Spring Creek Basin Watershed Study

Sedgwick County, Kansas

Water Resources Solutions

NORTHWATER CONSULTING

CONTINENTAL MAPPING CONSULTANTS, Inc.

Shockey Consulting Services, llc

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January 2014

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Water Resources Solutions

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January 6, 2014

Jim Weber
Sedgwick County, Kansas
Deputy Director of Public Works
1144 S. Seneca
Wichita, Kansas 67213

Subject: Spring Creek Basin Watershed Study

Dear Mr. Weber:

Water Resources Solutions, LLC is please to present the Sedgwick County – Spring Creek Basin Watershed Study to Sedgwick County.

If you have any questions or would like additional information, please do not hesitate to contact me at DBaker@WRS-rc.com or 913-302-1030.

Sincerely,

Water Resources Solutions, LLC

Donald W Baker

Donald W. Baker, P.E., D. WRE, CPESC
Principal and Owner

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January 2014

DONALD W. BAKER
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KANSAS
PROFESSIONAL ENGINEER
1-6-2014

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CONTENTS

FIGURES

TABLES

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EXECUTIVE SUMMARY

Introduction

The Sedgwick County Stormwater Management Advisory Board recommended that a watershed management study be completed for the Spring Creek Basin located between Derby and Wichita, Kansas. The Sedgwick County Stormwater Management Advisory Board retained the consultant team of Water Resources Solutions, LLC (WRS), in association with Northwater Consulting (NWC), Shockey Consulting Services (SCS), and Continental Mapping Company (CMC) to develop the Spring Creek Basin Watershed Study.

Study Purpose

The Spring Creek Basin Watershed Study is the first study of its kind in Sedgwick County and will serve as a benchmark for completing future plans and assessments. The purpose of the Spring Creek Basin Watershed Study is to characterize the condition of the watershed by assessing the water quantity and quality issues, analyzing alternative solutions and recommending solutions to any issues discovered. The watershed study follows EPA's Handbook for Developing Watershed Plans to Restore and Protect Our Waters and includes the Nine Minimum Elements of Watershed Plans. These nine elements include:

- Identification of cause of impairment and pollutant sources
- An estimate of load reductions from management measures
- Description of the nonpoint source management measures
- An estimate of the amount of technical and financial assistance
- An information and education component
- Schedule for implementing the nonpoint source management measures
- Description of interim measurable milestones
- Set of criteria to be used to determine if loading reductions are being achieved
- Monitoring component to evaluate the effectiveness of the implemented measures

The purpose of the watershed study also includes public participation and education components to help identify and understand the water quality issues within the local communities. More information on the public participation and education can be found in Section 4.0 Public Involvement of this report.

This report includes an existing conditions assessment, proposed mitigation measures, and project cost estimates for flood risk management, stream stability, and water quality management within the Spring Creek watershed.

Watershed Description

A tributary of the Lower Arkansas River, Spring Creek is approximately 16 miles long and located entirely within Sedgwick County, Kansas. The Spring Creek watershed is 20,467 acres and is located southeast of Wichita and McConnell Air Force base. The City of Derby, with a population of 22,943, is located within the watershed, along with a small portion of Wichita and a large amount of unincorporated Sedgwick County. Figure ES-1 Spring Creek Basin Watershed Map shows the location of the Spring Creek watershed.

The Spring Creek watershed is comprised of both urban and rural areas. Agricultural land, grasslands, farm homes and sparsely populated residential areas make up the northern portion of the watershed. Agricultural areas include pasture for livestock and crop production such as wheat, corn and cotton. In the downstream reaches, the City of Derby makes up a more densely populated urban area. Derby is growing with development occurring primarily to the north and to the east. Residential development and large home sites north of Derby are slowly replacing existing grasslands and agricultural areas. Further discussion on the Spring Creek watershed including hydrology, landuse, impervious surfaces, soils, geology, land slope, and 100-yr floodplain are found in the Section 2.0 Watershed Description of this report.

Public Participation and Education

The Spring Creek Basin Watershed Study incorporated extensive Public Involvement efforts. Public Involvement activities included three open houses, a project website, a survey and questionnaire, and news releases to local newspapers and through City of Derby utility mailings.

The objectives for communication and public involvement for the Spring Creek Watershed Study include:

- *Inform* stakeholders by providing balanced and objective information to assist them in understanding the problems, alternatives, opportunities, and solutions.
- *Consult* stakeholders by obtaining feedback on analysis, alternatives and/or decisions.
- *Involve* stakeholders by working directly with them throughout the process to ensure that concerns and aspirations are consistently understood and considered, ensuring all stakeholder groups are included and consulted.
- *Develop* an informed group of stakeholders.
- *Enlist* stakeholders in evaluating alternatives.
- *Build* partnerships with other agencies and stakeholders, recognizing the effect this effort has on the region.

Three public meetings were held during the study to foster communication with residents, property owners, government officials, and other interested parties. Public meeting notices were published in the local newspaper, posted on the City of Derby and Sedgwick County websites, and sent to stakeholders via email. All public meetings followed an open house format so attendees could attend at a time most convenient to them.

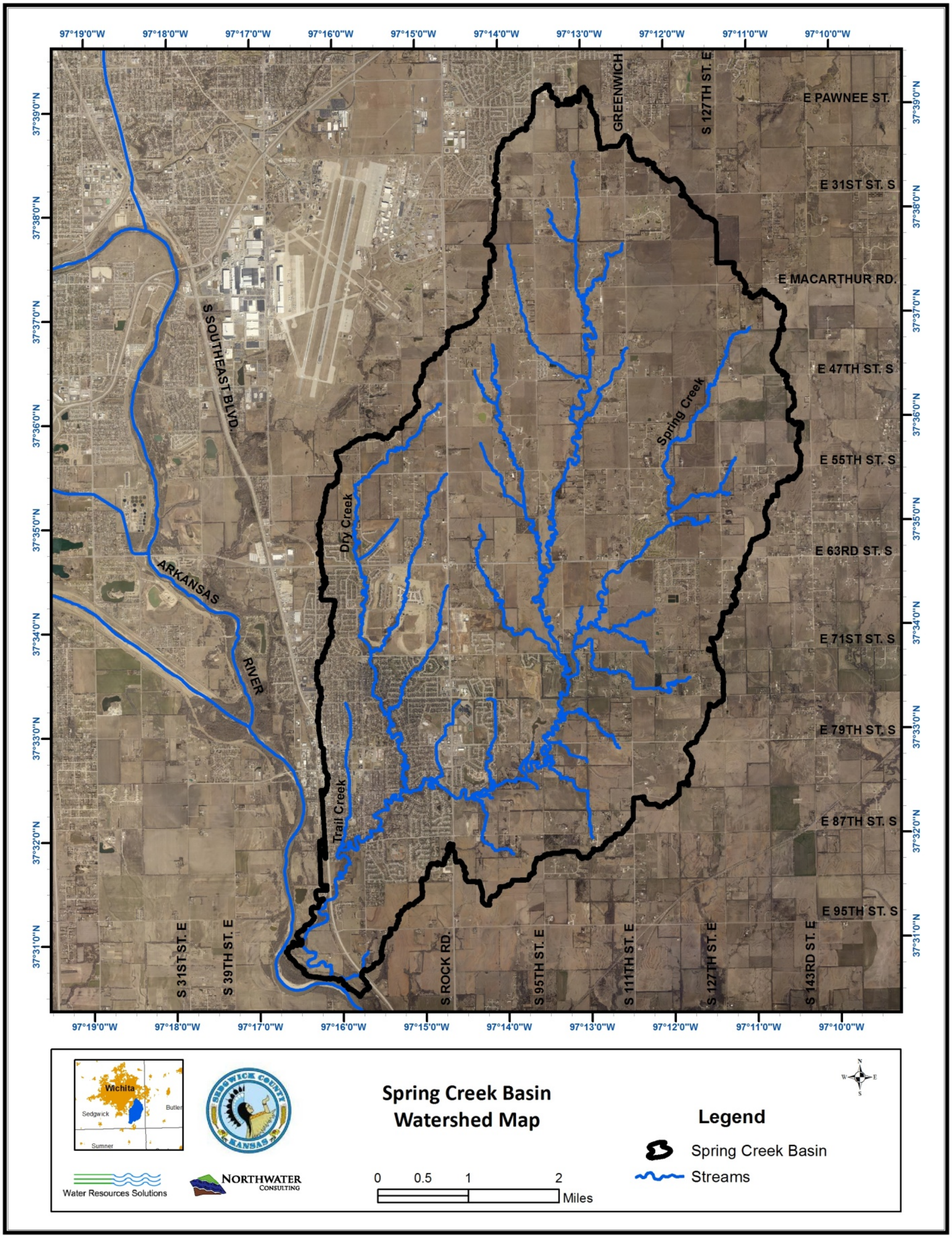

Figure ES-1: Spring Creek Basin Watershed Map

Stakeholder outreach included a survey about stormwater runoff, flooding, erosion, and water quality issues in the community. A 31-question survey was made available through the Sedgwick County website and was publicized through print media, the County's email list, the City of Derby, and the Stormwater Management Board. The survey was available during the month of May 2013.

A project website was developed to provide and disseminate information about the watershed study to interested stakeholders. The website can be accessed through the Sedgwick County Public Works website at www.sedgwickcounty.org/public_works. The project website was updated three times over the course of the project to reflect the project progress and to provide updates to stakeholders.

Flood Risk Management, Creek Management, and Water Quality Management

The Flood Risk Management, Creek Management, and Water Quality Management components of this watershed study resulted in identifying problems areas and concerns within the watershed. Results from the existing conditions analysis, concept level mitigation measures and cost estimates were developed to address the problems and concerns.

Flood Risk Management and Mitigation Measures

Flood risk management can be characterized as the plan and methods used to reduce flooding and protect lives and property. Flood risk management for Spring Creek focuses on the 14 subbasins identified during the hydrologic and hydraulic analysis as having the existing 100-yr floodplain boundary encroaching on homes or buildings. Reducing flooding within the watershed will involve reducing the runoff volume within these subbasins. Further discussion on the hydrologic and hydraulic analysis can be found in Section 5.1 Hydrology/Hydraulics and Section 6.1 Flood Risk Management of this report.

Reducing runoff volume in the 14 subbasins can be accomplished by increasing detention volume. Stormwater runoff can be detained at multiple locations, including existing ponds, parking lots, and parks. Figure ES-2 shows the locations of existing ponds, parking lots, and parks identified as potential storage locations.

There are 29 existing stormwater ponds within the watershed that could potentially be used for stormwater storage and reducing runoff. A majority of the ponds are located in rural areas of the watershed and the outskirts of Derby. The existing outfall structures of these ponds would need to be retrofitted to increase the storage. Additional grading or dredging may also be required.

There are 45 parking lots identified within watershed that can provide opportunities to store stormwater runoff. These parking lots are located within the City of Derby. Runoff from parking lots can easily be directed to stormwater BMPs such as bioretention cells, rain gardens, and underground vaults. These BMPs allow stormwater to be captured and naturally filtered into the ground.

There are two parks within the basin that can provide opportunities to store stormwater runoff. These parks are located within the City of Derby. Parks provide the undeveloped land needed to install BMPs such as bioretention cells, stormwater detention basins, ponds and stormwater wetlands. Bioretention cells allow stormwater to be captured and naturally filtered, while stormwater detention basins and wetlands allow stormwater to be captured, treated and released at a reduced rate.

There is also an opportunity within the watershed for a large regional detention facility. It located between E. 71st Street S. and E. 63rd Street S. near S. 99th Street E. With approximately 80 acres of area for a lake, approximately 1600 ac/ft of detention storage could be provided. A space like this can not only provide the stormwater runoff storage for the watershed, but also provide the opportunity for public recreation. Aside from the 80 acre lake, other amenities may include a park with multi-use trails, public camping, and fishing. There are educational opportunities with Boy and Girl Scout camping, bird watching, and wetland areas identified throughout the park.

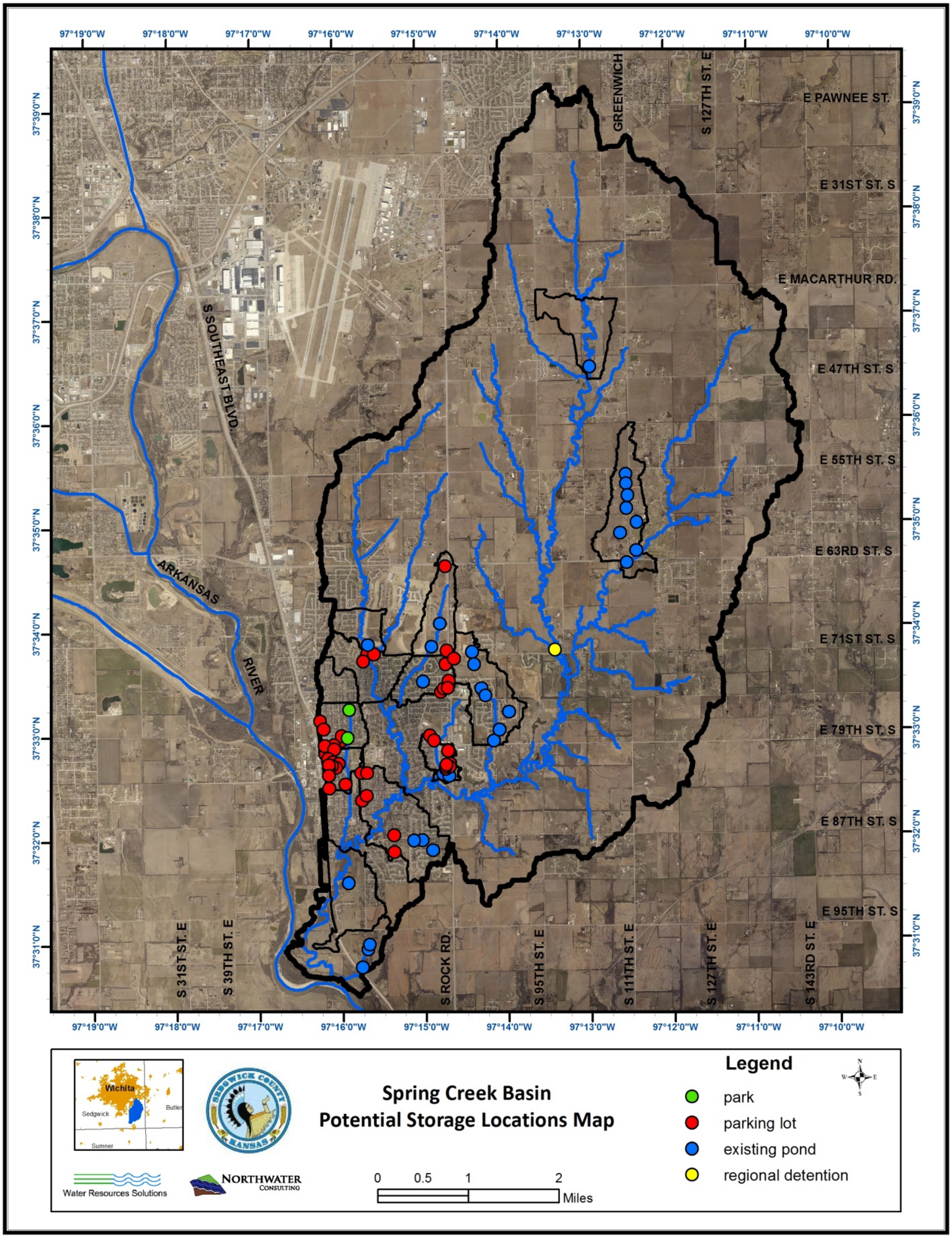

Figure ES-2: Spring Creek Basin Potential Storage Locations Map

Creek Management and Mitigation Measures

Conceptual recommendations, designs and an opinion of probable cost for stream improvement projects were developed. These conceptual recommendations provide stability for both the stream channel and banks throughout the basin for the unstable stream reaches identified during the stream stability analysis.

Much of the Spring Creek basin is experiencing incision or channel down-cutting. This is evident by knickpoints or sharp changes in the channel elevation. To stabilize the streams, it is recommended that engineered rock riffles (ERR) with 1' to 1.5' drops be used. Engineered rock riffles help stabilize streams by halting incision and providing grade control and appropriately spaced pools and riffles.

Incision, bank erosion and steep unstable banks are predominant throughout the watershed. To stabilize stream banks, reshaping and bank armoring at the toe of slope with longitudinal peak stone toe protection (LPSTP) is recommended. The upper banks should be reshaped and revegetated to provide stabilization and a functioning riparian corridor. There are four proposed stream representative sections recommended for the watershed. The stream representative sections are:

- LPSTP with 3:1 side slopes
- LPSTP with 3:1 side slopes and retaining wall at upper left descending bank
- LPSTP with 3:1 side slopes and retaining wall at upper right descending bank
- LPSTP with 3:1 side slopes and retaining walls at upper bank of both banks
- Retaining walls on both banks

Further discussion on the current stream stability and proposed mitigation measures can be found in Section 5.2 Stream Stability and Section 6.2 Creek Management of this report. Figure ES-3 and Figure ES-4 show the proposed stream restoration grade stabilization and bank stabilization mitigation measure locations.

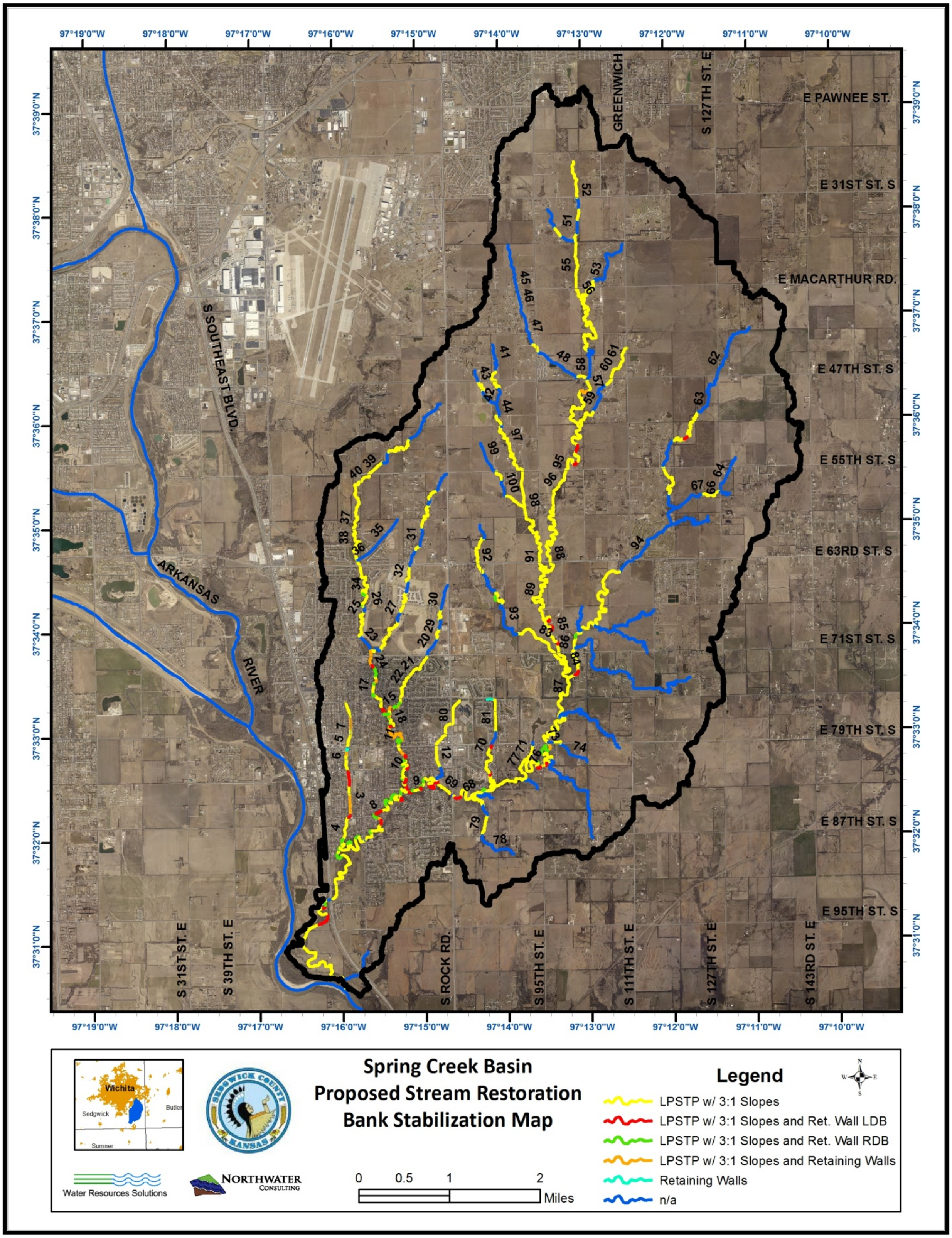

Figure ES-3: Spring Creek Basin Proposed Stream Restoration Bank Stabilization Map

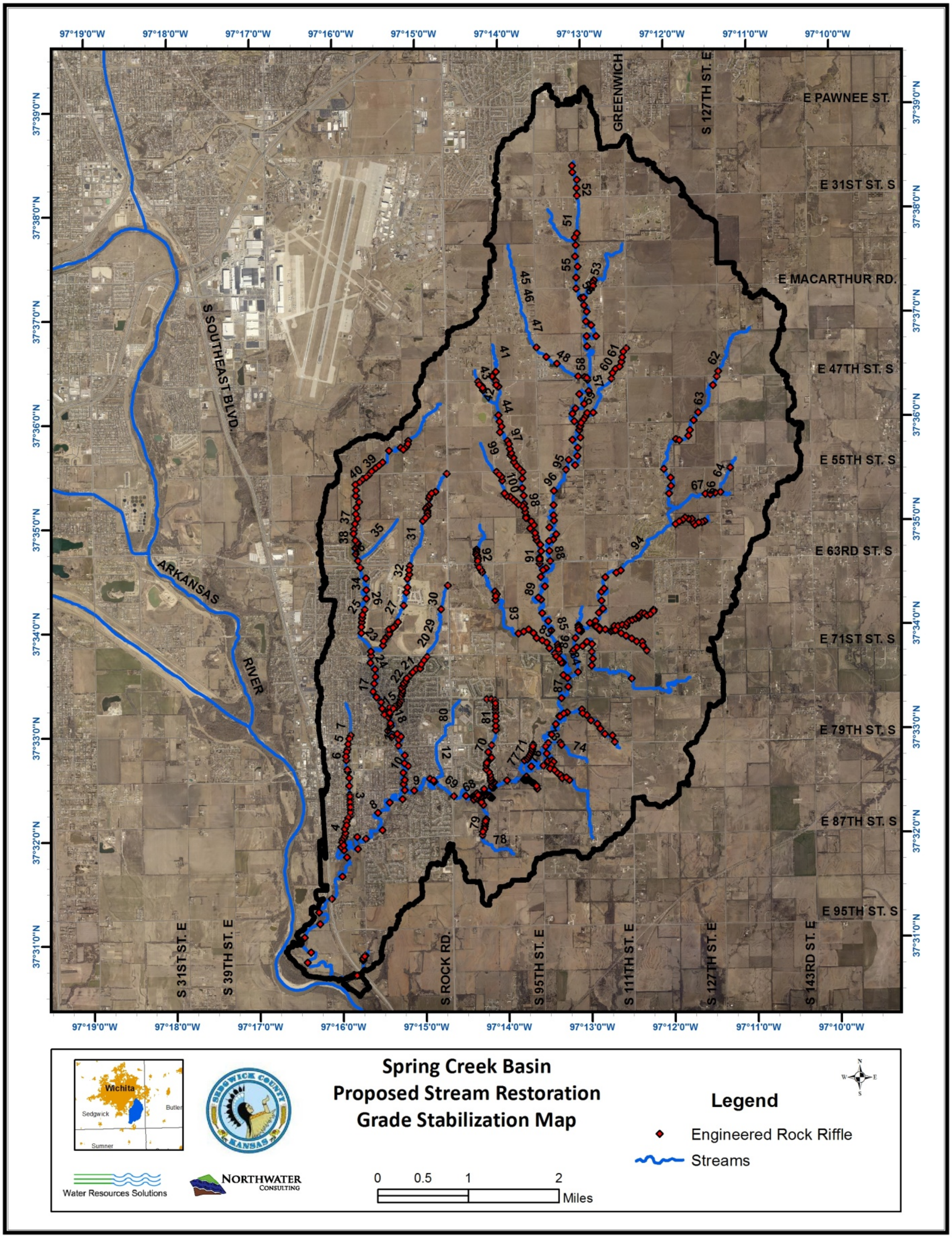

Figure ES-4: Spring Creek Basin Proposed Stream Restoration Grade Stabilization Map

Water Quality Management and Best Management Practices

Like many mixed urban/rural watersheds such as Spring Creek, water pollution can originate from both point and nonpoint sources. The assessment of point source pollution and modeled NPS pollution indicates that NPS pollution is the primary source of water pollution in the watershed. As part of the water quality analysis, critical areas, or areas described as those areas in a watershed that need to be protected or restored, were identified. By focusing BMPs in these areas, pollutants can be reduced at a more efficient rate. Further discussion regarding the water quality management for the Spring Creek watershed can be found in Section 5.3 Water Quality Problem Assessment and Section 6.3 Water Quality Management & Pollution Load Reduction of this report.

Both site specific BMPs as well as those that can be applied basin wide to achieve measurable load reductions in flooding, Nitrogen, Phosphorus, Sediment, bacteria and Chloride are included in this report. Site Specific BMPs are those practices where a field visit has resulted in the identification of a specific project and project location. Figure ES-5 shows the locations of the site specific BMPs. Basin wide BMPs are those practices or procedures that can be applied throughout the watershed where exact project locations may be unknown or where locations may not have been verified through a site visit. Basin wide BMP recommendations cover 5,933 acres or 30% of the watershed.

Agricultural basin wide BMPs include cover crop, conservation tillage, and pasture management. A total of 1,082 acres of cover crops and conservation tillage is recommended; this represents approximately 5% of the greater Spring Creek basin. Pasture management practices are recommended on 838 acres or 4% of the watershed. Figure ES-6 shows the locations of the agricultural basin wide BMPs.

Urban and point source basin wide BMPs include private waste lagoon, rain garden, rain barrel, infiltration trench, porous/permeable pavement, and road salt management. Many standard urban and point source BMPs exist that will reduce runoff and pollution loading from urban areas, roads and septic systems. Basin wide urban and point source BMPs specifically recommended for the Spring Creek watershed include: A total of 97 acres of porous or permeable pavement can be developed on existing parking lots in Spring Creek. A combination of rain barrels and rain gardens can be implemented on 3,019 acres in the watershed and 262 acres of road and parking lots can be targeted for road salt management. Figure ES-7 and Figure ES-8 show the locations of the urban basin wide and point source BMPs.

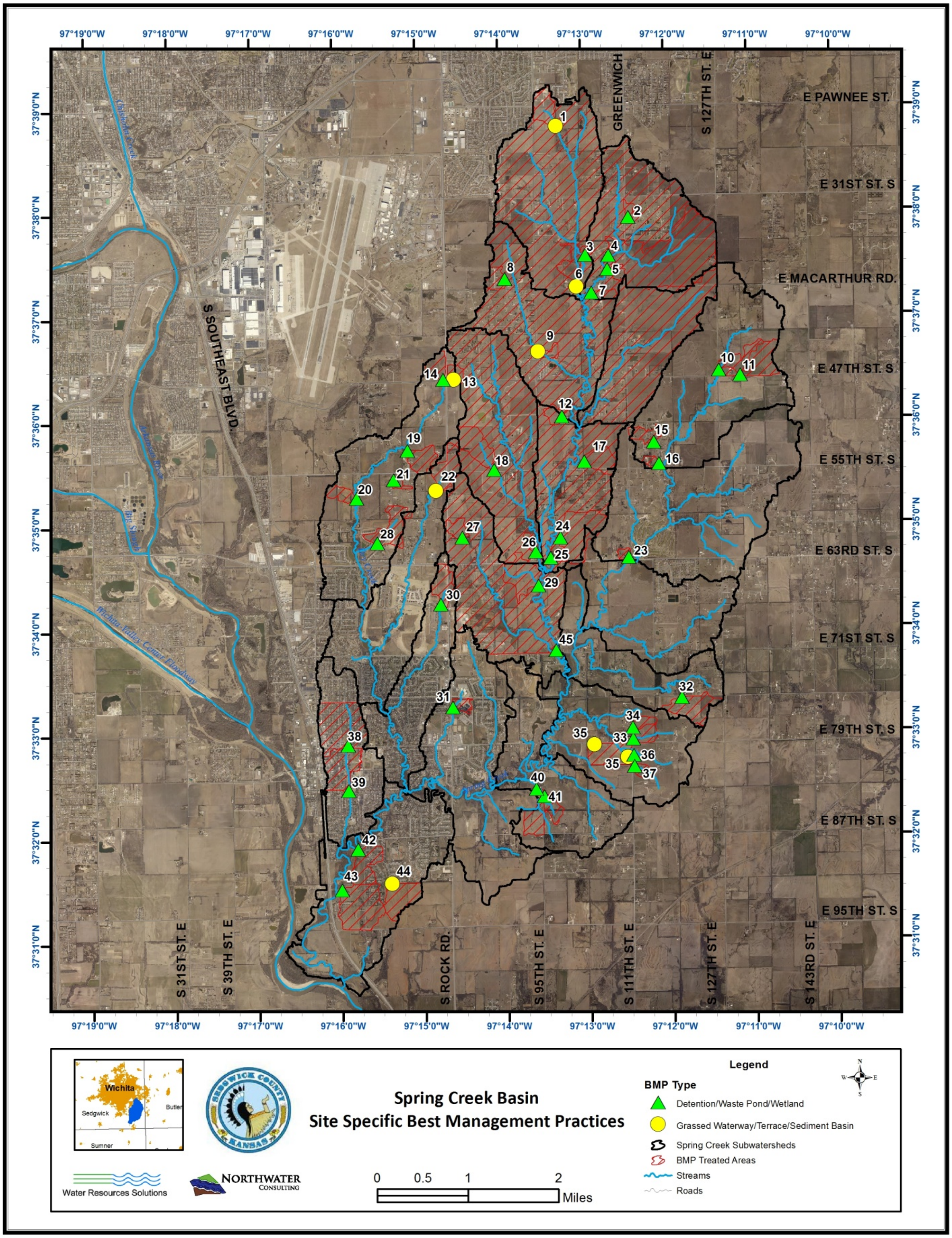

Figure ES-5: Spring Creek Basin Site Specific Best Management Practices

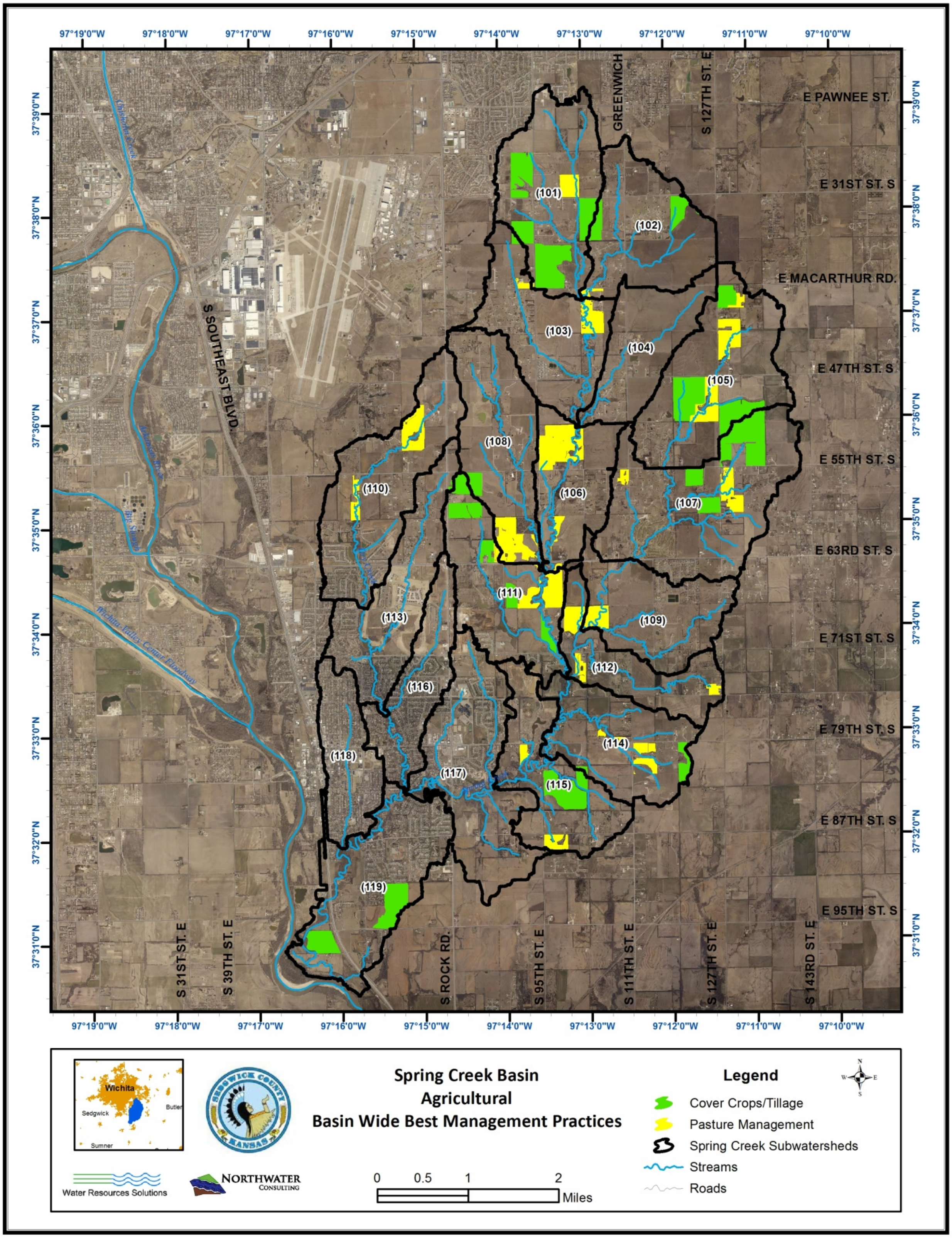

Figure ES-6: Spring Creek Basin Agricultural Basin Wide Best Management Practices

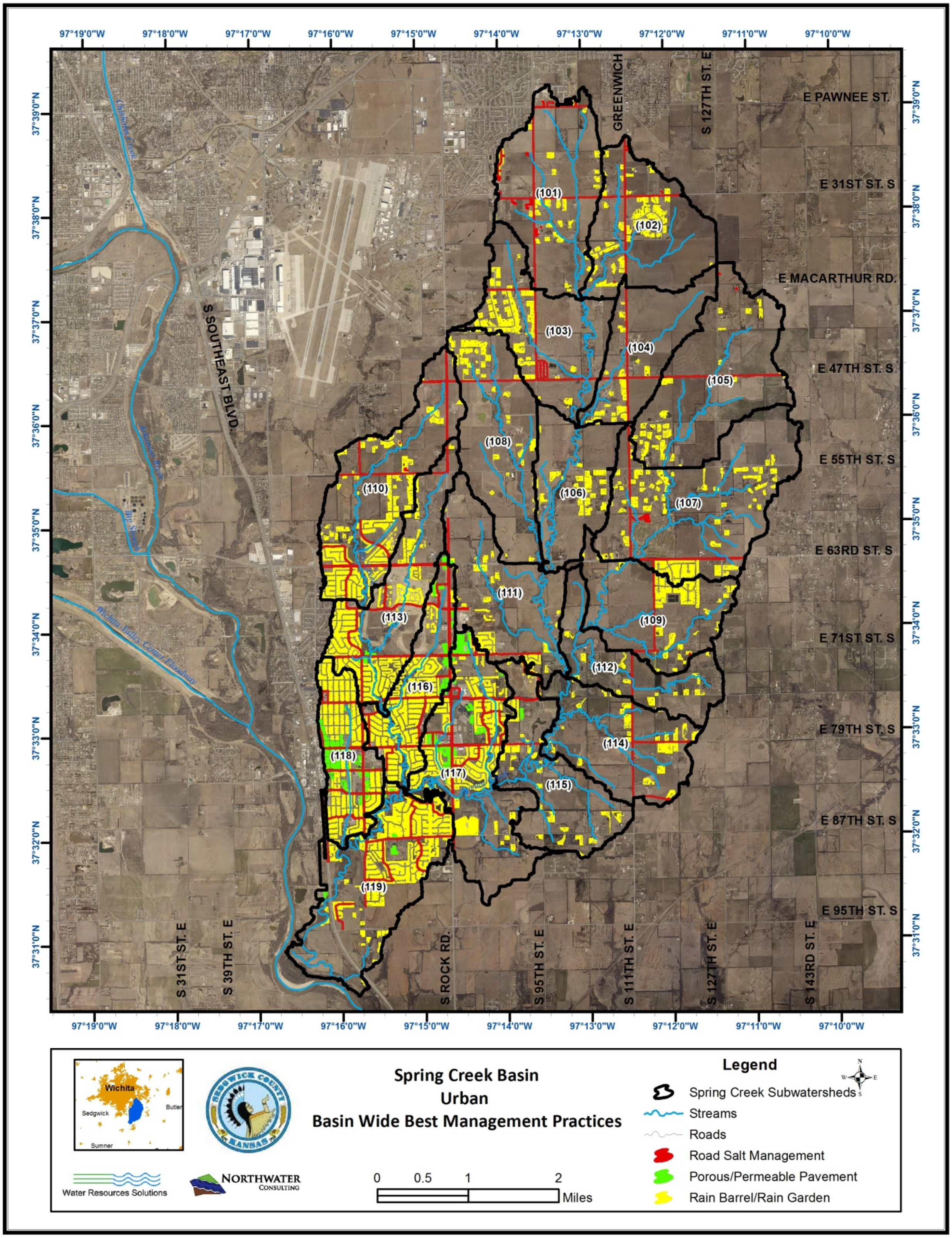

Figure ES-7: Spring Creek Basin Urban Basin Wide Best Management Practices

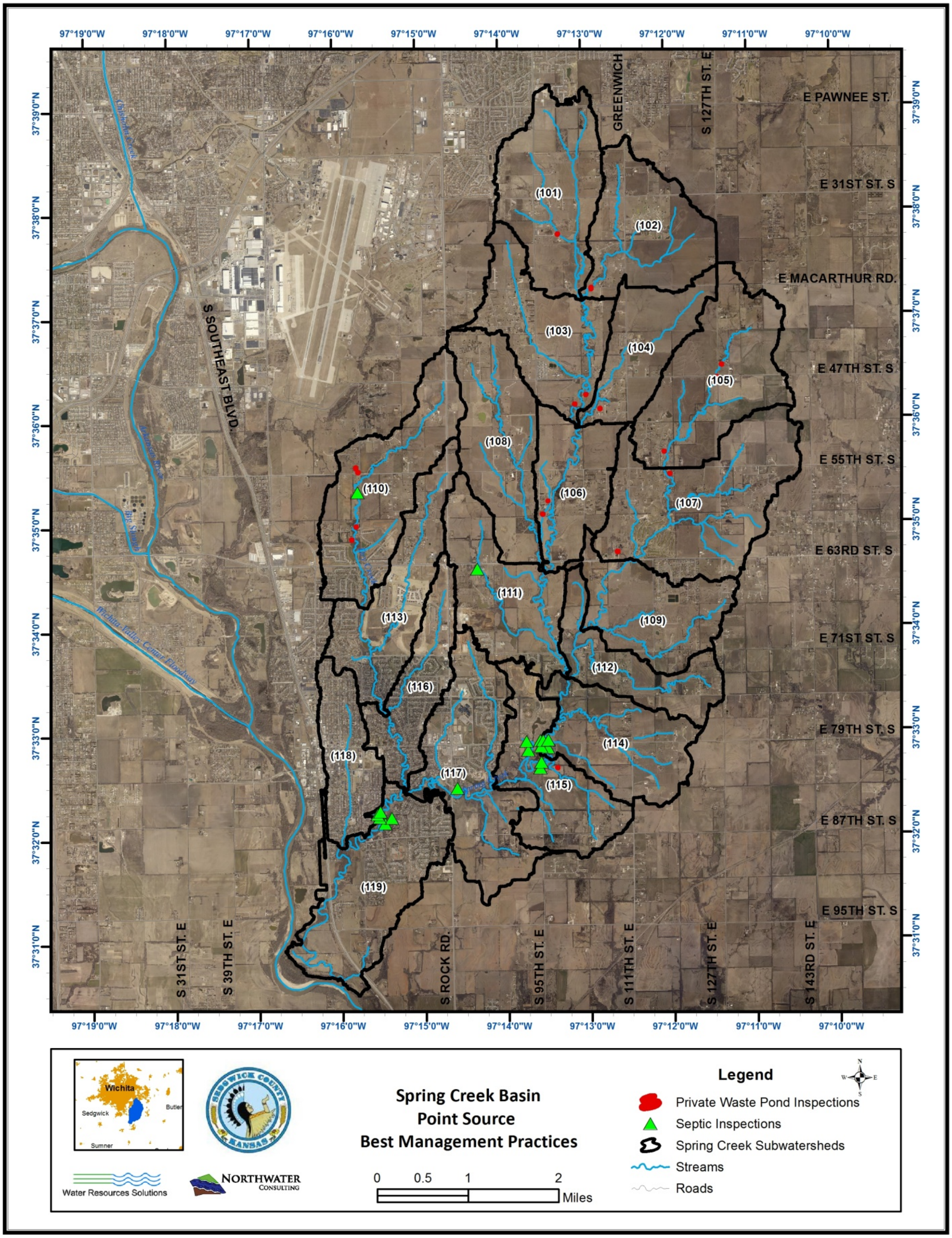

Figure ES-8: Spring Creek Basin Point Source Best Management Practices

Mitigation Measure Cost Estimates & Financing Options

Cost Estimates

Cost estimates were developed for the flood risk management, stream restoration, and water quality mitigation measures identified as part of this watershed study. It should be noted that the cost estimates are concept level, based on 2013 unit costs and are subject to inflation.

Flood risk management cost estimates were developed for each of the 47 potential parking lot and park area stormwater storage locations identified. The costs were based on surface area, potential storage depth, potential storage volume, demolition and mobilization cost, engineering design, surveying, and geotechnical. A 25% contingency was also included in the total project cost to cover undetermined construction items. The complete table showing the total project cost for each of the parking lot and park area flood risk management areas is located in the Appendix C. Cost estimates were not determined for the 29 existing ponds identified within the watershed due to the lack of detailed topographic survey information of these ponds. The total cost of the flood risk management projects totaled $29,962,560. More information regarding the cost estimates for the flood risk management can be found in Section 6.1 Flood Risk Management.

Stream restoration cost estimates were developed for each reach within the Spring Creek watershed. The costs were based on the number of engineered rock riffles, type of stream bank restoration measures, demolition and mobilization cost, engineering design, surveying, and geotechnical. A 25% contingency was also included in the total project cost to cover undetermined construction items. The complete table showing the total project cost for each of the stream reaches is located in the Appendix E. The total cost of the stream restoration projects totaled $155,799,000. More information regarding the stream restoration cost estimates can be found in Section 6.2 Creek Management.

Water Quality BMP estimated costs were determined using local rates, existing literature and professional judgment. Further discussion on the assumptions and methodology for determining the estimated costs for the water quality BMPs can be found in Section 6.3 Water Quality Management & Pollution Load Reductions.

Table ES-1 lists estimated costs for site specific BMPs and Table ES-2 lists estimated costs for basin wide BMPs.

Table ES-1: Cost Estimates, Site Specific Best Management Practices

BMP Code	Estimated Cost	BMP Code	Estimated Cost	BMP Code	Estimated Cost
1	$6,500	17	$22,000	32	$60,000
2	$18,500	18	$46,000	33	$55,000

3	$21,000	19	$45,000	34	$40,000
4	$65,000	20	$25,000	35	$4,000
5	$25,000	21	$20,000	35	$8,000
6	$3,200	22	$9,000	36	$22,000
7	$20,000	23	$38,000	37	$30,000
8	$22,000	24	$28,000	38	$120,000
9	$4,500	25	$45,000	39	$120,000
10	$35,000	26	$19,000	40	$55,000
11	$55,000	27	$26,000	41	$45,000
12	$18,000	28	$70,000	42	$85,000
13	$6,500	29	$55,000	43	$100,000
14	$22,000	30	$80,000	44	$9,000
15	$35,000	31	$75,000	45	XXX
16	$20,000			**Grand Total**	**$1,733,200**

Table ES-2: Cost Estimates, Basin Wide Best Management Practices

BMP Type	Total Cost if all Implemented	Number/acres of BMPs	Maximum Cost	Minimum Cost	Average Cost
Septic Inspections/Identify Remedial Actions	$42,500	17	$2,500	$2,500	$2,500
Private Waste Pond Inspection/Identify Remedial Action	$45,000	18	$2,500	$2,500	$2,500
Agricultural Conservation Tillage and Cover Crops	$75,722	1,082 acres or 23 fields	$8,844	$137	$3,292
Pasture Management and Livestock Practices	$1,026,000	838 acres or 28 fields	$62,000	$16,000	$36,643
Residential Rain Barrels and Rain Gardens/Infiltration Trench	$8,029,275	3,019 acres / greater than 832 individual properties; assumes every acre is treated	$1,753,058	$471	$96,506
Parking Lot Retro-fit; Porous/Permeable Pavement	$53,733,473	97 acres	$6,055,056	$24	$227,684
Road Salt Management	N/A - Could reduce current costs by 30-40%	266	N/A	N/A	N/A
Grand Total	**$62,951,970**				

Financing Options

One of the goals of the Sedgwick County Stormwater Advisory Board is to secure a dedicated funding source for stormwater management. The following list includes some financing options that were investigated as part of this study.

- Stormwater Utility
- Watershed District
- Dedicated Sales Tax
- Property Tax
- Development Fees
- State Funding
- Conservation Easements
- Carbon Banking (Carbon Offsets) or Carbon Credits
- U.S. Department of Agriculture
- U.S. Army Corp of Engineers – Program Assistance
- Federal Emergency Management Agency – Hazard Mitigation Grant Program
- Other Funding Options

Further discussion of the financing options can be found in Section 7.5 Financing Options of this report.

Summary

The Spring Creek Basin Watershed Study provides the necessary planning tools and mitigation measures to address flood management, stream stability, and water quality management needed to improve the condition of the Spring Creek basin watershed. This study can be a referenced by providing guidance for future development and growth in the watershed. Being the first study of its kind in Sedgwick County, it will serve as a benchmark for completing future plans and assessments.

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1.0 INTRODUCTION

The Sedgwick County Stormwater Management Advisory Board recommended that a watershed management study be completed for the Spring Creek Basin located between Derby and Wichita, Kansas. The Sedgwick County Stormwater Management Advisory Board retained the consultant team of Water Resources Solutions, LLC (WRS), in association with Northwater Consulting (NWC), Shockey Consulting Services (SCS), and Continental Mapping Company (CMC) to develop the Spring Creek Basin Watershed Study.

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The purpose of the watershed study also includes public participation and education to help identify and understand the water quality issues within the local communities. More information on the public participation and education can be found in Section 4.0 Public Involvement of this report.

1.2 Steering Committee

A project Steering Committee was chosen by the Stormwater Management Advisory Board to provide guidance to the project. The Steering Committee members include:

- Jim Weber, Sedgwick County
- Daniel Scrant, Sedgwick County
- Clement Dickerson, Commission District 2
- Scott Lindebak, City of Wichita
- Kathy Sexton, City of Derby

- Dan Squires, City of Derby
- Clark Sholts, Commission District 5

2.0 WATERSHED DESCRIPTION

A tributary of the Lower Arkansas River, Spring Creek is approximately 16 miles long and located entirely within Sedgwick County, Kansas. The Spring Creek watershed is 20,467 acres and is located southeast of Wichita and McConnell Air Force base. The City of Derby, with a population of 22,943, is located within the watershed, along with a small portion of Wichita and a large amount of unincorporated Sedgwick County.

The Spring Creek watershed is comprised of both urban and rural areas. Agricultural land, grasslands, farm homes and sparsely populated residential areas make up the northern portion of the watershed. Agricultural areas include pasture for livestock and crop production such as wheat, corn and cotton. In the downstream reaches, the City of Derby makes up a more densely populated urban area. Derby is growing with development occurring primarily to the north and to the east. Residential development and large home sites north of Derby are slowly replacing existing grasslands and agricultural areas.

Figure 1 Spring Creek Basin Location Map shows the location of the Spring Creek Basin watershed. This section discusses the characteristics of the Spring Creek Basin watershed including geography, geology, soils, natural resources, hydrology, land use and demographics.

2.1 Hydrology

Hydrology in the Spring Creek basin is primarily a function of surface runoff; there is little baseflow to streams. Dense clay soils, impervious land and intense precipitation events contribute to high peak flows and flooding throughout the watershed. There are 87 stream miles in the watershed, including Spring Creek and all of its tributaries. Based on data over the last ten years (2002-2012) average annual rainfall for the watershed is 37.8 inches with an average annual number of rain days of 93.

The spring creek basin can be divided up into nineteen (19) distinct sub-basins. These sub-basins are referred to nationally as fourteen-digit hydrologic units (HUC 14). The HUC 14 sub-basins are used throughout this plan to characterize the watershed and simplify planning.

2.2 Landuse

A custom GIS layer was created from existing base maps and aerial imagery. This landuse layer accurately depicts watershed features and landuse at the parcel level. Grassland and agriculture are the dominant landuses in the watershed making up 25% and 24% of the watershed, respectively. Residential areas comprise of 14% of the watershed and pastureland makes up 11%. Table 1 illustrates the landuse breakdown of the watershed. Figure 2 is a map of the data in Table 1.

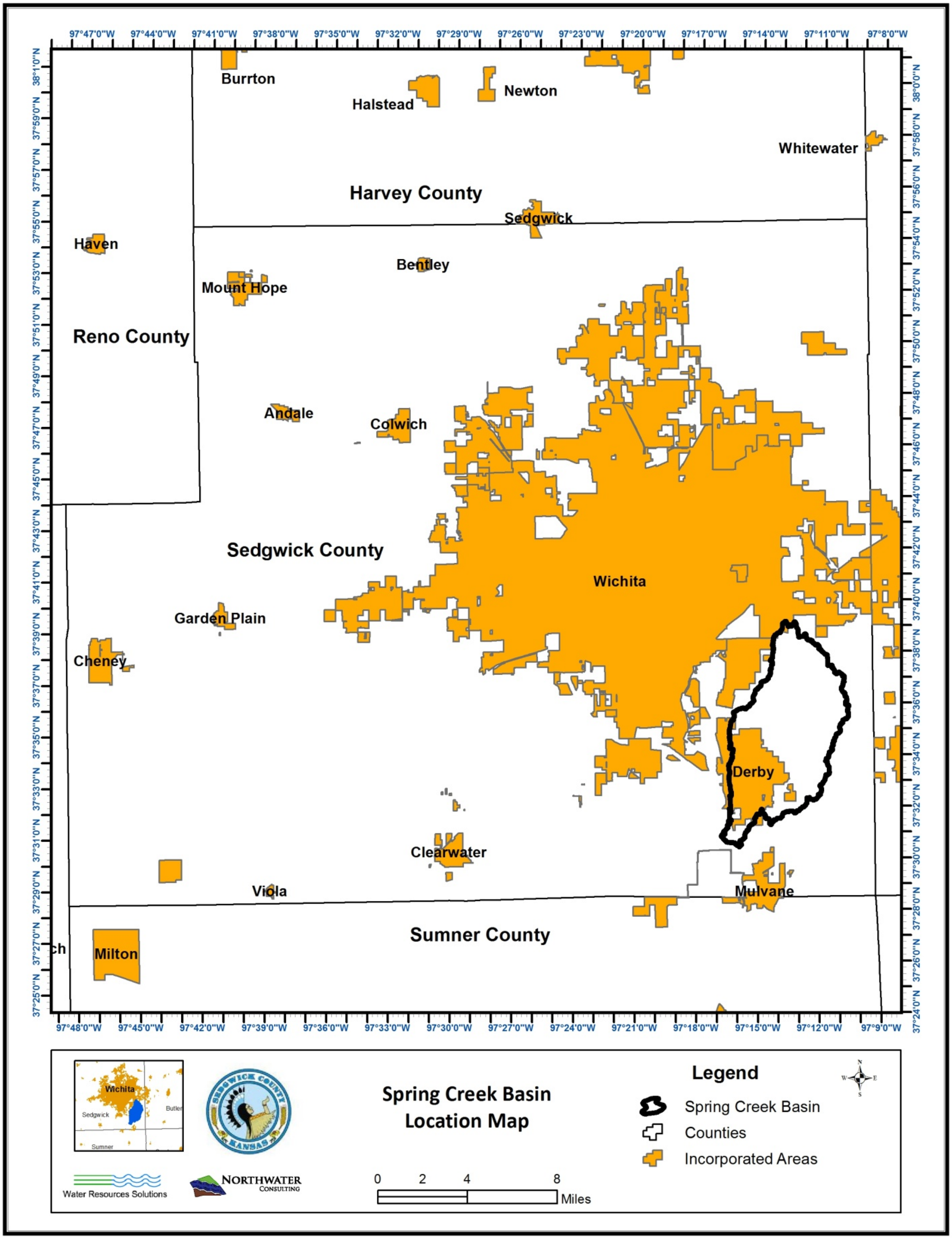

Figure 1: Spring Creek Basin Location Map

Table 1: Landuse Data

Landuse Category	Acres	Percentage of Watershed
Grass	5,215	25.48%
Row Crop	5,004	24.45%
Residential	2,958	14.45%
Pasture	2,287	11.17%
Woodland	896	4.38%
Grass/Woodland/Open Space	779	3.81%
Road	539	2.63%
Open Water - Pond	421	2.06%
Shrubland	344	1.68%
Golf Course	283	1.38%
Driveway	225	1.10%
School/Church	211	1.03%
Residential Farm	205	1.00%
Parking Lot	192	0.94%
Open Space - Park	190	0.93%
Unpaved Driveway	123	0.60%
Commercial	114	0.56%
Farm Building	113	0.55%
Sidewalk	96	0.47%
Unpaved Road	94	0.46%
Residential Multi-Family	60	0.29%
Open Water - Stream	58	0.28%
Unpaved Parking	37	0.18%
Mobile Home Park	16	0.08%
Utility	14	0.07%
Road Median	9	0.05%
Paved Ditch	4.9	0.02%
Bridge	2.4	0.01%

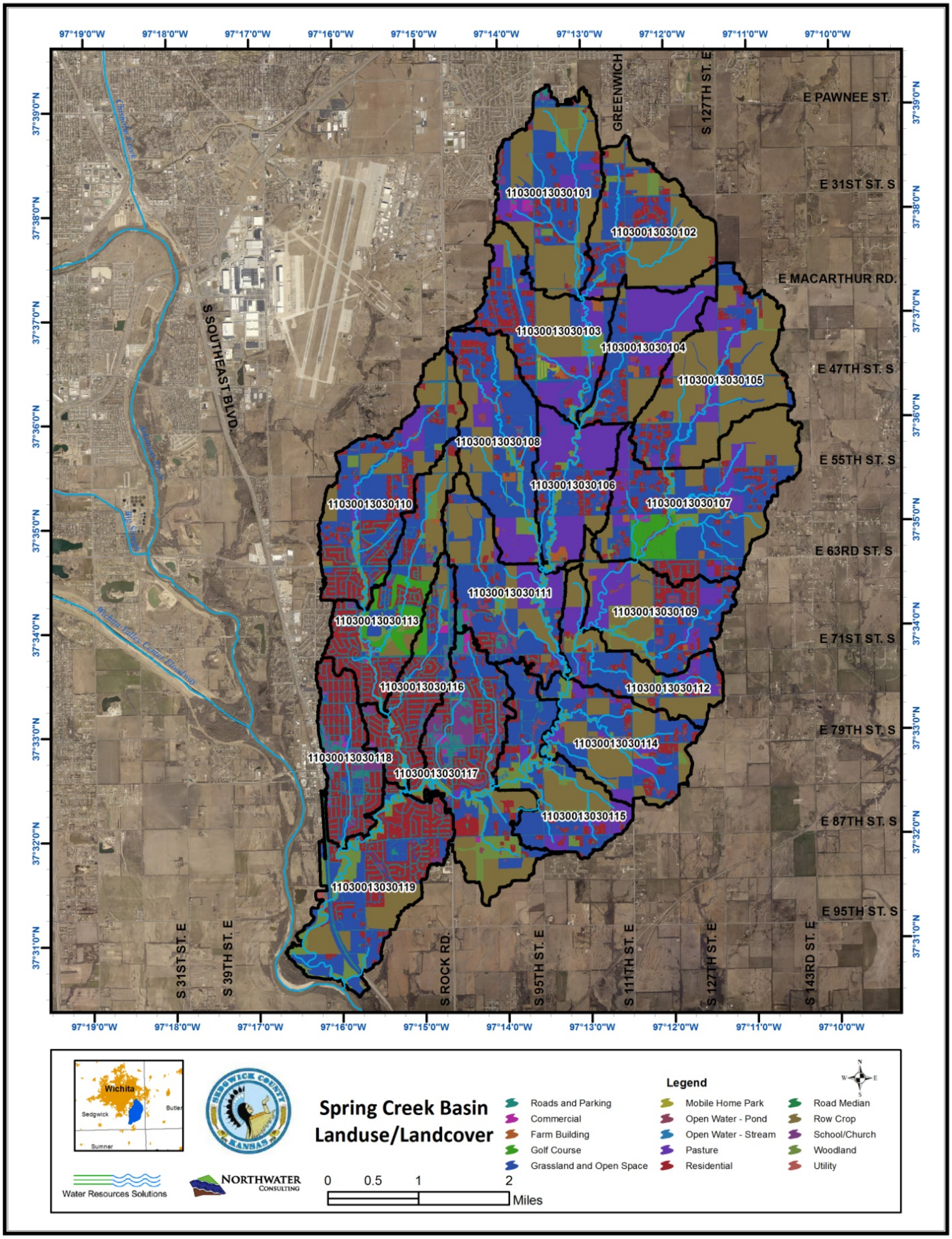

Figure 2: Spring Creek Basin Landuse/Landcover Map

Taking into account pasture and other open space, grassland makes up nearly half of the entire watershed. Much of this grassland can be found in large open areas or within residential developments in the upper watershed. Woodland exists to a much lesser extent in the basin and is located almost entirely along stream corridors.

The 5,004 acres of non-irrigated row crop agriculture in the watershed consists of wheat, corn, cotton, sorghum and other hays. Wheat is the primary crop in the watershed. Approximately 90% of the farms in the watershed practice conventional tillage. Conventional tillage involves disking, plowing and other methods of tilling up crop residue left behind after harvest. To control erosion on crop ground, many of the fields in the watershed employ some type of conservation practice such as field terraces or grassed waterways. Although the full extent of existing agricultural conservation practices is unknown, observations made during a watershed survey indicate that soil conservation is common practice.

Pasture in Spring Creek consists of areas for cattle and horses. Cattle pasture operations range in size from large grazing areas to small feed paddocks. Horse pasture areas are generally small in size and are connected to other farm buildings and small farmsteads.

Residential areas in the watershed include dense single-family homes and multi-family dwellings in the City of Derby and less dense residential developments and farm homes north of Derby and into the upstream areas of Spring Creek and its tributaries.

As noted in Table 1 above, there are 421 acres of open water in the watershed. A high percentage of these open water areas are constructed "farm" ponds or detention areas built to capture runoff from developed areas.

2.3 Impervious Surfaces

There are 1,679 acres of impervious surface in the Spring Creek watershed, primarily within the City of Derby and adjacent areas. Although only 8% of the entire watershed can be classified as impervious, many of the subwatersheds that encompass the City of Derby have greater than 20% impervious surface. Table 2 provides the percent of impervious area for each of the HUC 14 subwatersheds. This data is graphically presented in Figure 3.

2.4 Soils

Soils in the Spring Creek watershed are primarily silty clay loams on 0-3% slopes. The dominant soil type is Irwin Silty Clay Loam, making up 47% of the watershed, or 9,566 acres. The Irwin series consists of deep and very deep, moderately well drained, very slowly permeable soils on uplands formed in clayey sediments. Other major soil associations include Vanoss silt loam (14% or 2,949 acres), Tabler silty clay loam (8% or 1,625 acres), and Rosehill silty clay (7% or 1,498 acres). Table 3 provides an itemized listing of the watershed soil types.

Table 2: Spring Creek Basin Watershed Impervious Surface

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres Impervious	Percent of Subwatershed
11030013030(101)	1,262	35.38	2.80%
11030013030(102)	1,081	19.16	1.77%
11030013030(103)	1,078	31.05	2.88%
11030013030(104)	796	15.99	2.01%
11030013030(105)	1,394	14.08	1.01%
11030013030(106)	794	10.04	1.26%
11030013030(107)	1,701	50.31	2.96%
11030013030(108)	1,143	14.88	1.30%
11030013030(109)	967	28.09	2.90%
11030013030(110)	1,317	132.18	10.04%
11030013030(111)	1,082	64.80	5.99%
11030013030(112)	716	10.29	1.44%
11030013030(113)	1,049	191.23	18.24%
11030013030(114)	1,013	21.42	2.12%
11030013030(115)	965	37.08	3.84%
11030013030(116)	729	227.89	31.26%
11030013030(117)	1,380	291.74	21.15%
11030013030(118)	640	279.79	43.73%
11030013030(119)	1,362	203.44	14.94%
Grand Total	**20,467**	**1,679**	**8.20%**

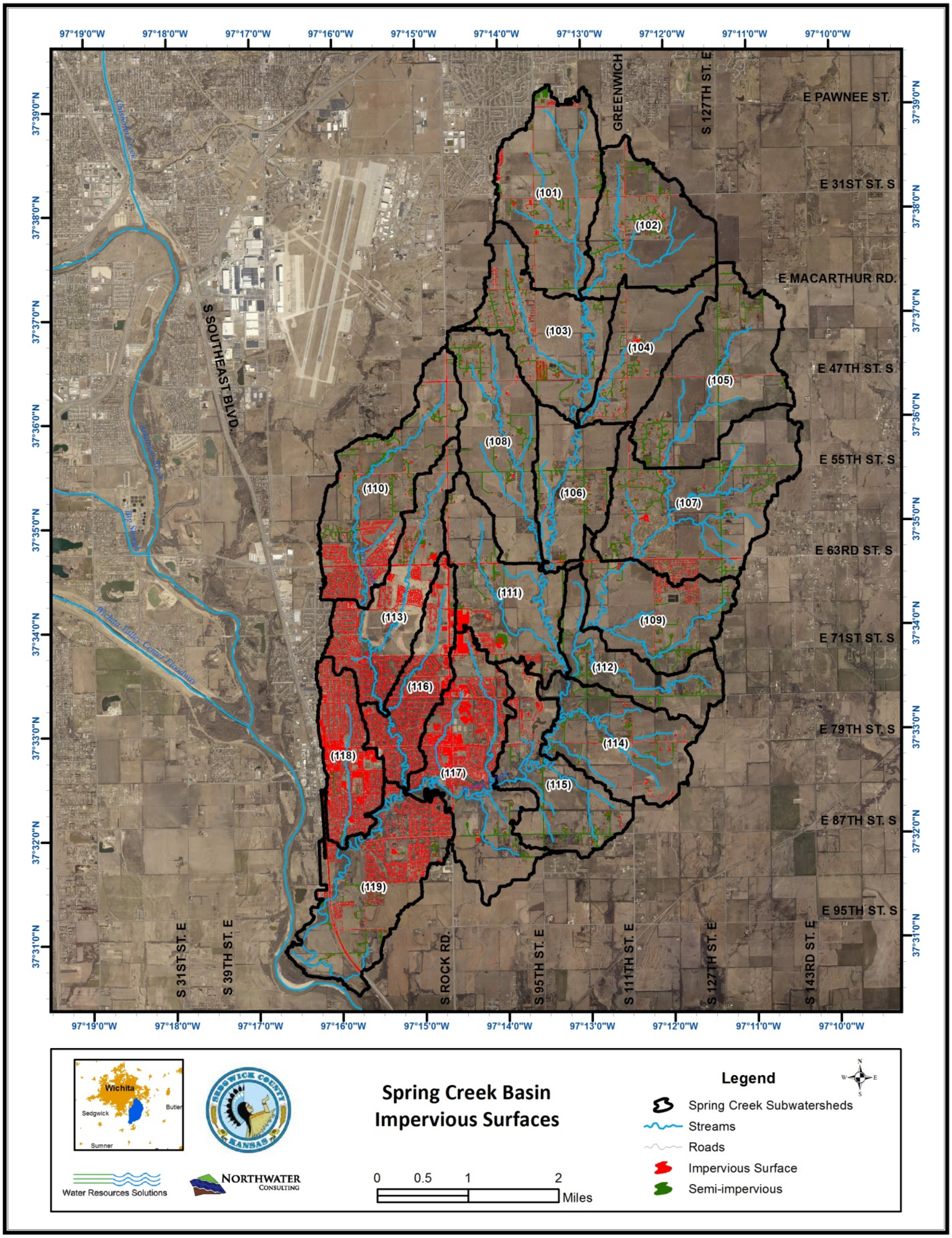

Figure 3: Spring Creek Basin Impervious Surfaces Map

Table 3: Spring Creek Basin Watershed Soils

Soil Name	Acres	% of Watershed
Irwin silty clay loam, 1 to 3 percent slopes	9,566	46.72%
Tabler silty clay loam, 0 to 1 percent slopes	1,625	7.94%
Rosehill silty clay, 1 to 3 percent slopes	1,498	7.31%
Vanoss silt loam, 1 to 3 percent slopes	1,451	7.09%
Vanoss silt loam, 3 to 7 percent slopes	949	4.63%
Elandco silt loam, frequently flooded	802	3.92%
Elandco silt loam, occasionally flooded	749	3.66%
Clime silty clay, 3 to 7 percent slopes	585	2.86%
Irwin silty clay loam, 3 to 7 percent slopes, eroded	545	2.66%
Irwin silty clay loam, 3 to 7 percent slopes	521	2.55%
Elandco silt loam, rarely flooded	499	2.44%
Blanket silt loam, 1 to 3 percent slopes	395	1.93%
Milan loam, 1 to 3 percent slopes	366	1.79%
Blanket silt loam, 0 to 1 percent slopes	191	0.93%
Milan loam, 3 to 6 percent slopes	163	0.80%
Vanoss silt loam, 3 to 7 percent slopes, eroded	125	0.61%
Goessel silty clay, 1 to 3 percent slopes	114	0.56%
Imano clay loam, occasionally flooded	101	0.49%
Water	69	0.34%
Canadian fine sandy loam, rarely flooded	31	0.15%
Farnum loam, 1 to 3 percent slopes	29	0.14%
Milan clay loam, 3 to 6 percent slopes, eroded	24	0.12%
Vanoss silt loam, 0 to 1 percent slopes	18	0.09%
Lincoln soils, frequently flooded	18	0.09%
Saltcreek and Naron fine sandy loams, 0 to 1 percent slopes	13	0.06%
Pits	11	0.05%
Clark-Ost clay loams, 1 to 3 percent slopes	9	0.04%
Pratt-Tivoli loamy fine sands, 5 to 15 percent slopes	6	0.03%
Plevna fine sandy loam, frequently flooded	3	0.01%

2.5 Hydrologic Groups

The Natural Resource Conservation Service (NRCS) has classified all soils into four Hydrologic Soil Groups (HSG) based on the infiltration capacity and runoff potential of the soil. The soil groups are identified as A, B, C, and D. Group A has the greatest infiltration capacity and least runoff potential, while group D has the least infiltration capacity and greatest runoff potential.

Table 4 illustrates the number of acres of each HSG by HUC 14 subwatershed. The upper watershed is primarily group D soils (67% or 13,873 acres), shown in green (Figure 4), which indicates this portion of the watershed, has a lower infiltration capacity and a greater runoff potential. The lower section of the watershed and along stream corridors is generally group B soils (25% or 1,525 acres) shown in brown, with greater infiltration and less susceptible to runoff damage. Hydrologic group B and D soils encompass the majority of the watershed. The only section of group A soils is 24 acres in size and is located at the outlet of Spring Creek and is associated with the sand deposits of the Lower Arkansas River system.

Table 4: Spring Creek Basin Watershed Hydrologic Groups

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres Hydrologic Group A Soils	Acres Hydrologic Group B Soils	Acres Hydrologic Group C Soils	Acres Hydrologic Group D Soils	Hydrologic Group Unclassified Soils
11030013030(101)	1,262	0	67	17	1,165	11
11030013030(102)	1,081	0	3	0	1,078	0
11030013030(103)	1,078	0	86	31	954	0
11030013030(104)	796	0	2	0	795	0
11030013030(105)	1,394	0	59	0	1,336	0
11030013030(106)	794	0	134	0	659	0
11030013030(107)	1,701	0	105	232	1,352	12
11030013030(108)	1,143	0	122	122	891	8
11030013030(109)	967	0	45	174	734	15
11030013030(110)	1,317	0	314	33	965	8
11030013030(111)	1,082	0	183	2	878	19
11030013030(112)	716	0	77	167	472	0
11030013030(113)	1,049	0	396	14	638	0
11030013030(114)	1,013	0	244	106	662	0
11030013030(115)	965	0	401	95	470	0
11030013030(116)	729	0	344	46	339	0
11030013030(117)	1,380	0	853	67	460	0
11030013030(118)	640	0	607	39	0	0
11030013030(119)	1,362	24	1,172	140	26	0
Grand Total	**20,467**	**24**	**5,215**	**1,285**	**13,873**	**72**
% of Watershed		**0.12%**	**25.48%**	**6.28%**	**67.78%**	**0.35%**

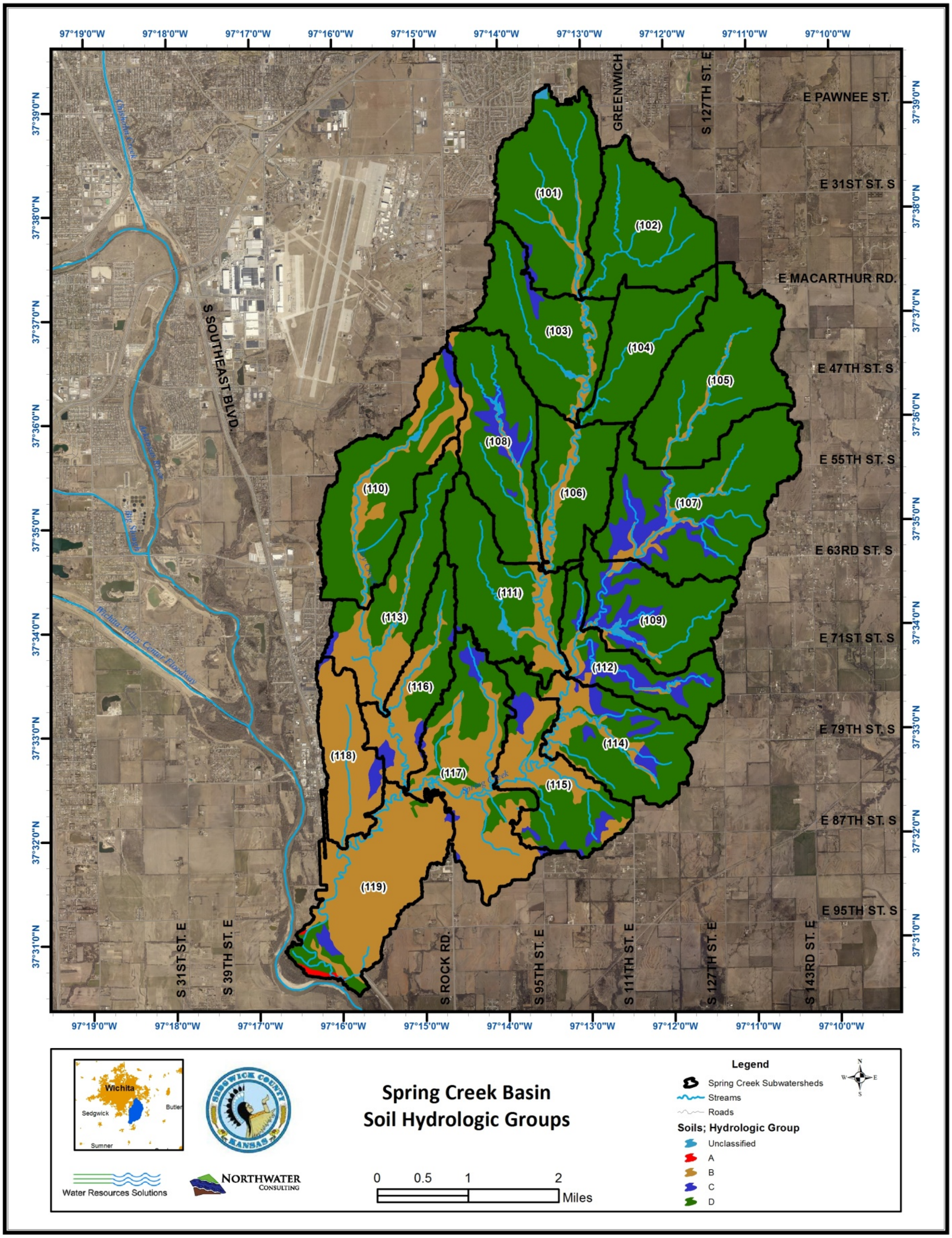

Figure 4: Spring Creek Basin Soil Hydrologic Groups Map

2.6 Geology

Spring Creek is located along the eastern valley edge of the Arkansas River Lowland alluvial plain. Only the lowermost point in the watershed includes the vast alluvial plain that resulted from over 10-million years of deposition from sources as far as the Rocky Mountains. A majority of the watershed is unconsolidated Pleistocene and Holocene-aged loess, which are wind deposits that have a matrix of silts and fine sands. The loess was deposited during windy dry periods that were predominant during the retreat of glaciers during the last 2-million years. Beneath these loess deposits is bedrock known as the Sumner group. The Sumner group is Permian-aged sedimentary rock and consists primarily of silty shale; limestone, dolomite, anhydrite, gypsum, and salt. Redbeds are common in this group, which are strata of red color due to the presence of ferric oxides. The Sumner group bedrock lies beneath the entire watershed, however, is only seen at the surface in the center part of the watershed where Spring Creek has eroded away the overlying Loess soils.

The geology is important in this watershed because Loess deposits are known to be highly erodible and not very permeable. Since a majority of the watershed is covered in loess, it makes the watershed highly erodible and susceptible to runoff events due to the fine-grained nature of the loess.

Table 5 illustrates the area associated with alluvium, loess and bedrock in the watershed. Figure 5 illustrates the location of these three geologic features

Table 5: Spring Creek Basin Watershed Surficial Geology

Geology	Acres	Percentage	Description
Alluvium	632	3%	Unconsolidated river deposits associated with Arkansas River lowlands, mostly silts, sands and gravels. Only located at the lower portion of the watershed.
Loess	15,153	74%	Unconsolidated wind deposited silts and fine sands deposited during drier glacial retreat periods
Sumner Group Bedrock	4,689	23%	Permian-aged sedimentary bedrock, located beneath the Loess and exposed at the surface in the center of the watershed

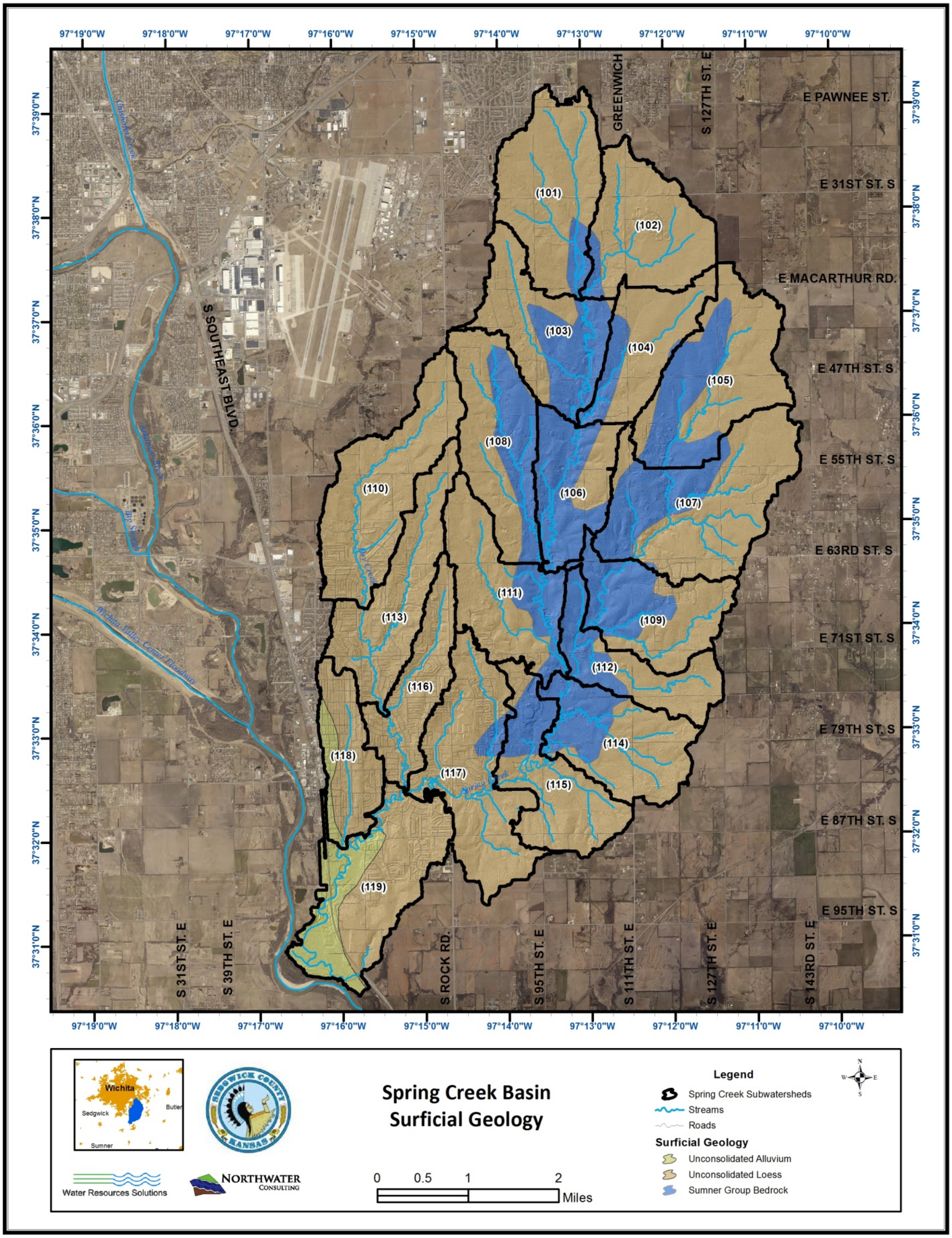

Figure 5: Spring Creek Basin Surficial Geology Map

2.7 Highly Erodible Soils

As defined by the NRCS, Highly Erodible Land (HEL) is cropland, hayland or pasture that can erode at excessive rates, with erodibility indices of 8 or higher. Fields identified as highly erodible land require a conservation system of practices that maintains erosion rates at a substantial reduction of soil loss. The Spring Creek watershed has 3,173 acres of HEL soils with the highest percentage occurring in the most northern section or subwatershed and the headwaters. Within Derby and south of the city, there is a low percentage of HEL soils. Table 6 provides the area of HEL soils by sub-basin.

Table 6: Spring Creek Basin Watershed Hel Soils

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres HEL Soils	Percent of Subwatershed
11030013030(101)	1,262	410	33%
11030013030(102)	1,081	154	14%
11030013030(103)	1,078	273	25%
11030013030(104)	796	17	2%
11030013030(105)	1,394	208	15%
11030013030(106)	794	129	16%
11030013030(107)	1,701	442	26%
11030013030(108)	1,143	271	24%
11030013030(109)	967	236	24%
11030013030(110)	1,317	105	8%
11030013030(111)	1,082	114	11%
11030013030(112)	716	78	11%
11030013030(113)	1,049	212	20%
11030013030(114)	1,013	122	12%
11030013030(115)	965	163	17%
11030013030(116)	729	105	14%
11030013030(117)	1,380	109	8%
11030013030(118)	640	0	0%
11030013030(119)	1,362	24	2%
Grand Total	**20,467**	**3,173**	**16%**

Many crop fields located on HEL ground within the watershed (see Figure 6) have erosion control measures in place such as terraces or grassed waterways. A small selection of fields could benefit from these types of practices and those landowners should be consulted. In many cases, these fields are already eligible for federal cost-share assistance through the Farm Services Agency (FSA) or the NRCS to install erosion and runoff control measures. A more comprehensive list of funding resources and specific program descriptions is provided later in

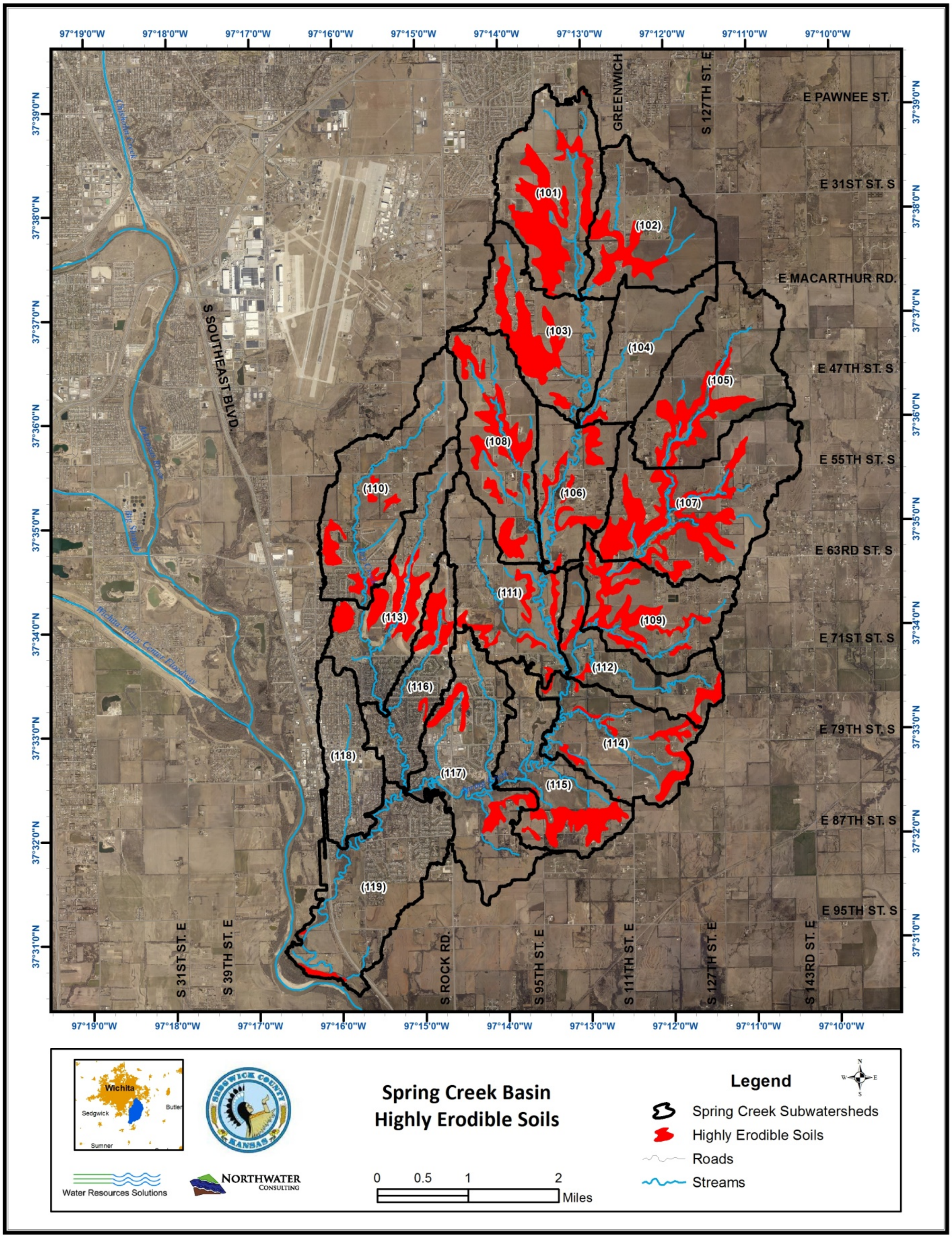

Figure 6: Spring Creek Basin Highly Erodible Soils Map

this report. Areas where treatment is recommended and the associated erosion reduction estimates are presented in a later section of this report.

Highly erodible land can have a negative impact on water quality when eroded soil and polluted runoff enter waterways. Particular attention should be paid to HEL ground in either agricultural use (row crops and pasture) or forested/grassland directly adjacent to streams where sediment is more likely to be eroded and delivered directly to a waterway. Table 7 and Figure 7 show the extent of HEL ground in agriculture, grassland or forest within 500 feet of a stream.

Table 7: Spring Creek Basin Watershed HEL Soils Within 500 ft of Stream

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres Highly Erodible Soils (within 500ft of a stream)	Percent of Subwatershed
11030013030(101)	1,262	314	25%
11030013030(102)	1,081	135	12%
11030013030(103)	1,078	122	11%
11030013030(104)	796	7	1%
11030013030(105)	1,394	183	13%
11030013030(106)	794	103	13%
11030013030(107)	1,701	314	18%
11030013030(108)	1,143	177	15%
11030013030(109)	967	202	21%
11030013030(110)	1,317	31	2%
11030013030(111)	1,082	67	6%
11030013030(112)	716	41	6%
11030013030(113)	1,049	98	9%
11030013030(114)	1,013	76	8%
11030013030(115)	965	124	13%
11030013030(116)	729	57	8%
11030013030(117)	1,380	58	4%
11030013030(118)	640	0	0%
11030013030(119)	1,362	23	2%
Grand Total	**20,467**	**2,133**	**10%**

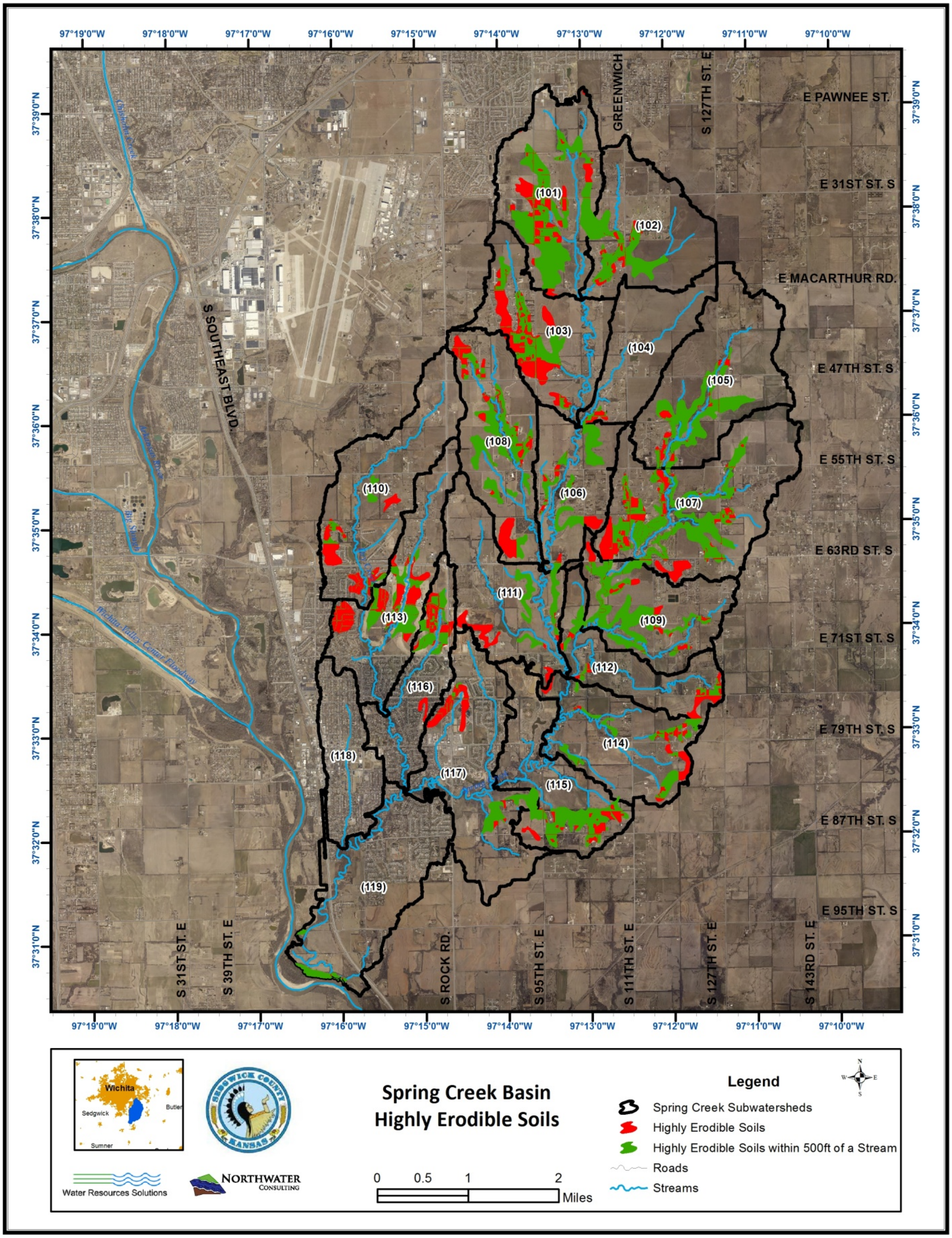

Figure 7: Spring Creek Basin Highly Erodible Soils Map

2.8 Watershed Land Slope

Using a two-foot resolution digital elevation model (DEM), an analysis was performed to show percent land slope throughout the watershed. The Spring Creek watershed is relatively flat with an average land slope of 4.98 percent. As with most midwestern watersheds, land slope in the Spring Creek basin is lower in the headwaters and increases downstream. Areas with steep slopes will be more susceptible to the effects of runoff and soil erosion if not adequately protected. The land slopes are illustrated in Table 8 and Figure 8.

Table 8: Spring Creek Watershed Percent Slope

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Average Percent Slope	Basin Average
11030013030(101)	1,262	3.85	4.98
11030013030(102)	1,081	3.28	4.98
11030013030(103)	1,078	4.28	4.98
11030013030(104)	796	3.28	4.98
11030013030(105)	1,394	3.51	4.98
11030013030(106)	794	5.06	4.98
11030013030(107)	1,701	4.30	4.98
11030013030(108)	1,143	4.35	4.98
11030013030(109)	967	4.74	4.98
11030013030(110)	1,317	4.65	4.98
11030013030(111)	1,082	5.14	4.98
11030013030(112)	716	4.55	4.98
11030013030(113)	1,049	5.74	4.98
11030013030(114)	1,013	5.21	4.98
11030013030(115)	965	5.93	4.98
11030013030(116)	729	7.31	4.98
11030013030(117)	1,380	6.72	4.98
11030013030(118)	640	5.55	4.98
11030013030(119)	1,362	7.64	4.98
Grand Total	**20,467**		

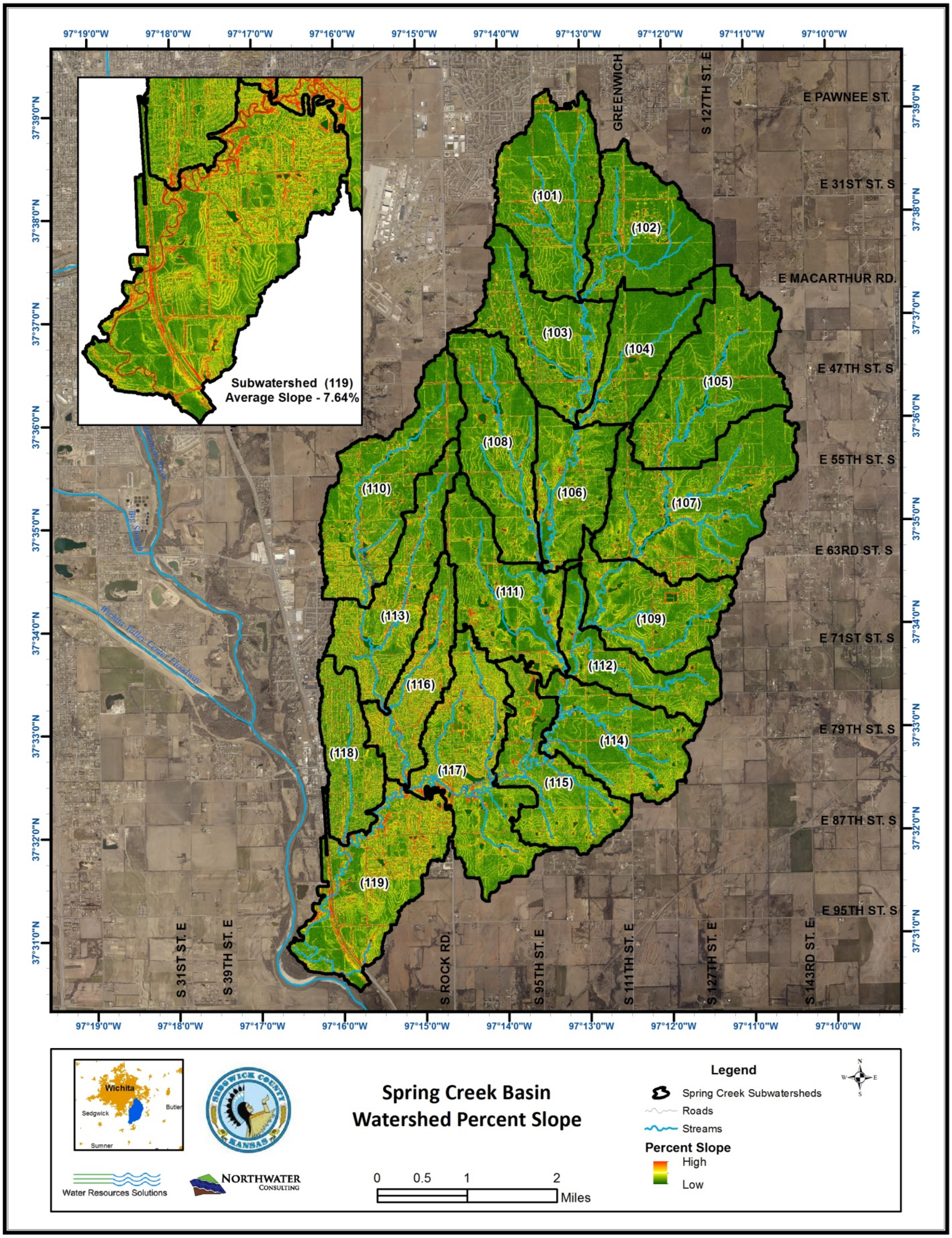

Figure 8: Spring Creek Basin Watershed Percent Slope Map

2.9 100-Year Floodplain

Flooding is a primary concern in the Spring Creek watershed. The extent to which major flooding can occur is best evaluated by analyzing the 100-year floodplain, or the area of land inundated during a 100-year flood event. Approximately 2,388 acres, or 12% of the watershed, is within the 100-year floodplain. Subwatersheds with the highest percentage of land area in the floodplain include 11030013030(111) at 28% or 299 acres, 11030013030(106) at 23% or 108 acres and 11030013030(119) at 21% or 285 acres. In these areas, activities should focus on limiting development within the floodplain and restoring native habitat. Figure 9 shows the extent of the 100-year floodplain; those three subwatersheds with the highest percentage of floodplain are labeled in red. Table 9 provides a summation of the area impacted by the 100-year floodplain.

Table 9: Spring Creek Basin Watershed 100-yr Floodplain

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres in 100 year floodplain	Percent of Subwatershed
11030013030(101)	1,262	67	5%
11030013030(102)	1,081	62	6%
11030013030(103)	1,078	150	14%
11030013030(104)	796	28	4%
11030013030(105)	1,394	94	7%
11030013030(106)	794	180	23%
11030013030(107)	1,701	101	6%
11030013030(108)	1,143	122	11%
11030013030(109)	967	73	8%
11030013030(110)	1,317	123	9%
11030013030(111)	1,082	299	28%
11030013030(112)	716	134	19%
11030013030(113)	1,049	109	10%
110300130309114)	1,013	95	9%
11030013030(115)	965	177	18%
11030013030(116)	729	65	9%
11030013030(117)	1,380	177	13%
11030013030(118)	640	48	8%
11030013030(119)	1,362	285	21%
Grand Total	**20,467**	**2,388**	**12%**

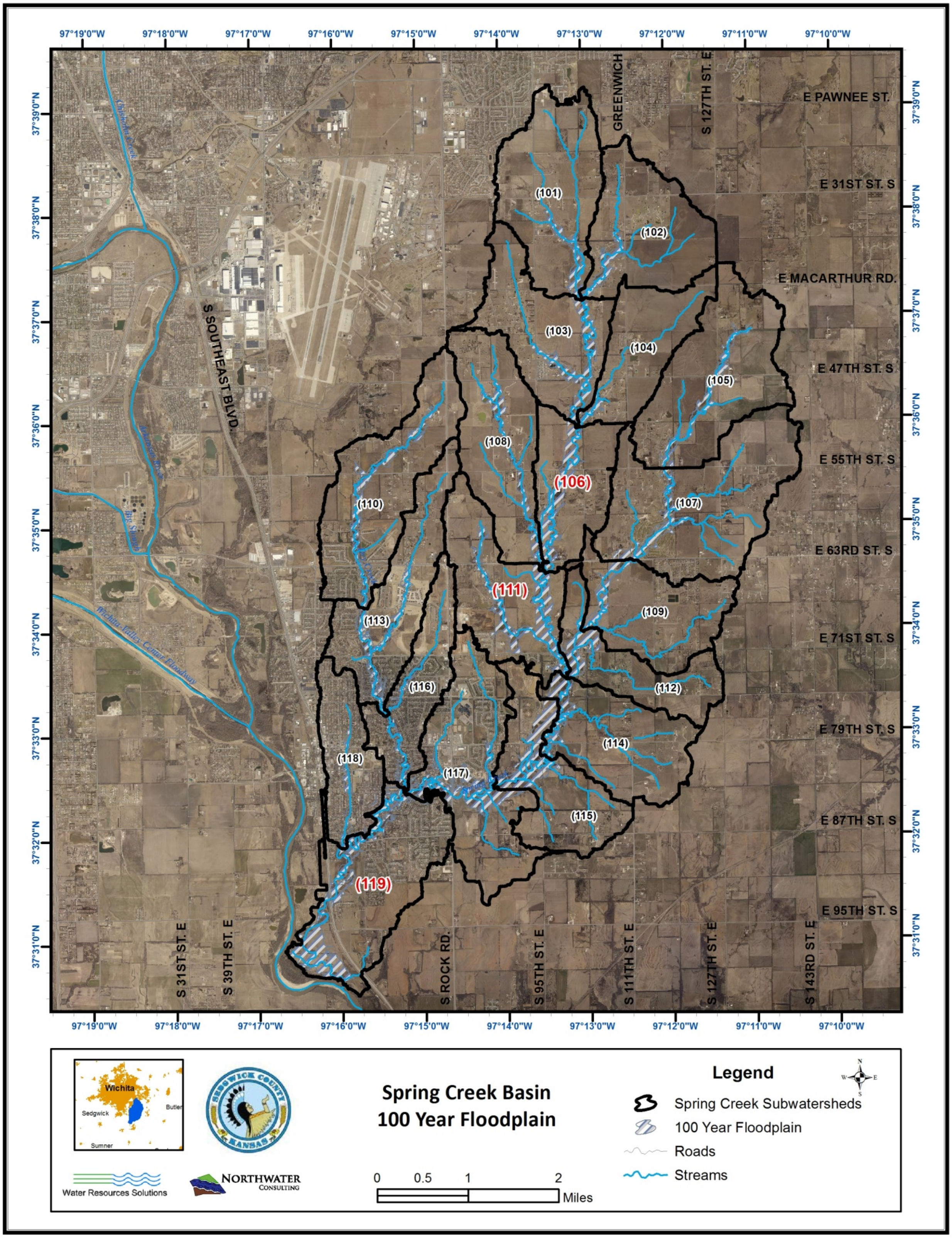

Figure 9: Spring Creek Basin 100-yr Floodplain Map

3.0 DATA COLLECTION

Data collection includes collecting, compiling, and evaluating existing data applicable to the Spring Creek Basin watershed study. The data collection and evaluation was used to identify existing information to be used by the project team.

3.1 Geographical Information Systems (GIS)

Much of the data was provided to the project team by Sedgwick County and the City of Derby. Other GIS data, including subwatershed boundaries, floodplain boundaries, and stream centerlines were provided with the hydrologic and hydraulics models from AMEC. The data was provided in the form of GIS shapefiles. In this format, the project team is able to quickly analyze the data using mapping software. Table 10 below shows the data that provided the basis for analysis in the GIS processing.

Table 10: GIS Data

Layer	Source	Description
Transportation	Sedgwick County	Roadways, bridges, driveways, parking lots, etc.
Property Boundaries	Sedgwick County	Ownership parcels
Streams, Watershed Boundary	AMEC	
Soils	NRCS	U.S. General Soil Map developed by National Cooperative Soil Survey (Sedgwick County, KS)
Contours	Sedgwick County	Contours (1’ and 2’ intervals)
Collection Systems	City of Derby	Sanitary sewer infrastructure, septic systems, and wastewater lagoons
Stormwater Systems	City of Derby	Stormwater structures, pipe, ponds, and channels
DEM and DTM	Sedgwick County	Digital Elevation Model and Digital Terrain Model
LandCover	Sedgwick County	Existing landuse
Aerial Photos	Sedgwick County	MrSID format

3.2 Hydrology

The models used for the hydrologic analysis were provided by AMEC. They include Hydrologic Engineering Center Hydrologic Modeling System (HEC HMS) models dated April 2013 and were created as part of ongoing FEMA map revisions.

3.3 Hydraulics

The hydraulic models used for the floodplain analysis were provided by AMEC. They included HEC RAS models dated April 2013 and were created as part of ongoing FEMA map revisions.

The results of the models not yet effective and are in draft form, subject to minor changes as a result of further FEMA mapping reviews.

3.4 Stream Assessment

The stream assessment data for the Spring Creek watershed was collected by Don Baker, P.E., Water Resources Solutions, LLC, on April 29, 2013 and April 30, 2013. The field data was collected using a Trimble GeoHX GPS data collector. Other data was evaluated using the aerial photography and GIS information provided to Water Resources Solutions by Sedgwick County. This information included sinuosity and radius of curvature. Detailed stream asset inventories were performed at one hundred locations throughout the watershed. Figure 10 is a photo taken on Spring Creek just south of E. 71st S. during the stream asset inventory.

Figure 10: Photo taken during stream asset inventory

Data collected in the field and from the GIS information is based on requirements of the Channel Condition Scoring Matrix (Table 5605-2) in the Kansas City Metropolitan Chapter of the American Public Works Association Section 5600 design guidance document for Storm Drainage Systems & Facilities. The scoring matrix is a quantitative evaluation system for stream reaches. Its purpose is to provide an unbiased assessment and comparison of stream reaches. Further discussion on the Channel Condition Scoring Matrix and stream assessment methodology is found in the Section 5.0 Existing Conditions section of this report.

3.5 Water Quality

Northwater Consulting completed a visual assessment of the watershed in order to identify current water quality practices and deficiencies. The observations made during this assessment were used to understand watershed characteristics and to identify potential project locations.

3.6 Topographic Survey

Continental Mapping Consultants provided topographic survey services for the project. Continental Mapping Consultants collected the invert elevations, top of road and structure dimensions for all bridge and culvert crossings in the watershed. In addition, the elevations and structure dimensions for pond outlets was collected. Finally, Continental Mapping Consultants collected the low-opening elevations of homes that were identified as potential flood locations assuming all flood management recommendations in this report were followed.

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4.0 PUBLIC INVOLVEMENT

The Spring Creek Basin Watershed Study incorporated extensive Public Involvement efforts. Public Involvement activities included three open houses, a project website, a survey and questionnaire, and news releases to local newspapers and through City of Derby utility mailings.

The objectives for communication and public involvement for the Spring Creek Watershed Study include:

- *Inform* stakeholders by providing balanced and objective information to assist them in understanding the problems, alternatives, opportunities, and solutions.
- *Consult* stakeholders by obtaining feedback on analysis, alternatives and/or decisions.
- *Involve* stakeholders by working directly with them throughout the process to ensure that concerns and aspirations are consistently understood and considered, ensuring all stakeholder groups are included and consulted.
- *Develop* an informed group of stakeholders.
- *Enlist* stakeholders in evaluating alternatives.
- *Build* partnerships with other agencies and stakeholders, recognizing the effect this effort has on the region.

4.1 Public Meetings

Three public meetings were held during the study to foster communication with residents, property owners, government officials, and other interested parties. Public meeting notices were published in the local newspaper, posted on the City of Derby and Sedgwick County websites, and sent to stakeholders via email. All public meetings followed an open house format so attendees could attend at a time most convenient to them.

4.1.1 Initial Public Meeting

The first public meeting was held on May 15, 2013 at the Derby Public Library. Twenty-two people attended the meeting in addition to local officials. The goal of the meeting was to gather information on areas of concern in the watershed, areas where stormwater management solutions might be implemented, and the types of stormwater control improvements the public is most receptive to. Maps of the Spring Creek watershed were available for review; meeting attendees marked areas of flooding or erosion and any locations for stormwater structures. Several areas of concern for flooding or bank stabilization were identified as well as some areas where residents thought stormwater controls should be implemented.

Attendees were also given an opportunity to provide written comments. This shortened version of the electronic survey included 12 questions. A summary of the written comments is as follows:

- Responses were generated from residents of Sedgwick County and one was a farmer/rancher.
- Personal property has been affected by flooding with a financial impact ranging from less than $10,000 to $25,000.
- Locations of flooding identified include 5776 S. 107th Street, East Derby and 79th Street/Webb Road.
- Two people have been affected by erosion, including threats to a residential structure.
- The financial impact of the erosion ranged from minimal to moderate.
- Responses to four questions related to citizens' view of creeks, streams, water quality, and benefits to the community were generally positive.
- One additional comment identified an erosion or bank stability issue in the Wildwood neighborhood behind Valley Stream Drive and south of Madison Avenue.

4.1.2 Second Public Meeting

To further educate the public about flooding, erosion and water quality issues in the Spring Creek Watershed, the Sedgwick County Stormwater Advisory Board hosted an open house from 4 to 6 p.m. on September 18, 2013 at the Derby Welcome Center.

At the open house, participants viewed three separate displays for flooding, erosion and water quality. Each display outlined what stakeholders said at an initial public meeting and in the online survey; what the consultant team discovered through extensive field work, research and analysis; and an illustration of potential solutions. In addition, one station was devoted to providing an overview of possible sources of funding to address these issues.

At two separate times, identical presentations were given to provide information regarding specific findings related to creek erosion, flooding and water quality issues as well as preliminary information regarding solutions that were most feasible. Stakeholders were given an opportunity to ask questions during these presentations. Questions included where the detention basins would be located, who would be responsible for them, and how they would get paid for.

Finally, participants were asked to complete a comment card to prioritize issues and identify their level of agreement with stormwater issues and potential solutions. Thirty-three people attended the open house and twelve completed the comment forms.

Participants were asked to rank three issues (creek erosion, flooding and water quality) in order of importance. Flooding was identified as the most critical issue, as is illustrated in the chart in Figure 11.

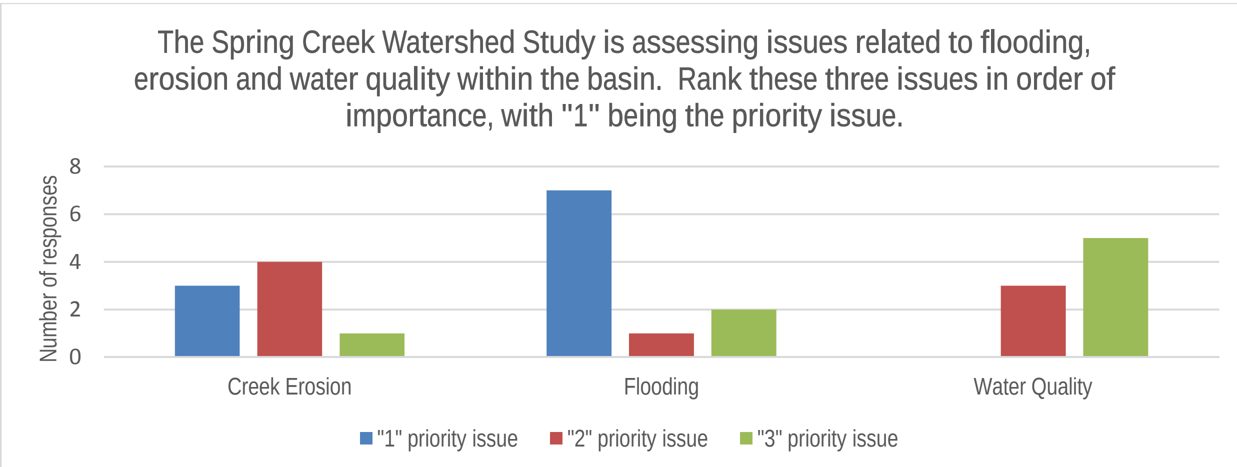


Figure 11: Spring Creek Watershed Issues

Participants were asked to rate their level of agreement with statements regarding stormwater issues, as illustrated in the chart below.

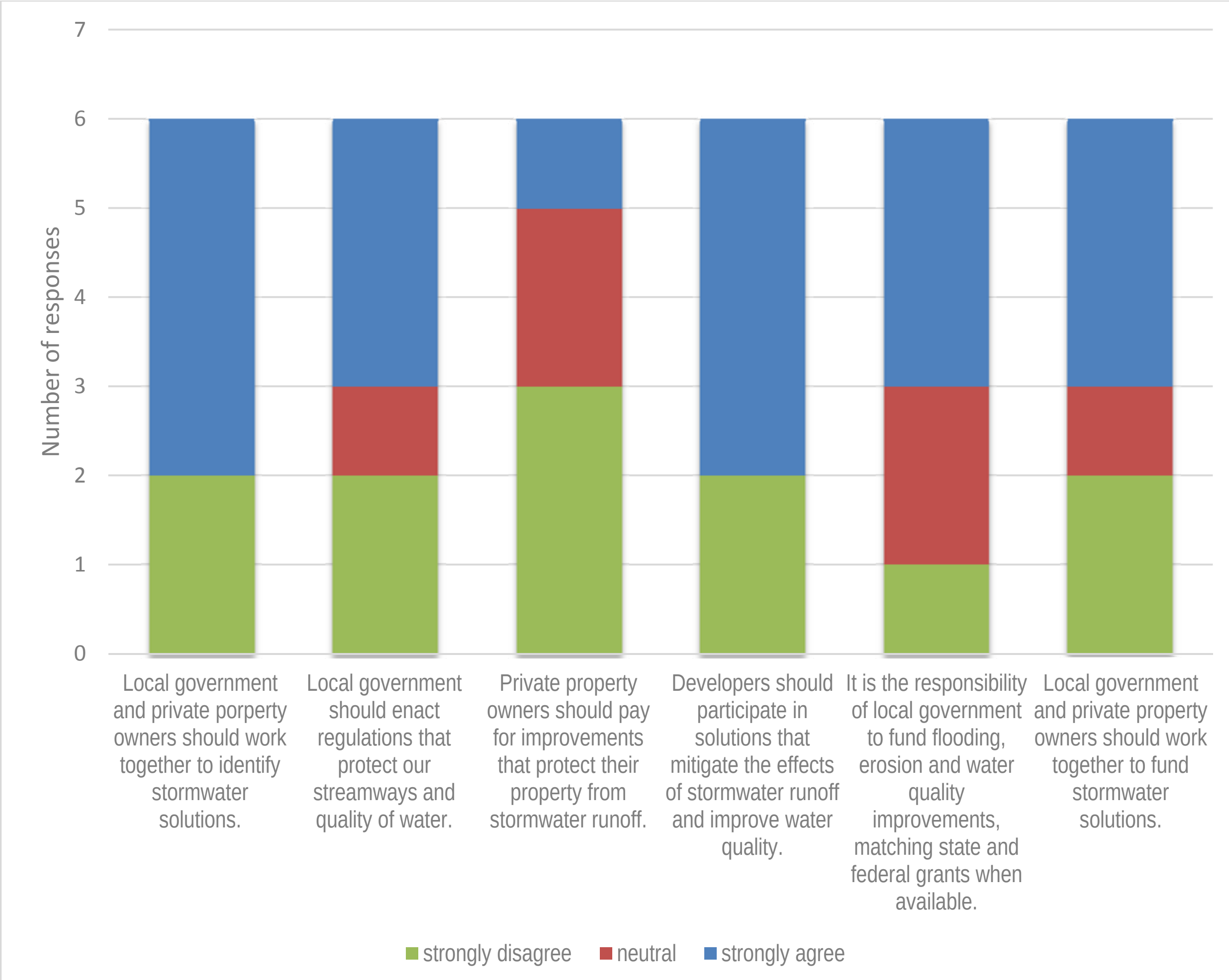


Figure 12: Addressing Stormwater Issues and Potential Solutions

4.1.3 Third Public Meeting

The third and final public meeting was held on November 6, 2013 from 4 to 6 p.m. at the Derby Welcome Center. This open house was designed to share the final recommendations regarding creek erosion, flooding and water quality issues in the basin.

At the open house, two presentations were given to present the recommendations regarding creek erosion, flooding and water quality issues. Also included in the presentations were financing and funding options as well as the next steps in the watershed study process. The next steps in the watershed study process were a draft report, final report and a presentation of the report to the County Commission.

The participants were able to go to four different stations that included a Flooding station, Creek Erosion station, a Water Quality station, and a Funding station. Display boards and large maps were on display at each station to provide the attendees with information on the respective topics.

4.2 Public Survey/Questionnaire

Stakeholder outreach included a survey about stormwater runoff, flooding, erosion, and water quality issues in the community. A 31-question survey was made available through the Sedgwick County website and was publicized through print media, the County's email list, the City of Derby, and the Stormwater Management Board. The survey was available during the month of May 2013.

Responses received from the survey assisted Sedgwick County and the consultant team with focusing the efforts of the watershed study. Information from residents is helpful in identifying specific areas of concern, such as locations where flooding occurs and the type and location of solutions that could be implemented to address flooding, erosion, and water quality issues.

The survey addressed three major issues in the Spring Creek watershed: flooding, stream bank stability, and water quality. Respondents gave multiple answers on a qualitative scale from "strongly agree" to "strongly disagree." Potential answers also included "unsure" and all applicable.

Fifty-one people responded to the survey, representing 13 neighborhoods with more than 68% of respondents residing within the city limits of Derby, Kansas. Subdivision representatives or business owners accounted for 12% each or 24% of the total number of respondents. Farmers and ranchers accounted for 8%. City employees also accounted for 8%.

The survey respondents are concerned about the watershed and issues facing the community. When asked what the watershed plan should address, 84% of the respondents either strongly agreed or agreed that it should address water quality; 71% indicated it should address stream erosion and bank stabilization, and 65% noted it should address flooding.

The results of the survey indicate that:

- Respondents are generally knowledgeable about stormwater runoff and the sources of pollution to streams and rivers. Respondents understand that water quality can affect their health and that they play a role in the water quality of local streams. However, they also indicated that there is a lack of specific information or data on the quality of water in Spring Creek.

- Erosion and stream bank stabilization are major issues affecting the people who responded to the survey. Comments were received about losing backyards, money spent to stop erosion of their property, and major changes to Spring Creek since purchasing their property.

- Most of the respondents (77%) had not personally been affected by flooding, either on their property or within the community.
- Comments received at the end of the survey indicate frustration by the residents living along Spring Creek with the lack of action and assistance by local government. The following are a sampling of those comments.
- Two previous studies did not result in any changes or actions by the City of Derby or Sedgwick County.
- The City of Derby does not provide any assistance to residents with erosion of their backyards and do not appear to care about their problems. Residents are left to fix problems on their own with no technical or financial assistance.
- Citizens value their water resources and desire a more positive connection and interaction with the natural resources. Comments included a desire to preserve the riparian corridor and vegetated stream banks, as well as greater access to the stream for passive recreation.

The complete survey results can be found in Appendix A.

4.3 Project Website

A project website was developed to provide and disseminate information about the watershed study to interested stakeholders. The website can be accessed through the Sedgwick County Public Works website at www.sedgwickcounty.org/public_works.

The project website was updated three times over the course of the project to reflect the project progress and to provide updates to stakeholders.

5.0 EXISTING CONDITIONS

To determine the Best Management Practices (BMPs) for the Spring Creek Basin, a clear understanding of existing watershed conditions is needed. This section describes existing conditions and major concerns within the watershed.

5.1 Hydrology/Hydraulics

The hydrologic and hydraulic models used for the Spring Creek Basin watershed study were provided by AMEC as part of the Federal Emergency Management Agency (FEMA) map revisions. The 32 square mile Spring Creek watershed was divided up into 82 sub-basins to support the FEMA mapping process. Sub-basin hydrology was modeled in the HEC HMS modeling program. Spring Creek and its tributaries were modeled using the Hydrologic Engineering Center River Analysis System (HEC RAS) modeling program. The HEC HMS modeling program was used to simulate the hydrology or rainfall runoff within the watershed, while the HEC RAS model was used to simulate the water flowing through the streams/rivers. Figure 13 shows the stream and sub-basin boundaries used in the hydrologic and hydraulic models.

5.1.1 Methodology

Locations where the existing 100-yr floodplain boundary encroached on homes or buildings were identified first. Beginning at the downstream end of the watershed, the flowrates were then reduced in HEC RAS to lower the 100-yr water surface elevation. This included areas where the current 100-yr water surface elevation encroached on homes or buildings. The rainfall was then reduced in the respective subbasins in HEC HMS to match the reduced flowrates. The reduced rainfall produced new runoff volumes for each subbasin. The difference between the current runoff volume and the reduced runoff volume represents the required detention volume to eliminate flooding of homes or buildings.

5.1.2 Modeling Results

The hydrologic and hydraulic analysis described in the previous section identified 14 subbasins that require a reduction in runoff volume to reduce flooding. Table 11 shows the 14 subbasins and associated detention volumes.

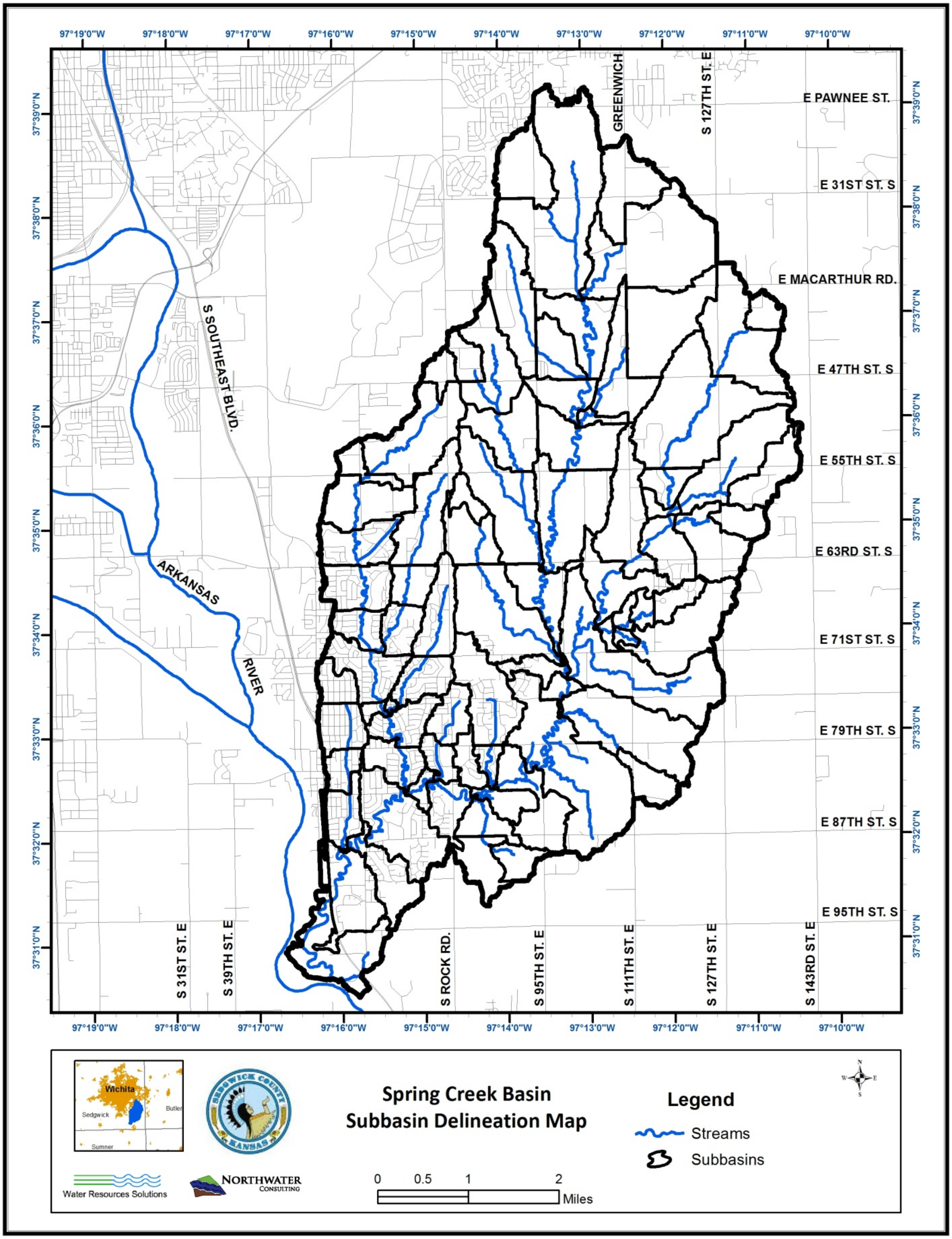


Figure 13: Spring Creek Basin Subbasin Delineation Map

Table 11: Subbasin Required Detention Volumes

Subbasin	Subbasin Area (ac)	100-yr Rainfall (in)	Current Runoff Volume (ac-ft)	Reduced Rainfall (in)	Reduced Runoff Volume (ac-ft)	Detention Volume (ac-ft)
SPG10000	414.73	7.8	168.0	5.6	101.7	66.3
SPG10100	310.77	7.8	126.0	5.6	80.7	45.3
SPG10300	438.45	7.8	190.2	5.7	121.1	69.1
SPG11200	365.66	7.8	179.8	3.0	46.2	133.6
SPG1T10000	94.35	7.8	49.0	7.4	46.8	2.2
SPG3T10100	356.51	7.8	178.8	6.2	133.4	45.4
SPG5T10500	289.17	7.8	136.7	3.8	51.5	85.2
TRL10100	97.90	7.8	46.3	6.0	32.5	13.8
TRL10200	166.24	7.8	72.2	3.8	24.0	48.2
DRY10300	239.73	7.8	111.1	6.5	86.8	24.3
DRY10400	132.40	7.8	61.3	5.7	37.9	23.4
DRY10800	91.25	7.8	41.5	5.2	23.4	18.1
DRY1T10100	173.20	7.8	88.7	5.1	46.8	41.9
DRY1T10200	227.52	7.8	116.2	5.1	67.4	48.8

5.1.3 Flood Issue Identification

The results presented in the previous section indicate there are potential flooding issues within the watershed. Flooding issues within the watershed are a result of high peak flows resulting from the type of landuse and soils. Included in the subbasins identified above, there are three locations where the 100-yr water surface elevation still encroached on homes or buildings regardless of how much the flowrate is reduced. One of these locations was located on the Spring Creek Mainstem, immediately upstream of the E. 79th Street South. The two other locations are on the Spring Creek mainstem, approximately 1,100 feet downstream of S. Rock Road and on the Spring Creek Tributary 3, approximately 400 feet downstream of E. 79th Street South. Figure 14 shows the 14 subbasins identified above and the three flood issue locations.

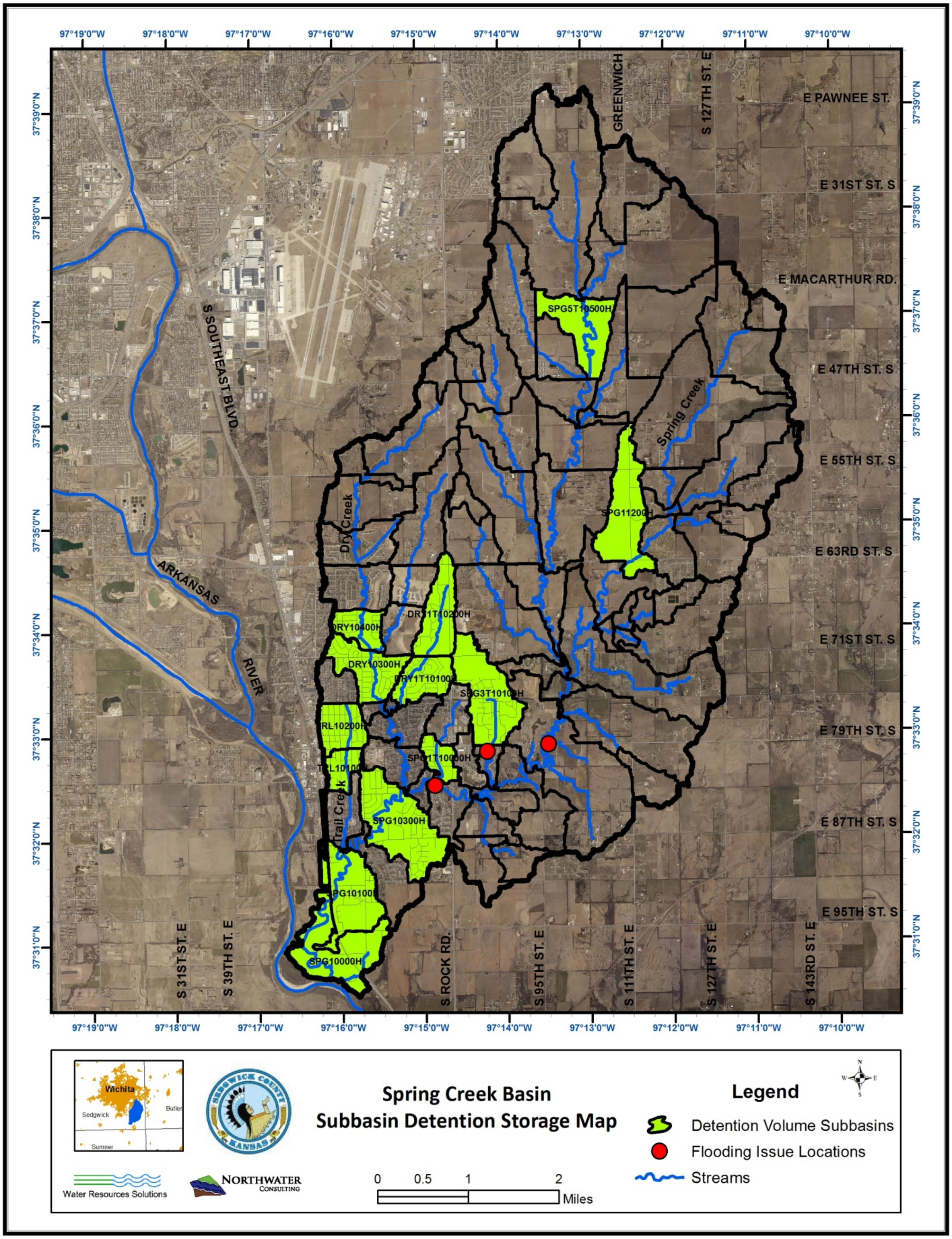


Figure 14: Spring Creek Basin Subbasin Detention Storage Map

5.2 Stream Stability

A stream asset assessment using a refined version of the protocol developed by Johnson, Gleason & Hey was completed. The stream asset inventory characterized the stream stability and sediment loading. This section outlines the process and results of the stream assessment.

5.2.1 Methodology

As discussed in Section 3.0 Data Collection, the data collected in the field and from the available GIS information was based on the requirements of the Channel Condition Scoring Matrix (Table 5605-2) in the Kansas City Metropolitan Chapter of the American Public Works Association Section 5600 design guidance document for Storm Drainage Systems & Facilities. A copy of the Channel Condition Scoring Matrix (CCSM) is found in the Appendix D of this report.

The CCSM is based on the scoring or assessment of 15 Channel Stability Indicators. A score of "Good" receives 1 point, "Fair" receives 2 points, and "Poor" receives 3 points. The Stability Indicators from the CCSM are listed in Table 12 below.

Table 12: Stability Indicator List

Stability Indicators	Weighting Factor
Bank soil texture and coherence	0.6
Average bank slope angle	0.6
Average bank height	0.8
Vegetative bank protection	0.8
Bank cutting	0.4
Mass wasting	0.8
Bar development	0.6
Debris jam potential	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	0.2
Channel bed material consolidation and armoring	0.8
Sinuosity	0.8
Ratio of radius of curvature to channel width	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	0.8
Percentage of channel constriction	0.8
Sediment movement	0.8

Each of the Stability Indicator scores described above was multiplied by a Weighting Factor that produces a numeric Rating for each Indicator. The Weighting Factor is a decimal ranging from 0.2 to 0.8 that establishes the relative importance of Indicators to stream stability. The sum of all the Weighting Factors total 9.8.

The Stability Indictor Ratings are then added together to produce a Total Ranking. As a result, the upper limit of Total Ranking for a stream reach to be ranked "Good" would be 9.8 (1 x9.8).

The upper limit for a stream reach to be ranked “Fair” is 19.6 (2 x 9.8). Similarly, the upper limit of the Total Ranking for a stream reach to be ranked “Poor” is 29.4 (3 x 9.8). A table that shows the total rating and ranking of each stream reach assessed can be found in the Appendix D. The results of the stream assessment and stream stability are discussed in the following section.

5.2.2 Stream Instability

The results of the previous section indicate that channel instability issues exist within the assessed reaches. The CCSM rating ranged from 14.2 to 25.8, representing stream conditions from fair stability to significant system wide instability. A CCSM rating of 12 indicates a stream of moderate stability. A rating between 12 and 18 indicates that special measures may be necessary to address issues noted in the assessment. Streams with ratings greater than 18 should be studied in further detail to determine recommendations; they may exhibit significant system-wide instability. While the detail of this assessment does not provide a specific recommendation for stream improvements, some general recommendations can be made. In general, the stream rating reflected poor bar development, steep bank slopes, poor channel bed material, and lack of vegetative protection. Most reaches scored poor on these indicators. Figure 15 Spring Creek Watershed Stream Reach Ranking Map illustrates the data collection point locations and the ranking of the stream reaches. Although no assessed stream reach received a “Good” ranking, they did receive a “Good” rating in some of the stability indicator rating categories. Those categories included bank soil texture and sediment movement. A majority of the reaches received a score of good on these indicators. It is important to remember this analysis was conducted at a watershed study level. The reaches should be studied in more detail as part of a more rigorous design process.

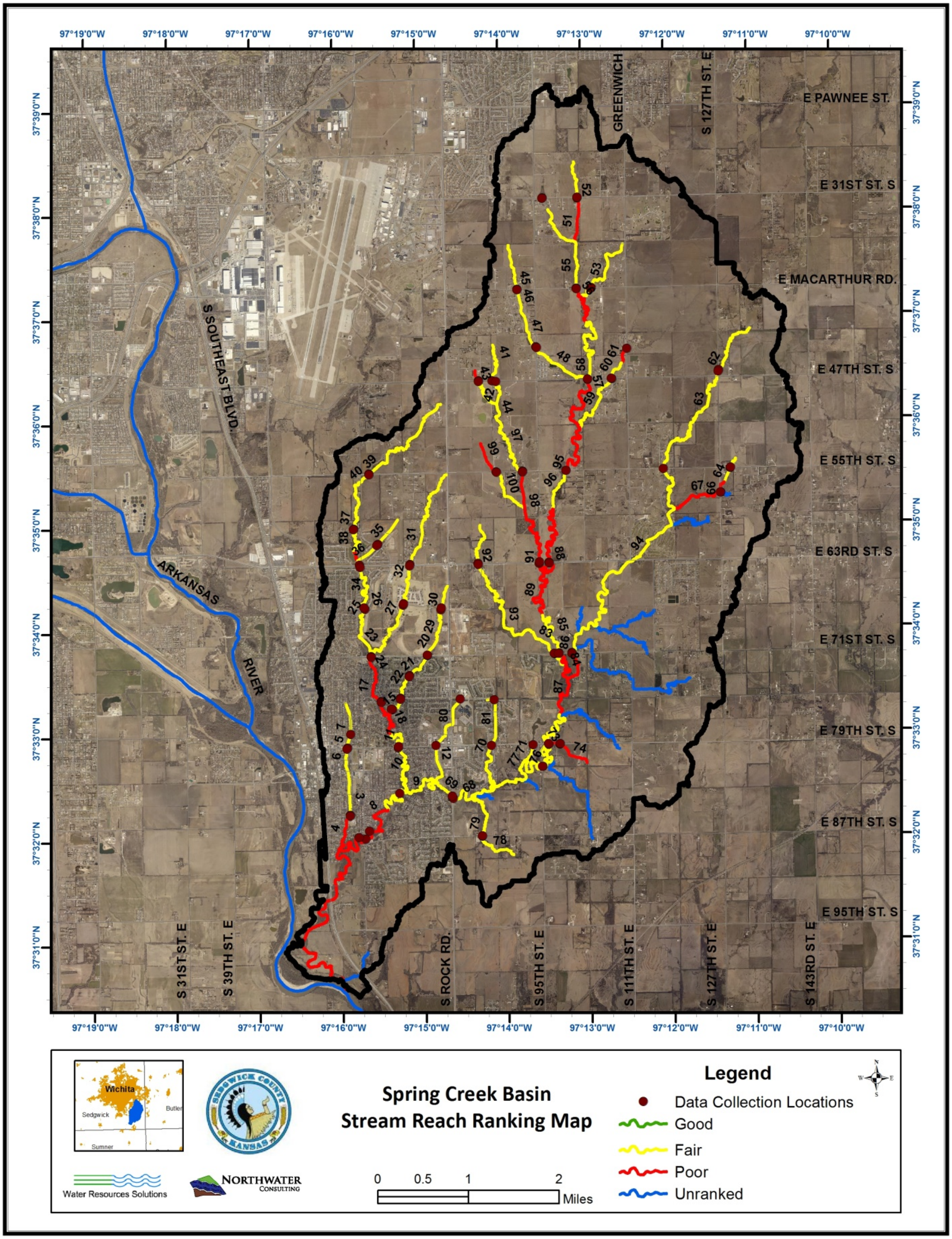


Figure 15: Spring Creek Basin Stream Reach Ranking Map

5.3 Water Quality Problem Assessment

In a typical watershed plan, water quality problems are generally defined by evaluating a history of water quality and streamflow data. This water quality information is assessed to determine if pollution concentrations exceed standards or recommended limits. The potential causes and sources of water quality impairments are evaluated and the desired water quality improvement targets are established. Finally, practices and actions are identified to achieve the desired water quality improvements.

Unfortunately, very little is known about the quality of surface water in the Spring Creek watershed. Aside from regular sampling of effluent from the Derby Waste Water Treatment Plant (WWTP), no known water quality data exists. It is important to note that the Derby WWTP does not discharge within the Spring Creek watershed; it discharges directly to the Lower Arkansas River near the confluence with Spring Creek.

A spatially based watershed-wide pollution load model was developed to address the lack of available water quality information and help evaluate and define any potential water quality problems, their cases and sources. A review of applicable water quality studies and reports from the Arkansas River was conducted to validate pollution causes and sources and to aid in establishing appropriate water quality/load reduction targets.

5.3.1 Water Quality Impairments & Standards

Water quality impairments and applicable state water quality standards are described in this section by evaluating conditions in the Arkansas River near Derby. Although the water quality impairments are specific to the Lower Arkansas River, they are applicable as Spring Creek is a direct tributary to the Arkansas and very likely a contributor of sediment, nutrients and other pollutants. Actions in Spring Creek to reduce pollution loading can only have a positive effect on the water quality of the Arkansas River.

To understand how water quality impairments are determined, one must first understand the regulations surrounding state water quality standards. The Environmental Protection Agency's (EPA) water quality standards regulations require Kansas (and all states) to adopt and implement an anti-degradation policy. The anti-degradation policy is a component of the surface water quality standards in the state's overall water quality program. Anti-degradation policy is a required process for protecting all existing uses, maintaining healthy waters and providing strict protection to outstanding waters.

The intent of the anti-degradation policy is to limit discharges and other activities that will negatively impact water quality, impair designated uses, or threaten to impair designated uses of surface waters. The EPA defines a designated use as:

“Those uses specified in water quality standards for each waterbody or segment. Recreational uses; the propagation and growth of a balanced, indigenous population of aquatic life; wildlife; and the production of edible and marketable natural resources are generally stated as "fishable and swimmable" uses. Other uses may be industrial water supply, irrigation, and navigation.”

The anti-degradation policy provides a baseline level of protection relative to established water quality criteria to all classified surface waters, and a higher level of protection to those waterbodies recognized as unique ecologically, highly valued for its resources, or having high water quality. The federal anti-degradation guidance presents three tiers for maintaining and protecting water quality and designated uses:

1. The first tier (Tier 1) provides a “floor” which protects existing uses. Water quality must be preserved to protect and maintain those existing uses. Activities that would lower water quality below levels necessary to maintain existing uses are prohibited.
2. The second tier (Tier 2) provides protection to high quality waters where water quality exceeds the criteria associated with the assigned designated uses. Limited water quality degradation is allowed in high quality waters where the degradation is necessary to accommodate important social or economic development, but only if designated uses are still maintained and the highest statutory and regulatory requirements for all point sources of pollution and all cost effective and reasonable best management practices for nonpoint sources (NPS) of pollution are achieved.
3. The third tier (Tier 3) provides special protection for Outstanding Resource Waters, such as those waters in National and State Parks, wildlife refuges, outstanding fisheries, and other waters of unique recreational or ecological value. Activities that would permanently lower water quality of these surface waters is forbidden.

Kansas provides protection to classified surface waters equivalent to the three tiers listed above in the Outstanding National Resource Water (Tier 3) and General Purpose Water (Tier 1 or Tier 2). Additionally, Kansas provides a level of protection frequently referred to as Tier 2½, to waters classified as Exceptional State Waters.

For Tier 2 waters, the State also evaluates potential nonpoint sources of pollution in the same surface water segment as the point source discharge. Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources.

Current statutes and regulations addressing nonpoint source pollution include:

1. K.S.A. 2-2438a et seq. - addresses proper pesticide use. Since a discharge of a pesticide from a new or expanded point source into a Tier II water is requisite to initiate a anti-

degradation review, it is equally rare that a review will involve an evaluation of pesticide application.

2. K.A.R. 28-18-1 et seq. - addresses requirements for livestock production which have a potential to pollute.
3. K.A.R. 28-5-1 et seq. - addresses proper on-site wastewater treatment.

Streams are sampled by the state to determine if conditions warrant impairment to a designated use. The designated uses applicable to Spring Creek include:

1. Domestic Water Supply Use: Surface waters that are used, after appropriate treatment, for a potable water resource. As used in these regulations, "point of diversion" is the location of a surface water intake structure used for domestic water supply or at the point of water removal from the alluvial aquifer by a well utilizing "groundwater under the influence of surface water" as defined under K.A.R. 28-15-11(cc).
2. Food Procurement Use: Surface waters that are used for obtaining edible aquatic or semi-aquatic life for human consumption.
3. Aquatic Life Support Use: Waters used for the maintenance of the ecological integrity of streams, lakes and wetlands including the aquatic, semi-aquatic, or terrestrial species dependent on surface water for survival.
4. Recreational Use: Surface water used for primary or secondary contact recreation. The secondary contact recreational use standards apply year round to surface waters designated for secondary contact recreational use.

If a stream is sampled and it is determined that it is impaired and a designated use is not being met, the stream is placed on the 303(d) list. The 303(d) list is a comprehensive list of all impaired stream segments. According to the federal Clean Water Act, each state must develop Total Maximum Daily Loads (TMDLs) for all the waters on the 303(d) list. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. It is at the discretion of states to set priorities for developing TMDLs for waters on the 303(d) list. Listings are determined based on whether or not sampling results meet the applicable designated use for a given parameter. Timelines for the completion of TMDLs vary across the country.

Although the Spring Creek Watershed Plan is focused on those water quality parameters listed in Table 14, a complete listing of 2012 Arkansas River impairments relevant to Spring Creek are listed below.

Table 13: 2012 303(d) List; Arkansas River Impairments

Stream	Impaired Use	Impairment	Station	Priority	Comment
Arkansas River at Derby	Aquatic Life	Lead	SC281	Low	N/A
Arkansas River at Derby	Food Procurement	PCB	SC281	Low	Fish consumption advisory
Arkansas River at Derby	Aquatic Life	Biology	SC281	Medium	TMDL Approved on 7/27/2001
Arkansas River at Derby	Aquatic Life	Total Phosphorus	SC281	Low	Median value: 0.678 > median flag value: 0.201
Arkansas River at Derby	Water Supply	Chloride	SC281	Medium	TMDL Approved on 9/20/2006
Arkansas River At Oxford	Water Supply	Chloride	SC527	Medium	TMDL Approved on 9/20/2006
Arkansas River at Derby	Recreation	Fecal Coliform	SC281	High	TMDL Approved on 8/9/2000; old FCB violation

5.3.2 Pollutant Reduction Targets

Water quality targets typically represent a desired pollutant concentration or volume; a water quality endpoint. How these targets are established varies by watershed but in general, they are based on state water quality standards or guidelines. Historical water quality data is compared against state standards to determine an appropriate and attainable target. Water quality targets may also be based on critical limits for aquatic life or established purely based on local preferences. The most effective way to set water quality targets is to base them on existing load reductions calculated in a TMDL plan, if available.

Since no watershed specific TMDL document or any historical water quality data exist for Spring Creek, water quality targets are based on three TMDL plans developed for the Lower Arkansas River of which Spring Creek is a tributary. These water quality targets therefore represent the same percentage reductions in fecal coliform bacteria, total nitrogen, total phosphorus, chloride and total suspended solids described in the TMDLs. Modeled annual nonpoint source pollution loading concentrations for Spring Creek (Section 5.3) serve as a water quality baseline or current conditions; the targets are a percentage reduction in the baseline non point source (NPS) pollutant loads. Table 14 describes current annual NPS pollution loads for Spring Creek, percentage reduction targets and the associated quantities of pollutants. Targets listed below should be revised once water quality data becomes available and a true comparison can be made between Spring Creek and state standards or limits.

Table 14: Spring Water Quality Targets

Water Quality Parameter	Total Nitrogen	Total Phosphorus	Fecal Coliform Bacteria	Chloride	Total Suspended Solids
Water quality Target (Percent Reduction)	16%	15%	*19%	**17%	34%
Current Pollution Load; Spring Creek	128,267	34,056	54,829	1,058,624	23,591
Load Reduction Required to Meet Target	20,523	5,108	10,418	179,966	8,021

* No specific reduction percentage or quantity is noted in the TMDL; used a percentage equal to the number of samples exceeding state standards. A similar approach is noted in the 2011 Lower Arkansas WRAPS plan
**No specific reduction percentage is noted in the TMDL; used percentage difference between 250mg/l standard and average sampled concentrations for the Arkansas River at Derby.

5.3.3 Pollutant Causes, Sources, & Loads

Like many mixed urban/rural watersheds such as Spring Creek, water pollution can originate from both point and nonpoint sources. Point source pollution is any single identifiable source of pollution from which pollutants are discharged, such as a pipe or outfall. Nonpoint Source pollution originates from many diffuses sources. NPS pollution is caused by rainfall or snowmelt moving over and through the land. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands and even groundwater. This section will describe, in detail potential pollution causes, their sources and quantities or total loading.

Pollution causes, sources and loading in the Spring Creek watershed were evaluated by:

1. Assessing the potential impacts of point source discharges
2. Modeling NPS pollution

The assessment of point source pollution and modeled NPS pollution indicates that NPS pollution is the primary source of water pollution in the watershed. Permitted point source discharges are well within permit limits and there are no known discharges from private waste ponds or septic systems. Although the likelihood is low, there is the possibility that some septic systems or private waste ponds are having an impact on water quality. An attempt was made to quantify this or allocate a specific loading to septic system point sources in the watershed. Since this allocation is just an estimation, the most appropriate next step to determine if any problems do in fact exist; these steps are outlined in subsequent sections of the plan.

Nonpoint source pollution can be quantified using accepted methods and models. A spatially based NPS pollution load model was developed for the Spring Creek watershed and was used to quantify pollution loading from nutrients, bacteria, sediment and chloride. Additional data on streambank and gully erosion was collected in the field to supplement modeled results and improve model outputs. Table 15 below summarizes annual NPS pollution loading for the watershed. A detailed breakdown of pollution loading by subwatershed is provided in Table 16.

Table 15: Spring Creek Annual NPS Pollution Loading

	Total Nitrogen (lbs)	Total Phosphorus (lbs)	Fecal Coliform Bacteria (billion coliform forming units)	Chloride (lbs)	Total Suspended Solids (tons)
NPS Modeled Pollution	85,945	12,869	53,296	1,058,624	5,367
Streambank Erosion	36,235	18,177	N/A	N/A	15,754
Gully Erosion	5,719	2,896	N/A	N/A	2,470
Septic Systems	368	114	1,533	N/A	0
Grand Total	128,267	34,056	54,829	1,058,624	23,591
Results per acre	6.3	1.7	2.7	52	1.15

5.3.3.1 Point Source Pollution

Wastewater treatment facilities and other point sources influence surface water quality throughout much of Kansas. There are three permitted point source discharge locations within the watershed, 96 known and mapped septic systems, 52 advance residential treatment systems and 513 known private waste lagoons. Many of these systems do not likely pose a threat to water quality unless they are within the floodplain or are known to be faulty. A proximity analysis shows that there are 17 septic systems and 18 private waste lagoons are within the floodplain. No advanced treatment systems or waste treatment lagoons exist within the floodplain. These thirty-five locations should be targeted for inspections and maintenance, if necessary.

Table 16: Spring Creek Watershed Point Sources

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Number of Septic Systems	Number of Advanced Waste Systems	Number of Private Waste Ponds	Number of Septic Systems in 100 year Floodplain	Number of Advanced Waste Systems in 100 year Floodplain	Number of Private Waste Ponds in 100 year Floodplain
11030013030(101)	1,262	0	0	30	0	0	1
11030013030(102)	1,081	0	0	62	0	0	2
11030013030(103)	1,078	0	39	63	0	0	2
11030013030(104)	796	0	0	25	0	0	1
11030013030(105)	1,394	0	0	35	0	0	3
11030013030(106)	794	0	1	20	0	0	2
11030013030(107)	1,701	0	0	61	0	0	2
11030013030(108)	1,143	0	0	39	0	0	0
11030013030(109)	967	0	0	27	0	0	0
11030013030(110)	1,317	1	0	56	1	0	4
11030013030(111)	1,082	6	0	15	1	0	0
11030013030(112)	716	3	1	23	0	0	0
11030013030(113)	1,049	0	0	9	0	0	0
11030013030(114)	1,013	5	4	22	2	0	0
11030013030(115)	965	18	6	14	7	0	1
11030013030(116)	729	0	0	1	0	0	0
11030013030(117)	1,380	8	1	7	1	0	0
11030013030(118)	640	0	0	0	0	0	0
11030013030(119)	1,362	55	0	4	5	0	0
Grand Total	**20,467**	**96**	**52**	**513**	**17**	**0**	**18**

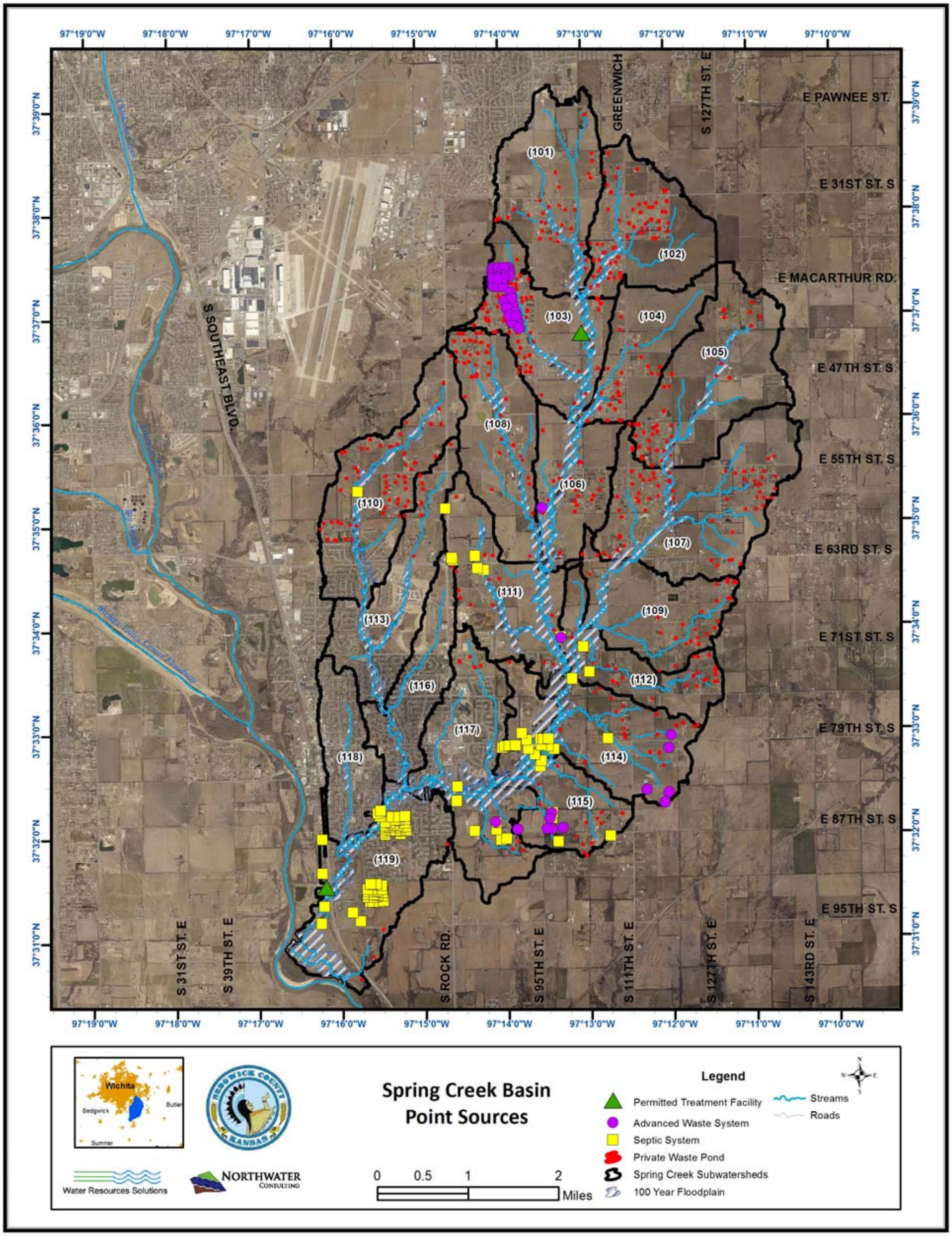


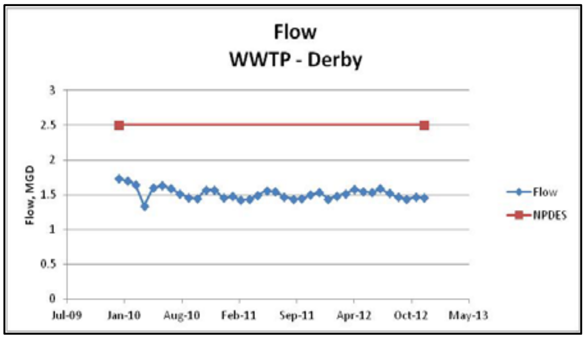
Figure 16: Spring Creek Basin Points Sources Map

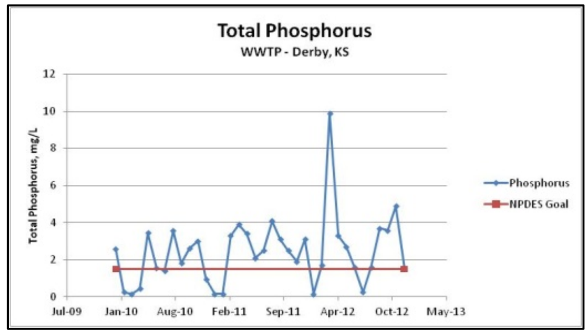
Domestic wastewater can often contribute unwanted nutrients such as nitrogen and phosphorus as well as bacteria to a watershed. Wastewater must be treated before being released into the environment in order to prevent pollution of local waterways. Most wastewater in the Spring Creek watershed is treated either by the Derby Waste Water Treatment Plant (WWTP) or on-site sewer treatment systems. There are also a few small lagoon systems treating wastewater for small rural developments.

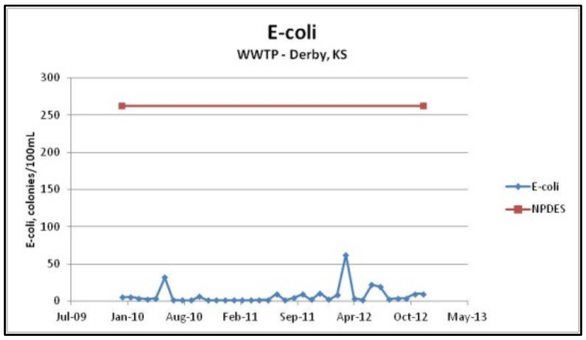
The Derby WWTP collects wastewater via a network of collection piping and pumping stations from roughly one-third of the watershed. The treatment process is continuously monitored by a staff of ten to fifteen certified operators twenty-four hours a day, seven days a week. The WWTP is well maintained and is in very excellent condition. Furthermore the effluent allowed to return to the Arkansas River is continuously sampled and water quality results are reported to the state on a monthly basis.

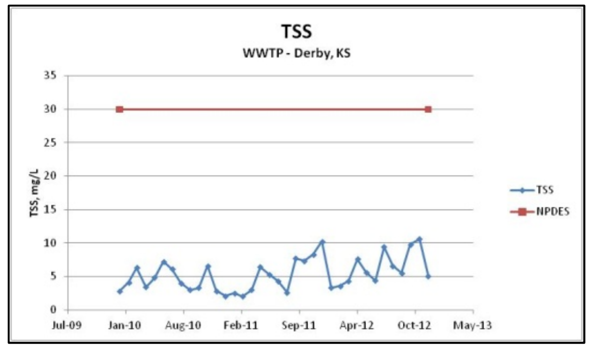
A good estimate of nutrients and E-coli bacteria released to the Arkansas River from the Derby WWTP can be made from available data. Any additional bacteria and nutrients must therefore originate from other sources. Figures below show treated monthly discharge concentrations from the Derby plant between 2010 and 2012. Flow and concentrations for Total Phosphorus, Total Nitrogen, Total Suspended Solids, Chloride and Ecoli are plotted against established permit limits, or where permit limits do not exist (for N and P), results are plotted against general guidelines. Results show that the Derby WWTP is consistently below state standards for flow levels, Chloride, TSS and Ecoli. Concentrations of N and P vary with some instances where recommended limits are exceeded as well as times where levels are well below limits.

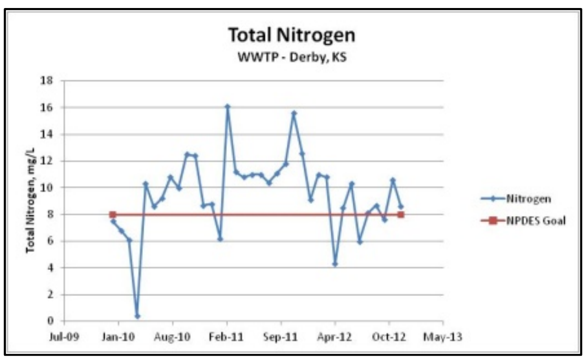
Table 17: Derby WWTP Water Quality Summary

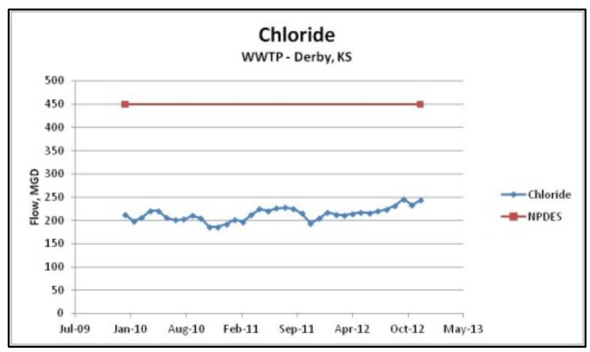












Lagoon treatment systems are divided into two categories; single residence and community lagoon treatment systems. Single residence lagoons are not permitted to discharge water. They are designed to evaporate all water sent. Any lagoon treatment system receiving wastewater from more than one residence is considered a community system and is subject to monitoring and reporting regulations of the State. There are three community lagoon treatment systems within the watershed. They are listed as follows:

- Calvary Baptist Church at 1636 E. Patriot Ave
- Long Branch Mobile Home Park at 9600 E. 47th St South
- City of Wichita at 6781 South 111th East

The community lagoon treatment systems are all operated under controlled discharge conditions. The water must be tested and pass State water quality regulations before it can be discharged to the environment. Lagoons are also not allowed to be constructed within floodplain areas. Properly functioning lagoons far away from floodplain areas are not likely to be contributing nutrients or bacteria to Spring Creek. However, lagoons located within the vicinity of a floodplain could potentially be contributing nutrients or bacteria to the watershed if their liners are leaking.

The third form of wastewater treatment present in the watershed is the traditional septic tank and drain field system. There are a number of septic/drain field systems within the watershed. However, once installed there is very little monitoring taking place to evaluate the effectiveness of their treatment. The newer systems have been built with two-compartment, 1,500 gallon septic tanks and larger drain fields that provide much better treatment than older one-compartment, 1,000 gallon tanks. Current law only allows for a septic system to be inspected when a property transfers ownership. The only other way to determine if a system is failing is when wastewater is found to be surfacing and is reported to the local officials.

Septic systems are typically only an active source of pollutants when the system is failing. Faulty or leaky septic systems are sources of E. coli, nitrogen, and phosphorus. Typical national septic system failure rates are 10-20 %. However, reported failure rates vary widely depending on the local definition of failure. The number of septic systems in Spring Creek was estimated based on locally available GIS data. The number of septic systems is 96 in the Spring Creek Watershed. At a 15% failure rate, it is estimated that 14 septic systems within the watershed are failing. At two people per system and an average of 0.15 billion coliform forming units per person, per day, it is estimated that failing septic systems may contribute an annual load of 368 pounds of Nitrogen, 114 pounds of Phosphorus and 1,533 billion coliform forming units.

5.3.3.2 Nonpoint Source Pollution

Nonpoint source pollution can have a profound influence on surface water quality conditions in Kansas. In agricultural areas, erosion of cropland soils produces elevated concentrations of sediment in many streams and lakes, often to the detriment of native aquatic and semi-aquatic life. The presence of nitrogen and phosphorus fertilizers in field runoff promotes nuisance growths of algae and detracts from the recreational and drinking water supply uses of surface water. Stormwater runoff from feedlots, livestock wintering areas, and heavily grazed pastures introduces pathogens and oxygen consuming organic wastes into nearby lakes and streams, sometimes compromising the sanitary condition of these waters. Streambank erosion, also considered NPS pollution is a natural process that can have negative impacts on infrastructure and water quality when excessive.

In urban areas, NPS pollution can also have negative effects on water quality. Stormwater runoff from lawns, golf courses, roadways, and parking lots often contains a complex mixture of chemical pollutants (e.g., biocides, fertilizers, oil, grease, antifreeze, deicing salts, solvents, detergents, and asbestos). These substances can prevent the development and maintenance of representative aquatic communities in receiving surface waters. Unplanned urban growth can negatively influence the physical habitats supporting aquatic life, in part because the attendant elimination and alteration of permeable land surfaces, wetlands and riparian areas diminishes the capacity of urban watersheds to remove pollutants and mitigate the effects of flooding. Stormwater runoff from impervious surfaces such as paved areas and rooftops can lead to powerful flooding events, capable of scouring stream bottoms and eliminating the habitat required by some native aquatic species. The channelization of urban streams results in highly simplified aquatic habitats incapable of supporting the full range of fish and wildlife indigenous to this region. In many instances, the negative effects of urban development on streams, lakes, and wetlands could be reduced through careful planning.

5.3.3.2.1 Modeled Pollution Loading

A NPS watershed pollution loading model was developed for the watershed. The Spatial Watershed Assessment and Management Model (SWAMM) was used to quantify pollution loading within the basin. SWAMM is a customized and spatially based NPS model designed to provide pollution load estimates within a watershed and aid in estimating benefits realized from the placement of Best Management Practices. The methodology used to develop the SWAMM is documented in the Appendix G.

No water quality data exists for Spring Creek or its tributaries and therefore, pollution load modeling was conducted to define any potential water quality issues. SWAMM was developed using local rainfall data, a custom landuse/landcover layer and soils information. Modeled water quality constituents include runoff, total nitrogen (N), total phosphorus (P), chloride (Cl), bacteria and total suspended sediment (TSS). Annual rainfall, a “first flush” event, a five year and twenty-five year storm were simulated; all results represent delivered loads based on a ten-year daily precipitation record.

Due to the lack of water quality data, SWAMM relied on literature based pollution concentrations and local watershed observations. When water quality data does become available for Spring Creek, SWAMM can be calibrated and adjusted accordingly; until such time, the modeled results are within acceptable ranges. Modeled results are further described in the tables that follow. The values highlighted in red are those with the largest per acre load.

Table 18: Annual Pollution Loading

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Runoff (ac-ft)	Total N Load (lbs/ yr)	Per acre N Load	Total P Load (lbs/yr)	Per acre P Load	Total Cl Load (lbs/yr)	Per acre Cl Load	Total Bacteria Load (billion Coliform forming units/yr)	Per acre Bacteria Load	TSS Load (tons/ yr)	Per acre TSS load
11030013030(101)	1,262	1,450	5,564	4.41	854	0.68	33,283	26	2,586	2.05	514	0.41
11030013030(102)	1,081	647	6,954	6.43	1,115	1.03	18,276	17	2,791	2.58	611	0.57
11030013030(103)	1,078	586	4,648	4.31	601	0.56	34,479	32	3,212	2.98	209	0.19
11030013030(104)	796	380	2,144	2.69	329	0.41	14,968	19	1,798	2.26	67	0.08
11030013030(105)	1,394	862	8,169	5.86	1,078	0.77	15,781	11	4,635	3.32	663	0.48
11030013030(106)	794	398	4,069	5.13	526	0.66	13,590	17	4,060	5.12	78	0.10
11030013030(107)	1,701	899	5,894	3.47	923	0.54	45,024	26	3,401	2.00	380	0.22
11030013030(108)	1,143	567	3,592	3.14	511	0.45	21,472	19	2,330	2.04	174	0.15
11030013030(109)	967	510	3,011	3.11	456	0.47	19,768	20	2,107	2.18	156	0.16
11030013030(110)	1,317	763	5,152	3.91	823	0.62	89,947	68	3,493	2.65	248	0.19
11030013030(111)	1,082	642	5,950	5.50	734	0.68	42,523	39	4,224	3.91	468	0.43
11030013030(112)	716	371	2,990	4.18	458	0.64	8,086	11	1,684	2.35	214	0.30
11030013030(113)	1,049	681	4,701	4.48	772	0.74	116,742	111	2,795	2.67	238	0.23
11030013030(114)	1,013	501	4,395	4.34	700	0.69	20,128	20	2,173	2.15	351	0.35
11030013030(115)	965	425	2,621	2.72	415	0.43	18,854	20	1,650	1.71	277	0.29
11030013030(116)	729	552	3,427	4.70	567	0.78	123,905	170	2,462	3.38	143	0.20
11030013030(117)	1,380	869	5,946	4.31	925	0.67	196,299	142	3,425	2.48	243	0.18
11030013030(118)	640	518	3,265	5.10	521	0.81	130,391	204	2,204	3.44	96	0.15
11030013030(119)	1,362	680	3,455	2.54	565	0.41	95,109	70	2,266	1.66	237	0.17
Grand Total	**20,467**	**12,300**	**85,945**	**4.20**	**12,869**	**0.63**	**1,058,624**	**52**	**53,296**	**2.60**	**5,367**	**0.26**

Table 19: Pollution Loading from a 1.2 Inch Event (First Flush)

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Runoff (ac-ft)	Total N Load (lbs/1.2 inches rain)	Per acre N Load	Total P Load (lbs/1.2 inches rain)	Per acre P Load	Total Cl Load (lbs/ 1.2 inches rain)	Per acre Cl Load	Total Bacteria Load (billion Coliform forming units/1.2 inches rain)	Per acre Bacteria Load	TSS Load (tons/ 1.2 inches rain)	Per acre TSS load
11030013030(101)	1,262	34	142	0.11	22	0.017	1,029	0.8	62	0.05	9	0.007
11030013030(102)	1,081	32	**185**	**0.17**	**29**	**0.027**	568	0.5	71	0.07	**15**	**0.014**
11030013030(103)	1,078	27	118	0.11	15	0.014	1,079	1.0	77	0.07	5	0.005
11030013030(104)	796	15	40	0.05	6	0.008	468	0.6	29	0.04	2	0.002
11030013030(105)	1,394	44	221	0.16	29	0.021	486	0.3	124	0.09	12	0.009
11030013030(106)	794	17	104	0.13	13	0.016	420	0.5	**103**	**0.13**	2	0.002
11030013030(107)	1,701	40	136	0.08	21	0.012	1,415	0.8	77	0.05	7	0.004
11030013030(108)	1,143	24	86	0.08	12	0.010	666	0.6	53	0.05	4	0.003
11030013030(109)	967	23	66	0.07	10	0.010	607	0.6	41	0.04	3	0.003
11030013030(110)	1,317	37	135	0.10	21	0.016	2,914	2.2	89	0.07	6	0.005
11030013030(111)	1,082	32	157	0.15	19	0.017	1,365	1.3	111	0.10	6	0.006
11030013030(112)	716	16	72	0.10	11	0.015	238	0.3	37	0.05	5	0.006
11030013030(113)	1,049	36	128	0.12	21	0.020	3,671	3.5	78	0.07	6	0.005
11030013030(114)	1,013	22	106	0.10	17	0.016	625	0.6	46	0.05	7	0.007
11030013030(115)	965	17	59	0.06	9	0.009	585	0.6	33	0.03	3	0.003
11030013030(116)	729	32	101	0.14	17	0.023	3,853	5.3	73	0.10	4	0.005
11030013030(117)	1,380	46	166	0.12	25	0.018	6,089	4.4	95	0.07	6	0.005
11030013030(118)	640	31	98	0.15	16	0.024	**3,990**	**6.2**	65	0.10	3	0.005
11030013030(119)	1,362	32	87	0.06	14	0.010	2,880	2.1	55	0.04	3	0.002
Grand Total	**20,467**	**559**	**2,209**	**0.11**	**325**	**0.016**	**32,948**	**1.6**	**1,319**	**0.06**	**108**	**0.005**

Table 20: Pollution Loading from a 4.5 Inch Event (5-Year Storm)

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Runoff (ac-ft)	Total N (lbs/4.5 inches rain)	Per acre N Load	Total P Load (lbs/4.5 inches rain)	Per acre P Load	Total Cl Load (lbs/4.5 inches rain)	Per acre Cl Load	Total Bacteria Load (billion Coliform forming units/4.5 inches rain)	Per acre Bacteria Load	TSS Load (tons/ 4.5 inches rain)	Per acre TSS load
11030013030(101)	1,262	305	1,146	0.91	177	0.140	5,689	4.5	547	0.43	71	0.056
11030013030(102)	1,081	275	1,418	1.31	229	0.211	3,050	2.8	580	0.54	114	0.106
11030013030(103)	1,078	251	950	0.88	125	0.116	5,791	5.4	672	0.62	38	0.036
11030013030(104)	796	173	483	0.61	74	0.093	2,430	3.1	423	0.53	14	0.018
11030013030(105)	1,394	360	1,647	1.18	219	0.157	2,665	1.9	935	0.67	92	0.066
11030013030(106)	794	173	825	1.04	109	0.138	2,299	2.9	834	1.05	15	0.019
11030013030(107)	1,701	387	1,233	0.72	195	0.115	7,406	4.4	723	0.43	55	0.033
11030013030(108)	1,143	249	749	0.66	109	0.095	3,563	3.1	497	0.43	30	0.026
11030013030(109)	967	222	648	0.67	99	0.102	3,360	3.5	469	0.49	23	0.024
11030013030(110)	1,317	309	1,011	0.77	162	0.123	14,520	11.0	698	0.53	44	0.034
11030013030(111)	1,082	262	1,189	1.10	148	0.137	6,882	6.4	847	0.78	47	0.043
11030013030(112)	716	162	629	0.88	97	0.136	1,401	2.0	366	0.51	36	0.050
11030013030(113)	1,049	261	891	0.85	147	0.140	19,920	19.0	527	0.50	40	0.038
11030013030(114)	1,013	217	918	0.91	148	0.146	3,297	3.3	473	0.47	59	0.058
11030013030(115)	965	184	551	0.57	88	0.092	3,117	3.2	359	0.37	26	0.027
11030013030(116)	729	199	613	0.84	102	0.140	21,521	29.5	450	0.62	22	0.030
11030013030(117)	1,380	325	1,095	0.79	172	0.125	33,680	24.4	638	0.46	45	0.032
11030013030(118)	640	182	569	0.89	92	0.143	22,969	35.9	402	0.63	17	0.026
11030013030(119)	1,362	268	663	0.49	110	0.081	16,772	12.3	451	0.33	25	0.018
Grand Total	**20,467**	**4,760**	**17,228**	**0.84**	**2,603**	**0.127**	**180,333**	**8.8**	**10,890**	**0.53**	**814**	**0.040**

Table 21: Pollution Loading from a 6.1 Inch Event (25-Year Storm)

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Runoff (ac-ft)	Total N Load (lbs/6.1 inches rain)	Per acre N Load	Total P Load (lbs/ 6.1 inches rain)	Per acre P Load	Total Cl Load (lbs/6.1 inches rain)	Per acre Cl Load	Total Bacteria Load (billion Coliform forming units/6.1 inches rain)	Per acre Bacteria Load	TSS Load (tons/ 4.5 inches rain)	Per acre TSS load
11030013030(101)	1,262	458	1,694	1.34	263	0.21	8,074	6.4	819	0.65	104	0.082
11030013030(102)	1,081	409	2,078	1.92	335	0.31	4,321	4.0	856	0.79	167	0.154
11030013030(103)	1,078	380	1,409	1.31	187	0.17	8,190	7.6	1,007	0.93	56	0.052
11030013030(104)	796	268	747	0.94	114	0.14	3,440	4.3	664	0.83	21	0.026
11030013030(105)	1,394	534	2,406	1.73	321	0.23	3,786	2.7	1,370	0.98	134	0.096
11030013030(106)	794	265	1,223	1.54	163	0.21	3,268	4.1	1,237	1.56	22	0.028
11030013030(107)	1,701	589	1,864	1.10	297	0.17	10,463	6.2	1,095	0.64	81	0.048
11030013030(108)	1,143	383	1,122	0.98	165	0.14	5,057	4.4	751	0.66	44	0.039
11030013030(109)	967	337	984	1.02	151	0.16	4,780	4.9	725	0.75	34	0.036
11030013030(110)	1,317	465	1,494	1.13	239	0.18	20,313	15.4	1,036	0.79	65	0.049
11030013030(111)	1,082	392	1,749	1.62	219	0.20	9,656	8.9	1,248	1.15	69	0.064
11030013030(112)	716	247	941	1.31	146	0.20	2,020	2.8	557	0.78	53	0.074
11030013030(113)	1,049	387	1,311	1.25	217	0.21	28,115	26.8	769	0.73	58	0.056
11030013030(114)	1,013	334	1,376	1.36	222	0.22	4,681	4.6	724	0.71	87	0.086
11030013030(115)	965	289	840	0.87	136	0.14	4,432	4.6	556	0.58	39	0.041
11030013030(116)	729	288	883	1.21	147	0.20	30,468	41.8	647	0.89	32	0.043
11030013030(117)	1,380	485	1,603	1.16	253	0.18	47,736	34.6	937	0.68	66	0.048
11030013030(118)	640	262	817	1.28	132	0.21	32,657	51.0	579	0.91	24	0.038
11030013030(119)	1,362	414	1,001	0.74	167	0.12	23,936	17.6	683	0.50	37	0.027
Grand Total	**20,467**	**7,184**	**25,540**	**1.25**	**3,874**	**0.19**	**255,393**	**12.5**	**16,260**	**0.79**	**1,194**	**0.058**

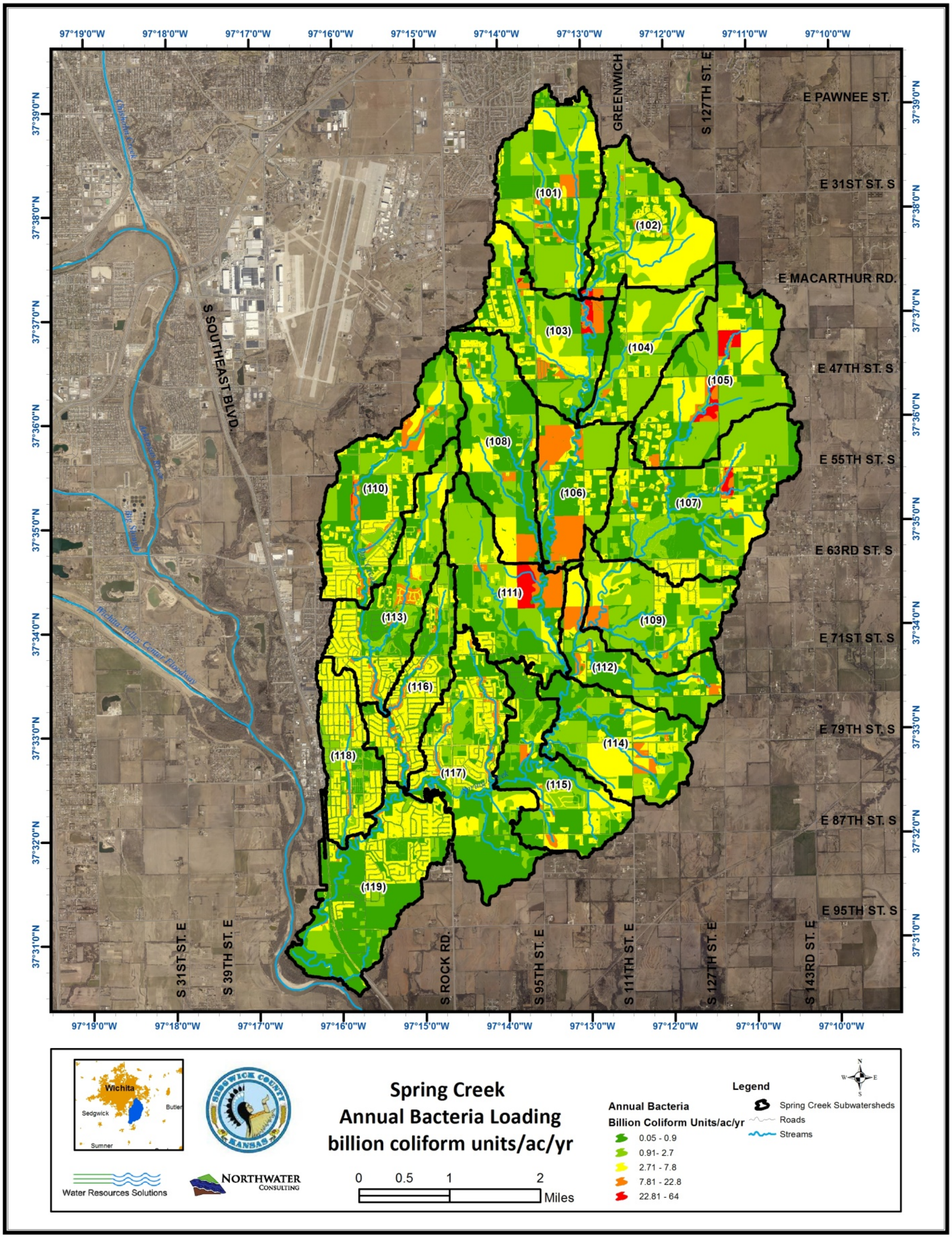


Figure 17: Spring Creek Annual Bacteria Loading Map

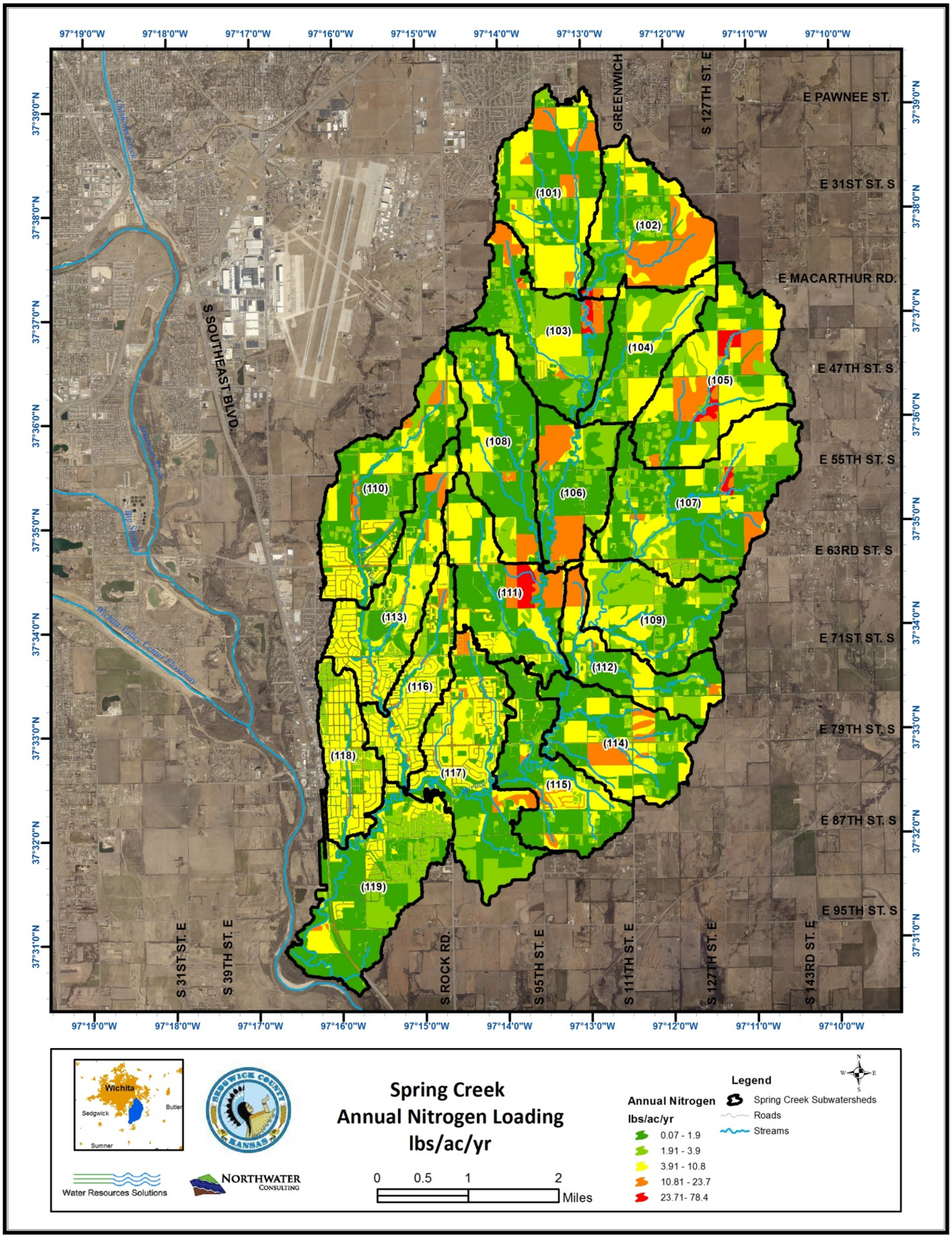


Figure 18: Spring Creek Annual Nitrogen Loading Map

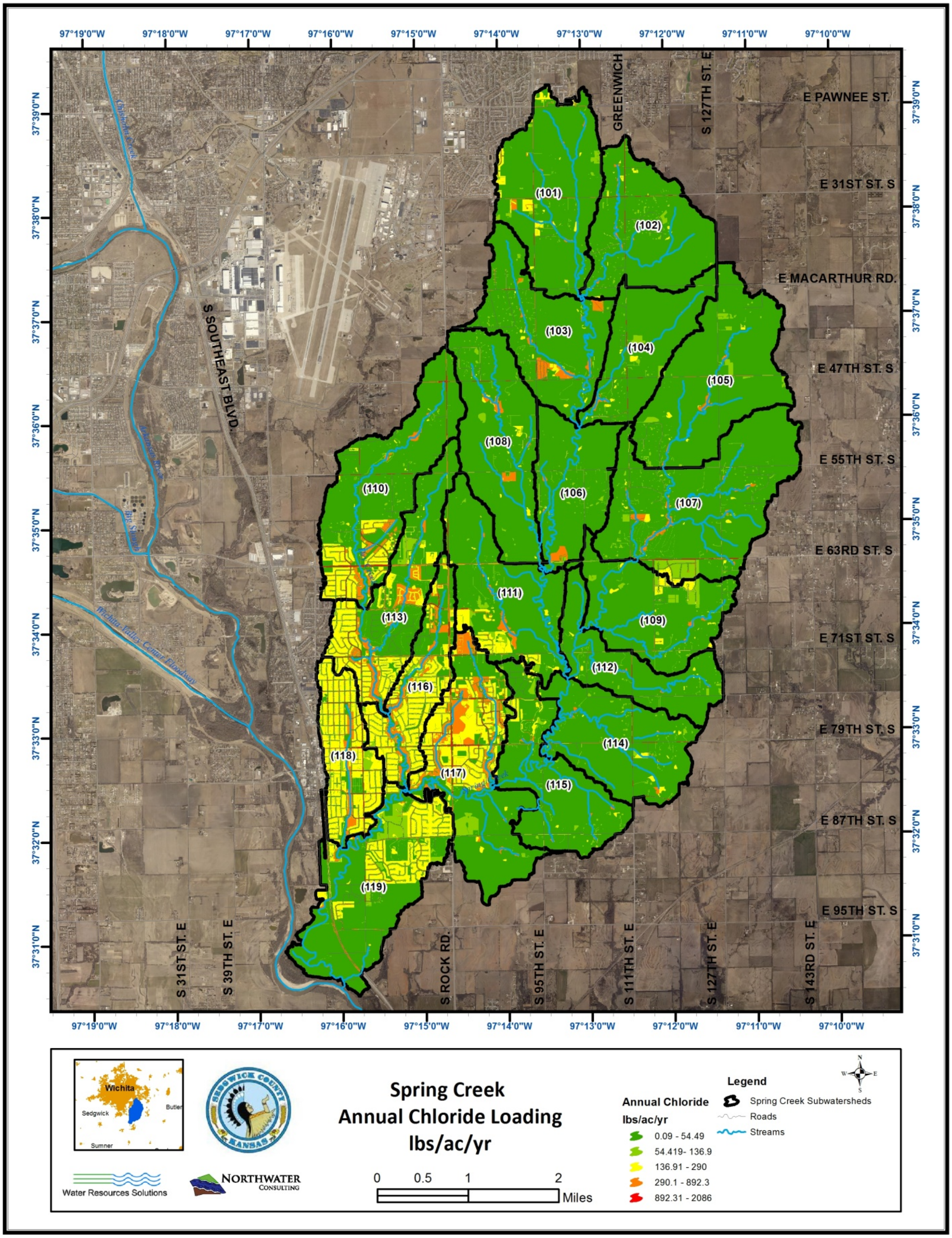


Figure 19: Spring Creek Annual Chloride Loading Map

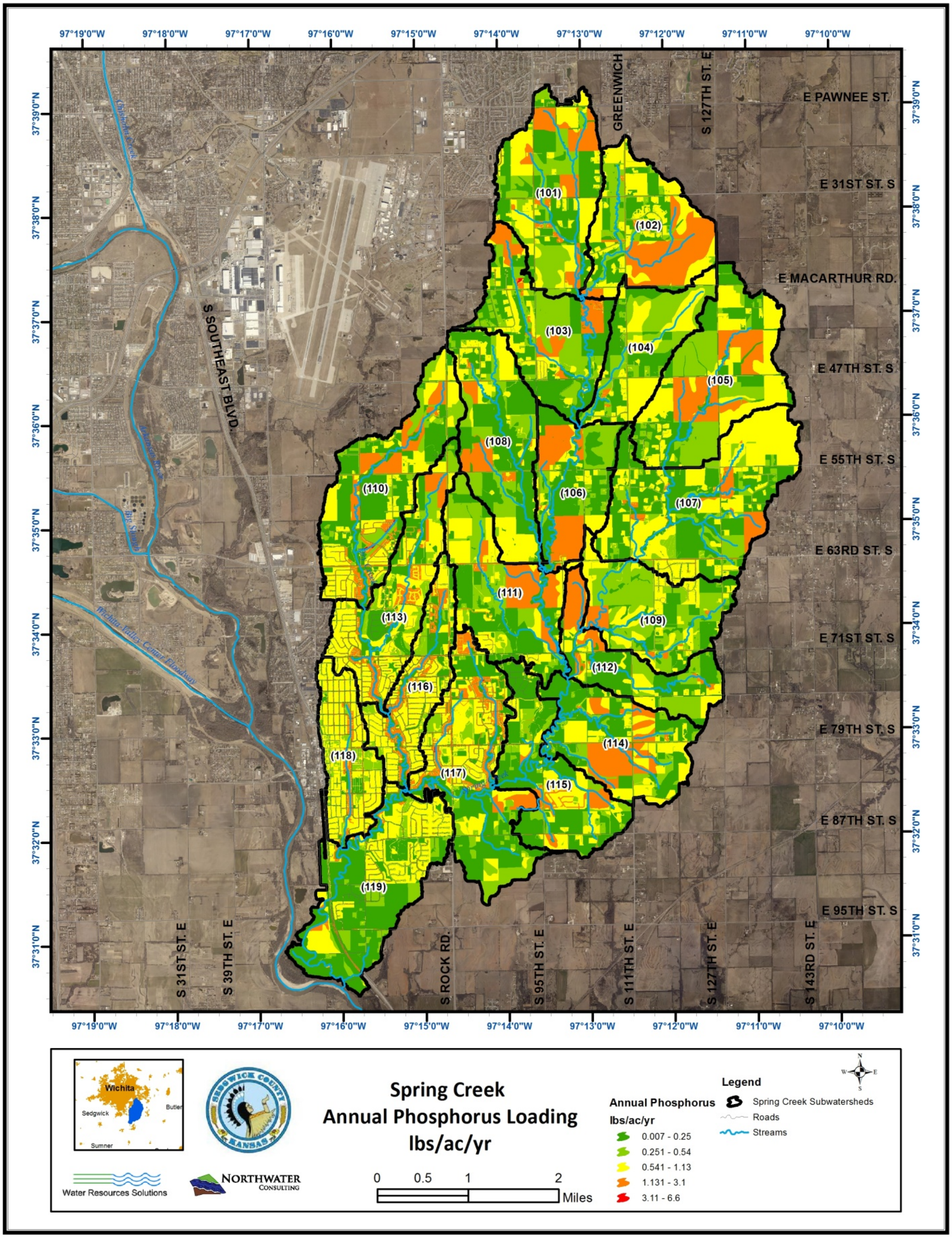


Figure 20: Spring Creek Annual Phosphorus Loading Map

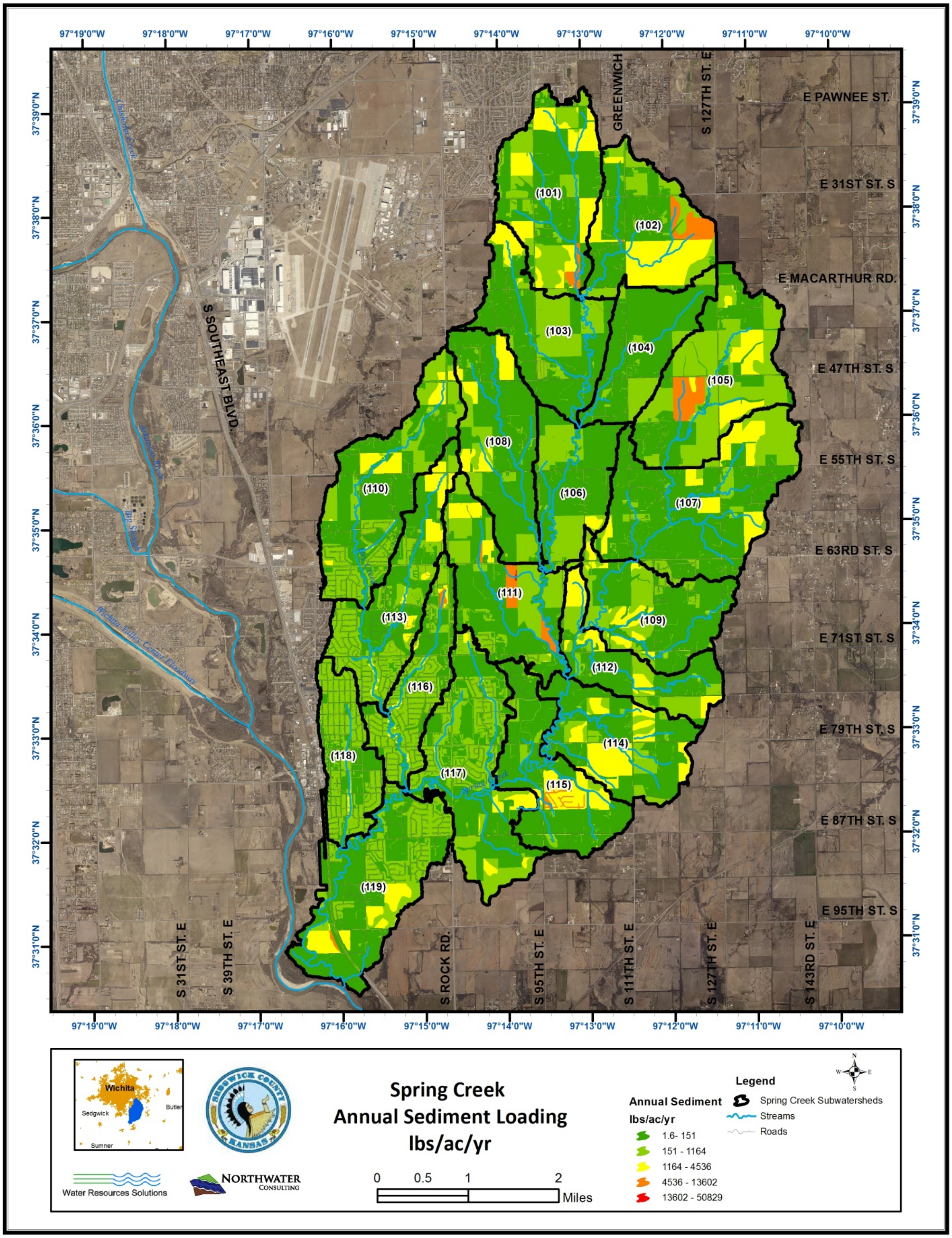


Figure 21: Spring Creek Annual Sediment Loading Map

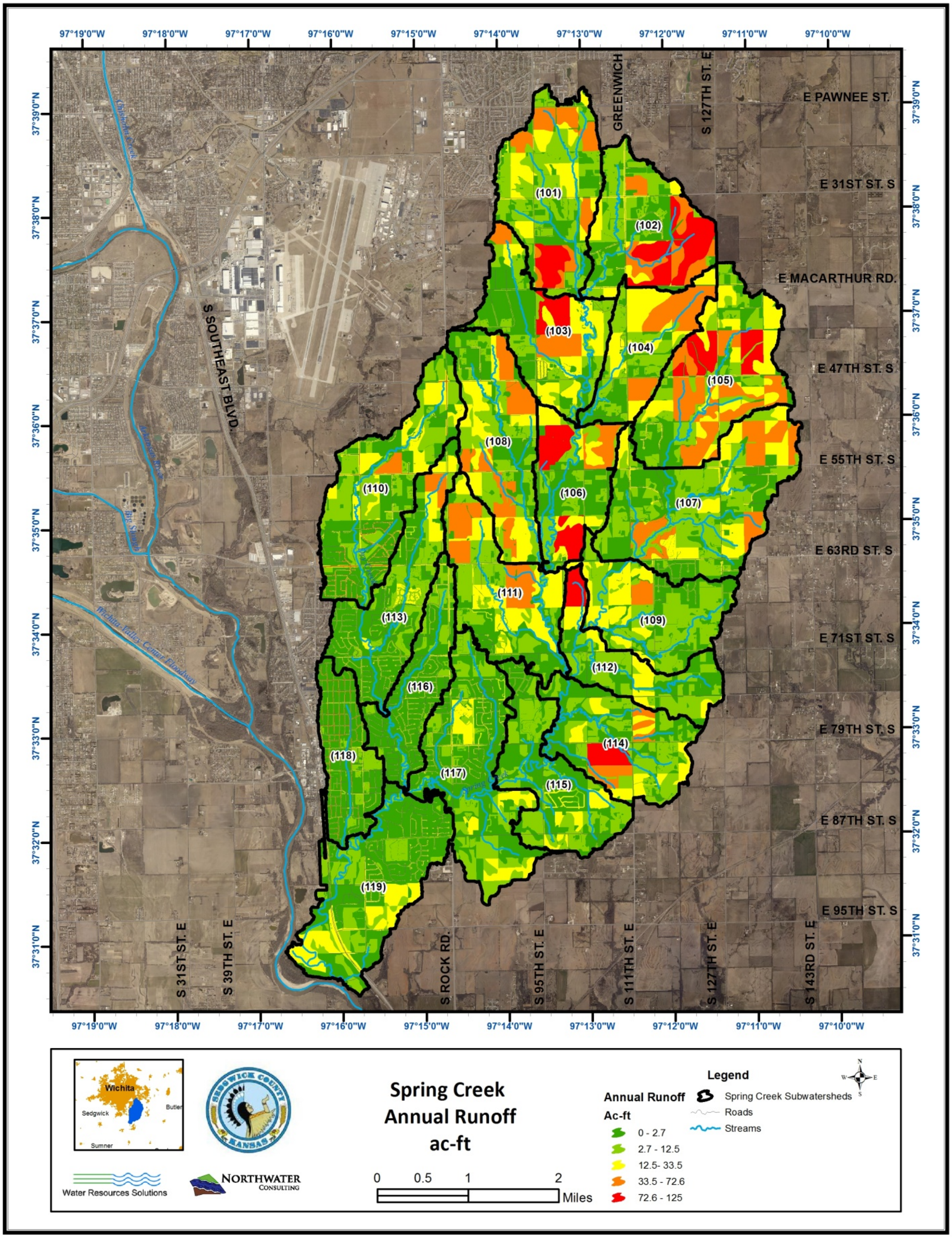


Figure 22: Spring Creek Annual Runoff Map

Stream Bank & Gully Erosion

Stream bank erosion was assessed in the field during a detailed stream assessment and evaluated using GIS. Erosion estimates include eroding bank height, length eroding and an estimate of the lateral recession rate (LRR) or the annual soil loss in feet. Overall, it is estimated that Spring Creek and tributaries are eroding at a total of 15,754 tons of sediment per year, with nitrogen and phosphorus loads of 36,235 and 18,117 pounds per year, respectively. As shown in the Figure 23, the most severe erosion is occurring on Spring Creek in Derby and directly east of Derby.

Table 22: Spring Creek Basin Watershed Stream Bank Erosion

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Bank Erosion (tons/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)
11030013030(101)	1,262	55	126	63
11030013030(102)	1,081	43	98	49
11030013030(103)	1,078	157	362	181
11030013030(104)	796	55	126	63
11030013030(105)	1,394	22	51	25
11030013030(106)	794	1,885	4,336	2,168
11030013030(107)	1,701	362	832	416
11030013030(108)	1,143	647	1,488	744
11030013030(109)	967	8.67	20	9.98
11030013030(110)	1,317	145	333	166
11030013030(111)	1,082	2,648	6,091	3,045
11030013030(112)	716	263	606	303
11030013030(113)	1,049	1,112	2,558	1,279
11030013030(114)	1,013	2,059	4,736	2,368
11030013030(115)	965	1,914	4,403	2,201
11030013030(116)	729	1,093	2,515	1,257
11030013030(117)	1,380	249	573	286
11030013030(118)	640	5.64	13	6.49
11030013030(119)	1,362	3,030	6,969	3,484
Grand Total	**20,467**	**15,754**	**36,235**	**18,117**

Gully erosion is the removal of soil along drainage lines by surface water runoff. Once started, gullies will continue to move by headward erosion or by slumping of the side walls unless steps are taken to stabilize the disturbance. Gully erosion occurs when water is channeled across unprotected land and washes away the soil along the drainage lines. Under natural conditions, run-off is moderated by vegetation which generally holds the soil together, protecting it from excessive run-off and direct rainfall. To repair gullies, the object is to divert and modify the flow of water moving into and through the gully so that scouring is reduced, sediment accumulates and vegetation can establish. Stabilizing the gully head is important to prevent damaging water flow and headward erosion. In most cases, gullies can be prevented by good land management practices.

Gully erosion in Spring Creek was evaluated during a watershed windshield survey. Where observed, gullies locations were noted and the appropriate dimensions recorded for calculating soil and nutrient loading. A total of seven gullies were observed in the watershed contributing an estimated annual sediment load of 2,470 tons, an annual phosphorus load of 2,896 pounds and a nitrogen load of 5,791 pounds. It is important to note that the only those gullies visible from the road were evaluated. There are likely many more gullies within the watershed contributing to overall loading totals. Additional field surveys to measure gully erosion or when available, a comparison of water quality data with modeled totals will help to gain a more complete picture of watershed wide gully erosion and loading.

Table 23: Spring Creek Gully Erosion and Nutrient Loading

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Gully Erosion (tons/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)
11030013030101	1,262	97	253	127
11030013030102	1,081	N/A	N/A	N/A
11030013030103	1,078	N/A	N/A	N/A
11030013030104	796	N/A	N/A	N/A
11030013030105	1,394	N/A	N/A	N/A
11030013030106	794	N/A	N/A	N/A
11030013030107	1,701	N/A	N/A	N/A
11030013030108	1,143	11	28	14
11030013030109	967	N/A	N/A	N/A
11030013030110	1,317	4	11	6
11030013030111	1,082	0.8	2.4	1.2
11030013030112	716	N/A	N/A	N/A
11030013030113	1,049	21	55	28
11030013030114	1,013	2,331	5,429	2,714
11030013030115	965	5	13	6
11030013030116	729	N/A	N/A	N/A
11030013030117	1,380	N/A	N/A	N/A
11030013030118	640	N/A	N/A	N/A
11030013030119	1,362	N/A	N/A	N/A
Grand Total	**20,467**	**2,470**	**5,719**	**2,896**

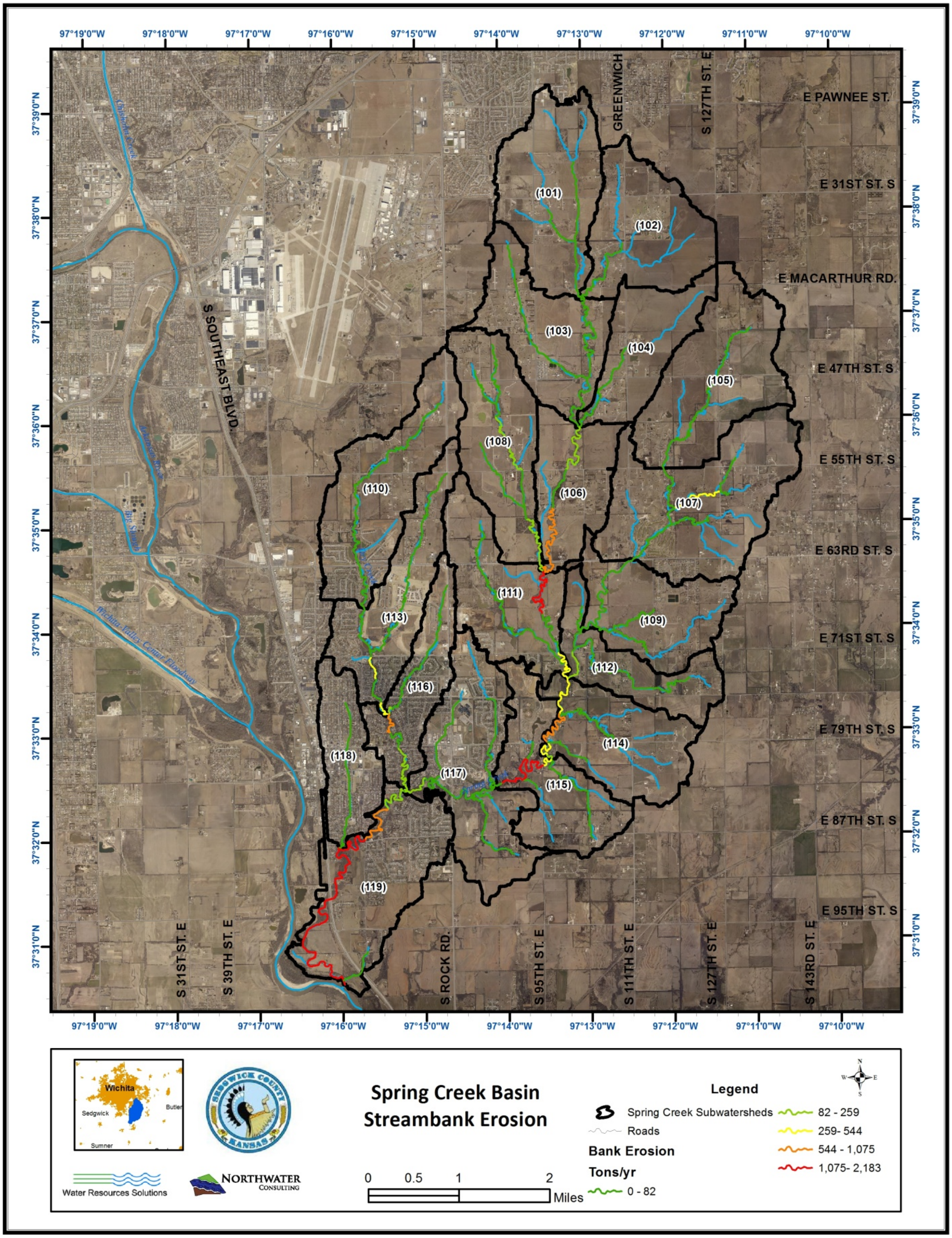


Figure 23: Spring Creek Basin Stream Bank Erosion Map

5.4 Critical Areas

Critical areas describe those areas in a watershed that need to be protected or restored as well as areas where implementation activities will achieve the "biggest bang-for-the buck." Critical areas for the Spring Creek watershed are identified by HUC 14 subwatershed considering the following criteria:

- Highest per acre Phosphorus load
- Highest per acre Nitrogen load
- Highest per acre Bacteria load
- Highest per acre Chloride load
- Highest per acre Sediment load
- Highest annual runoff (acre-feet)
- Highest percentage of row crops and pasture
- Highest percentage impervious surfaces
- Highest percentage HEL soils
- Highest percent area of treated land from site specific BMPs
- Highest percent area of basin wide BMP recommendations
- Greatest percent area detention subbasin
- Highest sediment load from bank erosion

In every watershed, there are specific locations that contribute a greater pollutant load due to soil type, proximity to a stream and land use practices. By focusing BMPs in these areas, pollutants can be reduced at a more efficient rate. Four of the fourteen subwatersheds in the Spring Creek watershed were selected as critical areas. These subwatersheds received the highest score based on a statistical analysis of the criteria listed above. The implementation of BMPs should be given priority if they fall within a critical subwatershed. Specific locations that require BMP placement in order to meet load reductions are described later in this document.

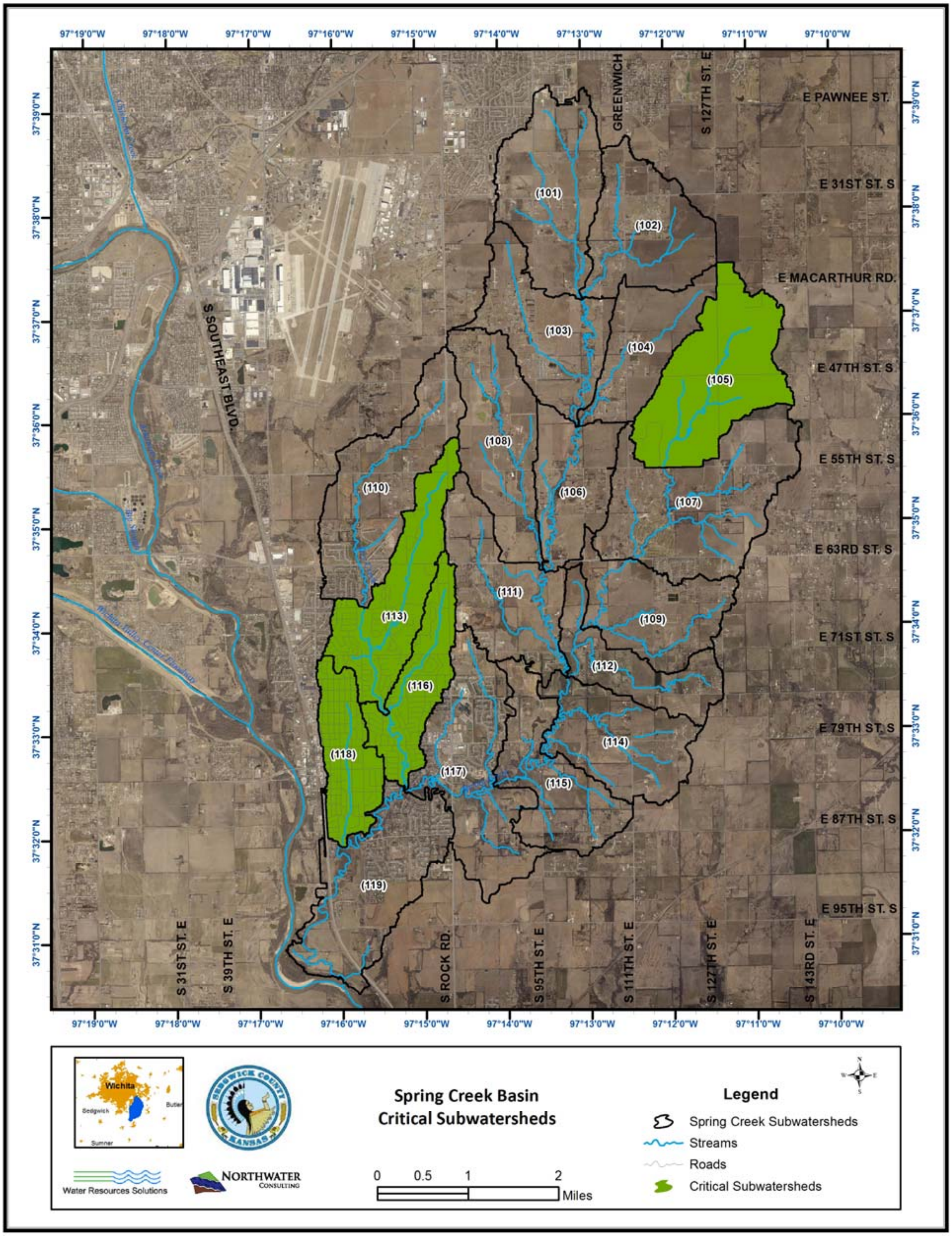


Figure 24: Spring Creek Basin Critical Subwatersheds Map

6.0 MITIGATION MEASURES

Mitigation measures can have an impact on the health and integrity of the watershed. Integration of mitigation measures into the Spring Creek watershed can substantially benefit water quality, habitat, and stream stability. This section will identify and quantify the mitigation measures for flood risk management, stream management, and water quality management.

6.1 Flood Risk Management

Flood risk management can be characterized as the plan and methods used to reduce flooding and protect lives and property. Flood risk management for Spring Creek focuses on the 14 subbasins identified during the hydrologic and hydraulic analysis. Reducing flooding within the watershed will involve reducing the runoff volume within these subbasins. This section describes potential alternatives to decrease the risks of flooding.

6.1.1 Alternatives

Reducing runoff volume in the 14 subbasins can be accomplished by increasing detention volume. Stormwater runoff can be detained at multiple locations, including existing ponds, parking lots, and parks. Figure 25 through Figure 29 show the locations of the existing ponds, parking lots, parks, and a regional detention facility that can provide opportunities for storage.

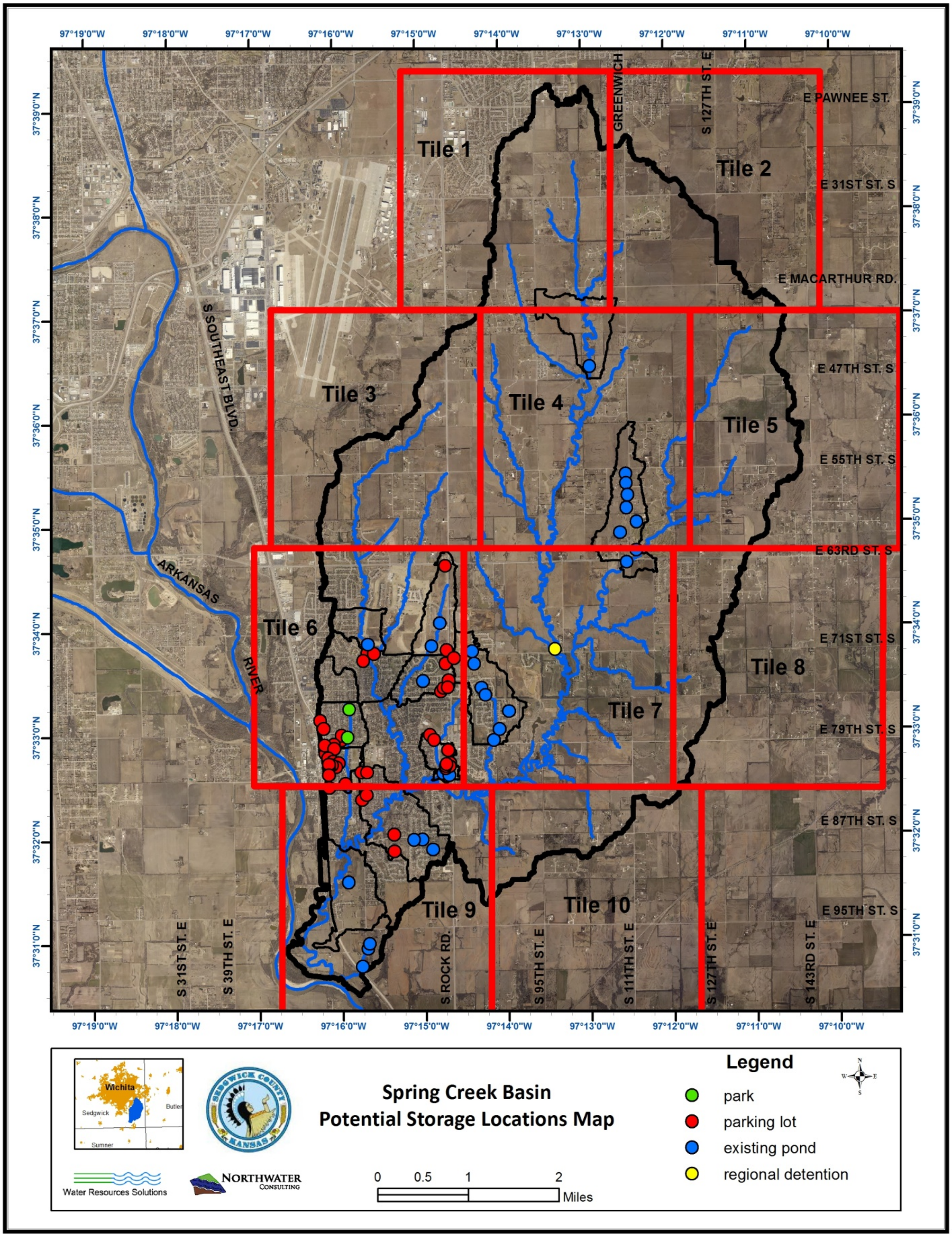


Figure 25: Spring Creek Basin Potential Storage Locations Map

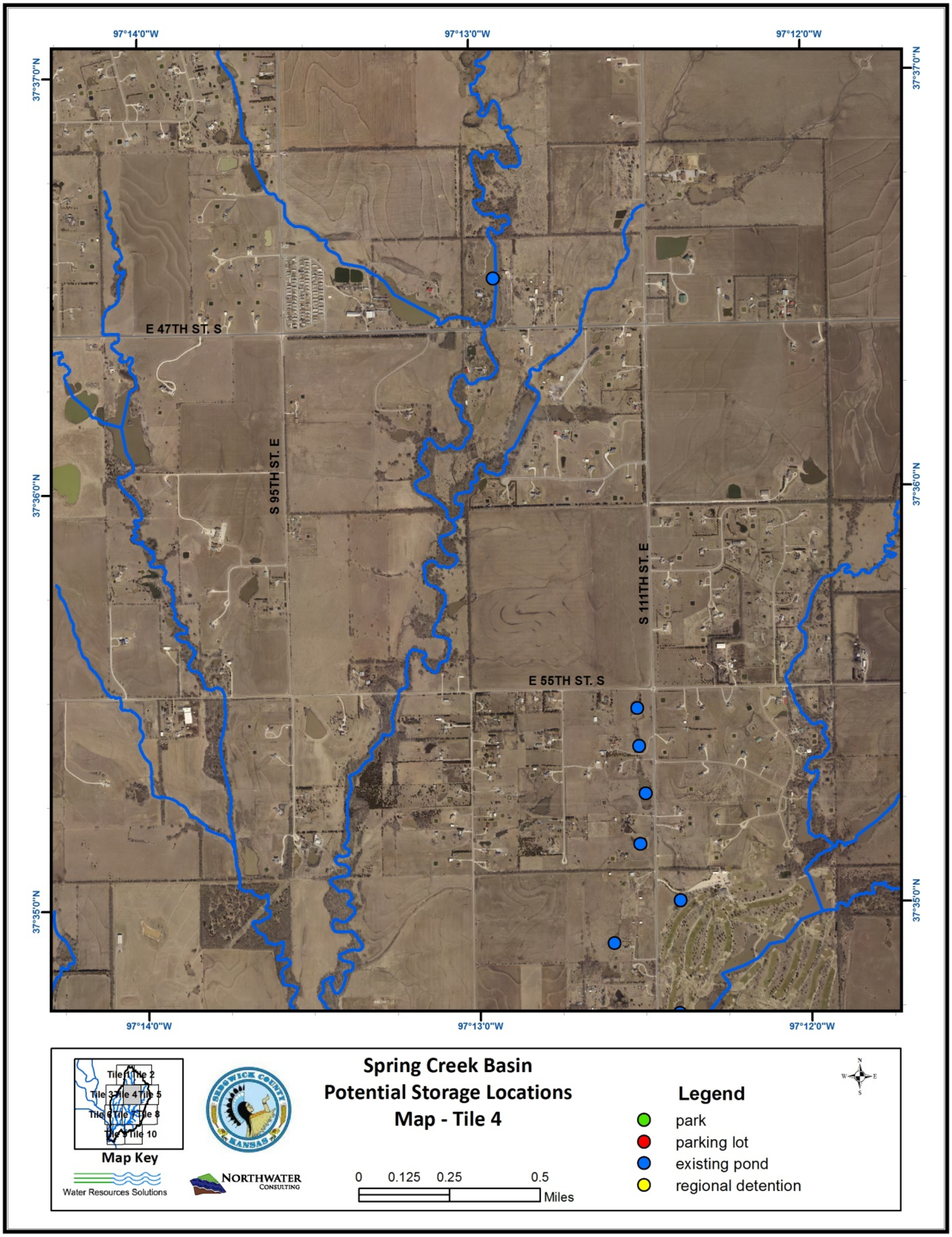


Figure 26: Spring Creek Basin Potential Storage Locations Map – Tile 4

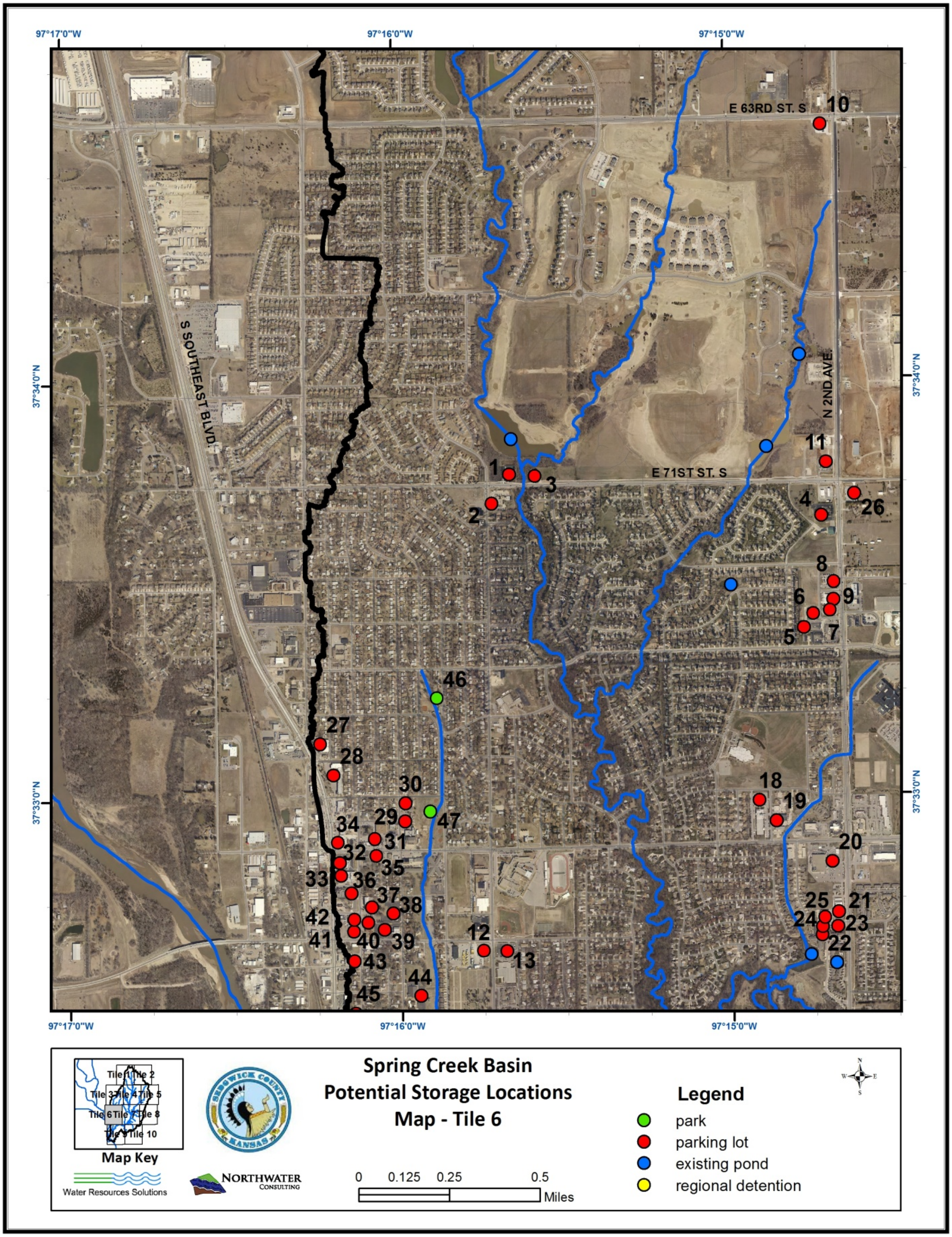


Figure 27: Spring Creek Basin Potential Storage Locations Map – Tile 6

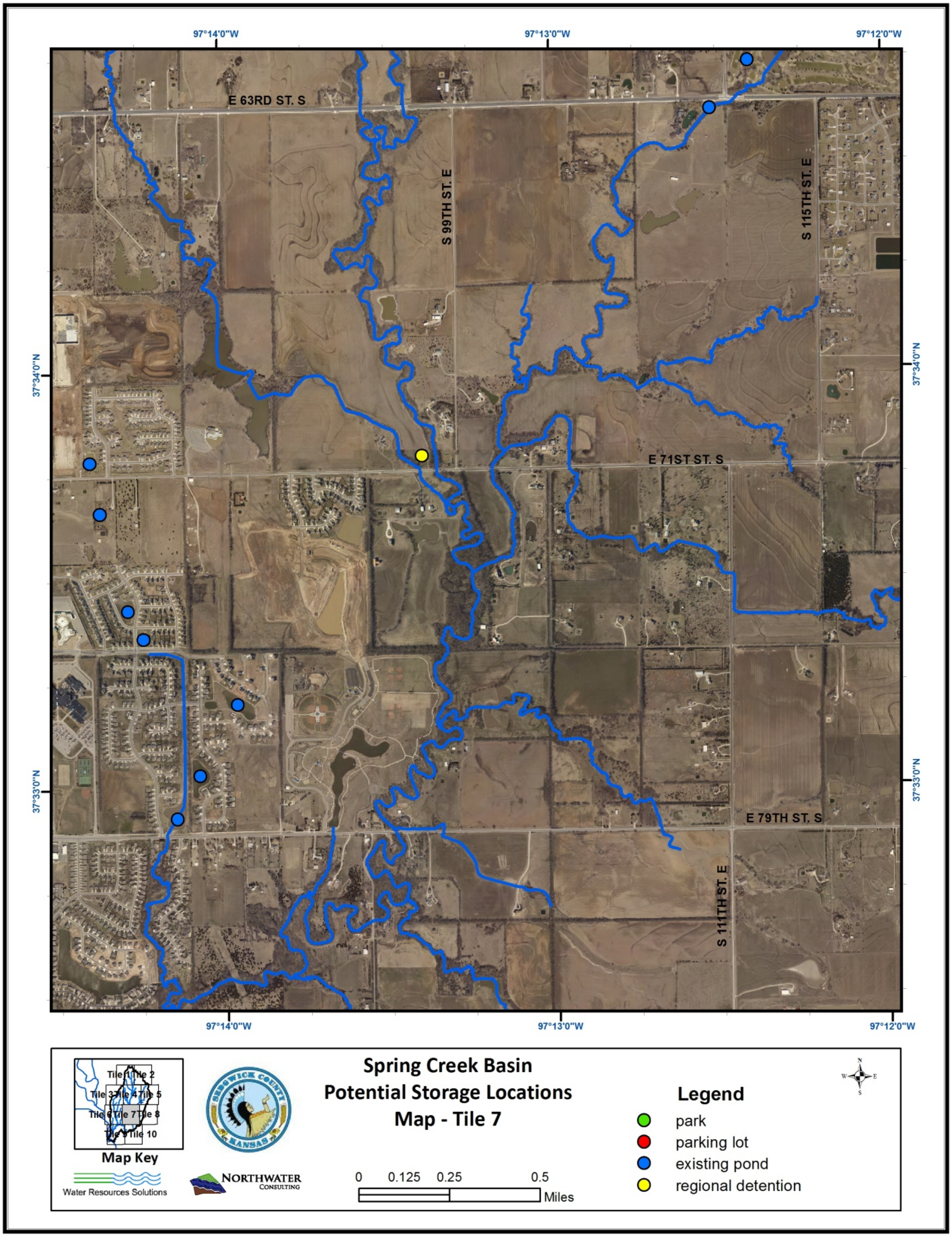


Figure 28: Spring Creek Basin Potential Storage Locations Map – Tile 7

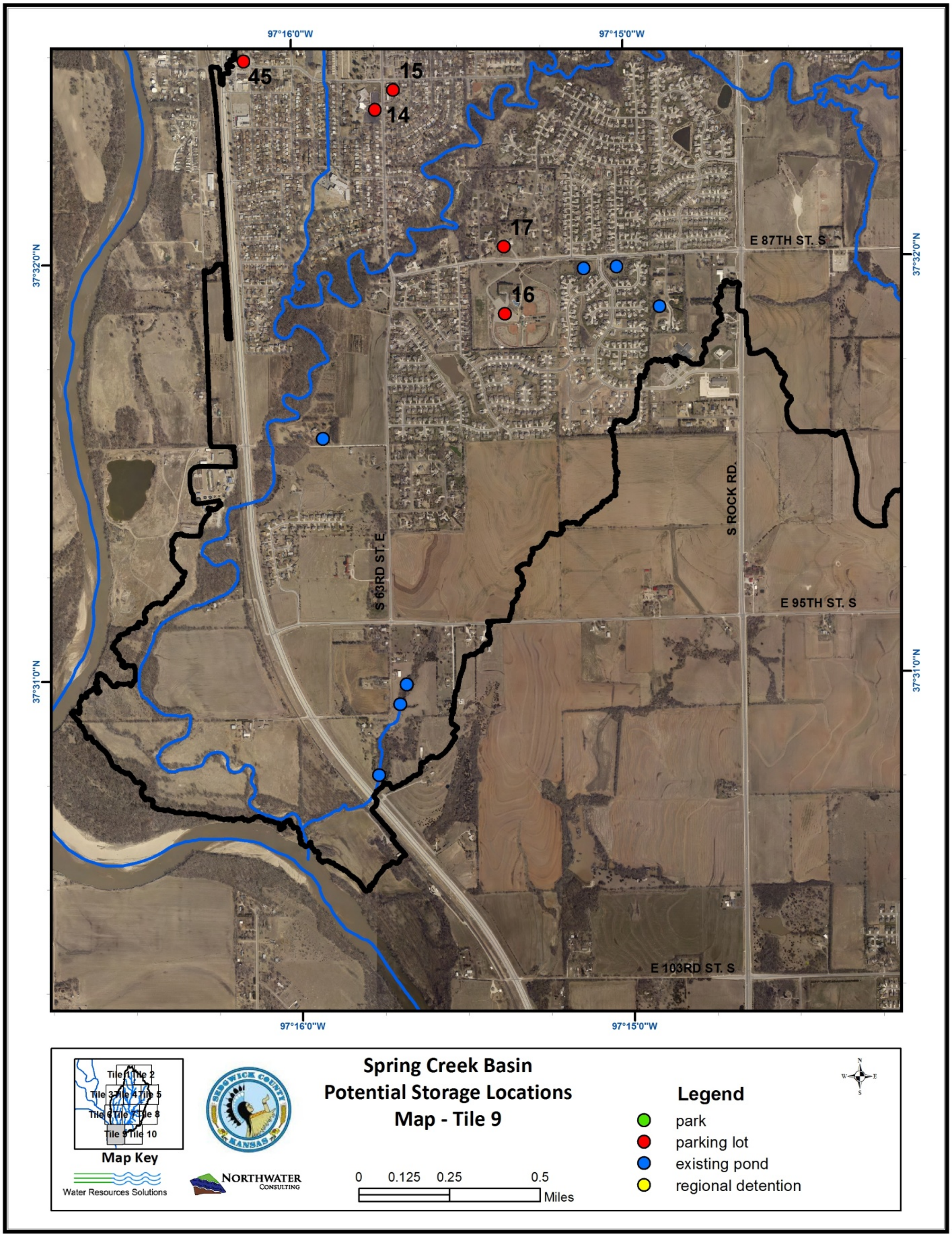


Figure 29: Spring Creek Basin Potential Storage Locations Map – Tile 9

Alternatives mitigation measures that can be used at the potential storage locations are described below.

6.1.1.1 Existing Ponds

There are 29 existing stormwater ponds within the watershed that could potentially be used for stormwater storage and reducing runoff. A majority of the ponds are located in rural areas of the watershed and the outskirts of Derby. The existing outfall structures of these ponds would need to be retrofitted to increase the storage volume. Additional grading or dredging may also be required. Figure 30 below is an example of an existing pond.

Figure 30: Stormwater Pond

6.1.1.2 Parking Lots

There are 45 parking lots identified within watershed that can provide opportunities to store stormwater runoff. Most of these parking lots are located within the City of Derby. Runoff from parking lots can easily be directed to stormwater BMPs such as bioretention cells, rain gardens, and underground vaults. These BMPs allow stormwater to be captured and naturally filtered into the ground. Figure 31 below is an example of an Atlantis D-Raintank underground detention system under a parking lot.

Figure 31: Altantis D-Raintank Underground Detention System

6.1.1.3 Parks

There are two parks within the basin that have the available area to provide opportunities to store stormwater runoff. These parks are all located within the City of Derby. Parks provide the undeveloped land needed to install BMPs such as bioretention cells, stormwater detention basins, ponds and stormwater wetlands. Bioretention cells allow stormwater to be captured and naturally filtered, while stormwater detention basins and wetlands allow stormwater to be captured, treated and released at a reduced rate. Figure 32 shows an example of a stormwater pond and wetland.

Figure 32: Stormwater Wetland

6.1.1.4 Regional Detention

There is also an opportunity within the watershed for a large regional detention facility. It is located between E. 71st Street S. and E. 63rd Street S. near S. 99th Street E. With approximately 80 acres of area for a lake, approximately 1600 ac/ft of detention storage could be provided. A space like this can not only provide the stormwater runoff storage for the watershed, but also provide the opportunity for public recreation. Aside from the 80 acre lake, other amenities may include a park with multi-use trails, public camping, and fishing. There are educational opportunities with Boy and Girl Scout camping, bird watching, and wetland areas identified throughout the park.

6.1.1.5 Other Flooding Issue Locations

There are three locations where the 100-yr water surface elevation is still encroaching on homes or buildings regardless of how much the flowrate is reduced. One location is on the Spring Creek mainstem at 9700 E. 79th Street South, immediately upstream of E. 79th Street South stream crossing. The existing configuration of the E. 79th Street South Bridge is a 40'x50'x40' 3-span concrete structure. Figure 33 shows a picture of the existing bridge. Based on the flowrate and existing opening, it appears that the existing bridge has sufficient capacity. To eliminate upstream property flooding, three options are recommended:

Figure 33: Existing E. 79th Street South Bridge

- Reconstruct approximately 3,100 feet of channel downstream of the bridge.
- Flood proof the threatened property.
- Purchase the property

Stream reconstruction options were not modeled at this location due to the concerns over feasibility and the fact this would involve dropping the channel invert elevation over 1.5 feet.

Two locations with flooding issues are located at 1640 E. Tiara Pines Place, approximately 1,100 feet downstream of S. Rock Road on the Spring Creek mainstem and 2201 E. Madison Avenue, approximately 400 feet downstream of E. 79th Street South on the Spring Creek Tributary 3. Property one is located at 1640 E. Tiara Pines Place in Derby, on the Spring Creek mainstem. The bottom opening to the cellar is below the Spring Creek 100-yr water surface elevation, and the top of the basement window well and first floor elevations are above the 100-yr water surface elevation. Flood proofing is recommended for the opening to the cellar. Property two is located at 2201 E. Madison Avenue on the Spring Creek Tributary 3. This property has a house at the front of the property and a detached garage approximately 170 feet behind the house. The sill elevation of the basement window is above the Spring Creek Tributary 3 100-yr water surface elevation, but the low opening elevation of the garage is below. Flood proofing is recommended for the garage.

6.1.2 Cost

Flood risk management cost estimates were developed for each of the 47 potential parking lot and park area stormwater storage locations identified. The costs were based on surface area, potential storage depth, potential storage volume, demolition and mobilization cost, engineering design, surveying, and geotechnical. A 25% contingency was also included in the total project cost to cover undetermined construction items. For the parking lot areas, it was assumed that 6' Atlantis D-raintank underground storage structures would be used. For the park areas, it was assumed that stormwater basins would be excavated to provide additional storage. Using the average surface area and storage volume, an average construction cost was calculated. This average construction cost was then used to determine an average cost per cubic foot of storage. The complete table showing the total project cost for each of the parking lot and park area flood risk management areas is located in the Appendix C. The cost estimates are concept level, based on 2013 unit costs and are subject to inflation. Cost estimates were not determined for the 29 existing ponds identified within the watershed due to the lack of detailed topographic survey information of these ponds.

6.2 Creek Management

Conceptual recommendations, designs and an opinion of probable cost for stream improvement projects were developed. These conceptual recommendations provide stability for both the stream channel and banks throughout the basin.

6.2.1 Alternatives

Much of the Spring Creek basin is experiencing incision or channel down-cutting. This is evident by knickpoints or sharp changes in the channel elevation. To stabilize streams, it is recommended that engineered rock riffles (ERR) with 1' to 1.5' drops be used. Engineered rock riffles help stabilize streams by halting incision and providing grade control and appropriately spaced pools and riffles. The process used to determine the conceptual designs and costs is outlined below.

- First place an ERR at the downstream end of each reach to stop any further incision.
- Moved up each reach, and using contour data, place an ERR at knickpoints. ERR's should also be placed at the upstream side of bridges to focus flow through the center of the bridge and at the downstream side of culverts. This will protect structures from erosion and incision.

- The elevation change between the initial ERRs was calculated to determine the number of additional ERRs needed to handle the grade change. The additional ERRs were then evenly spaced.

Incision, bank erosion and steep unstable banks are predominant throughout the watershed. To stabilize stream banks, reshaping and bank armoring at the toe of slope with longitudinal peak stone toe protection (LPSTP) is recommended. The upper banks should be reshaped and revegetated to provide stabilization and a functioning riparian corridor. There are four proposed stream representative sections recommended for the watershed. The stream representative sections are:

- LPSTP with 3:1 side slopes
- LPSTP with 3:1 side slopes and retaining wall at upper left descending bank
- LPSTP with 3:1 side slopes and retaining wall at upper right descending bank
- LPSTP with 3:1 side slopes and retaining walls at upper bank of both banks
- Retaining walls on both banks

The appropriate stream representative section was selected by using the contour data and aerial photos. Where space was available, the LPSTP with 3:1 side slopes representative section was chosen. Stream representative sections that include retaining walls are recommended in those areas where existing structures or residential yards are within the 3:1 slopes. Details of the proposed stream representative sections are found in Appendix G. Figure 34 through Figure 45 show the location of the grade and bank stabilization measures throughout the watershed.

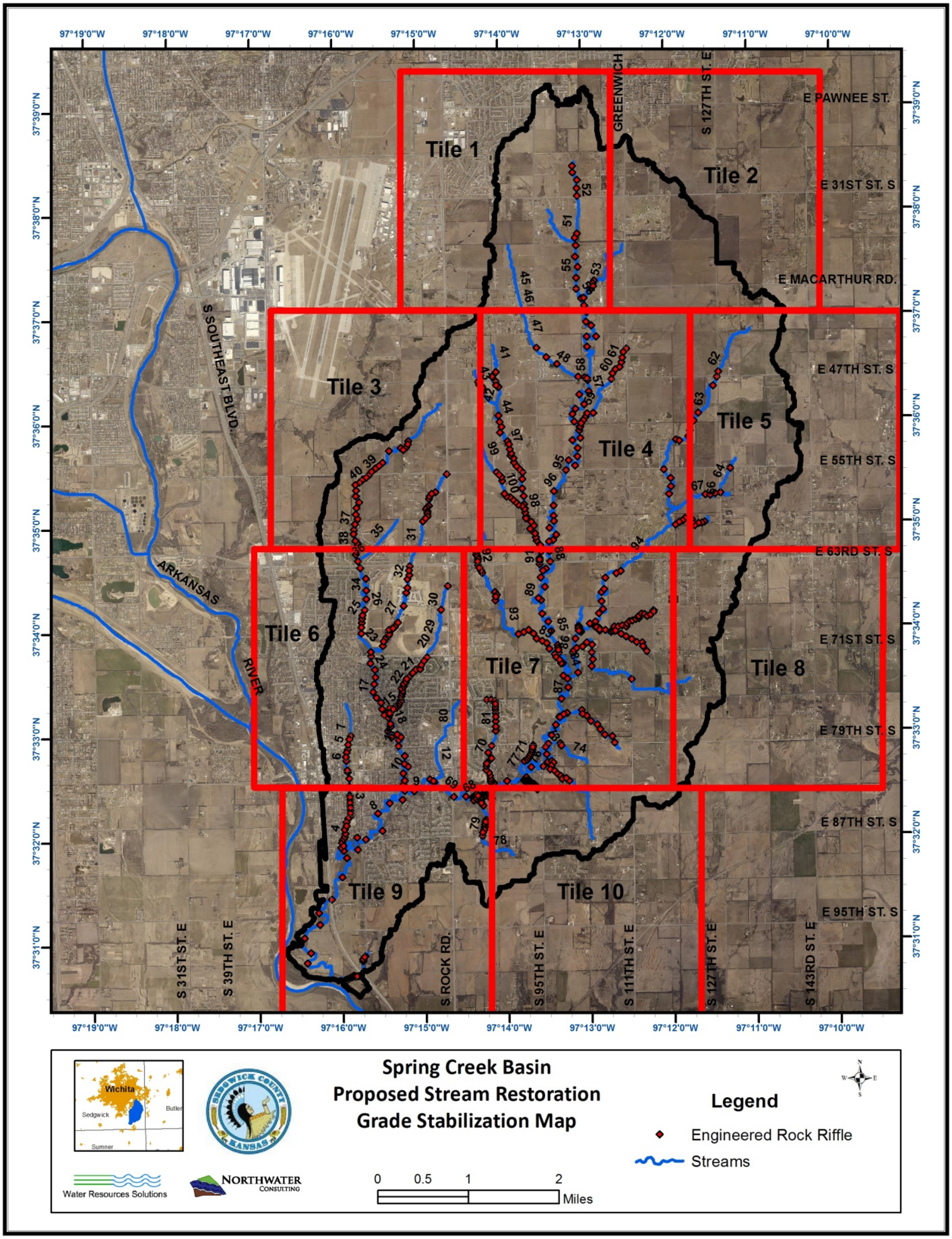


Figure 34: Spring Creek Basin Proposed Stream Restoration Grade Stabilization Map

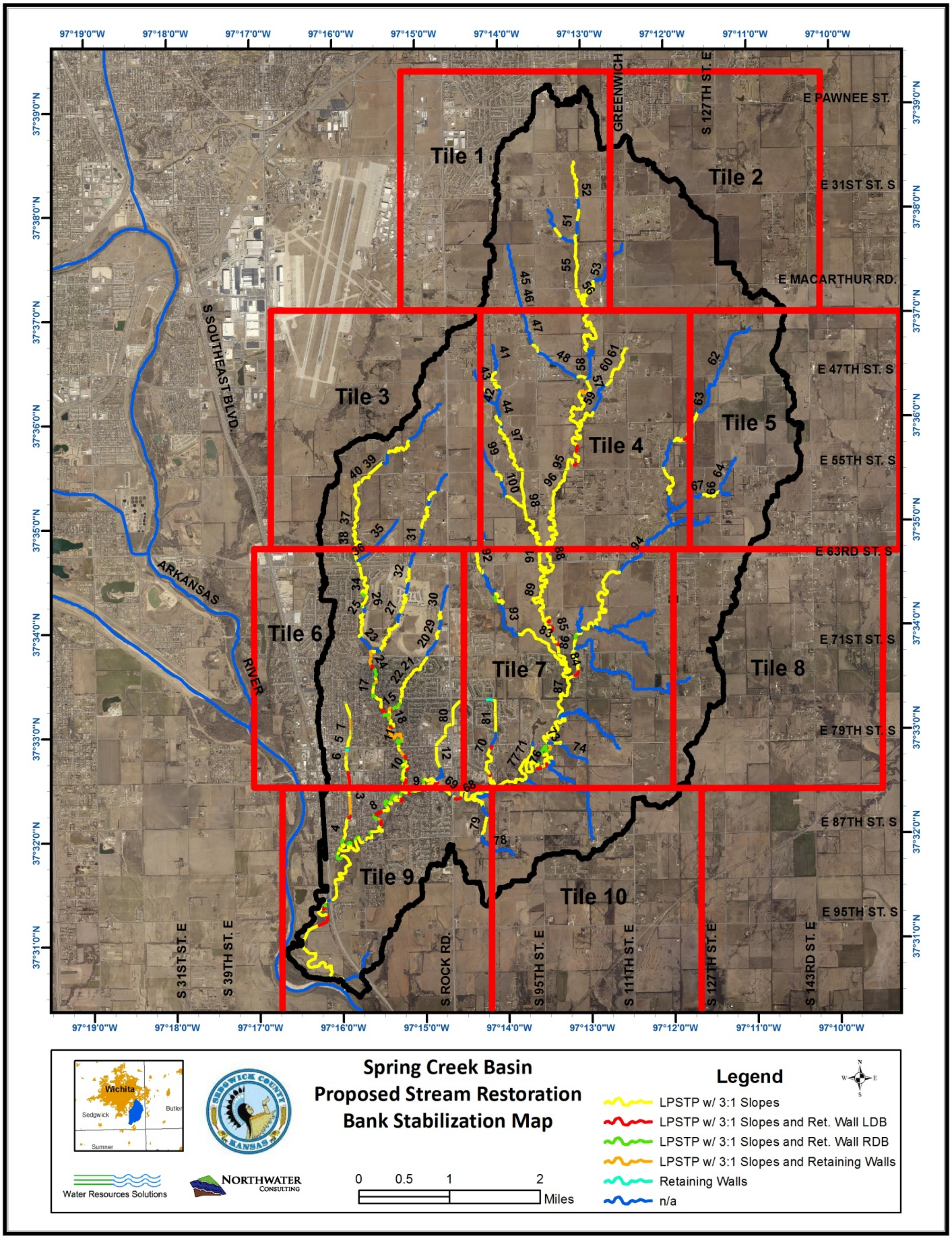


Figure 35: Spring Creek Basin Proposed Stream Restoration Bank Stabilization Map

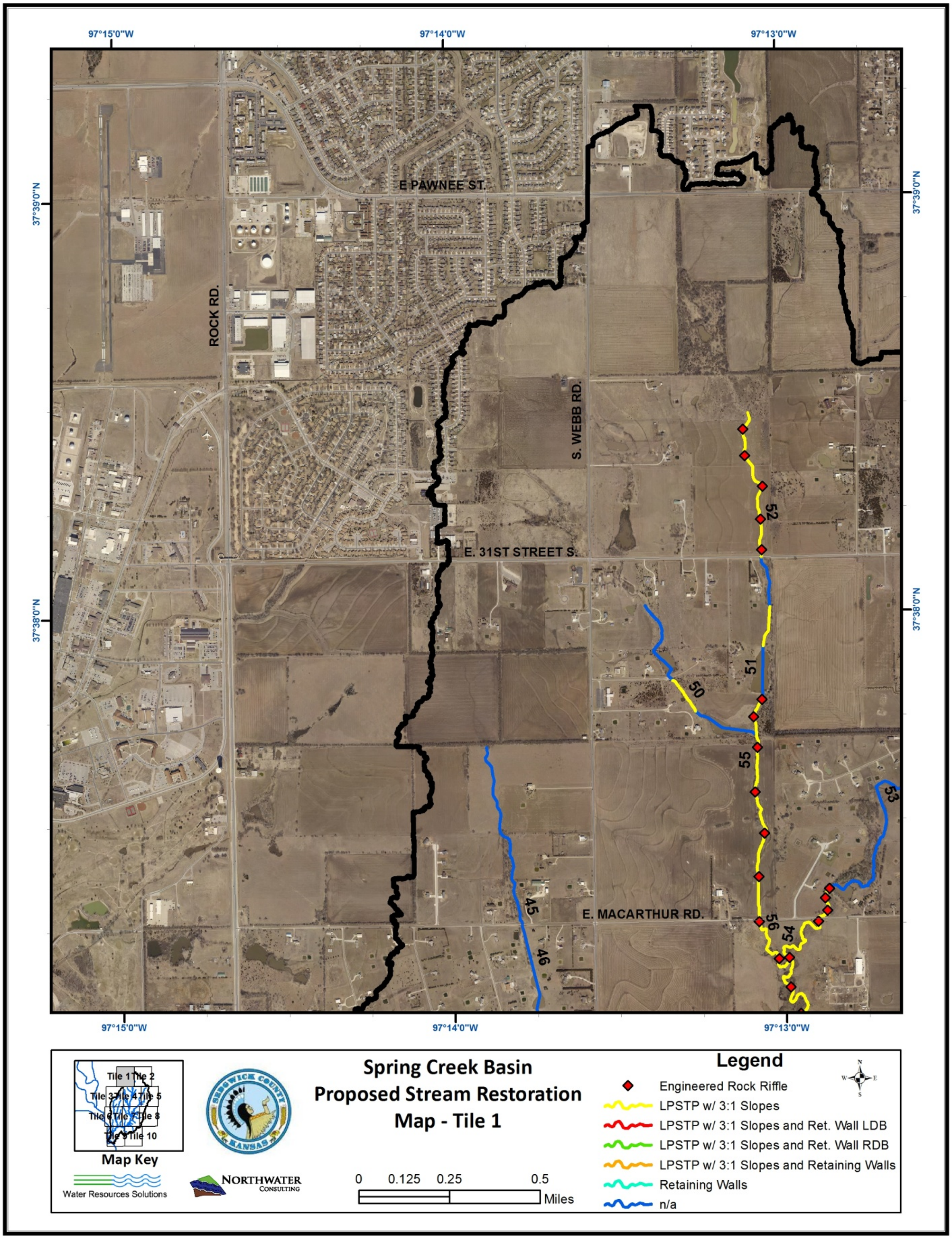


Figure 36: Spring Creek Basin Proposed Stream Restoration Map – Tile 1

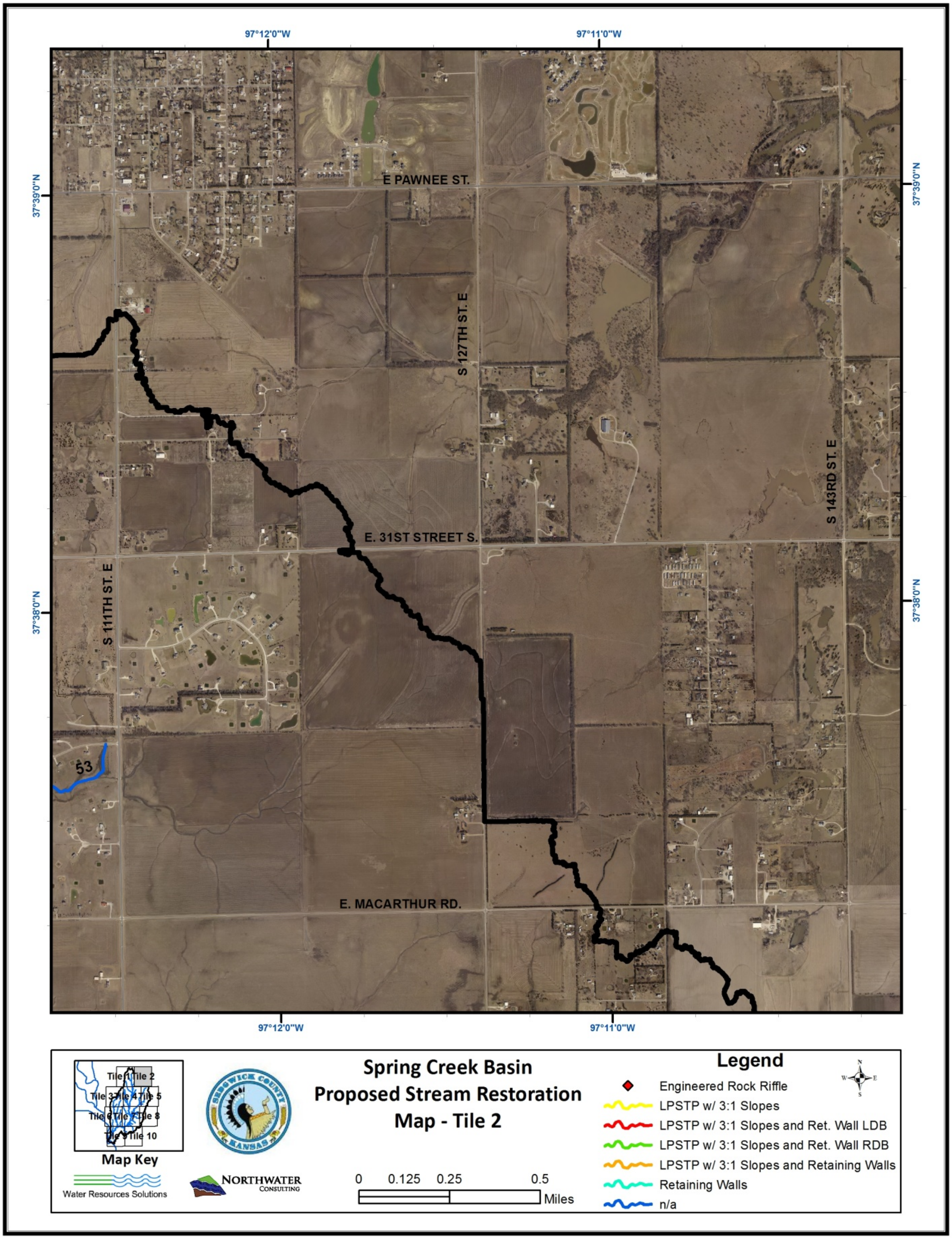


Figure 37: Spring Creek Basin Proposed Stream Restoration Map – Tile 2

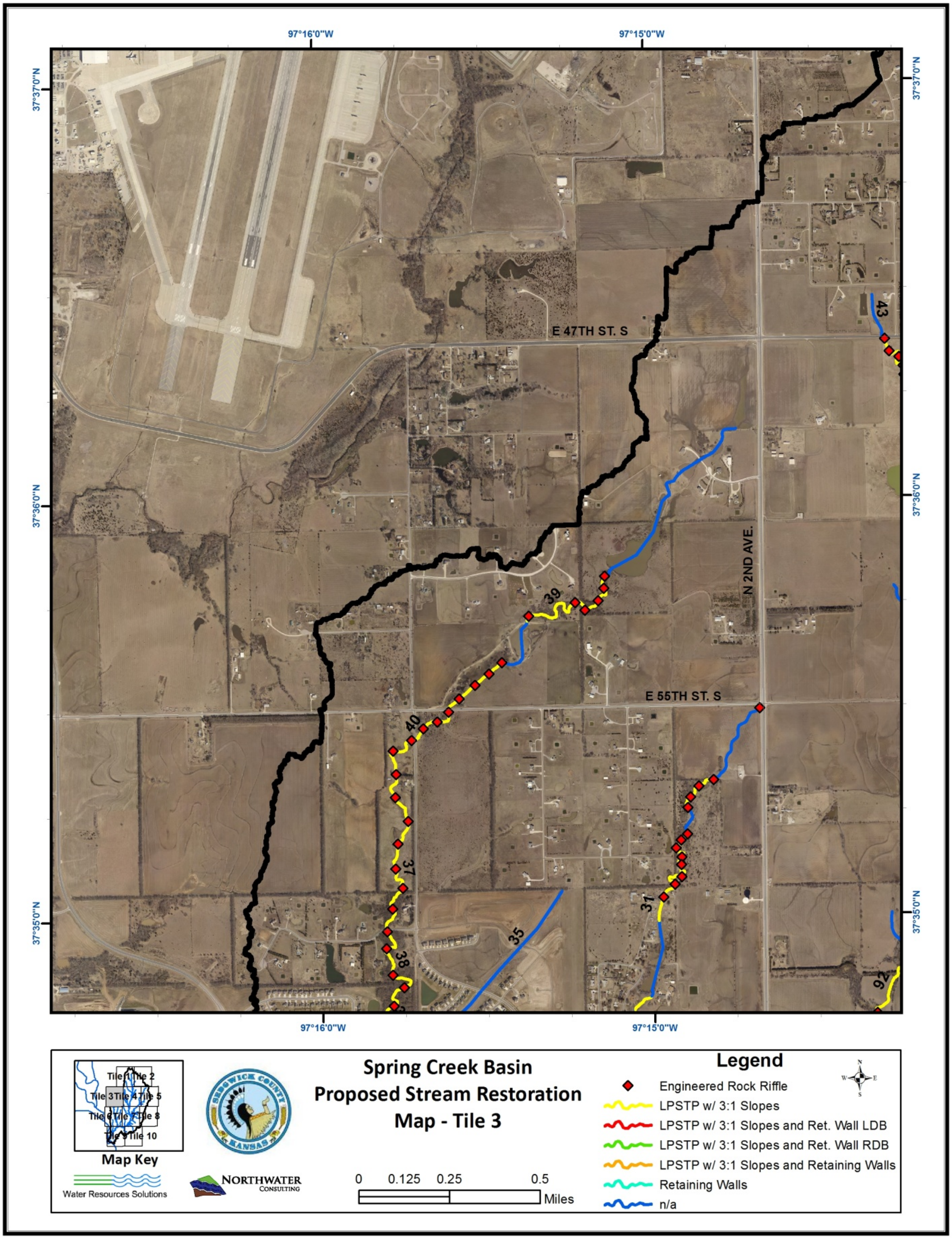


Figure 38: Spring Creek Basin Proposed Stream Restoration Map – Tile 3

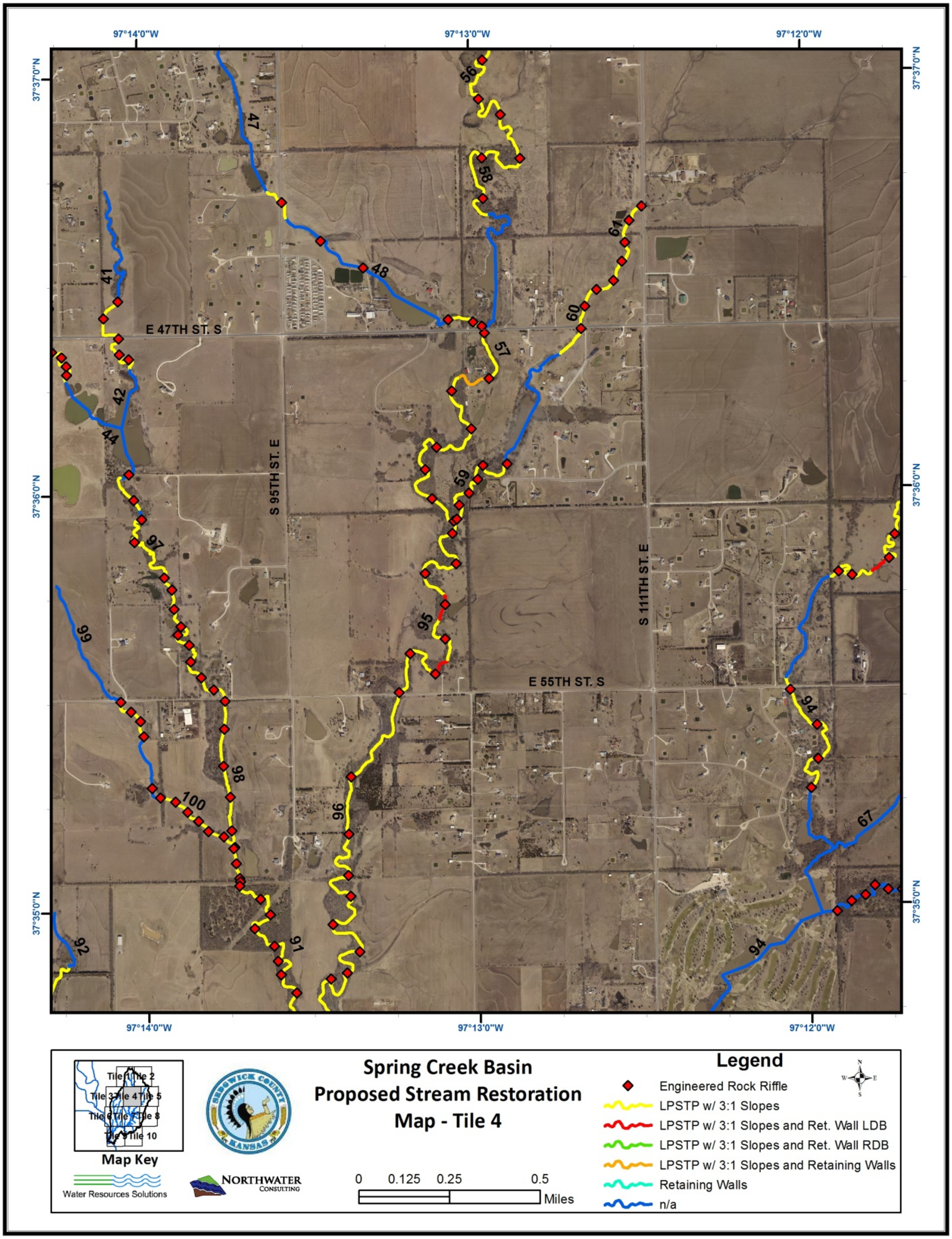


Figure 39: Spring Creek Basin Proposed Stream Restoration Map – Tile 4

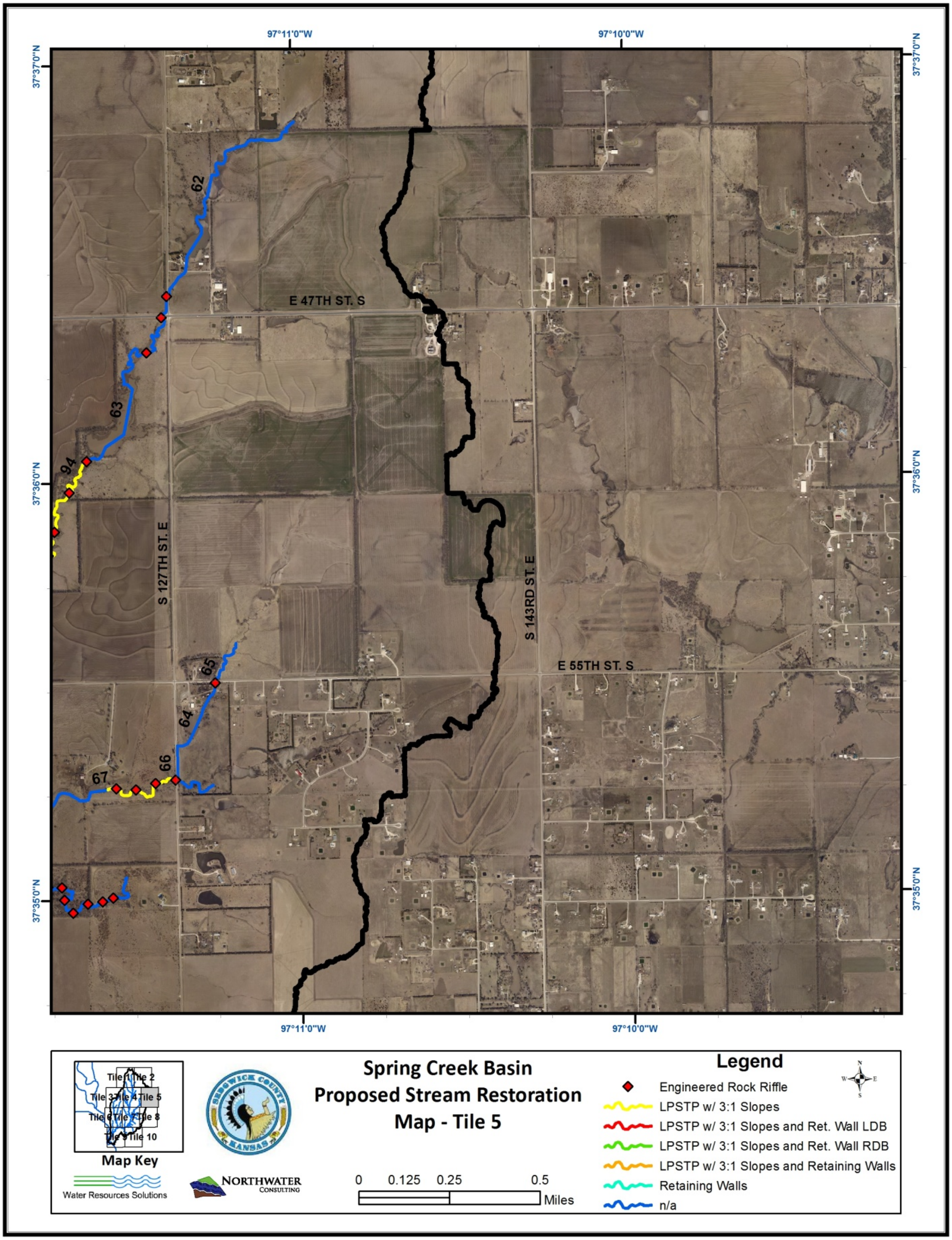


Figure 40: Spring Creek Basin Proposed Stream Restoration Map – Tile 5

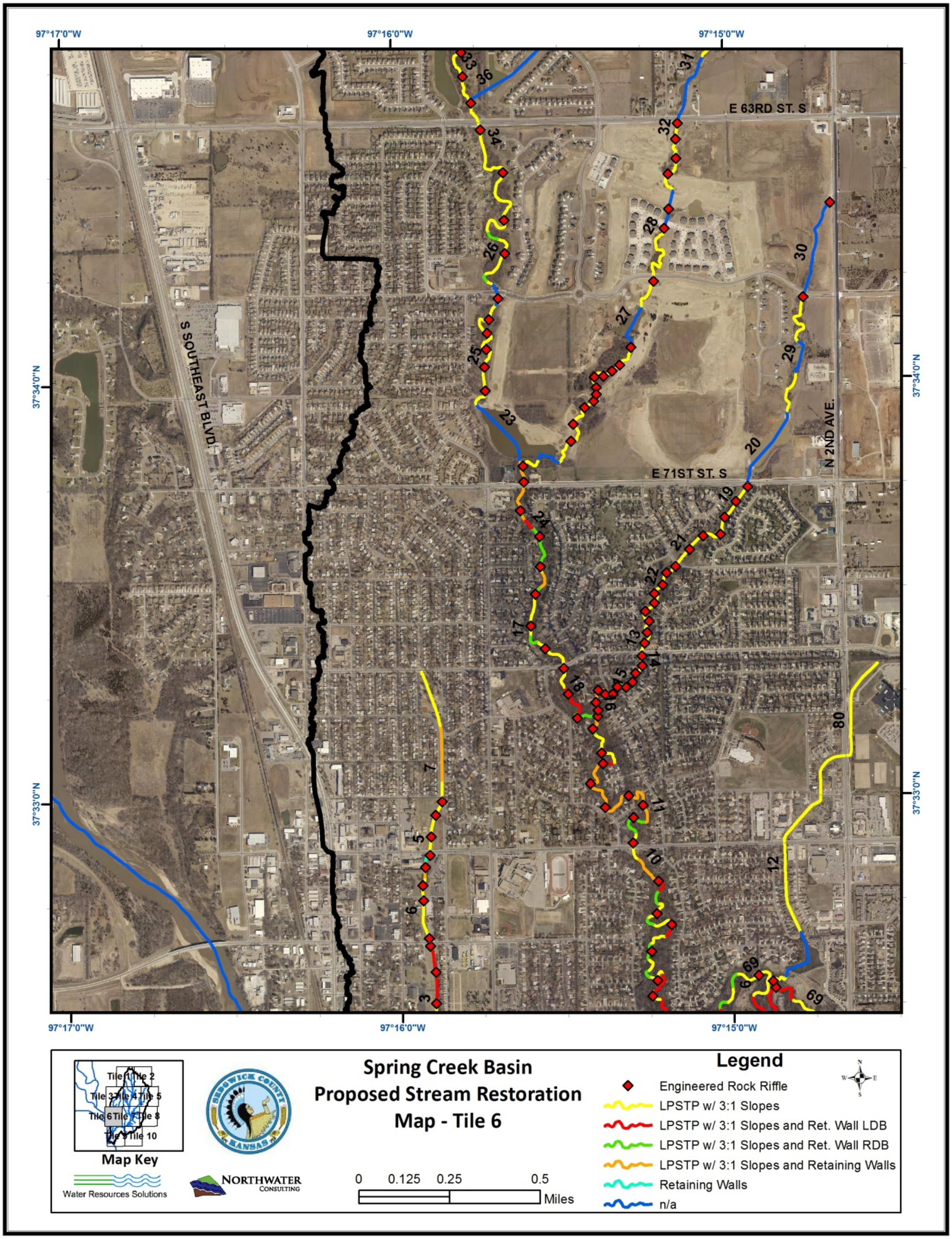


Figure 41: Spring Creek Basin Proposed Stream Restoration Map – Tile 6

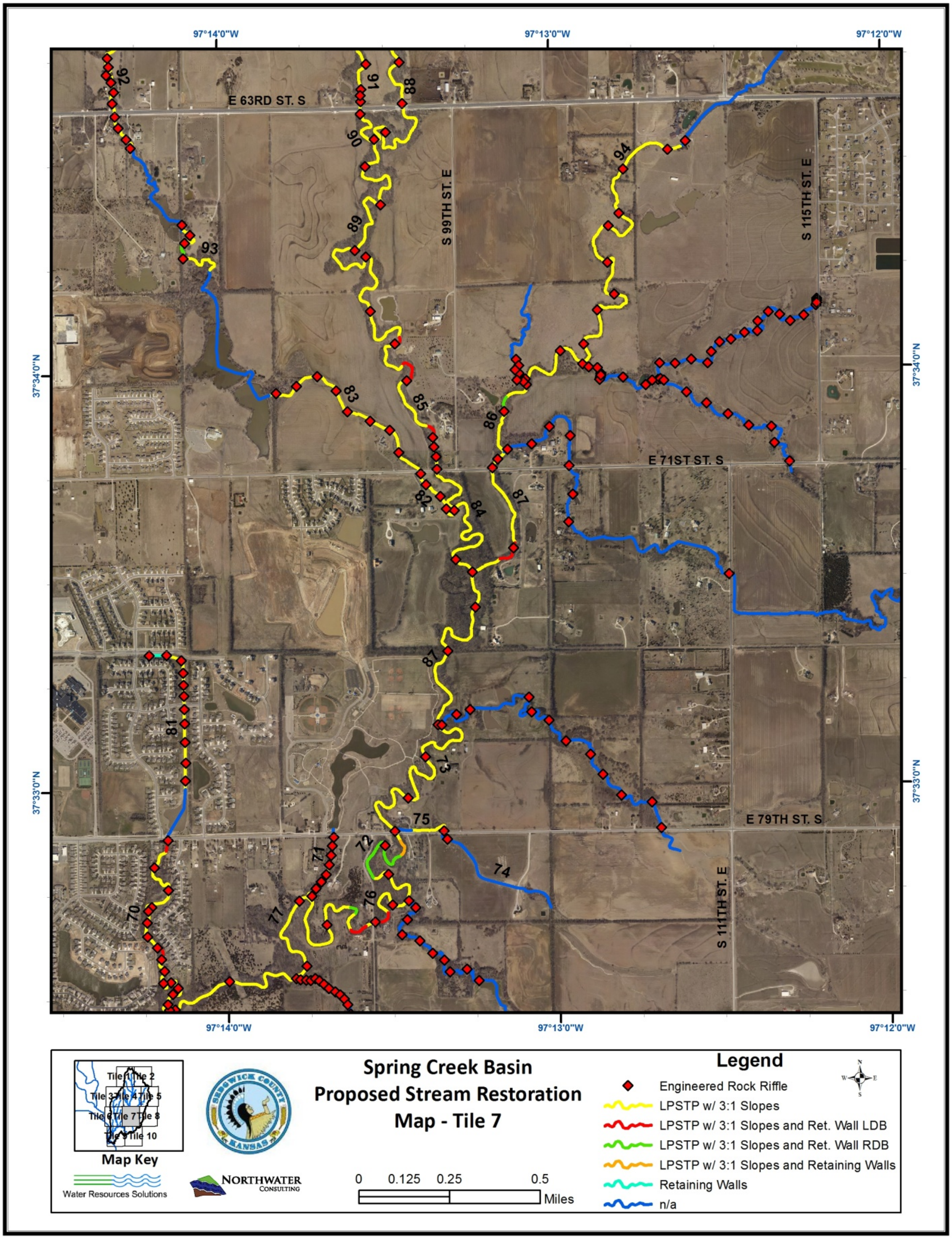


Figure 42: Spring Creek Basin Proposed Stream Restoration Map – Tile 7

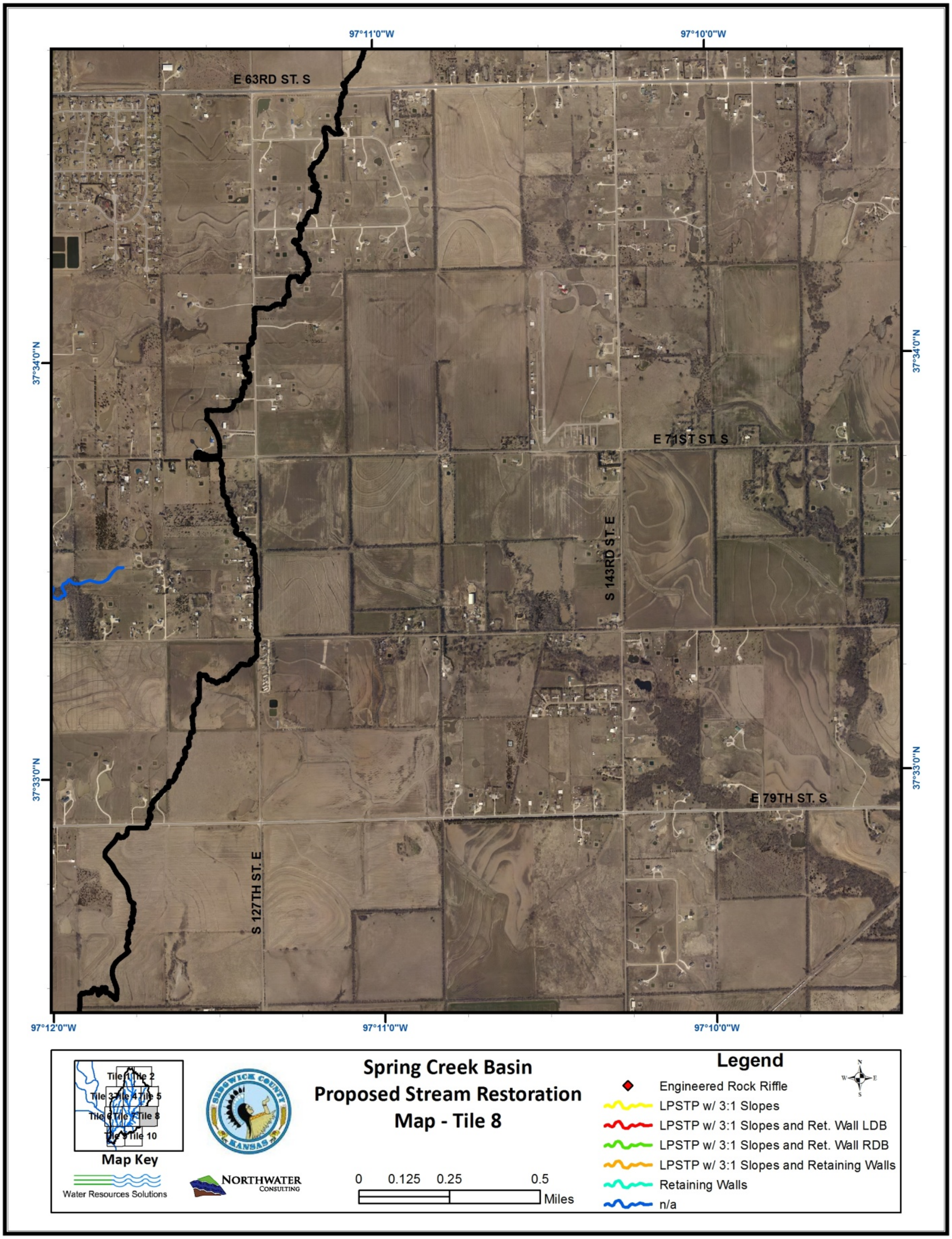


Figure 43: Spring Creek Basin Proposed Stream Restoration Map – Tile 8

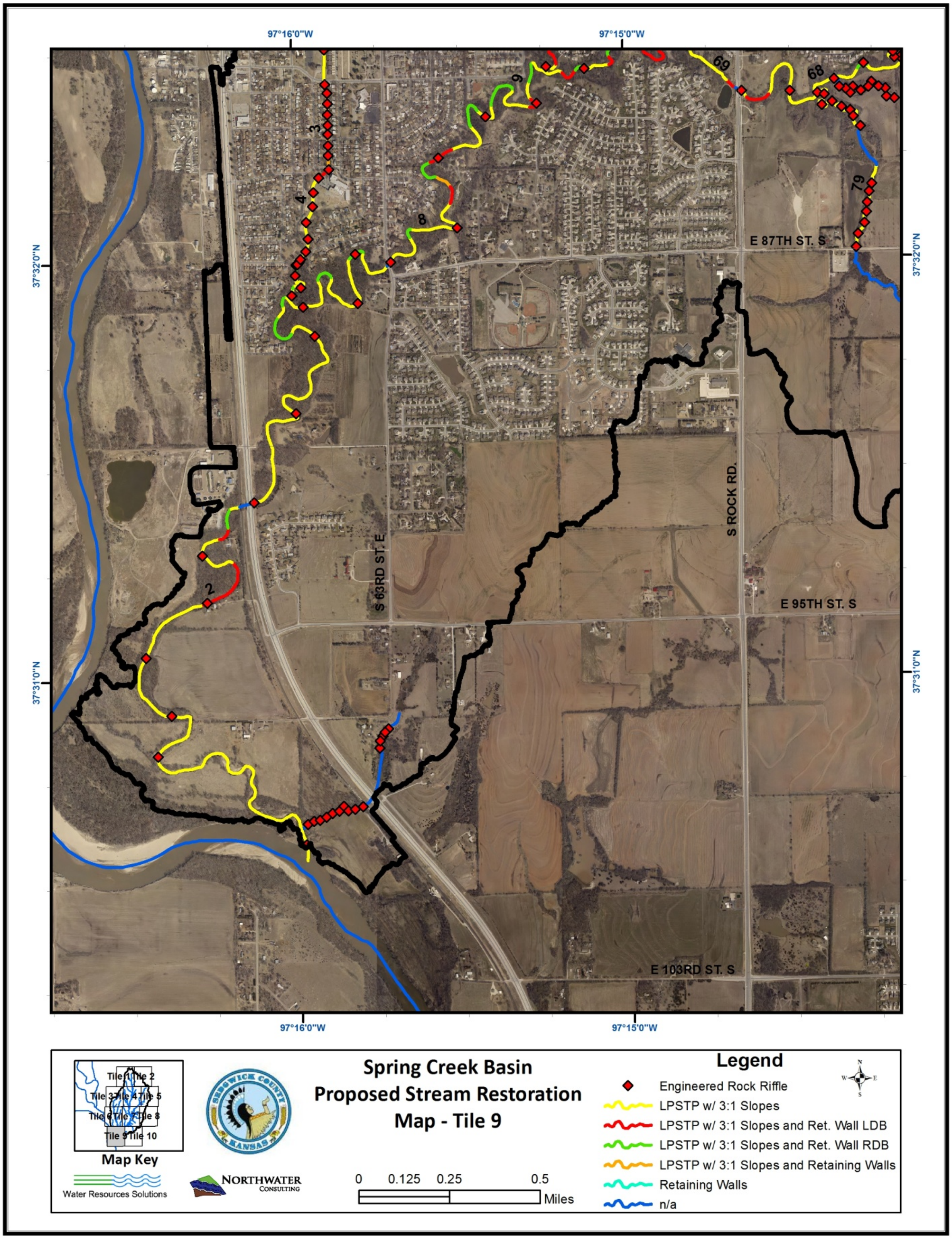


Figure 44: Spring Creek Basin Proposed Stream Restoration Map – Tile 9

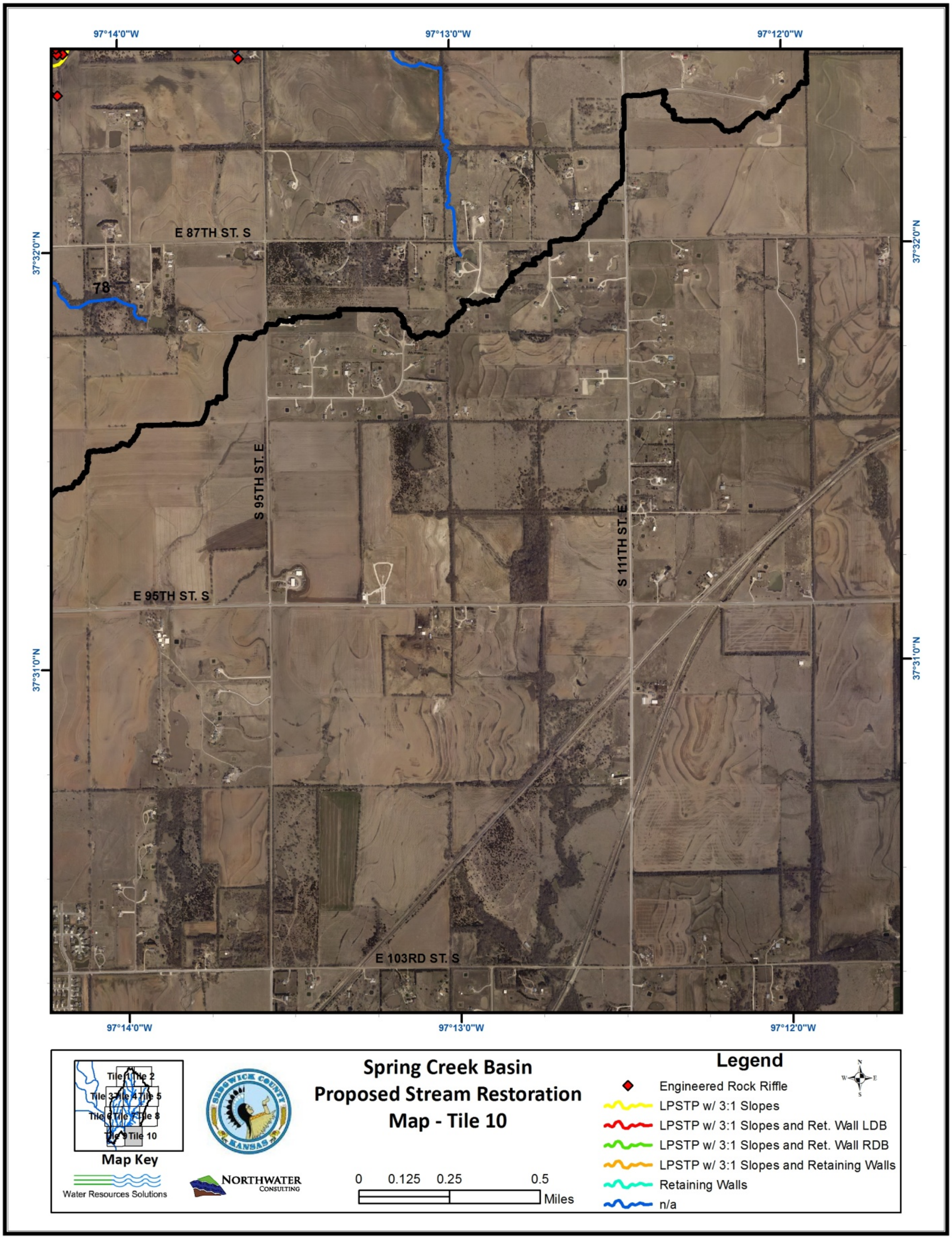


Figure 45: Spring Creek Basin Proposed Stream Restoration Map – Tile 10

6.2.2 Cost

Stream restoration cost estimates were developed for each reach within the Spring Creek watershed. The costs were based on the number of engineered rock riffles, type of stream bank restoration measures, demolition and mobilization cost, engineering design, surveying, and geotechnical. A 25% contingency was also included in the total project cost to cover undetermined construction items. Table 24 below shows the unit costs used to develop the total project costs for each stream reach. The cost estimates are concept level, based on 2013 unit costs and are subject to inflation. The complete table showing the total project cost for each of the stream reaches is located in the Appendix F.

Table 24: Creek Stabilization Unit Costs

Item	Unit Cost	Unit
LPSTP	$ 360	LF
LPSTP w/ Retaining Wall on LDB	$ 300	LF
LPSTP w/ Retaining Wall on RDB	$ 300	LF
LPSTP w/ Retaining Walls on Both Banks	$510	LF
Retaining Walls on Both Banks	$ 350	LF
Engineered Rock Riffle	$10,000	Each
Demolition/Mobilization	25%	n/a
Engineering Design	12%	n/a
Surveying	3%	n/a
Geotechnical	3%	n/a
Contingency	25%	n/a

*These costs are concept level based on 2013 unit costs and are subject to inflation.

6.3 Water Quality Management & Pollution Load Reductions

Best Management Practices (BMPs) can be described as a practice or procedure to prevent or reduce water pollution and flooding. BMPs typically include treatment requirements, operating procedures, and practices to control runoff and abate the discharge of pollutants. This section of the plan will describe both site specific BMPs as well as those that can be applied basin wide to achieve measurable load reductions in flooding, Nitrogen, Phosphorus, Sediment, bacteria and Chloride. A watershed wide survey was conducted to evaluate point source discharges, document watershed features and the location of potential BMPs. Basin wide BMPs were identified using GIS and other locally available information.

Recommended practices focus on both point source and NPS pollution. Estimates of the expected pollution load reductions associated with recommended practices are included in this section. Load reductions were calculated using pollutant removal efficiency percentages based on existing literature and local expertise. Pollutant removal efficiencies can be found in the SWAMM model methodology document in the Appendix H.

6.3.1 Relevant Documents

It is important to understand any existing plans or documents relevant to the watershed. This understanding is critical for informing current planning efforts, avoiding duplication of efforts and for ensuring a linkage with any higher level plans. Several planning projects/plans and reports have been completed for the Arkansas River and the State of Kansas. Although these plans do not specifically address Spring Creek, they do encompass the Arkansas River for which Spring Creek is a tributary. Each document provides guidance for the Spring Creek plan and a mechanism for developing future funding opportunities. Completed TMDL plans for example, identify water quality impairments relevant to Spring Creek and may be used to justify water quality project funding requests through the state's Clean Water 319 program. A TMDL also outlines project or practice recommendations required to reduce impairments; similar practices are recommended for Spring Creek in Section 6.3.2.

Currently, there are four active TMDL plans relevant for Spring Creek. Table 25 below lists each TMDL, their water quality impairments and relevance. Two additional TMDL documents completed for the Lower Arkansas River resulted in a water quality impairment delisting and are no longer relevant. A large scale Watershed Restoration and Protection Strategy (WRAPS) plan for the Little Arkansas River was completed in 2011. Although no WRAPS plan has been completed for the Lower Arkansas River and Spring Creek, the Little Arkansas River plan does provide guidance for improving water quality applicable to Spring Creek. Future plans to develop a Kansas WRAPS plan for the Lower Arkansas River are not known.

Table 25: Summary of Relevant Planning Documents

Plan Title	Plan Year	Plan Purpose	Notes/Relevance
Lower Arkansas River TMDL: Nutrients and Oxygen Demand Impact on Aquatic Life The Lower Arkansas River Below Wichita	2001	To establish percentage load reductions for Available Nitrogen, Total Phosphorus, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD) Macroinvertibrate Biotic Index (MBI) needed to meet the Aquatic Life Use and the narrative nutrient standard.	This report establishes a baseline number from which to measure and pollutant loading and improve aquatic life conditions in the Lower Arkansas. The most important thing about a TMDL is that once in place, the assessed waterbody will receive priority for funding. A TMDL, although very general in terms of implementation, is a mechanism to secure watershed improvement project funding. Often, once a TMDL is completed, additional planning is required to identify specific implementation projects. For Spring Creek, this TMDL provides water quality targets for Nitrogen, Phosphorus and TSS. It also outlines similar recommendations including: nutrient management, riparian buffer strips, terraces, grass waterways, sediment control basins, constructed wetlands and urban stormwater runoff controls
Lower Arkansas River TMDL: Fecal Coliform Bacteria	2000	To establish percentage load reductions for Fecal Coliform bacteria needed to meet the primary and	This report establishes a baseline number from which to measure and pollutant loading and improve recreation contact use in the Lower Arkansas. The most important thing about a TMDL is that once in place, the assessed

The Arkansas River Below Wichita		secondary contact recreation use and the Fecal Coliform standard.	waterbody will receive priority for funding. A TMDL, although very general in terms of implementation, is a mechanism to secure watershed improvement project funding. Often, once a TMDL is completed, additional planning is required to identify specific implementation projects. For Spring Creek, this TMDL provides water quality targets for Fecal Coliform. It also outlines similar recommendations including: permit reviews, livestock waste storage, pasture management, reducing livestock access to streams, riparian buffer strips, and urban stormwater runoff controls
Lower Arkansas River TMDL: Chloride The Lower Arkansas River, Derby to Ark City	2006	To establish percentage load reductions for Chloride needed to meet the domestic water supply use and the domestic water supply and aquatic life standard.	This report establishes a baseline number from which to measure and pollutant loading and improve domestic water supply use in the Lower Arkansas. The most important thing about a TMDL is that once in place, the assessed waterbody will receive priority for funding. A TMDL, although very general in terms of implementation, is a mechanism to secure watershed improvement project funding. Often, once a TMDL is completed, additional planning is required to identify specific implementation projects. For Spring Creek, this TMDL provides water quality targets for Chloride. It also outlines recommendations including: monitor and limit any anthropogenic contributions of chloride loading to the river and employ BMPs to reduce the use of ground water for irrigation.
Lower Arkansas River TMDL: Chloride The Lower Arkansas River, Maize to Derby	2006	To establish percentage load reductions for Chloride needed to meet the domestic water supply use and the domestic water supply and aquatic life standard.	This report establishes a baseline number from which to measure and pollutant loading and improve domestic water supply use in the Lower Arkansas. The most important thing about a TMDL is that once in place, the assessed waterbody will receive priority for funding. A TMDL, although very general in terms of implementation, is a mechanism to secure watershed improvement project funding. Often, once a TMDL is completed, additional planning is required to identify specific implementation projects. For Spring Creek, this TMDL provides water quality targets for Chloride. It also outlines recommendations including: monitor and limit any anthropogenic contributions of chloride loading to the river and Employ BMPs to reduce the use of ground water for irrigation.
Little Arkansas River Watershed Restoration and Protection Strategy (WRAPS)	2011	To outline a plan of restoration and protection goals and actions for the surface waters and ground waters of the watershed.	The goal of the WRAPS process is to create and implement a plan to restore the health of water bodies that do not meet their water quality standards. Additionally, the WRAPS process insures that water bodies that currently meet their water quality standards are protected. Relevant to Spring Creek, The WRAPS plan offers practice guidance and a framework for improving water quality.

6.3.2 Alternatives – Site Specific

Site Specific BMPs are those practices where a field visit has resulted in the identification of a specific project and project location. Site specific practices are located throughout the watershed and include:

1. Grassed Waterway: A grassed strip in fields that acts as an outlet for water to control silt, filter nutrients and limit gully formation.
2. Terraces/Water and Sediment Control Basin (WASCB): Earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
3. Detention Basin/Pond/Regional Detention Basin: A sediment or water impoundment made by constructing an earthen dam.
4. Waste Lagoon: A impoundment made by constructing an earthen dam used to trap livestock waste from concentrated feeding areas

Priority should be given to those BMPs with the greatest load reductions and/or that fall within a designated critical area. With the exception of a large regional detention basin located at 71st and 91st streets, site specific BMP recommendations for Spring Creek will treat 2,337 acres in the watershed or 11%. If implemented, the large regional detention basin will treat an additional 6,141 acres or 30% of the basin. Table 26 provides a breakdown of BMPs, their individual load reductions and the land area treated by the practice. The values highlighted in red are those located in the critical watersheds.

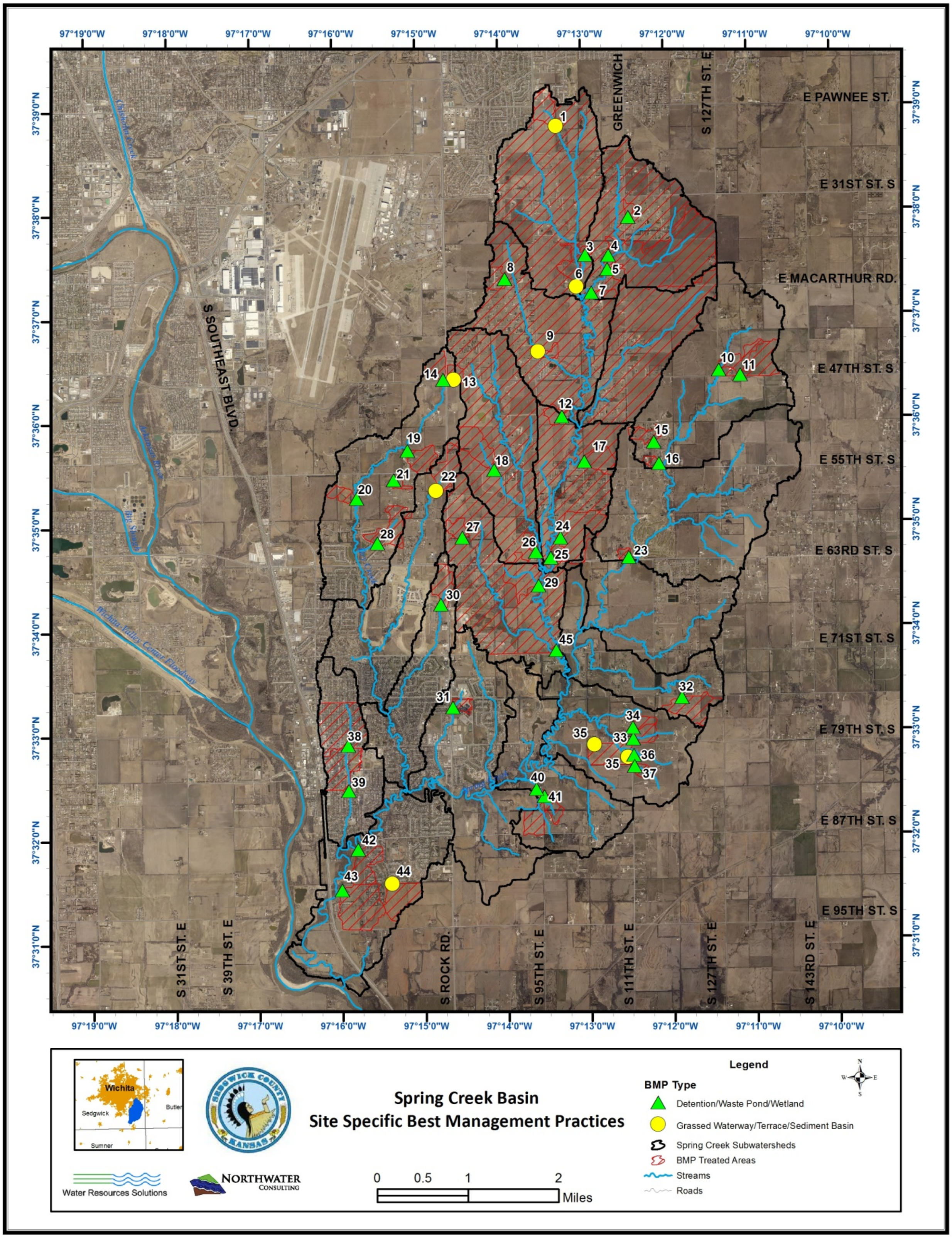


Figure 46: Spring Creek Basin Site Specific Best Management Practices

Table 26: Site Specific Best Management Practices and Load Reductions

BMP Code	BMP Type	In Priority Watershed (yes/no)	Acres Treated	Annual Runoff Reduction (acre/ft)	N Load Reduction (lbs/yr)	P Load Reduction (lbs/yr)	TSS Load Reduction (tons/yr)	Cl Load Reduction (lbs/yr)	Bacteria Load Reduction (Billion Coliform Forming Units/yr)
1	Grass Waterway	no	48	N/A	334	85	58	749	59
2	Detention Basin	no	11	1	8	1	0.4	107	5
3	Detention Basin	no	9	1	8	2	0.4	29	12
4	Detention Basin	no	**405**	**103**	**2,033**	**362**	**335**	**783**	**714**
5	Detention Basin	no	19	2	12	3	0.4	42	15
6	Grass Waterway	no	**41**	**N/A**	**303**	**85**	**109**	**26**	**44**
7	Detention Basin	no	18	5	82	9	5	199	77
8	Detention Basin	no	27	5	26	6	1	142	26
9	Grass Waterway	no	15	N/A	80	7	6	20	22
10	Detention Basin	yes	41	8	146	26	25	144	65
11	Detention Basin	yes	74	18	216	39	35	196	79
12	Detention Basin	no	21	1	14	2	0	4	20
13	Terraces	no	17	N/A	44	17	17	6	8
14	Detention Basin	no	30	6	55	10	8	9	19
15	Detention Basin	yes	30	4	15	4	1	74	22
16	Detention Basin	yes	11	4	56	6	1	94	69
17	Detention Basin	no	49	4	41	6	1	29	56
18	Detention Basin	no	79	13	192	27	23	49	67
19	Detention Basin	no	45	8	60	11	8	98	28
20	Detention Basin	no	27	4	53	7	4	12	49
21	Detention Basin	no	9	1	4	1	0.1	17	6
22	Detention Basin	yes	62	14	365	76	55	776	90
23	Detention Basin	no	10	0.1	2	0.4	0.1	10	2
24	Detention Basin	no	**129**	**37**	**684**	**71**	**27**	**268**	**778**
25	Waste Pond	no	**20**	**7**	**193**	**18**	**4**	**1,244**	**158**
26	Detention Basin	no	14	3	68	6	2	6	84
27	Detention Basin	no	25	6	55	10	8	244	19
28	Detention Basin/ Wetlands	no	**72**	**12**	**138**	**27**	**5**	**2,477**	**123**
29	Detention Basin	no	**78**	**22**	**747**	**81**	**93**	**257**	**800**
30	Detention Basin	yes	**48**	**15**	**149**	**26**	**33**	**1,948**	**62**
31	Detention Basin	no	**18**	**6**	**52**	**7**	**1**	**3,037**	**18**
32	Detention Basin	no	76	18	113	16	20	37	40
33	Detention Basin	no	28	6	90	16	16	121	30
34	Detention Basin	no	18	4	81	14	14	13	27
35	Grass Waterway	no	**74**	**N/A**	**5,728**	**2,802**	**2,401**	**50**	**96**
36	Detention Basin	no	1	0.2	5	1	0.2	34	5
37	Detention Basin	no	16	2	49	9	1	9	50
38	Detention Basin	yes	**166**	**58**	**268**	**50**	**11**	**6,833**	**209**
39	Detention Basin	yes	**98**	**32**	**159**	**27**	**6**	**4,322**	**107**

40	Detention Basin	no	53	6	89	16	12	206	48
41	Detention Basin	no	27	5	115	25	41	71	46
42	Detention Basin	no	67	12	83	16	4	2,152	70
43	Detention Basin	no	136	13	105	19	18	1,480	84
44	Grass Waterway/ Terraces	no	75	N/A	58	11	28	12	16
45	Regional Detention Basin	no	**6,141**	**1,016**	**4,558**	**831**	**400**	**31,719**	**3,883**
	Grand Total		**8,478**	**1,485**	**17,738**	**4,894**	**3,838**	**60,154**	**8,306**

6.3.3 Alternatives – Basin Wide

Basin wide BMPs are those practices or procedures that can be applied throughout the watershed where exact project locations may be unknown or where locations may not have been verified through a site visit. Basin wide BMPs include practices such as conservation tillage, rain barrels, converting existing parking lots to porous pavement or procedures that can reduce the impacts of road salt. Basin wide BMP recommendations cover 5,933 acres or 30% of the watershed.

6.3.3.1 Agricultural Basin Wide BMPs

Many standard agricultural BMPs exist that will reduce runoff and pollution loading from crop fields and pasture operations. Basin wide agricultural BMPs recommended specifically for the Spring Creek watershed include:

1. Cover Crops: A cover crop is a temporary vegetative cover that is grown to provide protection for the soil and improve soil conditions.
2. Conservation Tillage: Involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface through the use of minimum tillage, ridge tillage, or no-till.
3. Pasture Management: A variety of individual livestock management practices designed to manage runoff and improve profitability. Specific practices included under pasture management are fencing (stream and interior), stream crossings, alternative watering systems, filter/buffer strips and diversions or the relocation of feed areas.

A total of 1,082 acres of cover crops and conservation tillage is recommended; this represents approximately 5% of the greater Spring Creek basin. Pasture management practices are recommended on 838 acres or 4% of the watershed.

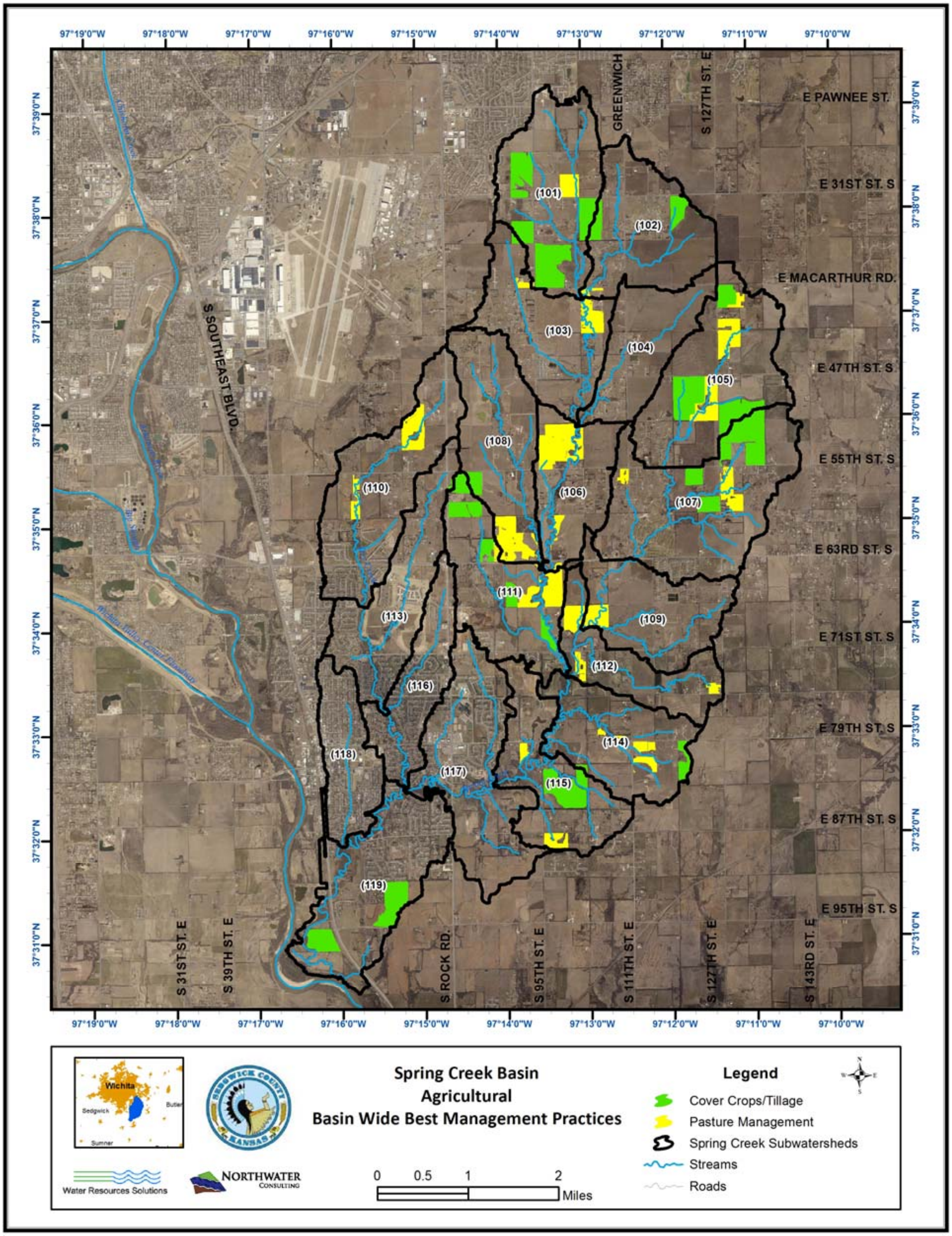


Figure 47: Spring Creek Basin Agricultural Basin Wide Best Management Practices

Table 27: Summary of Basin Wide Agricultural Best Management Practices

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres Cover Crops and Conservation Tillage	Percent of Watershed	Acres of Pasture Management	Percent of Watershed
11030013030(101)	1,262	245	19.43%	36	2.82%
11030013030(102)	1,081	67	6.19%	9	0.87%
11030013030(103)	1,078	6	0.55%	56	5.18%
11030013030(104)	796	0	0%	0	0%
11030013030(105)	1,394	186	13.35%	117	8.41%
11030013030(106)	794	0	0%	130	16.44%
11030013030(107)	1,701	180	10.58%	56	3.28%
11030013030(108)	1,143	23	2.04%	86	7.51%
11030013030(109)	967	0	0%	42	4.36%
11030013030(110)	1,317	0	0%	82	6.23%
11030013030(111)	1,082	121	11.15%	82	7.62%
11030013030(112)	716	0	0%	65	9.11%
11030013030(113)	1,049	3	0.31%	0	0%
11030013030(114)	1,013	34	3.34%	38	3.77%
11030013030(115)	965	94	9.74%	36	3.77%
11030013030(116)	729	0	0%	0	0%
11030013030(117)	1,380	0	0%	1	0.06%
11030013030(118)	640	0	0%	0	0%
11030013030(119)	1,362	123	9.01%	0	0%
Grand Total	**20,467**	**1,082**	**5.29%**	**838**	**4.09%**

Priority should be given to those BMPs that fall within a critical subwatershed (red highlighted HUC codes). Table 28 and Table 29 list load reductions for agricultural basin wide BMPs by subwatershed.

Table 28: Expected Load Reductions; Cover Crops and Conservation Tillage

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres Cover Crops/ Tillage	N Load Reduction (lbs/yr)	P Load Reduction (lbs/yr)	TSS Load Reduction (tons/yr)	Bacteria Load Reduction (Billion Coliform Forming Units/yr)	Cl Load Reduction (lbs/yr)
11030013030(101)	1,262	245	689	82	137	151	73
11030013030(102)	1,081	67	261	38	60	58	25
11030013030(103)	1,078	6	12	1	3	3	1
11030013030(104)	796	0	0	0	0	0	0
11030013030(105)	1,394	186	874	126	263	193	85
11030013030(106)	794	0	0	0	0	0	0
11030013030(107)	1,701	180	494	71	128	109	48

11030013030(108)	1,143	23	39	4	9	9	4
11030013030(109)	967	0	0	0	0	0	0
11030013030(110)	1,317	0	0	0	0	0	0
11030013030(111)	1,082	121	430	56	167	95	44
11030013030(112)	716	0	0	0	0	0	0
11030013030(113)	1,049	3	7	1	1	2	1
11030013030(114)	1,013	34	80	12	24	18	8
11030013030(115)	965	94	280	40	120	62	27
11030013030(116)	729	0	0	0	0	0	0
11030013030(117)	1,380	0	0	0	0	0	0
11030013030(118)	640	0	0	0	0	0	0
11030013030(119)	1,362	123	192	25	87	42	20
Grand Total	**20,467**	**1,082**	**3,360**	**455**	**1,000**	**740**	**335**

Table 29: Expected Load Reductions; Pasture Management

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres BMP Pasture Mgmt	N Load Reduction (lbs/yr)	P Load Reduction (lbs/yr)	TSS Load Reduction (tons/yr)	Bacteria Load Reduction (Billion Coliform Forming Units/yr)	Cl Load Reduction (lbs/yr)
11030013030(101)	1,262	36	167	39	5	316	20
11030013030(102)	1,081	9	101	12	3	169	6
11030013030(103)	1,078	56	512	63	13	861	29
11030013030(104)	796	0	0	0	0	0	0
11030013030(105)	1,394	117	1,104	141	28	1,867	66
11030013030(106)	794	130	660	147	17	1,236	74
11030013030(107)	1,701	56	344	50	9	593	24
11030013030(108)	1,143	86	229	42	5	411	21
11030013030(109)	967	42	159	38	4	303	19
11030013030(110)	1,317	82	384	69	10	686	34
11030013030(111)	1,082	82	638	80	15	1,075	37
11030013030(112)	716	65	238	50	6	440	25
11030013030(113)	1,049	0	0	0	0	0	0
11030013030(114)	1,013	38	107	26	3	204	13
11030013030(115)	965	36	139	26	3	250	13
11030013030(116)	729	0	0	0	0	0	0
11030013030(117)	1,380	1	1	0.3	0.03	2	0.1
11030013030(118)	640	0	0	0	0	0	0
11030013030(119)	1,362	0	0	0	0	0	0
Grand Total	**20,467**	**838**	**4,782**	**782**	**120**	**8,412**	**382**

6.3.3.2 Urban and Point Source Pollution Basin Wide BMPs

Many standard urban and point source BMPs exist that will reduce runoff and pollution loading from urban areas, roads and septic systems. Basin wide urban and point source BMPs specifically recommended for the Spring Creek watershed include:

1. Septic Systems and Private Waste Lagoons: recommendations to evaluate/mitigate the effects of septic/drain field systems and private waste lagoons on the watershed:

    a. Inspect the 17 septic systems and 18 private waste lagoons that fall within the 100-year floodplain.
    b. Certify septic pumpers to inspect septic tanks.
    c. Recommend homeowners have their septic tanks pumped and inspected every 3 years.
    d. Septic pumpers file an inspection report with the city.
    e. Define a "sensitive area" boundary in the watershed close to creeks and waterways. Base boundary on soil types and slopes – where seepage from a drain field could reasonably be expected to reach a watercourse before being adequately treated. Septics and lagoons within this boundary would receive additional attention and/or regulation.

2. Rain Barrel: A barrel used as a cistern to hold rainwater from residential roof runoff.
3. Rain Garden: A planted depression that allows rainwater runoff from impervious urban areas like roofs, driveways, walkways, parking lots, and compacted lawn areas the opportunity to be absorbed.
4. Infiltration Trench: An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. This practice can also help recharge groundwater, thus helping to maintain low flows in stream systems.
5. Porous/Permeable Pavement: Permeable pavement is a method of paving that allows stormwater to seep into the ground as it falls rather than running off into storm drains and waterways. Permeable pavements function similarly to sand filters, in that they filter the water by forcing it to pass through different aggregate sizes and typically some sort of filter fabric. Therefore most of the treatment is through physical (or mechanical) processes. As precipitation falls on the pavement it infiltrates down into the storage basin where it is slowly released into the surrounding soil. In Spring Creek, the recommendation is to retrofit existing parking lots with porous/permeable pavement.
6. Road Salt Management: A detailed list of road salt best management practices is located in the Appendix J.

A total of 97 acres of porous or permeable pavement can be developed on existing parking lots in Spring Creek. A combination of rain barrels and rain gardens can be implemented on 3,019 acres in the watershed and 262 acres of road and parking lots can be targeted for road salt management.

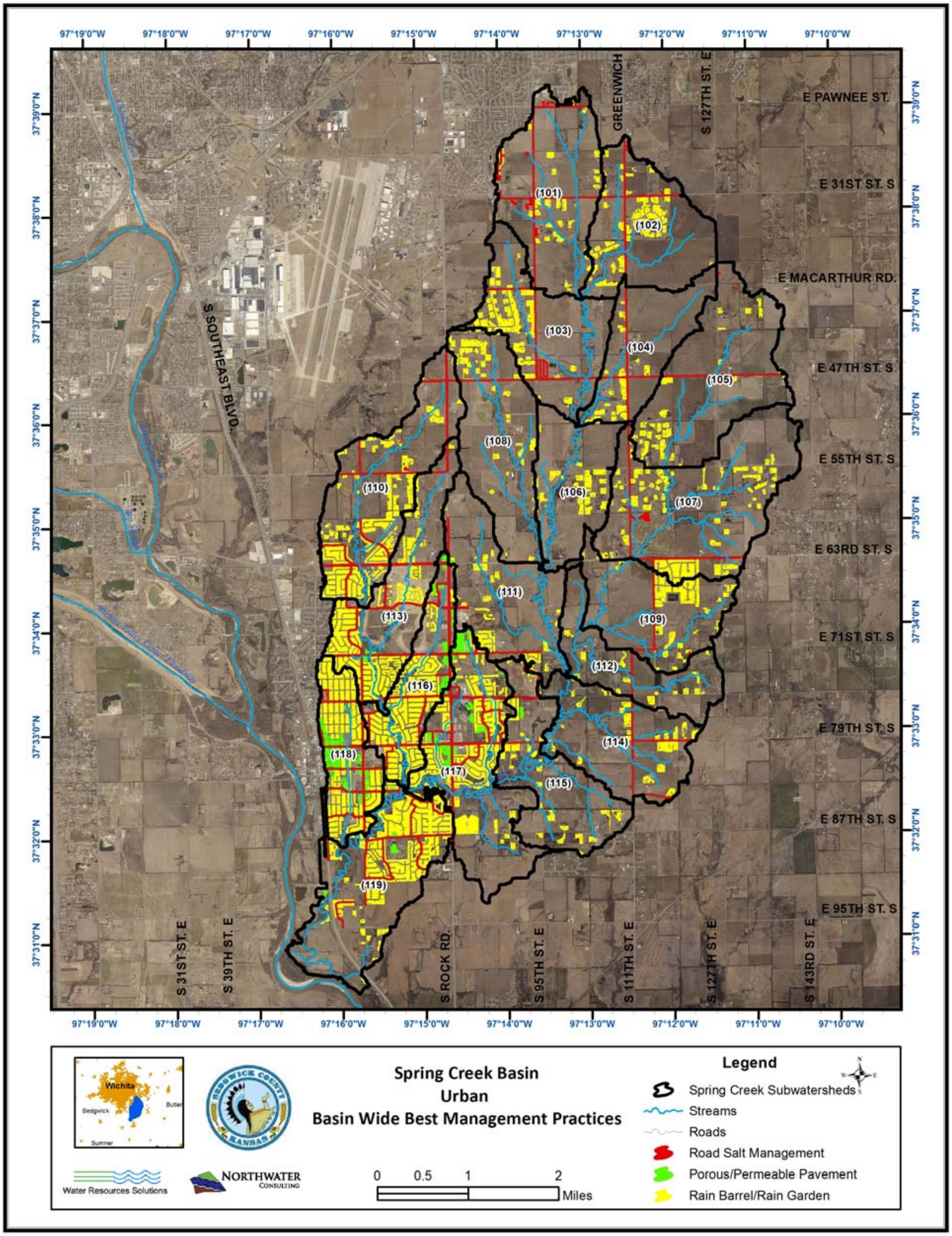


Figure 48: Spring Creek Basin Urban Basin Wide Best Management Practices

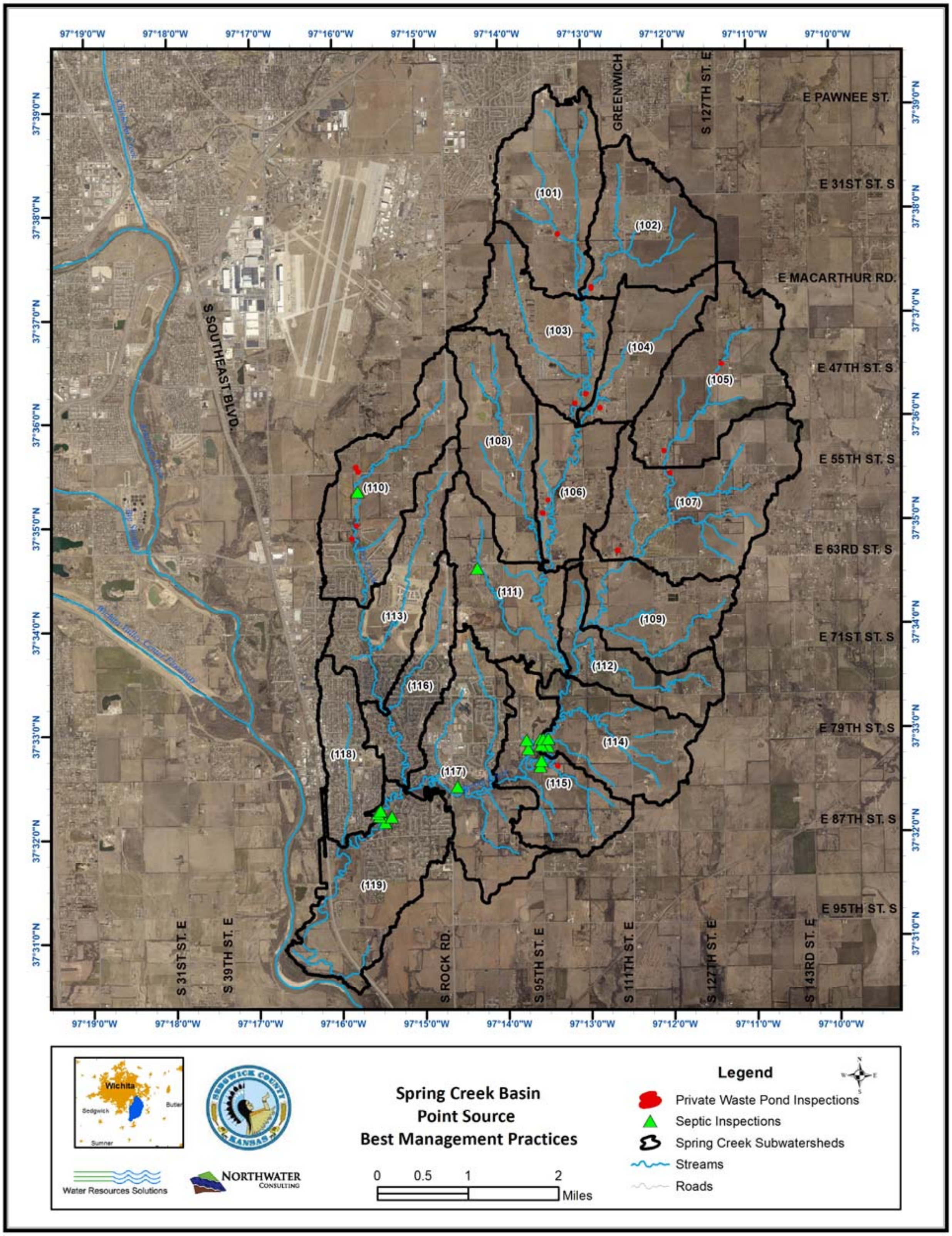


Figure 49: Spring Creek Basin Point Source Best Management Practices

Table 30: Summary of Urban & Point Source Basin Wide Best Management Practices

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres of Porous or permeable pavement	Percent of Watershed	Acres of Rain Barrels & Rain Gardens	Percent of Watershed	Acres of Road Salt Management	Percent of Watershed	Number of Septic Systems	Number of Private Waste Ponds
11030013030(101)	1,262	0	0%	75	5.97%	18	1.43%	0	1
11030013030(102)	1,081	0	0%	116	10.77%	8	0.69%	0	2
11030013030(103)	1,078	0	0%	129	11.92%	10	0.91%	0	2
11030013030(104)	796	0	0%	48	6.03%	7	0.82%	0	1
11030013030(105)	1,394	0	0%	68	4.89%	4	0.32%	0	3
11030013030(106)	794	0	0%	69	8.66%	0	0.00%	0	2
11030013030(107)	1,701	2	0.12%	184	10.82%	15	0.88%	0	2
11030013030(108)	1,143	0	0%	90	7.90%	2	0.17%	0	0
11030013030(109)	967	0	0%	105	10.90%	4	0.39%	0	0
11030013030(110)	1,317	0	0%	271	20.57%	28	2.09%	1	4
11030013030(111)	1,082	0.4	0.04%	78	7.18%	6	0.56%	1	0
11030013030(112)	716	0	0%	39	5.51%	2	0.21%	0	0
11030013030(113)	1,049	2	0.21%	282	26.87%	27	2.57%	0	0
11030013030(114)	1,013	0	0%	76	7.50%	7	0.66%	2	0
11030013030(115)	965	2	0.16%	87	8.98%	4	0.41%	7	1
11030013030(116)	729	17	2.33%	298	40.85%	34	4.72%	0	0
11030013030(117)	1,380	32	2.33%	336	24.38%	36	2.59%	1	0
11030013030(118)	640	36	5.67%	296	46.28%	25	3.84%	0	0
11030013030(119)	1,362	5	0.37%	371	27.25%	28	2.05%	5	0
Grand Total	**20,467**	**97**	**0.47%**	**3,019**	**14.75%**	**262**	**1.28%**	**17**	**18**

Priority should be given to those BMPs that fall within a critical subwatershed (red highlighted HUC codes) or those subwatersheds with the highest expected load reductions. Table 30 through Table 32 list load reductions for urban basin wide BMPs by subwatershed. Figure 48 and Figure 49 show those BMP areas.

Table 31: Porous/Permeable Pavement Load Reduction Totals

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres BMP	N Load Reduction (lbs/yr)	P Load Reduction (lbs/yr)	TSS Load Reduction (tons/yr)	Bacteria Load Reduction (Billion Coliform Forming Units/yr)	Cl Load Reduction (lbs/yr)	Runoff Reduction (acre-ft/yr)
11030013030(101)	1,262	0	0	0	0	0	0	0
11030013030(102)	1,081	0	0	0	0	0	0	0
11030013030(103)	1,078	0	0	0	0	0	0	0
11030013030(104)	796	0	0	0	0	0	0	0
11030013030(105)	1,394	0	0	0	0	0	0	0
11030013030(106)	794	0	0	0	0	0	0	0
11030013030(107)	1,701	2	13	2	0.23	4	388	3
11030013030(108)	1,143	0	0	0	0	0	0	0
11030013030(109)	967	0	0	0	0	0	0	0
11030013030(110)	1,317	0	0	0	0	0	0	0
11030013030(111)	1,082	0.4	1	0.1	0.01	0.3	26	0.6
11030013030(112)	716	0	0	0	0	0	0	0
11030013030(113)	1,049	2	10	1	0.14	3	293	4
11030013030(114)	1,013	0	0	0	0	0	0	0
11030013030(115)	965	2	4	0.5	0.05	1	111	3
11030013030(116)	729	17	46	6	0.66	13	1,366	29
11030013030(117)	1,380	33	158	21	2.62	45	4,715	55
11030013030(118)	640	36	104	14	1.49	30	3,069	62
11030013030(119)	1,362	5	15	2	0.22	4	447	9
Grand Total	**20,467**	**97**	**351**	**46**	**5.42**	**100**	**10,415**	**165**

Table 32: Rain Barrel/Rain Garden/Infiltration Trench Load Reduction Totals

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres BMP	N Load Reduction (lbs/yr)	P Load Reduction (lbs/yr)	TSS Load Reduction (tons/yr)	Bacteria Load Reduction (Billion Coliform Forming Units/yr)	Cl Load Reduction (lbs/yr)	Runoff Reduction (acre-ft/yr)
11030013030(101)	1,262	75	141	34	3.67	216	2,042	41
11030013030(102)	1,081	116	161	43	2.75	274	991	54
11030013030(103)	1,078	128	149	41	2.43	261	752	57
11030013030(104)	796	48	58	16	0.98	99	351	22
11030013030(105)	1,394	68	75	21	1.23	132	396	31
11030013030(106)	794	69	74	21	1.19	131	361	31
11030013030(107)	1,701	184	266	65	5.62	415	2,825	91
11030013030(1080	1,143	90	114	31	1.91	198	612	39
11030013030(109)	967	105	166	40	4.06	251	2,265	55
11030013030(110)	1,317	271	598	124	23	784	15,840	170
11030013030(111)	1,082	78	160	35	5.32	225	3,447	46
11030013030(112)	716	39	51	14	0.84	89	247	17
11030013030(113)	1,049	282	793	151	34	960	24,095	184
11030013030(114)	1,013	78	110	30	1.90	190	602	33
11030013030(115)	965	89	133	32	3.64	203	2,089	39
11030013030(116)	729	298	862	162	38	1,030	27,354	199
11030013030(117)	1,380	337	906	173	37	1,098	26,774	208
11030013030(118)	640	296	726	137	32	866	23,217	186
11030013030(119)	1,362	371	666	129	26	815	18,444	201
Grand Total	**20,467**	**3,024**	**6,208**	**1,299**	**225**	**8,235**	**152,705**	**1,704**

Table 33: Road Salt Management Load Reduction Totals

Subwatershed 14 Digit HUC Code	Subwatershed Area (Acres)	Acres BMP	Cl Load Reduction (lbs/yr)	Subwatershed Per acre Cl Load Reduction (lbs/yr)	BMP Specific Per acre Cl Load Reduction (lbs/yr)
11030013030(101)	1,262	18	2,322	1.84	128
11030013030(102)	1,081	8	1,570	1.45	209
11030013030(103)	1,078	10	1,381	1.28	141
11030013030(104)	796	6	1,417	1.78	219
11030013030(105)	1,394	4	424	0.30	95
11030013030(106)	794	0.04	11	0.01	244
11030013030(107)	1,701	15	2,612	1.54	174
11030013030(108)	1,143	2	407	0.36	214
11030013030(109)	967	4	465	0.48	123
11030013030(110)	1,317	27	5,819	4.42	212
11030013030(111)	1,082	6	1,075	0.99	176
11030013030(112)	716	2	274	0.38	181
11030013030(113)	1,049	27	4,583	4.37	170
11030013030(114)	1,013	7	1,409	1.39	211
11030013030(115)	965	4	434	0.45	108
11030013030(116)	729	34	4,366	5.99	127
11030013030(117)	1,380	36	7,549	5.47	208
11030013030(118)	640	25	4,661	7.28	190
11030013030(119)	1,362	28	3,212	2.36	115
Grand Total	**20,467**	**263**	**43,991**	**2.15**	**167**

6.3.4 Cost, Responsible Parties & Funding Options

The Spring Creek Watershed Management Plan describes the estimated costs of BMP implementation, responsible parties or lead entities and funding options for financing. Costs are estimated using local rates, existing literature and professional judgment. The listed responsible parties are those recommended to take the lead in project implementation in the Spring Creek watershed based on experience with other communities in the region; this includes private landowners and residents, city, county and state government. Funding options can come from a variety of sources including a local tax base, private investment, and competitive grants or existing state and federal programs.

Best Management Practice Costs & Responsible Parties

This section summarizes costs associated with BMPs and those entities or individuals who will likely be responsible for their implementation. The following costs associated with BMP recommendations in Spring Creek are only estimates and should be revised through project specific planning. The cost estimates are concept level, based on 2013 unit costs and are subject to inflation.

The following assumptions were used to determine the appropriate water quality implementation costs:

1. Detention basins and agricultural practice costs are based on the Lower Arkansas Watershed Restoration And Protection Plan (WRAP) and professional judgment/experience. All costs include engineering fees and costs are assumed to be higher within city limits or residential areas.
2. Septic system and private waste pond maintenance recommendations include an estimated cost for inspections and follow-up consultation on remedial actions. Total costs should adequately cover a training program for septic system pumpers.
3. All pasture management recommendations assume a combination of individual practices including: alternative water systems, stream and interior fencing, stream crossings and diversions or the relocation of concentrated feed areas. This cost for stream fence and stream crossings is only included if the pasture intersected by a stream.
4. Basin wide residential practices include a combination of rain barrels and rain gardens. Assumes an average treatment area of 0.1 acres. Each treatment area assumes 2, 60 gallon rain barrels and one rain garden or infiltration trench. Assumed costs are $160.00 for rain barrels and $2,500 for each rain garden or infiltration trench.
5. Porous/Permeable pavement retrofits assume an average material cost of $9/square foot and an average construction cost of $3.75/square foot.

Table 34 lists estimates costs for site specific BMPs and Table 35 lists estimated costs for basin wide BMPs.

Table 34: Cost Estimates; Site Specific Best Management Practices

BMP Code	Estimated Cost	BMP Code	Estimated Cost	BMP Code	Estimated Cost
1	$6,500	17	$22,000	32	$60,000
2	$18,500	18	$46,000	33	$55,000
3	$21,000	19	$45,000	34	$40,000
4	$65,000	20	$25,000	35	$4,000
5	$25,000	21	$20,000	35	$8,000
6	$3,200	22	$9,000	36	$22,000
7	$20,000	23	$38,000	37	$30,000
8	$22,000	24	$28,000	38	$120,000
9	$4,500	25	$45,000	39	$120,000
10	$35,000	26	$19,000	40	$55,000
11	$55,000	27	$26,000	41	$45,000
12	$18,000	28	$70,000	42	$85,000
13	$6,500	29	$55,000	43	$100,000

14	$22,000	30	$80,000	44	$9,000
15	$35,000	31	$75,000	45	XXX
16	$20,000			**Grand Total**	**$1,733,200**

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

Table 35: Cost Estimates, Basin Wide Best Management Practices

BMP Type	Total Cost if all Implemented	Number/acres of BMPs	Maximum Cost	Minimum Cost	Average Cost
Septic Inspections/Identify Remedial Actions	$42,500	17	$2,500	$2,500	$2,500
Private Waste Pond Inspection/Identify Remedial Action	$45,000	18	$2,500	$2,500	$2,500
Agricultural Conservation Tillage and Cover Crops	$75,722	1,082 acres or 23 fields	$8,844	$137	$3,292
Pasture Management and Livestock Practices	$1,026,000	838 acres or 28 fields	$62,000	$16,000	$36,643
Residential Rain Barrels and Rain Gardens/Infiltration Trench	$8,029,275	3,019 acres / greater than 832 individual properties; assumes every acre is treated	$1,753,058	$471	$96,506
Parking Lot Retro-fit; Porous/Permeable Pavement	$53,733,473	97 acres	$6,055,056	$24	$227,684
Road Salt Management	N/A - Could reduce current costs by 30-40%	266	N/A	N/A	N/A
Grand Total	**$62,951,970**				

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

Responsible parties in the Spring Creek watershed include city and county government and private landowners. City government refers to the City of Derby and county government refers to Sedgwick County. In some cases a project may include multiple responsible parties; for example, a project on private land within city limits may require participation from both the city and the landowner. Table 36 lists responsible parties for site specific BMPs and Table 37 lists responsible parties for basin wide BMPs.

Table 36: Responsible Parties; Site Specific Best Management Practices

BMP ID Code(s)	Responsible Party
28, 30, 31, 38, 39, 41-43	City of Derby
45	City of Derby and Sedgwick County
6, 9, 12-14, 17, 20, 22, 35	Private Landowner
1-5, 7, 8, 10, 11, 15, 16, 18, 19, 21, 23-27, 29, 32-34, 36, 37, 40, 44	City of Derby, Sedgwick County & Private Landowner

Table 37 : Responsible Parties; Basin Wide Best Management Practices

Basin Wide BMP	Responsible Party
Cover Crops an Conservation Tillage	Private Landowner / Optional financial incentive from City/County
Pasture Management	Private Landowner / Optional financial incentive from City/County
Residential Rain Barrels and Rain Gardens/Infiltration Trench	City of Derby, Sedgwick County
Porous/Permeable Pavement	City of Derby
Septic system and Private Waste Pond Inspections/Remedial Action	City of Derby, Sedgwick County
Road Salt Management	City of Derby, Sedgwick County

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7.0 IMPLEMENTATION & MONITORING PLAN

The previous sections of this report have outlined the watershed flood, stream stability and water quality issues, potential solutions and costs. This section discusses some of the implementation components that should be undertaken to determine which solutions can be implemented, how to finance these solutions, and additional planning and/or regulation and next steps.

7.1 Prioritization of Mitigation Measures

The proposed mitigation measures identified in Section 6.0 Mitigation Measures to the improve flood issues, stream stability, and water quality issues are prioritized based on a calculated prioritization score. The prioritization score is calculated using the total project cost, a rating value, and benefit value. This section describes the prioritization methodology used to prioritize the mitigation measures previously identified in this report.

7.1.1 Flood Risk Management Mitigation Measures

The parking lot and park area flood risk management mitigation measures identified in Section 6.1 are prioritized based on total project cost, subbasin detention volume, and provided detention volume of the mitigation measure.

The prioritization methodology includes calculating a rating value for each of the mitigation measures. The rating value is calculated by dividing the subbasin detention volume the mitigation measure is located in by the detention volume provided by the mitigation measure. The total project cost is then divided by the rating value to calculate a benefit value. This benefit value is then divided by the detention volume provided by the mitigation measure to determine the prioritization score for the mitigation measure. The lowest prioritization score is given the highest priority because it provides the most benefit for the lowest project cost. A complete list of the flood management improvements prioritization can be found in Appendix B.

7.1.2 Stream Improvement Mitigation Measures

The stream improvement mitigation measures identified in Section 6.2 are prioritized based on total project cost, total reach length, and channel rating score. The channel rating score for each stream reach is determined using the method outlined in Section 5.2 of this report.

For the stream improvement prioritization methodology, the channel rating score is the rating value for each stream reach. The total project cost is divided by the channel rating score to calculate the benefit value. The benefit value is then divided by the total reach length to determine the prioritization score for the stream reach. The lowest prioritization score is given the highest priority because it provides the most benefit for the lowest project cost. A complete list of the stream improvements prioritization can be found in Appendix E.

7.1.3 Site Specific Water Quality BMPs

The site specific water quality BMPs identified in Section 6.3 are prioritized based on total project cost, subbasin area, area treated by the BMP, and the per acre load reduction of total suspended solids (TSS).

The prioritization methodology includes calculating a rating value for each of the BMPs. The rating value is calculated by dividing the subbasin area the BMP is located in by the area treated by the BMP. The total project cost is then divided by the rating value to calculate a benefit value. This benefit value is then divided by the BMP's per acre load reduction of TSS to determine the prioritization score for the BMP. The lowest prioritization score is given the highest priority because it provides the most benefit for the lowest project cost. A complete list of the site specific water quality BMP prioritization can be found in Appendix I.

7.2 Programmatic Water Quality Monitoring Plan

The purpose of the programmatic monitoring plan for the Spring Creek watershed is to define action items and assess the overall implementation success of BMPs and other plan recommendations. This can be accomplished by conducting the following actions:

- Track implementation of management measures in the watershed.
- Estimate effectiveness of management measures.
- Implement water quality monitoring as outlined in the Water Quality Monitoring Plan section.

Tracking the implementation of plan recommendations can be used to address the following monitoring goals:

- Determine the extent to which plan recommendations and practices have been implemented over time compared to action needed to meet water quality targets.
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts.
- Measure the extent of voluntary implementation efforts.

A water quality specific monitoring plan is included in the Water Quality Monitoring Plan section and therefore water quality specific monitoring will not be addressed in this section. This section will focus on organizational monitoring or monitoring of project implementation.

Local resources agencies track program successes and implementation to satisfy internal requirements. For example, The USDA and local conservation districts monitor program successes and report at the county level. Tracking implementation at the watershed level is rarely conducted unless local agencies are 1) willing to provide the information and 2) a formal request is made from local stakeholders. This only occurs if a watershed group or interested entity is active in the area.

In the Spring Creek watershed, a local watershed committee or the City of Derby could work with the appropriate parties to voluntarily establish a monitoring program to track plan implementation. This could involve an annual report that summarizes BMPs currently in place and the work stakeholders have already completed, and would form the baseline from which to measure success and monitor plan implementation.

The following section provides direction for effective organizational monitoring, including a “score card” system that stakeholders can refer to when trying to determine next steps or actions and for tracking success or identifying areas of the plan that need to be re-visited.

7.2.1 Evaluating Performance of Plan Implementation

This plan is meant to be a flexible tool to achieve water quality improvements and flood reduction within the Spring Creek Watershed. The Watershed Management Plan can be evaluated by assessing the progress made toward implementing plan recommendations.

The plan should be evaluated every five (5) years to assess the progress made as well as to revise the plan, if appropriate, based on the progress achieved. The plan should also have a comprehensive review every 15-20 years. Amendments and changes may be made more frequently as laws change or new information becomes available that will assist in providing a better outlook for the watershed. As goals are accomplished and additional information is gathered, efforts may need to be shifted to watershed issues of higher priority.

In addition to a five (5) year evaluation and update, local stakeholders and city/county staff will have a key role in evaluating implementation progress on an annual basis. They can review the status of milestones annually and then identify the top priority actions for the following years focus. Local stakeholders and professional staff should identify how they will implement the plan (subcommittees, reporting structure, meeting schedule, etc.). Other opportunities for evaluating the status of plan implementation can include the completion of quarterly project reports or group meeting minutes. Since this plan is a flexible tool tracking changes/modifications are anticipated based on usability and changes in priority throughout implementation.

According to expected load reductions, load reduction targets and quantities of recommended BMPs listed in previous sections, implementing all site specific and basin wide practices will, aside from sediment, result in greater than 100% of the target reductions needed to achieve the desired water quality. Table 34 compares target load reductions against estimated load reductions from recommended BMPs. Implementing just over one half of the recommended streambank stabilization practices alone will achieve the desired reductions in sediment loading. Achieving target load reductions for sediment are impossible to meet without implementing stream restoration/streambank stabilization practices.

Table 38: Comparison of Load Reduction Targets to Recommended Best Management Practices

	Acres/ Number BMP	Annual Nitrogen Load (lbs)	Annual Phosphorus Load (lbs)	Annual Sediment Load (tons)	Annual Bacteria Load (billion coliform forming units)	Annual Chloride Load (lbs)
Target Load Reduction		20,523	5,108	8,021	10,418	179,966
Expected Load Reductions; Site Specific BMPs**	8,478 /45	17,738	4,894	3,838	8,306	60,154
Expected Load Reductions; Septic/Waste Lagoon Inspections*	0/14	368	114	N/A	1,533	N/A
Expected Load Reductions; Basin Wide Cover Crops and Tillage	1,082/0	3,360	455	1,000	740	335
Expected Load Reductions; Basin Wide Pasture Management	838/0	4,782	782	120	8,412	382
Expected Load Reductions; Porous/Permeable Pavement**	97/0	351	46	5.42	100	10,415
Expected Load Reductions; Rain Barrel, Ran Garden, Infiltration Trench**	3,019/0	6,208	1,299	225	8,235	152,705
Expected Load Reductions; Road Salt Management	262/0	N/A	N/A	N/A	N/A	43,991
Grand Total, All BMPs		**32,807**	**7,590**	**5,188**	**27,326**	**267,982**

7.2.2 Milestones and Plan Performance

Interim measurable milestones are directly tied to the watershed load reductions and project recommendations. Milestones are essential when determining if management measures are being implemented and how effective they are at achieving plan action items over given time periods. This allows for periodic plan updates and changes that can be made if milestones are not being met.

Watersheds are often complex systems with varying degrees of interaction and interconnection between physical, chemical, biological, hydrological, habitat and social characteristics. “Indicators” that reflect these characteristics may be used as a measure of watershed health. Physical indicators are recommended for Spring Creek and include amount of a particular recommendation or BMP. Chemical indicators include load reduction targets and are achieved if physical indicators are met. Social indicators may also be measured using demographic data or for example the numbers of landowners adopting conservation practices, however, social indicators are not a recommended measurement tool for Spring Creek.

A simple score card was developed for the watershed. Score card milestones are based on short term (1-5 years), medium term (6-10 years) and long term (10+ years) objectives. The milestones and "score card" can be used to identify and track plan implementation to ensure that progress is being made towards achieving the plan targets and to make corrections as necessary.

In the early stages of the plan implementation process, watershed stakeholders should establish a sustainable and active planning committee that will meet at least quarterly to discuss watershed progress and work to implementing the plan. In Spring Creek, the existing Stormwater Management Advisory Board (SMAB) could act as this committee. During the monitoring process, the Board should discuss the results of monitoring, assess each milestone and adapt the watershed management plan and their actions accordingly.

7.2.2.1 Monitoring Score Card and Milestones

A monitoring "score card" example is presented below. The score card is based on BMP recommendations and load reduction targets. This score card system can serve as the organizational monitoring plan and a tool for tracking progress toward meeting specific recommendations/action items. Realistic short term (1-5 yr), medium (6-10 yr) and long term (10+ yr) milestones and indicators are included in the score card. Each milestone is a specific action recommendation and is intended to fulfill plan objectives if executed. Indicators are to be used as measurement tools when determining if each milestone has/has not been met. If the measurement of each indicator becomes problematic, the watershed planning committee should revisit and make adjustments where needed. It is up to local stakeholders to determine the priority of each milestone based on their ability to follow through with them.

Table 39 provides a score card or a list of suggested milestones and actions that, if implemented, will achieve the target water quality load reductions. Milestones in the score card can be graded based on the following criteria:

- A = Met or exceeded milestone(s)
- B = Milestone(s) 75% achieved
- C = Milestone(s) 50% achieved
- D = Milestone(s) 25% achieved
- F = Milestone(s) not achieved

Table 39: Monitoring and Milestones Score Card

Best Management Practice / Action Milestone	Implementation Target Indicator; Year 1-5	Implementation target indicator; Year 6-10	Implementation Target indicator; Year 10+
Inspect septic systems and private waste lagoons in 100-year floodplain	A) Inspect 17 septic systems B) Inspect 18 private waste lagoons	Ensure no new septic systems or lagoons are installed in the 100-year floodplain	Ensure no new septic systems or lagoons are installed in the 100-year floodplain
Implement septic/waste lagoon inspection and tracking system	Establish inspection and tracking program	Continue inspection and tracking program	Continue inspection and tracking program
Implement site specific BMPs	Implement 15 site specific BMPs	Implement 15 site specific BMPs, including 1 regional detention basin	Implement 15 site specific BMPs
Implement basin wide agriculture BMPs; conservation tillage and cover crops	A) Implement 200 acres of cover crops B) Implement 200 acres of conservation tillage	A) Implement 200 acres of cover crops B) Implement 200 acres of conservation tillage	A) Implement 100 acres of cover crops B) Implement 100 acres of conservation tillage
Implement basin wide agriculture BMPs; pasture Management	Implement 275 acres of pasture management	Implement 275 acres of pasture management	Implement 275 acres of pasture management
Implement basin wide urban BMPs; rain barrels/rain gardens/ infiltration trench	Implement rain barrels/rain gardens/ infiltration trench on 150 residential properties	Implement rain barrels/rain gardens/ infiltration trench on 200 residential properties	Implement rain barrels/rain gardens/ infiltration trench on 200 residential properties
Implement basin wide urban BMPs; porous/permeable pavement	Install/retrofit 40 acres of porous/permeable pavement	Install/retrofit 40 acres of porous/permeable pavement	Install/retrofit 17 acres of porous/permeable pavement
Implement Road Salt Management Best Practices	A) Assess current practices B) Implement best practices on all 262 acres	Continue best practices on all 262 acres	Continue best practices on all 262 acres

7.3 Water Quality Monitoring Plan

The Spring Creek Watershed is located in Sedgwick County, Kansas with a drainage area of 20,472 acres. Spring Creek drains to the Lower Arkansas River near Derby. This water quality monitoring plan is intended to support water quality and flood improvement activities described in the Watershed Plan. It outlines the steps and protocols required to monitor water quality as recommendations are implemented throughout the watershed. The monitoring plan also provides direction for establishing a water quality baseline; currently there is no active water quality monitoring occurring in the basin and no historic water quality data exists. It is important to note, this monitoring plan only provides general guidelines and prior to implementing a formal monitoring program in Spring Creek, responsible parties should prepare an official Quality Assurance Project Plan (QAPP) following EPA guidelines (EPA QA/G-5, 2002). Guidance can be found at http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf.

> *"A QAPP describes the activities of an environmental data operations project involved with the acquisition of environmental information whether generated from direct measurements activities, collected from other sources, or compiled from computerized databases and information systems. A QAPP documents the results of a project's technical planning process, providing in one place a clear, concise, and complete plan for the environmental data operation and its quality objectives and identifying key project personnel."*

7.3.1 Water Quality Monitoring Plan Objectives

This Water Quality Monitoring Plan (WQMP) will be used to obtain information to characterize current and future water quality. The objectives of the plan are as follows:

- Monitor water quality conditions monthly and over a range of flows at four locations to establish a baseline and to assess annual loading.
- Establish a continuous monitoring program to track improvements made to water quality through targeted project implementation.
- Verify that water quality conditions are within the prescribed limits of the State and EPA.
- Help determine when to take appropriate action to modify implementation activities to ensure protection of the environment if and when exceedances of water quality criteria occur.
- Promptly determine if modifications were effective.

This WQMP defines field procedures for conducting the water quality monitoring, laboratory analytical methods, and quality assurance procedures; and summarizes the requirements for the timing of monitoring activities.

7.3.2 Chemical and Flow Monitoring

To assess pollutant loading in the watershed before and after implementation of BMPs, it will be necessary to collect and analyze water samples for parameters predicted by the pollutant loading model. This brief description is meant only as a guideline on sampling, handling, and analyses of the collected water samples. There are many references available from the EPA, and the standard laboratory methodologies, which should be consulted if more information is required.

In any water quality sampling program, it is crucial to collect representative samples using grab, composite, or continuous sampling methods. Unrepresentative or samples contaminated during collection or handling are unusable. Therefore, careful collection and handling throughout the process is important. The sampling program must take into account the parameters to be analyzed and special collection procedures may be necessary for some parameters. The collected samples should be submitted to a certified laboratory for analysis. Generally, a certified laboratory works closely to assure that the samples are collected in the proper containers with preservatives for the parameter of interest.

7.3.2.1 Parameters

Several water quality parameters should be sampled, and the data recorded by trained volunteers or local agency staff. Recommended water quality parameters to be sampled in the Spring Creek Watershed include:

1. Escherichia coli (Ecoli)
2. Total Nitrogen (TN)
3. Total Phosphorus (TP)
4. Chloride (Cl)
5. Total Suspended Solids (TSS)

Discharge or flow measurements should also be taken and if the appropriate equipment is available, pH, dissolved oxygen, temperature, and conductivity, should be collected. Samples should be collected by trained volunteers or professionals, and tested by a certified laboratory. To control monitoring costs, it is recommended that samples be analyzed at the Derby Waste Water Treatment Plant.

7.3.2.2 Sampling Procedures and Equipment

All trained professionals or volunteers who will be involved in monitoring water quality and quantity parameters on Spring Creek and its tributaries should follow specific procedures and protocols for the collecting and processing the data.

1. All water quality parameters and stream flow should be monitored at all stations at a minimum of once a month. Since an objective of water quality monitoring is to

evaluate annual pollution loading and establish a credible baseline, additional samples should be taken over a range of flow conditions and seasons. In general, every attempt should be made to collect additional samples (as necessary) during low, average and high flow events throughout the year. The goal is to obtain samples consistent with an average annual range of stream flows. Table 40 below lists some sampling criteria for determining an appropriate frequency beyond regular monthly sampling efforts.

Table 40: Stream Flow Sampling Criteria

Stream Flow	Criteria
Low / Low-Midrange	Drought conditions / early summer or fall baseflow conditions
Mid-range	Spring stream flow, average conditions; small rainfall events during saturated conditions
High	Significant rainfall event/flood conditions

2. All parameters should be sampled on the same day. The water quality parameters that should also be monitored, field tested and recorded on data sheets include pH, temperature, dissolved oxygen, and conductivity. All parameters should be tested on the same day.

3. Results should be compared against Kansas Water Quality Standards where applicable (Table 41 below)

Table 41: Relevant Kansas Water Quality Standards

Parameter	Standard: Secondary Contact Designated Use	Standard; Aquatic Life Support Designated Use	Standard; Agriculture, Livestock Designated Use	Standard: Domestic Water Supply
Escherichia coli bacteria (Ecoli)	2000 (CFU/100 ml)	N/A	N/A	N/A
Total Nitrogen	N/A	N/A	100 (mg/L)	10 (mg/L)
Total Phosphorus	N/A	Narrative	N/A	N/A
Chloride	N/A	860 (mg/L)	N/A	250 (mg/L)
Total Suspended Solids	N/A	Narrative	N/A	N/A

7.3.2.3 Sampling Method and Equipment: pH, Temperature, Dissolved Oxygen, and Conductivity

Desired Equipment: Multi parameter sensor (i.e. a YSI or Hatch portable meter)

At The Office:

- Prepare the meter and probe for use.
- Calibrate the meter using the manufacturer's instructions. Complete the calibration and check the standard for this instrument. Record the calibration reading.

In The Field:

- At each station, turn the meter on and place the probe into the water column.
- Obtain the parameter readings for each station according to manufactures specifications.
- Record results on the data sheet.
- Secure and clean equipment.

7.3.2.4 Sampling Method and Equipment: TN, TP, Ecoli, CL and TSS

Equipment Needed: Sterile water bottles supplied by certified laboratory, cooler with ice and data sheet.

At The Office:

- Pre-label the sterile bottles with each station number that will be used to collect samples.
- Fill out a form per each bottle and return the form with the bottles to the lab.

In The Field:

- Take the pre-labeled, sterile, collection bottle and wade into the stream. Take a sample in the middle of the stream. During high flow and unsafe conditions, samples may be taken from the bank.
- Carefully unscrew the cap from the bottle. Be sure not to touch the inside of the cap, nor the inside of the bottle at any time during the collection of the water sample.
- Turn the bottle upside down, with open end towards the water column.
- Submerge the bottle into the water column. Avoid collecting any water from the water surface.
- While bottle is submerged face it upstream in the water column.

- Once enough water has entered the bottle, shake a small portion out of the bottle so the water level is just below the neck of the bottle. This allows for some air exchange in the bottle.

- Carefully screw on the cap.

- Place the bottle into the ice cooler as soon as possible. At the end of the monitoring day, take all samples to the lab for processing and testing. If samples cannot be taken to the lab during the day collected, observe holding times and preservation according to Table 38.

- Obtain additional sterile bottles from the lab.

- For quality control, take a duplicate sample once per month and have the lab test the sample. Label the bottle with a different number than those for each station. Record that a duplicate sample was taken on data sheets and record results from lab results.

Table 42 below lists the recommended container, preservation conditions, and holding times for each laboratory parameter. Table 43 includes the recommended sample analytical methods, required detection and reporting limits.

Table 42: Recommended Sample Container, Preservation and Holding Times

Parameter	Container (provided by lab)	Preservation	Holding Time
Escherichia coli bacteria (Ecoli)	1000 ml Sterile Polyethylene	Cool, 4°C, 0.008% Na2S2O3d	6-24 hours
Total Nitrogen	1000 ml Sterile Polyethylene	Cool, 4°C, H2SO4 to pH<2	28 days
Total Phosphorus	1000 ml Sterile Polyethylene	Cool, 4°C, H2SO4 to pH<2	28 days
Chloride	1000 ml Sterile Polyethylene	Cool, 4°C	28 days
Total Suspended Solids	1000 ml Sterile Polyethylene	Cool, 4°C	7 days

Table 43: Laboratory Methods, Detention Limits and Reporting

Analyte	Method	Detection Limit	Lower Reporting Limit
Escherichia coli bacteria (Ecoli)	EPA – APHA9223B	<1.0 MPN/100mL	1.0 MPN/100mL
Total Nitrogen	EPA – 351.2	0.01 mg/l	0.02 mg/l
Total Phosphorus	EPA – 300.0 /365.4	0.01 mg/l	0.02 mg/l
Chloride	EPA – 325.1	0.020 mg/l	0.020 mg/l
Total Suspended Solids	EPA – 160.2	0.1 mg/l	0.2 mg/l

7.3.2.5 Sampling Method and Equipment: Stream Discharge/Flow Measurements

Equipment Needed: Flow meter, measuring tape, clipboard, and data sheet.

In the Field:

- At each station, a flow measurement should be obtained.
- Follow the manufacturer's instructions and calibrate the flow meter.
- Determine where to take the flow measurement in the stream. Do not take the measurement in a pool. Take the measurement in a riffle or the tail out of a pool. The cross section of stream should be fairly uniform in depths across the section you will measure. There should be no major obstructions upstream or downstream of where the measurement is taken. Remove any movable obstructions from the stream such as debris, leaves, large rocks, sticks, etc. that would disrupt the flow or divert the flow of the stream. There should be enough water to submerge the flow meter as well. (If there is no available water at the station, for example, the water has gone subsurface, record this observation on the data sheets.)
- Spread the measuring tape out from left stream bank to right stream bank. Left and right banks are determined by looking downstream. The tape should be secured above the surface of the water on each bank and pulled taught. The tape should be within the wetted perimeter of the stream.
- Record the entire width distance from left to right bank on the data sheet. Leave the tape in place.
- Prepare the flow meter for use.
- Depending on the width of the stream, determine the increments across the width of the stream to obtain an accurate flow measurement. (Approximately 10 to 20 measurements may be necessary for accurate recordings of flows.) Increments should be equal distances apart. At each increment, record the tape value, or distance (width),

depth, and velocity. To begin, read the measuring tape out to where the water starts from the bank and record the distance. If there is no water at this distance record "no flow" on data sheet. Take the first flow measurement at the edge of the bank where the bank meets the water, and record the flow data. (This will be the second width distance recording, but probably the first depth, and velocity measurement.) Record all flow measurements on data sheet.

- Proceed across the width of the stream recording the distance, depth, and velocity (as above) until you reach the other bank.
- The actual discharge factor will be derived at the office with the use of a calculator and discharge formula.

7.3.2.6 Sampling Locations

Four monitoring sites are recommended, one on Dry Creek and three sites on Spring Creek (lower, middle and upper). With the exception of the site on Dry Creek, all sites are directly accessible from a road/bridge crossing.

Table 44: Sample Site Descriptions

Station Name/Code	Latitude	Longitude	Nearest Road Crossing	Notes/Station Description
SPR1	37.523495	-97.269993	Spring Creek and Hwy 15	Approximately 250 feet downstream of State Hwy 15
SPR2-DRY	37.541033	-97.253832	End of E Kay St and Dry Creek	Sample site 50 ft upstream of the confluence of Spring Creek and Dry Creek. The site is approximately 300 feet NE of E Kay St (dead-end). No bridge crossing at this site. Site is accessed through the woods at the end of E Kay St.
SPR3	37.548207	-97.224735	Spring Creek and E 79th St South	Take the sample at the downstream end of spring creek and E 79th St South
SPR4	37.562677	-97.222618	Spring Creek and E 71st St S	Take the sample at the downstream end of Spring Creek (stream to the West of S 99th St East.)

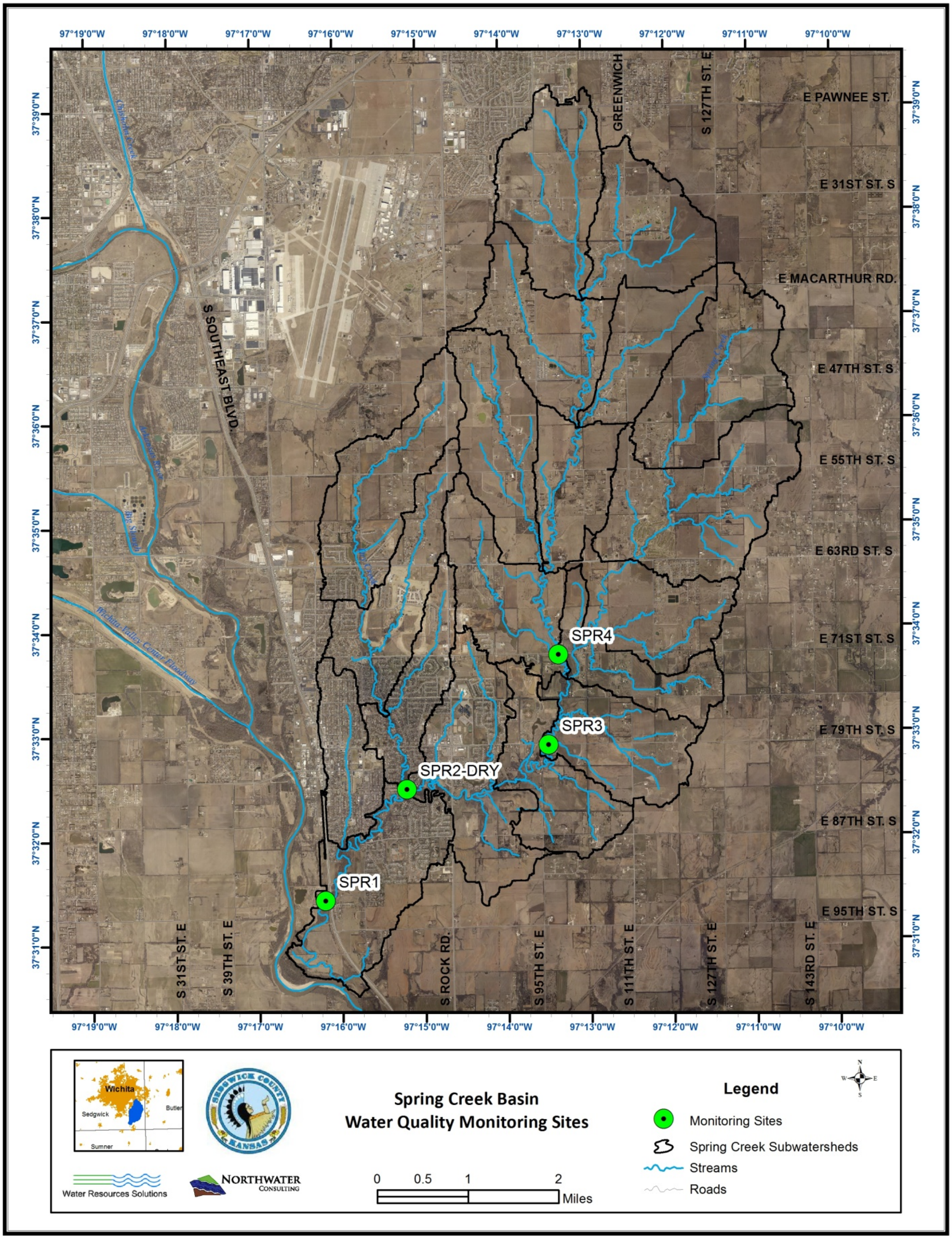

Figure 50: Spring Creek Basin Water Quality Monitoring Sites

7.4 Preliminary Engineering Studies

The potential solutions to the flooding, creek stability and water quality issues identified in this report are conceptual in nature. The costs associated with these improvements, while based on real design and construction projects in the region, are also conceptual in nature and primarily used for comparison purposes. In order to move to the next steps of designing and constructing these improvements, it is recommended that a preliminary engineering study be undertaken for the desired improvements in order to work out some of the detailed engineering issues and to develop more firm cost estimates. This process will not only provide a more solid budgeting cost, but will identify any engineering or construction issues that need to be addressed with the project.

7.5 Planning and Regulatory Guidance

Many of the proposed improvements identified in this report are based on the concept of improving the situation in the watershed as it exists. In other words, the improvements fix the problems that exist now.

It is vitally important that the impacts of future development in the watershed be addressed before development occurs and exacerbates any existing problems. In order to achieve this result, the County and City Planning and Engineering departments must work together to plan for future development in the watershed.

The most important aspect of this planning is centered on the idea of mitigating the impact of increased impervious area. Impervious area generates increased runoff that is responsible for increased flooding, stream instability and degraded water quality. Fortunately, many of the tools necessary are already in-place. In particular, the County has developed a stormwater management manual. This manual outlines appropriate engineering practices, flood management techniques, water quality BMPs, and other stormwater management tools.

The County has formally adopted this manual, but has not fully implemented its use. It is recommended that the City of Derby adopt the manual and begin requiring its use for any new development.

Much effort has been spent developing the manual; it draws on other manuals developed around the region. The only recommended change to the manual is that instead of the generic runoff rates outlined for various site development situations, the County and City should require that all improvements illustrate that any development does not increase runoff in the watershed. Proof of this would be based on the use and revision of the computer models used in this study. It is recommended that the County maintain the master model that all developers use to model the developments. By maintaining these models, the County always has the most up-to-date hydrologic, hydraulic and water quality information for the watershed.

As solutions are implemented and development continues to occur, the County and City should identify areas of regulation that are needed. Based on our Team's experience, it has been found that education tends to be more effective than excessive regulation.

7.6 Financing Options

One of the goals of the Sedgwick County Stormwater Advisory Board is to secure a dedicated funding source for stormwater management. The following list includes some financing options that were investigated as part of this study.

- Stormwater Utility
- Watershed District
- Dedicated Sales Tax
- Property Tax
- Development Fees
- State Funding
- Conservation Easements
- Carbon Banking (Carbon Offsets) or Carbon Credits
- U.S. Department of Agriculture
- U.S. Army Corp of Engineers – Program Assistance
- Federal Emergency Management Agency – Hazard Mitigation Grant Program
- Other Funding Options

7.6.1 Stormwater Utility

Municipalities and governmental entities create stormwater utilities so that dedicated funds are available to operate, maintain, manage, construct or reconstruct their municipal stormwater drainage systems. A stormwater utility is a dedicated revenue source intended to alleviate the burden on general funds. Essentially, the stormwater utility is identical to a water or sanitary sewer utility, in which the utility's users finance the utility's infrastructure costs. The stormwater utility charge is not associated in any way with property value, property taxes, or the owner's income.

Typically, the municipality charges a stormwater utility fee to all users within the municipality based on the amount of runoff that each property generates and contributes to the stormwater system. As a rule, the runoff generated relates directly to the amount of hard surface, or impervious area, found on the property. Hard surfaces such as roof-tops, driveways, and parking lots prevent rainfall from infiltrating into the ground, thus increasing the amount of runoff that a property generates. Consequently, a property with more impervious area uses the system to a greater extent than a property with less hard surface.

The City of Derby adopted such a mechanism in July 2012. Each residential household is assessed $3 per month per residential lot and a fee for non-residential calculated based on their impervious surface. According to the 2013 budget, it was expected to generate about $270,000 this year. The City of Wichita also has such a fee.

7.6.2 Watershed Districts

Watershed Districts have been authorized in the state of Kansas since 1953, when the Watershed District Act was passed.

A natural watershed includes all the land area that drains to a particular water resource – whether that is a stream, lake, or depression. A watershed district must be built around these natural watersheds and must be comprise at least one watershed, or two or more adjoining watersheds. A watershed district can develop a comprehensive plan to provide flood protection for the watershed and construct, operate and maintain works of improvement to assist in water management. Currently in Kansas there are 88 such districts.

According to the Kansas Legislative Research Department, "The process for creating a watershed district begins when local residents file a petition with the Secretary of State containing the signatures of not less than 20 percent of the landowners and 25 percent of the acreage within the proposed district. <u>A board of county commissioners also may adopt a resolution proposing the establishment of a watershed district within their county, but only if the lands within each proposed district are comprised substantially of a watershed, or two or more adjoining watersheds, and in the preceding five year period the governor issued a proclamation declaring a state of disaster within the county due to flooding.</u> *(Note: such a proclamation was issued for Sedgwick County in April 2012.)*

"If these two requirements are met, the board of county commissioners may pass a resolution creating a steering committee to look into organizing and creating a watershed district within the county. This steering committee then operates in the same manner as the steering committee created by private landowners. The steering committee files a petition with the Secretary of State asking for incorporation as a watershed district.

"After the petition has been filed with the Secretary of State and is found to be sufficient, it is then sent to the Chief Engineer of the Department of Agriculture, Division of Water Resources. It is the duty of the Chief Engineer to investigate the proposed district and to issue a written report either approving or disapproving the proposed district within ninety days. The Chief Engineer should approve the proposed district if he/she makes the following findings:

- The proposed watershed district is comprised substantially of a watershed or two or more adjoining watersheds;

- Each proposed district would not include lands in an existing watershed district;
- The statement of purposes in the petition conforms with the intent and purpose of the Watershed District Act;
- The lands within each proposed district are subject to erosion, floodwater or sediment damage, or would be benefited by the construction of works for the conservation, development, utilization, or disposal of water;
- The boundary of each proposed district is defined to include all quarter-quarter sections (40 acres) of which more than one half of each is within the watershed;
- The downstream limit of each proposed district is established with regard to:
    - Location of highways and railroads;
    - Location and character of existing works of improvement;
    - Boundaries of any organized levee, drainage, irrigation and watershed
    - districts; and
    - Physical characteristics and the probable effect of the proposed district on any flood plain area common to multiple streams or water courses; and
    - An adequate and correct map and description of land is attached to the petition.

Upon receiving a favorable report from the Chief Engineer, the steering committee elects a board of directors. It is then the responsibility of the board of directors to organize an election for the purpose of posing before all qualified voters within the proposed district the question of whether the watershed district should be organized. Qualified voters include any qualified elector of the proposed district, as well as any person over eighteen who owns land within the proposed district but who does not reside within the proposed district.

If the election results come back in favor of organizing a watershed district, the Secretary of State issues to the board of directors a certificate of incorporation and the board becomes authorized to function in accordance with the provisions of the Watershed District Act and its certificate of incorporation.

<u>Funding by the District</u>: The board may propose a general levy against all of the taxable tangible property located within the district, a special assessment against lands within the district to be specially benefited by any of the proposed projects, or a combination of both. The board may also in its resolution decide to issue "improvement bonds in order to pay for the

proposed works in installments. The issuing of bonds would require a special election by the qualified voters of the watershed district. In addition to the authority to raise money for improvements, each watershed district is annually allowed to levy a general mill tax, not to exceed two mills, to be used as a general fund for the district's daily operations.

7.6.3 Dedicated Sales Tax

Chapter 19-3311 of the Kansas Statutes allow for “a countywide retailers' sales tax in an amount not to exceed 1/10th of 1% for the purpose of paying for the cost of stormwater management and flood control improvements…The revenue produced by such tax (is) solely for the purposes of planning, constructing, maintaining and managing stormwater improvements. Any county proposing to impose a retailers' sales tax authorized by this section shall adopt a resolution stating its intention to levy such tax. Such notice shall be published once each week for two consecutive weeks in the official county newspaper and if within 30 days after the last publication of the notice a petition signed by at least 4% of the qualified voters of the county requesting an election upon such question, an election shall be called and held thereon. Such election shall be called and held in the manner provided by the general bond law.”

7.6.4 Property Tax

Property taxes are the primary revenue source for a local government’s general funds. These funds are used to complete public works projects including stormwater management and green infrastructure projects. However, many other public works projects such roads, lights, and sidewalks are funded with the general fund. Schools are also funded with property taxes. These competing uses must be considered when choosing to use property taxes to pay for stormwater management and green infrastructure.

7.6.5 Development Fees

Development fees generally are assessed to property owners pursuing construction activities. The revenue can be used to finance onsite or off-site stormwater management projects to help offset stormwater impacts from the development. Because such fees are usually assessed only once in association with a particular development activity, this funding method is not suitable for long-term maintenance of stormwater management programs.

7.6.6 State Funding

The KDHE WRAPS (Watershed Restoration and Protection Strategy) program provides about $2 million annually. It secures its funds from the Kansas Water Plan Fund and the EPA Section 319 grant funds, as well as other potential mechanisms as summarized here.

- Kansas Water Plan Funding: The KPWSLF is a state revolving loan fund (SRF) program available to cities and rural water districts. The program provides loans to Kansas municipalities at below market interest rates for construction of public water supply system infrastructure.

For a municipality to be eligible for consideration of a loan, it must adopt and implement a Water Conservation Plan. After a conservation plan is approved and implemented, the Municipality must then submit projects to KDHE, which then are ranked and placed a project priority list. Higher ranking is given to projects that address the most serious health risks, that are necessary to assure compliance with requirements of the national primary drinking water regulations, and that assist public water supplies most in need. Projects that are needed solely for future growth or fire protection are not considered for funding.

- Clean Water Neighbor Grants: This KDHE program currently has no funding. However, when funding is available, planning and implementation projects cannot exceed $10,000 each and projects that include both cannot exceed $20,000.

- The Kansas Department of Agriculture: This department has three cost-share programs. They are the Water Resources Cost-Share Program, the Non-Point Source Pollution Control Program, and the Riparian and Wetland Protection Program. These programs provide financial assistance to eligible landowners for conservation practices that reduce soil erosion, improve water quality and/or conserve water.

7.6.7 Conservation Easements

Conservation easements are lands and land use deeded to a local government or non-profit entity to use and manage within agreed upon limitations. The agreements are legally binding and the easements are deeded in perpetuity. Easements may provide a tax incentive for the private property owner. The value of the property may be used for the local match portion of grants.

Conservation easements can be used for a variety of goals and objectives such as drinking water protection, water quality protection, protection or restoration of native habitats or species, and protecting scenic views.

7.6.8 Carbon Banking (Carbon Offsets) or Carbon Credits

Carbon offsets or banking can be used to achieve air quality standards for emissions by private industry as well as communities. Carbon banks to meet air quality standards or program goals can be compatible with wetlands mitigation and habitat restoration efforts.

Forest conservation and reforestation projects include restoration of deforested or degraded forestry lands. The forest holdings must be verified as sustainably managed with a commitment to maintain the carbon stocks. Projects may include urban and suburban tree planting. Forest conservation projects are counted if they are contiguous with a reforestation project. The amount of carbon credits for a particular project is calculated based on the size and age of the forest stand. The types of projects include:

- Reforestation
- Habitat mitigation and restoration
- Sustainable agriculture and silviculture
- Wetland replacement and construction

Although there is no federal and climate change policy, carbon banks have been implemented as climate change initiatives are instituted in communities and companies across the United States. Often, carbon banking arrangements include a partnership between a private investment company and a local utility. The private company takes the utility company's investment, finds local farmers interested in changing their crops to trees, provide assistance to the farmer to plant, harvest and sell the tree crop. Many times a parallel business is set up to make compressed wood pellets, creating another business and employment. The plant to harvest cycle is 15-20 years for the farmer but he receives annual stipends for managing the tree crop. This strategy is similar to the CRP program, but is privately managed.

7.6.9 U.S. Department of Agriculture (USDA) – Conservation Reserve Program

As part of the Farm Service Agency of the USDA, the Conservation Reserve Program (CRP) is a voluntary program that provides annual rental payments to agricultural producers to safeguard environmentally sensitive lands by planting long-term, resource conserving vegetation to control soil erosion, improve water quality, and enhance wild-life habitat.

The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. Participants enroll in CRP contracts for 10 to 15 years.

While the CRP program is targeted toward individual property owners, municipalities could work with farmers in their jurisdictions, promoting and/or assisting with CRP projects as a way to achieve water quality goals. Program signups are held periodically. A continuous signup provision of the CRP provides funding for installing vegetative buffers and other practices to protect rivers, streams, and other environmentally sensitive areas.

7.6.10 U.S. Army Corps of Engineers – Planning Assistance to States (PAS)

The Planning Assistance to States (PAS) program authorizes the Corps of Engineers to assist any non-federal public body with preparing plans for the development, utilization and conservation of water-related land resources of drainage basins, watersheds or ecosystems located within the boundaries of the state. Types of studies conducted in recent years under this program include water supply and demand, water quality, environmental conservation/restoration, wetlands evaluation, dam safety/failure, flood damage reduction, and floodplain management.

Federal allotments for each state or tribe from the nationwide appropriation are limited to $500,000 annually. Historically, individual studies, of which there may be more than one per state or tribe per year, generally cost $25,000 to $75,000. Cost sharing is on a 50% local, 50% federal basis.

7.6.11 U.S.D.A. Natural Resources Conservation Service (NRCS)

The purpose of these programs are to assist in reducing soil erosion, enhance water supply, improve water quality, increase wildlife habitat and reduce damage caused by flooding. The NRCS has multiple programs, including Agricultural Management Assistance (AMA), Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentive Program (WHIP).

7.6.12 Federal Emergency Management Agency – Hazard Mitigation Grant Program

The Hazard Mitigation Grant Program was developed in 1988 to provide assistance to States, tribes and local communities in implementing long-term hazard mitigation measures following a major disaster. The grants can be used to fund projects to protect private and public property as long as it fits the States mitigation strategies. The grant funds may be used to pay up to 75 percent of eligible project costs. More information can be found at http://www.fema.gov/hazard-mitigation-grant-program.

7.6.13 Other Funding Options

The primary mechanisms for implementing both site specific and the basin wide agricultural BMPs is through existing Farm Bill and State Conservation District programs at the County Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA) and the Sedgwick County Conservation District (SCCD) office. The NRCS and FSA fall under the United State Department of Agriculture (USDA) and provide assistance through federal programs. The SCCD is considered a state agency represented by the Kansas Association of Conservation Districts (KACD); programs administered by the SCCD are funded through the state. In general, these programs provide both technical assistance funds for implementation or construction; funding is typically capped at a predetermined limit or a percentage of the overall cost.

Landowner enrollment into both state and federal programs begins with a request at the local county office. From here an eligibility determination is made and if the landowner wishes to proceed, staff from the NRCS and/or the FSA and SCCD work directly with the landowner to design and implement practice(s) under the most appropriate program. All state and federal assistance programs are voluntary and therefore, a landowner must initiate a request through the county office. In Spring Creek, this can be accomplished by:

1. Conducting a targeted mailing to local landowners describing available state and federal programs, eligibility requirements and next steps for enrollment. The intent here is to encourage landowners to voluntarily request assistance through the local county FSA, SCCD and/or NRCS.

2. Hire a contractor or outreach specialist to contact and meet one-on-one with landowners to discuss property specific resource concerns, describe available programs, assess eligibility and act as a liaison between the landowner and the local county offices. The contractor should have a strong background in agriculture, understand how to evaluate a site and communicate with landowners and be familiar with all available State and Federal programs, their eligibility requirements and cost-share limits. Staff contracted through the local SCCD should be considered.

If landowners are unwilling or ineligible to participate in FSA, USDA or SCCD programs, other options for implementation include the submittal of a competitive grant application or direct funding through a mechanism established by the City of Derby or Sedgwick County. These direct funding options are discussed below. Receiving funding through a competitive grant program is often desirable in that it provides an opportunity to leverage additional funding to cover a percentage of the overall project cost. Almost all funding programs aimed at improving water quality require that a watershed plan or other similar document is in place. The Spring Creek Watershed Management Plan is specifically tailored to meet state and federal requirements and can be utilized for the application of grant funds. Recommended action steps for accessing grant funding include:

1. Determine the most appropriate grant program.

2. Establish a project sponsor or grant applicant. The grant applicant should be a non-profit organization or unit of government such as the SCCD, the City of Derby or Sedgwick County and will be responsible for administering and managing the grant.

3. Using the Spring Creek Watershed Management Plan, develop a grant scope of work describing BMPs and their costs.

4. Solicit local partnerships and support from the FSA, USDA and the SCCD and define partner roles.

5. Determine the source of local matching grant funds. Some programs, for example require that 40% of the overall project cost originate from local or state sources.

Matching funds can be in the form of cash or services and can come from local government, individual landowners or other State sources.

6. Solicit input from representatives that oversee the grant program. Often times, it is beneficial to gauge interest prior to submitting the grant and understand if the project is, in fact eligible. Early coordination with the funding agency will ensure they are aware of the project, they support it and that there is sufficient funding available.

Once it is determined that the project is eligible for funding and the funding does exist, develop a detailed grant application. A detailed grant application will include exact project locations, their associated pollution load reductions, cost estimates and a commitment, in writing from landowners. Although this will require significant time and effort, an application will be much more successful if it is viewed to be "shovel-ready."

APPENDICES

Appendix A: **Public Survey/Questionnaire**

Appendix B: **Flood Management Improvements Prioritization**

Appendix C: **Flood Management Improvements Project Costs**

Appendix D: **Channel Condition Scoring Matrix and Stream Reach Rating and Ranking Table**

Appendix E: **Creek Improvements Prioritization**

Appendix F: **Creek Improvements Project Costs**

Appendix G: **Creek Improvements Project Representative Sections**

Appendix H: **SWAMM Methodology**

Appendix I: **Water Quality BMP Prioritization**

Appendix J: **Chloride and Road Salt Best Management Practices**

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APPENDIX A

Public Survey/Questionnaire

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Sedgwick County...
working for you

Spring Creek Watershed Study
Survey Results
July 22, 2013

As part of the outreach for the Spring Creek Watershed Study, stakeholders were surveyed about stormwater runoff, flooding, erosion, and water quality issues in the community. A 31-question survey was available through the Sedgwick County website and was publicized through the print media, the County's email list, through the City of Derby, Kansas, and the Stormwater Management Board. The survey was available during the month of May 2013.

Responses received from the survey will assist Sedgwick County and the consultant team to focus the efforts of the watershed study. Information from residents is helpful to identify specific areas of concern, such as places where flooding occurs, and the types and locations of solutions that could be employed to address flooding, erosion, and water quality issues.

Executive Summary

The survey addressed three major issues in the Spring Creek watershed – flooding, stream bank stability, and water quality. Respondents were generally given multiple answers on a qualitative scale from "strongly agree" to "strongly disagree." Potential answers could also include "unsure" or a list to select all that were applicable.

Fifty-one people responded to the survey, representing 13 neighborhoods with more than 68% residing within the city limits of Derby, Kansas. Subdivision representatives or business owners accounted for 12% each or 24% of the total respondents. Farmers and ranchers were represented by about 8%. City employees were also represented by 8% of the respondents.

The survey respondents are concerned about the watershed and the issues facing the community. When asked what the watershed plan should address, 84% of the respondents either strongly agreed or agreed that it should address water quality; 71% indicated it should address stream erosion and bank stabilization, and 65% said it should address flooding.

The results of the survey indicate that:

- Respondents are generally knowledgeable about stormwater runoff and the sources of pollution to streams and rivers. Respondents understand that water quality can affect their health and that they play a role in the water quality of local streams. However, they also indicated that there is a lack of specific information or data on the quality of water in Spring Creek.
- Erosion and stream bank stabilization are major issues affecting the people who responded to the survey. Comments were received about losing backyards, money spent to stop erosion of their property, and major changes to Spring Creek since purchasing their property.
- Most of the respondents (77%) had not personally been affected by flooding, either on their property or within the community.

Comments received at the end of the survey indicate frustration by the residents living along Spring Creek with the lack of action and assistance by local government. The following are a sampling of those comments.

- Two previous studies did not result in any changes or actions by the City of Derby or Sedgwick County.
- The City of Derby does not provide any assistance to residents with erosion of their backyards and do not appear to care about their problems. Residents are left to fix problems on their own with no technical or financial assistance.
- Citizens value their water resources and desire a more positive connection and interaction with the natural resources. Comments included a desire to preserve the riparian corridor and vegetated stream banks, as well as greater access to the stream for passive recreation.

General Questions

Question 1: What is your affiliation to the Spring Creek watershed?

More than 68% of the respondents resided in Derby and 47% responded as being from Sedgwick County. Twelve percent each represented subdivision or homes' associations and business owners. Farmers or ranchers and city employees were each represented by 7.8% of the survey respondents. It is noted that the survey allowed the participants to check more than one box to this question.

Question 2: If you live in a subdivision, what is the name of the subdivision?

Neighborhood affiliation received 25 responses, showing 13 neighborhoods, as follows:

Wyldwood	1
Oakwood Valley	5
Tiara Pines/Heather Creek	3
Stone Creek	1
Oakwood Valley	3
Dry Creek Addition	1
Spring Creek	7
Spring Creek II	1
Ridgepoint 4	1
Babcock - 2nd addition	1
Pleasant View	1
Woodland Townhomes	1
Greens at Derby	1

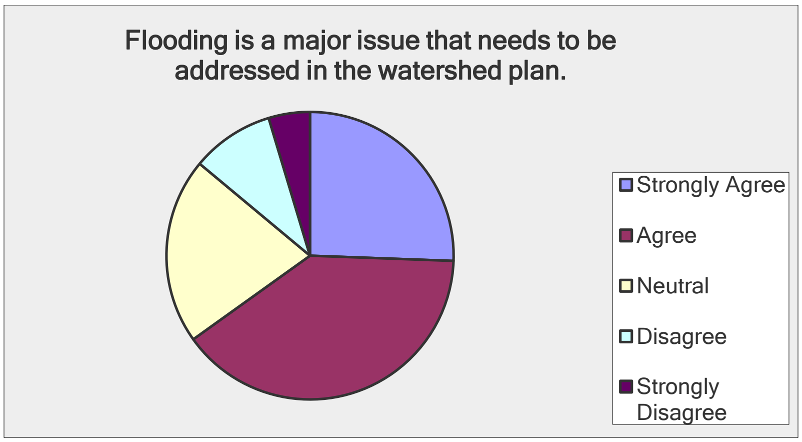
Question 3. Where do storm drains carry stormwater runoff?

Respondents are knowledgeable about where stormwater flows with 75% stating to nearby streams and lakes. Approximately 18% answered 'wastewater treatment plant.' About 21% of the respondents were unsure of where stormwater flows in their community.

Flooding Issues

Six questions in the survey queried respondents about flooding issues, asking respondents whether they thought it was an issue; whether they had been affected and about specific locations and events.

Forty-three (43) people responded that flooding is a major issue that needs to be addressed in the watershed study; 65% either agreed or strongly agreed that flooding is an issue.



Flooding on Personal Property

More than 77% of survey respondents stated their property had not been affected by flooding. About 13% of respondents have been affected by flooding events. Six respondents provided eight locations where flooding occurs. Most of the damage from flooding on personal property has been less than $10,000. There was one response each received for damages of $10,000 – 50,000 and over $50,000.

- 135 S. Valley Stream Dr 1995 and one more time since
- 1318 E. Kay St. Derby, KS Oakwood Valley
- In 2006 I purchased my home at 623 E. Park Lane St. in 2008 the rains came and it creek went over the island that I am also part owner of and came within a foot of my back fence. As the water went down it took my fence, sprinkler system and back yard. I looked 20 feet down to see my tulips blooming that had been in my yard. I live on the horseshoe bend and then believe it was 2010 another large rain came and formed a bowl to the left of my property. When it has risen, it does take out a tree or two and I have called and men have come and cut the trees into logs several feet long with the hope of the next heavy rains washing them to the river. Hopefully, something can be done to keep my and my neighbors yards from washing away. I love the view from my porch over to the island and all of the wildlife that resides there. Would love some ideas.
- Impacted means that water flowed in the area set aside for drainage - so - no monetary evaluation. 2121 E Country View Dr Two springs in the past 14 years

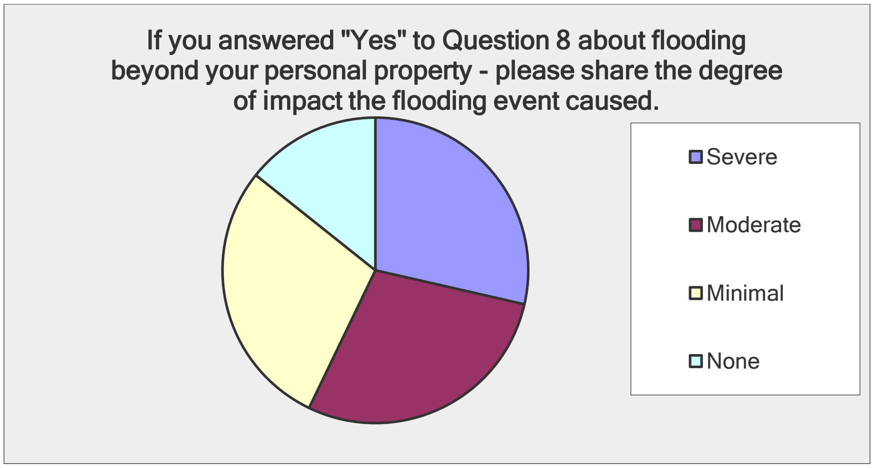
- 211 Park Place Ct., Derby, KS 67037-1250. There have been numerous flooding/erosion events beginning in the early 1980's. I have had numerous meetings with city, county, state and federal officials concerning Spring Creek.
- The creek comes out of its banks and floods the entire commons area behind our properties causing erosion due to dammed up areas in the creek. This has happened many times resulting in a rising rushing river like scenario approximately 40 ft. wide.
- 460 Mary Etta St summer 2008, summer 2009, summer 2010
- Crosswood Lane any heavy rain backyard floods. There is not proper drainage in this area. It was not done by developers or City ordinance.

Flooding Elsewhere (Not on personal property.)

Thirty-five people responded to questions about impacts to flooding besides personal property. Nine respondents, or 25%, said they had been affected by flooding not associated with their personal property. More than 68% had not been affected by flooding. For those affected by flooding in the community, the locations of flooding are listed below.

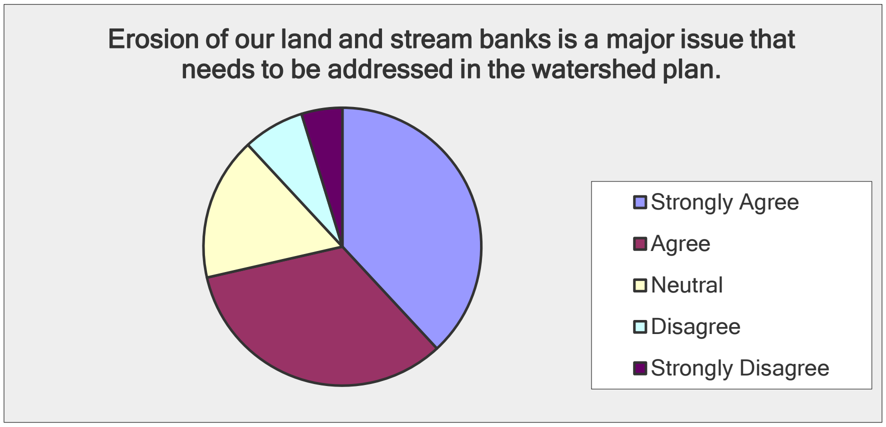
- 2nd and West street area
- Madison ave south of High Park in Derby has been closed several times due to high water
- While our house sustained no damage from the 1993 flood as we were the only dry house on the south side of the creek and north side of the street, we have spent thousands of dollars on erosion control or we would have been flooded since then. Water is often all around us.
- Slight on K-15
- See number 6. The number and dates are numerous. I can and will furnish if requested. Two other engineering/consulting studies have been conducted, Burns & McDonnel and PEC. I suggest that you review these documents.
- When the banks of the watershed holding pond overflow, the banks of my property is besieged with rubbish and trash from upstream. Our privately owned pond is not as deep as it once was due to filling-in of runoff from construction north of our property. This action is upsetting the natural balance of this section of the watershed and as well as destroying the natural aesthetics of the watershed area. I live at 201 N. Valley Stream Drive in Derby. It has become an ongoing event since development north of our property has increased. This development has and will continue to effect our property value. If this downstream flow of rubbish and dirt is allowed to continue, this area of the watershed will become a swamp endangering humans and pets and natural habitat of the area.
- Woodlands Townhomes located 2000-2108 N Woodlawn. Creek runs behind our units
- Madison Ave near High Park
- Madison Avenue on the east side of Derby (79th ST S)

The impact from publicly flooded areas was evenly distributed from Severe to None.



Erosion Issues

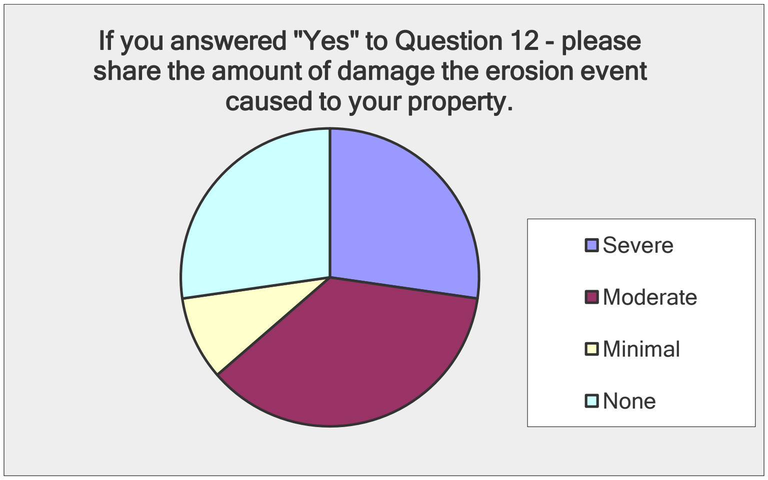
Seventy-one percent of respondents think that erosion of land and stream banks is a major issue to be addressed, marking either strongly agree or agree to the question in the survey. About 12% disagreed or strongly disagreed that this was an issue.



However when asked if they have been personally affected by erosion in the Spring Creek watershed, about 22% indicated they had. Specific locations provided are listed below.

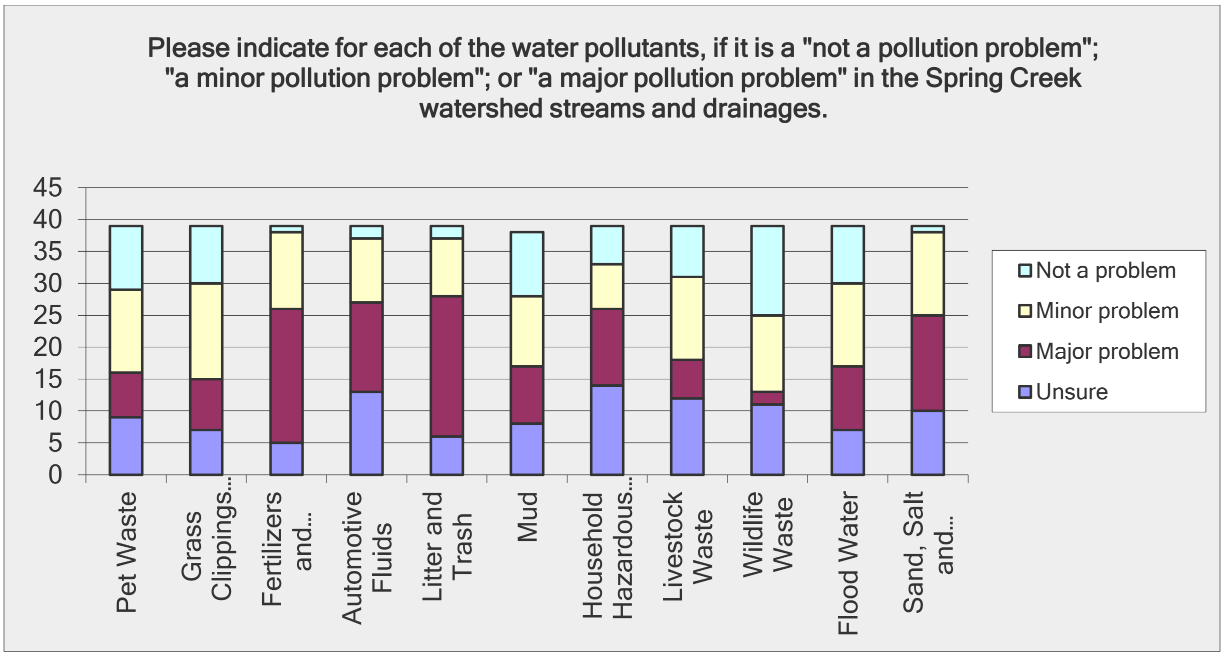
- 125 N. Valley Stream Dr., Derby, KS 67037 Over time
- In 1996 or 1997 when the bridge over rock road was being expanded we had all of that concrete delivered to our yard and we rented a bulldozer and pushed it over the creek edge to address the erosion. We then brought in 10 dump truck loads of dirt to cover the concrete. Our creek bank had eroded to the extend we only had about 5 feet from the creek edge to our fence around our pool. It cost us thousands of dollars to bring in all of that and repair our sprinklers and yard from the damage cause by the dump trucks and bulldozer.
- 2008 when the rains came it was about a foot from my back gate and all over the island that I'm also part owner of. Lost my fence, water sprinklers, about 6'of back yard. The tulips that were again the fence were 20 feet below and still blooming when the water resided. 623 E. Park Lane St.
- 2121 E Country View Drive
- Same as reported under earlier items.
- 2000-2108 N Woodlawn, Derby Woodlands Townhomes

The amount of damage from erosion in the watershed was distributed from none to severe. The percentages were 27.3% for severe, 36.4% for moderate, 9.1% for minimal damage, and 27.3% for none.

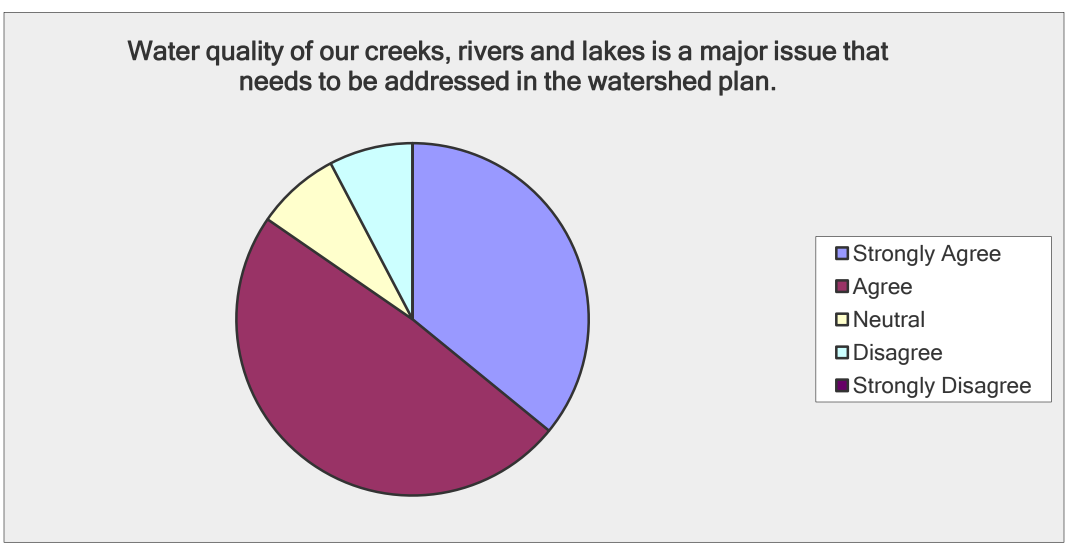


Water Quality Issues

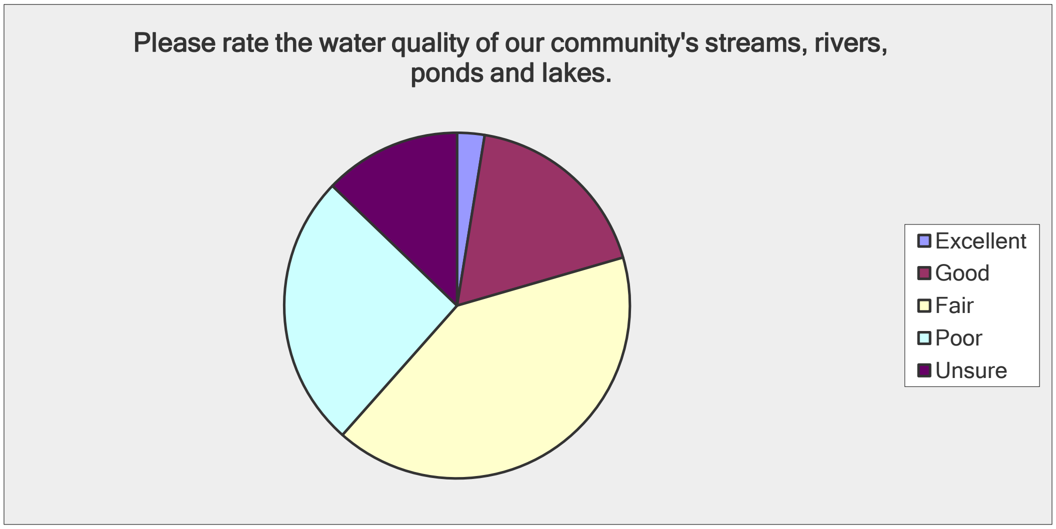
The respondents displayed a good knowledge of water quality issues, with more than 80% stating that water quality in area streams can affect their health and they have a role to play in the area's water quality. The major sources of water pollution in the community were spread across the spectrum, as is illustrated in the graph below. Trash, fertilizer/pesticides, sand and salt from roads, and automotive fluids received the most responses for being major problems.



More than 84% either agree or strongly agree water quality is an issue to address. Approximately 15% of respondents were neutral or disagreed on this issue, as illustrated in the chart below.



More than 66% of respondents think the Spring Creek water quality is either fair or poor. Almost 13% are unsure of the water quality in the community's water bodies. Comments were received regarding a lack of information about the water quality in the watershed to adequately answer the question. This indicated that more information may need to be distributed to the citizenry.



Potential Solutions

Respondents have a positive attitude towards streams, rivers, and lakes, with high marks given for wildlife habitat, a source of beauty, a source of recreation, helpful in controlling flooding, and improves property values.

Answer Options	Response Percent	Response Count
As a source of beauty	59.2%	29
As a source of recreation	49.0%	24
As a source of drinking water	30.6%	15
Provides wildlife habitat	73.5%	36
Causes flooding problems	26.5%	13
Helps control flooding problems	51.0%	25
Improves property values	46.9%	23
Decreases property values	8.2%	4
Unsure	4.1%	2
Other (please specify)	4.1%	2

Survey respondents were presented photographs of nine potential stormwater runoff and water quality control measures/methods/structures. The purpose was to gauge community acceptance to solutions that could be implemented in the future. Respondents were asked to evaluate each stormwater control measure on the following:

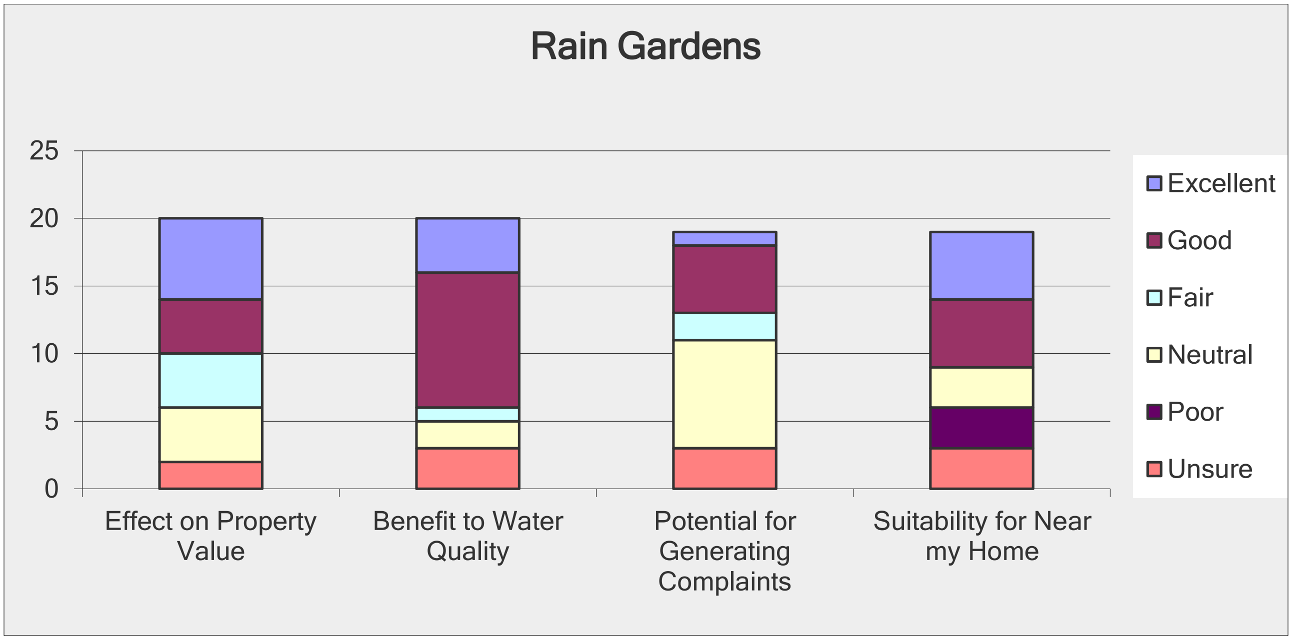
- Effect on property value (positive)
- Benefit to water quality
- Potential for generating complaints
- Suitability for near my home

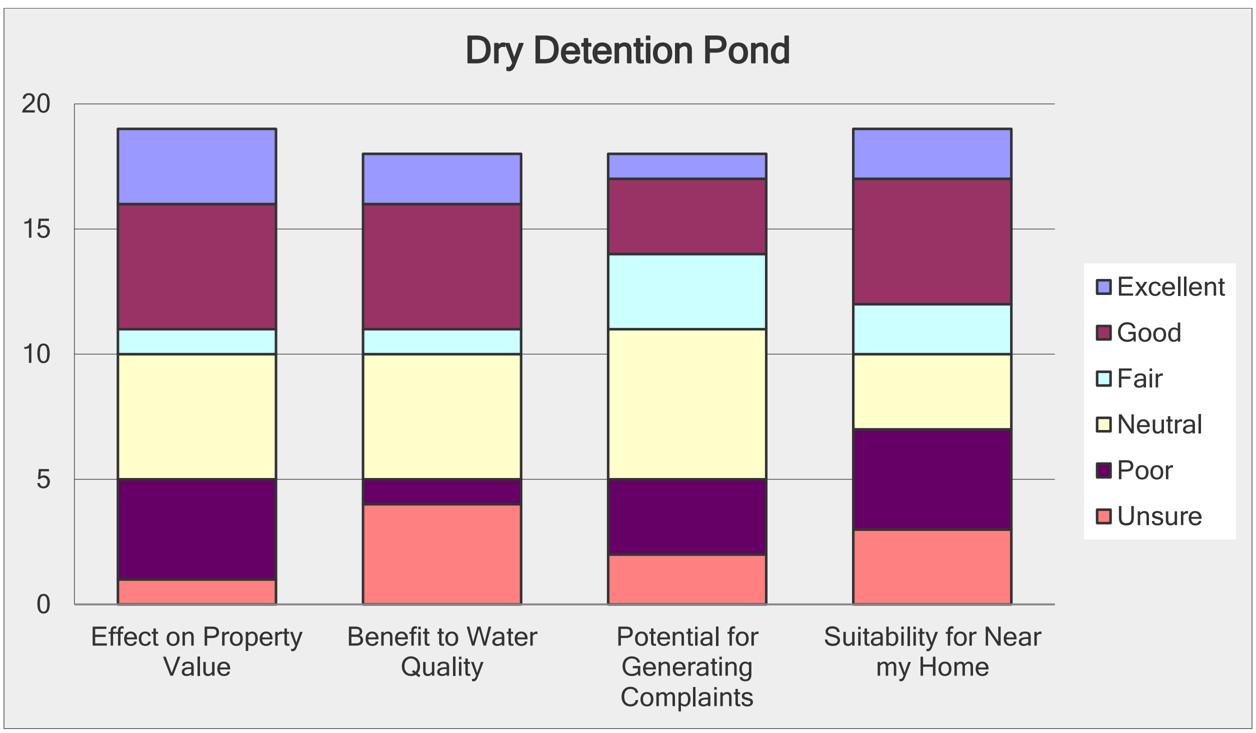
Seventeen to twenty survey respondents completed this portion of the survey. During the first release of the survey, this section of survey was incorrectly set up. This was corrected on May 15, 2013 and likely explains some of the low response counts to the “Potential Solutions” set questions. One respondent commented that they thought the questions were too leading and subjective. Another respondent commented that the questions “felt odd and off-putting.” Comments provided by respondents are listed at the end of this report.

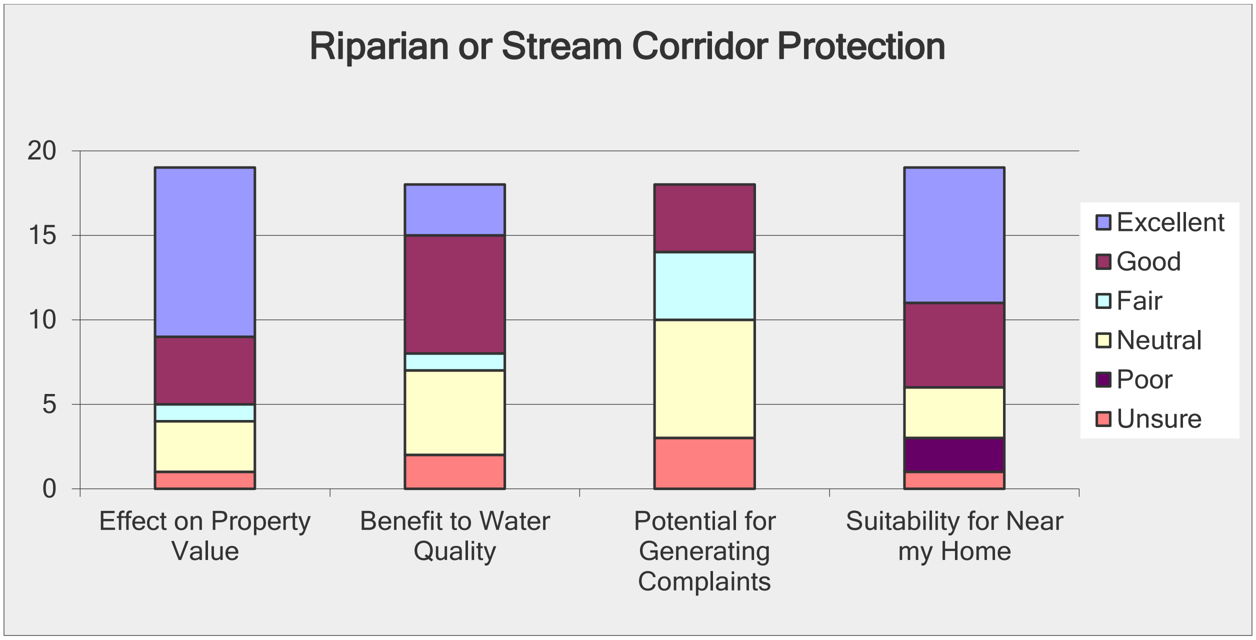
The survey indicates that the respondents were favorable to the following control measures: riparian or stream corridor protection, creek bank stabilization, stormwater ponds, and drainage and erosion control practices.

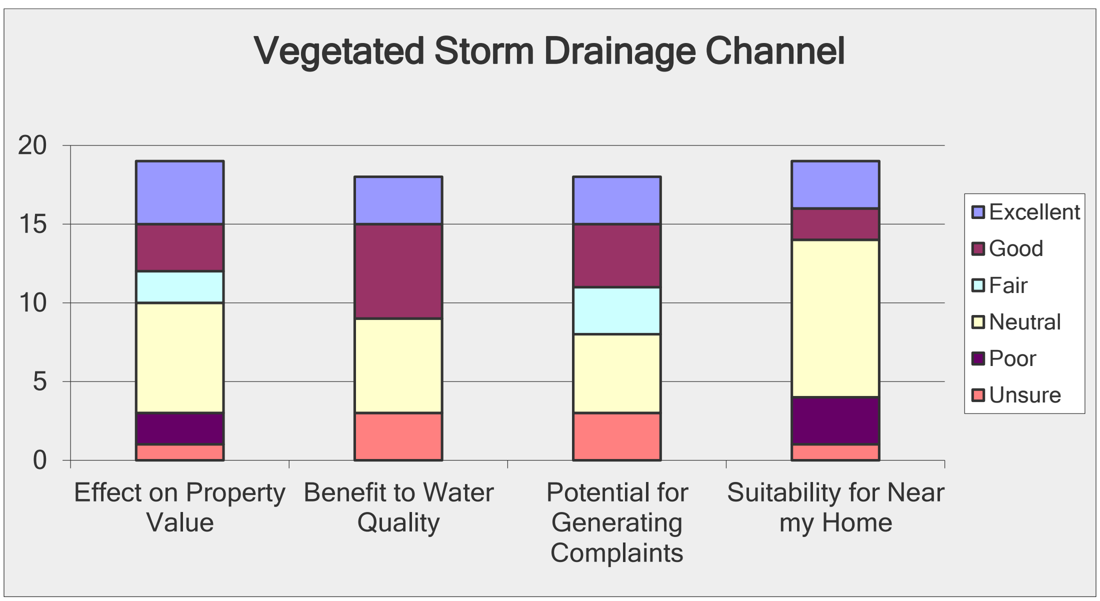
The fewest positive responses were given for low impact development housing, dry detention ponds, and vegetated stream channels.

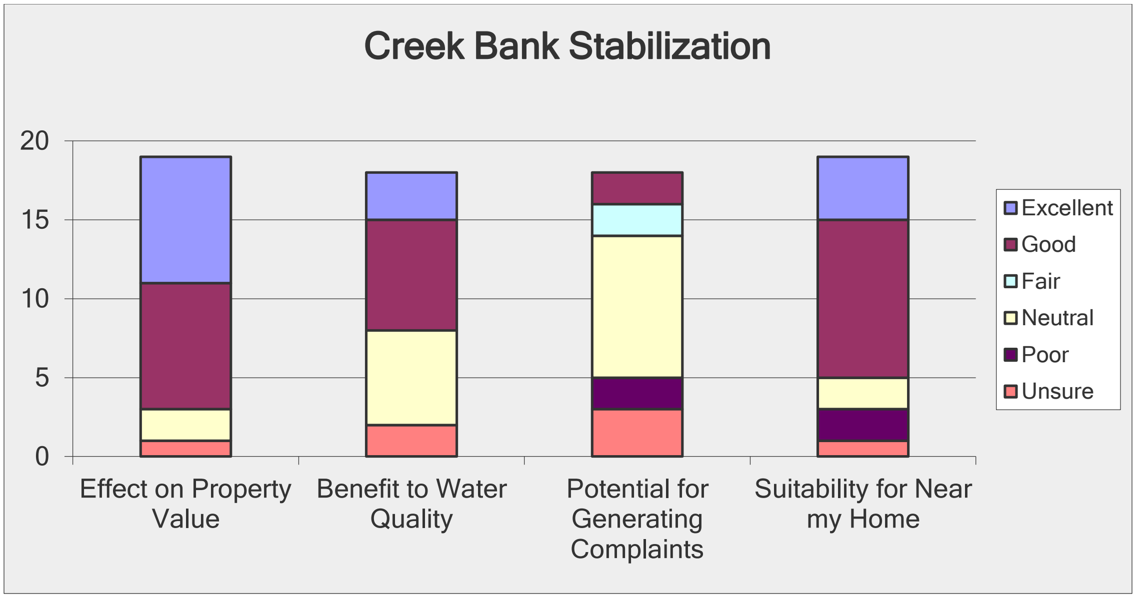
Survey results for each of the nine potential solutions are presented beginning on the following page. The vertical axis is the number of responses received.

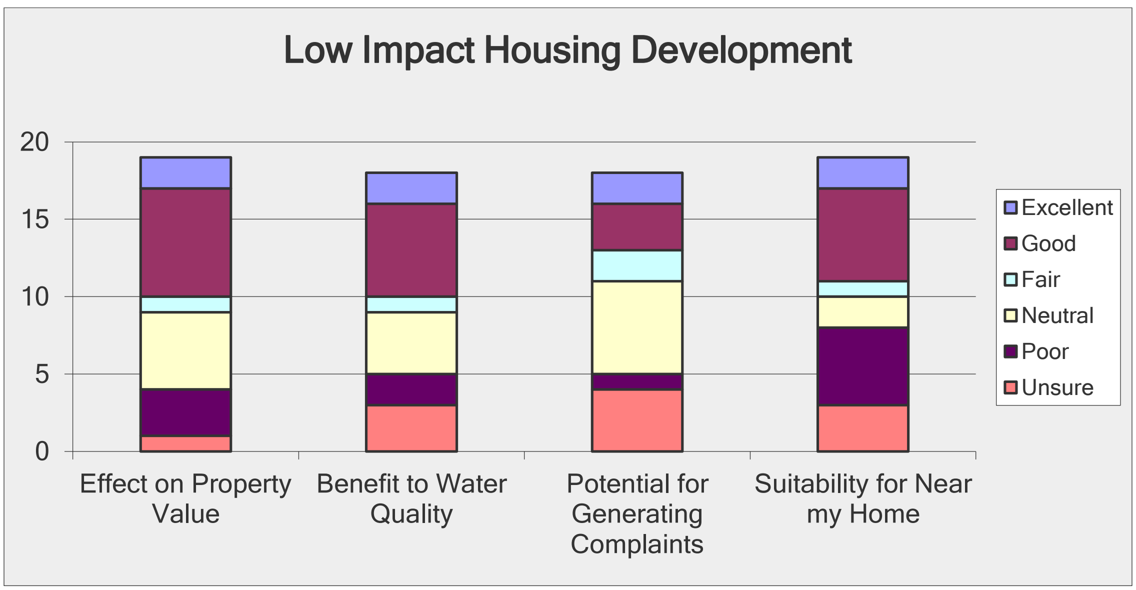

Rain Gardens
25
20
15
10
5
0
Excellent
Good
Fair
Neutral
Poor
Unsure
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home

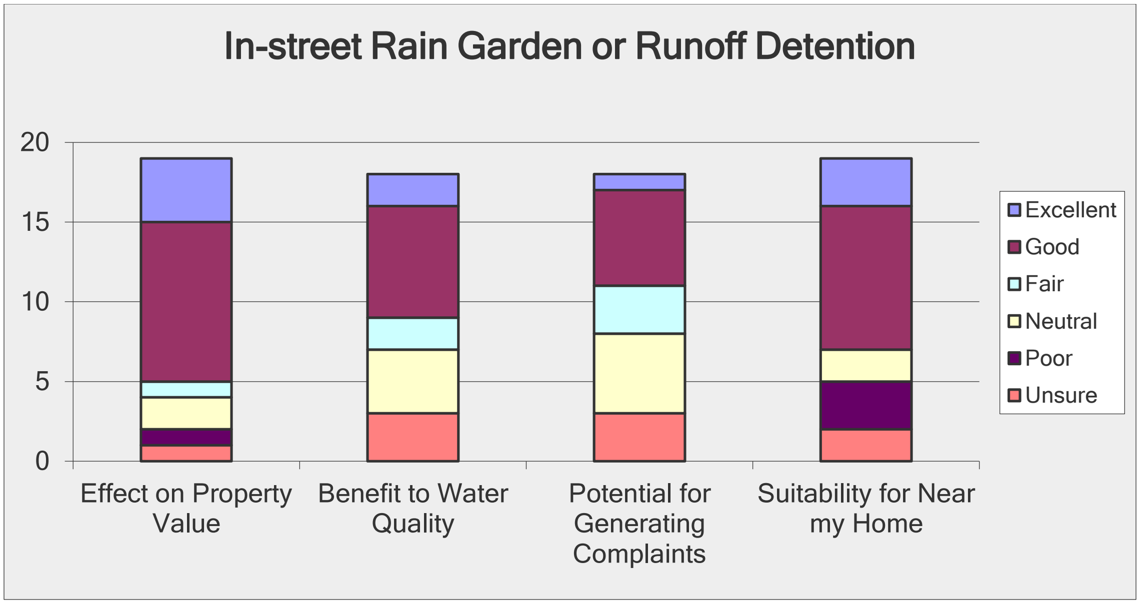

Dry Detention Pond
20
15
10
5
0
Excellent
Good
Fair
Neutral
Poor
Unsure
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home


Riparian or Stream Corridor Protection
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure

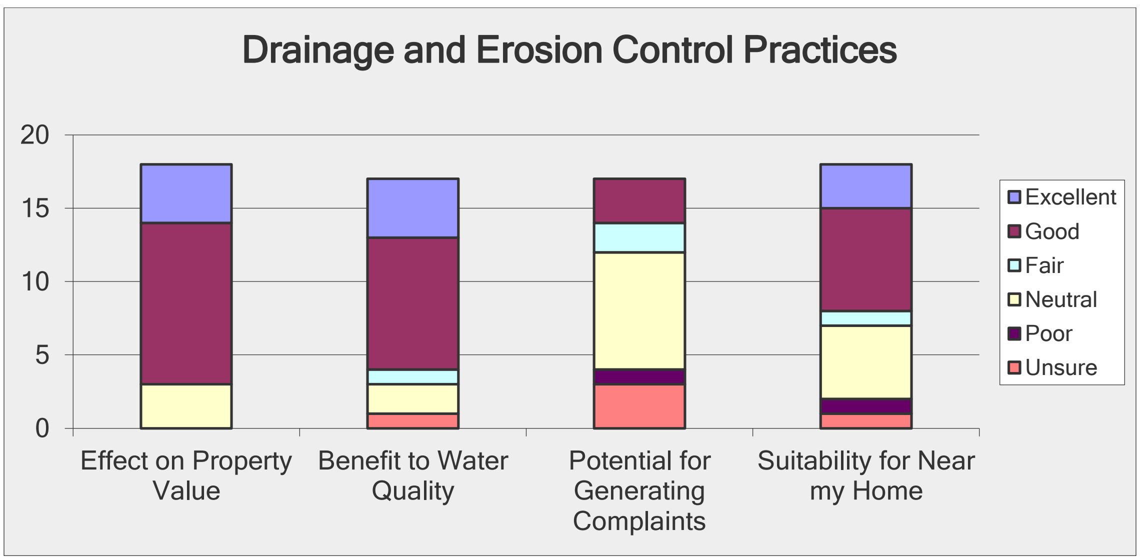

Vegetated Storm Drainage Channel
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure


Creek Bank Stabilization
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure

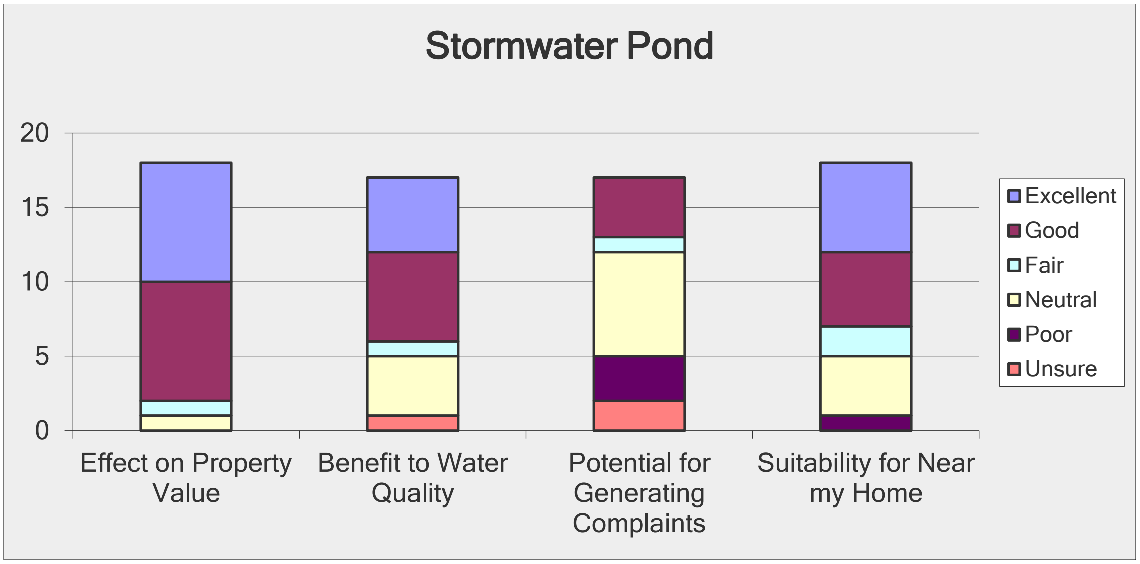

Low Impact Housing Development
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure

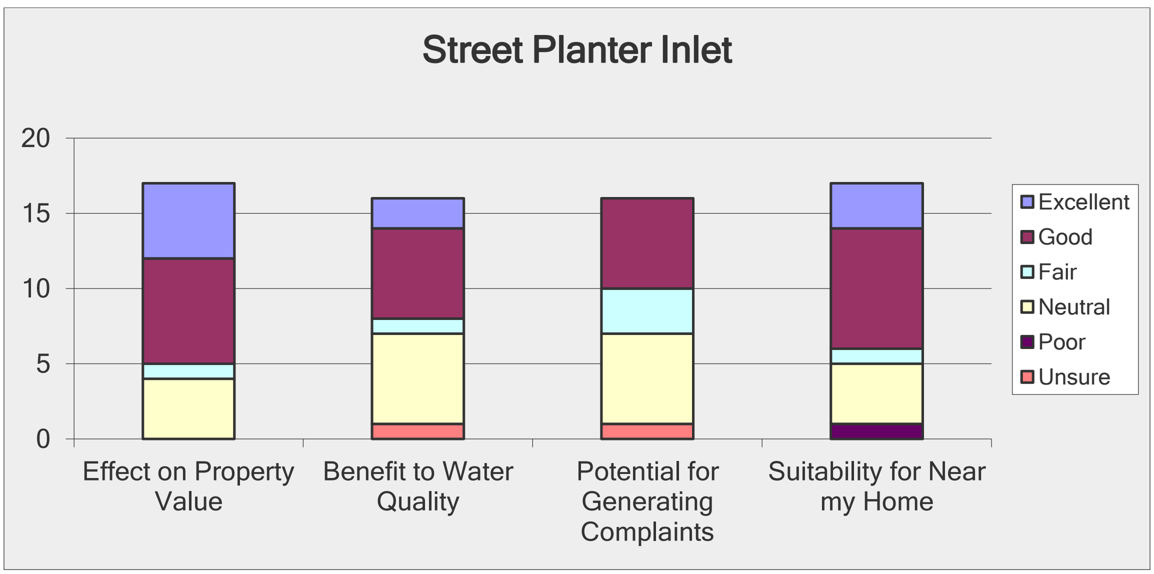


In-street Rain Garden or Runoff Detention
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure



Drainage and Erosion Control Practices
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure


Stormwater Pond
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure


Street Planter Inlet
20
15
10
5
0
Effect on Property Value
Benefit to Water Quality
Potential for Generating Complaints
Suitability for Near my Home
Excellent
Good
Fair
Neutral
Poor
Unsure

Communication Methods

The three best methods for communicating with residents about the watershed study and stormwater issues are through a website, utility bill mailings, and a newsletter, receiving a 73%, 64%, and 54% favorable response, respectively. Public meetings and TV each received a 27% favorable response.

What form of outreach and communication do you find beneficial? (Check all that apply.)		
Answer Options	Response Percent	Response Count
Utility Bill Mailings	63.6%	21
Public Meetings	27.3%	9
Website	72.7%	24
Newsletter	54.5%	18
Subdivision Meetings	21.2%	7
Radio	18.2%	6
TV	27.3%	9
Facebook, Twitter	21.2%	7
Other (please specify)	15.2%	5
	answered question	33

Comments

Survey respondents were given the opportunity at the end to provide any comments about the watershed study and the survey. These comments below are copied directly from the survey responses.

1. I found this survey very pointed and not objective. The questions were leading and not a good measure of true opinion. A message of environmentalism is clear. Conservation is necessary but this is not found in this survey.

2. We're all a part of the problem and we all need to be a part of the solution. If we don't change practices, we'll pay the price.

3. The potential for complaints about water retention or flood prevention reservoir areas is that they need to be maintained so they don't become overgrown with weeds and tree sprouts.

4. I have a home that backs up to a wooded area near Spring Creek on the SE side of Derby. It is my sincere hope that these wooded and natural areas are maintained.
   Too often creeks are turned into ditches in the name of flood control. I have lived in Derby for 19 years and have had water in on my property several times due to high water in the creek. My house was built to flood elevations and I have never had any property damage.

5. We don't have much trouble now that we addressed our own erosion problem. We had requested assistance and were told it was up to us to take care of the creek bank on our own so we did.

6. Wellllll. I keep losing land but my taxes for the island and home never go down so I feel I'm paying for something that floats downstream to someone else. At any given time there are balls, trash, etc. floating around.
   Have been told by friends that they used to play along the creek and it was not nearly as deep as it is today.

7. Some of the possible solutions shown were hard to evaluate because effectivity is so dependent upon actions not demonstrated - banning chemicals, etc.

8. The main concern that I have is that a large amount of time and money will be spent conducting this survey/study and then NO ACTION will be forthcoming. A method for funding the cost has to be agreed upon and pursued.

9. Within the Derby area, it would be nice to have better public access to much of the Spring Creek area. I would like to be able to enjoy the creek with trails and groomed park areas. Instead it is overgrown, inaccessible and does not enhance my neighborhood.
   To answer these questions with some confidence I would need to know the quality of storm water runoff and the effects it may have in relation to property damage or health.

10. One doesn't know the current level of water quality. What level of quality is desired, pristine, swimming, fishing, or only boating?

11. Derby does not want to correct the problem. I talked to them several times about my water problems on Crosswood Ln. They did nothing offered no solutions. There should have been a coordinated effort to re-direct the water yrs. ago instead
Of the hick backward neighbors dumping water on other people. I doubt you understand what I am saying a COORDINATED PLAN. Derby is just backward and unprogressive.
Buying that house was the worst mistake I ever made in my life. It has brought nothing but misery due to water issues and no one seems to care. Too little too late.

12. Answering Questions 22-30 felt odd and off-putting. You asked for a rating but they system wouldn't let me use the same more than once, making it more like a rank ordering, which didn't seem appropriate given the type of question. I'm afraid the results will be less than useful.

APPENDIX B

Flood Management Improvements Prioritization

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Proposed Flood Management Improvements

Flood Management Name	Flood Management Description	Subbasin	Total Project Cost	PRIORITIZATION SCORE
46	park	TRL10200H	$ 96,760	0.0461
47	park	TRL10200H	$ 103,840	0.0495
17	parking lot	SPG10300H	$ 250,160	0.0831
15	parking lot	SPG10300H	$ 251,340	0.0835
30	parking lot	TRL10200H	$ 195,880	0.0933
33	parking lot	TRL10200H	$ 274,940	0.1309
3	parking lot	DRY10300H	$ 160,480	0.1516
45	parking lot	TRL10100H	$ 97,940	0.1629
10	parking lot	DRY1T10200H	$ 398,840	0.1876
43	parking lot	TRL10100H	$ 116,820	0.1943
7	parking lot	DRY1T10100H	$ 365,800	0.2004
35	parking lot	TRL10100H	$ 121,540	0.2022
11	parking lot	DRY1T10200H	$ 430,700	0.2026
9	parking lot	DRY1T10100H	$ 391,760	0.2146
6	parking lot	DRY1T10100H	$ 441,320	0.2418
27	parking lot	TRL10200H	$ 519,200	0.2473
32	parking lot	TRL10200H	$ 539,260	0.2568
8	parking lot	DRY1T10100H	$ 477,900	0.2618
29	parking lot	TRL10200H	$ 571,120	0.2720
5	parking lot	DRY1T10100H	$ 516,840	0.2832
34	parking lot	TRL10200H	$ 641,920	0.3057
26	parking lot	SPG3T10100H	$ 614,780	0.3109
13	parking lot	SPG10300H	$ 938,100	0.3117
42	parking lot	TRL10100H	$ 187,620	0.3121
41	parking lot	TRL10100H	$ 204,140	0.3396
1	parking lot	DRY10300H	$ 387,040	0.3656
28	parking lot	TRL10200H	$ 879,100	0.4187
16	parking lot	SPG10300H	$ 1,263,780	0.4199
14	parking lot	SPG10300H	$ 1,340,480	0.4453
31	parking lot	TRL10200H	$ 956,980	0.4558
4	parking lot	DRY1T10100H	$ 1,033,680	0.5663
40	parking lot	TRL10100H	$ 357,540	0.5948
2	parking lot	DRY10300H	$ 672,600	0.6354
36	parking lot	TRL10100H	$ 440,140	0.7322
37	parking lot	TRL10100H	$ 515,660	0.8578
12	parking lot	SPG10300H	$ 3,203,700	1.0644
24	parking lot	SPG1T10000H	$ 120,360	1.2559
38	parking lot	TRL10100H	$ 808,300	1.3446
44	parking lot	TRL10100H	$ 967,600	1.6096
39	parking lot	TRL10100H	$ 1,089,140	1.8118
23	parking lot	SPG1T10000H	$ 175,820	1.8347
22	parking lot	SPG1T10000H	$ 192,340	2.0071
21	parking lot	SPG1T10000H	$ 266,680	2.7828
25	parking lot	SPG1T10000H	$ 381,140	3.9772
19	parking lot	SPG1T10000H	$ 1,163,480	12.1408
18	parking lot	SPG1T10000H	$ 1,492,700	15.5762
20	parking lot	SPG1T10000H	$ 3,345,300	34.9080
		Total Cost	**$ 29,962,560**	

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

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APPENDIX C

Flood Management Improvements Project Costs

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Proposed Flood Management Improvements - Project Costs

Location Name	Subbasin	Description	Subbasin Detention Volume (CF)	Surface Area (SF)	Storage Depth (ft)	Storage Volume (CF)	Flood Improvement Cost	Demo/Mob	Contingency	Total Construction Cost	Engineering Design Cost	Surveying Cost	Geotechnical Cost	TOTAL PROJECT COST
1	DRY10300H	parking lot	1058508.00	24,200	0.3003003	7,267	$ 218,018	$ 54,505	$ 54,505	$ 328,000	$ 39,360	$ 9,840	$ 9,840	$ 387,040
2	DRY10300H	parking lot	1058508.00	42,175	0.3003003	12,665	$ 379,955	$ 94,989	$ 94,989	$ 570,000	$ 68,400	$ 17,100	$ 17,100	$ 672,600
3	DRY10300H	parking lot	1058508.00	10,000	0.3003003	3,003	$ 90,090	$ 22,523	$ 22,523	$ 136,000	$ 16,320	$ 4,080	$ 4,080	$ 160,480
4	DRY1T10100H	parking lot	1825164.00	64,820	0.3003003	19,465	$ 583,964	$ 145,991	$ 145,991	$ 876,000	$ 105,120	$ 26,280	$ 26,280	$ 1,033,680
5	DRY1T10100H	parking lot	1825164.00	32,400	0.3003003	9,730	$ 291,892	$ 72,973	$ 72,973	$ 438,000	$ 52,560	$ 13,140	$ 13,140	$ 516,840
6	DRY1T10100H	parking lot	1825164.00	27,665	0.3003003	8,308	$ 249,234	$ 62,309	$ 62,309	$ 374,000	$ 44,880	$ 11,220	$ 11,220	$ 441,320
7	DRY1T10100H	parking lot	1825164.00	22,875	0.3003003	6,869	$ 206,081	$ 51,520	$ 51,520	$ 310,000	$ 37,200	$ 9,300	$ 9,300	$ 365,800
8	DRY1T10100H	parking lot	1825164.00	29,962	0.3003003	8,998	$ 269,928	$ 67,482	$ 67,482	$ 405,000	$ 48,600	$ 12,150	$ 12,150	$ 477,900
9	DRY1T10100H	parking lot	1825164.00	24,540	0.3003003	7,369	$ 221,081	$ 55,270	$ 55,270	$ 332,000	$ 39,840	$ 9,960	$ 9,960	$ 391,760
10	DRY1T10200H	parking lot	2125728.00	25,000	0.3003003	7,508	$ 225,225	$ 56,306	$ 56,306	$ 338,000	$ 40,560	$ 10,140	$ 10,140	$ 398,840
11	DRY1T10200H	parking lot	2125728.00	27,000	0.3003003	8,108	$ 243,243	$ 60,811	$ 60,811	$ 365,000	$ 43,800	$ 10,950	$ 10,950	$ 430,700
12	SPG10300H	parking lot	3009996.00	200,870	0.3003003	60,321	$ 1,809,640	$ 452,410	$ 452,410	$ 2,715,000	$ 325,800	$ 81,450	$ 81,450	$ 3,203,700
13	SPG10300H	parking lot	3009996.00	58,760	0.3003003	17,646	$ 529,369	$ 132,342	$ 132,342	$ 795,000	$ 95,400	$ 23,850	$ 23,850	$ 938,100
14	SPG10300H	parking lot	3009996.00	84,050	0.3003003	25,240	$ 757,207	$ 189,302	$ 189,302	$ 1,136,000	$ 136,320	$ 34,080	$ 34,080	$ 1,340,480
15	SPG10300H	parking lot	3009996.00	15,720	0.3003003	4,721	$ 141,622	$ 35,405	$ 35,405	$ 213,000	$ 25,560	$ 6,390	$ 6,390	$ 251,340
16	SPG10300H	parking lot	3009996.00	79,225	0.3003003	23,791	$ 713,739	$ 178,435	$ 178,435	$ 1,071,000	$ 128,520	$ 32,130	$ 32,130	$ 1,263,780
17	SPG10300H	parking lot	3009996.00	15,660	0.3003003	4,703	$ 141,081	$ 35,270	$ 35,270	$ 212,000	$ 25,440	$ 6,360	$ 6,360	$ 250,160
18	SPG1T10000H	parking lot	95832.00	93,570	0.3003003	28,099	$ 842,973	$ 210,743	$ 210,743	$ 1,265,000	$ 151,800	$ 37,950	$ 37,950	$ 1,492,700
19	SPG1T10000H	parking lot	95832.00	72,900	0.3003003	21,892	$ 656,757	$ 164,189	$ 164,189	$ 986,000	$ 118,320	$ 29,580	$ 29,580	$ 1,163,480
20	SPG1T10000H	parking lot	95832.00	209,750	0.3003003	62,988	$ 1,889,640	$ 472,410	$ 472,410	$ 2,835,000	$ 340,200	$ 85,050	$ 85,050	$ 3,345,300
21	SPG1T10000H	parking lot	95832.00	16,680	0.3003003	5,009	$ 150,270	$ 37,568	$ 37,568	$ 226,000	$ 27,120	$ 6,780	$ 6,780	$ 266,680
22	SPG1T10000H	parking lot	95832.00	12,000	0.3003003	3,604	$ 108,108	$ 27,027	$ 27,027	$ 163,000	$ 19,560	$ 4,890	$ 4,890	$ 192,340
23	SPG1T10000H	parking lot	95832.00	11,000	0.3003003	3,303	$ 99,099	$ 24,775	$ 24,775	$ 149,000	$ 17,880	$ 4,470	$ 4,470	$ 175,820
24	SPG1T10000H	parking lot	95832.00	7,500	0.3003003	2,252	$ 67,568	$ 16,892	$ 16,892	$ 102,000	$ 12,240	$ 3,060	$ 3,060	$ 120,360
25	SPG1T10000H	parking lot	95832.00	23,870	0.3003003	7,168	$ 215,045	$ 53,761	$ 53,761	$ 323,000	$ 38,760	$ 9,690	$ 9,690	$ 381,140
26	SPG3T10100H	parking lot	1977624.00	38,500	0.3003003	11,562	$ 346,847	$ 86,712	$ 86,712	$ 521,000	$ 62,520	$ 15,630	$ 15,630	$ 614,780
27	TRL10200H	parking lot	2099592.00	32,540	0.3003003	9,772	$ 293,153	$ 73,288	$ 73,288	$ 440,000	$ 52,800	$ 13,200	$ 13,200	$ 519,200
28	TRL10200H	parking lot	2099592.00	55,100	0.3003003	16,547	$ 496,396	$ 124,099	$ 124,099	$ 745,000	$ 89,400	$ 22,350	$ 22,350	$ 879,100
29	TRL10200H	parking lot	2099592.00	35,800	0.3003003	10,751	$ 322,523	$ 80,631	$ 80,631	$ 484,000	$ 58,080	$ 14,520	$ 14,520	$ 571,120
30	TRL10200H	parking lot	2099592.00	12,280	0.3003003	3,688	$ 110,631	$ 27,658	$ 27,658	$ 166,000	$ 19,920	$ 4,980	$ 4,980	$ 195,880
31	TRL10200H	parking lot	2099592.00	60,000	0.3003003	18,018	$ 540,541	$ 135,135	$ 135,135	$ 811,000	$ 97,320	$ 24,330	$ 24,330	$ 956,980
32	TRL10200H	parking lot	2099592.00	33,800	0.3003003	10,150	$ 304,505	$ 76,126	$ 76,126	$ 457,000	$ 54,840	$ 13,710	$ 13,710	$ 539,260
33	TRL10200H	parking lot	2099592.00	17,200	0.3003003	5,165	$ 154,955	$ 38,739	$ 38,739	$ 233,000	$ 27,960	$ 6,990	$ 6,990	$ 274,940
34	TRL10200H	parking lot	2099592.00	40,200	0.3003003	12,072	$ 362,162	$ 90,541	$ 90,541	$ 544,000	$ 65,280	$ 16,320	$ 16,320	$ 641,920
35	TRL10100H	parking lot	601128.00	7,560	0.3003003	2,270	$ 68,108	$ 17,027	$ 17,027	$ 103,000	$ 12,360	$ 3,090	$ 3,090	$ 121,540
36	TRL10100H	parking lot	601128.00	27,540	0.3003003	8,270	$ 248,108	$ 62,027	$ 62,027	$ 373,000	$ 44,760	$ 11,190	$ 11,190	$ 440,140
37	TRL10100H	parking lot	601128.00	32,290	0.3003003	9,697	$ 290,901	$ 72,725	$ 72,725	$ 437,000	$ 52,440	$ 13,110	$ 13,110	$ 515,660
38	TRL10100H	parking lot	601128.00	50,660	0.3003003	15,213	$ 456,396	$ 114,099	$ 114,099	$ 685,000	$ 82,200	$ 20,550	$ 20,550	$ 808,300
39	TRL10100H	parking lot	601128.00	68,300	0.3003003	20,511	$ 615,315	$ 153,829	$ 153,829	$ 923,000	$ 110,760	$ 27,690	$ 27,690	$ 1,089,140
40	TRL10100H	parking lot	601128.00	22,400	0.3003003	6,727	$ 201,802	$ 50,450	$ 50,450	$ 303,000	$ 36,360	$ 9,090	$ 9,090	$ 357,540
41	TRL10100H	parking lot	601128.00	12,740	0.3003003	3,826	$ 114,775	$ 28,694	$ 28,694	$ 173,000	$ 20,760	$ 5,190	$ 5,190	$ 204,140
42	TRL10100H	parking lot	601128.00	11,700	0.3003003	3,514	$ 105,405	$ 26,351	$ 26,351	$ 159,000	$ 19,080	$ 4,770	$ 4,770	$ 187,620
43	TRL10100H	parking lot	601128.00	7,275	0.3003003	2,185	$ 65,541	$ 16,385	$ 16,385	$ 99,000	$ 11,880	$ 2,970	$ 2,970	$ 116,820
44	TRL10100H	parking lot	601128.00	60,650	0.3003003	18,213	$ 546,396	$ 136,599	$ 136,599	$ 820,000	$ 98,400	$ 24,600	$ 24,600	$ 967,600
45	TRL10100H	parking lot	601128.00	6,100	0.3003003	1,832	$ 54,955	$ 13,739	$ 13,739	$ 83,000	$ 9,960	$ 2,490	$ 2,490	$ 97,940
46	TRL10200H	park	2099592.00	14,000	6	84,000	$ 54,600	$ 13,650	$ 13,650	$ 82,000	$ 9,840	$ 2,460	$ 2,460	$ 96,760
47	TRL10200H	park	2099592.00	15,000	6	90,000	$ 58,500	$ 14,625	$ 14,625	$ 88,000	$ 10,560	$ 2,640	$ 2,640	$ 103,840
													Total Project Cost	**$ 29,962,560**

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

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APPENDIX D

Channel Condition Scoring Matrix and

Stream Reach Rating and Ranking Table

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Project: ____

Stream Name and Location: ____

Evaluated by: ____________________Firm: __________________________________ Date:_______________

Table 5605-4: Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)		0.6	
Average bank slope angle	slopes ≤ 2:1 on one or occasionally both banks	slopes up to1.7:1 (60˚) common on one or both banks	bank slopes over 60˚ on one or both banks		0.6	
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet		0.8	
Vegetative bank protection	wide to medium band of woody vegetation with 70-90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank		0.8	
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent		0.4	
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.		0.8	

Table 5605-4: Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well-consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of bar	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation		0.6	
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent		0.2	
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow		0.2	
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm		0.8	
Sinuosity	1.2 ≤ Sinuosity ≤ 1.4	1.1<Sinuosity <1.2	Sinuosity <1.1		0.8	
Ratio of radius of curvature to channel width	3 ≤ Rc/Wb ≤ 5	2 < Rc/Wb < 3, 5 < Rc/Wb < 7	2 < Rc /Wb, Rc /Wb > 7		0.8	
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	4 ≤ Length/Wb < 8	3 ≤ Length/Wb < 4, 8 < Length/Wb ≤ 9	3 < Length/Wb, Length/Wb > 9, unless long pool or run because of geologic influence		0.8	
Percentage of channel constriction	< 25%	26-50%	> 50%		0.8	
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment		0.8	

TOTAL ____

Stream Reach Rating and Ranking

Site_ID	Easting	Northing	Bank Soil Texture and Coherence	Average Bank Slope Angle	Average Bank Height	Vegetative Bank Protection	Bank Cutting	Mass Wasting	Bar Development	Debris Jam Potential	Obstructions and Sediment Traps	Channel Bed Material Consolidation and Armoring	Sinuosity	Ratio of Radius of Curvature to Channel Width	Ratio of Pool-Riffle Spacing to Channel Width	Percentage of Channel Construction	Sediment Movement	Total Rating Score	Ranking
1	1671357.431	1630311.9	0.6	0.6	1.6	1.6	0.8	0.8	1.8	0.2	0.2	0.8	0.8	0.8	2.4	0.8	0.8	14.6	Fair
2	1670970.555	1630395.352	0.6	1.8	2.4	2.4	1.2	2.4	1.8	0.6	0.6	2.4	0.8	0.8	2.4	0.8	0.8	21.8	Poor
3	1670466.099	1631688.243	1.8	0.6	0.8	1.6	0.4	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	18.6	Fair
4	1670464.969	1631647.285	1.8	0.6	0.8	2.4	0.4	0.8	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	20.2	Poor
5	1670307.204	1635613.658	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	0.8	2.4	2.4	2.4	0.8	0.8	15.8	Fair
6	1670255.883	1635554.78	0.6	0.6	1.6	0.8	0.4	0.8	1.2	0.6	0.4	0.8	2.4	2.4	2.4	1.6	0.8	17.4	Fair
7	1670481.659	1636396.917	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.4	0.8	2.4	2.4	2.4	0.8	2.4	17.8	Fair
8	1671582.128	1630762.523	0.6	1.8	2.4	2.4	1.2	2.4	1.2	0.6	0.4	2.4	0.8	0.8	2.4	1.6	1.6	22.6	Poor
9	1673350.691	1632976.291	0.6	1.2	1.6	1.6	1.2	2.4	1.2	0.2	0.2	2.4	0.8	0.8	2.4	0.8	1.6	19.0	Fair
10	1673263.663	1635622.186	0.6	1.2	1.6	1.6	0.8	0.8	1.2	0.4	0.2	0.8	0.8	2.4	2.4	1.6	0.8	17.2	Fair
11	1673270.855	1635689.957	0.6	1.2	0.8	1.6	0.8	0.8	1.2	0.4	0.2	1.6	0.8	0.8	2.4	0.8	1.6	15.6	Fair
12	1675444.12	1635772.666	0.6	0.6	0.8	1.6	0.4	0.8	1.8	0.2	0.2	1.6	0.8	2.4	2.4	0.8	0.8	15.8	Fair
13	1673394.405	1638517.91	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.6	2.4	0.8	0.8	2.4	2.4	0.8	16.6	Fair
14	1673392.219	1638458.518	0.6	1.8	1.6	1.6	0.8	0.8	1.8	0.4	0.2	1.6	0.8	2.4	2.4	1.6	0.8	19.2	Fair
15	1672925.3	1637858.317	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	17.6	Fair
16	1672854.882	1637875.167	0.6	1.8	2.4	2.4	1.2	2.4	1.8	0.4	0.2	1.6	0.8	0.8	2.4	0.8	1.6	21.2	Poor
17	1672261.775	1638327.08	0.6	1.8	2.4	1.6	1.2	1.6	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	21.0	Poor
18	1672268.566	1638279.786	0.6	1.8	2.4	2.4	1.2	2.4	1.8	0.4	0.4	2.4	0.8	0.8	2.4	1.6	0.8	22.2	Poor
19	1674939.49	1641004.593	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	16.6	Fair
20	1674939.436	1641011.823	0.6	0.6	0.8	0.8	0.4	0.8	1.2	0.4	0.4	0.8	2.4	2.4	2.4	1.6	0.8	16.4	Fair
21	1673922.234	1639829.98	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.4	1.6	1.6	2.4	2.4	1.6	0.8	17.2	Fair
22	1673888.553	1639763.378	0.6	0.6	0.8	2.4	0.8	0.8	1.8	0.4	0.2	2.4	0.8	0.8	2.4	0.8	0.8	16.4	Fair
23	1671672.317	1640943.719	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.2	2.4	1.6	2.4	2.4	0.8	0.8	16.8	Fair
24	1671691.185	1640883.597	0.6	1.8	2.4	1.6	1.2	2.4	1.8	0.6	0.6	2.4	1.6	2.4	2.4	2.4	1.6	25.8	Poor
25	1671311.594	1643677.612	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.6	2.4	0.8	0.8	2.4	1.6	1.6	16.6	Fair
26	1671244.675	1643772.87	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.4	2.4	0.8	0.8	2.4	0.8	1.6	15.6	Fair
27	1673545.194	1643932.567	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.4	2.4	0.8	2.4	2.4	0.8	0.8	16.2	Fair
28	1673568.38	1644007.244	0.6	0.6	0.8	0.8	0.4	0.8	1.2	0.6	0.6	2.4	0.8	2.4	2.4	1.6	1.6	17.6	Fair
29	1675737.382	1643663.307	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.6	0.2	2.4	0.8	2.4	2.4	1.6	0.8	15.8	Fair
30	1675765.042	1643775.841	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.6	0.2	2.4	2.4	2.4	2.4	2.4	0.8	18.2	Fair
31	1673934.18	1646300.862	0.6	0.6	0.8	0.8	0.4	0.8	1.2	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	16.0	Fair
32	1673904.765	1646210.537	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.6	0.2	2.4	1.6	2.4	2.4	2.4	0.8	17.4	Fair
33	1670992.772	1646263.588	0.6	1.8	0.8	2.4	1.2	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	20.2	Poor
34	1671032.743	1646135.234	0.6	0.6	0.8	0.8	0.8	0.8	1.8	0.4	0.2	2.4	0.8	2.4	2.4	1.6	0.8	17.2	Fair
35	1672075.941	1647478.025	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.2	2.4	2.4	2.4	2.4	1.6	0.8	18.4	Fair
36	1671990.985	1647413.04	0.6	0.6	0.8	0.8	0.4	0.8	1.2	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	16.8	Fair
37	1670651.271	1648356.778	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.6	0.4	2.4	0.8	2.4	2.4	1.6	0.8	19.0	Fair
38	1670643.975	1648327.618	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	17.0	Fair
39	1671539.939	1651550.137	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	14.6	Fair
40	1671547.92	1651519.337	0.6	0.6	0.8	1.6	0.4	0.8	1.2	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	18.4	Fair
41	1678713.207	1656998.187	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	19.4	Fair
42	1678924.67	1656961.537	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	15.4	Fair
43	1677916	1656991.047	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.4	0.4	1.6	2.4	2.4	2.4	1.6	1.6	20.4	Poor
44	1677912.896	1656953.216	0.6	1.8	0.8	0.8	0.8	0.8	1.8	0.4	0.4	2.4	0.8	2.4	2.4	1.6	1.6	19.4	Fair
45	1680171.061	1662327.266	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.4	2.4	2.4	2.4	2.4	1.6	0.8	18.6	Fair
46	1680171.341	1662300.636	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.4	2.4	2.4	2.4	2.4	0.8	0.8	17.8	Fair
47	1681265.023	1658968.458	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.4	0.2	2.4	2.4	2.4	0.8	1.6	0.8	16.8	Fair
48	1681304.478	1658931.89	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.4	0.4	2.4	1.6	2.4	2.4	1.6	0.8	19.0	Fair
49	1681626.768	1667650.607	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	16.6	Fair
50	1681623.93	1667613.354	0.6	1.8	0.8	1.6	0.8	0.8	1.8	0.4	0.2	2.4	1.6	2.4	2.4	0.8	0.8	19.2	Fair
51	1683652.329	1667651.834	0.6	1.8	0.8	2.4	0.8	0.8	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	20.6	Poor
52	1683658.673	1667683.349	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	19.2	Fair
53	1684499.54	1662419.144	0.6	1.2	0.8	0.8	0.8	0.8	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	19.2	Fair
54	1684441.953	1662385.569	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	16.0	Fair
55	1683625.107	1662392.509	0.6	0.6	0.8	2.4	0.4	0.8	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	19.0	Fair
56	1683616.299	1662373.631	0.6	1.8	0.8	1.6	0.8	0.8	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	20.6	Poor
57	1684273.274	1657073.289	0.6	1.8	1.6	2.4	1.2	1.6	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	23.4	Poor
58	1684283.003	1657115.143	0.6	1.8	0.8	2.4	1.2	1.6	1.8	0.6	0.6	1.6	0.8	0.8	2.4	1.6	0.8	19.4	Fair
59	1685679.865	1657121.904	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.4	0.2	2.4	0.8	0.8	2.4	0.8	0.8	16.2	Fair
60	1685654.273	1657155.297	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.2	2.4	2.4	2.4	2.4	2.4	0.8	19.4	Fair
61	1686563.069	1658894.572	0.6	1.8	0.8	2.4	1.2	1.6	1.8	0.4	0.2	2.4	2.4	2.4	2.4	0.8	0.8	22.0	Poor
62	1691910.39	1657646.16	0.6	1.8	0.8	0.8	0.8	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	17.4	Fair
63	1691889.051	1657576.663	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	15.8	Fair
64	1692596.467	1651952.689	0.6	0.6	0.8	2.4	0.8	0.8	1.8	0.4	0.2	2.4	2.4	2.4	2.4	0.8	0.8	19.6	Fair
65	1692610.42	1651977.916	0.6	1.2	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	17.6	Fair
66	1692036.767	1650516.474	0.6	1.8	0.8	2.4	1.2	1.6	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	1.6	22.6	Poor
67	1692020.214	1650521.611	0.6	1.8	0.8	2.4	1.2	1.6	1.8	0.4	0.2	2.4	0.8	2.4	2.4	0.8	0.8	20.4	Poor
68	1676471.053	1632687.615	0.6	1.2	1.6	1.6	0.8	1.6	1.8	0.2	0.2	2.4	0.8	0.8	1.6	0.8	1.6	17.6	Fair
69	1676397.551	1632823.102	0.6	1.2	1.6	1.6	0.8	0.8	1.8	0.4	0.4	2.4	0.8	0.8	1.6	1.6	0.8	17.2	Fair
70	1678691.515	1635762.55	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.4	0.2	2.4	0.8	2.4	2.4	1.6	1.6	18.8	Fair
71	1681115.538	1635818.202	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.4	2.4	2.4	2.4	2.4	2.4	0.8	19.6	Fair

Site_ID	Easting	Northing	Bank Soil Texture and Coherence	Average Bank Slope Angle	Average Bank Height	Vegetative Bank Protection	Bank Cutting	Mass Wasting	Bar Development	Debris Jam Potential	Obstructions and Sediment Traps	Channel Bed Material Consolidation and Armoring	Sinuosity	Ratio of Radius of Curvature to Channel Width	Ratio of Pool-Riffle Spacing to Channel Width	Percentage of Channel Construction	Sediment Movement	Total Rating Score	Ranking
72	1682030.027	1635832.475	0.6	0.6	2.4	0.8	0.4	2.4	1.2	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	16.8	Fair
73	1681999.727	1635872.279	0.6	1.8	2.4	1.6	1.2	1.6	1.8	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	19.4	Fair
74	1682668.416	1635846.156	0.6	1.8	0.8	2.4	1.2	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	20.2	Poor
75	1682696.517	1635879.126	0.6	1.8	1.6	2.4	1.2	0.8	1.8	0.4	0.2	2.4	1.6	2.4	2.4	0.8	0.8	21.2	Poor
76	1681690.701	1634561.91	0.6	1.2	1.6	2.4	1.2	0.8	1.2	0.4	0.4	2.4	0.8	0.8	2.4	1.6	0.8	18.6	Fair
77	1681660.924	1634557.907	0.6	1.8	1.6	2.4	1.2	1.6	1.8	0.4	0.2	2.4	0.8	0.8	2.4	0.8	0.8	19.6	Fair
78	1678150.628	1630473.241	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	18.2	Fair
79	1678155.989	1630500.836	0.6	0.6	0.8	0.8	0.4	0.8	1.2	0.6	0.6	2.4	0.8	2.4	2.4	2.4	2.4	19.2	Fair
80	1676871.892	1638459.19	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	2.4	2.4	2.4	2.4	0.8	0.8	17.4	Fair
81	1678836.222	1638430.157	0.6	0.6	0.8	0.8	0.8	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	17.0	Fair
82	1682358.628	1641109.687	0.6	1.8	0.8	1.6	1.2	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	18.6	Fair
83	1682347.716	1641141.011	0.6	0.6	0.8	1.6	0.4	0.8	1.8	0.6	0.6	2.4	0.8	2.4	2.4	2.4	0.8	19.0	Fair
84	1682635.543	1641148.14	0.6	1.8	1.6	1.6	0.8	0.8	1.2	0.4	0.4	2.4	0.8	2.4	2.4	1.6	0.8	19.6	Fair
85	1682592.198	1641121.715	0.6	1.8	2.4	2.4	1.2	1.6	1.8	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	20.2	Poor
86	1683378.894	1641165.709	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.6	0.2	1.6	0.8	2.4	2.4	0.8	0.8	14.2	Fair
87	1683379.483	1641134.658	0.6	1.8	2.4	2.4	1.2	1.6	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	21.8	Poor
88	1682042.752	1646445.513	0.6	1.8	2.4	2.4	1.2	0.8	1.8	0.4	0.4	2.4	0.8	0.8	2.4	1.6	0.8	20.6	Poor
89	1682089.478	1646425.112	0.6	1.8	2.4	2.4	1.2	2.4	1.8	0.2	0.2	2.4	0.8	0.8	2.4	0.8	0.8	21.0	Poor
90	1681467.082	1646375.633	0.6	1.8	2.4	2.4	1.2	2.4	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	22.6	Poor
91	1681468.92	1646453.76	0.6	1.8	1.6	1.6	1.2	0.8	1.8	0.6	0.2	2.4	0.8	2.4	2.4	1.6	0.8	20.6	Poor
92	1677905.236	1646375.226	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.6	0.4	2.4	0.8	2.4	2.4	1.6	0.8	17.2	Fair
93	1677908.978	1646299.105	0.6	0.6	0.8	0.8	0.4	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	15.8	Fair
94	1688708.579	1651884.57	0.6	0.6	0.8	1.6	0.4	0.8	1.2	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	16.0	Fair
95	1683024.847	1651790.865	0.6	1.8	1.6	1.6	0.8	1.6	1.8	0.4	0.4	2.4	0.8	2.4	2.4	0.8	0.8	20.2	Poor
96	1683018.723	1651775.374	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.4	0.4	2.4	1.6	0.8	2.4	1.6	0.8	17.4	Fair
97	1680482.467	1651727.841	0.6	0.6	0.8	1.6	0.8	0.8	1.8	0.2	0.2	2.4	0.8	2.4	2.4	0.8	0.8	17.0	Fair
98	1680490.683	1651702.367	0.6	1.2	0.8	2.4	1.2	0.8	1.8	0.4	0.2	2.4	2.4	2.4	2.4	0.8	0.8	20.6	Poor
99	1678946.731	1651701.78	0.6	1.8	1.6	2.4	1.2	2.4	1.8	0.6	0.6	2.4	2.4	2.4	2.4	2.4	0.8	25.8	Poor
100	1678969.049	1651675.134	0.6	0.6	0.8	0.8	0.8	0.8	1.8	0.2	0.2	2.4	1.6	2.4	2.4	0.8	0.8	17.0	Fair

APPENDIX E

Creek Improvements Prioritization

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Proposed Stream Improvements

Stream Reach	Total Project Cost	Total Reach Length (ft)	Channel Rating Score	PRIORITIZATION SCORE
24	$ 1,087,000	1,439	25.8	29.3
8	$ 2,529,000	3,818	22.6	29.3
2	$ 12,143,000	18,445	21.8	30.2
87	$ 3,392,000	5,091	21.8	30.6
57	$ 3,313,000	4,549	23.4	31.1
90	$ 572,000	804	22.6	31.5
89	$ 4,784,000	7,039	21	32.4
18	$ 2,225,000	3,078	22.2	32.6
9	$ 3,365,000	5,427	19	32.6
75	$ 412,000	592	21.2	32.8
85	$ 2,560,000	3,829	20.2	33.1
61	$ 799,000	1,091	22	33.3
88	$ 4,097,000	5,950	20.6	33.4
95	$ 3,594,000	5,315	20.2	33.5
56	$ 2,464,000	3,573	20.6	33.5
51	$ 799,000	1,148	20.6	33.8
17	$ 1,276,000	1,785	21	34.0
77	$ 4,108,000	6,152	19.6	34.1
84	$ 2,089,000	3,091	19.6	34.5
91	$ 2,948,000	4,134	20.6	34.6
33	$ 749,000	1,071	20.2	34.6
50	$ 383,000	576	19.2	34.6
73	$ 2,908,000	4,269	19.4	35.1
58	$ 2,732,000	4,004	19.4	35.2
67	$ 974,000	1,355	20.4	35.2
98	$ 2,099,000	2,883	20.6	35.3
76	$ 1,131,000	1,690	18.6	36.0
55	$ 1,953,000	2,830	19	36.3
69	$ 2,150,000	3,438	17.2	36.4
60	$ 906,000	1,279	19.4	36.5
52	$ 1,609,000	2,283	19.2	36.7
41	$ 501,000	697	19.4	37.1
83	$ 2,191,000	3,076	19	37.5
37	$ 1,103,000	1,548	19	37.5
68	$ 2,887,000	4,356	17.6	37.7
4	$ 1,904,000	2,491	20.2	37.8
80	$ 1,026,000	1,544	17.4	38.2
72	$ 1,297,000	2,007	16.8	38.5
28	$ 729,000	1,069	17.6	38.7
70	$ 3,001,000	4,108	18.8	38.9
40	$ 2,041,000	2,850	18.4	38.9
96	$ 1,820,000	2,685	17.4	39.0
10	$ 3,092,000	4,577	17.2	39.3
79	$ 2,163,000	2,842	19.2	39.6
53	$ 437,000	574	19.2	39.7
44	$ 809,000	1,051	19.4	39.7
47	$ 148,000	222	16.8	39.7
34	$ 1,322,000	1,934	17.2	39.7
14	$ 307,000	394	19.2	40.6
71	$ 896,000	1,126	19.6	40.6
82	$ 749,000	988	18.6	40.8

Proposed Stream Improvements

Stream Reach	Total Project Cost	Total Reach Length (ft)	Channel Rating Score	PRIORITIZATION SCORE
48	$ 777,000	1,003	19	40.8
97	$ 3,435,000	4,841	17	41.7
38	$ 1,376,000	1,933	17	41.9
92	$ 1,404,000	1,946	17.2	41.9
21	$ 693,000	959	17.2	42.0
12	$ 2,304,000	3,470	15.8	42.0
26	$ 1,150,000	1,724	15.6	42.8
32	$ 857,000	1,151	17.4	42.8
29	$ 1,050,000	1,552	15.8	42.8
6	$ 1,268,000	1,691	17.4	43.1
54	$ 962,000	1,393	16	43.2
94	$ 6,773,000	9,800	16	43.2
81	$ 1,763,000	2,357	17	44.0
25	$ 998,000	1,362	16.6	44.1
7	$ 1,474,000	1,871	17.8	44.3
19	$ 540,000	729	16.6	44.6
59	$ 1,768,000	2,440	16.2	44.7
27	$ 2,562,000	3,497	16.2	45.2
100	$ 1,617,000	2,102	17	45.3
13	$ 616,000	816	16.6	45.5
93	$ 1,518,000	2,107	15.8	45.6
5	$ 612,000	837	15.8	46.3
31	$ 2,228,000	2,995	16	46.5
42	$ 769,000	1,074	15.4	46.5
3	$ 1,985,000	2,284	18.6	46.7
22	$ 690,000	899	16.4	46.8
16	$ 674,000	679	21.2	46.8
15	$ 515,000	612	17.6	47.8
23	$ 775,000	961	16.8	48.0
86	$ 3,557,000	5,167	14.2	48.5
39	$ 2,356,000	3,270	14.6	49.3
11	$ 2,027,000	2,328	15.6	55.8
74	$ 19,000	15	20.2	62.7
64	$ 19,000	15	19.6	64.6
30	$ 19,000	15	18.2	69.6
63	$ 56,000	45	15.8	78.8
Total Cost	**$ 155,779,000**			

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

APPENDIX F

Creek Improvements Project Costs

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Proposed Stream Improvements - Project Costs

Stream Reach	Length 1 (ft)	Length 2 (ft)	Length 3 (ft)	Length 4 (ft)	Length 5 (ft)	TOTAL LENGTH (ft)	Number of ERRs	Restoration Cost	Step Structure Cost	Demo/Mob Cost	Contingency Cost	Total Construction Cost	Engineering Design Cost	Surveying Cost	Geotechnical Cost	TOTAL PROJECT COST
2	15,701	1,169	1,575			18,445	11	$ 6,475,560	$ 110,000	$ 1,646,390	$ 2,057,988	$ 10,290,000	$ 1,234,800	$ 308,700	$ 308,700	$ 12,143,000
3	519	529		1,236		2,284	10	$ 975,900	$ 100,000	$ 268,975	$ 336,219	$ 1,682,000	$ 201,840	$ 50,460	$ 50,460	$ 1,985,000
4	2,081	183	227			2,491	16	$ 872,160	$ 160,000	$ 258,040	$ 322,550	$ 1,613,000	$ 193,560	$ 48,390	$ 48,390	$ 1,904,000
5	837					837	3	$ 301,320	$ 30,000	$ 82,830	$ 103,538	$ 518,000	$ 62,160	$ 15,540	$ 15,540	$ 612,000
6	1,031	305		249	106	1,691	6	$ 626,750	$ 60,000	$ 171,688	$ 214,609	$ 1,074,000	$ 128,880	$ 32,220	$ 32,220	$ 1,268,000
7	1,035			836		1,871	0	$ 798,960	$ -	$ 199,740	$ 249,675	$ 1,249,000	$ 149,880	$ 37,470	$ 37,470	$ 1,474,000
8	2,304	634	607	273		3,818	3	$ 1,340,970	$ 30,000	$ 342,743	$ 428,428	$ 2,143,000	$ 257,160	$ 64,290	$ 64,290	$ 2,529,000
9	2,771	724	1,932			5,427	3	$ 1,794,360	$ 30,000	$ 456,090	$ 570,113	$ 2,851,000	$ 342,120	$ 85,530	$ 85,530	$ 3,365,000
10	2,240	1,131	736	470		4,577	7	$ 1,606,200	$ 70,000	$ 419,050	$ 523,813	$ 2,620,000	$ 314,400	$ 78,600	$ 78,600	$ 3,092,000
11	251		482	1,595		2,328	5	$ 1,048,410	$ 50,000	$ 274,603	$ 343,253	$ 1,717,000	$ 206,040	$ 51,510	$ 51,510	$ 2,027,000
12	3,470					3,470	0	$ 1,249,200	$ -	$ 312,300	$ 390,375	$ 1,952,000	$ 234,240	$ 58,560	$ 58,560	$ 2,304,000
13	816					816	4	$ 293,760	$ 40,000	$ 83,440	$ 104,300	$ 522,000	$ 62,640	$ 15,660	$ 15,660	$ 616,000
14	303		91			394	3	$ 136,380	$ 30,000	$ 41,595	$ 51,994	$ 260,000	$ 31,200	$ 7,800	$ 7,800	$ 307,000
15		90	259	263		612	4	$ 238,830	$ 40,000	$ 69,708	$ 87,134	$ 436,000	$ 52,320	$ 13,080	$ 13,080	$ 515,000
16	208			471		679	5	$ 315,090	$ 50,000	$ 91,273	$ 114,091	$ 571,000	$ 68,520	$ 17,130	$ 17,130	$ 674,000
17	1,185		339	261		1,785	3	$ 661,410	$ 30,000	$ 172,853	$ 216,066	$ 1,081,000	$ 129,720	$ 32,430	$ 32,430	$ 1,276,000
18	946	747	642	743		3,078	7	$ 1,136,190	$ 70,000	$ 301,548	$ 376,934	$ 1,885,000	$ 226,200	$ 56,550	$ 56,550	$ 2,225,000
19	729					729	3	$ 262,440	$ 30,000	$ 73,110	$ 91,388	$ 457,000	$ 54,840	$ 13,710	$ 13,710	$ 540,000
21	959					959	3	$ 345,240	$ 30,000	$ 93,810	$ 117,263	$ 587,000	$ 70,440	$ 17,610	$ 17,610	$ 693,000
22	899					899	5	$ 323,640	$ 50,000	$ 93,410	$ 116,763	$ 584,000	$ 70,080	$ 17,520	$ 17,520	$ 690,000
23	604			357		961	2	$ 399,510	$ 20,000	$ 104,878	$ 131,097	$ 656,000	$ 78,720	$ 19,680	$ 19,680	$ 775,000
24	148	146	579	566		1,439	3	$ 559,440	$ 30,000	$ 147,360	$ 184,200	$ 921,000	$ 110,520	$ 27,630	$ 27,630	$ 1,087,000
25	1,362					1,362	5	$ 490,320	$ 50,000	$ 135,080	$ 168,850	$ 845,000	$ 101,400	$ 25,350	$ 25,350	$ 998,000
26	1,431		293			1,724	2	$ 603,060	$ 20,000	$ 155,765	$ 194,706	$ 974,000	$ 116,880	$ 29,220	$ 29,220	$ 1,150,000
27	3,497					3,497	13	$ 1,258,920	$ 130,000	$ 347,230	$ 434,038	$ 2,171,000	$ 260,520	$ 65,130	$ 65,130	$ 2,562,000
28	1,069					1,069	1	$ 384,840	$ 10,000	$ 98,710	$ 123,388	$ 617,000	$ 74,040	$ 18,510	$ 18,510	$ 729,000
29	1,552					1,552	1	$ 558,720	$ 10,000	$ 142,180	$ 177,725	$ 889,000	$ 106,680	$ 26,670	$ 26,670	$ 1,050,000
30						15	1	$ -	$ 10,000	$ 2,500	$ 3,125	$ 16,000	$ 1,920	$ 480	$ 480	$ 19,000
31	2,995					2,995	13	$ 1,078,200	$ 130,000	$ 302,050	$ 377,563	$ 1,888,000	$ 226,560	$ 56,640	$ 56,640	$ 2,228,000
32	1,151					1,151	5	$ 414,360	$ 50,000	$ 116,090	$ 145,113	$ 726,000	$ 87,120	$ 21,780	$ 21,780	$ 857,000
33	1,071					1,071	2	$ 385,560	$ 20,000	$ 101,390	$ 126,738	$ 634,000	$ 76,080	$ 19,020	$ 19,020	$ 749,000
34	1,934					1,934	2	$ 696,240	$ 20,000	$ 179,060	$ 223,825	$ 1,120,000	$ 134,400	$ 33,600	$ 33,600	$ 1,322,000
37	1,548					1,548	4	$ 557,280	$ 40,000	$ 149,320	$ 186,650	$ 934,000	$ 112,080	$ 28,020	$ 28,020	$ 1,103,000
38	1,933					1,933	5	$ 695,880	$ 50,000	$ 186,470	$ 233,088	$ 1,166,000	$ 139,920	$ 34,980	$ 34,980	$ 1,376,000
39	3,270					3,270	10	$ 1,177,200	$ 100,000	$ 319,300	$ 399,125	$ 1,996,000	$ 239,520	$ 59,880	$ 59,880	$ 2,356,000
40	2,850					2,850	8	$ 1,026,000	$ 80,000	$ 276,500	$ 345,625	$ 1,729,000	$ 207,480	$ 51,870	$ 51,870	$ 2,041,000
41	697					697	2	$ 250,920	$ 20,000	$ 67,730	$ 84,663	$ 424,000	$ 50,880	$ 12,720	$ 12,720	$ 501,000
42	1,074					1,074	3	$ 386,640	$ 30,000	$ 104,160	$ 130,200	$ 651,000	$ 78,120	$ 19,530	$ 19,530	$ 769,000
44	1,051					1,051	6	$ 378,360	$ 60,000	$ 109,590	$ 136,988	$ 685,000	$ 82,200	$ 20,550	$ 20,550	$ 809,000
47	222					222	0	$ 79,920	$ -	$ 19,980	$ 24,975	$ 125,000	$ 15,000	$ 3,750	$ 3,750	$ 148,000
48	1,003					1,003	6	$ 361,080	$ 60,000	$ 105,270	$ 131,588	$ 658,000	$ 78,960	$ 19,740	$ 19,740	$ 777,000
50	576					576	0	$ 207,360	$ -	$ 51,840	$ 64,800	$ 324,000	$ 38,880	$ 9,720	$ 9,720	$ 383,000
51	1,148					1,148	2	$ 413,280	$ 20,000	$ 108,320	$ 135,400	$ 677,000	$ 81,240	$ 20,310	$ 20,310	$ 799,000
52	2,283					2,283	5	$ 821,880	$ 50,000	$ 217,970	$ 272,463	$ 1,363,000	$ 163,560	$ 40,890	$ 40,890	$ 1,609,000
53	574					574	3	$ 206,640	$ 30,000	$ 59,160	$ 73,950	$ 370,000	$ 44,400	$ 11,100	$ 11,100	$ 437,000
54	1,393					1,393	2	$ 501,480	$ 20,000	$ 130,370	$ 162,963	$ 815,000	$ 97,800	$ 24,450	$ 24,450	$ 962,000
55	2,830					2,830	4	$ 1,018,800	$ 40,000	$ 264,700	$ 330,875	$ 1,655,000	$ 198,600	$ 49,650	$ 49,650	$ 1,953,000
56	3,573					3,573	5	$ 1,286,280	$ 50,000	$ 334,070	$ 417,588	$ 2,088,000	$ 250,560	$ 62,640	$ 62,640	$ 2,464,000
57	3,958			591		4,549	7	$ 1,726,290	$ 70,000	$ 449,073	$ 561,341	$ 2,807,000	$ 336,840	$ 84,210	$ 84,210	$ 3,313,000
58	4,004					4,004	4	$ 1,441,440	$ 40,000	$ 370,360	$ 462,950	$ 2,315,000	$ 277,800	$ 69,450	$ 69,450	$ 2,732,000
59	2,440					2,440	8	$ 878,400	$ 80,000	$ 239,600	$ 299,500	$ 1,498,000	$ 179,760	$ 44,940	$ 44,940	$ 1,768,000
60	1,279					1,279	3	$ 460,440	$ 30,000	$ 122,610	$ 153,263	$ 767,000	$ 92,040	$ 23,010	$ 23,010	$ 906,000
61	1,091					1,091	4	$ 392,760	$ 40,000	$ 108,190	$ 135,238	$ 677,000	$ 81,240	$ 20,310	$ 20,310	$ 799,000
63						45	3	$ -	$ 30,000	$ 7,500	$ 9,375	$ 47,000	$ 5,640	$ 1,410	$ 1,410	$ 56,000
64						15	1	$ -	$ 10,000	$ 2,500	$ 3,125	$ 16,000	$ 1,920	$ 480	$ 480	$ 19,000
67	1,355					1,355	4	$ 487,800	$ 40,000	$ 131,950	$ 164,938	$ 825,000	$ 99,000	$ 24,750	$ 24,750	$ 974,000
68	3,803	371	182			4,356	3	$ 1,534,980	$ 30,000	$ 391,245	$ 489,056	$ 2,446,000	$ 293,520	$ 73,380	$ 73,380	$ 2,887,000
69	1,908	1,530				3,438	2	$ 1,145,880	$ 20,000	$ 291,470	$ 364,338	$ 1,822,000	$ 218,640	$ 54,660	$ 54,660	$ 2,150,000
70	3,750	358				4,108	17	$ 1,457,400	$ 170,000	$ 406,850	$ 508,563	$ 2,543,000	$ 305,160	$ 76,290	$ 76,290	$ 3,001,000
71	1,126					1,126	8	$ 405,360	$ 80,000	$ 121,340	$ 151,675	$ 759,000	$ 91,080	$ 22,770	$ 22,770	$ 896,000
72	493		1,270	244		2,007	2	$ 682,920	$ 20,000	$ 175,730	$ 219,663	$ 1,099,000	$ 131,880	$ 32,970	$ 32,970	$ 1,297,000
73	4,269					4,269	4	$ 1,536,840	$ 40,000	$ 394,210	$ 492,763	$ 2,464,000	$ 295,680	$ 73,920	$ 73,920	$ 2,908,000
74						15	1	$ -	$ 10,000	$ 2,500	$ 3,125	$ 16,000	$ 1,920	$ 480	$ 480	$ 19,000
75	592					592	1	$ 213,120	$ 10,000	$ 55,780	$ 69,725	$ 349,000	$ 41,880	$ 10,470	$ 10,470	$ 412,000

Stream Reach	Length 1 (ft)	Length 2 (ft)	Length 3 (ft)	Length 4 (ft)	Length 5 (ft)	TOTAL LENGTH (ft)	Number of ERRs	Restoration Cost	Step Structure Cost	Demo/Mob Cost	Contingency Cost	Total Construction Cost	Engineering Design Cost	Surveying Cost	Geotechnical Cost	TOTAL PROJECT COST
76	1,434	256				1,690	2	$ 593,040	$ 20,000	$ 153,260	$ 191,575	$ 958,000	$ 114,960	$ 28,740	$ 28,740	$ 1,131,000
77	5,695	268	189			6,152	4	$ 2,187,300	$ 40,000	$ 556,825	$ 696,031	$ 3,481,000	$ 417,720	$ 104,430	$ 104,430	$ 4,108,000
79	2,842					2,842	15	$ 1,023,120	$ 150,000	$ 293,280	$ 366,600	$ 1,833,000	$ 219,960	$ 54,990	$ 54,990	$ 2,163,000
80	1,544					1,544	0	$ 555,840	$ -	$ 138,960	$ 173,700	$ 869,000	$ 104,280	$ 26,070	$ 26,070	$ 1,026,000
81	2,061				296	2,357	11	$ 845,560	$ 110,000	$ 238,890	$ 298,613	$ 1,494,000	$ 179,280	$ 44,820	$ 44,820	$ 1,763,000
82	988					988	5	$ 355,680	$ 50,000	$ 101,420	$ 126,775	$ 634,000	$ 76,080	$ 19,020	$ 19,020	$ 749,000
83	3,076					3,076	8	$ 1,107,360	$ 80,000	$ 296,840	$ 371,050	$ 1,856,000	$ 222,720	$ 55,680	$ 55,680	$ 2,191,000
84	3,091					3,091	2	$ 1,112,760	$ 20,000	$ 283,190	$ 353,988	$ 1,770,000	$ 212,400	$ 53,100	$ 53,100	$ 2,089,000
85	2,984	845				3,829	6	$ 1,327,740	$ 60,000	$ 346,935	$ 433,669	$ 2,169,000	$ 260,280	$ 65,070	$ 65,070	$ 2,560,000
86	4,975		192			5,167	8	$ 1,848,600	$ 80,000	$ 482,150	$ 602,688	$ 3,014,000	$ 361,680	$ 90,420	$ 90,420	$ 3,557,000
87	4,698	393				5,091	3	$ 1,809,180	$ 30,000	$ 459,795	$ 574,744	$ 2,874,000	$ 344,880	$ 86,220	$ 86,220	$ 3,392,000
88	5,950					5,950	8	$ 2,142,000	$ 80,000	$ 555,500	$ 694,375	$ 3,472,000	$ 416,640	$ 104,160	$ 104,160	$ 4,097,000
89	7,039					7,039	6	$ 2,534,040	$ 60,000	$ 648,510	$ 810,638	$ 4,054,000	$ 486,480	$ 121,620	$ 121,620	$ 4,784,000
90	804					804	2	$ 289,440	$ 20,000	$ 77,360	$ 96,700	$ 484,000	$ 58,080	$ 14,520	$ 14,520	$ 572,000
91	4,134					4,134	11	$ 1,488,240	$ 110,000	$ 399,560	$ 499,450	$ 2,498,000	$ 299,760	$ 74,940	$ 74,940	$ 2,948,000
92	1,946					1,946	6	$ 700,560	$ 60,000	$ 190,140	$ 237,675	$ 1,189,000	$ 142,680	$ 35,670	$ 35,670	$ 1,404,000
93	1,849		258			2,107	8	$ 743,040	$ 80,000	$ 205,760	$ 257,200	$ 1,286,000	$ 154,320	$ 38,580	$ 38,580	$ 1,518,000
94	9,542	258				9,800	16	$ 3,512,520	$ 160,000	$ 918,130	$ 1,147,663	$ 5,739,000	$ 688,680	$ 172,170	$ 172,170	$ 6,773,000
95	4,569	746				5,315	8	$ 1,868,640	$ 80,000	$ 487,160	$ 608,950	$ 3,045,000	$ 365,400	$ 91,350	$ 91,350	$ 3,594,000
96	2,685					2,685	2	$ 966,600	$ 20,000	$ 246,650	$ 308,313	$ 1,542,000	$ 185,040	$ 46,260	$ 46,260	$ 1,820,000
97	4,841					4,841	12	$ 1,742,760	$ 120,000	$ 465,690	$ 582,113	$ 2,911,000	$ 349,320	$ 87,330	$ 87,330	$ 3,435,000
98	2,883					2,883	10	$ 1,037,880	$ 100,000	$ 284,470	$ 355,588	$ 1,778,000	$ 213,360	$ 53,340	$ 53,340	$ 2,099,000
100	2,102					2,102	12	$ 756,720	$ 120,000	$ 219,180	$ 273,975	$ 1,370,000	$ 164,400	$ 41,100	$ 41,100	$ 1,617,000
TOTALS						**222,107**						**$ 131,979,000**				**$ 155,779,000**

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

APPENDIX G

Creek Improvements Project Stream Representative Sections and

Creek Improvement Details

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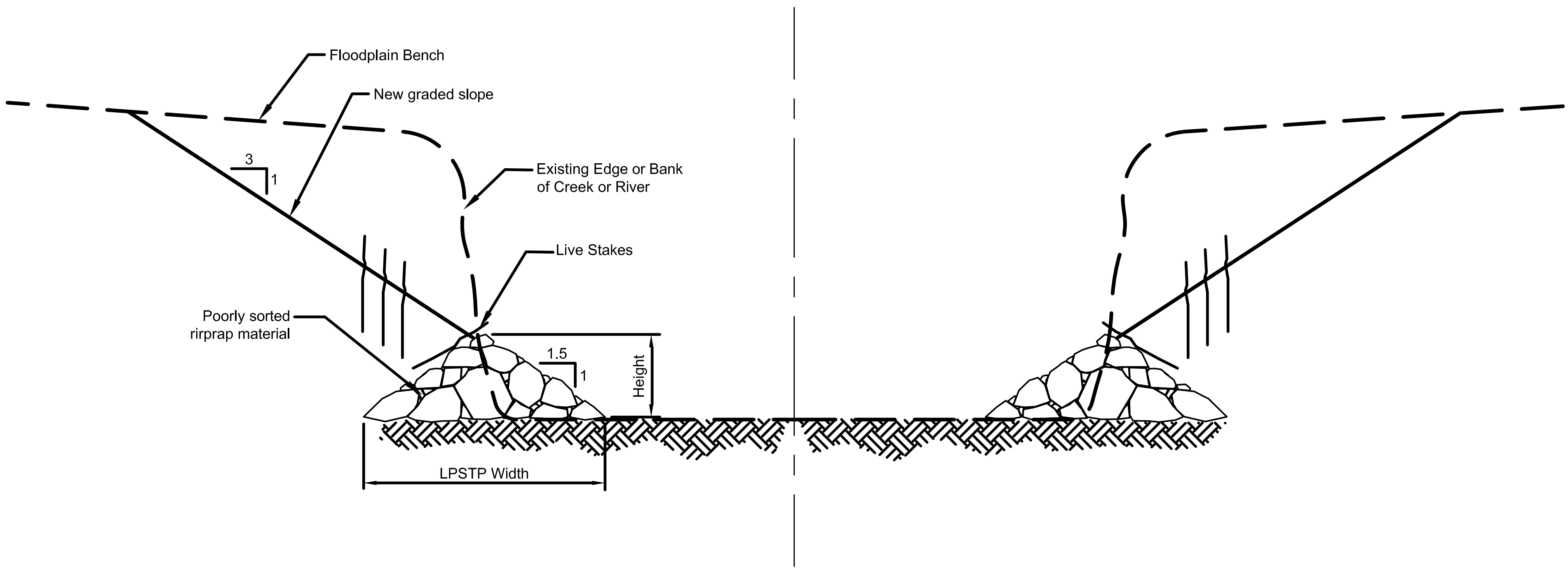
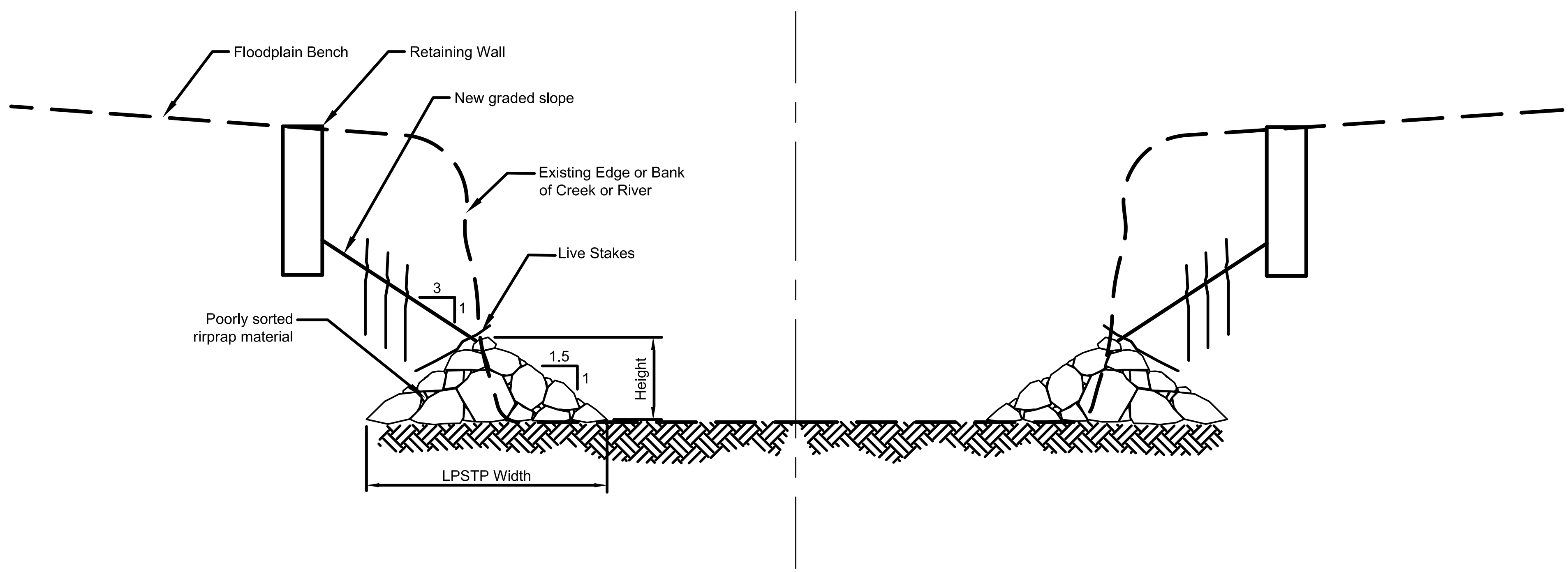
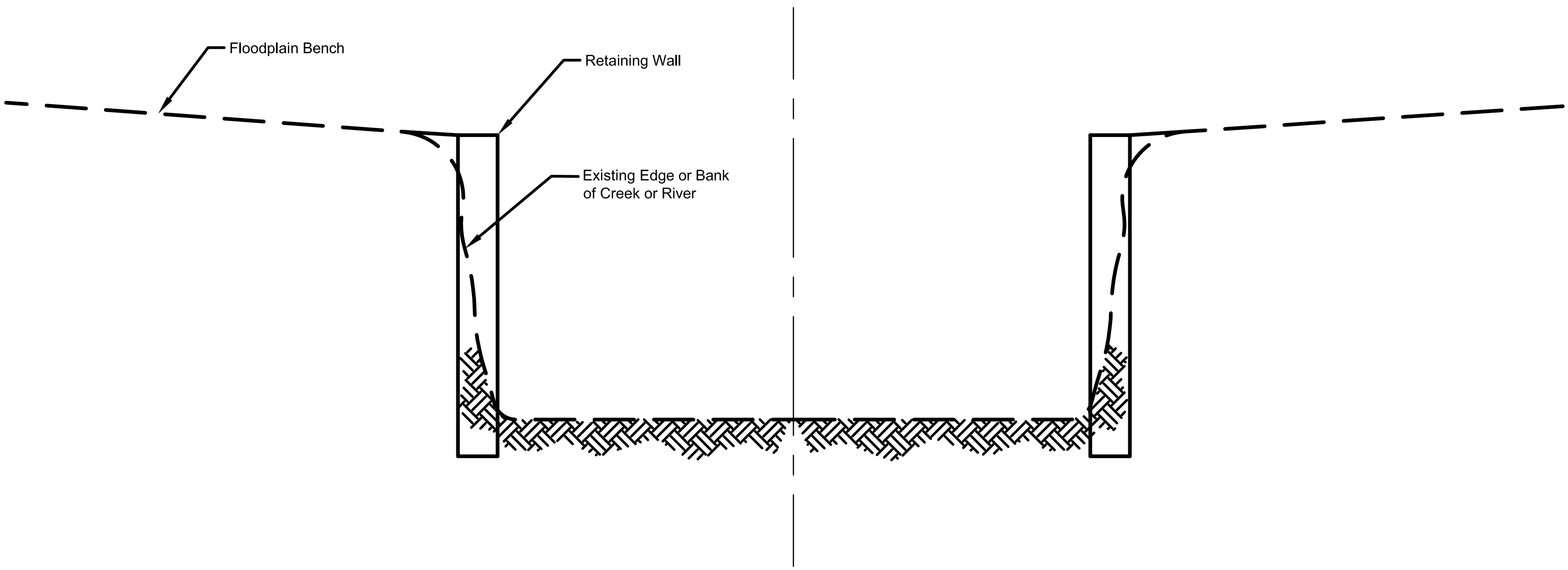


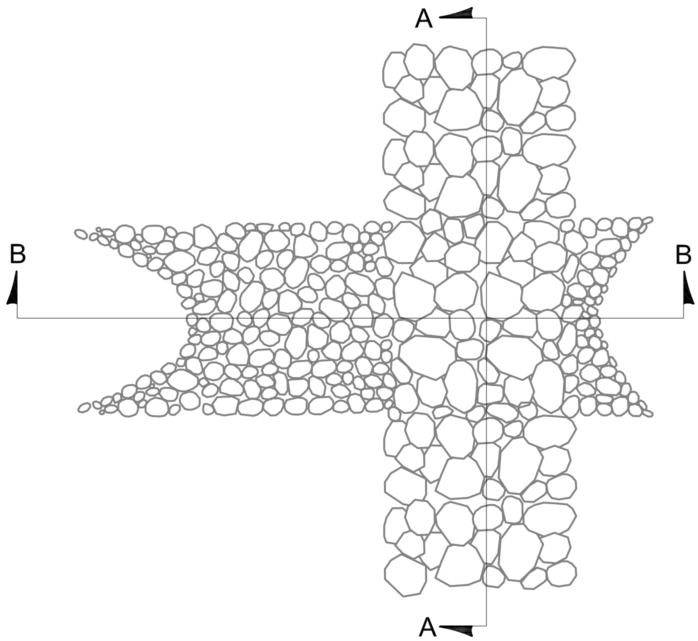
LPSTP Representative Section



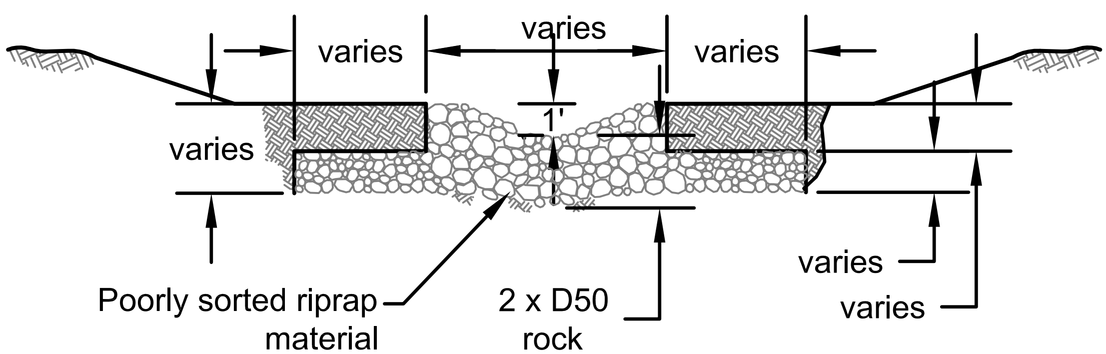
LPSTP with Retaining Wall Representative Section



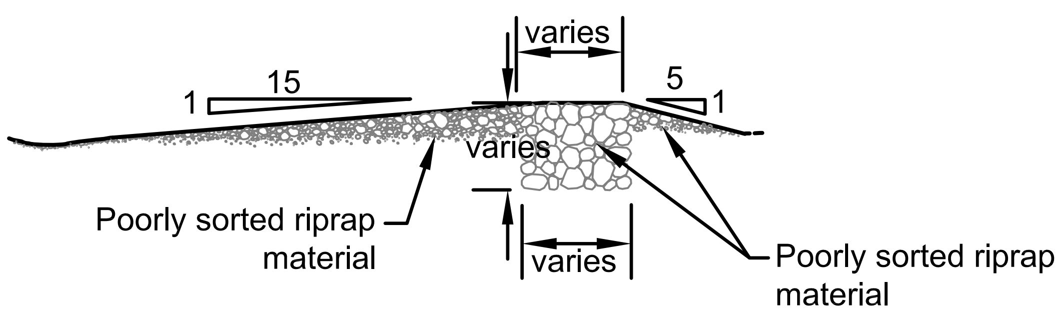
Retaining Wall Representative Section



ERR PLAN VIEW



TYPICAL ERR CROSS-SECTION A-A



TYPICAL ERR CROSS-SECTION B-B

Engineered Rock Riffle Detail

APPENDIX H

SWAMM Methodology

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Spring Creek Watershed SWAMM Pollutant Load Model Methodology

NORTHWATER
CONSULTING

1/1/2013

Table of Contents

Tables and Figures

Pollutant Loading Model Methodology

1.0 Introduction

A GIS spatially based pollution load model or SWAMM (Spatial Watershed Assessment and Management Model) was developed to estimate field level pollutant loading from Nitrogen, Phosphorus, Sediment, Chloride and Bacteria. Constructed using soils, landuse and precipitation data the model provides both annual and storm event loading for individual land parcels within the Spring Creek Watershed. Results are organized through a unique combination of parcel ownership, landuse and soils, delineated into individual units of pollution loading. Accepted equations for calculating runoff and soil erosion are integrated into the model to provide realistic estimations of the quantity and distribution of pollution loading throughout the study area. Due to a lack of sufficient water quality data for the watershed, the model was not directly calibrated to local water quality data. However, care was taken to ensure model inputs very accurately represented land features. Landuse was modified and adjusted using data collected in the field and a parcel by parcel comparison with the most recent aerial imagery. A time period of 2000 through 2012 was used for generating rainfall values.

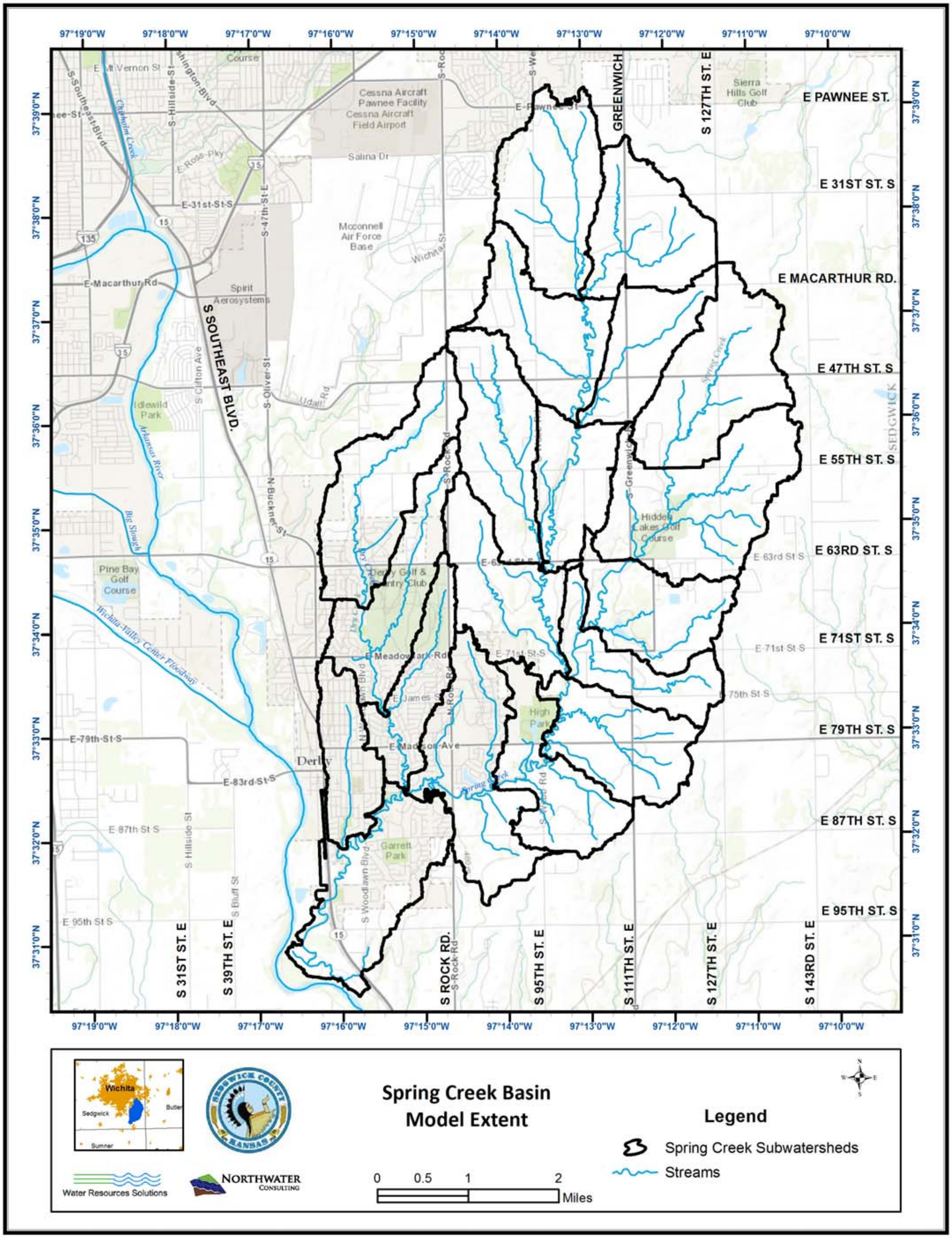
The GIS data set is organized in such a way that results can easily be queried by subwatersheds, by parcel boundaries and by landuse. Results can also be analyzed based on user defined boundaries and presented in map format, easily overlaid on existing base maps. The model includes 52,236 unique records from which to assess pollution loading. The following methodology document provides key model equations and values, references and summary statistics.

2.0 Methodology

The custom SWAMM model consists of two primary components:

- Universal Soil Loss Equation (USLE) Component
- Event Mean Concentration (EMC) Component

Figure 1 - Model Extent; Location Map



2.1 USLE Component

The overall analysis methodology modified by Northwater from*:*

Mitasova and Lubos Mitas: Modeling soil detachment with RUSLE3d using GIS, 1999; University of Illinois. http:/skagit.meas.ncsu.edu/~helena/gmslab/erosion/usle.html

The Universal Soil Loss Equation (USLE) component of the model is applied to agricultural land uses within the watershed (Row Crops). The USLE methodology incorporated into the model is summarized below:

- 1:24,000 NRCS Soil Survey Geographic Database (SSURGO) Digital Soils.
- Selected appropriate soil types and relevant USLE factors identified and calculated from SSURGO soils dataset and information from local Soil and Water Conservation District staff and staff from the Natural Resource Conservation Service.
- USLE erosion calculated with the following equation: LS * K * C * R. The P-factor was not incorporated as it is set to 1 for all soil units.

Table 1 - USLE factors

Landcover	C factor	K factor	LS factor	R factor	P factor
Agriculture Crops (Row Crops)	Corn (High) = 0.24 Corn (Low) = 0.08 Corn (All Other) = 0.16 Cotton (High) = 0.26 Cotton (All Other) = 0.2 Wheat/Other Crops (High) = 0.1 Wheat/Other Crops (Low) = 0.02 Wheat/Other Crops (All Other) = 0.07	Values included in SSURGO tabular data	Values included in SSURGO tabular data; calculated from slope and slope length values or from local NRCS Staff	200	0.5 for Terraced Fields 1 used for all soil polygons

2.2 EMC Component

A) All formulas and selected variables are derived from: *STEPL (Spreadsheet Tool for Estimation of Pollutant Load) Version 3, Tetra Tech, 2004.* For Bacteria, Schueler's Simple Method (1987) is modified for calculating bacterial loads.

B) A storm runoff module was created to estimate runoff and pollutant loading from a First Flush (1.2 inch), 5 year (4.5 inche) and 25 year (6.1 inche) rainfall event. Runoff was computed as described in the table below. P or rainfall/precipitation values were derived from: *Kansas Natural Resources Conservation Service, United States Department of Agriculture (USDA-NRCS), County Rainfall table*.

C) Event Mean Concentration Values and Curve Numbers were derived from the following sources:

1. *Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) Technical Guide, Version 1.0 Release 1, November 2004.*
2. *Lower DuPage River Watershed Plan Pollution Load Model Methodology, 2010.*
3. *Price, Thomas H., 1993. Unit Area Pollutant Load Estimates for Lake County Illinois Lake Michigan Watersheds.*
4. *Todd D. Stuntebeck, Matthew J. Komiskey, Marie C. Peppler, David W. Owens, and Dennis R. Frame 2011. Precipitation-Runoff Relations and Water-Quality Characteristics at Edge-of-Field. Stations, Discovery Farms and Pioneer Farm, Wisconsin, 2003–08.*

5. *Northwater Consulting, 2013. Spatial Watershed Assessment and Management Model. Prepared for Chicago Metropolitan Agency for Planning, Chicago, IL.*
6. *Northwater Consulting, 2012. Spatial Watershed Assessment and Management Model. Prepared for the Illinois Department of Natural Resources, Springfield, IL*
7. *Wagner, K., Redmon, L., Gentry, T., Harmel, D., and A., Jones, 2008. Environmental Management of Grazing Lands; Texas Water Resources Institute Technical Report TR – 344.*
8. *National Research Center, Office of Research and Monitoring; US Environmental Protection Agency, 1972. Characteristics of Rainfall Runoff from a Beef Cattle Feedlot. EPA-R2-72-061, Environmental Protection Technology Series.*

D) Precipitation: annual precipitation, number of rain days and correction factors using the following weather station: Wichita, Mid-Continent Airport, KS. A period of 10 years was used (2002-2012).

Table 2 – Rainfall Factors

Average Number of Rain Days	Rain Days Correction Factor	P Value (inches)
92.6	**0.46**	**0.82**

E) Delivery Ratio; distance based delivery ratio: *Minnesota Board of Water & Soil Resources, "Pollution Reduction Estimator Water Erosion - Microsoft Excel® Version September 2010."*

Polygon distance from major stream (ft) $^{-0.2069}$

Table 3 - Pollutant Load Model Values

Model	Rain days	Correction Factor (precipitation and rain days)	Curve Number (by soil hydrologic group)	Runoff (by soil hydrologic group in inches)	EMC for N, P, Chloride, TSS, Bacteria
All landuse	see table above	see table above	See below	Calculated using the following equation: $Q = \frac{((P-(IaXS))^{2}}{P + 0.8 X S}$ $S = \frac{1000}{CN} - 10$ Q = Runoff (inches) P = Precipitation (inches) S = Potential max retention (inches) CN = Curve Number Ia = Initial abstraction factor; set to 0 for annual runoff and 0.2 for first flush, 5 and 25yr events	See Table Below

Table 4 - Event Mean Concentrations and Curve Numbers

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Fecal Coliform counts / 100ml)	Chloride (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group	CL adjustment 8/23/13
Bridge	2.3	0.34	153	1700	148	98	98	98	98	60**
Commercial (High)	3.2	0.31	230	2500	148	89	92	94	95	
Commercial (Medium)	3.2	0.31	230	2500	148	77	85	90	92	
Driveway	2.3	0.3	65	2600	70	98	98	98	98	35*
Farm Building (High)	7.1	0.6	300	11500	148	89	92	94	95	
Farm Building (Medium)	3.3	0.55	240	8700	71	77	85	90	92	
Farm Building (Low)	2.2	0.3	120	8300	15	57	72	81	86	
Golf Course	3.6	0.6	84	2600	0.91	39	61	74	80	
Grass	0.7	0.13	30	1300	0.91	30	58	71	78	
Grass/Woodland/Open Space (road right of way)	1.4	0.15	60	1300	0.91	39	61	74	80	
Mobile Home Park	3.2	0.3	291	8700	148	77	85	90	92	
Open Space - Park (Medium)	1.25	0.3	65	2600	0.91	49	69	79	84	
Open Space - Park (Low)	1.25	0.3	65	2600	0.91	46	65	77	82	
Open Water - Pond	0.375	0.025	15	500	120	98	98	98	98	60**
Open Water - Pond (Private Waste Pond)	0.09375	0.00625	3.75	125	30	98	98	98	98	
Open Water - Stream	1.25	0.11	3.1	500	70	98	98	98	98	
Parking Lot	2.3	0.3	65	2600	75	98	98	98	98	
Pasture (High)	7.1	0.6	240	18000	0.91	77	85	90	92	
Pasture (Medium)	3.3	0.55	120	9500	0.91	67	78	85	89	
Pasture (Low)	2.2	0.3	60	6300	0.91	30	58	71	78	
Paved Ditch	2.3	0.34	390	1700	148	98	98	98	98	
Residential (High)	3.2	0.6	291	8700	148	89	92	94	95	
Residential (Medium)	3.1	0.6	153	8700	71	77	85	90	92	
Residential (Low)	2.16	0.6	72	8700	15	57	72	81	86	
Residential Farm (Medium)	3.1	0.6	160	9000	71	57	72	81	86	
Residential Farm (Low)	2.1	0.6	72	8700	15	46	65	77	82	
Residential Multi-Family (High)	3.2	0.6	291	8700	148	89	92	94	95	
Road	2.3	0.34	153	1700	148	98	98	98	98	60**
Road Median	1.25	0.3	65	2600	0.91	57	72	81	86	
Row Crop	3.75	0.6	N/A*	2600	0.91	74	83	88	90	
Row Crop (terraced fields and fields with substantial residue)	2.7	0.3	N/A*	1860	0.75	74	83	88	90	
School/Church (High)	2.4	0.3	52	1400	148	89	92	94	95	
School/Church (Medium)	2.4	0.3	52	1400	148	77	85	90	92	
School/Church (Low)	2.4	0.3	52	1400	148	57	72	81	86	
Shrubland	0.7	0.13	30	1300	0.91	30	58	71	78	
Sidewalk	2.3	0.3	65	2600	70	98	98	98	98	35**
Unpaved Driveway	2.3	0.3	390	2600	70	89	92	94	95	30**
Unpaved Parking	2.3	0.3	390	2600	70	89	92	94	95	30**
Unpaved Road	2.3	0.3	390	2600	70	89	92	94	95	30**
Utility	2.1	0.34	153	1400	148	81	88	91	93	
Woodland	0.7	0.13	60	1300	0.91	39	61	74	80	

Replaced by USLE - used 750mg/l for storm events on non-terraced fields and 375mg/l on terraced fields and fields with high residue
****Only for exclusion areas***

2.2 Gully and Streambank Erosion

Gully and streambank erosion were estimated using the Region 5 EPA Spreadsheet Tool for Estimating Pollution Load Reductions for Nonpoint Source Pollution BMPs.

A) Gully Erosion

The following equations were used to estimate erosion rate and N and P loadings:

Total Tons = Length (ft) X Depth (ft) X Width (ft) X Soil Weight Dry Density (tons/ft3; 0.035) X Delivery Ratio / Number of Years Eroding
N Load (lbs) = Total Tons X N concentration in Soil (0.002 lbs/lbs) X 2000 X Correction Factor (1.15)
P Load (lbs) = Total Tons X N concentration in Soil (0.0006 lbs/lbs) X 2000 X Correction Factor (1.15)

B) Streambank Erosion

The following equations were used to estimate streambank erosion rate and N and P loadings:

Total Tons = Maximum Bank Length X Bank Height X Estimated Annual Lateral Recession Rate X Soil Weight Dry Density (tons/ft3; 0.035)
N Load (lbs) = Total Tons X N concentration in Soil (0.002 lbs/lbs) X 2000 X Correction Factor (1.15)
P Load (lbs) = Total Tons X N concentration in Soil (0.0006 lbs/lbs) X 2000 X Correction Factor (1.15)

3.0 Model Calibration

Due to the absence of any water quality data for Spring Creek, model calibration was not performed. The model is estimating accumulated/delivered pollutant loading, represented mostly in the literature. Important notes on the model include:

- The model does not directly account for point-source pollution.
- The model estimates annual pollutant mobilization from individual parcels of land and does not take into account storage, fate and transport watershed processes.
- The model accounts for precipitation runoff; but not base flow, point source discharges or drainage-tile contributions.

4.0 Additional Model Notes

1. A Local Landuse layer was used. Landuse was modified to represent a hybrid landuse/landcover layer by interpreting recent aerial imagery, digitizing/labeling polygons and by incorporating data collected during a windshield survey. For example, the row crop was further dissected into type of crop and grazing lands were coded for grazing intensity; residential areas were dissected into urban residential and residential farms; grassed areas were cut out of residential parcels. Residential areas were also modified and classified into high, medium and low density areas.
2. High, medium and low areas were determined based on a visual interpretation of density. High areas generally represented greater than 50% impervious, medium 25-50% impervious and low, less than 25%.

3. In general, residential farm areas also include some type of livestock or animal feeding area/barn and therefore received higher EMC values for nutrients, sediment and bacteria.
4. Areas where no road salt is applied were incorporated into the model and accounted for with modified EMC values.
5. The stream/waterbody file used to run proximity calculations for the purposes of determining a delivery ratio was modified using NHD data and the modified landuse layer. Duplicate lines were deleted to create a "clean" line file.

4.0 Pollutant Removal Efficiencies

Table 5 - Pollutant Removal Effeciencies

Best Management Practice/Measure	Estimated Pollutant Removal Efficiencies					
	Nitrogen	Phosphorus	Total Suspended Solids	Fecal Coliform	Chloride	Runoff
Cover Crops & Conservation Tillage	50%	45%	75%	40%	20%	N/A
Grassed Waterway	30-55%	45-55%	60-80%	35-50%	20-30%	N/A
Terrace	30%	55%	60%	35%	20%	N/A
Detention Basin/Pond/Waste Pond	20-70%	30-70%	30-80%	25-75%	20-50%	100% of First Flush (1.2inch) Event; Occurs average 7 times/yr
Rain Barrels/Rain Garden	50%	50%	60%	55%	35%	100% of First Flush (1.2inch) Event; Occurs average 7 times/yr
Porous/Pervious Pavement Retrofit	55%	55%	70%	35%	50%	70% of annual runoff
Road Salt Application and Storage	N/A	N/A	N/A	N/A	25%	N/A
Livestock Management	45%	65%	70%	75%	20%	N/A

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APPENDIX I

Water Quality BMP Prioritization

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Proposed Site Specific Water Quality BMPs

BMP Code	BMP Type	Subwatershed 14 Digit HUC Code	Subwatershed Area (acres)	Acres Treated	Estmated BMP Cost	PRIORITIZATION SCORE
35	Grass Waterway	11030013030114	1,013	74	$ 4,000	9.00
6	Grass Waterway	11030013030101	1,262	41	$ 3,200	38.94
13	Terraces	11030013030110	1,317	17	$ 6,500	86.22
36	Detention Basin	11030013030114	1,013	1	$ 8,000	94.77
9	Grass Waterway	11030013030103	1,078	15	$ 4,500	154.28
1	Grass Waterway	11030013030101	1,262	48	$ 6,500	203.55
22	Detention Basin	11030013030113	1,049	62	$ 9,000	604.71
34	Detention Basin	11030013030114	1,013	18	$ 40,000	922.49
41	Detention Basin	11030013030115	965	27	$ 55,000	1,016.52
7	Detention Basin	11030013030102	1,081	18	$ 20,000	1,255.84
16	Detention Basin	11030013030105	1,394	11	$ 20,000	1,297.03
10	Detention Basin	11030013030105	1,394	41	$ 35,000	1,658.28
14	Detention Basin	11030013030110	1,317	30	$ 22,000	1,814.25
27	Detention Basin	11030013030111	1,082	25	$ 26,000	1,879.43
26	Detention Basin	11030013030108	1,143	14	$ 19,000	2,110.17
33	Detention Basin	11030013030114	1,013	28	$ 55,000	2,619.53
3	Detention Basin	11030013030101	1,262	9	$ 21,000	3,216.56
29	Detention Basin	11030013030111	1,082	78	$ 55,000	3,335.39
20	Detention Basin	11030013030110	1,317	27	$ 25,000	3,629.13
2	Detention Basin	11030013030102	1,081	11	$ 18,500	5,894.41
25	Waste Pond	11030013030106	794	20	$ 45,000	6,191.31
11	Detention Basin	11030013030105	1,394	74	$ 55,000	6,199.10
37	Detention Basin	11030013030114	1,013	16	$ 22,000	7,412.20
30	Detention Basin	11030013030116	729	48	$ 80,000	7,718.91
19	Detention Basin	11030013030110	1,317	45	$ 45,000	8,408.74
21	Detention Basin	11030013030110	1,317	9	$ 20,000	9,213.78
18	Detention Basin	11030013030108	1,143	79	$ 46,000	11,000.38
8	Detention Basin	11030013030103	1,078	27	$ 22,000	12,263.60
44	Grass Waterway/Terraces	11030013030119	1,362	75	$ 100,000	14,578.02
31	Detention Basin	11030013030117	1,380	18	$ 75,000	16,024.01
5	Detention Basin	11030013030102	1,081	19	$ 25,000	20,479.12
24	Detention Basin	11030013030106	794	129	$ 28,000	21,844.68
32	Detention Basin	11030013030112	716	76	$ 60,000	24,743.73
4	Detention Basin	11030013030102	1,081	405	$ 65,000	29,447.05
40	Detention Basin	11030013030115	965	53	$ 120,000	29,914.90
42	Detention Basin	11030013030119	1,362	67	$ 45,000	33,812.06
12	Detention Basin	11030013030106	794	21	$ 18,000	36,737.76
23	Detention Basin	11030013030107	1,701	10	$ 38,000	40,312.51
15	Detention Basin	11030013030105	1,394	30	$ 35,000	43,489.61
28	Detention Basin/Wetlands	11030013030110	1,317	72	$ 70,000	50,698.41
43	Detention Basin	11030013030119	1,362	136	$ 85,000	63,660.62
17	Detention Basin	11030013030106	794	49	$ 22,000	75,504.93
38	Detention Basin	11030013030118	640	166	$ 30,000	118,357.86
39	Detention Basin	11030013030118	640	98	$ 120,000	312,672.98
				Total Cost	**$ 1,724,200**	

*Cost estimates in this report are planning level and are based on 2013 unit costs and subject to inflation.

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APPENDIX J

Chloride and Road Salt Best Management Practices

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CHLORIDE AND ROAD SALT BEST MANAGEMENT PRACTICES

Introduction

Chloride is an ionic form of the element chlorine, is found in many common salts, and is readily soluble. In its dissolved form, it does not degrade chemically or organically over time. Removal of snow and ice from pavement is essential to both public safety and to the local economy. During winter storm events, the use of pavement deicing chemicals is a widely accepted and, as some would argue, essential means of keeping pavements safe and passable. Pavement deicing is typically accomplished though the use of road salts. There are a variety of road salts that may be used for deicing, including sodium chloride (NaCl), calcium chloride (CaCl2), magnesium chloride (MgCl2), and potassium chloride (KCl). Sodium chloride, or common salt, is by far the most popular roadway deicing chemical because of its reliability, economy, and usability. However, it is also corrosive to vehicles, roadway surfaces and bridges and has been found to have adverse effects on groundwater and environmentally sensitive areas.

Salt has been used to control snow and ice on U.S. streets since the 1800s. Although it still has undesirable effects, most notoriously corrosion, it is now the most popular deicing material in North American cities. In response to concerns about its effects on infrastructure and the environment, several guidelines and recommendations for salt application have been published.

Implementing best management practices can lead to considerable cost savings and chloride reduction. The City of Toronto, Canada for example, spent about $100,000 on staff training, fleet instrumentation and a salt management plan. As a result, their annual salt use was reduced by 25% over two winter periods, translating into annual savings of about $1,800,000. In Quebec, the Town of Otterburn Park reduced their salt use by a factor of six, between 1995 and 2000, by training staff, improving plowing practices, revising their level of service policy and prewetting salt. Their benefit-to-cost ratio for was 2.8:1 for the changes that were implemented.

The Salt Institute has produced a handbook for snowfighters (1999) and an online snowfighters training program; another publication is the Salt SMART Learning Guide, offering best management practices for Spreading, Maintenance, Application Rates & Timing (SMART) of road salt; and Minnesota’s Department of Transportation (MN/DOT) published a handbook for snowplow operators.

A few key recommendations from these documents include:

- A clear level of service (LOS) should be established for each route or area, based on usage levels or regulation. This LOS should be communicated to staff and to the public.
- Staff should be trained regularly in proper spreading procedures, record-keeping and the environmental impact of their work.
- Equipment should be maintained and inspected before and during the snow season, with spare parts available at all times.
- Spreader routes should be optimized to eliminate leftover salt and “deadheading” (driving without spreading).
- The spreaders should be covered to prevent loss of salt in wind and precipitation.

- The spreaders should be equipped with instrumentation to monitor current conditions and salt usage.
- Spreading equipment should be calibrated regularly and records should be kept of salt use in each truck and each route. Actual usage should be compared against the prescribed spreading rates to catch over-use and inefficiencies. Weigh-scales should be included on the spreading equipment and at the entrance to the storage area.
- Spreading rates should be based on the best available information, including the current road conditions, LOS and weather forecast. Communication with operators should be clear.

Best Management Practices for Salt Use on Private Roads, Parking Lots and Sidewalks

The following discussion of best practices is intended to guide private salt users on techniques that can be used to reduce the amount of salt entering the environment. When selecting practices it is important to ensure that safety is not compromised. However, this caution should not be interpreted as validating excessive salt use. The best practices are set out in the areas of sand and salt storage, salt application, and snow storage and disposal.

Salt and Sand Storage and Handling

Studies have shown that improper storage and handling of salt and sand/salt mixtures are major sources of salt releases to the environment. The following best practices apply to storage of solid materials (i.e. salt and sand/salt mixtures) and liquids.

- All sand and sand/salt mixtures4 should be covered to prevent salt from being washed or blown from the pile.
- All salt and sand/salt mixtures should be stored on pads of impermeable asphalt or concrete.
- Site drainage should be directed away from the stored materials to keep the stockpiles as dry as possible. This will prevent salt contamination of site drainage.
- Drainage that is contaminated with salt should be directed to a sewage treatment plant (subject to municipal approval), collected and used for brine production or sent for proper disposal.
- Solid bagged materials should be stored securely and indoors if possible.
- Loading areas where spreaders are loaded from the storage facilities should be impermeable asphalt or concrete pads.
- Annual inspection and repairs should be carried out prior to the start of each season. Ongoing inspection of storage structures and tanks should be carried out during the season.
- Spreaders should not be overloaded such that material spills off the vehicle.
- Salt spilled at the storage yard should be collected and returned to the storage site.
- Spreaders should only be washed at a location where the washwater is properly managed.
- Liquid storage tanks should be designed such that a plumbing failure will not result in release of the contents.

- Liquid storage tanks should be protected from impact from vehicles moving about the yard and be located such that spilled material can be contained and retrieved in the event of a tank or piping failure. Secondary containment should be provided around large liquid storage tanks.
- Some liquids need to be agitated/circulated to prevent separation and settling. The liquid suppliers should be consulted for proper storage procedures
- Sediment that collects in the bottom of mixing and storage tanks must be cleaned out periodically. The sediments may be mixed with abrasive piles.

Salt Application

There are several factors affecting effective application of snow and ice control materials. One should consider the 4 R's of snow and ice control.

- **Right Material** - The right material will depend upon the conditions being treated. In situations where the pavement temperature is extremely cold, chemicals with lower working temperatures or sand/salt mixtures may be warranted.
- **Right Amount** - The right amount of material is dependent upon the type of slippery condition being treated, the amount of residual chemical on the pavement surface, the expected pavement temperature and the amount of precipitation that is expected.
- **Right Place** - Precise placement of materials is important to keeping it in the right place to do the job rather than wasted to the environment. Proper material placement requires the right equipment and skilled operators.
- **Right Time** - The timing of salt placement is important to minimizing waste and maximizing chemical effectiveness. There are times when the pavement temperature is above freezing and therefore may not warrant salt application.

The following subsections discuss material, equipment and decision-making tools to help achieve the 4 R's of snow and ice control.

Materials

Snow and ice control materials fall into two main categories:

1. Freeze point depressants - used to melt frost, snow and ice and to prevent or break the bond between the ice and the pavement; and
2. Abrasives - used to improve traction on potentially slippery surfaces.

A variety of freeze point depressants is available. These include road salts (i.e. sodium chloride, calcium chloride, magnesium chloride and potassium chloride), acetates (i.e. calcium magnesium acetate, potassium acetate, sodium acetate), and engineered products composed of agricultural products and one or more of the previously listed materials.

These freeze point depressants can either be solid or liquid. They will also have different working temperatures, and may have some additional characteristics that affect when, where and how they are used. Each material has different costs and environmental implications associated with it. Some alternatives are less harmful to the environment and/or less corrosive to vehicles and infrastructure. The suppliers of these products should be consulted for specific information.

Applying solid salt has the advantage of ensuring that there is a supply of salt to go into solution as more moisture is added through melting of snow or ice. One disadvantage is that it takes longer for solid salt to form brine, which is necessary to melt frost, snow and ice. It is also unlikely that the brine will reach a sufficiently high concentration to provide the lowest freeze point depression. Consequently the effective working temperature will be higher than if the material was applied in a concentrated liquid form.

Applying a concentrated liquid anti-icing product has the advantage of providing instant melting capabilities, which can reduce slippery conditions more quickly. As well, because the concentration is at its optimum level, the effective working temperature can be much lower than with a solid form of the same product. A disadvantage is that there is not a continual supply of solid chemical present to maintain the concentration. Therefore, the brine will dilute with increased moisture making it susceptible to refreeze. Liquid anti-icing can be applied to dry pavement in advance of a storm or frost and will be present to begin melting when the frosting condition or snow arrives.

Pre-wetting salt involves the application of a concentrated liquid anti-icing product to solid salt either in the chute or at the spinner. The liquid increases the speed with which the salt begins to work while ensuring that there is solid salt present to slow the rate of dilution and the potential for refreeze. The amount of solid salt that is applied can usually be reduced when pre-wetted.

Pre-treating stockpiles is a technique being used by many public sector road authorities and some private snow and ice control companies. This technique involves mixing a liquid into the stockpiled solid material (e.g. abrasive or salt) to help the solid stick to the pavement surface and accelerate the melting process. Pre-treating has the advantage over pre-wetting of not requiring the same level of investment in infrastructure (i.e. chemical storage tanks) and equipment (i.e. on-board tanks and pumps).

Abrasives (e.g. sand, gravel, chips) are usually applied where a freeze point depressant is not desirable, either because the cost of a freeze point depressant is not warranted, or the pavement temperature is too cold for the product to work. These abrasives will usually be mixed with a small amount of salt to prevent the material from freezing in the storage pile or the spreader. The amount of salt should not exceed 3-5% by volume; enough to keep the pile from freezing.

Equipment

Placement of the right amount of material in the right place requires proper equipment. To minimize salt use, as much snow as possible should be removed through plowing. Proper plowing can significantly reduce the amount of chemical needed to keep an area ice-free. Solid materials are applied using truck-mounted spreaders for roads and parking lots and hand spreaders for sidewalks. Continuous uncontrolled spreading can be wasteful. Spreaders that can be set to meter out the right amount of material for the conditions and that can be turned on and off from the truck cab help the operator to place the right amount of material that is needed. Liquid anti-icing products are applied with tankers and spray trucks. The following considerations should be taken into account with respect to equipment:

- The owner/manager and contractor should ensure that sufficient equipment and staff are available to properly plow snow then apply material. It is not a best practice to quickly "burn off snow" with chemicals to avoid more time consuming plowing.
- Ensure that plowing equipment can reach all areas required and that the blade is appropriate and in good shape to remove the maximum amount of snow and ice.
- Spreaders should allow the operator to target material application so that materials are confined to the treatment area and not lost to adjacent areas.
- Operators should be able to control the spreader so that the amount of material being applied can be increased, decreased or stopped when appropriate.
- Combination plows and spreaders are efficient for removing snow and spreading materials at the same time.
- Drop spreaders rather than broadcast spreaders should be used on sidewalks to increase the amount of material retained on the sidewalks to work. This will also help to limit salt damage to vegetated areas adjacent to sidewalks.
- Broadcast spreaders should be used on parking lots to provide for rapid coverage since traffic cannot be relied on to distribute the salt.
- Each spreader unit should be thoroughly inspected and the mechanical spreader checked to ensure the spreading rate is correct.
- Pre-wetting kits (saddle tanks, pumps and spray nozzles) should be added to salt spreaders to improve the reaction time of the salt.
- On-board pre-wetting units should be designed such that a plumbing failure will not result in release of the entire contents of the tanks.
- Spray trucks can be used to apply liquid anti-icing to sidewalks (using a hose and wand) and roads and parking areas (using a truck-mounted spray bar).

Decision-Making Tools

Supervisors and operators are operating in a dynamic environment and are called upon to make decisions often with limited information. The following provides some guidance on tools that are available to assist in making snow and ice control decisions:

- Localized weather forecasts can provide information on the nature, timing and duration of winter storms.
- Local weather forecasts can provide information on dew point, however, pavement temperatures must be known.
- Pavement temperature trends can be determined using infrared thermometers.
- Internet-based radar images can provide information on where a storm is in relationship to the area being serviced. Decision-makers can determine when a storm is likely to arrive or end.

Operational Considerations

The sequence by which snow and ice control techniques are applied will affect the amount of salt used. The following discusses some operational considerations to be taken into account:

- Weather forecasts and radar images should be monitored to determine when frost, freezing rain, and snow could be expected in order to predict the need to treat an area.
- Both the owner and contractor should understand the size and the characteristics of the site. Both should estimate and agree on how much chemical will be required for each application. A lower application rate, acceptable for frost events or spot applications, should also be determined. Benchmarking should be done separately for both mechanical spreading and hand spreading. Once the benchmark amounts are determined, they can be periodically compared to actual usage.
- Trends in pavement temperatures should be monitored using infrared thermometers and compared with the dew point to determine if frost conditions will exist.
- Trends in pavement temperatures should be monitored to assess when pavement temperatures are above freezing and freeze point depressants are not required, and when pavement temperatures are below the effective working temperature.
- The presence of residual chemical on the pavement surface should be monitored to determine if additional application of a freeze point depressant is required.
- Freeze point depressants should be applied at the start of a storm to prevent the formation of a bond.
- Snow should be plowed from the treatment area prior to the application of a freeze point depressant to minimize the amount of material needed, and the potential for dilution and refreeze.
- Freeze point depressants should be applied after plowing only when pavement temperatures are below freezing and the remaining snow/ice that could not be removed by plowing presents a hazard.
- Only enough material should be applied to do the job.
- Owners can reduce salt use and risk by closing low traffic or under used areas or high-risk areas during storm events.

Snow Storage and Disposal

In many cases, plowed snow is stored on remote or unused parts of parking lots. However, in some cases snow must be removed from the site and transported to a disposal site. Snow that has been cleared from parking lots may contain salt and/or sand that have been applied to the pavement prior to the snow being plowed. When this snow needs to be removed and transported to centralized disposal sites, the contaminants are concentrated and then released to the environment when the snow melts. Disposal sites that are not properly located and designed can have significant adverse effects on the environment. The following practices should be considered when storing and disposing of snow:

- Owners should ensure that site plans provide for sufficient snow storage to eliminate the need to transport snow off-site.
- Snow storage sites should be located such that meltwater that may contain salt is not directed towards salt vulnerable areas such as streams.
- Melt water should be directed to sediment ponds or sanitary sewers where permitted by the local municipal sewer use by-law.
- Snow should be stored on-site in paved areas where the melt water will not drain into the parking area or form puddles that cause slippery conditions that require extra salting operations to maintain safety.
- Snow should be stored in areas of the parking lot where puddles frequently form to deter vehicles and pedestrians from using these areas.
- Snow should not block drains.
- Salt should never be used to promote rapid melting of stockpiled snow.
- Snow should be stored in areas where the sun will promote rapid melting.
- Snow that is removed from a facility and transported for disposal should be taken to a properly designed snow disposal site. Property owners and contractors should determine the disposal locations prior to the winter.

Documentation

Good, thorough documentation is critical to the successful implementation of Best Practices, good salt management and managing liability exposure. Documentation is not limited to just collecting statistical information such as time spent and the amount of material used. It also includes documenting service expectations, describing how the expectations are to be met and having site maps available. The documentation should also record the following for each site:

- Location.
- Date and time of treatment.
- Weather conditions (e.g. type of precipitation, air temperature) and pavement conditions (e.g. extent of snow cover, pavement temperature trends).
- Plowing activities.
- Type and quantity of material placed.

- Snow removal activities (e.g. amount removed, disposal location).
- Observed risk areas that could not be treated and why they could not be treated.

Contracts

In addition to the weather, the amount of salt used by a snow and ice management contractor is determined by the terms of his or her contract with the property owner. In some circumstances, the property owner retains control over what and when ice melting products are to be applied to a premises, and in what amounts. In others, the owner authorizes the contractor to apply specified ice melting products, which may include salt, at his or her discretion to manage the risk of hazardous conditions.

Property owners will often seek to have the contractor assume all risks associated with a slip and fall with the most economical products available. This approach can lead to increased salt use as the contractor looks to prioritize the avoidance of claims. Property owners are accordingly encouraged to require in their contracts that contractors follow best practices for salt management.

In addition, the following should be considered when developing snow and ice control contracts:

- Contracts should be developed to encourage mechanical removal thereby reducing the amount of salt needed to maintain safe and passable conditions.
- Service areas and application rates should be established.
- Property owners and contractors should detail the extent to which the contractor will report on the amount of salt used in order to aid the ongoing improvement in practices.
- Property owners and contractors should consider the use of non-toxic ice melting products as an alternative to road salts.

Training

Human behavior is predicated upon attitudes, which in turn are based on knowledge and experience. A successful salt management strategy requires effective procedures, practices and equipment. Success also requires acceptance of new approaches by property owners, managers, supervisors and operators. Any changes in approach will require changes in behavior. Training of property owners, managers, supervisors and operators will help to demonstrate the purpose and value of new procedures and ensures that personnel are competent to carry out their duties. A comprehensive Synthesis of Best Practices on Salt Management Training has been produced by the Transportation Association of Canada and is available free of charge from its website (www.tac-atc.ca). This document sets out the learning goals for a training program as well as adult learning principles for people developing a salt management training module as part of their snow and ice control program. Studies have shown that up to 50% of the salt in sand/salt mixtures can wash from uncovered stockpiles.

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