feet deep. The pretreatment storage volume is part of the total $WQ_v$ requirement and may be subtracted from $WQ_v$ for permanent pool sizing.
- A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
- Pond inflow channels are to be stabilized with flared riprap aprons, or the equivalent. Inlet pipes to the pond can be partially submerged. Inflow pipe, channel velocities, and exit velocities from the forebay must be nonerosive.

### E. OUTLET STRUCTURES

- Flow control from a stormwater pond is accomplished with the use of a principal spillway consisting of a concrete riser and barrel. The riser is a vertical pipe, typically with several weirs and/or orifices at various levels. The outlet barrel is a horizontal pipe attached to the riser that conveys flow under the embankment (see Figure 3-13). Where practicable, the riser should be located within the embankment for maintenance access, safety and aesthetics.

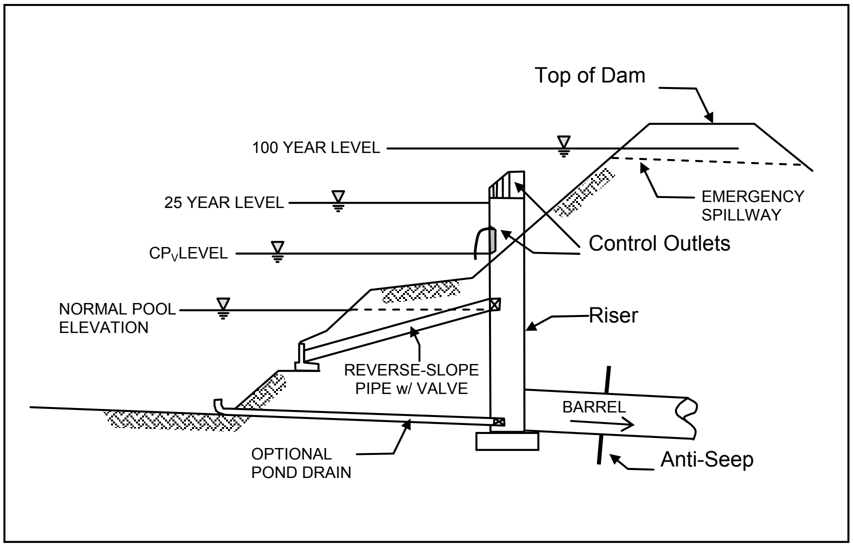


**Figure 3-13 Typical Pond Outlet Structure**

- A number of outlets at varying depths in the riser provide flow control for routing of the water quality (for extended wet detention), channel protection, and flood control runoff volumes. The number and configuration of the outlets (orifices and weirs) vary, depending on the specific pond design conditions.
- Ponds must be designed per Kansas dam safety guidelines, when applicable.
- As an example, a wet pond riser configuration is typically comprised of a channel protection outlet (usually an orifice) and flood control outlet (often a slot or weir). The channel protection orifice is sized to detain the channel protection storage volume for 24-hours. Since the $WQ_V$ is fully contained in the permanent pool in this example, no orifice sizing is necessary for this volume. As runoff from a water quality event enters the wet pond, it simply displaces that same volume through the channel protection orifice. Thus an off-line wet pond providing only water quality treatment can use a simple overflow weir as the outlet structure.
- In the case of an extended detention wet pond or extended detention micropool pond, there is a need for an additional outlet (usually an orifice) that is sized to pass the extended detention $WQ_V$ that is surcharged on top of the permanent pool. Flow will first pass through this orifice, which is sized to detain the water quality extended detention volume for 24 hours. All extended detention orifices shall be protected from clogging using treatments such as those described in Section 5.6.4. The preferred design is a reverse slope pipe attached to the riser, with its inlet submerged one foot or more below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond. The next outlet is usually sized for the release of the channel protection storage volume. The outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention $WQ_V$ and is sized in conjunction with the extended detention orifice to detain the channel protection storage volume for 24-hours.

- Other than orifices, alternative hydraulic control methods include broad-crested, sharp-crested, V-notch, and proportional weirs, or outlet pipes (discharging to the riser) protected by a hood that extends at least 12 inches below the normal pool.
- Higher flows (on-site and downstream flood control) pass through openings or slots protected by trash racks further up on the riser.
- After entering the riser, flow is conveyed through the outlet barrel and is discharged downstream. Anti-seep collars should be installed on the outlet barrel to reduce the potential for pipe failure.
- Riprap, plunge pools, pads, or other energy dissipators are to be placed at the outlet of the barrel to prevent scoure and erosion.  If a pond daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a vegetated riparian zone in the shortest possible distance.
- Each pond may have a bottom drain pipe with an adjustable valve that can drain the pond within 24 hours (from the crest of the riser to within 1 foot above the bottom of the pond). The bottom drain is optional. It is recommended to check with the local jurisdiction to see if a bottom drain is required.
- The pond drain should be sized one pipe size greater than the calculated design diameter. The drain valve is typically a handwheel activated knife or gate valve.  Valve controls shall be located inside of the riser, if practicable, at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner.

See the design procedures in Volume 2, Chapters 4 and 5 for additional information and specifications on pond routing and outlet works.

### F. EMERGENCY SPILLWAY

- A concrete emergency spillway is to be included in the stormwater pond design to safely pass the 100-year flood event.  The spillway prevents pond water levels from overtopping the embankment and causing structural damage.  The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.  All local and state dam safety requirements must be met, where applicable.
- A minimum of one foot of freeboard must be provided, measured from the top of the water surface elevation for the extreme (100-year, 24-hour) flood to the lowest point of the dam embankment, not counting the emergency spillway.  The water surface elevation must be based on routing the 100-year inflow hydrograph through the pond while assuming no discharge from the pond except through the emergency spillway.

### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the pond be placed in a reserve and/or establishment of a drainage easement to the pond, which is accessible from a public road or other accessible easement.  When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no

more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

- When required, reserves and/or drainage easements must extend to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.
- Access to the riser is to be provided by lockable manhole covers, and manhole steps should be within easy reach of valves and other controls.

#### H. SAFETY FEATURES

- All embankments and spillways must be designed to State of Kansas guidelines for dam safety, where applicable.
- Fencing of ponds may be required in some cases by the local review authority. In lieu of fencing, one method is to manage the contours of the pond through the inclusion of a safety bench (see above) to eliminate dropoffs and reduce the potential for accidental drowning. In addition, the safety bench can be landscaped to deter access to the pool.
- The spillway openings (riser and outlet barrel) should be protected to prevent entry by children. Endwalls above pipe outfalls greater than 36 inches in diameter should be fenced to prevent access and subsequent fall hazards.

#### I. LANDSCAPING

- Aquatic vegetation can play an important role in pollutant removal in a stormwater pond. In addition, vegetation can enhance the appearance of the pond, stabilize side slopes, serve as wildlife habitat, and can temporarily conceal unsightly trash and debris. Therefore, wetland plants should be encouraged in a pond design, along the aquatic bench (fringe wetlands), the safety bench and side slopes (ED ponds), and within shallow areas of the pool itself. The best elevations for establishing wetland plants, either through transplantation or volunteer colonization, are within 6 inches (plus or minus) of the normal pool elevation.
- Woody vegetation may not be planted on the embankment or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure (tree exclusion zone).
- Where practicable, a pond buffer should be provided that extends 25 feet outward from the maximum water surface elevation of the pond. The pond buffer should be contiguous with other buffer areas that are required by existing regulations (e.g., stream buffers) or that are part of the overall stormwater management concept plan. No structures should be located within the buffer.
- Existing trees should be preserved in the buffer area during construction in areas where the minimum distance requirements of the previous paragraph (tree exclusion zone) can be satisfied. It is desirable to locate conservation areas adjacent to ponds. The buffer can be planted with trees, shrubs and native ground covers.
- Selected fish species can be stocked in a pond to aid in mosquito prevention.

- A fountain or solar-powered aerator may be used for oxygenation of water in the permanent pool if required to sustain fish.
- Compatible multi-objective use of stormwater pond locations is encouraged.

### J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

Low Relief: Maximum normal pool depth is limited; providing pond drain can be problematic;

High Relief: Embankment heights may be restrictive;

Karst: Requires poly or clay liner to sustain a permanent pool of water and protect aquifers; limits on ponding depth; geotechnical tests may be required.

***Soils***

- Hydrologic group “A” soils, and some “B” soils, require pond liner.

***Special Downstream Watershed Considerations***

Local Sensitive Downstream Aquatic Habitat: Extended detention micropool pond is the best alternative to minimize or eliminate impacts due to warm water discharges when sensitive aquatic habitat is located downstream of the pond. For wet ponds and extended detention wet ponds, consider providing off-line $WQ_V$ treatment to reduce the size of pond or if possible, design a smaller, but deeper pond, with vegetation surrounding the pond to provide solar shading and minimize thermal impacts.

Aquifer Protection: Reduce potential groundwater contamination by pretreating hotspot runoff prior to hotspot runoff entering pond. May require liner for type “A” and “B” soils.

***Dams***

The most commonly used material for small dam construction is earth fill, but structural concrete can also be used. For on-site stormwater controls in high density areas of development or where land values are very costly, the use of a structural concrete dam can save a significant amount of land and in some cases make a more aesthetically appealing outfall structure than the typical riser and barrel assembly.

The following are general guidelines for the construction of detention pond dams. Where applicable, the construction specifications should be provided by a Professional Engineer of Record for the dam design.

- **General**
  - The dam area shall be cleared, grubbed and stripped of all vegetative material and topsoil prior to dam construction.

- **Earth Dams**
  - The dam construction plans shall indicate allowable soil materials to be used, compaction required, locations of core trenches if used, any sub-drainage facilities to be installed to control seepage, plus horizontal and vertical dimensions of the earthen structure.
  - The sub-grade of the dam shall be scarified prior to the placement and compaction of the first lift of soil backfill to ensure a good bond between the existing soil and the earthen dam.
  - Placement of earth fill shall be in controlled lifts with proper compaction.
  - Placement of spillway or outflow pipes through the dam shall be per the plan details, with proper backfill and compaction of any excavated trenches. Hydraulic flooding or other compaction methods of saturated soil shall not be allowed.
  - Topsoil and soil additives necessary for the establishment of permanent ground cover above the normal water surface elevation and on the downstream side of the dam shall be installed and seeded as soon as practical to avoid rilling and erosion of the dam's earthen embankment.
  - Do not plant trees or shrubs on the earth dam. Their root systems cause seepage and damage to the structure.

- **Concrete Dams**
  - Concrete dams shall be designed and built in accordance with the American Concrete Institute's (ACI) latest guidelines for Environmental Engineering Concrete Structures. Particular attention shall be paid to water tightness, crack control, concrete materials and construction practices.
  - The construction plans shall indicate materials, plus horizontal and vertical dimensions necessary for the construction of the dam. Details and information shall be provided on joint types and spacing to be used.
  - At least half of the water surface perimeter of the pond at normal pool elevation shall be constructed with a vegetated earthen embankment or graded slope.
  - Principal and emergency spillways can be incorporated into a weir overflow over the weir if splash pads or another type of control structure is provided to protect the downstream toe of the concrete structure.
  - Placement of drain valves, overflow controls and other penetrations of the concrete wall shall not be located on the same vertical line to prevent creating a weakened plane where uncontrolled cracks can form. Locations should also anticipate operation during storm events when overflow weirs will be operating.

### 3.2.1.6 Design Procedures for Stormwater Ponds

**Step 1** Compute runoff control volumes using the Integrated Design Approach: Calculate the WQv, CPv or channel protection inflow hydrograph, and the peak flow control inflow hydrographs using methods discussed in Volume 2, Chapter 4.

**Step 2** Confirm local design criteria and applicability:

Consider any special site-specific design conditions/criteria.

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Determine pretreatment volume:

A sediment forebay is provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay storage volume counts toward the total $WQ_v$ requirement and may be subtracted from the $WQ_v$ for subsequent calculations.

**Step 4** Determine permanent pool volume and water quality extended detention volume:

<u>Wet Pond:</u> Size permanent pool volume to 1.0 $WQ_v$

<u>Extended Detention Wet Pond:</u> Size permanent pool volume to 0.5 $WQ_v$. Size extended detention volume to 0.5 $WQ_v$.

<u>Extended Detention Micropool Pond:</u> Size permanent pool volume to 0.1 acre-inch per impervious acre. Size extended detention volume to remainder of $WQ_v$.

**Step 5** Layout pond grading and determine storage available for permanent pool and extended detention water quality pool, as applicable:

This step involves designing the grading for the pond (establishing contours) and determining the elevation-storage relationship for the pond. This typically requires a trial and revision approach as the design is refined.

Include safety and aquatic benches.

Set $WQ_V$ permanent pool elevation based on calculated permanent pool volume and the elevation-storage curve for the pond (see above).

**Step 6** Determine elevation and orifice size for extended detention portion of $WQ_V$ (for extended wet detention ponds and micropool ponds):

Set orifice elevation at top of permanent pool.

Set top of extended detention pool based on extended detention volume and pond elevation-storage curve.

By trial and revision, select an orifice size that will drain 90% of the $WQ_V$ in 24 hours. The 90% criteria is intended to address the tendency of the drawdown method (see Chapter 4 of Volume 2) to oversize the orifice.

**Step 7** Determine elevation and orifice size for channel protection extended detention:

Wet Pond: The $CP_V$ orifice is placed at the top of the permanent $WQ_V$ pool. The preferred method is to route the 1-year, 24-hour inflow hydrograph through the pond, and select an orifice size that provides 24 hours of detention between the centroid of the inflow hydrograph and the centroid of the outflow hydrograph.

In lieu of the routing method, a "simplified method" is available for determining the $CP_V$ and for configuring the $CP_V$ orifice. This method is described in detail in Chapter 4. In summary, the method consists of estimating the peak inflow and outflow to and from the pond for a 24-hour detention time, the $CP_V$, and the corresponding maximum head on the orifice. This information is then used to size the orifice.

Wet Extended Detention Pond and Wet Extended Detention Micropool Pond: For wet extended detention ponds, the $CP_V$ orifice is typically located at the top of the permanent part of the $WQ_V$ pool. As with the wet pond, the preferred method is to route the 1-year, 24-hour inflow hydrograph through the pond, and select the orifice size that provides 24 hours of detention between the centroids of the inflow and outflow hydrographs. However, in some cases, the simplified method discussed above may be used. The simplified method is strictly applicable to the situation where the active pool (in this case the $CP_V$ pool and the extended detention portion of the $WQ_V$ pool) is controlled by one or more orifices at the same elevation. However, it is rare that the $WQ_V$ orifice alone can serve to regulate both the $WQ_V$ and $CP_V$. In most cases, a $CP_V$ orifice is also required. If the elevations of the centers of the $WQ_V$ and $CP_V$ orifices are "approximately" the same, then the simplified method is applicable. Until further information is available, the elevations of the centers of the orifices will be considered "approximately" the same if the difference between the center elevations does not exceed 20% of the $CP_V$ depth.

**Step 8** Prepare hydrology analysis for floods and design embankment(s) and spillway(s):

Size additional control structure orifices, weirs and emergency spillway as required for flood control and freeboard.

Provide safe passage for the 100-year event.

**Step 9** Investigate potential pond hazard classification:

The design and construction of stormwater management ponds are required to follow the latest version of the Kansas dam safety guidelines, where applicable.

**Step 10** Design inlets, sediment pre-treatment facilities, outlet structures, maintenance access, and safety features:

See Volume 2, Chapter 5 for more details.

**Step 11** Prepare Vegetation and Landscaping Plan:

A landscaping plan for a stormwater pond and its buffer should be prepared to indicate how aquatic and terrestrial areas will be stabilized and established with vegetation.

### 3.2.1.7 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants").
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the pond, and also clearly identify drainage and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.1.8 Example Schematics

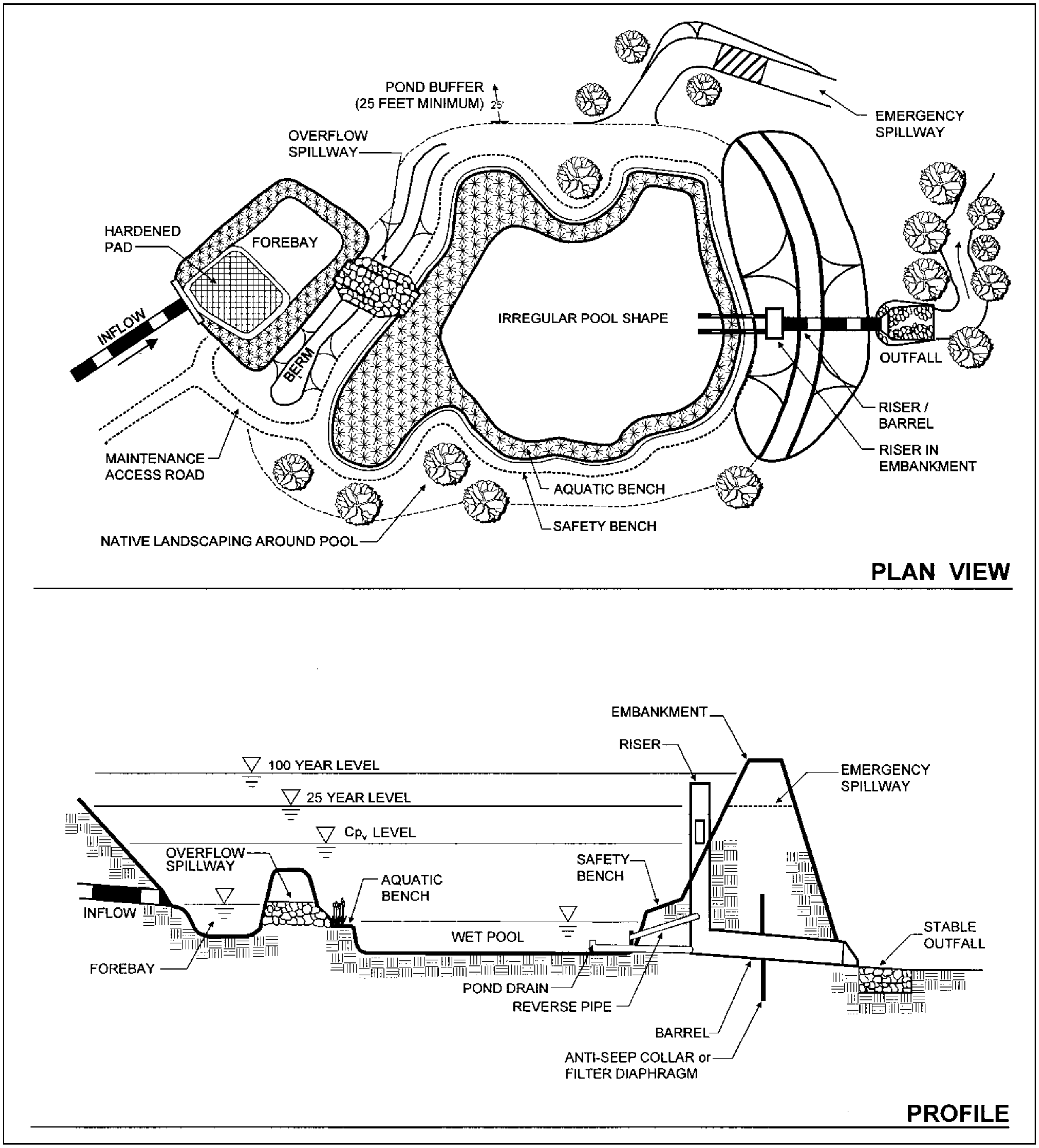


**Figure 3-14 Schematic of Wet Pond**
(MSDM, 2000)

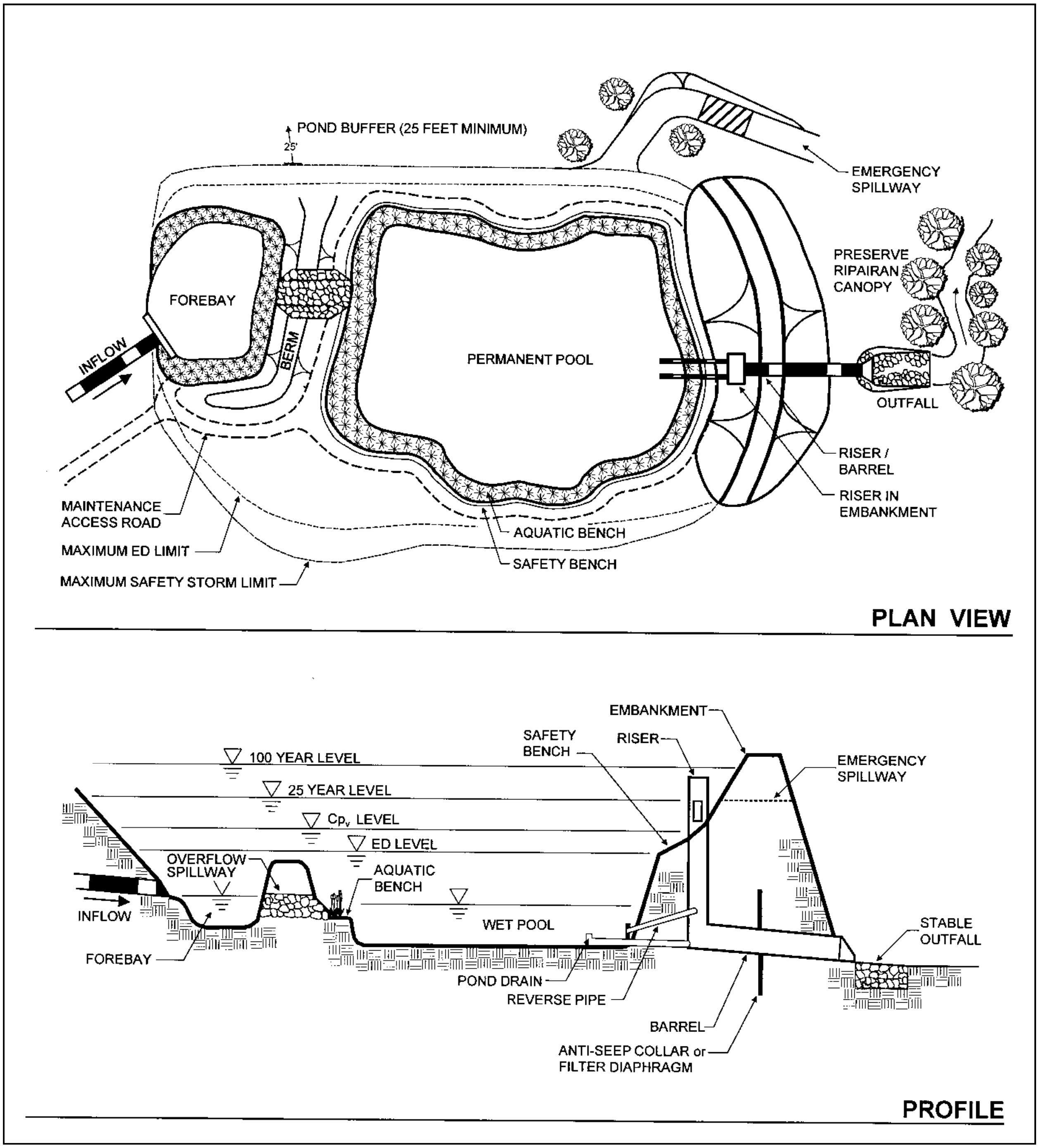


**Figure 3-15 Schematic of Wet Extended Detention Pond**
(MSDM, 2000)

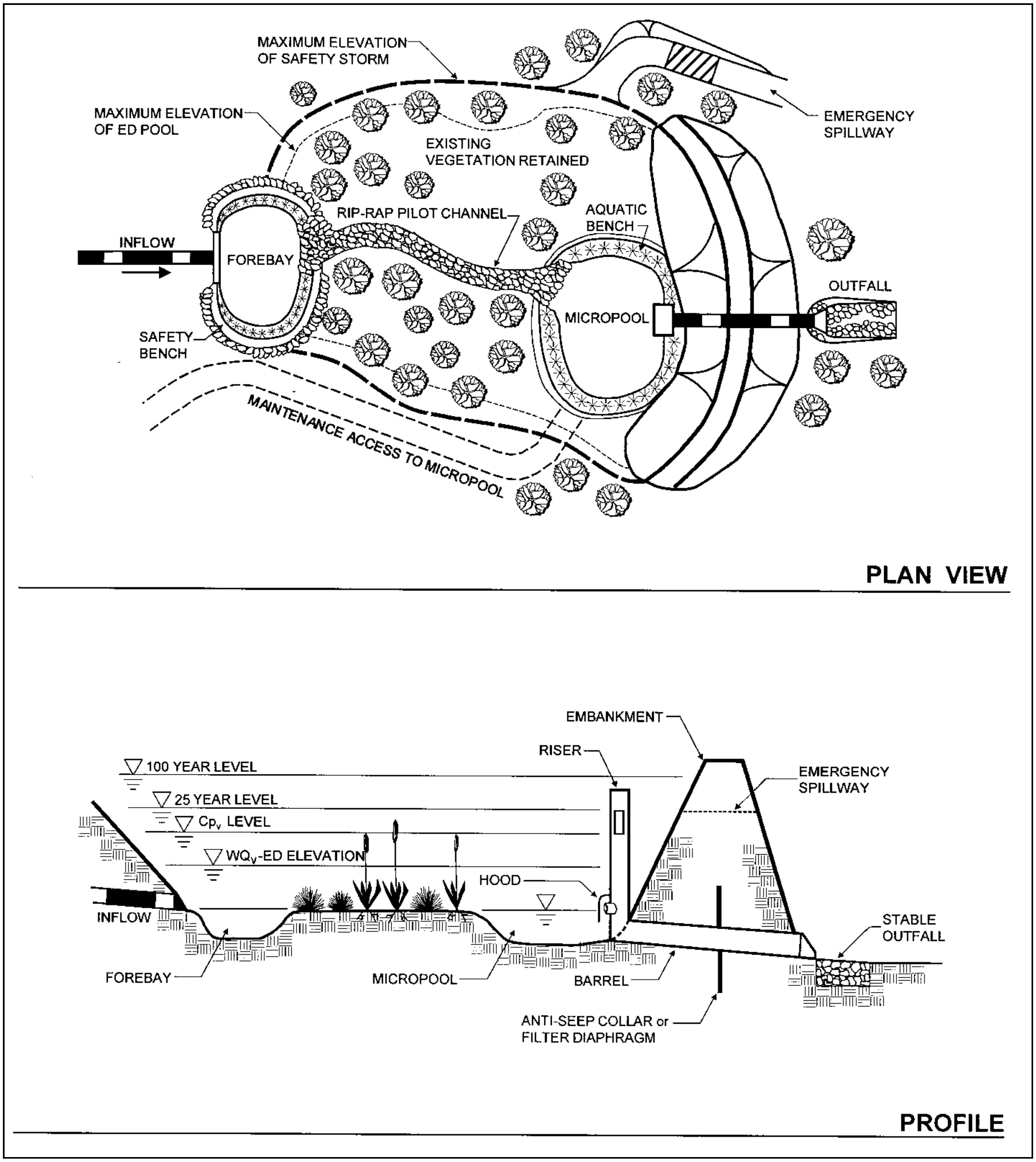


**Figure 3-16 Schematic of Micropool Extended Detention Pond**
(MSDM, 2000)

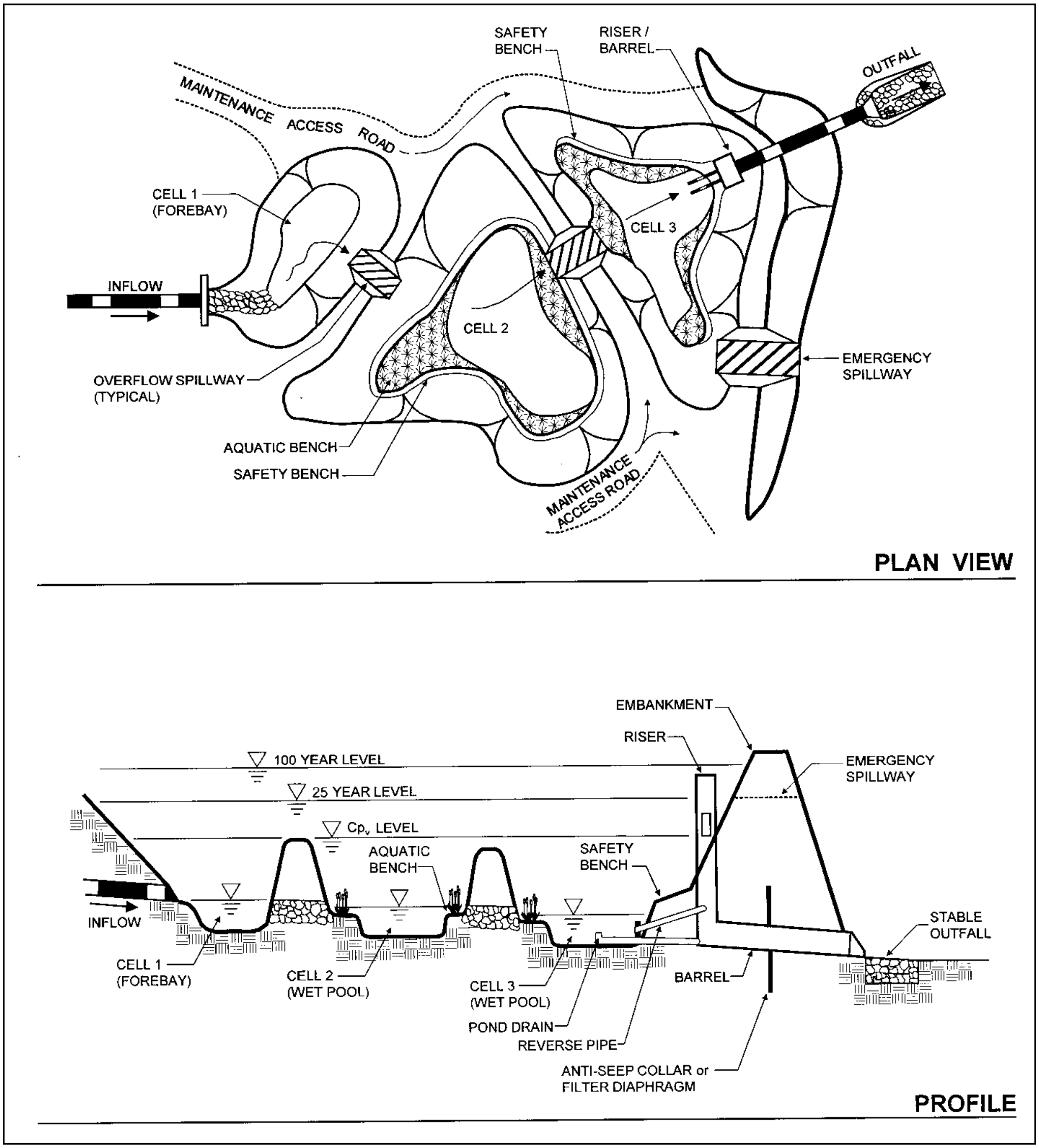


**Figure 3-17 Schematic of Multiple Pond System**
(MSDM, 2000)

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# 3.2.2 Extended Dry Detention Pond

**Primary Water Quality Facility**

**Description:** A surface storage basin or facility designed to provide water quantity and quality control through detention and/or extended detention of stormwater runoff.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Designed for the control of peak flood flows and the removal of stormwater pollutants

**ADVANTAGES / BENEFITS:**

- Useful alternative to "wet pond" when drainage area is not large enough to maintain a permanent pool
- May or may not be used in conjunction with water quality structural control
- Recreational and other open space opportunities between storm runoff events

**DISADVANTAGES / LIMITATIONS:**

- Pollutant removal efficiency less than wet pond

**MAINTENANCE REQUIREMENTS:**

- Remove debris from inlet and outlet structures
- Maintain side slopes/remove invasive vegetation
- Monitor sediment accumulation and remove periodically
- Dam inspection and maintenance

## POLLUTANT REMOVAL

| | |
|---|---|
| M | **Total Suspended Solids** |
| L | **Nutrients –** Total Phosphorus & Total Nitrogen |
| L | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Q ality Protection** |
| ✓ | **Channel Protection** |
| ✓ | **On-Site lood Control** |
| ✓ | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| M | **Capital Costs** |
| M | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *No restrictions*

**Soils**: *Hydrologic group 'A' and 'B' soils may require pond liner*

**Other Considerations**:

- *Recreational and open space uses for dry detention*

**L**=Low **M**=Moderate **H**=High

### 3.2.2.1 General Description

Dry extended detention (ED) ponds are surface facilities intended to provide extended periods of detention for water quality and channel protection control, and may also serve to control peak flood flows.

### 3.2.2.2 Pollutant Removal Capabilities

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 60%
- Total Phosphorus – 35%
- Total Nitrogen – 25%
- Heavy Metals – 25%
- Fecal Coliform – Insufficient data to provide pollutant removal rate

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.2.3 Design Criteria and Specifications

***Location***

- Extended dry detention ponds must combine with other structural stormwater controls to provide treatment of the full $WQ_v$. They may be part of a treatment train which treats the $WQ_v$.

***General Design***

- Extended dry detention ponds are sized to provide 24 hours of extended detention of the $WQ_V$.
- Extended dry detention ponds are sized to provide 24 hours of extended detention of the $CP_V$.
- Extended dry detention ponds can also provide additional storage volume for conventional detention (peak flow reduction) of the 2 through 100-year storm event.
- Routing calculations must be used to demonstrate that the flood storage volume and outlet structure configuration are adequate. See Volume 2, Chapters 4 and 5 for procedures on the design of detention storage.

- Design may be subject to the requirements of the Kansas dam safety program based on the volume, dam height, and level of hazard.
- Earthen embankments shall have side slopes no steeper than 3:1 (horizontal to vertical).
- Vegetated slopes shall be less than 20 feet in height and shall have side slopes no steeper than 4:1 (horizontal to vertical). Riprap-protected slopes shall be no steeper than 3:1. Geotechnical slope stability analysis is recommended for slopes greater than 10 feet in height.
- Areas above the normal high water elevations of the detention facility should be sloped toward the basin to allow drainage and to prevent standing water. Careful grading is required to avoid creation of upland surface depressions that may retain runoff. The bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap or a concrete flume) is recommended to convey low flows and prevent standing water conditions.
- Ponds cannot be located within a stream or any other navigable waters of the U.S., including wetlands, without obtaining applicable local, Kansas and federal permits.
- Dry extended detention ponds located in floodplains or backwater areas must perform as specified for peak flow control for any tailwater condition, up to the Base Flood Elevation (BFE). The potential for back flow into the pond must be addressed with flap gates or by providing sufficient volume to receive backflow up to the BFE, and still provide peak flow control surcharge volume in the pond (above the BFE).

***Inlet and Outlet Structures***

- Discharge into the pond from inflow channels or pipes are to be stabilized with flared riprap aprons, or the equivalent. A sediment forebay or equivalent upstream pretreatment with a volume of 0.1 inches per impervious acre of contributing drainage shall be provided upstream of the pond. The pre-treatment storage volume is part of the total $WQ_v$ required.
- An orifice capable of detaining the $WQ_v$ for 24 hours must be provided. The orifice shall be adequately protected from clogging using designs found in chapter 5.
- Likewise, the outlet structure must have an orifice capable of detaining the $CP_v$ for 24 hours. Orifice protection requirements are the same as for the $WQ_v$.
- For peak flow control, discharge is controlled by a principal spillway, typically consisting of a riser and outlet pipe. The $WQ_v$ and $CP_v$ orifices are usually incorporated into the riser. Additional orifices and weirs are incorporated into the riser to control the 2 through 100-year design storms.
- Small outlets that will be subject to clogging or are difficult to maintain are not acceptable.
- See Volume 2, Chapters 4 and 5 for more information on the design of outlet works.
- Seepage control or anti-seep collars should be provided for all outlet pipes.

- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the principal spillway outlet to prevent scouring and erosion. If the basin discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a vegetated riparian zone in the shortest possible distance.
- A concrete emergency spillway is to be included in the stormwater pond design to safely pass the extreme flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
- A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the 100 year flood event, to the lowest point of the dam embankment not counting the emergency spillway. The 100-year flood elevation for emergency spillway design is based on the elevation required to pass the 100-year flow with no discharge through the principal spillway.
- Please refer to “Stormwater Pond”, Section 3.2.1, for additional requirements applicable to all surface detention ponds.
- The use of the simplified method (Chapter 4) for configuring the $CP_v$ orifice is the same as for wet extended detention ponds (Section 3.2.1.).

***Maintenance Access***

- The local jurisdiction may require that the pond be placed in a reserve and/or establishment of a drainage easement to the pond, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- When required, reserves and/or drainage easements must extend to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.
- Access to the riser is to be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

### 3.2.2.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”).
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be

found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.

3. As-built drawings must accurately identify the location and layout of the pond, and also clearly identify drainage and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.2.5 Example Schematics

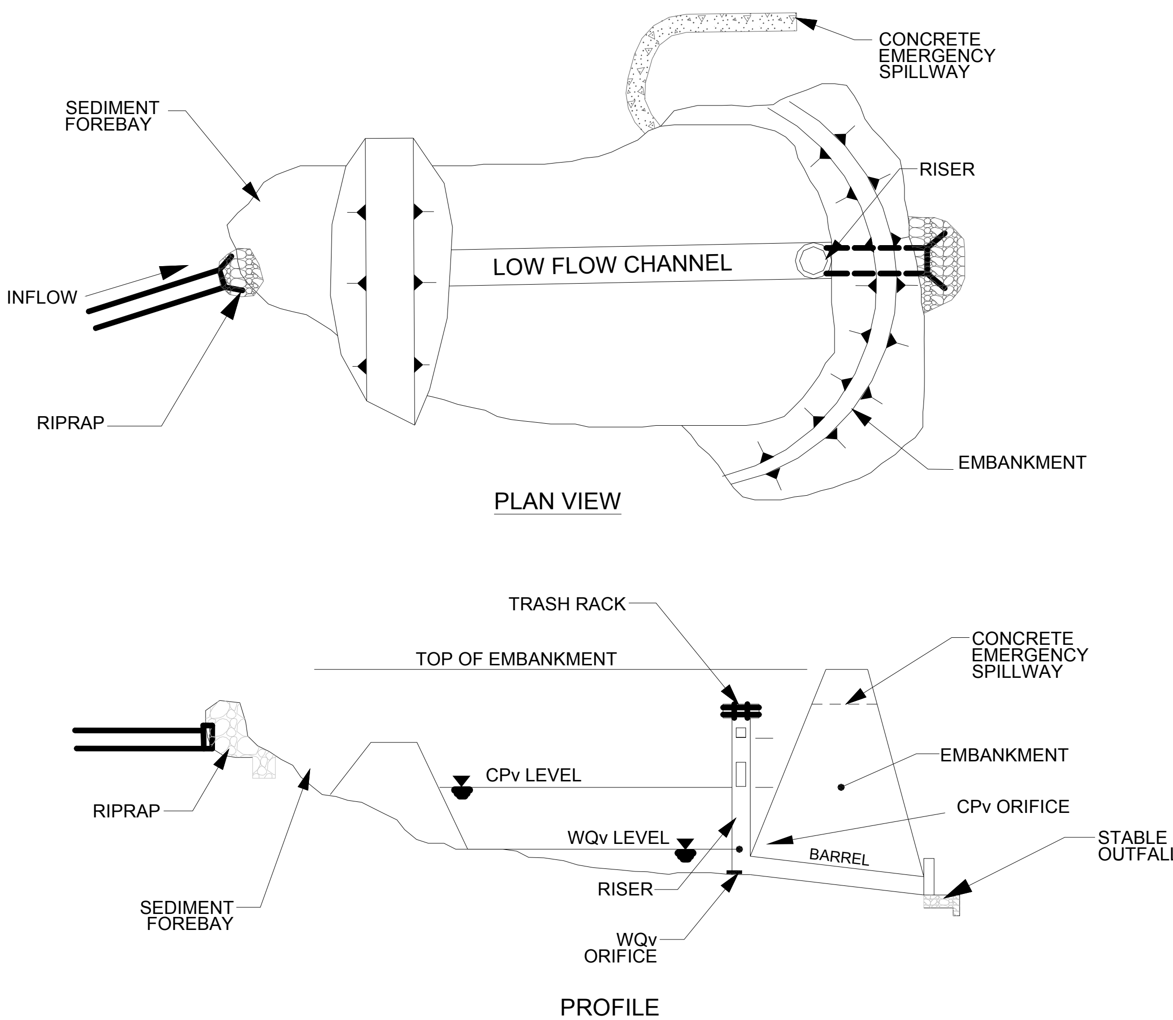


**Figure 3-18 Schematic of Dry Extended Detention Basin**

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# 3.2.3 Vegetative Filter Strip

**Primary Water Quality Facility**

**Description:** Filter strips are uniformly graded and well vegetated sections of land engineered and designed to treat runoff and remove pollutants through vegetative filtering and infiltration.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Runoff from an adjacent impervious area must be evenly distributed across the filter strip as sheet flow
- Sheet flow must be ensured via a combination of vegetation, slope and length criteria

**ADVANTAGES / BENEFITS:**

- Can be used as part of the runoff conveyance system to provide pretreatment
- Can provide groundwater recharge
- Reasonably low construction cost

**DISADVANTAGES / LIMITATIONS:**

- Cannot alone achieve the 80% TSS removal target
- Large land requirement

**MAINTENANCE REQUIREMENTS:**

- Requires periodic repair, regrading, and sediment removal to prevent channelization

## POLLUTANT REMOVAL

| | |
|---|---|
| M | **Total Suspended Solids** |
| L | **Nutrients –** Total Phosphorus & Total Nitrogen |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| | **Channel Protection** |
| | **On-Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| H | **Land Requirements** |
| L | **Relative Capital Costs** |
| L | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *2 acres max*

**Soils**: *No restrictions*

**Other Considerations**:

- *Use in buffer system*

**L**=Low **M**=Moderate **H**=High

### 3.2.3.1 General Description

Filter strips are uniformly graded and densely vegetated sections of land engineered to treat runoff and remove pollutants through vegetative filtering and infiltration. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and other pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer, or as pretreatment for another structural stormwater control. Filter strips can serve as a buffer between incompatible land uses, be landscaped to be aesthetically pleasing, and provide groundwater recharge in areas with pervious soils.

Filter strips rely on the use of vegetation to slow runoff velocities and filter out sediment and other pollutants from urban stormwater. There can also be a reduction in runoff volume for smaller flows that infiltrate pervious soils while contained within the filter strip. To be effective, however, sheet flow must be maintained across the entire filter strip. Once runoff flow concentrates, it effectively short-circuits the filter strip and reduces any water quality benefits. Therefore, a flow spreader is often included at the top of the filter strip design.

There are two different filter strip designs: a simple filter strip and a design that includes a permeable berm at the bottom. The presence of the berm increases the contact time with the runoff, thus reducing the overall width of the filter strip required to treat stormwater runoff. Filter strips are typically an on-line practice, so they must be designed to withstand the full range of storm events without eroding.

### 3.2.3.2 Pollutant Removal Capabilities

Pollutant removal from filter strips is highly variable and depends primarily on density of vegetation and contact time for filtration and infiltration. These, in turn, depend on soil and vegetation type, slope, and presence of sheet flow.

The following pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 50%
- Total Phosphorus – 20%
- Total Nitrogen – 20%
- Heavy Metals – 40%
- Fecal Coliform – insufficient data

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.3.3 Design Criteria and Specifications

***General Criteria***

- Filter strips may be used to treat small drainage areas. Flow must enter the filter strip as overland flow spread out over the width (long dimension; perpendicular to flow) of the strip. Flow usually concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (Claytor & Schueler, 1996). These are the maximum allowable contributing flow paths for filter strips unless special provisions are made to ensure design flows spread evenly across the filter strip, instead of becoming concentrated.
- Filter strips should be integrated within site designs.
- Filter strips should be constructed outside any natural stream buffer area whenever possible to maintain a more natural buffer along the channel.
- Filter strips should be designed for slopes between 2% and 6%. Greater slopes than this would encourage the formation of concentrated flow. Flatter slopes would encourage standing water.
- The depth of sheet flow along filter strips should normally be limited to approximately 1 inch to discourage flow concentrations. A depth of 0.5 inches is ideal, where practicable.
- Filter strips should not be used on soils that cannot sustain a dense grass cover with high retardance. Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.
- The flow path should be at least 15 feet across the strip to provide filtration and contact time for water quality treatment. A minimum of 25 feet is preferred (where available).
- Both the top and toe regions of the slope should be as flat and even as possible to encourage sheet flow and prevent erosion.
- An effective flow spreader is a gravel diaphragm at the top of the slope (ASTM D 448 size 6, 1/8” to 3/8”). The gravel diaphragm (a small trench running along the top of the filter strip) serves two purposes. First, it acts as a pretreatment device, settling out sediment particles before they reach the practice. Second it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip. Other types of flow spreaders include a concrete sill, curb stops, or curb and gutter with “sawteeth” cut into it.
- Ensure that flows in excess of design flow move through the strip without damaging it. A bypass channel or overflow spillway with protected channel section may be required to handle flows above the allowable as defined below.
- Pedestrian and vehicular traffic across the filter strip should be limited.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement to the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

- When a berm is used at the downstream end of the filter strip, outlets must be provided to drain the $WQ_V$ over a 24 hour period.
- Maximum discharge loading per foot of filter strip width (perpendicular to flow path) is found using the Manning's equation:

**Equation 3-1** $$q = \frac{0.00237}{n} Y^{\frac{5}{3}} S^{\frac{1}{2}}$$

where:

| | | |
|---|---|---|
| q | = | discharge per foot of width of filter strip (cfs/ft) |
| Y | = | allowable depth of flow (inches) |
| S | = | slope of filter strip (percent) |
| n | = | Manning's "n" roughness coefficient |

(use n = 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

- The minimum width of a filter strip is:

**Equation 3-2** $$W_{fMIN} = \frac{Q_{wv}}{q}$$

where:

| | | |
|---|---|---|
| $W_{fMIN}$ | = | minimum filter strip width perpendicular to flow (feet) |
| Q | = | peak flow for the water quality (1.2") storm (cfs) |
| q | = | flow per unit width of filter strip (cfs/ft) |

***Filter without Berm***

- Size filter strip (parallel to flow path) for a contact time of 5 minutes minimum
- Equation for filter length is based on the SCS TR55 sheet flow travel time (equation 4-5):

**Equation 3-3** $$L_f = \frac{(T_t)^{1.25}(P_{2-24})^{0.625}(S)^{0.5}}{3.34n}$$

where:

| | | |
|---|---|---|
| $L_f$ | = | length of filter strip parallel to flow path (ft) |
| $T_t$ | = | travel time through filter strip (5 minute minimum) |
| $P_{2-24}$ | = | 2-year, 24-hour rainfall depth = 3.5 inches (see Chapter 4) |
| S | = | slope of filter strip (percent) |
| n | = | Manning's "n" roughness coefficient |

(use n = 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

***Filter Strips with Berm***

- Size outlet pipes to ensure that the bermed area drains within 24 hours.
- Specify grasses resistant to frequent inundation within the shallow ponding limit.

- Berm material should be of sand, gravel and sandy loam to encourage grass cover (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”).
- Size filter strip to contain at least the $WQ_v$ within the wedge of water backed up behind the berm.
- Maximum berm height is 12 inches.

***Filter Strips for Pretreatment***

- A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a filter strip as a pretreatment measure. The required length of the filter strip flow path depends on the drainage area, imperviousness, and the filter strip slope. Table 3-5 provides sizing guidance for using filter strips for pretreatment.

**Table 3-5 Filter Strip Sizing Guidance When Using for Pretreatment**

| Parameter | Impervious Areas | | | | Pervious Areas (Lawns, etc) | | | |
|---|---|---|---|---|---|---|---|---|
| Maximum inflow approach length (feet) | 35 | | 75 | | 75 | | 100 | |
| Filter strip slope (max = 6%) | 2% | > 2% | 2% | > 2% | 2% | > 2% | 2% | > 2% |
| Filter strip minimum length (feet) | 10 | 15 | 20 | 25 | 10 | 15 | 15 | 20 |

(Source: Claytor and Schueler, 1996)

### 3.2.3.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operations and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.3.5 Example Schematic

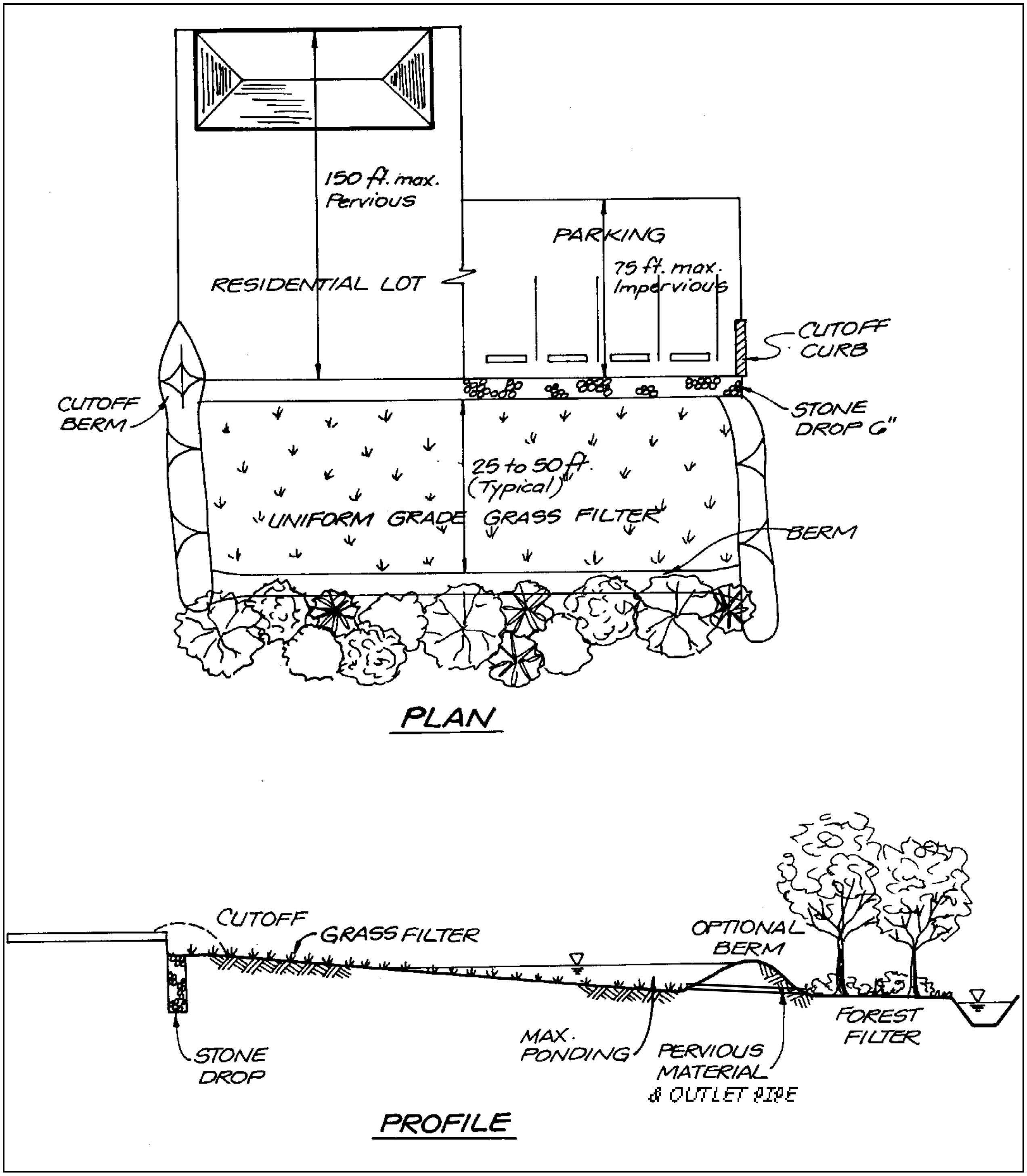



**Figure 3-19 Schematic of Filter Strip (with optional Berm)**
(Claytor & Schueler, 1996)

### 3.2.3.6 Design Example

***Basic Data***

Small commercial lot 150 feet length x 100 feet wide located

- Drainage area treated by filter (A) = 0.2 acres
- Runoff coefficient ($R_v$) = 0.70
- Slope (S) = 4%
- Depth (Y) = 0.5 inches
- Manning's n = 0.25
- Time of Concentration ($t_c$) = 8 minutes

***Calculate Maximum Discharge Loading Per Foot of Filter Strip Width***

Using Manning's equation again:

$$q = \frac{0.00237}{0.25} * (0.5)^{5/3} * (4)^{1/2} = 0.006\, {}^{cfs}\!/_{ft}$$

***Calculate the Water Quality Peak Flow***

Compute the $WQ_V$ in inches over the drainage area (thus expressed as $Q_{wv}$) using equation 4-25:

$$Q_{wv} = P * R_v = 1.2 * 0.7 = 0.84 inches$$

Compute modified CN for 1.2-inch rainfall (P=1.2); using $Q_{wv}$ (in inches) for Q:

$$CN = \frac{1000}{\left[10 + 5P + 10Q - 10\left(Q^2 + 1.25QP\right)^{1/2}\right]}$$

$$CN = \frac{1000}{\left[10 + (5*1.2) + (10*0.84) - 10*\left(0.84^2 + 1.25*0.84*1.2\right)^{1/2}\right]} = 96.3$$ (Use CN = 96)

For CN = 96 and an estimated time of concentration ($T_c$) of 8 minutes (0.13 hours), compute the $Q_{wq}$ for a 1.2-inch storm.

From Table 4-9, $I_a$ = 0.083, therefore $\frac{I_a}{P} = \frac{0.083}{1.2} = 0.07$

From Figure 4-6 for a Type II storm (using the limiting values) $q_u = 940\, csm/in$. Therefore, the peak discharge for the $WQ_v$ (expressed as $Q_{wq}$) can be calculated using equation 4-18:

$$Q_{wq} = q_u * A * WQ_v = 940\, csm/in * \frac{0.20ac}{640\, ac/mi^2} * 0.84in = 0.25cfs$$

***Minimum Filter Width***

Using Equation 3-2:

$$W_{fMIN} = \frac{Q_{wq}}{q} = \frac{0.25}{0.006} = 42\ feet$$

***Filter without Berm***

- 2-year, 24-hour storm = 3.5 inches (see Chapter 4)
- Use 5 minute travel (minimum contact) time

Using Equation 3-3:

$$L_f = \frac{(5)^{1.25} * (3.5)^{0.625} * (4)^{0.5}}{3.34 * 0.25} = 39feet$$

Note: Reducing the filter strip slope to 2% and planting a denser grass (raising the Manning n to 0.35) would reduce the filter strip length to 20 feet.

***Filter with Berm***

Compute the required $WQ_V$ in cubic feet:

$$WQ_v = \frac{P * R_v * A}{12} = \frac{1.2 * 0.7 * 0.2}{12} = 0.014 \text{ ac-ft or } 610 \text{ ft}^3$$

The volume of the “wedge” of water captured by the filter strip is:

$$Volume = W_f * depth * L_f$$

Where “depth” is average depth of water captured in the wedge.

For an average captured depth of 4.5 inches or 0.38 feet (a berm height of 9 inches):

$Volume = 42ft * 0.375ft * 40ft = 630ft^3$ is > 610 $ft^3$, therefore OK

Size outlet(s) to drain the stored volume of water over a 24 hour period.

# 3.2.4 Grassed Channel

**Primary Water Quality Facility**

**Description:** Vegetated open channels designed to filter stormwater runoff and meet velocity targets for the water quality design storm event.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Longitudinal slopes must be less than 4%
- Flow velocities in the channel must be less than 1 ft/s for the WQ storm

**ADVANTAGES / BENEFITS:**

- Can be used as part of the runoff conveyance system to provide pretreatment
- Grass channels can act to partially infiltrate runoff from small storm events if underlying soils are pervious
- Often less expensive to construct than curb and gutter systems

**DISADVANTAGES / LIMITATIONS:**

- May require more maintenance than curb and gutter system
- Cannot alone achieve the 80% TSS removal target
- Potential for bottom erosion and re-suspension
- Standing water may not be acceptable in some areas
- Cannot be used on steep slopes

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| H | **Land Requirements** |
| L | **Relative Capital Costs** |
| L | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *5 acres max*

**Soils**: *No restrictions*

**Other Considerations**:

- *Curb and gutter replacement*

**L**=Low **M**=Moderate **H**=High

## POLLUTANT REMOVAL

| | |
|---|---|
| L | **Total Suspended Solids** |
| L | **Nutrients –** Total Phosphorus & Total Nitrogen |
| L | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

### 3.2.4.1 General Description

Grass channels are typically designed to provide nominal treatment of runoff as well as reduce runoff velocities for treatment in other stormwater management facilities. Grass channels are well suited to a number of applications and land uses, including treating runoff from roads and parking lots, as well as from pervious surfaces.

Grass channels differ from the enhanced swale design in that they do not have an engineered filter media to enhance pollutant removal capabilities and, therefore, have a lower pollutant removal rate than for an enhanced swale. Grass channels can partially infiltrate runoff from small storm events in areas with pervious soils. When properly incorporated into an overall site design, grass channels can reduce impervious cover, slow runoff, accent the natural landscape, and provide aesthetic benefits.

When designing a grass channel, the two primary considerations are channel capacity and minimization of erosion. Runoff velocity should not exceed 1.0 foot per second during the peak discharge associated with the water quality design rainfall event, water depth must be less than 4 inches (height of the grass), and the total length of a grass channel should provide at least 5 minutes of residence time. (Depth and velocity may be greater for flood flows exceeding the water quality design event.) To enhance water quality treatment, grass channels must have broader bottoms, lower slopes, and denser vegetation than most drainage channels.

### 3.2.4.2 Pollutant Removal Capabilities

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or "treatment train" approach.

- Total Suspended Solids – 50%
- Total Phosphorus – 25%
- Total Nitrogen – 20%
- Heavy Metals – 30%
- Fecal Coliform – insufficient data

Fecal coliform removal is uncertain. In fact, grass channels are often a source of fecal coliforms from local residents walking their dogs.

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.4.3 Design Criteria and Specifications

- Grass channels should generally be used to treat small drainage areas of less than 5 acres. If the practices are used on larger drainage areas, the flows and volumes through the channel become too large to allow for filtering and infiltration of runoff.
- Grass channels shall be designed on slopes of less than 4%; channel slopes between 1% and 2% are recommended. However, for small slopes some longterm standing water may occur.
- Grass channels can be used on most soils with some restrictions on the most impermeable soils. Grass channels should not be used on hydrologic soil group D soils.
- A grass channel should accommodate the peak flow for the water quality design storm $Q_{wq}$.
- Grass channels shall have a trapezoidal or parabolic cross section with side slopes 3:1 or flatter.
- The bottom of the channel should be between 2 and 8 feet wide. The minimum width ensures an adequate filtering surface for water quality treatment, and the maximum width resists braiding, which is the formation of small channels within the swale bottom. The bottom width is a dependent variable in the calculation of velocity based on Manning's equation. If a larger channel is needed, the use of a compound cross section is recommended.
- Runoff velocities must be nonerosive. The full-channel design velocity will typically govern. See allowable velocities in Chapter 5. A mechanism for safely passing or bypassing flood flows larger than the water quality event must be provided.
- A 5 minute residence time is required for the water quality peak flow. Residence time may be increased by reducing the slope of the channel, increasing the wetted perimeter, or planting a denser grass (raising the Manning's n).
- The depth from the bottom of the channel to the historically high groundwater elevation should be at least 5 feet.
- Incorporation of permeable check dams within the channel will aid in obtaining the required minimum detention time.
- Designers should choose a grass that can withstand relatively high velocity flows at the downstream end of the channel where it discharges into other conveyances or ponds.
- A forebay is recommended in order to settle out the larger particles before they are introduced to the main channel.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement to the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

***Grass Channels for Pretreatment***

A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a grass channel as a pretreatment measure. The length of the grass channel depends on the drainage area, land use, and channel slope. Table 3-6 provides sizing guidance for grass channels for a 1 acre drainage area. The minimum grassed channel length should be 20 feet.

**Table 3-6 Bioretention Grass Channel Sizing Guidance When Used as Pretreatment**

| Parameter | ≤ 33% Impervious | | Between 34% and 66% Impervious | | ≥ 67% Impervious | |
|---|---|---|---|---|---|---|
| Slope (max = 4%) | ≤ 2% | > 2% | ≤ 2% | > 2% | ≤ 2% | > 2% |
| Grass channel minimum length (feet) assumes 2-foot wide bottom width | 25 | 40 | 30 | 45 | 35 | 50 |

(Source: Claytor and Schueler, 1996)

### 3.2.4.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.4.5 Example Schematics

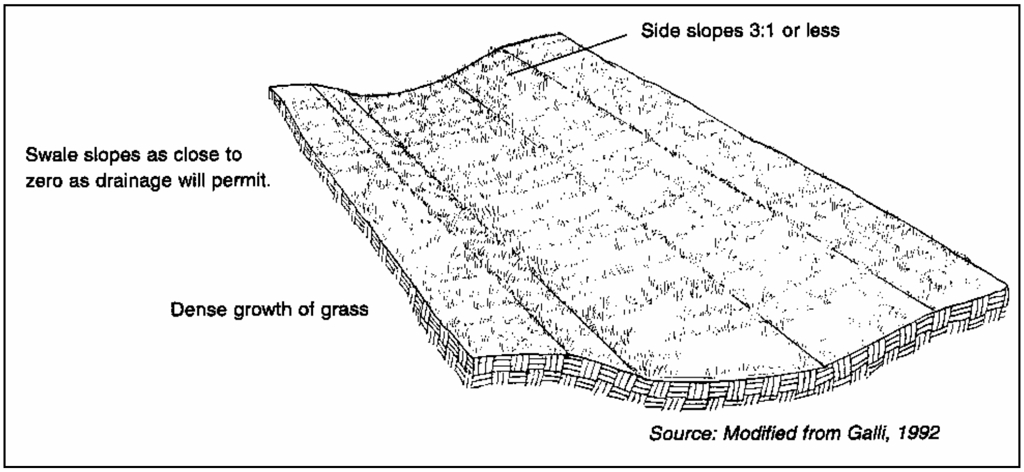



**Figure 3-20 Typical Grass Channel**

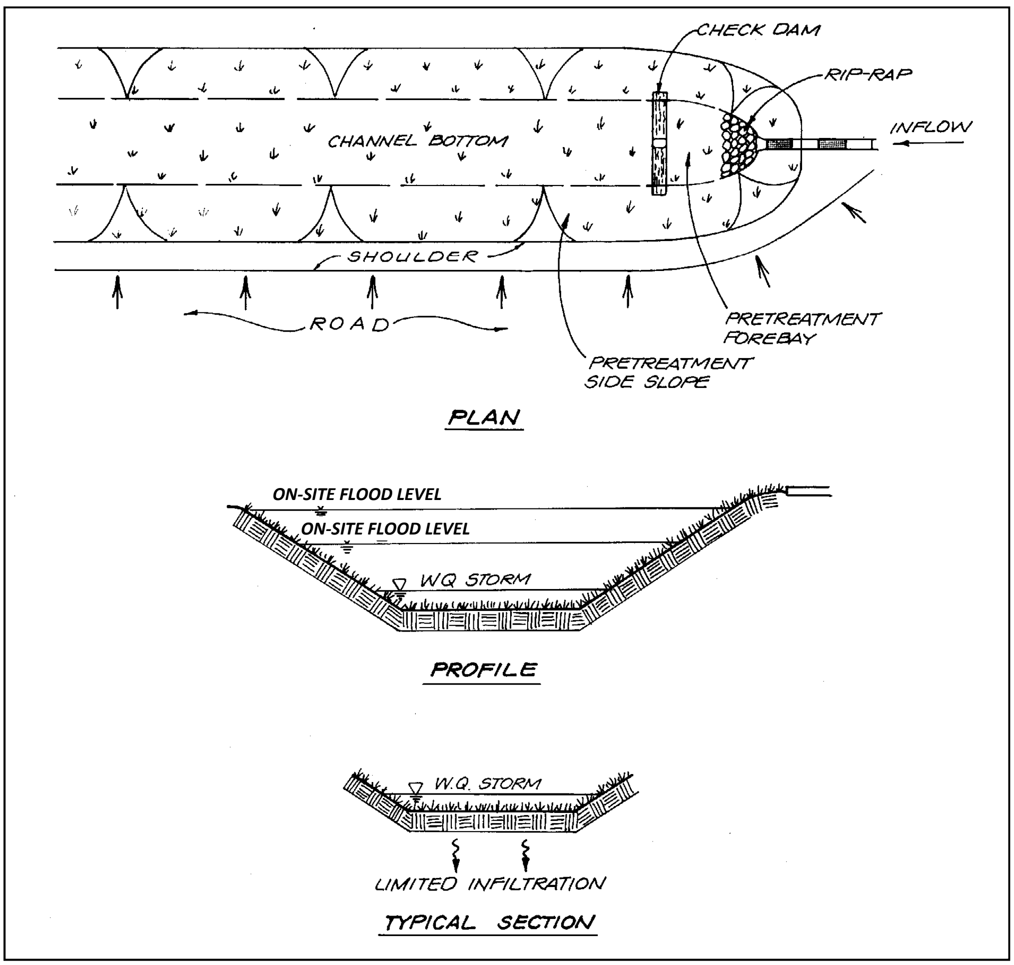



**Figure 3-21 Schematic of a Typical Grass Channel**
(Claytor & Schueler, 1996)

### 3.2.4.6 Design Example

***Basic Data***

Small commercial lot 300 feet deep x 145 feet wide

- Drainage area (A) = 1.0 acres
- Rainfall (P) = 1.2 inches (water quality event)
- Runoff coefficient ($R_v$) = 0.70

***Water Quality Peak Flow***

Compute the Water Quality Protection Volume in inches over the drainage area:

$$WQ_v = P * R_v = 1.2 * 0.70 = 0.84 inches$$

Compute modified CN for P = 1.2-inches and $WQ_v$ in inches for Q:

$$CN = \frac{1000}{\left[10 + 5P + 10Q - 10\left(Q^2 + 1.25QP\right)^{1/2}\right]}$$

$$CN = \frac{1000}{\left[10 + (5 * 1.2) + (10 * 0.84) - 10 * \left(0.84^2 + 1.25 * 0.84 * 1.2\right)^{1/2}\right]} = 96.3 \quad \text{(Use CN=96)}$$

For CN = 96 and an estimated time of concentration ($T_c$) of 8 minutes (0.13 hours), compute the $Q_{wq}$ for a 1.2-inch storm.

From Table 4-9, $I_a$ = 0.083, therefore $\frac{I_a}{P} = \frac{0.083}{1.2} = 0.07$

From Figure 4-6 for a Type II storm (using the limiting values) $q_u = 940\, csm/in$ and therefore:

$$Q_{wq} = 940\, csm/in * \frac{1.0ac}{640\, ac/mi^2} * 0.84in = 1.23cfs$$

***Utilize $Q_{wq}$ to Size the Channel***

The maximum flow depth for water quality treatment should be approximately the same height of the grass. A maximum flow depth of 4 inches is allowed for water quality design. A maximum flow velocity of 1.0 foot per second for water quality treatment is required. For Manning's n use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass. Site slope is 2% or 0.02 ft/ft for the example.

Input variables:

| | | |
|---|---|---|
| n | = | 0.15 |
| S | = | 0.02 ft/ft |
| D | = | 4/12 = 0.33 ft |

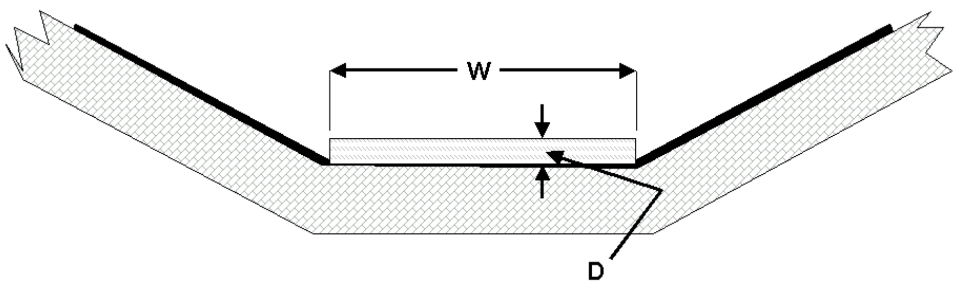
Then:

$$Q_{wq} = Q = VA = \frac{1.49}{n} D^{2/3} S^{1/2} DW$$

where:

| | | |
|---|---|---|
| Q | = | peak flow (cfs) |
| V | = | velocity (ft/sec) |
| A | = | flow area ($ft^2$) = WD |
| W | = | channel bottom width (ft) |
| D | = | flow depth (ft) |
| S | = | slope (ft/ft) |

(Note: D approximates hydraulic radius and WD approximates flow area for shallow flows)




Then for a known n, Q, D and S, a minimum width can be calculated.

$$W = \frac{nQ}{1.49 D^{5/3} S^{1/2}} = \frac{0.15 * 1.23}{1.49 * 0.33^{5/3} * 0.02^{1/2}} = 5.56\,ft \text{ minimum}$$

$$V = \frac{Q}{WD} = \frac{1.23}{5.56 * 4/12} = 0.66\,fps \text{ (OK)}$$

(Note: WD approximates flow area for shallow flows.)

Minimum length for 5-minute residence time:

$$L = V * T = 0.66 * 5 * 60 = 198\,ft$$

where:

| | | |
|---|---|---|
| L | = | Length (ft) |
| T | = | time (sec) |

Depending on the site geometry, the width or slope or density of grass (Manning's n value) might be adjusted to slow the velocity and shorten the channel in the next design iteration, if required.

# 3.2.5 Enhanced Swale

**Primary Water Quality Facility**

**Description:** Vegetated open channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry cells formed by check dams or other means.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Longitudinal slopes must be less than 4%
- Bottom width of 2 to 8 feet
- Side slopes of 3:1 or flatter required
- Convey the on-site design storm event with 1 foot minimum freeboard

**ADVANTAGES / BENEFITS:**

- Combines stormwater treatment with runoff conveyance system
- Often less expensive than curb and gutter
- Reduces runoff velocity
- Aesthetic improvement

**DISADVANTAGES / LIMITATIONS:**

- Higher maintenance than curb and gutter systems
- Cannot be used on steep slopes
- Possible resuspension of sediment
- Concerns with aesthetics of 4"-6" high grass in residential areas

**MAINTENANCE REQUIREMENTS:**

- Maintain grass heights of approximately 4 to 6 inches
- Remove sediment from forebay and channel

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| H | **Land Requirements** |
| M | **Relative Capital Costs** |
| M | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *5 acres max.*

**Soils**: *No restrictions*

**Other Considerations**:

- *Permeable soil layer (dry swale)*

**L**=Low **M**=Moderate **H**=High

## 3.2.5.1 General Description

Enhanced swales (also referred to as water quality swales) are conveyance channels engineered to capture and treat all or a portion of the $WQ_v$ for a drainage area. They differ from a normal drainage channel or swale through the incorporation of specific features that enhance stormwater pollutant removal effectiveness.

Enhanced swales are designed with limited longitudinal slopes to force the flow to be slow and shallow, thus allowing for particulates to settle and prevent erosion. Berms and/or check dams installed perpendicular to the flow path promote settling and infiltration.

The enhanced swale is designed to include a filter bed of prepared soil that overlays an underdrain system. The swales are sized to allow the $WQ_v$ to be filtered or infiltrated through the bottom of the swale. They are dry most of the time and are often a preferred option in residential settings.

**Figure 3-22 Enhanced Swale Example**

Enhanced swales are not to be confused with a filter strip or grass channel. Ordinary grass channels are not engineered to provide the same treatment capability as a well-designed enhanced swale with filter media. Filter strips are designed to accommodate overland flow rather than channelized flow. Both of these practices may be used for pretreatment or included in a “treatment train” approach where redundant treatment is provided.

## 3.2.5.2 Stormwater Management Suitability

Enhanced swale systems are designed primarily for stormwater quality and have only a limited ability to provide channel protection or peak flow reduction.

***Water Quality***

Enhanced swale systems rely primarily on filtration through an engineered media to provide removal of stormwater contaminants.

***Channel Protection***

Generally, only the $WQ_v$ is treated by an enhanced swale, and another structural control must be used to provide $CP_v$ extended detention. However, for some smaller sites, a swale may be designed to capture and detain the full $CP_v$.

***On-Site Flood Control***

Enhanced swales must provide flow diversion and/or be designed to safely pass on-site flood flows. Another structural control must be used in conjunction with an enhanced swale system to reduce the post-development peak flow.

### 3.2.5.3 Pollutant Removal Capabilities

The enhanced swale is presumed to be able to remove 90% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Undersized or poorly designed swales can reduce TSS removal performance.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 90%
- Total Phosphorus – 50%
- Total Nitrogen – 50%
- Heavy Metals – 40%
- Fecal Coliform – insufficient data

For additional information and data on pollutant removal capabilities for enhanced swales, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.5.4 Application and Feasibility Criteria

Enhanced swales can be used in a variety of development types; however, they are primarily applicable to residential and institutional areas of low to moderate density where the impervious cover in the contributing drainage area is relatively small and along roads and highways. Because of their relatively large land requirement, enhanced swales are generally not used in higher density areas.

The topography and soils of a site will determine the applicability of the use of enhanced swales. Overall, the topography should allow for the design of a swale with sufficient slope and cross-sectional area to maintain nonerosive velocities. The following criteria should be evaluated to ensure the suitability of an enhanced swale for meeting stormwater management objectives on a site or development.

***General Feasibility***

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – NO
- Regional Stormwater Control – NO

***Physical Feasibility - Physical Constraints at Project Site***

Drainage Area: 5 acres maximum

Space Required: Approximately 10% to 20% of the tributary impervious area.

Site Slope: Typically no more than 4% channel slope

Minimum Head: Elevation difference needed at a site from the inflow to the outflow: typically 1 to 5 feet.

Soils: Engineered media for swale underdrainage.

***Other Constraints / Considerations***

Aquifer Protection: 5 feet minimum separation between bottom of facility and historically high groundwater.

### 3.2.5.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of an enhanced swale system. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

#### A. LOCATION AND SITING

- An enhanced swale should be sited such that the topography allows for the design of a channel with sufficiently mild slope (unless small drop structures are used) and a minimized cross-sectional area to maintain nonerosive velocities.
- Enhanced swale systems should have a contributing drainage area of 5 acres or less.
- Swale siting should also take into account the location and use of other site features, such as buffers and undisturbed natural areas, and should attempt to aesthetically “fit” the facility into the landscape.

### B. GENERAL DESIGN

- Enhanced swales are designed to treat the $WQ_v$ through a volume-based design, and to safely pass larger storm flows.
- An enhanced swale system consists of an open conveyance channel with a filter bed of permeable soils that overlay an underdrain system. Flow passes into and is detained in the main portion of the channel where it is filtered through the soil bed. Runoff is collected and conveyed by a perforated pipe and gravel underdrain system to the outlet. Figure 3-23 provides a plan view and cross-section schematic for the design of a dry swale system.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

- Channel slopes between 1% and 2% are recommended unless topography necessitates a steeper slope, in which case 6 to 12 inch drop structures can be placed to limit the energy slope to within the recommended 1 to 2% range. Energy dissipation will be required below the drops. Spacing between the drops should not be spaced less than 50 feet.
- Enhanced swales should have a bottom width of 2 to 8 feet to ensure adequate filtration. Wider channels can be designed, but should contain a multi-level cross section to prevent channel braiding or uncontrolled sub-channel formation.
- Enhanced swales are parabolic or trapezoidal in cross section and shall be designed with moderate side slopes not greater than 3:1 for ease of maintenance and side inflow by sheet flow.
- Enhanced swales shall have a maximum $WQ_v$ ponding depth of 18 inches at the end point of the channel, with an average depth of less than12 inches, under peak $WQ_v$ conditions.
- The peak velocity for the design events must be nonerosive for the soil and vegetative cover provided. See Volume 2, Chapter 5 for allowable velocities.
- If the system is on-line, swales should be sized to convey or bypass runoff from the design flood event safely with 1 feet minimum freeboard.
- Enhanced swales are sized to store and infiltrate the $WQ_v$ with not more than 18 inches of ponding and allow for full filtering through the permeable soil layer. The maximum ponding time is 48 hours, though a 24-hour ponding time is more desirable.
- The bed of the enhanced swale consists of a permeable soil layer of at least 30 inches in depth, above a 4 inch diameter perforated PVC pipe (AASHTO M 252) longitudinal underdrain in a 6 inch gravel layer. The soil media should have an infiltration rate of 1.0 to 1.5 foot per day and contain a high level of organic material to facilitate pollutant removal. A permeable filter fabric is placed between the gravel layer and the overlying soil.
- The channel and underdrain excavation should be limited to the width and depth specified in the design. The bottom of the excavated trench shall not be loaded in a way that causes soil compaction, and shall be scarified prior to placement of gravel and permeable soil. The sides of the channel shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling.

### D. PRETREATMENT / INLETS

- Inlets to enhanced swales must be provided with energy dissipaters such as riprap.
- A forebay or equivalent upstream pretreatment (sized at 0.1 acre-inch of volume per impervious acre of contributing drainage area) shall be provided at the upstream end of the facility to capture the larger particles. The forebay volume may be counted as part of the $WQ_v$.
- Enhanced swale systems that receive direct concentrated runoff may have a 6-inch drop to a gravel diaphragm flow spreader at the upstream end of the control to help spread the inflow.
- A gravel diaphragm and gentle side slopes may be provided along the top of channels to provide pretreatment for lateral sheet flows.

### E. OUTLET STRUCTURES

- The underdrain system should discharge to the storm drainage infrastructure or a stable outfall.

### F. EMERGENCY SPILLWAY

- Enhanced swales must be adequately designed to safely pass flows that exceed the design storm flows.

### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement to the entire length of the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### H. SAFETY FEATURES

- Ponding depths should be limited to a maximum of 18 inches.

### I. LANDSCAPING

- Landscape design should specify proper grass species based on specific site and soils conditions present along the channel.

### J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

<u>Low Relief:</u> Reduced need for use of check dams.

High Relief: Often infeasible if slopes are greater than 4%.

Karst: No infiltration of hotspot runoff from dry swales; use impermeable liner.

***Soils***

- No additional criteria.

***Special Downstream Watershed Considerations***

Aquifer Protection: 5 feet minimum distance above historical groundwater for unlined swale, 2 feet for lined swale.

### 3.2.5.6 Design Procedures

**Step 1** Compute runoff control volumes.

Calculate the $WQ_v$.

**Step 2** Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria.

**Step 3** Determine pre-treatment volume.

**Step 4** Determine swale dimensions.

Size bottom width, depth, length, and slope necessary to store $WQ_v$ with not more than 18 inches of ponding at the downstream end.

- Slope cannot exceed 4% (1 to 2% recommended);
- Bottom width should range from 2 to 8 feet;
- Ensure that side slopes are not steeper than 3:1;
- Ensure swale can pass design storm with minimum 1' freeboard.

**Step 5** Compute number of check dams (or similar structures) required to detain $WQ_v$.

The size and spacing of check dams should be designed such that the $WQ_v$ will be detained within the length of the swale, and energy slope is less than 2%.

**Step 6** Calculate draw-down time.

Planting soil should pass (infiltrate) at least 1.0 feet in 24 hours and must completely filter $WQ_v$ within 48 hours.

**Step 7** Check water quality and design flood event velocity erosion potential and freeboard.

Check for erosive velocities and freeboard, and modify design as appropriate per guidance found in Chapter 5.

**Step 8** Design inlets, sediment forebay, and underdrain system.

See Chapter 4 and Chapter 5 for more details.

**Step 9** Prepare Vegetation and Landscaping Plan.

A landscaping plan for an enhanced swale should be prepared to indicate how the enhanced swale system will be stabilized and established with vegetation.

### 3.2.5.7 Design Example

***Basic Data***

Small commercial lot 300 feet deep x 145 feet wide.

- Drainage area (A) = 1.0 acres
- Rainfall (P) = 1.2 inches (water quality event)
- Runoff coefficient ($R_v$) = 0.70

***Water Quality Peak Flow***

Compute the Water Quality Protection Volume in inches over the drainage area:

$$WQ_v = P * R_v = 1.2 * 0.70 = 0.84 \text{ inches}$$

Compute the Water Quality Peak Flow (see the grassed swale example for detailed calculations).

$$Q_{wq} = 940 \, {}^{csm}\!/_{in} * \frac{1.0ac}{640 \, {}^{ac}\!/_{mi^2}} * 0.84in = 1.23 \text{ cfs}$$

***Pre-treatment Volume (Forebay)***

Compute the size of the sediment forebay (assume 80% of site is impervious)

$$V_{pre} = (0.80)(0.1'')(1'/12'') = 1.2 * 0.70 = 0.0067 \text{acre-ft}$$

***Enhanced Swale Design***

Determine the swale dimensions (assume trapezoidal channel with max depth of 18 inches). The $Q_{wq}$ will be utilized to size the channel. The maximum flow depth of 4 inches is allowed for water quality design. A maximum flow velocity of 1.0 foot per second for water quality treatment is required. For Manning's n use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass.

Input variables:

| | | |
|---|---|---|
| n | = | 0.15 |
| D | = | 1' |

| | | |
|---|---|---|
| Side Slopes | = | 2:1 |
| Channel Slope | = | 0.015 ft/ft |

Then:

$$Q_{wq} = Q = VA = \frac{1.49}{n} D^{2/3} S^{1/2} DW$$

where:

| | | |
|---|---|---|
| Q | = | peak flow (cfs) |
| V | = | velocity (ft/sec) |
| A | = | flow area ($ft^2$) = WD |
| W | = | channel bottom width (ft) |
| D | = | flow depth (ft) |
| S | = | slope (ft/ft) |

A minimum width can be calculated.

$$W = \frac{nQ}{1.49 D^{5/3} S^{1/2}} = \frac{0.15 * 1.23}{1.49 * 1^{5/3} * 0.015^{1/2}} = 1\,\text{ft}$$

$$V = \frac{Q}{WD} = \frac{1.23}{(1')(1')} = 1.23\,fps\,(>1\text{fps})$$

Increase width to 4'.

$$V = \frac{Q}{WD} = \frac{1.23}{(4')(1')} = 0.31\,fps\,(\text{OK})$$

***Check Dams***

Compute the number of check dams required to detain the $WQ_v$. With where:

- Dam height = 1.5 feet
- Spacing of check dams will be 60 feet (based on top of downstream dam same elevation as upstream dam's toe).

The total volume need to be storage behind dams equals:

$$WQ_v = (0.84\,\text{inches})(1\text{acre}) = 3050\,\text{ft}^3$$

Each dam stores: Volume = (length behind dam)(width of dam)(water depth behind dam) = (60')(1.5')(4') = 360 $ft^3$

A total of (3050)/(360) = 8 check dams will be needed to capture the water quality volume.

### 3.2.5.8 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.5.9 Example Schematics

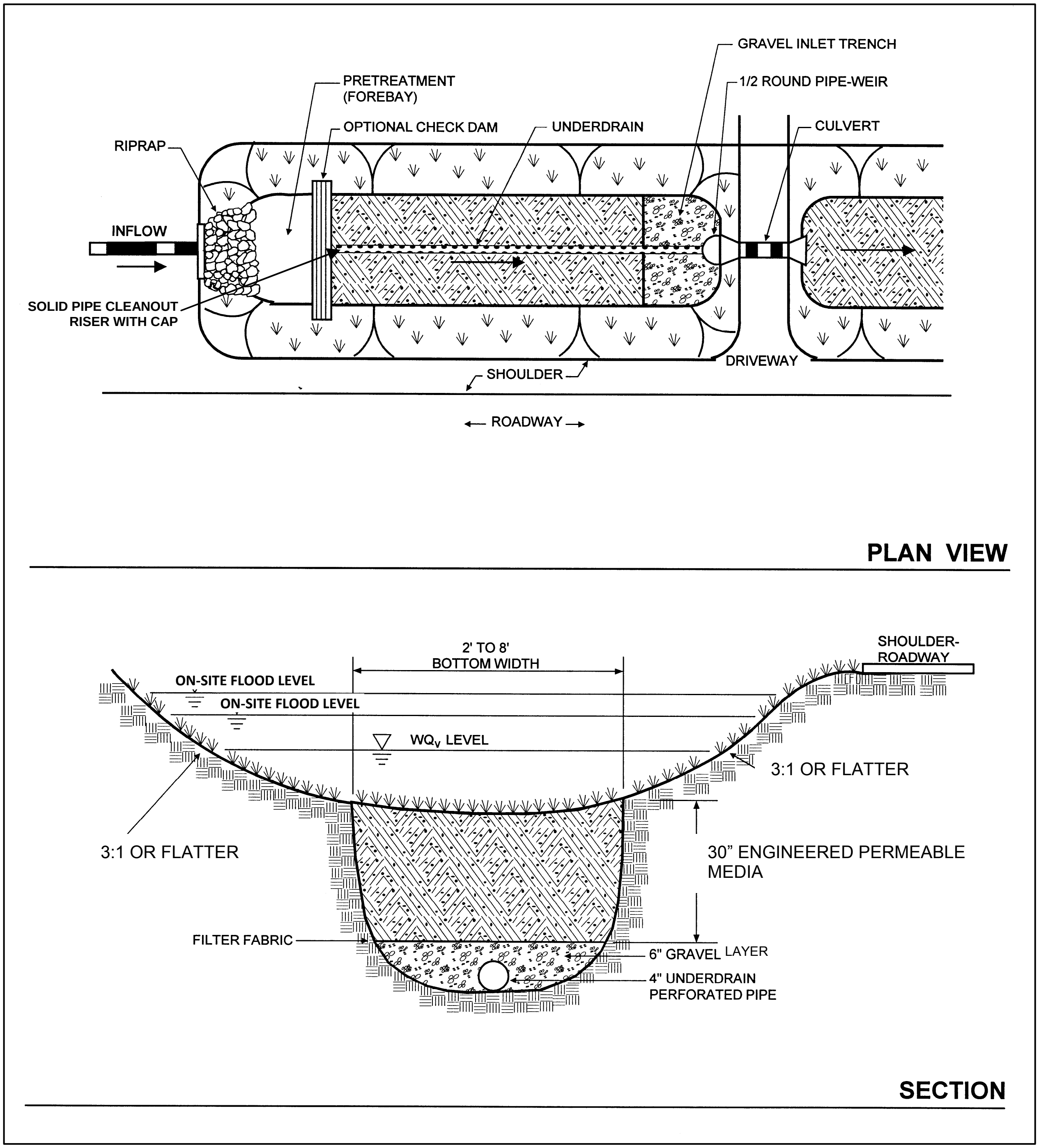



**Figure 3-23 Schematic of Dry Swale**
(MSDM, 2000)

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# 3.2.6 Infiltration Trench

**Primary Water Quality Facility**

**Description:** Excavated trench filled with stone aggregate used to capture and infiltrate stormwater runoff into the surrounding soils from the bottom and sides of the trench.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Soil infiltration rate of 0.5 in/hr or greater required
- Excavated trench (3 to 8 foot depth) filled with stone media (1.5 to 2.5-inch diameter), gravel, and sand layers
- A sediment forebay and grass channel, or equivalent upstream pretreatment, must be provided

**ADVANTAGES / BENEFITS:**

- Excellent water quality treatment
- Flexible configuration
- Can contribute to channel protection and peak flow control
- Provides for groundwater recharge
- Good for small sites with porous soils

**DISADVANTAGES / LIMITATIONS:**

- Potential for groundwater contamination
- High clogging potential; should not be used on sites with fine-particle soils (clays or silts) in drainage area
- Significant setback requirements
- Restrictions in karst areas
- Geotechnical testing required, two borings per facility

**MAINTENANCE REQUIREMENTS:**

- Inspect for clogging
- Remove sediment from forebay
- Replace gravel layer as needed

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| H | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *5 acres max.*

**Soils**: *Pervious soils required (0.5 in/hr or greater)*

**Other Considerations**:

- *Must not be placed under pavement or concrete*

**L**=Low **M**=Moderate **H**=High

### 3.2.6.1 General Description

Infiltration trenches are excavations typically filled with stone to create a temporary underground reservoir for stormwater runoff (see Figure 3-24). This runoff volume gradually filtrates through the bottom and sides of the trench into the subsoil and eventually reaches the water table. By diverting runoff into the soil, an infiltration trench not only treats the $WQ_V$, but also helps to preserve the natural water balance on a site and can recharge groundwater and preserve baseflow. Due to this fact, infiltration systems are limited to areas with highly porous soils (infiltration rate of > 0.5 in/hr) where the water table and/or bedrock are located well below the bottom of the trench (5' or more below). In addition, infiltration trenches must be carefully sited to avoid the potential of groundwater contamination.

Infiltration trenches are not intended to trap coarse sediment and must always be designed with a sediment forebay and grass channel or filter strip, or other appropriate pretreatment measures to prevent clogging and failure. Due to their potential for failure, these facilities must only be considered for sites where upstream sediment control can be ensured.

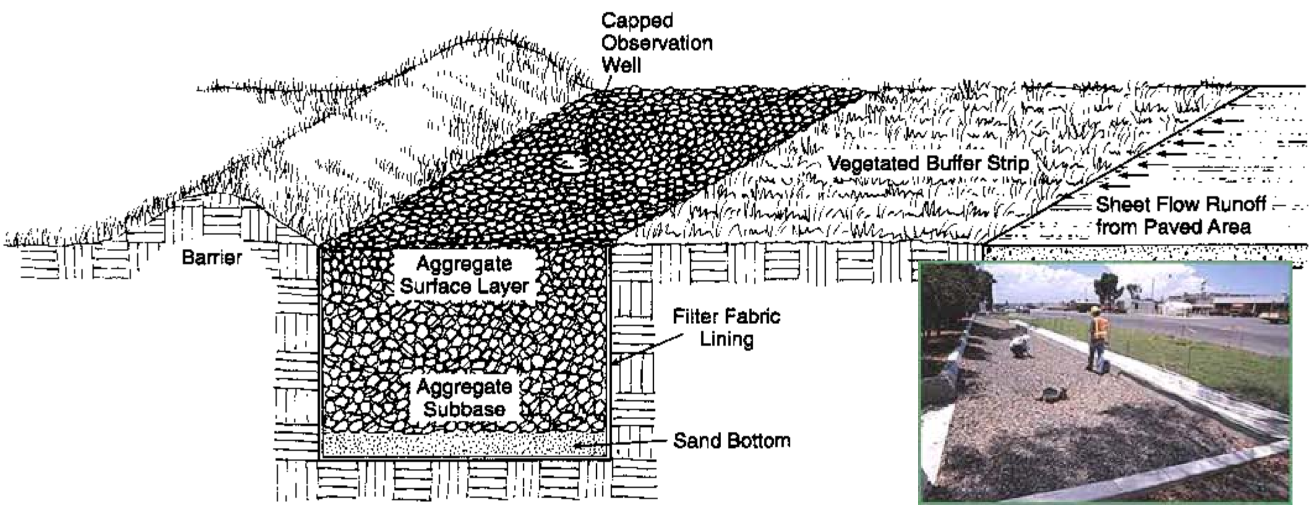



**Figure 3-24 Infiltration Trench Example**
(Knox Co., TN, 2008)

### 3.2.6.2 Stormwater Management Suitability

Infiltration trenches are designed primarily for stormwater quality, i.e. the removal of stormwater pollutants. However, they can provide limited runoff quantity control, particularly for smaller storm events. For some smaller sites, trenches can be designed to capture and infiltrate the $CP_v$ in addition to $WQ_v$. An infiltration trench will need to be used in conjunction with another structural control to provide flood control, if required.

***Water Quality Protection***

Using the natural filtering properties of soil, infiltration trenches can remove a wide variety of pollutants from stormwater through sorption, precipitation, filtering, and bacterial and chemical degradation. Sediment load and other suspended solids are removed from runoff by pretreatment measures in the facility that treats flows before they reach the trench surface.

Section 3.2.6.3 provides pollutant removal efficiencies that can be used for planning and design purposes.

***Channel Protection***

For smaller sites, an infiltration trench may be designed to capture and infiltrate the entire $CP_v$ in either an off- or on-line configuration. For larger sites, or where only the $WQ_v$ is diverted to the trench, another structural control must be used to provide $CP_v$ extended detention.

***Flood Control***

Infiltration trench facilities must provide flow diversion and/or be designed to safely pass design flood events and protect the filter bed and facility.

The volume of runoff removed and treated by the infiltration trench may be included in the on-site and/or downstream flood control calculations (see Chapter 3).

### 3.2.6.3 Pollutant Removal Capabilities

An infiltration trench is presumed to be able to remove 90% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Undersized or poorly designed infiltration trenches can reduce TSS removal performance.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 90%
- Total Phosphorus – 60%
- Total Nitrogen – 60%
- Heavy Metals – 90%
- Fecal Coliform – 90%

For additional information and data on pollutant removal capabilities for infiltration trenches, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.6.4 Application and Site Feasibility Criteria

Infiltration trenches are generally suited for medium-to-high density residential, commercial, and institutional developments where the subsoil is sufficiently permeable to provide an infiltration rate of 0.5 inches/hour or greater and the water table is 5 feet or more below the bottom of the trench, to prevent groundwater contamination. They are applicable primarily to impervious areas without high levels of fine particulates (clay/silt soils) in the runoff and should only be considered for sites where the sediment load is relatively low.

Infiltration trenches can either be used to capture sheet flow from a drainage area or function as an off-line device. Due to the relatively narrow shape, infiltration trenches can be adapted to many different types of sites. Unlike some other structural stormwater controls, they can easily fit into the margin, perimeter, or other unused areas of developed sites.

To protect groundwater from potential contamination, runoff from designated hotspot land uses or activities must not be infiltrated. Infiltration trenches should not be used for manufacturing and industrial sites, where there is a potential for high concentrations of soluble pollutants and heavy metals. In addition, infiltration should not be considered for areas with a high pesticide concentration. Infiltration trenches are also not suitable in areas with karst geology without adequate geotechnical testing by qualified individuals and in accordance with local requirements.

The following criteria should be evaluated to ensure the suitability of an infiltration trench for meeting stormwater management objectives on a site or development.

***General Feasibility***

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – YES (if no hotspots)
- Regional Stormwater Control – NO

***Physical Feasibility - Physical Constraints at Project Site***

<u>Drainage Area:</u> 5 acres maximum

<u>Space Required:</u> Will vary depending on the depth of the facility.

<u>Site Slope:</u> No more than 6% slope to limit excavation (trench bottom must be on zero grade).

<u>Minimum Head:</u> Elevation difference needed at a site from the inflow to the outflow: 1 foot

<u>Minimum Depth to Water Table:</u> 5 feet required between the bottom of the infiltration trench and the elevation of the historic high water table.

<u>Soils:</u> Infiltration rate greater than 0.5 inches per hour required (typically hydrologic group “A”, some group “B” soils).

***Other Constraints / Considerations***

Aquifer Protection: No hotspot runoff allowed. Bottom of trench to be five foot minimum above historic high groundwater table.

## 3.2.6.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of an infiltration trench facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

**A. LOCATION AND SITING**

- To be suitable for infiltration, underlying soils should have an infiltration rate ($f_c$) of 0.5 inches per hour or greater, as initially determined from NRCS soil textural classification and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration trenches cannot be used in fill soils.
- Infiltration trenches should have a contributing drainage area of 5 acres or less.
- Soils on the drainage area tributary to an infiltration trench should have a clay content of less than 20% and a silt/clay content of less than 40% to prevent clogging and failure.
- There should be at least 5 feet between the bottom of the infiltration trench and the elevation of the historic high water table.
- Clay lenses, bedrock or other restrictive layers below the bottom of the trench will reduce infiltration rates unless excavated.
- Minimum setback requirements for infiltration trench facilities per local regulations.
- When used in an off-line configuration, the WQv is diverted to the infiltration trench through the use of a flow splitter. Stormwater flows greater than the WQv are diverted to other controls or downstream using a diversion structure or flow splitter.
- To reduce the potential for costly maintenance and/or system reconstruction, it is recommended that the trench be located in an open or lawn area, with the top of the structure as close to the ground surface as possible.
- Infiltration trenches are designed for intermittent flow and must be allowed to drain and allow re-aeration of the surrounding soil between rainfall events. They must not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

**B. GENERAL DESIGN**

- A well-designed infiltration trench consists of:
  - Excavated shallow trench backfilled with sand, coarse stone, and gravel, and lined with a filter fabric;

  - Appropriate pretreatment measures; and,
  - One or more observation wells to show how quickly the trench dewaters or to determine if the device is clogged.

- An example of an on-line infiltration trench is shown in Figure 3-24. Figure 3-25 provides a plan view and profile schematic for the design of an off-line infiltration trench facility.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

- The required trench storage volume is equal to the $WQ_v$. For smaller sites, an infiltration trench can be designed with a larger storage volume to include the $CP_v$.
- A trench must be designed to fully dewater the entire $WQ_v$ within 24 to 48 hours after the $WQ_v$ rainfall event. The slowest infiltration rate obtained from tests performed at the site should be used in the design calculations.
- Trench depths should be between 3 and 8 feet, to provide for easier maintenance. The width of a trench must be less than 25 feet.
- Broad, shallow trenches reduce the risk of clogging by spreading the flow over a larger area for infiltration.
- The surface area required is calculated based on the trench depth; soil infiltration rate, aggregate void space, and fill time (assume a fill time of 2 hours).
- The bottom slope of a trench should be flat across its length and width to evenly distribute flows, encourage uniform infiltration through the bottom, and reduce the risk of clogging.
- The stone aggregate used in the trench should be washed gravel 1.5 to 2.5 inches in diameter with a void space of about 40%. Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 (this includes a factor of safety) should be used in calculations, unless aggregate specific data exist.
- A 6-inch layer of clean, washed sand is placed on the bottom of the trench to encourage drainage and prevent compaction of the native soil while the stone aggregate is added.
- The infiltration trench is lined on the bottom, sides and top by an appropriate geotextile filter fabric that prevents soil piping but has greater permeability than the parent soil. The top layer of filter fabric is located 2 to 6 inches from the top of the trench and serves to prevent sediment from passing into the stone aggregate. Since this top layer serves as a sediment barrier, it will need to be replaced more frequently and must be readily separated from the side sections.
- The top surface of the infiltration trench above the filter fabric is typically covered with gravel. The gravel layer improves sediment filtering and maximizes the pollutant removal in the top of the trench. In addition, it can easily be removed and replaced should the device begin to clog. Alternatively, the trench can be covered with permeable topsoil and planted with grass in a landscaped area.
- An observation well must be installed in every infiltration trench and should consist of a perforated PVC pipe, 4 to 6 inches in diameter, extending to the bottom of the trench (see

Figure 3-26 for an observation well detail). The observation well will show the rate of dewatering after a storm, as well as provide a means of determining sediment levels at the bottom and when the filter fabric at the top is clogged and maintenance is needed. It should be installed along the centerline of the structure, flush with the ground elevation of the trench. A visible floating marker should be provided to indicate the water level. The top of the well should be capped and locked to discourage vandalism and tampering.

- The trench excavation should be limited to the width and depth specified in the design. Excavated material should be placed away from the open trench so as not to jeopardize the stability of the trench sidewalls. The bottom of the excavated trench shall not be loaded in a way that causes soil compaction, and should be scarified prior to placement of sand. The sides of the trench shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling. All infiltration trench facilities should be protected during site construction and should be constructed after upstream areas have been stabilized.

### D. PRETREATMENT / INLETS

- Pretreatment facilities must always be used in conjunction with an infiltration trench to prevent clogging and failure.
- For a trench receiving sheet flow from an adjacent drainage area, the pretreatment system should consist of a vegetated filter strip with a minimum 20-foot length. A vegetated buffer strip around the entire trench is required if the facility is receiving runoff from both directions.
- For an off-line configuration, pretreatment should consist of a sediment forebay, vault, plunge pool, or similar sedimentation chamber (with energy dissipaters) sized to 25% of the $WQ_v$. Exit velocities from the pretreatment chamber must be nonerosive.

### E. OUTLET STRUCTURES

- Outlet structures are required for flood flows that cannot be infiltrated.

### F. EMERGENCY SPILLWAY

- Typically, for off-line designs, there is no need for an emergency spillway. However, a nonerosive overflow channel should be provided to pass safely flows that exceed the storage capacity of the trench to a stabilized downstream area or watercourse.

### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement to the entire length of the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

#### H. SAFETY FEATURES

- In general, infiltration trenches are not likely to pose a physical threat to the public and do not need to be fenced.

#### I. LANDSCAPING

- Vegetated filter strips and buffers should fit into and blend with surrounding area. Native grasses are preferable, if compatible. The trench may be covered with permeable topsoil and planted with grass in a landscaped area.

#### J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

Low Relief: No additional criteria.

High Relief: Maximum site slope of 6%.

Karst: Not suitable without adequate geotechnical testing.

***Special Downstream Watershed Considerations***

- No additional criteria.

### 3.2.6.6 Design Procedures

**Step 1** Compute runoff control volumes from the integrated design approach.

Calculate the $WQ_v$ using equation 1-1.

**Step 2** Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria.

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Compute $WQ_v$ peak discharge ($Q_{wq}$) using equation 4-18.

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion (see Chapter 4).

- Using $WQ_v$ (or total volume to be infiltrated), compute CN using equation 4-3.
- Compute time of concentration.
- Determine appropriate unit peak discharge from time of concentration.
- Compute $Q_{wq}$ from unit peak discharge, drainage area, and $WQ_v$.

**Step 4** Size flow diversion structure, if needed.

A flow regulator (or flow splitter diversion structure) should be supplied to divert the $WQ_v$ to the infiltration trench.

Size low flow orifice, weir, or other device to pass $Q_{wq}$.

**Step 5** Size infiltration trench

The area of the trench can be determined from the following equation: (MSDM, 2000).

$$A = \frac{WQ_v}{(nd + kT / 12)}$$

where:

| | | |
|---|---|---|
| A | = | Surface Area ($ft^2$) |
| $WQ_v$ | = | Water Quality Protection Volume (or total volume to be infiltrated) |
| n | = | porosity of aggregate |
| d | = | trench depth (feet) |
| k | = | soil percolation (inches/hour) |
| T | = | Fill Time (time for the practice to fill with water), in hours |

A porosity value n = 0.32 (includes a factor of safety) should be used for gravel having a void space of 40%.

All infiltration systems should be designed to fully dewater the entire $WQ_v$ within 24 to 48 hours after the rainfall event.

A fill time T = 2 hours may be used, which is a conservative estimate for T. A fill time of 2 hours is recommended since this would give the site adequate time to infiltrate and evaporate the water quality storm of 1.2 inches. Larger values, if used, will reduce the treatment of the water quality storm event and therefore would need to be validated by the site design engineer.

**Step 6** Determine pretreatment volume and design pretreatment measures.

Size pretreatment facility to treat 25% of the $WQ_v$ for off-line configurations.

**Step 7** Design spillway(s)

Adequate stormwater outfalls should be provided for the overflow exceeding the capacity of the trench, ensuring nonerosive velocities on the down-slope.

### 3.2.6.7 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.

2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and must clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.6.8 Example Schematics

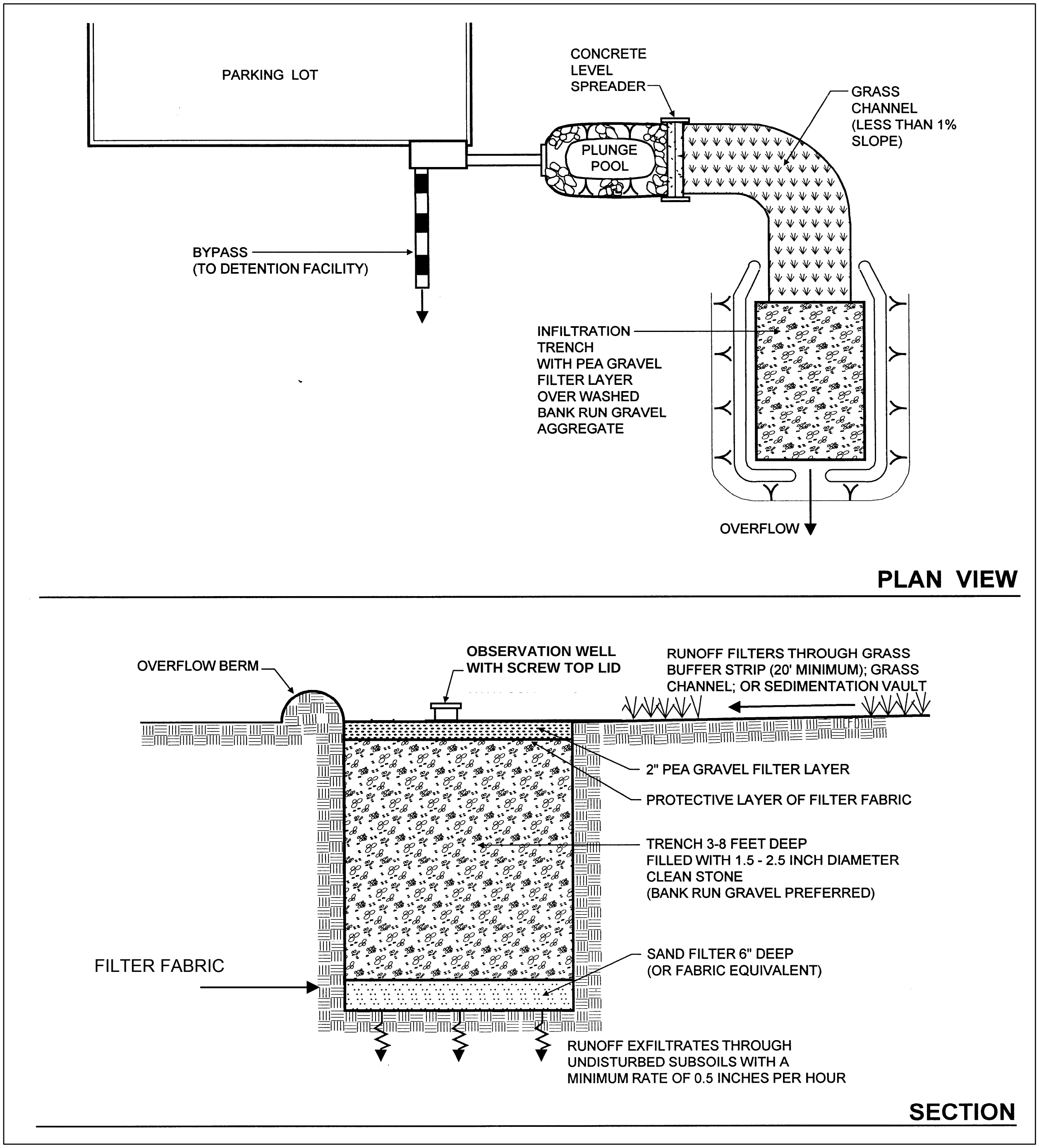



**Figure 3-25 Schematic of a Typical Infiltration Trench**
(MSDM, 2000)

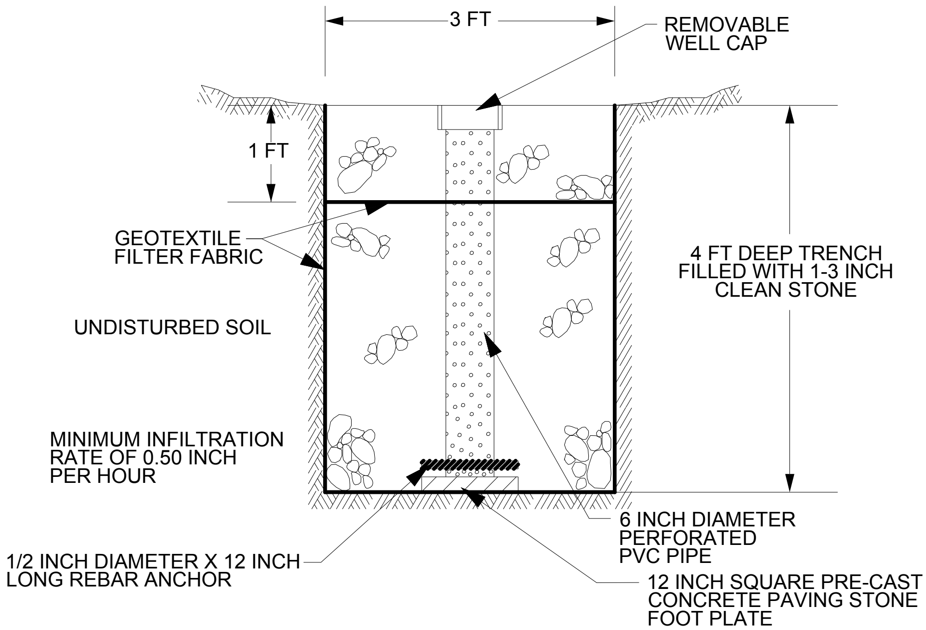
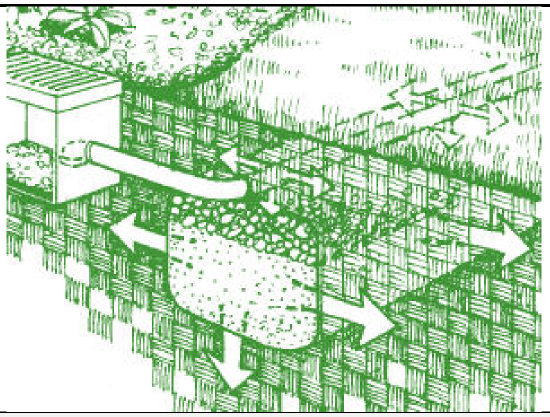



**Figure 3-26 Observation Well Detail**

- The aggregate material for the trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches.
- The aggregate should be graded such that there will be few aggregates smaller than the selected size. For design purposes, void space for these aggregates may be assumed to be 40%.
- A 6-inch layer of clean, washed sand is placed on the bottom of the trench to encourage drainage and prevent compaction of the native soil, while the stone aggregate is added.
- The aggregate should be completely surrounded with an engineering filter fabric. If the trench has an aggregate surface, filter fabric should surround all of the aggregate fill material except for the top 1 foot.
- The observation well should consist of perforated PVC pipe, 4 to 6 inches diameter, located in the center of the trench, and be constructed flush with the ground elevation of the trench.
- The screw top lid should be cast iron and clearly labelled as an observation well.

## 3.2.7 Soakage Trench

**Primary Water Quality Facility**



**Description:** Soakage trenches are a variation of infiltration trenches. Soakage trenches drain through a perforated pipe buried in gravel. They are used in highly impervious areas where conditions do not allow surface infiltration and where pollutant concentrations in runoff are minimal (i.e. non-industrial rooftops). They may also be used in conjunction with local unregulated stormwater devices, such as residential roof downspouts.

### KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Intended for space-limited applications
- Like other infiltration devices, soakage trenches should not be used for stormwater containing high sediment loads to minimize clogging

**ADVANTAGES / BENEFITS:**

- Filtration provides pollutant removal capability
- Reservoir decreases peak flow rates

**DISADVANTAGES / LIMITATIONS:**

- Subsurface pipe considered an injection well and may require special permit

**MAINTENANCE REQUIREMENTS:**

- Remove sediment and oil/grease from pre-treatment devices, as well as overflow structures
- Mow grass filter strips as necessary

### POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| H | **Pathogens –** Coliform, Streptococci & E. Coli |

### STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| | **Channel Protection** |
| | **On-Site Flood Control** |
| | **Downstream Flood Control** |

### IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *5 acres max.*

**Soils**: *Pervious soils required (0.5 in/hr or greater)*

**L**=Low **M**=Moderate **H**=High

### 3.2.7.1 General Description

Soakage trenches represent a variation of the infiltration trench. Regular infiltration trenches receive drainage from the surface, but in highly urbanized areas there is often not a suitable area available for this type of setup. Soakage trenches utilize a perforated pipe embedded within the trench to introduce inflow, thereby minimizing the surface area required for the device. They can be located under pavement, although this is not recommended because of the expense of maintaining if the trench ultimately clogs. A sediment sump may be used to decrease this problem.

<u>Soakage trenches used for stormwater disposal are considered Class V injection devices by the EPA and fall under the Kansas UIC program.</u>

### 3.2.7.2 Pollutant Removal Capabilities

Pollutant removal is similar to infiltration trenches, but care should be taken to avoid clogging with sediments.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 90%
- Total Phosphorus – 60%
- Total Nitrogen – 60%
- Heavy Metals – 90%
- Fecal Coliform – 90%

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.7.3 Design Criteria and Specifications

- The trench shall be excavated in native soil, uncompacted by heavy equipment.
- The trench should be at least 3 feet deep and 2.5 feet wide as shown in Figure 3-27. The exact dimensions will depend on the drainage characteristics of the surrounding soils.
- A minimum separation distance of 5 feet is required between the bottom of the trench and the elevation of the historical high water table for soakage trenches without underdrains, 2 feet for soakage trenches with underdrains. Soakage trenches shall not be used to infiltrate untreated hotspot runoff.

- A sediment trap may be installed upstream of the perforated pipe if pretreatment is needed prior to discharge.
- The bottom of the trench should be filled with at least 18 inches of medium sand meeting ASTM C-33 and enveloped in filter fabric.
- A minimum of six inches of ¾ inch – 2 ½ inch round or crushed rock shall be placed on top of the fabric covered sand base. The crushed rock shall also be enclosed in filter fabric.
- The inflow pipe should be sized based on delivery of the water quality flow to the trench, and should be a minimum of 3 inches in diameter.
- The perforated distribution pipe shall be an approved leach field pipe with holes oriented downward. It shall be covered with filter fabric, with at least 12 inches of backfill above the pipe.
- The trench should be sized in the same manner as a conventional infiltration trench (see Section 3.2.6.) and the pipe perforations over-sized to ensure that the sand is the limitation to flow and not the pipe perforations.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- A pipe inspection and cleanout port shall be employed to allow inspection and maintenance.

### 3.2.7.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.7.5 Example Schematics

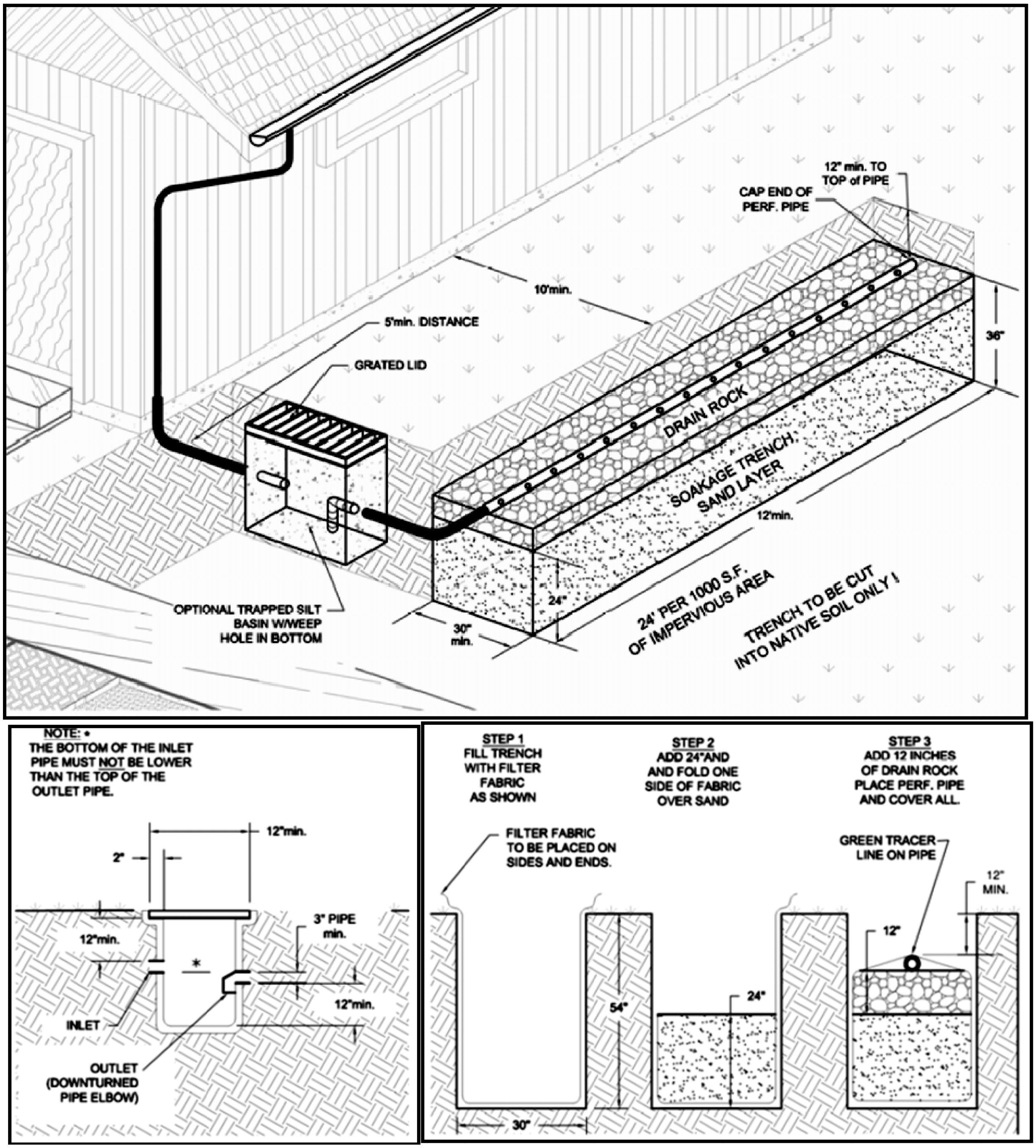



**Figure 3-27 Schematic of an Example Soakage Trench Installation**
(Source: City of Eugene, Oregon)

## 3.2.8 Surface Sand Filter

**Primary Water Quality Facility**

**Description:** Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a sand bed as its primary filter media, and an underdrain collection system.

### KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Typically requires 2 to 6 feet of head
- Maximum contributing drainage area of 10 acres for surface sand filter
- Sand filter media with underdrain system

**ADVANTAGES / BENEFITS:**

- Applicable to small drainage areas
- Good for highly impervious areas
- Good retrofit capability

**DISADVANTAGES / LIMITATIONS:**

- High maintenance burden
- Not recommended for areas with high sediment content in stormwater or clay/silt runoff areas
- Relatively expensive
- Possible odor problems

**MAINTENANCE REQUIREMENTS:**

- Inspect for clogging – rake first inch of sand
- Remove sediment from forebay/chamber
- Replace sand filter media as needed

### POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| M | **Pathogens –** Coliform, Streptococci & E. Coli |

### STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| | **On-Site Flood Control** |
| | **Downstream Flood Control** |

**Accepts Hotspot Runoff:** *Yes*

### IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *2-10 acres max*

**Soils**: *Clay or silty soils may require pretreatment*

**Other Considerations**:

- *Typically needs to be combined with other controls to provide water quantity control*
- *Hotspot treatment*

**L**=Low **M**=Moderate **H**=High

### 3.2.8.1 General Description

Sand filters (also referred to as filtration basins) are structural stormwater controls that capture and temporarily store stormwater runoff and pass it through a filter bed of sand. Most sand filter systems consist of two-chamber structures. The first chamber is a sediment forebay or sedimentation chamber, which removes floatables and heavy sediments. The second is the filtration chamber, which removes additional pollutants by filtering the runoff through a sand bed. The filtered runoff is typically collected and returned to the conveyance system, though it can also be partially or fully infiltrated into the surrounding soil in areas with porous soils if not used for hotspot treatment, and if the infiltration face is at least 5 feet above the historically high groundwater elevation.

Because they have few site constraints beside head requirements, sand filters can be used on development sites where the use of other structural controls may be precluded. However, sand filter systems can be relatively expensive to construct, install, and maintain.

<u>Surface Sand Filter:</u> The surface sand filter is a ground-level open air structure that consists of a pretreatment sediment forebay and a filter bed chamber. This system can treat drainage areas up to 10 acres in size and is typically located off-line. Surface sand filters can be designed as an excavation with earthen embankments or as a concrete or block structure.

**Figure 3-28 Sand Filter Example**

### 3.2.8.2 Stormwater Management Suitability

Sand filter systems are designed primarily as off-line systems for stormwater quality (i.e., the removal of stormwater pollutants) and will typically need to be used in conjunction with another structural control to provide downstream channel protection, on-site flood control, and downstream flood control, if required. However, under certain circumstances, filters can provide limited runoff quantity control, particularly for smaller storm events.

***Water Quality***

In sand filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration, and adsorption. The filtration process effectively reduces suspended solids and particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants. Surface sand filters with a grass cover have additional opportunities for vegetation uptake of pollutants, particularly nutrients.

***Channel Protection***

For smaller sites, a sand filter may be designed to capture the entire CPv in either an off- or on-line configuration. Given that a sand filter system is typically designed to completely drain over 40 hours, the requirement of extended detention of the 1-year, 24-hour storm runoff volume will be met. For larger sites or where only the WQv is diverted to the sand filter facility, another structural control must be used to provide CPv extended detention.

***On-Site Flood Control***

Another structural control must be used in conjunction with a sand filter system to reduce the post-development peak flow to pre-development levels (detention) if needed.

***Downstream Flood Control***

Sand filter facilities must provide flow diversion and/or be designed to safely pass design flood events and protect the filter bed and facility.

The volume of runoff removed and treated by the sand filter may be included in the on-site flood control and downstream flood control calculations. (See Chapter 3.)

### 3.2.8.3 Pollutant Removal Capabilities

The surface sand filter is presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the recommended specifications. Undersized or poorly designed sand filters can reduce TSS removal performance.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 80%
- Total Phosphorus – 50%
- Total Nitrogen – 30%
- Heavy Metals – 50%

- Fecal Coliform – 40%

For additional information and data on pollutant removal capabilities for sand filters, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.8.4 Application and Site Feasibility Criteria

Sand filter systems are well suited for highly impervious areas where land available for structural controls is limited. Sand filters should primarily be considered for commercial, industrial, and institutional areas where the sediment load is relatively low, such as: parking lots, driveways, loading docks, gas stations, garages, and storage yards. Sand filters may also be feasible and appropriate in some multi-family or higher density residential developments.

To avoid rapid clogging and failure of the filter media, the use of sand filters should be avoided in areas with less than 50% impervious cover, or high sediment yield sites with clay/silt soils.

The following basic criteria should be evaluated to ensure the suitability of a sand filter facility for meeting stormwater management objectives on a site or development.

***General Feasibility***

- Suitable for Residential Subdivision Usage – NO
- Suitable for High Density/Ultra Urban Areas – YES
- Regional Stormwater Control – NO

***Physical Feasibility - Physical Constraints at Project Site***

<u>Drainage Area:</u> 10 acres maximum for surface sand filter.

<u>Space Required:</u> Function of available head at site.

<u>Site Slope:</u> No more than 6% slope across filter location.

<u>Minimum Head:</u> Elevation difference needed at a site from the inflow to the outflow: 5 feet

<u>Minimum Depth to Water Table:</u> For a surface sand filter with infiltration, 5 feet is required between the bottom of the sand filter and the elevation of the historic high water table, and must not treat hotspot runoff.

<u>Soils:</u> No restrictions; Group “A” soils generally required if the filtered water is released into surrounding soils.

<u>Downstream Water Surface:</u> Downstream flood conditions need to be verified to avoid surcharging and back washing of the filter material.

***Other Constraints / Considerations***

Aquifer Protection: Do not allow infiltration of untreated hotspot runoff into groundwater. A minimum separation distance of 5 feet is required between the bottom of the filter and the elevation of the historical high water table.

## 3.2.8.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of a sand filter facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

### A. LOCATION AND SITING

- Surface sand filters should have a contributing drainage area of 10 acres or less.
- Sand filter systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with less than 50% imperviousness or high clay/silt sediment loads must not use a sand filter without adequate pretreatment due to potential clogging and failure of the filter bed. Any disturbed areas within the sand filter facility drainage area should be identified and stabilized. Filtration controls should only be constructed after the construction site is stabilized.
- Surface sand filters are generally used in an off-line configuration where the $WQ_v$ is diverted to the filter facility through the use of a flow diversion structure and flow splitter. Stormwater flows greater than the $WQ_v$ are diverted to other controls or downstream using a diversion structure or flow splitter.
- Sand filter systems are designed for intermittent flow and must be allowed to drain and reaerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

### B. GENERAL DESIGN

- A surface sand filter facility consists of a two-chamber open-air structure, which is located at ground-level. The first chamber is the sediment forebay (sedimentation chamber) while the second chamber houses the sand filter bed. Flow enters the sedimentation chamber where settling of larger sediment particles occurs. Runoff is then discharged from the sedimentation chamber through a perforated standpipe into the filtration chamber. After passing though the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. Figure 3-32 provides plan and profile schematics of a surface sand filter.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

- The entire treatment system (including the sedimentation chamber) must temporarily hold at least 75% of the $WQ_v$ prior to filtration. Figure 3-29 illustrates the distribution of the treatment volume (0.75 $WQ_v$) among the various components of the surface sand filter, including:

    - $V_s$ – volume within the sedimentation basin;
    - $V_f$ – volume within the voids in the filter bed;
    - $V_{f\text{-temp}}$ – temporary volume stored above the filter bed;
    - $A_s$ – the surface area of the sedimentation basin;
    - $A_f$ – surface area of the filter media;
    - $h_s$ – height of water in the sedimentation basin;
    - $h_{temp}$ – depth of temporary volume;
    - $h_f$ – average height of water above the filter media (1/2 $h_{temp}$);
    - $d_f$ – depth of filter media.

- The sedimentation chamber must be sized to at least 25% of the computed $WQ_v$ and have a length-to-width ratio of at least 2:1. Inlet and outlet structures should be located at opposite ends of the chamber.

The filter area is sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand should be used. The filter bed is typically designed to completely drain in 40 hours or less.

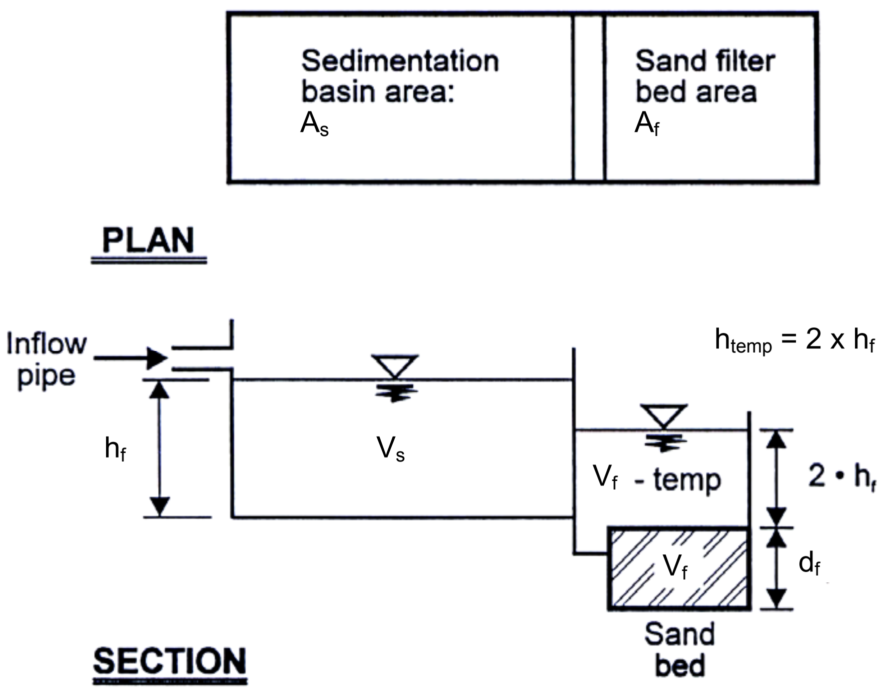



**Figure 3-29 Surface Sand Filter Volumes**
Source: Claytor and Schueler, 1996

- The filter media consists of an 18 inch layer of clean washed medium sand (meeting ASTM C-33 concrete sand) on top of the underdrain system. Three inches of topsoil are placed over the sand bed. Permeable filter fabric is placed both above and below the sand bed to prevent clogging of the sand filter and the underdrain system. A proper fabric selection is critical. Choose a filter fabric with equivalent pore openings to prevent clogging by sandy filler material. Figure 3-30 illustrates a typical media cross section.
- The filter bed is equipped with a 6 inch perforated PVC pipe (AASHTO M 252) underdrain in a gravel layer. The underdrain must have a minimum grade of 1/8-inch per foot (1% slope). Holes should be 3/8 inch diameter and spaced approximately 6 inches on center. Gravel should be clean washed aggregate with a maximum diameter of 2.5 inches and a minimum diameter of 0.5 inches with a void space of about 40% meeting the gradation listed below. Aggregate contaminated with soil shall not be used.

**Table 3-7 Percent Passing per Sieve Size for Aggregate Gradation**

| Gradation | |
|---|---|
| Sieve Size | % Passing |
| 2.5” | 100 |
| 2” | 90-100 |
| 1.5” | 35-70 |
| 1” | 0-15 |
| 0.5” | 0-5 |

- The structure containing the surface sand filter may be constructed of impermeable media such as concrete, or through the use of excavations and earthen embankments. When constructed with earthen walls/embankments, filter fabric should be used to line the bottom and side slopes of the structures before installation of the underdrain system and filter media.

### D. PRETREATMENT / INLETS

- Pretreatment of runoff in a sand filter system is provided by the sedimentation chamber.
- Inlets to surface sand filters are to be provided with energy dissipaters. Exit velocities from the sedimentation chamber must be nonerosive.
- Figure 3-31 shows a typical inlet pipe from the sedimentation basin to the filter media basin for the surface sand filter.

### E. OUTLET STRUCTURES

- Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways).

### F. EMERGENCY SPILLWAY

- An emergency or bypass spillway must be included in the surface sand filter to safely pass flows that exceed the water quality design flows. The spillway prevents filter water levels from overtopping the embankment and causing structural damage.

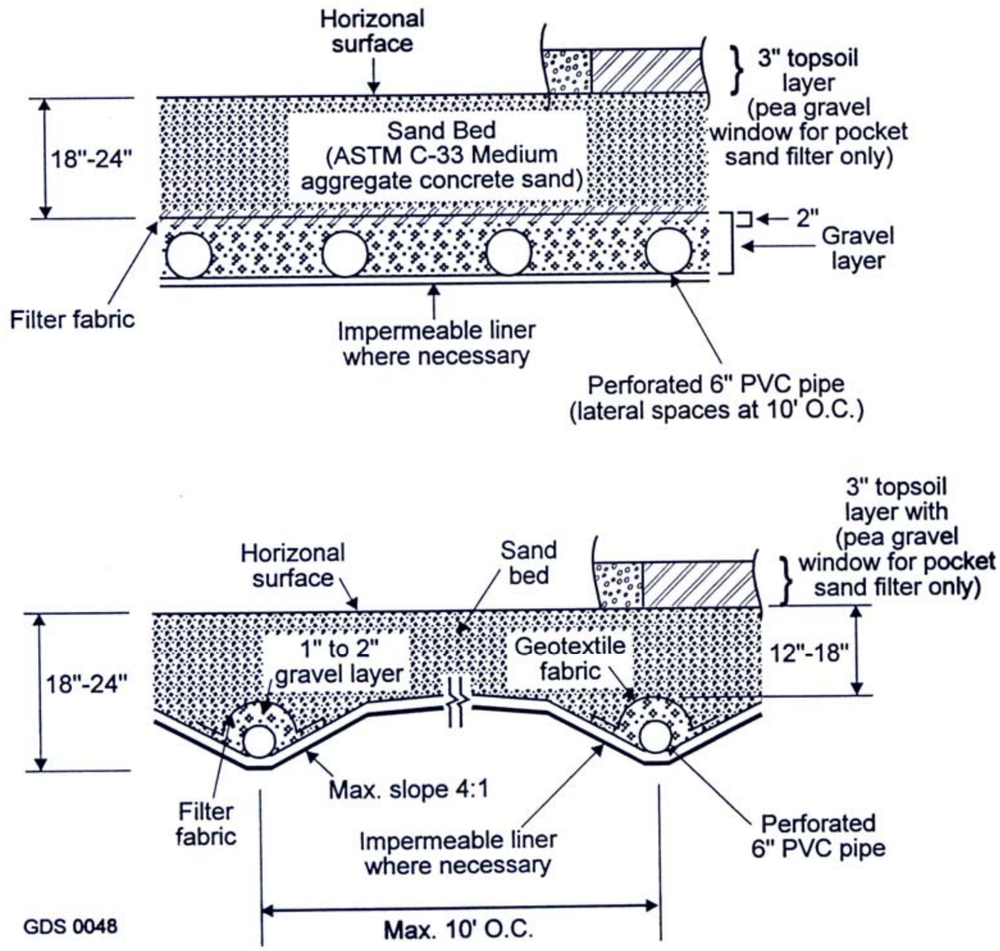



**Figure 3-30 Typical Sand Filter Media Cross Sections**
(Source: Claytor and Schueler, 1996)

### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### H. SAFETY FEATURES

- Surface sand filter facilities can be fenced to prevent access.

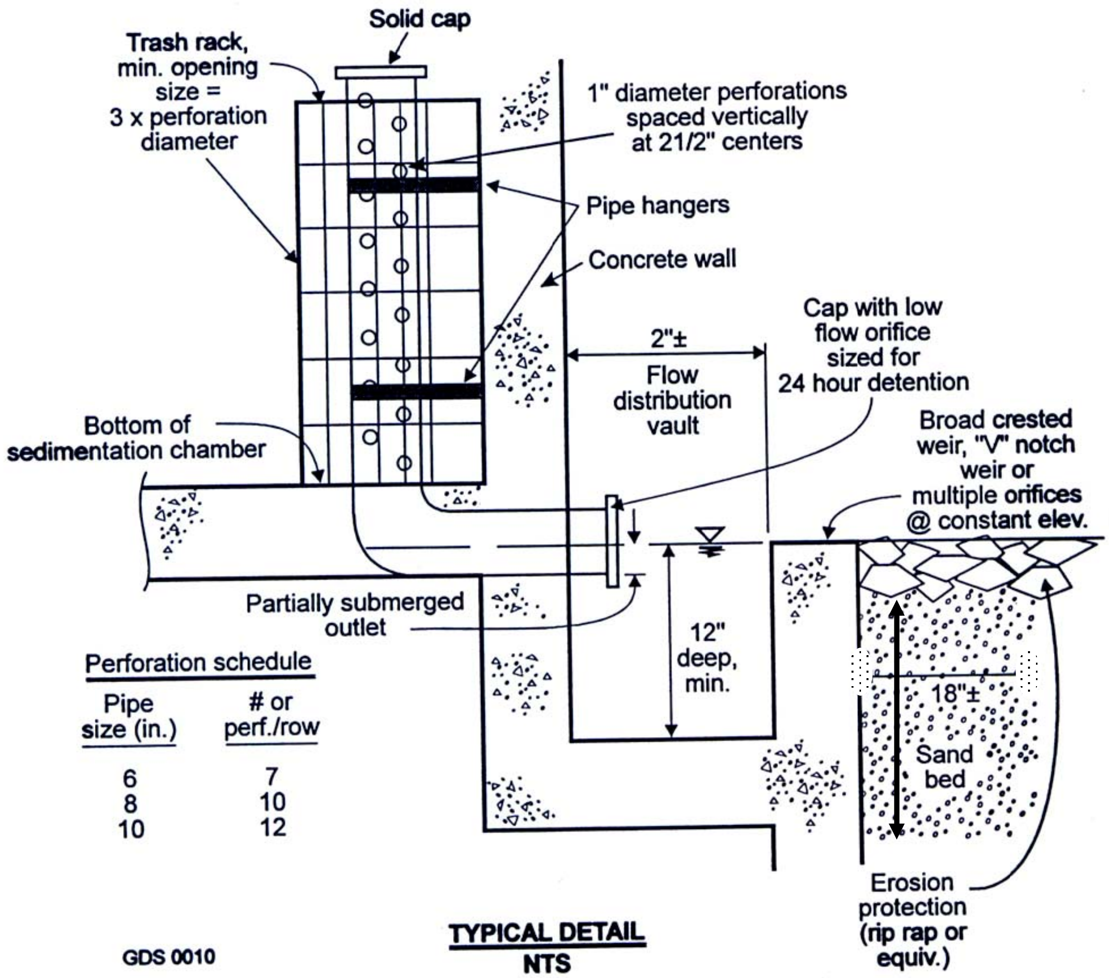



**Figure 3-31 Example Surface Sand Filter Perforated Stand-Pipe**
(Source: Claytor and Schueler, 1996)

### I. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

<u>Low Relief:</u> Use of surface sand filter may be limited by low head.

<u>High Relief:</u> Filter bed surface must be level.

<u>Karst:</u> Use polyliner or impermeable membrane to seal bottom of earthen surface sand filter or use watertight structure.

***Soils***

- No restrictions.

***Special Downstream Watershed Considerations***

Aquifer Protection: Use polyliner or impermeable membrane to seal bottom of sand filter if historically high water table is within 5 feet of surface or use watertight structure.

### 3.2.8.6 Design Procedures

**Step 1** Compute runoff control volume.

Calculate the $WQ_v$ using equation 1-1.

**Step 2** Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria.

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Compute peak discharge for the $WQ_v$, called $Q_{wq}$, using equation 4-18.

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures.

a. Using $WQ_v$, compute CN using equation 4-3.

b. Compute time of concentration (Chapter 4, Section 4).

c. Determine appropriate unit peak discharge from time of concentration (Chapter 4, Section 8).

d. Compute $Q_{wq}$ from unit peak discharge, drainage area, and $WQ_v$ using equation 4-18.

**Step 4** Size flow diversion structure if needed.

A flow regulator (or flow splitter diversion structure) should be supplied to divert the $WQ_v$ to the sand filter facility.

Size low flow orifice, weir, or other device to pass $Q_{wq}$.

**Step 5** Size filtration basin chamber.

The filter area is sized using the following equation (based on Darcy's Law):

**Equation 3-4**

$$A_f = \frac{WQ_v * d_f}{k * \left(h_f + d_f\right) * t_f}$$

where:

| | | |
|---|---|---|
| $A_f$ | = | surface area of filter bed (ft2) |
| $d_f$ | = | filter bed depth (ft)<br>(typically 1.5 ft, no more than 2 ft) |
| k | = | coefficient of permeability of filter media (ft/day)<br>(use 3.5 ft/day for sand) |
| $h_f$ | = | average height of water above filter bed (ft)<br>(1/2 $h_{temp}$, which varies based on site but $h_{temp}$ is typically ≤ 6 feet) |
| $t_f$ | = | design filter bed drain time (days)<br>(1.67 days or 40 hours is recommended maximum) |

Set preliminary dimensions of filtration basin chamber.

**Step 6** Size sedimentation chamber

The sedimentation chamber should be sized to at least 25% of the computed $WQ_v$ and have a length-to-width ratio of 2:1. The Camp-Hazen equation is used to compute the required surface area: (Claytor & Schueler, 1996)

**Equation 3-5** $$A_s = -\frac{Q_o}{w} * Ln(1 - E)$$

where:

| | | |
|---|---|---|
| As | = | sedimentation basin surface area (ft$^2$) |
| $Q_o$ | = | rate of outflow = the $WQ_v$ over a 24-hour period |
| w | = | particle settling velocity (ft/sec) |
| E | = | trap efficiency |

Assuming:

- 90% sediment trap efficiency (0.9);
- particle settling velocity (ft/sec) = 0.0033 ft/sec for imperviousness ≥ 75%;
- particle settling velocity (ft/sec) = 0.0004 ft/sec for imperviousness < 75%;
- average of 24 hour holding period.

Then:

| | | |
|---|---|---|
| As | = | (0.0081) ($WQ_v$) ft$^2$ for Imperviousness ≥ 75% |
| As | = | (0.066) ($WQ_v$) ft$^2$ for Imperviousness < 75% |

Set preliminary dimensions of sedimentation chamber.

**Step 7** Compute $V_{min}$ for 75% of the $WQ_v$, as required by the design specifications.

**Equation 3-6** $$V_{\min} = 0.75 * WQ_v$$

**Step 8** Compute storage volumes within facility and sedimentation chamber orifice size (Claytor & Schueler, 1996).

$$V_{\min} = 0.75 * WQ_v = V_s + V_f + V_{f-temp}$$

- Compute $V_f$ = water volume within filter bed/gravel/pipe = $A_f * d_f * n$

Where: n = porosity = 0.4 for most applications

- Compute $V_{f\text{-}temp}$ = temporary storage volume above the filter bed = $2 * h_f * A_f$
- Compute $V_s$ = volume within sediment chamber = $V_{min} - V_f - V_{f\text{-}temp}$
- Compute $h_s$ = height in sedimentation chamber = $V_s/A_s$
- Ensure $h_s$ and $h_f$ fit available head and other dimensions still fit; change as necessary in design iterations until all site dimensions fit.
- Size orifice from sediment chamber to filter chamber to release $V_s$ within 24-hours at average release rate with 0.5 $h_s$ as average head.

**Step 9** Design inlets, pretreatment facilities, underdrain system, and outlet structures

See Chapter 5 for more details.

**Step 10** Compute overflow weir sizes

- Size overflow weir at elevation $h_s$ in sedimentation chamber (above perforated stand pipe) to handle surcharge of flow through filter system from storms producing more than $WQ_v$ design event.
- Plan inlet protection for overflow from sedimentation chamber and size overflow weir at elevation $h_f$ in filtration chamber (above perforated stand pipe) to handle surcharge of flow through filter system from storms producing more than $WQ_v$ design event.

### 3.2.8.7 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the layout and location of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.8.8 Example Schematics

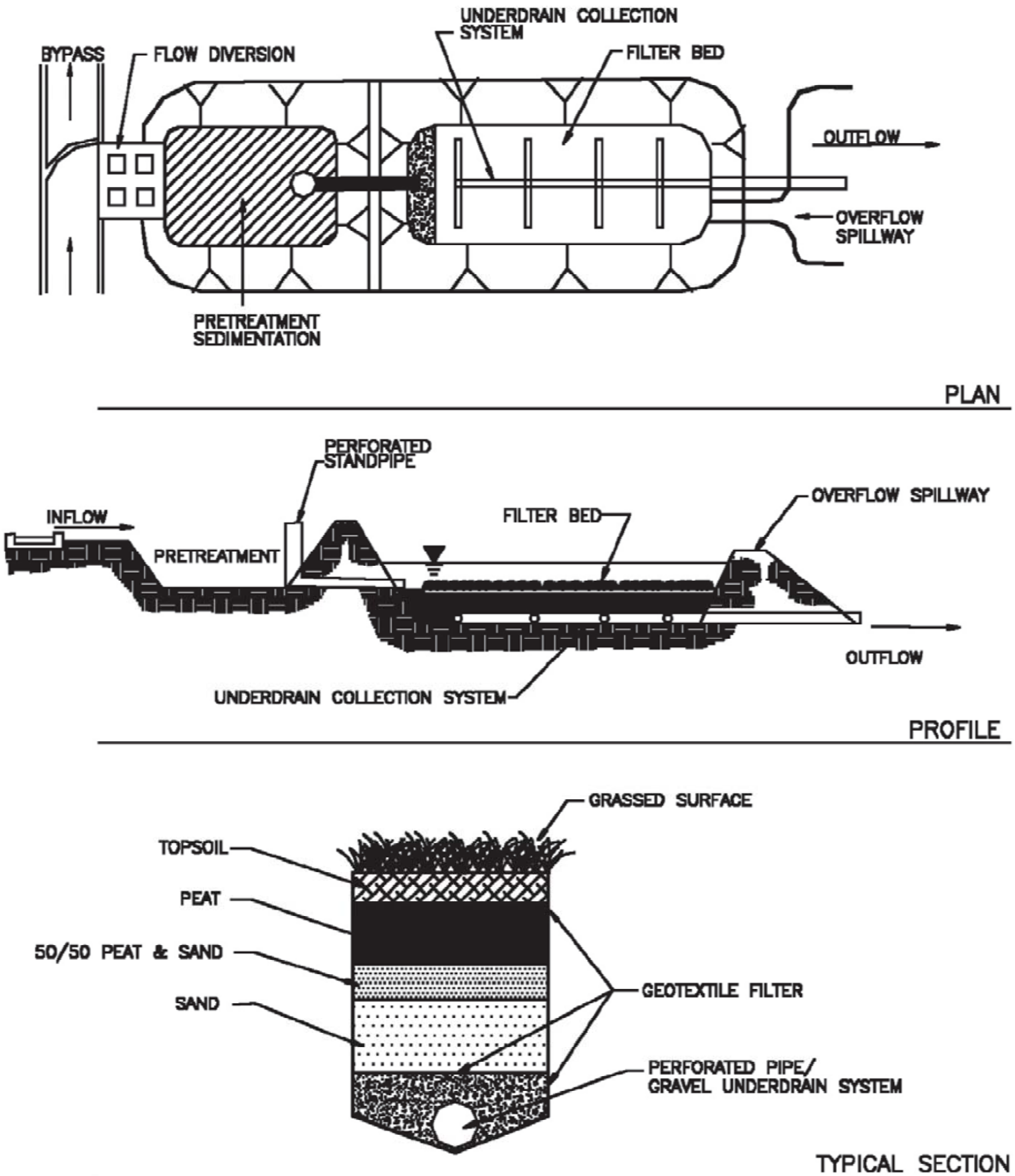



**Figure 3-32 Schematic of Surface Sand Filter**
(adapted from Claytor & Schueler, 1996).

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# 3.2.9 Bioretention Areas

**Primary Water Quality Facility**

**Description:** Shallow stormwater basin or landscaped area that utilizes engineered soils and vegetation to capture and treat runoff.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Maximum contributing drainage area of 5 acres (< 2 acres recommended)
- Treatment area consists of grass filter, sand bed, ponding area, organic/mulch layer, planting soil, and vegetation
- Typically requires 5 feet of head

**ADVANTAGES / BENEFITS:**

- Applicable to small drainage areas
- Good for highly impervious areas, flexible siting
- Relatively low maintenance requirements
- Can be planned as an aesthetic feature

**DISADVANTAGES / LIMITATIONS:**

- Requires extensive landscaping
- Not recommended for areas with steep slopes

**MAINTENANCE REQUIREMENTS:**

- Inspect and repair/replace treatment area components
- Prune and weed vegetation
- Remove sediment from forebay and retention chamber
- May require irrigation during establishment phase

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ✓ **Channel Protectio**
- ✓ **On-Site Flood Control**
- ✓ **Downstream Flood Control**

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| M | **Relative Capital Costs** |
| L | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *5 acres max (<2 acres recommended)*

**Soils**: *Planting soils must meet specified criteria; No restrictions on surrounding soils.*

**Other Considerations**:

- *Use of native plants is recommended.*

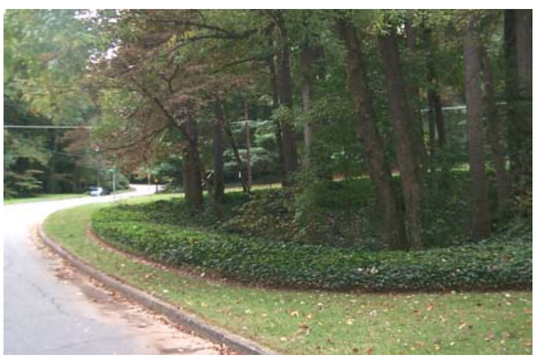
**L**=Low **M**=Moderate **H**=High

### 3.2.9.1 General Description

Bioretention areas (also referred to as bioretention filters or rain gardens) are structural stormwater controls that capture and temporarily store the $WQ_v$ using soils and vegetation in shallow basins or landscaped areas to remove pollutants from stormwater runoff.

Bioretention areas are engineered facilities in which runoff is conveyed as sheet flow to the “treatment area” which consists of a grass buffer strip, ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand or aggregate bed can also be included in the design to provide aeration and drainage of the planting soil. The filtered runoff is typically collected and returned to the conveyance system after detention, though it may infiltrate. Because bioretention areas remove pollutants using filtration, they are applicable primarly to impervious areas without high levels of fine particulates (clay/silt soils) in the runoff and should only be considered for sites where the sediment load is relatively low.

There are numerous design applications, both on- and off-line, for bioretention areas. These include use on single-family residential lots (rain gardens), as off-line facilities adjacent to parking lots, along highway and road drainage swales, within larger landscaped pervious areas, and as landscaped islands in impervious or high-density environments. Figure 3-33 and Figure 3-34 illustrate examples of bioretention facilities.



**Residential Rain Garden**

**Landscaped Island**

**Newly Constructed Bioretention Area**

**Newly Planted Bioretention Area**

**Figure 3-33 Bioretention Area Examples**

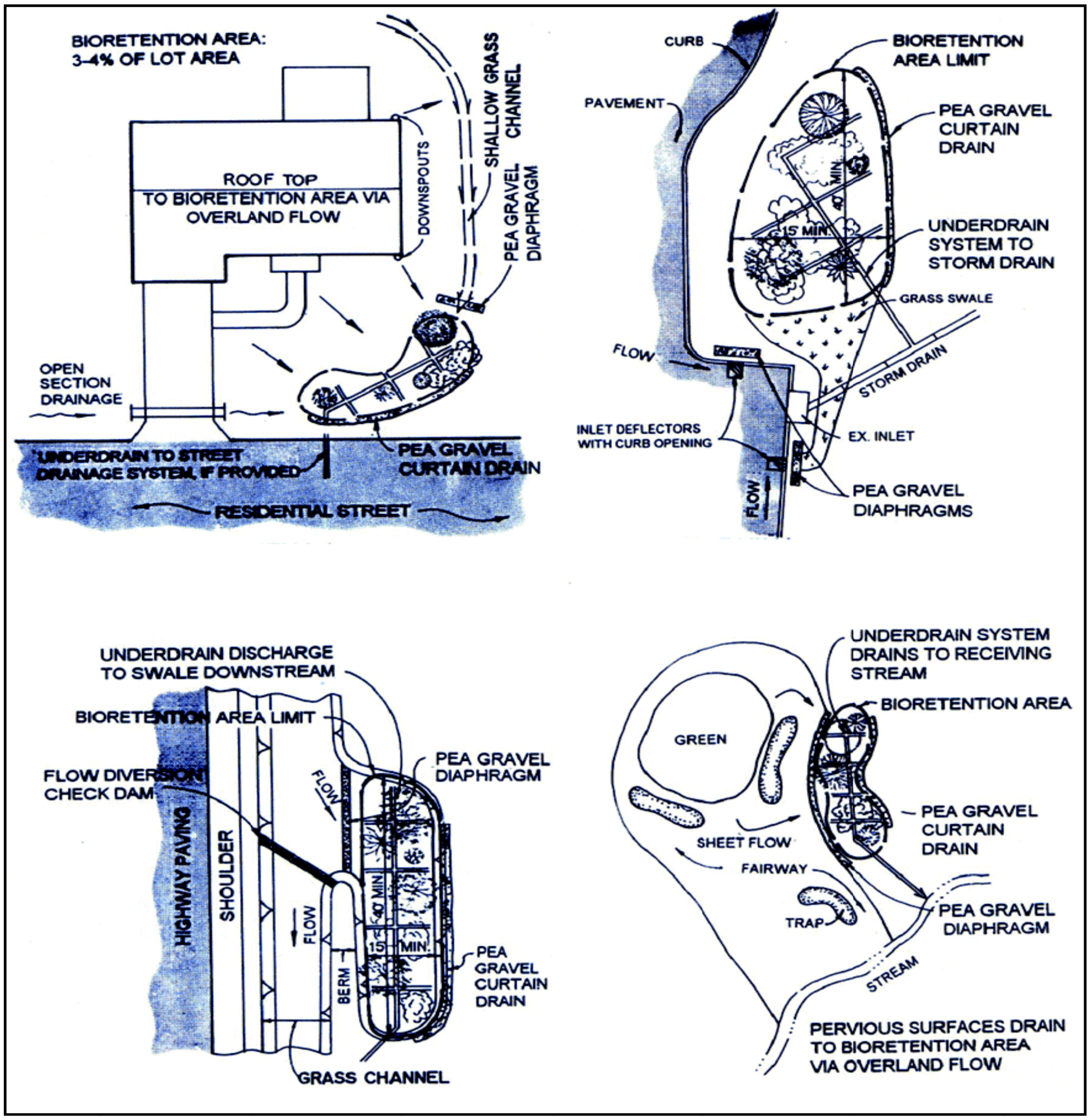



**Figure 3-34 Bioretention area examples**
(Claytor & Schueler, 1996)

### 3.2.9.2 Stormwater Management Suitability

Bioretention areas are designed primarily for stormwater quality, i.e. the removal of stormwater pollutants. Bioretention can provide limited runoff quantity control, particularly for smaller storm events. These facilities may sometimes be used to partially or completely meet channel protection requirements on smaller sites. However, bioretention areas will typically need to be used in conjunction with another structural control to provide channel protection as well as flood control. It is important to ensure that a bioretention area safely bypasses higher flows.

***Water Quality Protection***

Bioretention is an excellent stormwater treatment practice due to the variety of pollutant removal mechanisms. Each of the components of the bioretention area is designed to perform a specific function (see Figure 3-35). The grass filter strip (or grass channel) reduces incoming runoff velocity and filters particulates from the runoff. The ponding area provides for temporary storage of stormwater runoff prior to its infiltration or vegetation uptake, and provides additional settling capacity. The organic or mulch layer provides filtration as well as an environment conducive to the growth of microorganisms that degrade hydrocarbons and organic material. The planting soil in the bioretention facility acts as a filtration system, and clay in the soil provides adsorption sites for hydrocarbons, heavy metals, nutrients, and other pollutants. Both woody and herbaceous plants in the ponding area provide vegetative uptake of runoff and pollutants and also serve to stabilize the surrounding soils. Finally, a sand or aggregate bed provides for positive drainage and aerobic conditions in the planting soil and provides a final polishing treatment media.

Section 3.2.9.3 gives data on pollutant removal efficiencies that can be used for planning and design purposes.

***Channel Protection***

For smaller sites, a bioretention area may be designed to capture the entire $CP_v$ in either an off- or on-line configuration. Given that a bioretention facility is typically designed to completely drain over 48 hours, the requirement of extended detention of the 1-year, 24-hour storm runoff volume will usually be met. For larger sites where only the $WQ_v$ is diverted to the bioretention facility, another structural control usually must be used to provide $CP_v$ extended detention.

***Flood Control***

Bioretention areas must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the ponding area, mulch layer, and vegetation.

The volume of runoff removed and treated in the bioretention area may be included in flood control calculations (see Chapter 3).

### 3.2.9.3 Pollutant Removal Capabilities

Bioretention areas are presumed to be able to remove 85% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Undersized or poorly designed bioretention areas can reduce TSS removal performance.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or "treatment train" approach.

- Total Suspended Solids – 85%
- Total Phosphorus – 60%
- Total Nitrogen – 50%
- Heavy Metals – 80%
- Fecal Coliform – insufficient data

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.9.4 Application and Site Feasibility Criteria

Bioretention areas are suitable for many types of development, from single-family residential to high-density commercial projects. Bioretention is also well suited for small lots, including those of one acre or less. Because of its ability to be incorporated in landscaped areas, the use of bioretention is extremely flexible. Bioretention areas are an ideal structural stormwater control for use as roadway median strips and parking lot islands and are also good candidates for the treatment of runoff from pervious areas, such as a golf course.

The following criteria should be evaluated to ensure the suitability of a bioretention area for meeting stormwater management objectives on a site or development.

***General Feasibility***

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – YES
- Regional Stormwater Control – NO

***Physical Feasibility - Physical Constraints at Project Site***

Drainage Area: 5 acres maximum; 0.5 to 2 acres are preferred.

Space Required: Approximately 5-7% of the tributary impervious area is normally required.

Site Slope: No more than 6% slope

Minimum Head: Elevation difference needed at a site from the inflow to the outflow: 3 to 5 feet.

Minimum Depth to Water Table: A minimum separation distance of 5 feet is required between the bottom of the cell and the elevation of the historical high water table for bioretention areas without underdrains, 2 feet for cells with underdrains.

Soils: No restrictions; engineered media required.

### 3.2.9.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of a bioretention facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

#### A. LOCATION AND SITING

- Bioretention areas should have a maximum contributing drainage area of 5 acres or less; 0.5 to 2 acres are preferred. Multiple bioretention areas can be used for larger areas.
- Bioretention areas can either be used to capture sheet flow from a drainage area or function as an off-line device. On-line designs should be limited to a maximum drainage area of 0.5 acres unless special precautions are taken to protect from erosion during high flows.
- When used in an off-line configuration, the $WQ_v$ is diverted to the bioretention area through the use of a flow splitter. Stormwater flows greater than the $WQ_v$ are diverted to other controls or downstream.
- Bioretention systems are designed for intermittent flow and must be allowed to drain and re-aerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.
- Bioretention area locations should be integrated into the site planning process, and aesthetic considerations should be taken into account in their siting and design.

#### B. GENERAL DESIGN

- A well-designed bioretention area consists of:
  - Grass filter strip (or grass channel) between the contributing drainage area and the ponding area, except where site conditions preclude its use;
  - Ponding area containing vegetation with a planting soil bed;
  - Organic/mulch layer;
  - Sand or gravel layer between the planting soil and the gravel underneath to provide filtering of the particles prior to entering gravel layer; and,
  - Gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil – see description of infiltration trenches for infiltration criteria).
- A bioretention area design will also include some of the following:
  - Optional sand filter layer to spread flow, filter runoff, and aid in aeration and drainage of the planting soil;

- Stone diaphragm at the beginning of the grass filter strip to reduce runoff velocities and spread flow into the grass filter;
- Inflow diversion or an overflow structure consisting of one of five main methods:
  - Use a flow diversion structure;
  - For curbed pavements use an inlet deflector (see Figure 3-38);
  - Use a slotted curb and design the parking lot grades to divert the $WQ_v$ into the facility; bypass additional runoff to a downstream catch basin inlet; requires temporary ponding in the parking lot;
  - The use of a short deflector weir (maximum height 6 inches) designed to divert the maximum water quality peak flow into the bioretention area;
  - An in-system overflow consisting of an overflow catch basin inlet and/or a gravel curtain drain overflow.

See Figure 3-35 for an overview of the various components of a bioretention area. Figure 3-36 provides a plan view and profile schematic of an on-line bioretention area. An example of an off-line facility is shown in Figure 3-37.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

- Recommended minimum dimensions of a bioretention area are 10 feet wide by 40 feet long. All designs except small residential applications should maintain a length to width ratio of at least 2:1.
- The planting soil filter bed is sized using a Darcy's Law equation with a filter bed drain time of less than 48 hours (less than 6 hours residential neighborhoods and 24 hours non-residential preferred) and a coefficient of soil permeability (k) of greater than 0.5 ft/day.
- The maximum recommended ponding depth of the bioretention areas is 6 inches with a drain time normally of 3 to 4 hours in residential settings.
- The planting soil bed must be at least 2.5 feet in depth and up to 4 feet if shrubs or trees are to be planted. (Shallow-rooted shrubs or trees must be selected to avoid fouling of the drainage system by roots.) Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 5 to 8%. The soil must have an infiltration rate of at least 0.5 inches per hour (1.0 in/hr preferred) and a pH between 5.5 and 6.5. In addition, the planting soil should have a 1.5 to 3% organic content and a maximum 500 ppm concentration of soluble salts.
- For on-line configurations, a grass filter strip with a gravel diaphragm is typically utilized (see Figure 3-36) as the pretreatment measure. The required length of the filter strip depends on the drainage area, imperviousness, and the filter strip slope. Design guidance on filter strips for pretreatment can be found in Section 3.2.3.
- For off-line applications, a grass channel with a gravel diaphragm flow spreader is used for pretreatment. The length of the grass channel depends on the drainage area, land use,

and channel slope. The minimum grassed channel length should be 20 feet. Design guidance on grass channels for pretreatment can be found in Section 3.2.4.

- The mulch layer should consist of 2 to 4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips.
- The sand bed (optional) should be 12 to 18 inches thick. Sand should be clean and have less than 15% silt or clay content.
- Gravel for the 4” to 9” thick layer above the gravel bedding (and diaphragm and curtain, where used), should be ASTM D 448 size No. 6 (1/8 inch to ¼ inch).
- The underdrain collection system is equipped with a 6-inch perforated PVC pipe (AASHTO M 252) in an 8-inch gravel layer. The pipe should have 3/8-inch perforations, spaced at 6-inch centers, with a minimum of 4 holes per row. The pipe is spaced at a maximum of 10 feet on center and a minimum grade of 0.5% must be maintained.
- A narrow 24 inch wide permeable filter fabric is placed on the gravel layer directly above the perforated pipes to limit piping of soil directly into the pipe. Filter fabric is also placed along the vertical or sloping outer walls of the bioretention system to limit vertical infiltration prior to filtration through the soil.

#### D. PRETREATMENT / INLETS

- Adequate pretreatment and inlet protection for bioretention systems is provided when all of the following are provided: (a) grass filter strip below a level spreader, or grass channel, (b) gravel diaphragm and (c) an organic or mulch layer.

#### E. OUTLET STRUCTURES

- Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary.

#### F. EMERGENCY SPILLWAY

- An overflow structure and nonerosive overflow channel must be provided to safely pass flows from the bioretention area that exceeds the storage capacity to a stabilized downstream area or watercourse. If the system is located off-line, the overflow should be set above the shallow ponding limit.
- The high flow overflow system within the structure typically consists of an area drain catchbasin, though any number of conventional systems could be used. The throat of the catch basin inlet is normally placed 6 inches above the mulch layer. It should be designed as a domed grate or a covered weir structure to avoid clogging with floating mulch and debris, and should be located at a distance from inlets to avoid short circuiting of flow. It may also be placed into the side slope of the structure maintaining a neat contoured appearance.

### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### H. SAFETY FEATURES

- Bioretention areas generally do not require any special safety features. Fencing of bioretention facilities is not generally desirable.

### I. LANDSCAPING

- Landscaping is critical to the performance and function of bioretention areas. Native species are encouraged.
- A dense and vigorous vegetative cover should be established over the contributing pervious drainage areas before runoff can be accepted into the facility. Side slopes should be sodded to limit erosion of fine particles onto the bioretention surface.
- The bioretention area should be vegetated to resemble a terrestrial ecosystem,
    - With a mature tree canopy, subcanopy of understory trees, scrub layer, and herbaceous ground cover. Three species each of both trees and scrubs are recommended to be planted.
    - With native prairie grasses.
- For bioretention areas with trees, the tree-to-shrub ratio should be 2:1 to 3:1. On average, the trees should be spaced 8 feet apart. Plants should be placed to replicate a natural forest. Woody vegetation should not be specified at inflow locations.
- For bioretention areas with prairie grasses, native grasses should be well established, with a mixture of species. Wildflowers may be incorporated into the design to add color and visual interest.
- After the trees and shrubs or grasses are established, the ground cover and mulch should be established.
- Choose plants based on factors such as whether native or not, resistance to drought and inundation, cost, aesthetics, shallow or deep rooted, maintenance, etc. Planting recommendations for bioretention facilities are as follows:
    - Native plant species should be specified over non-native species.
    - Vegetation should be selected based on a specified zone of hydric tolerance.
    - A selection of trees with an understory of shrubs and herbaceous materials or a mixture of prairie grasses should be provided.

### J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

Low Relief: Use of bioretention areas may be limited by low head.

High Relief: Ponding area surface must be relatively level.

Karst: Use poly-liner or impermeable membrane to seal bottom if infiltration is deemed appropriate by a geotechnical engineer.

***Soils***

- No restrictions

***Special Downstream Watershed Considerations***

Aquifer Protection: A minimum separation distance of 5 feet is required between the bottom of the cell and the elevation of the historical high water table for bioretention areas without underdrains, 2 feet for cells with underdrains.

## 3.2.9.6 Design Procedures

**Step 1** Compute runoff control volumes from the integrated design approach.

Calculate the $WQ_v$ using equation 1-1

**Step 2** Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria.

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Compute $WQ_v$ peak discharge ($Q_{wq}$).

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures (see Chapter 4).

- Using $WQ_v$ (or total volume to be captured), compute CN using equation 4.3.
- Compute time of concentration (Chapter 4, Section 4).
- Determine appropriate unit peak discharge from time of concentration (Chapter 4, Section 8).
- Compute $Q_{wq}$ from unit peak discharge, drainage area, and $WQ_v$ using equation 4.18.

**Step 4** Size flow diversion structure, if needed.

A flow regulator (or flow splitter diversion structure) should be supplied to divert the $WQ_v$ to the bioretention area.

Size low flow orifice, weir, or other device to pass $Q_{wq}$ (Chapter 5, Section 6).

**Step 5** Determine size of bioretention ponding/filter area.

The required planting soil filter bed area is computed using the following equation (based on Darcy's Law): (Claytor & Schueler, 1996).

**Equation 3-7**

$$A_f = \frac{WQ_v * d_f}{k * (h_f + d_f) * t_f}$$

where:

$A_f$ = surface area of ponding area (ft$^2$)
$WQ_v$ = water quality protection volume (or total volume to be captured)
$d_f$ = filter bed depth (2.5 feet minimum)
$k$ = coefficient of permeability of filter media (ft/day) (use 0.5 ft/day for silt-loam)
$h_f$ = average height of water above filter bed (ft) (typically 3 in, half of the 6 in ponding depth)
$t_f$ = design filter bed drain time (days) (2.0 days or 48 hours is recommended maximum)

**Step 6** Set design elevations and dimensions of facility.

**Step 7** Design conveyances to facility (off-line systems) (Chapter 3, Section 1).

See the example Figure 3-37 to determine the type of conveyances needed for the site.

**Step 8** Design pretreatment (Chapter 2, Section 3).

Pretreat with a grass filter strip (on-line configuration) or grass channel (off-line), and stone diaphragm.

**Step 9** Size underdrain system

See Section 3.2.9.5.

**Step 10** Design emergency overflow

See Section 3.2.10.5.

An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Nonerosive velocities need to be ensured at the outlet point.

**Step 11** Prepare vegetation and landscaping plan.

A landscaping plan for the bioretention area should be prepared to indicate how it will be established with vegetation.

### 3.2.9.7 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.2.9.8 Example Schematics

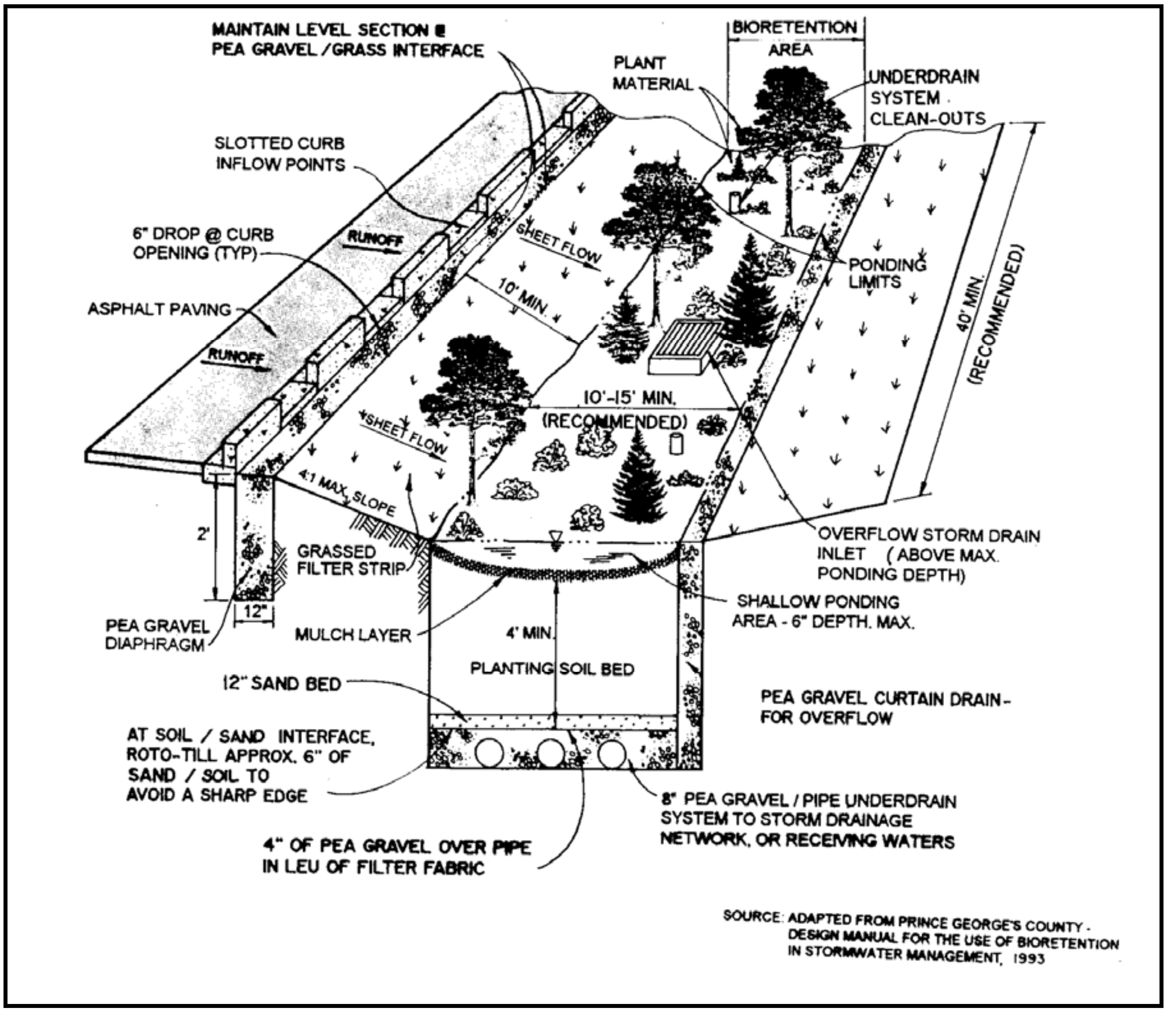



**Figure 3-35 Schematic of a Typical Bioretention Area**
(Source: Claytor and Schueler, 1996)

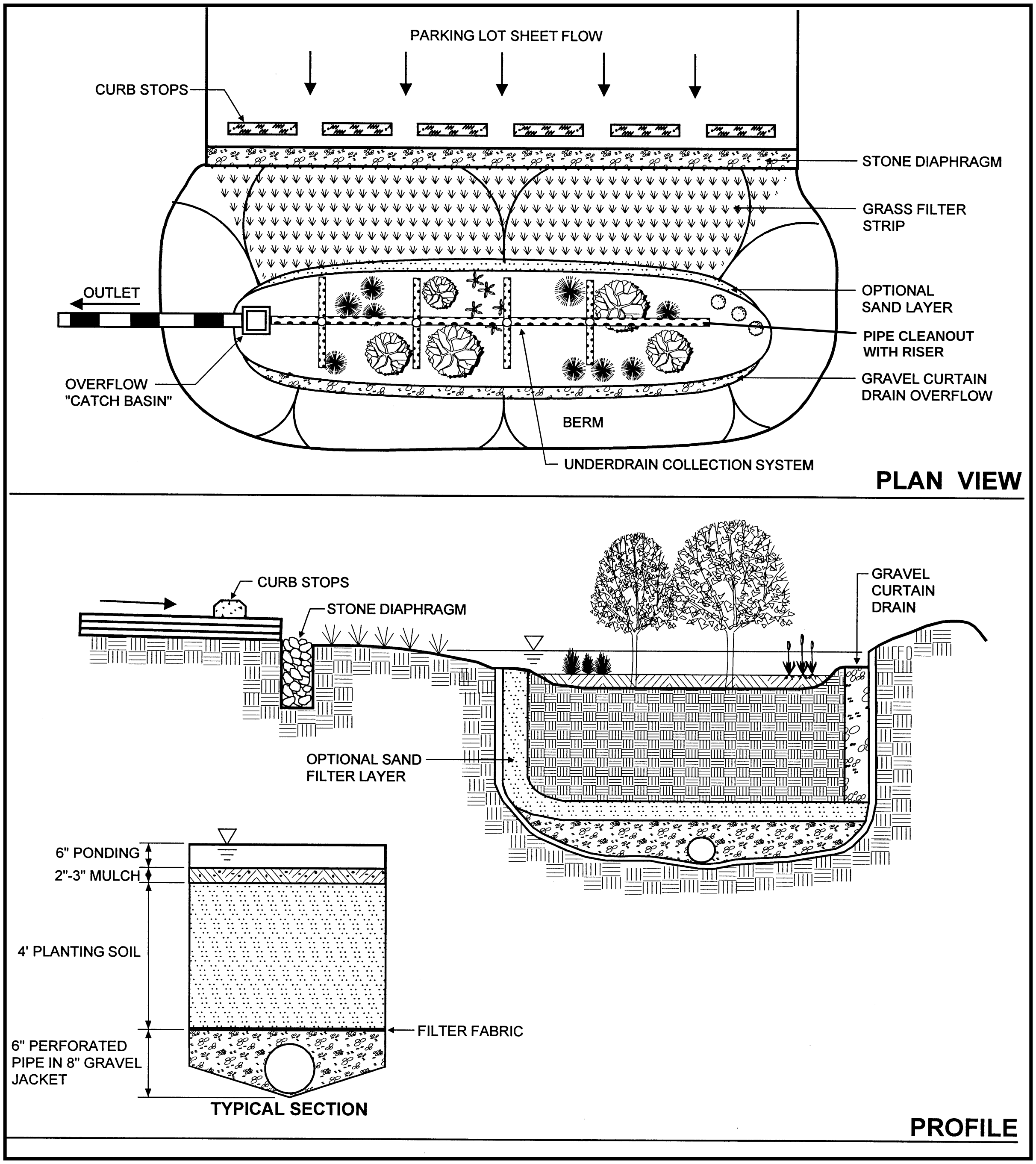



**Figure 3-36 Schematic of a Typical On-Line Bioretention Area**
(Source: Claytor and Schueler, 1996)

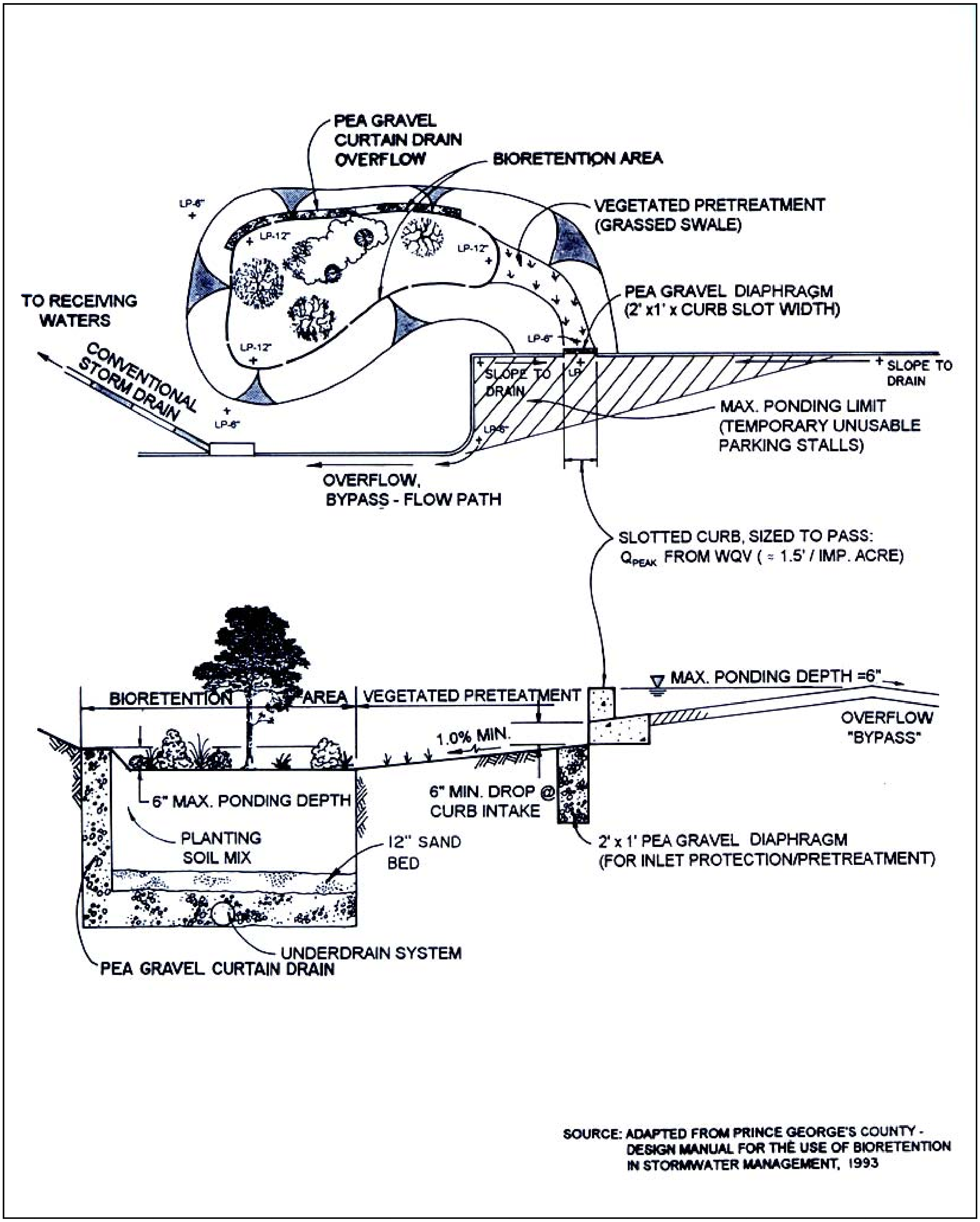



**Figure 3-37 Schematic of a Typical Off-Line Bioretention Area**
(Source: Claytor and Schueler, 1996)

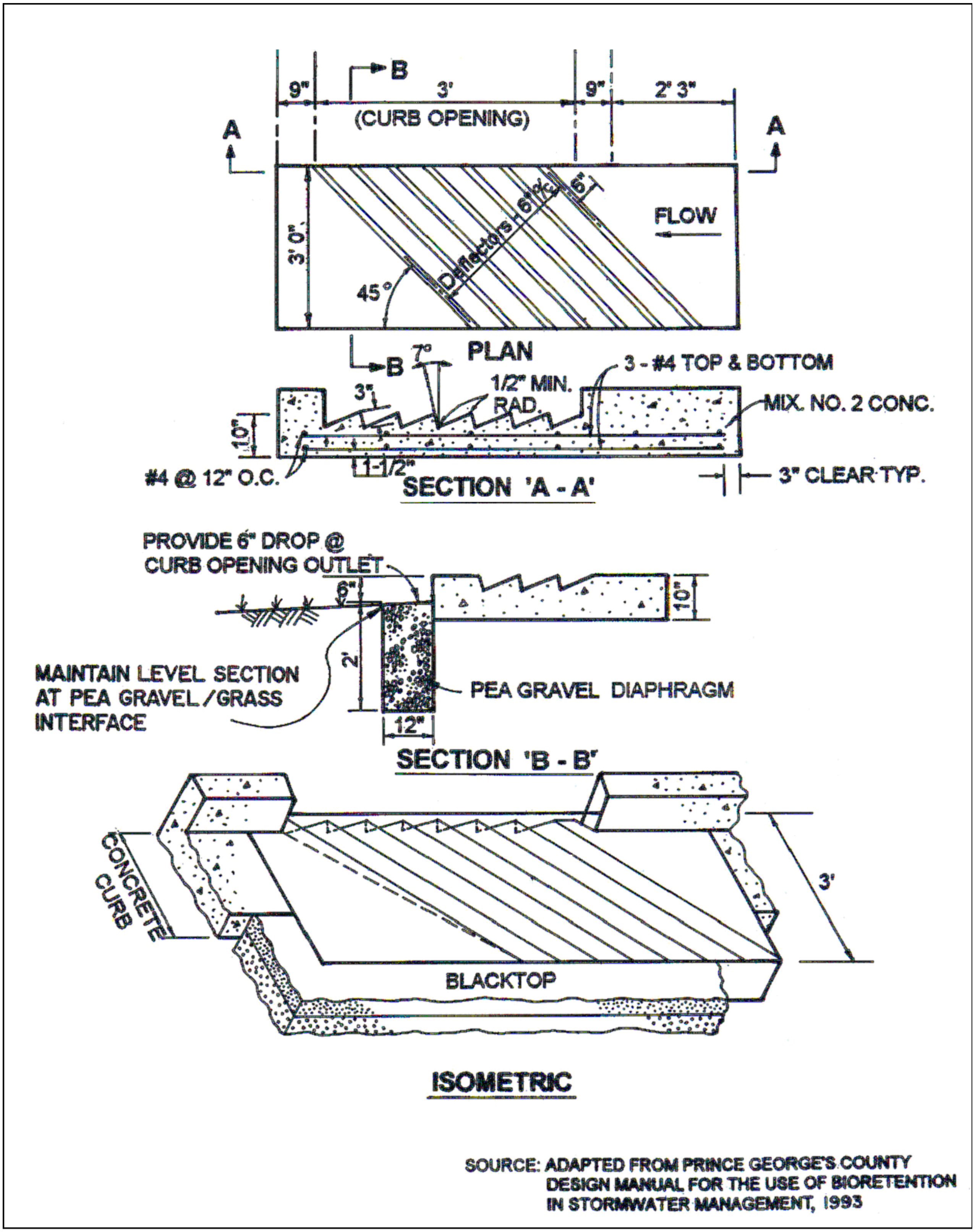



**Figure 3-38 Schematic of a Typical Inlet Deflector**

(Source: Claytor and Schueler, 1996).

# 3.2.10 Stormwater Wetland

**Primary Water Quality Facility**

**Description:** Constructed wetland used for stormwater management. Runoff is both stored and treated in the wetland facility.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**
- Minimum contributing drainage area of 25 acres
- Minimum dry weather flow path of 2:1 (length: width) should be provided from inflow to outflow
- Minimum of 35% of total surface area should have a depth of 6 inches or less; 10% to 20% of surface area should be deep pool (1.5 to 6 foot depth)

**ADVANTAGES / BENEFITS:**
- Good nutrient removal
- Provides natural wildlife habitat
- Relatively low maintenance costs

**DISADVANTAGES / LIMITATIONS:**
- Requires large land area
- Needs continuous baseflow for viable wetland
- Sediment regulation is critical to sustain wetlands
- Large commitment to establish vegetation in the first 3 years

**MAINTENANCE REQUIREMENTS:**
- Replace wetland vegetation to maintain at least 50% surface area coverage
- Remove invasive vegetation
- Monitor sediment accumulation and remove periodically

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| H | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| ✓ | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| H | **Land Requirements** |
| M | **Capital Costs** |
| | **Maintenance Burden** |
| M | **Shallow Wetland** |
| M | **ED Shallow Wetland** |
| M | **Pond/Wetland** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *25 acres min*

**Soils**: *Hydrologic group ‘A’ and ‘B’ soils may require liner*

**L**=Low **M**=Moderate **H**=High

## 3.2.10.1 General Description

Stormwater wetlands (also referred to as constructed wetlands) are constructed shallow marsh systems that are designed to both treat urban stormwater and control runoff volumes. As stormwater runoff flows through the wetland facility, pollutant removal is achieved through settling and uptake by marsh vegetation.

Wetlands are among the most effective stormwater practices in terms of pollutant removal and also offer aesthetic value and wildlife habitat. Constructed stormwater wetlands differ from natural wetland systems in that they are engineered facilities designed specifically for the purpose of treating stormwater runoff and typically have less biodiversity than natural wetlands both in terms of plant and animal life.

There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland. These include the shallow wetland, the extended detention shallow wetland, and the pond/wetland system. Figure 3-39 contains photos of various wetlands. Below are descriptions of each design variant:

<u>Shallow Wetland:</u> In the shallow wetland design, most of the water quality treatment volume is in the relatively shallow high marsh or low marsh depths. The only deep portions of the shallow wetland design are the forebay at the inlet to the wetland, and the micropool at the outlet. One disadvantage of this design is that, since the pool is very shallow, a relatively large amount of land is typically needed to store the $WQ_V$.

<u>Extended Detention (ED) Shallow Wetland:</u> The extended detention (ED) shallow wetland design is the same as the shallow wetland; however, part of the water quality treatment volume is provided as extended detention above the surface of the marsh and released over a period of 24 hours. This design can treat a greater volume of stormwater in a smaller space than the shallow wetland design. In the extended detention wetland option, plants that can tolerate both wet and dry periods need to be specified in the extended detention zone.

<u>Pond/Wetland Systems:</u> The pond/wetland system has two separate cells: a wet pond and a shallow marsh. The wet pond traps sediments and reduces runoff velocities prior to entry into the wetland where stormwater flows receive additional treatment. Less land is required for a pond/wetland system than for the shallow wetland or the extended detention shallow wetland systems.

Shallow Wetland

Shallow ED Wetland

**Figure 3-39 Stormwater Wetland Examples**

### 3.2.10.2 Stormwater Management Suitability

Similar to stormwater ponds, stormwater wetlands are designed to control both stormwater quantity and quality.

***Water Quality***

Pollutants are removed from stormwater runoff in a wetland through uptake by wetland vegetation and algae, vegetative filtering, and through gravitational settling in the slow moving marsh flows. Other pollutant removal mechanisms are also at work in a stormwater wetland including chemical and biological decomposition and volatilization. Section 3.2.10.3 provides pollutant removal efficiencies that can be used for planning and design purposes.

***Channel Protection***

The storage volume above the permanent pool/water surface level in a stormwater wetland is used to provide control of the channel protection volume ($CP_v$). This is accomplished by detaining the 1-year, 24-hour storm runoff for 24 hours (extended detention). It is best to do this with minimum vertical water level fluctuation, as extreme fluctuation may stress vegetation.

***Flood Control***

In situations where it is required, stormwater wetlands can also be used to provide detention to control peak flows. However, care must be exercised to provide a design that does not cause excessive velocities or other conditions that would disturb or damage the wetland system. When peak flow control is not incorporated into the design, a stormwater wetland must be designed to safely pass or bypass flood flows.

### 3.2.10.3 Pollutant Removal Capabilities

All of the stormwater wetland design variants are presumed to be able to remove 75% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the recommended specifications. Undersized or poorly designed wetland facilities can reduce TSS removal performance.

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or "treatment train" approach.

- Total Suspended Solids – 75%
- Total Phosphorus – 45%
- Total Nitrogen – 30%
- Heavy Metals – 50%
- Fecal Coliform – 70% (if no resident waterfowl population present)

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.2.10.4 Application and Site Feasibility Criteria

Stormwater wetlands are generally applicable to most types of development, and can be utilized in both residential and nonresidential areas. However, due to the large land requirements, wetlands may not be practical in higher density areas. The following criteria should be evaluated to ensure the suitability of a stormwater wetland for meeting stormwater management objectives on a site or development.

***General Feasibility***

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – Land requirements may preclude use
- Regional Stormwater Control – YES
- Hotspot Runoff – NO

***Physical Feasibility - Physical Constraints at Project Site***

Drainage Area: A minimum of 25 acres and a positive water balance is needed to maintain wetland conditions.

Space Required: Approximately 3 to 5% of the tributary drainage area.

Site Slope: There should not be a slope greater than 8% across the wetland site.

Minimum Head: Elevation difference needed at a site from the inflow to the outflow: 3 to 5 feet.

Minimum Depth to Water Table: The bottom of constructed wetlands must be at least 5 feet above the historical high groundwater elevation if unlined, or 2 feet if lined.

Soils: Permeable soils are not well suited for a constructed stormwater wetland. Underlying soils of hydrologic group 'C' or 'D' should be adequate to maintain wetland conditions. Most group 'A' soils and some group 'B' soils will require a liner. Evaluation of soils should be based on an actual subsurface analysis and permeability tests.

### 3.2.10.5 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of a stormwater wetland facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.

#### A. LOCATION AND SITING

- Stormwater wetlands should normally have a minimum contributing drainage area of 25 acres or more.
- A continuous base flow is required to support wetland vegetation. A water balance must be performed to demonstrate that a stormwater wetland can withstand a 30 day drought at summer evaporation rates without completely drawing down (see Chapter 4).
- Wetland siting should also take into account the location and use of other site features such as natural depressions, buffers, and undisturbed natural areas, and should attempt to aesthetically "fit" the facility into the landscape. Bedrock close to the surface may prevent excavation.
- Stormwater wetlands cannot be located within navigable waters of the U.S., including natural wetlands, without obtaining a Section 404 permit under the Clean Water Act, and other applicable federal and State permits. In some isolated cases, a wetlands permit may be granted to convert an existing degraded wetland in the context of local watershed restoration efforts.
- If a wetland facility is not used for flood control, it should be designed as an off-line system to bypass higher flows rather than passing them through the wetland system.
- Minimum setback requirements for stormwater wetland facilities shall be a specified by local regulations.
- All utilities should be located outside of the wetland site.

#### B. GENERAL DESIGN

- A well-designed stormwater wetland consists of:
  - Shallow marsh areas of varying depths with wetland vegetation;

- Permanent micropool; and,
- Overlying zone in which runoff control volumes are stored.

- Pond/wetland systems also include a stormwater pond facility (see Section 3.2.1 for pond design information).
- In addition, all wetland designs must include a sediment forebay or equivalent upstream pre-treatment (providing a volume of 0.1 inch over the contributing impervious area) at the inflow to the facility to allow heavier sediments to drop out of suspension before the runoff enters the wetland marsh. The pre-treatment storage volume is part of the total $WQ_v$.
- Wetlands functioning as flood control facilities located in floodplains or backwater areas must perform as specified for peak flow control for any tailwater condition, up to the Base Flood Elevation (BFE). The potential for back flow into the pond must be addressed with flap gates or by providing sufficient volume to receive backflow up to the BFE, and still provide peak flow control surcharge volume in the pond (above the BFE).
- Additional wetland design features include an emergency spillway, maintenance access, safety bench, wetland buffer, and appropriate wetland vegetation and native landscaping.

Figure 3-41 through Figure 3-43 provide plan and profile schematics for the design of a shallow wetland, extended detention shallow wetland and pond/wetland system, respectively.

### C. PHYSICAL SPECIFICATIONS / GEOMETRY

In general, wetland designs are unique for each site and application. However, there are a number of geometric ratios and limiting depths for the design of a stormwater wetland that must be observed for adequate pollutant removal, ease of maintenance, and improved safety. Table 3-8 provides the recommended physical specifications and geometry for the various stormwater wetland design variants, (Schueler, 1992).

**Table 3-8 Recommended Design Criteria for Stormwater Wetlands**

| Design Criteria | Shallow Wetland | ED Shallow Wetland | Pond/Wetland |
|---|---|---|---|
| Length to Width Ratio (minimum) | 2:1 | 2:1 | 2:1 |
| Extended Detention (ED) | No | Yes | Optional |
| Allocation of WQv Volume (pool/marsh/ED) in % | 25/75/0 | 25/25/50 | 70/30/0 (includes pond volume) |
| Allocation of Surface Area (deepwater/low marsh/high marsh/semi-wet) in % | 20/35/40/5 | 10/35/45/10 | 45/25/25/5 (includes pond surface area) |
| Forebay/Upstream Pretreatment | Required | Required | Required |

| Design Criteria | Shallow Wetland | ED Shallow Wetland | Pond/Wetland |
|---|---|---|---|
| Micropool | Required | Required | Required |
| Outlet Configuration | Reverse-slope pipe or hooded broad-crested weir | Reverse-slope pipe or hooded broad-crested weir | Reverse-slope pipe or hooded broad-crested weir |

- The stormwater wetland should be designed with the recommended proportion of "depth zones." Each of the three wetland design variants has depth zone allocations which are given as a percentage of the stormwater wetland surface area. Target allocations are found in Table 3-8. The four basic depth zones are:

***Deepwater zone***

From 1.5 to 6 feet deep. Includes the outlet micropool and deepwater channels through the wetland facility. This zone supports little emergent wetland vegetation, but may support submerged or floating vegetation.

***Low marsh zone***

From 6 to 18 inches below the normal permanent pool or water surface elevation. This zone is suitable for the growth of several emergent wetland plant species.

***High marsh zone***

From 6 inches below the pool to the normal pool elevation. This zone will support a greater density and diversity of wetland species than the low marsh zone. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone.

***Semi-wet zone***

Those areas above the permanent pool that are inundated during larger storm events. This zone supports a number of species that can survive flooding.

- A minimum dry weather flow path of 2:1 (length to width) is required from inflow to outlet across the stormwater wetland and should ideally be greater than 3:1. This path may be achieved by constructing internal dikes or berms, using marsh plantings, and by using multiple cells. Finger channels are commonly used in surface flow systems to create serpentine configurations and prevent short-circuiting. Microtopography (contours along the bottom of a wetland or marsh that provide a variety of conditions for different species needs and increases the surface area to volume ratio) is encouraged to enhance wetland diversity.
- A 4 to 6 foot deep micropool must be included in the design at the outlet to prevent the outlet from clogging and resuspension of sediments, and to mitigate thermal effects.

- Maximum depth of any permanent pool areas should generally not exceed 6 feet.
- The volume of the extended detention must not comprise more than 50% of the total $WQ_v$, and its maximum water surface elevation must not extend more than 3 feet above the normal pool. $Q_p$ and/or $CP_v$ storage can be provided above the maximum $WQ_v$ elevation within the wetland.
- The perimeter of all deep pool areas (4 feet or greater in depth) should be surrounded by safety and aquatic benches similar to those for stormwater ponds (see Section 3.2.1).
- The contours of the wetland should be irregular to provide a more natural landscaping effect.

### D. PRETREATMENT / INLETS

- Sediment regulation is critical to sustain stormwater wetlands. A wetland facility should have a sediment forebay or equivalent upstream pretreatment. A sediment forebay is designed to remove incoming sediment from the stormwater flow prior to dispersal into the wetland. The forebay should consist of a separate cell, formed by an acceptable barrier. A forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the wetland facility.
- The forebay is sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The pretreatment storage volume is part of the total $WQ_v$ requirement and may be subtracted from $WQ_v$ for wetland storage sizing.
- A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
- Pipes or channels discharging into the wetland are to be stabilized with flared riprap aprons, or the equivalent. Inlet pipes to the pond can be partially submerged. Inflow pipe discharge, channel velocities and exit velocities from the forebay must be nonerosive.

### E. OUTLET STRUCTURES

- Flow control from a stormwater wetland is typically accomplished with the use of a riser and barrel principal spillway. The riser is a vertical pipe or inlet structure that is attached to the base of the micropool with a watertight connection. The outlet barrel is a horizontal pipe attached to the riser that conveys flow under the embankment (see Figure 3-40). The riser should be located within the embankment for maintenance access, safety, and aesthetics.
- A number of outlets at varying depths in the riser provide internal flow control for routing of the water quality protection, channel protection, and flood control runoff volumes. The number of orifices can vary and is a function of the pond design requirements.
- For shallow wetlands, the riser configuration is typically comprised of a channel protection outlet (usually an orifice) and flood control outlet (often a slot or weir). The channel protection orifice is sized to detain the channel protection storage volume for 24 hours. Since the $WQ_V$ is fully contained in the permanent pool, no orifice sizing is necessary for

this volume. As runoff from a water quality event enters the wet pond, it simply displaces that same volume through the channel protection orifice. Thus an off-line shallow wetland providing only water quality treatment can use a simple overflow weir as the outlet structure.

- In the case of an extended detention (ED) shallow wetland, there is generally a need for an additional outlet (usually an orifice) that is sized to pass the extended detention $WQ_V$ that is surcharged on top of the permanent pool. Flow will first pass through this orifice, which is sized to detain the water quality extended detention volume for 24 hours. The preferred design is a reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond. The next outlet is sized for the release of the channel protection storage volume. The outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention $WQ_V$ and is sized to detain the channel protection storage volume for 24 hours.
- Alternative hydraulic control methods to an orifice can be used and include the use of a broad-crested rectangular, V-notch, proportional weir, or an outlet pipe protected by a hood that extends at least 12 inches below the normal pool.

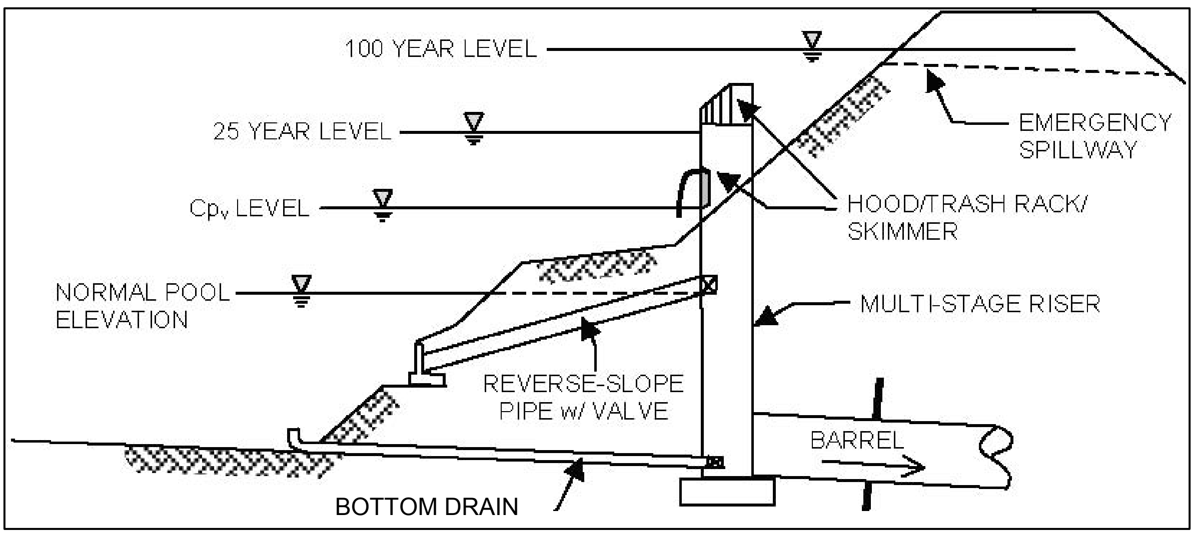



**Figure 3-40 Typical Wetland Facility Outlet Structure**

- The water quality outlet (if design is for an extended detention shallow wetland) and channel protection outlet may be fitted with adjustable gate valves or other mechanism that can be used to adjust detention time.
- Higher flows pass through openings or slots protected by trash racks further up on the riser.
- After entering the riser, flow is conveyed through the barrel and is discharged downstream. Anti-seep collars should be installed on the outlet barrel to reduce the potential for pipe failure.

- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the outlet of the barrel to prevent scouring and erosion. If a wetland facility daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
- The wetland facility may have a bottom drain pipe located in the micropool with an adjustable valve that can dewater the wetland within 24 hours. The bottom drain is optional. It is recommended to check with the local jurisdiction to see if a bottom drain is required.
- The bottom drain should be sized one pipe size greater than the calculated design diameter. The drain valve is typically a handwheel activated knife or gate valve. Valve controls shall be located inside of the riser at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner.

See the design procedures in Volume 2, Chapters 4 and 5 for additional information on pond routing and outlet works.

#### F. EMERGENCY SPILLWAY

- An emergency spillway is to be included in the stormwater wetland design to safely pass flows that exceed the design storm flows. The spillway prevents the wetland's water levels from overtopping the embankment and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
- A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the 100-year flood to the lowest point on top of the dam, not counting the emergency spillway. The 100-year flood elevation for emergency spillway design is based on the elevation required to pass the 100-year flow with no discharge through the principal spillway.

#### G. MAINTENANCE ACCESS

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- When required, the maintenance access must extend to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.
- Access to the riser is to be provided by lockable manhole covers and manhole steps within easy reach of valves and other controls.

### H. SAFETY FEATURES

- All embankments and spillways must be designed to Kansas dam safety regulations, when applicable.
- Fencing may be required for safety. A preferred method is to manage the contours of deep pool areas through the inclusion of a safety bench (see above) to eliminate dropoffs and reduce the potential for accidental drowning.
- The principal spillway opening should not permit access by small children, and endwalls above pipe outfalls greater than 36 inches in diameter should be fenced to prevent a fall hazard.

### I. LANDSCAPING

- A landscaping plan should be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed), and sources of plant material.
- Landscaping zones include low marsh, high marsh, and semi-wet zones. The low marsh zone ranges from 6 to 18 inches below the normal pool. This zone is suitable for the growth of several emergent plant species. The high marsh zone ranges from 6 inches below the pool up to the normal pool. This zone will support greater density and diversity of emergent wetland plant species. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone. The semi-wet zone refers to those areas above the permanent pool that are inundated on an irregular basis and can be expected to support wetland plants.
- The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.
- Woody vegetation may not be planted on a dam embankment or allowed to grow within 15 feet of the toe of the dam and 25 feet from the principal spillway structure (tree exclusion area).
- A wetland buffer shall extend 25 feet outward from the maximum water surface elevation, with an additional 15 foot setback to structures. The wetland buffer should be contiguous with other buffer areas that are required by existing regulations (e.g., stream buffers) or that are part of the overall stormwater management concept plan.
- Existing trees should be preserved in the buffer area during construction unless they would infringe on the tree exclusion area. It is desirable to locate vegetated conservation areas adjacent to ponds. To discourage resident water fowl populations, the buffer can be planted with trees, shrubs and native ground covers if not in the tree exclusion area.
- The soils of a wetland buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration and therefore may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed

planting sites and backfill these with uncompacted topsoil. However, these features must not be located within the tree exclusion area, and must not violate the groundwater clearance requirements.

### J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

***Physiographic Factors - Local terrain design constraints***

Low Relief: Providing wetland drain can be problematic.

High Relief: Embankment heights restricted

Karst: Requires poly or clay liner to sustain a permanent pool of water and protect aquifers; limits on ponding depth; geotechnical tests may be required.

***Soils***

- Hydrologic group 'A' soils and some group 'B' soils may require liner.

***Special Downstream Watershed Considerations***

Aquifer Protection: Inflow of untreated hotspot runoff not permitted. May require liner for type "A" and some "B" soils. Five foot minimum clearance above historical high groundwater for unlined wetlands, 2 feet for lined.

## 3.2.10.6 Design Procedures

**Step 1** Compute runoff control volumes from the integrated design approach.

Calculate the $WQ_v$. See Chapter 1 and Chapter 4.

**Step 2** Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria.

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Determine pretreatment volume

A sediment forebay is provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 acre-inch per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay storage volume counts toward the total $WQ_v$ requirement and may be subtracted from the $WQ_v$ for subsequent calculations.

**Step 4** Allocate the WQv volume among marsh, micropool, and extended detention volumes.

Use recommended criteria from Table 3-8.

**Step 5** Determine wetland location and preliminary geometry, including distribution of wetland depth zones.

This step involves initially laying out the wetland design and determining the distribution of wetland surface area among the various depth zones (high marsh, low marsh, and deepwater). Set $WQ_v$ permanent pool elevation (and $WQ_v$-ED elevation for extended detention shallow wetland) based on volumes calculated earlier.

**Step 6** Compute extended detention orifice release rate(s) and size(s), and establish $CP_v$ elevation.

Shallow Wetland: The $CP_v$ elevation is determined from the stage-storage relationship and the orifice is then sized to release the channel protection storage volume over a 24 hour period. The channel protection orifice shall be adequately protected from clogging by an acceptable treatment as shown in Chapter 5, or a similar treatment at the discretion of the site engineer. A reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool is a recommended design.

ED Shallow Wetland: Based on the elevations established in Step 5 for the extended detention portion of the $WQ_V$, the water quality orifice is sized to release this extended detention volume in 24 hours. The water quality orifice shall be adequately protected from clogging by an acceptable treatment as shown in Chapter 5, or a similar treatment at the discretion of the site engineer. A reverse slope pipe attached to the riser, with its inlet submerged one foot below the elevation of the permanent pool, is a recommended design. The $CP_v$ elevation is then determined from the stage-storage relationship. The invert of the channel protection orifice is located at the water quality extended detention elevation, and the orifice is sized to release the channel protection storage volume over a 24 hour period.

**Step 7** Calculate the flood control release rates and water surface elevations.

Set up a stage-storage-discharge relationship for the control structure for the extended detention orifice(s) and the flood control storms. Route floods through facility and adjust accordingly to achieve peak flow control.

**Step 8** Design embankment(s) and spillway(s).

Size the emergency spillway by routing 100-year flood through the spillway in accordance with the previously discussed criteria. Set the top of dam elevation based on a minimum of 1 foot of freeboard.

At final design, provide safe passage for the 100-year event.

**Step 9** Investigate potential pond/wetland hazard classification.

The design and construction of stormwater management ponds and wetlands are required to follow the latest version of the State of Kansas dam safety regulations, where applicable.

**Step 10** Design inlets, sediment forebay(s), outlet structures, maintenance access, and safety features.

**Step 11** Prepare Vegetation and Landscaping Plan

A landscaping plan for the wetland facility and its buffer should be prepared to indicate how aquatic and terrestrial areas will be stabilized and established with vegetation.

### 3.2.10.7 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the wetland and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

## 3.2.10.8 Example Schematics

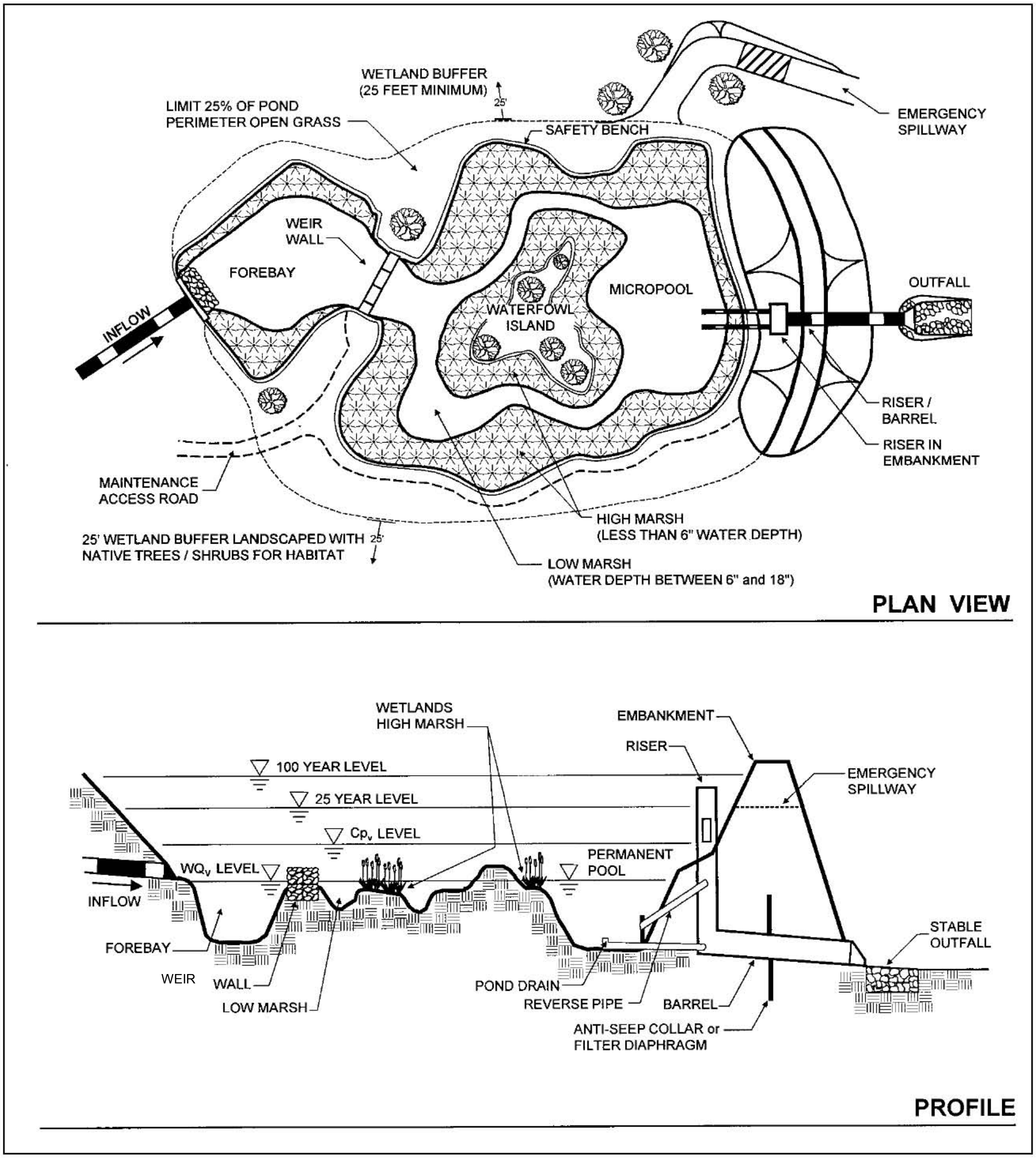



**Figure 3-41 Schematic of Shallow Wetland**
(MSDM, 2000)

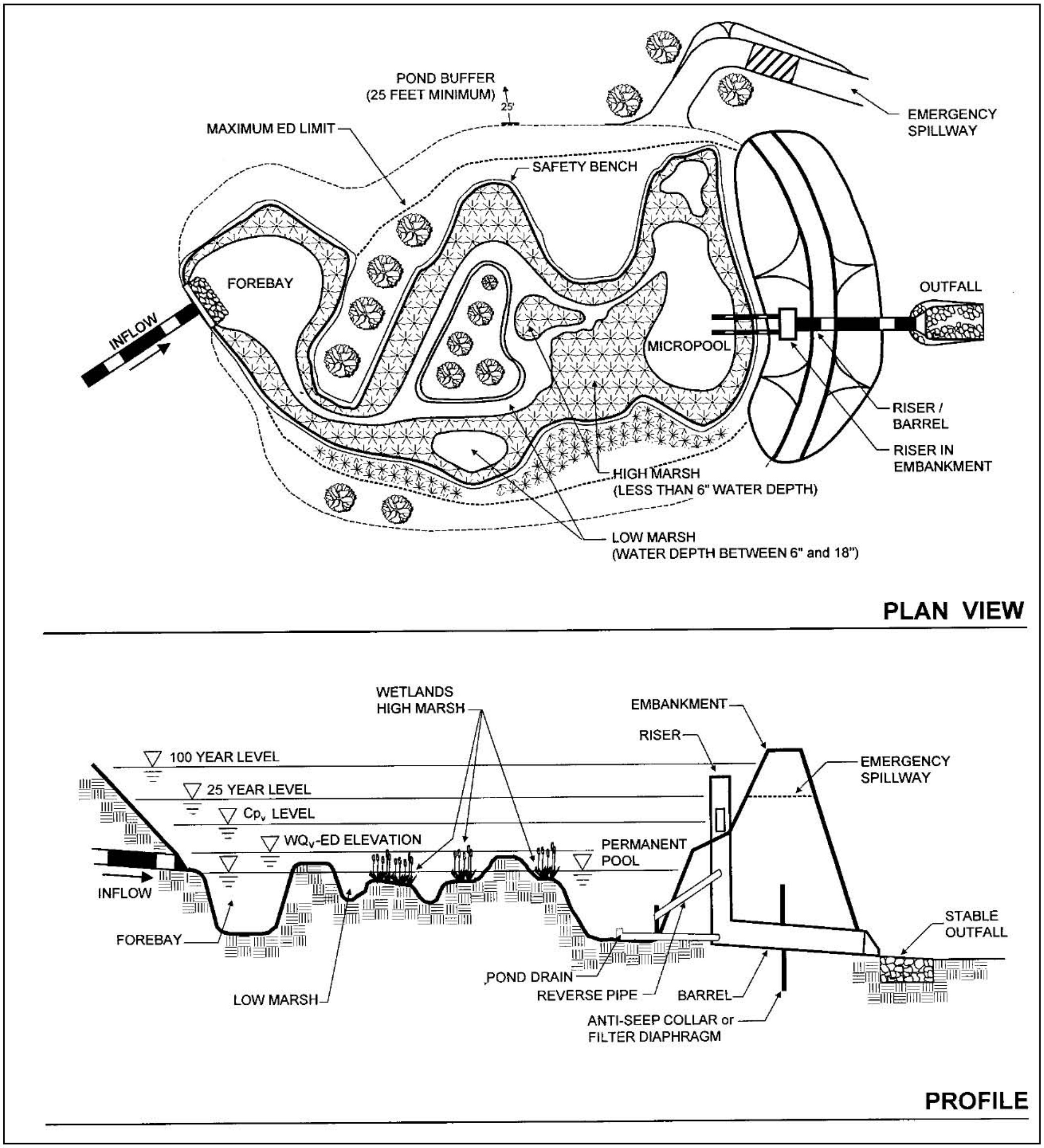



**Figure 3-42 Schematic of Extended Detention Shallow Wetland**
(MSDM, 2000)

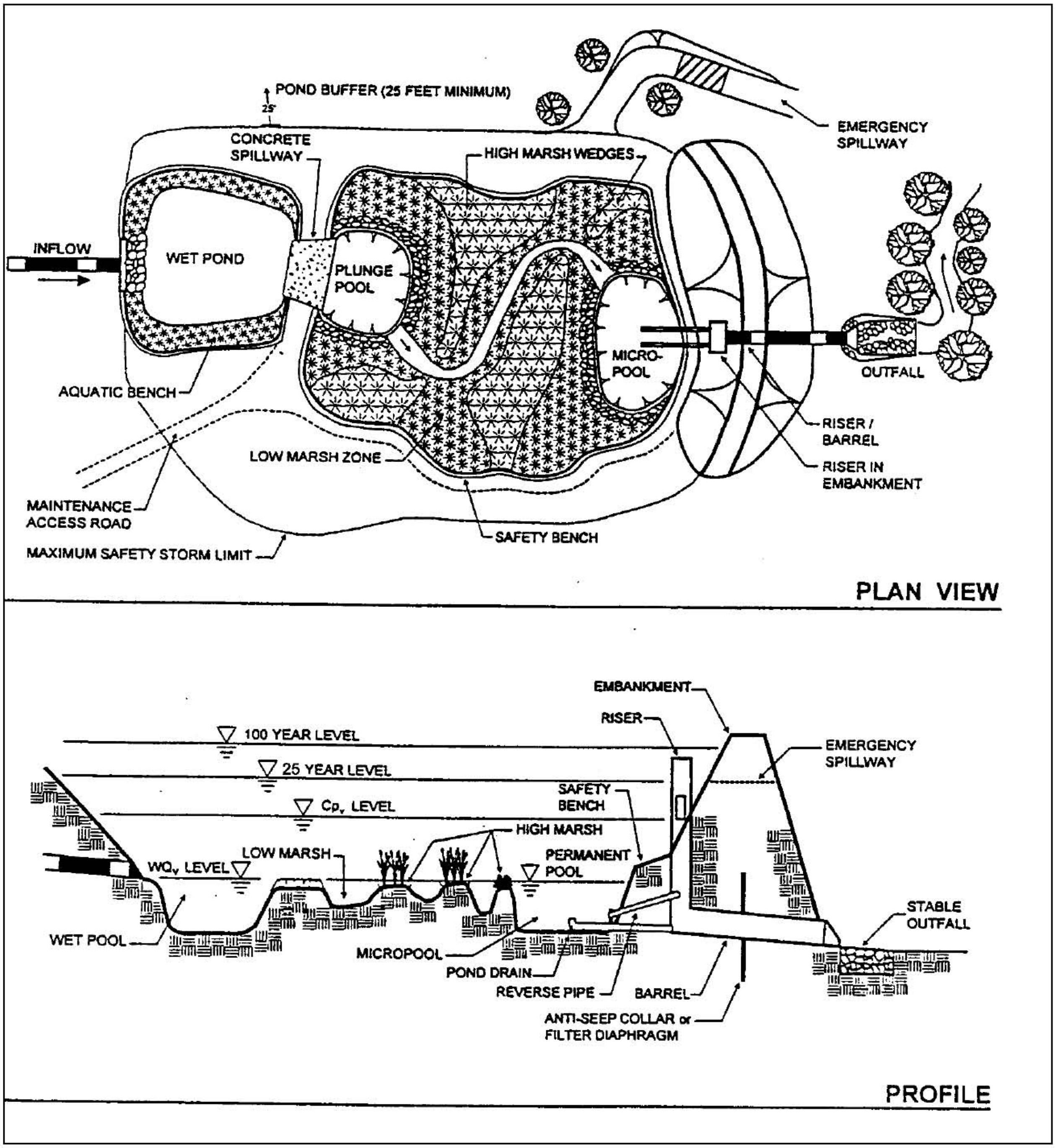



**Figure 3-43 Schematic of Pond/Wetland System**
(MSDM, 2000)

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## 3.3 Secondary TSS Treatment Facilities

This section contains design guidelines for the following TSS treatment facilities:

- Proprietary Treatment Systems
- Gravity (Oil-Water) Separator
- Alum Treatment
- Underground Sand Filter
- Organic Filter

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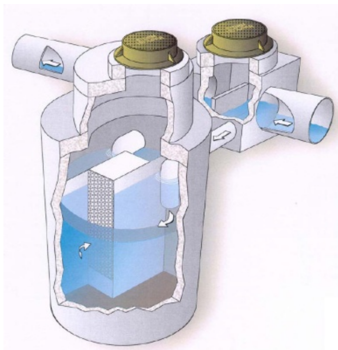
# 3.3.1 Proprietary Treatment Systems

**Secondary Water Quality Facility**



**Description**: Manufactured structural control systems available from commercial vendors designed to treat stormwater runoff.

*Example of a manhole media filtration system (Park Environmental Equipment)*

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Independent performance data must be available to prove a demonstrated capability of meeting claimed TSS removal performance
- System or device must be appropriate for use in Sedgwick County, Kansas conditions

**ADVANTAGES / BENEFITS:**

- Typically small space requirement
- Can often remove coarse sediments well

**DISADVANTAGES / LIMITATIONS:**

- Depending on the proprietary system, there may be:
  - Limited performance data;
  - Application constraints such as poor removal of fine sediment;
  - High maintenance requirements;
  - Higher costs than other structural control alternatives.
- Installation and operations/maintenance requirements must be understood by all parties approving, owning, using and maintaining the system or device in question

## STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ☐ **Channel Protection**
- ☐ **On-Site Flood Control**
- ☐ **Downstream**

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Depends on the specific proprietary structural control*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *Depends on the specific proprietary structural control*

**Soils**: *No restrictions*

**L**=Low **M**=Moderate **H**=High

***Note:*** *It is the policy of this Manual not to recommend any specific commercial vendors for proprietary systems. However, this section is being included in order to provide a base rationale for approving the use of a proprietary system or practice.*

### 3.3.1.1 General Description

There are many types of commercially-available proprietary stormwater structural controls available for water quality treatment. These systems include:

- Hydrodynamic systems such as gravity and vortex separators;
- Filtration systems;
- Catch basin media inserts;
- Chemical treatment systems; and,
- Package treatment plants.

Many proprietary systems are useful on small sites and space-limited areas where there is not enough land or room for other structural control alternatives. Proprietary systems can often be used in pretreatment applications in a treatment train. However, proprietary systems are often more costly than other alternatives and may have high maintenance requirements. Perhaps the most common difficulty in using a proprietary system is the lack of adequate independent performance data, particularly for use in south-central Kansas. Below are general guidelines that should be followed before considering the use of a proprietary commercial system.

### 3.3.1.2 Guidelines for Using Proprietary Systems

In order for use as a control, a proprietary system must have a demonstrated capability of meeting the stormwater management goals for which it is being intended. This means that the system must provide:

- Independent third-party scientific verification of the ability of the proprietary system to meet claimed water quality treatment performance;
- Proven record of longevity in the field;
- Proven ability to function in Sedgwick County, Kansas conditions (e.g., climate, rainfall patterns, soil types, etc.) or in satisfactorily similar conditions; and,
- Maintainability - Documented procedures for required maintenance including collection and removal of pollutants or debris, and no reliance on specially manufactured or proprietary materials/devices for long-term maintenance of the facility.

For a proprietary system to meet the above, the following monitoring criteria must be met for supporting studies:

- At least 15 storm events must be sampled;
- The study must be independent or independently verified (i.e., may not be conducted by the vendor or designer);

- The study must be conducted in the field, as opposed to laboratory testing;
- Field monitoring must be conducted using standard protocols which require proportional sampling both upstream and downstream of the device;
- Concentrations reported in the study must be flow-weighted; and,
- The propriety system or device must have been in place for at least one year at the time of monitoring.

Although local data is preferred, data from other regions can be accepted as long as the design accounts for the local conditions.

### 3.3.1.3 Other Requirements

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### 3.3.1.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Detailed inspection and maintenance guidance must be prepared by the manufacturer or design engineer.
3. As-built drawings must accurately show the location of the facility, and clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

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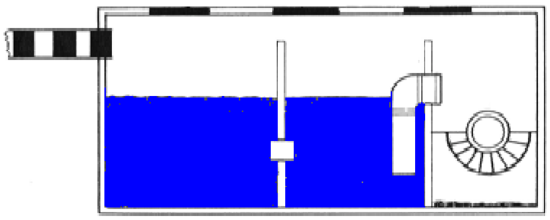
# 3.3.2 Gravity (Oil-Water) Separator

**Secondary Water Quality Facility**



**Description:** Hydrodynamic separation device designed to remove settleable solids, oil and grease, debris, and floatables from stormwater runoff through gravitational settling and trapping of pollutants.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Intended for hotspot, space-limited, or pretreatment applications
- Intended for the removal of settleable solids (grit and sediment) and floatable matter, including oil and grease
- Performance dependent on design and frequency of inspection and cleanout of unit

**DISADVANTAGES / LIMITATIONS:**

- Usually cannot alone achieve the 80% TSS removal target
- Limited performance data
- Dissolved pollutants are not effectively removed

**MAINTENANCE REQUIREMENTS:**

- Frequent maintenance required

## POLLUTANT REMOVAL

| | |
|---|---|
| Varies | **Total Suspended Solids** |
| Varies | **Nutrients –** Total Phosphorus & Total Nitrogen |
| No Data | **Metals –** Cadmium, Copper, Lead & Zinc |
| No Data | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ☐ **Channel Protection**
- ☐ **On-Site Flood Control**
- ☐ **Downstream Flood Control**

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *1 acres max.*

**Soils**: *No restrictions*

**Other Considerations**:

- *Hotspot areas*
- *Pretreatment*

**L**=Low **M**=Moderate **H**=High

### 3.3.2.1 General Description

Gravity separators (also known as oil-water separators) are hydrodynamic separation devices that are designed to remove grit and heavy sediments, oil and grease, debris, and floatable matter from stormwater runoff through gravitational settling and trapping. Gravity separator units contain a permanent pool of water and typically consist of an inlet chamber, separation/storage chamber, a bypass chamber, and an access port for maintenance purposes. Runoff enters the inlet chamber where heavy sediments and solids drop out. The flow moves into the main gravity separation chamber, where further settling of suspended solids takes place. Oil and grease are skimmed and stored in a waste oil storage compartment for future removal. After moving into the outlet chamber, the clarified runoff is then discharged.

The performance of these systems is based primarily on the relatively low solubility of petroleum products in water and the difference between the specific gravity of water and the specific gravities of petroleum compounds. Gravity separators are not designed to separate other products such as solvents, detergents, or dissolved pollutants. The typical gravity separator unit may be enhanced with a pretreatment swirl concentrator chamber, oil draw-off devices that continuously remove the accumulated light liquids, and flow control valves regulating the flow rate into the unit.

Gravity separators are best used in commercial, industrial, and transportation landuse areas and are intended primarily as a pretreatment measure for high-density or ultra urban sites, or for use in hydrocarbon hotspots, such as gas stations and areas with high vehicular traffic. However, gravity separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols, and alcohols.

Since re-suspension of accumulated sediments is possible during heavy storm events, gravity separator units are typically installed off-line. Gravity separators are available as prefabricated proprietary systems from a number of different commercial vendors.

### 3.3.2.2 Pollutant Removal Capabilities

Testing of gravity separators has shown that they can remove between 40 and 50% of the TSS loading when used in an off-line configuration (Curran, 1996 and Henry, 1999). Gravity separators also provide removal of debris, hydrocarbons, trash and other floatables. They provide only minimal removal of nutrients and organic matter.

The following design pollutant removal rates are achievable pollutant reduction percentages for planning purposes derived from sampling data, modeling and professional judgment. Actual design values will depend on the specific facility design. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 40% (varies by device)
- Total Phosphorus – 5% (varies by device)

- Total Nitrogen – 5% (varies by device)
- Heavy Metals – insufficient data
- Fecal Coliform – insufficient data

Actual field testing data and pollutant removal rates from an independent source should be obtained before using a proprietary gravity separator system.

### 3.3.2.3 Design Criteria and Specifications

- The use of gravity (oil-water) separators should be limited to the following applications:
    - Pretreatment for other structural stormwater controls;
    - High-density, ultra urban or other space-limited development sites;
    - Hotspot areas where the control of grit, floatables, and/or oil and grease are required.
- Gravity separators are typically used for areas less than 5 acres. It is recommended that the contributing area to any individual gravity separator be limited to 1 acre or less of impervious cover.
- Gravity separator systems can be installed in almost any soil or terrain. Since these devices are underground, appearance is not an issue and public safety risks are low.
- Gravity separators are flow rate based devices. This contrasts with most other stormwater structural controls, which are sized based on capturing and treating a specific volume.
- Gravity separator units are typically designed to bypass runoff flows in excess of the design flow rate. Some designs have built-in high flow bypass mechanisms. Other designs require a diversion structure or flow splitter ahead of the device in the drainage system. An adequate outfall must be provided.
- The separation chamber should provide for three separate storage volumes:
    - A volume for separated oil storage at the top of the chamber;
    - A volume for settleable solids accumulation at the bottom of the chamber;
    - A volume required to give adequate flow-through detention time for separation of oil and sediment from the stormwater flow.
- The total wet storage of the gravity separator unit should be at least 400 cubic feet per contributing impervious acre.
- The minimum depth of the permanent pools should be 4 feet.
- Horizontal velocity through the separation chamber should be 1 to 3 ft/min or less. No velocities in the device should exceed the entrance velocity.
- A trash rack should be included in the design to capture floating debris, preferably near the inlet chamber to prevent debris from becoming oil impregnated.

- Ideally, a gravity separator design will provide an oil draw-off mechanism to a separate chamber or storage area.
- Adequate maintenance access to each chamber must be provided for inspection and cleanout of a gravity separator unit.
- Gravity separator units should be watertight to prevent possible groundwater contamination.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- The design criteria and specifications of a proprietary gravity separator unit should be obtained from the manufacturer.

### 3.3.2.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately show the location of the facility, and clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.3.2.5 Example Schematic

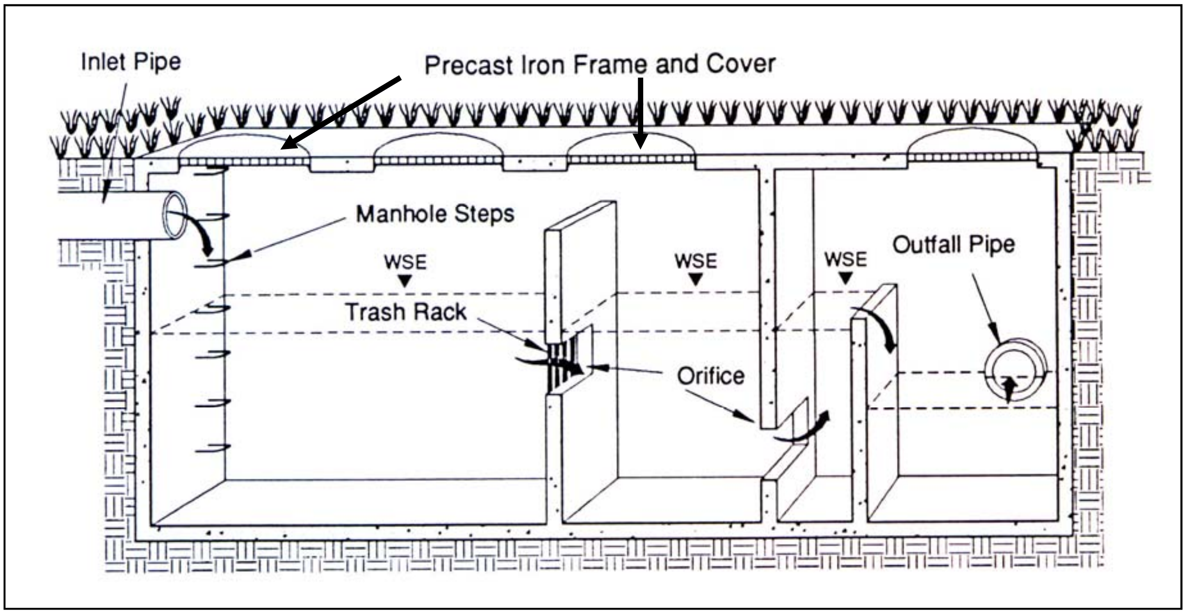



**Figure 3-44 Schematic of an Example Gravity (Oil-Water) Separator**
(NVRC, 1992)

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## 3.3.3 Alum Treatment

**Secondary Water Quality Facility**

**Description:** Chemical treatment of stormwater runoff entering a wet pond by injecting liquid alum into storm sewer lines on a flow-weighted basis during rain events.

### KEY CONSIDERATIONS

**ADVANTAGES / BENEFITS:**

- Reduces concentrations of total suspended sediments, phosphorus, and heavy metals

**DISADVANTAGES / LIMITATIONS:**

- Dependent on pH level ranging from 6.0 to 7.5 during treatment process
- Intended for areas requiring large-scale stormwater treatment from a piped stormwater drainage system
- High maintenance requirements
- Alum application will lower pH of receiving waters
- High capital and operations and maintenance costs

**MAINTENANCE REQUIREMENTS:**

- Adjust dosage to ensure proper dosage and delivery of runoff to the settling pond
- Dredge settling pond and properly dispose of accumulated floc

### POTENTIAL* POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| H/M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| H | **Pathogens –** Coliform, Streptococci & E. Coli |

*Depends On Specific Installation

### STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ☐ **Channel Protection**
- ☐ **On-Site Flood Control**
- ☐ **Downstream Flood Control**

**Accepts Hotspot Runoff:** *Yes, For Lined Off-line Ponds*

### IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *25 acres min.*

**Soils**: *No restrictions*

**Other Considerations**:

- *Regional Treatment*

**L**=Low **M**=Moderate **H**=High

### 3.3.3.1 General Description

The process of alum (aluminum sulfate) treatment provides treatment of stormwater runoff from a piped stormwater drainage system entering a wet pond or basin by injecting liquid alum into storm sewer lines on a flow-weighted basis during rain events. When added to runoff, liquid alum forms nontoxic precipitates of aluminum hydroxide [$Al(OH)_3$] and aluminum phosphate [$AlPO_4$]. However, alum will lower the pH of receiving waters and must be closely monitored to avoid adverse impacts on aquatic life.

The alum precipitate or “floc” formed during coagulation of stormwater combines with phosphorus, suspended solids, and heavy metals and removes them from the water column. Once settled, the floc is stable in sediments and will not re-dissolve due to changes in redox potential or pH under conditions normally found in surface water bodies. Laboratory or field testing may be necessary to verify feasibility and to establish design, maintenance, and operational parameters, such as the optimum coagulant dose required to achieve the desired water quality goals, chemical pumping rates, and pump sizes.

The capital construction costs of alum stormwater treatment systems is less independent of watershed size and more dependent on the number of outfall locations treated.

Estimated annual operations and maintenance (O&M) costs include chemical, power, manpower for routine inspections, equipment renewal, and replacement costs.

Ferric chloride has also been used for flow-proportional injection for removing phosphorus and other pollutants. Although ferric chloride is less toxic to aquatic life than alum, it has a number of significant disadvantages. Ferric chloride dosage rates are dependent on the pollutant concentrations in the stormwater runoff, unlike alum. Ferric chloride does not form a floc that settles out suspended pollutants. And, once settled, ferric chloride may be released from sediments under anaerobic conditions.

### 3.3.3.2 Pollutant Removal Capabilities

Alum treatment has consistently achieved a 85 to 95% reduction in total phosphorus, 90 to 95% reduction in orthophosphorus, 60 to 70% reduction in total nitrogen, 50 to 90% reduction in heavy metals, 95 to 99% reduction in turbidity and TSS, 60% reduction in BOD, and >99% reduction in fecal coliform bacteria compared with raw stormwater characteristics.

The following design pollutant removal rates are achievable reduction percentages for planning purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach. Actual removal rates will depend on the specific installation design.

- Total Suspended Solids – 90%
- Total Phosphorus – 80%

- Total Nitrogen – 60%
- Heavy Metals – 75%
- Fecal Coliform – 90%

### 3.3.3.3 Design Criteria and Specifications

Alum treatment systems are fairly complex, and design details are beyond the scope of this manual. However, further information can be obtained by contacting local municipalities and engineers who have designed and implemented successful systems. The following are general guidelines for alum treatment systems:

- Injection points should be 100 feet upstream of discharge points;
- Alum concentration is typically 10 $\mu$g/l;
- Alum treatment systems may need to control pH;
- For pond design, the required size is approximately 1% of the drainage basin size, as opposed to 2-5% of the drainage basin area for a standard detention pond;
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### 3.3.3.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

**Figure 3-45 Alum Treatment System and Injection Equipment**

# 3.3.4 Underground Sand Filter

**Secondary Water Quality Facility**

**Description:** The underground sand filter is a design variation of the surface sand filter, where the sand filter chambers and media are located in an underground vault.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Maximum contributing drainage area of 2 acres
- Typically requires 2 to 6 feet of head
- Precast concrete shells available, which decrease construction costs
- Underdrain required

**ADVANTAGES / BENEFITS:**

- High pollutant removal
- Applicable to small drainage areas
- Good for highly impervious areas
- Good retrofit capability

**DISADVANTAGES / LIMITATIONS:**

- High maintenance burden
- Not recommended for areas with high sediment content in stormwater or clay/silt runoff areas
- Cannot be installed until site construction is complete
- Possible odor problems

**MAINTENANCE REQUIREMENTS:**

- Inspect for clogging – rake first inch of sand
- Remove sediment from forebay/chamber
- Replace sand filter media as needed

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total |
| M | **Metals –** Cadmium, Copper, Lead & Zinc |
| M | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ✓ **Channel Protection**
- ☐ **On-Site Flood Control**
- ☐ **Downstream Flood**

**Accepts Hotspot Runoff:** *Yes*

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *2 acres maximum*

**Soils**: *Not recommended for clay/silt drainage areas that are not stabilized*

**Other Considerations**:

- *Typically needs to be combined with other controls to provide water quantity control*

**L**=Low **M**=Moderate **H**=High

### 3.3.4.1 General Description

The underground sand filter is a design variant of the surface sand filter. The underground sand filter is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. The system consists of a sedimentation chamber and a sand bed filter. Runoff flows into the structure through a series of inlet grates located along the top of the control. Underground sand filters are best used for high-density land uses or ultra-urban applications where space for surface stormwater controls is limited. Figure 33 presents an example of an underground sand filter.

**Figure 3-46 Example of an Underground Sand Filter**

Multiple configurations have been developed for underground filters including the DC filter and the Delaware filter. The DC filter is intended to treat stormwater that is conveyed by a storm drain system. The Delaware filter (also known as the perimeter sand filter) is designed to collect flow directly from impervious surfaces and is well suited for installation along parking areas. Both systems operate in the same manner.

The underground sand filter is a three-chamber system. The initial chamber is a sedimentation (pretreatment) chamber that temporarily stores runoff and utilizes a wet pool to capture sediment. The sedimentation chamber is connected to the sand filter chamber by a submerged wall that protects the filter bed from oil and trash. The filter bed is 18 to 24 inches deep and may have a protective screen of gravel or permeable geotextile to limit clogging. The sand filter chamber also includes an underdrain system with inspection and clean out wells. Perforated drain pipes under the sand filter bed extend into a third chamber that collects filtered runoff. Flows beyond the filter capacity are diverted through an overflow weir.

Due to its location below the surface, underground sand filters have a high maintenance burden and should only be used where adequate inspection and maintenance can be ensured.

### 3.3.4.2 Stormwater Management Suitability

Underground sand filter systems are designed primarily as off-line systems for treatment of the water quality volume and will typically need to be used in conjunction with another structural BMP that can provide downstream channel protection, overbank flood protection, and extreme flood protection. However, under certain circumstances, underground sand filters can provide limited runoff quantity control, particularly for smaller storm events.

***Water Quality (WQv)***
In underground sand filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration and adsorption. The filtration process effectively removes suspended solids and particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants.

***Channel Protection (CPv)***
For smaller sites, an underground sand filter may be designed to capture the entire channel protection volume (CPv) in either an off- or on-line configuration. Given that an underground sand filter system is typically designed to completely drain over 40 hours, the channel protection design requirement for extended detention of the 1-year, 24-hour storm runoff volume can be met. For larger sites or where only the WQv is diverted to the underground sand filter facility, another structural control must be used to provide extended detention of the CPv.

***Overbank Flood Protection (up to Qp25) and Extreme Flood Protection (Qp100)***
Underground sand filters are not useful for flood protection. Another structural control, such as a conventional detention pond, must be used in conjunction with an underground sand filter system to control stormwater peak discharges. Further, underground sand filter facilities utilized on-line must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the filter bed and facility.

### 3.3.4.3 Pollutant Removal Capabilities

Underground sand filters are presumed to be able to remove 80% of the total suspended solids (TSS) load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the recommended specifications. Undersized or poorly designed underground sand filters can reduce TSS removal performance.

Additionally, research has shown that use of underground sand filters will have benefits beyond the removal of TSS, such as the removal of other pollutants (i.e. phosphorous, nitrogen, fecal coliform and heavy metals), as well, which is useful information should the pollutant removal criteria change in the future. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data.

- Total Suspended Solids – 80%
- Total Phosphorus – 50%
- Total Nitrogen – 30%
- Heavy Metals – 50%
- Pathogens – 40%

For additional information and data on pollutant removal capabilities for underground sand filters, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the International Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.3.4.4 Application and Site Feasibility Criteria

Underground sand filter systems are well-suited for highly impervious areas where land available for structural BMPs is limited. Underground sand filters should primarily be considered for new construction or retrofit opportunities for commercial, industrial, and institutional areas where the sediment load is relatively low, such as: parking lots, driveways, loading docks, gas stations, garages, airport runways/taxiways, and storage yards.

To avoid rapid clogging and failure of the filter media, the use of underground sand filters should be avoided in areas with less than 50% impervious cover, or high sediment yield sites with clay/silt soils.

The following basic criteria should be evaluated to ensure the suitability of an underground sand filter facility for meeting stormwater management objectives on a site or development.

#### *General Feasibility*

- Not suitable for use in a residential subdivision.
- Suitable for use in high density/ultra-urban areas.
- Not suitable for use as a regional stormwater control. On-site applications are typically most feasible.

#### *Physical Feasibility - Physical Constraints at Project Site*

- <u>Drainage Area</u> – 2 acres maximum for an underground sand filter.
- <u>Space Required</u> – Function of available head at site.
- <u>Minimum Head</u> – The surface slope across the filter location should be no greater than 6%. The elevation difference needed at a site from the inflow to the outflow is 2 to 6 feet.

- Minimum Depth to Water Table – If used on a site with an underlying water supply aquifer, a separation distance of 2 feet is required between the bottom of the sand filter and the elevation of the seasonally high water table to prevent groundwater contamination.
- Soils – Not recommended for clay/silt drainage areas that are not stabilized.

***Other Constraints / Considerations***

- Aquifer Protection – Do not allow infiltration of filtered hotspot runoff into groundwater.

### 3.3.4.5 Planning and Design Standards

The following standards shall be considered minimum design standards for the design of underground sand filters. Underground sand filters that are not designed to these standards will not be approved. The local jurisdiction shall have the authority to require additional design conditions if deemed necessary.

#### A. Construction Sequencing

- Care shall be taken during construction to minimize the risk of premature failure of the underground sand filter due to deposition of sediments from disturbed, unstabilized areas. This can be minimized or avoided by proper construction sequencing.
- Ideally, the construction of an underground filter shall take place after the construction site has been stabilized. In the event that the underground sand filter is not constructed after site stabilization, diversion of site runoff around the sand filter and installation and maintenance of appropriate erosion prevention and sediment controls prior to site stabilization is required.
- Diversion berms shall be maintained around an underground sand filter during all phases of construction. No runoff shall enter the sand filter area prior to completion of construction and the complete stabilization of construction areas. Erosion prevention and sediment controls shall be maintained around the filter to prevent runoff and sediment from entering the sand filter during construction.
- Underground sand filters shall not be used as a temporary sediment trap for construction activities.
- During and after excavation of the underground sand filter area, all excavated materials shall be placed downstream, away from the sand filter, to prevent redeposit of the material during runoff events.

#### B. Location and Siting

- Underground sand filters shall have a contributing drainage area of 2 acres or less.
- Underground sand filter systems are generally applied to land uses with a high percentage of impervious surfaces. Sand filters shall not be utilized for sites that have less than 50% impervious cover. Any disturbed or denuded areas located within the area draining to and

treated by the underground sand filter shall be stabilized prior to construction and use of the sand filter.

- Delaware underground sand filters are typically sited along the edge, or perimeter, of an impervious area such as a parking lot.
- DC underground sand filters are installed within the storm drain system.
- Underground sand filter systems shall be designed for intermittent flow and must be allowed to drain and re-aerate between rainfall events. They shall not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

## C. Physical Specifications / Geometry

- The entire treatment system (including the sedimentation chamber) must temporarily hold at least 75% of the WQv prior to filtration. Figures 4-60 and 4-61 illustrate the distribution of the treatment volume (0.75 WQv) among the various components of the underground sand filters, including:
  - Vw – wet pool volume within the sedimentation basin
  - Vf – volume within the voids in the filter bed
  - Vtemp – temporary volume stored above the filter bed
  - As – the surface area of the sedimentation basin
  - Af – surface area of the filter media
  - hf – average height of water above the filter media (1/2 htemp)
  - df – depth of filter media
- The sedimentation chamber shall be sized to at least 50% of the computed WQv.
- The filter area shall be sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand shall be used. The filter bed shall be designed to completely drain in 40 hours or less.
- The filter media shall consist of an 18 inch to 24 inch layer of clean washed medium aggregate concrete sand (ASTM C-33) on top of the underdrain system. Figure 4-62 illustrates a typical media cross section.
- The filter bed shall be equipped with a 6 inch perforated pipe underdrain (PVC AASHTO M 252, HDPE, or other suitable pipe material) in a gravel layer. The underdrain shall have a minimum grade of 1/8 inch per foot (1% slope). Holes shall be 3/8 inch diameter and spaced approximately 6 inches on center. Gravel shall be clean-washed aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches with a void space of about 40%. Aggregate contaminated with soil shall not be used.

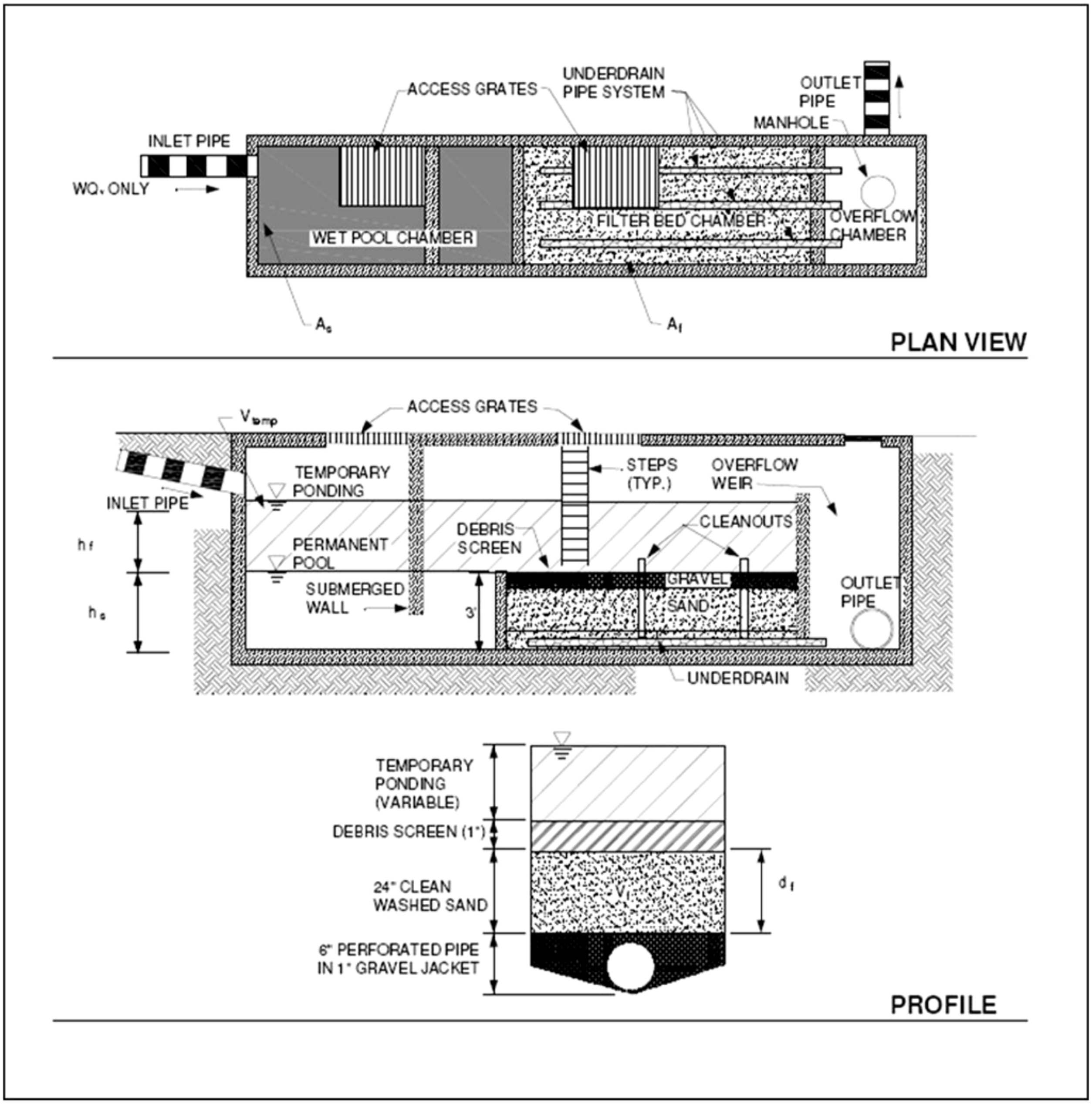


**Figure 3-47 Underground (DC) Sand Filter Volumes**
(Source: Center for Watershed Protection)

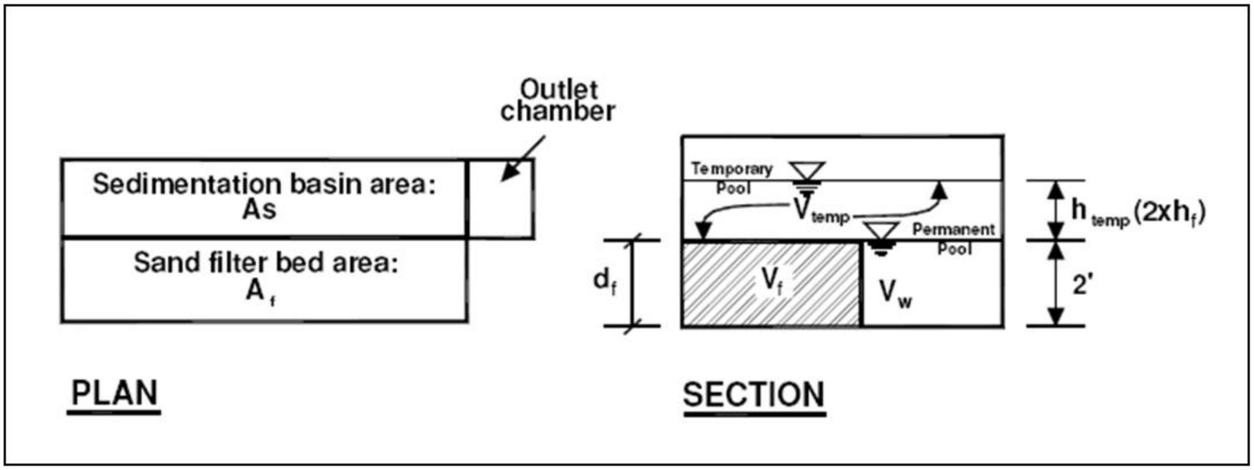


**Figure 3-48 Perimeter Sand Filter Volumes**
(Source: Claytor and Schueler, 1996)

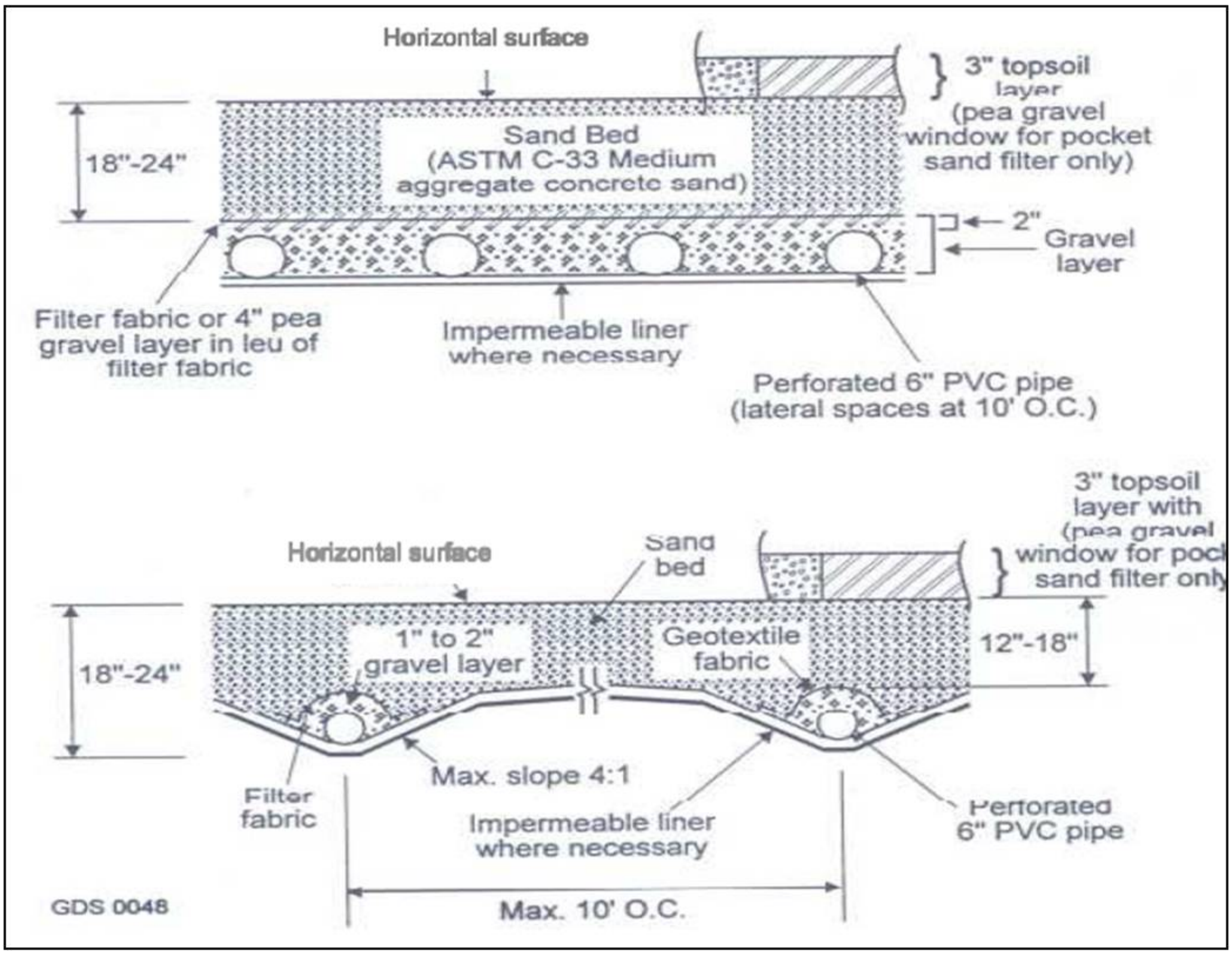


**Figure 3-49 Typical Sand Filter Media Cross Sections**
(Source: Claytor and Schueler, 1996)

### D. Outlet Structures

- An outlet pipe shall be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways). However, the design shall ensure that the discharges from the underdrain system occur in a non-erosive manner.

### E. Emergency Spillway

- An emergency bypass spillway or weir must be included in the underground sand filter design to safely pass flows that exceed the WQv (and CPv if the filter is utilized for channel protection purposes).

### F. Maintenance Access

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles. Adequate access must be provided to the grates of the filter bed. Facility designs must enable maintenance personnel to easily remove and replace upper layers of the filter media.

### G. Safety Features

- Inlets, access grates and outlets shall be designed and maintained so as not to permit access by children. Inlet and access grates to the underground sand filters may be locked.

## 3.3.4.6 Design Procedures

**Step 1** Compute runoff control volumes

Calculate the $WQ_v$ using equation 1-1.

**Step 2** Determine if the development site and conditions are appropriate for the use of an underground sand filter.

Consider the Application and Site Feasibility Criteria Check with local agencies as appropriate to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 3** Compute the peak discharge for the $WQ_v$, called $Q_{wq}$, using equation 4-18.

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures.

(a) Using $WQ_v$, compute CN using equation 4-3.

(b) Compute time of concentration (Chapter 4, Section 4).

(c) Determine appropriate unit peak discharge from time of concentration (Chapter 4, Section 8).

(d) Compute $Q_{wq}$ from unit peak discharge, drainage area, and WQv using equation 4-18.

**Step 4** Size flow diversion structure, (if needed)

If a diversion structure is utilized, a flow regulator should be supplied to divert the $WQ_v$ to the underground sand filter facility.

Size low flow orifice, weir, or other device to pass $Q_{wq}$.

**Step 5** Size filtration basin chamber

The filter area is sized using the following equation (based on Darcy's Law):

**Equation 3-8** $$A_f = \frac{WQ_v * d_f}{k * (h_f + d_f) * t_f}$$

where:

| | | |
|---|---|---|
| $A_f$ | = | surface area of filter bed (ft2) |
| $d_f$ | = | filter bed depth (ft)<br>(typically 1.5 ft, no more than 2 ft) |
| k | = | coefficient of permeability of filter media (ft/day)<br>(use 3.5 ft/day for sand) |
| $h_f$ | = | average height of water above filter bed (ft)<br>(1/2 $h_{temp}$, which varies based on site but $h_{temp}$ is typically ≤ 6 feet) |
| $t_f$ | = | design filter bed drain time (days)<br>(1.67 days or 40 hours is recommended maximum) |

Set preliminary dimensions of filtration basin chamber.

**Step 6** Size sedimentation chamber

Depending on the type of underground sand filter system utilized, the sedimentation chamber shall be sized to at least 50% of the computed $WQ_v$ and have a length-to-width ratio of 2:1. The Camp-Hazen equation is used to compute the required surface area: (Claytor & Schueler, 1996)

**Equation 3-9** $$A_s = -\frac{Q_o}{w} * Ln(1 - E)$$

where:

| | | |
|---|---|---|
| As | = | sedimentation basin surface area ($ft^2$) |
| $Q_o$ | = | rate of outflow = the $WQ_v$ over a 24-hour period |
| w | = | particle settling velocity (ft/sec) |
| E | = | trap efficiency |

Assuming:

- 90% sediment trap efficiency (0.9);

- particle settling velocity (ft/sec) = 0.0033 ft/sec for imperviousness ≥ 75%;
- particle settling velocity (ft/sec) = 0.0004 ft/sec for imperviousness < 75%;
- average of 24 hour holding period.

Then:
As = (0.0081) ($WQ_v$) ft$^2$ for Imperviousness ≥ 75%
As = (0.066) ($WQ_v$) ft$^2$ for Imperviousness < 75%

Set preliminary dimensions of sedimentation chamber.

**Step 7** Compute $V_{min}$ for 75% of the $WQ_v$, as required by the design specifications.

**Equation 3-10** $V_{\min} = 0.75 * WQ_v$

**Step 8** Compute storage volumes within entire facility and sedimentation chamber orifice size (Claytor & Schueler, 1996).

**Underground (D.C.) sand filter:**

Vmin = 0.75 WQv = Vs + Vf + Vf-temp

1. Compute Vf = water volume within filter bed/gravel/pipe = Af * df * n

   Where: n = porosity = 0.4 for most applications
2. Compute Vf-temp = temporary storage volume above the filter bed = 2 * hf * Af
3. Compute Vs = volume within sediment chamber = Vmin - Vf - Vf-temp
4. Compute hs = height in sedimentation chamber = Vs/As
5. Ensure hs and hf fit available head and other dimensions still fit – change as necessary in design iterations until all site dimensions fit.
6. Size orifice from sediment chamber to filter chamber to release Vs within 24-hours at average release rate with 0.5 hs as average head.
7. Design outlet structure with perforations allowing for a safety factor of safety times the orifice capacity.
8. Size distribution chamber to spread flow over filtration media – level spreader weir or orifices.

**Underground perimeter (Delaware) sand filter:**

1. Compute Vf = water volume within filter bed/gravel/pipe = Af * df * n

   where: Af = surface area of filter bed (ft2)

   df = filter bed depth (1.5 ft)

   (at least 18 inches, no more than 24 inches)

   n = porosity = 0.4 for most applications
2. Compute Vw = wet pool storage volume As * 2 feet minimum

3. Compute Vtemp = temporary storage volume = Vmin – (Vf + Vw)
4. Compute htemp = temporary storage height = Vtemp / (Af + As)
5. Ensure htemp ³ 2 * hf, otherwise decrease hf and re-compute. Ensure dimensions fit available head and area – change as necessary in design iterations until all site dimensions fit.
6. Size distribution slots from sediment chamber to filter chamber.

**Step 9** Design inlets, underdrain system, and outlet structures.

See Chapter 5 for more details.

**Step 10** Compute overflow weir sizes.

**Underground (D.C.) sand filter:**

Vmin = 0.75 WQv = Vs + Vf + Vf-temp

1. Compute Vf = water volume within filter bed/gravel/pipe = Af * df * n
   where: n = porosity = 0.4 for most applications
2. Compute Vf-temp = temporary storage volume above the filter bed = 2 * hf * Af
3. Compute Vs = volume within sediment chamber = Vmin - Vf - Vf-temp
4. Compute hs = height in sedimentation chamber = Vs/As
5. Ensure hs and hf fit available head and other dimensions still fit – change as necessary in design iterations until all site dimensions fit.
6. Size orifice from sediment chamber to filter chamber to release Vs within 24-hours at average release rate with 0.5 hs as average head.
7. Design outlet structure with perforations allowing for a safety factor of times the orifice capacity.
8. Size distribution chamber to spread flow over filtration media – level spreader weir or orifices.

**Underground perimeter (Delaware) sand filter:** Size overflow weir at end of sedimentation chamber to handle excess inflow, set at WQv elevation.

### 3.3.4.7 Example Schematics

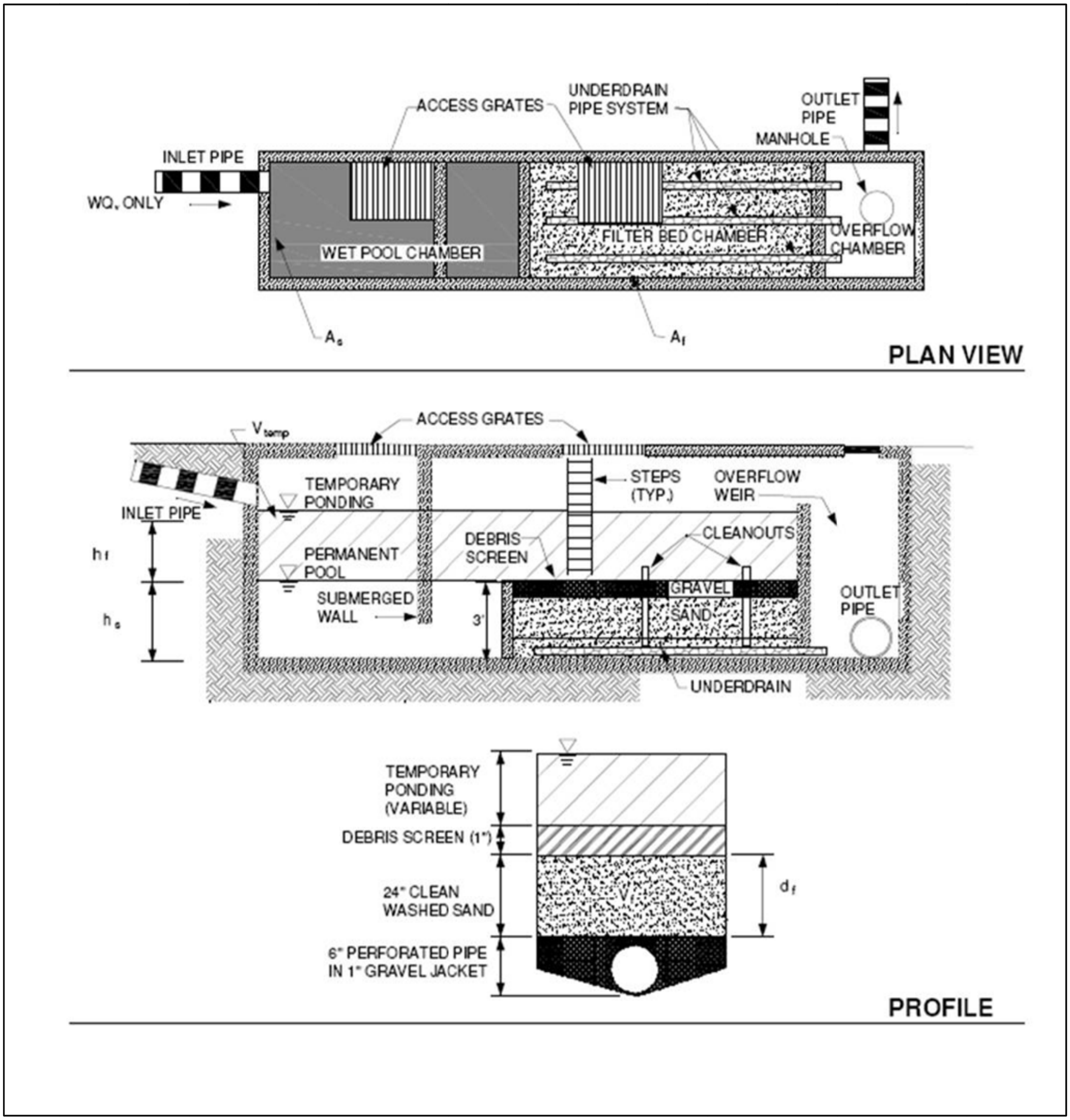


**Figure 3-50 Schematic of an Underground (D.C.) Sand Filter**
(Source: Center for Watershed Protection)

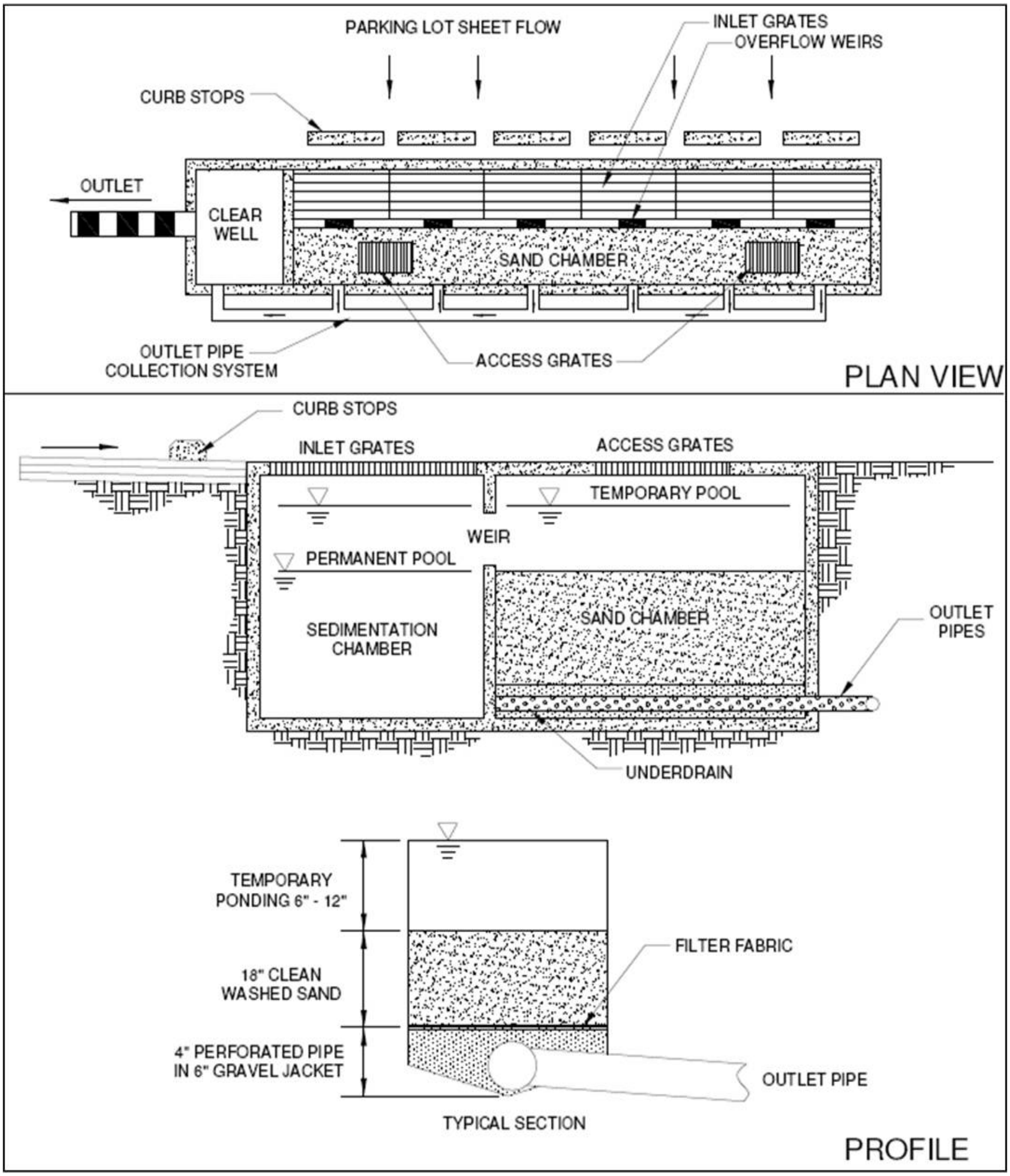


**Figure 3-51 Schematic of Perimeter (Delaware) Sand Filter**
(Source: Center for Watershed Protection)

# 3.3.5 Organic Filter

**Secondary Water Quality Facility**

**Description:** Design variation of the surface sand filter using organic materials in the filter media.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Minimum head requirement of 5 to 8 feet

**ADVANTAGES / BENEFITS:**

- High pollutant removal capability
- Removal of dissolved pollutants is greater than sand filters due to cation exchange capacity

**DISADVANTAGES / LIMITATIONS:**

- Severe clogging potential if exposed soil surfaces exist upstream
- Intended for hotspot or space-limited applications, or for areas requiring enhanced pollutant removal capability
- High maintenance requirements
- Filter may require more frequent maintenance than most of the other stormwater controls

**MAINTENANCE REQUIREMENTS:**

- Mow and stabilize the area draining to the organic filter
- Remove sediment from filter bed

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| M | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality Protection**
- ☐ **Channel Protection**
- ☐ **On-Site Flood Control**
- ☐ **Downstream Flood Control**

**Accepts Hotspot Runoff:** *Yes*

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *10 acres max.*

**Soils**: *No restrictions*

**Other Considerations**:

- *Hotspot areas*

**L**=Low **M**=Moderate **H**=High

### 3.3.5.1 General Description

The organic filter is a design variant of the surface sand filter, which uses organic materials such as leaf compost or a peat/sand mixture as the filter media. The organic material enhances pollutant removal by providing adsorption of contaminants such as soluble metals, hydrocarbons, and other organic chemicals.

As with the surface sand filter, an organic filter consists of a pretreatment chamber, and one or more filter cells. Each filter bed contains a layer of leaf compost or the peat/sand mixture, followed by filter fabric and a gravel/perforated pipe underdrain system. The filter bed and subsoils can be separated by an impermeable polyliner or concrete structure to prevent movement into groundwater.

Organic filters are typically used in high-density applications, or for areas requiring enhanced pollutant removal ability. Maintenance is typically higher than the surface sand filter facility due to the potential for clogging and breakdown of the filter media. In addition, organic filter systems have a higher head requirement than sand filters.

### 3.3.5.2 Pollutant Removal Capabilities

The following design pollutant removal rates are average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or “treatment train” approach. (Note: In some cases, organic materials may be a source of soluble phosphorus and nitrates.)

- Total Suspended Solids – 80%
- Total Phosphorus – 60%
- Total Nitrogen – 40%
- Heavy Metals – 75%
- Fecal Coliform – 50%

For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

### 3.3.5.3 Design Criteria and Specifications

- Organic filters are typically used on relatively small sites (up to 10 acres), to minimize potential clogging.
- The typical minimum head requirement (elevation difference needed at a site from the inflow to the outflow) for an organic filter is 5 to 8 feet.

- Organic filters can utilize a variety of organic materials as the filtering media. Two typical media bed configurations are the peat/sand filter and compost filter (see Figure 3-52). The peat filter includes an 18-inch 50/50 peat/sand mix over a 6-inch sand layer and can be optionally by 3 inches of topsoil and vegetation for aesthetic purposes. The compost filter has an 18-inch compost layer. Both variants utilize a gravel underdrain system.
- The type of peat used in a peat/sand filter is critically important. Fibric peat in which undecomposed fibrous organic material is readily identifiable is the preferred type. Hemic peat containing more decomposed material may also be used. Sapric peat made up of largely decomposed matter should not be used in an organic filter.
- Typically, organic filters are designed as "off-line" systems, meaning that the $WQ_v$ is diverted to the filter facility through the use of a flow diversion structure and flow splitter. Stormwater flows greater than the $WQ_v$ are diverted to other controls or downstream using a diversion structure or flow splitter.
- Consult the design criteria for the surface sand filter (see Section 3.2.8) for the organic filter siting requirements, and sizing/design steps. The following permeability values may be used: sand = 3.5 ft/day, peat = 2.0 ft/day, and leaf compost = 8.5 ft/day. A porosity of 0.4 may be assumed.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- A minimum separation distance of 5 feet is required between the bottom of the filter and the elevation of the historical high water table for filter without underdrains, 2 feet for filters with underdrains.

### 3.3.5.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.3.5.5 Example Schematic

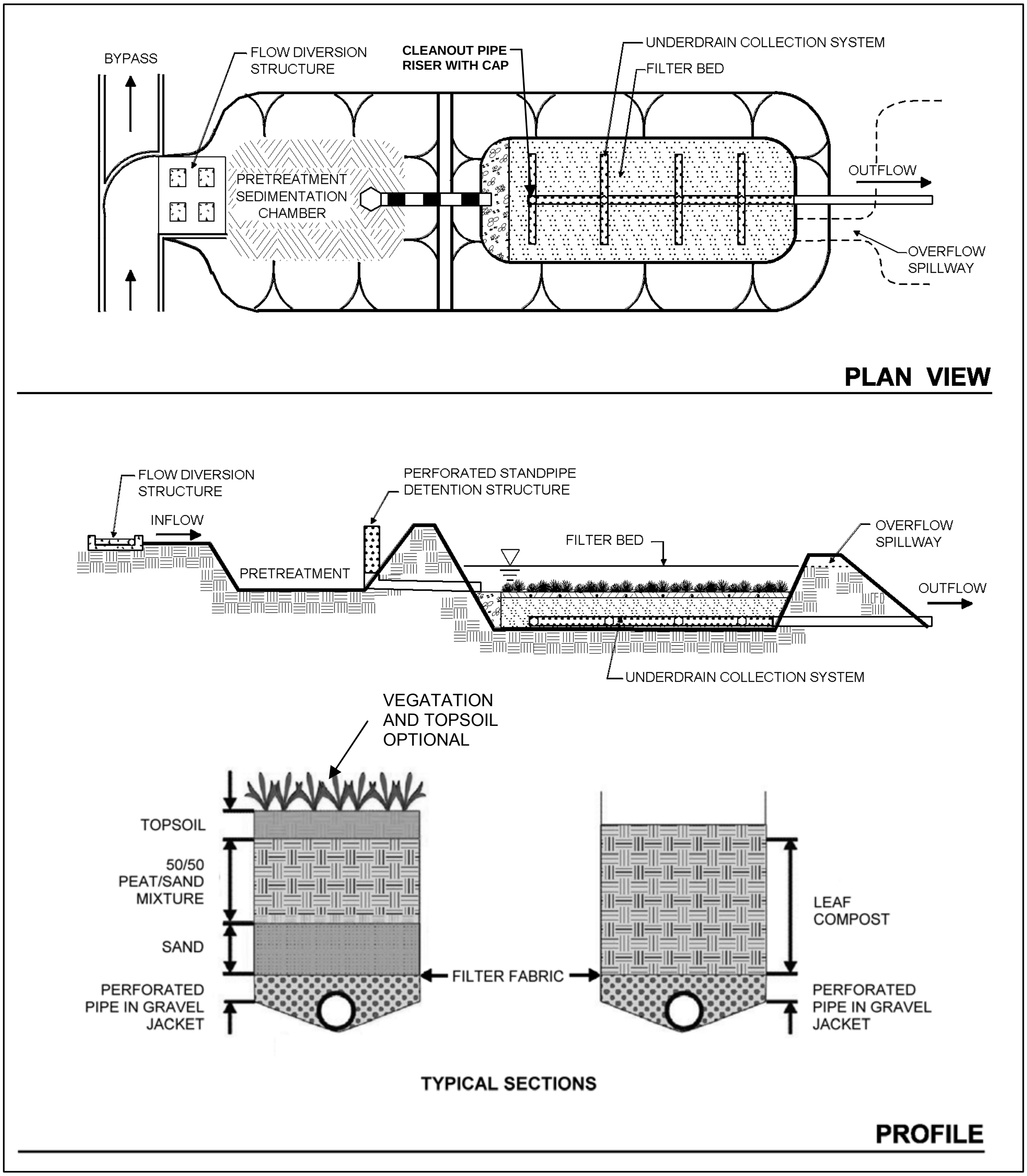


**Figure 3-52 Schematic of Organic Filter**
(adapted from Claytor & Schueler, 1996)

## 3.4 Other Stormwater Management Facilities

This section contains design guidelines for the following stormwater management facilities:

- Conventional Dry Detention
- Underground Dry Detention
- Porous Pavement
- Modular Porous Paver Systems
- Green Roof

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# 3.4.1 Conventional Dry Detention Pond

**Other Water Quantity Facility**

**Description:** A surface storage basin or facility designed to provide water quantity control through detention of stormwater runoff.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Designed for runoff quantity (peak flow) control

**ADVANTAGES / BENEFITS:**

- Typically less costly than stormwater (wet) ponds for equivalent flood storage
- Used in conjunction with water quality structural control
- Recreational and other open space opportunities between storm runoff events

**DISADVANTAGES / LIMITATIONS:**

- Controls for stormwater quantity only

**MAINTENANCE REQUIREMENTS:**

- Remove debris from inlet and outlet structures
- Maintain side slopes/remove invasive vegetation
- Monitor sediment accumulation and remove periodically
- Dam inspection and maintenance

## POLLUTANT REMOVAL

| | |
|---|---|
| -- | **Total Suspended Solids** |
| -- | **Nutrients –** Total Phosphorus & Total Nitrogen |
| -- | **Metals –** Cadmium, Copper, Lead & Zinc |
| -- | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| | **Water Quality Protection** |
| | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| ✓ | **Downstream** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| M | **Land Requirements** |
| L | **Relative Capital Costs** |
| M | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *No*

**Drainage Area:** *No restrictions*

**Soils**: *Hydrologic group 'A' and 'B' soils may require pond liner if groundwater mounding is not desirable*

**Other Considerations**:

- *Recreational and open space uses for dry detention*

**L**=Low **M**=Moderate **H**=High

### 3.4.1.1 General Description

Conventional dry detention ponds are surface facilities intended to provide for the temporary storage of stormwater runoff to control peak flood flows. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events.

Conventional dry detention ponds may be used to control peak flows on-site, at the project boundary, and downstream of the project. They can be designed to control the full range of flood flows, from the 2-year event up to the 100-year event. They provide limited pollutant removal benefits due to the typically short detention time and resuspension sediments in the pond. Conventional detention facilities must be used in a treatment train approach with other controls that provide treatment of the $WQ_v$.

### 3.4.1.2 Design Criteria and Specifications

***Location***

- Conventional dry detention ponds are to be located downstream of other structural stormwater controls providing treatment of the $WQ_v$ and control of the $CP_v$.

***General Design***

- Conventional dry detention ponds are sized to temporarily store the volume of runoff required to provide flood protection up to the 100-year storm.
- Routing calculations must be used to demonstrate that the storage volume and outlet structure configuration are adequate. See Chapter 4 for procedures on the design of detention storage.
- Conventional dry detention ponds located in floodplains or backwater areas must perform as specified for peak flow control for any tailwater condition, up to the Base Flood Elevation (BFE). The potential for back flow into the pond must be addressed with flap gates or by providing sufficient volume to receive backflow up to the BFE, and still provide peak flow control surcharge volume in the pond (above the BFE).
- The design may be subject to the requirements of the Kansas dam safety program based on the volume, dam height, and level of hazard.
- Earthen embankments shall have side slopes no steeper than 4:1 (horizontal to vertical) maximum.
- Vegetated slopes shall be less than 20 feet in height and shall have side slopes no steeper than 4:1 (horizontal to vertical). Riprap-protected slopes shall be no steeper than 3:1. Geotechnical slope stability analysis is required for slopes greater than 10 feet in height.
- Areas above the normal high water elevations of the detention facility should be sloped toward the basin to allow drainage and to prevent standing water. Careful finish grading is

required to avoid creation of upland surface depressions that may retain runoff. The bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap or a concrete flume) is recommended to convey low flows and prevent standing water conditions.

- To the extent practicable, the long axis of ponds should be oriented east-west to minimize wind wave bank erosion.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

***Inlet and Outlet Structures***

- The discharge from inflow channels or pipes is to be stabilized with flared riprap aprons, or the equivalent. A sediment forebay or equivalent upstream pretreatment sized to 0.1 acre-inch per impervious acre of contributing drainage should be provided for in-line dry detention basins that are located downstream of off-line water quality treatment controls.
- For a dry detention basin, the principal spillway or outlet structure (usually a concrete riser with orifices and an outlet pipe, or just an outlet pipe) is sized for its flood control functions (based on hydrologic routing calculations). Small outlet openings that will be subject to clogging or are difficult to maintain are not acceptable. Trash racks, hoods, or other protection against debris blockage of principal spillway outlets are required. See Section 3.2.1 and Chapter 5.
- See Chapter 4 and Chapter 5 for more information on the design of outlet works.
- Seepage control or anti-seep collars should be provided for all outlet pipes through earth dams.
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the pond outlet pipe to prevent scouring and erosion. If the basin discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a vegetated riparian zone in the shortest possible distance.
- A concrete emergency spillway is to be included in the stormwater pond design to safely pass the 100-year, 24-hour rainfall flood event. The spillway prevents pond water levels from overtopping the embankment. When applicable, the emergency spillway must be designed to State of Kansas requirements for dam safety and must be located so that downstream structures will not be impacted by spillway discharges.
- A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the 100-year flood, to the lowest point of the dam embankment not counting the emergency spillway. The 100-year flood elevation for emergency spillway

design is based on the elevation required to pass the 100-year flow with no discharge through the principal spillway.

- Please refer to "Stormwater Pond", Section 3.2.1, for additional requirements applicable to all surface detention ponds.

### 3.4.1.3 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location and layout of the pond, and also clearly identify drainage and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.4.1.4 Example Schematics

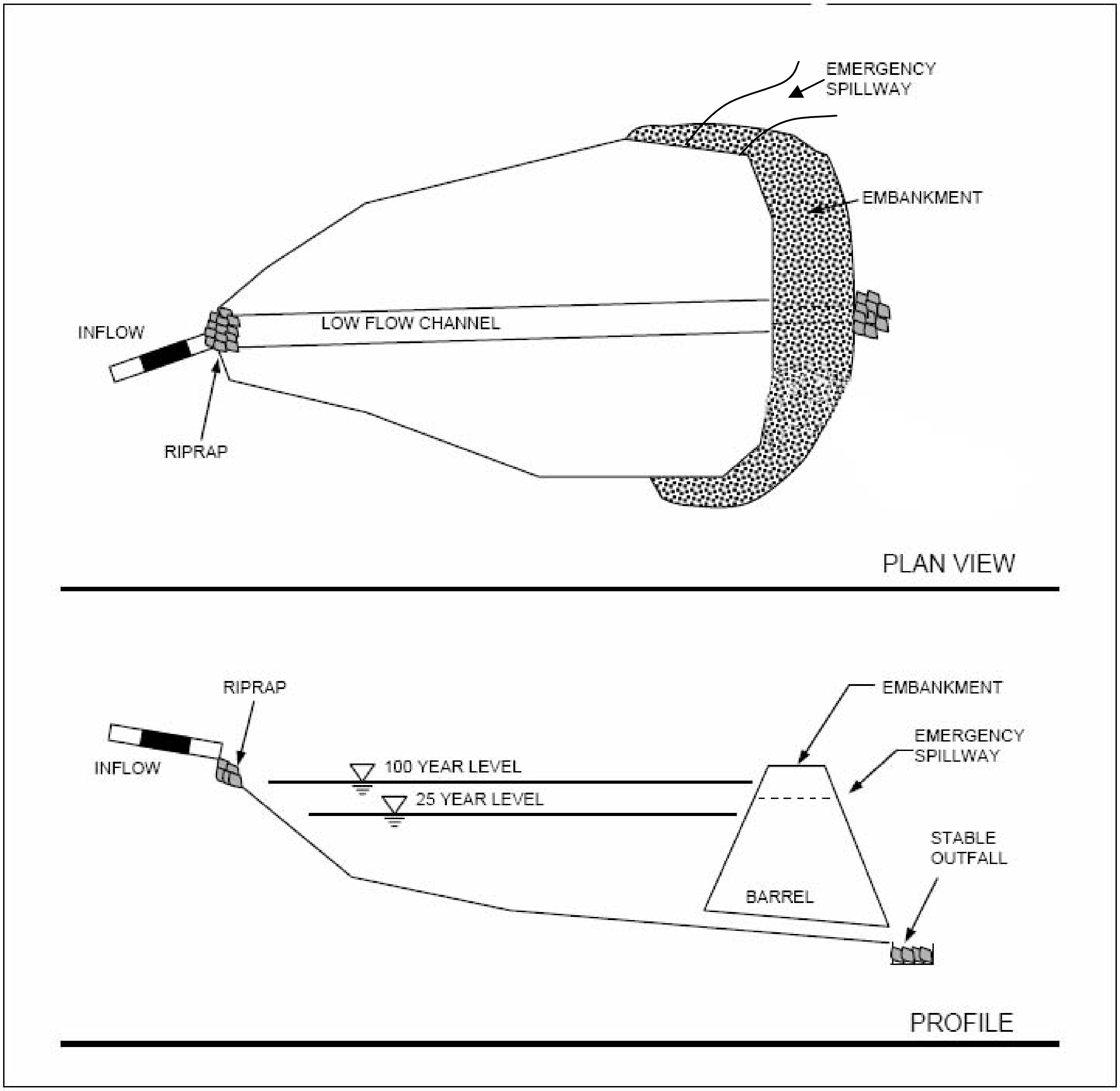


**Figure 3-53  Schematic of a Basic Conventional Dry Detention Pond**

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# 3.4.2 Underground Dry Detention Pond

**Other Water Quality Facility**

**Description:** Detention storage located in underground pipe/tank systems or vaults designed to provide water quantity control through detention of stormwater runoff.

## KEY CONSIDERATIONS

**ADVANTAGES / BENEFITS:**

- Does not take up surface space
- Used in conjunction with water quality controls
- Concrete vaults or pipe/tank systems can be used

**DISADVANTAGES / LIMITATIONS:**

- Controls for stormwater quantity only – not intended to provide water quality treatment
- Intended for space-limited applications
- High initial construction cost as well as replacement cost

**MAINTENANCE REQUIREMENTS:**

- Clean and remove debris from inlet and outlet structures
- Perform structural repairs to inlet and outlets

## POLLUTANT REMOVAL

| | |
|---|---|
| -- | **Total Suspended Solids** |
| -- | **Nutrients –** Total Phosphorus & Total Nitrogen |
| -- | **Metals –** Cadmium, Copper, Lead & Zinc |
| -- | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| ✓ | **On-Site Flood Control** |
| ✓ | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Soils**: *No restrictions*

**L**=Low **M**=Moderate **H**=High

### 3.4.2.1 General Description

Detention vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. Detention pipe/tank systems are underground storage facilities typically constructed with large diameter pipe or pre-cast concrete culvert sections. They serve as an alternative to surface dry detention for stormwater quantity control, particularly for space-limited areas where there is not adequate land for a detention basin.

Underground detention systems can provide channel protection through extended detention of the $CP_v$, and flood control through aboveground detention. Basic storage design and routing methods are the same as for detention basins except that a bypass for high flows may be included.

Underground detention systems are not intended for water quality treatment and must be used in a treatment train approach with other structural controls that provide treatment of the $WQ_v$. This will help prevent the underground vault or tank from becoming clogged with trash or sediment and significantly reduces the maintenance requirements for an underground detention system.

Underground detention systems located in floodplains or backwater areas must perform as specified for peak flow control for any tailwater condition, up to the Base Flood Elevation (BFE). The potential for back flow into the pond must be addressed with flap gates or by providing sufficient volume to receive backflow up to the BFE, and still provide peak flow control surcharge volume in the pond (above the BFE).

Prefabricated vaults are available from commercial vendors. In addition, several pipe manufacturers have developed packaged detention systems.

### 3.4.2.2 Design Criteria and Specifications

***Location***

- Underground detention systems are to be located downstream of other structural stormwater controls providing treatment of the $WQ_v$.
- The contributing drainage area to be served by a single underground detention vault or tank is typically less than 200 acres.

***General Design***

- Underground detention systems may be sized to provide extended detention of the $CP_V$ for 24 hours, and/or to temporarily store the volume of runoff required to provide the desired flood protection.
- Routing calculations must be used to demonstrate that the storage volume is adequate. See Chapter 4 for procedures on the design of detention storage.
- Detention Vaults: All construction joints must be provided with embedded waterstops.

- Detention Pipe/Tank Systems: The minimum pipe diameter for underground detention tanks is 36 inches.
- Underground detention vaults and pipe/tank systems must meet structural requirements for external and internal loads, as applicable.
- Adequate air venting above the maximum water surface is essential for proper operation of the detention system.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles. Access must be provided over the inlet pipe and outflow structure. Access openings can consist of a standard frame, grate and solid cover, or a removable panel. Vaults with widths of 10 feet or less should have removable lids.

***Inlet and Outlet Structures***

- A separate sediment sump or vault chamber with a volume of 0.1 inches per impervious acre of contributing drainage shall be provided at the inlet for on-line underground detention systems that are located downstream of an off-line water quality treatment control.
- For $CP_v$ control, a low flow orifice capable of detaining the $CP_V$ for 24 hours must be provided. The channel protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (i.e., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wirecloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.
- For on-site flood control, an additional outlet is sized for control of the chosen return period (based on hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure.
- See Chapter 5 for more information on the design of outlet works.
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. See Chapter 5 for more guidance.
- An emergency spillway shall be included in the underground detention system design to safely pass the 100-year flood flow.

### 3.4.2.3 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. “Covenants for Permanent Maintenance of Stormwater Management Facilities” (also called the “Maintenance Covenants”). An example covenants document can be found in Volume 3.
2. “Inspection Checklist and Maintenance Guidance” for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the layout and location of the facility, and also clearly identify reserves and access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.4.2.4 Example Schematics

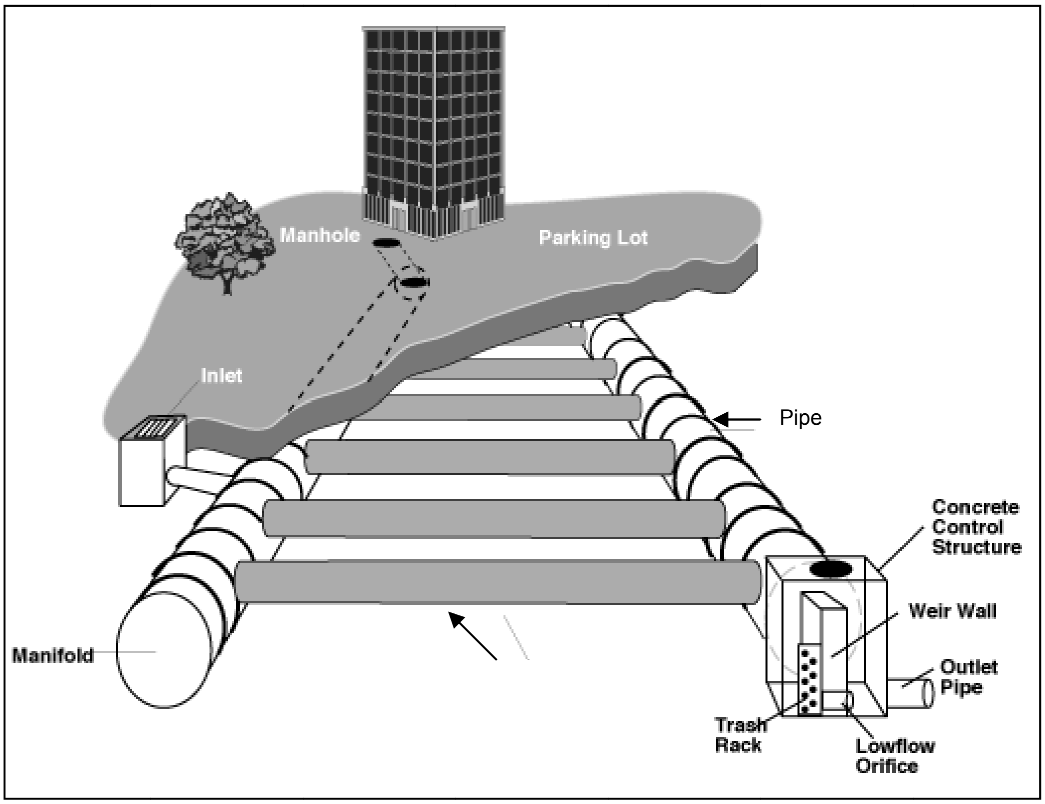


**Figure 3-54 Example Underground Detention Tank System**

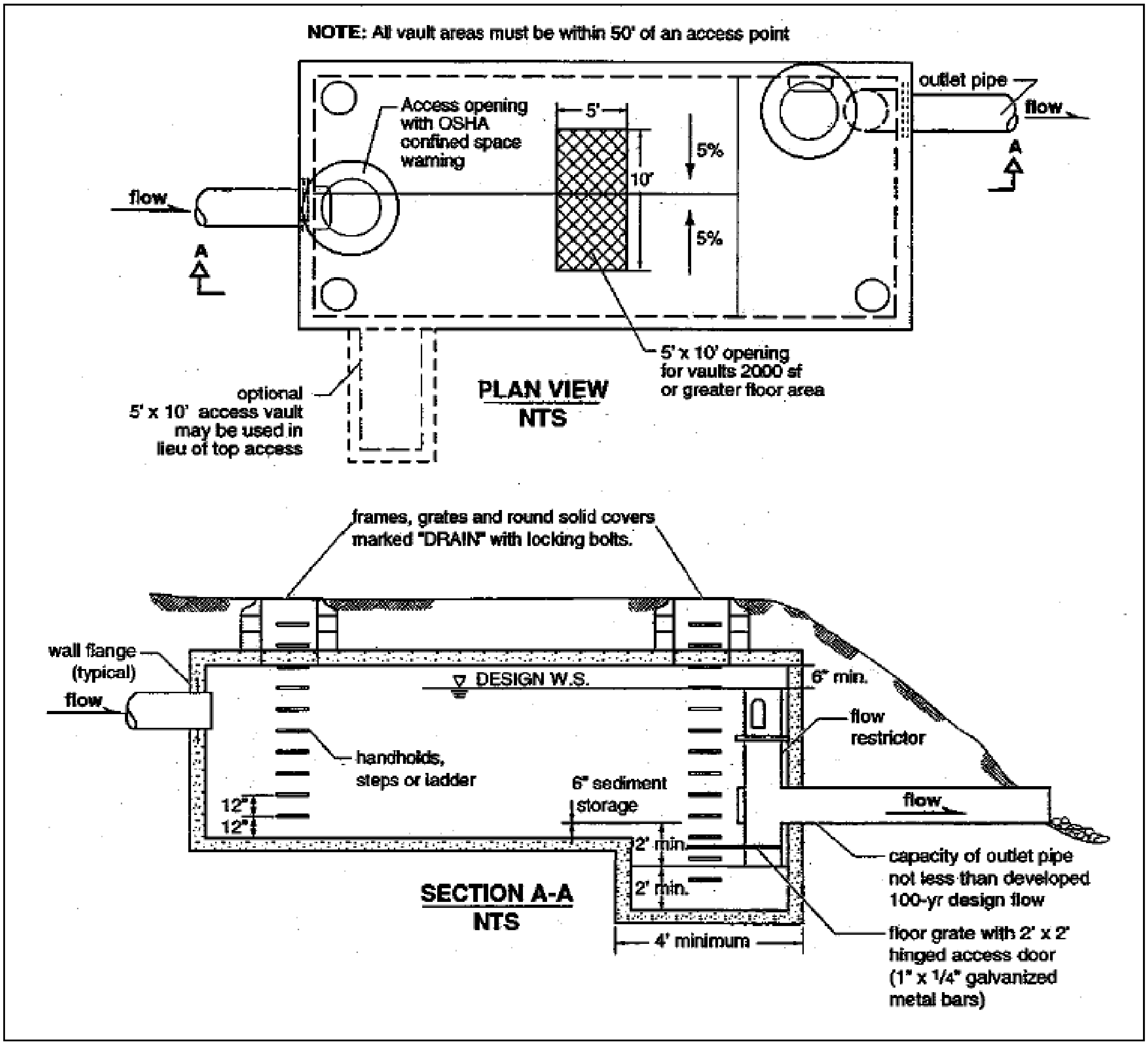


**Figure 3-55 Schematic of Typical Underground Detention Vault**
(Source: WDE, 2000)

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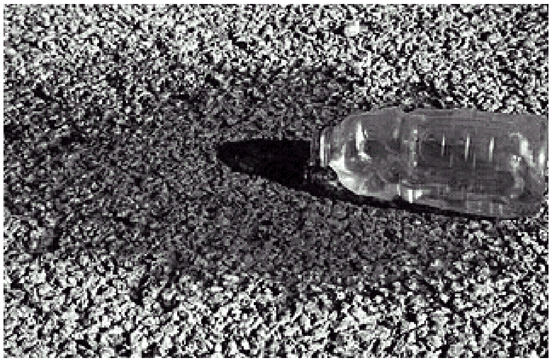
## 3.4.3 Porous Pavement

**Other Water Quantity Facility**



**Description:** Porous concrete is the term for a mixture of coarse aggregate, portland cement and water that allows for rapid infiltration of water through the material. The pavement overlays a stone aggregate base lined with geotextile. This aggregate reservoir provides temporary storage as runoff infiltrates into underlying permeable soils.

### KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Should not be used in areas of soils with low permeability, wellhead protection zones, or areas of water supply aquifer recharge
- Soil infiltration rate of 0.5 in/hr or greater required
- Excavated area filled with stone media, gravel and sand filter layers with observation well

**ADVANTAGES / BENEFITS:**

- Provides reduction in runoff volume
- Less need for inlets and piping

**DISADVANTAGES / LIMITATIONS:**

- Restrictions on use by heavy vehicles
- High maintenance requirements
- Special attention to design and construction needed
- Potential for high failure rate if poorly designed, poorly constructed, not adequately maintained, or used in unstabilized (eroding soil) areas
- Snow and ice removal limited
- Potential for groundwater contamination
- Not allowed for TSS removal

### POLLUTANT REMOVAL

| | |
|---|---|
| -- | **Total Suspended Solids** |
| H | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| -- | **Pathogens –** Coliform, Streptococci & E. Coli |

### STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| | **On-Site Flood Control** |
| | **Downstream Flood Control** |

### IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| M | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *5 acres max*

**Soils**: *Soil infiltration rate of 0.5 in/hr or greater required, unless an underdrain is provided*

**L**=Low **M**=Moderate **H**=High

### 3.4.3.1 General Description

Porous pavement (also referred to as enhanced porosity concrete, porous concrete, portland cement pervious pavement, and pervious pavement) is a subset of a broader family of pervious pavements including porous asphalt, and various kinds of grids and paver systems. Porous concrete is thought to have a greater ability than porous asphalt to maintain its porosity in hot weather and thus is provided as a limited application control in this manual. Although, porous concrete has seen growing use, there is still limited practical experience with this measure. According to the U.S. EPA, porous pavement sites have had a high failure rate – approximately 75 percent. Failure has been attributed to poor design, inadequate construction techniques, soils with low permeability, heavy vehicular traffic, and poor maintenance. This measure, if used, should be carefully monitored.

Porous concrete consists of a specially formulated mixture of portland cement, uniform open graded coarse aggregate, and water. The concrete layer has a high permeability that is often many times that of the underlying permeable soil layer which allows rapid percolation of rainwater through the surface and into the layers beneath. The void space in porous concrete is in the 15% to 22% range compared to three to five percent for conventional pavements. The permeable surface is placed over a layer of open-graded gravel and crushed stone. The void spaces in the stone act as a storage reservoir for runoff.

For some sites, porous pavement can be designed to capture and infiltrate part or all of the $CP_v$ when the option of infiltrating the difference between the pre- and post-development 1-year, 24-hour runoff is used. Porous concrete will need to be used in conjunction with another structural control to provide downstream flood control, as required.

The infiltration rate of the soils in the subgrade should be adequate to support drawdown of the entire runoff capture volume within 24 to 48 hours. Special care must be taken during construction to avoid undue compaction of the underlying soils which could affect the soil infiltration capability.

Porous concrete systems are typically used in low-traffic areas such as the following types of applications:

- Parking pads in parking lots;
- Overflow parking areas;
- Residential street parking lanes;
- Recreational trails;
- Golf cart and pedestrian paths;
- Plazas and public squares;
- Emergency vehicle and fire access lanes.

Slopes should be flat or gentle to facilitate infiltration versus runoff.

The historically high groundwater water table should be a minimum of five feet below the bottom of the gravel layer; 2 feet for pavements with under drains.

Porous concrete has the positive characteristics of volume reduction due to infiltration, groundwater recharge, and an ability to blend into the urban landscape relatively unnoticed.

A drawback is the complexity of porous concrete systems compared to conventional pavements. Porous concrete systems require a very high level of construction workmanship to ensure that they function as designed. They experience a high failure rate if they are not designed, constructed, and maintained properly.

Like other infiltration controls, porous concrete should not be used in areas that experience high rates of particle deposition by wind, and or in traffic areas where sanding or salting is used during winter weather.

### 3.4.3.2 Pollutant Removal Capabilities

The following deisgn pollutant removal rates are average polluntant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment.

- Total Suspnded Solids – must not be used to remove this pollutant
- Total Phosphorus – 80%
- Total Nitrogen – 80%
- Metals – 90%
- Fecal Coliform – must not be used to remove this pollutant

### 3.4.3.3 Design Criteria and Specifications

- Porous concrete systems can be used where the underlying in-situ subsoils have an infiltration rate greater than 0.5 inches per hour or the use of an underdrain. Therefore, porous concrete systems are not suitable on sites with hydrologic group D or most group C soils, or soils with a high (>30%) clay content. During construction and preparation of the subgrade, special care must be taken to avoid compaction of the underlying soils. If used on poorly drained soils, an underdrain may be provided beneath the base stone to dewater the pavement.
- Porous pavement may be used to achieve part or all of the channel protection requirements (i.e., infiltrating all or part of the difference between the pre- and post-development 1-year, 24-hour runoff) by sizing the pavement and infiltration bed to accommodate all or part of the $CP_V$ runoff.
- If it is a load bearing surface, then the pavement and underlying bed system should be able to support the maximum design load.

- Porous concrete systems shall not be used on slopes greater than 5% with slopes of no greater than 2% recommended. For slopes greater than 1% barriers perpendicular to the direction of drainage should be installed in sub-grade material to keep it from washing away. Filter fabric shall be placed at the bottom and sides of the aggregate to keep soil from migrating into the aggregate and reducing porosity.
- A minimum of two feet of clearance is recommended between the bottom of the gravel base course and underlying bedrock or five feet above the historic high groundwater table; 2 feet for systems with under drains.
- Porous concrete systems should be sited at least 10 feet down-gradient from buildings and a safe distance away from drinking water wells.
- To protect groundwater from potential contamination, runoff from untreated designated hotspot landuses or activities must not be infiltrated. Porous concrete should not be used for manufacturing and industrial sites, where there is a potential for high concentrations of soluble pollutants and heavy metals. In addition, porous concrete should not be considered for areas with a high pesticide concentration. Porous concrete is also not suitable in areas with karst geology without adequate geotechnical testing by qualified individuals and in accordance with local requirements.
- The design must use methods to convey runoff from rainfall larger than the design event to the conveyance system.
- A maintenance right of way or easement must be provided to the facility from a public road or easement. The maintenance access easement shall be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- The cross-section typically consists of four layers, as shown in Figure 3-56. Descriptions of each of the layers is presented below:

  <u>Porous Concrete Layer:</u> The porous concrete layer consists of an open-graded concrete mixture usually ranging from depths of 6 to 8 inches depending on required bearing strength and pavement design requirements. Porous concrete can be assumed to contain 18 percent voids (porosity = 0.18) for design purposes. Thus, for example, a 4 inch thick porous concrete layer would hold 0.72 inches of rainfall. The omission of the fine aggregate provides the porosity of the porous pavement. To provide a smooth riding surface and to enhance handling and placement a coarse aggregate of 3/8 inch maximum size is normally used. Use coarse aggregate (3/8 to No. 16) per ASTM C 33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448.

  <u>Top Filter Layer:</u> Consists of a 1/2 inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous concrete layer.

  <u>Reservoir Layer:</u> The reservoir gravel base course consists of washed, bank-run gravel, 0.5 to 2.5 inches in diameter with a void space of about 40% meeting the gradation listed below. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of ten inches. The layer should be designed to drain

completely in 48 hours. Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 (this includes a factor of safety) should be used in calculations unless aggregate specific data exist.

**Table 3-9 Percent Passing per Sieve Size for Aggregate Gradation**

| Gradation | |
|---|---|
| Sieve Size | % Passing |
| 2 ½” | 100 |
| 2” | 90 – 100 |
| 1 ½” | 35 – 70 |
| 1” | 0 – 15 |
| ½” | 0 - 5 |

<u>Bottom Filter Layer:</u> The surface of the subgrade should be an 6 inch layer of sand (ASTM C-33 concrete sand) and be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

<u>Filter Fabric:</u> It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Fabric should be MIRIFI # 140N or equivalent.

<u>Underlying Soil:</u> The underlying soil should have an infiltration capacity of at least 0.5 in/hr, but preferably greater than 0.5 in/hr as initially determined from NRCS soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test per 5000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability. Often a double-ring infiltrometer test is done at subgrade elevation to determine the infiltration rate of the least permeable layer, and, for safety, one-half that measured value is taken for infiltration calculations. Porous pavement cannot be used on fill soils.

- Details of construction of the concrete layer are beyond the scope of this manual. However, construction of porous concrete requires precision and requires special handling, timing, and placement to perform adequately (LACDPW, 2000, Paine, 1992, Maryland, 1984). Installers shall be certified in the placement of porous concrete.

- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no

more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### 3.4.3.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Templates for each stormwater management facility can be found in Volume 3 of this manual. These templates can be amended slightly for use in more customized O&M plans.
3. As-built drawings must accurately identify the location of porous pavement and maintenance access easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

### 3.4.3.5 Example Schematics

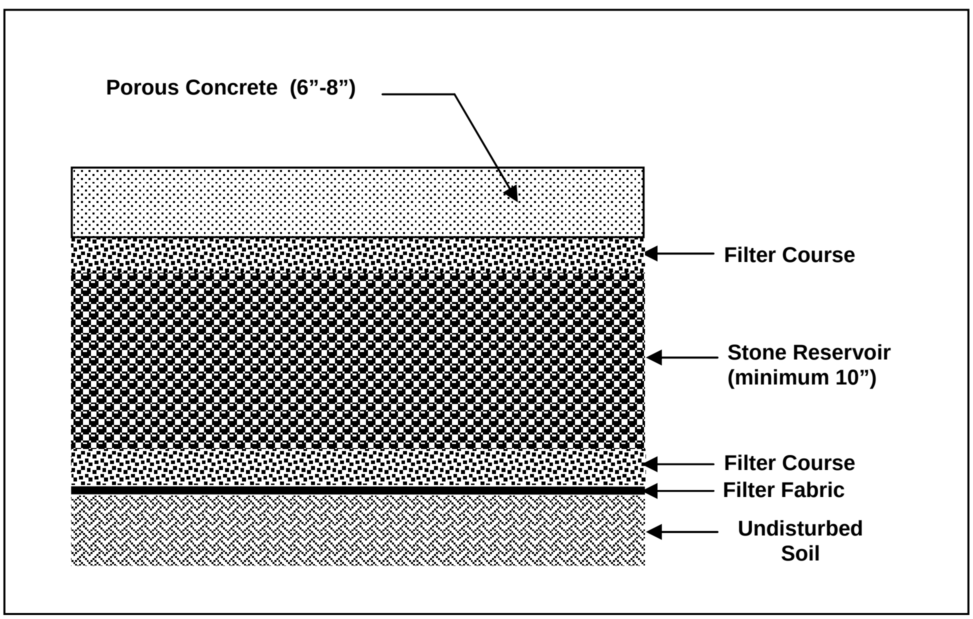



**Figure 3-56 Porous Concrete System Section**
(Modified From: LAC 2000)

**Figure 3-57 Porous Concrete System Installation**

**Figure 3-58 Typical Porous Concrete System Applications**
(Knox Co., TN, 2008)

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# 3.4.4 Modular Porous Paver Systems

**Other Water Quantity Facility**

**Description:** A pavement surface composed of structural units with void areas that are filled with pervious materials such as sand, gravel or grass turf. Porous pavers are installed over a gravel base course that provides storage as runoff infiltrates through the porous paver system into underlying permeable soils.

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Intended for low volume traffic areas, or for residential or overflow parking applications
- Should not be used in areas of soils with low permeability, wellhead protection zones, or recharge areas of water supply aquifer recharge
- Soil infiltration rate of 0.5 in/hr or greater required, unless an underdrain is provided

**ADVANTAGES / BENEFITS:**

- Provides reduction in runoff volume
- Available from commercial vendors

**DISADVANTAGES / LIMITATIONS:**

- Restrictions on use by heavy vehicles
- High maintenance requirements
- Potential for high failure rate if not adequately maintained or used in unstabilized areas
- Potential for groundwater contamination
- Not allowed for TSS removal

## POLLUTANT REMOVAL

| | |
|---|---|
| -- | **Total Suspended Solids** |
| H | **Nutrients –** Total Phosphorus & Total Nitrogen |
| H | **Metals –** Cadmium, Copper, Lead & Zinc |
| -- | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Protection** |
| ✓ | **Channel Protection** |
| | **On-Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| M | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *Yes*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *5 acres max*

**Soils**: *Soil infiltration rate of 0.5 in/hr or greater required, unless an underdrain is provided*

**L**=Low **M**=Moderate **H**=High

### 3.4.4.1 General Description

Modular porous pavers are structural units, such as concrete blocks, bricks, or reinforced plastic mats, with regularly interspersed void areas used to create a load-bearing pavement surface. The void areas are filled with pervious materials (gravel, sand, or grass turf) to create a system that allows for the infiltration of stormwater runoff. The use of porous paver systems results in a reduction of the effective impervious area on a site (see Section 3.4.4.3), and the additional infiltration may be used to infiltrate all or part of the difference between the pre- and post-development 1-year, 24-hour $CP_V$.

There are many different types of modular porous pavers available from different manufacturers, including both pre-cast and mold in-place concrete blocks, concrete grids, interlocking bricks, and plastic mats with hollow rings or hexagonal cells (see Figure 3-59).

Modular porous pavers are typically placed on a gravel (stone aggregate) base course. Runoff infiltrates through the porous paver surface into the gravel base course, which acts as a storage reservoir as it infiltrates to the underlying soil. The infiltration rate of the soils in the subgrade must be adequate to support drawdown of the entire runoff capture volume within 24 to 48 hours. Special care must be taken during construction to avoid undue compaction of the underlying soils, which could affect the soils' infiltration capability.

Modular porous paver systems are typically used in low-traffic areas such as the following types of applications:

- Parking pads in parking lots;
- Overflow parking areas;
- Residential driveways;
- Residential street parking lanes;
- Recreational trails;
- Golf cart and pedestrian paths;
- Emergency vehicle and fire access lanes.

Slopes should be flat or gentle to facilitate infiltration versus runoff. Bedrock should be a minimum of two feet below the bottom of the gravel layer, and historically high groundwater must be at least 5 feet below the bottom of the gravel bed.

Porous paver systems have the positive characteristics of volume reduction due to infiltration, groundwater recharge, and an ability to blend into the normal urban landscape relatively unnoticed. It also may result in a reduction in the need for (and cost of) other stormwater infrastructure which may somewhat offset the placement cost.

A major drawback is the cost and complexity of modular porous paver systems compared to conventional pavements. Porous paver systems require a very high level of construction workmanship to ensure that they function as designed and do not settle unevenly. In addition, there is the difficulty and cost of rehabilitating the surfaces should they become clogged. Therefore, consideration of porous paver systems should include the construction and maintenance requirements and costs.

Like other infiltration controls, porous paver systems should not be used in areas that experience high rates of wind deposited particulates, or receive inflow from areas with highly erosive (unstable) soils. Also it cannot be used in traffic areas where sanding or salting is used during winter weather.

### 3.4.4.2 Pollutant Removal Capabilities

The following deisgn pollutant removal rates are average polluntant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment.

- Total Suspnded Solids – must not be used to remove this pollutant
- Total Phosphorus – 80%
- Total Nitrogen – 80%
- Metals – 90%
- Fecal Coliform – must not be used to remove this pollutant

### 3.4.4.3 Design Criteria and Specifications

- Porous paver systems can be used where the underlying in-situ subsoils have an infiltration rate of between 0.5 and 3.0 inches per hour. Therefore, porous paver systems are not suitable on sites with hydrologic group D or most group C soils, or soils with a high (>30%) clay content without an under drain system. During construction and preparation of the subgrade, special care must be taken to avoid compaction of the soils.
- Porous paver systems should ideally be used in applications where the pavement receives tributary runoff only from impervious areas. The ratio of the contributing impervious area to the porous paver surface area should be no greater than 3:1.
- If runoff is coming from adjacent pervious areas, it is important that those areas be fully stabilized to prevent sediment loads and clogging of the porous paver surface. Pretreatment using filter strips or vegetated swales for coarse sediment removal is recommended.
- Porous paver systems are not recommended on sites with a slope greater than 2%.
- A minimum of 2 feet of clearance is required between the bottom of the gravel base course and underlying bedrock, or 5 feet above the historically high groundwater table. Inflow from untreated hotspots is not permitted.
- Porous paver systems should be sited at least 10 feet down gradient from buildings and a safe distance from drinking water wells.

- An appropriate modular porous paver should be selected for the intended application. A minimum of 40% of the surface area should consist of open void space. If it is a load bearing surface, then the pavers should be able to support the maximum load.
- For flood control calculations, the area may be assumed to be 60% impervious, and 40% disturbed “B” soil.
- The porous paver infill is selected based on the volume to be infiltrated and the infiltration rate. Masonry sand (such as ASTM C-33 concrete sand) has a high infiltration rate and should be used in applications where no vegetation is desired. A sandy loam soil has a substantially lower infiltration rate, but will provide for growth of a grass ground cover.
- A 1-inch top course (filter layer) of sand (ASTM C-33 concrete sand) underlain by filter fabric is placed under the porous pavers and above the gravel base course.
- The gravel base course consists of washed, bank-run gravel, 0.5 to 2.5 inches in diameter with a void space of about 40% meeting the gradation listed below. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer should be designed to drain completely in 24-48 hours. Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 (this includes a factor of safety) should be used in calculations unless aggregate specific data exist.

**Table 3-10 Percent Passing per Sieve Size for Aggregate Gradation**

| Gradation | |
|---|---|
| Sieve Size | % Passing |
| 2 ½” | 100 |
| 2” | 90 – 100 |
| 1 ½” | 35 – 70 |
| 1” | 0 – 15 |
| ½” | 0 - 5 |

- The surface of the subgrade should be lined with filter fabric and an 8-inch layer of sand (ASTM C-33 concrete sand) and be flat to promote infiltration across the entire surface.
- The porous paver system must be designed to convey larger storm event flows to the conveyance system.
- For the purpose of sizing downstream flood conveyance and controls, porous paver surface areas can be assumed to be 40% disturbed ”B” soil and 60% impervious rather than 100% impervious.
- The local jurisdiction may require that the facility be placed in a reserve and/or establishment of a drainage easement the facility, which is accessible from a public road or other accessible easement. When required, the drainage easement should be at least 20 feet wide, provide a minimum traversable width of 15 feet, have a maximum slope of no

more than 10%, and be appropriately stabilized to withstand maintenance equipment and vehicles.

### 3.4.4.4 Inspection and Maintenance Requirements

Regular inspection and maintenance is critical to the effective operation of stormwater management facilities. An operation and maintenance plan is required and shall include:

1. "Covenants for Permanent Maintenance of Stormwater Management Facilities" (also called the "Maintenance Covenants"). An example covenants document can be found in Volume 3.
2. "Inspection Checklist and Maintenance Guidance" for each type of stormwater facility that is located on the property. Detailed inspection and maintenance guidance shall be provided by the manufacturer and/or design engineer.
3. As-built drawings must accurately identify the location of the paver area, and also clearly identify the reserves and maintenance easements.

All stormwater management facilities must be maintained in accordance with the O&M Plan.

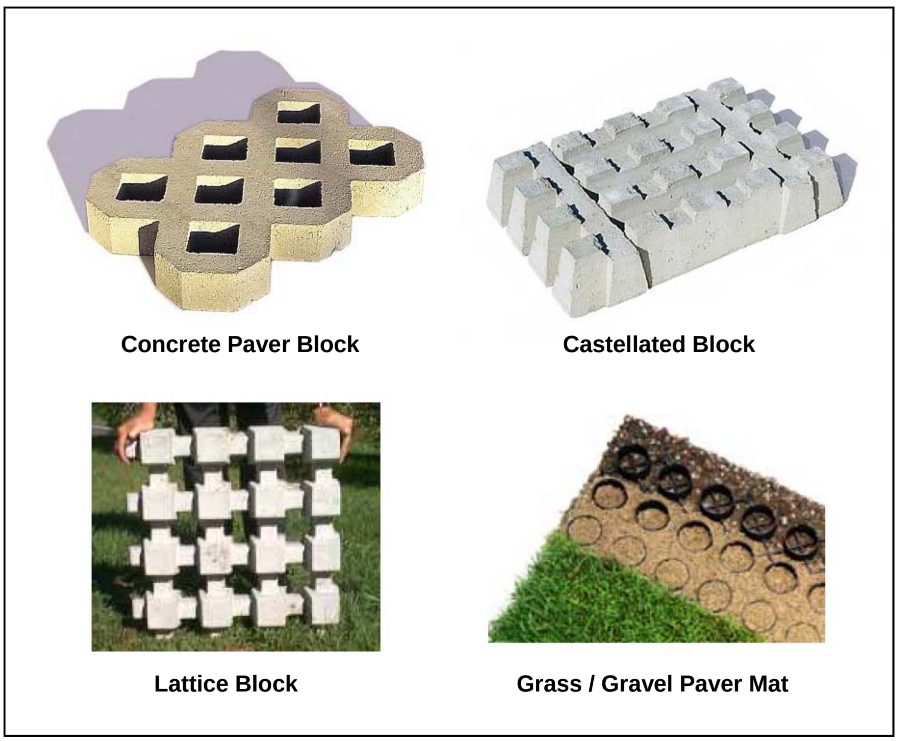


**Figure 3-59 Examples of Modular Porous Pavers**

## 3.4.4.5 Example Schematics

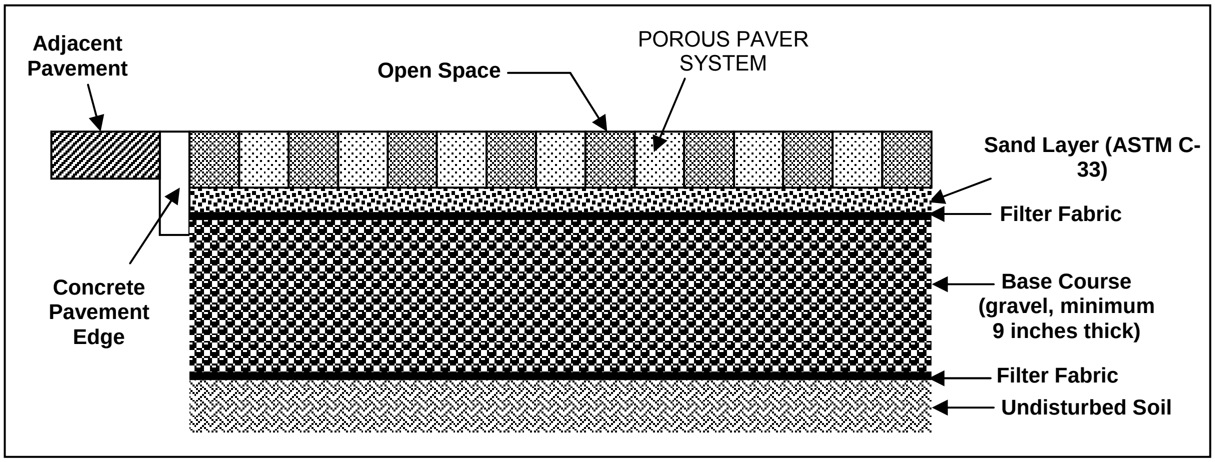


**Figure 3-60 Modular Porous Paver System Section**

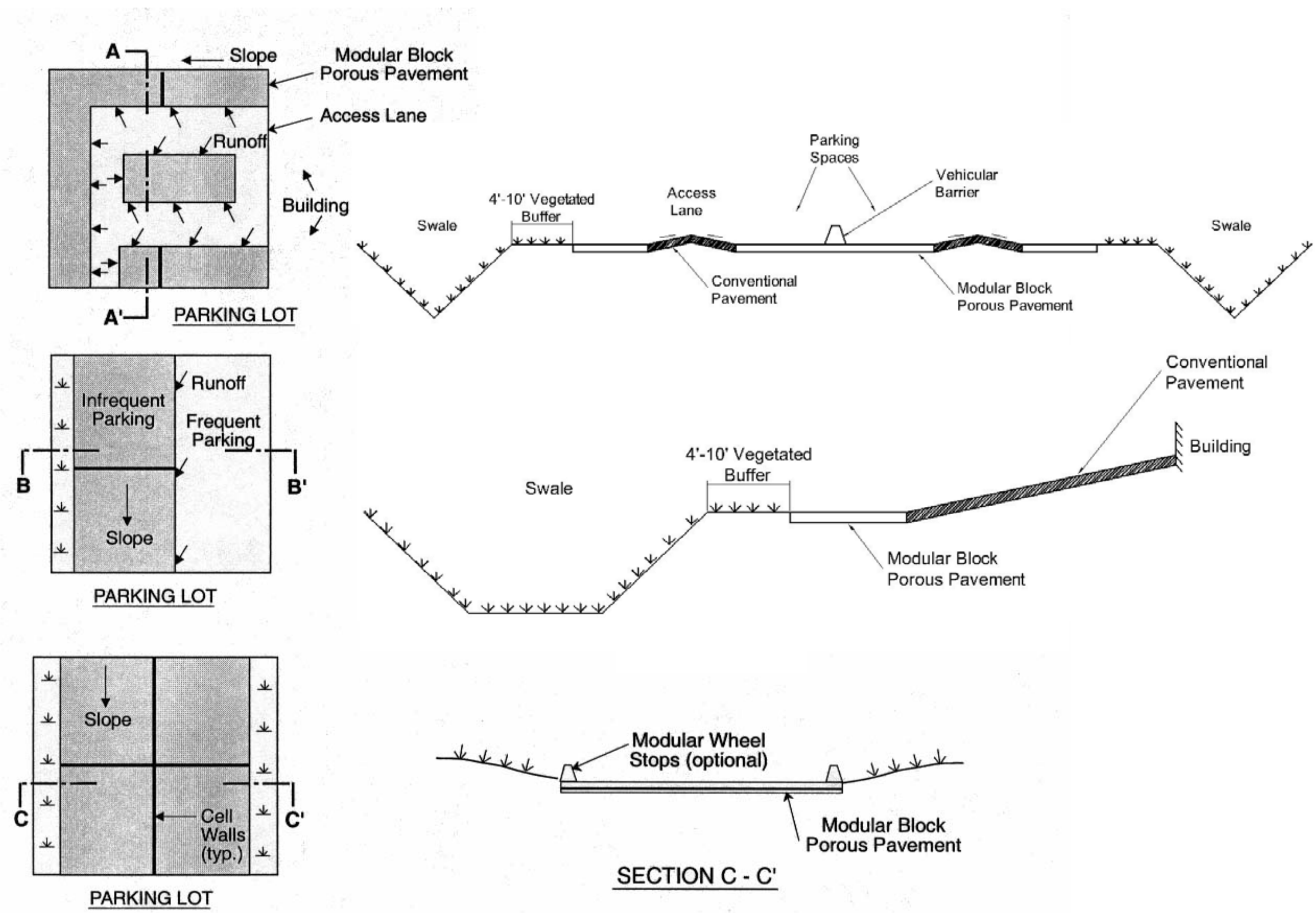


**Figure 3-61 Typical Modular Porous Paver System Applications**
(Source: UDFCD, 1999)

# 3.4.5 Green Roof

**Other Water Quality Facility**

**Description:** A green roof uses a small amount of substrate over an impermeable membrane to support a covering of plants. The green roof detains/retains runoff from the otherwise impervious roof surface as well as moderate rooftop temperatures. With the right plants, a green roof will also provide aesthetic or habitat benefits. Green roofs have been used in Europe for decades.

*(Hamilton Building, Portland OR)*

## KEY CONSIDERATIONS

**DESIGN CRITERIA:**

- Relatively new in North America
- Potential for high failure rate if poorly designed, poorly constructed, not adequately maintained

**ADVANTAGES / BENEFITS:**

- Provides reduction in runoff volume
- Energy savings, aesthetics, allows dual use, noise reduction, reduces urban heat island effect

**DISADVANTAGES / LIMITATIONS:**

- High cost
- Requires additional roof support
- Requires more maintenance than regular roofs
- Special attention to design and construction needed
- Requires close coordination with plant specialists
- Potential for leakage due to plant roots penetrating membrane

## POLLUTANT REMOVAL

| | |
|---|---|
| -- | **Total Suspended Solids** |
| -- | **Nutrients –** Total Phosphorus & Total Nitrogen |
| -- | **Metals –** Cadmium, Copper, Lead & Zinc |
| -- | **Pathogens –** Coliform, Streptococci & E. Coli |

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| ✓ | **Water Quality Prot ctio** |
| ✓ | **Channel Protection** |
| | **On Site Flood Control** |
| | **Downstream Flood Control** |

## IMPLEMENTATION CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirements** |
| H | **Relative Capital Costs** |
| H | **Maintenance Burden** |

**Residential Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *No restrictions.*

**Soils**: *No restrictions*

**L**=Low **M**=Moderate **H**=High

### 3.4.5.1 General Description

Green roofs (also referred to as vegetated roofs, ecoroofs, roof gardens, or roof meadows) are vegetated roofs used in place of conventional roofing, such as gravel-ballasted roofs. They are used as part of sustainable development initiatives, along with narrow streets, permeable pavement, and various infiltration devices. There are two main types of green roofs. The first is what is called roof gardens or intensive green roofs. They may be thought of as a garden on the roof. They have a greater diversity of plants, including trees and shrubs, but require deeper soil, increased load bearing capacity, and require more maintenance. The second has been referred to as roof meadows or extensive green roofs. The vegetation is limited and similar to an alpine meadow, requiring less soil depth and minimal maintenance. Due to the considerably greater costs and structural design requirements of intensive green roofs, only the second type of green roof, the roof meadow or extensive type is discussed in this manual.

The green roof is designed to control smaller storms by intercepting and retaining or storing water until the peak storm event has passed. The plants intercept and delay runoff by capturing and holding precipitation in the foliage, absorbing water in the root zone, and slowing the velocity of direct runoff by increasing retardance to flow and extending the flowpath through the vegetation. Water is also stored and evaporated from the growing media. Green roofs can capture and evaporate up to 100 percent of the incident precipitation, depending on the roof design and the storm characteristics.

Monitoring in Pennsylvania, for instance, showed reductions of approximately 2/3 in runoff from a green roof (15.5 inches runoff from 44 inches of rainfall). Furthermore, runoff was negligible for storm events of less than 0.6 inches. A study done for Portland, Oregon, indicated a reduction in stormwater discharges from the downtown area of between 11 and 15% annually if half of the roofs in the downtown area were retrofitted as green roofs.

Green roofs also:

- reduce the temperature of runoff;
- reduce the “heat island” effect of urban buildings;
- help insulate the building;
- improve visual aesthetics;
- protect roofs from weather;
- improve building insulation;
- reduce noise; and,
- provide habitat for wildlife.

As with a conventional roof, a green roof must safely drain runoff from the roof. It may be desirable to drain the runoff to a rainwater harvesting system such as rain barrels or other stormwater facilities such as rain gardens and swales.

Significant removals of heavy metals by green roofs have been reported, but there is not enough evidence to include removal rates at this time.

### 3.4.5.2 Design Criteria and Specifications

- An architect or structural engineer must be involved to ensure that the building will provide the structural support needed for a green roof.
- Generally, the building structure must be adequate to hold an additional 10 to 25 pounds per square foot (psf) saturated weight, depending on the vegetation and growth medium that will be used. (This is in addition to snow load requirements.) <u>These loads are for preliminary planning only and may vary significantly from design loads</u>.
- Green roofs can be used on flat or pitched roofs up to 40 percent. Although, on a roof slope greater than 10 degrees, the green roof installer needs to ensure that the plant layer does not slip or slump through its own weight, especially when it becomes wet. Horizontal strapping, wood, plastic, or metal, may be necessary. Some commercial support grid systems are also available for this purpose.
- A green roof typically consists of several layers, as shown in Figure 3-62. A waterproof membrane is placed over the roof's structure. A root barrier is placed on top of the membrane to prevent roots from penetrating the membrane and causing leaks. A layer for drainage is installed above this, followed by the growth media. The vegetation is then planted to form the top layer. Details of the various layers are given below.
- Waterproof membranes are made of various materials, such as synthetic rubber (EPDM), hypolan (CPSE), reinforced PVC, or modified asphalts (bitumens). The membranes are available in various forms, liquid, sheets, or rolls. Check with the manufacturer to determine their strength and functional characteristics of the membrane under consideration.
- Root barriers are made of dense materials or are treated with copper or other materials that inhibit root penetration, protecting the waterproof membrane from being breached. A root barrier may not be necessary for synthetic rubber or reinforced PVC membranes, but will likely be needed for asphalt mixtures. Check with the manufacturer to determine if a root barrier is required for a particular product.
- The drainage layer of a green roof is usually constructed of various forms of plastic sheeting, a layer of gravel, or in some cases, the growth medium.
- The growth medium is generally 2 to 6 inches thick and made of a material that drains relatively quickly. Commercial mixtures containing coir (coconut fiber), pumice, or expanded clay are available. Sand, gravel, crushed brick, and peat are also commonly used. Suppliers recommend limiting organic material to less than 33% to reduce fire hazards and prevent long-term degradation. The City of Portland, Oregon has found a mix of 1/3 topsoil, 1/3 compost, and 1/3 perlite may be sufficient for many applications. Growth media can weigh from 16 to 35 psf when saturated depending on the type (intensive/extensive), with the most typical range being from 10-25 psf.

- When dry, all of the growth media are light-weight and prone to wind erosion. It is important to keep media covered before planting and ensure good coverage after vegetation is established.
- Selecting the right vegetation is critical to minimize maintenance requirements. Due to the shallowness of the growing medium and the extreme desert-like microclimate on many roofs, plants are typically alpine, dryland, or indigenous. Ideally, the vegetation should be:
  - Drought-tolerant, requiring little or no irrigation after establishment;
  - Self-sustaining, without fertilizers, pesticides, or herbicides;
  - Able to withstand heat, cold, and high winds;
  - Shallow root structure;
  - Low growing, needing little or no mowing or trimming; and,
  - Perennial or self propagating, able to spread and cover blank spots by itself.
- A mix of sedum/succulent plant communities is recommended because they possess many of these attributes. Certain wildflowers, herbs, forbs, grasses, mosses, and other low groundcovers can also be used to provide additional habitat benefits or aesthetics; however, these plants need more watering and maintenance to survive and keep their appearance.
- Green roof vegetation is usually established by one or more of the following methods: seeding, cuttings, vegetation mats, and plugs/potted plants.
  - Seeds can be either hand sown or broadcast in a slurry (hydroseeded). Seeding takes longer to establish and requires more weeding, erosion control, and watering than the other methods.
  - Cuttings or sprigs are small plant sections. They are hand sown and require more weeding, erosion control, and watering than mats.
  - Vegetation mats are sod-like mats that achieve full plant coverage very quickly. They provide immediate erosion control, do not need mulch, and minimize weed intrusion. They generally require less ongoing maintenance than the other methods but are more expensive.
  - Plugs or potted plants may provide more design flexibility than mats. However, they take longer to achieve full coverage, are more prone to erosion, need more watering during establishment, require mulching, and more weeding.
- Irrigation is necessary during the establishment period and possibly during drought conditions, regardless of the planting method used. The goal is to minimize the need for irrigation by paying close attention to plant selection, soil, and various roof characteristics.
- It is necessary to provide controlled overflow point(s) to prevent overloading of roof.

### 3.4.5.3 Inspection and Maintenance Requirements

**Table 3-11 Typical Maintenance Activities for Green Roofs**

| Activity | Schedule |
|---|---|
| Watering to help establish vegetation | As needed |
| Replant to cover bare spots or dead plants | Monthly |
| Weeding (as needed, based on inspection) | Two or three times yearly |
| Water and trimming to prevent fire hazards (if grasses or similar plants are used) | As needed |
| Inspect drains for clogging | Twice per year |
| Inspect the roof for leakage | Annually, or as needed |
| If leaks occur, remove and stockpile vegetation, growth media, and drainage layer. Replace membrane and root barrier, followed by stockpiled material. | Upon failure |

### 3.4.5.4 Example Schematic

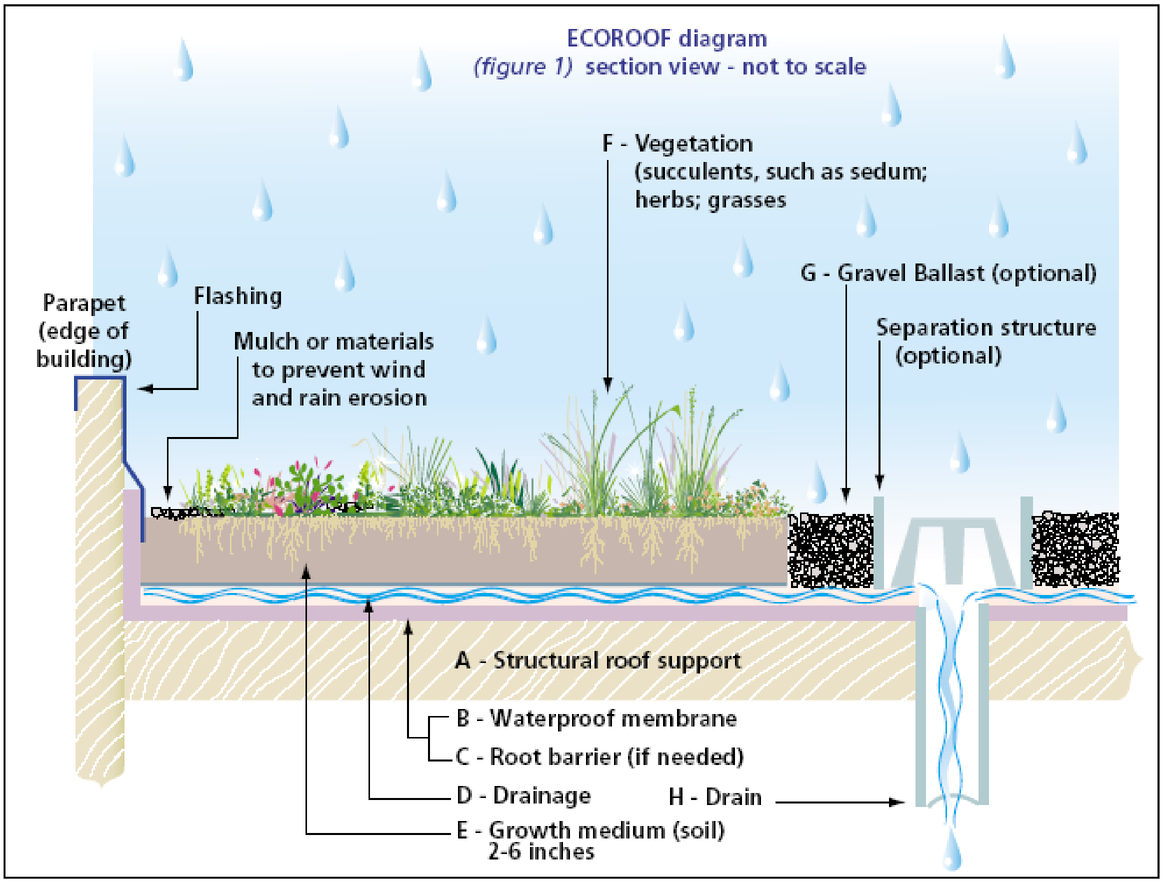


**Figure 3-62 Typical Green Roof Cross Section**
(from City of Portland, Oregon)

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CHAPTER

4

# HYDROLOGIC ANALYSIS

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## 4.1 Introduction to Hydrologic Analysis

This Section addresses surface water hydrology and % TSS Removal Calculation only; it does not address groundwater hydrology. Therefore all references in this Manual to “hydrology” means surface water hydrology. Also, in this chapter the terms “subbasin” and “catchment” (used interchangeably) refer to a single drainage area being analyzed by the various techniques, independently of any other subbasins or catchments that make up the basin or watershed being analyzed. For example, the peak flow computed by one of the peak flow only methods (Regression or Rational), or a unit hydrograph developed for a specific drainage area (e.g., NRCS), are applied to subbasins or catchments. Subbasins or catchments make up basins or watersheds, along with channels, reservoirs, and other hydrologic features as applicable.

Hydrology deals with estimating peak flows, runoff volumes, and time distributions of runoff. The analysis of these parameters is fundamental to the design of stormwater management facilities, such as storm drainage systems and structural stormwater controls. In the hydrologic analysis of a development/redevelopment site, there are a number of factors that affect the nature of stormwater runoff from the site. Some of the factors to be considered are:

- Rainfall amount and distribution;
- Drainage area size and shape;
- Ground cover and soil type;
- Slopes of terrain, streams and channels;
- Antecedent moisture (or runoff) conditions;
- Rainfall abstraction or loss rates (initial and continued);
- Storage potential (floodplains, ponds, wetlands, reservoirs, channels, etc.);
- Watershed development; and,
- Characteristics of the local drainage system.

There are a number of hydrologic methods available to estimate runoff characteristics for a site or drainage subbasin. Some of those methods provide estimates of peak discharge only. Some provide estimates of runoff volume only. Special methods estimate the runoff volume for small storms that are not readily analyzed using more conventional methods. Others provide estimates of the full hydrograph (discharge versus time, and thus the distribution of runoff volume). In addition, there are methods available for estimating long-term runoff for use in water balance applications.

Rainfall, of course, is the primary driver for all of the methods mentioned above. The depth and distribution of rainfall during storm events is critical to estimating peak flows as well as the distribution of discharge over time.

For some applications, it is necessary to “route” flow through a control structure such as a stormwater pond and outlet. The temporary storage of inflowing water (detention) tends to attenuate the inflow hydrograph, resulting in outflow with a lower peak but increased duration. Thus, routing is fundamental to the design of stormwater storage facilities.

This chapter provides descriptions of the hydrologic methods to be used to implement the requirements of this Manual.

## 4.2 Rainfall

A rainfall event-based hydrologic analysis requires an estimate of the amount (depth or intensity) of rainfall that will occur on the site during a specified duration for a specified average return period. The average return period (sometimes referred to as average return interval or frequency) is expressed in years. The average annual exceedance probability of the event is the reciprocal of the average return period, and is expressed as the probability that the event will be equalled or exceeded in any given year. (The probability lies between 0 and 1.) For example, an event with an average return interval of 100 years has an average annual probability of being equalled or exceeded of 1/100 = 0.01, or 1%.

For methods discussed in this Manual requiring a distributed rainfall event, the NRCS 24-hour Type 2 rainfall distribution (Figure 4-1) will be used. Table 4-1 lists the 24-hour point rainfall depths for various frequency storm events. These values were derived from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2.0 and the Precipitation Frequency Data Server (PFDS) from the Hydrometeorological Design Studies Center. (Note that the -year through 10-year values are partial durations series depths and the 25-year through 1000-year values are annual maximum series depths. For the larger storms, there is no significant difference between the partial duration and annual series.)

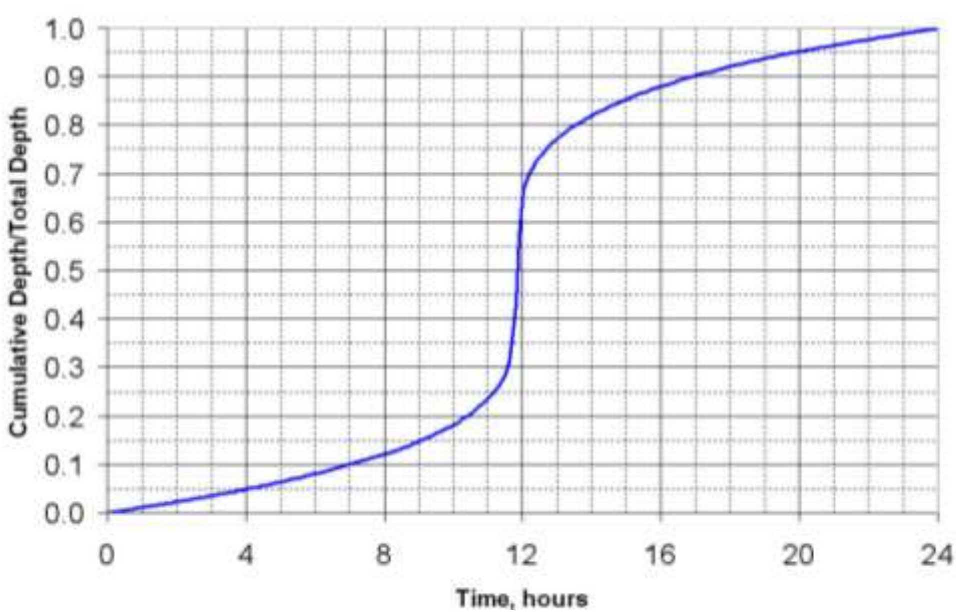


**Figure 4-1 NRCS 24-Hour, Type 2 Rainfall Distribution**

**Table 4-1 Point Rainfall Depths for 24-Hour Design Storms**

| Return Period | 1-Yr | 2-Yr | 5-Yr | 10-Yr | 25-Yr | 50-Yr | 100-Yr | 200-Yr | 500-Yr | 1000-Yr |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (Inches) | 2.90 | 3.39 | 4.24 | 4.98 | 6.03 | 6.91 | 7.83 | 8.78 | 10.10 | 11.10 |

For methods requiring the rainfall intensity of specific durations, a table of point rainfall intensities for Wichita and Sedgwick County has been derived from a regression analysis of the data obtained from NOAA Atlas 14, Volume 8, Version 2.0 and the PFDS, presented in Appendix B. The table is for durations of 15 to 120 minutes, and average return periods of 1 to 1000 years.

The depths and intensities provided herein are point values. Theoretically, these values may be adjusted for actual basin area. Figure 15 of the National Weather Service TP-40 rainfall atlas may be used for that purpose. However, it is general practice to use point values for drainage areas of 10 square miles or less. The reduction is minor (approximately 3% or less) for basins up to 20 square miles. Practically, for the majority of studies performed under the provisions of this Manual, aerial reduction will not be required.

## 4.3 Rainfall Losses

### 4.3.1 Curve Number Method

Except for unusual conditions, not all of the rainfall that falls on a subbasin is discharged as direct runoff. A portion of the rainfall may be retained in depressions, while some may infiltrate into the soil. Other portions of the rainfall may be returned to the atmosphere by vegetative interception and ultimately by transpiration and/or evaporation. The portions of rainfall that do not become direct runoff are referred to collectively as “rainfall losses” or “abstractions” while the rainfall that does become direct runoff is referred to as “excess rainfall” or “direct runoff.”

Rainfall loss is a function of soil characteristics, land-use, antecedent moisture (or runoff) conditions, and other factors. There are many methods used for estimating rainfall losses, with varying degrees of complexity from the standpoint of ease of use as well as data requirements.

For the applications of the hydrology methods presented in this Manual, the NRCS (formerly SCS) “Curve Number” (CN) method will be used. The CN indicates the runoff potential. The greater the CN value, the higher the runoff potential.

An approximate relationship between cumulative rainfall and cumulative runoff was derived by NRCS from experimental plots for numerous soils and cover conditions. The following NRCS runoff equation (SCS, 1986) is used to estimate direct runoff from storm rainfall:

**Equation 4-1** $$Q = \frac{(P - I_a)^2}{[(P - I_a) + S]}$$

where:

| | | |
|---|---|---|
| Q | = | cumulative direct runoff (in) |
| P | = | cumulative rainfall (in) |
| $I_a$ | = | initial abstraction including surface storage, interception, evaporation, and infiltration prior to any runoff occurring (in) |
| S | = | (1000/CN) - 10 where CN = NRCS Curve Number |

An empirical relationship used in the NRCS method (SCS, 1986) for estimating $I_a$ is:

$$I_a = 0.2S$$ (Note that for $P \leq I_a$, $Q = 0$)

This is an average value that could be adjusted if there are calibration data to substantiate the adjustment. Table 4-9 provides values of $I_a$ for a range of CNs.

Substituting 0.2S for $I_a$ in Equation 4-1, the equation becomes:

**Equation 4-2** $$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

**Figure 4-2** shows a graphical solution of this equation. For example, 4.1 inches of direct runoff would result if 5.8 inches of rainfall occurred on a watershed with a curve number of 85.

Equation 4-2 can be rearranged so the CN can be estimated if rainfall and runoff volume are known (Pitt, 1994). The equation then becomes:

**Equation 4-3** $$CN = \frac{1000}{\left[10 + 5P + 10Q - 10(Q^2 + 1.25QP)^{1/2}\right]}$$

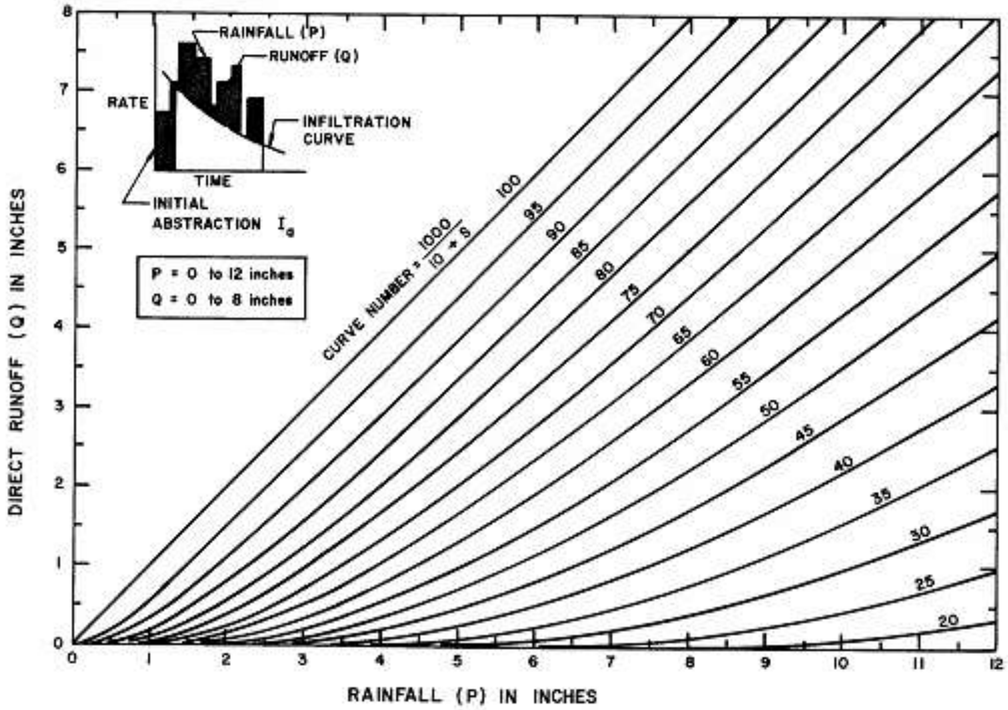


**Figure 4-2 SCS Solution of the Runoff Equation**
(Source: SCS, TR-55, Second Edition, June 1986)

### 4.3.2 Hydrologic Soil Groups

The Curve Number method uses the combination of soil conditions and land uses (ground cover and treatment) to assign a CN to an area.

Soil properties influence the relationship between runoff and rainfall since soils have differing rates of infiltration. Based on infiltration rates, the NRCS has divided soils into four hydrologic soil groups (HSGs).

- HSG A: Soils having a low runoff potential due to high infiltration rates: These soils consist primarily of deep, well-drained sands and gravels.
- HSG B: Soils having a moderately low runoff potential due to moderate infiltration rates: These soils consist primarily of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
- HSG C: Soils having a moderately high runoff potential due to slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water or soils with moderately fine to fine texture.
- HSG D: Soils having a high runoff potential due to very slow infiltration rates. These soils consist primarily of clays with high swelling potential, soils with permanently high water tables, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

Site plans with subbasin boundaries can be overlain on the hydrologic soil group map to aid in the determination of Curve Numbers. Please note that the map includes a soil group identified as “Urban.” These areas should be considered as HSG D soils unless the reviewing authority approves an alternate group classification based on a review of field tests provided by the design engineer.

### 4.3.3 Required Curve Numbers

The CN values in Table 4-2 shall be used for all pre- and post-development hydrologic calculations. The pre-developed CN values for pervious areas are an equal blending of pasture in fair condition and cultivated small grain in good condition. The City of Wichita and Sedgwick County elect to use this land use as a realistic basis for the condition of local watersheds prior to development. The detrimental effect of grading on infiltration rates is acknowledged in the disturbed pervious land use values. This effect can be reduced through preferred site design practices that minimize the grading footprint. The impervious CN of 98 accounts for the near total runoff of rainfall from impervious surfaces. A CN of 100 is to be used for permanent water surfaces such as lakes and ponds.

**Table 4-2 Pre- and Post-Development Curve Numbers**

| Land Use | Hydrologic Soil Group | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Pre-Developed or Undisturbed Pervious | 55 | 71 | 80 | 84 |
| Developed or Disturbed Pervious | 71 | 80 | 84 | 88 |
| Impervious | 98 | 98 | 98 | 98 |

### 4.3.4 Composite Curve Numbers

For a subbasin containing subareas of varying CNs, a composite CN is computed. It should be noted that when composite CNs are used, the analysis does not take into account the location of the specific land uses within the subbasin, but simplifies the drainage area conceptually as a uniform land use represented by the composite CN. The composite CN for a subbasin shall be calculated by using an area-weighted averaging procedure as illustrated in the following example:

**Table 4-3 Calculation of a Composite Curve Number**

| Land Use | Fraction of Total Land Area (1) | CN (2) | Weighted CN (1 x 2) |
|---|---|---|---|
| Disturbed Pervious, “B” Soil | 0.30 | 80 | 24.0 |
| Undisturbed Pervious, “B” Soil | 0.70 | 71 | 49.7 |
| Total Weighted Composite Curve Number = 24.0 + 49.7 = 73.7 | | | |

Except when the simplified method presented in Section 4.8.4 is used, runoff analysis using hydrograph methods shall be performed on pervious and impervious areas separately, rather than using a composite CN that includes the impervious areas for a given subbasin. The separation of pervious and impervious areas ensures the most accurate estimate of runoff peaks and volumes. Free modern software packages like HEC-1, HEC-HMS and EPA-SWMM allow the entry of a pervious CN and % imperviousness for a subbasin.

For large developed watersheds Table 4-4, may be used to estimate the percentage of subbasin area that is impervious.

**Table 4-4 Average Imperviousness per Land Use (Source NRCS, TR-55)**

| Land Use | Average % Impervious |
|---|---|
| **Urban Districts:** | |
| Commercial and business | 85% |
| Industrial | 72% |
| **Residential districts by average lot size:** | |
| 1/8 acre or less (town house) | 65% |
| 1/4 acre | 38% |
| 1/3 acre | 30% |
| 1/2 acre | 25% |
| 1 acre | 20% |
| 2 acres | 12% |

## 4.4 Time of Concentration

The "time of concentration" is equal to the cumulative time for runoff to travel from the hydraulically most remote point of the subbasin being analyzed, to the design point (outlet of the subbasin). In this Manual, the time of concentration is assumed to consist of three types of flow:

- Sheet flow;
- Shallow concentrated flow;
- Channel flow.

Time of concentration ($T_c$) is computed by summing the travel times for these consecutive components of the drainage conveyance system from the hydraulically most distant point of the watershed to the outlet of the subbasin. The following is a discussion of the required procedures and equations (USDA/SCS, 1986 and FHWA, 2001).

***Travel Time***

Travel time is the ratio of flow length to flow velocity, as shown by Equation 4-4 (HEC-22, 2001):

**Equation 4-4** $$T_T = \frac{L}{60V}$$

where:

| | | |
|---|---|---|
| $T_T$ | = | travel time (min) |
| L | = | flow length (ft) |
| V | = | average velocity (ft/s) |
| 60 | = | conversion factor from seconds to minutes |

***Sheet Flow***

Sheet flow shall be calculated using the Equation 4-5, which uses sheet flow roughness coefficients found in Appendix A: (SCS, 1986)

**Equation 4-5** $$T_{T(sheet)} = \frac{0.42(nL)^{0.8}}{(P_2)^{0.5}(S)^{0.4}}$$

where:

| | | |
|---|---|---|
| $T_{T\ (sheet)}$ | = | travel time (min) |
| n | = | Manning sheet flow roughness coefficient (see Appendix Table A-1) |
| L | = | flow length (ft): 100' maximum |
| $P_2$ | = | 2-year, 24-hour rainfall (3.4 inches from Table 4-1) |
| S | = | land slope (ft/ft) |

***Shallow Concentrated Flow***

Overland sheetflow often becomes shallow concentrated flow as it progress down the drainage area. By definition, sheet flow occurs only over plane surfaces at the head of the drainage area. Due to surface irregularities, sheet flow will eventually transition to shallow concentrated flow. The NRCS has determined that sheet flow will never occur for more than 300 feet, regardless of the evenness of the surface. When sheet flow conditions exist (or when the design exceeds the permitted length) the designer will generally use additional segments of shallow flow or channel flow to handle the remainder of the flow path. The average velocity for shallow concentrated flow shall be computed using Equation 4-6 (HEC 22, 2001). The equation uses Table 4-5 to determine K-values.

**Equation 4-6** $$V = KS^{0.5}$$

where:

| | | |
|---|---|---|
| V | = | average velocity (ft/s) |
| K | = | shallow concentrated flow velocity coefficient (see Table 4-5). |
| S | = | slope of hydraulic grade line approximated by the watercourse slope (ft/ft) |

**Table 4-5 Velocity Coefficient (K value) for Shallow Concentrated Flow**

| Shallow Concentrated Flow Cover | K value |
|---|---|
| Wooded w/heavy litter | 2.5 |
| Fallow or no-till cultivation | 4.7 |
| Wooded w/light litter | 5.0 |

| Shallow Concentrated Flow Cover | K value |
|---|---|
| Short grass pasture | 7 |
| Cultivated straight row crop | 9 |
| Nearly bare and untilled | 10 |
| Grassed waterway | 15 |
| Unpaved (as defined by TR-55) | 16.3 |
| Paved | 20.3 |

After determining the average velocity using, use Equation 4-4 to calculate travel time for the shallow concentrated flow segments ($T_{T(shallow)}$).

***Open Channels***

Velocity in channels should be calculated using the Manning equation, Equation 4-7. It is recommended that the upslope beginning of channels be determined in the field. Otherwise, open channels may be assumed to begin where channels are visible on aerial photographs, where channel characteristics are indicated on contour maps, where channels have been identified by the local municipality, or where stream designations appear on United States Geological Survey (USGS) quadrangle sheets. Average flow velocity for travel time calculations shall be determined for bankfull conditions (with the exception discussed below) using Equation 4-7 (HEC-22, 2001):

**Equation 4-7** $$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where:

| | | |
|---|---|---|
| $V$ | = | average velocity (ft/s) |
| $R$ | = | hydraulic radius (ft) and is equal to $A/P_w$ |
| $A$ | = | cross sectional flow area ($ft^2$) |
| $P_w$ | = | wetted perimeter (ft) |
| $S$ | = | slope of the hydraulic grade line approximated by the channel slope (ft/ft) |
| $n$ | = | Manning's roughness coefficient for open channel flow |

Bankfull flow conditions typically represent flow for the 1 to 2-year flood event which is considered to be a reasonable flow regime for estimating $T_c$. However, for streams that are significantly enlarged or incised due to long-term erosion, or for a constructed channel with bankfull flood capacity greater than the 1 to 2-year flow, bankfull conditions may overestimate the hydraulic radius for 1 to 2-year event capacity. Judgement should be exercised in selecting a representative value. In addition, open channel flow may pass through a closed conduit. The conduit should be treated the same as any other channel provided the conduit does not pressurize. If the conduit pressurizes, an estimate of flow velocity based on hydraulic pressure flow principles is appropriate (see Volume 2, Chapter 5).

After average velocity is computed using Equation 4-7, $T_T$ for the channel segment ($T_{T(open)}$) can be calculated using Equation 4-5.

***Total Time of Concentration for Subbasin or Catchment***

The time of concentration for a subbasin or catchment is the sum of all sheet flow, shallow concentrated flow, and open channel flow travel times, as shown in Equation 4-8: (SCS, 1986)

**Equation 4-8** $T_C = \sum T_{T(sheet)} + \sum T_{T(shallow)} + \sum T_{T(open)}$

***Limitations***

- Post-development overland flow paths and conveyances will probably not be the same as before development. Time of concentration calculations shall consider the effects of development on flow paths and conveyances.
- Sheet flow length shall be limited to 100 feet.
- The minimum total time of concentration value to be used with the Rational Method (see Section 4.6) for the design of on-site conveyances (ditches, gutters, inlets, pipes, etc.) is 15 minutes.

## 4.5 USGS Regression Methods

### 4.5.1 Introduction

Regional regression equations are commonly used to estimate peak flows for ungaged sites (or for sites with insufficient data for a statistical derivation of the peak discharge versus flood frequency relationship). Regression analyses use stream gage data to define hydrologic regions having similar flood frequency relationships, and are typically based on watershed, channel, and meteorological characteristics. In Wichita and Sedgwick County, the USGS regression equations provided below may be used to estimate peak flows for unregulated rural drainage areas between 0.17 mi$^2$ and 30 mi$^2$ in size. It should be noted that these equations have relatively large standard errors and should be used accordingly. Unless approved by the appropriate review authority, regression estimates of peak flow shall be limited to preliminary drainage designs and as a “reasonableness” check of the results of more rigorous analyses. Equations 4-9 through 4-14 provide the regional regression equations for the Sedgwick County area (USGS, 2004). Figure 4-3 can be used to determine the mean annual precipitation for use in Equations 4-9 through 4-14.

**Equation 4-9** $Q_2 = 0.0126(CDA)^{0.579}(P)^{2.824}$

**Equation 4-10** $Q_5 = 0.300(CDA)^{0.600}(P)^{2.138}$

**Equation 4-11** $Q_{10} = 1.224(CDA)^{0.611}(P)^{1.844}$

**Equation 4-12** $Q_{25} = 4.673(CDA)^{0.622}(P)^{1.572}$

**Equation 4-13** $Q_{50} = 10.26(CDA)^{0.628}(P)^{1.415}$

**Equation 4-14** $Q_{100} = 19.80(CDA)^{0.634}(P)^{1.288}$

where:

| | | |
|---|---|---|
| $Q_x$ | = | Peak flow for the x year storm (cfs) |
| CDA | = | Contributing drainage area (square miles) |
| P | = | Mean annual precipitation (inches); see Figure 4-3 |

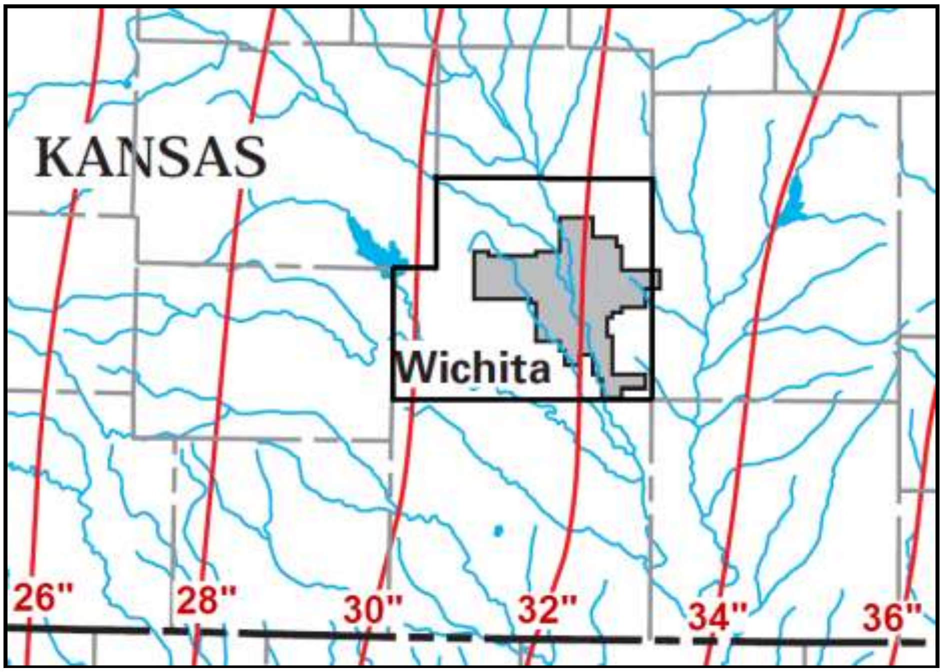


**Figure 4-3 Mean Annual Precipitation**

## Example Problem

Estimate the peak 100-year discharge for a 15.1 square mile rural drainage area located in western Sedgwick County.

Mean Annual Precipitation = 30.0"

**Peak Discharge Calculations**

Using Equation 4-14:

$$Q_{100} = 19.80(CDA)^{0.634}(P)^{1.288}$$
$$Q_{100} = 19.80(15.1)^{0.634}(30)^{1.288}$$
$$Q_{100} = 19.80(5.59)(79.90)$$
$$Q_{100} = 8843 \text{ cfs}$$

# 4.6 Rational Formula Method

## 4.6.1 Introduction

The Rational Formula is applicable to relatively small areas. The maximum drainage area that may be analyzed with the Rational Formula is 40 acres when used for the applications in this Manual.

The Rational Formula cannot be used for storage design or any other application where a runoff volume or routing is required (see Section 4.8). The Rational Formula should not be used for calculating peak flows downstream of bridges, culverts, or storm sewers if they act as flow restrictions that cause significant backwater storage, thus attenuating the peak rate of discharge, unless such storage effects are being purposely neglected. In general, the method may be used for computing design flows for gutters, inlets, storm sewers, and ditches for small drainage areas.

## 4.6.2 Equations

The Rational Formula method estimates the peak rate of runoff at a location in a watershed as a function of the drainage area, runoff coefficient, and the mean rainfall intensity for a rainfall duration equal to the time of concentration (i.e., the time required for water to flow from the hydraulically most remote point of the catchment to the location being analyzed).

The Rational Formula is expressed as shown in Equation 4-15 follows (HEC-22, 2001).

**Equation 4-15** $Q = CIA$

where:

| | | |
|---|---|---|
| Q | = | maximum rate of runoff (cfs) |
| C | = | coefficient representing ratio of peak runoff to rainfall intensity (see Appendix C) |
| I | = | rainfall intensity for a duration equal to the $T_c$ (in/hr) |
| A | = | drainage area contributing to the design location (acres) |

## 4.6.3 Runoff Coefficient (C)

The runoff coefficient (C) is a variable of the Rational Formula method which requires judgment and experience understanding on the part of the design engineer. While engineering judgment will always be required in the selection of runoff coefficients, typical coefficients represent the integrated effects of many drainage basin parameters. Appendix C gives the recommended runoff coefficients for the Rational Formula.

It is often necessary to develop a composite runoff coefficient based on the percentage of different types of surfaces in the contributing drainage area. Composite C values may be computed using values from Appendix C by using percentages of different land uses. This results in an area-weighted composite C value. The compositing procedure can be applied to an entire drainage area or to typical "sample" blocks as a guide in the selection of reasonable coefficient values for an entire area.

It should be noted that the Rational Formula method assumes that all land uses within a drainage area are uniformly distributed throughout the area. If it is important to consider the location of a specific land use within the drainage area, then another hydrologic method should be used where hydrographs can be generated for separate catchments, and routed through the drainage system. Also, it is possible that using only the impervious area from a highly impervious site (and the corresponding high C factor and shorter time of concentration) will yield a higher peak runoff value than by using the whole site in the calculation wherein peak flows may be underestimated. This should be checked, particularly in areas with relatively large sheet flow and shallow concentrated flow portions (e.g., grassy areas) which typically yield a long $T_{c.}$

### 4.6.4 Rainfall Intensity (I)

The rainfall intensity (I) is the rate of rainfall expressed in inches/hour for the duration equal to the time of concentration for a selected average return period. Once a particular return period has been selected for design and a time of concentration has been calculated for the drainage area, the rainfall intensity shall be selected from the rainfall intensity-duration-frequency data given in Appendix B.

---

**Example Problem – Weighted Runoff Coefficient**

Estimate the 25-year peak runoff rate at the inlet of a proposed culvert draining 20 acres. The land use for the drainage basin was estimated to be:

Residential (single family - ¼ acre lots) - 80%
Agricultural - 20%

To calculate the total weighted runoff coefficient (C), start with the values from Appendix C. Multiply the fraction of total land area by the runoff coefficient for the respective land uses to obtain the individual weighted runoff coefficients. Sum all of the individual weighted runoff coefficients to obtain the total weighted runoff coefficient for the drainage basin. This method is demonstrated in Table 4-6.

**Table 4-6 Calculate Weighted Runoff Coefficients (C)**

| Land Use | Fraction of Total Land Area (1) | Runoff Coefficient (2) | Weighted Runoff Coefficient (1 x 2) |
|---|---|---|---|
| Residential (Single Family – ¼ acre lots) | 0.80 | 0.60 | 0.48 |
| Agricultural | 0.20 | 0.30 | 0.06 |
| Total Weighted Runoff Coefficient = 0.48 + 0.06 = 0.54 | | | |

Based on the project map and a site inspection, the hydraulically longest flow path was then identified and the required hydraulic data were collected. In addition, the 2-year, 24-hour rainfall depth (3.5 inches) was determined from Table 4-1. The travel times for the sheet flow, shallow concentrated flow and channel flow were then computed using the methods described in Section 4.4.

- Sheet flow = 4 minutes (based on travel length, slope, 2-year 24-hour rainfall, and surface roughness);
- Shallow Concentrated flow time = 6 minutes (based on travel length, slope and surface roughness);
- Channel flow time = 12 minutes (based on travel length, slope, channel geometry and surface roughness);
- Therefore, time of concentration = Tc = 22 minutes.

Next, the rainfall intensity was found in the intensity-duration-frequency table of Appendix B, using a return interval of 25 years and a $T_c$ of 22 minutes.

$I_{25}$ = (25-yr return period) = 4.61 in/hr

Finally, the estimate of peak runoff for the 25-yr storm for the given basin was calculated using the Rational Method:

$$Q_{25} = CIA = (0.54)(4.61)(20) = 49.8 \text{ cfs}$$

## 4.7 Hydrograph Methods

### 4.7.1 General

Hydrograph methods are procedures used to estimate the hydrograph of runoff (flow versus time) for a subbasin based on the rainfall and physical characteristics of the subbasin. Hydrograph methods require three elements:

- A time distribution for the design rainfall event: For the methods presented in this Manual, this element shall be the 24-hour rainfall depth for the design return period as provided in Table 4-1, distributed in time in accordance with the NRCS Type 2 rainfall distribution pattern.
- A runoff versus rainfall relationship to account for rainfall losses (i.e., rainfall that does not become direct runoff): For the hydrograph procedures presented in this Manual, the NRCS “Curve Number” (CN) method, assuming Antecedent Moisture (or Runoff) Condition 2, will be used to determine runoff (or “rainfall excess”) volume.
- An analytical method for converting the time distribution of “rainfall excess” to a hydrograph of runoff: Three methods may be used:
  - the NRCS synthetic unit hydrograph;
  - the Clark synthetic unit hydrograph;
  - the RUNOFF block of the EPA-SWMM model.

## 4.8 NRCS Unit Hydrograph Method

### 4.8.1 Description

The development of a runoff hydrograph is a complex process not normally done by hand calculation. For that reason, only an overview of the process is given here to assist the designer in reviewing and understanding the input and output from a typical computer program.

The development of a runoff hydrograph for a subbasin involves the following steps:

- Develop or select a design storm hyetograph (i.e., rainfall versus time distribution);
- Estimate "lag time" (see discussion below) and CN;
- Develop a "unit hydrograph" using the standard (peaking factor of 484) dimensionless unit hydrograph (see discussion below);
- Perform step-wise computation of the rainfall losses and, thus, the excess rainfall hyetograph using a derivative form of the SCS rainfall-runoff equation;
- Apply each increment of excess rainfall to the unit hydrograph to develop a series of elemental runoff hydrographs, one for each increment of rainfall excess; and,
- Sum the flows from each of the elemental hydrographs (keeping proper track of time steps) to form a composite runoff hydrograph for that subbasin.

Figure 4-4 illustrates the unit hydrograph concept:

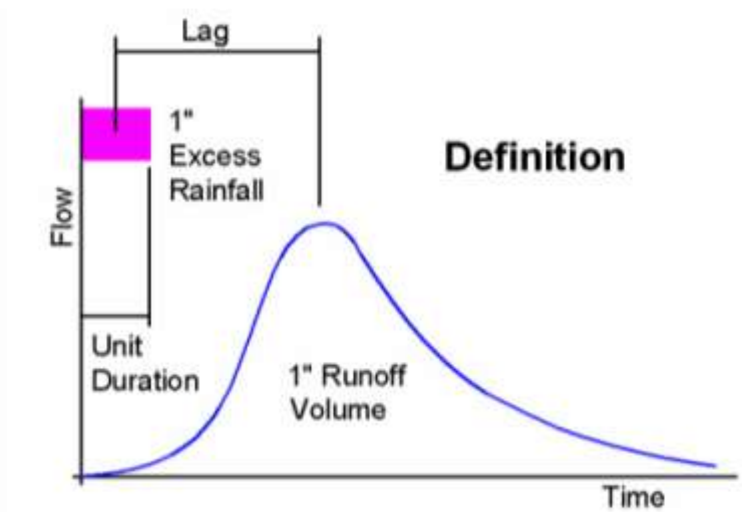


**Figure 4-4 Unit Hydrograph**

The unit hydrograph equations used in the NRCS method for generating hydrographs include a constant to account for the "peakiness" or "flatness" of the runoff response to excess rainfall in the watershed. The value of 484 is an "average" value that may not be representative of some flat or steep areas, or areas with significant transient runoff surface storage. For flat terrain or surface storage intensive areas, the factor can be as low as 300 or less. It is recognized that in some watersheds in Sedgwick County, the peaking factor of 484 is probably too high. However, in the absence of detailed hydrologic studies of County watersheds, a value of 484 shall be used for all computations unless the site design engineer provides sufficient technical basis to the local jurisdiction for the use of an alternative peaking factor.

Figure 4-5 shows dimensionless unit hydrographs for peaking factors of 300 (for comparative purposes only) and 484. Note that these graphs are dimensionless. If scaled to the actual time and flow values, the 300 curve would be much broader and would have a lower peak than the 484 curve.

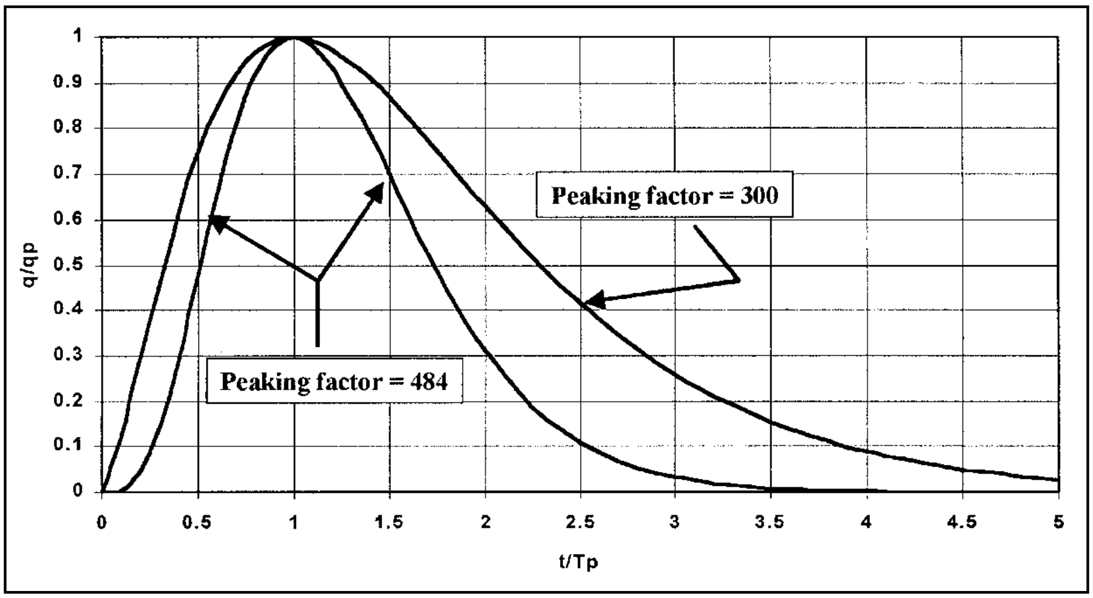


**Figure 4-5 Dimensionless Unit Hydrographs for Peaking Factors of 484 and 300**

Table 4-7 provides a tabulation of the dimensionless unit hydrograph for a factor of 484.

**Table 4-7 Dimensionless Unit Hydrograph with Peaking Factor of 484**

| $t/T_p$ | $q/q_p$ | $t/T_p$ | $q/q_p$ |
|---|---|---|---|
| 0.0 | 0.0 | 2.1 | 0.257 |
| 0.1 | 0.005 | 2.2 | 0.210 |
| 0.2 | 0.046 | 2.3 | 0.170 |
| 0.3 | 0.148 | 2.4 | 0.137 |
| 0.4 | 0.301 | 2.5 | 0.109 |
| 0.5 | 0.481 | 2.6 | 0.087 |
| 0.6 | 0.657 | 2.7 | 0.069 |
| 0.7 | 0.807 | 2.8 | 0.054 |
| 0.8 | 0.916 | 2.9 | 0.042 |

| $t/T_p$ | $q/q_p$ | $t/T_p$ | $q/q_p$ |
|---|---|---|---|
| 0.9 | 0.980 | 3.0 | 0.033 |
| 1.0 | 1.000 | 3.1 | 0.025 |
| 1.1 | 0.982 | 3.2 | 0.020 |
| 1.2 | 0.935 | 3.3 | 0.015 |
| 1.3 | 0.867 | 3.4 | 0.012 |
| 1.4 | 0.786 | 3.5 | 0.009 |
| 1.5 | 0.699 | 3.6 | 0.007 |
| 1.6 | 0.611 | 3.7 | 0.005 |
| 1.7 | 0.526 | 3.8 | 0.004 |
| 1.8 | 0.447 | 3.9 | 0.003 |
| 1.9 | 0.376 | 4.0 | 0.002 |
| 2.0 | 0.312 | -- | -- |

The procedure to develop a unit hydrograph from the dimensionless unit hydrograph presented in Table 4-7 is to multiply each time ratio value by the time-to-peak ($T_p$) and each value of $q/q_p$ by $q_p$. Equation 4-16 presents the calculation for $q_p$. (HEC-22, 2001).

**Equation 4-16** $$q_p = \frac{PF * A}{T_p}$$

where:

| | | |
|---|---|---|
| $q_p$ | = | unit hydrograph peak rate of discharge (cfs) |
| PF | = | peaking factor (484) |
| A | = | area ($mi^2$) |
| $T_p$ | = | time to peak = $d/2 + 0.6\ T_c$ (hr) |
| d | = | time increment (min) |

The parameter $0.6T_c$ is referred to as the "lag time" ($T_L$) and is the time between the centroid of unit excess rainfall and the peak of the unit hydrograph.

For ease of spreadsheet calculations, the dimensionless unit hydrograph for 484 can be approximated by Equation 4-17. In the equation, X = 3.79 for when using a 484 peaking factor.

**Equation 4-17** $$\frac{q}{q_p} = \left[ \frac{t}{T_p} e^{\left[1-\left(\frac{t}{T_p}\right)\right]} \right]^X$$

where:

| | | |
|---|---|---|
| X | = | 3.79 for a unit hy |
| t | = | time (hr) |
| q | = | peak rate of discharge (cfs) |

The example problem below provides the calculation of a unit hydrograph using the information provided previously.

## Example Problem – NRCS Unit Hydrograph

Compute the unit hydrograph for a 5-acre example watershed.

- Calculate $T_p$ and time increment

  The time of concentration ($T_c$) was calculated to be 12 minutes for this watershed. If we assume a computer calculation time step (d) of 2 minutes then:

$$T_p = \frac{d}{2} + \left(0.6T_c\right) = \frac{2}{2} + \left(0.6*12\right) = 8.2 \text{ minutes (0.14 hours)}$$

- Calculate $q_u$

$$q_p = \frac{PF * A}{T_p} = \frac{484 * \left(5/640\right)}{0.14} = 27 \text{ cfs}$$

- Calculate unit hydrograph.

  Based on spreadsheet calculations and interpolations using Equation 4-16, Equation 4-17, and the table below is derived.

**Table 4-8 Dimensionless Unit Hydrograph with Peaking Factor of 484**

| Time (min) | t/Tp | q/qp | q (cfs) | Time (min) | t/Tp | q/qp | q (cfs) |
|---|---|---|---|---|---|---|---|
| 0 | 0.000 | 0.000 | 0.00 | 16 | 2.145 | 0.235 | 6.3 |
| 1 | 0.134 | 0.013 | 0.35 | 17 | 2.279 | 0.178 | 4.8 |
| 2 | 0.268 | 0.109 | 2.9 | 18 | 2.413 | 0.133 | 3.6 |
| 3 | 0.402 | 0.305 | 8.2 | 19 | 2.547 | 0.098 | 2.6 |
| 4 | 0.536 | 0.546 | 14.7 | 20 | 2.681 | 0.072 | 1.9 |
| 5 | 0.670 | 0.766 | 21.0 | 21 | 2.815 | 0.052 | 1.4 |
| 6 | 0.804 | 0.920 | 24.8 | 22 | 2.949 | 0.037 | 1.0 |
| 7 | 0.938 | 0.993 | 26.8 | 23 | 3.083 | 0.027 | 0.73 |
| 8 | 1.072 | 0.991 | 26.8 | 24 | 3.217 | 0.019 | 0.51 |
| 9 | 1.206 | 0.931 | 25.1 | 25 | 3.351 | 0.013 | 0.35 |
| 10 | 1.340 | 0.835 | 22.5 | 26 | 3.485 | 0.009 | 0.24 |
| 11 | 1.475 | 0.721 | 19.5 | 27 | 3.619 | 0.006 | 0.16 |
| 12 | 1.609 | 0.604 | 16.3 | 28 | 3.753 | 0.004 | 0.11 |
| 13 | 1.743 | 0.492 | 13.3 | 29 | 3.887 | 0.003 | 0.08 |
| 14 | 1.877 | 0.392 | 10.6 | 30 | 4.021 | 0.002 | 0.05 |
| 15 | 2.011 | 0.306 | 8.3 | | | | |

### 4.8.2 Selection of Time Step

The "time step", d, should be selected as large as possible without exceeding $0.29T_L$ or $0.17T_c$. The time step (also called the "computation interval" or the "unit duration") is 2 minutes in the above example.

### 4.8.3 Application

Once the unit hydrographs for all subbasins have been determined, the process described in Section 4.8.1 is completed using computer hydrologic models. Computer models convolute the rainfall, loss rates, and unit hydrographs to create hydrographs for each subbasin. The subbasins are then "routed" downstream through stream reaches and reservoirs to the watershed outlet. Routing is discussed in Section 4.11.

The details of setting up and applying hydrologic modeling are beyond the scope of this Manual. However, the manuals for the major public domain models HEC-HMS and EPA-SWMM provide instructions on the use of the software.

### 4.8.4 Simplified NRCS Peak Runoff Rate Estimation

The following NRCS procedure (SCS TR-55, USDA, 1986) is a simplified method for calculating peak discharges. It is included here because it is based on the NRCS hydrograph method. While this procedure is applicable to drainage areas with relatively homogeneous land use, and which can be satisfactorily described by a single CN value. Such drainage areas can then be combined to develop a composite CN that includes both pervious and any impervious areas. It is important to note that the use of this method is limited to estimating peak flows for off-line $WQ_v$ treatment and for estimating peak inflow for $CP_v$ facilities when the simplified $CP_v$ method is used. For these applications, a composite CN that includes both pervious and any impervious areas is used.

Using the simplified NRCS procedure, the peak discharge is estimated using Equation 4-18.

**Equation 4-18** $Q_p = q_u AQF_p$

where:

| | | |
|---|---|---|
| $Q_p$ | = | peak discharge (cfs) |
| $q_u$ | = | unit peak discharge (cfs/mi$^2$-in of runoff) |
| A | = | drainage area (mi$^2$) |
| Q | = | runoff (in) |
| $F_p$ | = | pond and swamp adjustment factor |

Computations using the simplified NRCS peak discharge method generally follow the steps defined below.

1. Select the desired rainfall depth, P.
2. Select or otherwise determine the subbasin runoff curve number, CN.

3. Determine the initial abstraction, Ia, from Table 4-9, and compute the ratio Ia/P.

**Table 4-9 $I_a$ Values for Runoff Curve Numbers**

| Curve Number | $I_a$ (in) | Curve Number | $I_a$ (in) |
|---|---|---|---|
| 40 | 3.000 | 70 | 0.857 |
| 41 | 2.878 | 71 | 0.817 |
| 42 | 2.762 | 72 | 0.778 |
| 43 | 2.651 | 73 | 0.740 |
| 44 | 2.545 | 74 | 0.703 |
| 45 | 2.444 | 75 | 0.667 |
| 46 | 2.348 | 76 | 0.632 |
| 47 | 2.255 | 77 | 0.597 |
| 48 | 2.167 | 78 | 0.564 |
| 49 | 2.082 | 79 | 0.532 |
| 50 | 2.000 | 80 | 0.500 |
| 51 | 1.922 | 81 | 0.469 |
| 52 | 1.846 | 82 | 0.439 |
| 53 | 1.74 | 83 | 0.410 |
| 54 | 1.704 | 84 | 0.381 |
| 55 | 1.636 | 85 | 0.353 |
| 56 | 1.571 | 86 | 0.326 |
| 57 | 1.509 | 87 | 0.299 |
| 58 | 1.448 | 88 | 0.273 |
| 59 | 1.390 | 89 | 0.247 |
| 60 | 1.333 | 90 | 0.222 |
| 61 | 1.279 | 91 | 0.198 |
| 62 | 1.226 | 92 | 0.174 |
| 63 | 1.175 | 93 | 0.151 |
| 64 | 1.125 | 94 | 0.128 |
| 65 | 1.077 | 95 | 0.105 |
| 66 | 1.030 | 96 | 0.083 |
| 67 | 0.985 | 97 | 0.062 |
| 68 | 0.941 | 98 | 0.041 |
| 69 | 0.899 | -- | -- |

Source: SCS, TR-55, Second Edition, June 1986

4. The watershed time of concentration is computed using the procedures in Section 4.4 and is used with the ratio Ia/P to obtain the unit peak discharge (qu) from Figure 4-6 for the Type 2 rainfall distribution. When using Figure 4-6, if the ratio Ia/P lies outside the range shown in the figure, either the limiting values or another peak discharge method should be used. Also, note that Figure 4-6 is based on a standard peaking factor of 484. The standard peaking shall be used for all analyses unless specifically allowed otherwise by the reviewing authority. If a peaking factor other than 484 is used, this figure is not applicable and the simplified SCS method should not be used.

5. The pond and swamp adjustment factor, Fp, is estimated from Table 4-10 below. If the drainage area contains between 5% and 10% permanent water surface a value of 0.70

may be assumed. Please note that these adjustments are less accurate for small rainfall events and judgement should be exercised in the use of the simplified method for design.

**Table 4-10 Pond and Swamp Adjustment Factors, $F_p$**

| Pond and Swamp Areas (%*) | $F_p$ |
|---|---|
| 0 | 1.00 |
| 0.2 | 0.97 |
| 1.0 | 0.87 |
| 3.0 | 0.75 |
| 5.0 | 0.72 |

* Percent of drainage area

6. Finally, the peak runoff rate is computed using Equation 4-18.

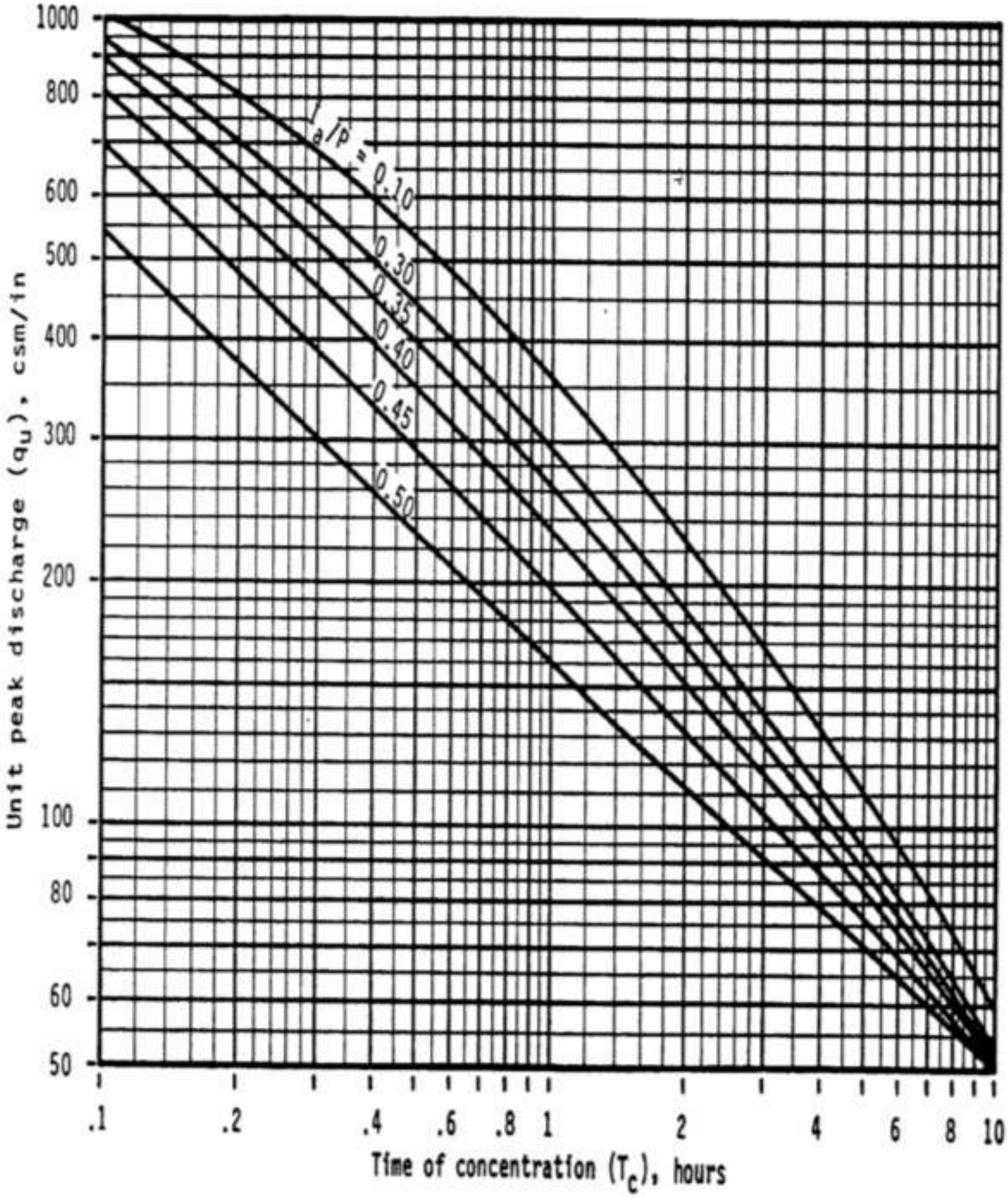


**Figure 4-6 SCS Type II Unit Peak Discharge Graph**
(Source: SCS, TR-55, Second Edition, June 1986)

## Example Problem – Simplified NRCS Peak Flow Method

Computehe 100-year peak discharge for a 28-acre site located in Wichita.

Separate the planned development into relatively homogeneous land uses to estimate a weighted CN for the entire site. For the example, the site will be developed as follows:

- Disturbed pervious area (hydrologic soil group B) = 10 ac
- Impervious area = 8 ac
- Undisturbed area (hydrologic soil group C) = 10 ac
- % pond surfaces = 1

Calculate rainfall excess:

- Look up the 100-year, 24-hour rainfall in Table 4-1; rainfall = 7.8"
- Compute the weighted CN:

| Land Use | Area (ac.) | Area Fraction | Curve Number | Weighted Curve Number (Area Fraction x CN) |
|---|---|---|---|---|
| Disturbed Pervious Area Soil Group B | 10 | 0.36 | 80 | 28.8 |
| Impervious Area | 8 | 0.28 | 98 | 27.4 |
| Undisturbed Area Soil Group C | 10 | 0.36 | 71 | 25.6 |

Weighted CN = 28.8 + 27.4 + 25.6 = 81.8

- Look up the initial abstraction ($I_a$) from Table 4-9 based on the curve number. $I_a$ = 0.439".
- Determine the potential maximum retention (S) from Equation 4-1. S = 2.2".
- Calculate the rainfall excess (Q) from $I_a$, S and rainfall depth.

$$Q = \frac{(P - I_a)^2}{[(P - I_a) + S]} = \frac{(7.8 - 0.439)^2}{[(7.8 - 0.439) + 2.2]} = \frac{54.18}{9.56} = 5.7''$$

Calculate time of concentration

| Segment | Type of Flow | Length (ft) | Slope (%) |
|---|---|---|---|
| 1 | Sheet flow through pasture | 100 | 1.5 |
| 2 | Shallow grassed channel | 450 | 1.0 |
| 3 | Main riprap channel (10'W x 2'D) | 600 | 0.5 |

Calculate sheet flow travel time using Equation 4-5.

$$T_{T(sheet)} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}(S)^{0.4}} = \frac{0.007(0.13*100)^{0.8}}{(3.5)^{0.5}(0.015)^{0.4}} = 0.156\,hr = 9\,\text{min.}$$

Calculate shallow concentrated flow travel time using Equation 4-6 and Equation 4-4

$$V = KS^{0.5} = 15*(0.01)^{0.5} = 1.5\ {ft}/{s}$$

$$T_{T(shallow)} = \frac{L}{60V} = \frac{450}{60*1.5} = 5\min$$

Calculate open channel flow travel time using Equation 4-7 and Equation 4-5.

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} = \frac{1.49}{0.04}\left(\frac{2*10}{10+2+2}\right)^{2/3} 0.005^{1/2} = 3.3\ {ft}/{s}$$

$$T_{T(open)} = \frac{L}{60V} = \frac{600}{60x3.3} = 3\min$$

Calculate total time of concentration using Equation 4-8.

$$T_C = \sum T_{T(sheet)} + \sum T_{T(shallow)} + \sum T_{T(open)} = 9+5+3 = 17\min$$

Calculate $I_a/P$

$$I_a/P = 0.439/7.8 = 0.056$$

Determine unit peak discharge qu (100-year) from Figure 4-6.

$q_u$ = 700 cfs/mi$^2$-inch (limit of graph)

Look up the pond/swamp adjustment factor for the swamp area of 1% from Table 4-10.

$F_p$ = 0.87

Calculate peak discharge using Equation 4-18.

$$Q_p = q_u AQF_p = 700\left(\frac{28}{640}\right)(6.0)(0.87) = 160cfs$$

# 4.9 Clark Method

## 4.9.1 Introduction

The Clark method defines a unit hydrograph for a given subbasin using the concept of the instantaneous unit hydrograph (IUH). Using this method, the subbasin is subdivided by a series of isochrones. An isochrone is a line on the ground wherein all points on the line flow to the subbasin outlet in an equal amount of time. Runoff from the subbasin can thus be routed to the subbasin outlet based on a time-area diagram. At the outlet, runoff transient storage effects are then routed through a theoretical linear reservoir. The resulting hydrograph is then adjusted to represent the hydrograph for a unit of rainfall excess for a specified unit duration. The clark Method is shown in Figure 4-7.

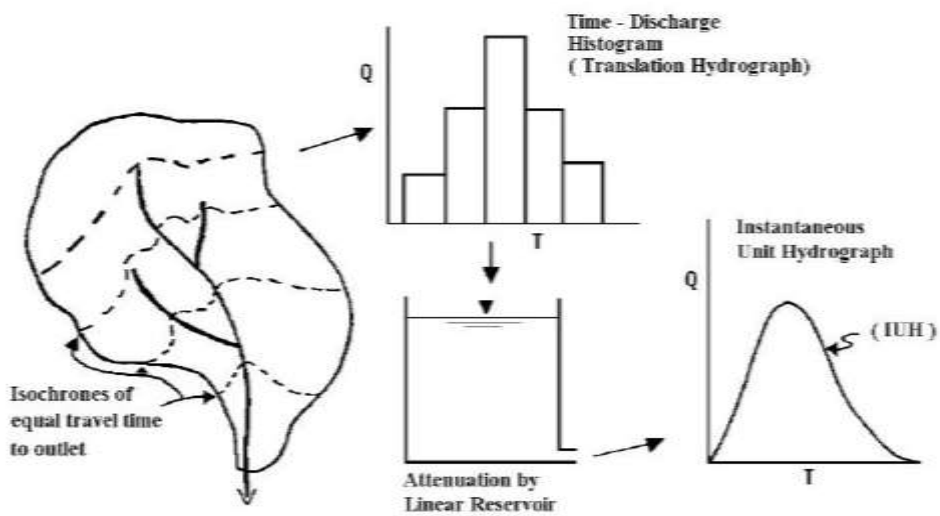


**Figure 4-7 Clark Concept (US Army Corps of Engineers EM 1110-2-1417)**

It should be noted that the theoretical linear reservoir as applied here is not an actual reservoir. It is a mathematical concept used to represent the distributed attenuation effects occurring in the subbasin runoff. The linear reservoir is represented by Equation 4-19 (USACE, 1994):

**Equation 4-19** $S = RO$

where:

| | | |
|---|---|---|
| S | = | Storage |
| R | = | Attenuation (Storage) Constant |
| O | = | Outflow |

## 4.9.2 Dimensionless Time-Area Curve

Studies have indicated that it is not necessary to produce detailed time-area curves in order to produce reasonably accurate synthetic unit hydrographs. The dimensionless time-area curve included in the HEC-1 and HEC-HMS hydrologic models (developed by the United States

Army Corps of Engineers) produce reasonably accurate synthetic unit hydrographs. The dimensionless curve, as implemented in HEC-HMS, is shown in Figure 4-8. For computer models having this method available (e.g., HEC-1 and HEC-HMS), it is not necessary to compute the time-area curve or unit hydrograph since those steps are performed by the program. However the user must provide two input parameters for each subbasin, as discussed below.

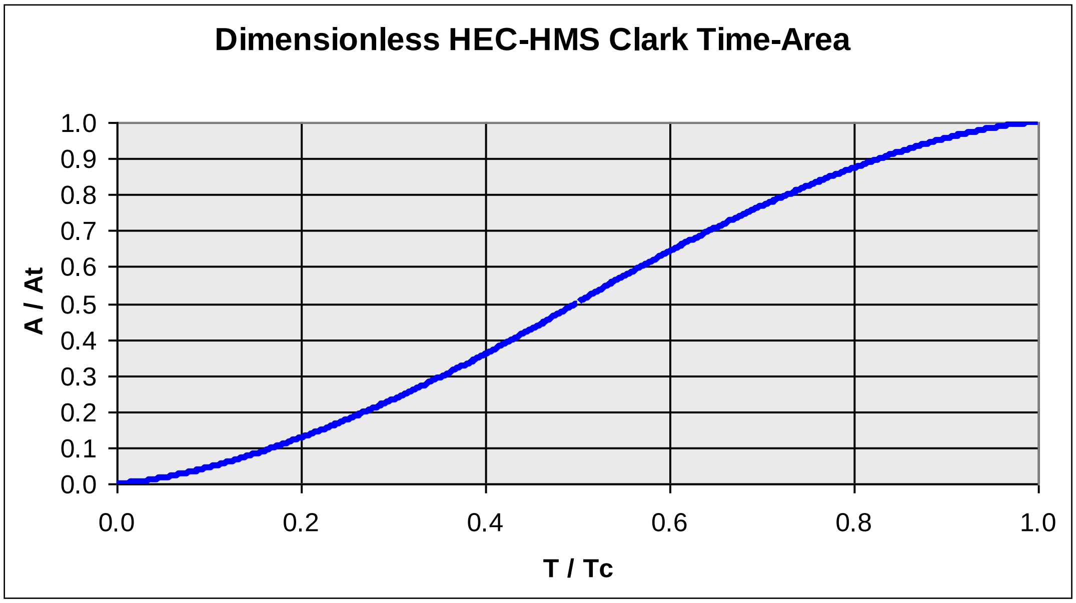


**Figure 4-8 Dimensionless Clark Time-Area Curve**

### 4.9.3 Storage Constant and Time of Concentration

In order to apply the Clark method in a model using the dimensionless time-area curve, the time of concentration ($T_c$) and the watershed storage constant (R) are required as inputs. The time of concentration can be estimated using the method provided in this Manual. However, the value of R is not as readily determined. The best procedure for determining the storage constant is to derive the parameter from a number of observed hydrographs in the region and determine the ratio shown in Equation 4-20 that is representative of the region of interest. Equation 4-20 is shown with a value of 0.5, however ratio values of 0.3 to 0.7 are common (USACE, 1994):

**Equation 4-20** $$\frac{R}{T_c + R} = 0.5$$

where:

| | | |
|---|---|---|
| R | = | Attenuation (Storage) Constant |
| $T_c$ | = | Time of concentration (minutes) |

### 4.9.4 Application

The unit hydrograph derived by the Clark method is applied to general hydrologic analysis in the same manner as the NRCS unit hydrograph. The NRCS rainfall distribution and Curve Number method for losses are used for the Clark method when implementing the requirements of this Manual. Typically the Clark method is applied using appropriate modeling software such as HEC-HMS, developed by the United States Army Corps of Engineers. The time of concentration ($T_c$) and the watershed storage constant (R) are required as inputs.

## 4.10 EPA-SWMM “RUNOFF” Method

### 4.10.1 Introduction

EPA-SWMM was developed by the Environmental Protection Agency (EPA) to analyze stormwater quantity and quality problems associated with runoff from urban areas. EPA-SWMM has become the model of choice of many engineers for simulation of drainage systems primarily composed of closed conduits. The model can simulate both single-event scenarios and continuous rainfall/runoff processes. The model does not use the unit hydrograph approach previously discussed, but instead uses a deterministic-based RUNOFF module for generating flows. EPA-SWMM has the capability to model both wet and dry weather flow. The basic output from EPA-SWMM consists of runoff hydrographs, pollutographs, storage volumes and flow stages and depths. EPA-SWMM's hydraulic computations are link-node based. EPA-SWMM solves the complete dynamic flow routing equations to simulate backwater, looped pipe connections, manhole surcharging and pressure flow. It is a comprehensive model in its capabilities to simulate urban storm flow and many cities have used EPA-SWMM successfully for stormwater, sanitary, or combined sewer system modeling.

EPA-SWMM also contains routines for hydrologic and water quality modelling. A large suite of hydrologic processes affecting the quantity and quality of runoff from drainage areas can be modelled. Pollutant transport is simulated in tandem with hydrologic and hydraulic computations and consists of calculation of pollutant buildup and washoff from land surfaces and pollutant routing, scour and in-conduit suspension in flow conduits and channels. EPA-SWMM is a public domain model. Because of the popularity of the model, commercial third party enhancements to EPA-SWMM have become common, making the model a strong choice for drainage modeling.

### 4.10.2 Approved EPA-SWMM Hydrologic Procedures

EPA-SWMM is approved for both hydrologic and hydraulic modelling within Wichita and Sedgwick County. Commercial third-party models based on EPA-SWMM must be pre-approved by the City and County, not only on the basis of technical acceptance but also on the basis of the cost for the City and County to maintain a license for the product for review purposes.

A detailed review of the use of the model is beyond the scope of this Manual. Details may be found in the manual distributed with the EPA-SMMM software. However, an overview of the application of the basic model options as they relate to hydrology follows. Guidelines addressing hydraulic flow principles are found in Volume 2, Chapter 5.

- The Curve Number method shall be chosen as the infiltration model;
- Dynamic wave routing shall be employed;
- The “allow ponding” option shall not be used. Rather, local ponding shall be modelled within storage nodes;
- The reporting time step shall be no greater than 5 minutes;
- The routing time step shall be small enough to prevent significant instabilities;
- Inertial terms of the dynamic wave equations shall be kept or dampened, not ignored;
- Conduit lengthening shall be employed;
- The model shall be run for 48-hours or until site outflow is less than 5% of peak flow, whichever is longer;
- Rainfall shall be applied to each subcatchment as a NRCS Type 2 distribution of the local 24-hour storm depth;
- Subcatchment width shall be defined as the subcatchment area in square feet divided by the longest flow path that does not enter a curb and gutter, lined channel or storm sewer;
- Curve numbers for pervious areas shall be determined per the guidance found in Section 4.3.3;
- The percent slope shall be calculated along the longest flow path;
- Area-weighted saturated hydraulic conductivity values for pervious areas shall be taken from the table below, or substantiated by on-site testing. These values are not critical for single event analysis, but are necessary for proper continuous simulation. Table 4-10 provides hydraulic conductivity values by hydrologic soil group.

**Table 4-11 Hydraulic Conductivity by Hydrologic Soils Group**

| NRCS Hydrologic Soil Group | Saturated Hydraulic Conductivity (in/hr) |
|---|---|
| A | 0.45 |
| B | 0.2 |
| C | 0.1 |
| D | 0.02 |
| Disturbed A | 0.2 |
| Disturbed B | 0.1 |
| Disturbed C | 0.05 |
| Disturbed D | 0.015 |

- Drying time shall be 4 days. This value is also important only for continuous simulation models. Depression storage shall be as indicated in Table 4-11 below.

**Table 4-12 Depression Storage Depths**

| Surface | Depression Storage Depth (in) |
|---|---|
| Impervious | 0.1 |
| Lawn | 0.3 |
| Cropland | 0.3 |
| Wooded Areas and Pasture | 0.4 |

- Manning's roughness values for subcatchment sheet flow shall be taken from Appendix Table A.
- Subarea flows shall be routed to the outlet unless specifically allowed by the local jurisdiction as a reduction for impervious disconnection.
- The percent of runoff routed shall be 100%.

## 4.11 Routing

### 4.11.1 Routing Methods

As water flows along a channel or through a reservoir, the hydrograph changes due to translation and attenuation. Translation reflects the time required for water to move from one location to another location downstream. For simple translation, the downstream hydrograph is identical to the upstream hydrograph except it occurs later in time due to the travel time between the two locations. Attenuation reflects the change in shape of the hydrograph as it moves downstream, primarily due to the effects of water temporarily stored in the stream, floodplain, and/or reservoir. The downstream hydrograph characteristics (its timing and shape) are determined by both translation and attenuation effects. "Routing" is the procedure used to analyze the upstream hydrograph and the downstream channel and floodplain or reservoir to predict the change in hydrograph characteristics as it travels through the "routing reach" (section of stream and floodplain or reservoir), and is transformed into the downstream hydrograph.

There are a number of methods used to route flows through streams, floodplains and reservoirs. For use in implementing the requirements of this Manual, three methods may be used for channel and floodplain routing, and one method will be used for reservoir routing. Those methods are discussed briefly herein. For more detailed treatment of these methods, the reader is referred to the documentation readily available from a number of sources, including the manuals that are distributed with HEC-1, HEC-HMS and EPA-SWMM.

#### 4.11.1.1 Stream and Floodplain Routing

***Muskingum-Cunge Method***

The Muskingum-Cunge method is a hydraulic routing technique that uses conservation of mass and the diffusion form of the conservation of momentum. The method considers the shape and roughness of the channel and floodplain, the energy gradient (approximated by the channel slope), and total energy loss. Input is relatively straightforward: channel shape, slope, length and roughness. The method is applicable to most flow conditions, with two notable exceptions. The method shall not be used if the flow is significantly affected by backwater conditions from downstream culverts, bridges, reservoirs, or other restrictive features if they tend to cause ponding effects in the reach of stream or floodplain being routed. Secondly, the method shall not be used for rapidly rising hydrographs on relatively flat streams. The Muskingum-Cunge method is a computation-intense procedure and is performed using computer models such as HEC-1 and HEC-HMS. Details of the application of this method are covered in numerous standard hydraulic routing references.

***Dynamic Wave Method***

The dynamic wave method uses the full equation of flow (Saint Venant's equation) to incorporate conservation of energy and momentum to perform a rigorous hydraulic analysis of flow in channels and streams. Some of the terms in the full equation are often neglected or dampened for computational stability purposes. This method is extremely computation-intense and is performed with computer models such as EPA-SWMM. The most common use of this method for urban hydrology applications is when EPA-SWMM is also used to compute runoff hydrographs and route those flows through pipe, storage and channel systems in the dynamic node. Details of the application of this method are covered in numerous standard hydraulic routing references.

***Stream and Floodplain Routing by Modified Puls Method***

The modified Puls stream routing method is a hydrologic routing procedure wherein the procedure used for flat reservoir routing (see below) is adapted for use in analyzing streams and floodplains with sloping hydraulic grade lines. With this method, the stream is segmented into routing reaches and a storage versus outflow relationship is developed for each reach based on steady state profile analyses for a range of flows. The storage-discharge relationship for each reach is then used to route the inflow hydrograph through the reach using the storage-indication method common to the modified Puls method of flat pool reservoir routing. The process is repeated until the hydrology and hydraulics models are "balanced". Although this method can be performed manually, it is much more efficient to use computer programs such as HEC-1 or HEC-HMS and HEC-2 or HEC-RAS for the analysis. Details of this method are covered in standard references.

### 4.11.1.2 Reservoir Routing

***Modified Puls Method***

For flat pools (ponds and lakes), flood routing is by the well-known and widely used modified Puls method. This is a hydrologic routing method that considers conservation of mass only. Basically, over a specified time interval the increase in volume stored in the reservoir is equal to the inflow volume minus the outflow volume during that time interval. These factors are dependent on the inflow hydrograph, the stage-storage relationship for the reservoir, and the stage-discharge relationship for the outlet(s) serving the reservoir. (Stage is the water surface elevation). Routing is performed in a time step-wise method that tracks inflow, change in volume, and outflow.

Since reservoir routing is a fundamental procedure for implementing many of the requirements of this Manual, the following provides a more detailed review of this method, including general guidance on stormwater runoff storage for meeting stormwater management control objectives (i.e., water quality protection, downstream channel protection, and flood control).

***Storage Facilities***

Storage of stormwater runoff within a stormwater management system is essential to providing the extended detention of flows for water quality protection and downstream channel protection, as well as for peak flow attenuation of larger flows for flood protection. Runoff storage can be provided within an on-site system through the use of structural stormwater controls and/or nonstructural features. Examples of storage facilities include:

- Lakes, ponds, wetlands;
- Bioretention areas, swales, channels and other water quality management facilities when engineered for detention;
- Underground detention; and,
- Rooftop and parking lot detention when permitted and approved.

***Storage Classification***

Stormwater storage can be classified as detention, extended detention or retention. Some facilities include one or more types of storage.

Conventional detention is used to reduce the peak discharge by detaining runoff for whatever time period is necessary to accomplish the desired peak outflow. The time period is not critical. Detention volumes are designed to completely drain after the storm has passed without regard to drain time. This type of detention can be used to meet flood criteria where required. Examples of this type of detention are conventional dry detention ponds, or the flood control pools located above the water quality and channel protection pools in ponds or wetlands.

Extended detention (ED) is used to detain a specified volume of runoff for a specified time. This type of detention can be used to provide water quality treatment and channel protection detention. Examples of this type of detention are extended dry detention ponds and extended wet detention ponds/wetlands.

Retention facilities are designed to contain a permanent pool of water, such as stormwater ponds and wetlands, which is used for water quality protection or other purposes. Routing is not applied to the permanent pool. However, detention or extended detention pools located above the permanent pool would be subject to routing.

Storage facilities are often classified on the basis of their location. *On-site* storage is constructed on individual development sites. *Regional* storage facilities are designed to manage stormwater runoff from multiple projects and/or properties. A discussion of regional stormwater controls is found in Chapter 3.

Storage can also be categorized as *on-line* or *off-line*. *On-line* storage uses a structural control facility that intercepts flows directly within a conveyance system or stream. *Off-line* storage is a separate storage facility to which flow is diverted from the conveyance system. Figure 4-9 illustrates *on-line* versus *off-line* storage.

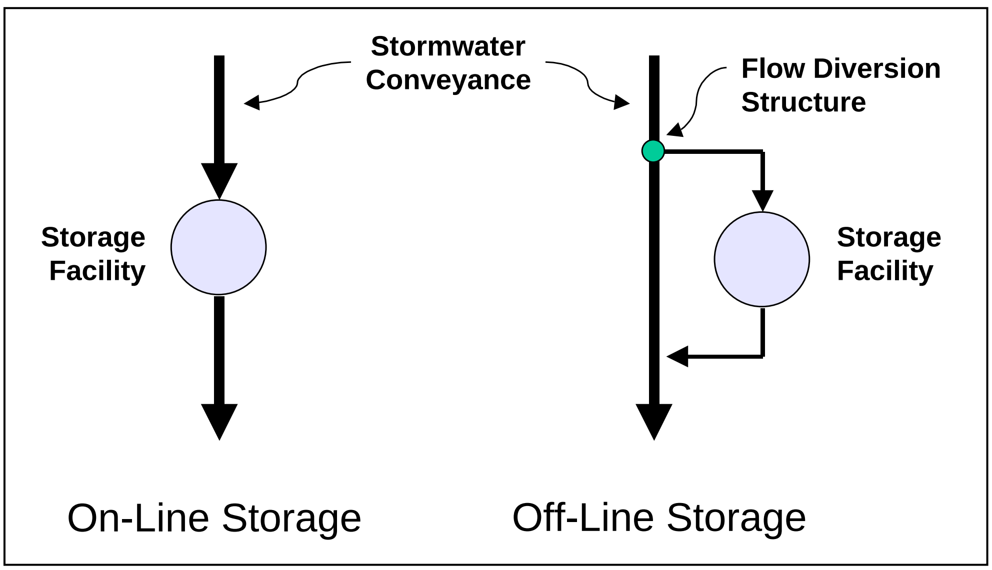


**Figure 4-9 On-Line versus Off-Line Storage**

***Stage-Storage Relationship***

A stage-storage curve or table defines the relationship between the elevation of water and the storage volume in a storage facility (see Figure 4-10).

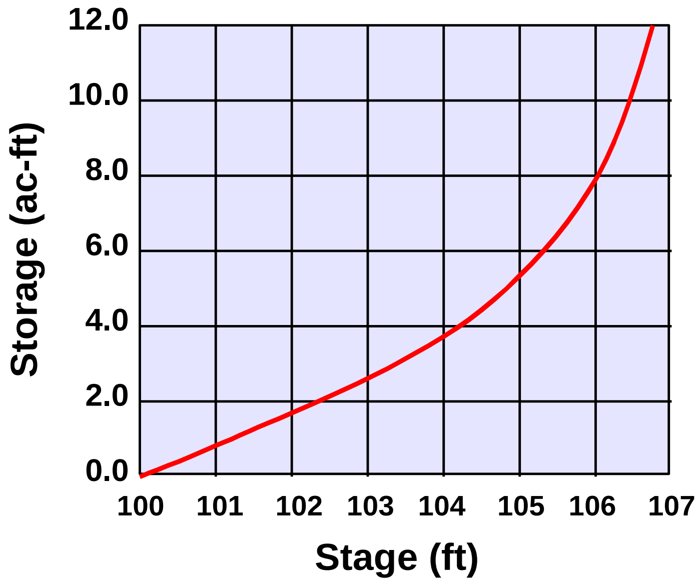


**Figure 4-10 Example Stage-Storage Curve**

The storage volume for basins may be developed using a topographic map, grading plan, or other suitable geometric definition, and either the average-end area method or the conic method formulas. The average-end area method is shown graphically in Figure 4-10.

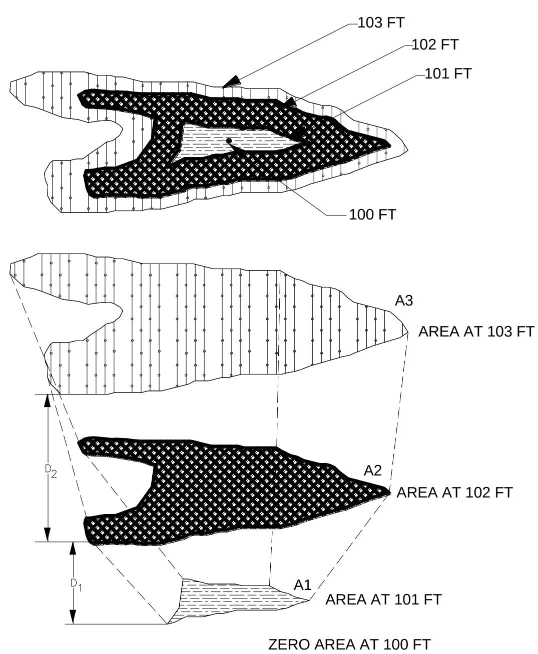


**Figure 4-11 Average-End Area Method**

The average-end area formula presented in Equation 4-21.

**Equation 4-21** $V_{1,2} = \left[ \frac{A_1 + A_2}{2} \right] * d$

where:

| | | |
|---|---|---|
| $V_{1,2}$ | = | storage volume (ft$^3$) between elevations 1 and 2 |
| $A_1$ | = | surface area at elevation 1 (ft$^2$) |
| $A_2$ | = | surface area at elevation 2 (ft$^2$) |
| d | = | change in elevation between points 1 and 2 (ft) |

The conic method formula is presented in Equation 4-22.

**Equation 4-22** $V_{1,2} = [d/3](A_1 + A_2 + [A_1 A_2]^{0.5})$

where:

| | | |
|---|---|---|
| $V_{1,2}$ | = | storage volume (ft$^3$) between elevations 1 and 2 |
| $A_1$ | = | surface area at elevation 1 (ft$^2$) |
| $A_2$ | = | surface area at elevation 2 (ft$^2$) |
| d | = | change in elevation between points 1 and 2 (ft) |

***Stage-Discharge Relationship***

A stage-discharge (or rating) curve defines the relationship between the elevation of the water surface in the storage facility and the rate of total discharge or outflow from the facility. A typical storage facility has two outlets: a principal outlet and a secondary (or emergency) outlet. The principal outlet is usually designed with a capacity sufficient to convey a relatively large design flow (for example, the 24-hour, 25-year flood event) without allowing flow to enter the emergency spillway. A riser, pipe culvert, weir, or other appropriate outlet can be used for the principal spillway or outlet.

The emergency spillway is sized to provide a bypass for floodwater during a flood that exceeds the design capacity of the principal outlet. For normal operating conditions, the stage-discharge curve may take into account the discharge characteristics of both the principal spillway and the emergency spillway. However, for emergency conditions, the stage-discharge curve should take into account only the capacity of the emergency spillway, assuming the principal spillway is blocked. See Volume 2, Chapters 3 and 5 for more details on pond spillway requirements.

Since the total discharge rating for a storage facility usually consists of several orifices and weirs in the principal outlet, plus the emergency overflow, the total rating will be a composite of the individual ratings. The discharge rating for each orifice and weir, and the emergency overflow, are developed and then the flows for each increment of elevation are summed to obtain the total rating. See Volume 2, Chapter 5 for more detail on outlet hydraulics.

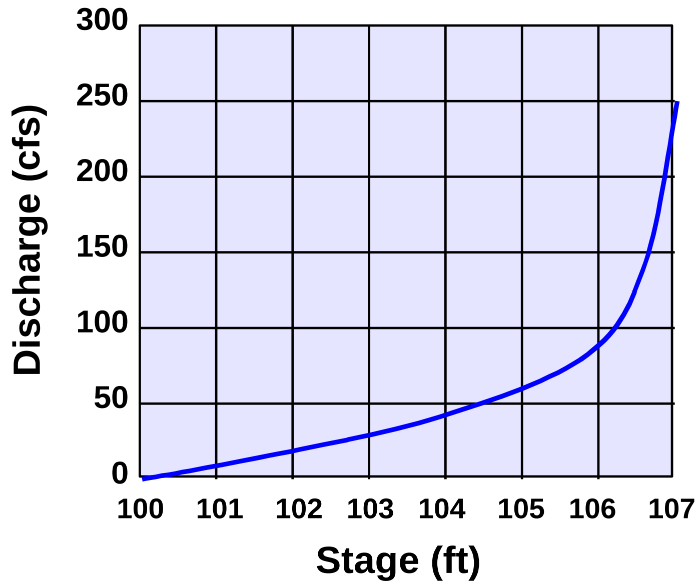


**Figure 4-12 Example Stage-Discharge Rating Curve**

***Routing through Storage Facility***

Given the hydrograph of inflow to the reservoir, the stage-storage relationship, and the stage-discharge relationship, the hydrograph of outflow may be determined. This is accomplished by first combining the stage-storage and stage-discharge curves into a single curve relating storage and discharge (possible since stage is common to both curves). This is put in the form of: O versus (2S/T + O) where O is outflow, S is storage, and T is the routing time interval. From this, and conservation of mass, the routing equation may be developed. (USACE, 1994)

**Equation 4-23** $$(2S_2/T)+O_2 = I_1 + I_2 + (2S_1/T) - O_1$$

where:

| | | |
|---|---|---|
| $S_1$, $S_2$ | = | storage volume at beginning and end of time step |
| $O_1$, $O_2$ | = | outflow at beginning and end of time step |
| $I_1$, $I_2$ | = | inflow at beginning and end of time step |
| T | = | duration of time step (the routing interval) |

Since the terms on the right side of the equation are known, the left side can be computed. Then, given the storage and outflow relationship developed as previously described, the outflow may be determined, and then the storage at the end of the interval may be computed. The routing continues one routing interval at a time, until the routing is complete. Figure 4-13 illustrates flat pool reservoir routing.

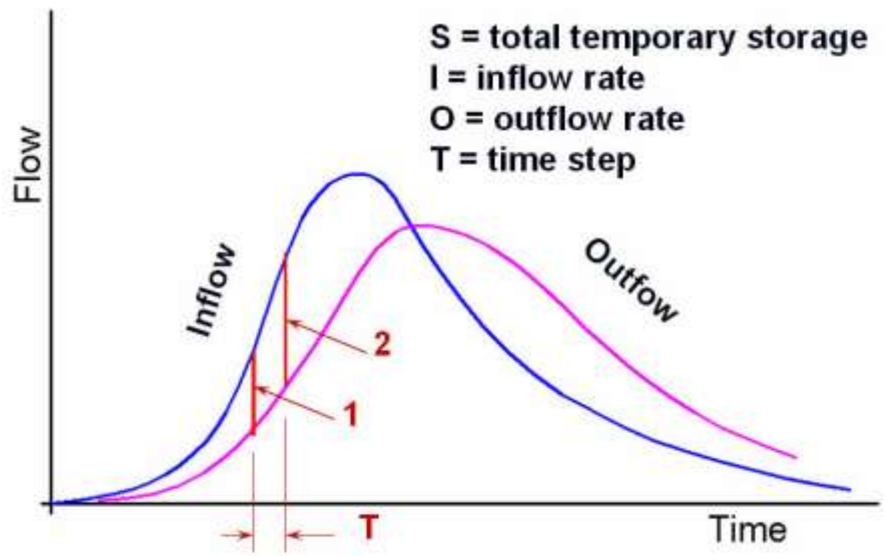


**Figure 4-13 Illustration of Flat-Pool Reservoir Routing**

## 4.12 Downstream Hydrologic Assessment

The purpose of peak flow control is to protect downstream properties from increased flooding and increased erosion impacts due to upstream development. Controlling peak flow at the outlet of a site such that post-development peak discharge does not exceed pre-development peak discharge does not necessarily accomplish this goal. It has been shown that in certain cases this does not always provide effective flood control downstream from the site and may actually exacerbate flooding problems downstream. The reasons for this are related to: (1) the timing of the flow peaks; and, (2) the increase in total volume of runoff.

### 4.12.1 Reasons for Downstream Problems

***Flow Timing***

If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may actually increase the peak discharge downstream. The reason for this may be seen in Figure 4-14. The peak flow from the site is reduced appropriately, but in this example case the timing of the flow is such that the combined detained peak flow (the larger dashed triangle) is actually higher than if no detention were required.

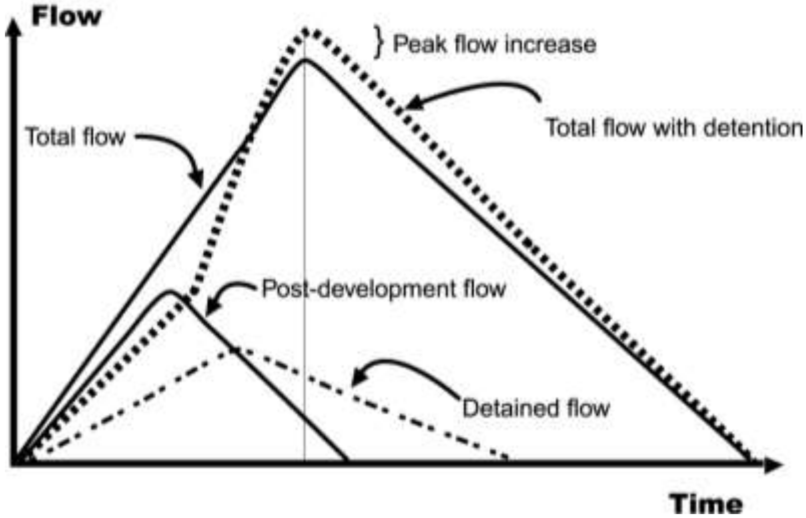


**Figure 4-14  Detention Timing Example**

In this case, the shifting of flows to a later time brought about by the detention pond actually makes the downstream flooding worse than if the post-development flows were not detained. This is most likely to happen if detention is placed on tributaries towards the downstream portion of the watershed, holding back peak flows and adding them as the peak from the upper reaches of the watershed arrives.

***Increased Volume***

An important impact of new development is an increase in the total runoff volume. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributary flows to increase the downstream peak flows.

Figure 4-15 illustrates this concept. The figure shows the pre and post-development hydrographs from a development site (Tributary 1). The post-development runoff hydrograph meets the flood protection criteria (i.e., the post-development peak flow is equal to the pre-development peak flow at the outlet from the site). However, the post-development combined flow at the first downstream tributary (Tributary 2) is higher than pre-development combined flow. This is because the increased volume and timing of runoff from the developed site increases the combined flow and flooding downstream. In this case, the detention volume would have to have been increased to account for the downstream timing of the combined hydrographs to mitigate the impact of the increased runoff volume.

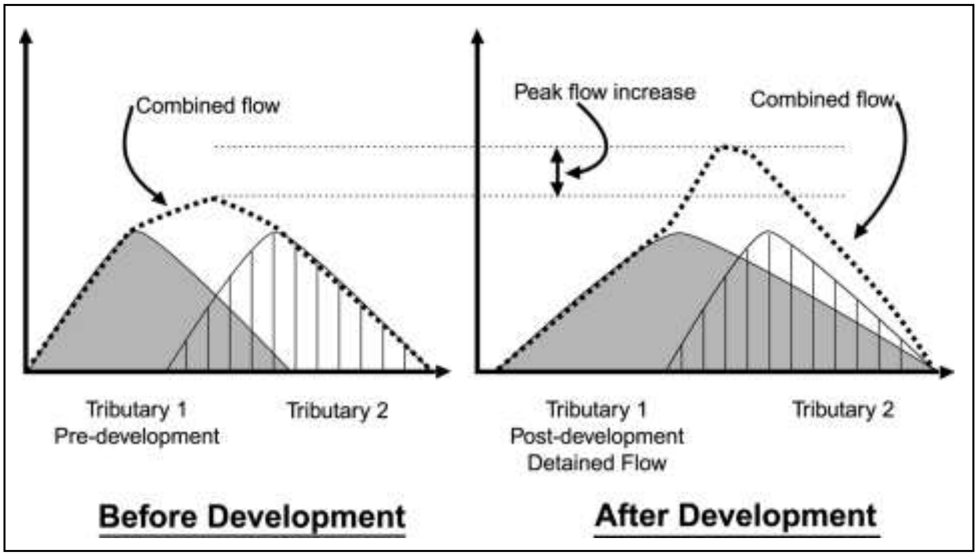


**Figure 4-15 Effect of Increased Post-Development Runoff Volume w/ Detention on a Downstream Hydrograph**

### 4.12.2 Methods for Downstream Evaluation

The downstream assessment is a tool by which the impacts of development on stormwater peak flows and velocities are evaluated downstream. The assessment begins at the outfall of a development and extends to a point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system. This is called the "zone of influence."

Beyond the zone of influence the stormwater effects of a structural control become relatively insignificant compared to the runoff from the total drainage area at that point. Based on studies and master planning results for a large number of sites, a general rule of thumb is that the zone of influence can be considered to end at the point where the drainage area controlled by the detention or storage facilities for a project comprise 10% of the total drainage area if the facilities are located on a tributary to the main stream (i.e., is *off-line* relative to the main receiving stream.) This is known as the *10% Rule*. As an example, if a structural control (or group of controls for a project) drains 10 acres, the zone of influence may be assumed to end at the point where the total drainage area is 100 acres.

#### 4.12.2.1 Off-line

The following downstream assessment procedure shall be employed for proposed projects with *off-line* detention

Determine the outfall location of the site and the pre- and post-development site conditions.

- Using a topographic map determine the location of the 10% point.

- Using a hydrologic model determine the pre-development peak flows and velocities at the project discharge point, and at each tributary junction or significant hydraulic structure (i.e., bridge or culvert) beginning at the location of the planned development outfall and ending at the next junction or significant structure (whichever is encountered first) beyond the 10% point. Undeveloped off-site areas are modeled in their existing condition for both the pre- and post-development analyses. The discharges and velocities are evaluated for the 2, 5, 10, 25 and 100-year, 24-hour storm events.
- Change the land use and/or stormwater facilities on the site and create a post-development model.
- Compare the pre- and post-development peak discharges and velocities at each junction and significant structure in the model. If the post-developed flows or velocities are higher than the pre-developed flows and velocities for the same frequency event, change the detention design. Repeat steps 3 and 4 until the post-development flows and velocities do not increase relative to pre-development conditions.
- If modelling of a site shows that flood protection storage is not necessary for downstream peak flow and velocity control, then the developer may request to the reviewing authority that the flood control detention requirement be waived. The request must be accompanied by an analysis demonstrating that detention is not required. In the event that a request to waive detention for flood control is approved, extended detention for long-term channel protection and water quality protection are still required.

Note that the requirement to not exceed existing peak flood flows or velocities may not be protective downstream if existing peak flood flows cause flooding or existing velocities are erosive. Such situations are beyond the scope of this Manual.

#### 4.12.2.2 On-line Detection Analysis

The above procedure addresses *off-line* ponds. That is, ponds located on a tributary to the main stream. If the detention pond serving a project is located *on-line*, the above procedure is modified. An *on-line* pond is located on the main receiving stream, and has significant off-project inflow from the upstream watershed passing through it in addition to the project runoff. In that case, the zone of influence is considered to the 10% point, as described above, or the point where the pre- and post-development flows are the same, whichever is further downstream.

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### Example Problem – 10% Rule

Figure 4-16 illustrates the concept of the ten-percent rule for two sites in a watershed.

***Discussion***

Site A is a development of 10 acres, all draining to a wet Extended Detention (ED) stormwater pond. The design will incorporate the ten-percent rule. Looking downstream at each tributary in turn, it is determined that the analysis should end at the tributary marked “120 acres.” The 100-acre (10%) point is in between the 80-acre and 120-acre tributary junction points.

The designer constructs a simple HEC-HMS model of the 120-acre area using existing condition subbasins for each tributary. Key detention structures existing in any tributary must be modeled. An approximate CN number is used for each off-site subbasin since the actual peak flow is not key for the analysis; only the increase or decrease is important. The accuracy in CN number determination for those subbasins is not as significant as an accurate estimate of the time-of-concentration. A more detailed subbasin model for the development site is required, using design values for CNs, time-of-concentration, etc. Since flooding and erosion are issues downstream, the pond is designed (through several iterations) until the peak flow and velocities do not increase at any location down to the 120-acre point.

Site B is located downstream at the point where the total drainage area is 190 acres. The site itself is only 6 acres. The first tributary junction downstream from the 10% point is the junction of the site outlet with the stream. The total 190 acres is modeled as one basin with care taken to estimate the time-of-concentration for input into the HEC-HMS model of the watershed. The model shows a detention facility, in this case, will actually increase the peak flow in the stream. Flood control detention will not be required for this site, though water quality and channel protection requirements must still be met.

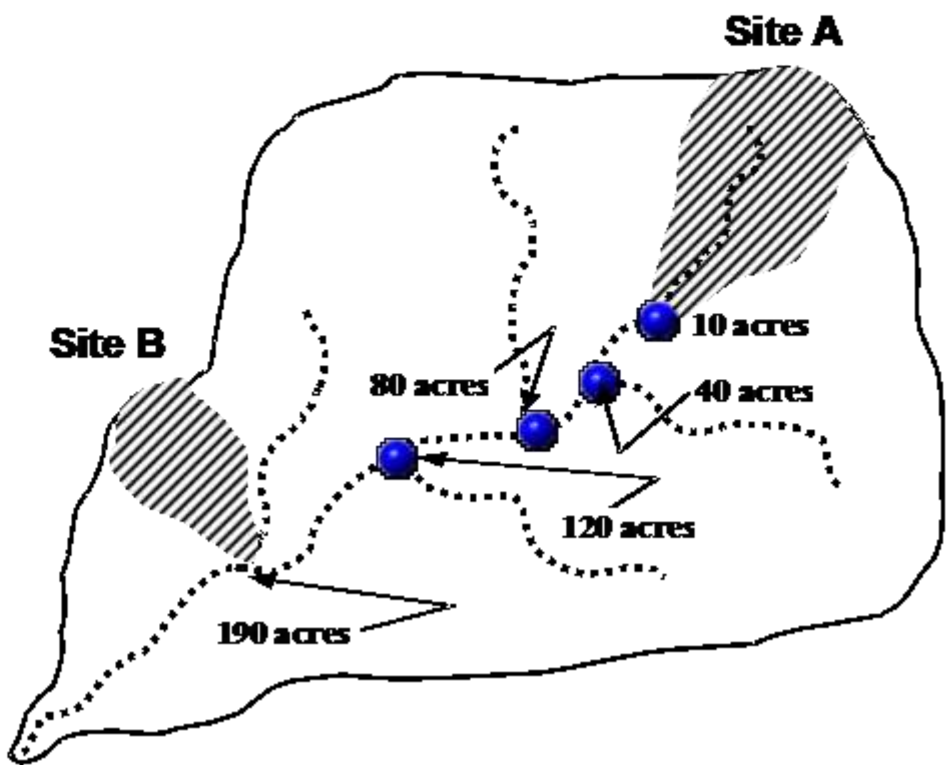



**Figure 4-16 Example of the Ten-Percent Rule**

## 4.13 Water Quality Protection Volume and Peak Flow

### 4.13.1 Water Quality Protection Volume Calculation

The Water Quality Protection Volume ($WQ_v$) is the treatment volume that must be treated to remove 80% of the post-development total suspended solids (TSS) load. This is achieved by intercepting and treating all of the runoff from 85% of the storms that occur, and a portion of the runoff from all larger storms. See Volume 1, Chapter 3 for a detailed presentation of the 80% TSS removal policy.

The $WQ_v$ is calculated by multiplying the 85$^{th}$ percentile annual rainfall event (1.2") by an area weighted volumetric runoff coefficient ($R_v$) and the effective site area. Equation 4-24 presents the $WQ_v$ calculation.

**Equation 4-24** $$WQ_v = \frac{PR_vA}{12}$$

where:

| | | |
|---|---|---|
| $WQ_v$ | = | water quality protection volume (acre-feet) |
| P | = | water quality rainfall depth (1.2 inches for Wichita/Sedgwick County) |
| $R_v$ | = | volumetric runoff coefficient |
| A | = | drainage area (acres) adjusted for $WQ_V$ Reductions per Volume 2, Chapter 2 of this Manual |

When a development project contains or is divided into multiple outfalls, $WQ_v$ should be calculated and addressed separately for each outfall. For any site design, it is possible to treat the $WQ_v$ using multiple treatment facilities. (Section 4.14 of this chapter presents the calculation of the 80% TSS removal standard).

When desired by the design engineer, $WQ_v$ can be expressed in inches over the drainage area ($Q_{wv}$) using the following formula:

**Equation 4-25** $$Q_{wv} = PR_v$$

where:

| | | |
|---|---|---|
| $Q_{wv}$ | = | water quality protection volume (inches) |

The volumetric runoff coefficient ($R_v$) relates total runoff to total rainfall for the range of small storms that dominate the total volume of precipitation. The value of the coefficient depends largely on the fraction of the site that is impervious, and to a lesser degree on the texture of the soil (i.e., sandy versus clayey) and whether or not the soil has been disturbed. If more than one category of runoff area is present, an area-weighted value of $R_v$ should be used in the $WQ_v$ calculation. $R_v$ is calculated as follows (Schueler, 2008):

**Equation 4-26** $$R_V = R_{VU}U + R_{VD}D + R_{VI}I$$

where:

| | | |
|---|---|---|
| $R_V$ | = | volumetric runoff coefficient |
| $R_{VU}$ | = | runoff coefficient for undisturbed wooded, meadow or agricultural cover |

| | | |
|---|---|---|
| U | = | fraction of site in wooded cover |
| $R_{VD}$ | = | runoff coefficient for turf cover or disturbed soils |
| D | = | fraction of site in turf cover or disturbed soils |
| $R_{VI}$ | = | runoff coefficient for impervious cover |
| I | = | fraction of site in impervious cover |

The values of the runoff coefficients to be used in the calculation of $R_v$ are presented in Table 4-13.

**Table 4-13 Volumetric Runoff Coefficients by Land Use and Hydrologic Soil Group**

| Land Use | Hydrologic Soil Group | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Undisturbed Woods, Meadow or Ag. Land ($R_{VU}$) | 0.02 | 0.03 | 0.04 | 0.05 |
| Turf or Disturbed Soils ($R_{VD}$) | 0.15 | 0.20 | 0.22 | 0.25 |
| Impervious Cover ($R_{VI}$) | 0.95 | 0.95 | 0.95 | 0.95 |

An example of the calculation of $R_v$ and $WQ_v$ is presented below.

## Example Problem 1 – Calculating the WQv for a New Development

Compute the water quality protection volume for a 20 acre undisturbed meadow on HSG "C" soils that is converted to a development containing:

- 4 acres undisturbed natural area not held in reserve as a "reduction";
- 10 acres disturbed pervious area;
- 6 acres impervious area.

First look up the appropriate $R_V$ coefficients from Table 4-13.

| | | |
|---|---|---|
| $R_{VU}$ | = | 0.04 |
| $R_{VD}$ | = | 0.22 |
| $R_{VI}$ | = | 0.95 |

Then calculate the overall volumetric runoff coefficient per Equation 4-26.

$$R_V = R_{VU}U + R_{VD}D + R_{VI}I$$
$$R_V = 0.04(4/20) + 0.22(10/20) + 0.95(6/20)$$
$$R_V = 0.008 + 0.110 + 0.285$$
$$R_v = 0.403$$

Finally, calculate the water quality protection volume per Equation 4-24.

$$WQ_v = \frac{PR_v A}{12}$$

$$WQ_v = \frac{1.2(0.403)20}{12}$$

$$WQ_v = 0.81\, acre - feet$$

## Example Problem 2 – Calculating the WQv for a Redevelopment

Compute the water quality protection volume for a 40-acre site on HSG “C” soils. The site as it currently exists has:

- 18 acres of impervious area comprised of office buildings and parking;
- 2 acres of disturbed, pervious green space, consisting of lawn and a few trees; and,
- an adjacent 20 acres of previously undisturbed pervious green space consisting of meadow, light forest and associated bushy undergrowth.

The proposed plan is to expand the office space by using the existing buildings and adding new buildings, parking and associated green spaces. The proposed plan is described below.

- The 18-acre existing site will be “refinished”, updating the interior and exterior of the old buildings and resurfacing the parking area. The impervious area of this 18 acres will remain intact,
- The 2-acres of previously undisturbed green space on the existing site will become an impervious parking area.
- The adjacent, previously undisturbed 20 acres will be developed to contain:
    - 10 acres of disturbed pervious green space which will consist of picnic tables, a pervious walking trail, lawn and trees; and,
    - 10 acres impervious area, consisting of an additional office building and associated parking.

Solution:

The 20-acre area that has existing development is considered a redevelopment site. First determine which one of the six Stormwater Quality Standards for Redevelopment (from Volume 1, Section 3.2.1 of this manual) will be used. For this example, it is assumed that the developer desires to use standard #2:

> *Stormwater runoff from at least thirty percent (30%) of the site’s existing impervious cover and for one-hundred percent (100%) of the impervious cover for any newly disturbed area must be treated for water quality prior in accordance with the standards and criteria presented in the manual.*

Using this standard, water quality treatment must be applied to 30% of the 18 acre existing impervious area and 100% of the new 2-acre impervious (parking) area.

The $R_V$ coefficient for impervious area from Table 4-13, is:

$R_{VI}$ = 0.95.

Calculate the water quality protection volume for 30% of the 18 acre existing development using Equation 4-24.

$$WQ_{v1} = \frac{PR_v(0.3A)}{12}$$
$$WQ_{v1} = \frac{1.2(0.95)(0.3*18)}{12}$$
$$WQ_{v1} = 0.51\ acre-feet$$

Calculate the water quality protection volume for 100% of the new 2 acre parking area, again using Equation 4-24.

$$WQ_{v2} = \frac{PR_v A}{12}$$
$$WQ_{v2} = \frac{1.2(0.95)(2)}{12}$$
$$WQ_{v2} = 0.19\ acre-feet$$

Now, the water quality protection volume must be calculated for the 20-acres of previously undeveloped/undisturbed area. This area is considered new development.

First, look up the appropriate $R_V$ coefficients for this newly developing area from Table 4-13.

$R_{VD}$ = 0.22
$R_{VI}$ = 0.95

Then calculate the overall volumetric runoff coefficient for this area using Equation 4-26.

$$R_V = R_{VU}U + R_{VD}D + R_{VI}I$$
$$R_V = 0.04(0/20) + 0.22(10/20) + 0.95(10/20)$$
$$R_V = 0 + 0.11 + 0.48$$
$$R_v = 0.58$$

Now, calculate the water quality protection volume for this area using Equation 4-24.

$$WQ_{v3} = \frac{PR_v A}{12}$$
$$WQ_{v3} = \frac{1.2(0.58)20}{12}$$
$$WQ_{v3} = 1.16\ acre-feet$$

Finally, calculate the overall water quality protection volume for the entire 40 acre area by adding the WQv's calculated for the existing redeveloped and the newly developed areas.

$$WQ_v = WQ_{v1} + WQ_{v2} + WQ_{v3}$$
$$WQ_v = 0.51 + 0.19 + 1.16$$
$$WQ_v = 1.86 acre - feet$$

### 4.13.2 Water Quality Peak Flow Calculation

When designing off-line stormwater management facilities, the peak discharge of the water quality storm ($Q_{wq}$) can be estimated using the method described in this section. The peak rate of discharge for the water quality design storm is needed for hydraulic sizing of off-line treatment facilities, such as for sand filters and infiltration trenches, and their respective hydraulic diversion structures. Conventional SCS methods have been found to be unsatisfactory for estimating volume and rate of runoff for rainfall events less than 2 inches. This discrepancy in estimating runoff and discharge rates can lead to situations where a significant amount of runoff by-passes the treatment practice due to an inadequately sized diversion structure, as well as lead to the design of undersized bypass channels.

The following procedure can be used to estimate peak discharges for small storm events. It relies on the Water Quality Protection Volume and the previously described NRCS simplified peak flow estimating method.

**Step 1** Using $Q_{wv}$ and Equation 4-3, compute a corresponding Curve Number (CN) utilizing the following equation:

$$CN = \frac{1000}{\left[10 + 5P + 10Q_{wv} - 10\left(Q_{wv}^{\ 2} + 1.25Q_{wv}P\right)^{1/2}\right]}$$

where:

| | | |
|---|---|---|
| P | = | rainfall, in inches (use 1.2 inches for the Water Quality Storm) |
| Qwv | = | Water Quality Protection Volume, in inches (1.2Rv) |

**Step 2** Compute S from the Curve Number

**Step 3** Compute $I_a$ from S

**Step 4** Compute $I_a$/P

**Step 5** Read the unit peak discharge ($q_u$) from Figure 4-6 for appropriate $t_c$ and $I_a$/P

**Step 6** Compute the peak discharge ($Q_{wq}$) using $q_u$, drainage area and $Q_{wv}$ using Equation 4-18

$$Q_{wq} = q_u * A * Q_{wv} * F_p$$

where:

| | | |
|---|---|---|
| $Q_{wq}$ | = | the water quality peak discharge (cfs) |
| $q_u$ | = | the unit peak discharge (cfs/mi²/inch) |
| A | = | drainage area ($mi^2$) |
| $Q_{wv}$ | = | Water Quality Protection Volume, in inches ($1.2R_v$) |
| $F_p$ | = | pond and swamp adjustment factor |

## Water Quality Peak Flow Example Problem

Using the data and information from the example problem 1 in Section 4.13.1, calculate the water quality peak flow for a site having a time of concentration is 0.35 hours.

- Compute runoff volume in inches ($Q_{wv}$) using Equation 4-26, where P = 1.2 inches:

$$Q_{wv} = 1.2 * R_v = 1.2 * 0.403 = 0.48\, inches$$

- Compute curve number using equation 4-3:

$$CN = \frac{1000}{\left[10 + 5P + 10Q_{wv} - 10\left(Q_{wv}^{\ 2} + 1.25Q_{wv}P\right)^{1/2}\right]}$$

$$CN = \frac{1000}{\left[10 + (5*1.2) + (10*0.48) - 10\left(0.48^2 + 1.25*0.48*1.2\right)^{1/2}\right]} = 90.5$$

- Compute S:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{90.5} - 10 = 1.05\, in$$

- Compute $I_a$:

$$I_a = 0.2S = 0.2(1.05) = 0.21\, in$$

- Compute $I_a/P$:

$$\frac{I_a}{P} = \frac{0.21}{1.2} = 0.175$$

- Find $q_u$ from Figure 4-6 for $I_a/P$ = 0.175 and $t_c$ = 0.35 hours:

$q_u$ = 600 cfs/mi$^2$/in

- Compute water quality peak flow using equation 4-18:

$$Q_{wq} = q_u * A * Q_{wv} = 600 * \frac{20}{640} * 0.48 = 9.0\, cfs$$

### 4.13.3 Water Quality Volume Extended Detention

The $WQ_v$ for a site must be detained for 24 hours to achieve the design TSS removal efficiencies for extended detention treatment. After the 24 hour detention period, this volume must be released over a reasonable period of time (e.g., 2 to 4 days) to return the pond to a dry condition (or its static pool elevation if a wet pond). Because the maximum pollutant load is carried by the first flush from the initial storm event, these drainage criteria do not apply to successive rain events within a 4-day period.

The $WQ_v$ for the entire site may be detained in a single detention pond at the downstream portion of the site, or the runoff may be detained in several facilities located within the development, including “treatment trains” as discussed in Volume 3, Chapter 3 of this Manual. The primary requirement is that all areas of the site (unless it is reserved as a “reduction” area per Volume 2, Chapter 2) must receive the required extended detention of their respective $WQ_v$. Please refer to Chapter 2 of Volume 2 for more details on this requirement.

Normally, a hydrograph for the water quality event would be routed through the treatment facilities, and the detention time could be determined as the time lapse between the centroid of the inflow hydrograph and the centroid of the outflow hydrograph. However, for the small events associated with the $WQ_v$ rainfall, this is not feasible. Instead, a simplified method is used to set controls (usually an orifice) in the facility to achieve the required detention time, as described below.

1. Develop a volume versus water surface elevation curve or table for the storage facility. (In this discussion, the term pond will be used for storage facilities. However, the procedure applies as well to wetlands and other storage features that may be used for extended detention (ED) for $WQ_v$ treatment.)
2. Using the computed $WQ_v$, determine the elevation of the pool with the $WQ_v$ added. (For a dry extended detention pond, this would be the elevation in the pond if it contains only the $WQ_v$. For a wet extended detention pond where ½ of the $WQ_v$ lies above the permanent pool, this would be the elevation of the pond if it contains the permanent pool plus ½ of the $WQ_v$.)
3. Select a trial orifice size to control the drain time for the $WQ_v$ held in temporary storage (full $WQ_v$ for dry ED pond, ½ $WQ_v$ for wet ED pond). The invert of the orifice will be located at the pond bottom for a dry ED pond, or at the surface of the permanent pool for a wet ED pond.
4. Using the hydraulic characteristics of the orifice and the volume-elevation curve for the pond, compute the time for approximately 90% of the $WQ_v$ in temporary storage to be in the pond at the $24^{th}$ hour and for the drainage facility to discharge the $WQ_v$ with a reasonable period of time afterward (e.g., 2 to 4 days) (see Volume 2, Chapter 5 for guidance on analyzing orifices). The reason 90% is used is that the simplified drawdown method for sizing orifices tends to over-estimate the orifice size and thus under-predict actual ED time. The additional 10% of drawdown after the end of the 24-hour period is intended to help compensate for that effect.

Repeat steps 3 and 4 until a satisfactory orifice size has been selected.

## 4.14 Calculation of %TSS Removal

As previously stated, the site design engineer must utilize one or more stormwater treatment facilities that achieve (or exceed) the 80% TSS removal standard. The % TSS removal is an area-weighted value for the site (excluding $WQ_V$ reductions), based upon the % TSS removal value of the structural facility(s) located on-site and the drainage area treated by each facility. Table 4-14 provides the % TSS Removal value for each structural stormwater treatment facility that is presented in this Manual.

**Table 4-14 % TSS Removal Values for Structural Stormwater Treatment Facilities**

| Structural Facility | TSS Removal % |
|---|---|
| Stormwater Pond | 80 |
| Dry Extended Detention Pond | 60 |
| Enhanced Swale | 90 |
| Grass Channel | 50 |
| Infiltration Trench | 90 |
| Soakage Trench | 90 |
| Vegetative Filter Strip | 50 |
| Surface Sand Filter | 80 |
| Organic Filter | 80 |
| Bioretention Area | 85 |
| Stormwater Wetland | 75 |
| Proprietary Manufactured Device | device-specific |
| Gravity Oil/Water Separator | device-specific |
| Alum Treatment | 90 |
| Green Roof | installation-specific |

If a single treatment facility is used for a site, the calculation of the % TSS removal is straightforward – the % TSS removal for the site equals the % TSS removal value for the stormwater treatment facility that is used. However, multiple facilities are often used at a site to achieve the overall required removal rate. The following sections provide guidance on calculating the % TSS Removal for sites with multiple stormwater management facilities.

### 4.14.1 Calculation of % TSS Removal for a site (Controls in Parallel)

The percent TSS removal (%TSS) that is achieved on a site can be calculated using Equation 4-27 (parallel treatment). Any untreated area is to be assigned a null control with a TSS removal rate of 0%.

**Equation 4-27** $$TSS_{site} = \frac{\sum_1^n \left(TSS_1 A_1 + TSS_2 A_2 + ... + TSS_n A_n\right)}{\sum_1^n \left(A_1 + A_2 + ... + A_n\right)}$$

where:

$TSS_n$ = TSS removal (Table 3-2) for each water quality control located on-site (%)
$A_n$ = the area draining to each control, excluding reduction areas (acres)

### 4.14.2 Calculation of % TSS Removal for a site (Controls in Series)

The site designer will often want to use two or more controls (structural and/or non-structural) in series, where stormwater treated in one control is discharged directly into another control for further treatment. Where controls are used in series, the total % TSS removal for the combination of controls shall be used for $TSS_n$ in Equation 4-27 for the area treated by the series of controls.

To calculate the total % TSS removal for two controls in series, Equation 4-28 shall be used.

**Equation 4-28** $$TSS_{train} = TSS_A + TSS_B - \frac{\left(TSS_A * TSS_B\right)}{100}$$

where:

$TSS_{train}$ = total TSS removal for series (%)
$TSS_A$ = % TSS removal of the first (upstream) control (%)
$TSS_B$ = % TSS removal of the second (downstream) control (%)

For more than two controls in series, use the combined removal for the first two controls as $TSS_A$, and the removal for the third control as $TSS_B$. Repeat this procedure as necessary to account for all controls in the series. For development sites where the series of controls (also called a "treatment train") provides the only stormwater treatment on the site, $TSS_{train}$ must be greater than or equal to 80%. For development sites that have other controls for stormwater treatment that are not included in the treatment train, $TSS_{train}$ must be included in Equation 4-27 in the calculation of the overall % TSS removal for the site. An example application of the latter situation is presented below.

---

**Example Problem – Calculation of %TSS when Controls in Series are Used**

A stormwater management system located on a 30 acre development site consists of a dry extended detention pond, a water quality swale, and a shallow wetland. The extended detention pond and swale are located in series, with the pond as the upstream control. The treatment train treats stormwater runoff from 20 acres of the site. The shallow wetland treats 10 acres. What is the % TSS removal rate for the site?

The % TSS removal value for each control located on the site is determined from Table 4-14, as follows:

**Control A** (dry extended detention pond) = 60% TSS removal

**Control B** (water quality swale) = 90% TSS removal
**Control C** (shallow wetland) = 75% TSS removal

**Step 1** Calculate $TSS_{train}$:
$TSS_{train} = TSS_A + TSS_B – (TSS_A \times TSS_B)/100 = 60 + 90 - (60 \times 90)/100 = 96\%$ removal

**Step 2** Calculate % TSS removal for the site:
$\%TSS = ((TSS_{train} \times 20 \text{ acres}) + (\%TSS_{wetland} \times 10 \text{ acres})) \div 30 \text{ acres}$
$\%TSS = ((96\% \times 20 \text{ acres}) + (75\% \times 10 \text{ acres})) \div 30 \text{ acres} = 89\%$

Therefore, the % TSS removal for the site is 89%, which exceeds the minimum standard of 80% TSS removal. No other water quality controls are required.

## 4.14.3 Calculation of % TSS Removal for Flow-through Situations

Water quality controls within a treatment train may sometimes be separated by a contributing drainage area. (That is, runoff requiring treatment may enter the train between two other controls located in series.) In this case, Equation 4-28 cannot be used, since some of the flow entering the downstream control has not been treated by the upstream control. This section presents the calculation of the total % TSS removal for flow-through situations.

To calculate the total % TSS removal for a treatment train separated by a contributing drainage area, Equation 4-29 shall be used (Knox County TN, 2008).

**Equation 4-29**
$$TSS_{train} = \frac{TSS_A A_A + TSS_B A_B + \dfrac{TSS_B A_A (100 - TSS_A)}{100}}{A_A + A_B}$$

where:

| | | |
|---|---|---|
| $TSS_{train}$ | = | total TSS removal for treatment train (%) |
| $TSS_A$ | = | % TSS removal of the first (upstream) control (%) |
| $TSS_B$ | = | % TSS removal of the second (downstream) control (%) |
| $A_A$ | = | Area draining to control A |
| $A_B$ | = | Area draining to control B |

For development sites where the treatment train provides the only stormwater treatment on the site, $TSS_{train}$ must be greater than or equal to 80%. If other areas of the site are treated by other controls, then the removal rate computed by Equation 4-29 is used in Equation 4-27 for its treatment area. An example application of Equation 4-29 is shown below.

### Example Problem – Calculation of %TSS in a Flow-through Situation

A stormwater management system located on a 9 acre development site consists of a dry extended detention pond, and a bioretention cell. Five acres drain to the bioretention cell, which then drains to a pipe system. The pipe system also drains an additional 4 acres that have not been treated for water quality. The pipe system leads to a dry extended detention pond, that is used for final treatment. What is the % TSS removal rate for the site?

The % TSS removal value for each control located on the site is determined from Table 4-14, as follows:

Control A (bioretention cell) = 85% TSS removal
Control B (dry extended detention pond) = 60% TSS removal

Calculate $TSS_{train}$:

$$TSStrain = \frac{TSS_A A_A + TSS_B A_B + \dfrac{TSS_B A_A (100 - TSS_A)}{100}}{A_A + A_B}$$

$$TSStrain = \frac{85*5 + 60*4 + \dfrac{60*5(100-85)}{100}}{5+4}$$

$$TSStrain = 79\%$$

The % TSS removal for the site is 79%, which is slightly below the minimum standard of 80% TSS removal. The conversion of the stormwater pipe system to a grass swale would add additional pollutant removal and help the site meet the 80% criteria.

### 4.14.4 Application of $WQ_v$ Reductions

The $WQ_v$ reductions discussed in Chapter 2 are primarily intended to reduce treatment volume requirements by excluding those areas from the $WQ_v$ calculations. However, reductions 1 through 4 also serve as water quality controls with TSS removal benefits. These benefits should be included in the TSS removal calculation if used in the project. The TSS removal efficiencies are provided in their respective reduction descriptions in Chapter 2. The TSS efficiencies should be included in the TSS calculations if used in the project.

It is important to note that site $WQ_v$ and site TSS removal computations, although related, are performed independently. For example, the area draining to a qualifying stream buffer (see Chapter 2) is subtracted from the site area for $WQ_v$ calculation purposes, but is still included in the site TSS removal calculation. However, the area that drains to the buffer receives 80% TSS removal in the site TSS calculation.

## 4.15 Channel Protection Volume

### 4.15.1 Description

Although the runoff associated with large, relatively infrequent storms can induce significant erosion in streams, the long-term channel forming storms are associated with smaller, more frequent events. Specifically, it has been shown that the 1 to 2-year storm events create the predominant channel forming runoff that causes long-term sustained channel erosion. These flows are commonly referred to as the “bankfull” flows that just fill the stream channel without significantly overflowing to the floodplain. (Note that the term “bankfull” would not apply to streams that are already deeply incised or enlarged from previous erosion or to engineered channels with capacity larger than the 1 to 2-year runoff.)

In order to provide a degree of protection from long-term erosion associated with these frequent channel forming events, the Channel Protection Volume ($CP_v$) concept is applied. This criteria requires (with certain exceptions) that the runoff from the project for the 24-hour, 1-year storm event (defined as the $CP_v$) be detained for a minimum of 24 hours. The $CP_v$ can then be drained within a reasonable amount of time (e.g., 2 to 4 days).

The $CP_v$ for the entire site may be detained in a single detention pond at the downstream portion of the site, or the runoff may be detained in several storage facilities located within the development, as discussed in Chapter 3 of this Manual. The primary requirement is that all areas of the site, including any $WQ_v$ reduction areas, must receive the required extended detention of their respective $CP_v$.

If $CP_v$ control is being provided by a single facility located at or near the project boundary (for example, an extended detention pond), or for facilities located in parallel, the design is relatively straightforward. The individual controls may be designed by applying the “centroid” method (see Section 4.15.2) to the facility inflow and outflow hydrographs, or by using the simplified methods for facilities that are not readily modeled by routing procedures.

Since $CP_v$ controls are detention facilities, they affect the rate and duration of flows downstream. Therefore, the effect of $CP_v$ controls placed in series is hydrologically complex since the upstream controls affect the downstream controls. The use of $CP_v$ facilities in series is generally inefficient and should be avoided if possible.

If $CP_v$ controls are placed in series, only the local inflow between the upstream and downstream controls is considered to be regulated by the downstream control. In addition, the designer must demonstrate that the outflow from the upstream control does not adversely affect the function of the downstream control.

### 4.15.2 Channel Protection Volume Extended Detention – Centroid Method

For ponds, wetlands, or other storage facilities used for extended detention (ED) of the $CP_v$ where routing procedures are practicable, the following procedure applies:

1. Develop a 24-hour, 1-year runoff storm event hydrograph for the catchment area draining to the storage facility using the previously described methods. This is the inflow hydrograph for the ED facility.
2. Select a trial hydraulic control (usually an orifice or weir) to control the $CP_v$ detention time for the facility. The invert of the control is located at the top of the $WQ_v$ pool for facilities that also treat the $WQ_v$.

3. Using the routing procedure previously described for ponds and reservoirs (i.e., flat pool), route the inflow hydrograph through the storage facility and thus determine the outflow hydrograph.
4. Compute the centroids of the inflow and outflow hydrographs. The time lapse between the two centroids is the extended detention time.
5. Repeat steps 3 and 4 until the ED time is at least 24 hours and the $CP_v$ will drain within a reasonable time period (e.g., 2 to 4 days).

An example calculation of the ED time using the Centroid Method is provided below.

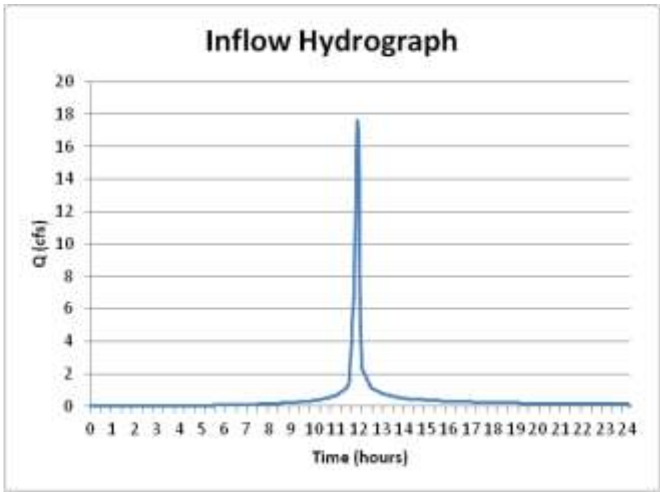
### Example Problem – $CP_v$ Outlet Sizing Using the Centroid Method

An ED pond is being designed for a 5 acre development site. Design the ED pond orifice using the centroid method to meet the $CP_v$ requirements. Relevant information is below:

Catchment area: 5 acres
24-hour, 1-year rainfall depth: 2.9 inches (from Table 4-1)
Use a NRCS Type II Rainfall Distribution
Pre-development curve number = 80 (from Table 4-1)
Post-development curve number = 90
Antecedent Moisture Condition II
Standard Peaking Factor 484
Travel time for sheet flow = $T_{Tsheet}$ = 1.16 minutes
Travel time for shallow concentrated flow = $T_{Tshallow}$= 0.72 minutes
Travel time for channel flow =$T_{Tchannel}$ = 1.84 minutes

**Step 1** Develop the inflow hydrograph for the 1-year, 24-hour storm event that will discharge to the ED pond from the 5 acre site.

For the purpose of this example, the NRCS synthetic unit hydrograph was used to determine the 24-hour, 1-year runoff storm event hydrograph.



**Step 2** Select a trial hydraulic control (usually an orifice or weir) to control the $CP_v$ detention time for the facility. The invert of the control is located at the top of the $WQ_v$ pool for facilities that will also treat the $WQ_v$.

The selected hydraulic control for this example is an orifice to be installed through the chosen outlet structure with the invert at the bottom of the facility. The initial orifice diameter chosen is 3 inches.

**Step 3** Using the routing procedure previously described for ponds and reservoirs (i.e., flat pool), route the inflow hydrograph through the storage facility and thus determine the outflow hydrograph.

The detention facility is a dry pond with bottom dimensions of 30' x 90' with 3:1 side slopes.

Using the Average-End Area Method, the Stage-Storage Relationship for the pond is as follows:

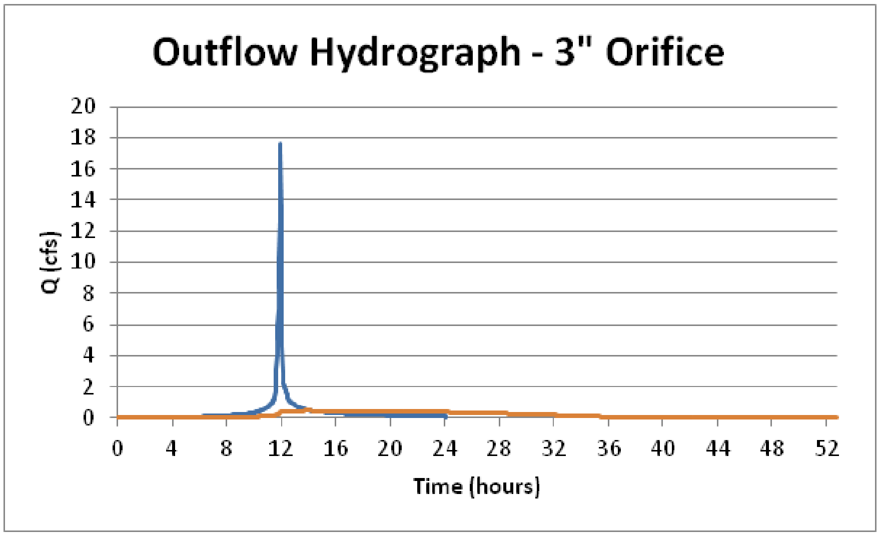
| Stage | Elevation | Contour Area | Incremental Storage | Total Storage |
|---|---|---|---|---|
| 0 | 100 | 2700 | 0 | 0 |
| 1 | 101 | 3456 | 3070 | 3070 |
| 2 | 102 | 4284 | 3862 | 6932 |
| 3 | 103 | 5184 | 4726 | 11659 |
| 4 | 104 | 6156 | 5662 | 17321 |
| 5 | 105 | 7200 | 6671 | 23992 |
| 6 | 106 | 8316 | 7751 | 31742 |
| 7 | 107 | 9504 | 8903 | 40645 |
| 8 | 108 | 10764 | 10126 | 50771 |

Then, using Equation 5-36 and the information given below, compute the Stage-Discharge Relationship.

Given: 3 inch diameter orifice (0.25 ft)
Discharge coefficient (C) = 0.80
A = 0.05 $ft^2$
G = 32.2ft/$s^2$
Diameter (D) = 0.25 ft
H = varies with stage

| Stage | Elevation | Discharge |
|---|---|---|
| 0 | 100 | 0.00 |
| 1 | 101 | 0.32 |
| 2 | 102 | 0.45 |
| 3 | 103 | 0.56 |
| 4 | 104 | 0.64 |
| 5 | 105 | 0.72 |
| 6 | 106 | 0.79 |
| 7 | 107 | 0.85 |
| 8 | 108 | 0.91 |

The outflow hydrograph is shown below.




**Step 4** Compute the centroids of the inflow and outflow hydrographs. The time lapse between the two centroids is the extended detention (ED) time.

The centroid of a hydrograph ($T_m$) is computed using the equation given below. For each point on the inflow and outflow hydrographs, multiply the flow value by the time step value between the flows.

$$T_m = \frac{\sum_0^t qt}{\sum_0^t q}$$

Using this equation, the centroid of the Inflow Hydrograph ($T_{mi}$) = 13 hours
The centroid of the Outflow Hydrograph ($T_{mo}$) = 21.5 hours

The ED time of the pond (ED) = $T_{mo} - T_{mi}$ = 21.5 hrs – 13 hrs = 8.5 hours.

The ED time of the pond must be at least 24 hours. Because ED for the 3 inch orifice is only 8.5 hours, the 3 inch orifice is too large.

**Step 5** Repeat steps 3 and 4 until the ED time is at least 24 hours, but not more than 48 hours. If we repeat steps 3 and 4 using a 1.75 inch orifice, the ED time is 26 hours. Therefore a 1.75 inch orifice is suitable for this pond. An example of inflow and outflow hydrographs with a suitable ED time is shown graphically below.

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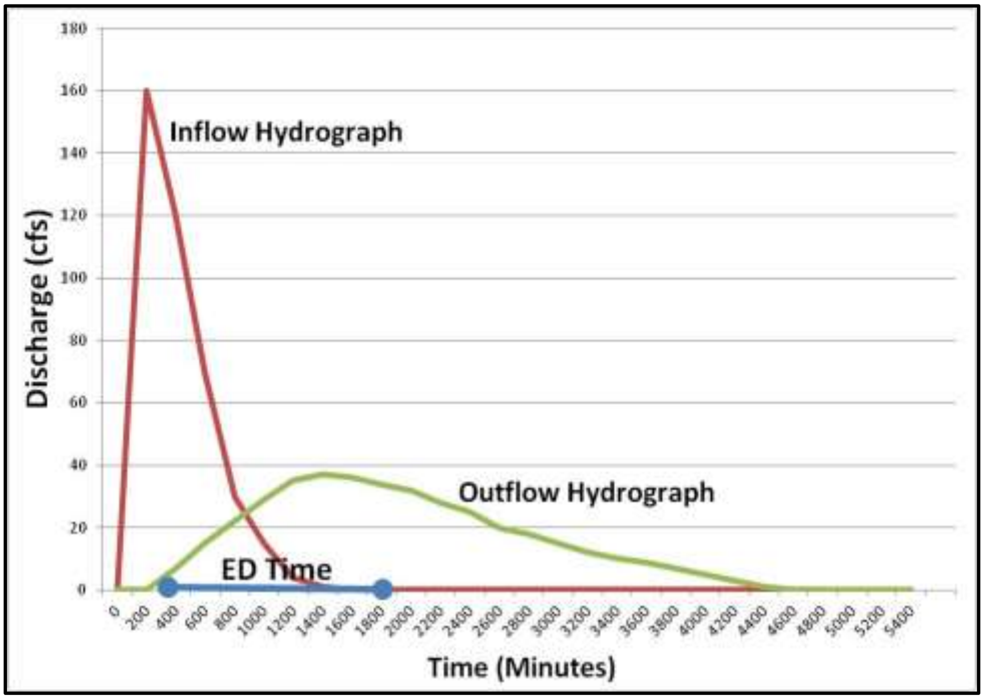


### 4.15.3 Channel Protection Volume Extended Detention – Simplified Method

For some $CP_v$ facilities, routing procedures may not be practicable. For example, some swales, pocket wetlands, and bioretention areas do not lend themselves to routing. For those facilities, a simplified method may be used.

The simplified method consists of determining the volume of runoff using the CN method, estimating the peak runoff rate using the previously described NRCS simplified peak flow method, and then estimating the volume of storage required using procedures derived from the NRCS TR-55 detention pond storage estimating method. Finally, the ED control (orifice or weir) is sized.

1. Using the simplified peak flow procedures described in Section 4.8, estimate the peak inflow ($q_i$) to the storage facility.
2. Using the unit peak discharge ($q_u$) determined in Step 1, determine the ratio of peak outflow to peak inflow ($q_o/q_i$) using the curve labelled “T = 24 hr” in Figure 4-17.
3. Using the ratio $q_o/q_i$, determine the ratio of the storage volume to runoff volume ($V_s/V_r$) using the curve labelled “Types II and III” in Figure 4-18.
4. Using the ratio $V_s/V_r$, and the runoff volume for the 1-year, 24-hour storm ($V_r$), compute the storage volume ($V_s$). This is equivalent to the $CP_v$.
5. Size the outflow hydraulic controls based on peak outflow $q_o$ and peak head (i.e. when pool contains $CP_v$).

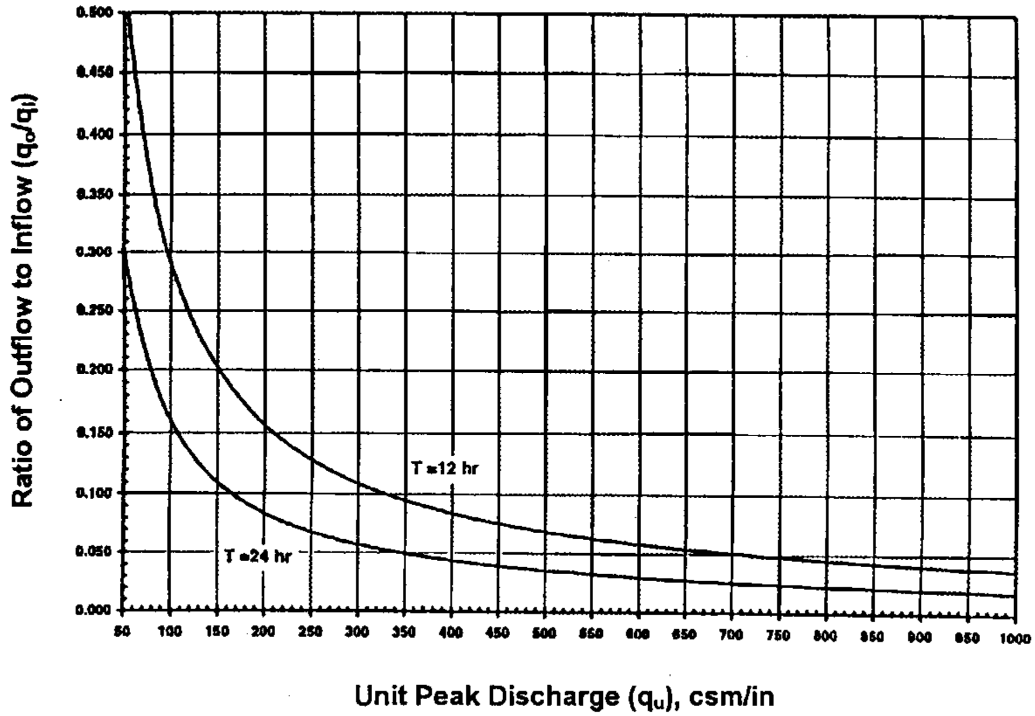


**Figure 4-17 Detention Time vs Discharge Ratios**
(Source: MDE, 1998)

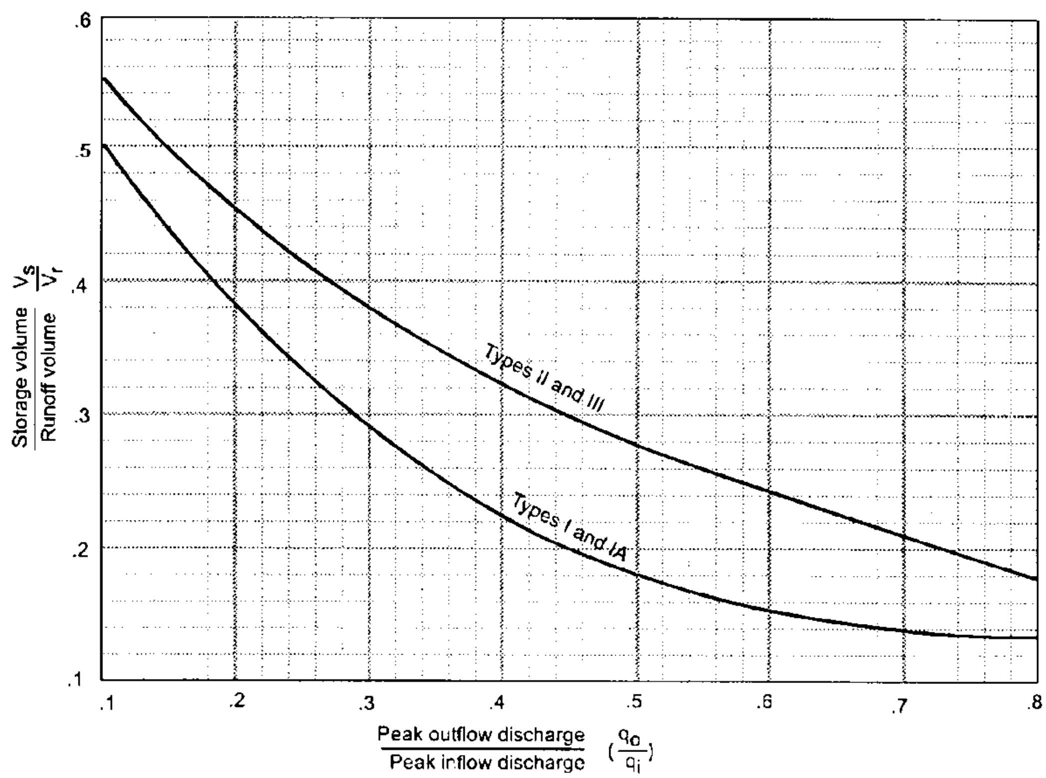


**Figure 4-18 Approximate Detention Basin Routing for Rainfall Types I, IA, II and III**
(Source: TR-55, 1986)

## Example Problem - Simplified Channel Protection Volume ED

Compute the Channel Protection Volume ($CP_v$) for the following catchment.

### *Computations*

Calculate rainfall excess for the 1-year storm using equation 4-1:

| | | |
|---|---|---|
| P | = | 2.9 inches (the 1-year, 24-hour rainfall) |
| CN | = | 81.8 (from previous calculation) |
| S | = | 2.2 inches |
| $I_a$ | = | 0.439 (from previous calculation) |
| $T_c$ | = | 11.6 minutes |
| A | = | 28 acres |

$$Q = \frac{(P - I_a)^2}{[(P - I_a) + S]} = \frac{(2.9 - 0.439)^2}{[(2.9 - 0.439) + 2.2]} = 1.3\,in$$

Calculate $I_a/P$

$$I_a \big/ P = 0.439 \big/ 2.9 = 0.15$$

Find unit discharge $q_u$ from Figure 4-6 for $I_a/P$ = 0.15 and $T_c$ = 11.6 min (0.19 hours)

$q_u$ = 780 cfs/mi$^2$-in

Find discharge ratio $q_o/q_i$ from Figure 4-17 for $q_u$ = 780 csm/in and T = 24 hr

$q_o/q_i$ = 0.02

From Figure 4-18, using $q_o/q_i$ = 0.02 determine the ratio $V_s/V_r$ using the Type II curve. Note that the lower limit of the curve is $q_o/q_i$ = 0.1, which is greater than the computed value. Although the accuracy of the estimate is diminished by extrapolating the curve, it is customary to do so for the purposes of analyzing CPv requirements. The extrapolation may be made using the following equation: (SCS, 1986)

**Equation 4-30**

$$\frac{V_s}{V_r} = 0.682 - 1.43\left(\frac{q_o}{q_i}\right) + 1.64\left(\frac{q_o}{q_i}\right)^2 - 0.804\left(\frac{q_o}{q_i}\right)^3$$

where:

| | | |
|---|---|---|
| $V_S$ | = | required storage volume (acre-feet) |
| $V_r$ | = | runoff volume (acre-feet) |
| $q_o$ | = | peak outflow discharge (cfs) |
| $q_i$ | = | peak inflow discharge (cfs) |

Using this equation, $V_s/V_r$ = 0.65.

Therefore, $CP_v$ for Q = 1.3 inches is

$$V_S = \frac{\left(\frac{V_S}{V_r}\right) QA}{12} = \frac{(0.65)(1.3)(28)}{12} = 1.97\, acre - \, feet$$

The simplified $CP_v$ detention control sizing procedure is as follows:

- The peak discharge from the pond is computed using the method described in Section 4.8.4 and the previously computed value of $q_o/q_i$ (i.e., ratio of peak pond outflow to inflow).
- Wet Ponds with Permanent $WQ_v$ Pools: For ponds where 100% of the $WQ_v$ is in a permanent pool, the $CP_v$ orifice is placed at the top of the permanent pool. The top of the $CP_v$ pool is determined based on the storage versus elevation curve for the pond and the combined CPv and $WQ_v$. The maximum head on the $CP_v$ orifice is computed as the difference between the $CP_v$ pool elevation and the elevation of the center of the $CP_v$ orifice. The orifice size is then determined based on the orifice equation, given the peak discharge from the pond and the maximum head.
- Extended Detention Wet Pond and Extended Detention Micropool Pond: For wet extended detention ponds, the $CP_v$ orifice is usually located at the top of the permanent part of the $WQ_v$ pool. As with the wet pond, the preferred method is to rout the 1-year, 24-hour inflow hydrograph through the pond, and select the orifice size that provides 24 hours of detention between the centroids of the inflow and outflow hydrographs. However, in some cases, the simplified method may be used. The simplified method is strictly applicable to the situation where the active pool (in this case the $CP_v$ pool and the extended detention portion of the $WQ_v$ pool) is controlled by one or more orifices at the same elevation. However it is rare that the $WQ_v$ orifice alone can serve to regulate both the $WQ_v$ and $CP_v$. In most cases a $CP_v$ orifice is also required. If the centers of the $WQ_v$ and $CP_v$ orifices are “approximately” the same then the simplified method is applicable. Until further information is available, the elevation of the centers of the orifices will be considered “approximately” the same if the difference between the center elevations does not exceed 20% of the height of the active pool. The procedure is basically the same as for wet ponds except the maximum head at peak discharge is computed for both the $WQ_v$ and $CP_v$ orifices, and the $CP_v$ orifice is sized such that the total discharge through both orifices is equal to the pond peak discharge.
- Dry Extended Detention Pond: The procedure is the same as for the Wet Extended Detention Pond.

## 4.16 Backwater Conditions

The control outlets for all stormwater management facilities are vulnerable to being inundated by backwater from the downstream conveyance. Stormwater ponds and wetlands located in floodplains and backwater streams are particularly susceptible. Such facilities must perform as specified for peak flow protection for any tailwater condition, up to and including the floodplain of the 100-year flood elevation. The potential for backflow into the facility must be addressed with flap gates or by providing sufficient volume to receive the backflow up to the 100-year flood elevation, and still provide peak flow control surcharge volume in the pond above the 100-year flood elevation. A joint probability analysis will not be accepted as justification to waive this requirement.

Due to the complexity of backwater conditions, it is often useful to use a dynamic model. EPA-SWMM is capable of analyzing these types of conditions, including the application of flap-gates and backflow.

## 4.17 Water Balance Calculations

### 4.17.1 Introduction

Water balance calculations can help determine if a drainage area is large enough, or has the right characteristics, to support a permanent pool of water during average or extreme conditions. When in doubt, a water balance calculation is advisable for a storage facility with a permanent pool that is solely dependent on rainfall and runoff to sustain the pool. This is particularly important for wetland and stormwater pond design.

The details of a rigorous water balance are beyond the scope of this Manual. However, a simplified procedure is described herein to provide an estimate of the feasibility of a permanent pool and an indication as to whether a more rigorous water balance analysis is needed. (Water balance can also be used to help establish planting zones in a wetland design.)

### 4.17.2 Basic Equations

Water balance is defined as the change in volume of the permanent pool resulting from the total inflow minus the total outflow, as shown in Equation 4-31.

**Equation 4-31** $\Delta V = \Sigma I - \Sigma O$

where:

| | | |
|---|---|---|
| $\Delta$ | = | "change in" |
| V | = | pond volume (ac-ft) |
| $\Sigma$ | = | "sum of" |
| I | = | Inflows (ac-ft) |
| O | = | Outflows (ac-ft) |

The inflows consist of rainfall, runoff, and baseflow into the pond. The outflows consist of infiltration (seepage losses), evaporation, evapotranspiration, and surface overflow out of the pond or wetland. Equation 4-32 reflects these factors.

**Equation 4-32** $\Delta V = P + R_o + B_f - I - E - E_t - O_f$

where:

| | | |
|---|---|---|
| V | = | pool volume (ac-ft) |
| P | = | precipitation (ac-ft) = rainfall in inches times pool area in acres divided by 12 |
| $R_o$ | = | runoff into pond from its catchment drainage area (ac-ft) |
| $B_f$ | = | baseflow into pond (ac-ft) |
| I | = | pool bottom and sides infiltration losses (ac-ft); use Equation 4-34 |
| E | = | pool evaporation (ac-ft); surface evaporation in feet times pool surface area |
| $E_t$ | = | plant evapotranspiration (ac-ft) |
| $O_f$ | = | overflow (ac-ft) |
| $\Delta$ | = | "change in" (+ gain; - loss) |

Rainfall (P): Mean monthly values of rainfall depth are commonly used for simplified water balance calculations. Rainfall depth is the direct amount that falls on the pond surface for the month. When multiplied by the pool surface area (in acres) and divided by 12, the volume of P, in acre-feet, is determined. Table 4-15 shows mean monthly rainfall for Sedgwick County as a percent of mean annual precipitation. Rainfall values for the site may be determined by multiplying these percentages by the mean annual depth at the site as provided in Figure 4-3.

**Table 4-15 Monthly Precipitation Values as % of Average Annual Precipitation**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation (% of Annual) | 2.8 | 3.4 | 8.9 | 8.4 | 13.7 | 14.0 | 10.9 | 9.7 | 9.7 | 8.1 | 6.0 | 4.4 |

Source: National Oceanic and Atmospheric Administration, "Comparative Climatic Data", 2006

Runoff ($R_o$): Runoff is equivalent to the rainfall for the period times the "efficiency" of the watershed, which is equal to the ratio of runoff to rainfall (Q/P). In lieu of gage information, Q/P can be estimated one of several ways.

The best method would be to perform long-term simulation modeling using rainfall records and a watershed model. However, this procedure is seldom justified for a small stormwater management facility and is not described herein.

Alternatively, Equation 4-33 calculates runoff based on the volumetric coefficient ($R_v$) of the drainage area. Not all monthly rainfall produces runoff. Thus a factor of 0.9 is applied to the calculated $R_v$ value to account for monthly rainfall producing no runoff. Equation 4-33 reflects this approach. Total runoff volume is then simply the product of runoff depth (Q) times the drainage area to the pond.

**Equation 4-33** $$R_O = 0.9\left(\frac{P}{12}\right)R_V A$$

where:

| | | |
|---|---|---|
| $R_o$ | = | runoff volume (acre-ft) |
| P | = | precipitation (inches) |
| $R_v$ | = | volumetric runoff coefficient (see Equation 4-26) |
| A | = | area (acres) |

Baseflow ($B_f$): Most stormwater ponds and wetlands have little, if any, baseflow, as they are rarely placed across perennial streams. If so, baseflow must be estimated from observation or through theoretical estimates. Methods of estimating baseflow can be found in most hydrology textbooks. Consideration may also have to be given to irrigation return flows.

Infiltration (I): Infiltration (seepage loss from the pond) is a complex subject and is not covered in detail in this Manual. The amount of infiltration depends on soils, water table depth, rock layers, surface disturbance, the presence or absence of a liner in the pond, and other factors. For ponds with permeable bottoms and sides, the infiltration rate is governed by the Darcy equation (Equation 4-34) as:

**Equation 4-34** $I = Ak_hG_h$

where:

| | | |
|---|---|---|
| I | = | infiltration (ac-ft/day) |
| A | = | cross sectional area through which the water infiltrates (ac) |
| $k_h$ | = | saturated hydraulic conductivity or infiltration rate (ft/day) |
| $G_h$ | = | hydraulic gradient = pressure head/distance |

For approximate analysis, $G_h$ can be set equal to 1.0 for pond bottoms and sides no steeper than 4:1, and 0.5 for pond sides steeper than 4:1. Infiltration rate can be established through testing. An approximate rate can be obtained from Table 4-16.

**Table 4-16 Saturated Hydraulic Conductivity**

| Material | Hydraulic Conductivity | |
|---|---|---|
| | in/hr | ft/day |
| ASTM Crushed Stone No. 3 | 50,000 | 100,000 |
| ASTM Crushed Stone No. 4 | 40,000 | 80,000 |
| ASTM Crushed Stone No. 5 | 25,000 | 50,000 |
| ASTM Crushed Stone No. 6 | 15,000 | 30,000 |
| Sand | 8.27 | 16.54 |
| Loamy sand | 2.41 | 4.82 |
| Sandy loam | 1.02 | 2.04 |
| Loam | 0.52 | 1.04 |
| Silt loam | 0.27 | 0.54 |
| Sandy clay loam | 0.17 | 0.34 |
| Clay loam | 0.09 | 0.18 |
| Silty clay loam | 0.06 | 0.12 |
| Sandy clay | 0.05 | 0.10 |
| Silty clay | 0.04 | 0.08 |
| Clay | 0.02 | 0.04 |

Source: Ferguson and Debo, "On-Site Stormwater Management," 1990

Evaporation (E): Evaporation rates for water surfaces are dependent on differences in vapor pressure, which, in turn, depend on temperature, wind, atmospheric pressure, sunlight, water purity, and shape and depth of the pond. It is estimated or measured in a number of ways, which can be found in most hydrology textbooks.

Table 4-17 gives the estimated average free water surface evaporation rate for Sedgwick County for a typical 12-month period. This table is based on a pan coefficient of 0.7, and class A pan evaporation rates estimated by the Penman method. (NOAA Technical Report NWS 33 and 34, 1982.)

**Table 4-17 Average Monthly Evaporation (inches)**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.16 | 1.47 | 2.90 | 4.12 | 5.25 | 6.13 | 6.76 | 6.42 | 4.20 | 3.28 | 1.84 | 1.39 |

<u>Evapotranspiration ($E_t$):</u> Evapotranspiration consists of the combination of evaporation and transpiration by plants. The estimation of $E_t$ for plants in a wet pool environment are not well documented, nor are there consistent studies to assist the designer in estimating the demand wetland plants would put on water volumes. Literature values for various places in the United States vary around the free water surface lake evaporation values. Estimating $E_t$ only becomes important when wetlands are being designed and emergent vegetation covers a significant portion of the pond surface. In these cases conservative estimates of lake evaporation should be compared to crop-based $E_t$ estimates and a decision made. Crop-based $E_t$ estimates can be obtained from hydrology references.

<u>Overflow ($O_f$):</u> Overflow is excess runoff lost from cumulative pool volumes in excess of the maximum available permanent storage. (Obviously, for continuous simulations of rainfall-runoff, overflow from large storms would play an important role in pond storage design. However, for the purposes of this simplified method, those large storms are not analyzed.)

---

### Example Problem – Simplified Water Balance

A 50-acre site is being developed along with an estimated 0.5-acre surface area water quality pond. There is no baseflow. The desired permanent pool volume is 2 acre-feet. Will the site be able to support the pond volume?

From the basic site data, we determine that $R_v$ = 0.72 and the pond bottom and sides are clay-loam soil.

- With the adjustment factor of 0.9 the watershed efficiency is 0.9 x 0.72 = 0.648.
- For a clay loam the approximate infiltration rate is I = 0.18 ft/day (Table 4-16).
- From a grading plan, none of the normal full pool pond area is sloped steeper than 4:1.
- Monthly rainfall, based on 32 inches per year, is derived from Table 4-15.
- Neglect evapotranspiration due to limited wetland plants.

The table to follow shows summary calculations for this site for each month of the year, beginning in January.

**Table 4-18 Data for Water Balance Example**

| | |
|---|---|
| Drainage Area (acres) | 50 |
| Pond Surface (acres) | 0.5 |
| Volume at Overflow (ac-ft) | 2 |
| Watershed Efficiency | 0.648 |
| Infiltration Rate (ft/day) | 0.18 Clay Loam |
| % Pond Bottom and Slopes 4:1 or Flatter | 100 |
| % Pond Slopes 4:1 or Steeper | 0 |

**Table 4-19 Water Balance Calculation**

| 1 | Months of Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Days Per Month | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 |
| 3 | Monthly Precipitation (in) | 0.90 | 1.09 | 2.85 | 2.69 | 4.38 | 4.48 | 3.49 | 3.10 | 3.10 | 2.59 | 1.92 | 1.41 |
| 4 | Monthly Evaporation (in) | 1.16 | 1.47 | 2.90 | 4.12 | 5.25 | 6.13 | 6.76 | 6.42 | 4.20 | 3.28 | 1.84 | 1.39 |
| 5 | Monthly Evapotranspiration (in) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | Runoff (ac-ft) | 2.43 | 2.94 | 7.70 | 7.26 | 11.83 | 12.10 | 9.42 | 8.37 | 8.37 | 6.99 | 5.18 | 3.81 |
| 7 | Precipitation (ac-ft) | 0.04 | 0.05 | 0.12 | 0.11 | 0.18 | 0.19 | 0.15 | 0.13 | 0.13 | 0.11 | 0.08 | 0.06 |
| 8 | Evaporation (ac-ft) | 0.05 | 0.06 | 0.12 | 0.17 | 0.22 | 0.26 | 0.28 | 0.27 | 0.18 | 0.14 | 0.08 | 0.06 |
| 9 | Infiltration (ac-ft) | 2.79 | 2.52 | 2.79 | 2.70 | 2.79 | 2.70 | 2.79 | 2.79 | 2.70 | 2.79 | 2.70 | 2.79 |
| 10 | Evapotranspiration (ac-ft) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | Balance (ac-ft) | -0.37 | 0.41 | 5.31 | 6.50 | 11.00 | 11.33 | 8.50 | 7.44 | 7.62 | 6.17 | 4.49 | 3.02 |
| 12 | Running Balance (Ac-ft) | 0.00 | 0.41 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |

## Explanation of Table Line Numbers:

1. Months of year
2. Days per month
3. Monthly precipitation
4. Monthly evaporation
5. Monthly evapotranspiration
6. In the example, watershed efficiency of 0.65 times the rainfall and area (in acres) and converted to acre-feet. The watershed efficiency must be determined for each watershed.
7. Precipitation volume directly into pond equals precipitation depth times pond surface area divided by 12 to convert to acre-feet.
8. Evaporation equals the monthly percentage of the annual gross lake evaporation in inches converted to acre-feet, excluding ice covered months.

9. Infiltration equals infiltration rate for the bottom of the pond plus infiltration rate for the inundated pond slopes that are steeper than 4:1 (none in this example), converted to acre-feet.
10. Evapotranspiration from wetland type plants.
11. The sum of lines 6 and 7, plus the line 12 from the previous month, minus the sum of lines 8, 9 and 10.
12. Accumulated total from line 11 keeping in mind that all volume above 2 acre-feet overflows and is lost in the trial design.

In practice, the balance in lines 11 and 12 should be continued for a 2 to 3 year period to adjust for the assumed starting conditions inherent in the simplified method (dry pond at the start of January). For this example, the pond has the potential to maintain its pool in all months except possibly January and February when rainfall depths are low. In this case, a liner may be required.

It should be noted that this type of analysis does not account for departures from average values. For marginal results, it is suggested that a sensitivity analysis, using conservatively low rainfall values and conservatively high infiltration values, be prepared. Excessive infiltration rates may be remedied in a number of ways including placing a clay liner or installing a synthetic liner in the pond.

## 4.18 Approved Hydrology Models

The following public domain software are approved for use in preparing hydrology analyses. Only the approved hydrology methods discussed above shall be employed within these software packages.

HEC-1: Flood Hydrograph Package, U.S. Army Corps of Engineers

HEC-HMS: Hydrologic Modeling System, U.S. Army Corps of Engineers

EPA-SWMM: Stormwater Management Model, U.S. Environmental Protection Agency

Other public domain hydrology software must be pre-approved by the local jurisdiction.

Commercial third-party software must be pre-approved by the local jurisdiction, not only on the basis of technical acceptance but also on the basis of the cost for the local jurisdiction to maintain a license for the product for review purposes.

CHAPTER

5

# HYDRAULIC DESIGN

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## 5.1 Hydraulic Design Overview

The stormwater system consists of all the site design practices and stormwater controls utilized on the site. Three considerations largely shape the design of the stormwater system: water quality, channel protection, and flood control. Previous chapters have discussed methods for calculating water quality and channel protection volumes, rainfall-runoff modelling to determine runoff rates for local design storms, design of detention practices to protect against peak flow increases, and flood routing techniques to determine peak flows on site and at key points downstream.

This chapter is provided to detail the required hydraulic engineering practices for design of stormwater facilities in Wichita and Sedgwick County. Hydraulic design generally uses the flows determined through hydrologic analysis as an input. These flow inputs are used to size facilities to safely handle the peak flows over the range of stormwater flows likely to occur. Protection from nuisance flooding for the design storm must be provided using the minor drainage system. Structures must be protected from flooding during the 100-year storm using the major drainage system.

The minor drainage systems are designed to minimize nuisance flooding and to remove stormwater from areas such as streets and sidewalks for public safety reasons. The minor drainage system typically consists of inlets, street and roadway gutters, roadside ditches, small channels and swales, stormwater ponds and wetlands, and small underground pipe systems which collect stormwater runoff from small to mid-frequency storms and transport it to structural control facilities, pervious areas, and/or the larger major stormwater system (i.e., natural waterways, large man-made conduits, and large water impoundments). The minor drainage system must handle the design storm specified for the land use which it serves.

The major drainage system consists of natural waterways, open channels, large man-made conduits, and large water impoundments. In addition, the major system includes some less obvious drainageways such as overload relief swales and infrequent temporary ponding areas. The major drainage system includes not only the main sewer system that receives the water, but also the natural overland relief which functions in case of overflow from or failure of the on-site flood control system.

The design storm frequencies for the stormwater system depend on the type of land use served by the system, as indicated in the following table:

**Table 5-1 Design Storm Frequency**

| Land Use | | Design Storm Return Period |
|---|---|---|
| 1 | Residential and Public Park Areas | 2 years |
| 2 | General Commercial Areas | 5 years |
| 3 | Public Building Areas | 5 years |
| 4 | Industrial Areas | 5-10 years |
| 5 | High Value Downtown Business Areas | 5-10 years |

Additionally, all structures shall be designed such that the lowest opening into the structure is elevated a minimum of 2 feet above the base flood elevation when located in an area with a mapped floodplain, or 2 feet minimum above the maximum elevation of localized flooding that would be caused by the 100-year return frequency storm event (as defined in Chapter 4) if the structure is not located in a mapped 100-year floodplain.

It is important that stormwater discharges from a new development or redevelopment onto adjacent property do not occur in a manner that is more severe to downstream property than pre-development conditions. Discharges from the developed or redeveloped site shall occur at the same location and in the same manner (e.g., distributed overland flow) as for the pre-development condition unless the altered manner of discharge can be demonstrated to be beneficial or not more severe than the pre-developed condition.

This chapter is intended to provide design criteria and guidance on minor and major drainage system components, including storm sewer systems (Section 5.62), culverts (Section 5.3), bridges (Section 5.4), vegetated and lined open channels (Section 5.5), outlet structures (Section 5.6), energy dissipation devices for outlet protection (Section 5.7), and level spreaders (Section 5.8). The section on channels is intended to cover development-scale channels only and is not intended to provide guidance on major flood control channels. In addition, the section on bridges is for general guidance only, and is not intended to provide detailed design criteria for bridges.

## 5.2 Storm Sewer Systems

### 5.2.1 Introduction

Minor drainage systems are intended to quickly remove runoff from areas such as streets, parking lots, and sidewalks. The minor drainage system consists of inlets, street and roadway gutters, roadside ditches, small channels and swales, and small underground pipe systems which collect stormwater runoff and transport it to structural control facilities, pervious areas, and/or the larger stormwater system (i.e., natural waterways, large man-made conduits, and large water impoundments).

This section provides criteria and guidance for the design of minor drainage system components including:

- Street and roadway gutters;
- Stormwater inlets;
- Storm drain pipe systems.

Ditch, channel, and swale design criteria and guidance are covered in Section 5.5.

## 5.2.2 General Policies Criteria

The following policies and criteria shall govern the design of storm sewer systems in the City of Wichita and Sedgwick County.

- The primary goal of storm sewer systems is to drain water from roadways, parking lots and sidewalks so that traffic can proceed safely without hydroplaning or becoming swamped. The minor drainage system must provide for the following water-free road travel widths for the design storm. Table 5-2 provides general guidance for allowable pavement encroachment. Ideally, the City of Wichita prefers that roadside ditches contain the 100-year design event right-of-way to right-of-way, however it is recognized that this is not practical in all situations. Please consult the local jurisdiction if this, or any of the allowed encroachments cannot be realized in the site design.

**Table 5-2 Allowable Pavement Encroachment for Design Storm**

| Street Classification | | Allowed Encroachment |
|---|---|---|
| 1 | Local | No curb overtopping. Flow may spread across crown. |
| 2 | Collector | No curb overtopping. One 8' lane width must be free of water. |
| 3 | Arterial | No curb overtopping. One 8' through lane width in each direction must be free of water. |
| 4 | Expressways and Freeways | No curb overtopping. Encroachment on travel lanes not permitted. |

- Gutter flow and inlet capacity calculations shall follow the procedures contained in the HEC-22 Urban Drainage Design Manual (USDOT, FHWA, 2001). The detailed calculation methods are presented in this chapter. Basic criteria for the application of those procedures are summarized below.
- A Manning's roughness value of 0.016 shall be used for asphalt and concrete roads and gutters.
- The standard road and gutter cross slope of 3/8" per foot or 0.031 ft/ft shall be used unless specialty applications are approved by the local jurisdiction.
- The standard inlet geometries presented in Table 5-3 shall be used unless specialty applications are approved by the local jurisdiction.

**Table 5-3 Local Inlet Geometries**

| | | Type I | | | Type IA | | | Type II | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Single | Double | Triple | Single | Double | Triple | Single | Double | Triple |
| h | Curb Orifice Height (in) | 6 | | | 6 | | | 5 | | |
| L | Curb Weir Length (ft) | 5 | 10 | 15 | 5 | 10 | 15 | 2 | 4 | 6 |
| A | Curb Opening Area ($ft^2$) | 2.5 | 5 | 7.5 | 2.5 | 5 | 7.5 | 0.83 | 1.67 | 2.50 |
| | Grate Type | N/A | | | N/A | | | Curved Vane | | |
| | Grate Width (ft) | N/A | | | N/A | | | 1.17 | | |
| L | Grate Length (ft) | N/A | | | N/A | | | 2.3 | 4.6 | 6.9 |
| A | Grate Area ($ft^2$) | N/A | | | N/A | | | 1.4 | 2.8 | 4.2 |
| P | Grate Perimeter (ft) | N/A | | | N/A | | | 4.6 | 6.9 | 9.2 |
| a | Local Depression (in) | 2 | | | 4 | | | 2 | | |
| $S_W$ | Std. Gutter Cross Slope (ft/ft) | 0.031 | | | 0.031 | | | 0.031 | | |
| $S_X$ | Std. Road Cross Slope (ft/ft) | 0.031 | | | 0.031 | | | 0.031 | | |
| W | Effective Gutter Width (ft) | 1.83 | | | 4.17 | | | 1.83 | | |

- The maximum junction criteria in Table 5-4 shall be used unless other specifications are approved by the local jurisdiciton.

**Table 5-4 Maximum Junction Spacing Criteria for Storm Sewer Access**

| Pipe Size (inches) | Maximum Spacing (feet) |
|---|---|
| 18 and smaller | 300 |
| 24 and larger | 400 |

- Manning's formula shall be used to calculate the flow of water in storm sewers. The water surface elevation shall not be higher than 1 foot below ground elevation for the design storm flow.
- Concrete pipe shall be used for all pipes in the right of way, in public drainage easements, and those used as outlets from stormwater facilities. Corrugated metal and other pipe materials may be used in selected applications if they meet local specifications.
- Maximum allowable storm sewer velocities are shown below.

**Table 5-5 Maximum Allowable Velocities for Storm Drains**

| Description | Maximum Allowable Velocity |
|---|---|
| Culverts (All types) | 15 ft/s |
| Storm Drains (Inlet laterals) | 18 ft/s |
| Storm Drains (Collectors) | 15 ft/s |
| Storm Drains (Mains) | 12 ft/s |

- Minimum allowable storm sewer slopes for proper self-cleaning are shown below. This table is based on achieving a velocity of 2 ft/s at a pipe flow depth of (0.2 x full depth). This standard can be used for calculating minimum slopes for alternative pipe shapes and materials.

**Table 5-6 Minimum Allowable Slopes for Reinforced Concrete Pipe**

| $d_o$ | $S_{min}$ | $d_o$ | $S_{min}$ |
|---|---|---|---|
| inches | % | inches | % |
| 12 | 0.51 | 39 | 0.11 |
| 15 | 0.38 | 42 | 0.1 |
| 18 | 0.3 | 48 | 0.08 |
| 21 | 0.24 | 54 | 0.07 |
| 24 | 0.2 | 60 | 0.06 |
| 27 | 0.17 | 66 | 0.05 |
| 30 | 0.15 | 72 | 0.05 |
| 33 | 0.13 | 84 | 0.04 |
| 36 | 0.12 | 96 | 0.03 |

- Outlets with flap gates shall have the bottom of the flap gate set a minimum of one foot above the anticipated or historical sediment accumulation elevation or baseflow elevation for the receiving channel, whichever is more restrictive.
- Drops through manholes or junction boxes for storm sewer design may be based on one or more of these “rules-of’thumb” criteria:
    - Set flow line elevations of pipes in structures such that the crowns of the pipes are at the same elevation;
    - When main line pipe size changes at a structure, the drop in flow line through the structure is set equal to the difference in the diamenter (rise, for non-circular) of the pipe;
    - Provide a 0.2 foot drop in the main line pipes through structures when the structure includes one side lateral; provide 0.3 foot drop in the main line pipes through the structure when the structure includes two or more laterals;
    - Provide 0.1 foot drop in the main line pipes through structures whenever the horizontal alignment of the main line pipes changes by 45-degrees or more.
- For concrete pipes, a minimum clearance of one foot is required between the top of the outside diameter of the pipe (including pipe bells, where applicable) and the bottom of pavements (including base course) when pipes are installed under or in close proximity to such pavement.

### 5.2.3 Street Gutters

Effective drainage of street pavements is essential to the maintenance of the roadway service level and to traffic safety. Water on the pavement can interrupt traffic flow, reduce skid resistance, increase potential for hydroplaning, limit visibility due to splash and spray, and cause difficulty in steering a vehicle when the front wheels encounter puddles. Surface drainage is a function of transverse and longitudinal pavement slope, pavement roughness, inlet spacing, and inlet capacity. The design of these elements is dependent on storm frequency and the allowable spread of stormwater on the pavement surface. This section presents design guidance for gutter flow hydraulics published in HEC-22.

Manning's Equation (Equation 5-1) shall be used to evaluate gutter flow hydraulics (HEC-22, 2001).

**Equation 5-1** $$Q = \left(\frac{0.56}{n}\right) S_x^{5/3} S^{1/2} T^{8/3}$$

where:

| | | |
|---|---|---|
| Q | = | gutter flow rate, cfs |
| $S_x$ | = | pavement cross slope, ft/ft (3.1%) |
| n | = | Manning's roughness coefficient |
| S | = | longitudinal slope, ft/ft |
| T | = | width of flow or spread, ft |

Figure 5-2 is a nomograph for solving Equation 5-1. A Manning’s n of 0.016 shall be used for asphalt and concrete paving and gutters. Manning's n values for various additional surfaces are presented in Appendix A for specialty applications.

The following two problems demonstrate the use of Figure 5-2 to check for allowable road water spread.

### Example Problem – Gutter Flow #1

You are designing a standard 66’ local residential collector street with a longitudinal slope of 4%. Can it handle 2.4 cfs on one half of the street and meet the road spread standard?

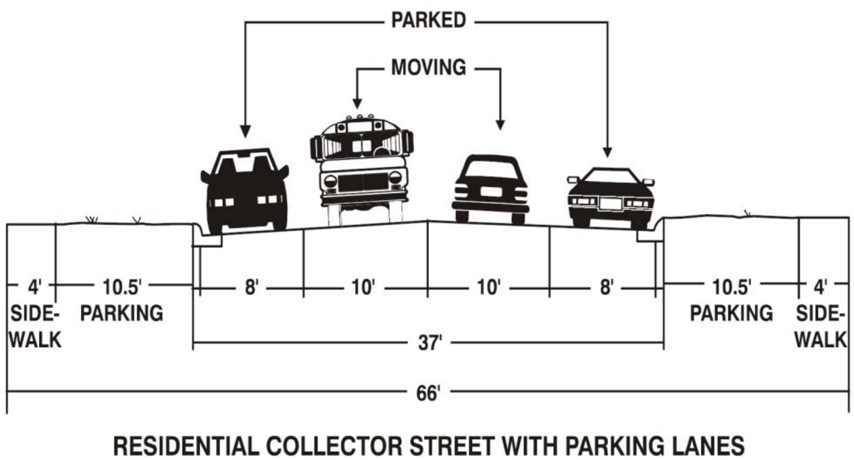


**Figure 5-1 Example Street**

Enter Figure 5-2 at the longitudinal slope (S) value of 0.04 ft/ft and draw a line through the $S_X$ scale at the standard cross slope ($S_X$) value of 0.031. Extend the line to the turning line.

Draw a line between the turning line intercept and a Q value of 2.4 cfs. Read the spread (T).

T = 6 feet

Determine the open width:

Open width = ½ road width – Spread
Open width = 18 – 6 = 12 ft

The road spread standard for a collector street is to prevent curb overtopping and leave on 8’ lane open for travel. This standard has been met.

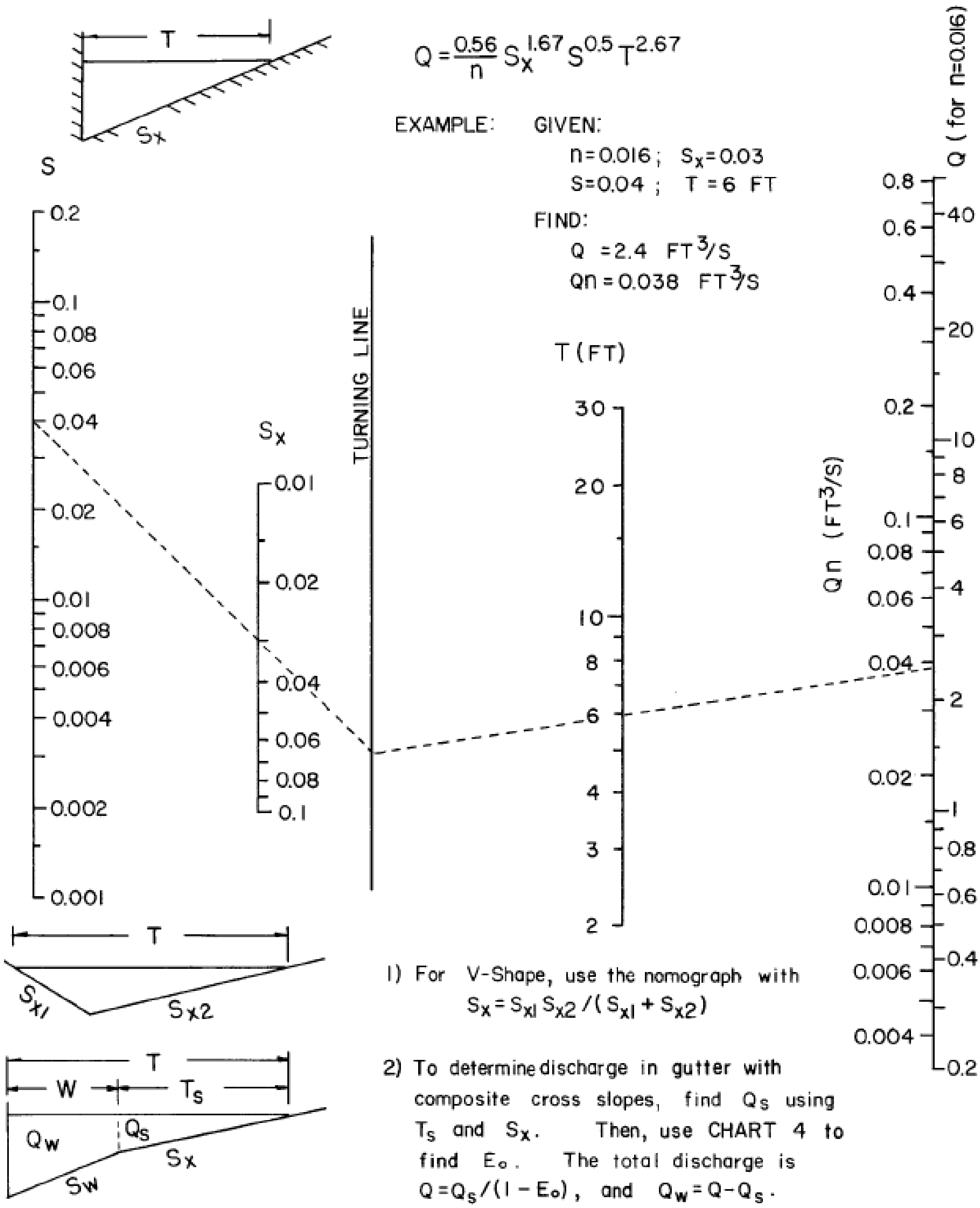


**Figure 5-2 Flow in Triangular Gutter Sections - English Units**
(HEC-22, 2001)

### Example Problem – Gutter Flow #2

For the same residential collector street with a longitudinal slope of 1%, what would be the maximum flow for ½ of the street?

Determine the allowable spread.

Open width = ½ road width – Spread
Spread = ½ road width – Open width
Spread = 18 – 8 = T
Spread = 10 = T

Enter Figure 5-2 at the longitudinal slope (S) value of 0.01 ft/ft and draw a line through the $S_X$ scale at the standard cross slope ($S_X$) value of 0.031. Extend the line to the turning line.

Draw a line between the turning line intercept and a T value of 10 ft. Read the flow (Q).

Q = 5.0 cfs

## 5.2.3.1 Gutter Flow vs. Total Flow

Figure 5-3 can be used to find the flow in a gutter with width (W) less than the total spread (T). The figure provides the ratio ($E_O$) of gutter flow ($Q_W$) to total flow (Q) in the ½ road section for a range of gutter and road cross slopes. Roads that have a steeper gutter cross slope than road cross slope are called composite gutters, and $S_W/S_X$ will be greater than 1. However, in Wichita and Sedgwick County a $S_W/S_X$ ratio of 1 shall be used for standard designs since the standard road slope is 3/8" per foot and the standard gutter cross slope is 3/8" per foot. This figure can also be used to determine the portion of total flow that will cross the front of a grate inlet by setting W equal to the width of the grate.

For cases where the road cross slope, gutter cross slope or road crown shape are non-standard, Appendix C of HEC-22 provides procedures for determining capacity using nomographs. The nomograph procedure involves a complex graphical solution of the equation for flow in the non-standard road shapes. Typical of graphical solutions, extreme care is necessary to obtain accurate results.

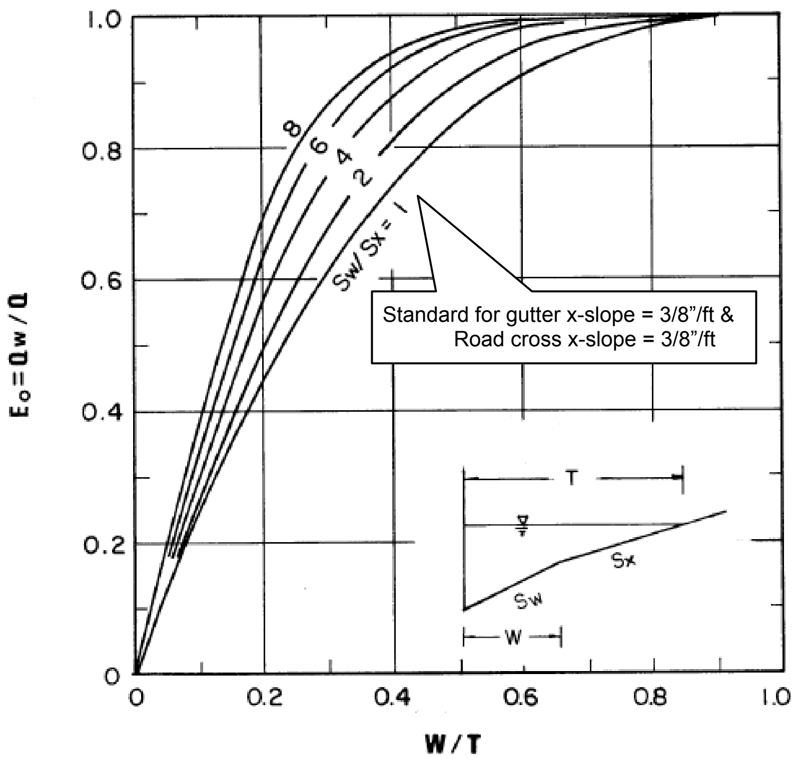


**Figure 5-3 Ratio of Gutter Flow to Total Road Section Flow**
(HEC-22, 2001)

### 5.2.4 Stormwater Inlets

Inlets are drainage structures used to collect surface water through grate or curb openings and convey it to storm drains. Inlets used for drainage of highway surfaces can be divided into three major classes:

<u>Grate Inlets:</u> These inlets consist of an opening in the gutter covered by one or more grates. These inlets are typically used in parking lots and yard drainage situations.

<u>Curb-Opening Inlets:</u> These inlets are vertical openings in the curb covered by a top slab. These inlets are particularly suited to sump applications and areas where heavy litter accumulation is expected because of their high capacity and anti-clogging tendencies. Local standard types I and IA fall into this category.

<u>Combination Inlets:</u> These inlets usually consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate. These inlets are particularly suited to roads with high longitudinal slopes because of their ability to capture faster moving water. Local standard type II falls into this category.

Figure 5-4 present standard inlets. Inlets may be classified as being on a continuous grade or in a sump. The term "continuous grade" refers to an inlet located on the street with a continuous slope past the inlet with water entering from one direction. The "sump" condition exists when the inlet is located at a low point and water enters from multiple directions. Sump areas must have an overflow route or channel to protect local structures should the inlet clog. Flanking inlets shall be placed on each side of road sump inlets. The flanking inlets shall be placed so they will limit spread on low gradient approaches and act in relief of the inlet at the low point if it should become clogged.

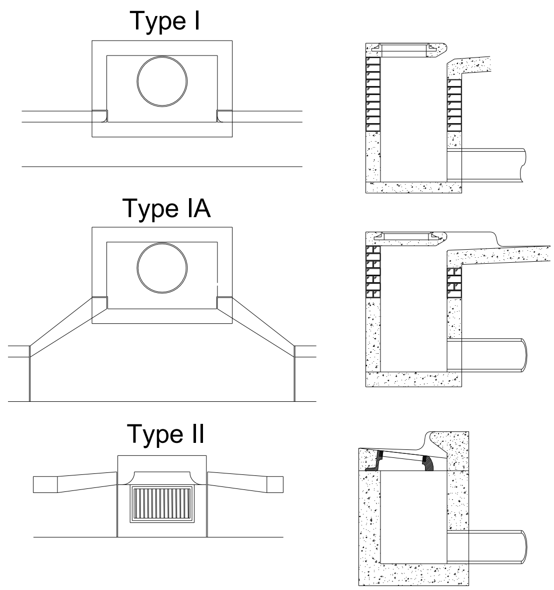


**Figure 5-4 Local Standard Inlets**

Inlet structures are located at the upstream end and at intermediate points within the closed conduit system. Inlet placement is generally a trial and error procedure that attempts to produce the most economical and hydraulically effective system (HEC 22, 2001).

The American Society of State Highway and Transportation Officials (AASHTO) geometric policy recommends a minimum gradient of 0.3% within 50 ft of the level point in a sag vertical curve. This longitudinal slope value shall be used when checking for spread at sag inlets.

The geometric values found in Table 5-3 shall be used for modelling the standard inlets, unless specialty applications are allowed by the Director or his/her designee.

### 5.2.4.1 Grate Inlets on Grade

The capacity of an inlet depends on its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow, and pavement roughness. The depth of water next to the curb is the major factor in the interception capacity of both gutter inlets and curb opening inlets. At low flows and velocities, all of the water flowing in the section of gutter occupied by the grate, called frontal flow, is intercepted by grate inlets, and a small portion of the flow along side the grate, termed side flow, is intercepted. On steep slopes, only a portion of the frontal flow will be intercepted if the flow and/or velocity is high or the grate is short and splash-over occurs. For grates less than 2 feet long, intercepted flow is usually small.

The ratio of frontal flow to total gutter flow, $E_O$, for a straight (uniform) cross slope is expressed by the Equation 5-2 (HEC-22, 2001):

**Equation 5-2** $$E_o = \frac{Q_w}{Q} = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

where:

| | | |
|---|---|---|
| $Q$ | = | total flow, cfs |
| $Q_w$ | = | flow in width W, cfs |
| $W$ | = | width of depressed gutter or grate, ft |
| $T$ | = | total spread of water in the gutter, ft |

Figure 5-3 provides a graphical solution of $E_O$ for either composite gutters or straight cross slopes. The ratio of side flow, $Q_s$, to total gutter flow calculated using Equation 5-3 (HEC-22, 2001).

**Equation 5-3** $$\frac{Q_s}{Q} = \frac{1 - Q_w}{Q} = 1 - E_o$$

The ratio of frontal flow intercepted by a grate to total frontal flow, $R_f$, is expressed by the Equation 5-4 (HEC-22, 2001).

**Equation 5-4** $$R_f = 1 - 0.09(V - V_o)$$

where:

| | | |
|---|---|---|
| $V$ | = | velocity of flow in the gutter, ft/s |
| $V_o$ | = | gutter velocity where splash-over first occurs, ft/s (a function of grate length) |

Figure 5-5 provides a solution of Equation 5-4, which takes into account grate length, bar configuration and gutter velocity at which splash-over occurs. The gutter velocity needed to use Figure 5-5 is total gutter flow divided by the cross-sectional area of flow.

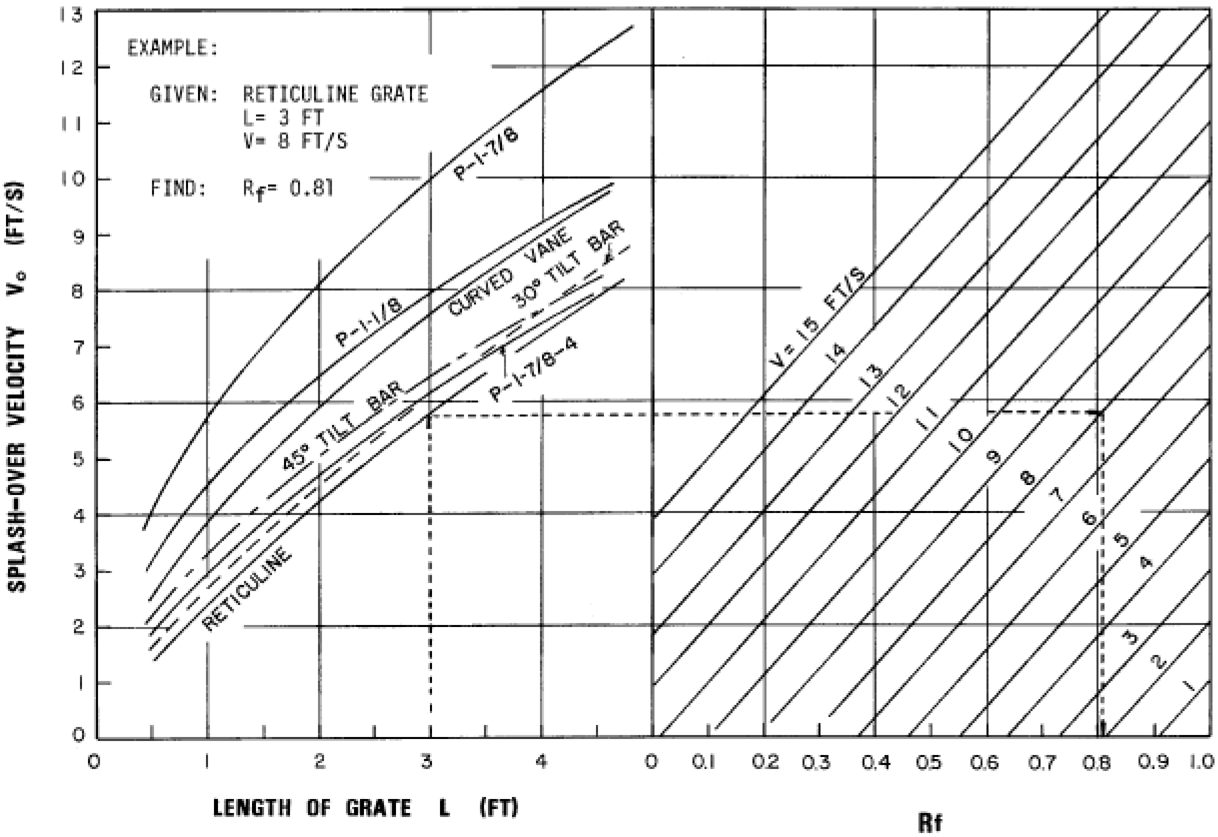


**Figure 5-5 Grate Inlet Frontal Flow Interception Efficiency**
(HEC-22, 2001)

The ratio of side flow intercepted to total side flow, $R_s$, or side flow interception efficiency (HEC-22, 2001), is expressed by Equation 5-5 below. Figure 5-6 provides a solution to Equation 5-5.

**Equation 5-5**

$$R_s = \frac{1}{\left[1 + \left(\frac{0.15V^{1.8}}{S_x L^{2.3}}\right)\right]}$$

where:

L = length of the grate, ft

The overall efficiency, E, of a grate (HEC-22, 2001) is expressed in Equation 5-6.

**Equation 5-6**

$$E = R_f E_O + R_s(1 - E_O)$$

The interception capacity of a grate inlet on grade is equal to the efficiency of the grate multiplied by the total gutter flow as shown in Equation 5-7 (HEC-22, 2001).

**Equation 5-7**

$$Q_i = EQ = Q\left[R_f E_O + R_s(1 - E_O)\right]$$

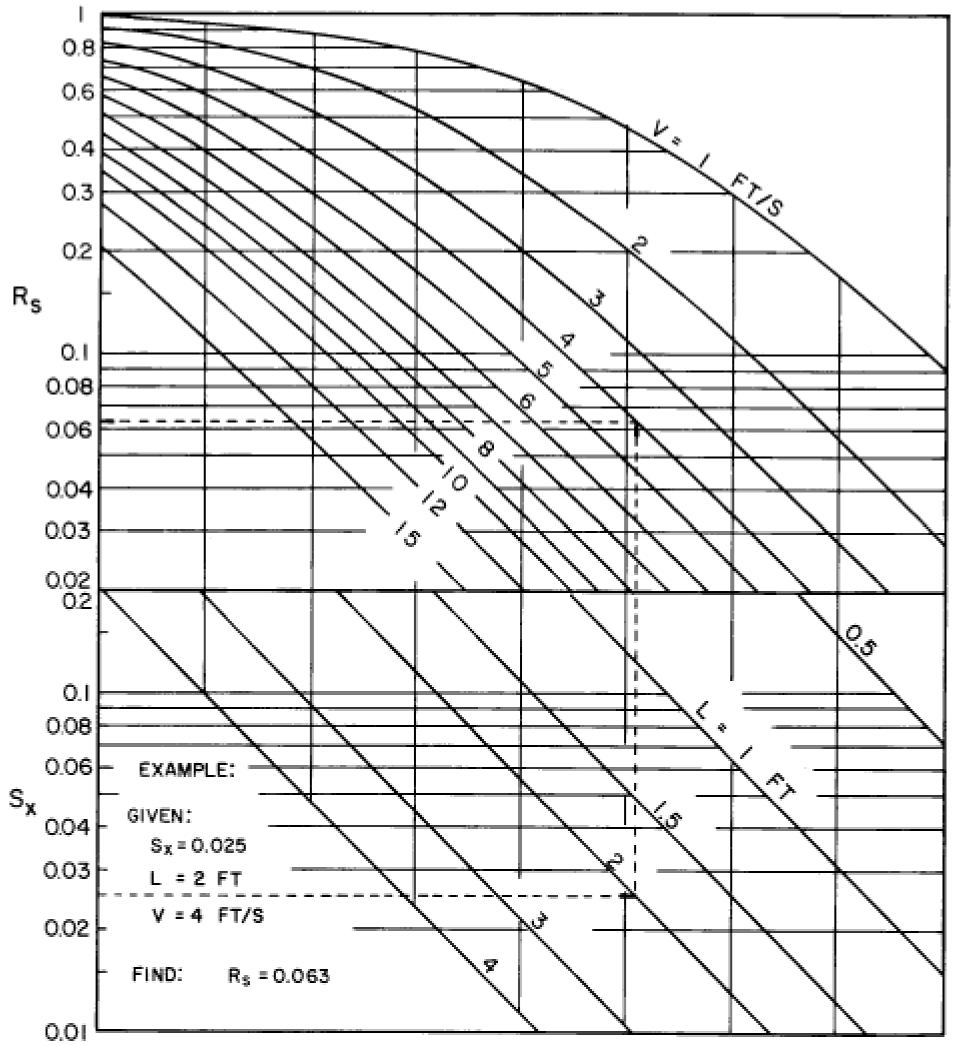


**Figure 5-6 Grate Inlet Side Flow Interception Efficiency**
(HEC-22, 2001)

The following problem illustrates the design of grate inlets on grade.

## Example Problem – Grate Inlets on Grade

Determine the interception capacity of a single Type II inlet for a ½ street with spread of 10 feet and longitudinal slope of 3.1%.

Determine the total flow rate using Equation 5-1.

$$Q = \left(\frac{0.56}{n}\right) S^{5/3} S^{1/2} T^{8/3}$$

$$Q = \left(\frac{0.56}{n}\right) 0.031^{5/3} 0.03^{1/2} 10^{8/3}$$
$$Q = \left(\frac{0.56}{0.016}\right) 0.003 * 0.173 * 464 = 8.4\,cfs$$

Determine the flow depth at the curb.

Flow depth = $TS_X$ = (10)(0.031) = 0.31 ft

Determine the flow area

Area of a right triangle = ½*LW* = (½)(10)(0.31) = 1.6 ft$^2$

Determine the flow velocity.

*V* = *Q/A*
*V* = 8.4/1.6 = 5.3 ft/s

Determine $E_O$ for the spread and standard gutter width.

$$E_O = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$
$$E_O = 1 - \left(1 - \frac{W}{T}\right)^{2.67} = 1 - \left(1 - \frac{1.83}{10}\right)^{2.67} = 0.42$$

Determine $R_f$ from Figure 5-5. Start at bottom left for standard single grate length of 2.3 ft, turn at curved vane grate curve, turn at V = 5.3 ft/s. Since V = 5.3 ft/s is off of the nomograph, $R_f$ = 1.0 and frontal flow capture is complete.

Determine $R_s$ from Figure 5-6. Start at bottom left for $S_x$ = 0.031, turn at the standard grate length of 2.3 ft, turn at V = 5.3 ft/s, arrive at $R_S$ = 0.065.

Determine interception capacity.

$$Q_i = QE = Q(R_f E_O + R_S(1 - E_O))$$
$$Q_i = QE = 8.4(1 * 0.42 + 0.065(1 - 0.42))$$
$$Q_i = QE = 8.4(0.42 + 0.038)$$
$$Q_i = QE = 3.8\,cfs$$

## 5.2.4.2 Grate Inlets in Sag

A grate inlet in a sag operates as a weir up to a certain depth, depending on the bar configuration and size of the grate, and as an orifice at greater depths. For a typical gutter inlet grate, weir operation continues to a depth of about 0.4 to 0.6 feet above the top of grate and when depth of water exceeds about 1.0 to 1.5 feet, the grate begins to operate as an orifice. Between depths of about 0.4 - 0.6 feet and about 1.0 - 1.5 feet, a transition from weir to orifice flow occurs.

The capacity of a grate inlet operating as a weir (HEC-22, 2001) is:

**Equation 5-8** $$Q_i = CPd^{1.5}$$

where:

| | | |
|---|---|---|
| P | = | perimeter of grate excluding bar widths and the side against the curb, ft |
| C | = | 3.0 |
| d | = | depth of water above grate, ft |

The capacity of a grate inlet operating as an orifice (HEC-22, 2001) is:

**Equation 5-9** $$Q_i = CA\left(2gd\right)^{0.5}$$

where:

| | | |
|---|---|---|
| C | = | 0.67 orifice coefficient |
| A | = | clear opening area of the grate, $ft^2$ |
| g | = | 32.2 $ft/s^2$ |

Figure 5-7 is a plot of Equation 5-8 and Equation 5-9 for various grate sizes. The effect of grate size on the depth at which a grate operates as an orifice is apparent from the chart. Transition from weir to orifice flow results in interception capacity less than that computed by either weir or the orifice equation. This capacity can be approximated by drawing in a curve between the lines representing the perimeter and net area of the grate to be used. The following example illustrates the use of this figure.

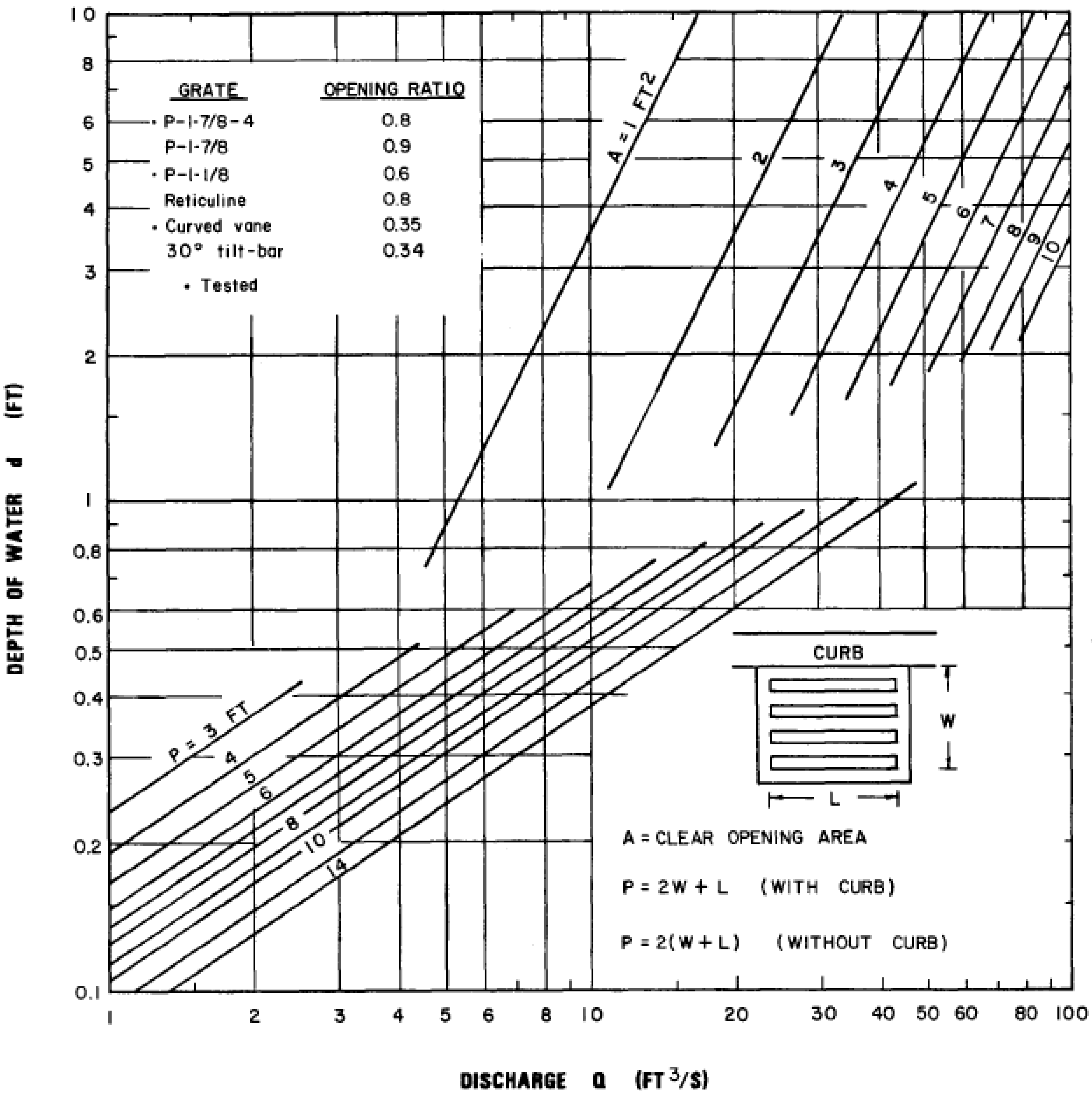


**Figure 5-7 Grate Inlet Capacity in Sump Conditions – English Units**
(HEC-22, 2001)

## Example Problem – Grate Inlets in Sag

How many Type II grates are needed for a design spread of 10 ft and flow of 2 cfs for a sag vertical curve? Allow for 50% clogging of the grate (based on designer's judgement.)

Check spread at S = 0.003 for approaches to the low point per the AASHTO sag guidance.

Determine depth at the curb, given the road cross slope and spread.

$D = TS_X = (10)(0.031) = 0.31$ ft

Determine the effective perimeter and area of various grate sizes. Effective perimeter is equal to the perimeter multiplied by the fraction of the area free of clogging.

Single Unit P = (4.6)(0.5) = 2.3 ft
Double Unit P = (6.9)(0.5) = 3.45 ft
Triple Unit P = (9.2)(0.5) = 4.6 ft

Single Unit A = (1.4)(0.5) = 0.7 $ft^2$
Double Unit A = (2.8)(0.5) = 1.4 $ft^2$
Triple Unit A = (4.2)(0.5) = 2.1 $ft^2$

The depth of 0.3 ft is in the weir flow range. Determine the total effective perimeter necessary to intercept 2 cfs at a depth of 0.31 ft from Figure 5-7.

From the figure, the grate must have an effective perimeter of 4 ft.

Determine the number of grates necessary.

A triple unit will provide the required perimeter of 4 ft, and should be selected.

Check spread (T) at S = 0.003 and Q = 2 cfs using Figure 5-2.

T = 9 ft
Thus, the triple grate can safely limit spread in the sag approach to less than the allowable 10 ft.

### 5.2.4.3 Curb Inlets on Grade

Curb-opening inlets are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb openings are relatively free of clogging tendencies and offer little interference to traffic operation. They are a viable alternative to grates in many locations where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists.

The length of inlet required for total interception by depressed curb-opening inlets or curb-openings in depressed gutter sections can be found by the use of an equivalent cross slope, $S_e$, computed with the Equation 5-10 (HEC-22, 2001).

**Equation 5-10** $S_e = S_x + S'_w E_o$

where:

| | | |
|---|---|---|
| $E_O$ | = | ratio of flow in the depressed section to total gutter flow |
| $S'_w$ | = | cross slope of depressed gutter measured relative to the cross slope of the pavement, ft/ft |
| $S'_w$ | = | a / (12 W), (a = Gutter depression, in and w = width of gutter, ft), diagram found in Figure 5-8 |

a = gutter depression, in
W = width of depressed gutter, ft
$S_e$ = equivalent cross slope, ft/ft
$S_x$ = pavement cross slope, ft/ft

The length of curb-opening inlet required for total interception of gutter flow on a pavement section with a straight cross slope is determined using Figure 5-8. It is apparent from examination of Figure 5-8 that the length of curb opening required for total interception can be significantly reduced by increasing the cross slope. The equivalent cross slope can be increased by use of a continuously depressed gutter section or a locally depressed gutter section.

The efficiency of curb-opening inlets shorter than the length required for total interception is determined using Figure 5-9.

The following problem illustrates the design of curb inlets on grade.

---

**Example Problem – Curb Inlets on Grade**

For a road with longitudinal slope of 3.5% and ½ street flow of 5 cfs, what is the captured flow for a double Type IA inlet?

Determine the spread (T) for a flow of 5 cfs, standard cross slope of 0.031 and standard roughness of 0.016. Using Figure 5-2, T = 8.5 ft.

Determine W/T for the gutter in front of the Type IA inlet.

W/T = 4.17/8.5 = 0.49 (note: Type I inlets should use W = 1.83)

Determine the frontal flow efficiency ($E_O$) using W/T and standard $S_W/S_X$=1 using Figure 5-5.

$E_O$ = 0.84

Determine the equivalent cross slope ($S_e$).

$$S_e = S_x + S'_w E_o$$

$$S_e = 0.031 + \left( 4 / 12 * 4.17 \right) 0.84 = 0.098$$ (note: Type I inlets should simply use $S_e = S_X$)

Use Figure 5-8 to determine the length for total interception (LT). Using Figure 5-8, LT = 18 ft.

Determine the inlet efficiency using Figure 5-9 for L/LT of 10/18 or 0.56. Using Figure 5-9, E = 0.77 .

Determine the captured flow rate (Qi)

$Q_i$ = EQ = (0.77)(5) = 3.9 cfs

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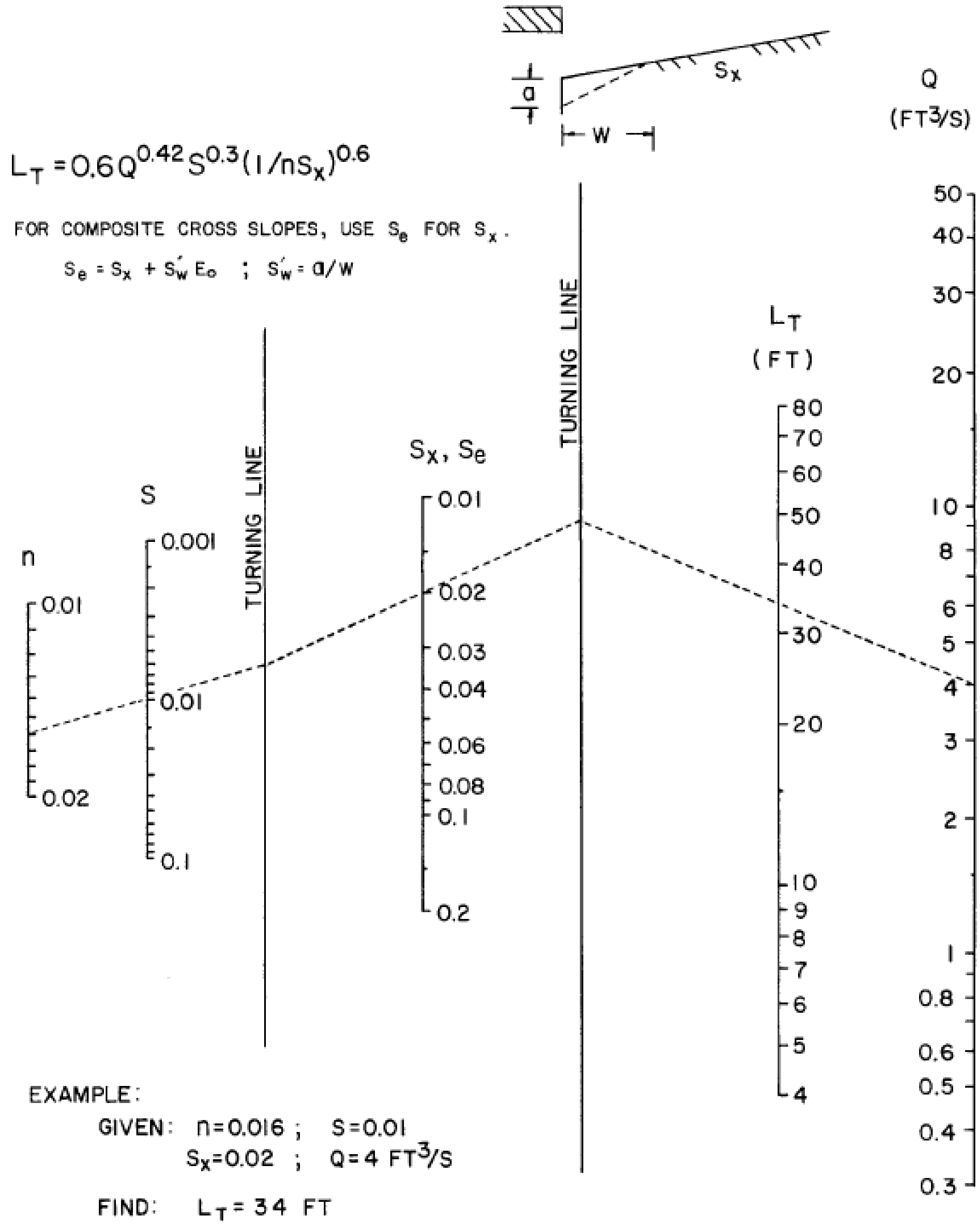


**Figure 5-8 Curb-Opening Inlet Length for Total Interception**
(HEC-22, 2001)

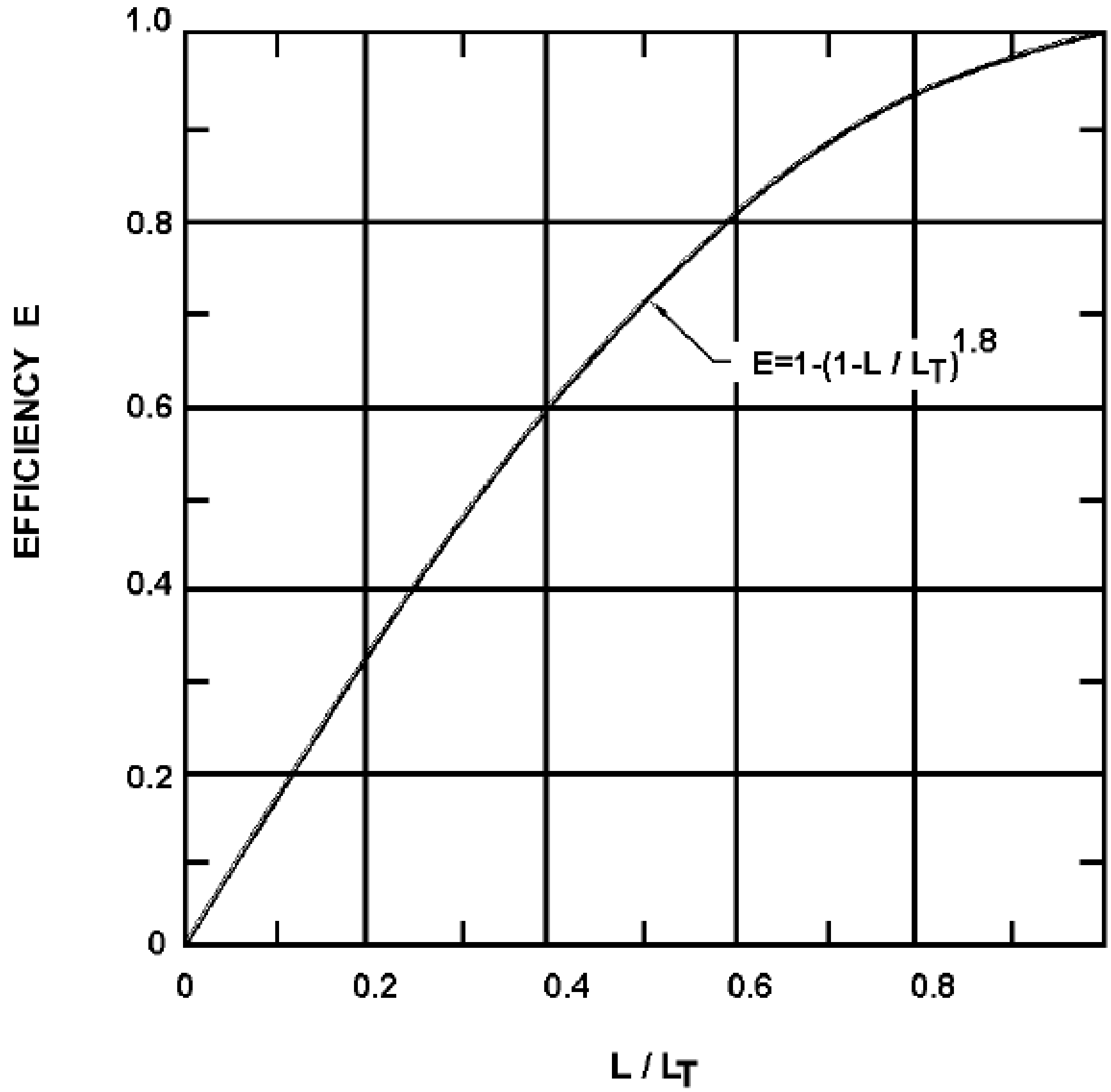


**Figure 5-9 Curb-Opening and Slotted Drain inlet Interception Efficiency**
(HEC-22, 2001)

### 5.2.4.4 Curb Inlets in Sump

For the design of a curb-opening inlet in a sump location, the inlet operates as a weir to depths equal to the curb opening height (h) and as an orifice at depths greater than approximately 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage. The capacity of curb-opening inlets in a sump location can be determined from Figure 5-10, which accounts for the operation of the inlet as a weir up to the opening height and as an orifice at depths greater than 1.4h.

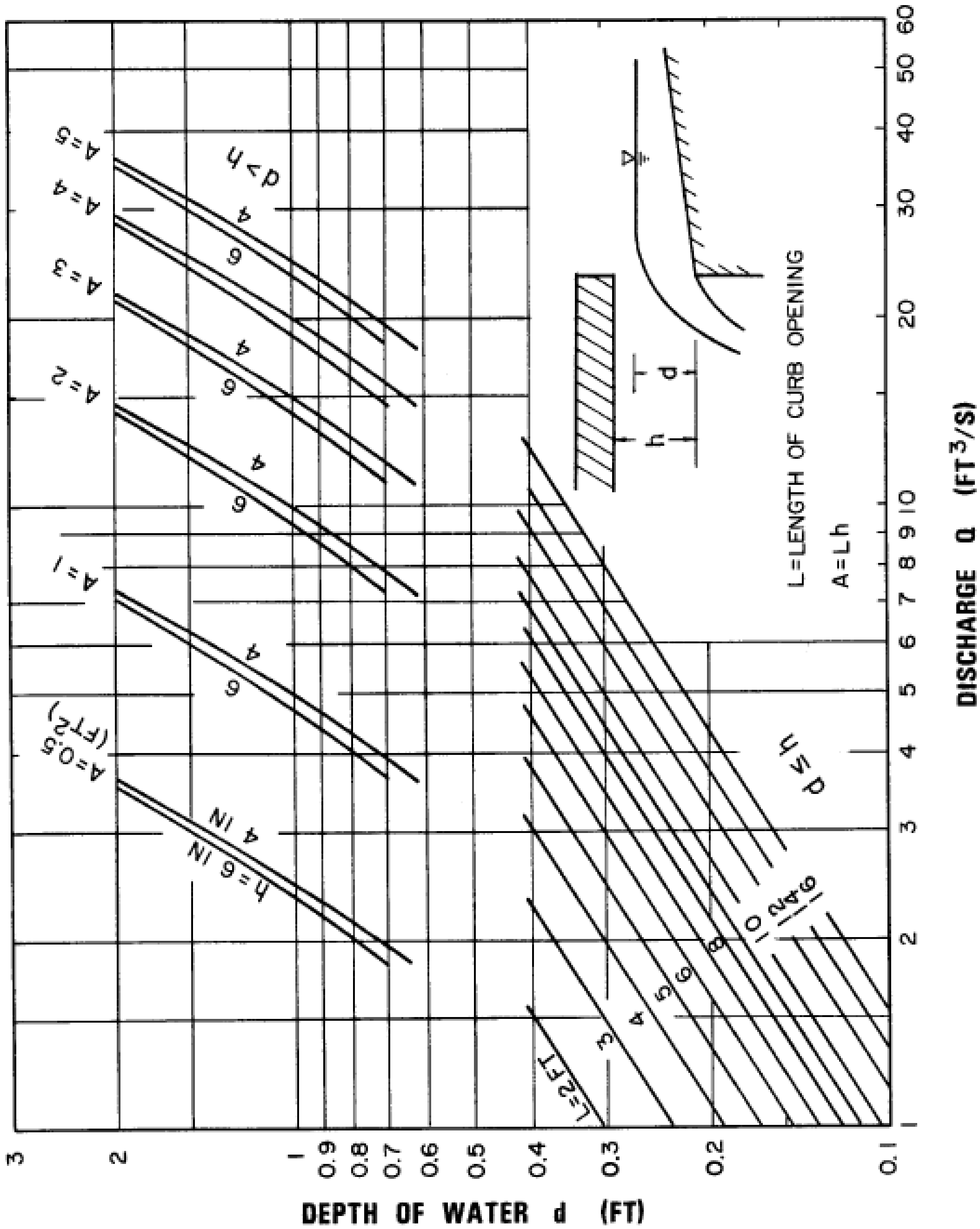


**Figure 5-10 Curb-Opening Inlet Capacity in Sump Locations**
(HEC-22, 2001)

The following problem illustrates the design of curb inlets in sump locations.

---

**Example Problem – Curb Inlets in Sump**

Determine discharge for a single Type I inlet in a sump location with road spread of 12 feet.

Determine depth at curb face

d = $TS_x$ = (12)(0.031) = 0.37 ft = 4.46 in

Determine $Q_i$ from Figure 5-10 for the standard single Type I inlet length of 5 ft, d = 0.37 ft and d < h

$Q_i$ = 3.4 cfs (note: the inlet is acting as a weir at this depth)

---

### 5.2.4.5 Combination Inlets on Grade

On a continuous grade, the capacity of an unclogged combination inlet with the curb opening located adjacent to the grate is approximately equal to the capacity of the grate inlet alone (per HEC-22 guidance). Thus, capacity shall be computed by neglecting the curb opening inlet, except for any curb opening length placed upstream of the grate in a "sweeper" configuration. In the latter case, total capacity may be used.

### 5.2.4.6 Combination Inlets in Sump

All debris carried by stormwater runoff that is not intercepted by upstream inlets will be concentrated at the inlet located at the low point, or sump. Because this will increase the probability of clogging for grated inlets, the capacity of a combination inlet at a sump shall be calculated by neglecting the grate inlet capacity.

### 5.2.4.7 Manholes

The primary functions of a stormwater manhole are to provide access to the closed conduit system where it is not provided by inlets, and to provide junctions for pipes. A stormwater manhole can also provide ventilation and pressure relief. Typical manholes are shown in Figure 5-11. At a minimum, manholes shall be located at the following points:

- Where two or more storm drains converge;
- Where pipe sizes change;
- Where a change in alignment occurs;
- Where a change in pipe grade occurs; and
- According to the maximum spacing criteria found in Table 5-4.

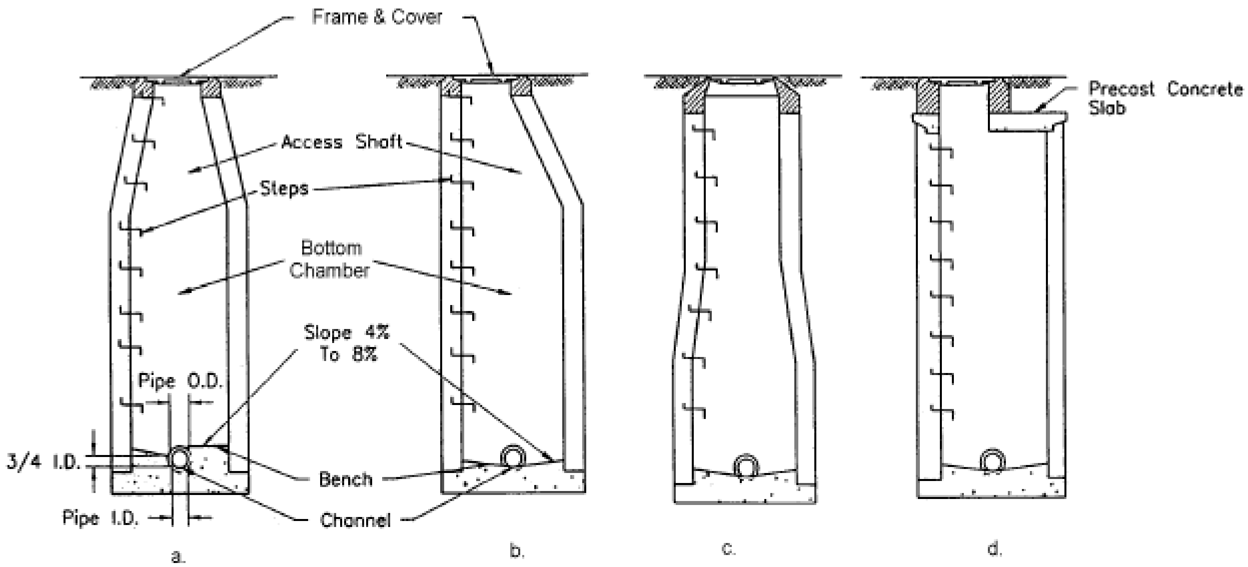


**Figure 5-11 Typical Manhole Configurations**
(HEC 22, 2001)

### 5.2.4.8 Junction and Inlet Boxes

A junction box is an underground chamber used to join two or more large storm drain conduits. This type of structure is required where storm drains are larger than the size that can be accommodated by standard manholes. Junction boxes do not need to extend to the ground surface and can be completely buried. However, riser structures must be used to provide access.

Inlet boxes are similar to junction boxes, except they are used in conjunction with inlets. They are often called inlet manholes or inlet boxes.

Where junction boxes or inlet boxes are used as access points for the storm drain system, their location must adhere to the spacing criteria outlined in Table 5-4.

### 5.2.4.9 Residential Backyard Drainage

Local experience has shown that many residential backyard drainage easements in Wichita and Sedgwick County tend to pond water if not adequately drained by ditches and storm sewers with enough inlets to receive the local runoff. In order to address this problem, backyard drainage ditches or swales must have a minimum slope of 1%. Inlets shall be placed to drain a maximum of 1.5 acres, or a maximum flow path length of 450 feet, whichever is most limiting. The inlets shall be sized for the residential design storm of 2-year recurrence interval.

Additionally, home lots shall be graded to provide a minimum of 1 foot of drop within the first 20 feet horizontally from the home.

### 5.2.5 Storm Sewers

Storm sewers are pipe conveyances used for transporting runoff from roadway and other inlets to outfalls at structural stormwater controls such as detention basins and to receiving waters. Pipe drain systems are suitable mainly for medium to high-density residential and commercial/industrial development where the use of open channels is not feasible.

Closed conduit systems are comprised of different lengths and sizes of conduits connecting structures. Segments are most often circular pipe, but may be a box or other enclosed conduit.

#### 5.2.5.1 Capacity Calculations

The design procedures presented here assume flow within each storm drain segment is steady and uniform. This means the discharge and flow depth in each segment are assumed to be constant with respect to time and distance. Also, the average velocity throughout a segment is considered to be constant.

In actual storm drainage systems, the flow at each inlet is variable, and flow conditions are not truly steady or uniform. However, since the usual hydrologic methods employed in storm drain design are based on computed peak discharges at the beginning of each run, it is a conservative practice to design using the steady uniform flow assumption.

At times flow in a closed conduit may be under pressure. At other times the conduit may flow partially full. However, the usual design assumption is that the conduit is flowing full but not under pressure. Under this assumption the rate of friction head loss is assumed to be the same as the slope of the pipe ($S_f$ = S). Designing for full flow is a slightly conservative assumption since the peak capacity actually occurs at slightly less than full flow.

The most widely used formula for determining the hydraulic capacity of storm drain pipes for gravity flow is Manning's formula, expressed by the Equation 5-11 (HEC-22, 2001).

**Equation 5-11** $$V = \left(\frac{1.486}{n}\right) R^{2/3} S^{1/2}$$

where:

| | | |
|---|---|---|
| V | = | mean velocity of flow, ft/s |
| R | = | the hydraulic radius, ft - defined as the area of flow divided by the wetted flow surface or wetted perimeter (A/WP) |
| S | = | the slope of hydraulic grade line, ft/ft |
| n | = | Manning's roughness coefficient |

In terms of discharge, the above formula becomes Equation 5-12.

**Equation 5-12** $$Q = \left(\frac{1.486}{n}\right) AR^{2/3} S^{1/2}$$

where:

| | | |
|---|---|---|
| Q | = | flow, cfs |
| A | = | cross sectional area of flow, $ft^2$ |

For pipes flowing full, the area is $(\pi/4)D^2$ and the hydraulic radius is D/4, so, the above equations can be transformed to Equation 5-13 and 5-14 (HEC-22, 2001).

**Equation 5-13** $$V = \frac{0.590 D^{2/3} S^{1/2}}{n}$$

**Equation 5-14** $$Q = \frac{0.463 D^{8/3} S^{1/2}}{n}$$

where:

| | | |
|---|---|---|
| D | = | diameter of pipe, ft |
| S | = | slope of the pipe, ft/ft |

A nomograph solution of Manning's equation for full flow in circular conduits is presented in Figure 5-12. Representative values of the Manning's coefficient for various storm drain materials are provided in Appendix A.

Figure 5-13 illustrates storm drain capacity sensitivity to the parameters in Manning's equation. This figure can be used to study the effect changes in individual parameters will have on storm drain capacity. For example, if the diameter of a storm drain is doubled, its capacity will be increased by a factor of 6.0; if the slope is doubled, the capacity is increased by a factor of 1.4; however, if the roughness is doubled, the pipe capacity will be reduced by 50 percent.

The hydraulic elements graph in Figure 5-14 is provided to assist in the solution of the Manning's equation for partially full flow in storm drains. The hydraulic elements chart shows the relative flow conditions at different depths in a circular pipe and illustrates the following important points:

- Peak capacity occurs at 93 percent of the height of the circular pipe. This means that if the pipe is designed for full flow, the design will be slightly conservative.
- The velocity in a pipe flowing half-full is the same as the velocity for full flow.
- Flow velocities for flow depths greater than half-full are greater than velocities at full flow.
- Velocities in sewers are important mainly because of the possibilities of excessive erosion on the storm drain inverts at high velocity, and clogging at low velocity.

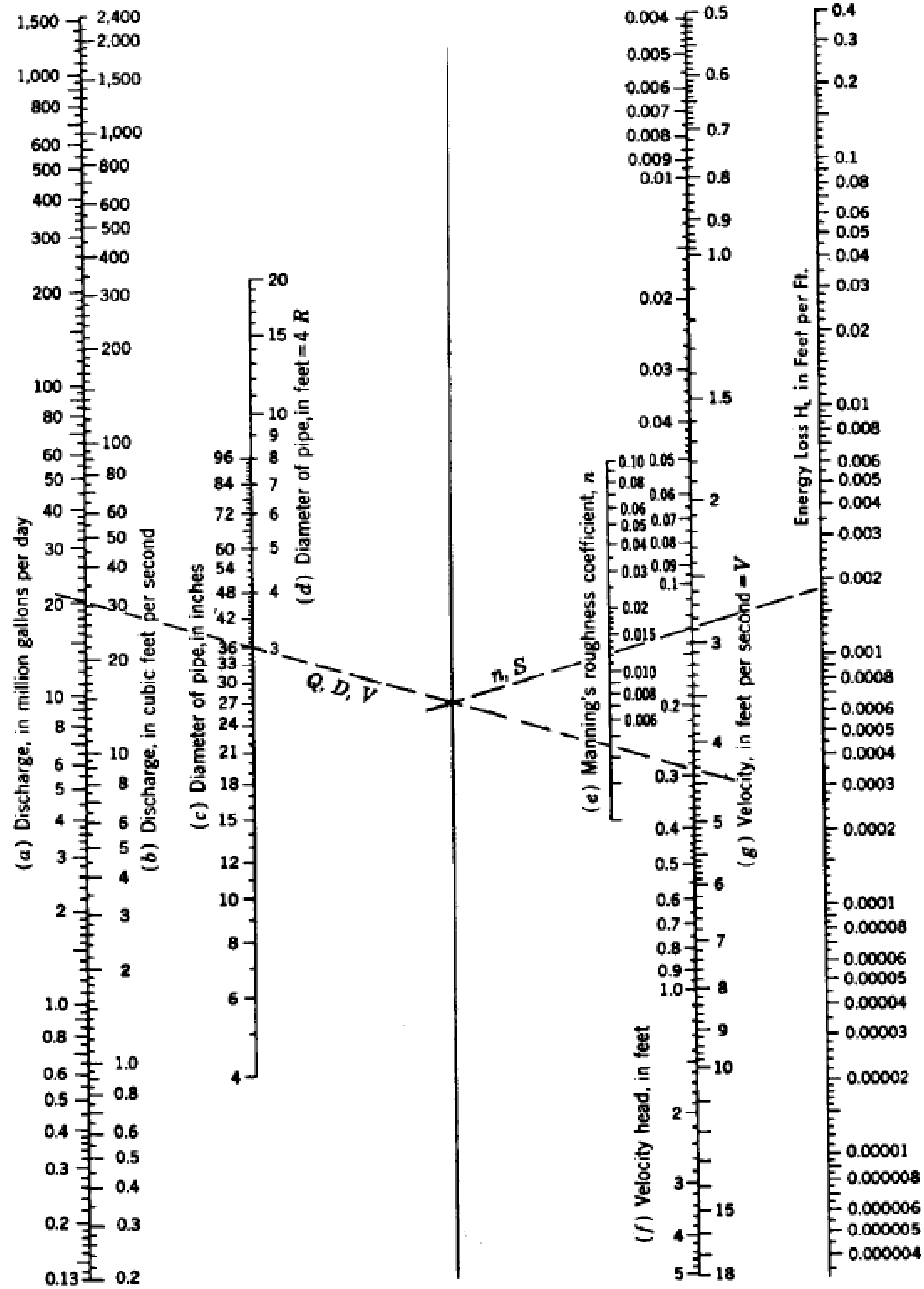


**Figure 5-12 Solution of Manning's Equation for Flow in Storm Drains-English Units**
(HEC-22, 2001)

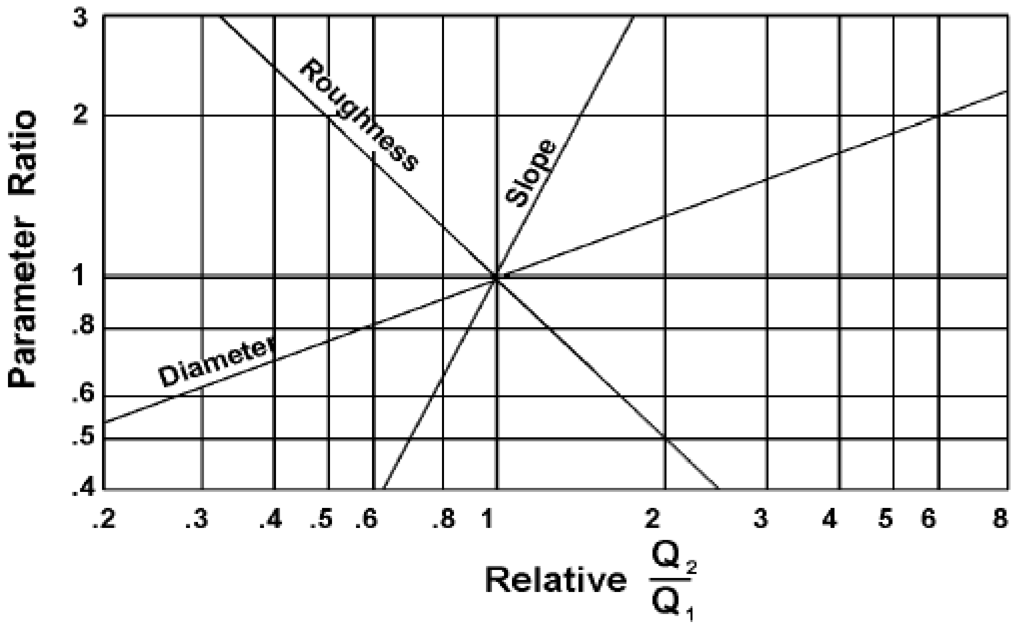


**Figure 5-13 Storm Drain Capacity Sensitivity**
(HEC 22, 2001)

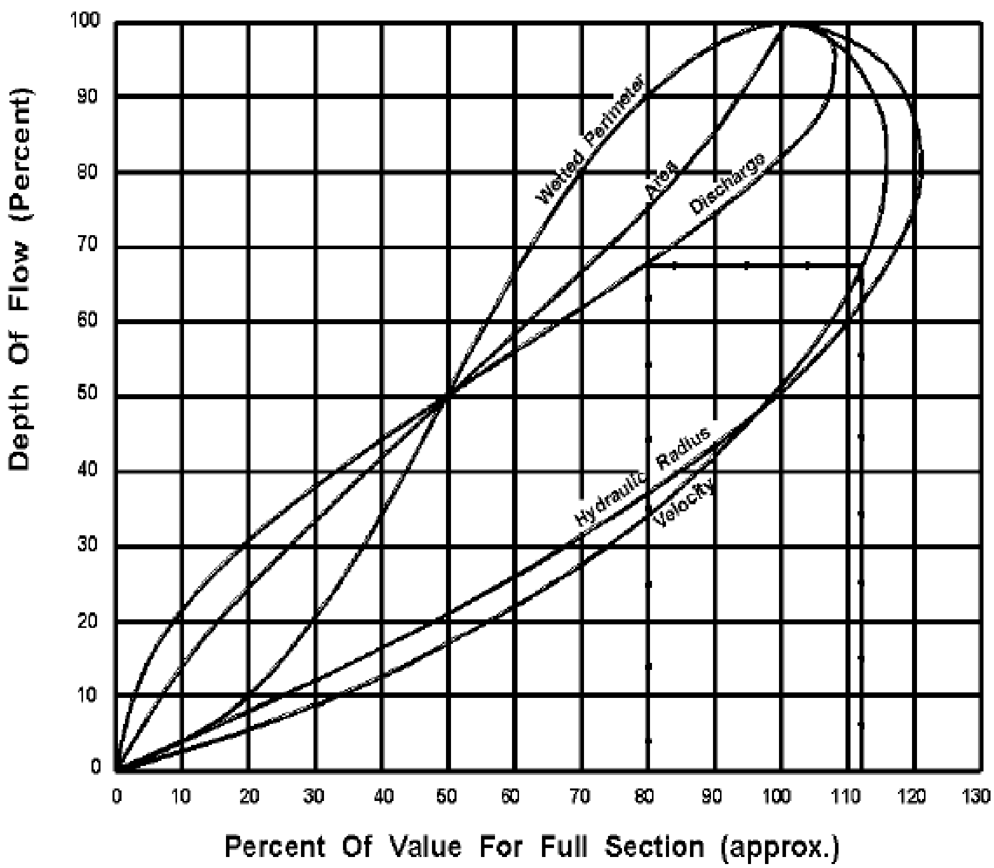


**Figure 5-14 Hydraulic Elements of Circular Section (HEC 22, 2001)**

#### 5.2.5.2 Energy Grade Line/Hydraulic Grade Line

The energy grade line (EGL) is an imaginary line that represents the total energy along a channel or conduit carrying water. Total energy includes elevation head, velocity head and pressure head as shown in Equation 5-15 (HEC-22, 2001).

**Equation 5-15** $$E = \frac{V^2}{2g} + \frac{p}{\gamma} + z$$

where:

| | | |
|---|---|---|
| E | = | Total energy, ft |
| p | = | Pressure, lbs/ft$^2$ |
| $\gamma$ | = | Unit weight of water, 62.4 lbs/ft$^3$ |
| $p/\gamma$ | = | Pressure head, ft (potential energy) |
| z | = | Elevation head, ft (potential energy) |
| V | = | Velocity, ft/s |
| g | = | Gravity, 32.2 ft/s$^2$ |

Bernoulli's Law expressed between points one (1) and two (2) in a closed conduit accounts for all energy forms and energy losses. The general form of the law may be written as shown in Equation 5-16.

**Equation 5-16** $$\frac{V_1^2}{2g} + \frac{p_1}{\gamma} + z_1 = \frac{V_2^2}{2g} + \frac{p_2}{\gamma} + z_2 - H_f - \sum H_m$$

where:

| | | |
|---|---|---|
| $H_f$ | = | Pipe friction loss, ft |
| $\Sigma H_m$ | = | Sum of minor or form losses, ft |

The calculation of the EGL for the full length of the system is critical to the evaluation of a storm drain. In order to develop the EGL it is necessary to calculate all of the losses through the system. The energy equation states that the energy head at any cross section must equal that in any other downstream section plus the intervening losses. The intervening losses are typically classified as either friction losses or form losses. The friction losses can be calculated using Manning's equation. Form losses are typically calculated by multiplying the velocity head by a loss coefficient, K. The HEC-22 method shall be used for developing the value of K depending on the structure or condition being evaluated for loss. Knowledge of the location of the EGL is critical to understanding and estimating the location of the hydraulic grade line.

The hydraulic grade line (HGL) is a line coinciding with the water level at any point along an open channel. In closed conduits flowing under pressure, the hydraulic grade line is the level to which water would rise in a vertical tube at any point along the pipe. The hydraulic grade line is used to aid the designer in determining the acceptability of a proposed storm drainage system by establishing the elevation to which water will rise when the system is operating under design conditions.

The HGL is determined by subtracting the velocity head ($V^2/2g$) from the EGL. Energy concepts can be applied to both pipe flow and open channel flow. Figure 5-15 illustrates the energy and hydraulic grade lines for open channel and pressure flow in pipes.

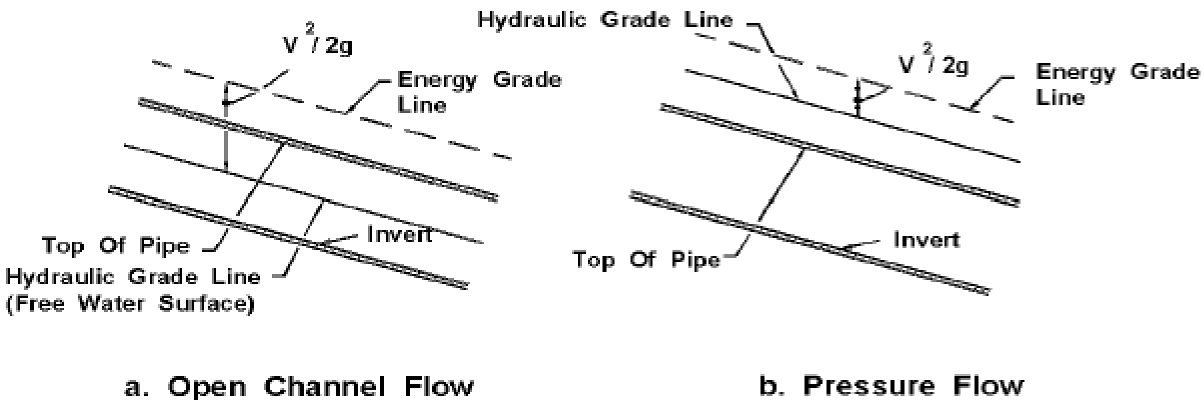


**Figure 5-15 Hydraulic and Energy Grade Lines in Pipe Flow**
(HEC 22, 2001)

When water is flowing through the pipe and there is a ventilated space of air between the top of the water and the inside of the pipe, the flow is considered as open channel flow and the HGL is at the water surface. When the pipe is flowing full under pressure flow, the HGL will be above the crown of the pipe. When the flow in the pipe just reaches the point where the pipe is flowing full, this condition lies in between open channel flow and pressure flow. At this condition the pipe is under gravity full flow and the flow is influenced by the resistance of the total circumference of the pipe. Under gravity full flow, the HGL coincides with the crown of the pipe.

Inlet surcharging and possible manhole lid displacement can occur if the hydraulic grade line rises above the ground surface. A design based on open channel conditions must include evaluation of the potential for excessive and inadvertent flooding created when a storm event larger than the design storm pressurizes the system. As hydraulic calculations are performed, frequent verification of the existence of the desired flow condition should be made. Storm drainage systems can often alternate between pressure and open channel flow conditions from one section to another.

A detailed procedure for evaluating the EGL and the HGL for storm drainage systems is presented in Section 5.2.5.5.

### 5.2.5.3 Energy Losses

Prior to computing the HGL, all energy losses in pipe runs and junctions must be estimated. In addition to the principal energy involved in overcoming the friction in each conduit run, energy (or head) is required to overcome changes in momentum or turbulence at outlets, inlets, bends, transitions, and junction structures. The following sections present relationships for estimating typical energy losses in storm drainage systems.

The major loss in a storm drainage system is usually the friction or boundary shear loss. The head loss due to friction in a pipe is computed as shown in Equation 5-17 (HEC-22, 2001).

**Equation 5-17** $H_f = S_f L$

where:

| | | |
|---|---|---|
| $H_f$ | = | pipe friction loss, ft |
| $S_f$ | = | friction slope, ft/ft |
| L | = | length of pipe, ft |

The friction slope in Equation 5-17 is also the slope of the hydraulic gradient for a particular uniform flow pipe run. As indicated by the equation, the friction loss is simply the hydraulic gradient multiplied by the length of the run. Since this design procedure assumes steady uniform flow in open channel flow, the friction slope will match the pipe slope for partially full flow. Pipe friction losses for full flow can be determined by the use of Equation 5-17.

The exit loss from a storm drain outlet is a function of the change in velocity at the outlet of the pipe. For a sudden expansion such as at an endwall, the exit loss is calculated using Equation 5-18 (HEC-22, 2001).

**Equation 5-18** $H_o = 1.0\left[\frac{V_o^2}{2g} - \frac{V_d^2}{2g}\right]$

where:

| | | |
|---|---|---|
| $H_o$ | = | outlet loss, ft |
| $V_o$ | = | average outlet velocity, ft/s |
| $V_d$ | = | channel velocity downstream of outlet, ft/s |
| g | = | gravity, 32.2 ft/s$^2$ |

Note that when $V_d$ = 0, as in a reservoir, the exit loss is one velocity head. For partially full flow where the pipe outlets into a channel with water moving in the same direction and velocity as the outlet water, the exit loss may be reduced to virtually zero.

An approximate method for estimating losses across manholes, junction boxes and inlet boxes/structures is provided in this section. The method involves multiplying the velocity head of the outflow pipe by a coefficient as represented in Equation 5-19. Applicable coefficients ($K_{ah}$) are provided in Table 5-7. For more than one pipe entering a structure, use the largest applicable value of $K_{ah}$ in Equation 5-19 (HEC-22, 2001).

**Equation 5-19** $H_{ah} = K_{ah}\left(\frac{V_o^2}{2g}\right)$

where:

| | | |
|---|---|---|
| $H_{ah}$ | = | approximate structure loss, ft |
| $K_{ah}$ | = | structure head loss coefficient (Table 5-7) |
| $V_o$ | = | velocity at outlet pipe, ft/s |
| g | = | gravity, 32.2 ft/s$^2$ |

**Table 5-7 Structure Head Loss Coefficients** (HEC-22, 2001)

| Structure Configuration | $K_{ah}$ | Structure Configuration | $K_{ah}$ |
|---|---|---|---|
| Inlet-straight run | 0.5 | Manhole-straight run | 0.15 |
| Inlet-angled through | | Manhole-angled through | |
| 90° | 1.5 | 90° | 1 |
| 60° | 1.25 | 60° | 0.85 |
| 45° | 1.1 | 45° | 0.75 |
| 22.5° | 0.7 | 22.5° | 0.45 |

Loss coefficients calculated using the approximate method are acceptable for sites where these types of losses are not a critical factor in system design. The more detailed procedures provided in HEC-22 must be used for sites where junction losses are a critical factor. The HEC-22 methodology is generally based on lab-scale and full-scale testing of flow through junction structures.

### 5.2.5.4 Preliminary Design Procedure

The preliminary design of storm drains can be accomplished by using the following steps and the storm drain computation sheet provided in Figure 5-16. This procedure assumes that each storm drain will be initially designed to flow full under gravity conditions. The designer must recognize that when the steps in this section are complete, the design is only preliminary. Final design is accomplished after the energy grade line and hydraulic grade line computations have been completed (See Section 5.2.5.5).

**Step 1** Prepare a working plan layout and profile of the storm drainage system establishing the following design information:

- Location of storm drains;
- Direction of flow;
- Location of junction structures;
- Number or label assigned to each structure;
- Location of all existing utilities (water, sewer, gas, underground cables, etc.).

**Step 2** Determine the following hydrologic parameters for the drainage areas tributary to each inlet to the storm drainage system:

- Drainage areas;
- Runoff coefficients;
- Travel time.

**Step 3** Using the information generated in Steps 1 and 2, complete the following information on the design form for each run of pipe starting with the most upstream storm drain run:

- "From" and "To" stations, Columns 1 and 2.
- "Length" of run, Column 3.
- "Inc." drainage area, Column 4. The incremental drainage area tributary to the inlet at the upstream end of the storm drain run under consideration.
- "C," Column 6. The runoff coefficient for the drainage area tributary to the inlet at the upstream end of the storm drain run under consideration. In some cases a composite runoff coefficient will need to be computed.
- "Inlet" time of concentration, Column 9. The time required for water to travel from the hydraulically most distant point of the drainage area to the inlet at the upstream end of the storm drain run under consideration.
- "System" time of concentration, Column 10. The time for water to travel from the most remote point in the storm drainage system to the upstream end of the storm drain section under consideration. For the most upstream storm drain section this value will be the same as the value in Column 9. For all other pipe sections this value is computed by adding the "System" time of concentration (Column 10) and the "Section" time of concentration (Column 17) from the previous section together to get the system time of concentration at the upstream end of the section under consideration. If Column 10 is less than 15 minutes the designer shall use 15 minutes.

**Step 4** Using the information from Step 3, compute the following:

- "TOTAL" area, Column 5. Add the incremental area in Column 4 to the previous sections total area and place this value in Column 5.
- "INC." area x "C," Column 7. Multiply the drainage area in Column 4 by the runoff coefficient in Column 6. Put the product, CA, in Column 7.
- "TOTAL" area x "C," Column 8. Add the value in Column 7 to the value in Column 8 for the previous storm drain run and put this value in Column 8.
- "I," Column 11. Using the larger of the two times of concentration in Columns 9 and 10, and an Intensity-Duration-Frequency (IDF) curve, determine the rainfall intensity, I, and place this value in Column 11.
- "TOTAL Q," Column 12. Calculate the discharge as the product of Columns 8 and 11. Place this value in Column 12.
- "SLOPE," Column 21. Place the pipe slope value in Column 21. The pipe slope will be approximately the slope of the finished roadway. The slope can be modified as needed.
- "PIPE DIA.," Column 13. Size the pipe using relationships and charts presented in Section 5.2.5.1 to convey the discharge by varying the slope and pipe size as necessary. The storm drain should be sized as close as possible to a full gravity flow. Since most calculated sizes will not be available, a nominal size will be

used. The designer will decide whether to go to the next larger size and have partially full flow or whether to go to the next smaller size and have pressure flow.

- "CAPACITY FULL," Column 14. Compute the full flow capacity of the selected pipe using Equation 5-14 and put this information in Column 14.
- "VELOCITIES," Columns 15 and 16. Compute the full flow and design flow velocities (if different) in the conduit and place these values in Columns 15 and 16. If the pipe is flowing full, the velocities can be determined from V = Q/A. If the pipe is not flowing full, the velocity can be determined from Figure 5-14.
- "SECTION TIME," Column 17. Calculate the travel time in the pipe section by dividing the pipe length (Column 3) by the design flow velocity (Column 16). Place this value in Column 17.
- "CROWN DROP," Column 20. Calculate an approximate crown drop at the structure to off-set potential structure energy losses using the "previously described "rules-of-thumb." Place this value in Column 20.
- "INVERT ELEV.," Columns 18 and 19. Compute the pipe inverts at the upper (U/S) and lower (D/S) ends of this section of pipe, including any pipe size changes that occurred along the section.

**Step 5** Repeat steps 3 and 4 for all pipe runs to the storm drain outlet. Use equations and nomographs to accomplish the design effort.

**Step 6** Check the design by calculating the energy grade line and hydraulic grade line as described in Section 5.2.5.5. Adjust as necessary.

## Preliminary Storm Drain Computation Sheet

Computed By ______________ Checked By ______________ Page ____

Date ______________ Date ______________ Of ____

| Str ID | | Length | Drainage Area | | Runoff | "Area" * "C" | | Time of Concentration | | Rain | Runoff | Pipe | Q Full | Velocity | | Sec. | Invert Elev. | | Crown | Slope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | | Inc | Total | Coefficient "C" | Inc | Total | Inlet | System | "I" | "Q" | Diameter | | Full | Design | Time | U/S | D/S | Drop | |
| | | ( ft ) | ( Ac ) | ( Ac ) | | ( Ac ) | ( Ac ) | (min) | (min) | ( in/hr ) | ( $ft^3/s$ ) | (     ) | ( $ft^3/s$ ) | ( ft/s ) | ( ft/s ) | (min) | ( ft ) | ( ft ) | ( ft ) | ( ft/ft ) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
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**Figure 5-16 Preliminary Storm Drain Computation Sheet (HEC-22)**

### 5.2.5.5 Energy Grade Line Evaluation Procedure

This section presents a step-by-step procedure for manual calculation of the energy grade line (EGL) and the hydraulic grade line (HGL) using the energy loss method. For most storm drainage systems, computer methods such as EPA-SWMM are the most efficient means of evaluating the EGL and the HGL. However, it is important that the designer understand the analysis process to better interpret the output from computer generated storm drain designs.

Figure 5-17 provides a sketch illustrating use of the two grade lines in developing a storm drainage system. (Note that in this figure, extracted from HEC-22, junction structures are referred to as “access holes.”) The following step-by-step procedure can be used to manually compute the EGL and HGL. The computation tables in Figure 5-18 and Figure 5-19 can be used to document the procedure outlined below.

Before outlining the computational steps in the procedure, a comment relative to the organization of data on the form is appropriate. In general, a line will contain the information about a specific structure and the line downstream from the structure. As the table is started, the first two lines may be unique. The first line will contain information about the outlet conditions. This may be a pool elevation or information on a known downstream system. The second line will be used to define the conditions at the end of the last conduit. Following these first two lines the procedure becomes more general. A single line on the computation sheet is used for each junction or structure and its associated outlet pipe. For example, data for the first structure immediately upstream of the outflow pipe and the outflow pipe would be tabulated in the third full line of the computation sheet (lines may be skipped on the form for clarity). Sheet A (Figure 5-18) is used to calculate the HGL and EGL elevations while Sheet B (Figure 5-19) is used to calculate the pipe losses and structure losses. Values obtained in Sheet B are transferred to Sheet A for use during the design procedure. In the description of the computation procedures, a column number will be followed by a letter A or B to indicate the appropriate table to be used.

EGL computations begin at the outfall and are worked upstream taking each junction into consideration. Most storm drain systems are designed to function in a subcritical flow regime. In subcritical flow, pipe and junction structure losses are summed to determine the upstream EGL levels. If supercritical flow occurs, pipe and access losses are not carried upstream. When a storm drain section is identified as being supercritical, the designer should advance to the next upstream pipe section to determine its flow regime. This process continues until the storm drain system returns to a subcritical flow regime.

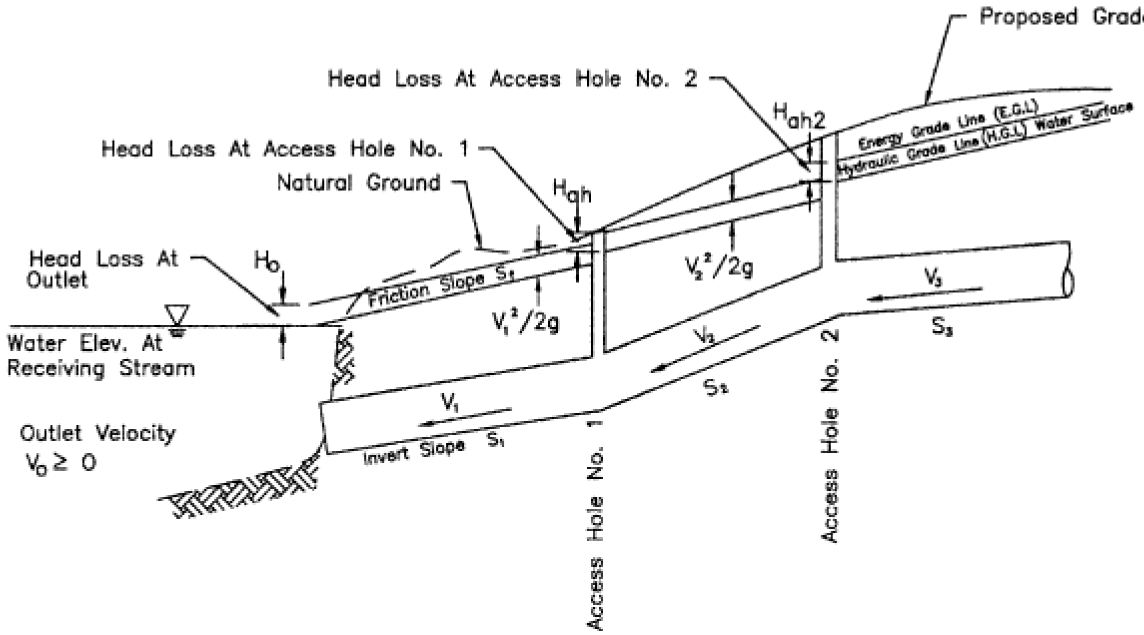


**Figure 5-17 Energy and Hydraulic Grade Line Illustration**
(HEC 22, 2001)

The EGL computational procedure follows:

**Step 1** The first line of Sheet A includes information on the system beyond the end of the conduit system. Define this as the stream, pool, existing system, etc. in column 1A. Determine the EGL and HGL for the downstream receiving system. If this is a natural body of water, the HGL will be at the water surface. The EGL will also be at the water surface if no velocity is assumed, or will be a velocity head above the HGL if there is a velocity in the water body. If the new system is being connected to an existing storm drain system, the EGL and the HGL will be that of the receiving system. Enter the HGL in Column 14A and the EGL in Column 10A of the first line on the computation sheet.

**Step 2** Identify the structure number at the outfall (this may be just the end of the conduit, but it needs a structure number), the top of conduit (TOC) elevation at the outfall end, and the surface elevation at the outfall end of the conduit. Place these values in Columns 1A, 15A, and 16A respectively. Also add the structure number in Column 1B.

**Step 3** Determine the EGL just upstream of the structure identified in Step 2. Several different cases exist as defined below when the conduit is flowing full:

Case 1: If the TW at the conduit outlet is greater than (dc + D)/2, the EGL will be the TW elevation plus the velocity head for the conduit flow conditions (where dc is the critical depth and D is the conduit diameter).

Case 2: If the TW at the conduit outlet is less than (dc + D)/2, the EGL will be the HGL plus the velocity head for the conduit flow conditions. The equivalent hydraulic grade line, HGL, will be the invert elevation plus (dc + D)/2.

The velocity head needed in either Case 1 or 2 will be calculated in the next steps, so it may be helpful to complete Step 4 and work Step 5 to the point where velocity head (Column 7A) is determined and then come back and finish this step. Put the EGL in Column 13A.

Note: The values for dc for circular pipes can be determined from Figure 5-25. Charts for other conduits or other geometric shapes can be found in Hydraulic Design of Highway Culverts, HDS-5, and cannot be greater than the height of the conduit.

**Step 4** Identify the structure ID for the junction immediately upstream of the outflow conduit (for the first conduit) or immediately upstream of the last structure (if working with subsequent lines) and enter this value in Columns 1A and 1B of the next line on the computation sheets. Enter the conduit diameter (D) in column 2A, the design discharge (Q) in Column 3A, and the conduit length (L) in Column 4A.

**Step 5** If the barrel flows full, enter the full flow velocity from continuity in Column 5A and the velocity head ($V^2/2g$) in column 7A. Put “full” in Column 6a and not applicable (n/a) in Column 6b of Sheet A. Continue with Step 6. If the barrel flows only partially full, continue with Step 5A.

Note: If the pipe is flowing full because of high tailwater or because the pipe has reached its capacity for the existing conditions, the velocity will be computed based on continuity using the design flow and the full cross sectional area. Do not use the full flow velocity determined in Column 15 of the Preliminary Storm Drain Computation Form for part-full flow conditions. For part-full conditions discussed in Step 5, the calculations in the preliminary form may be helpful. Actual flow velocities need to be used in the EGL/HGL calculations.

- **5A**: Partially full flow: Using the hydraulic elements graph in Figure 5-14 with the ratio of partially full to full flow (values from the preliminary storm drain computation form), compute the depth and velocity of flow in the conduit. Enter these values in Column 6a and 5A respectively of Sheet A. Compute the velocity head ($V^2/2g$) and place in Column 7A.
- **5B**: Compute critical depth for the conduit using Figure 5-25. If the conduit is not circular, see HDS-5 for additional charts. Enter this value in Column 6b of Sheet A.
- **5C**: Compare the flow depth in Column 6a (Sheet A) with the critical depth in Column 6b (Sheet A) to determine the flow state in the conduit. If the flow depth in Column 6a is greater than the critical depth in Column 6b, the flow is subcritical, continue with Step 6. If the flow depth in Column 6a is less than or equal to the critical depth in Column 6b, the flow is supercritical, continue with Step 5D. In either case, remember that the EGL must be higher upstream for

flow to occur. If after checking for super critical flow in the upstream section of pipe, assure that the EGL is higher in the pipe than in the structure.

- **5D**: Pipe losses in a supercritical pipe section are not carried upstream. Therefore, enter a zero (0) in Column 7B for this structure.
- **5E**: Enter the structure ID for the next upstream structure on the next line in Columns 1A and 1B. Enter the pipe diameter (D), discharge (Q), and conduit length (L) in Columns 2A, 3A, and 4A respectively of the same line.

  Note: After a downstream pipe has been determined to flow in supercritical flow, it is necessary to check each succeeding upstream pipe for the type of flow that exists. This is done by calculating normal depth and critical depth for each pipe. If normal depth is less than the diameter of the pipe, the flow will be open channel flow and the critical depth calculation can be used to determine whether the flow is sub or supercritical. If the flow line elevation through a junction structure drops enough that the invert of the upstream pipe is not inundated by the flow in the downstream pipe, the designer goes back to Step1 and begins a new design as if the downstream section did not exist.
- **5F**: Compute normal depth for the conduit using Figure 5-12 and critical depth using Figure 5-25. If the conduit is not circular see HDS-5 for additional charts. Enter these values in Columns 6A and 6b of Sheet A.
- **5G**: If the pipe barrel flows full, enter the full flow velocity from continuity in Column 5A and the velocity head ($V^2/2g$) in Column 7A. Go to Step 3, Case 2 to determine the EGL at the outlet end of the pipe. Put this value in Column 10A and go to Step 6. For partially full flow, continue with Step 5H.
- **5H**: Partially full flow: Compute the velocity of flow in the conduit and enter this value in Column 5A. Compute the velocity head ($V^2/2g$) and place in Column 7A.
- **5I**: Compare the flow depth in Column 6a with the critical depth in Column 6b to determine the flow state in the conduit. If the flow depth in Column 6a is greater than the critical depth in Column 6b, the flow is subcritical, continue with Step 5J. If the flow depth in Column 6a is less than or equal to the critical depth in Column 6b, the flow is supercritical, continue with Step 5K.
- **5J**: Subcritical flow upstream: Compute EGLo at the outlet of the previous structure as the outlet invert plus the sum of the outlet pipe flow depth and the velocity head. Place this value in Column 10A of the appropriate structure and go to Step 9.
- **5K**: Supercritical flow upstream: manhole losses do not apply when the flow in two (2) successive pipes is supercritical. Place zeros (0) in Columns 11A, 12A, and 7B of the intermediate structure (previous line). The HGL at the structure is equal to the pipe invert elevation plus the flow depth. Check the invert elevations and the flow depths both upstream and downstream of the structure to determine where the highest HGL exists. The highest value should be placed in Column

14A of the previous structure line. Perform Steps 20 and 21 and then repeat Steps 5E through 5K until the flow regime returns to subcritical. If the next upstream structure is end-of-line, skip to step 10b then perform Steps 20, 21, and 24.

**Step 6** Compute the friction slope ($S_f$) for the pipe by dividing friction loss by length for a pipe flowing full, as shown below (n = Manning's n value). Enter this value in Column 8A of the current line. If full flow does not exist, set the friction slope equal to the pipe slope.

$$S_f = \frac{H_f}{L} = \frac{185n^2\left(\frac{V^2}{2g}\right)}{D^{4/3}}$$

**Step 7** Compute the friction loss ($H_f$) by multiplying the length (L) in Column 4A by the friction slope ($S_f$) in Column 8A and enter this value in Column 2B. Compute other losses along the pipe run such as expansion ($H_e$) losses, and junction losses ($H_j$) and place the values in Columns 3B and 4B, respectively. Add the values in 3B and 4B and place the total in Column 5B and 9A.

**Step 8** Compute the energy grade line value at the outlet of the structure ($EGL_o$) as the EGLi elevation from the previous structure (Column 13A) plus the total pipe losses (Column 9A). Enter the $EGL_o$ in Column 10A.

**Step 9** Estimate the depth of water in the manhole (estimated as the depth from the outlet pipe invert to the hydraulic grade line in the pipe at the outlet). Computed as $EGL_o$ (Column 10A) minus the pipe velocity head in Column 7A minus the pipe invert elevation (from the preliminary storm drain computation form). Enter this value in Column 6B. If supercritical flow exists in this structure, leave this value blank and skip to Step 5E.

**Step 10** If the inflow storm drain invert is submerged by the water level in the junction structure, compute the structure head loss coefficient, $K_{ah}$, based on the pipe deflection angle (θ) through the structure. Enter the deflection angle in Column 7B. Look up $K_{ah}$ in Table 5-7 based on the deflection angle. Enter this value in Column 7B and 11A. If the inflow storm drain invert is not submerged by the water level in the junction structure, compute the head in the junction structure using culvert techniques from HDS-5 as follows:

- **10A:** If the structure outflow pipe is flowing full or partially full under outlet control, compute the manhole loss per Equation 5-18. Enter this value in Column 12A and 11A, continue with Step 12. Add a note on Sheet A indicating that this is a drop structure.
- **10B:** If the outflow pipe functions under inlet control, compute the depth in the junction structure (HGL) using Figure 5-22. If the storm conduit shape is other than circular, select the appropriate inlet control nomograph from HDS-5. Add these values to the manhole invert to determine the HGL. Since the velocity in

the junction structure is negligible, the EGL and HGL are the same. Enter HGL in Column 14A and EGL in Column 13A. Add a note on Sheet A indicating that this is a drop structure. Go to Step 14.

**Step 11** Compute the total junction structure loss, $H_{ah}$, by multiplying the $K_{ah}$ value in Column 11A by the velocity head in Column 7A. Enter this value in Column 12A.

**Step 12** Compute $EGL_i$ at the structure by adding the structure losses in Column 12A to the EGLo value in Column 10A. Enter this value in Column 13A.

**Step 13** Compute the hydraulic grade line (HGL) at the structure by subtracting the velocity head in Column 7A from the $EGL_i$ value in Column 13A. Enter this value in Column 14A.

**Step 14** Determine the top of conduit (TOC) value for the inflow pipe (using information from the storm drain computation sheet) and enter this value in Column 15A.

**Step 15** Enter the ground surface, top of grate elevation or other high water limits at the structure in Column 16A. If the HGL value in Column 14A exceeds the limiting elevation, design modifications will be required.

**Step 16** Enter the structure ID for the next upstream structure in Column 1A and 1B of the next line. When starting a new branch line, skip to Step 18.

**Step 17** Continue to determine the EGL through the system by repeating Steps 4 through 18. (Begin with Step 2 if working with a drop structure. This begins the design process again as if there were no system down stream from the drop structure).

**Step 18** When starting a new branch line, enter the structure ID for the branch structure in Column 1A and 1B of a new line. Transfer the values from Columns 2A through 10A and 2B to 7B associated with this structure on the main branch run to the corresponding columns for the branch line. If flow in the main storm drain at the branch point is subcritical, continue with Step 9; if supercritical, continue with Step 5E.

## Energy Grade Line Computation Sheet - Table A

Computed By ____________ Checked By ____________ Initial Tailwater Page ______

Date ____________ Date ____________ Elevation ______ Of ______

| Str ID | D | Q | L | V | d | dc | $V^2/2g$ | $S_f$ | Total Pipe Loss (Table B) | $EGL_o$ | $K_{ah}$ (Table B) | $K_{ah}(V^2/2g)$ | $EGL_i$ | HGL | U/S TOC | Surf Elev |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ( ft ) | ( cfs ) | ( ft ) | ( ft / s ) | ( ft ) | ( ft ) | ( ft ) | ( ft / ft ) | ( ft ) | ( ft ) | | ( ft ) | ( ft ) | ( ft ) | ( min ) | ( ft ) |
| 1A | 2A | 3A | 4A | 5A | 6a | 6b | 7A | 8A | 9A | 10A | 11A | 12A | 13A | 14A | 15A | 16A |
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**Figure 5-18 Energy Grade Line Computation Sheet - Sheet A (HEC-22)**

## Energy Grade Line Computation Sheet - Table B

Page ______ Of ______

Computed By ______ Date ______

Checked By ______ Date ______

| Str ID | Losses (ft) | | | | Depth (ft) | Structure Loss Coefficient ( dim ) |
|---|---|---|---|---|---|---|
| | $H_f$ | $H_e$ | $H_j$ | Total | $d_{aho}$ | $K_{ah}$ |
| 1B | 2B | 3B | 4B | 5B | 6B | 7B |
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**Figure 5-19  Energy Grade Line Computation Sheet - Sheet B**

### 5.2.6 Software for Storm Sewer Analysis

The calculation of gutter flow, inlet capture and pipe hydraulic grade lines can be extremely time consuming when performed by hand. There are several widely-used programs created by public agencies that can be acquired at no cost to speed these calculations.

Gutter and inlet calculations can be made at minimal effort using the FHWA “HY-22 Urban Drainage Design” program, which runs the procedures found in HEC-22. A screen capture from HY-22 is shown below, displaying the parameters previously discussed for inlet design.

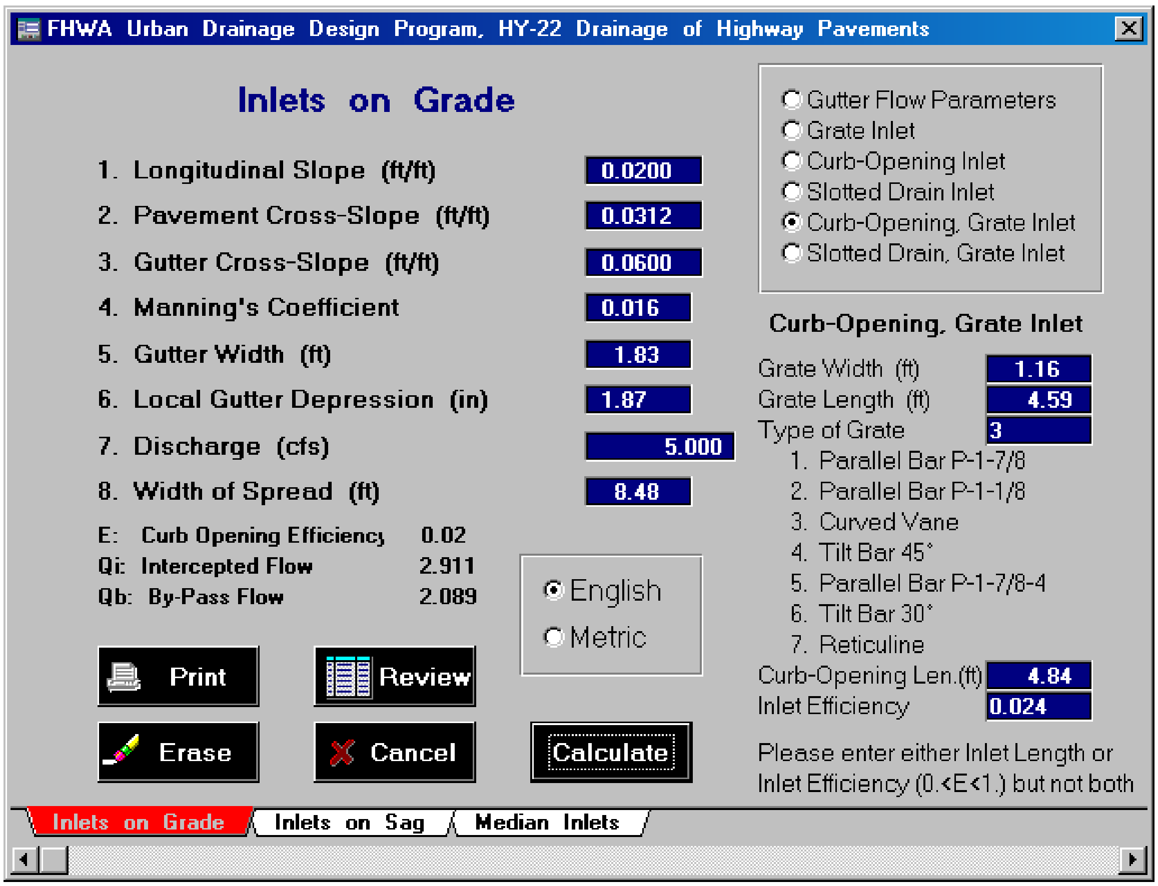



**Figure 5-20 Screen Capture from Visual Urban**

Visual Urban can be downloaded from:

http://www.fhwa.dot.gov/engineering/hydraulics/software/softwaredetail.cfm

The Urban Drainage and Flood Control District (UDFCD) of Denver has also published an inlet design spreadsheet based on the HEC-22 methodology. This spreadsheet can be used to create head-discharge curves for a wide variety of gutter and inlet conditions. These curves can be used with EPA-SWMM to create a dynamic model of gutter and storm sewer flow. The UDFCD spreadsheet can be downloaded from:

http://www.udfcd.org/downloads/down_software.htm

Storm sewer hydraulic grade line calculations can be performed using the EPA program, "EPA-SWMM". In addition to benefits described elsewhere, EPA-SWMM can be used when considering complex tailwater effects, storage routing, channel flow, and storm sewer flow. Inlets can be modeled using an outlet with head-discharge relationships based on HEC-22. EPA-SWMM can be downloaded from:

http://www.epa.gov/ednnrmrl/models/swmm/

Proprietary software may also be used for storm sewer analysis. However, commercial third-party models must be pre-approved by the City and County, not only on the basis of technical acceptance but also on the basis of the cost for the City and County to maintain a license of the product for review purposes.

## 5.3 Culverts

### 5.3.1 Introduction

A culvert is a short, closed (covered) conduit that conveys stormwater runoff under an embankment or away from the street right-of-way. The primary purpose of a culvert is to convey surface water, but it may also be designed to restrict flow and reduce downstream peak flows.

For economy, engineers may design culverts to operate with the inlet submerged during flood flows, if conditions permit. Design considerations include site and roadway data, design parameters (including shape, material, and orientation), hydrology (flood magnitude versus frequency relation), and channel analysis (stage versus discharge relation).

### 5.3.2 General Criteria

The design of a culvert for new developments or redevelopments must take into account many different engineering and technical aspects at the culvert site and adjacent areas. The following design criteria shall be used for all culvert designs as applicable.

Culvert design shall follow the analytical procedures outlined in: FHWA Hydraulic Design of Highway Culverts, HDS-5, 2001. The FHWA computer program HY-8 is recommended to implement these procedures.

Culverts that do not cross public roadways shall provide allowable headwater protection for the design storm. Culverts that do cross public roadways shall provide allowable headwater protection for the 100-year storm. The allowable headwater is the depth of water that can be ponded at the upstream end of the culvert, which will be limited by one or more of the following constraints:

- Allowable headwater shall be no greater than one foot below the low point in the road grade unless overflow has been allowed by the roadway design and approved by the Director or his/her designee.
- Allowable headwater shall be no greater than the elevation where flow diverts around the culvert.
- Ponding shall not increase base flood elevations for streams with current FEMA floodplain mapping.
- The 100-year frequency storm shall be analyzed through all culverts to ensure a minimum of 2 feet of freeboard for building structures (e.g., houses and commercial buildings).

Either the headwater shall be controlled to produce acceptable exit velocities per Section 5.7, or energy dissipation shall be provided where these velocities are exceeded.

To ensure self-cleaning velocities during partial depth flow, a minimum velocity of 2.5 feet per second is required for the 1-year flow where practicable.

Culverts shall have a slope no less than 0.3% and no more than 10%.

Reinforced concrete pipe (RCP), pre-cast concrete boxes, or cast-in-place concrete boxes shall be used under all public roadways and for all flowing streams.

In the City the minimum allowable pipe diameter shall be 15 inches for pipes in the right-of-way, pipes conveying offsite drainage, or pipes draining structural stormwater facilities. This minimum pipe diameter shall be 18 inches in the County.

The hydraulic conditions downstream of the culvert site must be evaluated to determine a tailwater depth for a range of discharges. The following conditions must be considered when setting tailwater elevations:

- If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined.
- For culverts that discharge to an open channel, the stage-discharge curve for the channel shall be determined.
- If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert shall establish the design tailwater depth for the upstream culvert.
- If the culvert discharges to a lake, pond, or other major water body, the corresponding high water elevation of the particular water body shall establish the culvert tailwater.

The culvert inlet loss coefficients given in Table 5-8 shall be used for all culverts per HDS-5, 2001.

**Table 5-8 Inlet Coefficients**

| Type of Structure and Design of Entrance | Coefficient $K_e$ |
|---|---|
| Pipe, Concrete | |
| Projecting from fill, socket end (groove-end) | 0.2 |
| Projecting from fill, square cut end | 0.5 |
| Headwall or headwall and wingwalls | |
| Socket end of pipe (groove-end) | 0.2 |
| Square-edge | 0.5 |
| Rounded [radius = 1/12(D)] | 0.2 |
| Mitered to conform to fill slope | 0.7 |
| *End-Section conforming to fill slope | 0.5 |
| Beveled edges, 33.7$^o$ or 45$^o$ bevels | 0.2 |
| Side- or slope-tapered inlet | 0.2 |
| Pipe, or Pipe-Arch, Corrugated Metal[1] | |
| Projecting form fill (no headwall) | 0.9 |
| Headwall or headwall and wingwalls square-edge | 0.5 |
| Mitered to fill slope, paved or unpaved slope | 0.7 |
| End Section conforming to fill slope | 0.5 |
| Beveled edges, 33.7$^o$ or 45$^o$ bevels | 0.2 |
| Slide- or slope-tapered inlet | 0.2 |
| Box, Reinforced Concrete | |
| Headwall parallel to embankment (no wingwalls) | |
| Square-edged on 3 edges | 0.5 |
| Rounded on 3 edges or beveled edges on 3 sides | 0.2 |
| Wingwalls at 30$^o$ to 75$^o$ to barrel | |
| Square-edged at crown | 0.4 |
| Crown edge rounded to radius of [1/12(D)] or beveled top edge | 0.2 |
| Wingwalls at 10$^o$ or 25$^o$ to barrel | |
| Square-edged at crown | 0.5 |
| Wingwalls parallel (extension of sides) | |
| Square-edged at crown | 0.7 |
| Side- or slope-tapered inlet | 0.2 |

[1]Although laboratory tests have not been completed on $K_e$ values for High-Density Polyethylene (HDPE) pipes, the $K_e$ values for corrugated metal pipes are recommended for HDPE pipes.

*Note: "End Section conforming to fill slope" are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.

Source: HDS-5, 2001

## 5.3.3 Design Procedures

***Culvert Shapes***

The cross sectional shape of a culvert can be square, rectangular, circular, elliptical, or arch shaped. Reinforced concrete boxes are square or rectangular. Reinforced concrete pipes are available in circular, arch, and elliptical shapes. Pipe-arch, elliptical, and box shapes are appropriate in situations with limited cover or low allowable headwater. Pipe-arch and box shapes can also be used where less obstruction of the waterway is desirable. Round pipes are generally more economical than noncircular pipes. Therefore, the use of noncircular pipe should be justified by dimensional constraints or unusual allowable headwall elevation constraints.

***Box Culverts***

Box culverts are available in a wide range of sizes with one or more barrels. Box culverts are either cast in place in the field by forming and pouring or delivered to the site as precast sections.

***Multiple Barrel Culverts***

Culverts with multiple barrels are appropriate in situations with limited cover, low allowable flow depth or large capacity requirements. Also, a multiple cell box culvert is generally more economical than a box culvert with a single long span. They can be used in wide, shallow channels to limit the constriction of the flow. However, widening a natural channel to accommodate a multiple-barrel culvert often results in sediment and debris accumulation in the widened channel section and in the culvert. Low flow barrels may be required by the Director or his/her designee to ensure self-cleaning velocities for the 1-year storm.

***Types of Flow Control***

There are two basic types of flow control conditions for culverts, and these conditions are defined by the location of the control section and the critical flow depth. Variations of these basic types are numerous. Please refer to HDS-5 (FHWA Hydraulic Design of Highway Culverts) for more information on various culvert flow regimes.

<u>Inlet Control:</u> The Inlet control condition occurs when the culvert barrel is capable of conveying more flow than the inlet will accept. This typically happens when a culvert is operating on a steep slope. The control section of a culvert is located just inside the entrance. Critical depth occurs at or near this location, and the flow regime immediately downstream is supercritical.

<u>Outlet Control:</u> The outlet control condition occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept. The control section for the outlet control condition in a culvert is located at the barrel exit or further downstream. Subcritical or pressure flow exists in the culvert barrel under these conditions.

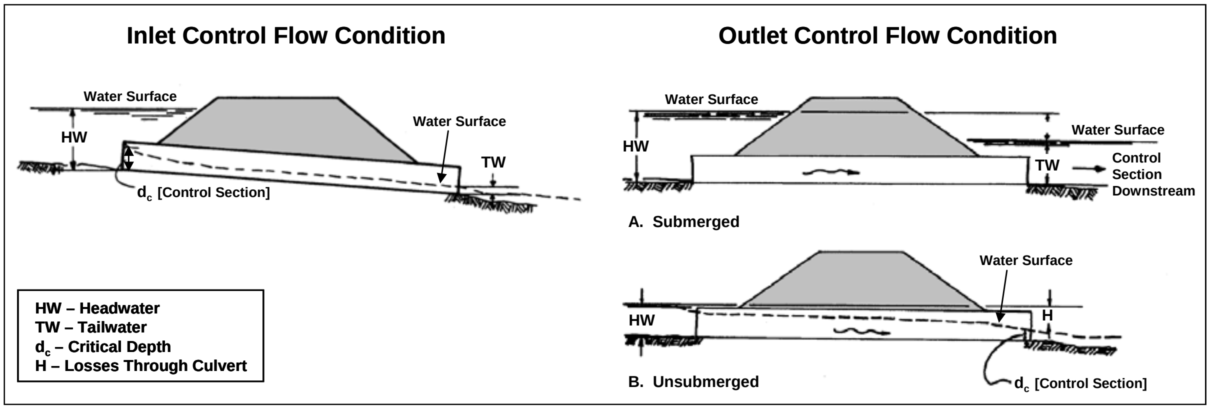



**Figure 5-21 Culvert Flow Conditions**
(Adapted from: HDS-5, 2001)

Proper culvert design and analysis requires checking for both inlet and outlet control to determine which will govern the particular culvert design.

***Procedures***

The culvert design process includes the following basic steps:

- Define the location, orientation, shape, length and material (usually concrete) for the culvert to be designed.
- With consideration of the site data, compute design flows and establish maximum barrel height, allowable outlet velocity, tailwater elevations, and maximum allowable headwater.
- Using the culvert sizing methods described below, size the culvert and entrance treatments.
- Optimize the culvert configuration by repeating the procedure as necessary.
- Treat any excessive outlet velocity with an energy dissipator (see Section 5.7).

There are three basic procedures used for designing culverts: (1) inlet control and pipe flow design equations, (2) manual use of inlet and outlet control nomographs, and (3) the use of computer programs such as FHWA HY-8. <u>It is highly recommended that the HY-8 computer model be used for culvert design.</u> However, the nomograph solution method is presented below as an example of the basic design method.

***Nomographs***

The use of culvert design nomographs requires a trial and error solution. Nomograph solutions provide reliable designs for many applications. It should be remembered that velocity, hydrograph routing, roadway overtopping, and outlet scour require additional, separate computations beyond what can be obtained from the nomographs. Figure 5-22 and Figure 5-23 show examples of inlet control and outlet control nomographs for the design of circular concrete pipe culverts. For other culvert designs, refer to the complete set of nomographs in FHWA <u>Hydraulic Design of Highway Culverts</u>, HDS-5, 2001.

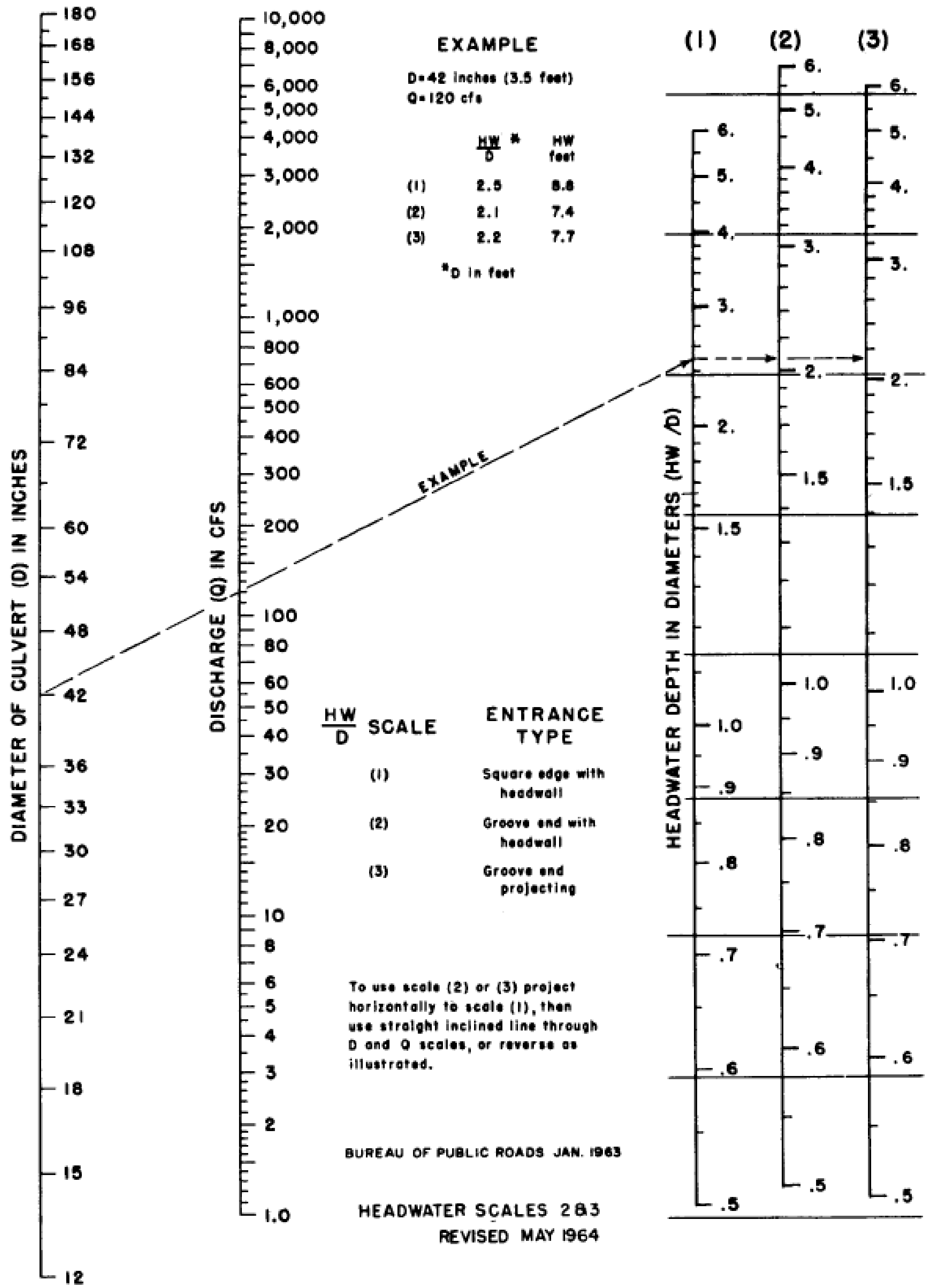



**Figure 5-22 Headwater Depth for Circular Concrete Pipe Culvert with Inlet Control**
(HEC-22, 2001)

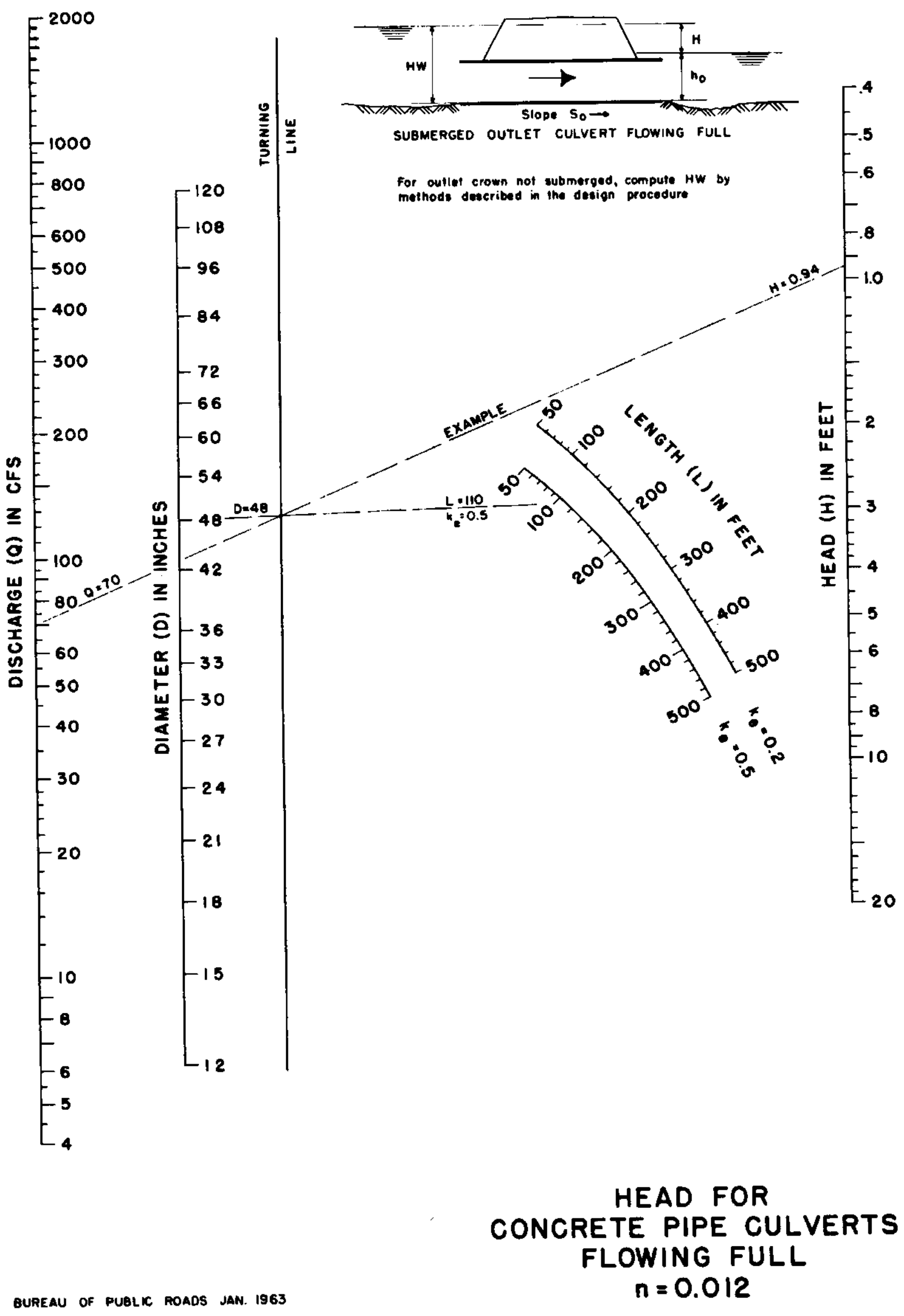



**Figure 5-23 Head for Circular Concrete Pipe Culverts Flowing Full**
(HDS-5, 2001)

***Design Procedure***

The following design procedure requires the use of inlet and outlet control nomographs.

**Step 1** List design data:

| | | |
|---|---|---|
| Q | = | discharge (cfs) |
| L | = | culvert length (ft) |
| S | = | culvert slope (ft/ft) |
| TW | = | tailwater depth (ft) |
| V | = | velocity for trial diameter (ft/s) |
| $K_e$ | = | inlet loss coefficient |
| HW | = | allowable headwater depth for the design storm (ft) |

**Step 2** Determine a trial culvert size by assuming a trial velocity of 3 to 5 ft/s and computing the culvert area, A = Q/V. Determine the culvert diameter.

**Step 3** Find the actual HW for the trial size culvert for both inlet and outlet control.

- For inlet control, enter inlet control nomograph with D and Q and find HW/D for the proper entrance type.

  Compute HW and, if too large or too small, try another culvert size before computing HW for outlet control.

- For outlet control enter the outlet control nomograph with the culvert length, entrance loss coefficient, and trial culvert diameter. (Outlet loss is assumed to be one velocity head with this nomograph.)

  To compute HW, connect the length scale for the type of entrance condition and culvert diameter scale with a straight line, pivot on the turning line, and draw a straight line from the design discharge through the turning point to the head loss scale H. Compute the headwater elevation HW from the equation per (HDS-5, 2001):

**Equation 5-20** $HW = H + h_o - LS$

where:

| | | |
|---|---|---|
| H | = | headloss, ft |
| $h_o$ | = | ½ (critical depth + D), or tailwater depth, whichever is greater |
| L | = | culvert length, ft |
| S | = | culvert slope, ft/ft |

For critical depth, see Figure 5-25.

**Step 4** Compare the computed headwaters and use the higher HW nomograph to determine if the culvert is under inlet or outlet control.

- If inlet control governs, then the design is complete and no further analysis is required.

- If outlet control governs and the HW is unacceptable, select a larger trial size and find another HW with the outlet control nomographs. Since the smaller size of culvert had been selected for allowable HW by the inlet control nomographs, the inlet control for the larger pipe need not be checked.

**Step 5** Calculate exit velocity and if erosion problems might be expected, refer to Section 5.7 for appropriate energy dissipation designs. (An energy dissipation design that significantly changes the tailwater would affect outlet hydraulics of the culvert, and adjustments to the analysis would be required.)

***Performance Curves - Roadway Overtopping***

A performance curve for any culvert can be obtained from the nomographs by repeating the steps outlined above for a range of discharges that are of interest for that particular culvert design. A graph is then plotted of headwater versus discharge with sufficient points so that a curve can be drawn through the range of interest. These curves are applicable through a range of headwater versus discharges for culvert. Such computations are made much easier by the use of computer program HY-8.

To complete the culvert design, roadway overtopping shall be analyzed if overtopping is allowed. A performance curve showing the culvert flow as well as the flow across the roadway is a useful analysis tool. Rather than using a trial and error procedure to determine the flow division between the overtopping flow and the culvert flow, an overall performance curve can be developed.

The overall performance curve can be determined as follows:

**Step 1** Select a range of flow rates and determine the corresponding headwater elevations for the culvert flow alone. The flow rates should fall above and below the design discharge and cover the entire flow range of interest. Both inlet and outlet control headwaters shall be calculated.

**Step 2** Combine the inlet and outlet control performance curves to define a single performance curve for the culvert based on the lower flow.

**Step 3** When the culvert headwater elevations exceed the roadway crest elevation, overtopping will begin. Calculate the equivalent upstream water surface depth above the roadway (crest of weir) for each selected flow rate. Use these water surface depths and Equation 5-21 to calculate flow rates across the roadway per (HDS-5, 2001).

**Equation 5-21** $$Q = C_d L(HW_r)^{1.5}$$

where:

| | | |
|---|---|---|
| Q | = | Overtopping flow rate ($ft^3/s$) |
| $C_d$ | = | overtopping discharge coefficient |
| L = | length of roadway (ft) | |

$HW_r$ = upstream depth, measured from the roadway crest to the water surface upstream of the weir drawdown (ft)

Note: See Figure 5-24 for guidance on determining a value for $C_d$. For more information on calculating overtopping flow rates see pages 38 - 44 in HDS-5, 2001.

**Step 4** Add the culvert flow and the roadway overtopping flow at the corresponding headwater elevations to obtain the overall culvert performance curve.

***Storage Routing***

Storage capacity behind a roadway embankment may significantly attenuate a flood hydrograph. Because of the reduction of the peak discharge associated with this attenuation, the required capacity of the culvert, and its size, may be reduced. However, storage should be taken into consideration only if the storage area will remain available for the life of the culvert as a result of ownership, right-of-way or easement. If significant storage is anticipated behind a culvert, the design should be checked by routing the design hydrographs through the culvert to determine the discharge and stage behind the culvert. See Volume 2, Chapter 4 for more information on routing. Additional routing procedures are outlined in HDS-5.

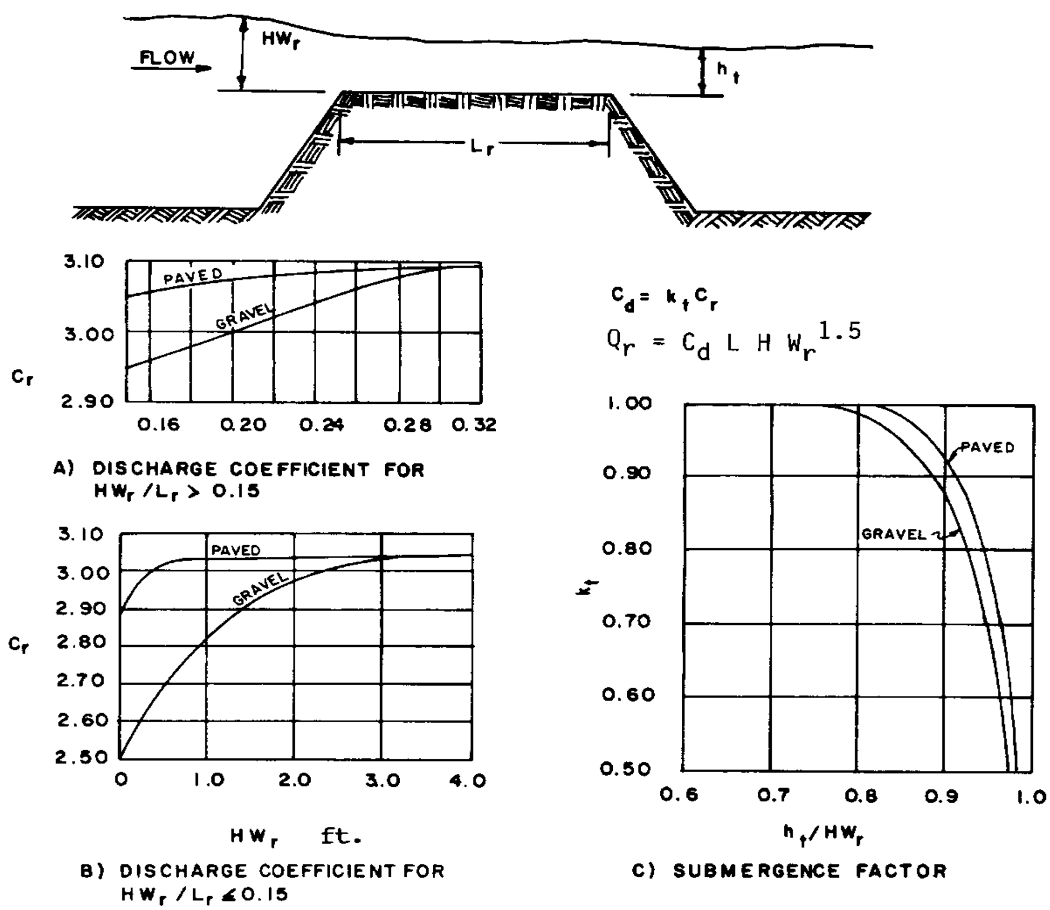



**Figure 5-24 Discharge Coefficients for Roadway Overtopping**

(HDS-5, 2001)

## Example Problem – Culvert Design

Size a circular concrete culvert given the following example data, which were determined by physical limitations at the culvert site.

- Discharge for 1-yr flood = 35 cfs
- Discharge for 25-yr flood = 70 cfs
- Allowable HW for 25-yr discharge = 5.25 ft
- Length of culvert = 100 ft
- Slope of culvert = 0.012
  - Natural channel invert elevations: inlet = 15.50 ft, outlet = 14.30 ft
  - Tailwater depth for 25-yr discharge = 3.5 ft
  - Tailwater depth is assumed to be approximately the normal depth in the downstream channel in this example
  - Entrance type = groove end with headwall

Assume a trial culvert velocity of 5 ft/s. Required flow area = (70 cfs)/(5 ft/s) = 14 $ft^2$ (for the 25-yr recurrence flood).

The corresponding culvert diameter is about 48 in. This can be calculated by using the formula for area of a circle: Area = $(\pi D^2)/4$ or D = $(\text{Area}*4/\pi)^{1/2}$ Therefore: D = $((14 \times 4)/3.14)^{1/2} \times 12$ in/ft) = 50.7 in

A grooved end concrete culvert with a headwall is selected for the design. Using the inlet control nomograph (Figure 5-22) with a pipe diameter of 48 inches and a discharge of 70 cfs; read a HW/D value of 0.93.

The depth of headwater (HW) is (0.93) x (4) = 3.72 ft, which is less than the allowable headwater of 5.25 ft. Since 3.72 ft is considerably less than 5.25 try a smaller culvert.

Using the same procedures outlined in steps 3 and 4 the following results were obtained.

- 42-inch culvert – HW = 4.13 ft
- 36-inch culvert – HW = 5.04 ft

Select a 36-inch culvert to check for outlet control.

The culvert is checked for outlet control by using Figure 5-23. With an entrance loss coefficient $K_e$ of 0.20 (Table 5-8) a flow rate of 70 cfs, a culvert length of 100 ft, and a pipe diameter of 36 inches, an H value of 2.8 ft is determined. The headwater for outlet control is computed by the equation: HW = H + $h_o$ - LS

Compute $h_o$:

$h_o$ = $T_w$ or ½ (critical depth in culvert + D), whichever is greater.

$h_o$ = 3.5 ft or $h_o$ = ½ (2.7 + 3.0) = 2.85 ft

Note: critical depth is obtained from Figure 5-25.

Therefore: $h_o$ = 3.5 ft

The headwater depth for outlet control is:

HW = H + $h_o$ - LS = 2.8 + 3.5 - (100) x (0.012) = 5.10 ft

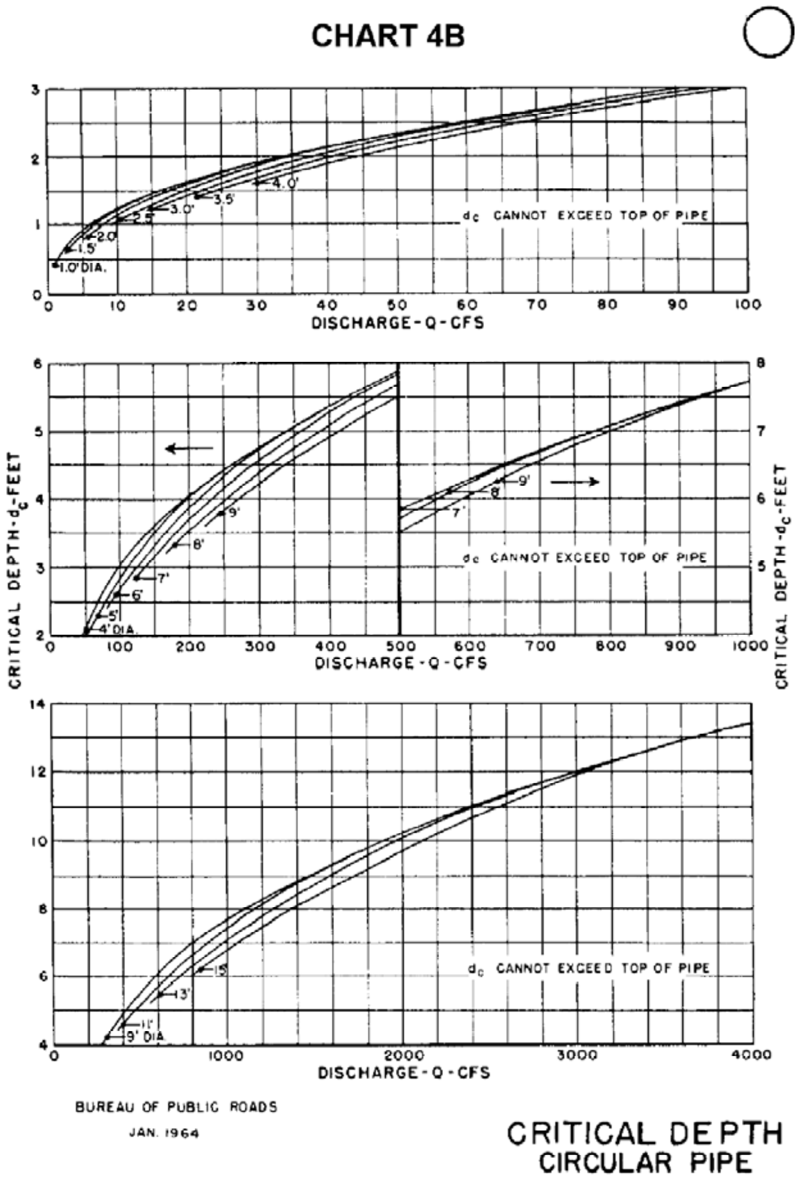



**Figure 5-25 Critical Depth for Circular Pipe**
(HDS-5, 2001)

Since HW for outlet control (5.10 ft) is greater than the HW for inlet control (5.04 ft), outlet control governs the culvert design. Thus, the maximum headwater expected for a 25-year recurrence flood is 5.10 ft, which is less than the allowable headwater of 5.25 ft.

Estimate outlet exit velocity. Since this culvert is in outlet control and discharges into an open channel downstream with tailwater above the culvert, the culvert will be flowing full at the flow depth in the channel. Using the design peak discharge of 70 cfs and the area of a 36-inch or 3.0-foot diameter culvert the average exit velocity will be:

> $Q = VA$
> Therefore: $V = 70 / ((3.14(3.0)^2)/4) = 9.9$ ft/s
> With this high velocity, provide an energy dissipator at the culvert outlet. See Section 5.57.

Check for minimum velocity using the 1-year flow of 35 cfs.

> Therefore: $V = 35 / ((3.14(3.0)^2/4) = 5.0$ ft/s, therefore V > minimum of 2.5 – OK

> (Note that for checking minimum velocity, the assumption of full pipe flow is conservative. If the computed velocity had been too low, then the resulting pipe flow velocity would need to be checked using Manning's equation or HY-8.)

The 100-year flow shall be analyzed through the culvert to determine if any flooding problems will be associated with this culvert.

> Figure 5-26 provides a convenient form to organize culvert design calculations.

| | | |
|---|---|---|
| PROJECT: ______________________ | STATION: ______________ | CULVERT DESIGN FORM |
| ______________________ | SHEET ______ OF ______ | DESIGNER / DATE: ______ OF ______<br>REVIEWER / DATE: ______ OF ______ |

**HYDROLOGICAL DATA**

SEE ADD'L SHTS.

☐ METHOD: ______________________

☐ DRAINAGE AREA: ________ ☐ STREAM SLOPE: ________

☐ CHANNEL SHAPE: ______________________

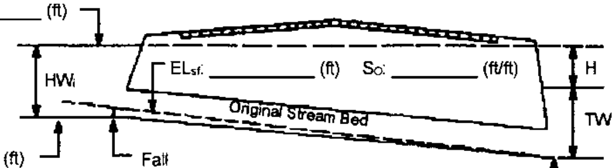
☐ ROUTING: ____________ ☐ OTHER: ____________

**DESIGN FLOWS/TAILWATER**

| R.I. (YEARS) | FLOW (cfs) | TW (ft) |
|---|---|---|
| | | |
| | | |

ROADWAY ELEVATION: ____________ (ft)

$EL_{hi}$: ________ (ft)




$EL_{sf}$: ________ (ft) $S_O$: ________ (ft/ft)

$EL_i$: ________ (ft)

$S = S_o - Fall/L_o$

$S =$ ________ (ft/ft)

$L_o =$ ________ (ft)

$EL_o$: ________ (ft)

| CULVERT DESCRIPTION:<br>MATERIAL-SHAPE-SIZE-ENTRANCE | TOTAL FLOW<br>Q (cfs) | FLOW PER BARREL<br>Q/N (1) | HEADWATER CALCULATIONS<br>INLET CONTROL<br>HW/D (2) | HW<sub></sub>$_i$ | FALL (3) | $EL_{hi}$ (4) | OUTLET CONTROL<br>TW (5) | $d_c$ | $\frac{d_c+D}{2}$ | $h_o$ (6) | $k_e$ | H (7) | $EL_{ho}$ (8) | CONTROL HEADWATER ELEVATION | OUTLET VELOCITY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

**TECHNICAL FOOTNOTES:**

(1) USE Q/NB FOR BOX CULVERTS

(2) HW/D = HW/D OR HW/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) $h_o = TW$ or $(d_c + D)/2$ (WHICHEVER IS GREATER)

(7) $H = [1+k_e+(29\ n^2L)/R^{1.33}]\ V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

**SUSCRIPT DEFINITIONS:**

a. Approximate
f. Culvert Face
hd. Design Headwater
hi. Headwater in Inlet Control
ho. Headwater in Outlet Control
i. Inlet Control Section
o. Outlet
sf. Streamed at Culvert Face
tw. Tailwater

**COMMENTS / DISCUSSION:**

**CULVERT BARREL SELECTED:**

SIZE: ______________________

SHAPE: ______________________

MATERIAL: ______________ n ______

ENTRANCE: ______________________

**Figure 5-26 Culvert Design Calculations Form**

(HDS-5, 2001)

## 5.3.4 Design Procedures for Beveled-Edged Inlets

***Introduction***

Improved inlets include inlet geometry refinements beyond those normally used in conventional culvert design practice. Several degrees of improvements are possible, including bevel-edged, side-tapered, and slope-tapered inlets. Designers interested in using side- and slope-tapered inlets should consult the detailed design criteria and example designs outlined in HDS-5.

***Design Figures***

Four inlet control figures for culverts with beveled edges are found in Section I of HDS 5.

**Table 5-9 Inlet Control Figures of HDS-5**

| Chart | Page | Use for |
|---|---|---|
| 3 | D-3A & B | circular pipe culverts with beveled rings |
| 10 | D-10-1 thru 10-3 | 90° headwalls (same for 90° wingwalls) |
| 11 | D-11-1 thru 11-4 | skewed headwalls |
| 12 | D-12-1 thru 12-3 | wingwalls with flare angles of 18 to 45 degrees |

The following symbols are used in these figures:
B – Width of culvert barrel or diameter of pipe culvert
D – Height of box culvert or diameter of pipe culvert
Hf – Depth of pool or head, above the face section of invert
N – Number of barrels
Q – Design discharge

***Design Procedure***

The figures for bevel-edged inlets are used for design in the same manner as the conventional inlet design nomographs discussed earlier. Note that Charts 10, 11, and 12 apply only to bevels having either a 33-degree angle (1.5:1) or a 45-degree angle (1:1).

For box culverts the dimensions of the bevels to be used are based on the culvert dimensions. The top bevel dimension is determined by multiplying the height of the culvert by a factor. The side bevel dimensions are determined by multiplying the width of the culvert by a factor. For a 1:1 bevel, the factor is 0.5 inch/ft. For a 1.5:1 bevel the factor is 1 inch/ft. For example, the minimum bevel dimensions for an 8 ft x 6 ft box culvert with 1:1 bevels would be:

- Top Bevel = d = 6 ft x 0.5 inch/ft = 3 inches
- Side Bevel = b = 8 ft x 0.5 inch/ft = 4 inches

The improved inlet design figures are based on research results from culvert models with barrel width-to-depth ratios (W/D) of from 0.5:1 to 2:1. For box culverts with more than one barrel, the figures are used in the same manner as for a single barrel, except that the bevels must be sized on the basis of the total clear opening rather than on individual barrel size.

Multibarrel pipe culverts shall be designed as a series of single barrel installations since each pipe requires a separate bevel.

### 5.3.5 Skewed Inlets

Ideally, culverts should be placed in the natural channel allowing for the best alignment with natural flow and minimum excavation and channel work. Where location in the natural channel would require an inordinately long culvert, some stream modification may be in order. Such modifications to reduce skew and shorten culverts shall be designed carefully to avoid erosion and sedimentation problems.

Culvert locations normal to the roadway centerline are not recommended where severe or abrupt changes in channel alignment are required upstream or downstream of the culvert. Short-radius bends are subject to erosion on the concave bank and deposition on the inside of the bend. Such changes upstream of the culvert result in poor alignment of the approach flow to the culvert; this subjects the embankment to erosion, and increases the likelihood of deposition in the culvert entrance, barrel, and exit.

Reinforced concrete box (RCB) culverts may be rotated or skewed to improve the alignment of the culvert with the stream. A rotated RCB is defined as an RCB that intersects the roadway centerline at an angle other than 90º and has entrance and exit faces normal to the RCB centerline. A skewed RCB is defined as an RCB that intersects the roadway centerline at an angle other than 90º and has entrance and exit faces parallel to the roadway centerline. Ordinary design practice allows normal (90º crossing) box culverts to be rotated up to 15º. Skewed boxes with variable angles may be used at RCB installations.

It is recommended that Chart 11 for skewed inlets not be used for multiple barrel installations, as the intermediate wall could cause an extreme contraction in the downstream barrels. This would result in underdesign due to a greatly reduced capacity. Inlets skewed at an angle with the centerline of the stream shall be avoided whenever possible and shall not be used with side- or slope-tapered inlets. It is important to align culverts with streams in order to avoid erosion problems associated with changing the direction of the natural stream flow.

Channel changes in Kansas streams are regulated by the Division of Water Resources (DWR) of the Kansas Department of Agriculture. The designer should inform the DWR of proposed channel changes as early as feasible, and promptly provide the design information needed for the permit application. The timely submittal of the permit application is necessary to avoid delays in the project.

### 5.3.6 Weep Holes

Weep holes are sometimes used to relieve uplift pressure on headwalls. Filter materials shall be used in conjunction with the weep holes to prevent the formation of internal soil erosion "piping" channels through the fill embankment. The filter materials shall be designed as a drain filter so as not to become clogged and so that piping cannot occur through the pervious material and the weep hole.

### 5.3.7 Safety Considerations

Roadside safety shall be considered for culverts crossing under roadways. Consult local, State and Federal road design standards for guidance.

### 5.3.8 Debris Control

In areas with expected high debris accumulations that could affect the hydraulic performance of the culvert, it is recommended that the FHWA HEC-9 entitled "Debris Control Structures: Evaluation and Countermeasures, Third Edition (FHWA, 2005) be consulted.

### 5.3.9 Comprehensive Design Guidance

The Federal Highway Administration, Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts, Second Edition (2005) is available from:

http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=7&id=13

### 5.3.10 Software for Culvert Analysis

The calculation of culvert hydraulics can be extremely time-consuming when performed by hand. Nomograph solutions are prone to error. However, the HY-8 program created by FHWA can be acquired at no cost to speed these calculations. HY-8 uses the procedures documented in HDS-5, and provides a good interface for analyzing options in culvert design. The program will output head-discharge rating curves for the culvert and associated road overflow. HY-8 can be downloaded free of charge from the following website:

http://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/

Following are a series of screen shots from HY-8 displaying the input screen (Figure 5-27), culvert profile output showing EGL and HGL (Figure 5-28) and rating curve (Figure 5-29).

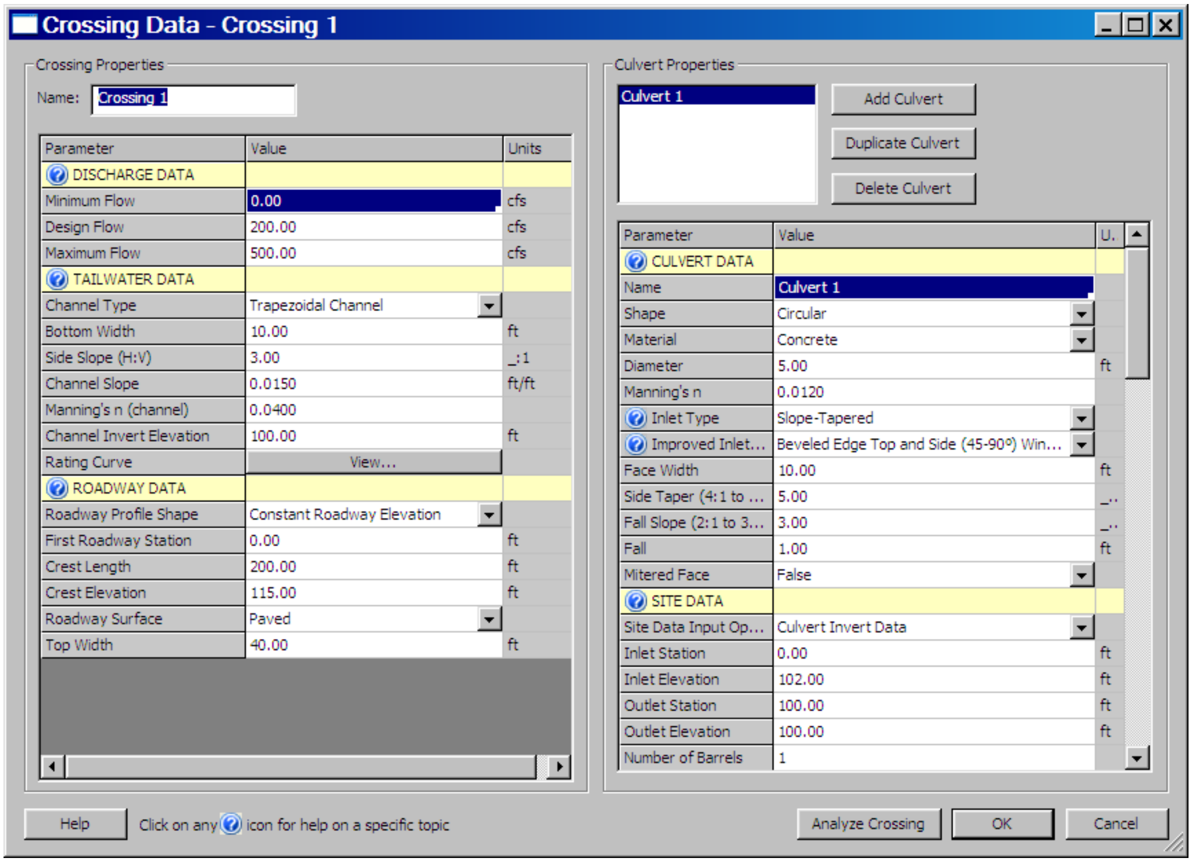



**Figure 5-27 HY-8 Input Screen**

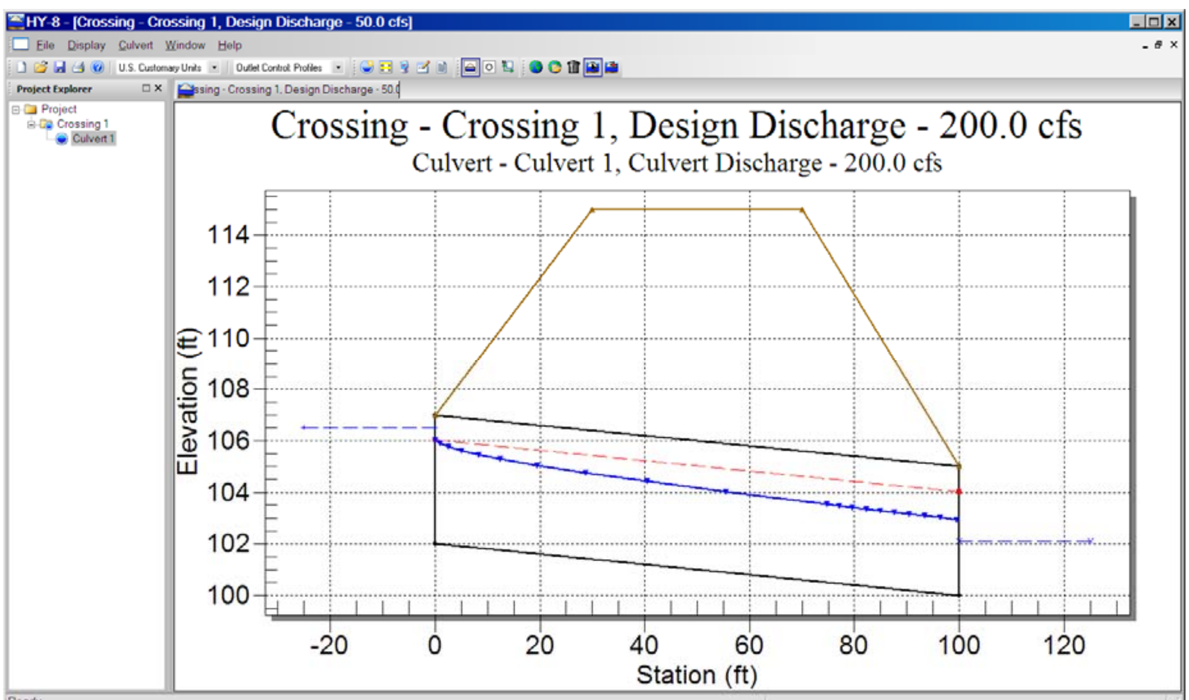



**Figure 5-28 HY-8 Culvert Profile**

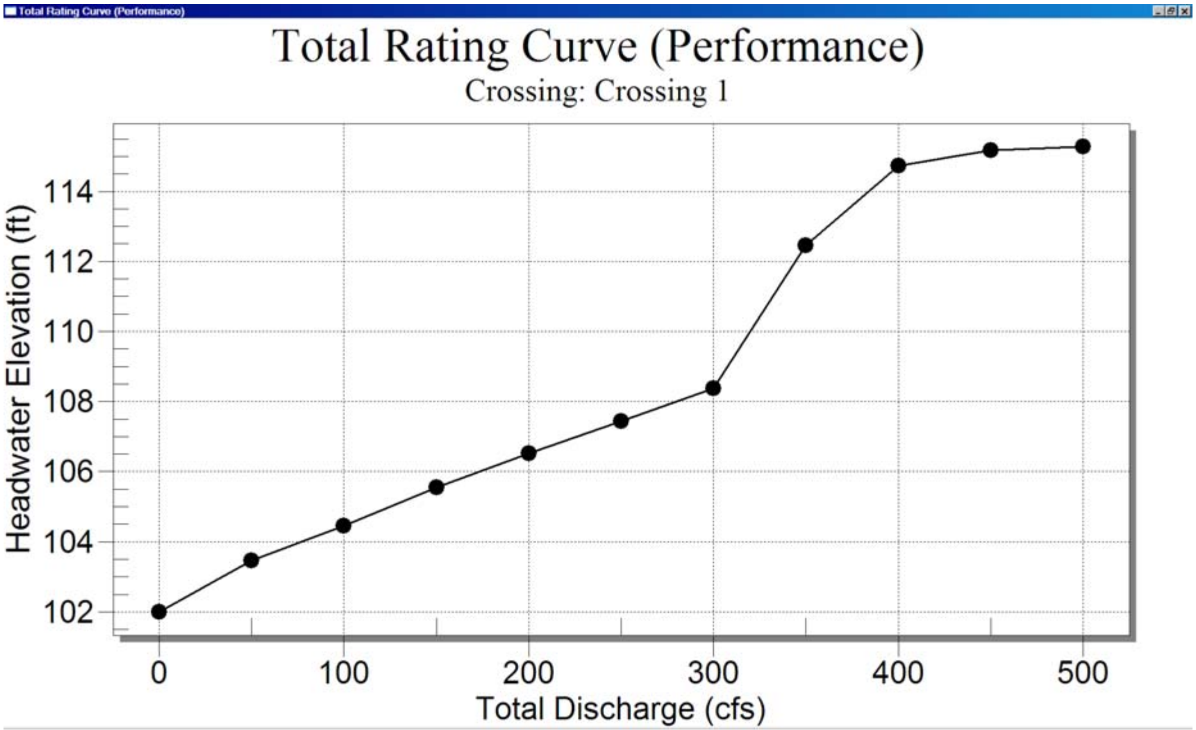



**Figure 5-29 HY-8 Rating Curve**

Proprietary software may also be used for culvert analysis. However, commercial third-party culvert software must be pre-approved by the City and County, not only on the basis of technical acceptance but also on the basis of the cost for the City and County to maintain a license of the product for review purposes.

## 5.4 Bridges

### 5.4.1 Introduction

This section provides an overview of the hydraulic design of bridges for new developments or redevelopments. For economy, engineers may design culverts to operate with the inlet submerged during flood flows, if conditions permit. Bridges, on the other hand, are not covered with embankment or designed to take advantage of submergence to increase hydraulic capacity, even though some are designed to be inundated under flood conditions. Bridges are usually selected instead of culverts if the discharge or the stream to be crossed is large. Both types of facilities (bridges and culverts) should be evaluated and a choice made based on performance and economics. If the stream crossing is wide with multiple concentrations of flow, a multiple opening facility may be in order.

## 5.4.2 General Criteria

The design of a bridge must take into account the many different engineering and technical aspects at the bridge site and adjacent areas. The following design criteria shall be followed for all bridge designs as applicable.

Hydraulic analysis of bridges shall be performed according to FEMA guidelines. All bridge design submittals to Wichita and Sedgwick County shall be created and presented in a format that would be acceptable to FEMA, whether the anlayis will need to be submitted to FEMA or not. Hydraulic modelling shall be based on current effective FEMA models where applicable.

All bridges designs shall be reviewed and approved by the Kansas Division of Water Resources.

Bridges carrying roadways shall provide 1 foot of freeboard for the 100-year storm. Additionally, the 100-year frequency storm shall be analyzed through all bridges to ensure a minimum of 2 feet of freeboard for building structures (e.g., houses and commercial buildings). Pedestrian bridges and other low water crossings shall be permitted with DWR and may be exempt from freeboard requirements.

Table 5-10 gives values that shall be used for the contraction ($K_c$) and expansion ($K_e$) coefficients to be used for bridge hydraulic analysis (USACE HEC-RAS Manual, 2008).

**Table 5-10 Loss Coefficients for Bridges**

| Transition Type | Contraction ($K_c$) | Expansion ($K_e$) |
|---|---|---|
| Gradual transition | 0.1 | 0.3 |
| Typical bridge | 0.3 | 0.5 |
| Severe transition | 0.6 | 0.8 |

Scour analysis and protection shall be provided for all bridges according to guidance found in FHWA publications, HEC-18, HEC-20 and HEC-23.

## 5.4.3 Bridge Site Analysis

***Crossing***

The horizontal alignment of a highway at a stream crossing shall be taken into consideration when selecting the design and location of the waterway opening as well as the crossing profile. If practicable, the roadway shall be aligned so that the crossing will be normal to the stream flow direction (roadway centerline perpendicular to the streamline).

Often, this is not possible because of the highway or stream configuration. When a skewed structure is necessary, it shall be ensured that substructure fixtures such as foundations, columns, piers, and bent caps offer minimum resistance to the stream flow. Bent caps shall be oriented as near to the skew of the streamlines at flood stage as possible. Headers shall be skewed to minimize eddy-causing obstructions.

#### *Factors Affecting Bridge Length*

The discussions of bridge design herein assume normal cross sections and lengths (perpendicular to flow at flood stage). Usually one-dimensional flow is assumed, and cross sections and lengths are considered 90° to the direction of stream flow at flood stage. The following examples illustrate various factors that can cause a bridge opening to be larger than that required by hydraulic design.

- Bank protection may be placed in a certain location due to local soil instability or a high bank.
- Bridge costs may be less expensive than embankment costs.
- A roadway profile grade line might dictate an excessive freeboard allowance. For sloping abutments, a higher freeboard will result in a longer bridge.
- High potential for an upstream or downstream stream meander to migrate, or other channel instabilities may warrant a longer opening.

### 5.4.4 Bridge Hydraulic Analysis

As previously stated, all bridge projects for new developments or redevelopments must be designed according to FEMA hydraulic procedures. Hydraulic analysis will be performed using software such as HEC-2 or HEC-RAS. The hydraulic design must meet the requirements of the floodplain and/or stormwater management ordinances. The following text describes the hydraulics of flow through bridges, and presents a very general overview of the hydraulic design for bridges.

#### *Flow Zones and Energy Losses*

Flows through bridges must be modelled using FEMA standard methodologies with approved software such as HEC-RAS. Such analysis is required for all bridge design projects. Figure 5-30 shows a plan of typical cross section locations that establish three flow zones that must be considered when estimating the effects of bridge openings:

**Zone 1** represents the area between the downstream face of the bridge and a cross section downstream of the bridge within which expansion of flow from the bridge is expected to occur. The distance over which this expansion occurs can vary depending on the flow rate and the floodplain characteristics. Generally, the expansion zone proceeds at a 2:1 to 3:1 flare away from the open area of the bridge. Section 1 represents the effective channel flow geometry at the end of the expansion zone, which is also called the “exit” cross section. Cross sections 2 and 3 are at the toe of roadway embankment and represent the portion of unconstricted channel geometry that approximates the effective flow areas near the bridge opening as shown in Figure 5-31.

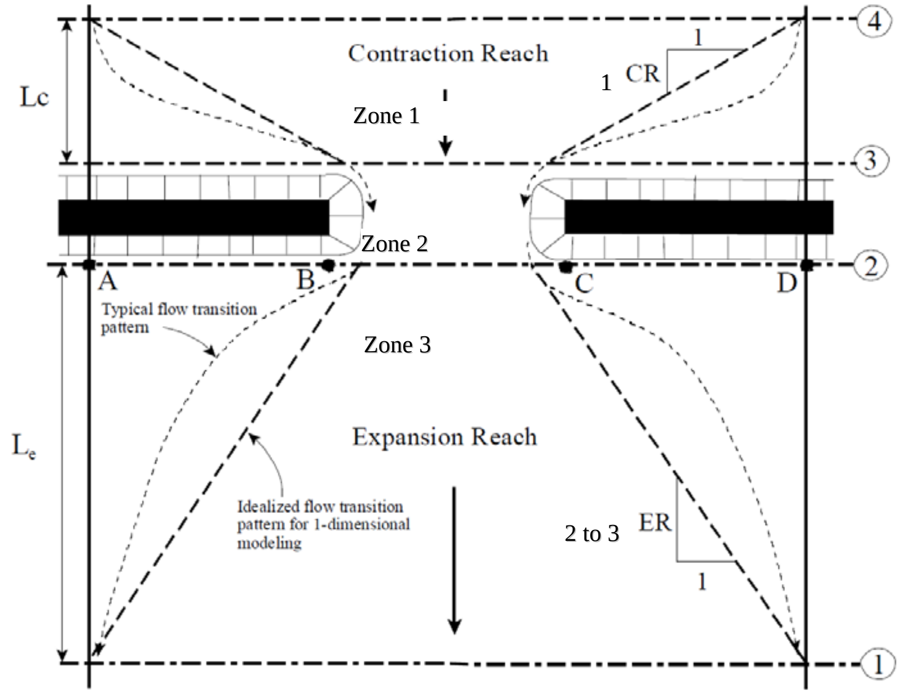



**Figure 5-30  Flow Zones at Bridges**
(USACE , HEC-RAS Hydraulic Reference Manual)

**Zone 2** represents the area under the bridge opening through which friction, turbulence, and drag losses are considered. Generally for HEC-RAS analysis, the bridge opening is obtained by superimposing the bridge geometry on cross sections 2 and 3, unless channel conditions under the bridge differ significantly.

**Zone 3** represents the area between the upstream face of the bridge and a cross section upstream where the contraction of flow starts. Contraction flare generally is modelled as proceeding away from the bridge opening at a 1:1 angle. Cross section 4 represents the effective channel flow geometry where contraction begins. This is sometimes referred to as the “approach” cross section.

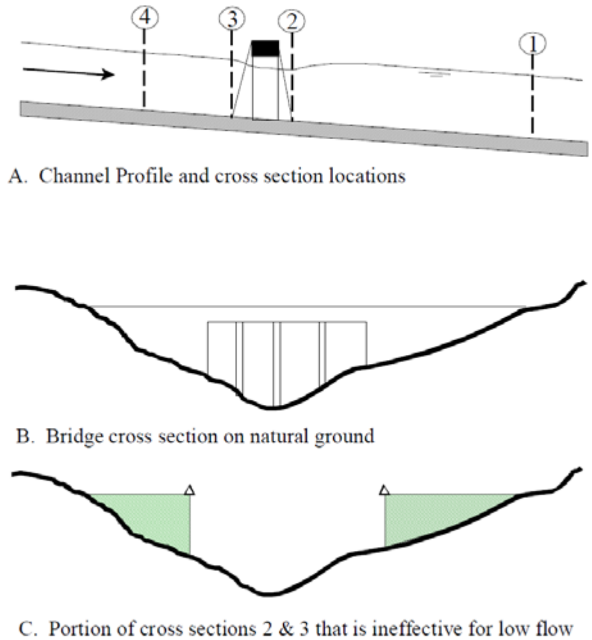



**Figure 5-31 Effective Geometry for Bridge**
(USACE , HEC-RAS Hydraulic Reference Manual)

***Bridge Flow Class***

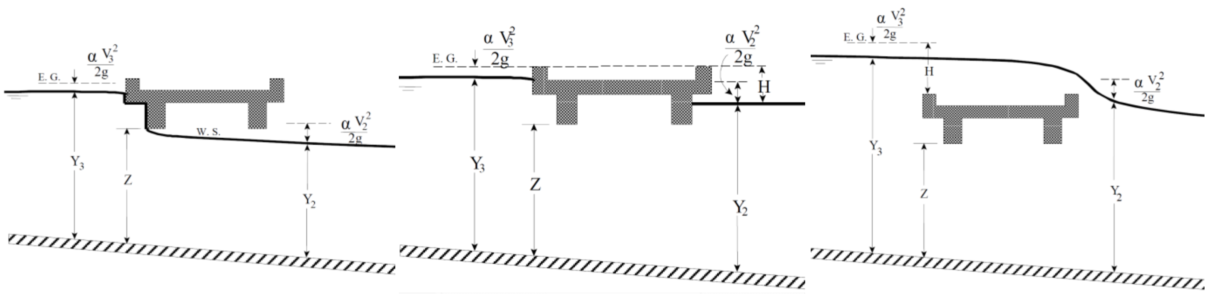
The losses associated with flow through bridges depend on the hydraulic conditions of low or high flow. Low flow describes hydraulic conditions in which the water surface between Zones 1, 2, and 3 is open to atmospheric pressure. That means the water surface does not impinge upon the superstructure. Low flow is divided into categories as described in Table 5-11. Type A is the most common in Kansas, although severe constrictions could result in Type B. Type C is usually limited to steep hills and mountainous regions not present in the region.

**Table 5-11 Bridge Opening Low Flow Classes**

| Low Flow Class | Description |
|---|---|
| A | Subcritical flow through all Zones |
| B | Flow passes through critical depth within bridge opening |
| C | Supercritical flow through all Zones |

High flow refers to conditions in which the water surface impinges on the bridge superstructure (Figure 5-32):

- When the water surface submerges the upstream low chord, but does not submerge the downstream low chord of the bridge, the flow condition is comparable to a pressure flow sluice gate.




**Sluice Gate Flow** **Orifice Flow** **Orifice and Weir Flow**

**Figure 5-32 High Flow Classes**
(USACE , HEC-RAS Hydraulic Reference Manual)

- When the water surface submerges the upstream and downstream low chords but does not exceed the elevation of critical depth over the road, the flow condition is comparable to orifice flow.
- If the water surface overtops the roadway, flow is usually orifice flow under the bridge and weir flow or open channel flow over the bridge (depending on tailwater conditions). However, under some conditions sluice gate flow and weir flow can occur.

The detailed analysis of bridge hydraulics is performed using computer software and is beyond the scope of this Manual. Additional information on bridge analysis techniques is provided in the HEC-RAS Hydraulic Reference Manual.

***Scour***

Water flowing through bridge openings has the tendency to create areas of scour due to the greater velocities at the bridge approach and exit, at the abutments and at the piers. These areas of scour can eventually undermine bridge stability if allowed to progress. Figure 5-33 provides an example of the effects of bridge scour. Figure 5-34 gives a generalized representation of the hydraulic forces that act to create scour around bridge piers.

**Figure 5-33 Effects of Bridge Scour**

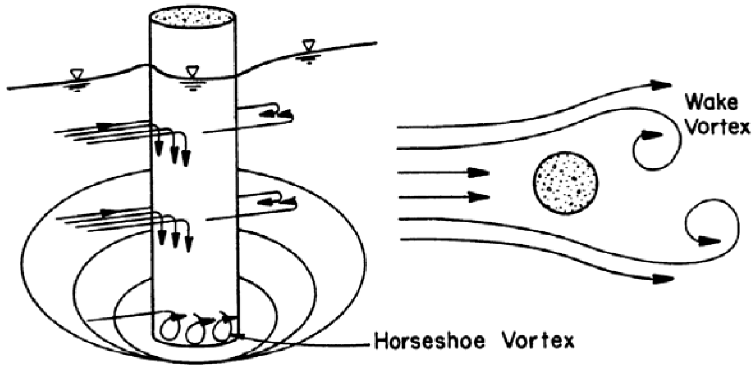



**Figure 5-34 Creation of Pier Scour**
(FHWA HEC-23)

Bridge design must account for and abate the effects of scour based on the guidance found in FHWA Hydraulic Engineering Circulars 18, 20, and 23. Scour calculations must include contraction scour, abutmet scour, and pier scour as outlined in the KDOT Design Manual: Volume 3, Bridge Section (2008). All bridge designs must ensure that the abutments and piers are not structurally compromised by the expected scour.

Scour calculations can be integrated into the same HEC-RAS model used for bridge hydraulic calculations. HEC-RAS implements many of the scour equations found in the FHWA publications. An example of scour shown in HEC-RAS is shown in Figure 5-35.

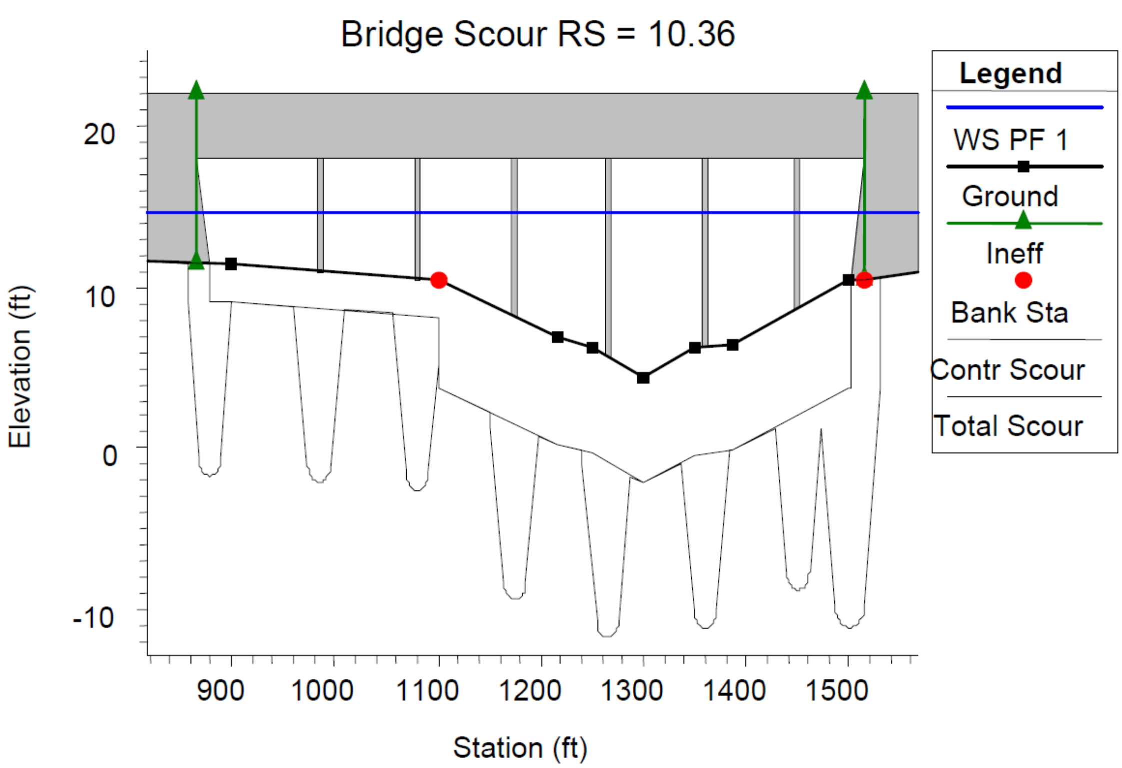



**Figure 5-35 HEC-RAS Bridge Scour Example**
(USACE , HEC-RAS Hydraulic Reference Manual)

### 5.4.5 Design Procedures

The following is a general bridge hydraulic design procedure that incorporates the topics discussed above.

**Step 1** Determine the most efficient alignment of proposed roadway, attempting to minimize skew at the proposed stream crossing.

**Step 2** Determine design discharge from hydrologic studies or available data (City, County, FEMA, USACE, KDOT, or similar sources).

**Step 3** If available, obtain the effective FEMA hydraulic model. If an effective FEMA model or other model is not available, a water surface profile analysis for the stream must be prepared. The HEC-RAS computer model is routinely used to compute water surface profiles.

**Step 4** Using FEMA guidelines, compute an existing conditions water surface profile for the appropriate storms as outlined in Section 5.4.2. Compute a profile for the fully-developed watershed to use as a baseline for design of a new bridge/roadway crossing.

**Step 5** Use the design discharge to compute an approximate opening that will be needed to pass the design storm (for preliminary sizing, use a normal-depth design procedure, or simply estimate a required trapezoidal opening).

**Step 6** Prepare a bridge crossing data set in the hydraulic model to reflect the preliminary design opening, which includes the required freeboard and any channelization upstream or downstream to transition the floodwaters through the proposed structure.

**Step 7** Compute the proposed bridge flood profile and design parameters (velocities, flow distribution, energy grade, etc.). Review for criteria on velocities and freeboard, and revise model as needed to accommodate design flows.

**Step 8** Review the velocities and model scour requirements downstream, through the structure, and upstream.

**Step 9** Revise design as necessary to prevent structural impacts of scour per KDOT, KSDA and local standards.

**Step 10** Finalize the design size and erosion control features to prevent impacts on other properties, meet all FEMA guidelines, and satisfy other local criteria.

**Step 11** Exceptions/Other Issues

- Conditional Letter of Map Amendment (CLOMR) may be needed for new or modified crossings of streams studied by FEMA.

- If applicable, coordinate with USACE Regulatory Permit requirements.
- Coordinate with DWR for any necessary water structures permits.
- Design shall be for fully developed watershed conditions. If the available discharges are from FEMA existing conditions hydrology, new hydrology must be developed for built-out conditions. (Note that for formal no-rise, CLOMR and LOMR submittals to FEMA, the flows are usually for existing conditions. Therefore, analyses for both existing and fully developed conditions would be required in those cases.)
- Freeboard criteria may require an unusually expensive bridge or impracticable roadway elevation. A reasonable variance in criteria **may** be available from the Director.

### 5.4.6 Software for Bridge Analysis

The calculation of bridge hydraulics can be extremely time-consuming when performed by hand. The HEC-RAS program created by the Corps of Engineers can be acquired at no cost to speed these calculations, along with culvert analysis and many types of open channel flow calculations. HEC-RAS can be downloaded free of charge from the following website:

http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html

## 5.5 Open Channels

### 5.5.1 Introduction

Open channel systems are an integral part of stormwater drainage designs, particularly for development sites utilizing preferred site design practices and open channel structural controls. Examples of open channels include drainage ditches, grassed channels and swales, enhanced swales, riprap channels and concrete-lined channels.

The purpose of this section is to provide an overview of open channel design criteria and methods, including the use of channel design nomographs. These procedures are intended for development-scale and site-scale channels used to convey local stormwater flows, where the channel is expected to flow under hydraulically “normal” flow conditions (EGL and channel bottom approximately parallel). For gradually varied flow conditions where the channel may flow with significant drawdown or backwater conditions, a water surface profile must be performed. Please note that the procedures provided herein are not intended for major flood control channels. The details of major flood control channel design are beyond the scope of this Manual.

The three main classifications of open channel types according to channel linings are vegetated, flexible, and rigid. Vegetated linings include grass, sod, and wetland channels. Stone riprap and some forms of flexible man-made linings or gabions are examples of flexible linings, while rigid linings are generally concrete or rigid block.

Vegetative Linings: Vegetation, where practical, is the most desirable lining for an artificial channel. It stabilizes the channel body, consolidates the soil mass of the bed, checks erosion on the channel surface, provides habitat, and provides water quality benefits (see Section 3.2.4 and Section 3.2.5 for more details on using enhanced swales and grass channels for water quality purposes).

Conditions under which vegetation may not be acceptable include but are not limited to:

- High velocities;
- Standing or continuously flowing water;
- Lack of regular maintenance necessary to prevent growth of taller or woody vegetation;
- Lack of nutrients and inadequate topsoil; and
- Excessive shade.

Proper seeding, mulching, and soil preparation are required during construction to assure establishment of healthy vegetation. If low flows are prevalent, a hard lined base flow channel may be needed. Channels shall be wide enough to accommodate maintenance equipment.

Flexible Linings: Rock riprap, including rubble and gabion baskets, is the most common type of flexible lining for channels. It presents a rough surface that can dissipate energy and mitigate increases in erosive velocity and is commonly used in areas of high flow and steep grade. These linings are usually less expensive than rigid linings and have self-healing qualities that reduce maintenance. However, they may require the use of a filter fabric depending on the underlying soils, and the growth of grass, weeds, and trees may present maintenance problems.

Rigid Linings: Rigid linings are generally constructed of concrete and used where high flow capacity is required. Higher velocities, however, create the potential for scour at channel lining transitions and channel headcutting. This type of lining comes with a higher initial cost and can be degraded by environmental factors.

## 5.5.2 General Criteria

The following criteria shall be followed for open channel design:

- Where practicable, a primary and auxiliary channel shall be employed. The purpose of the primary channel is to carry the design flood discharge. The purpose of the auxiliary channel is to contain frequent flow, provide self-cleaning velocities, minimize the portion of channel bottom that is normally wet, and reduce bank erosion caused by the natural tendency of stream flow to meander from bank to bank.
- **Error! Reference source not found.** provides the criteria for primary and auxiliary channels.

    - The primary channel shall provide a minimum of one foot of freeboard for the design storm.
    - The primary channel and overbanks shall convey the 100-year storm flow such that structures are protected with a minimum 2 feet of freeboard.
    - The auxiliary channel shall be sized to convey the 1-year storm with a velocity of at least 2.5 ft/s, where possible.
    - The auxiliary channel shall be centered in the primary channel wherever sufficient bottom width is available, or shifted to one side where the auxiliary channel slope is continuous with the primary channel slope; the minimum cross-slope on the bench shall be 2%.
    - Where the primary channel width will not accommodate an auxiliary channel, the primary channel shall feature a "V" bottom using 2% cross slope.

- Channel side slopes shall be no steeper than 4:1.
- Hydraulic analysis utilizing Manning's equation shall be used to calculate water surface profiles in open channels and roadside ditches. Manning's roughness values shall be taken from Appendix A based on the expected depth of flow.
- Velocities or shear stresses may not be increased in existing channels.
- Channel erosion shall be prevented by ensuring that shear stresses or velocities are less than the permissible values for the 2, 5 and 10-year storms, plus the design storm.
- Additional channel erosion protection shall be provided at bends where shear stresses would exceed the permissible shear shown for the 2, 5 and 10-year storms, plus the design storm.
- If relocation of a stable stream channel is unavoidable, the cross-sectional shape, meander, pattern, roughness, sediment transport, and slope should conform to the existing conditions insofar as practicable. Energy dissipation may be necessary when existing conditions cannot be duplicated.

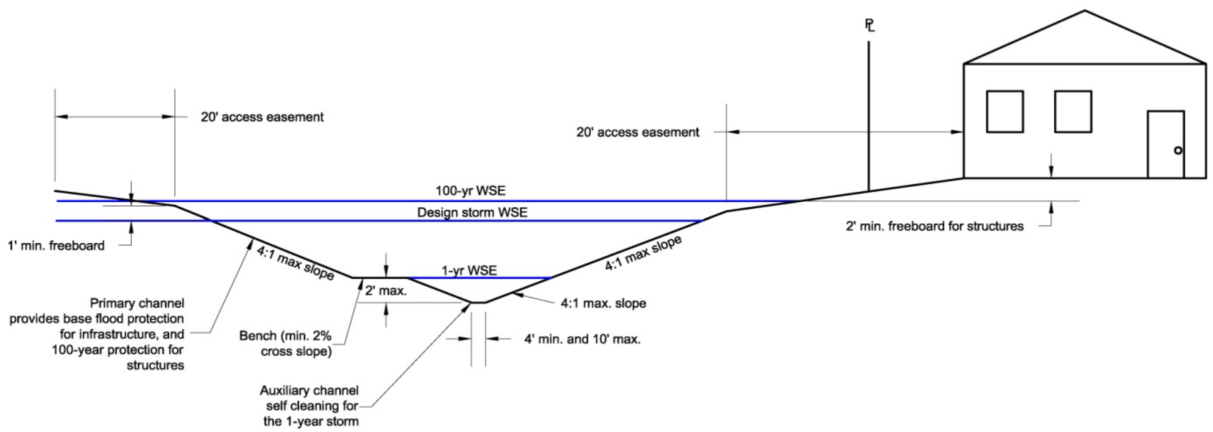



**Figure 5-36  Channel Geometry Criteria**

## 5.5.3 Channel Capacity

### 5.5.3.1 Design Charts

The following is a discussion of the equations that can be used for the design and analysis of open channel flow. The Federal Highway Administration has prepared numerous design charts to aid in the design of rectangular, trapezoidal, and triangular open channel cross sections. In addition, design charts for grass-lined channels have been developed. Examples of these charts and instructions for their use are given in Section 5.5.3.3.

### 5.5.3.2 Manning's Equation

Manning's Equation, presented in three forms below, shall be used for evaluating uniform flow conditions in open channels (HEC-15, 2005):

**Equation 5-22** $$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

**Equation 5-23** $$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

**Equation 5-24** $$S = \left[ \frac{Qn}{1.49 A R^{2/3}} \right]^2$$

where:

| | | |
|---|---|---|
| V | = | average channel velocity, ft/s |
| Q | = | discharge rate for design conditions, cfs |
| n | = | Manning's roughness coefficient |
| A | = | cross-sectional area, $ft^2$ |
| R | = | hydraulic radius = A/P, ft |
| P | = | wetted perimeter, ft |
| S | = | slope of the energy grade line, ft/ft |

For prismatic channels, in the absence of backwater conditions, the slope of the energy grade line, water surface and channel bottom are assumed to be equal. For a more comprehensive discussion of open channel theory and design, see Hydraulic Design of Flood Control Channels, USACE, 1994.

The wetted perimeter (P) and hydraulic radius (R) can be calculated from geometric dimensions of standard trapezoidal channel sections. Irregular channel cross sections, however, must be subdivided into segments so that the flow can be computed separately for the main channel and overbank portions. This same process of subdivision may be used when different parts of the channel cross section have different roughness coefficients. Hydraulic analysis programs such as HEC-RAS can greatly speed such calculations.

### 5.5.3.3 Direct Solutions

When the hydraulic radius, cross-sectional area, roughness coefficient and slope are known, discharge can be calculated directly from Equation 5-23. Nomographs for obtaining direct solutions to Manning's Equation are presented in Figure 5-37 and Figure 5-38.

The following steps are used for the general solution nomograph in Figure 5-37:

**Step 1** Determine open channel geometry, including slope in ft/ft, hydraulic radius in ft, and Manning's n value.

**Step 2** Connect a line between the Manning's n scale and slope scale and note the point of intersection on the turning line.

**Step 3** Connect a line from the hydraulic radius to the point of intersection obtained in Step 2.

**Step 4** Extend the line from Step 3 to the velocity scale to obtain the velocity in ft/s.

The trapezoidal channel nomograph solution to Manning's Equation in Figure 5-38 can be used to find the depth of flow if the design discharge is known or the design discharge if the depth of flow is known, according to the following steps.

***Given Q, find d:***

**Step 1** Determine input data, including slope in ft/ft, Manning's n value, bottom width in ft, and side slope in ft/ft.

**Step 2** Given the design discharge, find the product of Q times n, connect a line from the slope scale to the Qn scale, and find the point of intersection on the turning line.

**Step 3** Connect a line from the turning point to the b scale and find the intersection with the z = 0 scale.

**Step 4** Project horizontally from the point located in Step 3 to the appropriate z value and find the value of d/b.

**Step 5** Multiply the value of d/b obtained in Step 4 by the bottom width b to find the depth of uniform flow, d.

***Given d, find Q:***

**Step 1** Determine input data, including slope in ft/ft, Manning's n value, bottom width in ft, and side slope in ft/ft.

**Step 2** Given the depth of flow, find the ratio d divided by b and project a horizontal line from the d/b ratio at the appropriate side slope, z, to the z = 0 scale.

**Step 3** Connect a line from the point located in Step 2 to the b scale and find the intersection with the turning line.

**Step 4** Connect a line from the point located in Step 3 to the slope scale and find the intersection with the Qn scale.

**Step 5** Divide the value of Qn obtained in Step 4 by the n value to find the design discharge, Q.

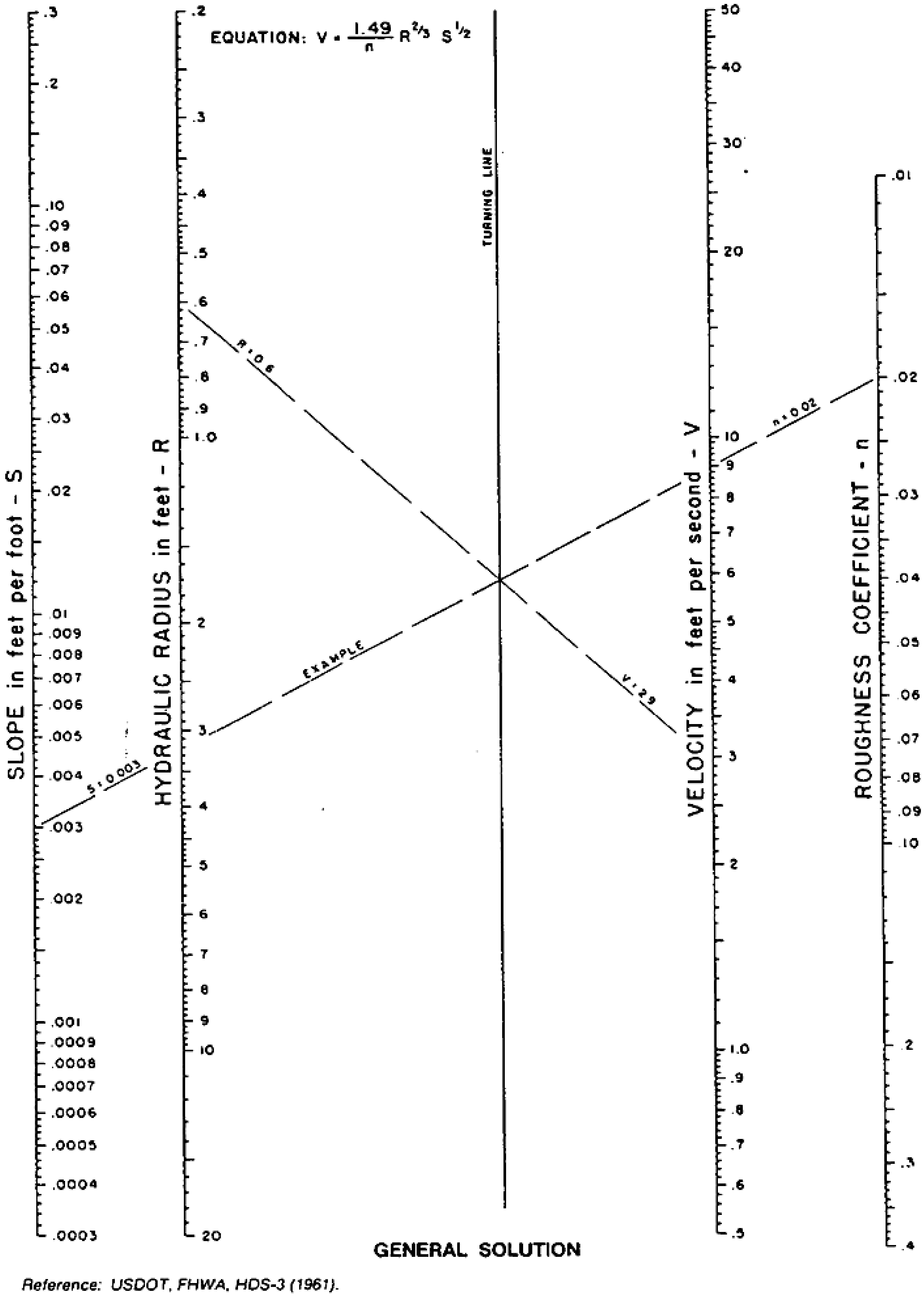



**Figure 5-37 Nomograph for the Solution of Manning's Equation**

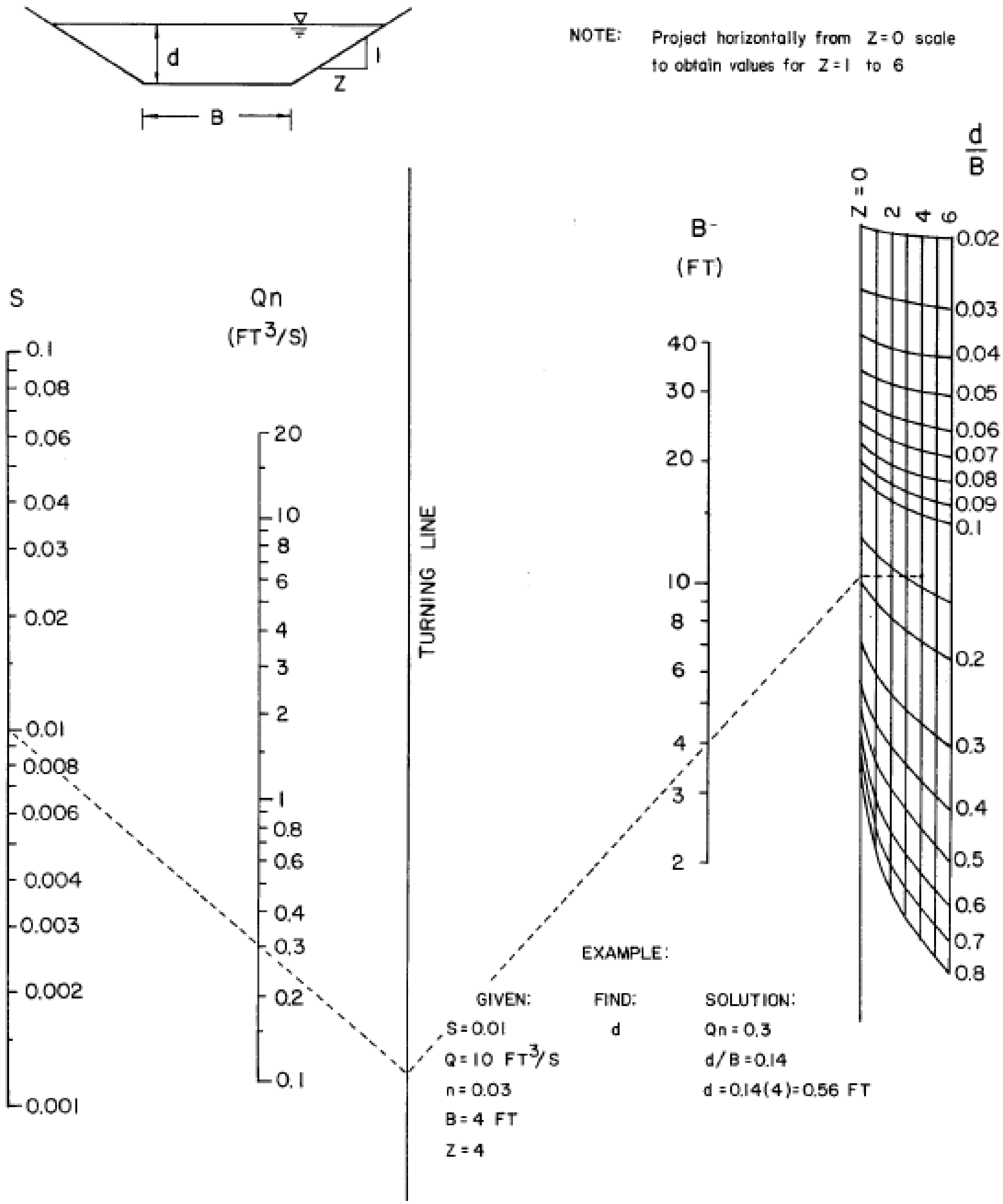



**Figure 5-38 Solution of Manning's Equation for Trapezoidal Channels**
(HEC-22, 2001)

### 5.5.3.4 Trial and Error Solutions

A trial and error procedure for solving Manning's equation can be used to compute the normal depth of flow in a uniform channel when the channel shape, slope, roughness, and design discharge are known. For purposes of the trial and error process, Manning's equation can be arranged as shown in Equation 5-25 (HEC-15, 2005).

**Equation 5-25** $$AR^{2/3} = \frac{Qn}{1.49S^{1/2}}$$

where:

| | | |
|---|---|---|
| A | = | cross-sectional area, ft |
| R | = | hydraulic radius = A/P, ft |
| Q | = | discharge rate for design conditions, cfs |
| n | = | Manning's roughness coefficient |
| S | = | slope of the energy grade line, ft/ft |

To determine the normal depth of flow in a channel by the trial and error process, trial values of depth are used to determine A, P, and R for the given channel cross section. Trial values of $AR^{2/3}$ are computed until the equality of Equation 5-25 is satisfied such that the design flow is conveyed for the slope and selected channel cross section. This trial and error calculation can be easily solved using a simple spreadsheet.

## 5.5.4 Channel Stability

For the design of grassed channels, stability against erosion will be evaluated based on flow shear stress and flow velocity. Shear stress will be used as the primary indicator of stability against erosion; however, in no case may the average flow velocity exceed the maximum permissible velocity.

For the analysis of existing unlined channels, and for riprapped channels, stability against erosion will be based on permissible velocities.

The maximum shear stress in a channel may be approximated by Equation 5-26 (HEC-15, 2005).

**Equation 5-26** $$\tau_d = \gamma * d * S$$

where:

| | | |
|---|---|---|
| $\tau_d$ | = | maximum shear stress, lb/ft$^2$ |
| $\gamma$ | = | specific weight of water = 62.4 lb/ft$^3$ |
| d | = | maximum depth, ft |
| S | = | slope of EGL, ft/ft |

The permissible shear stress for a grass channel is the maximum shear stress that the channel can sustain without erosion. Table 5-12 provides permissible shear stresses for the design of grassed channels and unlined channels. The permissible shear stress for a grass lining depends on the hydraulic resistance of the lining, as measured by Manning's n, and the erodibility of the underlying soil.

**Table 5-12 Permissible Shear Stresses and Velocities**

| Lining Category | Lining Type | Permissible Shear Stress, $\tau_p$ ($lb/ft^2$)[1] | Permissible Velocity (ft/s)[2] |
|---|---|---|---|
| Grass (good stand) | Grass with easily erodible soil (sands and silts) | $\tau_p = 310\ n^2$ | 5 |
| | Grass with average soil erodibility (silty clays) | $\tau_p = 1250\ n^2$ | 7 |
| | Grass with erosion-resistant soil (clays) | $\tau_p = 2190\ n^2$ | 7.5 |
| Unlined | Fine sand | --- | 2 |
| | Coarse sand | --- | 4 |
| | Sandy silt | --- | 2 |
| | Silt clay | --- | 3.5 |
| | Clay | --- | 6 |

where: n = Manning's roughness
[1] KDOT Drainage Design Manual 2008-07
[2] EM 1110-2 1601, USACE

The equation for permissible velocity in riprapped channels is provided in Equation 5-27 and Equation 5-28 (HDC 712-1, USACE).

**Equation 5-27** $$V = C\left[2g\left(\frac{\gamma_S - \gamma_W}{\gamma_W}\right)\right]^{1/2}(D_{50})^{1/2}$$

**Equation 5-28** $V = 12.3(D_{50})^{1/2}$ (for typical conditions as defined below)

where:

| | | |
|---|---|---|
| V | = | velocity, ft/s |
| C | = | Isbash constant = 1.2 |
| g | = | gravity = 32.2 $ft/s^2$ |
| $\gamma_s$ | = | unit weight of riprap, may assume 165 $lb/ft^3$ |
| $\gamma_w$ | = | unit weight of water = 62.4 $lb/ft^3$ |
| $D_{50}$ | = | median equivalent spherical diameter of riprap, ft |

### 5.5.5 Channel Lining Design

***Procedure***

This procedure is intended for channels used to convey local storm flows, where the channel is expected to flow under hydraulically "normal" flow conditions. For gradually varied flow conditions where the channel may flow with significant drawdown or backwater conditions, a water surface profile must be performed and the velocities and shear stresses resulting from that analysis are to be used. Also, as previously stated, this procedure is not for major flood control channels. The details of major flood control channel design are beyond the scope of this Manual.

**Step 1** Determine or select a channel cross-section (bottom width, side slopes, and depth) and bottom slope that are compatible with the overall design requirements.

**Step 2** Determine the design storm recurrence interval that governs the channel capacity.

**Step 3** Compute the design flow for the channel capacity according to the hydrologic procedures presented in Chapter 4.

**Step 4** Compute the normal depth for the design flow. If the normal depth is at least one foot below the bank-full depth, the channel has sufficient capacity for the design flow. Otherwise, increase the bottom width and/or the depth of the channel and repeat the capacity check.

**Step 5** Check the capacity of the channel to prevent flooding of nearby structures as follows: Compute the discharge for the 100-year recurrence interval by hydrologic analysis. Next, compute the normal depth at this discharge and the corresponding water-surface elevation. (This may include out-of-banks flow.) If this elevation is equal to or less than two feet below the lowest opening of the structure, the channel has sufficient capacity. Otherwise, increase the bottom width and/or the depth of the channel and repeat this check.

**Step 6** Check the stability of the channel. Compute the normal depth for the 2, 5 and 10-year storms. Compute shear stresses (for grassed channels) and average velocities for each event, and compare with the permissible values. Adjust the design to ensure permissible values are not exceeded.

**Step 7** Check for self-cleaning velocities. Compute the normal depth for the 1-year storm, and the corresponding average flow velocity. If the velocity is less than 2.5 fps, adjust the design.

**Step 8** Repeat steps 1 through 7 until all requirements are met.

### 5.5.6 Flow in Bends

Flow around a bend creates secondary currents, which impose higher shear stresses on the channel sides and bottom compared to a straight reach as shown in Figure 5-39. At the beginning of the bend, the maximum shear stress is near the inside and moves toward the outside as the flow leaves the bend. The increased shear stress caused by a bend persists downstream of the bend.

The maximum shear stress in a bend is a function of the ratio of channel curvature to the top (water surface) width, $R_C/T$. As $R_C/T$ decreases, that is as the bend becomes sharper, the maximum shear stress in the bend tends to increase.

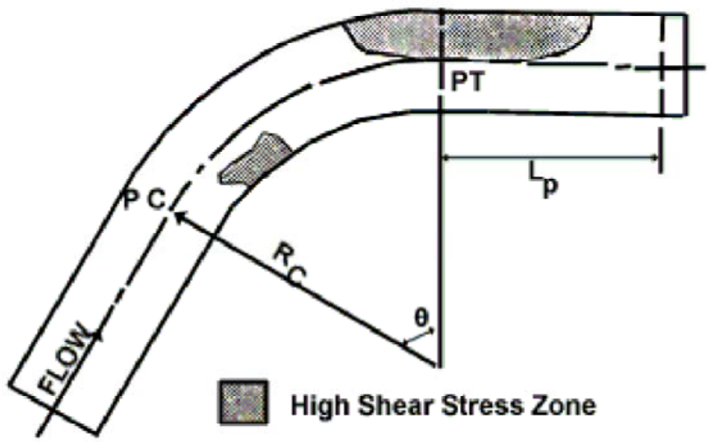



**Figure 5-39 Flow in Channel Bends**
(FHWA, HEC-15)

Equation 5-29 gives the maximum shear stress in a bend (HEC-15, 2005).

**Equation 5-29** $\tau_b = K_b \tau_d$

where,

$\tau_b$ = side shear stress on the channel, lb/ft$^2$
$K_b$ = ratio of channel curvature to bottom shear stress
$\tau_d$ = shear stress in channel at maximum depth, lb/ft$^2$

$K_b$ can be determined from the following equations, depending on the ratio of channel curvature per (HEC-15, 2005).

**Table 5-13 Ratio of Channel Bend to Bottom Shear Stress, $K_b$**

| $K_b$ | Channel Curvature Constraint |
|---|---|
| 2.00 | $R_C/T \le 2$ |
| **Equation 5-30** $2.38 - 0.206\left(\frac{R_c}{T}\right) + 0.0073\left(\frac{R_c}{T}\right)^2$ | $2 < R_C/T < 10$ |
| 1.05 | $10 \le R_C/T$ |

The length downstream to the point that curvature-induced stresses dissipate (HEC-15, 2005) is given by Equation 5-31.

**Equation 5-31** $$L_p = 0.6\left(\frac{R^{7/6}}{n}\right)$$

where,

| | | |
|---|---|---|
| $L_p$ | = | length of protection, ft |
| R | = | hydraulic radius of the channel, ft |
| n | = | Manning's roughness for lining material in the bend |

## Example Problem – Channel Design

Design a grass channel in silty clay soil to convey flow past a new shopping mall. The hydrologic calculations have shown that the channel will carry 10 cfs for the 1-year storm and 100 cfs for the 10-year storm. The channel slope is 1.3%. Design a channel to meet the local criteria.

Determine the design storm.

The design storm is the 10-year, since the design is for a high value business area per Table 5-1.

Determine Manning's roughness for the channel.

Look in "artificial channels" portion Appendix A to find a roughness value of 0.045 for flow in grassed swales with depth between 0.5 and 2.0 feet.

Estimate the size of an auxiliary channel to convey the 1-year storm using Equation 5-25.

Set auxiliary channel bottom width to the minimum of 4'. Set side slope to the maximum steepness of 4:1. Using the channel slope and roughness value, iterate Equation 5-25 until a flow depth is found for the auxiliary channel. The iteration process seeks to balance the depth-variable terms left of the equality sign and the depth-independent terms to the right. The correct flow depth is found once they balance. This process is shown in the upper portion of the example spreadsheet within Figure 5-40.

Auxiliary channel depth is found to be 0.66 ft.

Estimate the size of a primary channel to carry the design storm.

Estimate a primary channel bottom width of 14'. Choose a side slope of 4:1. Once again, iterate through Equation 5-25 until a depth of flow for the compound channel is found in the lower portion of Figure 5-40. The overall flow area, wetted perimeter, and hydraulic radius must be calculated to include both the auxiliary and primary channels for this step.

The primary channel depth is found to be 1.12 ft. This provides a total flow depth of 0.66 + 1.12 = 1.78 ft. A total channel depth of 2.8 feet will provide the minimum freeboard of 1' for the design storm.

Determine the actual channel shear for the 10-year storm using Equation 5-26:

$$\tau_d = \gamma d S$$

$$\tau_d = 62.4(1.78)0.013 = 1.44 \text{ lb/ft}^2$$

Determine the permissible channel shear per Table 5-12.

$$\tau_p = 1250 n^2$$

$$\tau_p = 1250(0.045)^2 = 2.53 \text{ lb/ft}^2$$

Determine the side shear stress on the channel assume an $R_c$ of 20 ft and a T of 6 ft.

To determine $K_b$ use Table 5-13. Since Rc/T is between 10 and 2 Equation 5-30 is used to calculate $K_b$.

$$K_b = 2.38 - 0.206\left(\frac{20}{6}\right) + 0.0073\left(\frac{20}{6}\right)^2 = 1.77$$

The side shear stress can be calculated using Equation 5-29:

$$\tau_b = K_b \tau_d = (1.77)(1.44) = 2.56 \text{ ft/lb}^2$$

Added lining may be needed to resist the bend stresses. Determine the distance stream of the bend that the added shear stress will dissipated.

To determine the length of protection needed first find the hydraulic radius of the entire channel. The hydraulic radius is found by using the calculations in Equation 5-40.

$$R = \frac{(A)}{(WP)} = \frac{(25.22)}{(23.44)} = 1.08$$

The protection length can be found by using Equation 5-31.

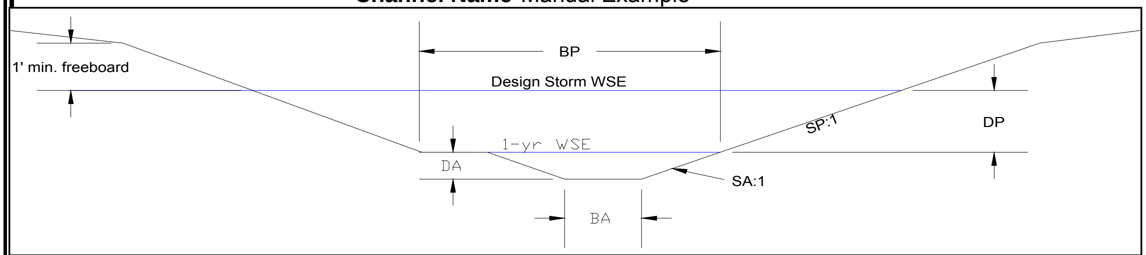
$$L_p = 0.6\left(\frac{R^{7/6}}{n}\right) = 0.6\frac{(1.08)^{7/6}}{(0.045)} = 14.58 \text{ ft}$$

The maximum permissible velocity in Table 5-12 is 7 fps. The average velocity for the total channel is 5.4 fps.

Check for self-cleaning velocity. The velocity in the auxiliary channel for the 1-year flow is 2.3 cfs, which is slightly less than 2.5 fps, suggesting a small adjustment to the auxiliary channel geometry or channel slope is needed.

## Compound Channel Sizing Spreadsheet

**Channel Name** Manual Example




| | | |
|---|---|---|
| | Channel Slope (ft/ft) | 0.013 |

$$AR^{2/3} = \frac{Qn}{1.49S^{1/2}}$$

### Auxiliary Channel Sizing for the 1-year Storm using Manning's Equation

**Match these per equation above**

| Auxiliary Channel Data | | |
|---|---|---|
| BA | Aux. B (ft) | 4 |
| SA | Aux. Side Slope:1 | 4 |
| | Aux. Q (cfs) | 10 |
| | Auxiliary n | 0.045 |

| Aux. $Qn/(1.49S^{1/2})$ | Aux. Depth | Aux. A | Aux. WP | Aux. R | Aux. $AR^{2/3}$ |
|---|---|---|---|---|---|
| 2.65 | 0 | 0.00 | 4.00 | 0.00 | 0.00 |
| 2.65 | 0.2 | 0.96 | 5.65 | 0.17 | 0.29 |
| 2.65 | 0.5 | 3.00 | 8.12 | 0.37 | 1.54 |
| 2.65 | 1 | 8.00 | 12.25 | 0.65 | 6.02 |
| 2.65 | 0.7 | 4.76 | 9.77 | 0.49 | 2.95 |
| 2.65 | 0.6 | 3.84 | 8.95 | 0.43 | 2.18 |
| 2.65 | 0.65 | 4.29 | 9.36 | 0.46 | 2.55 |
| 2.65 | 0.67 | 4.48 | 9.52 | 0.47 | 2.71 |
| 2.65 | 0.66 | 4.38 | 9.44 | 0.46 | 2.63 |
| 2.65 | 0.665 | 4.43 | 9.48 | 0.47 | 2.67 |
| 2.65 | 0.663 | 4.41 | 9.47 | 0.47 | 2.65 |
| 2.65 | | 0.00 | 4.00 | 0.00 | 0.00 |
| 2.65 | | 0.00 | 4.00 | 0.00 | 0.00 |
| Chosen Aux. Depth | 0.663 | 4.41 | 9.47 | 0.47 | 2.65 |
| Aux. Velocity (ft/s) | 2.27 | | | | |
| Aux. Shear ($lb/ft^2$) | 0.54 | | | | |

### Primary Channel Sizing for the Design Storm using Manning's Equation

**Match these per equation above**

| Primary Channel Data | | |
|---|---|---|
| BP | Prim. B (ft) | 14 |
| SP | Prim. Side Slope: 1 | 4 |
| | Total. Q (cfs) | 100 |
| | Primary n | 0.045 |

| Total $Qn/(1.49S^{1/2})$ | Prim. Depth | Prim. A | Prim. WP | Total A | Total WP | Total R | Total $AR^{2/3}$ |
|---|---|---|---|---|---|---|---|
| 26.49 | 0 | 0.00 | 4.70 | 4.41 | 14.16 | 0.31 | 2.03 |
| 26.49 | 2 | 44.00 | 21.19 | 48.41 | 30.66 | 1.58 | 65.65 |
| 26.49 | 1 | 18.00 | 12.94 | 22.41 | 22.41 | 1.00 | 22.41 |
| 26.49 | 1.2 | 22.56 | 14.59 | 26.97 | 24.06 | 1.12 | 29.10 |
| 26.49 | 1.1 | 20.24 | 13.77 | 24.65 | 23.23 | 1.06 | 25.64 |
| 26.49 | 1.15 | 21.39 | 14.18 | 25.80 | 23.65 | 1.09 | 27.34 |
| 26.49 | 1.12 | 20.70 | 13.93 | 25.11 | 23.40 | 1.07 | 26.32 |
| 26.49 | 1.13 | 20.93 | 14.01 | 25.34 | 23.48 | 1.08 | 26.66 |
| 26.49 | 1.125 | 20.81 | 13.97 | 25.22 | 23.44 | 1.08 | 26.49 |
| 26.49 | | 0.00 | 4.70 | 4.41 | 14.16 | 0.31 | 2.03 |
| 26.49 | | 0.00 | 4.70 | 4.41 | 14.16 | 0.31 | 2.03 |
| Chosen Prim. Depth | 1.125 | 20.81 | 13.97 | 25.22 | 23.44 | 1.08 | 26.49 |
| Total Depth | 1.788 | | | | | | |
| Prim. Velocity (ft/s) | 3.96 | | | | | | |
| Prim. Shear ($lb/ft^2$) | 1.45 | | | | | | |

Note: Total wetted perimeter and area includes that from the auxiliary channel.
Note: Total flow includes that from the auxiliary channel

**Figure 5-40 Channel Sizing Example Spreadsheet**

Flow around bends also creates localized increases and decreases in flow depth due to centrifugal force. For subcritical flow, the water surface elevation on the outside of the curve will increase and the depth on the inside of the curve will decrease an equal amount (approximately). The total difference in water surface elevation between the inside and outside of the curve, called “superelevation, may be estimated with Equation 5-32 (HEC-22, 2001).

**Equation 5-32** $$d = \frac{v^2 * T}{g * R_c}$$

where:

| | | |
|---|---|---|
| d | = | difference in water surface elevation across top of channel, feet |
| v | = | average flow velocity, fps |
| T | = | water surface top width, feet |
| g | = | gravitational acceleration, 32.2 ft/sec$^2$ |
| $R_c$ | = | radius of center of channel, feet |

Thus, the change in water surface elevation when compared with the nominally computed elevation is plus d/2 on the outside of the curve, and minus d/2 on the inside.

For supercritical flow, the elevation changes are more complex. In addition to superelevation, “standing waves” will also develop. The analysis of standing waves is beyond the scope of this Manual. However, the increase (at the outside of the curve) and decrease (at the inside of the curve) is approximately two times the values that would be computed for subcritical flow (EM-1110-2-1601, USACE, 1994).

## 5.5.7 Critical Flow Calculations

***Background***

In the design of open channels, it is important to calculate the critical depth in order to determine if the flow in the channel will be subcritical or supercritical. If the flow is subcritical, the flows through channel transitions are relatively tranquil and wave action is minimal. In subcritical flow, the depth at any point is influenced by a downstream control, which may be either the critical depth at a control structure (such as a weir) or the water surface elevation in a pond or downstream channel. In supercritical flow, the depth at any point is influenced by a control upstream, usually critical depth. Supercritical flows have relatively shallow depths and high velocities. Standing waves may develop and hydraulic jumps are possible under these conditions. Channel stabilization may require extensive measures.

Critical depth depends only on the discharge rate and channel geometry. The general equation for determining critical depth (King & Brater, 1963) is expressed in Equation 5-33.

**Equation 5-33** $$\frac{Q^2}{g} = \frac{A^3}{T}$$

where:

| | | |
|---|---|---|
| Q | = | discharge rate for design conditions, cfs |
| g | = | acceleration due to gravity = 32.2 ft/s$^2$ |
| A | = | cross-sectional area, ft$^2$ |
| T | = | top width of water surface, ft |

Note: A trial and error procedure is needed to solve Equation 5-33.

***Semi-Empirical Equations***

Semi-empirical equations (as presented in Table 5-14) or section factors (as presented in Figure 5-41) can be used to simplify trial and error critical depth calculations. The following equation is used to determine critical depth with the critical flow section factor, Z (King & Brater, 1963):

**Equation 5-34** $$Z = \frac{Q}{g^{0.5}}$$

where:

| | | |
|---|---|---|
| Z | = | critical flow section factor (not to be confused with Z used to denote side slope in some figures, such as Figure 5-41 |
| Q | = | discharge rate for design conditions, cfs |
| g | = | acceleration due to gravity = 32.2 ft/s$^2$ |

The Froude number, Fr, calculated by the following equation, is useful for evaluating the type of flow conditions in an open channel (King & Brater, 1963):

**Equation 5-35** $$Fr = \frac{v}{\sqrt{gd}}$$

where:

| | | |
|---|---|---|
| Fr | = | Froude number |
| v | = | velocity of flow, ft/s |
| g | = | acceleration of gravity = 32.2 ft/sec$^2$ |
| d | = | hydraulic depth = A/T, ft |
| A | = | cross-sectional area of flow, ft$^2$ |
| T | = | top width of flow, ft |

If Fr is greater than 1.0, flow is supercritical; if it is less than 1.0, flow is subcritical. Fr is 1.0 for critical flow conditions.

---

### Example Problem – Flow Calculations

Find the critical depth and Froude number at the 1-yr water surface elevation for the previous example. Note to calculate the critical depth for the design storm requires computing the depth in a compound channel which beyond the scope of this manual.

Table 5-14 is used to calculate the critical depth.

$$0.5522Q/b^{2.5} = 0.5522(10/4^{2.5}) = 0.17$$

This is within the range of applicability for estimated the depth in a trapezoidal channel. From Table 5-14 the critical depth can be calculated.

$$d_c = 0.81[10^2/((32.2)(4^{0.75}4^{1.25}))]^{0.27} - 4/((30)(4)) = 0.49 \text{ ft}$$

To determine the Froude number Equation 5-35 is used.

$$Fr = \frac{v}{\sqrt{gd}} = \frac{2.27}{\sqrt{(32.2)(4.41/9.30)}} = 0.58$$

The flow is subcritical because Fr < 1.

---

**Table 5-14 Critical Depth Equations for Uniform Flow in Selected Channel Cross Sections**

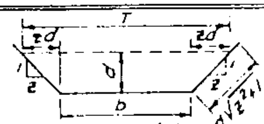
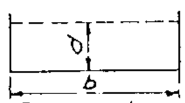
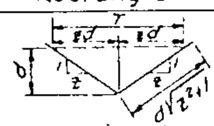
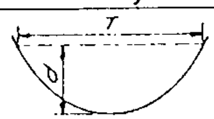
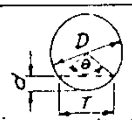
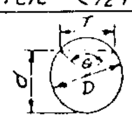
| Channel Type[1] | Semi-Empirical Equations[2] for Estimating Critical Depth | Range of Applicability |
|---|---|---|
| 1. Rectangular[3] | $d_c = [Q^2/(gb^2)]^{1/3}$ | All rectangular sections |
| 2. Trapezoidal[3] | $d_c = 0.81[Q^2/(gz^{0.75}b^{1.25})]^{0.27} - b/30z$ | $0.1 < 0.5522\ Q/b^{2.5} < 0.4$<br>For $0.5522\ Q/b^{2.5} < 0.1$, use rectangular channel equation |
| 3. Triangular[3] | $d_c = [(2Q^2)/(gz^2)]^{1/5}$ | All triangular sections |
| 4. Circular[4] | $d_c = 0.325(Q/D)^{2/3} + 0.083D$ | $0.3 < d_c/D < 0.9$ |
| 5. General[5] | $(A^3/T) = (Q^2/g)$ | All sections |

where:

| | | |
|---|---|---|
| $d_c$ | = | critical depth (ft) |
| Q | = | design discharge (cfs) |
| g | = | acceleration due to gravity (32.3 ft/s$^2$) |
| b | = | bottom width of channel (ft) |
| z | = | side slopes of a channel (horizontal to vertical) |
| D | = | diameter of circular conduit (ft) |
| A | = | cross-sectional area of flow (ft$^2$) |
| T | = | top width of water surface (ft) |

[1] See Figure 5-41 for channel sketches
[2] Assumes uniform flow with the kinetic energy coefficient equal to 1.0
[3] Reference: French (1985)
[4] Reference: USDOT, FHWA, HDS-4 (1965)
[5] Reference: Brater and King (1976)

If the water surface profile in a channel transitions from supercritical flow to subcritical flow, a hydraulic jump must occur. The location and length of the hydraulic jump and its sequent (downstream) depth are critical to proper design of free flow conveyances. To determine the location of a hydraulic jump, the standard step method is used to compute the water surface profiles, and specific force (momentum principle) and specific energy relationships are used. For computational methods, including length and sequent depth, refer to Chow, 1959, and Mays, 1999. The HEC-RAS computer program can be used to compute water surface profiles for both subcritical and supercritical flow regimes.

| Section | Area $A$ | Wetted Perimeter $P$ | Hydraulic Radius $R$ | Top Width $T$ | Critical Depth Factor, $Z$ |
|---|---|---|---|---|---|
|  Trapezoid | $bd+zd^2$ | $b+2d\sqrt{z^2+1}$ | $\frac{bd+zd^2}{b+2d\sqrt{z^2+1}}$ | $b+2zd$ | $\frac{[(b+zd)d]^{1.5}}{\sqrt{b+2zd}}$ |
|  Rectangle | $bd$ | $b+2d$ | $\frac{bd}{b+2d}$ | $b$ | $bd^{1.5}$ |
|  Triangle | $zd^2$ | $2d\sqrt{z^2+1}$ | $\frac{zd}{2\sqrt{z^2+1}}$ | $2zd$ | $\frac{\sqrt{2}}{2}\,zd^{2.5}$ |
|  Parabola | $\frac{2}{3}dT$ | $T+\frac{8d^2}{3T}$ 1 | $\frac{2dT^2}{3T^2+8d^2}$ 1 | $\frac{3a}{2d}$ | $\frac{2}{9}\sqrt{6}\,Td^{1.5}$ |
|  Circle - <½ full 2 | $\frac{D^2}{8}\left(\frac{\pi\theta}{180}-\sin\theta\right)$ | $\frac{\pi D\theta}{360}$ | $\frac{45D}{\pi\theta}\left(\frac{\pi\theta}{180}-\sin\theta\right)$ | $D\sin\frac{\theta}{2}$ or $2\sqrt{d(D-d)}$ | $a\sqrt{\frac{a}{D\sin\frac{\theta}{2}}}$ |
|  Circle - >½ full 3 | $\frac{D^2}{8}\left(2\pi-\frac{\pi\theta}{180}+\sin\theta\right)$ | $\frac{\pi D(360-\theta)}{360}$ | $\frac{45D}{\pi(360-\theta)}\left(2\pi-\frac{\pi\theta}{180}+\sin\theta\right)$ | $D\sin\frac{\theta}{2}$ or $2\sqrt{d(D-d)}$ | $a\sqrt{\frac{a}{D\sin\frac{\theta}{2}}}$ |

1 Satisfactory approximation for the interval $0 < \frac{d}{T} \leq 0.25$
When $d/T > 0.25$, use $P = \frac{1}{2}\sqrt{16d^2+T^2} + \frac{T^2}{8d}\sinh^{-1}\frac{4d}{T}$

2 $\theta = 4\sin^{-1}\sqrt{d/D}$
3 $\theta = 4\cos^{-1}\sqrt{d/D}$
Insert $\theta$ in degrees in above equations

Note: Small z = Side Slope Horizontal Distance
Large Z = Critical Depth Section Factor

Reference: USDA, SCS, NEH-5 (1956).

Figure 5-41 Open Channel Geometric Relationships for Various Cross Sections

### 5.5.8 Gradually Varied Flow

Many computer programs are available for computation of water surface profiles. The most general and widely used programs are HEC-2 and HEC-RAS, both developed by the U.S. Army Corps of Engineers, and EPA-SWMM developed by the Environmental Protection Agency. These programs can be used to compute water surface profiles for both natural and artificial channels.

For prismatic channels, the profiles can be computed manually using the Direct Step method (Chow, 1959). In the Direct Step method an increment of water depth is chosen, and the distance over which the depth change occurs is computed. This method is often used in association with culvert hydraulics. It is most accurate when the slope and depth increments are small. It is appropriate for prismatic channel sections that occur in most conduits, and can be useful when estimating both supercritical and subcritical profiles. For supercritical flow, the water surface profile is computed upstream-to-downstream. For subcritical flow, the water surface profile is computed downstream-to-upstream.

For an irregular nonprismatic channel, the Standard Step method is used. It is a more tedious and iterative process than the direct step method. The use of HEC-RAS is recommended for Standard Step calculations.

Cross sections for water surface profile calculations should be normal to the direction of flood flow. The number of sections required will depend on the irregularity of the waterway. Channel cross sections will be required at each location along the waterway where there are hydraulically significant changes in channel shape or dimensions, slope, or roughness. These sections are in addition to any sections necessary to define obstructions such as culverts, bridges, dams, energy dissipation features, or aerial crossings (pipelines). Sections should usually be no more than 4 to 5 channel widths apart or 100 feet apart for ditches or streams and 500 feet apart for floodplains, unless the channel is very regular.

## 5.6 Outlet Structures

Outlet structures are used to regulate the flow of water. They are primarily used in stormwater management facilities that pool water. Chapter 3 discusses many of these facilities. Chapter 4 provides methods for incorporating outlet structures into overall calculations of water quality volume extended detention, channel protection volume extended detention and flood flow detention. This section outlines the governing equations for outlet structures and provides guidance on detailed design.

### 5.6.1 General Criteria

- All outlet structures shall be of cast-in-place or precast concrete. No outlet structures of earth, corrugated metal, riprap, grouted riprap, or plastics are allowed.
- All outlet rating curves shall be created using the equations presented in this section.
- All extended detention outlets shall be provided with outlet protection from clogging.

- All riser overflows shall have trash racks sized according to guidance provided in Section 5.6.4.
- All ponds shall be designed such that the secondary outlet can convey the 100-year storm with a minimum of one foot of freeboard with all primary outlets clogged.

## 5.6.2 Primary Outlets

Primary outlets provide the critical function of the regulation of flow for structural stormwater controls. There are several different types of outlets such as single stage outlet structures or several outlet structures combined to provide multi-stage outlet control.

For a single stage system, the stormwater facility outlet can be designed as a simple orifice, pipe or culvert. For multistage control structures, the inlet is designed with multiple outlets.

A stage-discharge curve is developed for the full range of flows that the structure may experience. Typically, the outlets are housed in a riser structure connected to a single outlet conduit. An alternative approach would be to provide several pipe or culvert outlets at different levels in the facility that are either discharged separately or are combined to discharge at a single location.

This section provides an overview of outlet structure hydraulics and design for stormwater storage facilities. The design engineer is referred to an appropriate hydraulics text for additional information on outlet structures not contained in this section.

### 5.6.2.1 Outlet Structure Functions

There are two main outlet types that serve different purposes:

- Water quality and channel protection flows are normally handled with smaller, more protected outlet structures such as reverse slope pipes, hooded orifices, orifices located within screened pipes or risers, perforated plates or risers, and V-notch weirs.
- Larger flows, such as flood flows, are typically handled through a riser with different sized openings, through an overflow at the top of a riser (drop inlet structure), or a weir/spillway. The orifices and weirs can be of different heights and configurations to control multiple design flows.

Water quality and channel protection outlets are typically found at or near the bottom of a riser, while flood protection outlets are found higher up.

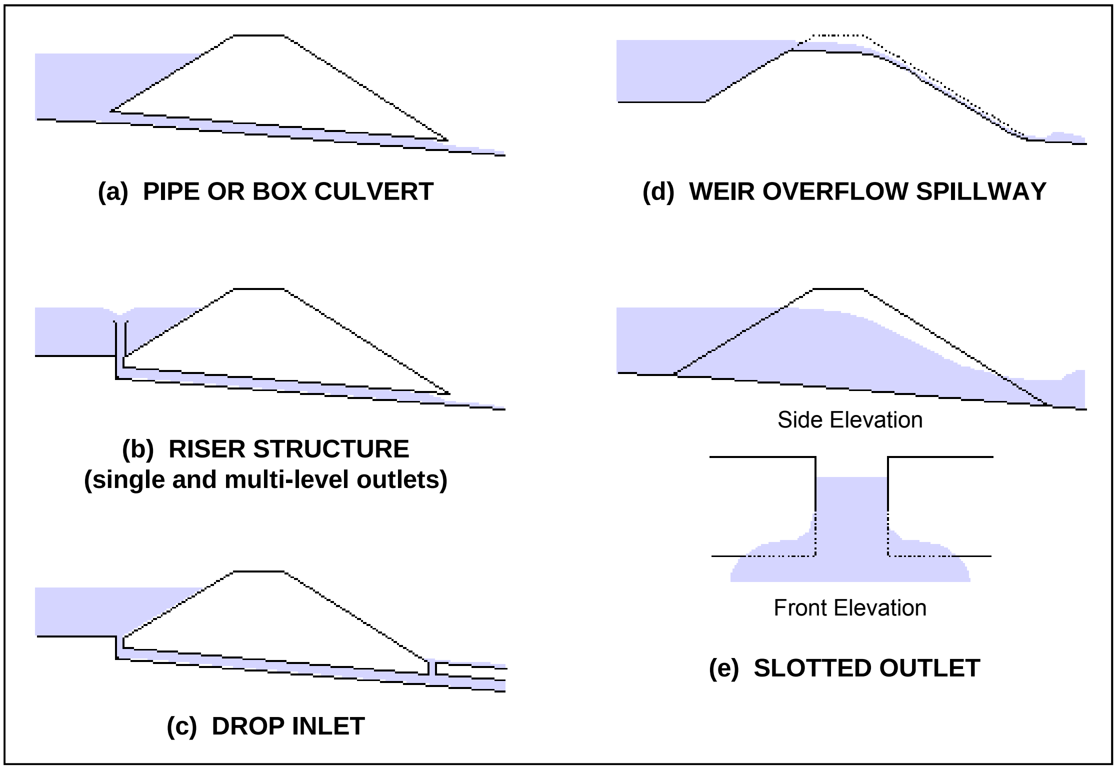



**Figure 5-42 Typical Primary Outlets**

### 5.6.2.2 Outlet Structure Types

There are a wide variety of outlet structure types, the most common of which are covered in this section. Descriptions and equations are provided for the following outlet types for use in stormwater facility design:

- Orifices;
- Pipes / culverts;
- Sharp-crested weirs;
- Broad-crested weirs;
- V-notch weirs;
- Proportional weirs;
- Combination outlets.

***Orifices***

An orifice is a circular or rectangular opening of a prescribed shape and size. The flow rate depends on the height of the water above the opening and the size and edge treatment of the orifice. For a single orifice the discharge can be determined using the standard orifice equation below, Equation 5-36 (King & Brater, 1963).

**Equation 5-36** $Q = CA(2gH)^{0.5}$

where:

| | | |
|---|---|---|
| Q | = | the orifice flow discharge, cfs |
| C | = | discharge coefficient |
| A | = | cross-sectional area of orifice or pipe, $ft^2$ |
| g | = | acceleration due to gravity = 32.2 $ft/s^2$ |
| D | = | diameter of orifice or pipe, ft |
| H | = | effective head on the orifice, from the center of orifice to the water surface, ft |

If the orifice discharges as a free outfall, then the effective head is measured from the center of the orifice to the upstream (headwater) surface elevation. If the orifice discharge is submerged, then the effective head is the difference in elevation between the headwater and tailwater surfaces.

When the orifice wall material is thinner than the orifice diameter, with sharp edges, a coefficient of 0.6 should be used. When the material is equal to or thicker than the orifice diameter a coefficient of 0.80 should be used. If the edges of the latter are rounded, a coefficient of 0.92 can be used.

***Pipes and Culverts***

Discharge pipes are often used as outlet structures for stormwater control facilities. The design of these pipes can be for either single or multi-stage discharges. A reverse-slope underwater pipe is often used for water quality or channel protection outlets.

Outlet pipes shall be analyzed as a discharge pipe with headwater and tailwater effects taken into account. The outlet hydraulics for pipe flow can be determined from the culvert nomographs and procedures given in Section 5.3.3 or using approved software such as EPA-SWMM, HY-8, or approved commercial programs.

***Sharp-Crested Weirs***

If the overflow portion of a weir has a sharp, thin leading edge such that the water springs clear as it overflows, the overflow is termed a sharp-crested weir. If the sides of the weir also cause the through flow to contract, it is termed an end-contracted sharp-crested weir. Sharp-crested weirs have stable stage-discharge relationships and are often used as measurement devices. Equation 5-37 is the discharge equation for a sharp-crested weir without end contractions. This equation can also be used for the overflow of circular pipe risers using the riser circumference as the weir length (HEC-22, 2001):

**Equation 5-37** $Q = \left[3.27 + 0.4\frac{H}{H_c}\right] * LH^{1.5}$

where:

| | | |
|---|---|---|
| Q | = | discharge, cfs |
| H | = | head above weir crest excluding velocity head, ft |

| | | |
|---|---|---|
| $H_C$ | = | height of weir crest above channel bottom, ft |
| L | = | horizontal weir length, ft |

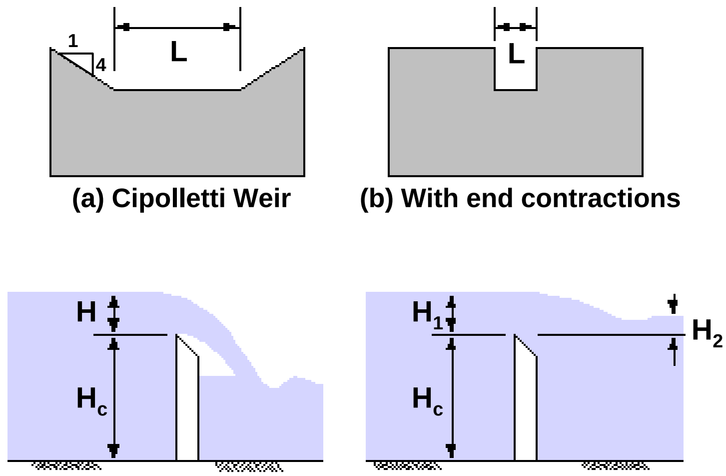



**Figure 5-43  Sharp-Crested Weir**

A sharp-crested weir with two end contractions is illustrated in item (b) of Figure 5-43. The discharge equation for this configuration presented in Equation 5-38 (Chow, 1959).

**Equation 5-38**

$$Q = \left[3.27 + \frac{0.4H}{H_C}\right](L - 0.1N)H^{1.5}$$

where:

| | | |
|---|---|---|
| Q | = | discharge, cfs |
| H | = | head above weir crest excluding velocity head, ft |
| $H_C$ | = | height of weir crest above channel bottom, ft |
| L | = | horizontal weir length, ft |
| N | = | number of end contractions (0, 1 or 2) |

A sharp-crested weir will be affected by submergence when the tailwater rises above the weir crest elevation. The result is that the discharge over the weir will be reduced. The discharge equation for a sharp-crested submerged weir is provided in Equation 5-39 (HEC-22, 2001).

**Equation 5-39**

$$Q_s = Q_f\left[1 - \left(\frac{H_2}{H_1}\right)^{1.5}\right]^{0.385}$$

where:

| | | |
|---|---|---|
| $Q_S$ | = | submerged flow, cfs |
| $Q_f$ | = | free flow from weir equations, cfs |
| $H_1$ | = | upstream head above crest, ft |
| $H_2$ | = | downstream head above crest, ft |

The discharge equation for the Cipolletti weir (configured to compensate for end contractions) is given in Equation 5-40.

**Equation 5-40** $Q = 3.367LH^{1/2}$

where:

| | | |
|---|---|---|
| Q | = | discharge, cfs |
| L | = | length of horizontal portion of Cippolletti weir, cfs |
| H | = | head above weir crest excluding velocity head, ft |

***Broad-Crested Weirs***

A weir in the form of a relatively long overflow section or a raised channel control crest section is a broad-crested weir. True broad-crested weir flow occurs when upstream head above the crest is between the limits of about 1/20 and 1/2 the crest length in the direction of flow. The equation for the broad-crested weir is Equation 5-41 (King & Brater, 1963).

**Equation 5-41** $Q = CLH^{1.5}$

where:

| | | |
|---|---|---|
| Q | = | discharge, cfs |
| C | = | broad-crested weir coefficient |
| L | = | broad-crested weir length perpendicular to flow, ft |
| H | = | head above weir crest, ft |

If the upstream edge of a broad-crested weir is so rounded as to prevent contraction and if the slope of the crest is as great as the loss of head due to friction, flow will pass through critical depth at the weir crest; this gives the maximum C value of 3.087. For sharp corners on the broad-crested weir, a minimum C value of 2.6 should be used. Information on C values as a function of weir crest breadth and head is given in Table 5-15.

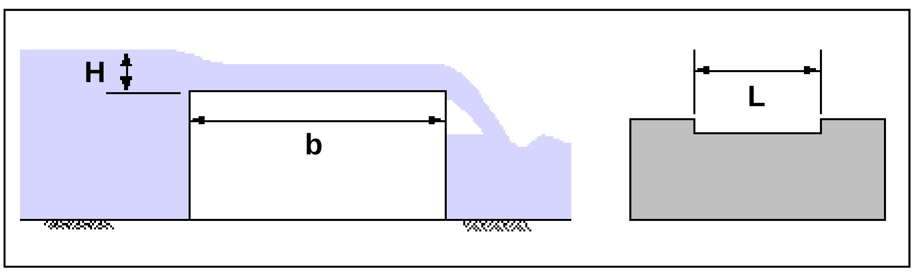



**Figure 5-44 Broad-Crested Weir**

**Table 5-15 Broad-Crested Weir Coefficient (C) Values**

| Measured Head (H)* In feet | Weir Crest Breadth (b) in feet 0.50 | 0.75 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 4.00 | 5.00 | 10.00 | 15.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 2.80 | 2.75 | 2.69 | 2.62 | 2.54 | 2.48 | 2.44 | 2.38 | 2.34 | 2.49 | 2.68 |
| 0.4 | 2.92 | 2.80 | 2.72 | 2.64 | 2.61 | 2.60 | 2.58 | 2.54 | 2.50 | 2.56 | 2.70 |
| 0.6 | 3.08 | 2.89 | 2.75 | 2.64 | 2.61 | 2.60 | 2.68 | 2.69 | 2.70 | 2.70 | 2.70 |
| 0.8 | 3.30 | 3.04 | 2.85 | 2.68 | 2.60 | 2.60 | 2.67 | 2.68 | 2.68 | 2.69 | 2.64 |
| 1.0 | 3.32 | 3.14 | 2.98 | 2.75 | 2.66 | 2.64 | 2.65 | 2.67 | 2.68 | 2.68 | 2.63 |
| 1.2 | 3.32 | 3.20 | 3.08 | 2.86 | 2.70 | 2.65 | 2.64 | 2.67 | 2.66 | 2.69 | 2.64 |
| 1.4 | 3.32 | 3.26 | 3.20 | 2.92 | 2.77 | 2.68 | 2.64 | 2.65 | 2.65 | 2.67 | 2.64 |
| 1.6 | 3.32 | 3.29 | 3.28 | 3.07 | 2.89 | 2.75 | 2.68 | 2.66 | 2.65 | 2.64 | 2.63 |
| 1.8 | 3.32 | 3.32 | 3.31 | 3.07 | 2.88 | 2.74 | 2.68 | 2.66 | 2.65 | 2.64 | 2.63 |
| 2.0 | 3.32 | 3.31 | 3.30 | 3.03 | 2.85 | 2.76 | 2.72 | 2.68 | 2.65 | 2.64 | 2.63 |
| 2.5 | 3.32 | 3.32 | 3.31 | 3.28 | 3.07 | 2.89 | 2.81 | 2.72 | 2.67 | 2.64 | 2.63 |
| 3.0 | 3.32 | 3.32 | 3.32 | 3.32 | 3.20 | 3.05 | 2.92 | 2.73 | 2.66 | 2.64 | 2.63 |
| 3.5 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.19 | 2.97 | 2.76 | 2.68 | 2.64 | 2.63 |
| 4.0 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.07 | 2.79 | 2.70 | 2.64 | 2.63 |
| 4.5 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 2.88 | 2.74 | 2.64 | 2.63 |
| 5.0 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.07 | 2.79 | 2.64 | 2.63 |
| 5.5 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 2.88 | 2.64 | 2.63 |

* Measured at least 2.5H upstream of the weir.
Source: Brater and King (1963)

***V-Notch Weirs***

The discharge through a V-notch weir (Figure 5-45) can be calculated from Equation 5-42 (King & Brater, 1963).

**Equation 5-42** $$Q = 2.5 \tan\left(\frac{\theta}{2}\right) H^{2.5}$$

where:

Q = discharge (cfs)
$\theta$ = angle of V-notch (degrees)
H = head on apex of notch (ft)

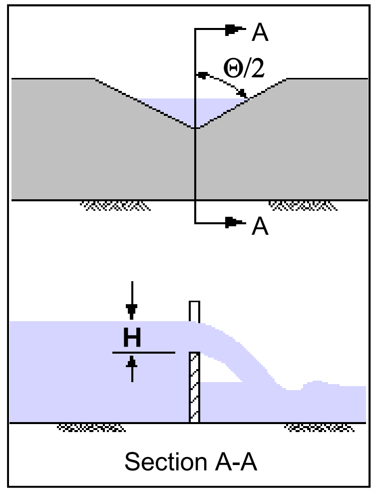



**Figure 5-45 V-Notch Weir**

***Proportional Weirs***

Although it may be more complex to design and construct, a proportional weir may significantly reduce the required storage volume for a given site. The proportional weir is distinguished from other control devices by having a linear head-discharge relationship achieved by allowing the discharge area to vary nonlinearly with head. A typical proportional weir is shown in Figure 5-46. Design Equations 5-43 and 5-44 are for proportional weirs (HEC-22, 2001).

**Equation 5-43** $$Q = 4.97a^{0.5}b\left(H - \frac{a}{3}\right)$$

**Equation 5-44** $$\frac{x}{b} = 1 - \left(\frac{1}{3.17}\right)\left(\arctan\left(\frac{y}{a}\right)^{0.5}\right)$$

where:

Q = discharge, cfs

Dimensions a, b, H, x, and y are shown in Figure 5-46.

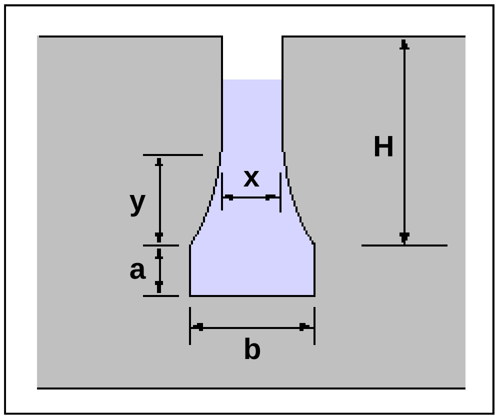



**Figure 5-46 Proportional Weir Dimensions**

***Combination Outlets***

Combinations of orifices, weirs, and pipes can be used to provide multi-stage outlet control for different purposes within a storage facility (i.e., water quality protection volume, channel protection volume, and flood control).

There are generally two types of combination outlets: shared outlet control structures and separate outlet controls. Shared outlet control is typically a number of individual outlet openings (orifices), weirs, or drops at different elevations on a riser pipe or box which all flow to a common larger conduit or pipe. Figure 5-47 shows an example of a riser designed for a wet extended detention pond.

Separate outlet controls are less common and may consist of several pipe or culvert outlets at different levels in the storage facility that are either discharged separately or are combined to discharge at a single location.

The use of a combination outlet requires the construction of a composite stage-discharge curve (as shown in Figure 5-48) suitable for control of multiple storm flows. The design of multi-stage combination outlets is discussed later in this section.

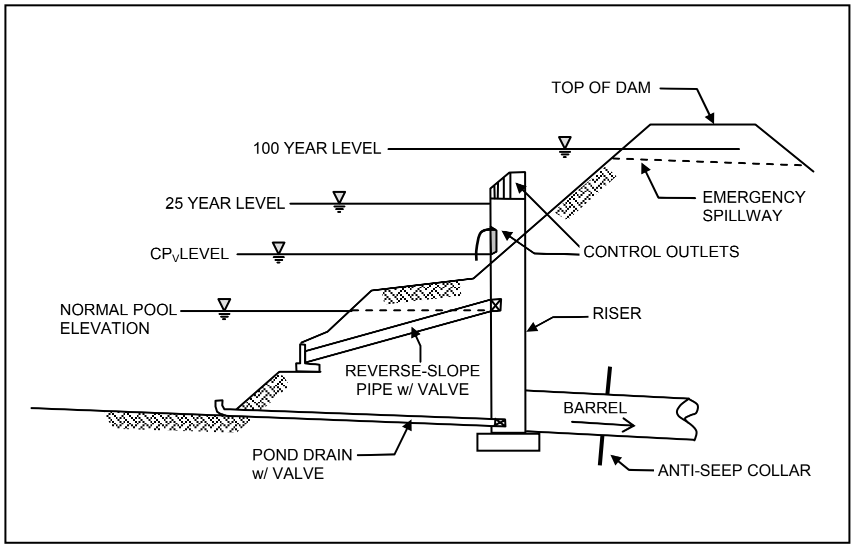



**Figure 5-47 Schematic of Combination Outlet Structure**

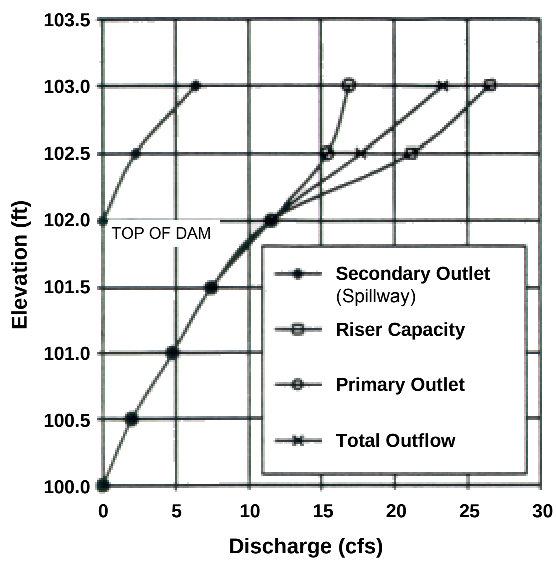



**Figure 5-48 Composite Stage-Discharge Curve**

## 5.6.3 Extended Detention Outlet Protection

Small low flow orifices such as those used for small storm detention and extended detention applications can easily clog, preventing the structural control from meeting its design purpose(s) and potentially causing adverse impacts. Therefore, orifices shall be adequately protected from clogging. There are a number of different anti-clogging designs, including:

- The use of a reverse slope pipe attached to a riser for a stormwater pond or wetland with a permanent pool (see Figure 5-47). The inlet is submerged a minimum of 1 foot below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond.

- The use of a hooded outlet for a stormwater pond or wetland with a permanent pool (see Figure 5-49 and Figure 5-50).
- Internal orifice protection through the use of an over-perforated vertical stand pipe with ½-inch orifices or slots that are protected by wirecloth and a stone filtering jacket (see Figure 5-51). Internal orifice size requirements may be attained by the use of adjustable gate valves to achieve an equivalent orifice diameter.

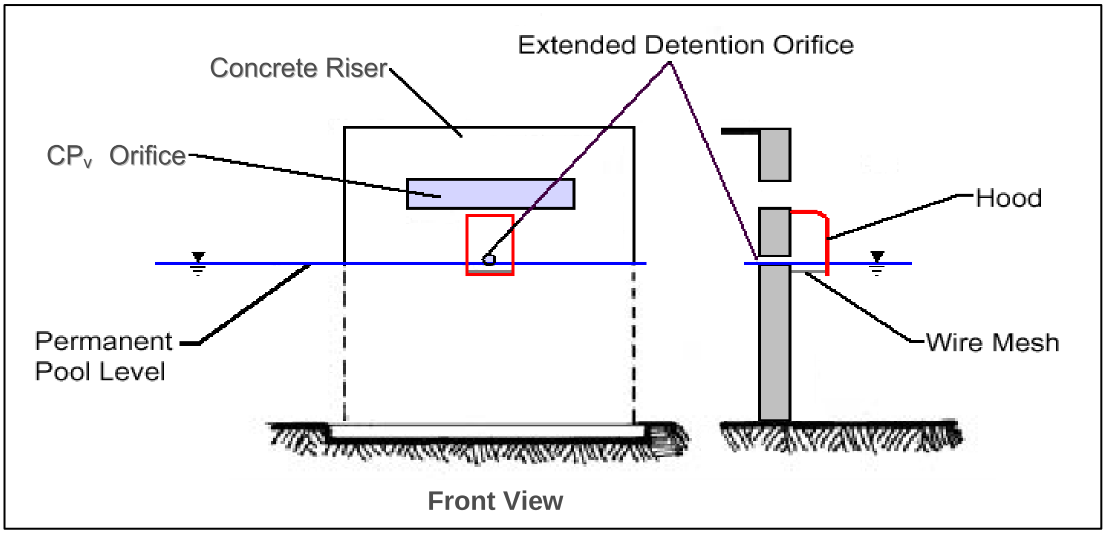



**Figure 5-49 Hooded Outlet**

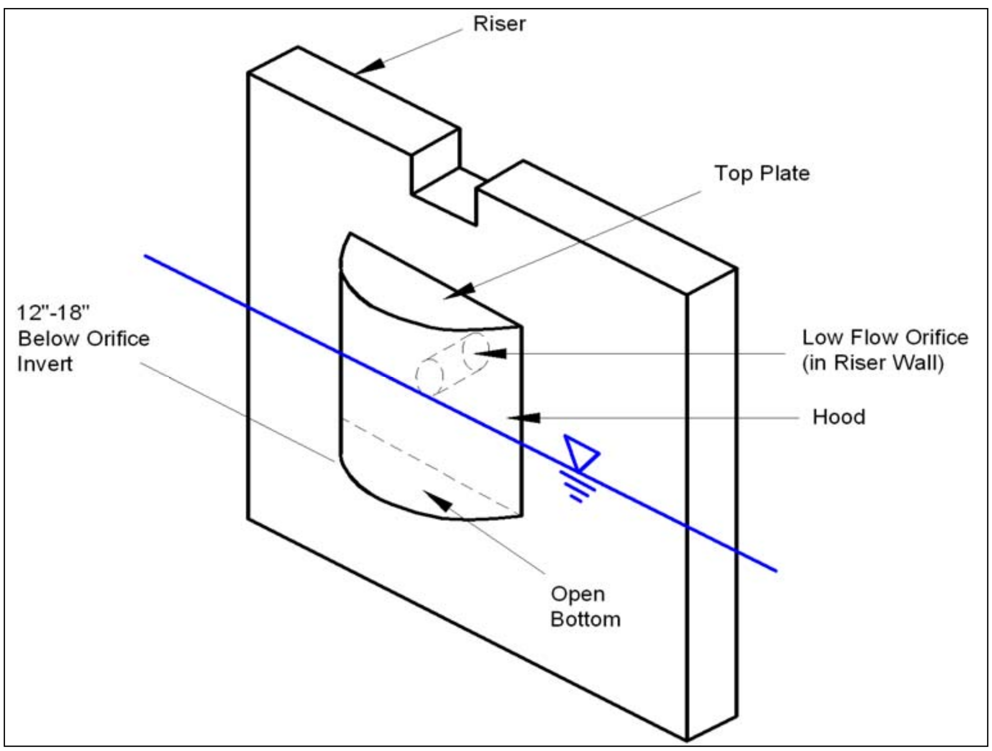



**Figure 5-50 Orifice Hood**

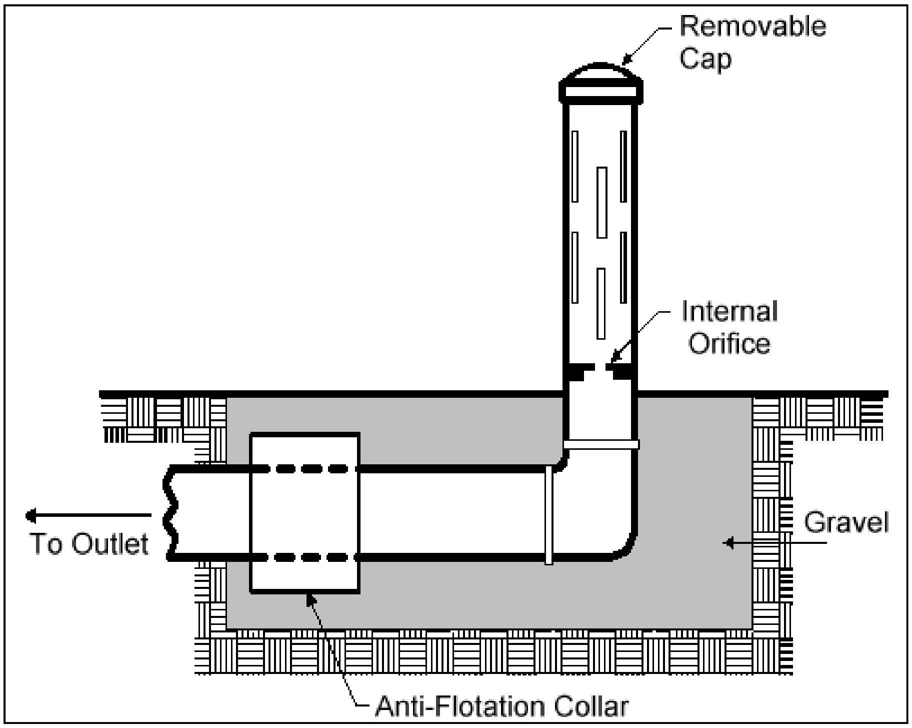



**Figure 5-51  Internal Control for Orifice Protection**

### 5.6.4 Trash Racks and Safety Grates

***Introduction***

The susceptibility of larger inlets to clogging by debris and trash must be considered when estimating their hydraulic capacities. In most instances trash racks will be needed. Trash racks and safety grates are a critical element of outlet structure design and serve several important functions:

- Keeping debris away from the entrance to the outlet works where they will not clog the critical portions of the structure.
- Capturing debris in such a way that relatively easy removal is possible.
- Ensuring that people and animals are kept out of confined conveyance and outlet areas.
- Providing a safety system that prevents anyone from being drawn into the outlet and allows them to climb to safety.

When designed properly, trash racks serve these purposes without interfering significantly with the hydraulic capacity of the outlet (or inlet in the case of conveyance structures) (ASCE, 1985; Allred-Coonrod, 1991). The location and size of the trash rack depends on a number of factors, including head losses through the rack, structural convenience, safety and size of outlet.

An example of trash racks used on a riser outlet structure is shown in Figure 5-52. The inclined vertical bar rack is most effective for lower stage outlets. Debris will ride up the trash rack as water levels rise. This design also allows for removal of accumulated debris with a rake while standing on top of the structure.

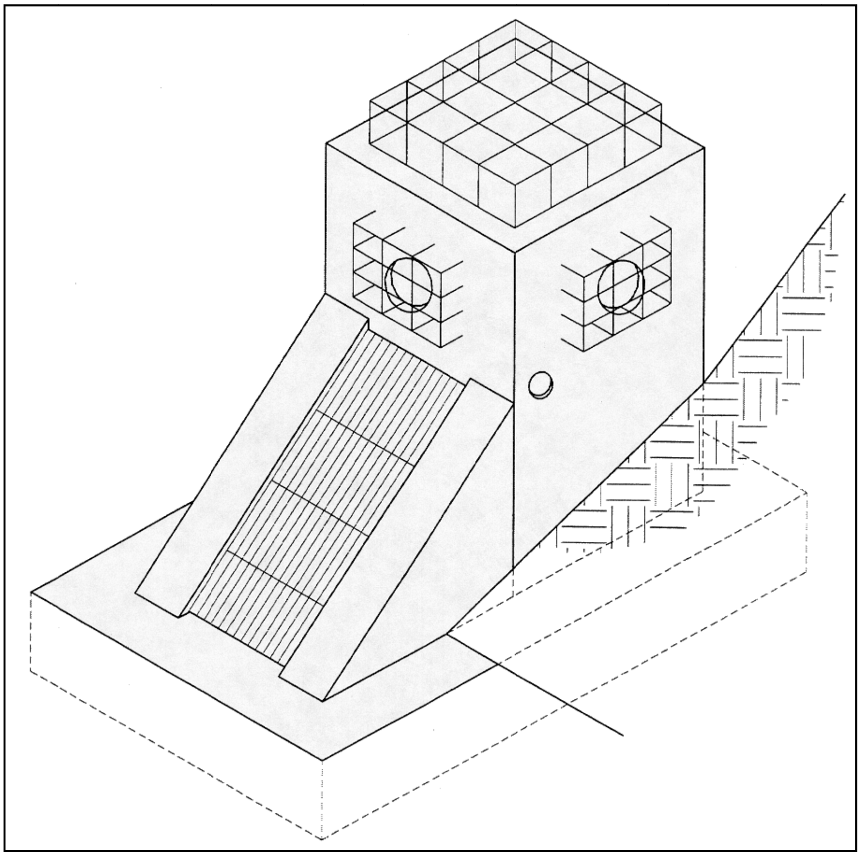


**Figure 5-52 Example of Various Trash Racks Used on a Riser Outlet Structure**
(VDCR, 1999)

***Trash Rack Design***

Trash racks must be large enough so that partial clogging will not adversely restrict flows reaching the control outlet. The surface area of all trash racks should be maximized and the trash racks shall be located a suitable distance from the protected outlet to avoid interference with the hydraulic capacity of the outlet. The control for the outlet shall not shift to the rack, nor shall the rack cause the headwater to rise above planned levels. The bar opening spacing shall be less than the pipe diameter, and in no case greater than 6 inches.

However, where a small orifice is provided, a separate trash rack for that outlet shall be used, so that a simpler, sturdier trash rack with more widely spaced members can be used for the other outlets. Spacing of the rack bars shall be wide enough to avoid interference, but close enough to provide the level of clogging protection required.

Figure 5-53 shall be used to size trash rack openings based on outlet diameter (UDFCD, 1992). Judgment should be used in that an area with higher debris (e.g., a wooded area) may require more opening space.

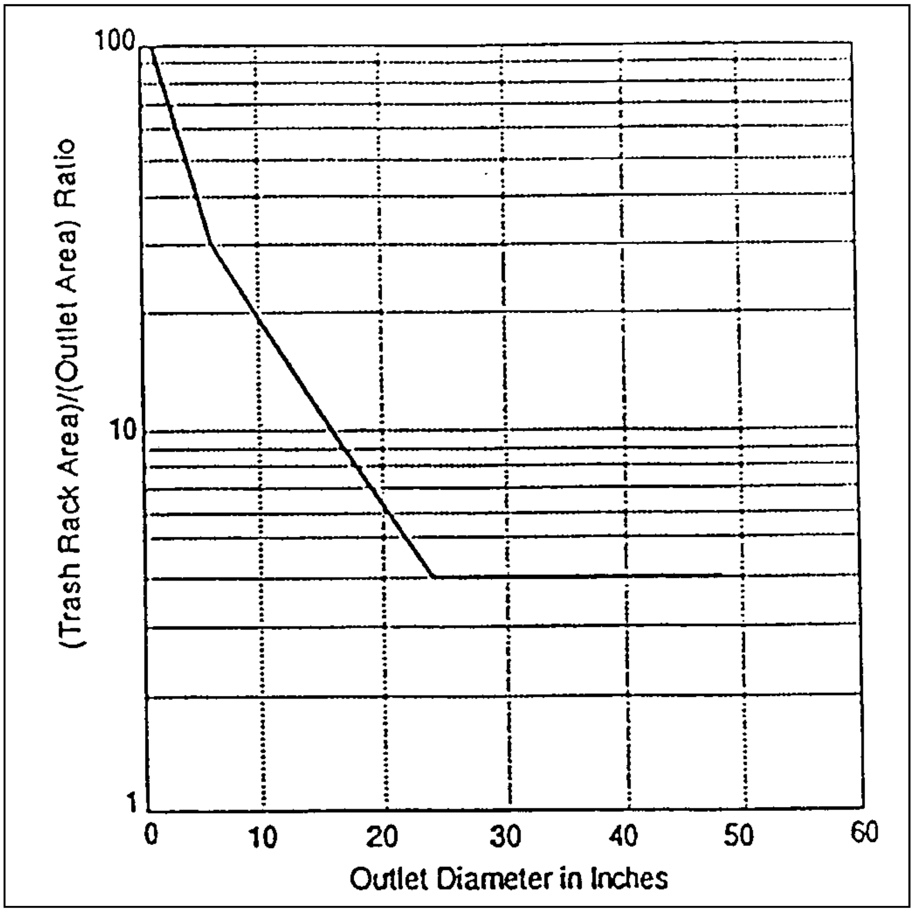



**Figure 5-53 Minimum Rack Size vs. Outlet Diameter**
(UDCFD, 1992)

Trash racks at entrances to pipes and conduits should be sloped at about 3H:1V to 5H:1V to allow trash to slide up the rack with flow pressure and rising water level — the slower the approach flow, the flatter the angle.

To facilitate removal of accumulated debris and sediment from around the outlet structure, the racks shall have hinged connections. If the rack is bolted or set in concrete it will preclude removal of accumulated material and will eventually adversely affect the outlet hydraulics.

Since sediment will tend to accumulate around the lowest orifice of a multistage riser, the riser outlet must be set far enough below the lowest orifice to ensure that sediment is flushed through the riser.

Collapsible racks have been used in some places if clogging becomes excessive or a person becomes pinned to the rack. Alternately, debris for culvert openings can be caught upstream from the opening by using barriers such as a chain safety net (USBR, 1978; UDFCD, 1999).

### Example Problem

Find the trash rack open area:

Outlet Diameter = 20 in
Outlet Area = 2.18 $ft^2$

From Figure 5-53:
(Trash Rack Area)/(Outlet Area) ratio = 6

Therefore the required track rack opening area = (2.18)(6) = 13 $ft^2$
See (UDCFD, 1992) for more examples.

## 5.6.5 Secondary Outlets

The purpose of a secondary outlet (emergency spillway) is to provide a controlled overflow for the maximum design storm for a storage facility. Figure 5-54 shows an example of an emergency spillway.

Emergency spillway designs are open channels, usually rectangular or trapezoidal in cross section, and consist of an inlet channel, a control section, and an exit channel (see Figure 5-54). The emergency spillway is proportioned to pass flows for the storage facility maximum design flood (the 100-year flood in Wichita and Sedgwick County) without overtopping the embankment. The 100-year flood discharge, assuming blockage of all primary outlets, must be conveyed with 1 foot of freeboard to the top of the dam. The concrete discharge channel of the spillway shall also have a minimum of 1 foot of freeboard. Flow in the emergency spillway is open channel flow. Normally, it is assumed that critical depth occurs at the control section.

**Figure 5-54 Emergency Spillway**

# 5.7 Energy Dissipation

## 5.7.1 Introduction

The outlets of pipes and lined channels are points of critical erosion potential. Stormwater transported through man-made conveyance systems at design capacity often reaches a velocity that exceeds the capacity of the receiving channel to resist erosion. To prevent scour at stormwater outlets, protect the outlet structure, and minimize the potential for downstream erosion, a flow transition structure shall be used to absorb the initial impact of flow and reduce the flow velocity to a non-erosive value.

Energy dissipators are engineered devices such as riprap aprons or concrete baffles placed at the outlet of stormwater conveyances for the purpose of reducing the velocity, energy and turbulence of the discharged flow.

The orientation of the outfall is another important design consideration. Where practical, the outlet of the storm drain should be positioned in the outfall channel so that it is oriented in a downstream direction relative to the streambed. This will reduce turbulence and the potential for excessive erosion.

## 5.7.2 General Criteria

Erosion problems at culvert, storm sewer, and spillway outlets are common. Determination of the flow conditions, scour potential, and channel erosion resistance shall be standard procedure for all designs.

Energy dissipators shall be employed whenever the shear of flow leaving a stormwater management facility exceeds the permissible shear, or the velocity exceeds the permissible velocity for the downstream channel system, for the 2, 5 and 10-year storms. Energy dissipator designs will vary based on discharge specifics and tailwater conditions.

In addition, protection against damage to any component of a dam must be provided for all flows up to and including the 100-year maximum design event. This usually requires the installation of protective riprap on the downstream face of the dam and adjacent areas where flow velocities or high turbulence will occur. Riprap in those areas may be sized using Equation 5-27 with a C value of 0.86 instead of 1.2 (HDC 712-1, USACE).

Pipe and culvert outlet structures should provide uniform redistribution or spreading of the flow without excessive separation and turbulence. For most designs, the following outlet protection devices and energy dissipators provide sufficient protection at a reasonable cost:

- Riprap apron;
- Riprap outlet basins;
- Grade Control Structures.

This section focuses on the design on these measures. The reader is referred to the Federal Highway Administration Hydraulic Engineering Circular No. 14 entitled, Hydraulic Design of Energy Dissipators for Culverts and Channels, for the design procedures for other energy dissipators.

## 5.7.3 Design Guidelines

If outlet protection is required, choose an appropriate type. Suggested outlet protection facilities and applicable flow conditions (based on Froude number and dissipation velocity) are described below:

- Riprap aprons may be used when the outlet Froude number (Fr) is less than or equal to 2.5. In general, riprap aprons prove economical for transitions from culverts to overland sheet flow at terminal outlets, but may also be used for transitions from culvert sections to stable channel sections. Stability of the surface at the termination of the apron shall be considered.
- Riprap outlet basins may also be used when the outlet Fr is less than or equal to 2.5. They are generally used for transitions from culverts to stable channels. Since riprap outlet basins function by creating a hydraulic jump to dissipate energy, performance is impacted by tailwater conditions.

When outlet protection facilities are selected, appropriate design flow conditions and site-specific factors affecting erosion and scour potential, construction cost, and long-term durability shall be considered. Evaluate the downstream channel stability and provide appropriate erosion protection if channel degradation is otherwise expected to occur per the guidance found in Section 5.5.4.

## 5.7.4 Riprap Aprons

***Description***

A riprap-lined apron is a commonly used practice for energy dissipation because of its relatively low cost and ease of installation. A flat riprap apron can be used to prevent erosion at the transition from a pipe or box culvert outlet to a natural channel. Protection is provided primarily by having sufficient length and flare to dissipate energy by expanding the flow.

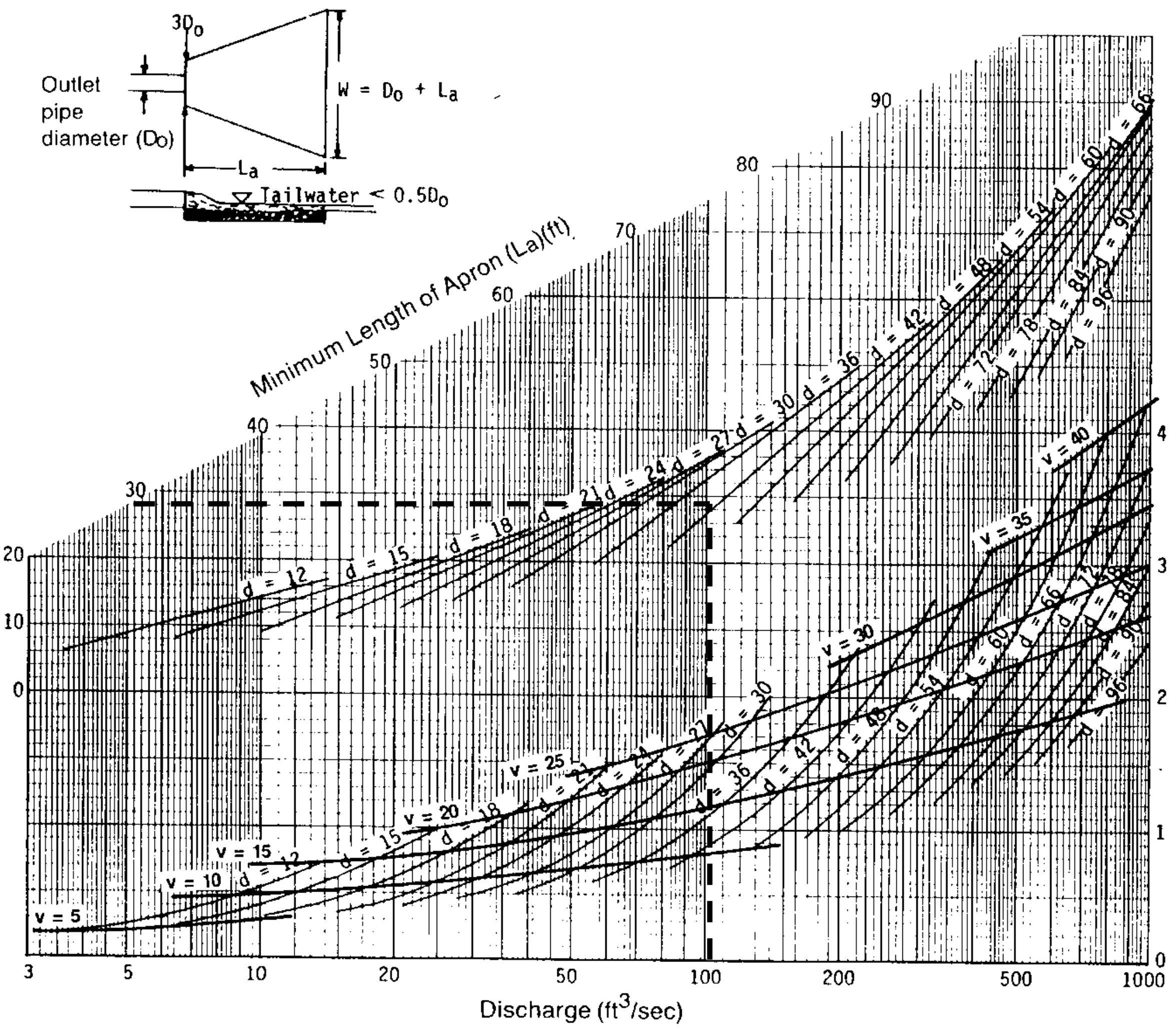
***Design Procedure***

The procedure presented in this section is taken from USDA, SCS (1975). Two sets of curves, one for minimum and one for maximum tailwater conditions, are used to determine the apron size and the median riprap diameter, $d_{50}$. If tailwater conditions are unknown, or if both minimum and maximum conditions may occur, the apron shall be designed to meet criteria for both. Although the design curves are based on round pipes flowing full, they can be used for partially full pipes and box culverts. The design procedure consists of the following steps:

**Step 1** If possible, determine tailwater conditions for the channel. If tailwater is less than one-half the discharge flow depth (pipe diameter if flowing full), minimum tailwater conditions exist and the curves in Figure 5-55 apply. Otherwise, maximum tailwater conditions exist and the curves in Figure 5-56 shall be used.

**Step 2** Determine the correct apron length and median riprap diameter, $d_{50}$, using the appropriate curve. If tailwater conditions are uncertain, find the values for both minimum and maximum conditions and size the apron as shown in Figure 5-57.

- For pipes flowing full use the depth of flow, d, which equals the pipe diameter, in feet, and design discharge, in cfs, to obtain the apron length, $L_a$, and median riprap diameter, $d_{50}$, from the appropriate curves.
- For pipes flowing partially full use the depth of flow, d, in feet, and velocity, v, in ft/s. On the lower portion of the appropriate figure, find the intersection of the d and v curves, and then find the riprap median diameter, $d_{50}$, from the scale on the right. From the lower d and v intersection point, move vertically to the upper curves until intersecting the curve for the correct flow depth, d. Find the minimum apron length, La from the scale on the left.
- For box culverts use the depth of flow, d, in feet, and velocity, v, in feet/second. On the lower portion of the appropriate figure, find the intersection of the d and v curves, and then find the riprap median diameter, $d_{50}$, from the scale on the right. From the lower d and v intersection point, move vertically to the upper curve until intersecting the curve equal to the flow depth, d. Find the minimum apron length, $L_a$, using the scale on the left.




Curves may not be extrapolated.

**Figure 5-55 Design of Riprap Apron under Minimum Tailwater Conditions**
(USDA, SCS, 1975)

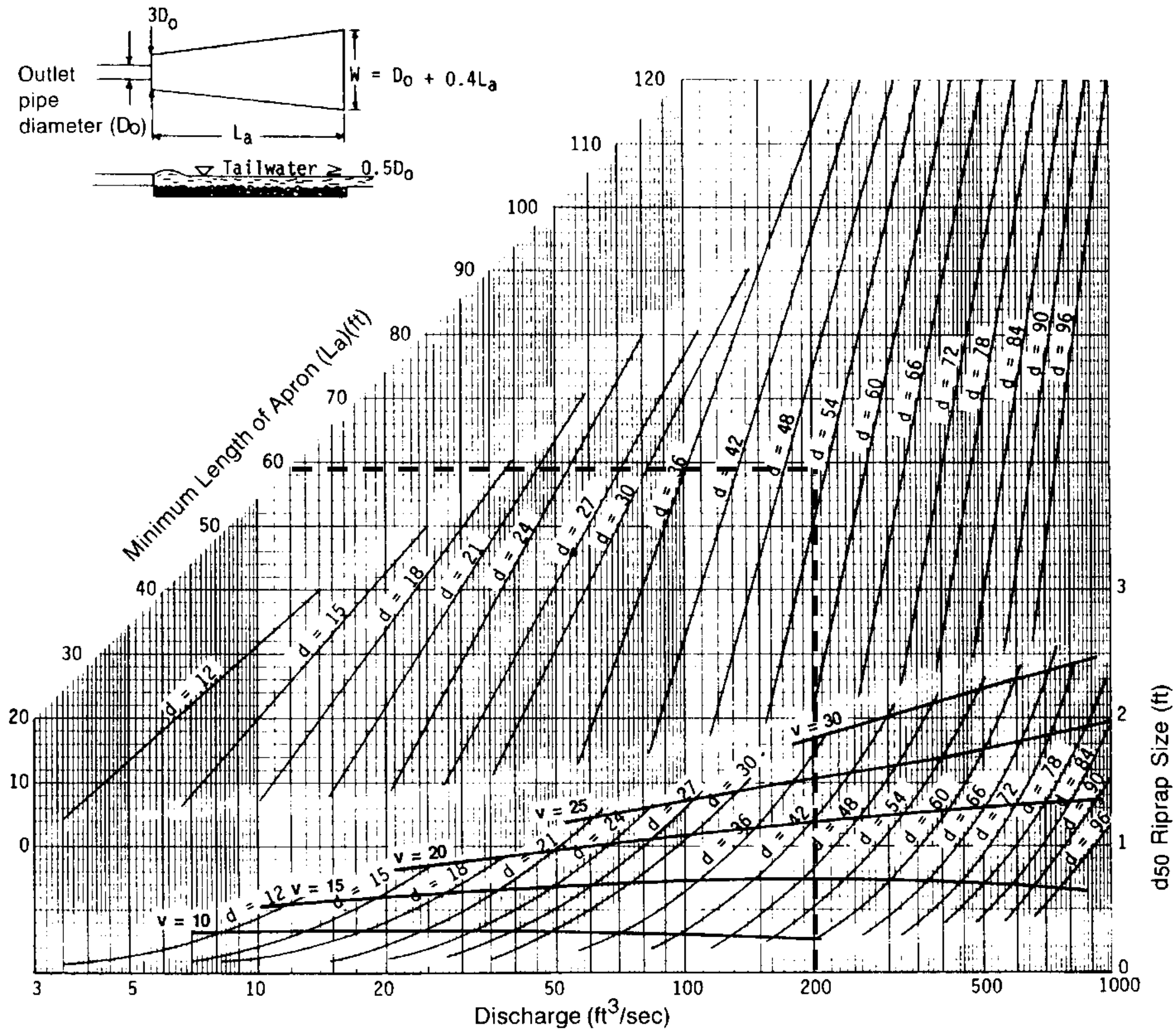
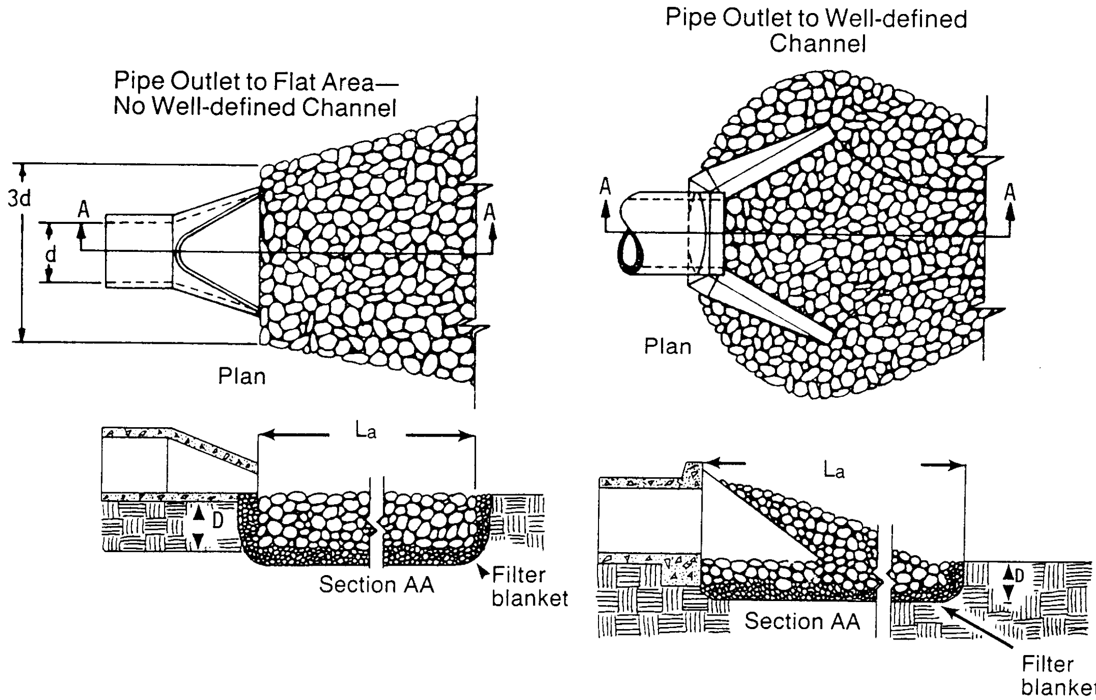



**Figure 5-56 Design of Riprap Apron under Maximum Tailwater Conditions**
(USDA, SCS, 1975)




NOTES:
1. $L_a$ is the length of the riprap apron.
2. D = 1.5 times the maximum stone diameter but not less than 6 inches.
3. In a well defined channel extend the apron up the channel banks to an elevation of 6 inches above the maximum tailwater depth or to the top of the bank, whichever is less.
4. A filter blanket or filter fabric shall be installed between the riprap and soil foundation.

**Figure 5-57 Riprap Apron**
(Manual for Erosion and Sediment Control in Georgia, 1996)

***Design Considerations***

The following items shall be considered during riprap apron design:

- The maximum stone diameter should be 1.5 times the median riprap diameter.
- The riprap thickness should be 1.5 times the maximum stone diameter or 6 inches, whichever is greater. (Apron thickness may be reduced to 1.5 x $d_{50}$ when an appropriate filter fabric is used under the apron.)
- The apron width at the discharge outlet shall be at least equal to the pipe diameter or culvert width, $d_w$. Riprap shall extend up both sides of the apron and around the end of the pipe or culvert at the discharge outlet at a maximum slope of 3:1 and a height not less than the pipe diameter or culvert height, and shall taper to the flat surface at the end of the apron.
- If there is a well-defined channel, the apron length shall be extended as necessary so the downstream apron width is equal to the channel width. The sidewalls of the channel shall not be steeper than 3:1.

- If the ground slope downstream of the apron is steep, channel erosion may occur. The apron shall be extended as necessary until the slope is gentle enough to prevent further erosion.

### Example Problem – Riprap Apron Design #1

A flow of 280 cfs discharges from a 66-in pipe with a tailwater of 2 ft above the pipe invert. Find the required design dimensions for a riprap apron.

Determine 0.5 $D_o$.

$D_o$ = 66 in = 5.5 ft; therefore, 0.5 $D_o$ = 2.75 ft.
Since TW = 2 ft is less than 2.75 ft, use Figure 5-55 for minimum tailwater conditions.

Determine the apron length ($L_a$) and median stone size ($d_{50}$) using Figure 5-55.

Start at discharge = 280 cfs and read right to $d_{50}$ of 1.2 ft.
Continue up to the intersection with the d = 66 in curve, and read left to $L_a$ = 38 ft.

Determine the downstream apron width.

The downstream apron width equals the pipe diameter plus the apron length:
$W = D_o + L_a = 5.5 + 38 = 43.5$ ft

Determine the maximum riprap diameter.

Maximum riprap diameter is 1.5 times the median stone size:
$d_{max} = 1.5\ (d_{50}) = 1.5\ (1.2) = 1.8$ ft

Determine the riprap depth.

Riprap depth is 1.5 times the maximum riprap diameter
Riprap depth = 1.5 ($d_{max}$) = 1.5 (1.8) = 2.7 ft.

### Example Problem – Riprap Apron Design #2

A concrete box culvert 5.5 ft high and 10 ft wide conveys a flow of 600 cfs at a depth of 5.0 ft. Tailwater depth is 5.0 ft above the culvert outlet invert. Find the design dimensions for a riprap apron.

Determine 0.5 $D_o$.

$D_o$ = 0.5 (5.0) = 2.5 ft.
Since TW = 5.0 ft is greater than 2.5 ft, use Figure 5-56 for maximum tailwater conditions.

Determine the outlet velocity

v = Q/A = 600/[(5)(10)] = 12 ft/s

Determine the apron length ($L_a$) and median stone size ($d_{50}$) using Figure 5-56.

Start at the intersection of the curves, $D_o$ = 60 in and v = 12 ft/s.
Read right to $d_{50}$ = 0.4 ft.
Reading up to the intersection with d = 60 in, read left to $L_a$ = 40 ft.

Determine the downstream apron width.

Apron width downstream is equal to the pipe diameter plus 0.4 times apron length
$W = D_o + 0.4\ L_a = 10 + 0.4\ (40) = 26$ ft.

Determine the maximum riprap diameter.

$d_{max} = 1.5\ (d_{50}) = 1.5\ (0.4) = 0.6$ ft.

Determine the riprap depth.

Riprap depth = $1.5\ (d_{max}) = 1.5\ (0.6) = 0.9$ ft.

---

## 5.7.5 Riprap Basins

***Description***

Another method to reduce the exit velocities from stormwater outlets is through the use of a riprap basin. A riprap outlet basin is a preshaped scourhole lined with riprap that functions as an energy dissipator by forming a hydraulic jump.

***Basin Features***

General details of the basin recommended in this section are shown in Figure 5-58. Principal features of the basin are:

- The basin is preshaped and lined with riprap of median size ($d_{50}$).
- The floor of the riprap basin is constructed at an elevation of $h_s$ below the culvert invert. The dimension $h_s$ is the approximate depth of scour that would occur in a thick pad of riprap of size $d_{50}$ if subjected to design discharge. The ratio of $h_s$ to $d_{50}$ of the material shall be between 2 and 4.
- The length of the energy dissipating pool is 10 x $h_s$ or 3 x $W_o$, whichever is larger. The overall length of the basin is 15 x $h_s$ or 4 x $W_o$, whichever is larger.

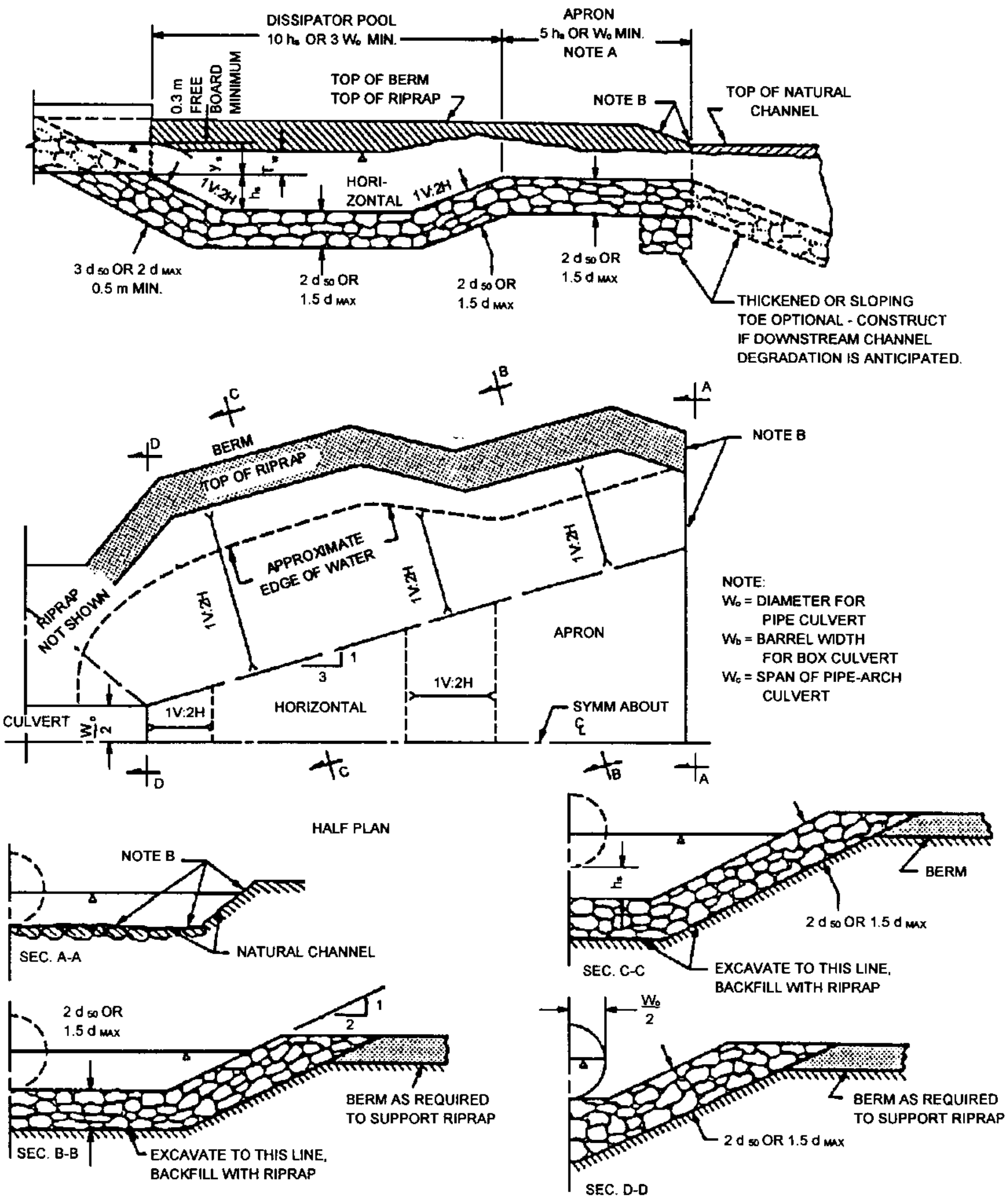
***Design Procedure***

The following procedure shall be used for the design of riprap basins.

- Estimate the flow properties at the brink (outlet) of the culvert. Establish the outlet invert elevation such that $TW/y_o \le 0.75$ for the design discharge.

- For subcritical flow conditions (culvert set on mild or horizontal slope) use Figure 5-59 or Figure 5-60 to obtain $y_o/D$, then obtain $V_o$ by dividing Q by the wetted area associated with $y_o$. D is the height of a box culvert. If the culvert is on a steep slope, $V_o$ will be the normal velocity obtained by using the Manning equation for appropriate slope, section, and discharge.
- For channel protection, compute the Froude number for brink conditions with $y_e = (A/2)^{1.5}$. Select $d_{50}/y_e$ appropriate for locally available riprap (usually the most satisfactory results will be obtained if $0.25 < d_{50}/y_e < 0.45$). Obtain $h_s/y_e$ from Figure 5-61, and check to see that $2 < h_s/d_{50} < 4$. Recycle computations if $h_s/d_{50}$ falls out of this range.
- Size basin as shown in Figure 5-58.

Material, construction techniques, and design details for riprap shall be in accordance with specifications in the Federal Highway publication HEC No. 11 entitled Use of Riprap For Bank Protection.




NOTE A - IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS-SECTIONAL AREA AT SECTION A-A SUCH THAT Q/(CROSS SECTION AREA AT SEC. A-A) = SPECIFIED EXIT VELOCITY.

NOTE B - WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A-A.

**Figure 5-58 Details of Riprap Outlet Basin**

(Source: HEC-14, 2006)

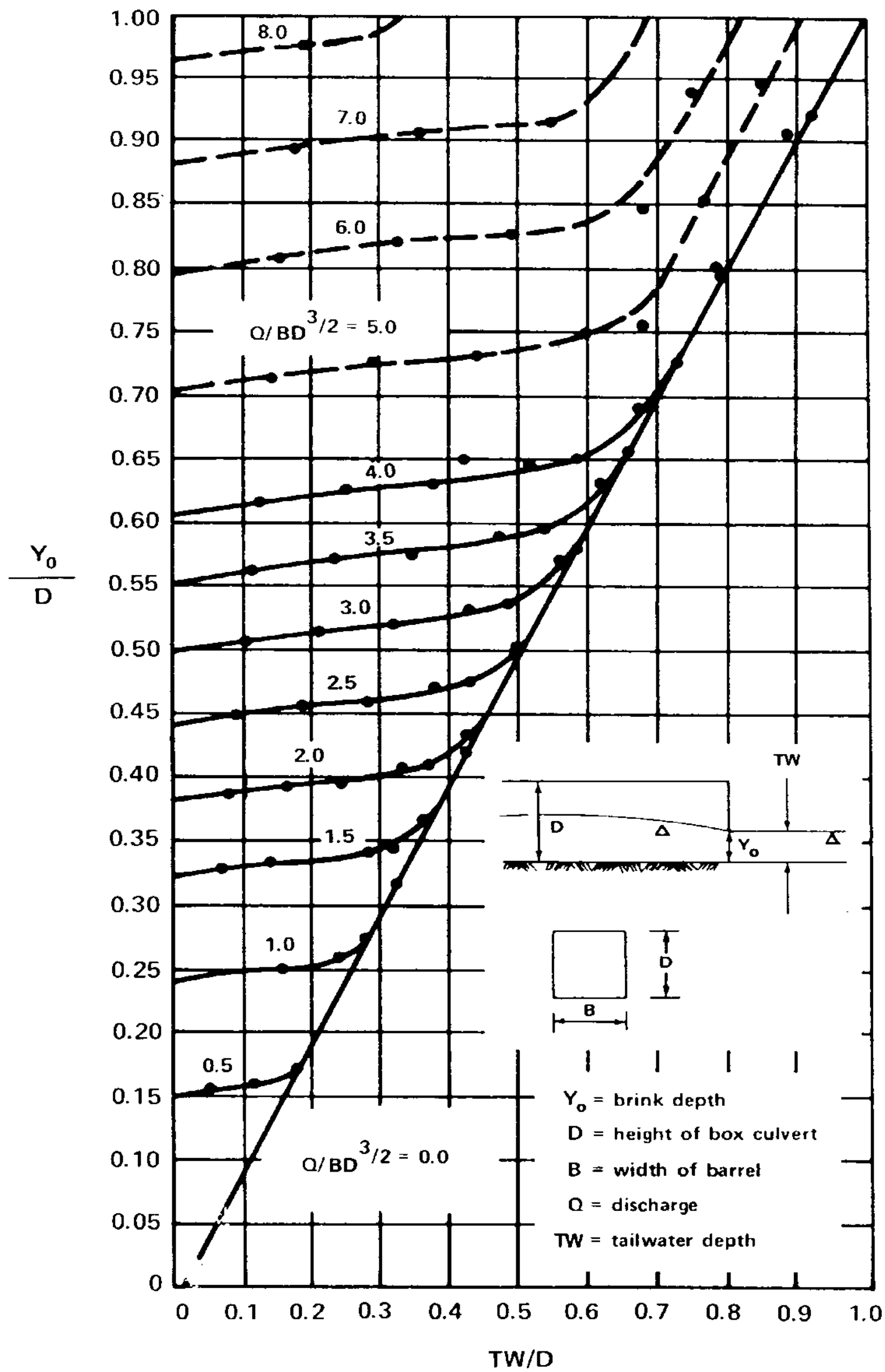



**Figure 5-59 Dimensionless Rating Curves for Rectangular Culvert Outlets on Horizontal and Mild Slopes**

(Source: USDOT, FHWA, HEC-14, 2006)

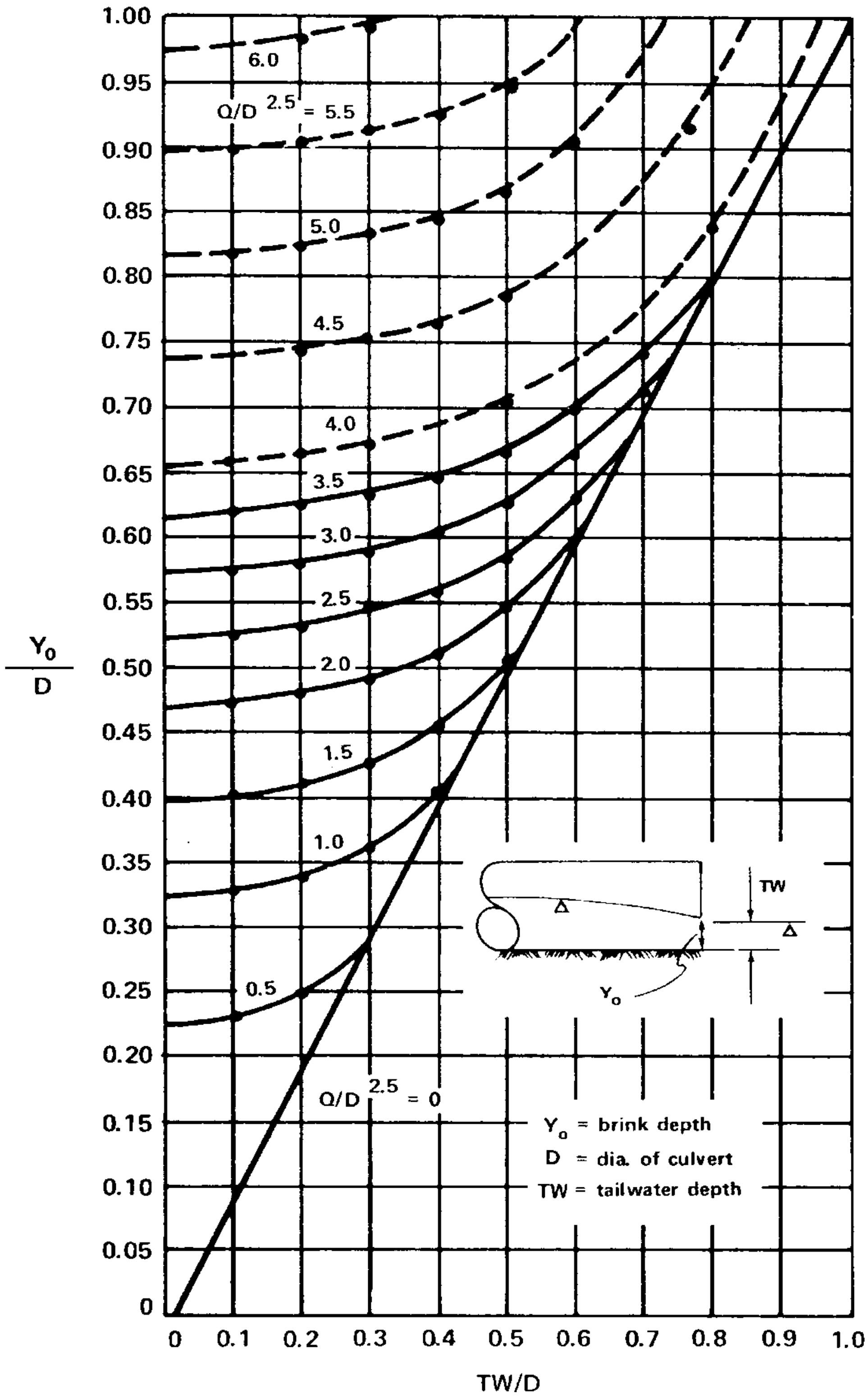



**Figure 5-60 Dimensionless Rating Curves for Circular Culvert Outlets on Horizontal and Mild Slopes**
(Source: USDOT, FHWA, HEC-14, 2006)

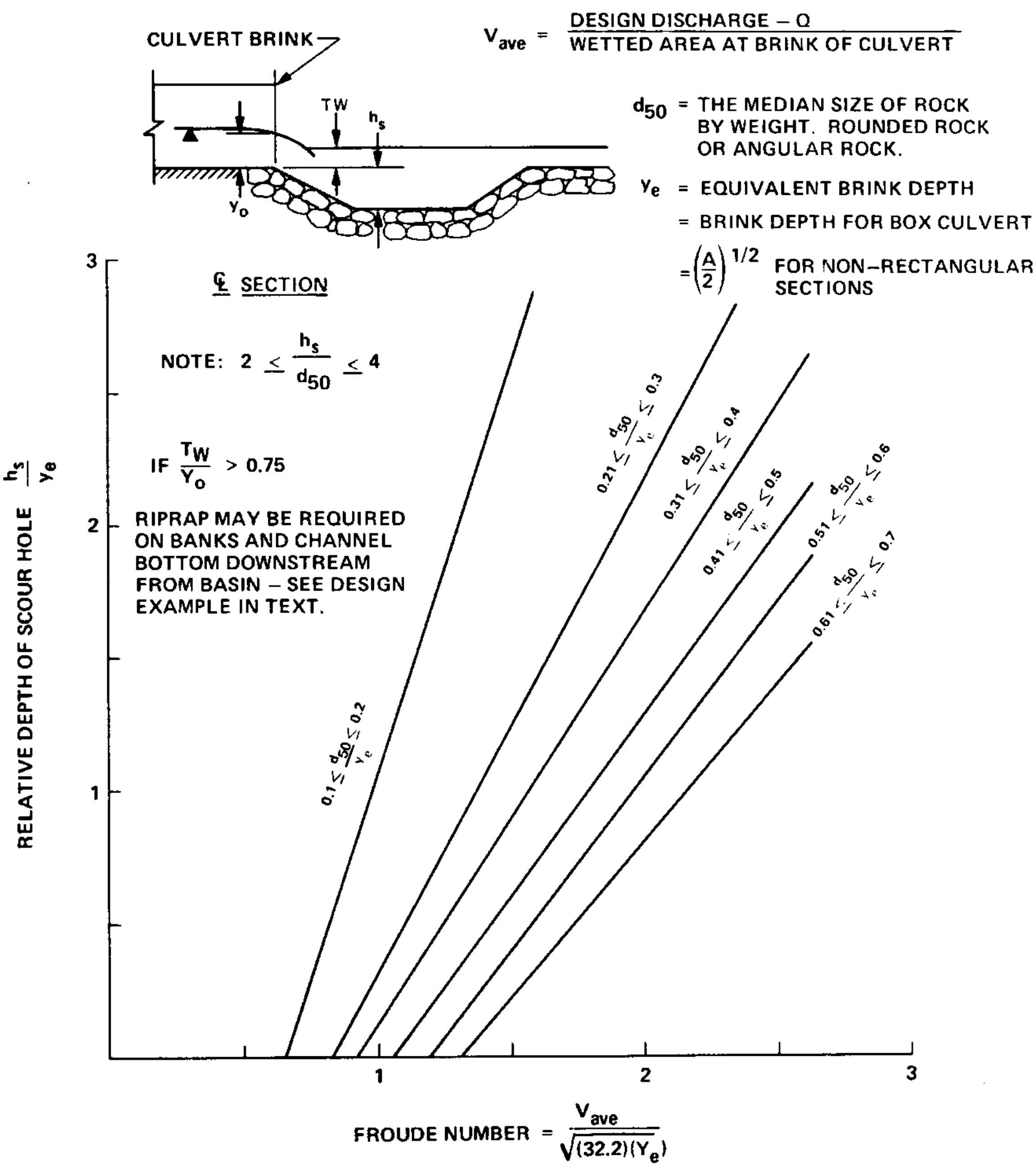



**Figure 5-61 Depth of Scour Hole vs Froude Number at Brink of Culvert (with respect to Size of Riprap)**
(USDOT, FHWA, HEC-14, 2006)

***Design Considerations***

Riprap basin design shall include consideration of the following:

The dimensions of a scourhole in a basin constructed with angular rock can be approximately the same as the dimensions of a scourhole in a basin constructed of rounded material when rock size and other variables are similar.

When the ratio of tailwater depth to brink depth, $TW/y_o$, is less than 0.75 and the ratio of scour depth to size of riprap, $h_s/d_{50}$, is greater than 2.0, the scourhole should function very efficiently as an energy dissipator. The concentrated flow at the culvert brink plunges into the hole, a jump forms against the downstream extremity of the scourhole, and flow is generally well dispersed leaving the basin.

The mound of material formed on the bed downstream of the scourhole contributes to the dissipation of energy and reduces the size of the scourhole; that is, if the mound from a stable scoured basin is removed and the basin is again subjected to design flow, the scourhole will enlarge.

For high tailwater basins ($TW/y_o$ greater than 0.75), the high velocity core of water emerging from the culvert retains its jet-like character as it passes through the basin and diffuses similarly to a concentrated jet diffusing in a large body of water. As a result, the scourhole is much shallower and generally longer. Consequently, riprap may be required for the channel downstream of the rock-lined basin.

It should be recognized that there is a potential for limited degradation to the floor of the dissipator pool for rare event discharges. With the protection afforded by the $2(d_{50})$ thickness of riprap, the heavy layer of riprap adjacent to the channel prism, and the apron riprap in the downstream portion of the basin, such damage should be superficial.

See Standards in FHWA HEC No. 11 for details on riprap materials and use of filter fabric.

Stability of the surface at the outlet of a basin shall be considered using the methods for open channel flow as outlined in Section 5.5.5.

---

## Example Problem – Riprap Basin Design #1

Size a riprap basin to protect against scour for the following conditions:

| | |
|---|---|
| Box culvert - 8 ft by 6 ft (invert = 112.2') | Design Discharge Q = 800 cfs |
| Supercritical flow in culvert | Normal flow depth = brink depth |
| $Y_o$ = 4 ft | Tailwater depth TW = 2.8 ft |

Determine $y_{e.}$

$y_o = y_e$ for rectangular section; therefore, with $y_o$ given as 4 ft, $y_e$ = 4 ft.

Determine culvert exit velocity.

$V_o$ = Q/A = 800/(4 x 8) = 25 ft/s

Determine exit Froude number and check that it is less than 2.5. Froude numbers greater than 2.5 must utilize dissipators more structurally sound than riprap basins.

Froude Number = Fr = $V/(g \times y_e)^{0.5}$
Fr = $25/(32.2 \times 4)^{0.5}$ = 2.20, therefore Fr < 2.5 OK

Determine TW/$y_e$ and check that it is less than 0.75 so that the scourhole does not grow beyond the dissipator by jet action.

TW/$y_e$ = 2.8/4.0 = 0.7, therefore, TW/$y_e$ < 0.75 OK

Choose median size of stone ($d_{50}$) such that $h_s/d_{50}$ is between 2 and 4.

Try $d_{50}/y_e$ = 0.45, $d_{50}$ = 0.45 x 4 = 1.80 ft
From Figure 5-61, $h_s/y_e$ = 1.6
$h_s$ = 4 x 1.6 = 6.4 ft
$h_s/d_{50}$ = 6.4/1.8 = 3.6 ft, therefore 2 < $h_s/d_{50}$ < 4 OK

Determine dissipator pool length.

$L_s$ = 10 x $h_s$ = 10 x 6.4 = 64 ft
$L_s$ min = 3 x $W_o$ = 3 x 8 = 24 ft; therefore, use $L_s$ = 64 ft

Determine riprap basin length.

$L_B$ = 15 x $h_s$= 15 x 6.4 = 96 ft
$L_B$ min = 4 x $W_o$ = 4 x 8 = 32 ft; therefore, use $L_B$ = 96 ft

Determine riprap pool invert.

Based on Figure 5-58, pool invert = culvert invert – $h_s$
Pool invert = 112.2 – 6.4 = 105.8

Determine riprap thickness.

Thickness of riprap on the approach = 3 x $d_{50}$ = 3 x 1.8 = 5.4 ft
Thickness of riprap on the remainder = 2 x $d_{50}$ = 2 x 1.8 = 3.6 ft

Other basin dimensions per Figure 5-58.

## Example Problem – Riprap Basin Design #2

Size a riprap basin to protect against scour for the following conditions:

| | |
|---|---|
| 6' circular culvert - (invert = 120.2') | Design Discharge Q = 135 cfs |
| Subcritical flow in culvert | Normal flow depth in pipe = 4.5' |
| Tailwater depth TW = 2.0 ft | Normal velocity in channel = 5.9 ft/s |

Determine $y_{o.}$

$Q/D^{2.5} = 135/6^{2.5} = 1.53$
$TW/D = 2.0/6 = 0.33$
From Figure 5-60, $y_o/D = 0.45$
$y_o = 0.45 \times 6 = 2.7$ ft

Check $TW/y_{o.}$

$TW/y_o = 2.0/2.7 = 0.74$, therefore $TW/y_o < 0.75$ OK

Determine brink area for $y_o/D = 0.45$ from Figure 5-14 for depth = 45% of full.

Brink area = 42% of full area = $0.42*(\pi D^2/4) = 0.42*(3.14*6^2/4) = 11.9\ ft^2$

Determine pipe exit velocity.

$V_o = Q/A = 135/11.9 = 11.3$ ft/s

Determine $y_e$.

$y_e = (A/2)^{1/2} = (11.9/2)^{1/2} = 2.4$ ft

Determine Froude number (Fr).

$Fr = V_o/(32.2*y_e)^{1/2} = 11.3/(32.2*2.4)^{1/2} = 1.3$, therefore $Fr < 2.5$ OK

Choose median size of stone ($d_{50}$) such that $h_s/d_{50}$ is between 2 and 4.

Try $d_{50}/y_e = 0.25$
$d_{50} = (d_{50}/y_e)*y_e = 0.25*2.4 = 0.6$ ft
From Figure 5-61 with Fr = 1.3 and $d_{50}/y_e = 0.25$, the value of $h_s/y_e = 0.8$
$h_s = (h_s/y_e)*y_e = 0.8*2.4 = 1.9$ ft
$h_s/d_{50} = 1.9/0.6 = 3.2$, therefore $2 < h_s/d_{50} < 4$ OK

Determine dissipator pool length.

$L_s = 10 \times h_s = 10 \times 1.9 = 19$ ft
$L_s$ min $= 3 \times W_o = 3 \times 6 = 18$ ft; therefore, use $L_s = 19$ ft

Determine riprap basin length.

$L_B = 15 \times h_s = 15 \times 1.9 = 28.5$ ft

$L_B$ min = 4 x $W_o$ = 4 x 6 = 24 ft; therefore, use $L_B$ = 28.5 ft

Determine riprap pool invert.

Based on Figure 5-58, pool invert = culvert invert – $h_s$
Pool invert = 120.2 – 1.9 = 118.3

Determine riprap thickness.

Thickness of riprap on the approach = 3 x $d_{50}$ = 3 x 0.6 = 1.8 ft
Thickness of riprap on the remainder = 2 x $d_{50}$ = 2 x 0.6 = 1.2 ft

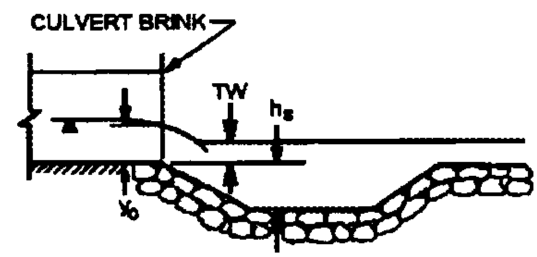
Other basin dimensions per Figure 5-58.

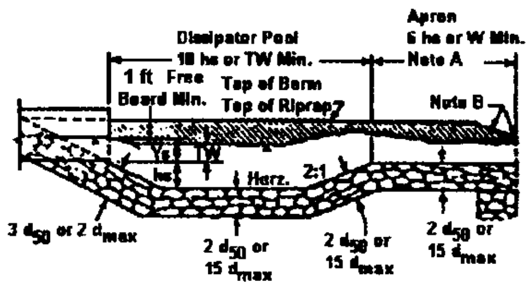
## RIPRAP BASIN

Project No. ____________________________________________

Designer ______________________________________ Date ________

Reviewer ______________________________________ Date ________




| DESIGN VALUES | TRIAL 1 | FINAL TRIAL |
|---|---|---|
| Equi. Depth, $d_E$ | | |
| $D_{50}/d_E$ | | |
| $D_{50}$ | | |
| Froude No., Fr | | |
| $h_s/d_E$ | | |
| $h_s$ | | |
| $h_s/D_{50}$ | | |
| $2 < h_s/D_{50} < 4$ | | |

| BASIN DIMENSIONS | | FEET | |
|---|---|---|---|
| Pool length is the larger of: | $10h_s$ | | |
| | $3W_o$ | | |
| Basin length is the larger of: | $15h_s$ | | |
| | $4W_o$ | | |
| Approach Thickness | $3D_{50}$ | | |
| Basin Thickness | $2D_{50}$ | | |

| TAILWATER CHECK | |
|---|---|
| Tailwater, TW | |
| Equivalent depth, $d_E$ | |
| $TW/d_E$ | |
| IF $TW/d_E > 0.75$, calculate riprap downstream | |
| $D_E = (4A_c/\pi)^{0.5}$ | |

| DOWNSTREAM RIPRAP | | | | |
|---|---|---|---|---|
| $L/D_E$ | L | $V_L/V_o$ | $V_L$ | $D_{50}$ |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Figure 5-62 Riprap Basin Design Form**
(USDOT, FHWA, HEC-14, 2006)

### 5.7.6 Grade Control Structures

When channels are relocated through easily erodible soils and stream gradients are increased, it may be unusually difficult to meet the stability requirements. This can cause bank instability, increased upstream scouring, and sloughing of natural slopes. Wichita and Sedgwick County require that streambed stability be maintained. This can be accomplished by grade stabilization structures; in essence a series of low-head weirs. The effect of these weirs is to reduce the effective energy grade line in all places except for the stabilized drop over the weir. This flatter energy grade line can then be used in channel permissible shear calculations to reduce the need for armoring of the entire channel.

If designed and constructed with ecological considerations in mind, these structures can double as habitat enhancement devices. If improperly planned however, they can actually degrade habitat values. The most productive method of installing these structures is to use low weirs that pool water just a short distance (approximately 100 feet) upstream. A plunge pool will form just below the structures, and a riffle area should develop below this pool. The next structure should be located downstream a sufficient distance to avoid frequent impounding of the riffle area below the pool at the base of the upstream weir.

Specific construction requirements and techniques can be obtained from the NRCS or other agencies upon request. In addition, “natural channel design” methods may be utilized for this type of control. The intent of this general discussion of grade stabilization structures is to promote consideration of such measures early in the planning process.

## 5.8 Level Spreaders

### 5.8.1 Introduction

A level spreader is a mechanism used to disperse concentrated runoff uniformly over the ground surface as sheet flow. The purpose of this practice is to convert concentrated, potentially erosive flow to sheet flow and release it uniformly over a stabilized area or filter strip. The resultant sheet flow enhances pollutant filtering and runoff infiltration and reduces the potential for erosion.

The level spreader is a relatively low cost structure that is used for two primary applications: to disperse shallow concentrated or channelized stormwater runoff from impervious areas to a filter strip, water quality or other buffer, or other vegetated area; or, outlet diversion (release small volumes of concentrated flow from diversions when conditions are suitable). To accomplish these purposes, a high degree of care must be taken to construct the spreader lip so it is completely level. Level spreaders must be constructed correctly since any depressions in the spreader lip will concentrate the flow, resulting in a loss of adequate dispersion of runoff. Improperly designed or constructed level spreaders can reduce the effectiveness of filter strips and buffer areas to remove pollutants, and can increase the potential for erosion in vegetated areas to which the level spreader discharges.

### 5.8.2 General Criteria

All level spreaders shall conform to the design standards listed below.

***For impervious surface runoff applications:***

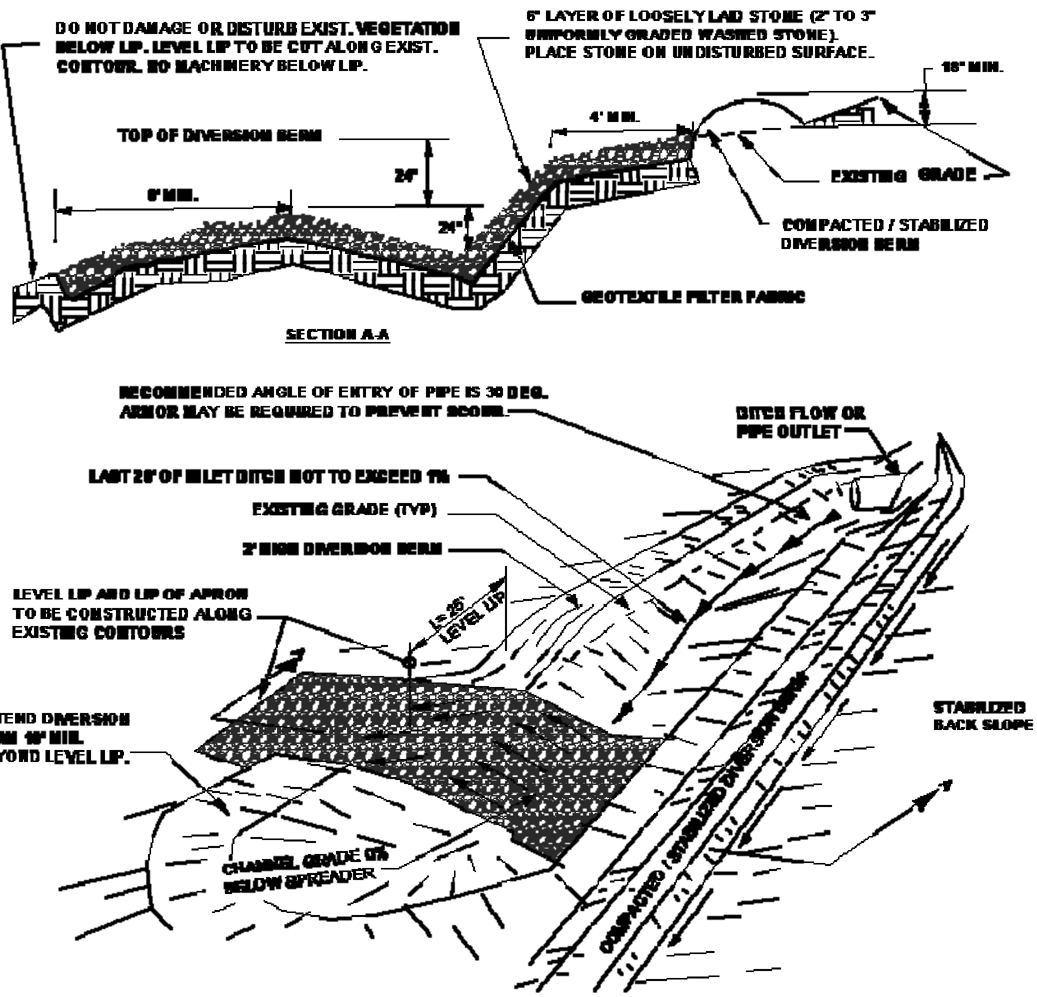
- The capacity for the level spreader is determined in the design of the filter strip to which it discharges. For filter strip design guidance, refer to Section 3.2.
- The spreader shall run linearly along the entire length of the filter strip (or buffer area) to which it discharges. In most cases, the spreader will be the same length as the contributing impervious surface. The ends of the spreader shall be tied into higher ground to prevent flow around the spreader.

***For diversion outlet applications:***

The capacity of the spreader shall be determined using the peak flow from the 10-year, 24-hour storm. The drainage area shall be restricted so that maximum 10-year design flows into the spreader will not exceed 30 cfs.

***For all level spreader applications:***

- The minimum depth shall be 6 inches and the minimum width shall be 6 feet for the lower side slope. Side slopes shall be 4:1 (horizontal to vertical) or flatter.
- The grade of the spreader shall be 0%.
- The appropriate length, width, and depth of spreader shall be selected from Table 5-16.
- It will be necessary to construct a 20 foot transition section in the diversion channel so the width of the channel will smoothly meet the width of the spreader to ensure uniform outflow.
- The last 20 feet of the diversion channel shall provide a smooth transition from the channel grade to the level spreader and shall have slope less than or equal to 1%.




**CONSTRUCTION SPECIFICATIONS:**

1. SPREADERS SHALL BE INSTALLED WITH A LEVEL INSTRUMENT. CONSTRUCT LEVEL LIP TO 0% GRADE TO ENSURE UNIFORM SHEET FLOW. LEVEL SPREADER SHALL BE CONSTRUCTED ON UNDISTURBED SOIL (NOT FILL)
2. SELECT GEOTEXTILE FABRIC BASED ON UNDISTURBED SOILS (SANDS, SILTS, CLAYS, ECT.)
3. PLACE 6" LAYER OF UNIFORMLY GRADED STONE (2" TO 3" IN DIA.) RAKE TO FORM SMOOTH UNIFORM SURFACE. DO NOT FILL VOIDS IN STONE.
4. THE INLET DITCH SHALL NOT EXCEED A 1% GRADE FOR AT LEAST 20 FEET BEFORE ENTERING THE SPREADER.
5. STORM RUNOFF CONVERTED TO SHEET FLOW ACROSS OUTLET APRON SHALL FLOW ONTO STABILIZED AREAS. RUNOFF SHALL NOT BE RECONCENTRATED IMMEDIATELY BELOW THE POINT OF DISCHARGE.
6. PERIODIC INSPECTION AND REQUIRED MAINTENANCE SHALL BE PROVIDED.
7. CONSTRUCTION OF LEVEL LIP SPREADER SHALL BE FROM UPHILL SIDE ONLY. LEVEL LIP & AREA BELOW SPREADER SHALL BE AT EXISTING GRADES & UNDISTURBED BY EARTHWORK OR EQUIPMENT
8. CONSTRUCT SPREADER WITH LIP AT EXISTING ELEVATION AS SPECIFIED.
9. DOWNGRADIENT RECEIVING AREA MUST BE NATURALLY WELL VEGETATED.

**Figure 5-63  Level Spreader**

(Maine Erosion and Sediment Control BMP Manual, 2003)

- The receiving area below the level spreader shall be protected from harm during construction. Minor disturbed areas shall be stabilized with vegetative measures. A temporary stormwater diversion may be necessary until the level spreader has fully stabilized.

- Level spreaders must blend smoothly into the downstream receiving area without any sharp drops or irregularities, to avoid channelization, turbulence and hydraulic “jumps.”

**Table 5-16 Level Flow Spreader Dimensions**

| Design Flow (cfs) | Minimum Entrance Width (ft) | Minimum Depth (ft) | Minimum End Width (ft) | Minimum Length (ft) |
|---|---|---|---|---|
| 0-10 | 10 | 0.5 | 3 | 10 |
| 10-20 | 16 | 0.6 | 3 | 20 |
| 20-30 | 24 | 0.7 | 3 | 30 |

Source: NCDENR, 2006

- Level spreaders shall be constructed on undisturbed soil where possible. If fill is used, it shall be constructed of material compacted to 95% of standard proctor test levels for the area not considered the seedbed.
- Immediately after level spreader construction, seed and mulch the entire disturbed area of the spreader.

The level spreader lip shall be protected with erosion resistant material to prevent erosion and allow vegetation to be established. Alternatively, the lip may be constructed of concrete on a prepared foundation to ensure that it is level and erosion resistant.

CHAPTER

6

# FLOODPLAIN MANAGEMENT

## TABLE OF CONTENTS



## LIST OF FIGURES

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## 6.1 Introduction

Three types of floodplains are addressed in this chapter:

- Floodplains as defined and regulated under the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP);
- Floodplains for streams not regulated under the NFIP; and,
- Local (site-scale) potentially floodprone areas.

The City of Wichita and Sedgwick County have adopted floodplain ordinances that set specific requirements for the management of FEMA-regulated floodplains in each respective community. In addition, the City and County have adopted a Stormwater Management ordinance that includes special provisions for FEMA-regulated floodplains, as well as for floodplains not regulated by FEMA, and local potentially floodprone areas.

A brief overview of these requirements is presented below. The ordinances are included as appendices to Volume 1, and should be consulted for the specific requirements for new developments.

## 6.2 FEMA/NFIP Regulated Floodplains

Floodplain management for FEMA-regulated streams is based on the requirements of the NFIP. Through the community's participation in the NFIP, flood insurance studies (FIS) are completed for the community and flood insurance rate maps (FIRMs) are generated. Based on the information contained in the FIS and on the FIRMs, FEMA authorizes the sale of flood insurance for the community.

For NFIP purposes, the "floodplain" is defined as the area inundated by the one-percent chance (100-year) flood, also called the base flood (see Figure 6-1). In Wichita and Sedgwick County floodplains must be shown on development and redevelopment plans based by mapping the base flood elevations to the most up to date topographic survey to yield accurate floodplain boundaries.

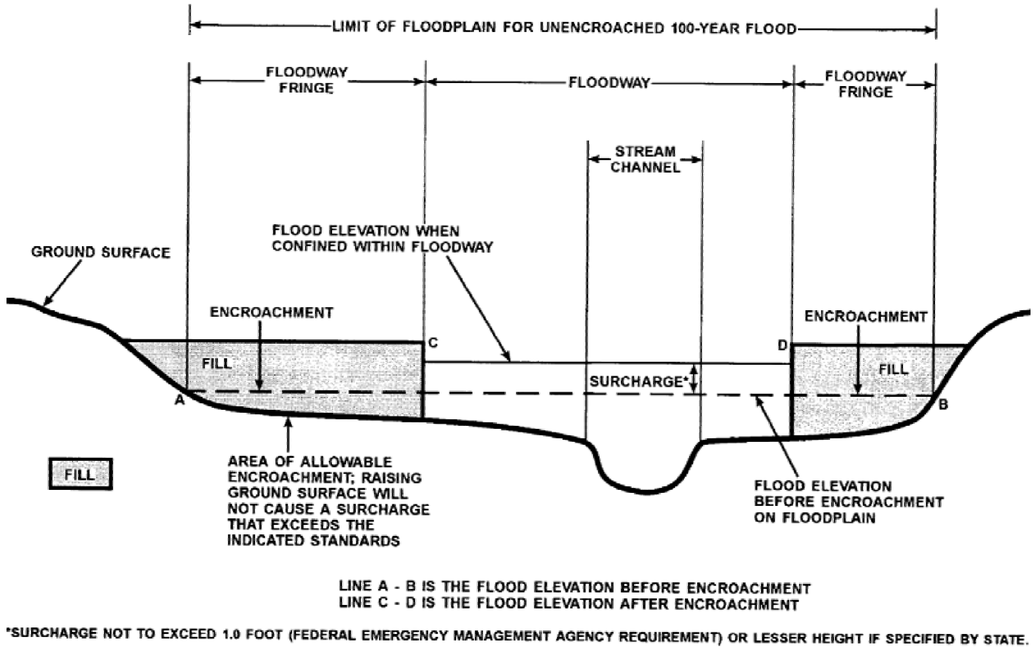


**Figure 6-1 NFIP Floodplain Definitions**

The “floodway” is a zone within the floodplain reserved to pass flood flows without increasing food elevations more than a specified amount (normally, 1.0 foot or less). Construction within the floodway is prohibited except under specific limited conditions. The zones between the floodway and the outer edges of the 100-year floodplain are termed the “floodway fringe”.

In general, the restrictions for floodplains as dictated by FEMA-requirements include (but are not limited to) limiting construction in the floodway, elevating structures above the 100-year flood elevations, stabilizing structures located in the floodplain, limiting the use of the floodplain for storage of certain materials, limiting the increase in flood elevations for floodway fringe encroachments and providing compensatory storage excavation when fill is placed in volume sensitive basins. All of these requirements are explained in detail within the Wichita and Sedgwick County floodplain and stormwater management ordinances found in the Volume 1 appendices.

Figure 6-2 shows an example of a FEMA flood map used in the NFIP.

Penalties for non-participation in the federal program involve reduced or denial of access to federal disaster funding and home loans, higher flood insurance rates, or loss of ability to obtain any flood insurance. Information on the Kansas National Flood Insurance Program can be obtained by contacting the Kansas DWR Floodplain Management Unit.

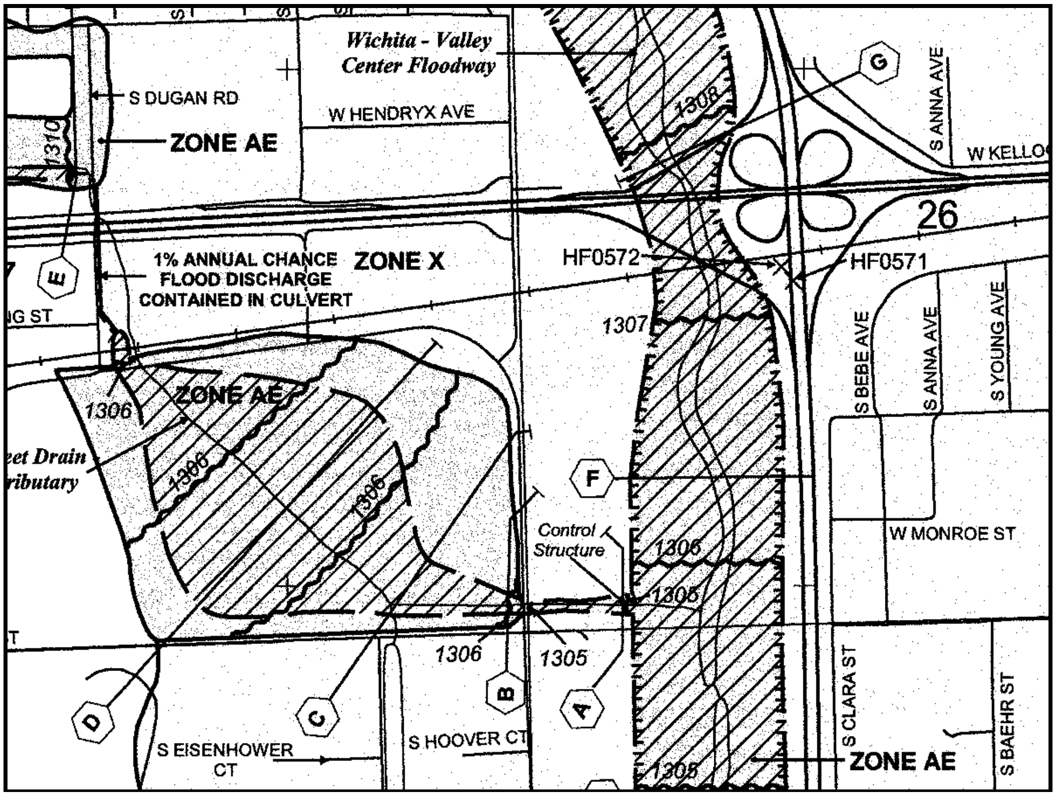


Figure 6-2  Example of a FEMA Flood Risk Map

## 6.3 Floodplains for Streams not Regulated by FEMA

FEMA-defined and regulated floodplains do not usually extend upstream far enough to include relatively small watersheds. However, the floodplains associated with small watersheds can be important flooding sources and are therefore further regulated by the City and County.

The previously referenced floodplain and stormwater ordinances provide requirements for channels and floodplains associated with watersheds for non-FEMA regulated streams and watersheds upstream of the upstream end of FEMA-regulated zones of streams. Those requirements apply to floodplain and channel drainage areas in excess of 40 acres. In general, the requirements contained in the ordinances include (but are not limited to) prohibiting increases in flood elevations and erosive velocities, providing maintenance access to new or modified channels, providing self-cleaning velocities for new or modified channels when hydraulic conditions permit, controlling the degree to which existing or new channels may be enclosed as opposed to left open, minimum freeboard requirements for the channel banks and adjacent structures, and compensatory storage excavation to offset fill placed in the floodway fringe in volume sensitive floodplains.

Refer to the ordinances appended to Volume 1 for specific requirements.

## 6.4 Local (Site-Scale) Potential Floodprone Areas

Most site-scale conveyances (swales, ditches, inlets, gutters, and overland flow zones) are designed for peak flows smaller than those associated with the 100-year rainfall or flood event. When an event in excess of the design event occurs, out-of-bank flows flood adjacent areas. These flooded areas are essentially local floodplains.

The Stormwater Ordinance adopted by the City and County, along with the design criteria provided in Volume 2 of the Stormwater Manual, require that conveyance systems be designed to limit out-of-bank flooding as well as ensure adequate performance and stability of the conveyance facilities. In general, the requirements include (but are not limited to) provisions to avoid erosive velocities, providing maintenance access to new or modified channels, providing self-cleaning velocities for new or modified channels when hydraulic conditions permit, controlling the degree to which existing or new channels may be enclosed as opposed to left open, minimum freeboard requirements for the channel banks and adjacent structures, and flow spreads onto streets.

## 6.5 FEMA Resources

A list of FEMA guidance documents and other published resources can be found at the following website (http://www.fema.gov/plan/prevent/fhm/frm_docs.shtm).

The Guidelines and Specification for Flood Hazard Mapping Partners provides details on modeling requirements for all studies submitted to FEMA, or other studies that are required to be consistent with FEMA requirements. This document can be downloaded from the FEMA Library (http://www.fema.gov/library/viewRecord.do?id=2206).

To determine the current status of the floodplain in the study area the effective FIRMs and FIS reports should be consulted. These can be obtained from FEMA's Map Service Center (http://msc.fema.gov).

In order to revise an existing model the effective model must first be obtained and be used as a basis for the new study. Effective models can be purchased from FEMA's Engineering Library (http://www.fema.gov/plan/prevent/fhm/st_order.shtm).

All studies submitted to FEMA must be performed using one of the numerical models from the approved list (http://www.fema.gov/plan/prevent/fhm/en_modl.shtm). Alternative models may be approved if it meets the requirements stated in Subparagraph 65.6(a)(6) of the National Flood Insurance Program (NFIP) regulations.

# APPENDIX A

Manning’s n Table of Values

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**Table A-1 Roughness Coefficients (Manning's n) for Sheet Flow**

| Surface Description[1] | Manning's n |
|---|---|
| Smooth surfaces | |
| (concrete, asphalt, gravel or bare soil) | 0.011 |
| Fallow | |
| (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover < 20% | 0.06 |
| Residue cover > 20% | 0.17 |
| Grass: | |
| Short grass prairie | 0.15 |
| Dense grasses[A] | 0.24 |
| Bermuda grass | 0.41 |
| Range | |
| (natural) | 0.13 |
| Woods[B] | |
| Light underbrush | 0.40 |
| Dense underbrush | 0.80 |

[1] Source: SCS, TR-55, Second Edition, June 1986.
[A] Includes species such as bluestem grass, buffalo grass, grama grass, and native grass mixtures.
[B] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

**Table A-2 Manning's n Values**

| Street and Pavement Gutters [2] | | Manning's n |
|---|---|---|
| Asphalt pavement | | 0.016 |
| Concrete gutter | | 0.016 |
| Concrete pavement | | 0.018 |
| | | |
| **Culverts and Storm Sewers[3]** | **Roughness or Corrugation** | **Manning's n** |
| Concrete Pipe | Smooth | 0.013 |
| Concrete Boxes | Smooth | 0.013 |
| Corrugated Polyethylene | Corrugated | Per manufacturer |
| Smooth Polyethylene | Smooth | 0.011 |
| Polyvinyl chloride (PVC) | Smooth | 0.011 |

| **Artificial Channels [4]** | | **Depth Ranges** | | |
|---|---|---|---|---|
| Category | Lining Type | 0-0.5 ft | 0.5-2.0 ft | >2.0 ft |
| Grassed | Grass | 0.050 | 0.040 | 0.035 |
| Rigid | Concrete | 0.016 | 0.013 | 0.013 |
| | Grouted Riprap | 0.040 | 0.030 | 0.028 |
| | Gabions | 0.030 | 0.030 | 0.030 |
| | Stone Masonry | 0.042 | 0.032 | 0.030 |
| | Soil Cement | 0.025 | 0.022 | 0.020 |
| | Asphalt | 0.018 | 0.016 | 0.016 |
| Unlined | Bare Soil | 0.023 | 0.020 | 0.020 |
| | Rock Cut | 0.045 | 0.035 | 0.025 |
| Temporary* | Woven Paper Net | 0.016 | 0.015 | 0.015 |
| | Jute Net | 0.028 | 0.022 | 0.019 |
| | Fiberglass Roving | 0.028 | 0.022 | 0.019 |
| | Straw with Net | 0.065 | 0.033 | 0.025 |
| | Curled Wood Mat | 0.066 | 0.035 | 0.028 |
| | Synthetic Mat | 0.036 | 0.025 | 0.021 |
| Gravel Riprap | 1-inch $D_{50}$ | 0.044 | 0.033 | 0.030 |
| | 2-inch $D_{50}$ | 0.066 | 0.041 | 0.034 |
| Rock Riprap | 6-inch $D_{50}$ | 0.104 | 0.069 | 0.035 |
| | 12-inch $D_{50}$ | – | 0.078 | 0.040 |

| Natural Channels[5] | Manning's n |
|---|---|
| **NATURAL STREAMS** | |
| **Main Channels** | |
| 1. Clean, straight, full, no rifts or deep pools | 0.030 |
| 2. Same as "1", but more stones and weeds | 0.035 |
| 3. Clean, winding, some pools and shoals | 0.040 |
| 4. Same as "3", but some weeds and stones | 0.045 |
| 5. Same as "4", lower stages, more ineffective slopes and sections | 0.048 |
| 6. Same as "4" but more stones | 0.050 |
| 7. Sluggish reaches, weedy, deep pools | 0.070 |
| 8. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush | 0.100 |
| **Floodplain – Pasture** | |
| 1. Short grass | 0.030 |
| 2. Tall grass | 0.035 |
| **Floodplain – Cultivated Areas** | |
| 1. No crop | 0.030 |
| 2. Mature row crops | 0.035 |
| 3. Mature field crops | 0.040 |
| **Floodplain – Brush** | |
| 1. Heavy weeds scattered brush | 0.050 |
| 2. Light brush and trees, in winter | 0.050 |
| 3. Light brush and trees, in summer | 0.060 |
| 4. Medium to dense brush, in winter | 0.070 |
| 5. Medium to dense brush in summer | 0.100 |
| **Floodplain – Trees** | |
| 1. Heavy stand of timber, few down trees, little undergrowth, flow below branches | 0.100 |
| 2. Same as "1", but with flow in branches | 0.120 |
| 3. Dense willows, summer, straight | 0.150 |

* Lining designed for the interim condition, typically serving the needs of construction sequencing

2 Source: HEC-22, 2001

3 Source: Typical manufacturer data

4 Source: HEC-15, 1988

5 Source: HEC-RAS Hydraulic Reference Manual, 2008

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# APPENDIX B

Rainfall Intensity Table for Sedgwick County, Kansas

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Intensity values are based on regression analysis of data obtained from NOAA Atlas 14, Volume 8); Return Periods 1-yr through 10-yr based on Point Precipitation Frequency Estimates (Partial Duration Series); Return Periods 25-yr through 1000-yr based on Point Precipitation Frequency Estimates (Annual Maximum Series). Data values used in the regression analysis were obtained from the NOAA Precipitation Frequency Data Server for Wichita-Mid Continent weather station location.

**Table 1 City of Wichita and Sedgwick County, KS Rainfall Intensity Table (Duration 5 min – 120 min)**

| DURATION in hours | DURATION in | Return Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
| 0.0833 | 5 | 5.07 | 5.43 | 6.79 | 7.82 | 9.14 | 10.16 | 11.17 | 12.16 | 13.45 | 14.44 |
| 0.1000 | 6 | 4.75 | 5.08 | 6.35 | 7.30 | 8.53 | 9.46 | 10.38 | 11.28 | 12.45 | 13.32 |
| 0.1167 | 7 | 4.47 | 4.78 | 5.97 | 6.87 | 8.02 | 8.88 | 9.73 | 10.56 | 11.64 | 12.44 |
| 0.1333 | 8 | 4.22 | 4.52 | 5.65 | 6.49 | 7.58 | 8.39 | 9.18 | 9.96 | 10.97 | 11.71 |
| 0.1500 | 9 | 4.01 | 4.29 | 5.36 | 6.16 | 7.19 | 7.96 | 8.71 | 9.44 | 10.40 | 11.10 |
| 0.1667 | 10 | 3.82 | 4.09 | 5.11 | 5.87 | 6.86 | 7.59 | 8.30 | 9.00 | 9.91 | 10.57 |
| 0.1833 | 11 | 3.65 | 3.90 | 4.88 | 5.62 | 6.56 | 7.26 | 7.94 | 8.61 | 9.48 | 10.12 |
| 0.2000 | 12 | 3.50 | 3.74 | 4.68 | 5.38 | 6.29 | 6.96 | 7.62 | 8.26 | 9.10 | 9.72 |
| 0.2167 | 13 | 3.36 | 3.59 | 4.50 | 5.18 | 6.05 | 6.70 | 7.33 | 7.95 | 8.76 | 9.36 |
| 0.2333 | 14 | 3.23 | 3.46 | 4.33 | 4.99 | 5.83 | 6.46 | 7.07 | 7.67 | 8.46 | 9.04 |
| 0.2500 | 15 | 3.12 | 3.34 | 4.18 | 4.81 | 5.63 | 6.24 | 6.83 | 7.42 | 8.19 | 8.75 |
| 0.2667 | 16 | 3.01 | 3.22 | 4.04 | 4.66 | 5.45 | 6.04 | 6.62 | 7.19 | 7.94 | 8.49 |
| 0.2833 | 17 | 2.92 | 3.12 | 3.92 | 4.51 | 5.28 | 5.86 | 6.42 | 6.98 | 7.71 | 8.25 |
| 0.3000 | 18 | 2.83 | 3.02 | 3.80 | 4.37 | 5.13 | 5.69 | 6.24 | 6.78 | 7.50 | 8.03 |
| 0.3167 | 19 | 2.74 | 2.93 | 3.69 | 4.25 | 4.99 | 5.53 | 6.07 | 6.60 | 7.31 | 7.83 |
| 0.3333 | 20 | 2.67 | 2.85 | 3.58 | 4.13 | 4.85 | 5.38 | 5.91 | 6.43 | 7.13 | 7.64 |
| 0.3500 | 21 | 2.59 | 2.77 | 3.49 | 4.02 | 4.73 | 5.25 | 5.76 | 6.28 | 6.96 | 7.46 |
| 0.3667 | 22 | 2.52 | 2.70 | 3.40 | 3.92 | 4.61 | 5.12 | 5.63 | 6.13 | 6.80 | 7.30 |
| 0.3833 | 23 | 2.46 | 2.63 | 3.32 | 3.83 | 4.50 | 5.00 | 5.50 | 6.00 | 6.65 | 7.14 |
| 0.4000 | 24 | 2.40 | 2.57 | 3.24 | 3.74 | 4.40 | 4.89 | 5.38 | 5.87 | 6.52 | 7.00 |
| 0.4167 | 25 | 2.34 | 2.51 | 3.16 | 3.65 | 4.30 | 4.78 | 5.27 | 5.75 | 6.39 | 6.87 |
| 0.4333 | 26 | 2.29 | 2.45 | 3.09 | 3.57 | 4.21 | 4.68 | 5.16 | 5.63 | 6.26 | 6.74 |
| 0.4500 | 27 | 2.24 | 2.40 | 3.02 | 3.50 | 4.12 | 4.59 | 5.06 | 5.53 | 6.15 | 6.62 |
| 0.4667 | 28 | 2.19 | 2.34 | 2.96 | 3.42 | 4.04 | 4.50 | 4.96 | 5.42 | 6.04 | 6.50 |
| 0.4833 | 29 | 2.15 | 2.30 | 2.90 | 3.35 | 3.96 | 4.42 | 4.87 | 5.33 | 5.94 | 6.39 |
| 0.5000 | 30 | 2.10 | 2.25 | 2.84 | 3.29 | 3.89 | 4.33 | 4.78 | 5.24 | 5.84 | 6.29 |
| 0.5167 | 31 | 2.06 | 2.20 | 2.79 | 3.23 | 3.82 | 4.26 | 4.70 | 5.15 | 5.74 | 6.19 |
| 0.5333 | 32 | 2.02 | 2.16 | 2.74 | 3.17 | 3.75 | 4.18 | 4.62 | 5.06 | 5.65 | 6.10 |
| 0.5500 | 33 | 1.98 | 2.12 | 2.69 | 3.11 | 3.68 | 4.11 | 4.55 | 4.98 | 5.57 | 6.01 |
| 0.5667 | 34 | 1.95 | 2.08 | 2.64 | 3.06 | 3.62 | 4.05 | 4.48 | 4.91 | 5.48 | 5.92 |
| 0.5833 | 35 | 1.91 | 2.05 | 2.59 | 3.01 | 3.56 | 3.98 | 4.41 | 4.83 | 5.40 | 5.84 |
| 0.6000 | 36 | 1.88 | 2.01 | 2.55 | 2.96 | 3.50 | 3.92 | 4.34 | 4.76 | 5.33 | 5.76 |
| 0.6167 | 37 | 1.85 | 1.98 | 2.51 | 2.91 | 3.45 | 3.86 | 4.28 | 4.70 | 5.26 | 5.69 |
| 0.6333 | 38 | 1.82 | 1.94 | 2.47 | 2.86 | 3.40 | 3.80 | 4.22 | 4.63 | 5.19 | 5.61 |
| 0.6500 | 39 | 1.79 | 1.91 | 2.43 | 2.82 | 3.35 | 3.75 | 4.16 | 4.57 | 5.12 | 5.54 |
| 0.6667 | 40 | 1.76 | 1.88 | 2.39 | 2.78 | 3.30 | 3.70 | 4.10 | 4.51 | 5.06 | 5.48 |
| 0.6833 | 41 | 1.73 | 1.85 | 2.36 | 2.74 | 3.25 | 3.65 | 4.05 | 4.45 | 4.99 | 5.41 |
| 0.7000 | 42 | 1.71 | 1.83 | 2.32 | 2.70 | 3.21 | 3.60 | 3.99 | 4.39 | 4.93 | 5.35 |
| 0.7167 | 43 | 1.68 | 1.80 | 2.29 | 2.66 | 3.16 | 3.55 | 3.94 | 4.34 | 4.88 | 5.29 |
| 0.7333 | 44 | 1.66 | 1.77 | 2.26 | 2.62 | 3.12 | 3.51 | 3.89 | 4.29 | 4.82 | 5.23 |
| 0.7500 | 45 | 1.63 | 1.75 | 2.22 | 2.59 | 3.08 | 3.46 | 3.85 | 4.24 | 4.76 | 5.17 |
| 0.7667 | 46 | 1.61 | 1.72 | 2.19 | 2.55 | 3.04 | 3.42 | 3.80 | 4.19 | 4.71 | 5.12 |
| 0.7833 | 47 | 1.59 | 1.70 | 2.17 | 2.52 | 3.00 | 3.38 | 3.76 | 4.14 | 4.66 | 5.07 |
| 0.8000 | 48 | 1.57 | 1.68 | 2.14 | 2.49 | 2.97 | 3.34 | 3.71 | 4.10 | 4.61 | 5.01 |
| 0.8167 | 49 | 1.55 | 1.66 | 2.11 | 2.46 | 2.93 | 3.30 | 3.67 | 4.05 | 4.56 | 4.96 |
| 0.8333 | 50 | 1.53 | 1.63 | 2.08 | 2.43 | 2.90 | 3.26 | 3.63 | 4.01 | 4.52 | 4.92 |
| 0.8500 | 51 | 1.51 | 1.61 | 2.06 | 2.40 | 2.86 | 3.22 | 3.59 | 3.97 | 4.47 | 4.87 |
| 0.8667 | 52 | 1.49 | 1.59 | 2.03 | 2.37 | 2.83 | 3.19 | 3.56 | 3.93 | 4.43 | 4.82 |
| 0.8833 | 53 | 1.47 | 1.57 | 2.01 | 2.34 | 2.80 | 3.16 | 3.52 | 3.89 | 4.39 | 4.78 |
| 0.9000 | 54 | 1.45 | 1.56 | 1.99 | 2.32 | 2.77 | 3.12 | 3.48 | 3.85 | 4.35 | 4.74 |
| 0.9167 | 55 | 1.43 | 1.54 | 1.96 | 2.29 | 2.74 | 3.09 | 3.45 | 3.81 | 4.31 | 4.69 |
| 0.9333 | 56 | 1.42 | 1.52 | 1.94 | 2.27 | 2.71 | 3.06 | 3.41 | 3.78 | 4.27 | 4.65 |
| 0.9500 | 57 | 1.40 | 1.50 | 1.92 | 2.24 | 2.68 | 3.03 | 3.38 | 3.74 | 4.23 | 4.61 |
| 0.9667 | 58 | 1.39 | 1.49 | 1.90 | 2.22 | 2.65 | 3.00 | 3.35 | 3.71 | 4.19 | 4.57 |
| 0.9833 | 59 | 1.37 | 1.47 | 1.88 | 2.19 | 2.63 | 2.97 | 3.32 | 3.67 | 4.16 | 4.54 |

| DURATION in hours | DURATION in | Return Period 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0000 | 60 | 1.36 | 1.45 | 1.86 | 2.17 | 2.60 | 2.94 | 3.29 | 3.64 | 4.12 | 4.50 |
| 1.0167 | 61 | 1.34 | 1.44 | 1.84 | 2.15 | 2.58 | 2.91 | 3.26 | 3.61 | 4.09 | 4.46 |
| 1.0333 | 62 | 1.33 | 1.42 | 1.82 | 2.13 | 2.55 | 2.88 | 3.23 | 3.58 | 4.05 | 4.43 |
| 1.0500 | 63 | 1.31 | 1.41 | 1.80 | 2.11 | 2.53 | 2.86 | 3.20 | 3.55 | 4.02 | 4.39 |
| 1.0667 | 64 | 1.30 | 1.39 | 1.78 | 2.09 | 2.50 | 2.83 | 3.17 | 3.52 | 3.99 | 4.36 |
| 1.0833 | 65 | 1.29 | 1.38 | 1.77 | 2.07 | 2.48 | 2.81 | 3.14 | 3.49 | 3.96 | 4.33 |
| 1.1000 | 66 | 1.27 | 1.36 | 1.75 | 2.05 | 2.46 | 2.78 | 3.12 | 3.46 | 3.93 | 4.30 |
| 1.1167 | 67 | 1.26 | 1.35 | 1.73 | 2.03 | 2.44 | 2.76 | 3.09 | 3.43 | 3.90 | 4.26 |
| 1.1333 | 68 | 1.25 | 1.34 | 1.72 | 2.01 | 2.41 | 2.74 | 3.07 | 3.41 | 3.87 | 4.23 |
| 1.1500 | 69 | 1.24 | 1.33 | 1.70 | 1.99 | 2.39 | 2.71 | 3.04 | 3.38 | 3.84 | 4.20 |
| 1.1667 | 70 | 1.22 | 1.31 | 1.69 | 1.97 | 2.37 | 2.69 | 3.02 | 3.35 | 3.81 | 4.18 |
| 1.1833 | 71 | 1.21 | 1.30 | 1.67 | 1.96 | 2.35 | 2.67 | 2.99 | 3.33 | 3.78 | 4.15 |
| 1.2000 | 72 | 1.20 | 1.29 | 1.65 | 1.94 | 2.33 | 2.65 | 2.97 | 3.30 | 3.76 | 4.12 |
| 1.2167 | 73 | 1.19 | 1.28 | 1.64 | 1.92 | 2.31 | 2.63 | 2.95 | 3.28 | 3.73 | 4.09 |
| 1.2333 | 74 | 1.18 | 1.27 | 1.63 | 1.91 | 2.30 | 2.61 | 2.93 | 3.26 | 3.70 | 4.06 |
| 1.2500 | 75 | 1.17 | 1.25 | 1.61 | 1.89 | 2.28 | 2.59 | 2.91 | 3.23 | 3.68 | 4.04 |
| 1.2667 | 76 | 1.16 | 1.24 | 1.60 | 1.88 | 2.26 | 2.57 | 2.88 | 3.21 | 3.66 | 4.01 |
| 1.2833 | 77 | 1.15 | 1.23 | 1.59 | 1.86 | 2.24 | 2.55 | 2.86 | 3.19 | 3.63 | 3.99 |
| 1.3000 | 78 | 1.14 | 1.22 | 1.57 | 1.85 | 2.22 | 2.53 | 2.84 | 3.17 | 3.61 | 3.96 |
| 1.3167 | 79 | 1.13 | 1.21 | 1.56 | 1.83 | 2.21 | 2.51 | 2.82 | 3.15 | 3.58 | 3.94 |
| 1.3333 | 80 | 1.12 | 1.20 | 1.55 | 1.82 | 2.19 | 2.49 | 2.80 | 3.12 | 3.56 | 3.91 |
| 1.3500 | 81 | 1.11 | 1.19 | 1.53 | 1.80 | 2.17 | 2.47 | 2.78 | 3.10 | 3.54 | 3.89 |
| 1.3667 | 82 | 1.10 | 1.18 | 1.52 | 1.79 | 2.16 | 2.46 | 2.76 | 3.08 | 3.52 | 3.87 |
| 1.3833 | 83 | 1.09 | 1.17 | 1.51 | 1.77 | 2.14 | 2.44 | 2.75 | 3.06 | 3.49 | 3.84 |
| 1.4000 | 84 | 1.08 | 1.16 | 1.50 | 1.76 | 2.13 | 2.42 | 2.73 | 3.04 | 3.47 | 3.82 |
| 1.4167 | 85 | 1.08 | 1.15 | 1.49 | 1.75 | 2.11 | 2.41 | 2.71 | 3.02 | 3.45 | 3.80 |
| 1.4333 | 86 | 1.07 | 1.15 | 1.48 | 1.74 | 2.10 | 2.39 | 2.69 | 3.01 | 3.43 | 3.78 |
| 1.4500 | 87 | 1.06 | 1.14 | 1.47 | 1.72 | 2.08 | 2.37 | 2.68 | 2.99 | 3.41 | 3.76 |
| 1.4667 | 88 | 1.05 | 1.13 | 1.45 | 1.71 | 2.07 | 2.36 | 2.66 | 2.97 | 3.39 | 3.73 |
| 1.4833 | 89 | 1.04 | 1.12 | 1.44 | 1.70 | 2.05 | 2.34 | 2.64 | 2.95 | 3.37 | 3.71 |
| 1.5000 | 90 | 1.04 | 1.11 | 1.43 | 1.69 | 2.04 | 2.33 | 2.63 | 2.93 | 3.35 | 3.69 |
| 1.5167 | 91 | 1.03 | 1.10 | 1.42 | 1.68 | 2.03 | 2.31 | 2.61 | 2.92 | 3.33 | 3.67 |
| 1.5333 | 92 | 1.02 | 1.09 | 1.41 | 1.66 | 2.01 | 2.30 | 2.59 | 2.90 | 3.32 | 3.65 |
| 1.5500 | 93 | 1.01 | 1.09 | 1.40 | 1.65 | 2.00 | 2.28 | 2.58 | 2.88 | 3.30 | 3.64 |
| 1.5667 | 94 | 1.01 | 1.08 | 1.39 | 1.64 | 1.99 | 2.27 | 2.56 | 2.87 | 3.28 | 3.62 |
| 1.5833 | 95 | 1.00 | 1.07 | 1.38 | 1.63 | 1.97 | 2.25 | 2.55 | 2.85 | 3.26 | 3.60 |
| 1.6000 | 96 | 0.99 | 1.06 | 1.37 | 1.62 | 1.96 | 2.24 | 2.53 | 2.83 | 3.25 | 3.58 |
| 1.6167 | 97 | 0.98 | 1.06 | 1.37 | 1.61 | 1.95 | 2.23 | 2.52 | 2.82 | 3.23 | 3.56 |
| 1.6333 | 98 | 0.98 | 1.05 | 1.36 | 1.60 | 1.94 | 2.21 | 2.50 | 2.80 | 3.21 | 3.54 |
| 1.6500 | 99 | 0.97 | 1.04 | 1.35 | 1.59 | 1.93 | 2.20 | 2.49 | 2.79 | 3.19 | 3.53 |
| 1.6667 | 100 | 0.96 | 1.04 | 1.34 | 1.58 | 1.91 | 2.19 | 2.48 | 2.77 | 3.18 | 3.51 |
| 1.6833 | 101 | 0.96 | 1.03 | 1.33 | 1.57 | 1.90 | 2.18 | 2.46 | 2.76 | 3.16 | 3.49 |
| 1.7000 | 102 | 0.95 | 1.02 | 1.32 | 1.56 | 1.89 | 2.16 | 2.45 | 2.74 | 3.15 | 3.48 |
| 1.7167 | 103 | 0.95 | 1.01 | 1.31 | 1.55 | 1.88 | 2.15 | 2.43 | 2.73 | 3.13 | 3.46 |
| 1.7333 | 104 | 0.94 | 1.01 | 1.30 | 1.54 | 1.87 | 2.14 | 2.42 | 2.71 | 3.12 | 3.44 |
| 1.7500 | 105 | 0.93 | 1.00 | 1.30 | 1.53 | 1.86 | 2.13 | 2.41 | 2.70 | 3.10 | 3.43 |
| 1.7667 | 106 | 0.93 | 1.00 | 1.29 | 1.52 | 1.85 | 2.12 | 2.40 | 2.69 | 3.09 | 3.41 |
| 1.7833 | 107 | 0.92 | 0.99 | 1.28 | 1.51 | 1.84 | 2.10 | 2.38 | 2.67 | 3.07 | 3.40 |
| 1.8000 | 108 | 0.92 | 0.98 | 1.27 | 1.50 | 1.83 | 2.09 | 2.37 | 2.66 | 3.06 | 3.38 |
| 1.8167 | 109 | 0.91 | 0.98 | 1.27 | 1.49 | 1.82 | 2.08 | 2.36 | 2.65 | 3.04 | 3.36 |
| 1.8333 | 110 | 0.90 | 0.97 | 1.26 | 1.49 | 1.81 | 2.07 | 2.35 | 2.63 | 3.03 | 3.35 |
| 1.8500 | 111 | 0.90 | 0.96 | 1.25 | 1.48 | 1.80 | 2.06 | 2.33 | 2.62 | 3.01 | 3.34 |
| 1.8667 | 112 | 0.89 | 0.96 | 1.24 | 1.47 | 1.79 | 2.05 | 2.32 | 2.61 | 3.00 | 3.32 |
| 1.8833 | 113 | 0.89 | 0.95 | 1.24 | 1.46 | 1.78 | 2.04 | 2.31 | 2.60 | 2.99 | 3.31 |
| 1.9000 | 114 | 0.88 | 0.95 | 1.23 | 1.45 | 1.77 | 2.03 | 2.30 | 2.58 | 2.97 | 3.29 |
| 1.9167 | 115 | 0.88 | 0.94 | 1.22 | 1.44 | 1.76 | 2.02 | 2.29 | 2.57 | 2.96 | 3.28 |
| 1.9333 | 116 | 0.87 | 0.94 | 1.21 | 1.44 | 1.75 | 2.01 | 2.28 | 2.56 | 2.95 | 3.26 |
| 1.9500 | 117 | 0.87 | 0.93 | 1.21 | 1.43 | 1.74 | 2.00 | 2.27 | 2.55 | 2.93 | 3.25 |
| 1.9667 | 118 | 0.86 | 0.93 | 1.20 | 1.42 | 1.73 | 1.99 | 2.26 | 2.54 | 2.92 | 3.24 |
| 1.9833 | 119 | 0.86 | 0.92 | 1.19 | 1.41 | 1.72 | 1.98 | 2.25 | 2.52 | 2.91 | 3.22 |
| 2.0000 | 120 | 0.85 | 0.92 | 1.19 | 1.41 | 1.71 | 1.97 | 2.23 | 2.51 | 2.90 | 3.21 |

- -

Constants for use in the General Rainfall Intensity Equation are based on regression analysis of data obtained from NOAA Atlas 14, Volume 8); Return Periods 1-yr through 10-yr based on Point Precipitation Frequency Estimates (Partial Duration Series); Return Periods 25-yr through 1000-yr based on Point Precipitation Frequency Estimates (Annual Maximum Series). Data values used in the regression analysis were obtained from the NOAA Precipitation Frequency Data Server for Wichita-Mid Continent weather station location.

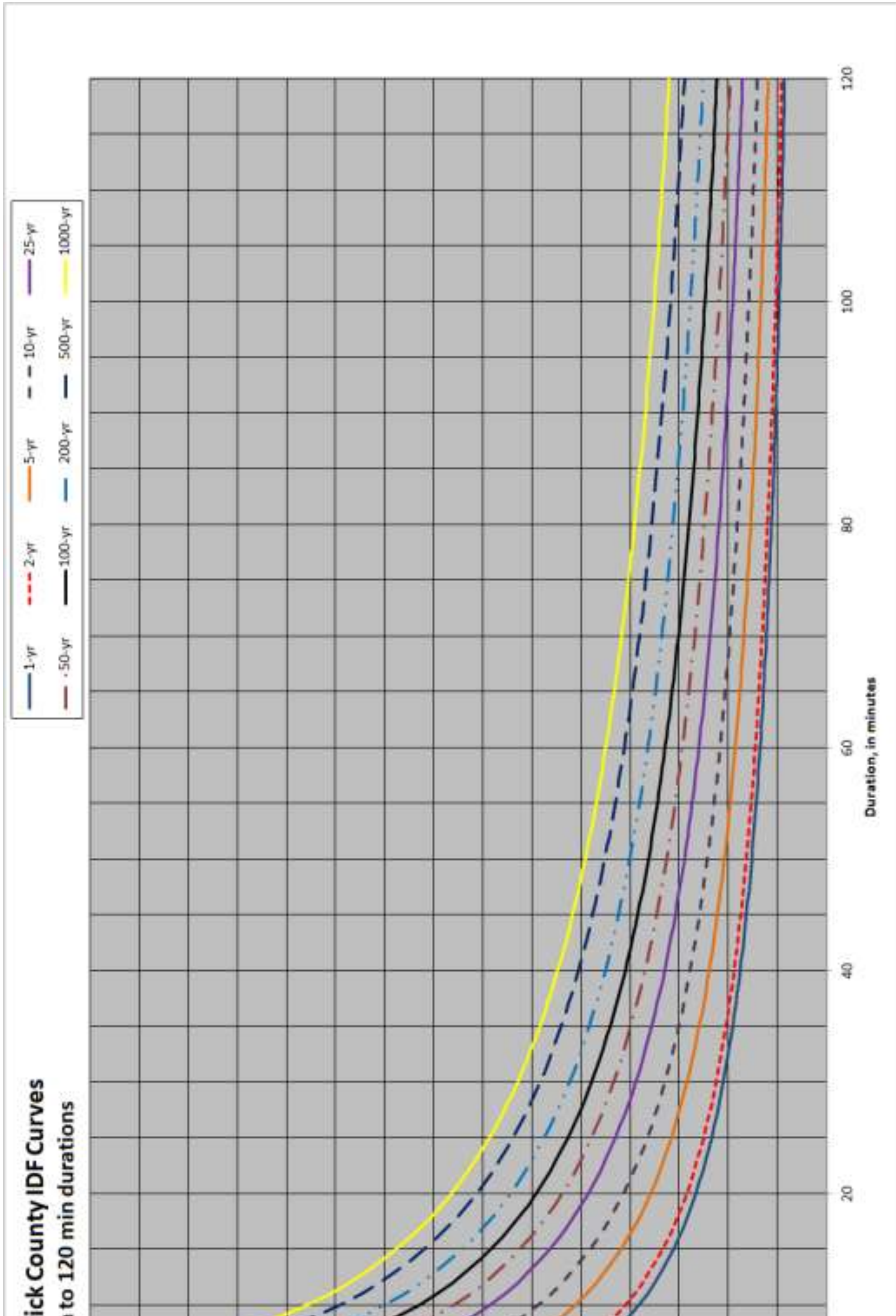
**General Rainfall Intensity Equation**

$$i = \frac{a}{(D+b)^m}$$

*i* = intensity in in/hr
D = Duration of rainfall in minutes
a, b, & m = constants shown in Table 2 below

**Table 2 City of Wichita and Sedgwick County, General Rainfall Intensity Equation Constants (Durations from 5-min to 120 min)**

| | Return Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1-yr | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 200-yr | 500-yr | 1000-yr |
| a | 26.462 | 27.843 | 31.881 | 33.778 | 35.588 | 35.372 | 34.955 | 34.688 | 34.486 | 33.743 |
| b | 5.20 | 5.08 | 4.67 | 4.20 | 3.66 | 2.99 | 2.35 | 1.81 | 1.19 | 0.64 |
| m | 0.7113 | 0.7072 | 0.6817 | 0.6593 | 0.6298 | 0.6004 | 0.5721 | 0.5466 | 0.5164 | 0.4908 |


Sedgwick County IDF Curves
5 min to 120 min durations
1-yr
2-yr
5-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
1000-yr
Intensity, in inches/hour
Duration, in minutes
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120

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# APPENDIX C

Rational C Table of Values

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**Table C-1 Rational C Values**

| Land Use or Surface Characteristics | Percent Impervious | Frequency 2 | 5 | 10 | 100 |
|---|---|---|---|---|---|
| Business | | | | | |
| Downtown Areas | 95 | 0.84 | 0.85 | 0.87 | 0.91 |
| Neighborhood Areas | 70 | 0.68 | 0.69 | 0.73 | 0.80 |
| Residential Single Family (Soil Group D) | | | | | |
| 1/8 Acre | 50 | 0.57 | 0.61 | 0.66 | 0.79 |
| 1/4 Acre | 38 | 0.50 | 0.54 | 0.62 | 0.76 |
| 1/3 Acre | 30 | 0.46 | 0.50 | 0.59 | 0.73 |
| 1/2 Acre | 25 | 0.42 | 0.48 | 0.56 | 0.72 |
| 3/4 Acre | 22 | 0.42 | 0.46 | 0.55 | 0.71 |
| 1 Acre | 20 | 0.41 | 0.45 | 0.54 | 0.71 |
| Residentia Multi-Family (Soil Group D) | | | | | |
| Multi-Unit (detached) | 60 | 0.62 | 0.66 | 0.72 | 0.82 |
| Multi-Unit (attached) | 65 | 0.64 | 0.68 | 0.73 | 0.83 |
| Apartments | 75 | 0.70 | 0.73 | 0.79 | 0.86 |
| Residential Single Family (Soil Group C) | | | | | |
| 1/8 Acre | 50 | 0.55 | 0.58 | 0.64 | 0.73 |
| 1/4 Acre | 38 | 0.48 | 0.51 | 0.57 | 0.68 |
| 1/3 Acre | 30 | 0.43 | 0.46 | 0.53 | 0.65 |
| 1/2 Acre | 25 | 0.40 | 0.43 | 0.50 | 0.63 |
| 3/4 Acre | 22 | 0.39 | 0.42 | 0.49 | 0.62 |
| 1 Acre | 20 | 0.37 | 0.40 | 0.48 | 0.61 |
| Residential Multi-Family (Soil Group C) | | | | | |
| Multi-Unit (detached) | 60 | 0.60 | 0.63 | 0.69 | 0.77 |
| Multi-Unit (attached) | 65 | 0.63 | 0.66 | 0.71 | 0.79 |
| Apartments | 75 | 0.68 | 0.72 | 0.77 | 0.83 |
| Residential Single Family (Soil Group B) | | | | | |
| 1/8 Acre | 50 | 0.52 | 0.54 | 0.59 | 0.67 |
| 1/4 Acre | 38 | 0.44 | 0.46 | 0.52 | 0.61 |
| 1/3 Acre | 30 | 0.39 | 0.41 | 0.47 | 0.57 |
| 1/2 Acre | 25 | 0.36 | 0.38 | 0.44 | 0.54 |
| 3/4 Acre | 22 | 0.34 | 0.36 | 0.42 | 0.52 |
| 1 Acre | 20 | 0.33 | 0.35 | 0.40 | 0.51 |
| Residential Multi-Family (Soil Group B) | | | | | |
| Multi-Unit (detached) | 60 | 0.58 | 0.60 | 0.65 | 0.72 |
| Multi-Unit (attached) | 65 | 0.61 | 0.64 | 0.68 | 0.75 |
| Apartments | 75 | 0.67 | 0.70 | 0.74 | 0.80 |
| Single Family (Soil Group A) | | | | | |
| 1/8 Acre | 50 | 0.47 | 0.50 | 0.54 | 0.60 |
| 1/4 Acre | 38 | 0.39 | 0.41 | 0.45 | 0.52 |
| 1/3 Acre | 30 | 0.33 | 0.35 | 0.39 | 0.47 |
| 1/2 Acre | 25 | 0.30 | 0.31 | 0.35 | 0.44 |

| Land Use or Surface Characteristics | Percent Impervious | Frequency 2 | 5 | 10 | 100 |
|---|---|---|---|---|---|
| 3/4 Acre | 22 | 0.28 | 0.29 | 0.33 | 0.42 |
| 1 Acre | 20 | 0.26 | 0.28 | 0.32 | 0.40 |
| Multi-Family (Soil Group A) | | | | | |
| Multi-Unit (detached) | 60 | 0.55 | 0.57 | 0.61 | 0.67 |
| Multi-Unit (attached) | 65 | 0.58 | 0.60 | 0.64 | 0.70 |
| Apartments | 75 | 0.65 | 0.68 | 0.72 | 0.77 |
| Industrial | | | | | |
| Light Areas | 70 | 0.68 | 0.69 | 0.73 | 0.80 |
| Heavy Areas | 80 | 0.74 | 0.76 | 0.79 | 0.84 |
| Playgrounds | 15 | 0.33 | 0.35 | 0.42 | 0.55 |
| Schools | 40 | 0.49 | 0.51 | 0.56 | 0.66 |
| Railroad Yard Areas | 30 | 0.43 | 0.45 | 0.50 | 0.62 |
| Undeveloped Urban Areas | | | | | |
| Offsite Flow Analysis (when land use not defined) | 45 | 0.52 | 0.54 | 0.59 | 0.68 |
| Streets | | | | | |
| Paved | 99 | 0.87 | 0.88 | 0.90 | 0.93 |
| Gravel | 00 | 0.24 | 0.26 | 0.33 | 0.48 |
| Drive, Parking Lots and Walks: | 96 | 0.87 | 0.87 | 0.88 | 0.89 |
| Roofs | 90 | 0.80 | 0.85 | 0.90 | 0.93 |
| Urban Lawn Areas (Soil Group A) | | | | | |
| Slope less than 1% | 00 | 0.08 | 0.09 | 0.13 | 0.23 |
| Slope 1% to 4% | 00 | 0.12 | 0.13 | 0.17 | 0.27 |
| Slope more than 4% | 00 | 0.16 | 0.17 | 0.21 | 0.31 |
| Urban Lawn Areas (Soil Group B) | | | | | |
| Slope less than 1% | 00 | 0.16 | 0.18 | 0.24 | 0.37 |
| Slope 1% to 4% | 00 | 0.20 | 0.22 | 0.28 | 0.41 |
| Slope more than 4% | 00 | 0.24 | 0.26 | 0.32 | 0.45 |
| Urban Lawn Areas (Soil Group C) | | | | | |
| Slope less than 1% | 00 | 0.24 | 0.27 | 0.35 | 0.51 |
| Slope 1% to 4% | 00 | 0.26 | 0.29 | 0.37 | 0.53 |
| Slope more than 4% | 00 | 0.28 | 0.31 | 0.39 | 0.55 |
| Urban Lawn Areas (Soil Group D) | | | | | |
| Slope less than 1% | 00 | 0.28 | 0.33 | 0.43 | 0.63 |
| Slope 1% to 4% | 00 | 0.30 | 0.35 | 0.45 | 0.65 |
| Slope more than 4% | 00 | 0.32 | 0.37 | 0.47 | 0.67 |

# APPENDIX D

Wind Roses for the City of Wichita (based on data from 1961-1990)

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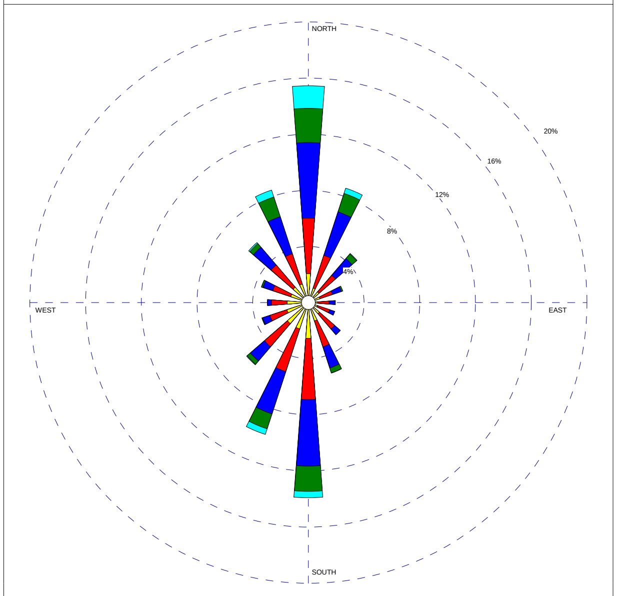
WIND ROSE PLOT

**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**

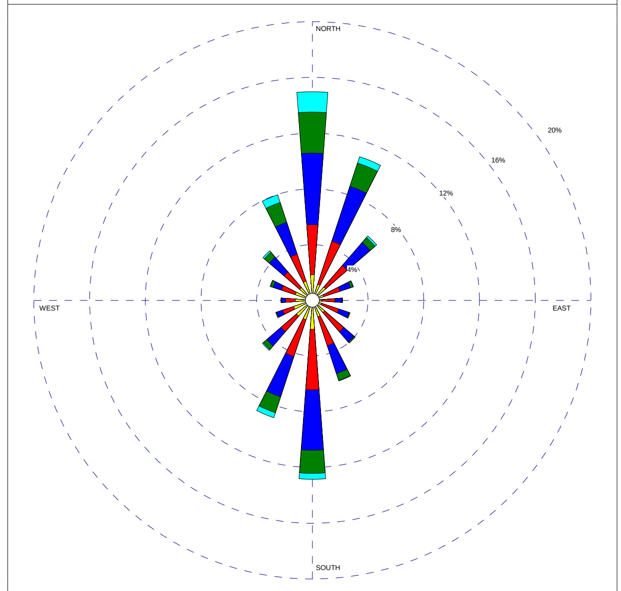



| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06<br>8.49 - 11.06<br>5.40 - 8.49<br>3.34 - 5.40<br>1.80 - 3.34<br>0.51 - 1.80 | Sara West | 8/28/2002 | USDA-ARS |
| | DISPLAY<br>**Wind Speed** | UNIT<br>**m/s** | COMMENTS |
| | AVG. WIND SPEED<br>**5.51 m/s** | CALM WINDS<br>**2.66%** | |
| | ORIENTATION<br>**Direction (blowing from)** | PLOT YEAR-DATE-TIME<br>**1961**<br>**Jan 1 - Jan 31**<br>**Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

WIND ROSE PLOT

**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**

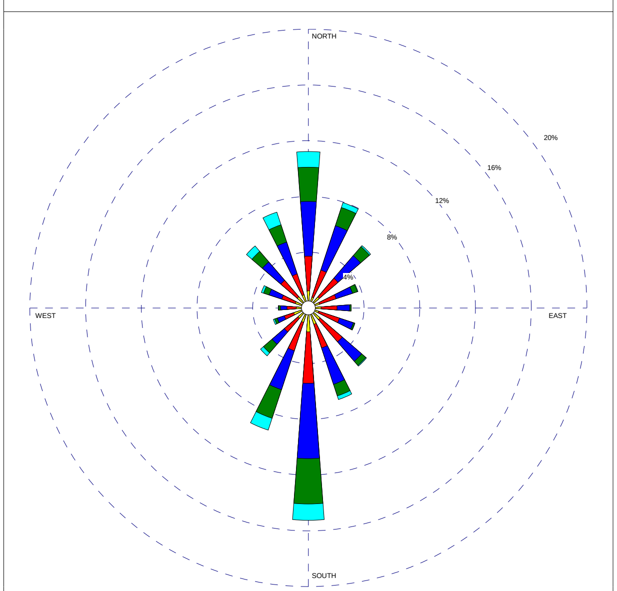



| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06<br>8.49 - 11.06<br>5.40 - 8.49<br>3.34 - 5.40<br>1.80 - 3.34<br>0.51 - 1.80 | Sara West | 8/28/2002 | USDA-ARS |
| | DISPLAY<br>**Wind Speed** | UNIT<br>**m/s** | COMMENTS |
| | AVG. WIND SPEED<br>**5.69 m/s** | CALM WINDS<br>**2.42%** | |
| | ORIENTATION<br>**Direction (blowing from)** | PLOT YEAR-DATE-TIME<br>**1961**<br>**Feb 1 - Feb 29**<br>**Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

WIND ROSE PLOT

**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**

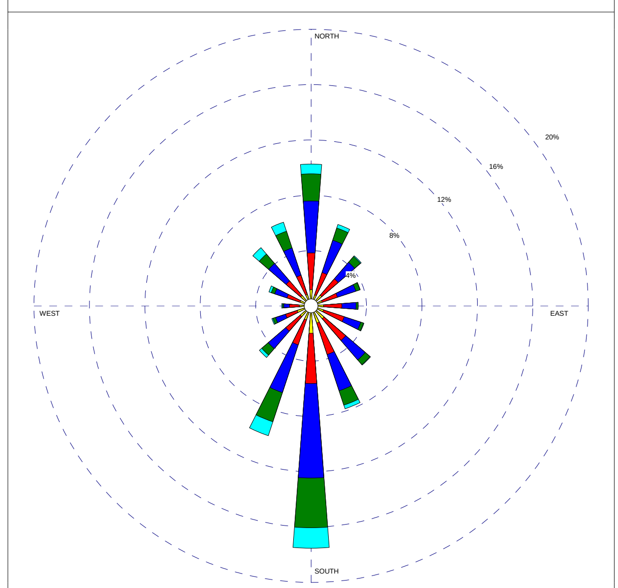



| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06<br>8.49 - 11.06<br>5.40 - 8.49<br>3.34 - 5.40<br>1.80 - 3.34<br>0.51 - 1.80 | Sara West | 8/28/2002 | USDA-ARS |
| | DISPLAY<br>**Wind Speed** | UNIT<br>**m/s** | COMMENTS |
| | AVG. WIND SPEED<br>**6.27 m/s** | CALM WINDS<br>**1.59%** | |
| | ORIENTATION<br>**Direction (blowing from)** | PLOT YEAR-DATE-TIME<br>**1961**<br>**Mar 1 - Mar 31**<br>**Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

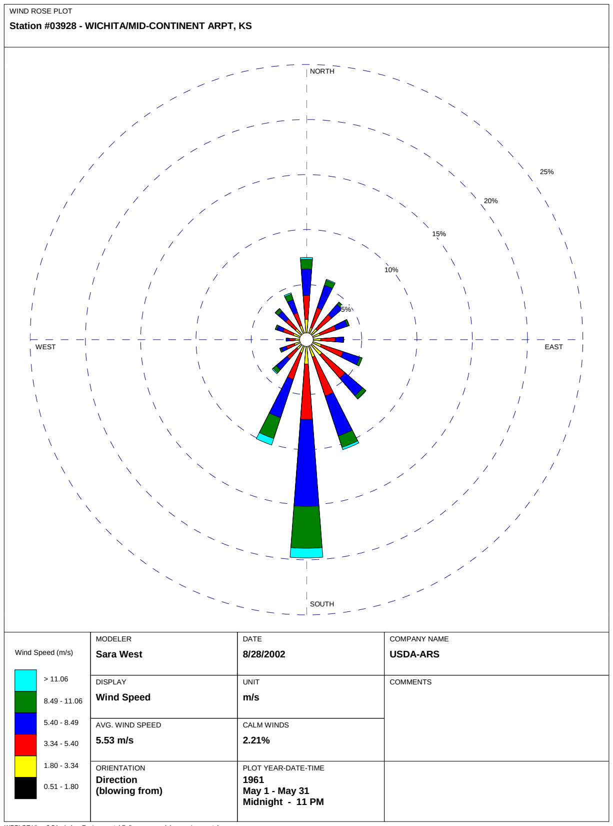
WIND ROSE PLOT

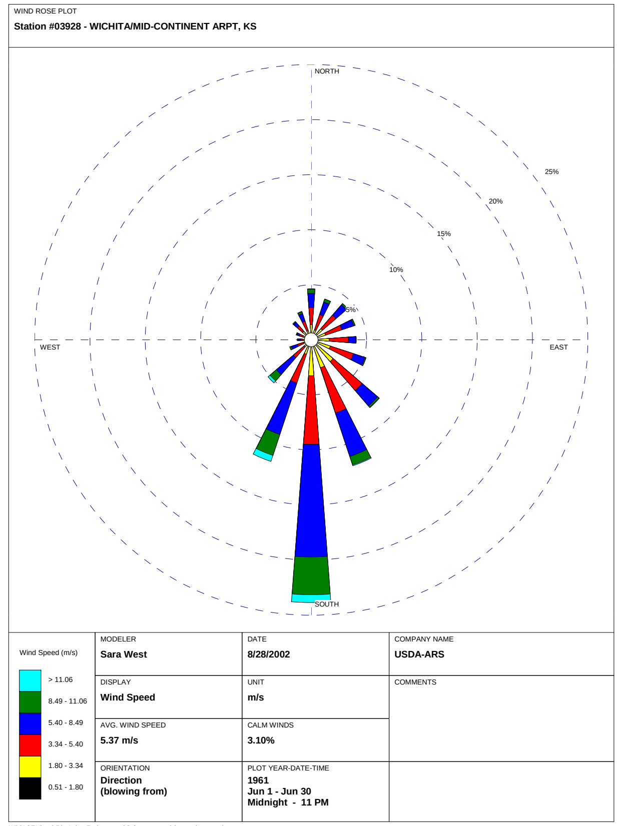
**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**

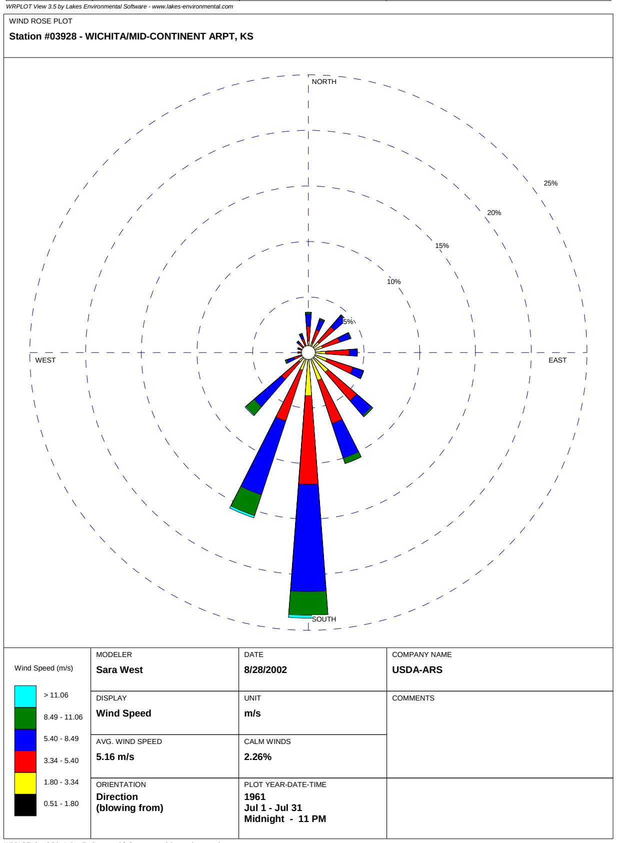


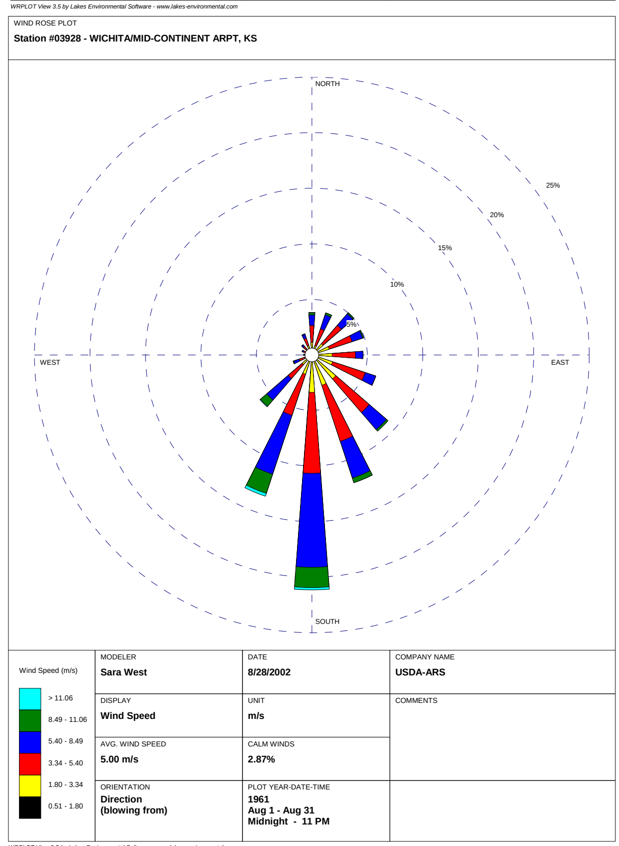

| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06<br>8.49 - 11.06<br>5.40 - 8.49<br>3.34 - 5.40<br>1.80 - 3.34<br>0.51 - 1.80 | Sara West | 8/28/2002 | USDA-ARS |
| | DISPLAY<br>**Wind Speed** | UNIT<br>**m/s** | COMMENTS |
| | AVG. WIND SPEED<br>**6.23 m/s** | CALM WINDS<br>**1.55%** | |
| | ORIENTATION<br>**Direction (blowing from)** | PLOT YEAR-DATE-TIME<br>**1961**<br>**Apr 1 - Apr 30**<br>**Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

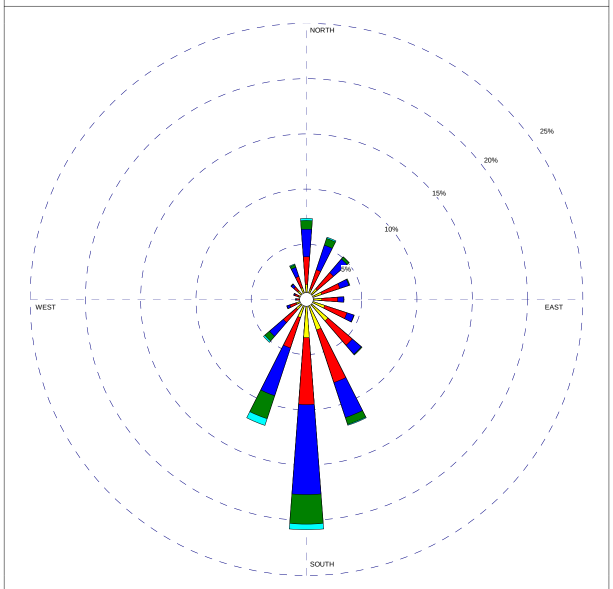

WIND ROSE PLOT
Station #03928 - WICHITA/MID-CONTINENT ARPT, KS
NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
Wind Speed (m/s)
> 11.06
8.49 - 11.06
5.40 - 8.49
3.34 - 5.40
1.80 - 3.34
0.51 - 1.80
MODELER
Sara West
DATE
8/28/2002
COMPANY NAME
USDA-ARS
DISPLAY
Wind Speed
UNIT
m/s
COMMENTS
AVG. WIND SPEED
5.53 m/s
CALM WINDS
2.21%
ORIENTATION
Direction
(blowing from)
PLOT YEAR-DATE-TIME
1961
May 1 - May 31
Midnight - 11 PM
WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com


WIND ROSE PLOT
Station #03928 - WICHITA/MID-CONTINENT ARPT, KS
NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
Wind Speed (m/s)
> 11.06
8.49 - 11.06
5.40 - 8.49
3.34 - 5.40
1.80 - 3.34
0.51 - 1.80
MODELER
Sara West
DATE
8/28/2002
COMPANY NAME
USDA-ARS
DISPLAY
Wind Speed
UNIT
m/s
COMMENTS
AVG. WIND SPEED
5.37 m/s
CALM WINDS
3.10%
ORIENTATION
Direction
(blowing from)
PLOT YEAR-DATE-TIME
1961
Jun 1 - Jun 30
Midnight - 11 PM
WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com


WIND ROSE PLOT
Station #03928 - WICHITA/MID-CONTINENT ARPT, KS
NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
Wind Speed (m/s)
> 11.06
8.49 - 11.06
5.40 - 8.49
3.34 - 5.40
1.80 - 3.34
0.51 - 1.80
MODELER
Sara West
DATE
8/28/2002
COMPANY NAME
USDA-ARS
DISPLAY
Wind Speed
UNIT
m/s
COMMENTS
AVG. WIND SPEED
5.16 m/s
CALM WINDS
2.26%
ORIENTATION
Direction
(blowing from)
PLOT YEAR-DATE-TIME
1961
Jul 1 - Jul 31
Midnight - 11 PM
WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com


WIND ROSE PLOT
Station #03928 - WICHITA/MID-CONTINENT ARPT, KS
NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
Wind Speed (m/s)
> 11.06
8.49 - 11.06
5.40 - 8.49
3.34 - 5.40
1.80 - 3.34
0.51 - 1.80
MODELER
Sara West
DATE
8/28/2002
COMPANY NAME
USDA-ARS
DISPLAY
Wind Speed
UNIT
m/s
COMMENTS
AVG. WIND SPEED
5.00 m/s
CALM WINDS
2.87%
ORIENTATION
Direction
(blowing from)
PLOT YEAR-DATE-TIME
1961
Aug 1 - Aug 31
Midnight - 11 PM
WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com

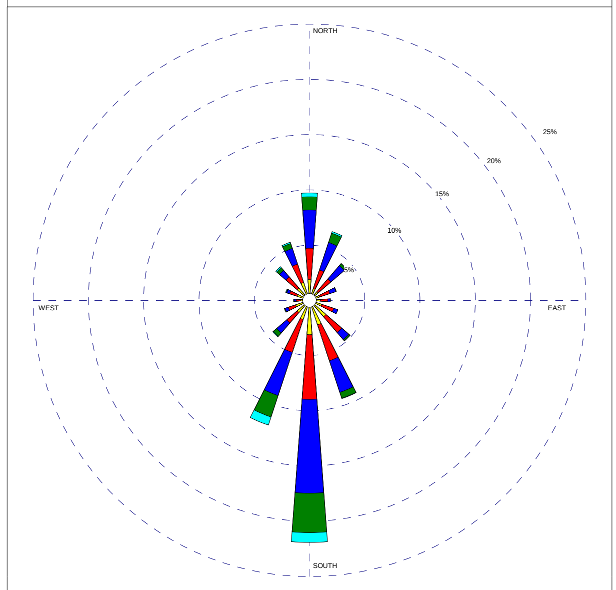
WIND ROSE PLOT
**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**




| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06 / 8.49 - 11.06 / 5.40 - 8.49 / 3.34 - 5.40 / 1.80 - 3.34 / 0.51 - 1.80 | **Sara West** | **8/28/2002** | **USDA-ARS** |
| | DISPLAY: **Wind Speed** | UNIT: **m/s** | COMMENTS |
| | AVG. WIND SPEED: **5.22 m/s** | CALM WINDS: **3.54%** | |
| | ORIENTATION: **Direction (blowing from)** | PLOT YEAR-DATE-TIME: **1961 Sep 1 - Sep 30 Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

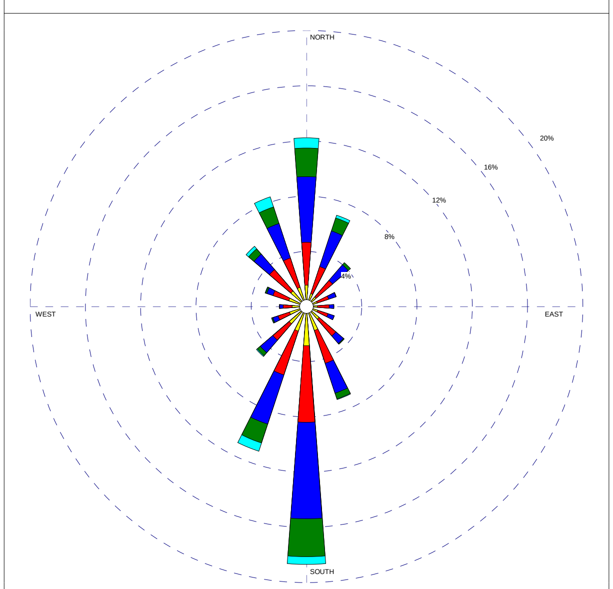
WIND ROSE PLOT
**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**




| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06 / 8.49 - 11.06 / 5.40 - 8.49 / 3.34 - 5.40 / 1.80 - 3.34 / 0.51 - 1.80 | **Sara West** | **8/28/2002** | **USDA-ARS** |
| | DISPLAY: **Wind Speed** | UNIT: **m/s** | COMMENTS |
| | AVG. WIND SPEED: **5.41 m/s** | CALM WINDS: **4.07%** | |
| | ORIENTATION: **Direction (blowing from)** | PLOT YEAR-DATE-TIME: **1961 Oct 1 - Oct 31 Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

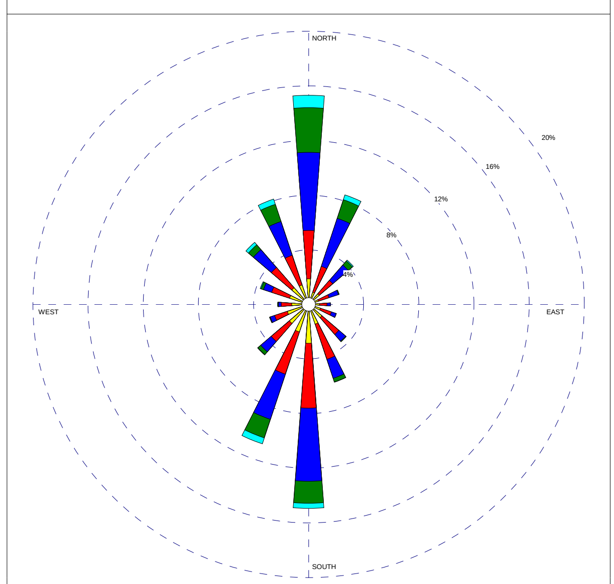
WIND ROSE PLOT
**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**




| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06 / 8.49 - 11.06 / 5.40 - 8.49 / 3.34 - 5.40 / 1.80 - 3.34 / 0.51 - 1.80 | **Sara West** | **8/28/2002** | **USDA-ARS** |
| | DISPLAY: **Wind Speed** | UNIT: **m/s** | COMMENTS |
| | AVG. WIND SPEED: **5.55 m/s** | CALM WINDS: **3.07%** | |
| | ORIENTATION: **Direction (blowing from)** | PLOT YEAR-DATE-TIME: **1961 Nov 1 - Nov 30 Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

WIND ROSE PLOT
**Station #03928 - WICHITA/MID-CONTINENT ARPT, KS**




| Wind Speed (m/s) | MODELER | DATE | COMPANY NAME |
|---|---|---|---|
| > 11.06 / 8.49 - 11.06 / 5.40 - 8.49 / 3.34 - 5.40 / 1.80 - 3.34 / 0.51 - 1.80 | **Sara West** | **8/28/2002** | **USDA-ARS** |
| | DISPLAY: **Wind Speed** | UNIT: **m/s** | COMMENTS |
| | AVG. WIND SPEED: **5.50 m/s** | CALM WINDS: **2.63%** | |
| | ORIENTATION: **Direction (blowing from)** | PLOT YEAR-DATE-TIME: **1961 Dec 1 - Dec 31 Midnight - 11 PM** | |

*WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com*

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# APPENDIX E

Stormwater Controls Screening Matrix (See Chapter 3)

**Table E-i Legend for Table E-1 parameters.**

| | |
|---|---|
| ✓ | Meets suitability criteria |
| **P** | Primary Control |
| **S** | Secondary Control |
| **O** | Other, for use as quantity control or special applications |
| * | Unless resident water fowl are present; in that case, assume no removal (may be a source instead, pending further analysis) |
| ** | Smaller area acceptable with adequate water balance and anti-clogging device |
| *** | Drainage area can be larger in some instances |
| **** | The application and performance of specific commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data |
| **a** | For peak flow control only |
| **b** | Insufficient data to assign a value |
| **c** | Removal efficiency depends on specific device |
| **d** | Usually not applicable or determinable |
| **e** | Removal efficiencies depend on specific installation |
| **f** | Porous surfaces provide water quantity benefits by reducing the effective impervious area |
| **g** | Due to the potential for clogging, porous surfaces should not be used for the removal of sediment or other coarse particulate pollutants |

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**Table E-1 Overall Applicability**

| Category | On-Site Storm Water Controls | STORMWATER MANAGEMENT SUITABILITY | | | | WATER QUALITY PERFORMANCE | | | | | SITE APPLICABILITY | | | | | IMPLEMENTATION CONSIDERATIONS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Water Quality Protection | Channel Protection | On-Site Flood Control | Downstream Flood Control | TSS/ Sediment Removal Rate | Nutrient Removal Rate (TP/TN) | Metals Removal Rate | Bacteria Removal Rate | Hotspot Application | Drainage Area (acres) | Typical Space Req'd (% Tributary Area) | Typical Facility Location Slope Limits | Typical Minimum Head Required | Minimum Bottom Depth to Maximum Water Table | Residential Subdivision Use | High Density/ Ultra Urban | Relative Capital Cost | Maintenance Burden |
| Ponds | Wet Pond | P | P | P | P | 80% | 55%/30% | 50% | 70%* | --- | 25 min | 2-5% | 15% | 6 to 8 ft | 5 ft unlined, 2 ft lined | ✓ | ✓ | Low | Low |
| | Wet ED Pond | P | P | P | P | 80% | 55%/30% | 50% | 70%* | --- | 25 min** | | | | | ✓ | ✓ | Low | Low |
| | Micropool ED Pond | P | P | P | P | 80% | 55%/30% | 50% | 70%* | --- | 10 min** | | | | | ✓ | --- | Low | Moderate |
| Detention | Conventional Dry Detention | --- | P | P | P | a | a | a | a | --- | --- | 2-5% | 15% | 6 to 8 ft | 5 ft unlined, 2 ft lined | ✓ | ✓ | Low | Moderate |
| | Extended Dry Detention | P | P | P | P | 60% | 35%/25% | 25% | b | --- | --- | 2-5% | 15% | 6 to 8 ft | 5 ft unlined, 2 ft lined | ✓ | ✓ | Low | Moderate |
| | Underground Detention | --- | P | P | P | a | a | a | a | --- | — | --- | --- | --- | --- | --- | ✓ | High | High |
| Channels | Enhanced Swales | P | S | S | S | 90% | 50%/50% | 40% | b | --- | 5 max*** | --- | 4% | 1 ft | 5 ft unlined, 2 ft lined | ✓ | --- | Moderate | Moderate |
| | Grass Channel | P | --- | S | --- | 30% | 25%/20% | 30% | b | --- | | | | --- | --- | ✓ | --- | Low | Low |
| Infiltration | Infiltration Trenches | P | S | --- | --- | 90% | 60%/60% | 90% | 90% | --- | 5 max*** | --- | 6% | 1 ft | 5 ft | ✓ | ✓ | High | High |
| | Soakage Trenches | P | --- | --- | --- | 90% | 60%/60% | 90% | 90% | --- | 5 max*** | --- | 6% | 1 ft | 5 ft | ✓ | ✓ | High | High |
| Filtration | Filter Strips | P | --- | --- | --- | 50% | 20%/20% | 40% | b | --- | 2 max*** | --- | 1%-6% | - | --- | ✓ | · | Low | Low |
| | Organic Filters | P | --- | --- | --- | 80% | 60%/40% | 75% | 50% | ✓ | 10 max*** | --- | --- | 2 to 3 ft | --- | --- | ✓ | High | High |
| | Surface/Underground Sand Filters | P | S | --- | --- | 80% | 50%/30% | 50% | 40% | ✓ | 10 max *** | --- | 6% | 2 to 3 ft | --- | --- | ✓ | High | High |
| Bioretention | Bioretention | P | S | S | S | 85% | 60%/50% | 80% | b | --- | 5 max*** | --- | 6% | 3 to 5 ft | 5 ft | ✓ | ✓ | Moderate | Moderate |
| Wetlands | Stormwater Wetlands | P | P | P | P | 75% | 45%/30% | 50% | 70%* | --- | 25 min** | --- | 8% | 3 to 5 ft (shallow) 6 to 8 ft (pond) | 5 ft unlined, 2 ft lined | ✓ | --- | Moderate | Moderate |
| Proprietary Systems | Proprietary Systems | S | S | --- | --- | c | c | c | d | ✓ | **** | --- | --- | --- | --- | **** | ✓ | High | High |
| Gravity Separator | Gravity (Oil/Water) Separator | S | --- | --- | --- | c | c | d | d | ✓ | 1 max*** | --- | --- | --- | --- | --- | ✓ | High | High |
| Chemical Treatment | Alum Treatment System | S | --- | --- | --- | c | c | c | d | ✓ | 25 min | --- | --- | --- | --- | --- | ✓ | High | High |
| Porous Surfaces | Green Roof | O | --- | P | S | e | e | e | e | --- | --- | --- | --- | --- | --- | --- | ✓ | High | High |
| | Modular Porous Paver Systems | O | --- | S | S | f, g | f, g | f, g | f, g | --- | 5 max | --- | --- | --- | --- | ✓ | ✓ | Moderate | High |
| | Porous Pavement | O | --- | S | S | f, g | f, g | f, g | f, g | --- | 5 max | --- | --- | --- | --- | ✓ | ✓ | Moderate | High |

## Table E-2  Specific Criteria

| Category | On-Site Storm Water Controls | PHYSIOGRAPHIC FACTORS | | | SOILS | SPECIAL WATERSHED CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|
| | | Low Relief | High Relief | Karst | | High Quality Stream | Aquifer Protection | Reservoir Protection |
| **Ponds** | Wet Pond | Limits maximum pool depth; providing pond drain can be problematic | Embankment heights may be restrictive | Requires geotechnical assessment and may require special construction techniques | Underlying soils of hydrologic group "C" or "D" usually adequate to maintain a permanent pool. Most group "A" soils and some group "B" soils will require a pond liner. | Check for possible thermal impacts of discharge | "A" soils and some "B" soils may require liner; 5 ft min separation distance from maximum water table for unlined ponds, 2 ft for lined ponds | Check for possible thermal impacts of discharge |
| | Wet ED Pond | | | | | | | |
| | Micropool ED Pond | | | | | | | |
| **Detention** | Conventional Dry Detention | Limits maximum pool depth; providing pond drain can be problematic | Embankment heights may be restrictive | Requires geotechnical assessment and may require special construction techniques | --- | --- | 5 ft min separation distance from maximum water table for unlined ponds, 2 ft for lined ponds | --- |
| | Extended Dry Detention | | | | | --- | | --- |
| | Underground Detention | | | May not be allowed, depending on site-specific assessment | --- | --- | --- | --- |
| **Channels** | Enhanced Swales | Generally feasible however small slopes may lead to longterm standing water | May be infeasible due to excessive slope | --- | --- | --- | --- | --- |
| | Grass Channels | | | --- | --- | --- | --- | --- |
| **Infiltration** | Infiltration Trenches | Minimum distance to maximum water table of 5 feet | Slopes may be restrictive; trenches must have flat bottom | May not be allowed, depending on site-specific assessment | Infiltration rate should be >0.5 inch/hr | --- | Maintain safe distance from wells per regulations; 5 ft min separation distance from maximum water table | --- |
| | Soakage Trenches | | | | | --- | | --- |
| **Filtration** | Filter Strips | --- | --- | --- | --- | --- | --- | |
| | Organic Filters | Design variations will likely be limited by low head | --- | May not be allowed, depending on site-specific assessment | Facilities receiving fine (clay or silty) soils may require pretreatment to minimize maintenance | Check for possible thermal impacts of discharge | Must be designed with no exfiltration (i.e. outflow to groundwater) | |
| | Surface/Underground Sand Filters | | --- | | | | | Check for possible thermal impacts of discharge |
| **Bioretention** | Bioretention Areas | Design variations will likely be limited by low head | Slopes may be restrictive | May not be allowed, depending on site-specific assessment | Facilities receiving fine (clayey or silty) soils may require pretreatment to minimize maintenance | --- | 5 ft min separation distance from maximum water table | --- |
| **Wetlands** | Stormwater Wetlands | --- | Embankment heights may be restrictive | Requires geotechnical assessment and may require special construction techniques | "A" soils and some "B" and "C" soils may require pond liner | Check for possible thermal impacts of discharge | "A" soils and some "B" soils may require liner; 5 ft min separation distance from maximum water table for unlined, 2 ft for lined | Check for possible thermal impacts of discharge |
| **Proprietary Systems** | Proprietary Systems | --- | --- | --- | --- | --- | --- | --- |
| **Gravity Separator** | Gravity (Oil-Grit/Water) Separator | --- | --- | --- | --- | --- | --- | --- |
| **Chemical Treatment** | Alum Treatment System | --- | --- | --- | --- | --- | --- | --- |
| **Porous Surfaces** | Green Roof | --- | --- | --- | --- | Check for possible thermal impacts of discharge | --- | Check for possible thermal impacts of discharge |
| | Modular Porous Paver Systems | --- | --- | --- | --- | --- | --- | --- |
| | Porous Pavement | --- | --- | --- | --- | --- | --- | --- |

# APPENDIX F

Acronym List

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**Table F-1 Acronym List and Respective Definitions**

| Acronym | Definition |
|---|---|
| AASHTO | American Society of State Highway and Transportation Officials |
| ACI | American Concrete Institute |
| ASCE | American Society of Civil Engineers |
| ASTM | American Society for testing of Materials |
| BFE | Base Flood Elevation |
| BMP | Best Management Practices |
| CLOMR | Conditional Letter of Map Revision |
| CN | Curve Number |
| CWA | Clean Water Act |
| ED | Extended Detention |
| EGL | Energy Grade Line |
| EPA-SWMM | EPA-Stormwater Management Model |
| ESA | Endangered Species Act |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| HEC-HMS | Hydrologic Engineering Centers Hydrologic Modeling System |
| HEC-RAS | Hydrologic Engineering Centers River Analysis System |
| HDC | Hydroelectric Design Center (USACE) |
| HDS-5 | Hydraulic Design of Highway Culverts |
| HGL | Hydraulic Grade Line |
| HSG | Hydrologic Soil Group |
| HW | Headwater Depth |
| HY-8 | FHWA Culvert Hydraulic Analysis and Design Program |
| IDF | Intensity Duration Frequency Curve |
| ISD | Integrated Site Design |
| IUH | Instantaneous Unit Hydrograph |
| KDA | Kansas Department of Agriculture |
| KDHE | Kansas Department of Health and Environment |
| KDOT | Kansas Department of Transportation |
| KDWP | Kansas Department of Wildlife and Parks |
| KHRI | Kansas Historic Resources Inventory |
| KHS | Kansas Historical Society |
| KSDA | Kansas Department of Agriculture |
| LOMR | Letter of Map Revision |
| MAPC | Metropolitan Area Planning Commission |
| MSDM | Maryland Department of Environment |
| MS4 | Municipal Separate Storm Sewer System |
| NEH | National Engineering Handbook |
| NEPA | National Environmental Policy Act |
| NFIP | National Flood Insurance Program |
| NOC | Notice of Coverage |
| NOI | Notice of Intent |
| NOT | Notice of Termination |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resources Conservation Service (formerly SCS) |
| O&M | Operations & Maintenance |
| PVC | Polyvinyl chloride |
| PSD | Preferred Site Design |
| RCB | Reinforced Concrete Box |

| | |
|---|---|
| RCP | Reinforced Concrete Pipe |
| SCS | Soil Conservation Service (Now NRCS) |
| SWMM | Stormwater Management Model |
| SWMP | Stormwater Management Program |
| SWPPP | Stormwater Pollution Prevention Plan |
| TAC | Technical Advisory Committee |
| TOC | Top of Conduit |
| TMDL | Total Maximum Daily Loads |
| TSS | Total Suspended Solids |
| TR-55 | Technical Release 55 |
| TW | Tailwater |
| UDFCD | Urban Drainage and Flood Control District |
| USACE | U.S. Army Corps of Engineer |
| USBR | U.S. Bureau of Reclamation |
| USDA | U.S. Department of Agriculture |
| USDOT | U.S. Department of Transportation |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |

# APPENDIX G

Reference List

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## REFERENCES

Brater, E.F and H.W. King, 1963. “Handbook of Hydraulics.” 5th edition McGraw-Hill Book Company.

Capuccitti, D and W, 2000. “Stream Response to Stormwater Management Best Management Practices in Maryland.” Maryland Department of the Environment.

Clark, C.O., 1945, Storage and the unit hydrograph: Transactions: American Society of Civil Engineers, Vol. 110, p. 1419-1488.

Claytor, R.A., and T.R. Schueler. 1996. “Design of Stormwater Filtering Systems.” Chesapeake Research Consortium, Inc.

Chow, Ven Te., 1959. “Open –Channel Hydraulics” McGraw-Hill Book Company.

City of Austin, TX. 1988 Design Guidelines for Water Quality Control Basins. Environmental Criteria Manual. Environmental and Conservation Services. Austin, TX.

City of Sacramento, CA 2000. “Guidance Manual for On-Site Stormwater Quality Control Measures.” Department of Utilities.

Ferguson, B. and T.N. Debo. 1990. “On-Site Stormwater Management – Applications for Landscape and Engineering.” Van Nodstrandt, Reinhold, New York.

French, R.H., 1985. “Open Channel Hydraulics.” McGraw-Hill Book Company.

Kansas Division of Water Resources, 2007. “Kansas Dam Safety Laws and Regulations.” KSA 82a-301 thru 305a, KAR 5-40-1 thru 5-40-94.

Kansas Department of Transportation, 2008. “Design Manual Volume I”.

Knox County Department of Engineering & Public Works, 2008. “Knox County, Tennessee Stormwater Management Manual Volume II.” Prepared by AMEC Earth & Environmental, Inc.

Los Angeles County Department of Public Works (LAC), 2000. Standard Plan Manual.

Maine Department of Environmental Protection, Bureau of Land and Water Quality, 2003. “Maine Erosion and Sediment Control BMPS Manual.”

Maryland Department of the Environment, 2000. Maryland Stormwater Design Manual Volumes I & II. (MSDM) Prepared by Center for Watershed Protection.

Maryland Department of Environment Resources, 1999. “Low-Impact Development Design Strategies: An Integrated Design Approach.” Prince George County, MD.

Minnesota Pollution Control Agency, 1989. “Protecting Water Quality in Urban Areas.”

National Weather Service, TP-40. 1961. “Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 hours and Return Periods from 1 to 100 Years.”

Natural Resources Defense Council, 2006. “Rooftops to rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows.”

North Carolina Department of Environment and Natural Resources, the Division of Land Resources, 2006. “Erosion and Sediment Control Planning and Design Manual,” Revised 2009.

North Carolina Department of Environment and Natural Resources, 1998. “Storm Water Management Site Planning.”

Northern Virginia Regional Commission (NVRC), 1992. “The Northern Virginia BMP Handbook.” Annandale, VA.

Pitt, Robert, 1994. “Small Storm Hydrology.” Department of Civil Engineering, University of Alabama at Birmingham.

Prince George’s County, MD, 1999. “Low-Impact Design Strategies, an Integrated Design Approach.”

Schueler, T., 1987. “Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.” Metropolitan Washington Council of Governments.

Schueler, T.J., 1992. “Design of Stormwater Wetland Systems.” Metropolitan Washington Council of Governments.

Schueler, T. and Chesapeake Stormwater Network, 2008. “Technical Support for the Bay-wide Runoff Reduction Model.”

Schueler, T., 1995. “Site Planning for Urban Stream Protection.”Prepared by Center of Watershed Protection (CWP). Metropolitan Washington Council of Governments.

Urban Drainage and Flood Control District, 1999. “Urban Storm Drainage Criteria Manual,” Denver, Co.

Urban Land Institute, 1992. “Density by Design.”

U.S. Army Corps of Engineers. Engineering and Design. 1994. “ Flood-Runoff Analysis.” EM1110-2-1417.

U.S. Army Corps of Engineers, Engineering and Desgin. 1994. “Hydraulic Design of Flood Control Channels,” EM 1110-2-1601.

U.S. Army Corps of Engineers, Hydraulic Design of Flood Control Channels (EM-1110-2-1601), 1994.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. 2008. HEC-RAS Hydraulic Reference Manual.

U.S. Department of Agriculture, Soil Conservation Services (SCS), 1956. “National Engineering Handbook 5.”

U.S. Department of Agriculture, Soil Conservation Services (SCS), 1975, “Standards and Specifications for Soil Erosion and Sedimentation in Developing Areas”.

U.S. Department of Agriculture, Soil Conservation Services (SCS), 1986 Urban Hydrology for Small Watersheds. Engineering Division. Technical Release 55.

U.S. Department of Transportation, Federal Highway Administration, 2001, Hydraulic Design Series No. 5, Revised May 2005 “Hydraulic Design of Highway Culverts,” FHWA-NHI-01-020.

U.S. Department of Transportation, Federal Highway Administration, 2001, Hydraulic Engineering Circular No. 18, Fourth Edition “Evaluating Scour At Bridges,” FHWA-NHI-01-001.

U.S. Department of Transportation, Federal Highway Administration, 2001, Hydraulic Engineering Circular No. 20, Third Edition “Stream Stability at Highway Structures,” FHWA-NHI-01-002.

U.S. Department of Transportation, Federal Highway Administration, 2001, Hydraulic Engineering Circular No. 22, Second Edition “Urban Drainage Design Manual,” FHWA-NHI-01-021.

U.S. Department of Transportation, Federal Highway Administration, 2006, Hydraulic Engineering Circular No. 14, Third Edition “Hydraulic Design of Energy Dissipators for Culverts and Channels,” FHWA-NHI-06-086.

U.S. Department of Transportation, Federal Highway Administration, 2005, Hydraulic Engineering Circular No. 15, Third Edition “Design of Roadside Channels with Flexible Linings,” FHWA-NHI-05-114.

U.S. Department of Transportation, Federal Highway Administration, 2003, Hydraulic Engineering Circular No. 23, Second Edition “ Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance.” FHWA-NHI-01-003.

U.S. Geological Survey, Department of Interior. 2004. “Estimates of Flow Duration, Mean Flow, and Peak-Discharge Frequency Values for Kansas Stream Locations.” SI 2004-5033.

Virginia Department of Conservation and Recreation, 1999. “Virginia Stormwater Management Handbook.”

Washington State Department of Ecology, 2000. “Stormwater Management Manual for Western Washington.”

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CHAPTER

1

# Plan Preparation Guidance

## TABLE OF CONTENTS



## LIST OF FIGURES

## LIST OF APPENDICIES

# 1.0 INTRODUCTION

The City of Wichita and Sedgwick County Stormwater Manual is primarily intended to provide policy and guidance for the portions of the land development process that pertain to stormwater management. The purpose of Volume 3 is to define the policies and procedures for the site plan review process, which falls largely under the public works and codes enforcement arms within both jurisdictions. Detailed information about the requirements or procedures of other agencies in this process, such as the Metropolitan Area Planning Commission (MAPC) and various utilities, is not presented in this manual and the reader is referred to the agency of interest for further information.

## 1.1 How to Use this Manual

A graphical stormwater manual navigation aide is provided in Volume 3, Appendix A to assist the user in the application of this Manual to the specific local development processes. This aide depicts the general steps for land development in the City of Wichita and Sedgwick County. The appropriate corresponding chapters/sections/appendices for each development process step are also shown.

# 2.0 OVERVIEW OF THE STORMWATER PLANNING PROCESS

## 2.1 Relevant Local Government Agencies

The following figure displays the organizational structure of the entities involved in local stormwater management for the City of Wichita and Sedgwick County.

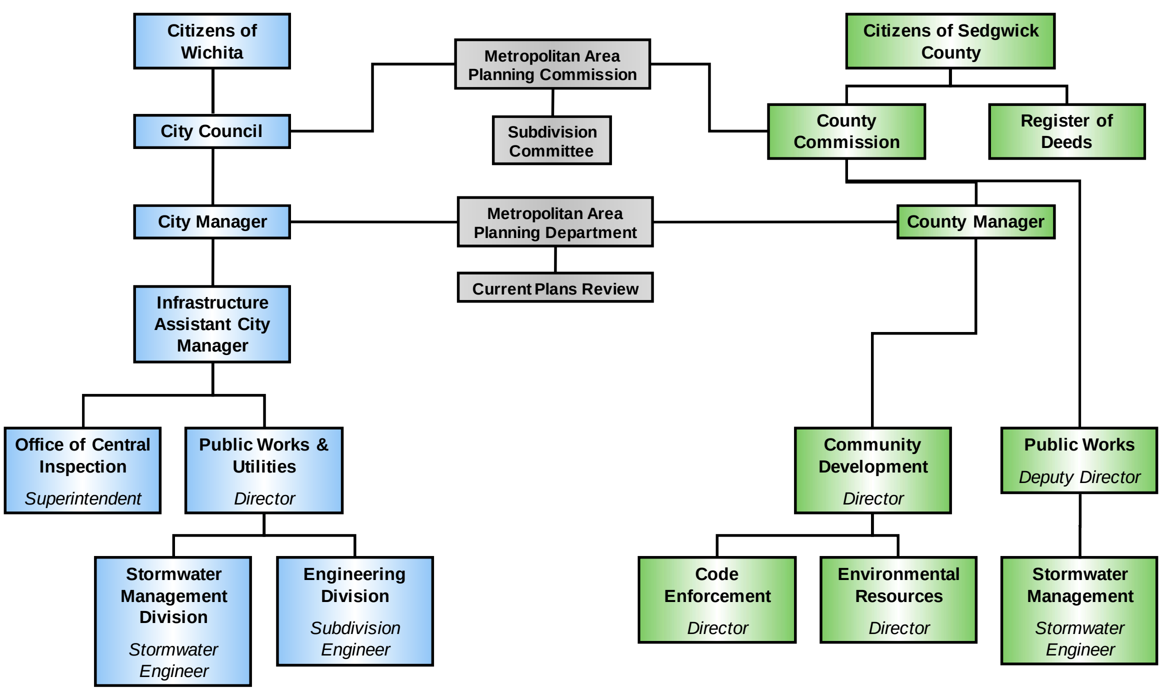


**Figure 1-1 Wichita and Sedgwick County Entities Involved with Stormwater Management**

To avoid confusion in the following text "Codes Department" shall mean the Office of Central Inspection for Wichita, and the Codes Enforcement Department for Sedgwick County.

## 2.2 Site Planning Process Flowcharts

The flow charts presented in Volume 3, Appendix B present the sequence of events that comprise the site development processes in the City of Wichita and Sedgwick County.

- Appendix B-1 depicts the subdivision drainage plan and platting process for both jurisdictions;
- Appendix B-2 presents the construction planning and inspection process for subdivisions after platting and for single lot developments in the City of Wichita; and,
- Appendix B-3 presents the construction planning and inspection process for subdivisions after platting and for single lot developments in Sedgwick County.

# 3.0 STORMWATER PLANS SUBMITTED IN THE PLATTING PROCESS

## 3.1 The Drainage Concept

The drainage concept is the first stormwater plan that is encountered in the subdivision planning/platting process, and is submitted with the preliminary plat application. Submission of a drainage concept is not mandatory except when specifically requested by the local jurisdiction, but it is highly recommended for all sites. When required, preliminary plat applications will be denied if the drainage concept plan is not approved.

The purpose of the drainage concept is to provide an understanding of the anticipated stormwater management system/facilities on the site to the local jurisdiction. Ideally, preparation of a drainage concept will aide the site developer and site design engineer in the determination of the most feasible approach for site stormwater management. The drainage concept presents general stormwater management information and does not include detailed design calculations. A complete checklist of stormwater information elements that must be included in the drainage concept can be found in Appendix C.

The drainage concept must be submitted to the local jurisdiction's Stormwater Management Division by 4 PM on the Thursday two weeks prior to the Subdivision Committee hearing on the preliminary plat. The concept will be reviewed and comments will be returned to the applicant within one week. The drainage concept will be approved only after all comments have been resolved prior to the hearing on the preliminary plat.

## 3.2 The Drainage Plan

The drainage plan builds on the information provided in the drainage concept by including detailed calculations used to locate, size, and design the proposed stormwater management facilities. Submittal of a drainage plan to the local jurisdiction is mandatory with the final plat application. Final plat applications will be denied if the drainage plan is not approved.

The drainage plan must include all items found in the checklist of Appendix D. Some highlights include:

- Pre- and post-development hydrology calculations to prevent against peak flow increases for the 2 through 100 year storms;
- 1-year storm calculations to protect against downstream channel erosion;
- Small storm hydrology calculations to determine the volume of water that must be treated to the 80% TSS removal standard, including any adjustments for $WQ_v$ reduction areas;
- TSS removal calculations proving the removal of at least 80% of the site TSS load;
- Detailed hydraulic calculations to ensure proper inlet design, proper protection of structures from flooding, protection of ditches from erosion, etc.;
- Floodplain modelling and documentation where required for sites that propose to fill in the floodplain; and,
- A Restrictive Covenants for Stormwater Management Facilities document executed by the Owner(s) of the facilities and the local government.

The drainage plan must be submitted to the local jurisdiction's Stormwater Management Division by 4 PM on the Thursday two weeks prior to the Subdivision Committee hearing on the final plat. The concept will be reviewed and comments will be returned to the applicant within one week. The drainage plan will be approved only after all comments have been resolved prior to the hearing on the final plat.

### 3.2.1 Covenants for Stormwater Management Facilities

Templates for Restrictive Covenants for Stormwater Management Facilities for both the City of Wichita and Sedgwick County are provided in Appendix E. The covenants bind the property owner (and subsequent property owners) to the long-term proper operation and maintenance of stormwater facilities and any optional $WQ_v$ reduction areas that are located on the development/redevelopment. *Approval of the final plat by the local jurisdiction cannot be obtained until the covenant for the property has been executed by the property owner(s) and the local jurisdiction.*

# 4.0 STORMWATER PLANS SUBMITTED IN THE SITE CONSTRUCTION PROCESS

## 4.1 The Stormwater Permit Application

For developments in both the City of Wichita and Sedgwick County, a Wichita/Sedgwick County Stormwater Permit must be issued by the local jurisdiction's Stormwater Management Division prior to the commencement of land disturbance/construction activities and/or issuance of a building permit. The Stormwater Permit Application is provided in Appendix F of this Volume.

As indicated on the Stormwater Permit Application, the stormwater-related items listed below must be on-file with the Stormwater Management Division or attached with the application. These items are discussed as indicated in the list below.

- The subdivision drainage plan, if available for the proposed development (discussed in Section 3.2);
- The construction plan (discussed in Section 4.1.1);
- The Stormwater Pollution Prevention Plan and Authorized Notice of Intent (discussed in Section 4.1.2);
- The draft O&M Plan (discussed in section 4.1.3)
- Supplemental drainage calculations, if required (discussed in Section 4.1.4);
- The ERU plan sheet (discussed in Section 4.1.5);
- Sewer Permit Application (discussed in Section 4.1.6); and,
- A completed Stormwater Design Certification Form (discussed in section 4.1.7).

### 4.1.1 The Construction Plan

The construction plan can be created once the final plat has been approved and when site improvements are imminently planned. The plan includes construction related information for stormwater management, erosion prevention and sediment control (EPSC), non-stormwater related public infrastructure, and other building codes related issues. In both the City of Wichita and Sedgwick County, the plan is reviewed/approved by staffs in engineering, stormwater management and codes enforcement.

Note: In the City of Wichita, the proper name or identifier for the stormwater portion of the construction plan varies depending upon the source of funding (private or public) for the project and the improvement type. For privately funded projects, the stormwater portion of the construction plan is also referred to as a Private Project Drainage (PPD) plan. For publicly funded improvements, the stormwater information can be termed a stormwater drain (SWD), storm sewer (SWS), or can even be referred to as paving improvement that includes incidental drainage.

Relevant to site stormwater management, the plan provides specifications for the construction of the stormwater management facilities, as designed in the drainage plan. The construction plan must include all items found in the checklist of Appendix G.

Construction plans must be created according to the local jurisdiction's construction standards. The following documents must be incorporated into the construction plan:

- Local Standard Specifications (per template specification file);

- Local Plan Sheet Information (per template CAD files);
- Local EPSC Plan View Standards (per template CAD files);
- Local Bid Items (per standard bid tabs);
- Local Notes for Stormwater Projects (per template CAD files); and,
- Local Standard Stormwater Construction Details (per template CAD files).

Templates for all of these documents can be found at Wichita's stormwater management website.

The applicant is responsible for obtaining all relevant and required Federal, State and local permits associated with the development. These are discussed in Volume 1, Chapter 2 of this Manual. Proof that all applicable permits have been obtained is required with the construction plan.

The construction plans must be submitted to the appropriate Stormwater Management Division for review. A review of the construction plans will be performed by staff and comments will be returned to the applicant within two weeks. Construction plans will not be approved until all required local, State and Federal permits have been obtained by the applicant and presented to the local Stormwater Management Division, and all comments provided by Stormwater Management Division staff have been resolved.

### 4.1.2 The Operations & Maintenance Plan

Stormwater design information that is submitted with the drainage plan will include a draft Operations & Maintenance (O&M) Plan. A checklist for the O&M Plan contents is provided in Appendix H0. The O&M plan is linked to the Restrictive Covenants for Stormwater Management Facilities, as indicated in the covenants language. Both documents are used to ensure the long term, proper operation and maintenance of stormwater management facilities located on the development. Long-term maintenance of water quality treatment facilities is a requirement that the State of Kansas imposes on both the City of Wichita and Sedgwick County through their municipal separate storm sewer system (MS4) permits.

While the covenants bind the property owner (and subsequent property owners) to the maintenance of stormwater facilities, the O&M plan provides information to accurately identify and locate the stormwater feature/facilities and WQv reduction areas on the property, and guidance to adequately inspect and maintain the facilities. The draft O&M Plan must be submitted and approved as part of the construction plan. A final O&M Plan is provided with the As-Built Plan (discussed in section 4.2) and is recorded with the Sedgwick County Registrar of Deeds.

Two of the required elements of the O&M plan are the Inspection and Maintenance Guidance and the Inspection Checklist. Both of these sheets (8.5" x 11" paper) must be provided in the O&M plan for each stormwater management facility that is located on the development site. These sheets are provided in Appendices H1 through H18 of this volume for each stormwater management facility included in this manual, with the exception of proprietary stormwater controls for which maintenance guidance should be provided by the control's vendor. The Guidance includes information what to inspect/maintain and the expected frequency of inspections and routine maintenance activities. The Checklist provides a list of inspection items with spaces for an indication of inspection result (satisfactory or unsatisfactory) and notation for any corrective actions/maintenance activities undertaken.

After development is complete, property owners are strongly encouraged to use the Guidance and Checklists that are provided in the O&M plan to perform and document their facility inspections and maintenance, as is required by the stormwater management regulations in the City of Wichita and Sedgwick County.

### 4.1.3 Stormwater Pollution Prevention Plan

The stormwater pollution prevention plan (SWPPP) that was submitted to the State of Kansas for coverage under the Kansas Water Pollution Control General Permit and Authorization to Discharge Stormwater Runoff from Construction Activities Under the National Pollutant Discharge Elimination System (also called the Kansas Construction General Permit) must be submitted with the Stormwater Permit Application. The SWPPP must be accompanied by the Authorized Notice of Intent (NOI). An authorized NOI indicates to the local jurisdiction that the Kansas Department of Health and Environment (KDHE) has received and approved the SWPPP and issued coverage under the Kansas Construction General Permit.

A template for preparation of a SWPPP is provided in Appendix I. This template is based on SWPPP preparation guidance developed by EPA.

### 4.1.4 Supplemental Drainage Calculations

The local jurisdiction may require submittal of supplemental drainage calculations. This occurs when the plat on file does not reflect the development being proposed (making the original drainage plans no longer applicable), or when the local jurisdiction does not have a current drainage plan on file. These situations sometimes arise when platting occurs many years prior to actual construction. When planning such a development, the site developer is strongly encouraged to check with the local jurisdiction's Stormwater Management Division to determine whether supplemental drainage calculations are going to be required. *The supplemental design calculations must be reviewed and approved by the division prior to issuance of a Stormwater Permit (discussed in the next section).*

The purpose of providing supplemental drainage calculations is to either confirm that the stormwater designs in the previous drainage plan are sufficient to meet current stormwater regulations, or to present the re-design of stormwater management facilities for water quality treatment, channel protection and peak discharge control. When required, the calculations will include:

- a short narrative of the proposed improvements, which describes the need for drainage calculations and other special conditions;

- a Professional Engineer's certification;
- stormwater design specifications and calculations for all water quality treatment, channel protection and peak discharge control facilities. The calculations must indicate that stormwater designs meet the requirements of the stormwater management regulations of the local jurisdiction;
- a revised draft O&M Plan for the stormwater management facilities located on the property.

### 4.1.5 ERU Plan Sheet (City of Wichita only)

When submitting a Stormwater Permit Application to the Wichita Office of Central Inspection (OCI), the Stormwater Management Division requires a separate ERU plan sheet that includes the following:

- the project name and address and/or legal description of property;
- the building permit number (if known);
- a map showing a delineation of project limits with:
  - the project area (in acres) clearly indicated;
  - property lot lines clearly marked and lot number labels;
  - proposed improvements shown as a background (note: the site grading plan and/or landscape plan is often used as a base drawing background);
  - impervious areas located within the project's property limits shown in cross-hatch. Impervious areas include the driveways from the city street right-of-way. Public streets and sidewalks located in street right-of-way should not be included in the impervious area calculations;
  - a map legend;
- area measurements for total pervious and total impervious surfaces, in square feet.

Per Chapter 16.30.010(p) of the City Code, "impervious area" is defined as the number of square feet of hard surface areas which either prevent or retard the entry of water into soil mantle, as it entered under natural conditions as undisturbed property, and/or causes water to run off the surface in greater quantities or at an increased rate of flow from that present under natural conditions as undisturbed property, including, but not limited to, roofs, roof extensions, patios, porches, driveways, sidewalks, pavement, athletic courts, and compacted dirt or graveled areas.

The ERU plan sheet shall be submitted to Stormwater Management electronically in PDF format and as a half-scale (11"x17") hard copy with the above referenced information included.

Directions for submittal of the City's ERU plan sheet can be found at the following link: http://www.wichita.gov/CityOffices/PublicWorks/StormWater/Regulatory+Documents.htm.

### 4.1.6 Sewer Permit Application (City of Wichita only)

For proposed developments in the City of Wichita that will connect a roof drain, sump pump discharge, or storm sewer (and the discharge pipe is 10-inches in diameter or smaller), the applicant must submit a Sewer Permit Application. The application is provided in Appendix J. *A complete Sewer Permit Application must be submitted to the City of Wichita Office of Central Inspection's Sewer Department desk prior to obtaining a City Stormwater Permit.*

The Sewer Permit Application shall include a site specific map that depicts the following items:

- the location, type, material, flowline and slope of all storm sewer pipes; and,
- the location and type of all drainage structures (e.g., catchbasins, headwalls, etc.).

### 4.1.7 Stormwater Design Certification Form

Construction plans must be accompanied by a Stormwater Design Certification form. The form must be completed and stamped by the Professional Engineer overseeing the design of the stormwater facilities at the development site. A blank form is provided in Appendix K.

## 4.2 The As-built Plan

The As-built plan are submitted to the local Stormwater Management Division for review and approval after construction of the facilities is compete. The as-built plan must include all items found in the checklist of Appendix L. *A complete as-built plan must be reviewed and approved by the local jurisdiction prior to obtaining a Certificate of Occupancy.*

Policies associated with as-built plans are as follows:

- The as-built plans shall reflect the "as-constructed" condition of the development, and shall include sufficient information to demonstrate substantial conformance with the approved plans. Significant deviations from the approved plans shall be considered violations of the local jurisdictions stormwater management regulation and are grounds for the invocation of the injunctions and penalties defined therein, and/or withholding the release of a bond or letter of credit pending the completion of corrective action(s), and/or requiring a submittal of a revised drainage plan. In the event that the local jurisdiction requires submittal of a revised plan, the revision shall include a description of the discrepancies between the site conditions and the prior approved plans, along with design calculations that demonstrate that the as-built conditions comply with local requirements. Should the as-built conditions be shown to have a negative impact with regards to flooding, maintenance, erosion or water quality; the local jurisdiction may require other mitigation measures and proposed design plans to mitigate any potential impacts from the development.

- The final O&M plan must be included with the as-built plan. Plats, reserves, easements and stormwater management facility locations shown in the O&M Plan must be field checked by the property owner or developer prior to submitting the as-built plan to ensure that the field locations are approximately correct. The final O&M Plan must be recorded in the Sedgwick County Register of Deeds' office. Copies of the recorded documents or other verification of the recording must be included with the as-built drawings.

### 4.2.1 As-Built Certification Form

As-built plans must be accompanied by an As-Built Certification form. The form must be completed and stamped by the appropriate design professional as required to stamp the original plan, and/or a registered land surveyor licensed to practice in the State of Kansas. A blank form is provided in Appendix K.

## 5.0 POLICIES FOR THE SUBMITTAL OF STORMWATER DESIGN INFORMATION

The reader is referred to the local jurisdiction's stormwater management regulation for provisions pertaining to the submittal of stormwater-related design information on plats and plans. These regulations are provided in Volume 1, Appendix A (City of Wichita Code Chapter 16.32) and Volume 1, Appendix C (Sedgwick County Code 196-10). Beyond the provisions of the regulation, the policies that shall apply to stormwater-related submittals are listed below.

- Stormwater design information for the new development or redevelopment must be submitted as part of, and at the same time as, the preliminary plat, final plat, construction plan, or as-built plan, as appropriate for the stage of the development/redevelopment project. The stormwater design information will be reviewed for compliance with local stormwater and floodplain management regulations, this Manual, and any other applicable local requirements.
- The required elements for each stormwater design plan are provided in a series of checklists that provide a complete inventory of the required stormwater design information at each stage of the site development process. These checklists are listed below and are provided in the Appendices to this volume.

  a. The Drainage Concept checklist (Appendix C);

  b. The Drainage Plan checklist (Appendix D);

  c. The Construction Plan checklist (Appendix G); and,

  d. The As-built Plan checklist (Appendix L).

- The use of the appropriate checklist is required for each plat/plan submittal, to ensure that the portion of the plat/plan that contains the required stormwater design information is complete. A completed checklist MUST be submitted with the plan. When a plat/plan is submitted, the applicant must attach a signed copy of the checklist to indicate his/her understanding of what is to be included with the submitted plan.

- At a minimum, the stormwater design information portion of each plat/plan shall include all of the elements listed in the appropriate checklist, unless the element is not applicable to the site development. The checklist must included an indication of what elements are submitted/excluded. An explanation must be provided for all elements not included in the plan. Omission of any of the plan elements that are applicable to the site development shall render the plat/plan incomplete and it will be returned to the applicant, or their engineer, for completion.

- In general, drainage plans shall be prepared and stamped by an engineer, landscape architect, or architect competent in civil and site design and licensed to practice in the State of Kansas. However, the elements of a drainage plan that are listed below must be prepared and stamped by a professional engineer competent in civil and site design and licensed to practice in the State of Kansas.

  a. Any portions of the drainage plan that require hydraulic or hydrologic calculations and design, including those temporary best management practices designed for purposes of erosion prevention and sediment control.

  b. Any portions of the erosion prevention and sediment control plan that require hydraulic or hydrologic calculations and design.

  c. All public roads.

- A stormwater design certification statement signed by the professional engineer of record performing (or overseeing) hydraulic and hydrologic calculations and designs must be included with all construction plan submittals. A blank copy of the certification statement that must be used is included in Appendix K.

- Site development projects that do not require the subdivision of land will not undergo platting with MAPC. In this case, a combined drainage plan and construction plan can be submitted.

- The stormwater management regulation gives the local jurisdiction the authority to request the submittal of additional stormwater design information with the plat/plan as necessary to allow a thorough review of the intended design or the as-constructed conditions.

- Approval of the preliminary plat, final plat, stormwater permit application, construction plan, as-built plan, or grading or building permits may be contingent on approval of the stormwater design information, as appropriate for the stage of the development/redevelopment. The reader is referred to other applicable regulations or policies for information on the plat/plan review and approval process.

  The applicant may also be required to meet local, State and Federal regulations for construction activities that will have an impact on Waters of the State, wetlands, environmentally-sensitive features, and threatened or endangered species. It is the responsibility of the applicant to thoroughly review, understand and adhere to all applicable local, State and Federal laws and regulations with regard to site development and property regulations when submitting plats/plans.

- The majority of subdivision projects constructed in the City of Wichita are built under the public project process, wherein the City constructs the public infrastructure and bills the construction cost over a 15-year to 20-year repayment period to the landowners that are served by the infrastructure. However, some subdivisions are built under the private project process, in which the developer funds the site improvements. This difference in project funding affects the bonding, inspection and legal aspects of the project, but has little impact on how the stormwater facilities are designed. Each phase of plan submittal and review, construction inspection and as-built certification proceeds in the same manner regardless of whether a project is publicly or privately funded.

## 6.0 THE PRE-DESIGN CONSULTATION

City of Wichita and Sedgwick County Stormwater Management staffs are available to meet with the property owner and site design engineer to discuss stormwater management options prior to submittal of a plat or plan. <u>A pre-design consultation is not mandatory; however, it is highly encouraged and strongly recommended that owners and/or design engineers of new subdivision developments request such a consultation to review the preliminary site drainage concept.</u>

The pre-design consultation provides an opportunity to quickly assess most factors that will influence the design of stormwater facilities for the site. Probable design difficulties can be identified and solutions found much easier when projects are discussed with the appropriate Stormwater Division staff early in the design process. Early consultation also provides an opportunity to consider preferred site design practices. From the perspective of the local jurisdiction, the objectives of the pre-design consultation are:

- review the site topography, existing vegetative condition, and preliminary development lay-out (if determined);
- identify the natural drainage conditions (for new development) and existing drainage conditions (for redevelopments);
- identify any features, such as streams, wetlands and floodplains that must be considered and/or avoided when designing the development or redevelopment;
- discuss preliminary strategies for stormwater and floodplain management;
- discuss preliminary strategies for site clearing, grading, erosion and sediment control practices and construction practices to ensure that construction activities that may impact the effectiveness of stormwater controls are understood and being considered;
- discuss opportunities for preferred site design practices and water quality volume ($WQ_v$) reductions; and,
- determine how the technical guidelines and criteria presented in this manual should be applied to the site.

It is important to note that local jurisdiction staff will not be responsible for development of a plat or plan for the site. Further, the pre-design consultation should not be considered by the property owner or site design engineer as an endorsement or pre-approval of any plat or plan that will be submitted to the local jurisdiction later in the development process. The property owner is responsible for requesting and scheduling the pre-design consultation, and for inviting others as appropriate for his/her needs (e.g., the site design engineer or representatives of other agencies).

## 7.0 PERFORMANCE BONDS

Where necessary for the reasonable implementation of local stormwater management regulations, the local jurisdiction may, by written notice, order any owner of a property affected by the ordinance to file a satisfactory bond, payable to the local government, in a sum not to exceed a value determined by the local jurisdiction to be necessary to achieve consistent compliance with this volume. The local government may deny approval of any building permit, grading permit, subdivision plat, site development plan, or any other City/County permit or approval necessary to commence or continue construction or industrial activity at the site, or to assume occupancy, until such a performance bond has been filed.

The purpose of the performance bond is to ensure that the person(s) responsible for completing the land disturbing activities and/or construction work that has the potential to impact the public interest if performed improperly is completed in an appropriate manner. The performance bond provides assurance that the local government will be reimbursed if it must assume the costs of corrective measures and/or work not completed by the responsible person(s) according to the required specifications and approved plans. A performance bond can be used to cover costs for the remediation or demolition of roadways, stormwater management facilities and related appurtenances, the installation and maintenance of EPSC measures and EPSC corrective actions, final soil stabilization of a site, and the establishment, protection, and maintenance of water quality buffers.

In the City of Wichita, performance bonds are authorized in the Stormwater Management Ordinance and are administered by the Public Works & Utilities Department's Engineering Division. The dollar amount of the performance bond will be determined by the Public Works & Utilities Department, based on the information presented in the approved SWPPP and/or drainage and construction plans.

General policies regarding release of a performance bond are as follows:

- An accurate as-built plan must be completed for the property; and,
- The O&M plan must be recorded with the Sedgwick County Registrar of Deeds.

If found within the boundaries of the development, any one of the following items could keep areas or activities from being released from the performance bond: areas of erosion or unstabilized areas that require vegetation; less than 70% perennial vegetation coverage of non-paved areas. There may be additional requirements for sites that are considered a priority construction activity or have caused past damages off-site due to sediment discharges; potential for discharges of sediment, or construction-related and other wastes;

- engineering or structural deficiencies or maintenance issues associated with constructed roadways, the stormwater system, or stormwater management best management practices;
- unsafe conditions;
- $WQ_v$ reduction areas not meeting specified requirements; and,
- O&M Plan not complete and/or recorded with the Sedgwick County Registrar of Deeds.

## 8.0 LOCAL JURISDICTION STORMWATER WEBSITES

Relevant web-links for the City of Wichita and Sedgwick County are below:

City of Wichita Stormwater Management Division: www.wichita.gov/stormwater

Sedgwick County Stormwater Management:
www.sedgwickcounty.org/Public_Works/stormwater_managment.html.

This manual, along with all supporting documentation, forms, CAD drawings, online tools and supporting data can be found at the following link:

http://www.wichita.gov/StormWaterManual.htm.

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# APPENDIX A

Stormwater Manual Navigational Aide

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CITY OF WICHITA

| | Stormwater Approval Process | Applicable Stormwater Manual Sections |
|---|---|---|
| | Pre-Design Conference, Drainage ConceptSubmittal/Approval | Vol. 2, Chapters 2 & 3<br>Vol. 3, Sections 2, 3, 5 & 6<br>Vol. 3, Appendices B & C |
| | Stormwater Regulatory and Policy Review | Vol. 1, Chapters 2 & 3<br>Vol. 1, Appendices A, B, C & D |
| | Engineering Design of Site Stormwater System | Vol. 2, All Chapters |
| *Subdivision Platting Process* | Drainage Plan Submittal & Approval, Master Grading Plan Submittal | Vol. 2, All Chapters<br>Vol. 3, Sections 3 & 5<br>Vol. 3, Appendix D |
| *Subdivision Platting Process* | Stormwater Covenants Execution | Vol. 3, Appendix E |
| *Construction Approval Process* | Construction Plan Submittal & Approval: Stormwater Permit, Stormwater Design Plan, Operations & Maintenance Plan, SWPPP | Vol. 2, All Chapters<br>Vol. 3, Sections 4 & 7<br>Vol. 3, Appendices F, G, H, I & J |
| *Construction Approval Process* | Stormwater System Construction, Construction Inspection | Vol. 1, Chapter 4<br>Vol. 1, Appendices A & B |
| *Construction Approval Process* | As-Built Drawings and Final Acceptance by the City of Wichita<br>O&M Plan recorded with Register of Deeds | Vol. 3, Sections 4 & 7<br>Vol. 3, Appendices H & K |
| | Post-Construction Stormwater Facility Inspection and Maintenance<br>(In-Perpetuity) | Vol. 1, Chapter 4<br>Vol. 1, Appendices A & B<br>Vol. 2, Chapter 3, Section 5 |

# APPENDIX B

Wichita/Sedgwick County Development Process Flowcharts

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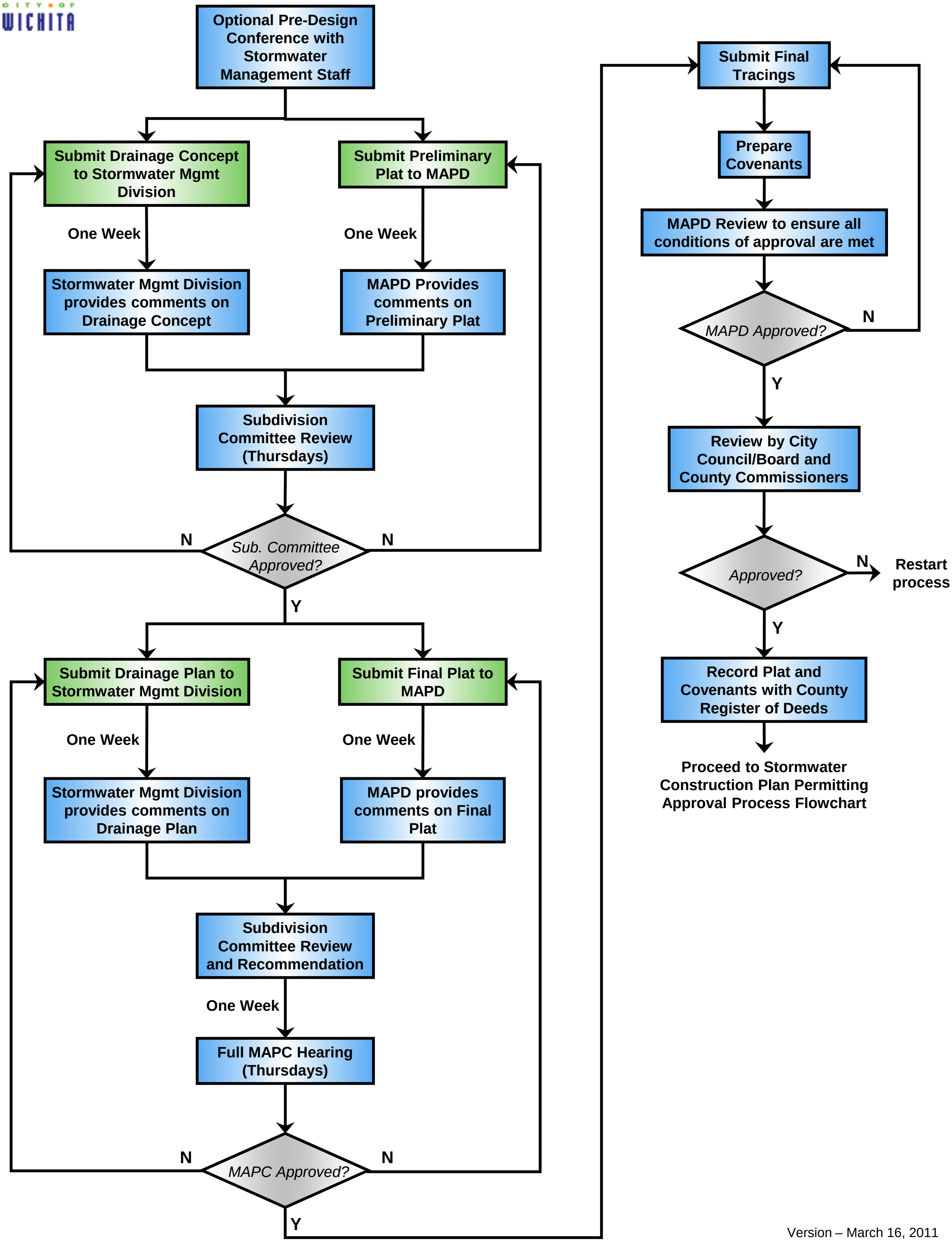
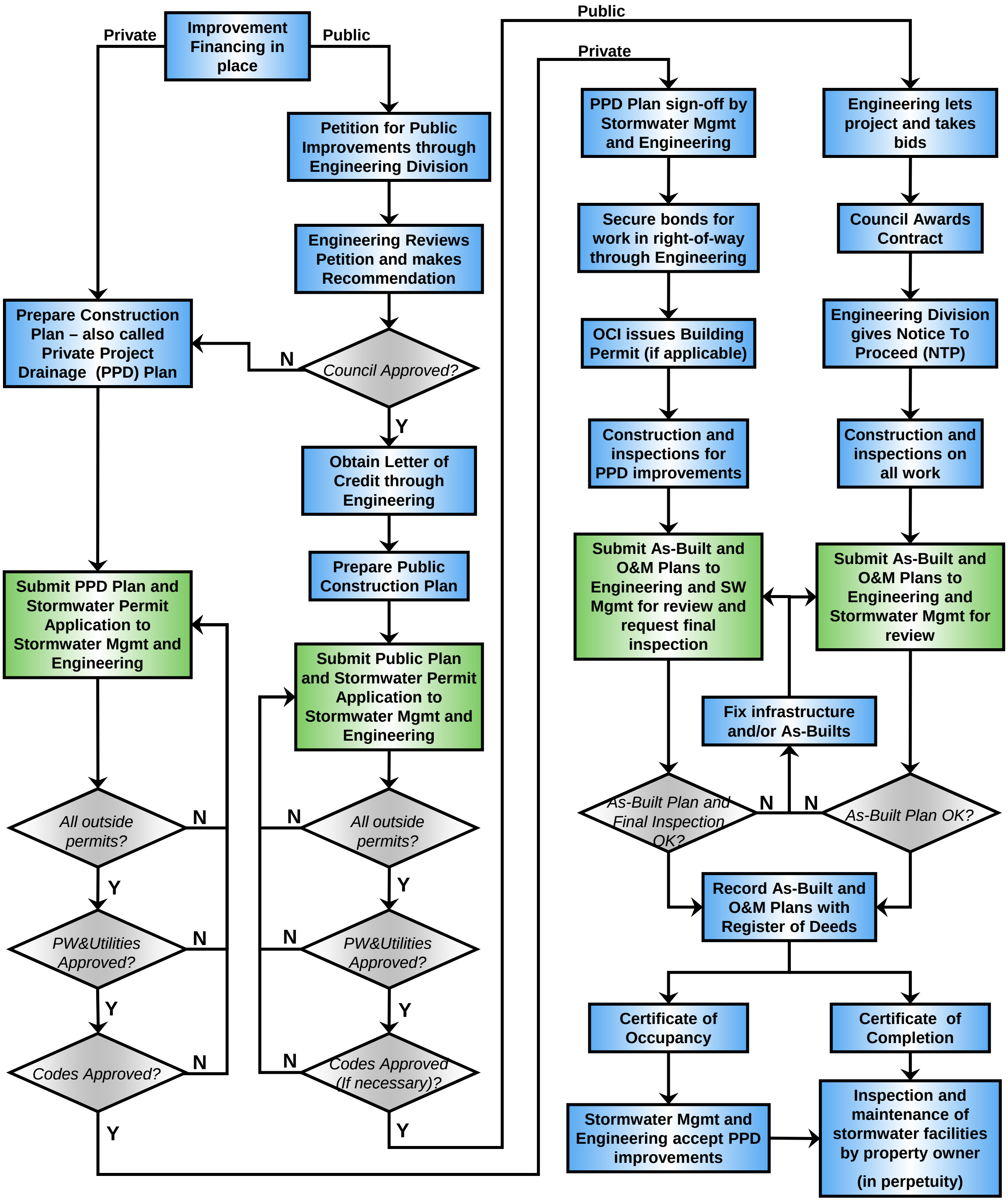
# CITY OF WICHITA/SEDGWICK COUNTY
# SUBDIVISION DRAINAGE APPROVAL & PLATTING PROCESS




Version – March 16, 2011

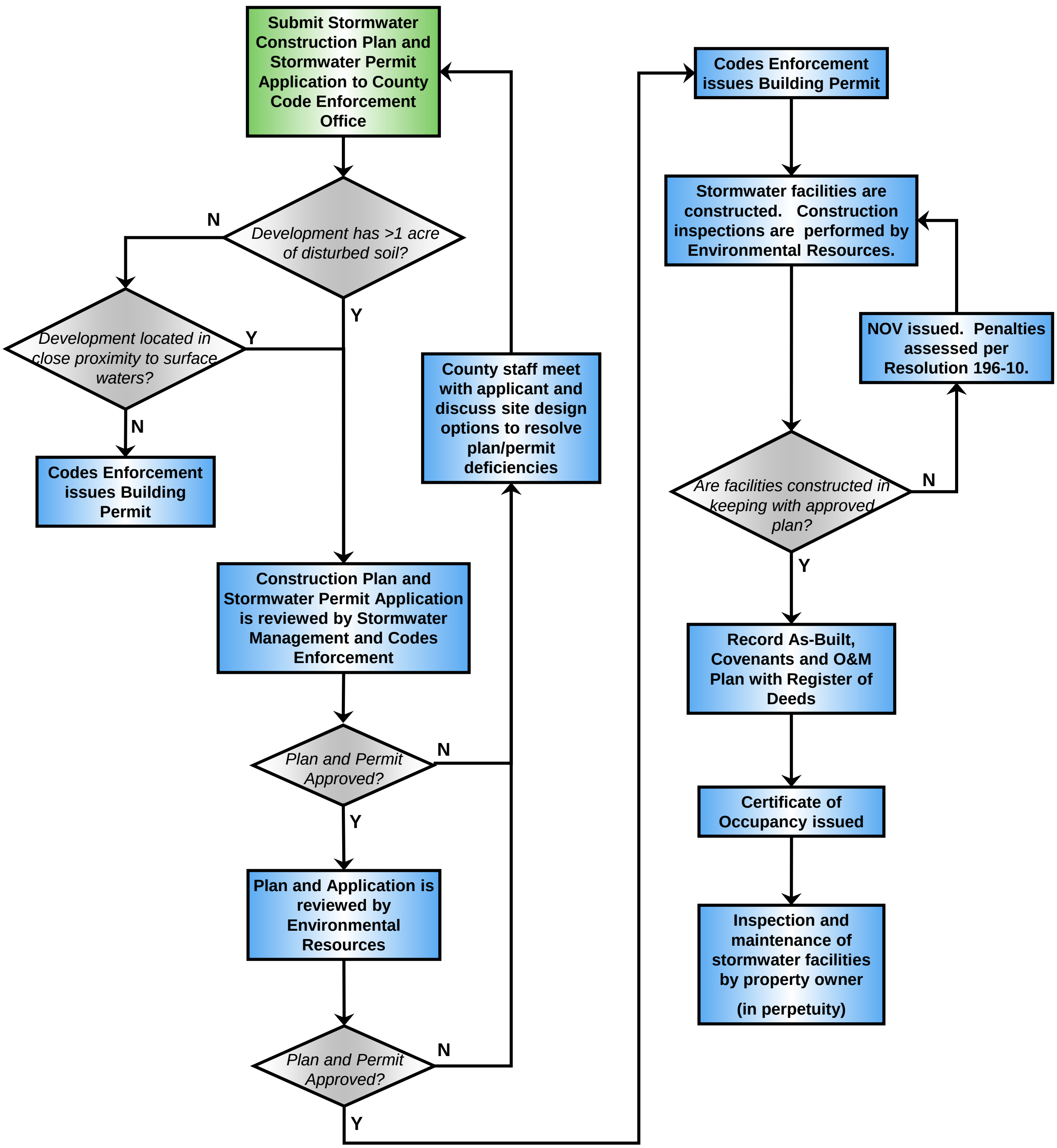
# CITY OF WICHITA
# CONSTRUCTION PLAN & STORMWATER PERMITTING APPROVAL PROCESS




**Note:** Private project drainage plans are submitted independent of a building permit. However, if a building permit is required for the development, the final certificate of occupancy shall not be granted until the private project drainage (PPD) improvement is certified by the Stormwater Management and Engineering Divisions and is accepted by Public Works and Utilities.

Version – March 16, 2011

# SEDGWICK COUNTY
# CONSTRUCTION PLAN & STORMWATER PERMITTING APPROVAL PROCESS




Version – March 16, 2011

# APPENDIX C

Drainage Concept Checklist

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# City of Wichita/Sedgwick County
# Subdivision Drainage Concept Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | **Other:** | | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the Drainage Concept submittal. Incomplete Drainage Concept and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Drainage Concept Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General** | | |
| 1.1 | Clear indication of subdivision boundaries. | | |
| 1.2 | Location, width and name(s) of all existing public or private streets within or adjacent to the tract. | | |
| 1.3 | Location, width and name(s) of all existing easements, railroad rights-of-way, section lines, corners, monuments, city/county boundary lines and other similarly important features. | | |
| 1.4 | Contour lines based on NAVD 88 at two foot maximum intervals and extending a minimum of 200 feet beyond the tract boundaries. | | |
| 1.5 | The date of the property survey. | | |
| 1.6 | The location, flow direction and name(s) of all perennial and intermittent watercourses. | | |
| 1.7 | Natural and manmade features such as rock outcroppings, wetlands, lakes, sewage disposal facilities, water wells, wooded areas and tree rows. | | |
| 1.8 | Storm sewers and culverts located in the tract, on adjacent properties and rights-of-way. Include the structure type, horizontal location, flow direction and size. | | |
| 1.9 | Location, elevation and description of the benchmark controlling the vertical survey. | | |
| **2.0** | **Proposed Subdivision** | | |
| 2.1 | Location, width and name(s) of all proposed streets. | | |
| 2.2 | Proposed lots showing lot boundaries on all sides. | | |
| **3.0** | **Preliminary Hydrologic Analysis** | | |
| 3.1 | Topographic map showing on-site and off-site drainage areas for predeveloped conditions. Use City/County LIDAR data. | | |
| 3.2 | Proposed use of existing drainage features, showing those that will be removed and those that will remain after final plat is recorded. | | |
| 3.3 | Location and type of proposed stormwater conveyance system and peak discharge control facilities. Components shall be clearly labeled with basic descriptions (e.g., concrete pipe, channel, detention pond, etc.). | | |
| 3.4 | Location and type of proposed stormwater quality management facilities. Facilities and related components shall be clearly labeled with basic descriptions (e.g., bioretention, wet pond, etc.). | | |
| 3.5 | Location and type of proposed water quality volume reduction areas. | | |
| 3.6 | Drawing and note showing all stormwater management facilities that will be placed in reserves. | | |
| 3.7 | Reserve areas shown with adequate width and location/area for access and maintenance. | | |
| 3.8 | Areas of overland flow. Indicate the boundaries and flow direction in such areas. | | |
| 3.9 | FEMA floodway and floodplain boundaries and base flood elevations. | | |

**End of Checklist**

# APPENDIX D

Drainage Plan Checklist

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# City of Wichita/Sedgwick County
# Subdivision Drainage Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

**Project Name:**

**Total Area of Project:** ______ **acres**

**Development Type:** ______ **Other:**

**Developer Name:** ______ **Contact:** ______ **Phone:** ______

**Email:**

**Engineer Name:** ______ **Contact:** ______ **Phone:** ______

**Email:**

*Directions:*

*(1) Fill-out this checklist completely and include it with the Drainage Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete Drainage Plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Drainage Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General** | | |
| 1.1 | Digital copy of drainage plan, including preliminary Master Grading Plan, preliminary plat and proposed plat, in PDF format and one half size, bound, paper copy. | | |
| 1.2 | Professional Engineer's seal, signature and date on plan cover. | | |
| 1.3 | Site location map, using color ortho-imagery and showing the project boundaries, a north arrow and an accurate scale. | | |
| 1.4 | Narrative of the development type, existing conditions and proposed impacts on stormwater runoff, wetlands, riparian zones and floodplains/floodways. | | |
| 1.5 | Discussion of off-site conditions surrounding the proposed development. | | |
| 1.6 | Summary table of runoff calculations (pre/post development). | | |
| 1.7 | Narrative description of the type and function of the permanent structural stormwater management facilities. | | |
| **2.0** | **Existing Conditions Information** | | |
| **2.1** | **Existing Conditions Drainage Map** | | |
| 2.1.1 | On-site and off-site topography: NAVD 88 datum, one-foot contours with spot elevations | | |
| 2.1.2 | On-site and off-site drainage features, including perennial and intermittent streams (with names labeled), conveyance systems such as open channels, ditches, swales and areas of overland flow. Flow direction must be indicated by arrows. | | |
| 2.1.3 | Storm sewer system components, including storm drains, inlets, catch basins, gutters, manholes, headwalls, pipes and culverts. Material and size must be noted for all pipes and culverts. | | |
| 2.1.4 | Location and boundaries of natural features such as wetlands, lakes, ponds with the normal water elevation noted, rock outcroppings, wooded areas and tree rows. | | |
| 2.1.5 | Location, dimensions and elevations of existing bridges and culvert crossings. | | |
| 2.1.6 | Location of existing utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 2.1.7 | Groundwater elevations, if applicable. | | |
| 2.1.8 | Delineation of predominant soil based on USDA soil surveys and/or on-site soil borings; indicate NRCS soil name and Hydrologic Soil Group for undisturbed surface soils. | | |
| 2.1.9 | Land use types per NRCS nomenclature. | | |
| 2.1.10 | Footprint of existing impervious areas (labeled, area given in acres). | | |
| 2.1.11 | Internal drainage subbasin boundaries used for hydrologic calculations (labeled with ID, total area in acres, impervious area in acres and curve number). | | |
| 2.1.12 | Time of concentration flow paths. Indicate and label each segment separately (i.e., overland flow, shallow concentrated, channel1, channel2, etc.). For each segment, provide the appropriate data to calculate Tc (e.g., length, slope, cover type, paved/unpaved, roughness parameters, geometric properties, etc.). | | |
| **2.2** | **Existing Conditions Hydrology and Hydraulics Analysis** | | |

| Drainage Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 2.2.1 | Narrative of the hydrologic analysis methodology used (e.g., unit hydrograph or other approved methods). | | |
| 2.2.2 | A summary table of drainage subbasin hydrologic parameters (subbasin ID, area in acres, curve number, Tc, etc.). | | |
| 2.2.3 | Table of existing condition runoff curve numbers with supporting data and calculations. | | |
| 2.2.4 | Table of existing condition times of concentration with supporting data and calculations. | | |
| 2.2.5 | A summary table of rainfall data used in the hydrologic analysis, and a reference for the source of the data. | | |
| 2.2.6 | Cross-sections and other diagrams of existing open channels, bridge and culvert sections and other hydraulic features as required to illustrate the basis for hydraulic analysis. | | |
| 2.2.7 | Hydrologic and hydraulic analyses for runoff rates, volumes, velocities and elevations. Provide supporting data not specified above and identify assumptions. Include detailed calculations for the 2, 5, 10, 25 & 100-year, 24-hour storm events. Provide results in a tabular form. Provide digital copies of any computer files and models used. | | |
| **3.0** | **postdevelopment Conditions Information** | | |
| **3.1** | **postdevelopment Conditions Drainage Map** | | |
| 3.1.1 | Proposed project boundary. | | |
| 3.1.2 | on-site and off-site topography: NAVD 88 datum, one-foot contours with spot elevations. | | |
| 3.1.3 | Existing on-site and off-site drainage features that are to remain after development, including perennial and intermittent streams (with names labeled), conveyance systems such as open channels, ditches, swales and areas of overland flow. Flow direction must be indicated by arrows. | | |
| 3.1.4 | Location and description of off-site through-drainage conveyances which are confined to an easement, dedication and/or reserve. | | |
| 3.1.5 | Footprint of proposed impervious areas, including roads, parking lots, buildings and other structures. | | |
| 3.1.6 | Location of proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 3.1.7 | Delineation of predominant soils, based on anticipated soil textures and NRCS guidelines if different from predevelopment soil conditions; indicate NRCS soil name and Hydrologic Soil Group for surface soils. | | |
| 3.1.8 | Land use cover per NRCS nomenclature. | | |
| 3.1.9 | Internal drainage subbasin boundaries used for hydrologic calculations (labeled with ID, total area in acres, impervious area in acres and curve number). | | |
| 3.1.10 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| 3.1.11 | Time of concentration flow paths. Indicate and label each segment separately (i.e., overland flow, shallow concentrated, channel1, channel2, etc.). For each segment, provide the appropriate data to calculate Tc (e.g., length, slope, cover type, paved/unpaved, roughness parameters, geometric properties, etc.). | | |
| **3.2** | **Proposed Conveyances Map** | | |
| 3.2.1 | on-site and off-site drainage features, including perennial and intermittent streams (with names labeled), proposed conveyance systems (such as open channels, ditches, swales and areas of overland flow, including backyard drainage). Flow direction must be indicated by arrows. | | |
| 3.2.2 | Storm sewer system components, including storm drains, inlets, catchbasins, gutters, manholes, headwalls, pipes and culverts. Material and size must be noted for all pipes and culverts. | | |
| 3.2.3 | For any subbasin or drainage area > 40 acres, show that the stormwater flow is confined to an open channel with required side benches and freeboard, or conformance to applicable policy and design requirements if partially enclosed. | | |
| 3.2.4 | Location(s) of stormwater management facilities and any associated drainage easements. | | |
| 3.2.5 | Proposed energy dissipaters and other channel protection devices. | | |
| 3.2.6 | Location(s) and dimension(s) of proposed channel, bridge and culvert crossings. | | |
| 3.2.7 | Normal pool and 100-year pool elevations for ponds and lakes. | | |
| 3.2.8 | Permanent concrete outfall control structure(s) for ponds. | | |
| 3.2.9 | Emergency overflow spillways and top of berm elevations for ponds and other volume/peak discharge control facilities. | | |
| 3.2.10 | Floodplains, ponds, and stormwater management facilities located in reserves. | | |
| **3.3** | **postdevelopment Conditions Hydrology & Hydraulics** | | |
| 3.3.1 | Narrative of the hydrologic analysis methodology used (e.g., unit hydrograph or other approved methods). | | |

| Drainage Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 3.3.2 | A summary table of drainage subbasin hydrologic parameters (subbasin ID, area in acres, curve number, Tc, etc.). | | |
| 3.3.3 | Table of postdevelopment condition runoff curve numbers with supporting data and calculations. | | |
| 3.3.4 | Table of postdevelopment condition times of concentration with supporting data and calculations. | | |
| 3.3.5 | Cross-sections and other diagrams of existing open channels, bridge and culvert sections and other hydraulic features as | | |
| 3.3.6 | Hydrologic and hydraulic analyses for runoff rates, volumes, velocities and elevations. Provide supporting data not specified above and identify assumptions. Include detailed calculations for the 2, 5, 10, 25 & 100-year, 24-hour storm events. Provide results in a tabular form. Provide digital copies of any computer files and models used. | | |
| 3.3.7 | Downstream peak discharge assessment (10% Rule) results and supporting data and calculations. Provide digital copies of any computer files and models used. | | |
| 3.3.8 | Stage-storage-discharge or other outlet rating curves and inflow/outflow hydrographs for all ponds. | | |
| 3.3.9 | Demonstrate that the pond contours on the master grading plan and the stage-storage-discharge data are consistent for all ponds. | | |
| 3.3.10 | Demonstrate that all ponds have one foot of freeboard above the 100-year, 24-hour high water level. | | |
| 3.3.11 | Demonstrate that runoff from the proposed project site is discharged in the same manner as prior to development, using level spreaders, energy dissipaters, other devices or grading as required, or identify an appropriate flowage easement. | | |
| **3.4** | **Stormwater Quantity Control Sizing** | | |
| 3.4.1 | Hydraulic sizing calculations for all stormwater management controls. | | |
| 3.4.2 | Table(s) listing all stormwater management controls. Present the types, sizes, elevations, flows, velocities and depths for each control, as applicable. Verify that velocities are self-cleaning and non-erosive. | | |
| 3.4.3 | Typical details (including cross-sections where applicable) for outlet structures, embankments, spillways, grade control structures, conveyance channels, etc. | | |
| **3.5** | **Stormwater Quality Management Facilities** | | |
| 3.5.1 | Table(s) listing all stormwater management facilities. Present the description, % TSS removal value, water quality volume handled, contributing drainage area in acres and contributing impervious area in acres. | | |
| 3.5.2 | Indicate the responsible party for maintenance, as shown in the plat text (i.e., Home Owners Association, Lot Owners Association, property owner, etc.). | | |
| 3.5.3 | Water quality volume (total and by facility), with supporting data and calculations. | | |
| 3.5.4 | % TSS removal value (total and by facility) with supporting data and calculation. Must be equal to or greater than 80%. | | |
| 3.5.5 | Channel protection volume with supporting data and calculations. | | |
| 3.5.6 | Water quality volume and channel protection volume orifice size calculations. | | |
| 3.5.7 | Other calculations required for each stormwater management facility as specified in the Wichita/Sedgwick County Stormwater Manual. | | |
| 3.5.8 | Typical details (including cross-sections where applicable) for outlet structures, embankments, internal grading, forebays and other siltation prefilters, filtration/infiltration media, vegetation, check dams, operational controls, etc. | | |
| **4.0** | **Floodplains** | | |
| 4.1 | Reference the source of flood profile, floodplain, floodway and stream discharge information. | | |
| 4.2 | Delineation of nearest base flood elevations. | | |
| 4.3 | Delineation of predevelopment regulatory floodplain/floodway limits using FEMA's current GIS database; limits to be per elevation and scaled location. | | |
| 4.4 | Delineation of postdevelopment regulatory floodplain/floodway limits; limits to be per elevation and scaled location, with project limits shown. | | |
| 4.5 | Floodway data table and discharges. | | |
| 4.6 | Hydrologic and hydraulic study information for local floodplain analysis, unnumbered Zone A elevation determinations and floodplain map revisions or required permits. | | |
| 4.7 | Regulatory floodway and four natural profile models (10, 50, 100 and 500-year) for existing and postdevelopment conditions. | | |
| 4.8 | Floodplains and floodways located within a reserve, where necessary. | | |
| 4.9 | Floodplain cut and fill calculations for volume sensitive basins. | | |

| Drainage Plan Checklist | | | |
|---|---|---|---|
| **#** | **Plan Element Description** | **Element Included?** | **Explanation/Notes** |
| 4.10 | Demonstrate that floodway elevations and velocities do not increase due to construction in the floodway ("No Rise Certification"). | | |
| **5.0** | **Federal, State and Local Permits** | | |
| 5.1 | US Army Corps of Engineers regulatory program permits (Section 404 permit) | | |
| 5.2 | Kansas Department of Agriculture - Division of Water Resources Permits (Stream Obstruction, Channel Change, Floodplain Fill, Levee, Water Appropriations, Dam Safety permit, etc.). | | |
| 5.3 | FEMA letters of map change/revision - LOMA, LOMR, LOMR-f, CLOMR, etc.; shall be included and approved when project modifies the limits of the floodplain/floodway. | | |
| **6.0** | **Half Scale Preliminary Master Grading Plan** | | |
| 6.1 | One set of plans and associated PDF of plans. | | |
| 6.2 | Professional Engineer's seal, signature and date. | | |
| 6.3 | Title block including subdivision name and phase and dated revision documentation. | | |
| 6.4 | Future phases shown but cross-hatched as information only. | | |
| 6.5 | Scale, not greater than 1-inch = 60 feet. | | |
| 6.6 | North arrow. | | |
| 6.7 | Index or legend key. | | |
| 6.8 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 6.9 | Existing contours of entire site with contour interval of one foot. | | |
| 6.10 | Proposed contours for channels, ponds, and other permanent stormwater management facilities, with contour interval of one foot. | | |
| 6.11 | Spot elevations shown to the nearest tenth of a foot for critical locations, including lot and property boundaries. | | |
| 6.12 | Proposed lot and street layout. | | |
| 6.13 | Locations of underground storm drains. | | |
| 6.14 | Overflow locations for storms exceeding storm drain capacity, with elevations. | | |
| 6.15 | Top elevations of storm drains at all inlets, manholes, and flow line elevations for all outfalls. | | |
| 6.16 | Locations of open ditches and lakes. | | |
| 6.17 | Flow direction arrows. | | |
| 6.18 | Proposed flow line elevations of all open ditches at maximum 100 foot intervals, and 100-year flood elevations thereon. | | |
| 6.19 | Ponds: Location, bottom elevation, normal pool elevation, 100-year flood elevation, emergency overflow elevation. | | |
| 6.20 | Proposed top-of-curb elevations at points where drainage will be required to flow over the curb. | | |
| 6.21 | Platted minimum building opening elevation for each lot, in table form for all lots (excluding basement floor elevations). | | |
| 6.22 | Standard foundation and elevation detail for slab on grade, full basement, view-out, partial view-out and/or walk-out construction. | | |
| 6.23 | Top of foundation elevation for each lot. | | |
| 6.24 | Notation for builders for each lot as to the type of structure that may be constructed and the view-out, walk-out or pad elevation, as applicable. | | |
| 6.25 | Indicate that all lots are above the 100-year flood elevation. | | |
| 6.26 | Indicate that grading around structures conforms to perimeter drainage requirements. | | |
| 6.27 | Indicate that backyard drainage grading conforms to backyard drainage requirements. | | |
| 6.28 | Adjacent subdivision lot lines, with lot labels and subdivision names. | | |
| 6.29 | Boundaries and labels for all easements, rights-of-way and reserves. | | |
| 6.30 | Statement on proposed final plat: "*A drainage plan has been developed for the subdivision and all drainage easements, rights-of-way, or reserves shall remain at the established grades and remain unobstructed to allow for the conveyance of stormwater.* " | | |
| | | | |
| End of Checklist | | | |

# APPENDIX E

Restrictive Covenants Templates

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**Restrictive Covenants for Stormwater Management Facilities**

**Located in the City of Wichita, Kansas**

This Covenant, executed this __________ day of _________________, 20____.

WITNESSETH

WHEREAS, the undersigned (hereinafter "Property Owner") is in the process of platting real property to be known as ________________________________________________ Addition (hereinafter the "Property"), an addition to Wichita, in Sedgwick County, Kansas; and

WHEREAS, the City of Wichita (hereinafter the "City") is required to protect water quality to the maximum extent practicable under its Municipal Separate Storm Sewer System permit; and

WHEREAS, Chapter 16.32 of the Wichita Stormwater Management Ordinance requires Property Owners to enter into permanent maintenance agreements for stormwater management facilities and volume reduction areas before the Property is developed; and

WHEREAS, Chapter 16.32 of the Wichita Stormwater Management Ordinance requires Property Owners to inspect and properly maintain all stormwater management facilities and volume reduction areas to maintain their full function in perpetuity; and

WHEREAS, the stormwater management facilities and volume reduction areas are located on the Property as shown the "Operations and Maintenance Plan" which is recorded with the deed after acceptance by the City as a complete and final document; and

WHEREAS, the stormwater management facilities and volume reduction areas have been constructed as shown in the "As-built Plan", which is accepted by the City as a complete and final document;

NOW THEREFORE, the undersigned does hereby subject the Property, an addition to Wichita, in Sedgwick County, Kansas, to have the following covenants and restrictions (hereinafter the "Agreement"):

## 1.0 Maintenance Requirements

**1.1** The Property Owner will construct and maintain the stormwater management facilities and volume reduction areas in strict accord with the plans, specifications, calculations, and conditions required by the City as provided in Chapter 16.32, in perpetuity.

**1.2** Maintenance of all stormwater management facilities and volume reduction areas will be performed by the Property Owner according to the minimum maintenance frequencies and measures provided in the Operations and Maintenance Plan. In the absence of the Operations and

Maintenance Plan, the maintenance guidelines provided in the Stormwater Manual shall be used.

**1.3** The Property Owner shall not use or attempt to use the stormwater management facilities, volume reduction areas or the reserves or easements which may contain these facilities or areas in any manner which would interfere with the continuous and perpetual maintenance and use thereof and, in particular, shall not build thereon or thereover any structure which may interference or cause to interfere with the maintenance and long-term operation thereof.

## 2.0 Right of Entry

**2.1** The Property Owner does herein grant the City, its agents and contractors, reasonable access to the property necessary for the purpose of inspecting, sampling, reconstructing, maintaining or repairing each of the stormwater facilities and volume reduction areas in accordance with Section 1 of this agreement, and shall execute any documents deemed necessary by the City, if any, thereto.

**2.2** The Property Owner shall, upon written request of the City, remove any temporary or permanent obstruction that prevents reasonable access to any stormwater management facility or volume reduction area.

**2.3** For purposes of this agreement, “reasonable access” means an access path from the public street right of way to the stormwater management facility or volume reduction area with a minimum 20 foot width and a maximum ground slope of 10% that is accessible by construction equipment or vehicles that may be needed to inspect, sample, reconstruct, maintain, repair, replace or construct the stormwater management facility or volume reduction area. Such access path shall remain free of obstructions that would hinder access such as retaining walls, buildings, utility structures, walls, fences, trees, landscape monuments, permanent water bodies, gardens, amenities and other items that would prevent access to the stormwater management facility or volume reduction area.

**2.4** Stormwater management facilities and/or volume reduction areas and any associated access areas, Reserves or Easements are shown on the Final Plat of ___________________________________. The actual access path shall be provided whether or not one is shown on the Final Plat.

**2.5** The rights granted herein shall not be construed to interfere with or restrict the Property Owner, his/her/its heirs, executors, administrators, successors and assigns from the use of the premises with respect to the construction and maintenance of property improvements along and over the premises herein described so long as the same are so constructed as not to impair the rights of access to a stormwater management facility or volume reduction area granted herein.

## 3.0 Maintenance Enforcement by the City

**3.1** If, after reasonable notice to the Property Owner, the Property Owner shall fail to maintain all stormwater facilities and volume reduction areas as set forth herein and other applicable legal requirements, the City may perform all necessary repair or maintenance work, and the City may assess the Property Owner and the Property, for the cost of the work and any applicable penalties. For the purposes of this document, "reasonable notice" shall consist of 30 days prior written notice sent to the Property Owner, unless there are exigent circumstances requiring either immediate or shorter response than said 30 days would provide, in which case the notice provided shall be whatever is reasonable under those circumstances.

**3.2** The City may record an Affidavit of Nonpayment of Maintenance Charges in the Register of Deeds Office for Sedgwick County, Kansas, stating (a) the legal description of the property upon which the lien is claimed, (b) the name(s) of the Property Owner as last known to the City, and (c) the amount of the Maintenance Charge which is unpaid. The lien shall be created at the time of the filing and recording of the affidavit and such lien shall be superior to all other charges, liens, or encumbrances which may thereafter in any manner arise or be imposed upon the subject property, whether arising from or imposed by judgment or decree by any agreement, contract, mortgage, or other instrument, saving and excepting only such liens for taxes and other public charges as are by applicable law made superior.

**3.3** It is understood by Property Owner that the City is under no past, present, or future obligation to expend public funds or take any other action whatsoever to maintain or improve any stormwater management facility or volume reduction area. The City or Property Owner shall have the right to enforce, by any proceeding at law or in equity, all restrictions, conditions, covenants, reservations, liens, and charges now or hereafter imposed by the provisions of this declaration. The City or the Property Owner shall have the right to include in their claim for relief a reasonable sum to reimburse them for their attorneys' fees and any other expenses reasonably incurred in enforcing their rights hereunder. Failure by the City or by the Property Owner to enforce any covenant or restriction herein contained shall in no event be deemed a waiver of the right to do so thereafter. Neither shall failure by the City to enforce the provisions hereof be deemed a waiver of any provision hereof as to any other owner.

## 4.0 Indemnification

**4.1** The Property Owner shall indemnify and hold the City harmless from any and all damage, loss, claims or liability of any kind whatsoever arising from the installation, maintenance, repair, operation or use of any stormwater management facility or volume reduction area including, but not limited to, any loss occasioned by reason of damage or injury to persons or property which may occur. In addition, the Property Owner shall pay all costs and expenses involved in defending all actions arising there from.

## 5.0 Homeowners or Business Association Requirements

**5.1** If the stormwater management facilities and/or volume reduction areas on the Property will be maintained by a Homeowners or Business Association, the following requirements shall apply:

5.1.1 At such time as the Property shall be developed by erection of improvements thereon, the undersigned agrees to cause an association (hereinafter the "Association") to be formed as a Kansas corporation to provide for the perpetual care, maintenance and repair of the stormwater management facilities shown on the Operations and Maintenance Plan.

5.1.2 Prior to the sale of any lot in the subdivision, the Property Owner shall cause to be recorded with the Register of Deeds for Sedgwick County, Kansas a Homeowners or Business Association Declaration (hereinafter the "Declaration") covering all of the platted lots within the subdivision that includes this Agreement by reference.

5.1.3 The Declaration shall require that the Association levy assessments against the lots within the subdivision sufficient to pay for maintenance and future replacement of the stormwater facilities and volume reduction areas and for any costs incurred by reason of this Agreement. The Association shall have an enforceable lien on any lot in the subdivision in the event that any lot owner fails to pay the stormwater assessment. All purchasers of lots shall be given an outline summary of the maintenance obligations and costs per this Agreement.

5.1.4 The Declaration shall contain a provision requiring the written consent of the City for the termination of the Association in its entirety or to any amendment, modification or termination of any provision thereto regarding stormwater facilities and volume reduction areas.

5.1.5 The Declaration shall name the City as a third-party beneficiary of all provisions therein relating to the stormwater treatment facilities and volume reduction areas and will give the City the right to enforce all restrictions, obligations and other provisions regarding the stormwater facilities and volume reduction areas.

5.1.6 Any reserves located on said Property will be conveyed to the Association at such time as the property is sold to or occupied by owners or tenants other than the undersigned. Until said reserves are so conveyed, the ownership and maintenance of the reserves shall be by the undersigned.

These covenants and agreements as set forth herein, fully executed, shall be filed by the Register of Deeds for Sedgwick County, Kansas, and the filing of the same shall constitute constructive notice to all heirs, successors, transferees, and assigns of the Property Owner of these covenants and agreements running with the land and notice of all stipulations made thereto.

This document may not be amended or modified in any way without the prior written approval of the authorized officials of the City of Wichita, Kansas, and that approval must be indicated on the face of any subsequently recorded document amending or modifying this document.

Notwithstanding other provisions of this document placing rights, duties, obligations and responsibilities on the Property Owner, as that term is defined herein, those rights, duties, obligations and responsibilities shall only be exercised or enforced in the following manner: when the property is owned by the current owner, or by a succeeding developer, those requirements shall only be exercised or enforced by or against those legal entities. When an approved Association takes over ownership of the Property, those rights, duties, obligations and responsibilities shall succeed to that Association as provided in the legal documents creating the same. It is not the intent of this document to create or impose any rights, duties, obligations and responsibilities directly on subsequent owners of individual lots within the subdivision, unless or until the Association is unwilling or unable to exercise or comply with and enforce the terms of this document and fully meet all the duties, obligations and responsibilities set forth herein, including, without being limited to, payment of any costs imposed by this document by all means specified in the documents creating the Association, including assessment of individual lot owners when necessary. If that Association shall cease to exist or be in default of its duties, obligations or responsibilities as set forth herein, the City shall have the option of directly enforcing them against individual owners of lots within the subdivision.

The covenants, conditions, and restrictions on the property created and established in this instrument may be waived, terminated, or modified only upon written consent of the City of Wichita. No such waiver, termination or modification shall be effective until such written consent is recorded in the office of the Register of Deeds for Sedgwick County, Kansas.

The City, at Property Owner's cost, shall cause this agreement to be filed with the Register of Deeds for Sedgwick County, Kansas. Each party hereto shall receive a duly executed copy of this agreement for its official records.

IN WITNESS WHEREOF, the undersigned have caused this stormwater management facility maintenance Agreement to be duly executed the day and year first written above.

By:_______________________________________________________ (signature)

Print or Type name: __________________________________________

Street:__________________________________

City, State:_______________________________

COUNTY OF SEDGWICK )<br>
)<br>
STATE OF KANSAS )

BE IT REMEMBERED, that on this ___________ day of _______________, 20_____, before me, the undersigned, a Notary Public, in and for the County and State aforesaid, came __________________________________, personally known to me to be the same person who executed the within instrument of writing and such person duly acknowledged the execution of the same, for and behalf of the corporation.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed my official seal the day and year above written.

Notary:___________________________________

(My Commission Expires:___________)

-------------------------------------------------- End of Document --------------------------------------------------

**Restrictive Covenants for Stormwater Management Facilities**

**Located in Sedgwick County, Kansas**

This Covenant, executed this __________ day of _________________, 20____.

WITNESSETH

WHEREAS, the undersigned (hereinafter "Property Owner") is in the process of platting real property to be known as ________________________________________________ Addition (hereinafter the "Property"), an addition to Sedgwick County, Kansas; and

WHEREAS, Sedgwick County (hereinafter the "County") is required to protect water quality to the maximum extent practicable under its Municipal Separate Storm Sewer System permit; and

WHEREAS, Chapter 23, Article VII of the Sedgwick County Code requires Property Owners to enter into permanent maintenance agreements for stormwater facilities and volume reduction areas before the Property is developed; and

WHEREAS, Chapter 23, Article VII of the Sedgwick County Code requires Property Owners to inspect and properly maintain all stormwater facilities and volume reduction areas to maintain their full function in perpetuity; and

WHEREAS, the stormwater management facilities and volume reduction areas are located on the Property as shown on **Attachment A**, "Operations and Maintenance Plan" and "Stormwater As-Built Drawings", which have been accepted by the County as complete and final documents;

NOW THEREFORE, the undersigned does hereby subject the Property, to have the following covenants and restrictions (hereinafter the "Agreement"):

## 1.0 Reserve Requirement

**1.1** All stormwater management facilities and volume reduction areas shall be placed in a reserve shown on the Final Plat for the Property.

## 2.0 Home or Business Association Requirements for Stormwater Management Facilities that Serve Residential and/or Non-Residential Subdivisions

**2.1** At such time as the Property shall be developed by erection of improvements thereon, the undersigned agrees to cause an association (hereinafter the “Association”) to be formed as a Kansas corporation to provide for the perpetual care, maintenance and repair of the stormwater facilities found on Attachment A.

**2.2** Prior to the sale of any lot in the subdivision, the Property Owner shall cause to be recorded with the Register of Deeds for Sedgwick County, Kansas a Homes or Business Association Declaration (hereinafter the “Declaration”) covering all of the platted lots within the subdivision that includes this Agreement by reference.

**2.3** The Declaration shall require that the Association levy assessments against the lots within the subdivision sufficient to pay for maintenance and future replacement of the stormwater facilities and volume reduction areas and for any costs incurred by reason of this Agreement. The Association shall have an enforceable lien on any lot in the subdivision in the event that any lot owner fails to pay the stormwater assessment. All purchasers of lots shall be given an outline summary of the maintenance obligations and costs per this Agreement.

**2.4** The Declaration shall contain a provision requiring the written consent of the County for the termination of the Association in its entirety or to any amendment, modification or termination of any provision thereto regarding stormwater facilities and volume reduction areas.

**2.5** The Declaration shall name the County as a third-party beneficiary of all provisions therein relating to the stormwater treatment facilities and volume reduction areas and will give the County the right to enforce all restrictions, obligations and other provisions regarding the stormwater facilities and volume reduction areas.

**2.6** The reserves located in said Addition will be conveyed to the Association at such time as the project is sold to or occupied by owners or tenants other than the undersigned. Until said reserves are so conveyed, the ownership and maintenance of the reserves shall be by the undersigned.

## 3.0 Maintenance Requirements

**3.1** The Property Owner will construct and maintain the stormwater management facilities and volume reduction areas in strict accord with the plans, specifications, calculations, and conditions required by the County as provided in Chapter 23, Article VII of the Sedgwick County Code.

**3.2** Maintenance of all stormwater management facilities and volume reduction areas will be performed by the owner of the reserves according to the minimum maintenance frequencies and measures provided on **Attachment B**, “Inspection and Maintenance Requirements”, as provided in Chapter 23, Article VII of the Sedgwick County Code and the Stormwater Manual.

**3.3** The Property Owner shall not use or attempt to use the reserves containing stormwater management facilities or volume reduction areas in any manner which would interfere with the continuous and perpetual maintenance and use thereof and, in particular, shall not build thereon or thereover any structure which may interference or cause to interfere with the maintenance thereof.

**3.4** It is understood by the Property Owner and County that actual maintenance costs and future replacement costs are variable, however for budgetary purposes, the project designer is required to estimate future maintenance and replacement costs so that the Property Owner may better plan future required expenditures. Based on the project designer’s estimates, **Attachment C** is a tabulation of the anticipated maintenance and replacement costs.

## 4.0 Right of Entry

**4.1** The Property Owner does herein grant the County, its agents and contractors, reasonable access to the property necessary for the purpose of inspecting, sampling, reconstructing, maintaining or repairing each of the stormwater facilities and volume reduction areas in accordance with Section 5 of this agreement, and shall execute any documents deemed necessary by the County, if any, thereto.

**4.2** The Property Owner shall, upon written request of the County, remove any temporary or permanent obstruction that prevents reasonable access to any stormwater management facility or volume reduction area.

**4.3** For purposes of this agreement, “reasonable access” means an access path from the public street right of way to the stormwater management facility or volume reduction area with a minimum 20 foot width and a maximum ground slope of 10% that is accessible by construction equipment or vehicles that may be needed to inspect, sample, reconstruct, maintain, repair, replace or construct the stormwater management facility or volume reduction area. Such access path shall remain free of obstructions that would hinder access such as retaining walls, buildings, utility structures, walls, fences, trees, landscape monuments, permanent water bodies, gardens, amenities and other items that would prevent access to the stormwater management facility or volume reduction area.

**4.4** Stormwater management facility and volume reduction area access easements have been granted on the Final Plat of ________________________________ and are shown on Attachment A. The actual access path shall be provided whether or not one is shown on the Final Plat.

**4.5** The rights granted herein shall not be construed to interfere with or restrict the Property Owner, his/her/its heirs, executors, administrators, successors and assigns from the use of the premises with respect to the construction and maintenance of property improvements along and over the premises herein described so long as the same are so constructed as not to impair the rights of access to a stormwater management facility or volume reduction area granted herein.

## 5.0 Maintenance Enforcement by the County

**5.1** If, after reasonable notice to the Property Owner, the Property Owner shall fail to maintain all stormwater facilities and volume reduction areas as set forth herein and other applicable legal requirements, the County may perform all necessary repair or maintenance work, and the County may assess the Property Owner and the Property, for the cost of the work and any applicable penalties. For the purposes of this document, “reasonable notice” shall consist of 30 days prior written notice sent to the Property Owner, unless there are exigent circumstances requiring either immediate or shorter response than said 30 days would provide, in which case the notice provided shall be whatever is reasonable under those circumstances.

**5.2** The County may record an Affidavit of Nonpayment of Maintenance Charges in the Register of Deeds Office for Sedgwick County, Kansas, stating (a) the legal description of the property upon which the lien is claimed, (b) the name(s) of the Property Owner as last known to the County, and (c) the amount of the Maintenance Charge which is unpaid. The lien shall be created at the time of the filing and recording of the affidavit and such lien shall be superior to all other charges, liens, or encumbrances which may thereafter in any manner arise or be imposed upon the subject property, whether arising from or imposed by judgment or decree by any agreement, contract, mortgage, or other instrument, saving and excepting only such liens for taxes and other public charges as are by applicable law made superior.

**5.3** It is understood by Property Owner that the County is under no past, present, or future obligation to expend public funds or take any other action whatsoever to maintain or improve any stormwater management facility or volume reduction area. The County or Property Owner shall have the right to enforce, by any proceeding at law or in equity, all restrictions, conditions, covenants, reservations, liens, and charges now or hereafter imposed by the provisions of this declaration. The County or the Property Owner shall have the right to include in their claim for relief a reasonable sum to reimburse them for their attorneys’ fees and any other expenses reasonably incurred in enforcing their rights hereunder. Failure by the County or by the Property Owner to enforce any covenant or restriction herein contained shall in no event be deemed a waiver of the right to do so thereafter. Neither shall failure by the County to enforce the provisions hereof be deemed a waiver of any provision hereof as to any other owner.

## 6.0 Indemnification

**6.1** The Property Owner shall indemnify and hold the County harmless from any and all damage, loss, claims or liability of any kind whatsoever arising from the installation, maintenance, repair, operation or use of any stormwater management facility or volume reduction area including, but not limited to, any loss occasioned by reason of damage or injury to persons or property which may occur. In addition, the Property Owner shall pay all costs and expenses involved in defending all actions arising there from.

These covenants and agreements as set forth herein, fully executed, shall be filed by the Register of Deeds for Sedgwick County, Kansas, and the filing of the same shall constitute constructive notice to all heirs, successors, transferees, and assigns of the Property Owner of these covenants and agreements running with the land and notice of all stipulations made thereto.

This document may not be amended or modified in any way without the prior written approval of the authorized officials of Sedgwick County, Kansas, and that approval must be indicated on the face of any subsequently recorded document amending or modifying this document.

Notwithstanding other provisions of this document placing rights, duties, obligations and responsibilities on the Property Owner, as that term is defined herein, those rights, duties, obligations and responsibilities shall only be exercised or enforced in the following manner: when the property is owned by the current owner, or by a succeeding developer, those requirements shall only be exercised or enforced by or against those legal entities. When an approved Association takes over ownership of the Property, those rights, duties, obligations and responsibilities shall succeed to that Association as provided in the legal documents creating the same. It is not the intent of this document to create or impose any rights, duties, obligations and responsibilities directly on subsequent owners of individual lots within the subdivision, unless or until the Association is unwilling or unable to exercise or comply with and enforce the terms of this document and fully meet all the duties, obligations and responsibilities set forth herein, including, without being limited to, payment of any costs imposed by this document by all means specified in the documents creating the Association, including assessment of individual lot owners when necessary. If that Association shall cease to exist or be in default of its duties, obligations or responsibilities as set forth herein, the County shall have the option of directly enforcing them against individual owners of lots within the subdivision.

The covenants, conditions, and restrictions on the property created and established in this instrument may be waived, terminated, or modified only upon written consent of Sedgwick County. No such waiver, termination or modification shall be effective until such written consent is recorded in the office of the Register of Deeds for Sedgwick County, Kansas.

The County, at Property Owner’s cost, shall cause this agreement to be filed with the Register of Deeds for Sedgwick County, Kansas. Each party hereto shall receive a duly executed copy of this agreement for its official records.

IN WITNESS WHEREOF, the undersigned have caused this Restrictive Covenant for Stormwater Management Facilities to be duly executed the day and year first written above.

By:_______________________________________________________ (signature)

Print or Type name: __________________________________________

Street:___________________________________

County, State:_______________________________

COUNTY OF SEDGWICK )
)
STATE OF KANSAS )

BE IT REMEMBERED, that on this ____________ day of ________________, 20_____, before me, the undersigned, a Notary Public, in and for the County and State aforesaid, came _____________________________________, personally known to me to be the same person who executed the within instrument of writing and such person duly acknowledged the execution of the same, for and behalf of the corporation.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed my official seal the day and year above written.

Notary:______________________________________

(My Commission Expires:____________)

-------------------------------------------------- End of Document --------------------------------------------------

# APPENDIX F

City/County Stormwater Permit Application

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# Wichita/Sedgwick County Stormwater Permit

For Authorization to Discharge Stormwater Runoff from Construction Activities
In Accordance with the Kansas Water Pollution Control General Permit
Under the National Pollution Discharge Elimination System (NPDES)

Submission of this Permit application constitutes notice that the identified parties in the "OWNER OPERATOR" Section of this form have requested and received a copy of a signed NOTICE OF INTENT (NOI) from the Kansas Department of Health and Environment (KDHE). Becoming a permittee within the Wichita/Sedgwick County region obligates the discharger to comply with the terms and conditions of the general permit as well as all local regulations and ordinances. Completion of this Permit application does not provide automatic coverage under the general permit. City of Wichita Engineering or Sedgwick County Stormwater Management will notify owners or operators and or agents of such, when Stormwater permit application and supporting documentation is incomplete, deficient, or denied.

**Submit completed forms to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202 or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

**Please Type or Print**

☐ **Owner** ☐ **Operator**

Name: ____________________

E-Mail Address: ____________________

Area of site disturbance (acres) ____________________

**Project Information & Location**

Project Name: ____________________

Project Address: ____________________

Impervious Area Before Construction :(sq ft) ____________

Impervious Area Post Construction: (sq ft) ____________

☐ **Unincorporated Sedgwick County**

☐ **City of Wichita**

**Below is a list of Supporting documentation required to be supplied for this Permit application:**

Signed copy of State (NOI) Must be Attached. Ks Permit No. ____________ Federal Permit No. ____________

*Copy of submitted (NOI) ok to start plan review process, KDHE approved front page of (NOI) required before this permit will be issued.*

**Items listed below will need to be submitted in electronic pdf, as well as two hard copies of ½ scale prints.**

☐ On File ☐ Attached Subdivision drainage plan for site.

☐ On File ☐ Attached Private Project Drainage (PPD) construction plans (City Only) & or Public Drainage Improvements.

☐ Yes ☐ No PPD Plan Review Fee Paid. (City Only)

☐ On File ☐ Attached Stormwater Pollution Prevention Plan. (SWPPP)

☐ On File ☐ Attached Draft of Operation & Maintenance (O & M) Plan for Stormwater Management Facility.

☐ On File ☐ Attached ERU plan sheet. (City Only)

☐ On File ☐ Attached Project narrative.

☐ On File ☐ Attached Engineer Project certification statement, & supplemental drainage calculations.

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

# Wichita/Sedgwick County Stormwater Permit

## OWNER/OPERATOR STORMWATER QUALITY COMPLIANCE STATEMENT

The undersigned, being the owner of a facility that has applied to the City of Wichita or Sedgwick County, Kansas, for a storm sewer tap/discharge/ stormwater permit, hereby acknowledges the requirements of Section 16.32 of the Wichita City Code, and/or Sedgwick County resolution #196-10, which states that only stormwater can be discharged into the municipal storm sewer system, with the following exceptions:

1. A discharge authorized by, and in full compliance with, a federal or state NPDES permit.
2. A discharge from emergency fire fighting.
3. A discharge from water line flushing.
4. A discharge from lawn watering, landscape irrigation, or other irrigation water.
5. A discharge or flow from a diverted stream flow or natural spring.
6. A discharge or flow from uncontaminated ground water or rising groundwater.
7. Uncontaminated groundwater infiltration.
8. Uncontaminated flow from a foundation drain, crawl space pump, footing drain, or sump pump (no discharge onto street per City Code 10.04.060 City only).
9. A discharge from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container.
10. A flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant.
11. Flows from individual residential car washing.
12. A flow from a riparich habitat, wetland, or natural spring.
13. Storm water runoff from a roof that is not contaminated by any runoff from an emissions scrubber or filter or any other source of pollutant.
14. Residential heat pump discharges.
15. Swimming pool water, excluding filter backwash, that has been de-chlorinated so it contains no harmful quantity of chlorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning.
16. Contaminated groundwater if authorized by KDHE and approved the County. (County Only)
17. Street wash water.(excluding street sweepings which have been removed from the street) (County Only)
18. Discharges specified in writing by the Director as necessary to protect public health and safety. (County only)

I further understand that allowing any other discharge will subject me to the penalties provided in said City Section 16.32, and or Sedgwick County Stormwater Management Resolution #196-10, as well as other federal and state penalties.

Owner or Operator Signature: ______________________ Date: ______________________

Name typed or printed: ______________________ Title: ______________________

**Upon completion of construction for this project, a copy of the certified as-built stormwater plans as well as the final O & M Plan shall be filed with City of Wichita Engineering or the Sedgwick County Stormwater office (depending on project location, City or County). The final O & M Plan shall be recorded with the Sedgwick County Registrar of Deeds. Proof of this filing shall also be submitted to the appropriate City/County office prior to the Owner or Operator receiving a full use Occupancy Certificate.**

| | | |
|---|---|---|
| Reviewer Name ______________ | City project No. ______________ | SW ID No. ______________ |
| Date Packet Received: ________ | Date Approved: ________ | Date Recorded Final O & M Plans Received: ________ |

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

# APPENDIX G

Construction Plan Checklist

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# City of Wichita/Sedgwick County
# Construction Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | **Other:** | | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the Construction Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Construction Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **Submittal Formats** | | |
| 1.1 | Hard copy of all plan sheets in 11"x17" (half-scale) size. | | |
| 1.2 | Digital copy of construction plan, including all sheets submitted as single PDF file. | | |
| 1.3 | Electronic copy of all CAD files. | | |
| 1.4 | Preliminary cost estimate in Excel format. | | |
| **2.0** | **All Plan Sheets (except City/County Std Detail Sheets)** | | |
| 2.1 | Title block with address of project, phase or addition name, original date of issue and dated revision control, name/address of site design engineer/company. | | |
| 2.2 | Sheet number. | | |
| 2.3 | North arrow. | | |
| 2.4 | Scale (horizontal and vertical, as applicable). | | |
| 2.5 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 2.6 | Legend key. | | |
| **3.0** | **Cover Sheet** | | |
| 3.1 | Professional Engineer's seal, signature and date. | | |
| 3.2 | Sheet index. | | |
| 3.3 | Site map, including north arrow, scale, lot lines (with lot numbers), project boundaries, special benefit districts labeled and shaded or cross-hatched, and accurate references for section, township and range. | | |
| 3.4 | Vicinity map with north arrow. | | |
| 3.5 | Table of bid items and quantities. | | |
| 3.6 | A statement from the site design engineer that the construction plan conforms with the final approved drainage plan or, if not, that supplemental drainage calculations are included. (Note: Required elements for supplemental drainage calculations are presented in Volume 3 of the Stormwater Manual.) | | |
| **4.0** | **Grading Plan** | | |
| 4.1 | Property boundary, lot lines and lot numbers. | | |
| 4.2 | Property boundaries, names, lot lines and lot numbers for all adjacent subdivisions. | | |
| 4.3 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| 4.4 | Existing contours of entire site, with contour interval of one foot. | | |
| 4.5 | Proposed contours for entire site, with contour interval of one foot. | | |
| 4.6 | Elevation-storage table for each pond. Show next to pond or elsewhere on same sheet and properly referenced to applicable pond. | | |
| 4.7 | Pond bottom elevations. | | |
| 4.8 | Spot elevations shown to the nearest tenth of a foot for critical locations, including lot and property boundaries. | | |
| 4.9 | Proposed flow line elevations for all open ditches and swales at maximum 100 feet intervals. | | |

| Construction Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 4.10 | Location of existing and proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 4.11 | Identifying label, location and boundaries (if applicable) of all sediment prevention and erosion control BMPs if/where required to supplement the construction erosion control BMP plan sheets. | | |
| 4.12 | Identifying label and location of all concrete outfall structures (no earthen or rip-rap outfall structures are permitted). | | |
| **5.0** | **Storm Sewer Plan Sheets** | | |
| 5.1 | Storm sewer horizontal alignments, including stationing, coordinates and offsets from property lines. | | |
| 5.2 | Storm sewer vertical alignments, including stationing, elevations, with flow grades shown every 50 feet and at all structures. | | |
| 5.3 | Storm sewer lines. Each line must have line number, profile line length, material and size. | | |
| 5.4 | Location, size and elevation of all storm sewer stubs. | | |
| 5.5 | Location and size of inlets, energy dissipaters and other storm sewer structures. | | |
| 5.6 | Storm sewer inlets and other structures with elevations, shown in both plan and profile views. | | |
| 5.7 | Peak flow and depth for each design storm event (2, 5, 10, 25 and 100-year, 24-hour storms) at each pipe, inlet and other structure, in table form. | | |
| 5.8 | Identifying label and location of riprap and other protective revetments. | | |
| 5.9 | Identifying label and location of zones of special backfill, such a flowable fill. | | |
| 5.10 | Identifying label, location and boundaries (if applicable) of all sediment prevention and erosion control BMPs if/where required to supplement the construction erosion control BMP plan sheets. | | |
| 5.11 | Identifying label, location and boundaries of all right-of-ways, reserves and easements. | | |
| 5.12 | Identifying label and location of existing and proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 5.13 | Utility interference cautions, where applicable. | | |
| 5.14 | Indication that utility conflicts have been resolved, where applicable. | | |
| **6.0** | **Stormwater Management Facilities Plan** | | |
| 6.1 | Copy of the draft Operations and Maintenance Plan. Must include inspection and maintenance guidance for each stormwater management facility. See Volume 2 of the Stormwater Manual for guidance. | | |
| 6.2 | Identifying label, type and location of all stormwater management facilities, with associated easement/reserve boundaries as applicable. | | |
| 6.3 | Identifying label, type and location of all water quality volume reduction areas, with associated easement/reserve boundaries as applicable. | | |
| 6.4 | Identifying label, type and location of all proprietary stormwater quality systems. Must include commercial name of the device, vendor name/address, manufacturer name, make, model and size details. | | |
| **7.0** | **Other Sheets and Documents** | | |
| 7.1 | Construction erosion control plan sheets, standard detail sheets, and non-standard detail sheets. | | |
| 7.2 | Storm sewer standard and non-standard detail sheets. | | |
| 7.3 | Other detail sheets (specify in notes box). | | |
| 7.4 | Special Provisions to Standard Specifications. | | |
| 7.5 | Cost estimate for all bid items. | | |
| 7.6 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| **8.0** | **Federal, State and Local Permits** | | |
| 8.1 | KDHE Section 401 Water Quality Certification (in conjunction with USACE Section 404 Permit). | | |
| 8.2 | KDHE Authorized NOI under Kansas Construction General Permit. | | |
| 8.3 | Sedgwick County Right-of-Way Permit. | | |
| 8.4 | KDA Division of Water Resources Water Structures Permit. | | |
| 8.5 | FEMA CLOMR/LOMR Approval. | | |
| 8.6 | City of Wichita or Sedgwick County Floodplain Development Permit approval. | | |
| 8.7 | KDWP approval of construction and/or endangered species habitat protection plan. | | |
| | | | |
| End of Checklist | | | |

# APPENDIX H

H0 – Operations & Maintenance Plan Submittal Checklist

H1 – Inspection & Maintenance Guidance for Stormwater (Wet) Ponds

H2 – Inspection & Maintenance Guidance for Vegetative Filter Strips

H3 – Inspection & Maintenance Guidance for Grassed Channels

H4 – Inspection & Maintenance Guidance for Extended Dry Ponds

H5 – Inspection & Maintenance Guidance for Enhanced Swales

H6 – Inspection & Maintenance Guidance for Infiltration Trenches

H7 – Inspection & Maintenance Guidance for Soakage Trenches

H8 – Inspection & Maintenance Guidance for Sand Filters (Surface and Underground)

H9 – Inspection & Maintenance Guidance for Bioretention Areas

H10 – Inspection & Maintenance Guidance for Stormwater Wetlands

H11 – Inspection & Maintenance Guidance for Gravity (Oil-Water) Separators

H12 – Inspection & Maintenance Guidance for Alum Treatment

H13 – Inspection & Maintenance Guidance for Organic Filters

H14 – Inspection & Maintenance Guidance for Conventional Dry Detention Ponds

H15 – Inspection & Maintenance Guidance for Underground Dry Detention Facilities

H16 – Inspection & Maintenance Guidance for Porous Pavement Systems

H17 – Inspection & Maintenance Guidance for Modular Porous Pavement Systems

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# APPENDIX I

SWPPP Template

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# Stormwater Pollution Prevention Plan

# for:

## Project: ______________________________

### Owner

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |

### Operator

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |

### SWPPP Contact

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |

# SWPPP Preparation Date:

________________

**Estimated Project Dates:**

**Project Start Date:** ________________

**Project Completion Date:** ________________

# Contents

## Appendices

| | |
|---|---|
| Attachment 1 | Site Location Map |
| Attachment 2 | Plan Set (Under Separate Cover) |
| Attachment 3 | Construction General Permit |
| Attachment 4 | NOI and NOC |
| Attachment 5 | Inspection Reports |
| Attachment 6 | Corrective Action Plan |
| Attachment 7 | SWPPP Amendment log |
| Attachment 8 | Contractor Certification Forms |
| Attachment 9 | Grading and Stabilization Activities Log |
| Attachment 10 | Additional Information (i.e., Endangered Species and Historic Preservation Documentation etc.) |
| Attachment 11 | NOT Form |

## End Notes

1 www.epa.gov/npdes/pubs/sw_swppp_guide.pdf
2 The current KDHE NPDES Stormwater Runoff from Construction Activities General Permit is Federal Permit Number KSR100000 dated January 2, 2007.
3 www.kdheks.gov/tmdl/
4 www.kshs.org/resource/shpohome.htm
5 Refer to Section 7.2.3 of the Kansas Construction Permit (CGP)
6 Refer to Section 7.2.4 of the Kansas Construction Permit (CGP)
7 Refer to Section 7.2.5 of the Kansas Construction Permit (CGP)
8 Refer to Section 7.2.7 of the Kansas Construction Permit (CGP)
9 Refer to Section 7.2.8 of the Kansas Construction Permit (CGP)

***Tips for using the SWPPP Template:***

Each section of this template includes “instructions” (in green boxes) describing the intended use of the section and type of information expected to be provided. Some sections will have editable fields to directly provide project information; others will ask that the relevant information be attached to the final SWPPP. This template was developed as a Smart PDF so you can easily edit each location requiring a response.

If there is more than one construction operator for your project, consider coordinating development of your SWPPP with the other operators.

Multiple operators may share the same SWPPP, but make sure that responsibilities are clearly described.

# SECTION 1: SITE EVALUATION, ASSESSMENT, AND PLANNING

## *1.1 Project/Site Information*

Instructions:

- In this section, provide basic information on the project that will be helpful throughout the project and when you file for permit coverage.
- More information and guidance on completing the SWPPP can be found in the EPA's Developing Your Stormwater Pollution Prevention Plan: A SWPPP Guide for Construction Sites (also known as the SWPPP Guide) [1]
- Detailed information on determining your site's latitude and longitude can be found at www.epa.gov/npdes/stormwater/latlong

[1] www.epa.gov/npdes/pubs/sw_swppp_guide.pdf

| | | | |
|---|---|---|---|
| Project/Site Name: | | | |
| Project Street/Location: | | | |
| City: | | KS | ZIP Code: |
| Latitude: º ' " North | Longitude: º ' " West | | |
| Range of center of site (to the nearest quarter/quarter section; 40 acres): | | | |

| | | |
|---|---|---|
| Is this project considered a federal facility? | ☐ Yes | ☐ No |
| NPDES project or permit tracking number*: | | |

**This is the unique identifying number assigned to your project by KDHE.*

## *1.2 Contact Information/Responsible Parties*

Instructions:

- List the owner(s), contractor's project manager, subcontractor(s), SWPPP preparer and emergency contact. Indicate respective responsibilities, where appropriate.
- Also, list subcontractors expected to work on-site. Notify subcontractors of stormwater requirements applicable to their work.
- Each contractor and subcontractor shall sign KDHE's Contractor Certification Form found in Attachment 8.

## Owner

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |

## Contractor's Project Manager

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## Subcontractors

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## Subcontractors

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## Subcontractors

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## Subcontractors

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## Subcontractors

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |
| Insert area of control | |

## This SWPPP was Prepared by

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Address | |
| City, State and Zip Code | |
| Telephone Number | |
| Fax or Email | |

## Emergency 24-Hour Contact

| | |
|---|---|
| Company or Organization Name | |
| Name | |
| Telephone Number | |

## 1.3 Nature and Sequence of Construction Activity

Instructions:

- Briefly describe the nature of the construction activity and approximate time frames.
- Enter the function of the construction activity and Project Start/Completion Dates at the bottom.
- For additional guidance, refer to the current effective Kansas Construction General Permit (CGP). [2]

[2] The KDHE NPDES Stormwater Runoff from Construction Activities General Permit.

**Describe the general scope of the work for the project, major phases of construction, etc.**

| |
|---|
| |
| ☐ Residential ☐ Commercial ☐ Industrial ☐ Road Construction ☐ Linear Utility |
| Other (please specify): |
| Estimated Project Start Date: |
| Estimated Project Completion Date: |

## 1.4 Soils, Slopes, Vegetation, and Current Drainage Patterns

Instructions:

- Describe the existing soil conditions at the construction site including soil types, slopes and slope lengths, drainage patterns, and other topographic features that might affect erosion and sediment control.
- Also, note any historic site contamination evident from existing site features and known past usage of the site.
- This information should also be included on your site maps.

**Soil type(s):**

**Slopes (describe current slopes and note any changes due to grading or fill activities):**

**Drainage Patterns (describe current drainage patterns and note any changes dues to grading or fill activities):**

**Vegetation:**

**Other:**

## 1.5 Construction Site Estimates

Instructions:

- Estimate the area to be disturbed by excavation, grading, or other construction activities, including dedicated off-site borrow and fill areas.
- Calculate the percentage of impervious surface area before and after construction.
- Calculate the runoff coefficients before and after construction.

**The following are estimates for the construction site.**

| | |
|---|---|
| Project area: | acres |
| Construction site area to be disturbed: | acres |
| Percentage impervious area before construction: | % |
| Runoff coefficient before construction: | -- |
| Percentage impervious area after construction: | % |
| Runoff coefficient after construction: | -- |

## 1.6 Receiving Waters

Instructions:

- List the waterbody(s) that would receive stormwater from your site, including streams, rivers, lakes and wetlands. Describe each as clearly as possible, such as *Mill Creek, a tributary to the Little Arkansas River*, and so on.
- Indicate the location of all waters, including wetlands, on the site map.
- Note any stream crossings, if applicable.
- List the storm sewer system or drainage system that stormwater from your site could discharge to and the waterbody(s) that it ultimately discharges to.
- If any of the waterbodies above are impaired and/or subject to Total Maximum Daily Loads (TMDLs), please list the pollutants causing the impairment and any specific requirements in the TMDL(s) that are applicable to construction sites. Your SWPPP should specifically include measures to prevent the discharge of these pollutants.
- More information can be found on the Kansas TMDL webpage. [3]

[3] www.kdheks.gov/tmdl/

**Description of receiving waters:**

**Description of storm sewer systems:**

**Description of impaired waters or waters subject to TMDLs:**

**Other:**

## 1.7 Site Features and Sensitive Areas to be Protected

Instructions:

- Describe unique site features including streams, stream buffers, defined drainage course buffers, wetlands, specimen trees, natural vegetation, steep slopes, or highly erodible soils that are to be preserved.
- Describe existing vegetation that shall be preserved where practical.
- Describe measures to protect these features.
- Include these features and areas on your site maps.

**Description of unique features that are to be preserved:**

**Describe measures to protect these features:**

| |
|---|
| |

## 1.8 Potential Sources of Pollution

Instructions:

- Identify and list all potential sources of sediment, which may reasonably be expected to affect the quality of stormwater discharges from the construction site.
- Identify and list all potential sources of pollution, other than sediment, which may reasonably be expected to affect the quality of stormwater discharges from the construction site.

**Potential sources of sediment to stormwater runoff:**

| |
|---|
| |

**Potential pollutants and sources, other than sediment, to stormwater runoff:**

| Trade Name Material | Stormwater Pollutants | Location |
|---|---|---|
| | | |
| | | |
| | | |

**Potential pollutants and sources, other than sediment, to stormwater runoff:**

| Trade Name Material | Stormwater Pollutants | Location |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

## 1.9 Endangered Species Certification

Instructions:

- Before beginning construction, send an Action Permit application to KDWP to determine whether endangered species are on or near your site.
- If endangered species or critical habitats are found, create a mitigation plan and obtain Action Permit approval based on the plan.
- Attach the Action Permit in Attachment 10.

## 1.10 Historic Preservation

Instructions:

- For federally funded projects, federally permitted projects, or projects within 500' of a historic structure, coordinate with the State Historic Preservation Officer (SHPO) to determine whether a project will require archaeological investigation.
- Perform investigations as needed and work with SHPO to meet state requirements and obtain a clearance letter.
- Add clearance letter to Attachment 10 if required by federal involvement.
- More information can be found at the Kansas historic preservation office website. [4]

[4] www.kshs.org/resource/shpohome.htm

## 1.11 Applicable Federal, Tribal, State or Local Programs

Instructions:

– Note other applicable federal, tribal, state or local soil and erosion control and stormwater management requirements that apply. Attach needed permits in Attachment 10. Some that may apply include:
    - Corps Section 404 permit;
    - KDHE underground injection control permit;
    - KDA Water Structures Program Permits for:
        - bridges, culverts;
        - weirs;
        - low-water crossings;
        - dams;
        - intake/outfall structures;
        - boat ramps;
        - pipeline/cable crossings;
        - grassed waterways;
        - channel change; and
        - levees.
        - placement of fill within the floodplain (above and beyond FEMA)
        - gravel/sand dredging

**Additional permits required:**

## 1.12 Site Maps, Grading Plans and Erosion Prevention and Sediment Control (EPSC) Plans

Instructions:

- Attach site maps. For most projects, a series of site maps is recommended. The first should show the undeveloped site and its current features on a topographic map. Additional maps should be created to show the major phases of development.

These maps should include the following:

- Direction(s) of stormwater flow and approximate slopes before and after major grading activities;
- Areas and timing of soil disturbance;
- Areas that will not be disturbed;
- Natural features to be preserved;
- Locations of major structural and non-structural BMPs identified in the SWPPP;
- Locations and timing of stabilization measures;
- Locations of off-site material, waste, borrow, or equipment storage areas;
- Locations of all waters, including wetlands;
- Locations where stormwater discharges to a surface water;
- Locations of storm drain inlets; and
- Areas where final stabilization has been accomplished.
- For more information, see SWPPP Guide, Chapter 3.

**Include the site maps in Attachment 1, include the grading and EPSC plans in Attachment 2, and provide text describing the BMPs in Section 2.**

# SECTION 2: EROSION PREVENTION AND SEDIMENT CONTROL BMPs

Instructions:

– Describe the BMPs that will be implemented to control pollutants in stormwater discharges. For each major activity identified, do the following:
  - ✓ Clearly describe appropriate control measures and the site and physical conditions that must be met for effective use of BMP.
  - ✓ Describe the general sequence during the construction process in which the measures will be implemented.
  - ✓ Describe the maintenance and inspection procedures that will be used for that specific BMP.
  - ✓ Include protocols, thresholds, and schedules for cleaning, repairing, or replacing damaged or failing BMPs.
  - ✓ Identify staff responsible for maintaining BMPs.
  - ✓ If your SWPPP is shared by multiple operators, indicate the operator responsible for each BMP.
  - ✓ Identify what site conditions must be met before removal of the BMP, for temporary BMPs.

– Categorize each BMP under one of the following 10 areas of BMP activity as described below:
  - *2.1 Minimize disturbed area and protect natural features and soil*
  - *2.2 Phase Construction Activity*
  - *2.3 Control Stormwater flowing onto and through the project*
  - *2.4 Stabilize Soils*
  - *2.5 Protect Slopes*
  - *2.6 Protect Storm Drain Inlets*
  - *2.7 Establish Perimeter Controls and Sediment Barriers*
  - *2.8 Retain Sediment On-Site and Control Dewatering Practices*
  - *2.9 Establish Stabilized Construction Exits*
  - *2.10 Additional BMPs*

– Note the location of each BMP on your EPSC plans.

– All plans shall include the applicable standard plan sheets for soil erosion BMPs as follows:
  - Subdivision BMPs – for all subdivision projects
  - Street Improvement BMPs – for all projects that impact streets
  - Soil erosion BMPs – for all projects

– For more information, see *SWPPP Guide*, Chapter 4 and the National Menu of BMPs at http://www.epa.gov/npdes/stormwater/menuofbmps

## 2.1 Minimize Disturbed Area and Protect Natural Features and Soil

Instructions:

- Describe the areas that will be disturbed with each phase of construction and the methods (e.g., signs, fences) that you will use to protect those areas that should not be disturbed. Describe natural features identified earlier and how each will be protected during construction activity. Also describe how topsoil will be preserved. Include these areas and associated BMPs on your EPSC plans.
- For more information see EPA's *Preserving Natural Vegetation BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/perserve_veg

## 2.2 Phase Construction Activity

Instructions:

- Describe the intended construction sequencing and timing of major activities, including any opportunities for phasing grading and stabilization activities to minimize the overall amount of disturbed soil that will be subject to potential erosion at one time. Also, describe opportunities for timing grading and stabilization so that all or a majority of the soil disturbance occurs during a time of year with less erosion potential (i.e., during the dry or less windy season).
- It might be useful to develop a separate, detailed site map for each phase of construction.
- Also, see EPA's *Construction Sequencing BMP Fact Sheet* at: http://www.epa.gov/npdes/stormwater/menuofbmps/construction/cons_seq
- For each Phase please include the following information:
  - General description
  - Duration (start and end dates)
  - List of BMPs to be installed during that phase
  - Describe what site conditions need to be met before BMP can be removed.
    - Temporary stabilization
    - Final stabilization

**Phase 1:**

Repeat as needed

**Phase 2:**

Repeat as needed

**Phase 3:**

Repeat as needed

## 2.3 *Control Stormwater Flowing onto and through the Project*

Instructions:

– Describe structural practices (e.g., diversions, berms, ditches, storage basins) including design specifications and details used to divert flows from exposed soils, retain or detain flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site.
– For additional guidance, refer to the Kansas Construction General Permit (CGP)[6].

[6] Refer to Section 7.2.4 of the Kansas Construction Permit (CGP)

| | |
|---|---|
| **BMP Description** → | |
| Installation Schedule | |
| Maintenance and Inspection | |
| Responsible Staff | |

| | |
|---|---|
| **BMP Description** → | |
| Installation Schedule | |
| Maintenance and Inspection | |
| Responsible Staff | |

| | |
|---|---|
| **BMP Description** → | |
| Installation Schedule | |
| Maintenance and Inspection | |
| Responsible Staff | |

| | |
|---|---|
| **BMP Description** → | |
| Installation Schedule | |
| Maintenance and Inspection | |
| Responsible Staff | |

| | |
|---|---|
| **BMP Description →** | |
| Installation Schedule | |
| Maintenance and Inspection | |
| Responsible Staff | |

| | |
|---|---|
| **BMP Description →** | |
| Installation Schedule | |
| Maintenance and Inspection | |
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## 2.4 Stabilize Soils

Instructions:

- Describe controls (e.g., interim seeding with native vegetation, hydro seeding) to stabilize exposed soils where construction activities have temporarily or permanently ceased. Also describe measures to control dust generation. Avoid using impervious surfaces for stabilization whenever possible.
- Any exposed soil area shall be stabilized any time earth moving activities cease in the area for one month or more.
- Track major grading operations and stabilization on the form in Attachment 9.
- Also, see EPA's *Seeding BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/seeding
- For additional guidance, refer to the Kansas Construction General Permit (CGP) [5].

[5] Refer to Section 7.2.3 of the Kansas Construction Permit (CGP)

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## 2.5 Protect Slopes

Instructions:

- Describe controls (e.g., erosion control blankets, tackifiers) including design specifications and details that will be implemented to protect all slopes.
- Also, see EPA's *Geotextiles BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/geotextiles
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[5].

[5] Refer to Section 7.2.3 of the Kansas Construction Permit (CGP)

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## 2.6 Protect Storm Drain Inlets

Instructions:

- Describe controls (e.g., inserts, rock-filled bags, or block and gravel) including design specifications and details that will be implemented to protect all inlets receiving stormwater from the project during the entire project.
- Also, see EPA's *Storm Drain Inlet Protection BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/storm_drain
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[6].

[6] Refer to Section 7.2.4 of the Kansas Construction Permit (CGP)

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## 2.7 Establish Perimeter Controls and Sediment Barriers

Instructions:

- Describe structural practices (e.g., silt fences or fiber rolls) including design specifications and details to filter and trap sediment before it leaves the construction site.
- Also, see EPA's *Silt Fence BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/silt_fences or *Fiber Rolls BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/fiber_rolls
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[6].

[6] Refer to Section 7.2.4 of the Kansas Construction Permit (CGP)

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## 2.8 Retain Sediment On-Site

Instructions:

- Describe sediment control practices (e.g., sediment trap or sediment basin), including design specifications and details (volume, dimensions, outlet structure) that will be implemented at the construction site to retain sediments on-site.
- Sedimentation basins are required for projects draining 10 or more acres of disturbed land. Show calculations to provide wet storage volume of 3,600 cubic feet per acre.
- No more than 20% of the sediment basins capacity shall be taken up with sediment.
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[7].

[7] Refer to Section 7.2.5 of the Kansas Construction Permit (CGP)

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## 2.9 *Establish Stabilized Construction Exits*

Instructions:

- Describe location(s) of vehicle entrance(s) and exit(s), procedures to remove accumulated sediment off-site (e.g., vehicle tracking), and stabilization practices (e.g., stone pads or wash racks or both) to minimize off-site vehicle tracking of sediments and discharges to stormwater.
- Also, see EPA's *Construction Entrances BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/cons_entrance
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[5].

[5] Refer to Section 7.2.3 of the Kansas Construction Permit (CGP)

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## 2.10 Additional BMPs

Instructions:

- Describe additional BMPs that do not fit into the above categories.
- For additional guidance, refer to the Kansas Construction General Permit (CGP)[8].

[8] Refer to Section 7.2.7 of the Kansas Construction Permit (CGP)

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# SECTION 3: GOOD HOUSEKEEPING BMPs

Instructions:

- Describe the key good housekeeping and pollution prevention measures that will be implemented to control pollutants in stormwater.
- Categorize each good housekeeping and pollution prevention BMP under one of the following eight categories:
  - *3.1 Material Handling and Waste Management*
  - *3.2 Establish Proper Building Material Staging Areas*
  - *3.3 Designate Washout Areas*
  - *3.4 Establish Proper Equipment/Vehicle Fueling and Maintenance Practices*
  - *3.5 Control Equipment/Vehicle Washing*
  - *3.6 Spill Prevention and Control Plan*
  - *3.7 Additional BMPs*
  - *3.8 Allow Non-Stormwater Discharge Management*
- For more information or ideas on BMPs, see EPA's National Menu of BMPs at: http://www.epa.gov/npdes/stormwater/menuofbmps
- For additional guidance, refer to the Kansas Construction General Permit (CGP) [8].

[8] Refer to Section 7.2.7 of the Kansas Construction Permit (CGP)

## *3.1 Material Handling and Waste Management*

Instructions:

- Describe measures (e.g., trash disposal, sanitary wastes, recycling, and proper material handling) to prevent the discharge of solid materials to receiving waters, except as authorized by a permit issued under section 404 of the CWA.
- Also, see EPA's *General Construction Site Waste Management BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/cons_wasteman

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## 3.2 Establish Proper Building Material Staging Areas

Instructions:

- Describe construction materials expected to be stored on-site and procedures for storage of materials to minimize exposure of the materials to stormwater.

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## 3.3 Designate Washout Areas

Instructions:

- Describe location(s) and controls to eliminate the potential for discharges from washout areas for concrete mixers, paint, stucco, and so on.
- Also, see EPA's *Concrete Washout BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/concrete_wash

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## 3.4 Establish Proper Equipment/Vehicle Fueling and Maintenance Practices

Instructions:

- Describe equipment/vehicle fueling and maintenance practices that will be implemented to control pollutants to stormwater (e.g., secondary containment, drip pans, and spill kits).
- Also, see EPA's *Vehicle Maintenance and Washing Areas BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/vehicile_maintain

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## 3.5 Control Equipment/Vehicle Washing

Instructions:

- Describe equipment/vehicle washing practices that will be implemented to control pollutants to stormwater.
- Also, see EPA's *Vehicle Maintenance and Washing Areas BMP Fact Sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/vehicile_maintain

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## 3.6 Spill Prevention and Control Plan

Instructions:

- Describe the spill prevention and control plan to include ways to reduce the chance of spills, stop the source of spills, contain and clean up spills, dispose of materials contaminated by spills, and train personnel responsible for spill prevention and control.
- Also, see EPA's *Spill Prevention and Control Plan BMP Fact sheet* at: www.epa.gov/npdes/stormwater/menuofbmps/construction/spill_control

## 3.7 Additional BMPs

Instructions:

– Describe any additional BMPs that do not fit into the previous categories. Indicate the problem they are intended to address.

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### 3.8 Allowable Non-Stormwater Discharge Management

Instructions:

- Identify all allowable sources of non-stormwater discharges that are not previously identified. The allowable non-stormwater discharges include:
  - ✓ A discharge or flow resulting from emergency fire fighting;
  - ✓ A discharge or flow of fire protection water that does not contain oil or hazardous substances or materials;
  - ✓ A discharge or flow resulting from waters used to wash vehicles where detergents are not used;
  - ✓ A discharge or flow resulting from waters used to control dust in accordance with EPA's CGP;
  - ✓ A discharge or flow from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container;
  - ✓ A discharge or flow resulting from waters in routine external building wash down that does not use detergents;
  - ✓ A discharge or flow from water used in street washing that is not contaminated with any soap, detergent, degreaser, solvent, emulsifier, dispersant, or any other harmful cleaning substance;
  - ✓ A discharge or flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant;
  - ✓ A discharge or flow from a diverted stream flow or natural spring;
  - ✓ Uncontaminated discharge or flow from a foundation drain, crawl space pump, footing drain, or sump pump;
  - ✓ Uncontaminated excavation dewatering; and
  - ✓ A discharge or flow from lawn watering, landscape irrigation, or other irrigation water.
- Identify measures used to eliminate or reduce these discharges and the BMPs used to prevent them from becoming contaminated.

List allowable non-stormwater discharges and the measures used to eliminate or reduce them and to prevent them from becoming contaminated:

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# SECTION 4: POST-CONSTRUCTION BMPs

Instructions:

- Describe all post-construction stormwater management measures that will be installed during the construction process to control pollutants in stormwater discharges after construction operations have been completed. Examples of post-construction BMPs including the following:
    - Biofilters
    - Detention/retention devices
    - Earth dikes, drainage swales, and lined ditches
    - Infiltration basins
    - Porous pavement
    - Other proprietary permanent structural BMPs
    - Outlet protection/velocity dissipation devices
    - Slope protection
    - Vegetated strips and/or swales
- Identify any applicable federal, state, local, or tribal requirements for design or installation.
- Describe how low-impact designs or smart growth considerations have been incorporated into the design.
- For any structural BMPs, you should have design specifications and details and refer to them. Attach them as appendices to the SWPPP or include the appropriate information within the text of the SWPPP.

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# SECTION 5: INSPECTIONS

## 5.1 Inspections

Instructions:

- Identify the individual(s) responsible for conducting inspections and describe their qualifications. Reference or attach the inspection form that will be used.
- Inspections shall take place at least once weekly and within 24 hours following a ½" or greater rain event.
- Describe the frequency that inspections will occur at your site including any correlations to storm frequency and intensity.
- Note that inspection details for particular BMPs should be included in Sections 2 and 3.
- Inspections should include BMPs in areas that have not been fully stabilized and locations where runoff leaves the site.
- You should also document the repairs and maintenance that you undertake as a result of your inspections. These actions can be documented in the corrective action log described in Part 5.3 below.
- Also, see inspection form in Attachment 5.
- Inspection reports shall be kept on-site or at a disclosed location with the NOI.
- State requirements for inspection documentation include:
    - Inspector's name
    - Date of Inspection
    - BMP effectiveness
    - Actions to correct deficiencies
    - Areas where construction operations have permanently or temporarily stopped.
    - Observations of stormwater discharge locations with respect to the effectiveness of the upgradient BMPs.
    - Signature of Inspector
- For additional guidance, refer to the Kansas Construction General Permit (CGP) [9].

[9] Refer to Section 7.2.8 of the Kansas Construction Permit (CGP)

1. ***Inspection Personnel:*** Identify the person(s) who will be responsible for conducting inspections and describe their qualifications:

**2. *Inspection Schedule and Procedures:*** Describe the inspection schedules and procedures you have developed for your site (include frequency of inspections for each BMP or group of BMPs, indicate when you will inspect, e.g., before/during/and after rain events, spot inspections):

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**3. *Addressing Problems:*** Describe the general procedures for correcting problems when they are identified. Include responsible staff and time frames for making corrections:

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**Attach a copy of the inspection report you will use for your site in Attachment 5.**

## 5.2 Delegation of Authority

Instructions:

- Attach a copy of the signed KDHE contractor certification form for each contractor responsible for the installation, operation or maintenance of any BMP in Attachment 8.
- On the form, identify the individual(s) or specifically describe the position and title of the person that the construction site operator has delegated authority for the purposes of signing inspection reports, certifications, or other information.

## 5.3 Corrective Action Log

Instructions:

- Attach corrective action logs in Attachment 6. This log should describe repair, replacement, and maintenance of BMPs undertaken as a result of the inspections and maintenance procedures described above. Actions related to the findings of inspections should reference the specific inspection report.
- This log should describe actions taken, date completed, and note the person that completed the work.

# SECTION 6: RECORDKEEPING

## 6.1 Recordkeeping

Instructions:

– The following is a list of records you should keep at your project site for inspectors to review:
  - Dates of grading, construction activity, and stabilization (which is covered in Sections 2 and 3)
  - A copy of the construction general permit (Attachment 3)
  - The signed and certified NOI form or permit application form (Attachment 4)
  - A copy of the NOC from KDHE (Attachment 4)
  - Inspection reports (Attachment 5)
  - Records relating to endangered species and historic preservation (Attachment 10)

## 6.2 Log of Changes to the SWPPP

Instructions:

– Attach a log of changes to the SWPPP in Attachment 7. You should include additions of new BMPs, replacement of failed BMPs, significant changes in the activities or their timing on the project, changes in personnel, changes in inspection and maintenance procedures, updates to site maps, and so on.

## 6.3 Training

Instructions:

– Training staff and subcontractors is an effective BMP. As with the other steps you take to prevent stormwater problems at your site, you should document the training that you conduct for general staff, for those with specific stormwater responsibilities (e.g. installing, inspecting and maintaining BMPs), and for subcontractors.

– Include dates, individual responsible for the training, number of attendees and length of training.

– Also provide a description of the training conducted:
  - General stormwater and BMP awareness training for staff and subcontractors.
  - Detailed training for staff and subcontractors with specific stormwater responsibilities.

# SECTION 7: FINAL STABILIZATION

Instructions:

– Describe procedures for final stabilization. If you complete major construction activities on part of your site, you can document your final stabilization efforts for that portion of the site.
– Update your site plans to indicate areas that have achieved final stabilization.
– All final stabilization BMP's shall be permanent.
– For additional guidance, refer to the Kansas Construction General Permit (CGP) [6].

[6] Refer to Section 7.2.4 of the Kansas Construction Permit (CGP)

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# SECTION 8: PROJECT COMPLETION

Instructions:

- The permittee shall notify KDHE of the project completion by submitting a Notice of Termination (NOT). The permittee shall sign the NOT and mail it to KDHE.
- When the soil disturbing activities are complete, and the final stabilization has been achieved, the permittee can terminate coverage under this general permit by submitting the NOT. The project is considered to be stabilized when perennial vegetation, pavement, buildings, or structures using man-made materials cover all areas which have been disturbed. Vegetation must have a density of at least 70 percent of disturbed areas at the site.
- For subdivision development projects, termination of coverage can be requested after three years, provided the entire subdivision is stabilized and the rate of home construction disturbs less than one (1.0) acre per year or less than one (1.0) acre of land remains to be developed.

# SECTION 9: CERTIFICATION AND NOTIFICATION

Instructions:

- The SWPPP should be signed and certified by the construction operator(s). Attach a copy of the NOI and permit authorization letter received from EPA or the state in Attachment 4.
- For more information see the Kansas CGP.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: ______________________________ Title: ______________________________

Signature: ____________________________________ Date: _________________

Repeat as needed for multiple construction operators at the site

# SWPPP APPENDICES

Attach the following documentation to the SWPPP:

***Attachment 1 – Site Location Map***

***Attachment 2 – Plan Set – Under Separate Cover***

***Attachment 3 – Construction General Permit***

***Attachment 4 – NOI and NOC***

***Attachment 5 – Inspection Reports***

***Attachment 6 – Corrective Action Log***

***Attachment 7 – SWPPP Amendment Log***

***Attachment 8 – Contractor Certifications Form***

***Attachment 9 – Grading and Stabilization Activities Log***

***Attachment 10 – Additional Information (i.e., Endangered Species and Historic Preservation Documentation, etc.)***

***Attachment 11 – NOT Form***

Attachment 1: Site Location Map

Attachment 2:  Plan Set (Under Separate Cover)

Attachment 3:  Construction General Permit

Insert CGP PDF Here

Attachment 4:  NOI and COC

# Attachment 5:  Inspection Reports

| Inspection Date | Inspector Name(s) | Rainfall (in) | BMP Name | Status of BMP | Corrective Action/Responsible Person |
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# Attachment 6:  Corrective Action Log

**Project Name:** ______________________________________________

**SWPPP Contact:** ______________________________________________

| Inspection Date | Inspector Name(s) | Description of BMP Deficiency | Corrective Action Needed (including planned date/responsible person) | Date Action Taken |
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# Attachment 7: SWPPP Amendment Log

**Project Name:** ______________________________________________

**SWPPP Contact:** ______________________________________________

| Amendment No. | Description of the Amendment | Date of Amendment | Amendment Prepared by [Name(s) and Title] |
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# Attachment 8: Contractor Certification Forms

## CONTRACTOR'S CERTIFICATION FORM

For Discharge of Stormwater Runoff from Construction Activities
In accordance with the Kansas Water Pollution Control General Permit
Under the National Pollutant Discharge Elimination System

This form is to be completed by each Contractor responsible for installation, operation, or maintenance of any construction stormwater best management practices (BMPs) necessary to complete the requirements of the Stormwater Pollution Prevention Plan. This completed form must be included in, or kept with, the Stormwater Pollution Prevention Plan for the site identified below.

I certify under penalty of law that I understand the terms and conditions of the Kansas Water Pollution Control general permit that authorizes the stormwater discharges associated with construction activity from the construction site identified below, and the Stormwater Pollution Prevention Plan prepared for the project.

Name of Project: ____________________

City: ____________________ County: __________ State: KS

Kansas Water Pollution Control General Permit No. S-MCST-0701-1

Kansas Permit No. ____________________ Federal Permit No. ____________________

**Contractor Information**

Company Name: ____________________

Company Address: ____________________

____________________

Company Phone Number: ____________________

Project Responsibilities: ____________________

____________________

____________________

____________________

____________________

Contractor's Signature: ____________________ Date: ____________________

Name (typed or printed): ____________________

# Attachment 9: Grading and Stabilization Activities Log

**Project Name:** ______________________________________________

**SWPPP Contact:** ______________________________________________

| Date Grading Activity Initiated | Description of Grading Activity | Date Grading Activity Ceased (Indicate Temporary or Permanent) | Date Stabilization Measures are Initiated | Description of Stabilization Measure and Location |
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Attachment 10: Additional Information (i.e., Endangered Species and Historic Preservation Documentation, etc.)

# Attachment 11: NOT Form

## NOTICE OF TERMINATION FORM (NOT)

**To Relinquish the Authorization to Discharge**
**Stormwater Runoff from Industrial Activity**
**from the Industrial Facility Described Herein.**
**Kansas Water Pollution Control General Permit No. S-ISWA-0507-1**

Submission of this Notice of Termination (NOT) constitutes notice that the party identified in Section I of this form relinquishes authorization for coverage under the Kansas Water Pollution Control general permit, or KDHE authorized successors, issued for Stormwater Runoff from Industrial Activity in the State of Kansas. Submission of this Notice of Termination to KDHE relinquishes the permittee's authorization to discharge stormwater associated with industrial activity at the industrial facility described herein. Completion of this NOT does not automatically relieve the former permittee of any civil, criminal and/or administrative penalties.

Coverage is terminated when the Kansas Department of Health and Environment (KDHE) receives a complete NOT. For transfer of ownership, coverage is terminated when KDHE receives a complete NOT and a complete NOTO for the industrial facility, and KDHE authorizes the transfer. To be considered complete, the NOT and the NOTO must be signed by the relinquishing permittee or a duly authorized representative of the relinquishing permittee, and must include the permit number assigned to the industrial facility. The new permittee or duly authorized representative must also sign the NOTO. KDHE will notify any permittee whose NOT is incomplete, deficient or denied.

**Certification**

I certify under penalty of law that all authorized discharges of stormwater associated with industrial activity at the industrial facility described herein have been eliminated; or the permittee named herein is no longer the owner or operator of this industrial facility. I understand that by submitting this Notice of Termination, I am no longer authorized under the general NPDES permit S-ISWA-0507-1 to discharge stormwater associated with industrial activity at this industrial facility. I understand that discharging pollutants in stormwater associated with industrial activity to waters of the State is unlawful under K.S.A. 65-164 and 65-165 and the Clean Water Act without authorization by a valid Kansas Water Pollution Control Permit. I understand that by submitting this Notice of Termination, I am not released from liability for any violations of the general NPDES permit S-ISWA-0507-1, K.S.A. 65-164 and 65-165, the Kansas Surface Water Quality Standards (K.A.R. 28-16-28 et seq.), or the Clean Water Act. When ownership of the entire industrial facility is being transferred, I understand that the transfer of permit responsibilities is effective when KDHE confirms the transfer. *I also hereby certify that I am authorized to sign this Notice of Termination as a representative of the permittee named herein.*

**Please Print or Type.**

Name of Industrial Facility: ______________________________________________

Address: ____________________ City: ____________ County: __________ State: KS Zip Code: ______

Kansas Permit No. ______________________ Federal Permit No. ______________________

Print Name: ______________________ Date: ______________________

Signature: ______________________ E-mail address: ______________________

This Notice of Termination is being submitted because:

☐ The industrial facility is inactive/abandoned and no longer has stormwater discharges from the facility that meet the definition of stormwater discharges associated with industrial activity. No significant materials remain at the site and production has ceased. (See Part 1.8 of the general NPDES permit).

☐ Ownership of the site has changed. [The relinquishing permittee shall submit an NOT and a copy of the Notice of Transfer of Ownership (NOTO).]

Submit the NOT (and NOTO if applicable) with original signature to:

Kansas Department of Health and Environment
Bureau of Water, Industrial Programs Section
1000 SW Jackson, Suite 420
Topeka, KS 66612 - 1367

KDHE Contact Information

Phone: (785) 296-5545
e-mail: stormwater@kdhe.state.ks.us

# APPENDIX J

City of Wichita Sewer Permit Application

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# City of Wichita Sewer Permit Application

All provisions of laws and ordinances governing this type of work shall be followed.
The granting of a permit does not give authority to violate the provisions of any other federal, state, or local law regulating the performance of construction.

**If applying for a Sanitary Sewer Permit complete page one only.**
**If applying for a storm sewer permit please complete pages one and two of this application.**

**Please Type or Print**

☐ **Sanitary Sewer Permit** ☐ **Storm Sewer Permit**

**Project Information & Location**

Location Address: ______________________ Legal Description: ______________________

Project Name: ______________________ General Cont. Permit Number: ______________________

Sewer Contractor: ______________________ License Number: ______________________

Business Address: ______________________ Phone Number: ______________________

☐ **New Construction:** (Check appropriate box(s) below)

☐ Residential ☐ Commercial ☐ Main Bldg. ☐ Accessory Bldg. ☐ Modular/Mfg. Bldg./Mobile Home
☐ Off Septic ☐ Mud & Oil Trap Incl. ☐ Other: ______________________

☐ **Repair/Replacement:** (Check appropriate box(s) below)

☐ Full Replacement (Bldg. to City main): ☐ Open Cut ☐ Pipe Burst ☐ Install Cleanout Only
☐ Partial Replacement: Location: ______________ ☐ Repair: Location: ______________
☐ Mud & Oil Trap Incl. ☐ Other: (Explanation) ______________________

☐ **Reconnection: (Seal off permit required for original location)** (Check appropriate box(s) below)

☐ Reroute & replace existing line with new tap to City main ☐ Other: ______________________

☐ **Seal Off:** (Check appropriate box(s) below)

☐ Building to be wrecked ☐ Building to be moved ☐ Main Bldg. ☐ Accessory Bldg.
☐ Other: ______________

☐ **Grease Interceptor:** (indicate Size) Number of Gallons: __________ Number of Tanks: __________

☐ Connect building to service line ☐ Separate by City main

A separate permit number and fee is required if submitting an application for more than one of the above mentioned categories. The fee schedule for sewer permits is as follows:

Permit Fee: $30.00 Reinspection Fee: $25.00 Investigation Fee: $100.00

Authorized Person's Signature: ______________________ Date: ______________________

Printed Name: ______________________

## OWNER/OPERATOR STORMWATER QUALITY COMPLIANCE STATEMENT

The undersigned, being the owner of a facility that has applied to the City of Wichita or Sedgwick County, Kansas, for a storm sewer tap/discharge/ stormwater permit, hereby acknowledges the requirements of Section 16.32 of the Wichita City Code, and/or Sedgwick County resolution #196-10, which states that only stormwater can be discharged into the municipal storm sewer system, with the following exceptions:

1. A discharge authorized by, and in full compliance with, a federal or state NPDES permit.
2. A discharge from emergency fire fighting.
3. A discharge from water line flushing.
4. A discharge from lawn watering, landscape irrigation, or other irrigation water.
5. A discharge or flow from a diverted stream flow or natural spring.
6. A discharge or flow from uncontaminated ground water or rising groundwater.
7. Uncontaminated groundwater infiltration.
8. Uncontaminated flow from a foundation drain, crawl space pump, footing drain, or sump pump (no discharge onto street per City Code 10.04.060 City only).
9. A discharge from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container.
10. A flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant.
11. Flows from individual residential car washing.
12. A flow from a riparich habitat, wetland, or natural spring.
13. Storm water runoff from a roof that is not contaminated by any runoff from an emissions scrubber or filter or any other source of pollutant.
14. Residential heat pump discharges.
15. Swimming pool water, excluding filter backwash, that has been de-chlorinated so it contains no harmful quantity of chlorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning.
16. Contaminated groundwater if authorized by KDHE and approved the County. (County Only)
17. Street wash water.(excluding street sweepings which have been removed from the street) (County Only)
18. Discharges specified in writing by the Director as necessary to protect public health and safety. (County only)

I further understand that allowing any other discharge will subject me to the penalties provided in said City Section 16.32, and or Sedgwick County Stormwater Management Resolution #196-10, as well as other federal and state penalties.

Owner or Operator Signature: ______________________________ Date: ______________________________

Name typed or printed: ______________________________ Title: ______________________________

# APPENDIX K

Stormwater Design Certification Form

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# Wichita/Sedgwick County
# Stormwater Design Certification Form

This form must be submitted with all construction plans.

**Submit completed form with Stormwater Permit Application**
**to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202**
**or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

## STORMWATER DESIGN CERTIFICATION STATEMENT

I, ______________________________ of ______________________________ , a Professional Engineer registered in the State of Kansas, hereby certify that this Stormwater Permit Application, the associated Construction Plan and all associated hydrologic and hydraulic analyses for ______________________________________ was prepared by me (or under my direct supervision).

I further certify that the plans and analyses were prepared in accordance with the provisions of the stormwater management regulation (Regulation) of the appropriate governing locality (i.e., the City of Wichita Stormwater Management Ordinance 16.32 or the Sedgwick County Stormwater Management Resolution 196-10), and the policies and guidelines presented in the Wichita/Sedgwick County Stormwater Manual (Manual).

I further certify that all stormwater management components of the Development, including stormwater management facilities, water quality volume reduction areas, stormwater system components and erosion prevention and sediment control best management practices are designed to comply with the provisions of the Regulation and the Manual.

I understand that the City of Wichita, Kansas and/or Sedgwick County, Kansas does not, and will not, assume liability for drainage facilities designed by others unless such facilities are formally accepted for public ownership by the City or County.

______________________________ ______________________________

Professional Engineer Seal/Signature | Consulting Engineering Firm

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

# APPENDIX L

As-Built Plan Checklist

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# City of Wichita/Sedgwick County
# As-Built Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

**Project Name:**

**Total Area of Project:** ____________ **acres**

**Development Type:** ____________ **Other:**

**Developer Name:** ____________ **Contact:** ____________ **Phone:** ____________

**Email:**

**Engineer Name:** ____________ **Contact:** ____________ **Phone:** ____________

**Email:**

*Directions:*

*(1) Fill-out this checklist completely and include it with the As-built Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**As-built Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General Information** | | |
| 1.1 | Digital copy of as-built plan, showing changes from approved designs as redlined items. Include all sheets and submitted as a single PDF file. | | |
| 1.2 | Digital copy of as-built digital terrain model in Civil3D CAD format (for projects involving mass grading only). | | |
| 1.3 | Digital copy of video inspection of storm sewer conduits (private construction only) in MPG format. | | |
| 1.4 | Northing, easting, elevation, description, date and survey quality for all items surveyed, in comma delimited (CSV) file that can be transferred into ESRI GIS inventory. | | |
| 1.5 | All points surveyed in State Plane Kansas South (feet) NAD 83 for horizontal control and NAVD 88 for vertical control using the most current geoid. | | |
| 1.6 | Digital copy of Operations and Maintenance Plan with proof that O&M plan that has been recorded with the Sedgwick County Registrar of Deeds, PDF format. | | |
| 1.7 | Hard copy of all plan sheets in 11"x17" (half-scale) size. | | |
| 1.8 | Copy of all white cards from City of Wichita Public Works & Utilities Engineering staff. | | |
| 1.9 | Title block with address of project, phase or addition name, original date of issue and date of revisions made, name/address of site design engineer/company. Note: Engineer of record must be same as original design plans. | | |
| 1.10 | Date of completion of construction. | | |
| 1.11 | Copy of Notice of Termination filed with KDHE. | | |
| 1.12 | Copy of engineering certifications submitted to KDA-DWR. | | |
| 1.13 | Copy of closeout form submitted to USACE. | | |
| 1.14 | Name and address of land surveyor/company. Name of person performing as-built inspection. | | |
| 1.15 | Name and address of site contractor. | | |
| 1.16 | Professional Engineer's seal, signature and date. | | |
| 1.17 | Notation that construction is complete. | | |
| 1.18 | As-Built Certification Form completed with Engineer's Certification and Land Surveyor's Certification. | | |
| **2.0** | **Stormwater Management Facilities As-built Info** | | |
| 2.1 | Type (using proper name in accordance with the Stormwater Manual) and location of all stormwater management facilities, with boundary lines for the facilities and all easement/reserve boundaries as applicable. | | |
| 2.2 | Type, material, dimensions, surface area, storage volume, slope, invert elevation, rim elevation and other appropriate elevations/information for all stormwater system control structures and stormwater management facilities. | | |
| 2.3 | *Items 2.3.1 to 2.3.12 denote specific survey locations for storm sewer system structures. Indicate whether the surveyed locations for these structures conform to these requirements by answering "Yes" or "No". An explanation must be provided for all "No" answers.* | | |

| As-built Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 2.3.1 | Note: Were all structures with manhole lids surveyed on the northern most point of the rim? If more than one lid is on the structure, the survey point is on the lid on the left side of the structure, as viewed from the street. | | |
| 2.3.2 | Were all Type 2 inlets surveyed on the left side closest to the curb, as viewed from the street? | | |
| 2.3.4 | Were all drop inlets surveyed on the northernmost point of the outside frame? | | |
| 2.3.5 | Were all headwalls surveyed in the center of the headwall? If there are multiple boxes with the same headwall, a survey point must be taken separately at the center of each box on the headwall. | | |
| 2.3.6 | Were all pipe ends surveyed at the invert (flow line) of the pipe end? | | |
| 2.3.7 | Were all end sections surveyed at the invert (flow line) at the downstream end? | | |
| 2.3.8 | Were all beehive covers with manhole lids surveyed on the northern most point of the rim? If more than one cover is on the structure, the survey point is on the lid on the left side of the rim, as viewed from the street. | | |
| 2.3.9 | Were all 2x5 curb inlets surveyed at the left side top of curb, as viewed from the street? | | |
| 2.3.10 | Were all 2x2 curb inlets surveyed at the left side top of curb, as viewed from the street? | | |
| 2.3.11 | Were all curb flow lines surveyed at the left side of the structure, as viewed from the street? | | |
| 2.3.12 | Have all curb flow lines been surveyed for all structures and labeled differently from structure invert flow lines? | | |
| 2.4 | Identifying label, type and location of all proprietary stormwater quality systems. Must include commercial name of the device, vendor name/address, manufacturer name, make, model and size details. | | |
| 2.5 | Indication that stage-area-discharge/volume data meets or exceeds the approved design for all ponds and detention/retention facilities. | | |
| 2.6 | Identifying label, type and location of all water quality volume reduction areas, with boundary lines for areas and all easement/reserve boundaries as applicable. | | |
| 2.7 | Indication that water quality volume reduction areas are protected by signage as required by the local jurisdiction. Show label and location of such signage. | | |
| 2.8 | Scale (horizontal and vertical, as applicable). | | |
| 2.9 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 2.10 | Legend key. | | |
| **3.0** | **Pervious Area Stabilization** | | |
| 3.1 | Copy of Notice of Termination filed with KDHE. | | |
| 3.2 | Narrative of stabilization techniques and vegetation establishment progress for all pervious areas. Indicate areas of seeding/planting and estimate % stabilized coverage for entire site. | | |
| 3.3 | *Provide answers to questions 3.3.1 through 3.3.6. "Yes" answers indicate that the site is not yet stabilized. For all "Yes" answers provide the relevant location(s), an explanation for the answer and the name/address/contact phone for the party responsible for resolution of the issue.* | | |
| 3.3.1 | Question: Are there any areas of bare soil, where vegetative cover has not been established? If Yes, provide location of unstabilized areas and reason for lack of stabilization. | | |
| 3.3.2 | Question: Are there any unstable slopes on the site? | | |
| 3.3.3 | Question: Are any temporary erosion and sediment controls still on-site? | | |
| 3.3.4 | Question: Are there any sediment deposits at the outfalls from the site? | | |
| 3.3.5 | Question: Are there any signs of sediment discharges on the streets or adjacent properties that can be attributed to the site? | | |
| 3.3.6 | Question: Are all stormwater management facilities and the storm sewer system free of sediment? | | |
| | | | |
| End of Checklist | | | |

# APPENDIX M

As-Built Certification Form

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# Wichita/Sedgwick County
# Stormwater As-Built Certification Form

A completed copy of this form must be submitted with all as-built plans.

**Submit completed form(s) to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202 or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

Project Name: ________________________________________

Project Number/OCA: __________________________________

Contractor: __________________________________________

**ENGINEER'S CERTIFICATION OF COMPLETION**

**To the City Engineer, City of Wichita, Kansas or County Engineer, Sedgwick County, Kansas**

I, ____________________________ of ____________________________ , being a licensed engineer in the State of Kansas, do hereby certify that the above described improvements have been completed in substantial conformance with the approved plans and specifications, and do hereby recommend acceptance of same by the City of Wichita and/or Sedgwick County, Kansas, for use by the public for the purposes for which they were intended.

________________________________ ________________________________

Professional Engineer Seal/Signature Consulting Engineering Firm

# Wichita/Sedgwick County
# Stormwater As-Built Certification form

A completed copy of this form must be submitted with all as-built plans, if necessary.

**Submit completed form(s) to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202 or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

The Stormwater As-Built Certification Form must be completed when a survey is performed by a company or firm other than the engineering inspection firm.

Project Name: ______________________________

Project Number/OCA: ______________________________

Contractor: ______________________________

## LAND SURVEYOR'S CERTIFICATION STATEMENT

**To the City Engineer, City of Wichita, Kansas or County Engineer, Sedgwick County, Kansas**

I, ______________________ of ______________________ , being a registered licensed surveyor in the State of Kansas, do hereby certify that I have located all stormwater features shown herein were located in accordance with the current Standards of Practice as adopted by the Kansas Society of Land Surveyors. I certify the location, elevation and description of these features.

______________________ ______________________

Registered Licensed Surveyor Seal/ Signature | Land Survey Firm

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

VOLUME

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# APPENDIX N

Acronym List

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**Table L-1 Acronym List and Respective Definitions.**

| Acronym | Definition |
|---|---|
| AASHTO | American Society of State Highway and Transportation Officials |
| ACI | American Concrete Institute |
| BFE | Base Flood Elevation |
| BMP | Best Management Practices |
| CLOMR | Conditional Letter of Map Revision |
| CGP | Construction General Permit |
| CWA | Clean Water Act |
| DWR | Kansas Division of Water Resources |
| EPSC | Erosion Prevention and Sediment Control |
| ESA | Endangered Species Act |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| HSG | Hydrologic Soil Group |
| HWL | High Water Line |
| ISD | Integrated Site Design |
| KDA | Kansas Department of Agriculture |
| KDHE | Kansas Department of Health and Environment |
| KDOT | Kansas Department of Transportation |
| KDWP | Kansas Department of Wildlife and Parks |
| KHRI | Kansas Historic Resources Inventory |
| KHS | Kansas Historical Society |
| LIDAR | Light Detection And Ranging |
| LOMR | Letter of Map Revision |
| MAPC | Metropolitan Area Planning Commission |
| MS4 | Municipal Separate Storm Sewer System |
| NAVD88 | North American Vertical Datum of 1988 |
| NEPA | National Environmental Policy Act |
| NFIP | National Flood Insurance Program |
| NOC | Notice of Coverage |
| NOI | Notice of Intent |
| NOT | Notice of Termination |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resources Conservation Service (formerly SCS) |
| O&M | Operations & Maintenance |
| OCI | Wichita Office of Central Inspection |
| PSD | Preferred Site Design |
| SCS | Soil Conservation Service (Now NRCS) |
| SHPO | State Historic Preservation Officer |
| SWMM | Stormwater Management Model |
| SWMP | Stormwater Management Program |
| SWPPP | Stormwater Pollution Prevention Plan |
| TAC | Technical Advisory Committee |
| TMDL | Total Maximum Daily Loads |
| UDFCD | Urban Drainage and Flood Control District |
| USACE | U.S. Army Corps of Engineer |
| USDA | U.S. Department of Agriculture |
| USDOT | U.S. Department of Transportation |
| USFWS | U.S. Fish and Wildlife Service |

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# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Underground Dry Detention Ponds

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for underground dry detention ponds. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **After several storm events or an extreme storm event, inspect for: signs of clogging of the inlet or outlet structures and sediment accumulation.** | **As Needed** |
| • **Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability.** | **Semi-annually** |
| • **Inspect that the outlet structures, pipes, and downstream and pilot channels are free of debris and are operational.**<br>• **Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors.**<br>• **Check for sediment accumulation in the facility.**<br>• **Check for proper operation of control gates, valves or other mechanical devices.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Perform structural repairs to inlet and outlets**<br>• **Clean and remove debris from inlet and outlet structures.** | **Monthly or as needed** |
| • **Repair damage to inlet or outlet structures, control gates, valves, or other mechanical devices; repair undercut or eroded areas.** | **As Needed** |
| • **Monitor sediment accumulations, and remove sediment when the pond volume has become reduced 20% or more.** | **As Needed** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:
**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Underground Dry Detention Pond Inspection Checklist

Project Name: ____________________ Project #: ____________

BMP Name/ID (as shown on the O&M Plan): ____________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ____________________

Property Address: ____________________

Owner Phone #: ____________ Owner Email Address: ____________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ____________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ____________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the inlet and outlet structures and channels – these are the locations/structures where water enters and exits the pond.** | | |
| 1. Are the inlets and outlets and channels clear of debris and functional? **Yes = Satisfactory** | | |
| 2. Are trash racks clear of debris and functional? **Yes = Satisfactory** | | |
| 3. Has sediment accumulated at any of the inlet and outlet structures? **Yes = Unsatisfactory** | | |
| 4. Does the concrete/masonry appear to be in good condition? **Yes = Satisfactory** | | |
| 5. Do the pipes appear to be in good condition? **Yes = Satisfactory** | | |
| 6. Is the pond control valve operating properly? **Yes = Satisfactory** | | |

# Wichita/Sedgwick County
# Underground Dry Detention Pond Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Is the pond drain valve operating properly? **Yes = Satisfactory** | | |
| 8. Are there signs of erosion (washing away of soil) in the outlet channels? **Yes = Unsatisfactory** | | |
| 9. Other (describe)? | | |
| **Inspect bottom of the facility.** | | |
| 10. Are there visible signs of pollution (e.g., excessive trash, oil, foul smell, etc.)? **Yes = Unsatisfactory** | | |
| 11. Is there excessive sediment accumulation? **Yes = Unsatisfactory** | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 12. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 13. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_____________________________________________

Inspected by (Signature):__________________________________________

# City of Wichita/Sedgwick County
# Subdivision Drainage Concept Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | **Other:** | | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the Drainage Concept submittal. Incomplete Drainage Concept and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Drainage Concept Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General Information** | | |
| 1.1 | Clear indication of subdivision boundaries. | | |
| 1.2 | Location, width and name(s) of all existing public or private streets within or adjacent to the tract. | | |
| 1.3 | Location, width and name(s) of all existing easements, railroad rights-of-way, section lines, corners, monuments, city/county boundary lines and other similarly important features. | | |
| 1.4 | Contour lines based on NAVD 88 at two foot maximum intervals and extending a minimum of 200 feet beyond the tract boundaries. | | |
| 1.5 | The date of the property survey. | | |
| 1.6 | The location, flow direction and name(s) of all perennial and intermittent watercourses. | | |
| 1.7 | Natural and manmade features such as rock outcroppings, wetlands, lakes, sewage disposal facilities, water wells, wooded areas and tree rows. | | |
| 1.8 | Storm sewers and culverts located in the tract, on adjacent properties and rights-of-way. Include the structure type, horizontal location, flow direction and size. | | |
| 1.9 | Location, elevation and description of the benchmark controlling the vertical survey. | | |
| **2.0** | **Proposed Subdivision** | | |
| 2.1 | Location, width and name(s) of all proposed streets. | | |
| 2.2 | Proposed lots showing lot boundaries on all sides. | | |
| **3.0** | **Preliminary Hydrologic Analysis** | | |
| 3.1 | Topographic map showing on-site and off-site drainage areas for predeveloped conditions. Use City/County LIDAR data. | | |
| 3.2 | Proposed use of existing drainage features, showing those that will be removed and those that will remain after final plat is recorded. | | |
| 3.3 | Location and type of proposed stormwater conveyance system and peak discharge control facilities. Components shall be clearly labeled with basic descriptions (e.g., concrete pipe, channel, detention pond, etc.). | | |
| 3.4 | Location and type of proposed stormwater quality management facilities. Facilities and related components shall be clearly labeled with basic descriptions (e.g., bioretention, wet pond, etc.). | | |
| 3.5 | Location and type of proposed water quality volume reduction areas. | | |
| 3.6 | Drawing and note showing all stormwater management facilities that will be placed in reserves. | | |
| 3.7 | Reserve areas shown with adequate width and location/area for access and maintenance. | | |
| 3.8 | Areas of overland flow. Indicate the boundaries and flow direction in such areas. | | |
| 3.9 | FEMA floodway and floodplain boundaries and base flood elevations. | | |

**End of Checklist**

# City of Wichita/Sedgwick County
# Subdivision Drainage Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | | **Other:** | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the Drainage Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete Drainage Plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Drainage Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General Information** | | |
| 1.1 | Digital copy of drainage plan, including preliminary Master Grading Plan, preliminary plat and proposed plat, in PDF format and one half size, bound, paper copy. | | |
| 1.2 | Professional Engineer's seal, signature and date on plan cover. | | |
| 1.3 | Site location map, using color ortho-imagery and showing the project boundaries, a north arrow and an accurate scale. | | |
| 1.4 | Narrative of the development type, existing conditions and proposed impacts on stormwater runoff, wetlands, riparian zones and floodplains/floodways. | | |
| 1.5 | Discussion of off-site conditions surrounding the proposed development. | | |
| 1.6 | Summary table of runoff calculations (pre/post development). | | |
| 1.7 | Narrative description of the type and function of the permanent structural stormwater management facilities. | | |
| **2.0** | **Existing Conditions Information** | | |
| **2.1** | **Existing Conditions Drainage Map** | | |
| 2.1.1 | On-site and off-site topography: NAVD 88 datum, one-foot contours with spot elevations | | |
| 2.1.2 | On-site and off-site drainage features, including perennial and intermittent streams (with names labeled), conveyance systems such as open channels, ditches, swales and areas of overland flow. Flow direction must be indicated by arrows. | | |
| 2.1.3 | Storm sewer system components, including storm drains, inlets, catch basins, gutters, manholes, headwalls, pipes and culverts. Material and size must be noted for all pipes and culverts. | | |
| 2.1.4 | Location and boundaries of natural features such as wetlands, lakes, ponds with the normal water elevation noted, rock outcroppings, wooded areas and tree rows. | | |
| 2.1.5 | Location, dimensions and elevations of existing bridges and culvert crossings. | | |
| 2.1.6 | Location of existing utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 2.1.7 | Groundwater elevations, if applicable. | | |
| 2.1.8 | Delineation of predominant soil based on USDA soil surveys and/or on-site soil borings; indicate NRCS soil name and Hydrologic Soil Group for undisturbed surface soils. | | |
| 2.1.9 | Land use types per NRCS nomenclature. | | |
| 2.1.10 | Footprint of existing impervious areas (labeled, area given in acres). | | |
| 2.1.11 | Internal drainage subbasin boundaries used for hydrologic calculations (labeled with ID, total area in acres, impervious area in acres and curve number). | | |
| 2.1.12 | Time of concentration flow paths. Indicate and label each segment separately (i.e., overland flow, shallow concentrated, channel1, channel2, etc.). For each segment, provide the appropriate data to calculate Tc (e.g., length, slope, cover type, paved/unpaved, roughness parameters, geometric properties, etc.). | | |

| Drainage Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| **2.2** | **Existing Conditions Hydrology and Hydraulics Analysis** | | |
| 2.2.1 | Narrative of the hydrologic analysis methodology used (e.g., unit hydrograph or other approved methods). | | |
| 2.2.2 | A summary table of drainage subbasin hydrologic parameters (subbasin ID, area in acres, curve number, Tc, etc.). | | |
| 2.2.3 | Table of existing condition runoff curve numbers with supporting data and calculations. | | |
| 2.2.4 | Table of existing condition times of concentration with supporting data and calculations. | | |
| 2.2.5 | A summary table of rainfall data used in the hydrologic analysis, and a reference for the source of the data. | | |
| 2.2.6 | Cross-sections and other diagrams of existing open channels, bridge and culvert sections and other hydraulic features as required to illustrate the basis for hydraulic analysis. | | |
| 2.2.7 | Hydrologic and hydraulic analyses for runoff rates, volumes, velocities and elevations. Provide supporting data not specified above and identify assumptions. Include detailed calculations for the 2, 5, 10, 25 & 100-year, 24-hour storm events. Provide results in a tabular form. Provide digital copies of any computer files and models used. | | |
| **3.0** | **postdevelopment Conditions Information** | | |
| **3.1** | **postdevelopment Conditions Drainage Map** | | |
| 3.1.1 | Proposed project boundary. | | |
| 3.1.2 | on-site and off-site topography: NAVD 88 datum, one-foot contours with spot elevations. | | |
| 3.1.3 | Existing on-site and off-site drainage features that are to remain after development, including perennial and intermittent streams (with names labeled), conveyance systems such as open channels, ditches, swales and areas of overland flow. Flow direction must be indicated by arrows. | | |
| 3.1.4 | Location and description of off-site through-drainage conveyances which are confined to an easement, dedication and/or reserve. | | |
| 3.1.5 | Footprint of proposed impervious areas, including roads, parking lots, buildings and other structures. | | |
| 3.1.6 | Location of proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 3.1.7 | Delineation of predominant soils, based on anticipated soil textures and NRCS guidelines if different from predevelopment soil conditions; indicate NRCS soil name and Hydrologic Soil Group for surface soils. | | |
| 3.1.8 | Land use cover per NRCS nomenclature. | | |
| 3.1.9 | Internal drainage subbasin boundaries used for hydrologic calculations (labeled with ID, total area in acres, impervious area in acres and curve number). | | |
| 3.1.10 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| 3.1.11 | Time of concentration flow paths. Indicate and label each segment separately (i.e., overland flow, shallow concentrated, channel1, channel2, etc.). For each segment, provide the appropriate data to calculate Tc (e.g., length, slope, cover type, paved/unpaved, roughness parameters, geometric properties, etc.). | | |
| **3.2** | **Proposed Conveyances Map** | | |
| 3.2.1 | on-site and off-site drainage features, including perennial and intermittent streams (with names labeled), proposed conveyance systems (such as open channels, ditches, swales and areas of overland flow, including backyard drainage). Flow direction must be indicated by arrows. | | |
| 3.2.2 | Storm sewer system components, including storm drains, inlets, catchbasins, gutters, manholes, headwalls, pipes and culverts. Material and size must be noted for all pipes and culverts. | | |
| 3.2.3 | For any subbasin or drainage area > 40 acres, show that the stormwater flow is confined to an open channel with required side benches and freeboard, or conformance to applicable policy and design requirements if partially enclosed. | | |
| 3.2.4 | Location(s) of stormwater management facilities and any associated drainage easements. | | |
| 3.2.5 | Proposed energy dissipaters and other channel protection devices. | | |
| 3.2.6 | Location(s) and dimension(s) of proposed channel, bridge and culvert crossings. | | |
| 3.2.7 | Normal pool and 100-year pool elevations for ponds and lakes. | | |
| 3.2.8 | Permanent concrete outfall control structure(s) for ponds. | | |
| 3.2.9 | Emergency overflow spillways and top of berm elevations for ponds and other volume/peak discharge control facilities. | | |
| 3.2.10 | Floodplains, ponds, and stormwater management facilities located in reserves. | | |
| **3.3** | **postdevelopment Conditions Hydrology & Hydraulics** | | |

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **Drainage Plan Checklist** | | | |
| 3.3.1 | Narrative of the hydrologic analysis methodology used (e.g., unit hydrograph or other approved methods). | | |
| 3.3.2 | A summary table of drainage subbasin hydrologic parameters (subbasin ID, area in acres, curve number, Tc, etc.). | | |
| 3.3.3 | Table of postdevelopment condition runoff curve numbers with supporting data and calculations. | | |
| 3.3.4 | Table of postdevelopment condition times of concentration with supporting data and calculations. | | |
| 3.3.5 | Cross-sections and other diagrams of existing open channels, bridge and culvert sections and other hydraulic features as | | |
| 3.3.6 | Hydrologic and hydraulic analyses for runoff rates, volumes, velocities and elevations. Provide supporting data not specified above and identify assumptions. Include detailed calculations for the 2, 5, 10, 25 & 100-year, 24-hour storm events. Provide results in a tabular form. Provide digital copies of any computer files and models used. | | |
| 3.3.7 | Downstream peak discharge assessment (10% Rule) results and supporting data and calculations. Provide digital copies of any computer files and models used. | | |
| 3.3.8 | Stage-storage-discharge or other outlet rating curves and inflow/outflow hydrographs for all ponds. | | |
| 3.3.9 | Demonstrate that the pond contours on the master grading plan and the stage-storage-discharge data are consistent for all ponds. | | |
| 3.3.10 | Demonstrate that all ponds have one foot of freeboard above the 100-year, 24-hour high water level. | | |
| 3.3.11 | Demonstrate that runoff from the proposed project site is discharged in the same manner as prior to development, using level spreaders, energy dissipaters, other devices or grading as required, or identify an appropriate flowage easement. | | |
| **3.4** | **Stormwater Quantity Control Sizing** | | |
| 3.4.1 | Hydraulic sizing calculations for all stormwater management controls. | | |
| 3.4.2 | Table(s) listing all stormwater management controls. Present the types, sizes, elevations, flows, velocities and depths for each control, as applicable. Verify that velocities are self-cleaning and non-erosive. | | |
| 3.4.3 | Typical details (including cross-sections where applicable) for outlet structures, embankments, spillways, grade control structures, conveyance channels, etc. | | |
| **3.5** | **Stormwater Quality Management Facilities** | | |
| 3.5.1 | Table(s) listing all stormwater management facilities. Present the description, % TSS removal value, water quality volume handled, contributing drainage area in acres and contributing impervious area in acres. | | |
| 3.5.2 | Indicate the responsible party for maintenance, as shown in the plat text (i.e., Home Owners Association, Lot Owners Association, property owner, etc.). | | |
| 3.5.3 | Water quality volume (total and by facility), with supporting data and calculations. | | |
| 3.5.4 | % TSS removal value (total and by facility) with supporting data and calculation. Must be equal to or greater than 80%. | | |
| 3.5.5 | Channel protection volume with supporting data and calculations. | | |
| 3.5.6 | Water quality volume and channel protection volume orifice size calculations. | | |
| 3.5.7 | Other calculations required for each stormwater management facility as specified in the Wichita/Sedgwick County Stormwater Manual. | | |
| 3.5.8 | Typical details (including cross-sections where applicable) for outlet structures, embankments, internal grading, forebays and other siltation prefilters, filtration/infiltration media, vegetation, check dams, operational controls, etc. | | |
| **4.0** | **Floodplains** | | |
| 4.1 | Reference the source of flood profile, floodplain, floodway and stream discharge information. | | |
| 4.2 | Delineation of nearest base flood elevations. | | |
| 4.3 | Delineation of predevelopment regulatory floodplain/floodway limits using FEMA's current GIS database; limits to be per elevation and scaled location. | | |
| 4.4 | Delineation of postdevelopment regulatory floodplain/floodway limits; limits to be per elevation and scaled location, with project limits shown. | | |
| 4.5 | Floodway data table and discharges. | | |
| 4.6 | Hydrologic and hydraulic study information for local floodplain analysis, unnumbered Zone A elevation determinations and floodplain map revisions or required permits. | | |
| 4.7 | Regulatory floodway and four natural profile models (10, 50, 100 and 500-year) for existing and postdevelopment conditions. | | |
| 4.8 | Floodplains and floodways located within a reserve, where necessary. | | |

| Drainage Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 4.9 | Floodplain cut and fill calculations for volume sensitive basins. | | |
| 4.10 | Demonstrate that floodway elevations and velocities do not increase due to construction in the floodway ("No Rise Certification"). | | |
| **5.0** | **Federal, State and Local Permits** | | |
| 5.1 | US Army Corps of Engineers regulatory program permits (Section 404 permit) | | |
| 5.2 | Kansas Department of Agriculture - Division of Water Resources Permits (Stream Obstruction, Channel Change, Floodplain Fill, Levee, Water Appropriations, Dam Safety permit, etc.). | | |
| 5.3 | FEMA letters of map change/revision - LOMA, LOMR, LOMR-f, CLOMR, etc.; shall be included and approved when project modifies the limits of the floodplain/floodway. | | |
| **6.0** | **Half Scale Preliminary Master Grading Plan** | | |
| 6.1 | One set of plans and associated PDF of plans. | | |
| 6.2 | Professional Engineer's seal, signature and date. | | |
| 6.3 | Title block including subdivision name and phase and dated revision documentation. | | |
| 6.4 | Future phases shown but cross-hatched as information only. | | |
| 6.5 | Scale, not greater than 1-inch = 60 feet. | | |
| 6.6 | North arrow. | | |
| 6.7 | Index or legend key. | | |
| 6.8 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 6.9 | Existing contours of entire site with contour interval of one foot. | | |
| 6.10 | Proposed contours for channels, ponds, and other permanent stormwater management facilities, with contour interval of one foot. | | |
| 6.11 | Spot elevations shown to the nearest tenth of a foot for critical locations, including lot and property boundaries. | | |
| 6.12 | Proposed lot and street layout. | | |
| 6.13 | Locations of underground storm drains. | | |
| 6.14 | Overflow locations for storms exceeding storm drain capacity, with elevations. | | |
| 6.15 | Top elevations of storm drains at all inlets, manholes, and flow line elevations for all outfalls. | | |
| 6.16 | Locations of open ditches and lakes. | | |
| 6.17 | Flow direction arrows. | | |
| 6.18 | Proposed flow line elevations of all open ditches at maximum 100 foot intervals, and 100-year flood elevations thereon. | | |
| 6.19 | Ponds: Location, bottom elevation, normal pool elevation, 100-year flood elevation, emergency overflow elevation. | | |
| 6.20 | Proposed top-of-curb elevations at points where drainage will be required to flow over the curb. | | |
| 6.21 | Platted minimum building opening elevation for each lot, in table form for all lots (excluding basement floor elevations). | | |
| 6.22 | Standard foundation and elevation detail for slab on grade, full basement, view-out, partial view-out and/or walk-out construction. | | |
| 6.23 | Top of foundation elevation for each lot. | | |
| 6.24 | Notation for builders for each lot as to the type of structure that may be constructed and the view-out, walk-out or pad elevation, as applicable. | | |
| 6.25 | Indicate that all lots are above the 100-year flood elevation. | | |
| 6.26 | Indicate that grading around structures conforms to perimeter drainage requirements. | | |
| 6.27 | Indicate that backyard drainage grading conforms to backyard drainage requirements. | | |
| 6.28 | Adjacent subdivision lot lines, with lot labels and subdivision names. | | |
| 6.29 | Boundaries and labels for all easements, rights-of-way and reserves. | | |
| 6.30 | Statement on proposed final plat: "*A drainage plan has been developed for the subdivision and all drainage easements, rights-of-way, or reserves shall remain at the established grades and remain unobstructed to allow for the conveyance of stormwater.* " | | |
| | | | |
| End of Checklist | | | |

# City of Wichita/Sedgwick County
# Construction Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | acres | | | |
| **Development Type:** | | | **Other:** | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the Construction Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**Construction Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **Submittal Formats** | | |
| 1.1 | Hard copy of all plan sheets in 11"x17" (half-scale) size. | | |
| 1.2 | Digital copy of construction plan, including all sheets submitted as single PDF file. | | |
| 1.3 | Electronic copy of all CAD files. | | |
| 1.4 | Preliminary cost estimate in Excel format. | | |
| **2.0** | **All Plan Sheets (except City/County Std Detail Sheets)** | | |
| 2.1 | Title block with address of project, phase or addition name, original date of issue and dated revision control, name/address of site design engineer/company. | | |
| 2.2 | Sheet number. | | |
| 2.3 | North arrow. | | |
| 2.4 | Scale (horizontal and vertical, as applicable). | | |
| 2.5 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 2.6 | Legend key. | | |
| **3.0** | **Cover Sheet** | | |
| 3.1 | Professional Engineer's seal, signature and date. | | |
| 3.2 | Sheet index. | | |
| 3.3 | Site map, including north arrow, scale, lot lines (with lot numbers), project boundaries, special benefit districts labeled and shaded or cross-hatched, and accurate references for section, township and range. | | |
| 3.4 | Vicinity map with north arrow. | | |
| 3.5 | Table of bid items and quantities. | | |
| 3.6 | A statement from the site design engineer that the construction plan conforms with the final approved drainage plan or, if not, that supplemental drainage calculations are included. (Note: Required elements for supplemental drainage calculations are presented in Volume 3 of the Stormwater Manual.) | | |
| **4.0** | **Grading Plan** | | |
| 4.1 | Property boundary, lot lines and lot numbers. | | |
| 4.2 | Property boundaries, names, lot lines and lot numbers for all adjacent subdivisions. | | |
| 4.3 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| 4.4 | Existing contours of entire site, with contour interval of one foot. | | |
| 4.5 | Proposed contours for entire site, with contour interval of one foot. | | |
| 4.6 | Elevation-storage table for each pond. Show next to pond or elsewhere on same sheet and properly referenced to applicable pond. | | |
| 4.7 | Pond bottom elevations. | | |
| 4.8 | Spot elevations shown to the nearest tenth of a foot for critical locations, including lot and property boundaries. | | |
| 4.9 | Proposed flow line elevations for all open ditches and swales at maximum 100 feet intervals. | | |

| Construction Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 4.10 | Location of existing and proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 4.11 | Identifying label, location and boundaries (if applicable) of all sediment prevention and erosion control BMPs if/where required to supplement the construction erosion control BMP plan sheets. | | |
| 4.12 | Identifying label and location of all concrete outfall structures (no earthen or rip-rap outfall structures are permitted). | | |
| **5.0** | **Storm Sewer Plan Sheets** | | |
| 5.1 | Storm sewer horizontal alignments, including stationing, coordinates and offsets from property lines. | | |
| 5.2 | Storm sewer vertical alignments, including stationing, elevations, with flow grades shown every 50 feet and at all structures. | | |
| 5.3 | Storm sewer lines. Each line must have line number, profile line length, material and size. | | |
| 5.4 | Location, size and elevation of all storm sewer stubs. | | |
| 5.5 | Location and size of inlets, energy dissipaters and other storm sewer structures. | | |
| 5.6 | Storm sewer inlets and other structures with elevations, shown in both plan and profile views. | | |
| 5.7 | Peak flow and depth for each design storm event (2, 5, 10, 25 and 100-year, 24-hour storms) at each pipe, inlet and other structure, in table form. | | |
| 5.8 | Identifying label and location of riprap and other protective revetments. | | |
| 5.9 | Identifying label and location of zones of special backfill, such a flowable fill. | | |
| 5.10 | Identifying label, location and boundaries (if applicable) of all sediment prevention and erosion control BMPs if/where required to supplement the construction erosion control BMP plan sheets. | | |
| 5.11 | Identifying label, location and boundaries of all right-of-ways, reserves and easements. | | |
| 5.12 | Identifying label and location of existing and proposed utilities (e.g., water, sewer, gas, electric, cable, etc.) with labels and easement boundaries. | | |
| 5.13 | Utility interference cautions, where applicable. | | |
| 5.14 | Indication that utility conflicts have been resolved, where applicable. | | |
| **6.0** | **Stormwater Management Facilities Plan** | | |
| 6.1 | Copy of the draft Operations and Maintenance Plan. Must include inspection and maintenance guidance for each stormwater management facility. See Volume 2 of the Stormwater Manual for guidance. | | |
| 6.2 | Identifying label, type and location of all stormwater management facilities, with associated easement/reserve boundaries as applicable. | | |
| 6.3 | Identifying label, type and location of all water quality volume reduction areas, with associated easement/reserve boundaries as applicable. | | |
| 6.4 | Identifying label, type and location of all proprietary stormwater quality systems. Must include commercial name of the device, vendor name/address, manufacturer name, make, model and size details. | | |
| **7.0** | **Other Sheets and Documents** | | |
| 7.1 | Construction erosion control plan sheets, standard detail sheets, and non-standard detail sheets. | | |
| 7.2 | Storm sewer standard and non-standard detail sheets. | | |
| 7.3 | Other detail sheets (specify in notes box). | | |
| 7.4 | Special Provisions to Standard Specifications. | | |
| 7.5 | Cost estimate for all bid items. | | |
| 7.6 | Proposed limits of land disturbing activity (i.e., grading limits). | | |
| **8.0** | **Federal, State and Local Permits** | | |
| 8.1 | KDHE Section 401 Water Quality Certification (in conjunction with USACE Section 404 Permit). | | |
| 8.2 | KDHE Authorized NOI under Kansas Construction General Permit. | | |
| 8.3 | Sedgwick County Right-of-Way Permit. | | |
| 8.4 | KDA Division of Water Resources Water Structures Permit. | | |
| 8.5 | FEMA CLOMR/LOMR Approval. | | |
| 8.6 | City of Wichita or Sedgwick County Floodplain Development Permit approval. | | |
| 8.7 | KDWP approval of construction and/or endangered species habitat protection plan. | | |
| | | | |
| End of Checklist | | | |

# City of Wichita/Sedgwick County
# Operations & Maintenance Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | | **Other:** | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the O&M Plan submittal. Incomplete plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all "No" answers.*

***NOTE: THE O&M PLAN IS A DOCUMENT THAT IS INTENDED FOR USE BY THE PROPERTY OWNER (I.E., NOT AN ENGINEER OR LANDSCAPE ARCHITECT) TO GUIDE IN THE INSPECTION AND MAINTENANCE OF SITE STORMWATER MANAGEMENT FACILITIES. IT IS THE IMPORTANT THAT THE O&M PLAN BE WRITTEN IN A MANNER THAT CAN BE UNDERSTOOD BY THE GENERAL PUBLIC. PLEASE CONSIDER THIS WHEN PREPARING THE O&M PLAN.***

**Operations & Maintenance Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General Information** | | |
| 1.1 | Digital copy of O&M plan. Include all sheets and submit as a single PDF file. | | |
| 1.2 | Hard copy of all O&M Plan sheets. | | |
| 1.3 | **Final O&M Plans only**: Digital copy of as-built plan, showing changes from approved designs as redlined items. Include all sheets and submit as a single PDF file. | | |
| 1.4 | Narrative describing the name, location and function of all of the stormwater management facilities located on the property. Each facility must be identified using its proper name (as used in the Wichita/Sedgwick County Stormwater Manual). | | |
| 1.5 | An *Inspection and Maintenance Guidance* sheet (8.5x11) for **each** stormwater management facility located on the property. Use guidance sheets provided in Volume 2, Chapter 3 of the Wichita/Sedgwick County Stormwater Manual, suitably modified (if necessary) to describe the required inspection and maintenance activities and the expected schedule/frequency for inspection and maintenance activities. | | |
| 1.6 | An *Inspection Checklist* template (8.5x11) for **each** stormwater management facility located on the property. Use inspection templates provided in Volume 2, Chapter 3 the Wichita/Sedgwick County Stormwater Manual. | | |
| 1.7 | **Proprietary BMPs only**: BMP inspection and maintenance guidance is not provided in the Wichita/Sedgwick County Stormwater Manual for proprietary BMPs. This information, including a suggested frequency for inspection and maintenance activities must be provided, in accordance with the BMP manufacturer's inspection and maintenance recommendations. | | |
| **2.0** | **Stormwater Facility Map** | | |
| 2.1 | Title block with address of project, phase or addition name, date of O&M plan, name/address of site design engineer/company. | | |
| 2.2 | Date of completion of construction. | | |
| 2.3 | Identifying label, type (using proper name in accordance with the Wichita/Sedgwick County Stormwater Manual) and location of all stormwater management facilities, with boundary lines for the facilities and all easements/reserves as applicable. | | |
| 2.4 | Identifying label, type and location of all proprietary stormwater quality systems. Must include commercial name of the device, vendor name/address, manufacturer name, make, model and size details. | | |
| 2.5 | Identifying label, type and location of all water quality volume reduction areas, with boundary lines for areas and all easements/reserves as applicable. | | |
| 2.6 | Label and location of permanent signage for stormwater management facilities and water quality volume reduction areas located on the property. | | |
| 2.7 | Scale (horizontal). | | |
| 2.8 | Legend key. | | |

| Operations & Maintenance Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| **3.0** | **Cost Estimates** | | |
| 3.1 | Estimate(s) of the expected annual cost associated with routine inspection and maintenance of **each and every** stormwater management facility over the expected life of the facility(s). | | |
| 3.2 | Estimate(s) of any non-routine costs associated with expected remedial maintenance (e.g., removal of sediment from a wet pond every 10 to 15 years) of **each and every** stormwater management facility over the expected life of the facility(s). | | |
| | | | |
| End of Checklist | | | |

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Extended Dry Detention Ponds

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for extended dry detention ponds. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **After several storm events or an extreme storm event, inspect for: bank stability; signs of erosion; and damage to, or clogging of, the outlet structures and pilot channels.** | **As needed** |
| • **Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin, forebay and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability.** | **Semi-annually** |
| • **Inspect that the outlet structures, pipes, and downstream and pilot channels are free of debris and are operational.**<br>• **Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors.**<br>• **Check for sediment accumulation in the facility.**<br>• **Check for proper operation of control gates, valves or other mechanical devices.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Clean and remove debris from inlet and outlet structures.**<br>• **Mow side slopes (embankment) and maintenance access. Periodic mowing is only required along maintenance rights-of-way and the embankment.** | **Monthly or as needed** |
| • **Repair and revegetate eroded areas.**<br>• **Remove vegetation that may hinder the operation of the pond.**<br>• **Repair damage to pond, outlet structures, embankments, control gates, valves, or other mechanical devices; repair undercut or eroded areas.** | **As Needed** |
| • **Monitor sediment accumulations, and remove sediment when the pond volume has become reduced significantly.** | **As Needed**<br>**(typically every 15 to 50 years)** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:
**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Extended Dry Detention Pond Inspection Checklist

Project Name: ______________________________ Project #: ____________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ____________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the embankment (the dam/berm that holds water in the pond) and the emergency spillway (the location where water exits the facility in the event that the embankment is overtopped).** | | |
| 1. Does the vegetation appear to be healthy and adequately covering the embankment to prevent erosion? **Yes = Satisfactory** | | |
| 2. Are there signs that soil is eroding (washing away) on/from the embankment? **Yes = Unsatisfactory** | | |
| 3. Are there signs of animal burrows in embankment? **Yes = Unsatisfactory** | | |
| 4. Are there signs of cracking, sliding and/or bulging of the berm/dam? **Yes = Unsatisfactory** | | |
| 5. Are the drains (if any) blocked or malfunctioning? **Yes = Unsatisfactory** | | |
| 6. Are there signs of leaks or seeps on the embankment? **Yes = Unsatisfactory** | | |

Wichita/Sedgwick County
# Extended Dry Detention Pond Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Are there any obstructions of the emergency spillway(s)? **Yes = Unsatisfactory** | | |
| 8. Are there signs of erosion (washing away of soil) in or around the emergency spillway? **Yes = Unsatisfactory** | | |
| 9. Other (describe)? | | |
| **Inspect the inlet and outlet structures and channels – these are the locations/structures where water enters and exits the pond.** | | |
| 10. Are the inlets and outlets and channels clear of debris and functional? **Yes = Satisfactory** | | |
| 11. Are trash racks clear of debris and functional? **Yes = Satisfactory** | | |
| 12. Has sediment accumulated at any of the inlet and outlet structures? **Yes = Unsatisfactory** | | |
| 13. Does the concrete/masonry appear to be in good condition? **Yes = Satisfactory** | | |
| 14. Do the pipes appear to be in good condition? **Yes = Satisfactory** | | |
| 15. Is the slide gate (if any) operating properly? **Yes = Satisfactory** | | |
| 16. Is the pond drain valve operating properly? **Yes = Satisfactory** | | |
| 17. Are there signs of erosion (washing away of soil) in the outlet channels? **Yes = Unsatisfactory** | | |
| 18. Other (describe)? | | |
| **Inspect the bottom of the dry pond.** | | |
| 19. Is the vegetation healthy and adequately covering the dry areas to prevent soil erosion? **Yes = Satisfactory** | | |

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 20. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 21. Is there excessive sediment accumulation? **Yes = Unsatisfactory** | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 22. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 23. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Vegetative Filter Strips

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for vegetative filter strips. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Inspect gravel diaphragm for clogging (i.e., standing water or sediment build-up).**<br>• **Inspect vegetation for signs of erosion or un-vegetated areas.**<br>• **Inspect to ensure that grass has established.**<br>• **Inspect general flow paths to determine if runoff discharges into and across the filter strip in an unchannelized fashion.** | **Annually**<br>**(Semi-annually first year)** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Maintain a dense, healthy stand of grass and other vegetation by frequent mowing. Grass heights of 3 to 5 inches should be maintained, with a maximum grass height of 8 inches.** | **Regularly (frequently)** |
| • **Repair areas of erosion and re-vegetate.**<br>• **Re-vegetate as needed to maintain healthy vegetation.**<br>• **Remove sediment build-up.** | **As needed** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Vegetative Filter Strip Inspection Checklist

Project Name: ______________________________ Project #:______________

BMP Name/ID (as shown on the O&M Plan):______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #:______________ Owner Email Address:______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time:______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.):______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the vegetative filter strip area. The location of inspection areas/elements should be noted on the O&M Plan for the facility.** | | |
| 1. Does the vegetation appear to be healthy and adequately covering filter strip? **Yes = Satisfactory** | | |
| 2. Are there signs of soil erosion? **Yes = Unsatisfactory** | | |
| 3. Does the gravel diaphragm appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Are there signs of sediment build-up behind level spreader? **Yes = Unsatisfactory** | | |
| 5. Are there signs of sediment build-up in the filter strip? **Yes = Unsatisfactory** | | |
| 6. Other (describe)? | | |

# Wichita/Sedgwick County
# Vegetative Filter Strip Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| **Identify any potential hazards to humans or the environment.** | | |
| 7. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 8. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):______________________________________________

Inspected by (Signature):___________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Grassed Channels

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for grassed channels. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • Inspect check dams (if used) for clogging (i.e., standing water or sediment build-up).<br>• Inspect vegetation for signs of erosion or un-vegetated areas.<br>• Inspect to ensure that grass is healthy and well-established. | Annually<br>(Semi-annually first year) |
| **Maintenance Activities** | **Suggested Schedule** |
| • Maintain a dense, healthy stand of grass and other vegetation by frequent mowing. Grass heights of 3 to 5 inches should be maintained, with a maximum grass height of 8 inches. | Regularly (frequently) |
| • Remove all accumulated sediment that may obstruct flow through the channel. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation. Replace the grass areas damaged in the process.<br>• Remove trash, debris and sediment accumulated in the channel or behind check dams (if present).<br>• Repair areas of erosion and re-vegetate.<br>• Re-vegetate as need to maintain healthy vegetation. | As-needed |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Grassed Channel Inspection Checklist

Project Name: ____________________________________________ Project #:________________

BMP Name/ID (as shown on the O&M Plan):____________________________________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ________________________________________________________________

Property Address: ___________________________________________________________________

Owner Phone #:_____________________ Owner Email Address:________________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time:___________________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.):_______________________________

______________________________________________________________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect all areas of the grassed channel.** | | |
| 1. Does the vegetation appear to be healthy and adequately covering the embankment to prevent erosion? **Yes = Satisfactory** | | |
| 2. Are there signs that soil is eroding (washing away)? **Yes = Unsatisfactory** | | |
| 3. Do the check dams located in the channel have signs of debris build-up or do they appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Are there signs of sediment build-up on the channel bottom? **Yes = Unsatisfactory** | | |
| 5. After a storm, does is water held in the channel for extended periods? **Yes = Unsatisfactory** | | |
| 6. After a storm, is the bottom of the channel wet and soggy for extended periods? **Yes = Unsatisfactory** | | |
| 7. Other (describe)? | | |

# Wichita/Sedgwick County
# Grassed Channel Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| **Identify any potential hazards to humans or the environment.** | | |
| 8. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 9. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Enhanced Swales

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for enhanced swales. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Inspect after seeding and after first major storm for any damage to vegetation, side slopes and bottom.** | **Post construction** |
| • **Inspect for signs of erosion, unhealthy or damaged vegetation, denuded areas, channelization of flow, debris and litter, and areas of sediment accumulation. Perform inspections at the beginning and end of the wet season. Additional inspections after periods of heavy rainfall are desirable.** | **Semi-annually** |
| • **Inspect level spreader for clogging (if applicable), grass along side slopes for erosion and formation of rills or gullies, and sand/soil bed for erosion problems. Inspect gravel diaphragm for clogging.**<br>• **Inspect sediment forebays and/or pretreatment areas for debris and sediment accumulation.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Mow grass to maintain a height of 3–4 inches, for safety, aesthetic, or other purposes, if needed. Litter should always be removed prior to mowing. Grass clippings, if captured, should not be dumped in the swale.**<br>• **Irrigate swale during dry season (April through October) or when necessary to maintain the vegetation.**<br>• **Repair damaged areas (e.g., erosion rills or gullies) and re-establish vegetation where needed. Remove invasive species manually. The use of fertilizers, herbicides and pesticides should occur only when absolutely necessary, and then in minimal amounts.** | **As needed**<br>**(frequent, seasonally)** |
| • **Remove litter, branches, rocks blockages, and other debris and dispose of properly.**<br>• **Clear accumulated debris and sediment from the inlet flow spreader (if applicable) and gravel diaphragm.** | **Semi-annually** |
| • **Inspect gravel diaphragm for clogging and correct the problem.**<br>• **Plant an alternative grass species if the original grass cover has not been successfully established. Reseed and apply mulch to damaged areas.** | **Annually**<br>**(if needed)** |
| • **Remove all accumulated sediment that may obstruct flow through the swale. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation, or once it has accumulated to 10% of the original design volume. Replace the grass areas damaged in the process.**<br>• **Remove all accumulated sediment in the sediment forebay and pretreatment areas.**<br>• **Repair areas of erosion around swale and underdrain outlets. Reestablish soil stabilization measures (e.g., rip-rap stone, turf grasses) as needed.**<br>• **Roto-till or cultivate the surface of the sand/soil bed of dry swales if the swale does not draw down within 48 hours. Re-establish swale vegetation after roto-till activities.** | **As needed**<br>**(infrequent)** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.


For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**

**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Enhanced Swale Inspection Checklist

Project Name: ______________________________________ Project #:______________

BMP Name/ID (as shown on the O&M Plan):______________________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________________

Property Address: ______________________________________

Owner Phone #:____________________ Owner Email Address:______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time:______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.):______________________________

______________________________________________________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the enhanced swale.** | | |
| 1. Does the vegetation appear to be healthy and adequately covering the embankment to prevent erosion? **Yes = Satisfactory** | | |
| 2. Are there signs that soil is eroding (washing away) on the bottom or side slopes? **Yes = Unsatisfactory** | | |
| 3. Are there signs of animal burrows in embankment? **Yes = Unsatisfactory** | | |
| 4. Does the bottom of the swale appear to be clear of debris and functional? **Yes = Satisfactory** | | |
| 5. Are the check dams in place (if applicable)? **Yes = Satisfactory** | | |
| 6. Is there evidence of sediment accumulation on the bottom of the channel? **Yes = Unsatisfactory** | | |

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Are there an obstructions or blockages other than the check dams? **Yes = Unsatisfactory** | | |
| 8. Does the gravel diaphragm appear to be clogged? **Yes = Unsatisfactory** | | |
| 9. Is there undesirable vegetation or vegetation overgrowth? **Yes = Unsatisfactory** | | |
| 10. Is the swale visibly polluted (e.g., trash, signs of oil, foul odor, etc.)? **Yes = Unsatisfactory** | | |
| 11. Other (describe)? | | |
| **Inspect the inlet and outlet structures and channels – these are the locations/structures where water enters and exits the pond.** | | |
| 12. Are the inlets and outlets and channels clear of debris and functional? **Yes = Satisfactory** | | |
| 13. Has sediment accumulated at any of the inlet and outlet structures? **Yes = Unsatisfactory** | | |
| 14. Are there signs of erosion (washing away of soil)? **Yes = Unsatisfactory** | | |
| 15. Other (describe)? | | |
| **Inspect the sediment pre-treatment area (usually a forebay) – the location and type of the pre-treatment area should be indicated on the O&M Plan.** | | |
| 16. Has sediment accumulated in the pre-treatment area? Note – sediment accumulation would indicate that the pre-treatment area is not working as intended and must be cleaned. **Yes = Unsatisfactory** | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 17. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 18. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):_____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Infiltration Trench

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for infiltration trenches. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **A record should be kept of the dewatering time (i.e., the time required to drain the infiltration trench completely after a storm event) of the trench to determine if maintenance is necessary. The trench should drain completely in about 24 hours after the end of the rainfall. Ponded water inside the trench (as visible from the observation well or on the surface) longer than 48 hours or several days after a storm event is an indication that the trench is clogged.** | **After Rain Events** |
| • **Check that the area draining to the trench, the trench and its inlets are clear of debris.**<br>• **Check the area draining to the trench for evidence of erosion.** | **Monthly** |
| • **Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.** | **Semi-annual Inspection** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Remove sediment and oil/grease from pretreatment devices, as well as overflow structures.**<br>• **Mow grass filter strips as necessary. Remove grass clippings.** | **Monthly** |
| • **Remove trees that start to grow in the vicinity of the trench.** | **Semi-annual Inspection** |
| • **Replace gravel/topsoil and top surface filter fabric (when clogged). Removed sediment and media may usually be disposed of in a landfill.**<br>• **Stabilize (i.e., vegetate or cover) areas of erosion in the area draining to the trench.** | **As needed** |
| • **Perform total rehabilitation of the trench to maintain design storage capacity.**<br>• **Excavate trench walls to expose clean soil.** | **Upon Failure** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Infiltration Trench Inspection Checklist

Project Name: ______________________________ Project #: ____________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ____________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the trench area.** | | |
| 1. Does infiltration trench appear to drain completely in about 24 to 48 hours after a rain event? **Yes = Satisfactory** | | |
| 2. Does the surface of the trench appear to be clogged? **Yes = Unsatisfactory** | | |
| 3. Doe the inlet/outlet structures of the trench appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Does the trench appear to be clear of debris and functional? **Yes = Satisfactory** | | |
| 5. Is there any evidence of leaks or seeps in the trench? **Yes = Unsatisfactory** | | |
| 6. Are there signs of animal burrows in the trench? **Yes = Unsatisfactory** | | |
| 7. Are there signs of cracking, spalling and/or bulging of the concrete? **Yes = Unsatisfactory** | | |

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Are there signs of erosion (washing away of soil) in the area that is draining to the trench? **Yes = Unsatisfactory** | | |
| 9. Are there signs of erosion around inlets/outlets or in the trench? **Yes = Unsatisfactory** | | |
| 10. Do the pipes and other structures appear to be in good condition? **Yes = Satisfactory** | | |
| 11. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 12. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 13. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 14. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_____________________________________________

Inspected by (Signature):__________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Soakage Trench

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for soakage trenches. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **A record should be kept of the dewatering time (i.e., the time required to drain the infiltration trench completely after a storm event) of the trench to determine if maintenance is necessary. The trench should drain completely in about 24 hours after the end of the rainfall. Ponded water inside the trench (as visible from the observation well or on the surface) longer than 48 hours or several days after a storm event is an indication that the trench is clogged.** | **After Rain Events** |
| • **Check that the area draining to the trench, the trench and its inlets are clear of debris.**<br>• **Check the area draining to the trench for evidence of erosion.** | **Monthly** |
| • **Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.** | **Semi-annual Inspection** |

| Maintenance Activities | Suggested Schedule |
|---|---|
| • **Remove sediment and oil/grease from pretreatment devices, as well as overflow structures.**<br>• **Mow grass filter strips as necessary. Remove grass clippings.** | **Monthly** |
| • **Remove trees that start to grow in the vicinity of the trench.** | **Semi-annual Inspection** |
| • **Replace gravel/topsoil and top surface filter fabric (when clogged). Removed sediment and media may usually be disposed of in a landfill.**<br>• **Stabilize (i.e., vegetate or cover) areas of erosion in the area draining to the trench.** | **As needed** |
| • **Perform total rehabilitation of the trench to maintain design storage capacity.**<br>• **Excavate trench walls to expose clean soil.** | **Upon Failure** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Soakage Trench Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________________________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the trench area.** | | |
| 1. Does infiltration trench appear to drain completely in about 24 to 48 hours after a rain event? **Yes = Satisfactory** | | |
| 2. Does the surface of the trench appear to be clogged? **Yes = Unsatisfactory** | | |
| 3. Doe the inlet/outlet structures of the trench appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Does the trench appear to be clear of debris and functional? **Yes = Satisfactory** | | |
| 5. Is there any evidence of leaks or seeps in the trench? **Yes = Unsatisfactory** | | |
| 6. Are there signs of animal burrows in the trench? **Yes = Unsatisfactory** | | |
| 7. Are there signs of cracking, spalling and/or bulging of the concrete? **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Soakage Trench Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Are there signs of erosion (washing away of soil) in the area that is draining to the trench? **Yes = Unsatisfactory** | | |
| 9. Are there signs of erosion around inlets/outlets or in the trench? **Yes = Unsatisfactory** | | |
| 10. Do the pipes and other structures appear to be in good condition? **Yes = Satisfactory** | | |
| 11. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 12. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 13. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 14. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Surface Sand Filter / Underground Sand Filter

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for surface sand filters and underground sand filters. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **A record should be kept of the dewatering time (i.e., the time required to drain the filter bed completely after a storm event) for a sand filter to determine if maintenance is necessary. The filter bed should drain completely in about 40 hours after the end of the rainfall.**<br>• **Check to ensure that the filter surface does not clog after storm events.** | **After Rain Events** |
| • **Check the contributing drainage area, facility, inlets and outlets for debris.**<br>• **Check to ensure that the filter surface is not clogging.** | **Monthly** |
| • **Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full or 6 inches, whichever is less, of sediment. Remove sediment as necessary.**<br>• **Make sure that there is no evidence of deterioration, spalling, bulging, or cracking of concrete.**<br>• **Inspect grates (perimeter sand filter).**<br>• **Inspect inlets, outlets and overflow spillway to ensure good condition and no evidence of erosion.**<br>• **Check to see if stormwater flow is bypassing the facility.**<br>• **Ensure that no noticeable odors are detected outside the facility.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Mow and stabilize (prevent erosion, vegetate denuded areas) the area draining to the sand filter. Collect and remove grass clippings. Remove trash and debris.**<br>• **Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system.**<br>• **If permanent water level is present (perimeter sand filter), ensure that the chamber does not leak, and normal pool level is retained.** | **Monthly** |
| • **Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full or 6 inches, whichever is less, of sediment. Remove sediment as necessary.**<br>• **Repair or replace any damaged structural parts.**<br>• **Stabilize any eroded areas.** | **Annually** |
| • **If filter bed is clogged or partially clogged, manual manipulation of the surface layer of sand may be required. Remove the top few inches of sand, roto-till or otherwise cultivate the surface, and replace media with sand meeting the design specifications.**<br>• **Replace any filter fabric that has become clogged.** | **As needed** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Surface Sand Filter/ Underground Sand Filter Inspection Checklist

Project Name: ______________________________ Project #:______________

BMP Name/ID (as shown on the O&M Plan):______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #:______________ Owner Email Address:______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time:______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.):______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the filter area.** | | |
| 1. Does the filter appear to drain completely in about 36 to 48 hours after a rain event? **Yes = Satisfactory** | | |
| 2. Does the filter surface appear to be clogged? **Yes = Unsatisfactory** | | |
| 3. Do the inlet/outlet areas or structures appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Does the filter fabric appear to be clogged? **Yes = Unsatisfactory** | | |
| 5. Is the filter area clear of debris and does it appear to be functional? **Yes = Satisfactory** | | |
| 6. Are there signs of any leaks or seeps in the filter? **Yes = Unsatisfactory** | | |
| 7. Are there any obstructions of the filter spillway(s)? **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Surface Sand Filter/ Underground Sand Filter Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Are there signs of animal burrows in the filter? **Yes = Unsatisfactory** | | |
| 9. Is there sediment accumulation in the filter bed? **Satisfactory = sediment accumulation in less than 50% of bed area** | | |
| 10. Are there signs of cracking, spalling and/or bulging of the concrete? **Yes = Unsatisfactory** | | |
| 11. Are there signs of erosion (washing away of soil) in the area that is draining to the filter? **Yes = Unsatisfactory** | | |
| 12. Are there signs of erosion around inlets/outlets or in the filter? **Yes = Unsatisfactory** | | |
| 13. Do the pipes and other structures appear to be in good condition? **Yes = Satisfactory** | | |
| 14. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 15. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 16. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 17. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Bioretention Areas

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for bioretention areas. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **After several storm events or an extreme storm event, inspect for signs of erosion, signs of mulch movement out of the treatment area, signs of damage to plants or dead or diseased vegetation.** | **As needed** |
| • **Inspect: inflow points for clogging (off-line systems), strip/grass channel for erosion or gullying,**<br>• **Inspect trees, shrubs and other vegetation to evaluate their health and replace any dead or diseased vegetation.**<br>• **Inspect surrounding drainage area for erosion or signs of sediment delivery to the bioretention area.** | **Semi-annually** |
| • **Check for signs of vegetation overgrowth.**<br>• **Inspect treatment area during a rain event and visually verify that stormwater recedes within 24-48 hours from the treatment area.** | **Annually** |

| Maintenance Activities | Suggested Schedule |
|---|---|
| • **Replace mulch and repair areas of erosion, when identified.**<br>• **Replace dead or diseased plants.** | **As needed** |
| • **Remove clogs from the stormwater system inflow and overflow components.**<br>• **Remove sediments from pretreatment areas and restabilize with stone or vegetation as appropriate.** | **Semi-annually** |
| • **Harvest overgrown vegetation and remove from the bioretention area.** | **As needed** |
| • **The planting soils should be tested for pH to establish acidic levels. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH.**<br>• **Check that planting soils still have specified infiltration rate.** | **Annually** |
| • **Replace mulch over the entire area.**<br>• **Replace gravel diaphragm if warranted.**<br>• **Note that the surface of the ponding area may become clogged with fine sediment over time. Core aeration or cultivating of un-vegetated areas may be required to ensure adequate filtration.** | **2 to 3 years** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

**For more information on the maintenance of your stormwater facility, please contact:**

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Bioretention Area Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the Inflow and Overflow Points – these are the locations where stormwater runoff enters or exits the facility.** | | |
| 1. Are the stormwater inflow and outflow points clear of debris and functional? **Yes = Satisfactory** | | |
| 2. Has sediment accumulated at any of the inflow and/or outflow points? **Yes = Unsatisfactory** | | |
| 3. If vegetated, is the vegetation in good condition? **Yes = Satisfactory** | | |
| 4. Are there signs of soil or mulch erosion at the inflow or outflow points? **Yes = Unsatisfactory** | | |
| 5. Other (describe)? | | |

# Wichita/Sedgwick County
# Bioretention Area Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| **Inspect the sediment pre-treatment area – the location and type of the pre-treatment area should be indicated on the O&M Plan.** | | |
| 6. Has sediment accumulated in the pre-treatment area? Note - sediment accumulation would indicate that the pre-treatment area is working as intended, but must be cleaned. **Yes = Unsatisfactory** | | |
| **Inspection Items** | **Condition*** | **Comments/Corrective Action** |
| **Inspect the treatment facility.** | | |
| 7. Are there signs of soil or mulch erosion or the movement of mulch? **Yes = Unsatisfactory** | | |
| 8. Is the vegetation healthy and growing? **Yes = Satisfactory** | | |
| 9. Is vegetation overgrown and in need of pruning? **Yes = Unsatisfactory** | | |
| 10. Are there signs of sediment, debris or trash accumulation? **Yes = Unsatisfactory** | | |
| 11. Is the mulch layer showing signs of thinning? **Yes = Unsatisfactory** | | |
| 12. Is there standing water in the facility for more than 24-48 hours after rain events? **Yes = Unsatisfactory** | | |
| 13. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 14. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 15. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Stormwater Wetland

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for stormwater wetlands. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **After several storm events or an extreme storm event, inspect for: bank stability; signs of erosion; vegetation growth; drainage system function; and structural damage.** | **As needed** |
| • **Inspect for: invasive vegetation; trash and debris; clogging of the inlet/outlet structures and any pilot or low flow channels; excessive erosion; sediment accumulation in the basin, forebay and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability.** | **Semi-annually** |
| • **Inspect the inlet/outlet structures, pipes, sediment forebays, and upstream, downstream, and pilot channels to ensure they are free of debris and are operational.**<br>• **Check for signs of unhealthy or overpopulation of plants and/or fish (if utilized).**<br>• **Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors.**<br>• **Check sediment marker(s) for sediment accumulation in the facility and forebay.**<br>• **Check for proper operation of control gates, valves or other mechanical devices.**<br>• **Note changes to the wetland or contributing drainage area as such changes may affect wetland performance.** | **Annually** |

| Maintenance Activities | Suggested Schedule |
|---|---|
| • **Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.** | **One-time** |
| • **Clean and remove debris from inlet and outlet structures. Mow side slopes (embankment) and maintenance access. Periodic mowing is only required along maintenance rights-of-way and the embankment. The wetland buffer surrounding the wetland can be managed as a meadow (mowing every other year) or forest.** | **Frequently**<br>**(3 to 4 times per year)** |
| • **Supplement wetland plants if a significant portion have not established (at least 50% of the surface area). Remove unhealthy, invasive or nuisance plant species and replant with appropriate species if necessary. Harvest plant species if vegetation becomes too thick causing flow backup and flooding, or an overabundance of undesirable wildlife.** | **Annually**<br>**(if needed)** |
| • **Repair damage to pond, outlet structures, embankments, control gates, valves, or other mechanical devices; repair undercut or eroded areas. Remove litter, debris, pollutants as appropriate.** | **As needed** |
| • **Remove sediment from the forebay. Sediments excavated from stormwater wetlands that receive treated runoff from hotspot land uses are not considered toxic or hazardous material and can be safely disposed of by either land application or landfilling. Sediment testing is required prior to sediment disposal when the wetland receives discharge from a hotspot land use.** | **As needed**<br>**(typically every 5 to 7 years)** |
| • **Monitor sediment accumulations, and remove sediment when the volume in the wetland, forebay, or micropool has become reduced significantly or the wetland area is not providing a healthy habitat for vegetation and fish (if used). Discharges of turbid or untreated stormwater from the wetland may be considered an illegal discharge by local ordinances. Care should be exercised during wetland drawdowns to prevent downstream discharge of sediments, anoxic water, or high flows with erosive velocities. The appropriate authorities should be notified before draining a stormwater wetland.** | **As needed**<br>**(typically every 20 to 50 years)** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**

**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Stormwater Wetland Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Owner Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
| --- | --- | --- |
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the embankment (the dam/berm that holds water in the pond) and the emergency spillway (the location where water exits the facility in the event that the embankment is overtopped).** | | |
| 1. Does the vegetation appear to be healthy and adequately covering the embankment to prevent erosion? **Yes = Satisfactory** | | |
| 2. Are there signs that soil is eroding (washing away) on/from the embankment? **Yes = Unsatisfactory** | | |
| 3. Are there signs of animal burrows in embankment? **Yes = Unsatisfactory** | | |
| 4. Are there signs of cracking, sliding and/or bulging of the berm/dam? **Yes = Unsatisfactory** | | |
| 5. Are the drains (if any) blocked or malfunctioning? **Yes = Unsatisfactory** | | |
| 6. Are there signs of leaks or seeps on the embankment? **Yes = Unsatisfactory** | | |
| 7. Are there any obstructions of the emergency spillway(s)? **Yes = Unsatisfactory** | | |

## Wichita/Sedgwick County
## Stormwater Wetland Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Are there signs of erosion (washing away of soil) in or around the emergency spillway? **Yes = Unsatisfactory** | | |
| 9. Other (describe)? | | |
| **Inspect the inlet and outlet structures and channels – these are the locations/structures where water enters and exits the pond.** | | |
| 10. Are the inlets and outlets and channels clear of debris and functional? **Yes = Satisfactory** | | |
| 11. Are trash racks clear of debris and functional? **Yes = Satisfactory** | | |
| 12. Has sediment accumulated at any of the inlet and outlet structures? **Yes = Unsatisfactory** | | |
| 13. Does the concrete/masonry appear to be in good condition? **Yes = Satisfactory** | | |
| 14. Do the pipes appear to be in good condition? **Yes = Satisfactory** | | |
| 15. Is the slide gate (if any) operating properly? **Yes = Satisfactory** | | |
| 16. Is the pond drain valve operating properly? **Yes = Satisfactory** | | |
| 17. Are there signs of erosion (washing away of soil) in the outlet channels? **Yes = Unsatisfactory** | | |
| 18. Other (describe)? | | |
| **Inspect the sediment pre-treatment area (usually a forebay) – the location and type of the pre-treatment area should be indicated on the O&M Plan.** | | |
| 19. Has sediment accumulated in the pre-treatment area? Note – sediment accumulation would indicate that the pre-treatment area is not working as intended and must be cleaned. **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Stormwater Wetland Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| **Inspect the permanent pool – this is the area that stays permanently (or nearly permanently) filled with water.** | | |
| 20. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 21. Is the pool visibly polluted (trash, oily sheen, foul or chemical odor, discoloration, foaming, etc.)? **Yes = Unsatisfactory** | | |
| 22. Are there areas of erosion (soil washing away) on the shoreline? **Yes = Unsatisfactory** | | |
| 23. Are there signs of erosion (soil washing away) at the location where water enters the wetland? **Yes = Unsatisfactory** | | |
| 24. Are the headwalls and endwalls in good condition? **Yes = Satisfactory** | | |
| 25. Are other activities (e.g., grading, recreational, etc.) encroaching on the wetland? **Yes = Unsatisfactory** | | |
| 26. Is there evidence of sediment accumulation? **Yes = Unsatisfactory** | | |
| **Inspect the wetland vegetation – adequate, healthy and appropriate vegetation is vital to the operation of the wetland as a water quality treatment area.** | | |
| 27. Is the vegetation adequately covering the wetland area? **Yes = Satisfactory** | | |
| 28. Does the vegetation appear to be healthy? **Yes = Satisfactory** | | |
| 29. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 30. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 31. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Gravity (Oil/Water) Separators

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for gravity (oil/water) separators. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Inspect the gravity separator unit for clogging, accumulated debris, sediment, and/or oil and grease.** | **Regularly (at least every three months)** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Clean out sediment, oil and grease, and floatables, using catch basin cleaning equipment (vacuum pumps). Manual removal of pollutants may be necessary.** | **As Needed** |

### Additional Maintenance Considerations and Requirements

- Additional maintenance requirements for a proprietary system should be obtained from the manufacturer and included in the Operations and Maintenance Plan for the site.
- Use a licensed commercial subcontractor, who has special equipment and abilities to perform periodic cleanout on oil-grit separators.
- Cleanout may require the implementation of confined-space procedures and equipment as required by OSHA regulations, such as non-sparking electrical equipment, oxygen meter, flammable gas meter, etc.
- Proper disposal of oil, solids and floatables removed from the gravity separator must be ensured. Floating oil, grease and petroleum substances removed using special vacuum hoses; should be treated as hazardous waste. Sediments may also contain heavy metals or other toxic substances and should be handled as hazardous waste.
- Removal of sediment depends upon accumulation rate, available storage, watershed size, nearby construction, industrial or commercial activities upstream, etc. The sediment composition should be identified by testing prior to disposal. Some sediment may contain contaminants that require special disposal procedures. Generally, give special attention or sampling to sediments accumulated in industrial or manufacturing facilities, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants are suspected to accumulate.
- There is usually uncertainty about what types of oil or petroleum products may be encountered. A significant percentage of petroleum products is attached to fine suspended solids, and therefore, are not easily removed by settling.

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The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:
**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Gravity (Oil/Water) Separator Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the trench area.** | | |
| 1. Have there been/are there signs that the gravity separator is clogged? **Yes = Satisfactory** | | |
| 2. Has debris (trash) accumulated in the gravity separator? **Yes = Unsatisfactory** | | |
| 3. Has oil accumulated in the gravity separator? **Yes = Unsatisfactory** | | |
| 4. Has sediment accumulated in the gravity separator? **Yes = Unsatisfactory** | | |
| 5. Are there signs of, or has there been, standing water upstream of the gravity separator? **Yes = Unsatisfactory** | | |
| 6. Are there signs of erosion (soil washing away) downstream of the gravity separator? **Yes = Unsatisfactory** | | |
| 7. Other (describe)? | | |

# Wichita/Sedgwick County
# Gravity (Oil/Water) Separator Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Other (describe)? | | |
| 9. Other (describe)? | | |
| 10. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 11. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 12. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):_____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Alum Treatment Systems

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for alum treatment systems. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

**Note: Inspections and maintenance of the alum treatment system must be performed by a trained system operator.**

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Dosing equipment – monitor dosage of alum and other chemicals. Also monitor the expected flows through the system.**<br>• **Perform routine inspection of dosing equipment and pump-out facility to ensure that all equipment is in proper operating condition.**<br>• **Inspect dosing equipment and storage facility for signs of leaks or spills.**<br>• **Inspect chemical amounts and restock if needed.**<br>• **Monitor pH and other parameters in the settling pond to determine potential negative impacts to receiving waters.**<br>• **Inspect settling pond for signs of damage, impending failure, and poor water quality.**<br>• **Inspect storage capacity of settling pond and floc drying beds (if used).** | **Monthly or more frequently** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Adjust the dosage of alum and other chemicals and possibly regulate flows through the basin to ensure proper dosage and delivery of runoff to the settling pond.**<br>• **Perform maintenance and repair of pump equipment, chemical supplies and delivery system.**<br>• **Dredge settling pond and properly dispose of accumulated floc.** | **As Needed** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:
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**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Alum Treatment System Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

**Note: Inspections and maintenance of the alum treatment system must be performed by a trained system operator.**

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the dispensing system.** | | |
| 1. Is the alum treatment system dispensing the proper dose? **Yes = Satisfactory** | | |
| 2. Are there signs of leaks or spills? **Yes = Unsatisfactory** | | |
| 3. Does the system appear to be working in proper operating condition? **Yes = Satisfactory** | | |
| **Inspect the chemical storage facility.** | | |
| 4. Are there signs of leaks or spills in the chemical storage facility? **Yes = Unsatisfactory** | | |
| 5. Is there proper delivery of chemicals to dosing system? **Yes = Satisfactory** | | |
| 6. Does the facility appear to be working in proper operating condition? **Yes = Satisfactory** | | |

# Wichita/Sedgwick County
# Alum Treatment System Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| **Inspect the settling pond.** | | |
| 7. Note the pH and water quality parameters in the “Comments” section. | | |
| 8. Are there signs that soil is eroding (washing away) on/from the embankment? **Yes = Unsatisfactory** | | |
| 9. Are there signs of animal burrows in embankment? **Yes = Unsatisfactory** | | |
| 10. Are there signs of cracking, sliding and/or bulging of the berm/dam? **Yes = Unsatisfactory** | | |
| 11. Are the drains (if any) blocked or malfunctioning? **Yes = Unsatisfactory** | | |
| 12. Are there signs of leaks or seeps on the embankment? **Yes = Unsatisfactory** | | |
| 13. Are there any obstructions of the emergency spillway(s)? **Yes = Unsatisfactory** | | |
| 14. Are there signs of erosion (washing away of soil) in or around the emergency spillway? **Yes = Unsatisfactory** | | |
| 15. Are there signs of sediment/floc accumulation? **Yes = Unsatisfactory** | | |
| 16. Does the concrete/masonry appear to be in good condition? **Yes = Satisfactory** | | |
| 17. Do the pipes appear to be in good condition? **Yes = Satisfactory** | | |
| 18. Is the control valve operating properly? **Yes = Satisfactory** | | |
| 19. Is the pond drain valve operating properly? **Yes = Satisfactory** | | |

# Wichita/Sedgwick County
# Alum Treatment System Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 20. Are there signs of erosion (washing away of soil) in the outlet channels? **Yes = Unsatisfactory** | | |
| 21. Other (describe)? | | |
| 22. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 13. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 14. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

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Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Organic Filters

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for organic filters. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **A record should be kept of the dewatering time (i.e., the time required to drain the filter bed completely after a storm event) for an organic filter to determine if maintenance is necessary. The filter bed should drain completely in about 40 hours after the end of the rainfall.**<br>• **Check to ensure that the filter surface does not clog after storm events.** | **After Rain Events** |
| • **Check the contributing drainage area, facility, inlets and outlets for debris.**<br>• **Check to ensure that the filter surface is not clogging.** | **Monthly** |
| • **Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full of sediment or the sediment accumulation is not more than 6 inches, whichever is less sediment. Remove sediment as necessary.**<br>• **Make sure that there is no evidence of deterioration, spalling, bulging, or cracking of concrete.**<br>• **Inspect inlets, outlets and overflow spillway to ensure good condition and no evidence of erosion.**<br>• **Check to see if stormwater flow is bypassing the facility.**<br>• **Ensure that no noticeable odors are detected outside the facility.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Mow and stabilize (prevent erosion, vegetate denuded areas) the area draining to the organic filter. Collect and remove grass clippings. Remove trash and debris.**<br>• **Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system.** | **Monthly** |
| • **Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full of sediment or the sediment accumulation is not more than 6 inches, whichever is less sediment. Remove sediment as necessary.**<br>• **Repair or replace any damaged structural parts.**<br>• **Stabilize any eroded areas.** | **Annually** |
| • **If filter bed is clogged or partially clogged, manual manipulation of the surface layer of filter media may be required. Remove the top few inches of filter media, roto-till or otherwise cultivate the surface, and replace with media meeting the design specifications.**<br>• **Replace any filter fabric that has become clogged.** | **As needed** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Organic Filter Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the organic filter.** | | |
| 1. Does organic filter appear to drain completely in about 36 to 48 hours after a rain event? **Yes = Satisfactory** | | |
| 2. Does the filter surface appear to be clogged? **Yes = Unsatisfactory** | | |
| 3. Do the inlet/outlet areas or structures appear to be clogged? **Yes = Unsatisfactory** | | |
| 4. Does the filter fabric appear to be clogged? **Yes = Unsatisfactory** | | |
| 5. Is the filter area clear of debris and does it appear to be functional? **Yes = Satisfactory** | | |
| 6. Are there signs of any leaks or seeps in the filter? **Yes = Unsatisfactory** | | |
| 7. Are there any obstructions of the filter spillway(s)? **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Organic Filter Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 8. Are there signs of animal burrows in the filter? **Yes = Unsatisfactory** | | |
| 9. Is there sediment accumulation in the filter bed? **Satisfactory = sediment accumulation in less than 50% of bed area** | | |
| 10. Are there signs of cracking, spalling and/or bulging of the concrete? **Yes = Unsatisfactory** | | |
| 11. Are there signs of erosion (washing away of soil) in the area that is draining to the filter? **Yes = Unsatisfactory** | | |
| 12. Are there signs of erosion around inlets/outlets or in the filter? **Yes = Unsatisfactory** | | |
| 13. Do the pipes and other structures appear to be in good condition? **Yes = Satisfactory** | | |
| 14. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 15. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 16. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 17. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Conventional Dry Detention Ponds

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning to treat and control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for conventional dry detention ponds. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • After several storm events or an extreme storm event, inspect for: bank stability; signs of erosion; and damage to, or clogging of, the outlet structures and pilot channels. | As Needed |
| • Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability. | Semi-annually |
| • Inspect that the outlet structures, pipes, and downstream and pilot channels are free of debris and are operational.<br>• Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors.<br>• Check for sediment accumulation in the facility.<br>• Check for proper operation of control gates, valves or other mechanical devices. | Annually |
| **Maintenance Activities** | **Suggested Schedule** |
| • Clean and remove debris from inlet and outlet structures.<br>• Mow side slopes (embankment) and maintenance access. Periodic mowing is only required along maintenance rights-of-way and the embankment. | Monthly or as needed |
| • Repair and revegetate eroded areas.<br>• Remove vegetation that may hinder the operation of the pond.<br>• Repair damage to pond, outlet structures, embankments, control gates, valves, or other mechanical devices; repair undercut or eroded areas. | As Needed |
| • Monitor sediment accumulations, and remove sediment when the pond volume has become reduced 20% or more. | As Needed<br>(typically every 20 to 50 years) |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Conventional Dry Detention Pond Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the embankment (the dam/berm that holds water in the pond after a rain event) and the emergency spillway (the location where water exits the facility in the event that t the embankment is overtopped.** | | |
| 1. Does the vegetation appear to be healthy and adequately covering the embankment to prevent erosion? **Yes = Satisfactory** | | |
| 2. Are there signs that soil is eroding (washing away) on/from the embankment? **Yes = Unsatisfactory** | | |
| 3. Are there signs of animal burrows in embankment? **Yes = Unsatisfactory** | | |
| 4. Are there signs of cracking, sliding and/or bulging of the berm/dam? **Yes = Unsatisfactory** | | |
| 5. Are the drains (if any) blocked or malfunctioning? **Yes = Unsatisfactory** | | |
| 6. Are there signs of leaks or seeps on the embankment? **Yes = Unsatisfactory** | | |

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Are there any obstructions of the emergency spillway(s)? **Yes = Unsatisfactory** | | |
| 8. Are there signs of erosion (washing away of soil) in or around the emergency spillway? **Yes = Unsatisfactory** | | |
| 9. Other (describe)? | | |
| **Inspect the inlet and outlet structures and channels – these are the locations/structures where water enters and exits the pond.** | | |
| 10. Are the inlets and outlets and channels clear of debris and functional? **Yes = Satisfactory** | | |
| 11. Are trash racks clear of debris and functional? **Yes = Satisfactory** | | |
| 12. Has sediment accumulated at any of the inlet and outlet structures? **Yes = Unsatisfactory** | | |
| 13. Does the concrete/masonry appear to be in good condition? **Yes = Satisfactory** | | |
| 14. Do the pipes appear to be in good condition? **Yes = Satisfactory** | | |
| 15. Is the slide gate (if any) operating properly? **Yes = Satisfactory** | | |
| 16. Is the pond drain valve operating properly? **Yes = Satisfactory** | | |
| 17. Are there signs of erosion (washing away of soil) in the outlet channels? **Yes = Unsatisfactory** | | |
| 18. Other (describe)? | | |
| **Inspect bottom of the dry pond.** | | |
| 19. Is the vegetation healthy and covering the entire bottom? **Yes = Satisfactory** | | |

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 20. Is there growth of undesirable vegetation or overgrowth of vegetation? **Yes = Unsatisfactory** | | |
| 21. Is there excessive sediment accumulation? **Yes = Unsatisfactory** | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 22. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 23. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Porous Pavement Areas

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for porous pavement areas. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Ensure that the porous pavement surface is free of sediment and debris (e.g., mulch, leaves, trash, etc.).**<br>• **Ensure that the contributing area upstream of the porous pavement surface is free of sediment and debris.** | **As needed** |
| • **Check to make sure that the porous pavement dewaters between storms.** | **Monthly** |
| • **Inspect the surface for structural integrity. Inspect for evidence of deterioration or spalling.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Ensure that contributing area and porous pavement surface are clear of debris (e.g., mulch, leaves, trash, etc.).**<br>• **Ensure that the contributing and adjacent area is stabilized and mowed, with clippings removed.** | **As needed, based on inspection** |
| • **Vacuum sweep porous pavement surface to keep free of sediment.** | **Typically three to four times a year** |
| • **Replace the porous pavement, including the top and base course, as needed.** | **Upon failure** |

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:

**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Porous Pavement Area Inspection Checklist

Project Name: ________________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ________________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ________________________________

Property Address: ________________________________

Owner Phone #: ______________ Owner Email Address: ________________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ________________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ________________________________

________________________________________________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the porous pavement area.** | | |
| 1. Are there signs that the pavement area is clogged (e.g., standing water)? **Yes = Unsatisfactory** | | |
| 2. Is there debris (mulch, trash) accumulation? **Yes = Unsatisfactory** | | |
| 3. Is there sediment accumulation? **Yes = Unsatisfactory** | | |
| 4. Is there standing water? **Yes = Unsatisfactory** | | |
| 5. Are there signs of erosion (washing away of soil) from underdrain? **Yes = Unsatisfactory** | | |
| 6. Is there exposed soil in the areas that drain to, or the areas adjacent to, the porous pavement area? **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Porous Pavement Area Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Does stormwater runoff discharge from pavement area within 24 to 48 hours after the end of a storm event? **Yes = Satisfactory** | | |
| 8. Other (describe)? | | |
| 9. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 10. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 11. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):____________________________________________

# Wichita/Sedgwick County
# Stormwater Facility Inspection & Maintenance Guidance
# Modular Porous Paver Areas

Regular inspection and maintenance is critical to the effective operation of this stormwater management facility so that it can function as designed. In the City of Wichita and Sedgwick County, local regulations (City of Wichita Code Chapter 16.32 and Sedgwick County Resolution 196.10) require that property owners maintain all stormwater facilities on their properties to ensure they are fully functioning control stormwater runoff, and to document facility inspections and maintenance activities. This documentation must be kept by the property owner and must be made available to Stormwater Management staff upon their request.

This page provides guidance on inspection and maintenance activities that must be performed for modular porous pavement areas. Some facilities may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes in the land (e.g., development, landscaping, etc.) that drains to the facility.

| Inspection Activities | Suggested Schedule |
|---|---|
| • **Determine if the porous paver surface is free of sediment and debris (e.g., mulch, leaves, trash, etc.).**<br>• **Determine if standing water exists for long periods of time after a storm event.** | **As needed** |
| • **Check that stormwater is not stored in the paver system longer than 48 hours after a storm.**<br>• **Inspect vegetated areas that drain to the paver system and the paver system itself for evidence of erosion.** | **Monthly** |
| • **Inspect the surface of the paver system for structural integrity, deterioration, compaction, or spalling.** | **Annually** |
| **Maintenance Activities** | **Suggested Schedule** |
| • **Ensure that contributing area and porous paver surface are clear of debris (e.g., mulch, leaves, trash, etc.).**<br>• **Stabilize (i.e., cover exposed soil) vegetated areas that discharge, or are adjacent to, the porous paver system. Grassy areas should be fully vegetated and mowed, with grass clippings removed. Landscaped areas should be designed and/or maintained such that they will not discharge debris (e.g., mulch, leaves) to the paver system, or that such debris is removed often.** | **As needed** |
| • **Vacuum sweep porous paver surface to keep free of sediment.** | **Quarterly** |
| • **Repair or reinstall the porous paver system, including the top and base course.** | **As needed** |

### Additional Maintenance Considerations and Requirements

- Additional maintenance requirements for a porous paver system should be obtained from the manufacturer of the system and included in the Operations and Maintenance Plan for the site.

The inspection checklist that is presented on the next page is provided to guide and document inspection and maintenance activities. Please use this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the stormwater management facility.

For more information on the maintenance of your stormwater facility, please contact:
**City of Wichita Stormwater Management, 455 N. Main 8th floor Wichita KS. 67202, (316) 268-4498**
**or Sedgwick County Stormwater Management, 1144 S. Seneca Wichita KS. 67213, (316) 383-7901**

# Wichita/Sedgwick County
# Modular Porous Paver Area Inspection Checklist

Project Name: ______________________________ Project #: ______________

BMP Name/ID (as shown on the O&M Plan): ______________________________

Refer to the Operations & Maintenance Plan for this property to get the information requested in this box. The Operations and Maintenance Plan for this property is recorded with the Sedgwick County Register of Deeds.

Property Owner Name: ______________________________

Property Address: ______________________________

Owner Phone #: ______________ Owner Email Address: ______________________________

Owner Change since last inspection? Y ☐ N ☐

Inspection Date/Time: ______________________________

Weather and Site Conditions (last rainfall date, dry/wet soil, etc.): ______________________________

______________________________

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| ***Note - Condition should be marked as Satisfactory (S) or Unsatisfactory (U). An explanation of corrective actions must be provided for all items marked as Unsatisfactory. The completion date of any corrective actions taken must also be documented.** | | |
| **Inspect the porous pavement area.** | | |
| 1. Are there signs that the paver area is clogged (e.g., standing water)? **Yes = Unsatisfactory** | | |
| 2. Is there debris (mulch, trash) accumulation? **Yes = Unsatisfactory** | | |
| 3. Is there sediment accumulation? **Yes = Unsatisfactory** | | |
| 4. Is there standing water? **Yes = Unsatisfactory** | | |
| 5. Are there signs of erosion (washing away of soil) from underdrain? **Yes = Unsatisfactory** | | |
| 6. Is there exposed soil in the areas that drain to, or the areas adjacent to, the porous pavement area? **Yes = Unsatisfactory** | | |

# Wichita/Sedgwick County
# Modular Porous Paver Area Inspection Checklist

| Inspection Items | Condition* | Comments/Corrective Action |
|---|---|---|
| 7. Does stormwater runoff discharge from pavement area within 24 to 48 hours after the end of a storm event? **Yes = Satisfactory** | | |
| 8. Other (describe)? | | |
| 9. Other (describe)? | | |
| **Identify any potential hazards to humans or the environment.** | | |
| 10. Have there been complaints from residents? **Yes = Unsatisfactory** | | |
| 11. Are there any other public hazards that should be noted? **Yes = Unsatisfactory** | | |

By signing my name below, I certify that the information submitted in this document (and all attachments) is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are penalties for knowingly submitting false information, including the possibility of regulatory violations and associated fines.

Inspected by (Name):_______________________________________________

Inspected by (Signature):_____________________________________________

# City of Wichita Sewer Permit Application

All provisions of laws and ordinances governing this type of work shall be followed.
The granting of a permit does not give authority to violate the provisions of any other federal, state, or local law regulating the performance of construction.

**If applying for a Sanitary Sewer Permit complete page one only.**
**If applying for a storm sewer permit please complete pages one and two of this application.**

**Please Type or Print**

☐ **Sanitary Sewer Permit** ☐ **Storm Sewer Permit**

**Project Information & Location**

Location Address: ______________________________ Legal Description: ______________________________

Project Name: ______________________________ General Cont. Permit Number: ______________________

Sewer Contractor: ______________________________ License Number: ______________________________

Business Address: ______________________________ Phone Number: ______________________________

☐ **New Construction:** (Check appropriate box(s) below)

☐ Residential ☐ Commercial ☐ Main Bldg. ☐ Accessory Bldg. ☐ Modular/Mfg. Bldg./Mobile Home
☐ Off Septic ☐ Mud & Oil Trap Incl. ☐ Other: ______________________________

☐ **Repair/Replacement:** (Check appropriate box(s) below)

☐ Full Replacement (Bldg. to City main): ☐ Open Cut ☐ Pipe Burst ☐ Install Cleanout Only
☐ Partial Replacement: Location: ____________________ ☐ Repair: Location: ____________________
☐ Mud & Oil Trap Incl. ☐ Other: (Explanation) ______________________________

☐ **Reconnection: (Seal off permit required for original location)** (Check appropriate box(s) below)

☐ Reroute & replace existing line with new tap to City main ☐ Other: ______________________________

☐ **Seal Off:** (Check appropriate box(s) below)

☐ Building to be wrecked ☐ Building to be moved ☐ Main Bldg. ☐ Accessory Bldg.
☐ Other: ____________________

☐ **Grease Interceptor:** (indicate Size) Number of Gallons: __________ Number of Tanks: __________

☐ Connect building to service line ☐ Separate by City main

A separate permit number and fee is required if submitting an application for more than one of the above mentioned categories. The fee schedule for sewer permits is as follows:

Permit Fee: $30.00 Reinspection Fee: $25.00 Investigation Fee: $100.00

Authorized Person's Signature: ______________________________ Date: ______________________________

Printed Name: ______________________________________________

# City of Wichita Sewer Permit Application

## OWNER/OPERATOR STORMWATER QUALITY COMPLIANCE STATEMENT

The undersigned, being the owner of a facility that has applied to the City of Wichita or Sedgwick County, Kansas, for a storm sewer tap/discharge/ stormwater permit, hereby acknowledges the requirements of Section 16.32 of the Wichita City Code, and/or Sedgwick County resolution #196-10, which states that only stormwater can be discharged into the municipal storm sewer system, with the following exceptions:

1. A discharge authorized by, and in full compliance with, a federal or state NPDES permit.
2. A discharge from emergency fire fighting.
3. A discharge from water line flushing.
4. A discharge from lawn watering, landscape irrigation, or other irrigation water.
5. A discharge or flow from a diverted stream flow or natural spring.
6. A discharge or flow from uncontaminated ground water or rising groundwater.
7. Uncontaminated groundwater infiltration.
8. Uncontaminated flow from a foundation drain, crawl space pump, footing drain, or sump pump (no discharge onto street per City Code 10.04.060 City only).
9. A discharge from a potable water source not containing any harmful substance or material from the cleaning or draining of a storage tank or other container.
10. A flow from air conditioning condensation that is unmixed with water from a cooling tower, emissions scrubber, emissions filter, or any other source of pollutant.
11. Flows from individual residential car washing.
12. A flow from a riparich habitat, wetland, or natural spring.
13. Storm water runoff from a roof that is not contaminated by any runoff from an emissions scrubber or filter or any other source of pollutant.
14. Residential heat pump discharges.
15. Swimming pool water, excluding filter backwash, that has been de-chlorinated so it contains no harmful quantity of chlorine, muriatic acid or other chemical used in the treatment or disinfection of the swimming pool water or in pool cleaning.
16. Contaminated groundwater if authorized by KDHE and approved the County. (County Only)
17. Street wash water.(excluding street sweepings which have been removed from the street) (County Only)
18. Discharges specified in writing by the Director as necessary to protect public health and safety. (County only)

I further understand that allowing any other discharge will subject me to the penalties provided in said City Section 16.32, and or Sedgwick County Stormwater Management Resolution #196-10, as well as other federal and state penalties.

Owner or Operator Signature: ______________________ Date: ______________________

Name typed or printed: ______________________ Title: ______________________

# Wichita/Sedgwick County
# Stormwater Design Certification Form

This form must be submitted with all construction plans.

**Submit completed form with Stormwater Permit Application**
**to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202**
**or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

## STORMWATER DESIGN CERTIFICATION STATEMENT

I, ______________________________ of ______________________________ , a Professional Engineer registered in the State of Kansas, hereby certify that this Stormwater Permit Application, the associated Construction Plan and all associated hydrologic and hydraulic analyses for ______________________________________ was prepared by me (or under my direct supervision).

I further certify that the plans and analyses were prepared in accordance with the provisions of the stormwater management regulation (Regulation) of the appropriate governing locality (i.e., the City of Wichita Stormwater Management Ordinance 16.32 or the Sedgwick County Stormwater Management Resolution 196-10), and the policies and guidelines presented in the Wichita/Sedgwick County Stormwater Manual (Manual).

I further certify that all stormwater management components of the Development, including stormwater management facilities, water quality volume reduction areas, stormwater system components and erosion prevention and sediment control best management practices are designed to comply with the provisions of the Regulation and the Manual.

I understand that the City of Wichita, Kansas and/or Sedgwick County, Kansas does not, and will not, assume liability for drainage facilities designed by others unless such facilities are formally accepted for public ownership by the City or County.

Professional Engineer Seal/Signature

Consulting Engineering Firm

# City of Wichita/Sedgwick County
# As-Built Plan Checklist

Submit completed forms to:
City of Wichita Public Works & Utilities, 455 N. Main 8th Floor, Wichita KS 67202; or
Sedgwick County Stormwater Management, 1144 S. Seneca, Wichita KS 67213.

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | | | | | |
| **Total Area of Project:** | | **acres** | | | |
| **Development Type:** | | | **Other:** | | |
| **Developer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |
| **Engineer Name:** | | **Contact:** | | **Phone:** | |
| **Email:** | | | | | |

*Directions:*

*(1) Fill-out this checklist completely and include it with the As-built Plan submittal. This checklist should be included in the bound copy, behind the cover sheet for the submittal. Incomplete plans and checklists will not be accepted.*

*(2) Indicate whether a plan element is included or not included in the submittal by choosing "**Yes**" or "**No**" from the dropdown list in the **"Element Included?"** column. The question must be answered for every plan element for this checklist to be considered complete. An explanation must be provided for all **"No"** answers.*

**As-built Plan Checklist**

| # | Plan Element Description | Element Included? | Explanation/Notes |
|---|---|---|---|
| **1.0** | **General Information** | | |
| 1.1 | Digital copy of as-built plan, showing changes from approved designs as redlined items. Include all sheets and submitted as a single PDF file. | | |
| 1.2 | Digital copy of as-built digital terrain model in Civil3D CAD format (for projects involving mass grading only). | | |
| 1.3 | Digital copy of video inspection of storm sewer conduits (private construction only) in MPG format. | | |
| 1.4 | Northing, easting, elevation, description, date and survey quality for all items surveyed, in comma delimited (CSV) file that can be transferred into ESRI GIS inventory. | | |
| 1.5 | All points surveyed in State Plane Kansas South (feet) NAD 83 for horizontal control and NAVD 88 for vertical control using the most current geoid. | | |
| 1.6 | Digital copy of Operations and Maintenance Plan with proof that O&M plan that has been recorded with the Sedgwick County Registrar of Deeds, PDF format. | | |
| 1.7 | Hard copy of all plan sheets in 11"x17" (half-scale) size. | | |
| 1.8 | Copy of all white cards from City of Wichita Public Works & Utilities Engineering staff. | | |
| 1.9 | Title block with address of project, phase or addition name, original date of issue and date of revisions made, name/address of site design engineer/company. Note: Engineer of record must be same as original design plans. | | |
| 1.10 | Date of completion of construction. | | |
| 1.11 | Copy of Notice of Termination filed with KDHE. | | |
| 1.12 | Copy of engineering certifications submitted to KDA-DWR. | | |
| 1.13 | Copy of closeout form submitted to USACE. | | |
| 1.14 | Name and address of land surveyor/company. Name of person performing as-built inspection. | | |
| 1.15 | Name and address of site contractor. | | |
| 1.16 | Professional Engineer's seal, signature and date. | | |
| 1.17 | Notation that construction is complete. | | |
| 1.18 | Surveyor's certification: *"I certify that all stormwater features shown herein were located in accordance with the current Standards of Practice as adopted by the Kansas Society of Land Surveyors. I certify the location, elevation and description of these features."* Provide printed name, date and RLS number below certification statement. | | |
| 1.19 | Certificate of Completion submitted as a separate sheet, with the seal and signature of the Professional Engineer of record and the date: *"I, __(name of engineer)__ of __(engineering firm or company)__, being a licensed engineer in the State of Kansas, do hereby certify that the above described improvements have been completed in substantial conformance with the approved plans and specifications, and do hereby recommend acceptance of same by Wichita, Sedgwick County, Kansas, for use by the public for the purposes for which they were intended*." | | |
| **2.0** | **Stormwater Management Facilities As-built Info** | | |

| As-built Plan Checklist | | | |
|---|---|---|---|
| # | Plan Element Description | Element Included? | Explanation/Notes |
| 2.1 | Type (using proper name in accordance with the Stormwater Manual) and location of all stormwater management facilities, with boundary lines for the facilities and all easement/reserve boundaries as applicable. | | |
| 2.2 | Type, material, dimensions, surface area, storage volume, slope, invert elevation, rim elevation and other appropriate elevations/information for all stormwater system control structures and stormwater management facilities. | | |
| 2.3 | *Items 2.3.1 to 2.3.12 denote specific survey locations for storm sewer system structures. Indicate whether the surveyed locations for these structures conform to these requirements by answering "Yes" or "No". An explanation must be provided for all "No" answers.* | | |
| 2.3.1 | Note: Were all structures with manhole lids surveyed on the northern most point of the rim? If more than one lid is on the structure, the survey point is on the lid on the left side of the structure, as viewed from the street. | | |
| 2.3.2 | Were all Type 2 inlets surveyed on the left side closest to the curb, as viewed from the street? | | |
| 2.3.4 | Were all drop inlets surveyed on the northernmost point of the outside frame? | | |
| 2.3.5 | Were all headwalls surveyed in the center of the headwall? If there are multiple boxes with the same headwall, a survey point must be taken separately at the center of each box on the headwall. | | |
| 2.3.6 | Were all pipe ends surveyed at the invert (flow line) of the pipe end? | | |
| 2.3.7 | Were all end sections surveyed at the invert (flow line) at the downstream end? | | |
| 2.3.8 | Were all beehive covers with manhole lids surveyed on the northern most point of the rim? If more than one cover is on the structure, the survey point is on the lid on the left side of the rim, as viewed from the street. | | |
| 2.3.9 | Were all 2x5 curb inlets surveyed at the left side top of curb, as viewed from the street? | | |
| 2.3.10 | Were all 2x2 curb inlets surveyed at the left side top of curb, as viewed from the street? | | |
| 2.3.11 | Were all curb flow lines surveyed at the left side of the structure, as viewed from the street? | | |
| 2.3.12 | Have all curb flow lines been surveyed for all structures and labeled differently from structure invert flow lines? | | |
| 2.4 | Identifying label, type and location of all proprietary stormwater quality systems. Must include commercial name of the device, vendor name/address, manufacturer name, make, model and size details. | | |
| 2.5 | Indication that stage-area-discharge/volume data meets or exceeds the approved design for all ponds and detention/retention facilities. | | |
| 2.6 | Identifying label, type and location of all water quality volume reduction areas, with boundary lines for areas and all easement/reserve boundaries as applicable. | | |
| 2.7 | Indication that water quality volume reduction areas are protected by signage as required by the local jurisdiction. Show label and location of such signage. | | |
| 2.8 | Scale (horizontal and vertical, as applicable). | | |
| 2.9 | Benchmarks (minimum of 2) used for site control (NAVD 88 vertical datum). | | |
| 2.10 | Legend key. | | |
| **3.0** | **Pervious Area Stabilization** | | |
| 3.1 | Copy of Notice of Termination filed with KDHE. | | |
| 3.2 | Narrative of stabilization techniques and vegetation establishment progress for all pervious areas. Indicate areas of seeding/planting and estimate % stabilized coverage for entire site. | | |
| 3.3 | *Provide answers to questions 3.3.1 through 3.3.6. "Yes" answers indicate that the site is not yet stabilized. For all "Yes" answers provide the relevant location(s), an explanation for the answer and the name/address/contact phone for the party responsible for resolution of the issue.* | | |
| 3.3.1 | Question: Are there any areas of bare soil, where vegetative cover has not been established? If Yes, provide location of unstabilized areas and reason for lack of stabilization. | | |
| 3.3.2 | Question: Are there any unstable slopes on the site? | | |
| 3.3.3 | Question: Are any temporary erosion and sediment controls still on-site? | | |
| 3.3.4 | Question: Are there any sediment deposits at the outfalls from the site? | | |
| 3.3.5 | Question: Are there any signs of sediment discharges on the streets or adjacent properties that can be attributed to the site? | | |
| 3.3.6 | Question: Are all stormwater management facilities and the storm sewer system free of sediment? | | |
| | | | |
| End of Checklist | | | |

# Wichita/Sedgwick County
# Stormwater As-Built Certification Form

A completed copy of this form must be submitted with all as-built plans.

**Submit completed form(s) to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202**
**or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

Project Name: ________________________________________

Project Number/OCA: __________________________________

Contractor: __________________________________________

**ENGINEER'S CERTIFICATION OF COMPLETION**

**To the City Engineer, City of Wichita, Kansas or County Engineer, Sedgwick County, Kansas**

I, ____________________________ of ____________________________ , being a licensed engineer in the State of Kansas, do hereby certify that the above described improvements have been completed in substantial conformance with the approved plans and specifications, and do hereby recommend acceptance of same by the City of Wichita and/or Sedgwick County, Kansas, for use by the public for the purposes for which they were intended.

________________________________ ________________________________
Professional Engineer Seal/Signature Consulting Engineering Firm

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
City of Wichita Public Works & Utilities ♦ Stormwater Management ♦ 455 North Main 8th Floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4498
Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901

# Wichita/Sedgwick County
# Stormwater As-Built Certification form

A completed copy of this form must be submitted with all as-built plans, if necessary.

**Submit completed form(s) to City of Wichita Engineering 455 N. Main 7th floor Wichita Ks. 67202 or to Sedgwick County Stormwater Management 1144 S. Seneca Wichita Ks. 67213**

The Stormwater As-Built Certification Form must be completed when a survey is performed by a company or firm other than the engineering inspection firm.

Project Name: ______________________________

Project Number/OCA: ______________________________

Contractor: ______________________________

## LAND SURVEYOR'S CERTIFICATION STATEMENT

**To the City Engineer, City of Wichita, Kansas or County Engineer, Sedgwick County, Kansas**

I, ______________________ of ______________________ , being a registered licensed surveyor in the State of Kansas, do hereby certify that I have located all stormwater features shown herein were located in accordance with the current Standards of Practice as adopted by the Kansas Society of Land Surveyors. I certify the location, elevation and description of these features.

| | |
|---|---|
| ______________________ | ______________________ |
| Registered Licensed Surveyor Seal/ Signature | Land Survey Firm |

City of Wichita Public Works & Utilities ♦ Engineering ♦ 455 N Main 7th floor ♦ Wichita, Kansas 67202 ♦ (316) 268-4501
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Sedgwick County Public Works ♦ Stormwater Management ♦ 1144 S. Seneca ♦ Wichita, Kansas 67213 ♦ (316) 383-7901