North Farm Creek and Dry Run Tributary Implementation Plan

December 2012

Prepared for
U.S. Environmental Protection Agency
Region 5

Prepared by
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EPA United States Environmental Protection Agency

TETRA TECH

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Acronyms and Abbreviations

BMP	best management practice
CRP	Conservation Reserve Program
CSO	combined sewer overflow
E. coli	Escherichia coli
EQIP	Environmental Quality Incentive Program
HSG	hydrologic soil group
IEPA	Illinois Environmental Protection Agency
ILDOT	Illinois Department of Transportation
LID	low impact development
LRS	load reduction strategy
L-THIA	Long-Term Hydrologic Impact Analysis
MS4	municipal separate storm sewer system
N/A	not applicable
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
P2/E2	Pollution Prevention and Energy Efficiency
SSO	sanitary sewer overflow
SWMM	Storm Water Management Model
SWAT	Soil and Water Assessment Tool
TCRPC	Tri-County Regional Planning Commission
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
WWTP	wastewater treatment plant

Units of Measure

ac	acres
cfu/100mL	colony forming units per 100 milliliters
lbs	pounds
mg/L	milligrams per liter

1. Introduction

The U.S. Environmental Protection Agency (USEPA) and Illinois EPA (IEPA) have provided additional resources, in the form of technical assistance, to the Peoria and Tri-County Area Total Maximum Daily Load (TMDL) partnership to increase the usefulness and effectiveness of the Middle Illinois River TMDL and Load Reduction Strategy (LRS) (report completed August 2012) for local watershed decision-makers and groups that have a stake in water quality improvement. The entire Middle Illinois River watershed with TMDL/LRS impairments identified is shown in Figure 1. Two pilot areas within the Middle Illinois River watershed—North Farm Creek and Dry Run Tributary subwatersheds—have been selected to demonstrate the development of an implementation plan to address impairments in those watersheds (Figure 2 and Figure 3).

This implementation plan addresses the following pollutants or response indicators for subwatersheds of Farm Creek and Kickapoo Creek: bacteria, phosphorus, nitrogen, total suspended solids, sedimentation/ siltation, and chloride. Details regarding the TMDLs and LRSs for these water quality impairments can be found in the report titled, *Middle Illinois River Total Maximum Daily Load and Load Reduction Strategies* (IEPA 2012).

Recommended activities that will achieve TMDL and LRS pollutant load reductions in the pilot watersheds are outline in this implementation plan. Not only will the identified implementation activities help to achieve the TMDL target reductions and attain water quality standards, these activities will also result in a cleaner, healthier Illinois River for the people who depend on the resources of the watershed for their livelihood now and in the future.

Stakeholders can also use the TMDL and implementation planning process to meet USEPA's watershed plan Nine Key Elements for Clean Water Act section 319 funding.

1.1 TMDL/LRS Summary

The Middle Illinois River watershed TMDL and LRS study addresses approximately 2,100 square miles of the Middle Illinois River watershed near Peoria, located in central Illinois. The TMDL aims to attain water quality standards in the Middle Illinois River watershed,, while the LRSs were included to address pollutants in the watershed that do not have water quality standards, namely nutrients and sediment.

Several waters within the Middle Illinois River project area required the development of MDLs, including portions of the mainstem of the Illinois River, Kickapoo Creek, Big Bureau Creek, West Bureau Creek, Farm Creek, Depue Lake, and Senachwine Lake. TMDLs were developed to address the following impairments: bacteria, phosphorus, total suspended solids, sedimentation / siltation, dissolved oxygen, chloride, aquatic algae, pH, alteration in streamside vegetative cover, manganese, and total dissolved solids as identified on the State of Illinois section 303(d) list. In addition, phosphorus, nitrogen, and suspended sediment were addressed as part of LRSs (Figure 1).

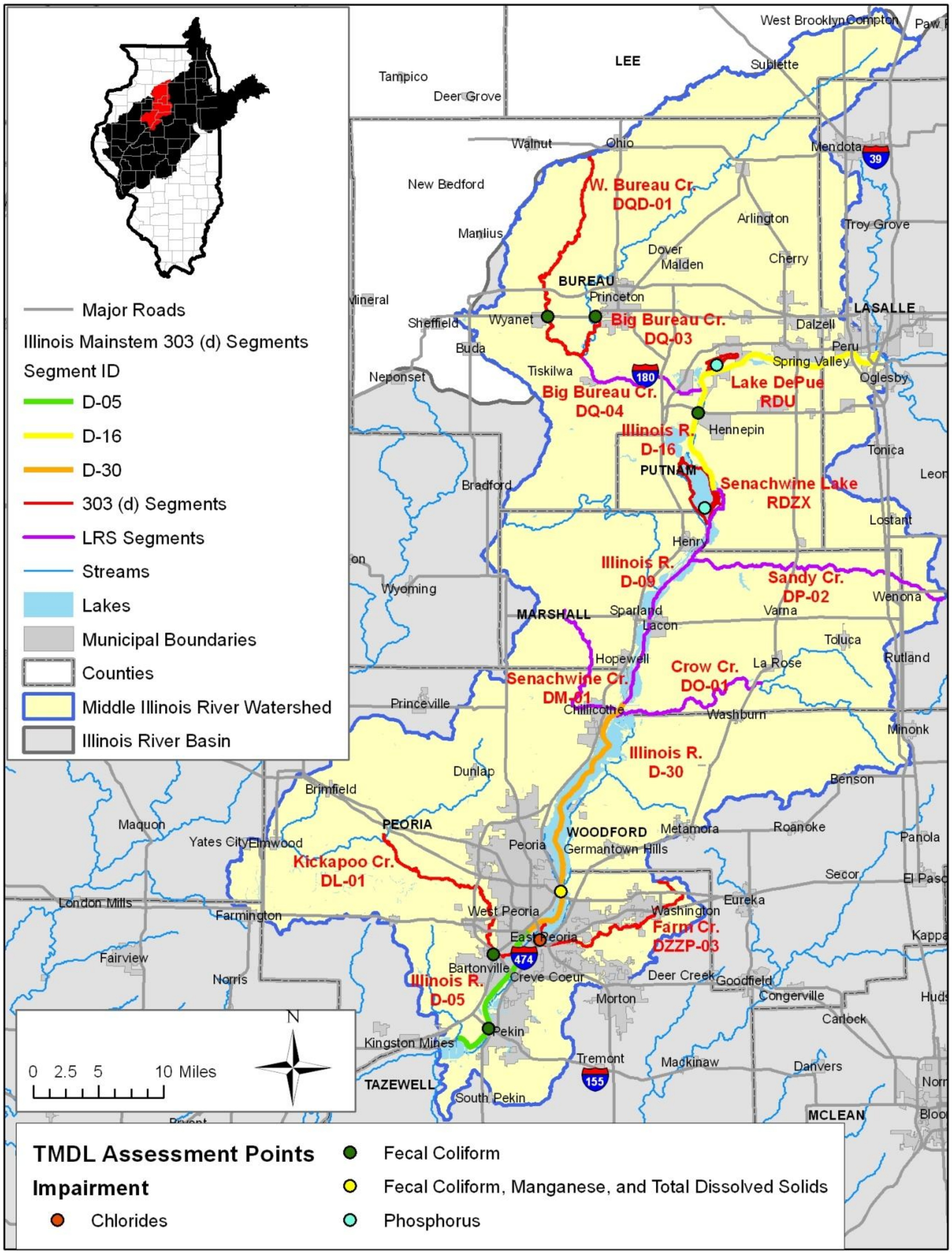

Figure 1. Middle Illinois River TMDL and LRS locations.

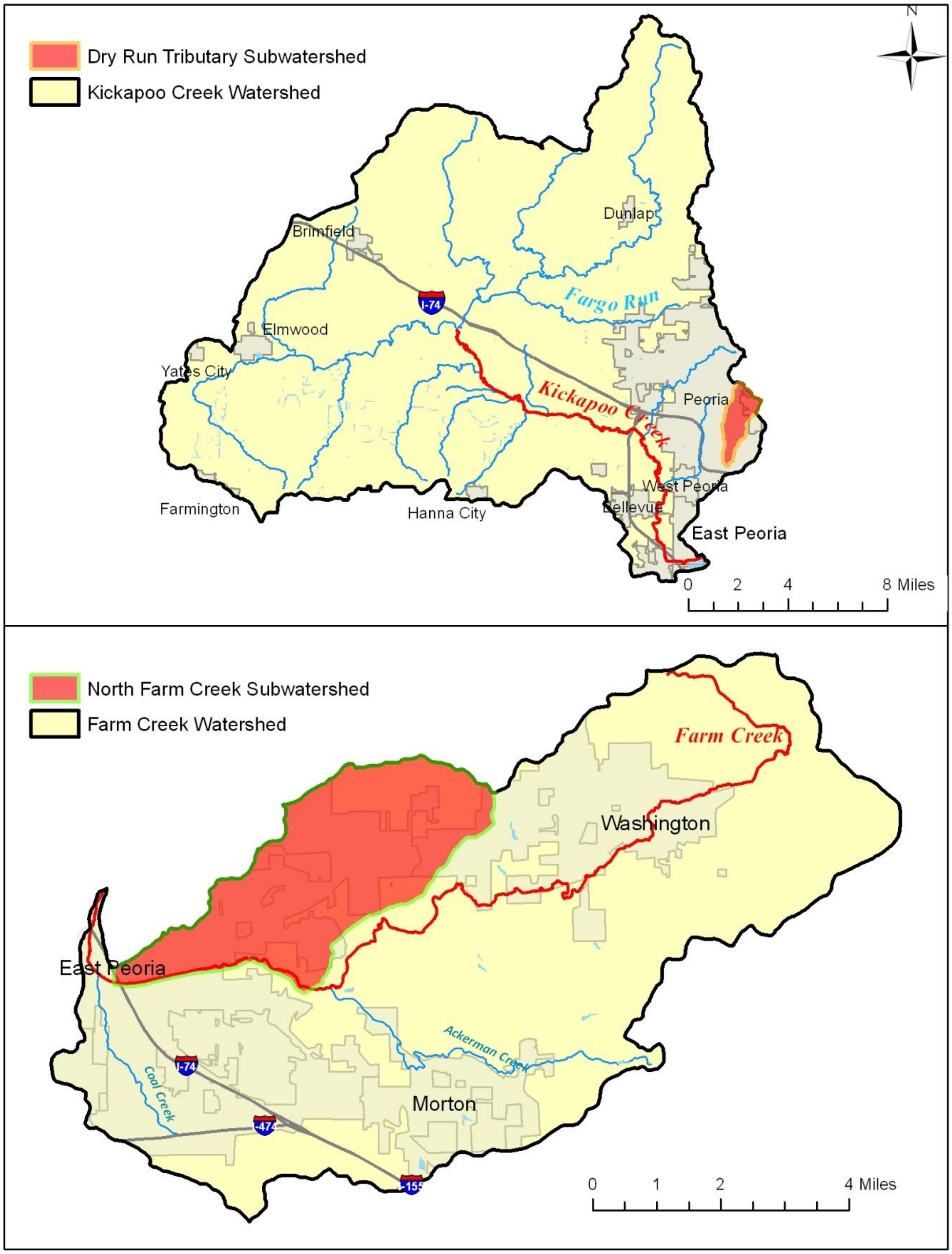

Figure 2. Middle Illinois River watersheds with pilot project area subwateresheds.

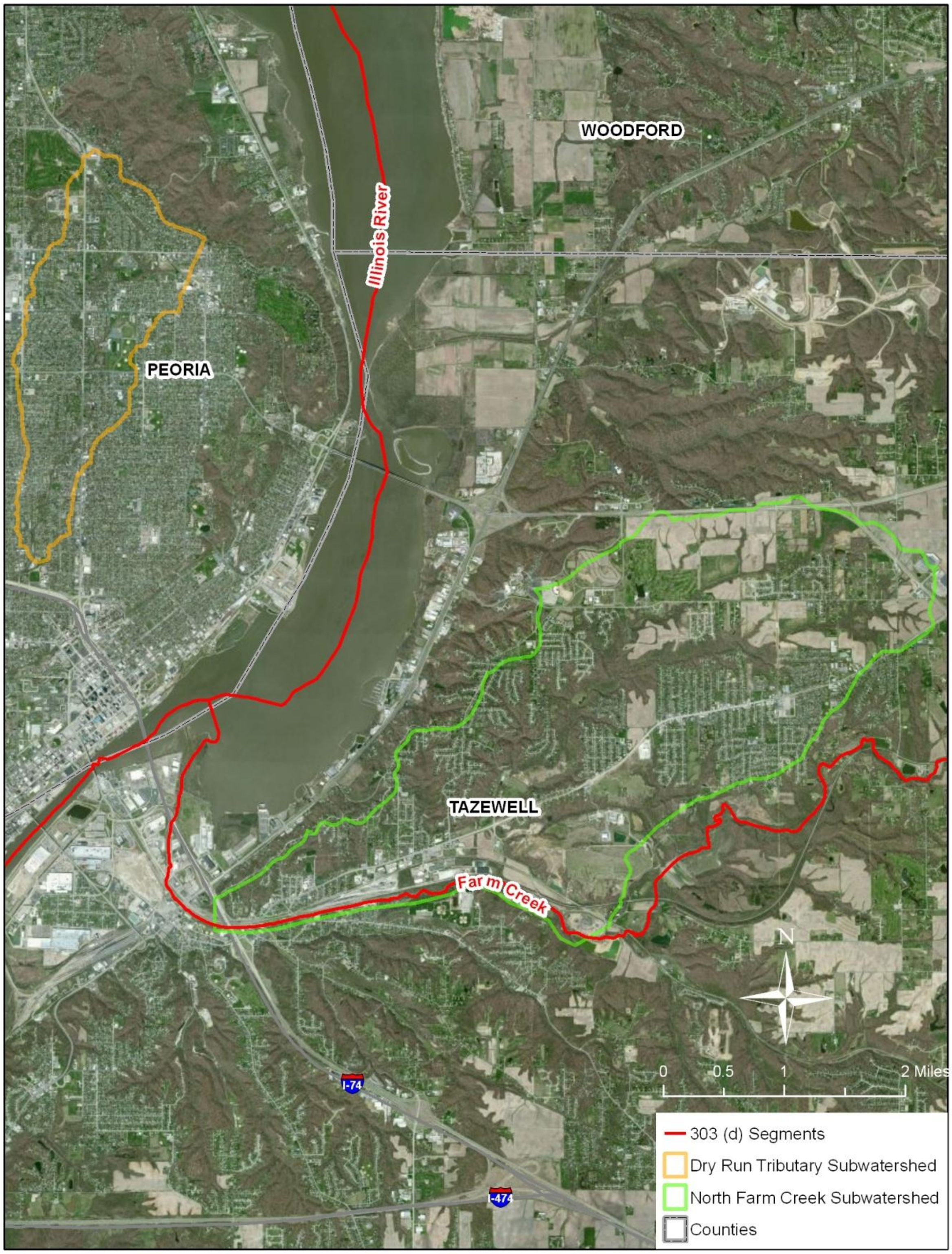

Figure 3. Aerial view of the pilot project area subwatersheds.

The sources of pollutants in the Middle Illinois River watershed include:

- NPDES permitted facilities
    - wastewater treatment facilities
    - regulated stormwater
    - combined and separate sanitary sewer overflows
- Nonpoint source pollution
    - stormwater runoff (both agricultural and developed areas)
    - watershed, in-stream, gully and bluff erosion
    - onsite wastewater treatment systems
    - animal feeding operations
    - livestock populations

Table 1 presents the TMDLs and LRSs for the Middle Illinois River watershed. The required pollutant reductions vary between zero and 100 percent, depending on the waterbody, pollutant, and flow condition. An implementation plan for the entire Middle Illinois River watershed is presented in Section 15 of the Middle Illinois River TMDL and LRS study (IEPA 2012) and includes potential implementation activities for both urban and agricultural sources of pollutants.

Table 1. TMDL and LRS summary of pollutants and potential sources

Watershed Cluster	Pollutants of Concern	Pollutant Reduction Requirement (%)	Potential Sources
Illinois River	Fecal coliform	0 - 79	agricultural and urban runoff; NPDES facilities; MS4s; CSOs/SSOs; watershed, streambank and gully erosion, bluff erosion; hydromodification; tributary loads; animal agriculture; livestock
	Manganese	0 - 26	
	Total dissolved solids	0	
	Total suspended solids	0 - 39	
	Nitrogen	9 -68	
	Phosphorus	72 -89	
Big Bureau Creek	Fecal coliform	15 - 99	streambank, bluff, and gully erosion; urban and agricultural stormwater runoff; livestock access to waterways; animal agriculture; untreated sewage; NPDES facilities; CSOs
	Total suspended solids	0 - 82	
	Nitrogen	9 - 86	
	Phosphorus	8 - 97	
Farm Creek	**Chloride**	**75**	**watershed, streambank, and gully erosion; urban and agricultural stormwater runoff; NPDES facilities; MS4s; SSOs; hydromodification; deicing agents**
	Total suspended solids	**88**	
	Nitrogen	**17 - 63**	
	Phosphorus	**21 - 73**	
Kickapoo Creek	**Fecal coliform**	**97 - 100**	**watershed, streambank, and gully erosion; urban and agricultural stormwater runoff; animal agriculture; MS4s; NPDES facilities**
	Total suspended solids	**96**	
	Nitrogen	**20 - 65**	
	Phosphorus	**32 - 76**	
Senachwine Creek	Total suspended solids	0	agricultural activities; watershed runoff; livestock; streambank and gully erosion
	Nitrogen	78 - 83	
	Phosphorus	0	
Crow Creek and Snag Creek	Total suspended solids	0	agricultural runoff; streambank and gully erosion; NPDES facilities
	Nitrogen	77 - 81	
	Phosphorus	0	
Sandy Creek	Total suspended solids	0	streambank and gully erosion; agricultural runoff; NPDES facilities; CSOs
	Nitrogen	73 - 78	
	Phosphorus	0	
Lake Depue	Phosphorus	91	Illinois River inflows; NPDES facilities; watershed runoff
	Total suspended solids	20	
Senachwine Lake	Phosphorus	83 -92	Illinois River inflows; NPDES facilities; watershed runoff
	Total suspended solids	20	

Note: **Bolded** text indicates watersheds that are addressed as part of this Implementation Plan.

1.2 Watershed Plan Requirements - Nine Key Elements

The 2008 USEPA *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_handbook.pdf) establishes nine key elements to ensure improvements in water quality to threatened or impaired waterbodies. These nine key elements are required for watershed plans funded with incremental Clean Water Act section 319 funds. Section 319 grant money supports implementation activities including technical and financial assistance, education, training, demonstration projects, and monitoring to assess the success of nonpoint source implementation projects. The nine key elements, which watershed management plans must address to be eligible for 319 grants, are listed below:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve load reductions estimated within the plan
2. Estimate of the load reductions expected from management measures
3. Description of the nonpoint source management measures that will need to be implemented to achieve load reductions estimated in element 2; and identification of critical areas
4. Estimate of the amounts of technical and financial assistance needed, associated costs, and the sources and authorities (e.g., ordinances) that will be relied upon to implement the plan
5. An information and public education component; early and continued encouragement of public involvement in the design and implementation of the plan
6. Implementation schedule
7. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented
8. Criteria to measure success and reevaluate the plan
9. Monitoring component to evaluate the effectiveness of the implementation efforts over time

Table 2 provides a cross-walk between the nine key elements (column on the left) and the location within the TMDL/LRS report (middle column) or this implementation plan (column on the right) that addresses each element. The table is only relevant for the two pilot project area subwatersheds included in this implementation plan.

Table 2. Comparison of Middle Illinois River TMDL and LRS study and Implementation Plan to USEPA's watershed plan nine key elements

Section 319 Nine Key Elements	Applicable Section of the TMDL and LRS Report /Implementation Plan (IEPA 2012)	Applicable Section of the Implementation Plan (this document)
1. Identification of **causes of impairment and pollutant sources** or groups of similar sources that need to be controlled to achieve **load reductions** estimated within the plan.	Fully addressed in TMDL (Sections 2 [Watershed Source Assessment] and 5-15 [TMDL Endpoints and LRS Targets])	Addressed in Sections 3.1 and 4.1
2. Estimate of the **load reductions expected from management measures**		Addressed in Section 7
3. Description of the **nonpoint source management measures** that will need to be implemented to **achieve load reductions** estimated in element 2; and identification of **critical areas**		Addressed in Sections 3 and 4; Critical areas identified in Sections 3.4 (Table 13) and 4.4 (Table 20)

Section 319 Nine Key Elements	Applicable Section of the TMDL and LRS Report /Implementation Plan (IEPA 2012)	Applicable Section of the Implementation Plan (this document)
4. Estimate of the amounts of **technical and financial assistance needed**, associated **costs**, and the **sources and authorities** (e.g., ordinances) that will be relied upon to implement the plan.	Partially addressed in TMDL through sections on Reasonable Assurances (Section 15.4)	Addressed in Sections 3.4 (Table 13) and 4.4 (Table 20)
5. An **information and public education component**; early and continued encouragement of public involvement in the design and implementation of the plan.		Addressed in Sections 3.2.1 and 4.2.1
6. **Implementation schedule**		Schedule provided in Sections 3.4 and 4.4 and Section 7
7. A description of **interim, measurable milestones** for determining whether nonpoint source management measures or other control actions are being implemented.		Milestones are provided in Section 7
8. Criteria to **measure success** and **reevaluate** the plan		Criteria established within interim milestones and Adaptive Management for re-evaluation provided in Section 7
9. **Monitoring component** to evaluate the effectiveness of the implementation efforts over time.		Monitoring plan for both water quality improvement and BMP effectiveness provided in Section 6

1.3 Implementation Plan Approach

This implementation plan was developed to address the requirements of the USEPA's nine key elements for watershed management plans, thus enabling Clean Water Act section 319 funding for implementation efforts. Implementation activities can be separated into nonstructural and structural management opportunities. This section describes the difference between those opportunities and outlines best management practices (BMPs) that can be used to address TMDL/LRS goals. A general implementation schedule is outlined for each watershed, assuming a twenty-year timeline, in Section 7.

Overall goals for implementation plan include:

- Reduce pollutant loads from Dry Run Tributary to Kickapoo Creek
  - Nutrient loads by 20 - 76 percent, dependent on flow regimes
  - Sediment loads by 96 percent
  - Bacteria loads by 97 - 100 percent, dependent on flow regime)
- Reduce pollutant loads from North Farm Creek to Farm Creek
  - Nutrient loads by 17 - 73 percent, dependent on flow regimes
  - Sediment loads by 88 percent
  - Bacteria loads by 68 - 79 percent, to the downstream Illinois River
  - Chloride loads by 75 percent during winter high flows
- Reduce erosion from watershed, streambank and gullies for both pilot project area subwatersheds
- Monitor effectiveness of implementation activities
- Support adaptive management

1.3.1 Nonstructural Management Opportunities

Nonstructural management opportunities are often classified as pollution prevention or source control BMPs since they aim to prevent runoff from a site. Source control BMPs reduce the exposure of materials to runoff, and thereby reduce the amount of pollutants picked up by runoff. It is typically more cost-effective to prevent pollution from entering runoff rather than treat either the collected runoff flow or waterbodies affected by stormwater discharges (UDFCD 2010). Traditional source control methods include land use or site planning practices, as well as structures and ordinances that aim to prevent runoff; these BMPs, reduce runoff from the source of pollution. During the early stages of implementation, efforts should first focus on the refinement of existing programs to verify that the existing programs target sources effectively. Table 3 summarizes the available pollutant removal efficiencies for nonstructural BMPs identified in this plan and the data needed to track BMP effectiveness.

Table 3. Summary of nonstructural BMP pollutant removal efficiencies and data needs

Nonstructural BMP	Source Load Addressed	Percent Reduction (Volume or Load) (%)					Data Needs
		TSS	Nitrogen	Phosphorus	Fecal coliform	Chloride	
Education and Pollution Prevention Program	Urban and Agricultural Stormwater Runoff, Watershed, Streambank, and Gully Erosion	ukw	Moderate[a]	Moderate[a]	ukw	ukw	Need for baseline behavior data to set up goals and objectives for modifying/improving behaviors that will address target pollutants
Ordinance Development	Urban Stormwater Runoff	ukw	ukw	ukw	ukw	ukw	Need for baseline conditions data
Street and Parking Lot Sweeping	Urban Stormwater Runoff	9-31[b]	3-7[b]	3-8[b]	O	O	Need for baseline conditions data
Pet Waste Education and Outreach Campaign	Urban Stormwater Runoff	O	ukw	ukw	ukw	O	Need for baseline conditions data
Wildlife Implementation Practices	Urban and Agricultural Stormwater Runoff	O	ukw	ukw	ukw	O	Need for baseline conditions data
Salt Management Plan and Education	De-icing Agents	ukw	O	O	O	10-40[c]	Need for baseline conditions data

Notes
O does not address the pollutant
Ukw: Unknown

a. Source: USEPA 2009d
b. Source: CWP 2007
c. Source: DRSCW 2012

1.3.2 Structural Management Opportunities

Structural management opportunities are BMPs primarily limited to redevelopment projects or retrofits in built- out areas. Structural BMPs can be incorporated in urban landscapes to capture, infiltrate, filter, and treat stormwater runoff. Structural management opportunities include storage-based and conveyance-based BMPs. Storage-based BMPs provide both volume reduction and water quality treatment whereas conveyance-based BMPs only provide water quality treatment. Often, a blend of storage-based and conveyance-based BMPs are most effective at meeting water quality or volume reduction goals (UDFCD 2010). Table 4 summarizes the available pollutant removal efficiencies for structural BMPs identified in this plan and the data needed to track BMP effectiveness.

Table 4. Summary of structural BMP removal efficiencies and data needs

Structural BMP	Source Load Addressed	Percent reduction					Data Needs
		TSS	Nitrogen	Phosphorus	Fecal coliform	Chloride	
Green Infrastructure Retrofitting	Urban Stormwater Runoff in North Farm Creek Subwatershed[a]	52	48	47	46	O	Monitoring of pollutants upstream and downstream of BMPs
	Urban Stormwater Runoff in Dry Run Tributary Subwatershed[b]	35	42	45	45	O	Monitoring of pollutants upstream and downstream of BMPs
Sanitary Sewer Overflow Control	NPDES Facilities	O	100	100	100	O	Need East Peoria STP#1 SSO Plans/Data
Disinfection of Primary Effluent from Sewage Treatment Plants	NPDES Facilities	O	O	O	ukw	O	Need baseline/DMR data. If allowed to discharge, facility must be meeting standards.
Stabilize Erosion on Steep Slopes	Watershed, Streambank, and Gully Erosion	ukw	ukw	ukw	O	O	Need for baseline conditions data
Streambank Restoration	Watershed, Streambank, and Gully Erosion	2.55 lb/linear foot/year[c]	0.02 lb/linear foot/year[c]	0.0035 lb/linear foot/year[c]	O	O	Need for baseline conditions data
Riparian Area Management	Watershed, Streambank, and Gully Erosion	70-90[d]	60-74[e]	ukw	40-90[f]	O	Need for baseline conditions data
Grassed Waterways	Agricultural Stormwater Runoff, Watershed, Streambank, and Gully Erosion	68[g]	ukw	ukw	5[g]	O	Need for baseline conditions data
Conservation Tillage	Agricultural Stormwater Runoff, Watershed, Streambank, and Gully Erosion	50-90[h]	ukw	38-85[i]	O	O	Need for baseline conditions data

Notes

O does not address the pollutant

Ukw: Unknown

a. Source: Appendix A

b. Source: Appendix B

c. Source: Baltimore County 2002

d. Source: NCSU 2002

e. Source: Dillaha et al. 1989

f. Source: Wenger 1999

g. Source: Winer 2000

h. Source: USEPA 2003

i. Source: Czapar et al. 2006

2. Implementation Partners and Existing Implementation Efforts

2.1 Implementation Partners

A series of meetings with stakeholders to communicate the need for implementation was included in the Middle Illinois River watershed TMDL and LRS study. This watershed has a high potential for implementing recommendations based on past work and cooperation between local and state agencies and organizations. All parties are interested in the watershed and the improvements to be made, however leadership and multi-jurisdictional cooperation is needed to ensure successful implementation and water quality improvement. The following partners (Table 5) can play a key role in technical and financial assistance, BMP implementation, and project consultation.

Table 5. Implementation partners

Partner	Description	Role in Implementation
Local Governments	Municipalities are cooperatively working to improve stormwater quality through the Illinois River Valley Council of Governments' Stormwater Advisory Committee and the implementation of their Regional Stormwater Plan, *Honoring Our Water.*	BMP implementation
Local Soil and Water Conservation Districts	Promote stewardship and create a desire in individuals to conserve, protect, or enhance our natural resources. They assist landowners and operators with state and federal conservation programs that help to reduce soil erosion, improve water quality, and increase wildlife habitat.	Technical assistance, consultation
Local NRCS Offices	Conservation leader for all natural resources, ensuring private lands are conserved, restored, and more resilient to environmental challenges.	Technical and financial assistance, consultation
The Peoria Lakes Basin Alliance	A multi-agency cooperative alliance including the Tri-County Regional Planning Commission, the Heartland Water Resources Council, and the Nature Conservancy, working together to ensure a coordinated and successful unified message for the restoration and revitalization of the Illinois River and Peoria Lakes.	BMP implementation
Tri-County Regional Planning Commission (TCRPC)	TCRPC actively works to protect watersheds through collaborative environmental planning, the creation of model ordinances, and the construction of BMPs through grant programs.	Technical assistance, BMP implementation
Heartland Water Resources Council	Organization dedicated to the preservation and restoration of the Peoria & Pekin Lakes of the Illinois River and its tributaries.	BMP Implementation
Heart of Illinois Sierra Club	850 members work to protect our communities and the planet.	Technical assistance
Park Districts	Active in ecological restoration of the forested bluffs for the purpose of improving biodiversity and reducing sedimentation of local stream systems and the Illinois River.	BMP implementation
The Nature Conservancy	The Nature Conservancy, through their participation in the Peoria Lakes Basin Alliance, contributes their world-class scientific expertise to the local effort in Illinois River restoration.	Technical assistance
Illinois Department of Transportation (ILDOT)	Responsible for State road construction programs.	BMP implementation
Illinois EPA	Provides technical expertise as well as grant funding for watershed protection programs and practices.	Technical assistance and financial assistance
Private sector and landowners		BMP implementation

2.2 Existing Implementation Efforts

Stakeholders can make use of many existing implementation efforts already in place in and around the North Farm Creek and Dry Run Tributary subwatersheds. The following sections summarize existing plans and ordinances that are applicable to North Farm Creek and Dry Run Tributary subwatersheds.

2.2.1 Honoring our Water Stormwater Plan

The *Honoring our Water Stormwater Plan* (TCRPC 2009) outlines recommendations for improving stormwater management throughout Peoria, Tazewell, and Woodford counties. The plan won an award from the Illinois Chapter of the American Planning Association in 2009. The plan contains information on many previous and ongoing activities aimed at reducing stormwater pollution. It also has many recommended actions needed in the tri-county watershed including potential implementers and costs. Peoria County has secured approximately $500,000 to begin implementing the plan, and projects listed in the plan are being submitted for inclusion in the reauthorization of the Water Resources Development Act. The stormwater plan includes many activities which overlap with this Implementation Plan.

2.2.2 Ackerman Creek Watershed Restoration

The Ackerman Creek watershed, which is tributary to Farm Creek, covers approximately 7,408 acres southeast of Peoria (TCRPC 2004a). Predominating land uses are deciduous forests, cultivated crops, and development, including low, medium and high intensity. Ackerman Creek has been classified for overall, swimming, and aquatic life use; however, concerns include agriculture, hydromodification, municipal point sources, resource extraction and urban runoff/storm sewers. The 2004 Ackerman Creek Watershed Restoration Plan identified development, specifically, development along the ridges and bluffs, as a primary cause of erosion, gullying, sedimentation, and reduced water quality. Erosion concerns were also identified in farm fields, construction sites and bluffs. In total, it is estimated that the Ackerman Creek watershed contributes 16,000 tons of sediment to Farm Creek (TCRPC 2004a). Ultimately this sediment load may wash to the Illinois and Mississippi rivers.

2.2.3 Farm Creek Watershed Plan

The Farm Creek watershed drains 40,000 acres in Tazewell County and is a major contributor of sediment to the Illinois River and Peoria Lake. In regards to erosion and sedimentation, it has been indicated that the streams in the Farm Creek watershed do not appear to be approaching equilibrium, and, without interdiction, it is thought that the streams will continue to degrade and enlarge for many years to come. Results from an erosion study completed by the USDA (United States Department of Agriculture) and Natural Resources Conservation Service (NRCS) are presented within the 2001 Farm Creek Watershed Management Plan. The study found that an estimated total of 203,650 tons of sediment are eroded within the watershed annually, and of this, 33,600 tons were delivered from the Farm Creek watershed to the Illinois River (TCRPC 2001).

2.2.4 Tenmile Creek Watershed Restoration

The Tenmile Creek watershed covers approximately 11,027 acres and flows ten miles northwest from Washington Township to Peoria Lake. Predominating land uses are deciduous forests, cultivated crops and urban development surrounding Germantown Hills. Tenmile Creek has been classified for *overall* and *aquatic life* use; however, concerns include agriculture, hydromodification, municipal point sources, resource extraction and urban runoff/storm sewers (TCRPC 2004c). The *2004 Tenmile Watershed Restoration Plan* identified the lack of stormwater management as the primary cause of water quality degradation in the watershed (TCRPC 2004c). Additionally, specific concerns associated with stormwater were identified in the *2004 Tenmile Watershed Restoration Plan*, including: increased volumes of stormwater flows generated from human alterations; soil erosion and soil washed from the watershed to Peoria Lake; and, a lack of stable stream channels contributing to downstream sedimentation, loss of aquatic life and property damage (TCRPC 2004c).

2.2.5 Partridge Creek Watershed Restoration

Partridge Creek originates north of the Village of Metamora and flows northwest for approximately 12 miles to Upper Peoria Lake. Including all tributaries that drain to Partridge Creek, the watershed is composed of 73.5 stream miles and drains approximately 18,000 acres of land (TCRPC 2004b). The Partridge Creek watershed is dominated by row crops with urbanization concentrated around Village of Metamora. Partridge Creek has been classified for *overall* and *aquatic life* use. Potential sources of impacts include agriculture, hydromodification, municipal point sources, resource extraction and urban runoff/storm sewers (TCRPC 2004b).

2.2.6 Mossville Bluffs Watershed Restoration Master Plan

The Mossville Bluffs Watershed restoration master plan (TCRPC 2002) is a study to determine the primary factors that cause the 3,800 acre Mossville Bluffs watershed to contribute approximately 11,400 tons of sediment to Peoria Lake each year. The plan identifies actions to reduce sedimentation and proposes tools for preventing future sedimentation from development near currently undeveloped slopes. The plan suggests the use of the following BMPs to reduce bluff erosion and the resulting sedimentation: vegetation restoration, buffers and setbacks, open spaces and greenways, minimized impervious surfaces, mixed-use development, cluster development, infiltrated ravine runoff, as well as stormwater management BMPs.

The following BMPs were prioritized for specific locations in the watershed: vegetative buffer strips, infiltration trenches, rainwater gardens, native vegetation, vegetative restoration, and ravine restoration. The use of rain gardens, rain barrels and vegetated buffer strips with level spreaders were prioritized for residential properties throughout the subwatershed.

2.2.7 Peoria Long-Term Control Plan –Clean River Healthy Riverfront Program

The City of Peoria is working with USEPA and IEPA to develop a long-term control plan that meets Clean Water Act requirements and protects the Illinois River. This plan will reduce CSO overflows from the City of Peoria. The City has formed a Clean River Committee to provide advice and recommendations to the Peoria Department of Public Works as it develops the long-term control plan.

2.2.8 Tazewell and Woodford County Comprehensive Plans

The Tazewell and Woodford County Comprehensive Plans were updated in 2011 with the help of the Tri-County Regional Planning Commission. An important component of the plans is the future land use map. The map guides future growth and the location of specific land uses. The plans also include goals related to water quality improvement. Both plans are available online at: http://www.tricountyrpc.org/documents.

2.2.9 Model Ordinances

Several model ordinances can be used to address stormwater and erosion in the North Farm Creek and Dry Run Tributary subwatersheds. The following model ordinances can be found online at: http://www.tricountyrpc.org/environment-documents.

Low Impact Development Model Ordinances - These model ordinances enable low impact development. Low impact development is a set of practices designed to manage stormwater runoff in a way that improves the water quality of rivers, lakes and streams. These ordinances address zoning, subdivision development, stormwater management, and parking.

Tri-County Unified Stormwater Ordinances - These model ordinances outline a stormwater management program to improve water quality, reduce flood damage, and facilitate sustainable development.

Stream Buffer Ordinance - This ordinance was developed by the City of Peoria in 2007 to reduce soil erosion and improve water quality in rivers and streams.

Steep Slope Protection Model Ordinance - This model ordinance can be adapted by communities to reduce soil erosion and mitigate negative impacts such as poor water quality and property damage.

3. North Farm Creek Subwatershed Implementation Plan

The North Farm Creek subwatershed is located just upstream and northeast of the confluence of Farm Creek with the Illinois River and includes portions of East Peoria and Washington (Figure 4). The subwatershed is 6,248 acres and lies east of Peoria Lake and the Illinois River. Developed areas comprise 54 percent of the subwatershed including significant roadways and several smaller commercial areas focused around East Washington Street (Figure 5). A large portion of the watershed is used by the Tazewell County Asphalt Company and the local construction company R. A. Cullinan and Sons. The majority of the residential part of the subwatershed contains single family homes. The subwatershed also includes agricultural fields, parks, and golf courses. Forested areas are typically found along steep slopes and in ravines.

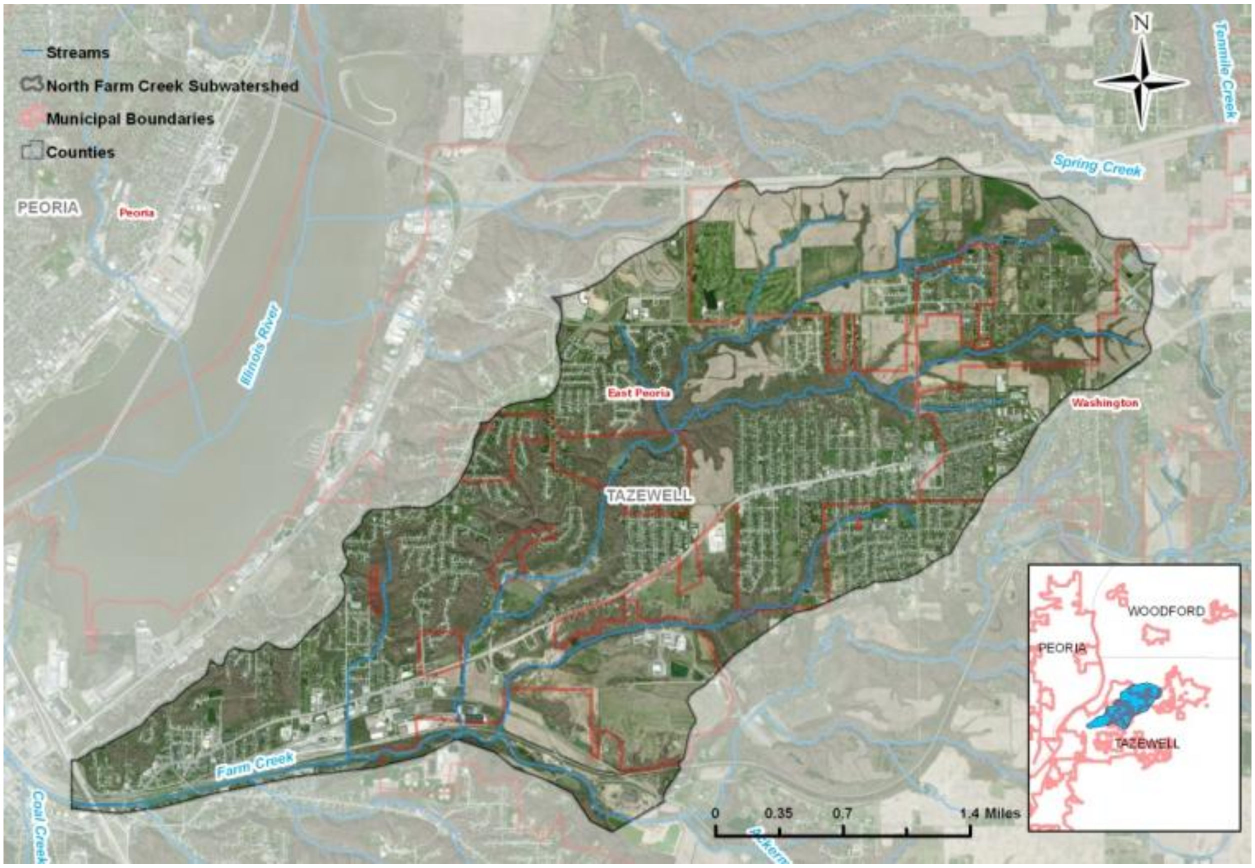

Figure 4. North Farm Creek subwatershed.

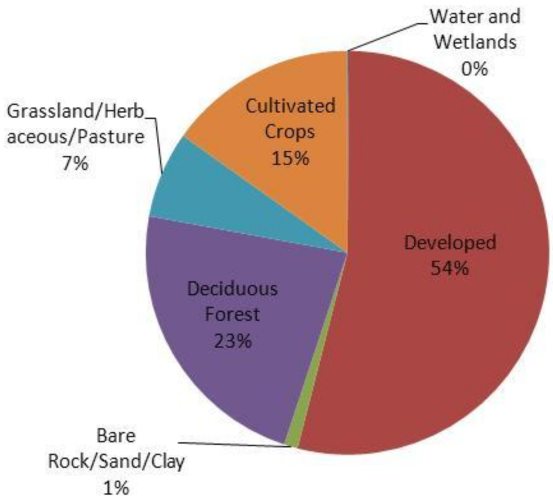

Figure 5. Land use in the North Farm Creek subwatershed (USDI 2006).

In the larger Farm Creek watershed, the North Farm Creek subwatershed is contributing to the high downstream concentrations of chloride, total suspended solids, bacteria, and nutrients. Water quality monitoring showed high levels of bacteria are present in the stream, but the stream is not listed as impaired due to a current exemption from disinfection procedures. The North Farm Creek subwatershed drains to Farm Creek which has pollutant load reductions goals set in the TMDL and LRS Study (shown in Table 6). In addition, the Farm Creek watershed is tributary to the Illinois River which requires reductions in bacteria, total suspended solids, and nutrients to meet water quality goals. TMDL monitoring of Farm Creek at East Peoria showed that there was an average fecal coliform concentration of 698 colony forming units per 100 milliliters (cfu/100ml) and a geometric mean of 366 cfu/100ml. Almost half the samples were over the instantaneous standard of 400 cfu/100ml, and the geometric mean was over the standard of 200 cfu/100ml.

Table 6. Farm Creek Cluster TMDL and LRS reductions

Pollutants of concern	Pollutant Reduction Requirement (%)	Potential Sources
Chloride	75	Watershed, streambank, and gully erosion; urban and agricultural stormwater runoff; NPDES facilities; MS4s; SSOs; hydromodification; deicing agents
Total suspended solids	88	
Nitrogen	17 - 63	
Phosphorus	21 - 73	

3.1 Pollutant Sources

Within the North Farm Creek subwatershed, the following pollutant sources have been identified based on the TMDL/LRS study:

- Watershed, streambank, and gully erosion
- Urban and agricultural stormwater runoff
- NPDES facilities including regulated MS4 stormwater and sanitary sewer overflows
- Deicing agents

3.1.1 Watershed, Streambank, and Gully Erosion

Watershed, streambank and gully erosion has been identified as a primary source of pollutants in the North Farm Creek subwatershed. The subwatershed contains many steep slopes and ravines which, if managed improperly, can lead to gully erosion and ravine formation. Sediment is being transported from these areas to Farm Creek and subsequently impacting the Illinois River. In addition, homes and structures near these slopes are being threatened. One of the primary causes of erosion is stormwater runoff.

Figure 6. Eroding bank within North Farm Creek subwatershed.

3.1.2 Urban and Agricultural Stormwater Runoff

Urban stormwater pollutants are typically deposited upon and transported via impervious surfaces. Connected impervious areas (e.g. roads) convey higher runoff flow volumes and peak discharges and associated pollutants to downstream receiving waters, which can degrade habitat and lower the assimilative capacity of the waterbody. Sediment, nutrients, bacteria, and chloride are commonly associated with stormwater runoff from urban areas. Deforestation near streams and bluffs also contribute to impairments in the urban area. The headwaters of the North Farm Creek subwatershed are mostly agricultural with approximately 75 percent of the land used for row crops and 25 percent used for pasture.

To further evaluate the sources of pollutants in the North Farm Creek subwatershed, the North Farm Creek subwatershed was modeled using Long Term Hydrologic Impact Analysis (L-THIA; available at https://engineering.purdue.edu/~lthia/). L-THIA was used to generate annual average pollutant loads for sediment, nutrients, and bacteria. This approach was chosen for North Farm Creek because the tool is web-based, publicly-available and simple to use. The L-THIA model has been left uncalibrated. Researchers have noted that predicted runoff is often less than runoff derived from streamflow records (Muthukrishnan et al. 2006). This is due mainly to L-THIA only representing surface runoff while ignoring baseflow contributions to the stream. Other factors including actual antecedent moisture conditions, evapotranspiration, generalized land-cover data, surface topography, and spatial and temporal variability of rainfall can also account for differences in L-THIA predicted runoff and streamflow records. Because the purpose of this study is to evaluate the effect of green infrastructure on pollutant loadings, the relative difference between the predicted current conditions and future conditions with BMPs should not be affected. Appendix A includes the technical documentation on model development.

Table 7 and Figure 7 present baseline model results that simulate runoff under existing conditions. The target load is based on required TMDL/LRS reductions. Reductions for fecal coliform were derived from the main stem Illinois River downstream of Farm Creek at sampling Station D-05, which required bacteria reductions between 68 and 79 percent depending on flow conditions. Chlorides are not modeled in the L-THIA model and are not presented here. Activities to reduce chlorides will be discussed later in this document.

Table 7. Summary of area, runoff volume, and pollutant loadings

Land use	Area (Acres)	Runoff Volume (acre-ft)	Nitrogen (pounds)	Phosphorus (pounds)	Suspended Solids (pounds)	Pathogens (millions of coliform)
High Density Residential	588	349	1,729	541	38,953	86,370
Low Density Residential	1,815	359	1,777	556	40,052	88,807
Commercial	76	83	303	72	12,555	7,095
Industrial	99	76	262	58	12,607	9,188
Agriculture	843	240	2,875	849	69,934	77,242
Grass/Pasture	1,542	156	297	4	425	386
Forest	1,282	80	152	2	217	197
Total Existing Load	**6,245**	**1,343**	**7,395**	**2,082**	**174,743**	**269,285**
TMDL/LRS Reduction (%)	**--**	**--**	**17 - 63**	**21 - 73**	**88**	**68 - 79**
Target Load	**--**	**--**	**2,737 - 5,990**	**562 - 1,645**	**20,969**	**56,550 - 86,171**

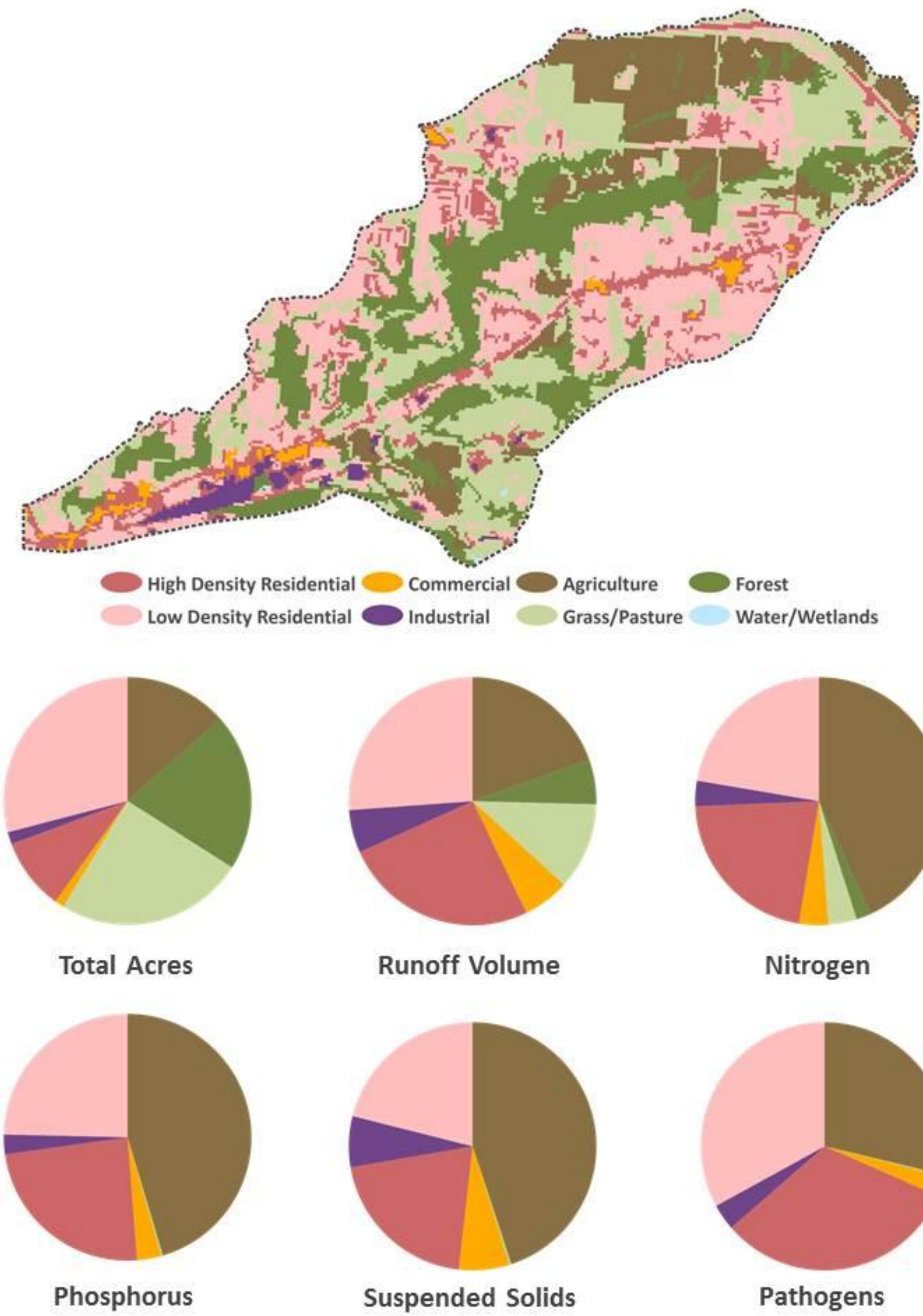

Figure 7. Land use distribution and baseline contributions by land use.

3.1.3 NPDES Facilities

There are three permitted facilities in the North Farm Creek subwatershed: 1) the East Peoria sewage treatment plant, 2) Sundale Hills sewage treatment plant, and 3) Sundale Sewer Corp-Highland sewage treatment plant. Wastewater discharges from these facilities contribute to elevated in-stream loads of bacteria and nutrients in Farm Creek. There is one sanitary sewer overflow outfall in the watershed which has discharged untreated wastewater into Farm Creek near East Oakwood Ave on one occasion (4,500 gallons).

IEPA regulates stormwater from municipal separate storm sewer systems (MS4s) under the federal NPDES stormwater program. The regulated Phase II MS4s within the watershed are: Tazewell County, East Peoria, Washington Township, and ILDOT. Regulated MS4s are required to meet six minimum control measures for stormwater as specified in the Phase II MS4 general permit:

- Public education and outreach on stormwater impacts
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site stormwater runoff control
- Post construction stormwater management in new development and redevelopment
- Pollution prevention/good housekeeping for municipal operations

3.1.4 De-Icing Agents

Winter road materials management can help to address the chloride problems in Farm Creek. High levels of chloride have been identified during both high and low flow conditions, indicating that chloride is likely present in both the surface water and ground water systems. Tazewell County Health Department referenced the Illinois State Water Survey data, to find a trend of 1 milligram per liter (mg/L) per year increase in groundwater chlorides for the Illinois River in Peoria. Since chloride does not degrade in the environment, pollution prevention is especially important. Road salt typically contains chloride; the storage and application (i.e., procedures and rates) of these materials should be continually evaluated and fine-tuned.

3.2 Nonstructural Management Opportunities

Nonstructural management opportunities that could be used to achieve the load reductions needed for the North Farm Creek subwatershed include:

- Education and pollution prevention program
- Ordinance development
- Street and parking lot sweeping
- Pet waste education and outreach campaign
- Wildlife implementation practices
- Salt management plan and education

Table 8 summarizes the TMDL/LRS pollutants that are addressed by each BMP.

Table 8. Summary of nonstructural BMPs to support TMDL implementation

Nonstructural BMP	Pollutant Source Addressed	TMDL/LRS Pollutant Addressed			
		Sediment	Nutrients	Bacteria	Chloride
Education and Pollution Prevention Program	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	●	●
Ordinance Development	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	●	○
Street and Parking Lot Sweeping	Urban and Agricultural Stormwater Runoff	●	◗	○	○
Pet Waste Education and Outreach Campaign	Urban and Agricultural Stormwater Runoff	○	◗	●	○
Wildlife Implementation Practices	Urban and Agricultural Stormwater Runoff	○	◗	●	○
Salt Management Plan and Education	De-icing Agents	◗	○	○	●

Notes

● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

3.2.1 Education and Pollution Prevention Programs

Education and pollution prevention programs are important implementation tools. Examples of outcomes may include newsletter articles on proper yard waste disposal, storm drain stenciling, or rain barrel construction workshops. Residential waste collection and disposal programs that include community composting and yard waste pick up can help to limit nutrient loading from the waste that is dumped into low lying areas and along stream banks. In addition, an education and information program can be used to inform residents and property owners on the care and maintenance needed in a ravine landscape. Education outcomes could highlight setback requirements, recommended vegetation cover, stabilization techniques, and implementation opportunities. The program should target those landowners adjacent to ravines and stream channels. Education for farm owners and operators should include the benefits of agricultural BMPs on crop yield, soil quality, and water quality as well as cost share programs available in the watershed. Educational opportunities include public meetings, mass mailings, TV and radio announcements, and newspaper articles.

In 2004 TCRPC partnered with a number of local NPDES Phase II MS4 communities and Bradley University to create an educational video focused on stormwater issues. This video was played on public access channels and is available for viewing on Tri-County Regional Planning Commission's website.

Existing efforts are underway to replicate workshops conducted through the TCRPC and IEPA program entitled *Implementing BMPs in the Mossville Bluffs Watershed*. These workshops educate landowners on urban stormwater BMPs and ravine stabilization technologies. In addition, there are existing efforts to educate planners, engineers, and developers on LID and BMPs approved by the USEPA, as well as the impacts of nonpoint source pollutants on local water bodies.

The existing *Peoria Lakes Watersheds* or *Clean River – Healthy Watershed* websites could also be enhanced to provide further educational opportunities such as fact sheets related to pollution prevention.

3.2.2 Ordinance Development

Many communities are undertaking efforts to improve current development ordinances, stormwater regulations, and environmental protection ordinances to prevent poor environmental practices. The City of East Peoria has adopted a steep slope ordinance that regulates the removal and replacement of vegetation from steep slopes, the construction of improvements on steep slopes, and the flow of stormwater in the vicinity of steep slopes. Steep slopes are defined as a slope that is 18 percent or greater. The City of Peoria has adopted a buffer ordinance which requires a 30-50 foot buffer adjacent to waterways in the City and the Village of Morton adopted a pet waste management ordinance in 2011. In addition, the TCRPC has created a model LID and stormwater ordinance that local governments could adopt and implement. The TCRPC model ordinance could be further strengthened by adding in a volume control requirement to meet water quality and stormwater goals.

Ordinance development in the Farm Creek watershed can help to reduce erosion and sediment transport, as well as pollutant loads. The development of more restrictive ordinances for steep slopes could require further setbacks, buffers, and a more restrictive definition of what constitutes a *steep slope*. New ordinances can also add sediment and nutrient removal as part of new development or redevelopment projects to further enhance stormwater management activities and require additional buffers, similar to the Peoria buffer ordinance.

Local land use planning requirements and stormwater regulations can be strengthened to more fully address the activities that are causing impairments. The following ordinances are encouraged to address future development and redevelopment:

- Buffer requirements
- Stormwater quality treatment requirements
- Stormwater volume control
- Pet waste management (Section 3.2.4)

3.2.3 Street and Parking Lot Sweeping

Streets and parking lots accumulate significant amounts of pollutants, including sediment, road salt, trash, and debris. Street sweeping can decrease the accumulation of pollutants in catch basins while improving curb appeal and controlling dust. Municipal street sweeping programs can target regulatory requirements, assess the BMPs effectiveness, and minimize pollutants from roadways.

Figure 8. East Peoria Street Sweeper.

Currently, the City of East Peoria sweeps a minimum of every street at least once per year, and considers requests from residents throughout the year for additional sweeping.

An effective street sweeping program can remove several tons of debris per year while minimizing pollutants in stormwater runoff. Studies have shown that street sweeping programs can reduce sediment and nutrients, depending on the frequency of sweeping and the sweeping technology used (Table 9).

Table 9. Pollutant removal efficiencies from street sweeping

Frequency of Sweeping	Technology	Pollutant reduction (%)		
		Total Suspended Solids	Total Phosphorus	Total Nitrogen
Monthly	Mechanical	9	3	3
	Regenerative air/vacuum	22	4	4
Weekly	Mechanical	13	5	6
	Regenerative air/vacuum	31	8	7

Source: CWP 2008

Sweeper type and frequency will dictate the expected removal efficiency. There are three types of sweepers: the mechanical broom, regenerative-air, and vacuum-assist. Using a combination of these sweepers in tandem can increase the pollutant load removed. Sweeping should occur at a minimum of twice annually: once following the spring melt and again in the fall when the majority of leaves have fallen.

3.2.4 Pet Waste Education and Outreach Campaign

Components necessary to implement a successful pet waste program include pet waste stations, an animal feces provision in the municipal codes or ordinances, and a survey instrument to understand residents' perceptions and behaviors. Recommended implementation activities are intended to use these components to create a more comprehensive, coordinated, and robust pet waste or *Scoop the Poop* education and outreach program in the Middle Illinois River watershed. Priority areas for domestic waste implementation practices are areas with high pet ownership and with a high degree of impervious cover, specifically the residential areas. This type of program would benefit from a partnership involving all stormwater communities within the watershed.

The following activities are recommended for the development of a robust pet waste education and outreach program:

- **Review number, location, and use of pet waste stations.** It is important to determine if residents and visitors are using any existing pet waste stations or if stations are being overlooked. This can be achieved by an informal survey of park users or a visual inspection of parks. An assessment should be made to determine if there are other locations within the watershed that attract dog owners that could benefit from a pet waste station or outreach signage.
- **Create and publicize code violations.** Create provisions in municipal code which require that dog owners must clean up after their pets. Penalties may include fines ranging from $20 to $200. Review codes and ensure that enforcement of provisions is widespread. To ensure that pet owners are aware of provisions, signs near pet waste stations should include a reference to code provisions and state any monetary penalty with failure to comply. While enforcement provisions may be limited, increased awareness of the provision and the associated penalties could serve as a disincentive from pet waste mismanagement.
- **Include pet waste outreach and education as a top priority in the stormwater management program.** Public education and outreach should be a key component of any updated stormwater program. Regulated MS4 communities should place significant emphasis on pet waste management education and awareness when developing public education and outreach priorities.
- **Develop a *Scoop the Poop* campaign.** A campaign refers to a coordinated, comprehensive outreach effort that integrates a variety of education and outreach techniques. Campaign development starts with a baseline survey to understand existing dog owner behaviors and perceptions, uses survey information to craft effective messages delivered using formats tailored to target audiences, and follows up with a post-campaign survey to determine effectiveness.

Because *Scoop the Poop* programs are a popular component of stormwater management programs, there are a great deal of materials available for use by other communities. However, there are not a lot of data available about the effectiveness of these programs with changing behavior and improving water quality conditions. Assumptions related to the amount of dog waste diverted from the stream can be made based on bag usage from pet waste stations. For example, the typical deposit per dog collected in a pet waste station bag is approximately 0.3 – 0.5 pounds (lbs). Therefore, it is possible to track how many bags are used annually and determine the *Escherichia coli* (*E. coli*) colonies associated with the estimated pounds of dog waste collected (1 lb of dog waste is equivalent to approximately 9 billion *E. coli* colonies).

Another evaluation mechanism used by these programs is changes in awareness, although a more aware target audience does not always translate into an audience that exhibits behavior changes. Increased enforcement and municipal staff serving as "Poop Police" with increased prompts via pet waste stations have the greatest potential to change pet waste management behavior over time. Developing and implementing a more robust, comprehensive pet waste program is likely to require additional staff and resources.

3.2.5 Wildlife Implementation Practices

Wildlife are a source of bacteria. Priority areas for implementation include high-density wildlife populations near or in riparian areas with unstable banks or poor riparian vegetation and recreational areas where food/dumping might attract wildlife. Recommended implementation activities include outreach and education on impacts of feeding wildlife near riparian areas and riparian buffers to reduce wildlife access.

3.2.6 Salt Management Plan and Education

A Salt Management Plan should be developed to address the use of chloride-based de-icing materials and their effect on Farm Creek. The plan could include the following:

1) Inventory of salt management policies for each entity responsible for road maintenance
2) Policies and objectives for salt management that commits to improved salt management practices
3) Procedures and guidelines for salt storage, handling, and application
4) Education and training program for managers and operators
5) Monitoring program to measure progress

This plan could be developed by the county, municipalities, the TCRPC, or a combination of these entities.

The Tazewell County Health Department is actively implementing an education initiative on proper road salt application. This program included a Snow and Ice Operators certification course attended by over 90 participants from around the state. The course taught participants how to determine appropriate salt slurry mixtures and proper calibration (according to pavement temperatures) to reduce over-salting. The course included a hands-on calibration and field handbooks for future reference. Feedback from the course indicated that many of the highway departments and municipalities were not previously calibrating their trucks for salt application but they indicated that they will calibrate in the future. A second workshop was planned for November 1, 2012.

The DuPage River Salt Creek Workgroup has dedicated significant resources to promote the reduction of chlorides in the watershed. The workgroup is a compilation of communities, sanitary districts, environmental organizations, and professionals working to improve the health of Salt Creek and the Upper DuPage River in Illinois. In 2007, the workgroup composed a *Chloride Usage Education and Reduction Program Study*. The study compiled information on chloride usage within the watershed to calculate an estimated annual chloride load. A literature review was included in the study and the following activities are recommended for chloride reduction (DRSCW 2012):

- Public education, staff training, and improved salt storage and handling practices.
- Watershed-wide implementation of pre-wetting and anti-icing programs.
- Consideration of alternative non-chloride products such as acetate deicers and beet and corn derivatives.
- Chloride monitoring in streams to demonstrate program effectiveness.

The study found that potential for a 10-40 percent reduction of chloride resulting from the activities presented above. As a result of the study the workgroup produced two-page factsheets for commercial users, homeowners, mayors and managers, and public works directors and staff using IEPA section 319 funds. The fact sheets educated stakeholders about the current use of chlorides and management practices that can be used to lower cost and address excess chlorides in the watershed.

3.3 North Farm Creek Structural Management Opportunities

Structural management opportunities that could be used to achieve the load reductions needed for the North Farm Creek subwatershed include:

- Green infrastructure retrofitting
- Sanitary sewer overflow control
- Disinfection of primary effluent from sewage treatment plants
- Stabilize erosion on steep slopes
- Streambank restoration
- Riparian area management
- Grassed waterways
- Conservation tillage

Table 10 summarizes the TMDL/LRS pollutants that are addressed by each BMP.

Table 10. Summary of structural BMPs to support TMDL/LRS implementation

Structural BMPs	Pollutant Source Addressed	TMDL/LRS Pollutant Addressed			
		Sediment	Nutrients	Bacteria	Chloride
Green Infrastructure Retrofitting	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	◗	◗
Sanitary Sewer Overflow Control	NPDES Facilities	○	●	●	○
Disinfection of Primary Effluent from Sewage Treatment Plants	NPDES Facilities	○	○	●	○
Stabilize Erosion on Steep Slopes	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	◗	○	○
Streambank Restoration	Watershed, Streambank, and Gully Erosion	●	◗	○	○
Riparian Area Management	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	◗	○
Grassed Waterways	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	○	○
Conservation Tillage	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	○	○

Notes
● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

3.3.1 Green Infrastructure Retrofitting

The use of green infrastructure, especially those practices that reduce the volume of runoff from urban areas, can address pollutant loads from existing developed areas and prevent or mitigate stormwater runoff volume. A number of green infrastructure practices may be appropriate, considering land use constraints, and are likely to be effective for reducing watershed loadings of bacteria, nutrients, and sediment. Functioning as a first line of defense, green infrastructure is a fundamentally different approach than traditional stormwater management. Where traditional stormwater management is designed to efficiently convey runoff away from urban areas to nearby surface waters (neglecting to focus on water quality treatment), green infrastructure aims to manage stormwater at the site, often including some form of treatment and volume control for smaller storm events.

Figure 9. Green infrastructure examples: top - residential rain garden; bottom - permeable pavement.

Offering considerable versatility with design and implementation, green infrastructure concepts can be incorporated into new and existing developments and can be less cost intensive than traditional, structural stormwater management systems (USEPA 2007). Furthermore, green infrastructure practices offer an innovative way to integrate stormwater management into natural landscapes, minimizing alterations to the natural hydrologic regime and reducing site runoff. In fact, with USEPA's encouragement of integrated planning, they also state that this approach can lead to the identification of sustainable and comprehensive solutions, such as green infrastructure that improve water quality as well as support other quality of life attributes that enhance the vitality of communities (USEPA 2011). Implementation of green infrastructure practices also encourages groundwater recharge, and decreases surface erosion and pollutant transport. Additional benefits of green infrastructure implementation include improved greenways and enrichment of natural environmental aesthetics within the urban setting.

When selecting the most appropriate BMPs for a specific site or drainage area, site-specific conditions (e.g., land availability, slope, soil characteristics, climate condition, utilities, and characterization of contributing drainage including imperviousness) must be taken into consideration. Care must also be given to ensure the proper treatment identifies any site concerns or hazards. For example, infiltration should not be encouraged in areas surrounding stormwater hot spots, such as automotive repair shops, gasoline stations, or industrial areas where groundwater contamination or pollutant transfer is a possibility. Infiltration techniques may also not be appropriate in areas at risk of media clogging. This could include areas near restaurants where the possibility of oil and grease contamination exists.

Alternatively, in areas where groundwater contamination is not a concern, structural BMPs can incorporate infiltration as well as other treatment techniques to effectively reduce treatment volume and flow rates. Since the use of BMPs is quickly advancing, new research is supporting the use of varying BMPs for pollutant removal, provided the systems are constructed and maintained properly (Hathaway 2011, 2012; Hunt 2008). Theses BMPs can provide other water quality benefits by reducing runoff amounts, and therefore, reducing the amount of bacteria, nutrients, and sediment washed from surfaces.

There are many examples of successful green infrastructure programs across the country. Within the Midwest, MetroBlooms in the Twin Cities Minnesota area has been guiding implementation of rain garden programs over the past 10 years. One successful program focused on a nutrient impaired lake in the City of Minneapolis (MetroBlooms 2012). Through this program, 125 rain gardens were installed within a 28-acre neighborhood in 2010; 50 percent of property owners participated in this project. This project is presented in the following document: http://www.metroblooms.org/files/CBASM%20Report%20FINAL_063012.pdf. Key outcomes of the project included the following recommendations for citizen engagement:

- Enlist local champions of stormwater management to reach out to community members.
- Use a combination of outreach methods: workshops, mass mailings, door knockers, neighborhood home meetings, and canvassing.
- Include multi-lingual staff and community members to engage non-English speaking community members.
- Use a non-profit organization for outreach and implementation to offset skepticism associated with a private firm or city-led effort.
- Provide an economic incentive and a well-crafted, educated message.

Stormwater runoff from urban sources in the North Farm Creek subwatershed and the potential effect of green infrastructure practices was evaluated using the L-THIA model (see Appendix A). L-THIA adjusts the runoff and associated pollutant loads with the level of connected imperviousness in the watershed based on BMP implementation. BMPs serve to disconnect impervious surfaces in the model, thus reducing the runoff volume and associated pollutant loads. The model results show the effectiveness of implementing different BMPs on a watershed scale by demonstrating the potential pollutant load reductions including nitrogen, phosphorus, sediment, and bacteria loads.

A sensitivity analysis was conducted for each of the available BMPs within the L-THIA model. The model results indicate that bioretention (e.g. rain gardens) and porous pavement are the most effective green infrastructure practices at reducing pollutant loads in the developed portions of this subwatershed. These practices were modeled at various levels of implementation (percent of watershed that is treated by LID practices) to determine the potential for green infrastructure to meet TMDL/LRS load reductions.

Application of bioretention and porous pavement in developed areas of the subwatershed can reduce targeted TMDL pollutants from urban stormwater. Table 11 and Figure 10 through Figure 14 summarize the model results for various levels of implementation. If LID practices were applied on all developed land, the L-THIA model suggests that between 46 and 52 percent of annual pollutant loads could be reduced from these land uses. This analysis does not include any reductions for agricultural areas or as part of gully, ravine, or streambank stabilization.

Bioretention and Rain Gardens

Bioretention practices, which include rain gardens, are stormwater basins that utilize soil media, mulch, and vegetation to treat runoff and improve water quality for small drainage areas. A bioretention area consists of a depression that allows shallow ponding of runoff and gradual percolation through a soil media or uptake by vegetation. Water then either infiltrates through undisturbed soils or enters a storm sewer system through an underdrain system.

Numerous designs exist for bioretention. These include use in residential lots, on commercial and industrial sites, as off-line facilities adjacent to parking lots, and along highways and roads. Bioretention and rain gardens can remove between 0 and 98 percent of sediment bound pollutants with the median removal of TSS being 59 percent. The national pollutant removal database was updated in 2007 and suggests that bioretention practices median removal rate of total phosphorus is 5 percent and total nitrogen is 46 percent (CWP 2007).

Porous Pavement

Impervious surfaces such as streets, sidewalks, and parking lots increase the rate and volume of runoff and the associated pollutant load. Runoff is typically routed to storm sewers which discharge into nearby surface waters. Porous pavement allows for rainfall to infiltrate through the pavement into underlying soils, thus minimizing runoff and associated pollutants.

Porous pavement can consist of porous asphalt or concrete, permeable paving blocks, and grass pavers. Porous pavements can be constructed over a stone filled storage bed that allows for water to be held for longer duration. Underdrains can be used to route excess water from storage beds downstream. Porous pavement can be used in place of most impervious areas including parking lots, driveways, and streets. Porous pavement can also be used in combination with swales or bioretention. Infiltration practices like porous pavement provide a median 89 percent removal of TSS, 65 percent removal of total phosphorus, and 42 percent removal of total nitrogen based on studies found in the 2007 National Pollutant Removal Database (CWP 2007).

Table 11. Potential reduction at various percentages of LID application on developed land uses

Percent of Area with LID	Percent Reduction				
	Runoff Volume	Nitrogen	Phosphorus	TSS	Fecal Coliform
25%	12.5%	12.1%	11.7%	13.0%	11.6%
50%	25.0%	24.2%	23.7%	26.0%	23.2%
75%	37.5%	36.3%	35.5%	39.0%	34.8%
100%	50.0%	48.4%	47.3%	52.0%	46.4%

Percent of Area with LID	Load Reduction				
	Runoff Volume (acre-ft)	Nitrogen (pounds)	Phosphorus (pounds)	TSS (pounds)	Fecal Coliform (millions of coliform)
25%	758.5	3,580	1,083	90,624	169,272
50%	650.2	3,085	936	77,077	147,082
75%	541.9	2,593	792	63,533	124,894
100%	433.7	2,101	647	49,987	102,704

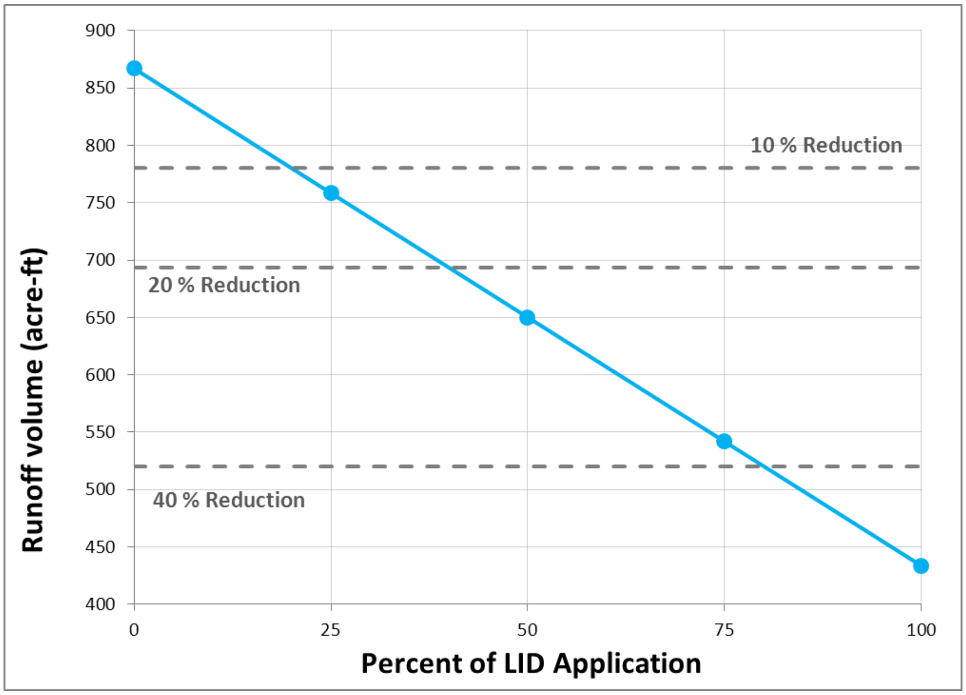

Figure 10. Potential runoff volume reduction at various percentages of LID application.

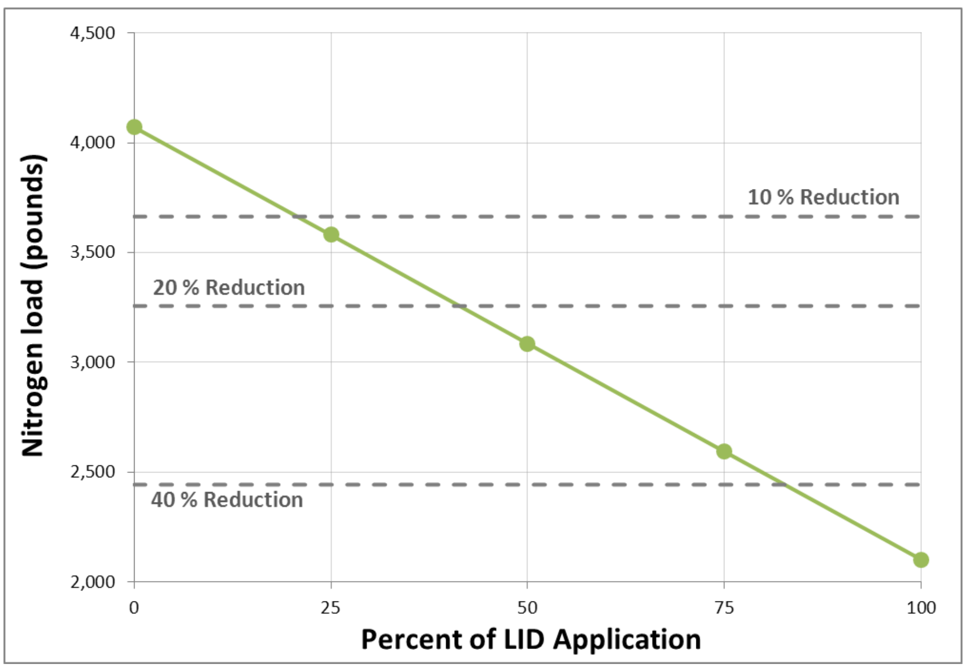

Figure 11. Potential nitrogen load reduction at various percentages of LID application.

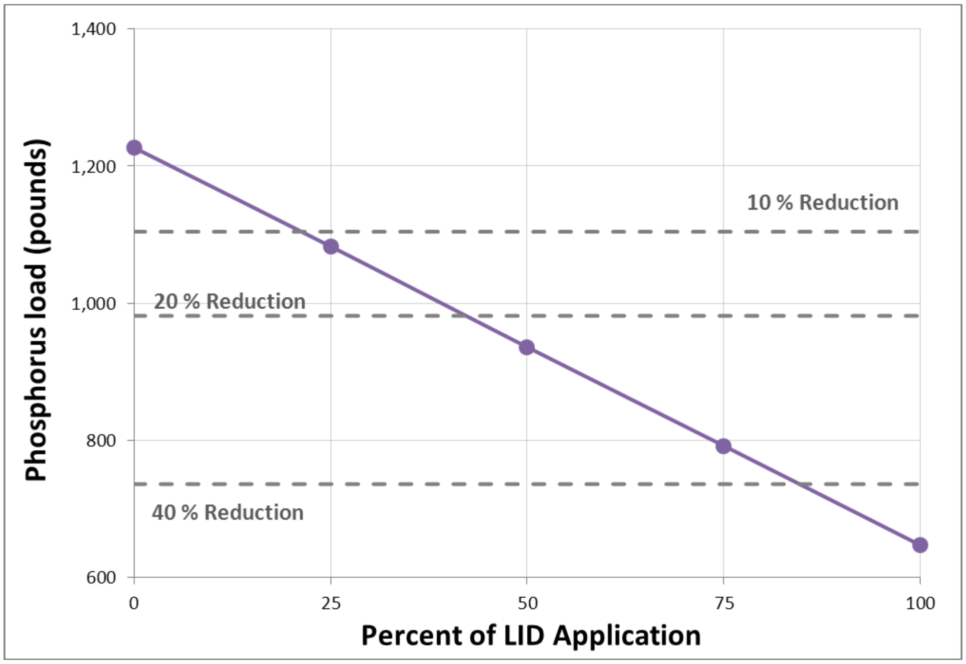

Figure 12. Potential phosphorus load reduction at various percentages of LID application.

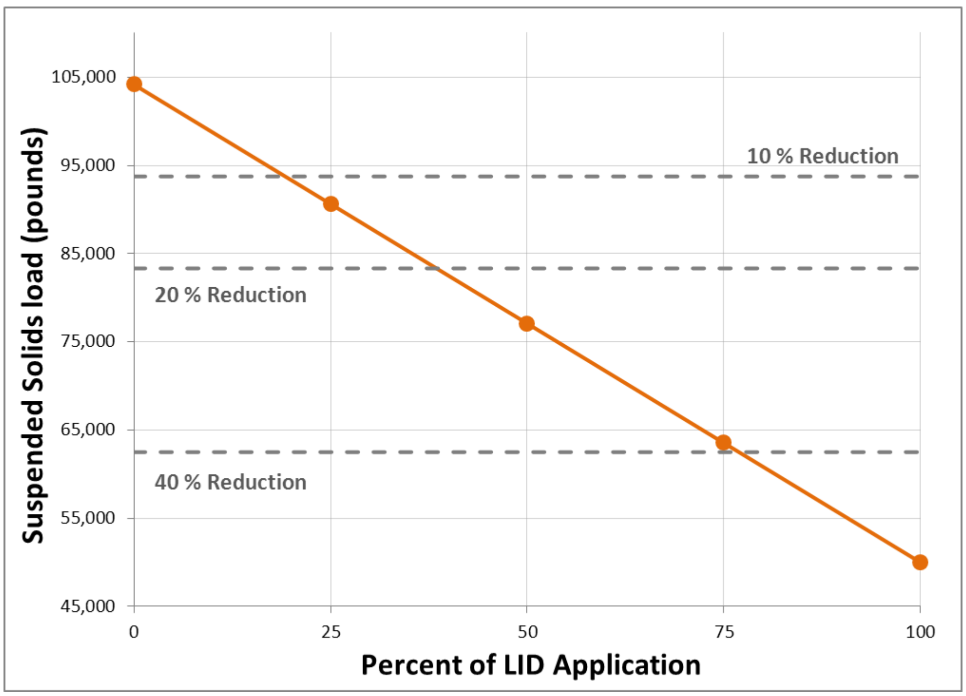

Figure 13. Potential suspended solids load reduction at various percentages of LID application.

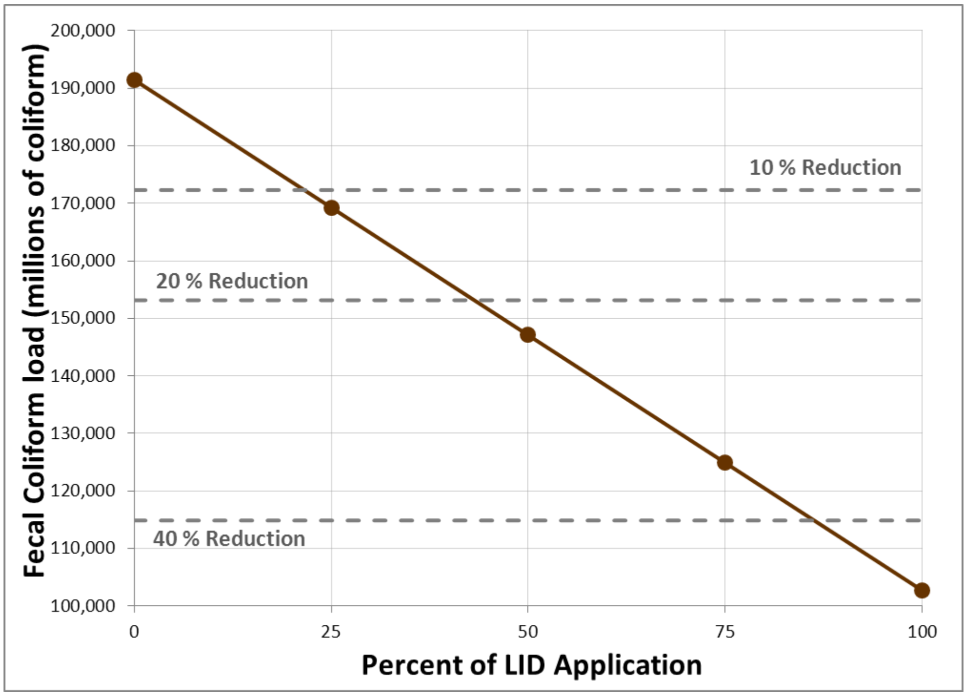

Figure 14. Potential fecal coliform load reduction at various percentages of LID application.

A successful green infrastructure program will begin with an information and education campaign and a series of demonstration projects. Typically, demonstration projects are built on public property such as at city halls, parks, or libraries. Educational signage should be included to inform residents about the BMPs. These BMPs would be publically owned and maintained and could be monitored to provide data on their effectiveness. LID practices can also be used in place of traditional practices on public projects, such as street reconstruction including porous pavement. Existing capital improvement plans should be evaluated to identify opportunities for green infrastructure implementation. A green infrastructure program can then be expanded to include practices on private property.

The extent and design of BMPs are not explicitly modeled in L-THIA, nor are costs accounted for in the model. Estimates of various types of impervious cover can be derived from L-THIA. For example, parking lots are assumed to account for 53 percent of commercial land uses, while 26 foot wide streets account for 22 percent of high density residential areas. These values were used to determine the extent of impervious cover types, but the extent of LID practices applied to them were based on the following assumptions:

- Porous pavement is applied to 60 percent of the parking lot area in commercial and industrial areas
- High density residential streets include two four foot wide porous pavement strips.
- Bioswales are present along 30 percent of the high density residential streets at a width of ten feet and a ponding depth of 12 inches. An amended soil is assumed.
- Bioretention/rain garden areas are sized to treat 1-inch of runoff from impervious surfaces with a ponding depth of 12 inches.

BMP lifecycle costs are presented as net present worth in 2012 dollars and include the probable construction costs, annual operation and maintenance, and repair and replacement costs. The lifecycle period was defined as 20-years to take into account costs for replacing some BMPs. No land, administration, demolition, or legal cost factors were defined for any costs.

The following sources were reviewed when defining the lifecycle costs:

- *BMP and Low Impact Development Whole Life Cost Models Version 2.0*. Water Environment Research Foundation (WERF 2009).
- Lake County Stormwater Management Commission. 2012. *Central Permit Facility Fact Sheet*.
- Long-Term Hydrologic Impact Analysis Low Impact Development Version - 2.0.
- National Green Values Calculator. (Center for Neighborhood Technology 2009).
- *The Cost and Effectiveness of Stormwater Management Practices*, University of Minnesota (Weiss et al. 2005).
- *Low Impact Development for Big Box Retailers. Prepared for U.S. Environmental Protection Agency* (Low Impact Development Center 2005).
- *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (USEPA 2003).

Additional Tetra Tech projects and best professional judgment were also considered when defining the range of lifecycle unit costs. Table 12 summarizes the potential costs based on the assumptions previously presented, averaging $31,640 per developed acre. The costs are linear related to the percent of application in the watershed; therefore if 50 percent of the watershed is converted to LID, the cost estimate would be between $33 and $49 Million.

Table 12. Cost estimates for BMP application to 100 percent of the North Farm Creek subwatershed

Land use	BMP	BMP size (acres)	Lifecycle cost (2012 $/ft^2)	Total cost (2012 $)
Commercial	Parking with porous pavement	24.1	$9 to $13	$9,459,556 to $13,663,804
Industrial	Parking with porous pavement	25.6		$10,041,345 to $14,504,165
High Density Residential	Streets with Porous Pavement	39.8		$15,614,394 to $22,554,125
	Streets with swales	29.9	$8 to $12	$10,409,596 to $15,614,394
	Bioretention/Rain garden	21.1		$7,347,177 to $11,020,766
Low Density Residential	Bioretention/Rain garden	37.8		$13,176,550 to $19,764,825
			TOTAL	**$66 to $97 Million**

3.3.2 Sanitary Sewer Overflow Control

East Peoria Sewage Treatment Plant #1 (NPDES Permit: IL0028576) has one SSO outfall at East Oakwood Ave in the North Farm Creek subwatershed. The TMDL requires that this SSO be eliminated (no wasteload allocated). Therefore, this overflow must be controlled. The cause of the SSOs should be investigated which could include blockages, line breaks, power failures, inadequate sewer design and vandalism.

Use of grey and green infrastructure practices can help eliminate flows from SSOs. SSO controls can also include wastewater treatment plant upgrades, sewer replacement, and elimination of SSOs by sewer separation. Wastewater treatment plant upgrades could include:

- Sewer system cleaning and maintenance
- Reduction of infiltration and inflow through system rehabilitation
- Broken or leaking service lines should be repaired

- Sewer, pump station, or sewage treatment plant can be upgraded for capacity and/or reliability
- Wet weather storage and treatment facilities to treat excess flows can be constructed

Capital projects to control SSOs can be assisted by the State Revolving Fund which can help arrange low-interest loans for municipalities.

3.3.3 Disinfection of Primary Effluent from Sewage Treatment Plants

Many of the sewage treatment plants in the Middle Illinois River watershed operate under a disinfection exemption. Reducing the fecal coliform concentrations from a primary outfall of an exempt facility to 200 cfu/100 mL will require a permit change that requires disinfection of the effluent prior to discharge. Common disinfection techniques include chlorination, ozonation, and ultraviolet (UV) disinfection. In most cases, chlorination is the most cost-effective alternative, although residuals and oxidized compounds are toxic to aquatic life; subsequent dechlorination may be necessary prior to discharge which will increase costs similar to the other two options (USEPA 1999b). The options most frequently employed include:

- Chlorination
- Ozonation
- Ultraviolet disinfection

IEPA is reevaluating disinfection exemption status for NPDES facilities. All facilities that are within three miles of a bacteria impaired segment will be reexamined. Sundale Sewer Corp-Highland (ILG551039) drains to Farm Creek and will have to reapply for the exemption status at the time of their next permit renewal.

3.3.4 Stabilize Erosion on Steep Slopes

Stabilizing erosion on steep slopes throughout the North Farm Creek subwatershed which is contributing to sediment loading downstream and potentially endangering private property is critical to meeting the TMDL/LRS reductions. Gullies, ravines, and erosion as a result of lack of ground cover on steep slopes should be addressed.

A program could be put in place to focus efforts on stabilizing gully and ravine formation. This program could include the following:

1) Inventory and identify spatial location of all outfalls
2) Evaluation of each outfall for effect of erosion or gully formation
3) Prioritization of those outfalls and downstream erosion problems which require immediate stabilization measures
4) Implementation program to address all outfalls which contribute to downstream erosion and stabilization of gully and ravine formation

Figure 15 presents the soils within the SSURGO database that are classified as highly erodible and mapped stormwater outfall locations. Locations where outfalls discharge directly onto highly erodible soils indicate possible erosion hot spots where gully and ravine formation is likely.

A cost-share program for residents could be developed to contribute towards projects such as tree planting, understory establishment, and buffer construction that would protect steep slopes and mitigate local drainage issues. A monitoring program could also be put in place to determine the current rate of gully and ravine formation and evaluate the effects of implementation activities (see Section 6).

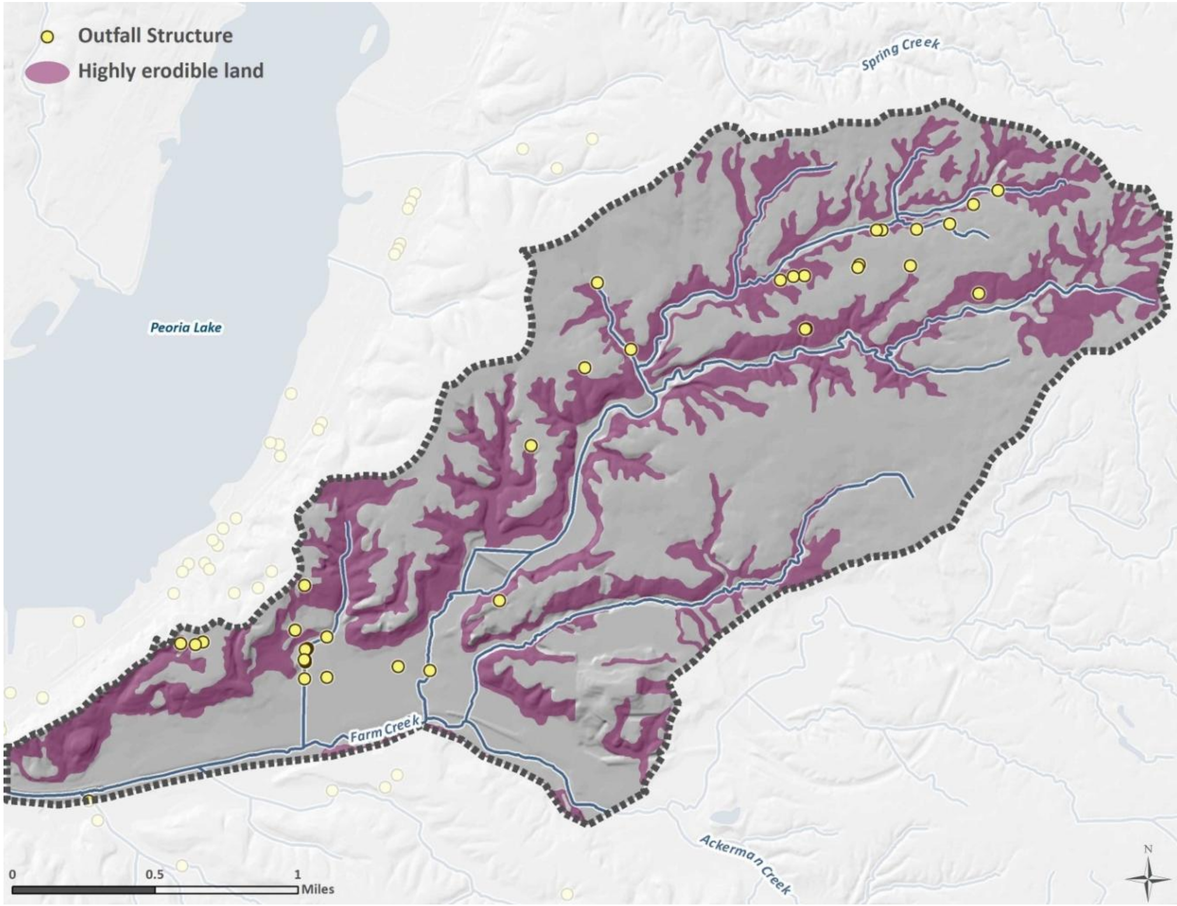

Figure 15. Stormwater outfalls draining onto highly erodible land (source: East Peoria and NRCS 2002).

In addition to gully and ravine erosion, woodland management is also needed on sensitive slopes. The effect of invasive species such as sugar maple trees on many of these slopes has led to severe erosion due to lack of ground cover. A woodland management plan should be developed and implemented which could include an inventory of invasive species and prioritization of implementation opportunities on both public and private lands. Forest management activities are further described on the TCRPC's website: http://www.tricountyrpc.org/forest-management-project.

Figure 16. Typical steep slope in North Farm Creek watershed.

3.3.5 Streambank Restoration

Reducing streambank erosion will reduce sediment loadings in tributaries and within Farm Creek. Streambanks in the watershed should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from adjacent areas can be mitigated by infiltration in grassed waterways and passage of runoff through filter strips. Streambank restoration should be conducted only after upstream stormwater management controls are in place.

3.3.6 Riparian Area Management

Preserving the natural vegetation along a stream corridor can mitigate pollutant loading associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow sheet. Concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks and steep slopes. The rooting systems of the vegetation serve as reinforcements in soils, which help to hold material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer.

Riparian buffers/filter strips should consist of native species and may include grasses, forbs, shrubs, and trees. Minimum buffer widths of 25 to 30 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. In addition to pollutant reductions, buffers increase channel stability which will reduce streambank erosion.

Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms. Riparian buffers should be placed in conjunction with drift fences that exclude cattle access from the riparian area.

The following activities could take place as part of a riparian area management program:

- Adopt and/or implement buffer ordinances for new development or redevelopment
- Document the presence of gullies or invasive species that could contribute to water quality concerns
- Prioritize potential buffer restoration sites
- Develop a program or project to fund high priority buffer restoration
- Work with landowners to install and maintain buffers on private property
- Monitor water quality or other environmental conditions prior to, and following riparian project completion

3.3.7 Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. Grassed waterways are used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas.

The effectiveness of grass swales for treating agricultural runoff has not been quantified. The Center for Watershed Protection reports the following reductions in urban settings (Winer 2000):

- 5 percent reduction in fecal coliform
- 68 percent reduction of total suspended solids

3.3.8 Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residuals not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al. 2004).

Several practices are commonly used to maintain surface residues:

- No-till systems disturb only a small row of soil during planting, and typically use a drill or knife to plant seeds below the soil surface.
- Strip till operations leave the areas between rows undisturbed, but remove residual cover above the seed to allow for proper moisture and temperature conditions for seed germination.
- Ridge till systems leave the soil undisturbed between harvest and planting: cultivation during the growing season is used to form ridges around growing plants. During or prior to the next planting, the top half to two inches of soil, residuals, and weed seeds are removed, leaving a relatively moist seed bed.
- Mulch till systems are any practice that results in at least 30 percent residual surface cover, excluding no-till and ridge till systems.

Corn residues are more durable and capable of sustaining the required 30 percent cover required for conservation tillage. Soybeans generate less residue, the residue degrades more quickly, and supplemental measures or special care may be necessary to meet the 30 percent cover requirement (UME 1996).

Czapar et al. (2006) summarize past and present tillage practices and their impacts on erosion control and nutrient delivery. Historically, the mold board plow was used to prepare the field for planting. This practice disturbed 100 percent of the soil surface and resulted in basically no residual material. Today, conventional tillage typically employs the chisel plow, which is not as disruptive to the soil surface and tends to leave a small amount of residue on the field (0 to 15 percent). Mulch till systems were classified as leaving 30 percent residue; percent cover was not quantified for the no-till systems in this study. The researchers used WEPP modeling to simulate changes in sediment and nutrient loading for these tillage practices. Relative to mold board plowing, chisel plowing reduced phosphorus loads leaving the field by 38 percent, strip tilling reduced loads by 80 percent, and no-till reduced loads by 85 percent. If chisel plowing is now considered conventional, then the strip till and no-till practices are capable of reducing phosphorus loads by 68 percent and 76 percent, respectively (Czapar et al. 2006).

USEPA (2003) reports the findings of several studies regarding the impacts of tillage practices on nutrient and sediment loading. The reductions achieved by conservation tillage reported in these studies are summarized below:

- 50 percent reduction in sediment for practices leaving 20 to 30 percent residual cover.
- 90 percent reduction in sediment for practices leaving 70 percent residual cover.
- 69 percent reduction in runoff losses for no-till practices.

Hydrologic inputs are often the limiting factor for crop yields and farm profits. Conservation practices reduce evaporative losses by covering the soil surface. USDA (1999) reports a 30 percent reduction in evaporative losses when 30 percent ground cover is maintained. Harman et al. (2003) and the Southwest Farm Press (2001) report substantial yield increases during dry years on farms managed with conservation or no-till systems compared to conventional till systems.

Conservation tillage practices generally require fewer trips to the field, saving on labor, fuel, and equipment repair costs, though increased weed production may result in higher pesticide costs relative to conventional till (USDA 1999).

Depending on the type of equipment currently used, replacing conventional till equipment with no-till equipment can either result in a net savings or slight cost to the producer. Al-Kaisi et al. (2000) estimated that converting conventional equipment to no-till equipment costs approximately $1.25 to $2.25/ac/yr, but that for new equipment, purchasing no-till equipment is less expensive than conventional equipment. Other researchers report a net gain when conventional equipment is sold to purchase no-till equipment (Harman et al. 2003).

3.4 Implementation Summary, Schedule, and Goals

Table 13 presents a summary of the proposed implementation activities for the North Farm Creek subwatershed. Implementation Phases are further described in Section 7 and potential financial assistance programs are further described in Section 5. The estimated annual cost of implementing this plan is $1.5 to $2.5 million, which equates to an estimated cost of $250 - $400 per acre per year.

Table 13. Implementation activity summary, North Farm Creek subwatershed

Implementation Activity	Critical Areas	Emphasis by Phase	Potential Financial Assistance	Lead Partners	Level of Pollutant Removal (H – M – L)	Activity Cost (H – M – L)
Nonstructural Management Opportunities						
Education and Pollution Prevention Programs	Watershed wide	Phase 1:High Phase 2: Continued Phase 3: Continued	Section 319(h)	TCRPC, City of East Peoria, Washington Township, Tazewell County	Moderate	Low
Ordinance Development	Watershed wide	Phase 1:High Phase 2: Continued Phase 3: Continued		TCRPC, City of East Peoria, Washington Township, Tazewell County	Moderate	Moderate
Street and Parking Lot Sweeping	Impervious surfaces (streets, parking lots)	Phase 1:High Phase 2: Continued Phase 3: Continued		City of East Peoria, Washington Township, Tazewell County	Moderate	Moderate
Pet Waste Education and Outreach Campaign	Residential areas	Phase 1:High Phase 2: Continued Phase 3: Continued	Section 319(h)	TCRPC, City of East Peoria, Washington Township, Tazewell County	Moderate	Low
Wildlife Implementation Practices	Riparian areas	Phase 1:High Phase 2: Continued Phase 3: Continued		City of East Peoria, Washington Township, Tazewell County	Moderate	Low
Salt Management Plan	Impervious salted areas watershed wide (streets, parking lots)	Phase 1:High Phase 2: Continued Phase 3: Continued		City of East Peoria, Washington Township, Tazewell County	High	Low
Structural Management Opportunities						
Green Infrastructure Retrofitting	Impervious areas (i.e. parking lots, roofs, streets, driveways, alleys)	Phase 1:Moderate Phase 2: High Phase 3: Continued	Section 319(h), IEPA	Private Sector, City of East Peoria, Washington Township, Tazewell County, TCRPC	High	High
SSO Control	East Peoria Oakwood Ave outfall	Phase 1: High Phase 2: Continued Phase 3: Continued	Clean Water Act State Revolving Fund Assistance	City of East Peoria/East Peoria STP#1	High	High
Disinfection of Primary Effluent from Sewage Treatment Plants	Sundale Sewer Corp-Highland	Phase 1: High Phase 2: Continued Phase 3: Continued		Sundale Sewer Corp	High	High
Stabilize Erosion on Steep Slopes	Storm sewer outfalls, steep slopes	Phase 1:High Phase 2: High Phase 3: Continued	Section 319(h)	City of East Peoria, Washington Township, Tazewell County SWCD, Private owners	High	Moderate – High
Streambank Restoration	Eroding streambanks	Phase 1: Low Phase 2: Low Phase 3: High	Conservation 2000	City of East Peoria, Washington Township, Tazewell County SWCD, Private owners	High	High
Riparian Area Management	Riparian areas	Phase 1: High Phase 2: High Phase 3: Continued	Section 319(h)	City of East Peoria, Washington Township, Tazewell County SWCD, Private owners	High	Moderate
Grassed Waterways	Cultivated agricultural	Phase 1: High	EQIP, CRP	Tazewell County SWCD,	High	Low

Implementation Activity	Critical Areas	Emphasis by Phase	Potential Financial Assistance	Lead Partners	Level of Pollutant Removal (H – M – L)	Activity Cost (H – M – L)
	areas	Phase 2: Moderate Phase 3: Low		Private owners		
Conservation Tillage	Cultivated agricultural areas	Phase 1: High Phase 2: Moderate Phase 3: Low	EQIP, Conservation 2000	Tazewell County SWCD, Private owners	High	Low

4. Dry Run Tributary Subwatershed Implementation Plan

The Dry Run Tributary subwatershed is located northeast of the confluence of Kickapoo Creek with the Illinois River and includes portions of Peoria and Peoria Heights (Figure 18). The watershed is 1,690 acres in size lying west of Peoria Lake and the Illinois River. There are no point source facilities or combined sewer outfalls in this watershed. The entire watershed lies within regulated MS4 areas of Peoria and Peoria Heights. Developed areas comprise 94 percent of the watershed including Peoria Heights High School, significant roadways, and several smaller commercial areas (Figure 17). The majority of the watershed contains single family residential homes and is served by traditional curb and gutter with buried storm sewers.

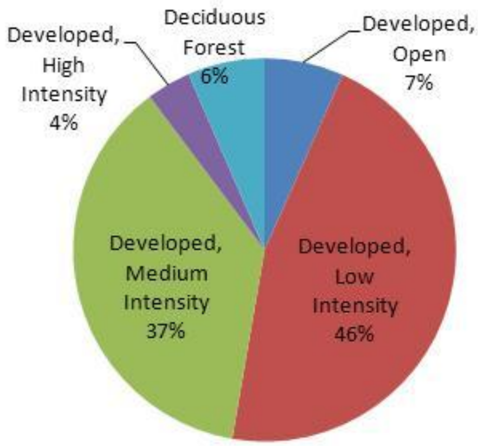

Figure 17. Dry Run Tributary land use.

In the Kickapoo Creek watershed, the Dry Run Tributary is contributing to the high concentrations of fecal coliform, total suspended solids, and nutrients downstream. The Dry Run Tributary subwatershed drains to Kickapoo Creek which has pollutant load reductions goals set in the TMDL and LRS Study. Pollutant reductions for Kickapoo Creek are summarized in Table 14. In addition, the watershed is also tributary to the Illinois River which requires reductions in bacteria, total suspended solids, and nutrients to meet water quality goals. Urban stormwater runoff is the most prominent source of pollutants in the Dry Run Tributary subwatershed.

Table 14. Kickapoo Creek TMDL and LRS Reductions

Pollutants of Concern	Pollutant Reduction Requirement (%)	Potential Sources
Fecal coliform	97 - 100	watershed, streambank, and gully erosion; urban and agricultural stormwater runoff; animal agriculture; MS4s; NPDES facilities
Total suspended solids	96	
Nitrogen	20 - 65	
Phosphorus	32 - 76	

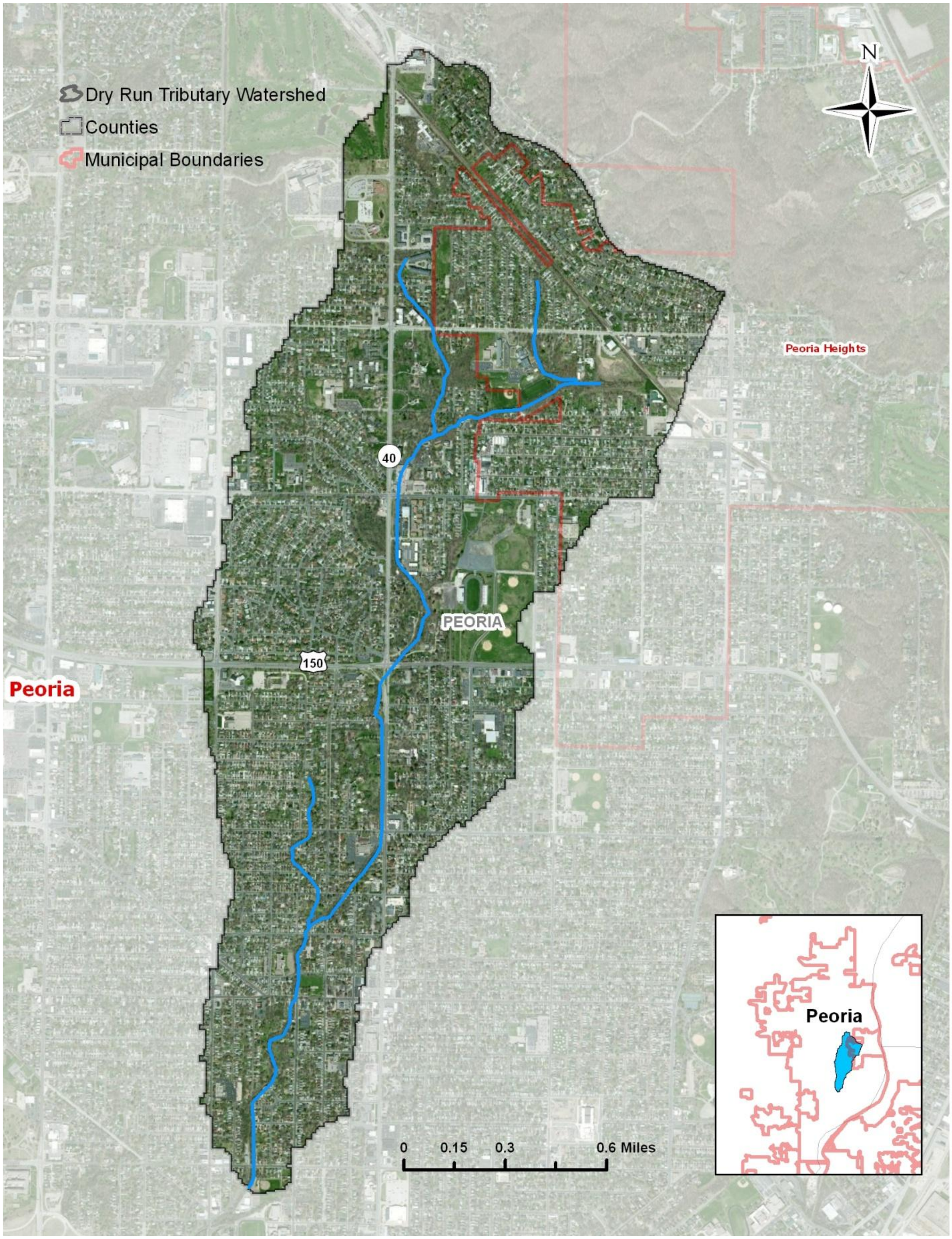

Figure 18. Dry Run Tributary subwatershed.

4.1 Pollutant Sources

Within the Dry Run Tributary subwatershed, the following pollutant sources are identified in the TMDL/LRS study:

- Watershed, streambank, and gully erosion
- Urban stormwater runoff including regulated MS4 stormwater

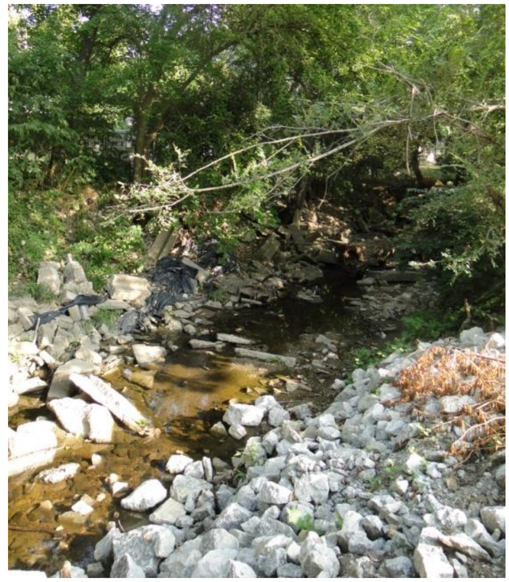

Figure 19. Dry Run Tributary at West Hampton Court.

4.1.1 Watershed, Streambank, and Gully Erosion

Watershed, streambank and gully erosion has been identified as a primary source of pollutants in the Kickapoo Creek watershed. Within the Dry Run Tributary subwatershed, streambank erosion is the most prevalent. High flow rates and stormwater volumes are eroding the stream channels, necessitating armoring of the banks and channel bottom. Gullies and ravines can also form where stormwater is being discharged into channels. Sediment is being transported from these areas to Kickapoo Creek and subsequently impacting the Illinois River. In addition, homes and structures near streams and dry channels are being threatened.

4.1.2 Urban Stormwater Runoff

Sources of urban stormwater pollutants typically result from impervious surfaces. Connected impervious areas (e.g. roads and parking lots) convey higher runoff flow volumes and peak discharges and associated pollutants to downstream receiving waters which can lead to channel and bank erosion, habitat degradation, and lower the assimilative capacity of the waterbody. Sediment, nutrients, and bacteria are commonly associated with stormwater runoff from urban areas.

IEPA regulates stormwater from MS4s under the federal NPDES stormwater program. Regulated Phase II MS4s within the watershed include: Peoria County, Peoria, Peoria Heights, and ILDOT. MS4s are required to meet six minimum control measures for stormwater as specified in the Phase II MS4 general permit:

- Public education and outreach on stormwater impacts
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site stormwater runoff control
- Post construction stormwater management in new development and redevelopment
- Pollution prevention/good housekeeping for municipal operations

Existing runoff conditions and pollutant loadings in the watershed were evaluated using both the Loading Simulation Platform in C++ (LSPC) and the BMP Decision Support System (BMPDSS). This approach was taken based on the ability of these models to accurately simulate an urban environment and associated BMPs. Appendix B presents the technical documentation for model development and expanded results. LSPC was used to model the rainfall runoff patterns in the watershed. For calibration purposes, four land use categories were configured in LSPC representing (1) urban pervious (2) residential urban impervious (3) non-residential urban impervious, (4) and forest. Each of these land use categories was parameterized in LSPC to reflect a range of typical surface and subsurface characteristics (USEPA 2000). Annual average runoff over the period from October 1, 2001 through September 30, 2011 was then summarized and compared to the annual average precipitation over the same period for the various land uses. Figure 20 shows the relative magnitude of runoff off the six modeled land uses which included a varying mixes of pervious and impervious land. Water quality results are summarized as unit-area loads and mapped spatially by subwatershed to identify hot spots or other areas of increased pollutant generation (Figure 21). Subwatersheds 4, 5b, 7c, and 7b are the highest pollutant yielding subwatersheds.

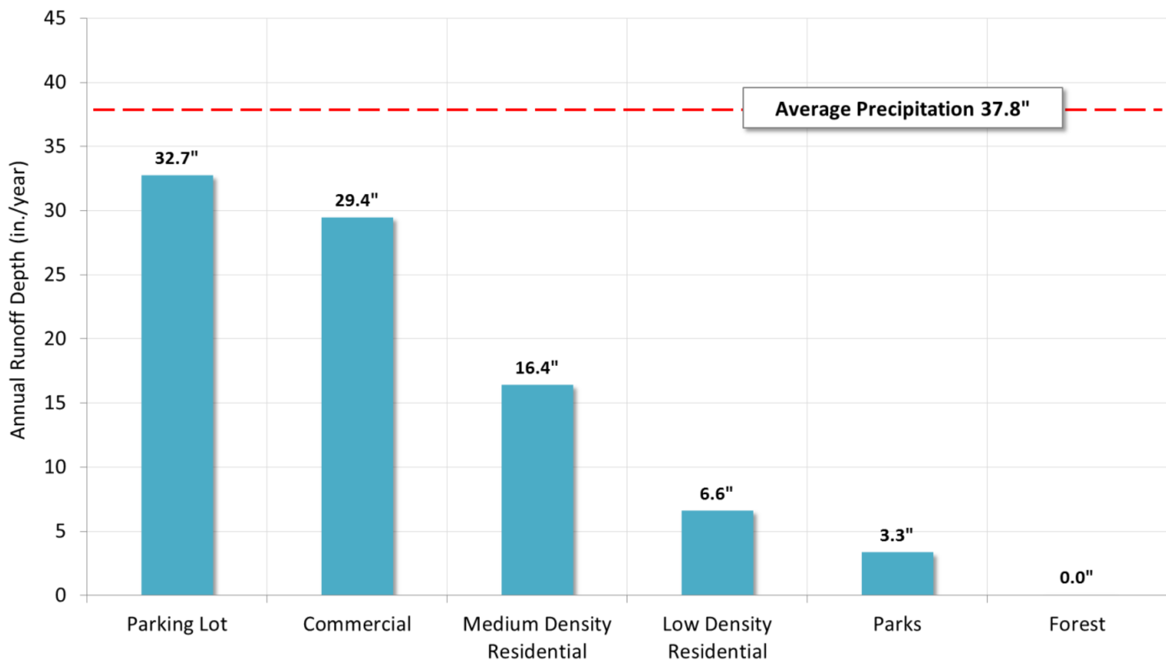

Figure 20. Summary of average annual runoff depth by land use category (10/1/2001 through 9/30/2011).

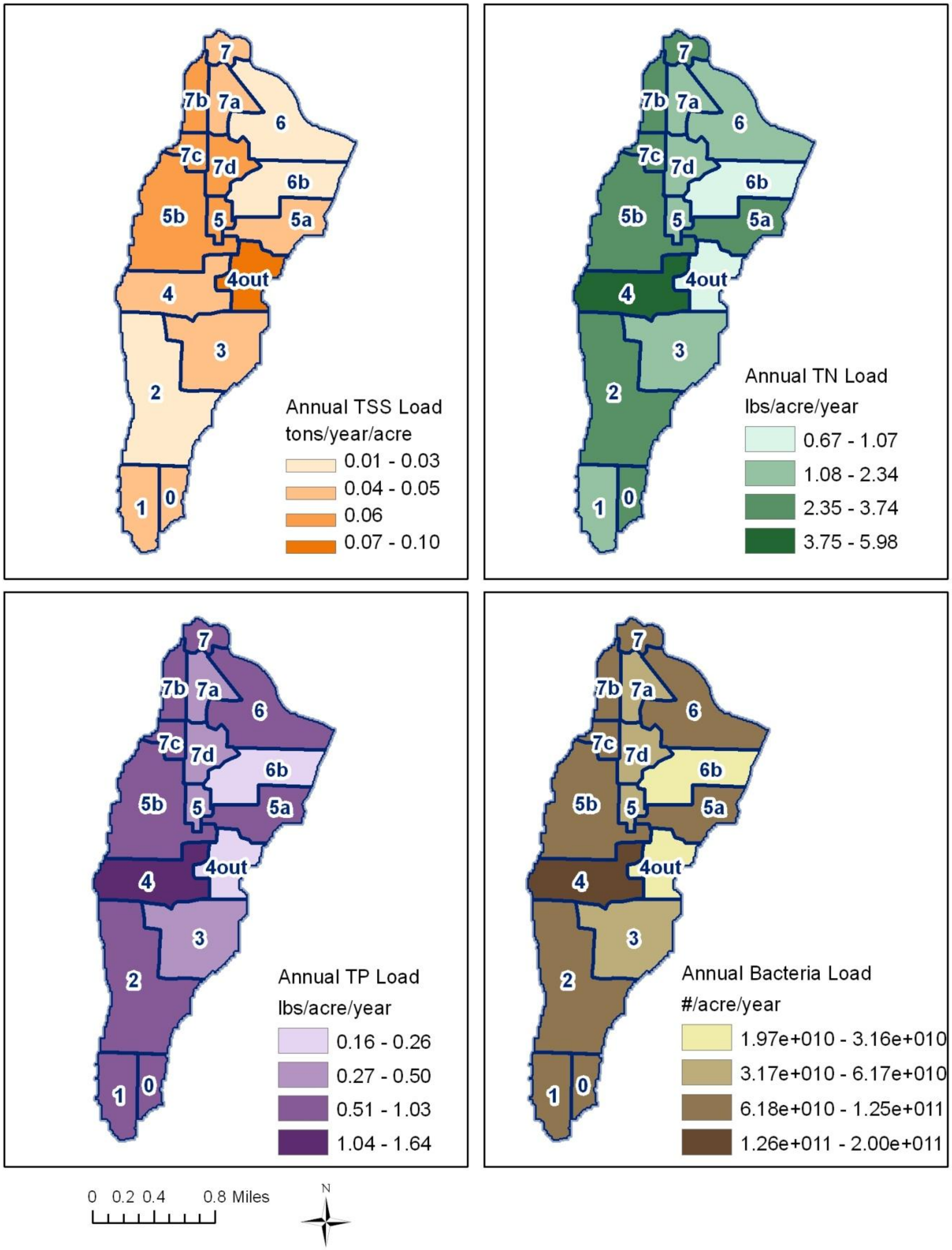

Figure 21. Dry Run Tributary watershed water quality model results.

4.2 Nonstructural Management Opportunities

Nonstructural management opportunities that could be used to achieve the load reductions needed for the Dry Run Tributary subwatershed include:

- Education and pollution prevention program
- Ordinance development
- Streep and parking lot sweeping
- Pet waste education and outreach campaign
- Wildlife implementation practices

Table 15 summarizes the TMDL/LRS pollutants that are addressed by each BMP.

Table 15. Summary of nonstructural BMPs to support TMDL implementation

Nonstructural BMP	Pollutant Source Addressed	TMDL/LRS Pollutant Addressed		
		Sediment	Nutrients	Bacteria
Education and Pollution Prevention Program	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	●
Ordinance Development	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	●
Street and Parking Lot Sweeping	Urban Stormwater Runoff	●	◗	○
Pet Waste Education and Outreach Campaign	Urban Stormwater Runoff	○	◗	●
Wildlife Implementation Practices	Urban Stormwater Runoff	○	◗	●

Notes

● addresses the pollutant

◗ partially addresses the pollutant

○ does not address the pollutant

4.2.1 Education and Pollution Prevention Program

Education and pollution prevention programs are important implementation tools. Examples of outcomes may include newsletter articles on proper yard waste disposal, storm drain stenciling, or rain barrel construction workshops. Residential waste collection and disposal programs that include community composting and yard waste pick up can help to limit nutrient loading from the waste that is dumped into low lying areas and along stream banks. In addition, an education and information program can be used to inform residents and property owners on the care and maintenance needed in a ravine landscape. Education outcomes could highlight setback requirements, recommended vegetation cover, stabilization techniques, and implementation opportunities. The program should target those landowners adjacent to ravines and stream channels. Educational opportunities include public meetings, mass mailings, TV and radio announcements, and newspaper articles.

In 2004 TCRPC partnered with a number of local NPDES Phase II MS4 communities and Bradley University to create an educational video focused on stormwater issues. This video was played on public access channels and is available for viewing on Tri-County Regional Planning Commission's website.

Existing efforts are underway to replicate workshops conducted through the TCRPC and IEPA program entitled *Implementing BMPs in the Mossville Bluffs Watershed*. These workshops educate landowners on urban stormwater BMPs and ravine stabilization technologies. In addition, there are existing efforts to educate planners, engineers, and developers on LID and BMPs approved by the USEPA, as well as the impacts of nonpoint source pollutants on local water bodies.

The existing Peoria Lakes Watersheds or Clean River – Healthy Watershed websites could also be enhanced to provide further educational opportunities such as fact sheets related to pollution prevention.

4.2.2 Ordinance Development

Many communities are undertaking efforts to improve current development ordinances, stormwater regulations, and environmental protection ordinances to prevent poor environmental practices. The City of East Peoria has adopted a steep slope ordinance which regulates the removal and replacement of vegetation from steep slopes, the construction of improvements on steep slopes, and the flow of stormwater in the vicinity of steep slopes. Steep slopes are defined as a slope that is 18 percent or greater. The City of Peoria has adopted a buffer ordinance which requires a 30-50 foot buffer adjacent to waterways in the City and the Village of Morton adopted a pet waste management ordinance in 2011. In addition, the TCRPC has created a model LID and stormwater ordinance which local governments could adopt and implement. The TCRPC model ordinance could be further strengthened by adding in a volume control requirement to meet water quality and stormwater goals.

Ordinance development in the Dry Run Tributary subwatershed should focus on stormwater quality treatment and reducing erosion and sediment transport. New ordinances can also add sediment and nutrient removal as part of new development or redevelopment projects to further enhance stormwater management activities and require additional buffers, similar to the Peoria buffer ordinance.

Local land use planning requirements and stormwater regulations can be strengthened to more fully address the activities that are causing impairments. The following ordinances are encouraged to address future development and redevelopment:

- Stormwater quality treatment requirements
- Stormwater volume control for new developments
- Pet waste management (Section 4.2.4)

4.2.3 Street and Parking Lot Sweeping

Streets and parking lots accumulate significant amounts of pollutants, including sediment, road salt, trash, and debris. Street sweeping can decrease the accumulation of pollutants in catch basins while improving curb appeal and controlling dust. Municipal street sweeping programs can target regulatory requirements, assess the BMPs effectiveness, and minimize pollutants from roadways. Currently, the City of Peoria conducts a spring and fall city-wide sweep of roads. The city also sweeps primary roads periodically during the summer and considers requests throughout the year from residents.

An effective street sweeping program can remove several tons of debris a year while minimizing pollutants in stormwater runoff. Studies have shown that street sweeping programs can reduce sediment and nutrients, depending on the frequency of sweeping and the sweeping technology used (Table 16).

Table 16. Pollutant removal efficiencies from street sweeping

Frequency of Sweeping	Technology	Pollutant reduction (%)		
		Total Suspended Solids	Total Phosphorus	Total Nitrogen
Monthly	Mechanical	9	3	3
	Regenerative air/vacuum	22	4	4
Weekly	Mechanical	13	5	6
	Regenerative air/vacuum	31	8	7

Source: CWP 2008

Sweeper type and frequency will dictate the expected removal efficiency. There are three types of sweepers including the mechanical broom, regenerative-air, and vacuum-assist. Using a combination of these sweepers in tandem can increase the pollutant load removed. The City of Peoria is meeting the minimum recommendations for street sweeping which suggests sweeping should occur a minimum of twice annually, once following the spring melt and again in the fall when the majority of leaves have fallen. Additional sweeping throughout the City could further reduce the pollutant load. The national average for sweeping is ten times per year.

4.2.4 Pet Waste Education and Outreach Campaign

Components necessary to implement a successful pet waste program include pet waste stations, an animal feces provision in municipal codes and ordinances, and a survey instrument to understand residents' perceptions and behaviors. Recommended implementation activities are intended to use these components to create a more comprehensive, coordinated, and robust pet waste or *Scoop the Poop* education and outreach program in the Middle Illinois River Watershed. Priority areas for domestic waste implementation practices are areas with high pet ownership and with a high degree of impervious cover, specifically residential areas. This type of program would benefit from a partnership involving all stormwater communities within the watershed.

Recommendations for a robust program include the following:

- **Review number, location, and use of pet waste stations.** It is important to determine if residents and visitors are using any existing pet waste stations or if stations are being overlooked. This can be achieved by an informal survey of park users or a visual inspection of parks. An assessment should be made to determine if there are other locations within the watershed that attract dog owners that could benefit from a pet waste station or outreach signage.
- **Create and publicize municipal code penalties.** Create provisions in code which require that dog owners must clean up after their pets. Penalties may include fines ranging from $20 to $200. Review codes and ensure that enforcement of provisions are widespread. To ensure that pet owners are aware of provisions, signs near pet waste stations should include a reference to code provisions and state any monetary penalty with failure to comply. While enforcement provisions may be limited, increased awareness of the provision and the associated penalties could serve as a disincentive from pet waste mismanagement.

Figure 22. Example signage.

- **Include pet waste outreach and education as a top priority in the stormwater management program.** Public education and outreach should be a key component of any updated stormwater program. Regulated MS4 communities should place significant emphasis on pet waste management education and awareness when developing public education and outreach priorities.
- **Develop a *Scoop the Poop* campaign.** A campaign refers to a coordinated, comprehensive outreach effort that integrates a variety of education and outreach techniques. Campaign development starts with a baseline survey to understand existing dog owner behaviors and perceptions, uses survey information to craft effective messages delivered using formats tailored to target audiences, and follows up with a post-campaign survey to determine effectiveness.

Because *Scoop the Poop* programs are a popular component of stormwater management programs, there are a great deal of materials available for use by other communities. However, there are not a lot of data available about the effectiveness of these programs with changing behavior and improving water quality conditions. Assumptions related to the amount of dog waste diverted from the stream can be made based on bag usage from pet waste stations. For example, the typical deposit per dog collected in a pet waste station bag is approximately 0.3 – 0.5 pounds (lbs). Therefore, it is possible to track how many bags are used annually and determine the *Escherichia coli* (*E. coli*) colonies associated with the estimated pounds of dog waste collected (1 lb of dog waste is equivalent to approximately 9 billion *E. coli* colonies).

4.2.5 Wildlife Implementation Practices

Wildlife are a potential source of bacteria. Priority areas for implementation include high-density wildlife populations near or in riparian areas with unstable banks or poor riparian vegetation and recreational areas where food/dumping might attract wildlife. Recommended implementation activities include outreach and education on impacts of feeding wildlife near riparian areas and riparian buffers to reduce wildlife access.

4.3 Structural Management Opportunities

Structural management opportunities that could be used to achieve the load reductions needed for the Dry Run Tributary subwatershed include:

- Green infrastructure retrofitting
- Streambank restoration
- Riparian area management

Table 17 summarizes the TMDL/LRS pollutants that are addressed by each BMP.

Table 17. Summary of structural BMPs to support TMDL/LRS implementation

Structural BMPs	Pollutant Source Addressed	TMDL/LRS Pollutant Addressed		
		Sediment	Nutrients	Bacteria
Green Infrastructure Retrofitting	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	◗
Streambank Restoration	Watershed, Streambank, and Gully Erosion	●	◗	○
Riparian Area Management	Watershed, Streambank, and Gully Erosion; Urban and Agricultural Stormwater Runoff	●	●	◗

Notes
● addresses the pollutant
◗ partially addresses the pollutant
○ does not address the pollutant

4.3.1 Green Infrastructure Retrofitting

The use of green infrastructure, especially those practices which reduce the volume of runoff from urban areas, can address pollutant loads from existing developed areas and prevent or mitigate stormwater runoff volume. A number of green infrastructure practices may be appropriate, considering land use constraints, and are likely to be effective for reducing watershed loadings of bacteria, nutrients, and sediment. Functioning as a first line of defense, green infrastructure is a fundamentally different approach than traditional stormwater management. Where traditional stormwater management is designed to efficiently convey runoff away from urban areas to nearby surface waters (neglecting to focus on water quality treatment), green infrastructure aims to manage stormwater at the site, often including some form of treatment and volume control for smaller storm events. Offering considerable versatility with design and implementation, green infrastructure concepts can be incorporated into new and existing developments and can be less cost intensive than traditional, structural stormwater management systems (USEPA 2007). Furthermore, green infrastructure practices offer an innovative way to integrate stormwater management into natural landscapes, minimizing alterations to the natural hydrologic regime and reducing site runoff. In fact, with USEPA's encouragement of integrated planning, they also state that this approach can lead to the identification of sustainable and comprehensive solutions, such as green infrastructure that improve water quality as well as support other quality of life attributes that enhance the vitality of communities (USEPA 2011). Implementation of green infrastructure practices also encourages groundwater recharge, and decreases surface erosion and pollutant transport. Additional benefits of green infrastructure implementation include improved greenways and enrichment of natural environmental aesthetics within the urban setting.

When selecting the most appropriate BMPs for a specific site or drainage area, site-specific conditions (e.g., land availability, slope, soil characteristics, climate condition, utilities, and characterization of contributing drainage including imperviousness, etc.) must be taken into consideration. Care must also be given to ensure the proper treatment identifies any site concerns or hazards. For example, infiltration should not be encouraged in areas surrounding stormwater *hot spots*, such as automotive repair shops, gasoline stations, or industrial areas where groundwater contamination or pollutant transfer is a possibility. Infiltration techniques may also not be appropriate in areas at risk of media clogging. This could include areas near restaurants where the possibility of oil and grease contamination exists.

Alternatively, in areas where groundwater contamination is not a concern, structural BMPs can incorporate infiltration as well as other treatment techniques to effectively reduce treatment volume and flow rates. Since the use of BMPs is quickly advancing, new research is supporting the use of varying BMPs for pollutant removal, provided the systems are constructed and maintained properly (Hathaway 2011, 2012; Hunt 2008). Theses BMPs can provide other water quality benefits by reducing runoff amounts, and therefore, reducing the amount of bacteria, nutrients, and sediment washed from surfaces.

There are many examples of successful green infrastructure programs across the country. Within the Midwest, MetroBlooms in the Twin Cities Minnesota area has been guiding implementation of rain garden programs over the past 10 years. One successful program focused on a nutrient impaired lake in the City of Minneapolis's (MetroBlooms 2012). Through this program, 125 rain gardens were installed within a 28-acre neighborhood in 2010; 50 percent of property owners participated in this project. This project is presented in the following document: http://www.metroblooms.org/files/CBASM%20Report%20FINAL_063012.pdf. Key outcomes of the project included the following recommendations for citizen engagement:

> The City of Peoria installed a rain garden on public property near MacArthur Highway and Richard Allen Drive, adjacent to Valeska Hinton Early Childhood Education Center, in 2012. The project was funded through an environmental grant for $6,000 from the Illinois American Water Company. The demonstration rain garden is approximately 500 square feet by 6 inches deep. The rain garden was built by volunteers from the Farnsworth Group, Natural Resources Conservation Service/Natural Resources-Your Development Task Force, Heart of Illinois Sierra Club, Peoria Park District, Tri-County Regional Planning Commission, Spring Grove Neighborhood Homeowners Association and Peoria Public Works Department.

- Enlist local champions of stormwater management to reach out to community members.
- Use a combination of outreach methods: workshops, mass mailings, door knockers, neighborhood home meetings, and canvassing.
- Include multi-lingual staff and community members to engage non-English speaking community members.
- Use a non-profit organization for outreach and implementation to offset skepticism associated with a private firm or city-led effort.

- Provide an economic incentive and a well-crafted, educated message.

There are a wide variety of models available that have been used to assist stormwater management activities with describing runoff and pollutant loading patterns and the effect of BMPs. Modeling approaches can range from simple to complex. The Dry Run Tributary subwatershed was modeled and evaluated using the BMPDSS. BMPDSS was developed by Tetra Tech for Prince George's County, Maryland and is the pre-cursor to the USEPA's System for Urban Stormwater Treatment and Analysis Integration (*SUSTAIN*) model. The BMPDSS system is a decision-making tool for placing BMPs at strategic locations in urban watersheds on the basis of integrated data collection and hydrologic, hydraulic, and water quality modeling. BMPDSS can be applied to analyze the overall performance of multiple BMPs and find an optimal solution for their implementation. BMPDSS can provide assessment of both distributed (including LID-type) and centralized BMPs in combinations and can support selection of the optimum plan that maximizes benefits and leads to significant cost savings. This quantitative approach can provide assurance to stormwater managers and regulators that goals or TMDL reduction requirements are achievable and practicable, thereby ensuring that investments in selected BMPs are justified. Hourly rainfall runoff time series are required as input to BMPDSS and were generated using LSPC.

Figure 23. Green infrastructure examples: top - bioswale in parking lot; middle - green roof; bottom - permeable pavement.

BMPs for the Dry Run Tributary pilot area were selected based upon the characteristics of the watershed, land uses, and soils conditions. The selection of BMPs is dependent upon the suitability of the BMPs for each area based upon site conditions and performance goals. Soils in this watershed are assumed to be fairly permeable, therefore practices which promote infiltration were included. The following BMPs were considered for this pilot area:

- Bioretention (bioswale/pond)
- Rain garden
- Porous pavement
- Rain barrel
- Green roof

Each of the BMPs was evaluated for applicability in the pilot area on the basis of a review of aerial imagery and field reconnaissance. Candidate locations were selected according to available land area and proximity to sources of runoff and pollutants and based on aerial photography analysis, field reconnaissance and on best professional judgment. Design assumptions for the BMPs were compiled from various design manuals and based on experience. Lifecycle costs, including operation and maintenance, were used to evaluate the economics of the various BMPs.

BMPs are simulated in BMPDSS according to design specifications, with the performance modeled using a unit-process parameter-based approach. That contrasts with and has many advantages over most other techniques that simply assign a single percent effectiveness value to each type of practice. BMPDSS predicts BMP performance as a function of its physical configuration, storm size and associated runoff intensity and volume, and moisture conditions in the BMP.

The objective of the Dry Run Tributary BMPDSS model run was to evaluate feasible reductions in annual flow volume using the previously described suite of management practices and evaluate the secondary benefits of pollutant reduction (TSS,TN, TP and bacteria) with respect to the Middle Illinois River watershed TMDL and LRS study. In assessing the study objectives, this analysis:

- Represents the maximum implementation of residential rain barrels and rain gardens
- Develops a trade-off curve of cost and average annual volume reduction evaluating opportunity for four additional BMP types by subwatershed
- Identifies solutions of interest on the trade-off curve from which to evaluate specific BMP selections by practice and subwatershed
    - Solution #1 - Maximum implementation of rain barrels and rain gardens
    - Solution #2 – Inflection point of the BMP trade-off curve (includes bioretention, porous pavement, and green roofs)
    - Solution #3 – Inclusive of both Solution #1 and Solution #2

Figure 24 shows the average annual stormwater runoff volume reduction trade-off curve for the Dry Run Tributary subwatershed as a result of running the BMPDSS model for a three year representative period. In this figure, the small points represent all solutions that were evaluated during the scatter search, while the larger points shown in clusters along the left-and-upper-most perimeter represent least cost options identified by the scatter search with respect to achieving annual volume reduction. Table 18 summarizes the three solutions presented in Figure 24.

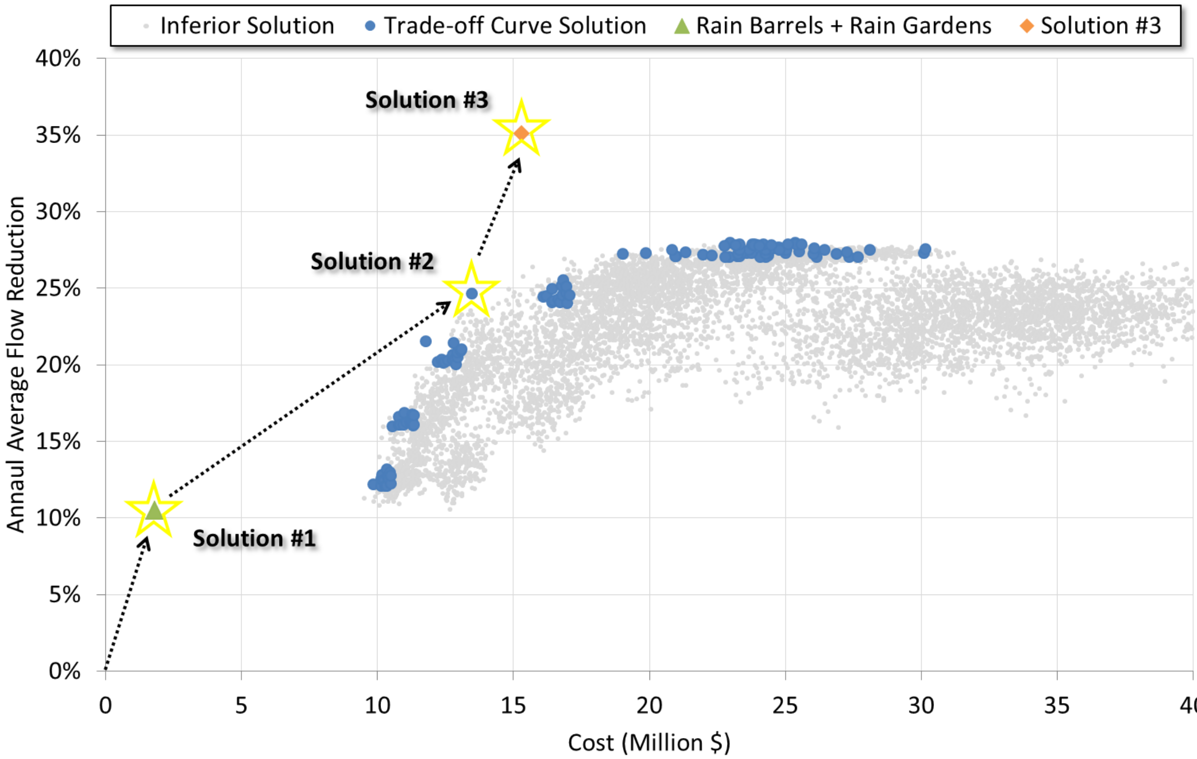

Figure 24. Trade-off curve for Dry Run Tributary management scenarios inclusive of rain barrel & rain garden boundary condition.

Table 18. Summary of trade-off curve solutions

Solution	Description	Flow Volume Reduction (%)	Cost (Million $)
1	Rain Barrels & Rain Gardens Only	10.5%	1.8
2	Trade-off curve BMPs (no Rain Barrels & Rain Gardens)	24.6%	13.5
3	Composite of Solution #1 & #2	35.1%	15.3

Figure 21 presents the annual average pollutant reduction for TSS, TN, TP, and bacteria from all three scenarios presented in Figure 24 which include (1) implementation of residential rain barrels and rain gardens only (2) trade-off curve BMPs only, and (2) all BMPs includes of rain barrels, rain gardens and selected trade-off curve BMPs.

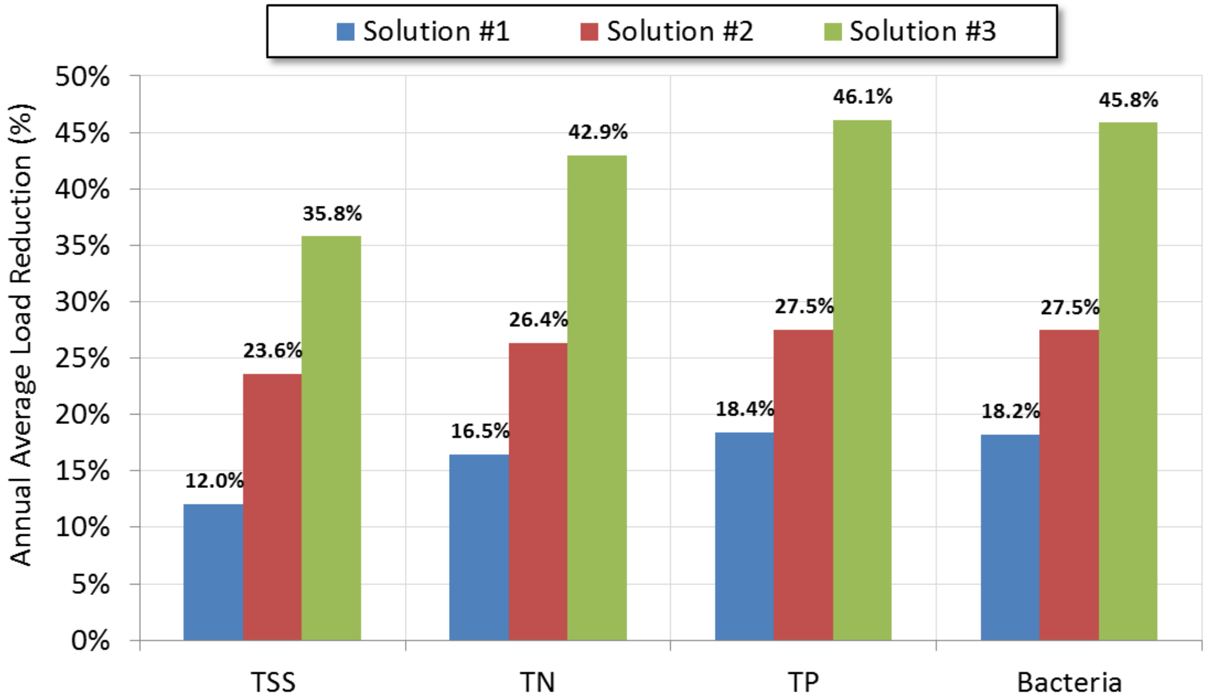

Figure 25. Annual average percent load reduction for three BMP scenarios (10/1/2005 through 9/30/2008).

Solution 3 is the preferred solution for green infrastructure retrofitting resulting in a 35 to 46 percent reduction in pollutant loads. Table 19 summarizes the BMP configuration that resulted in Solution 3. It is important to note that the suite of BMPs identified in Table 19 should be viewed as a starting point and guide to implementation, not as a prescriptive list of BMPs which should be installed. Adaptive management, as described in Section 7, should be followed, beginning with the most cost-effective BMPs which are rain gardens and rain barrels. A program with associated staff and financial resources which focuses on implementation of rain gardens and rain barrels is needed. This program will require BMPs to be installed on private property in addition to public property, and therefore education and outreach is critical. Some successful rain garden programs have used cost-share mechanisms while others have funded these BMPs using municipal capital improvement dollars. The City of Peoria conducted a successful Rain Barrel distribution program in 2011, a model which could be used to further BMP implementation on private property.

Table 19. Solution 3 BMPs

BMP	Solution 3 BMP Extent (unit or acre)	Percent of BMP Utilization
Rain Garden (unit)	1,022 (3.5 acres)	100%
Rain Barrel (unit)	2,044	100%
Bioretention (acres)	9.1	37%
Porous Pavement Roads (acres)	1.7	53%
Porous Pavement Parking Lots (acres)	11.9	19%
Green Roof (acres)	1.5	15%

A successful green infrastructure program will begin with an information and education campaign and a series of demonstration projects. Typically, demonstration projects are built on public property such as at city halls, parks, or libraries. Educational signage should be included to inform residents about the BMPs. These BMPs would be publically-owned and maintained and could be monitored to provide data on their effectiveness. Green infrastructure practices can also be used in place of traditional practices on public projects, such as street reconstruction including porous pavement. Existing capital improvement plans should be evaluated to identify opportunities for green infrastructure implementation. A green infrastructure program can then be expanded to include practices on private property.

4.3.2 Streambank Restoration

Reducing streambank erosion will reduce sediment loadings in tributaries and within Farm Creek. Streambanks in the watershed should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from adjacent areas can be mitigated by infiltration in grassed waterways and passage of runoff through filter strips. Streambank restoration should be conducted only after upstream stormwater management controls are in place.

4.3.3 Riparian Area Management

Preserving the natural vegetation along a stream corridor can mitigate pollutant loading associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow sheet. Concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks and steep slopes. The rooting systems of the vegetation serve as reinforcements in soils, which help to hold material in place and minimize erosion. Due to the increase in stormwater runoff volume and peak rates of runoff associated with development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer.

Riparian buffers/filter strips should consist of native species and may include grasses, forbs, shrubs, and trees. The City of Peoria’s buffer ordinance requires a 30 – 50 foot buffer on each side of the channel, depending on the drainage area. This buffer width is sufficient to provide water quality benefits. Higher removal rates are provided with greater buffer widths. In addition to pollutant reductions, buffers increase channel stability which will reduce streambank erosion. Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms.

The following activities could take place as part of a riparian area management program:

- Adopt and/or implement buffer ordinances for new development or redevelopment
- Document the presence of gullies or invasive species that could contribute to water quality concerns
- Prioritize potential buffer restoration sites
- Develop a program or project to fund high priority buffer restoration
- Work with landowners to install and maintain buffers on private property
- Monitor water quality or other environmental conditions prior to, and following riparian project completion

4.4 Implementation Summary, Schedule and Goals

Table 20 presents a summary of the proposed implementation activities for the Dry Run tributary subwatershed. Implementation Phases are further described in Section 7 and potential financial assistance programs are further described in Section 5. The estimated annual cost of implementing this plan is $600,000 to $800,000, which equates to an estimated cost of $350 - $450 per acre per year.

Table 20. Implementation activity summary, Dry Run Tributary subwatershed

Implementation Activity	Critical Areas	Emphasis by Phase	Potential Financial Assistance	Lead Partners	Level of Pollutant Removal (H – M – L)	Activity Cost (H – M – L)
Nonstructural Management Opportunities						
Education and Pollution Prevention Programs	Watershed wide	Phase 1:High Phase 2: Continued Phase 3: Continued	Section 319(h)	TCRPC, City of Peoria, Village of Peoria Heights, Peoria County	Moderate	Low
Ordinance Development	Watershed wide	Phase 1:High Phase 2: Continued Phase 3: Continued		TCRPC, City of Peoria, Village of Peoria Heights, Peoria County	Moderate	Moderate
Street and Parking Lot Sweeping	Impervious surfaces (streets, parking lots)	Phase 1:High Phase 2: Continued Phase 3: Continued		City of Peoria, Village of Peoria Heights, Peoria County	Moderate	Moderate
Pet Waste Education and Outreach Campaign	Residential areas	Phase 1:High Phase 2: Continued Phase 3: Continued	Section 319(h)	TCRPC, City of Peoria, Village of Peoria Heights, Peoria County	Moderate	Low
Wildlife Implementation Practices	Riparian areas	Phase 1:High Phase 2: Continued Phase 3: Continued		City of Peoria, Village of Peoria Heights, Peoria County	Moderate	Low
Structural Management Opportunities						
Green Infrastructure Retrofitting	Impervious areas (i.e. parking lots, roofs, streets, driveways, alleys)	Phase 1:Moderate Phase 2: High Phase 3: Continued	Section 319(h), IEPA	Private Sector, City of Peoria, Village of Peoria Heights, Peoria County, TCRPC	High	High
Streambank Restoration	Eroding streambanks	Phase 1: Low Phase 2: Low Phase 3: High	Conservation 2000	City of Peoria, Village of Peoria Heights, Peoria County SWCD, Private owners	High	High
Riparian Area Management	Riparian areas	Phase 1: High Phase 2: High Phase 3: Continued	Section 319(h)	City of Peoria, Village of Peoria Heights, Peoria County SWCD, Private owners	High	Moderate

5. Financial Assistance Programs

There are many existing financial assistance programs which may assist with funding implementation activities. Several of these programs are presented below. In addition to these programs, partnerships between local governments can help to leverage funds. State and federal grant programs may also be available, depending on the nature of the implementation activity. A stormwater utility may also be used to generate local funds for stormwater programs.

5.1 State Revolving Fund

The State Revolving Fund programs, including the Water Pollution Control Loan Program for wastewater projects and the Public Water Supply Loan Program for drinking water projects, are annually the recipients of federal capitalization funding, which is combined with state matching funds and program repayments to form a perpetual source of low interest financing for environmental infrastructure projects. Eligible projects include traditional pipe, storage, and treatment systems and also include green infrastructure projects.

5.2 Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to landowners who voluntarily implement resource conservation practices. The most comprehensive is the NRCS EQIP which offers cost sharing and incentives to farmers who utilize approved conservation practices to reduce pollutant loading from agricultural lands.

- The program will pay $10 for one year for each acre of farmland that is managed under a nutrient management plan (up to 400 acres per farm).
- Use of vegetated filter strips will earn the farmer $100/ac/yr for three years (up to 50 acres per farmer).
- The program will also pay 60 percent of the cost to construct grassed waterways, riparian buffers, and windbreaks.
- Use of residue management will earn the farmer $15/ac for three years (up to 400 acres per farm).
- Installation of drainage control structures on tile outlets will earn the farmer $5/ac/yr for three years for the effected drainage area as well as 60 percent of the cost of each structure.
- The program will pay 75 percent of the construction cost for a composting facility.
- Sixty percent of the fencing, controlled access points, spring and well development, pipeline, and watering facility costs are covered by the program.
- Waste storage facilities and covers for those facilities have a 50 percent cost share for construction.
- Prescribed grazing practices will earn the farmer $10/ac/yr for three years (up to 200 acres per farmer).

In order to participate in the EQIP cost share program, all BMPs must be constructed according to the specifications listed for each conservation practice. A demonstration of how this program could be targeted to specific areas in the TMDL is the Big Bureau Creek Targeted Subwatershed Project which will focus on various practices such as nutrient management plans, livestock practices and rotational grazing systems, tile drainage water management systems, wetland restoration, filter strips, dry dams and reduced tillage.

5.3 Conservation Reserve Program (CRP)

The Farm Service Agency of the USDA supports the CRP which rents land that is converted from crop production to grass or forestland for the purposes of reducing erosion and protecting sensitive waters. This program is available to farmers who establish vegetated filter strips or grassed waterways. The program typically provides 50 percent of the upfront cost to establish vegetative cover for up to 15 years.

5.4 Conservation 2000/Partners for Conservation

In 1995 the Illinois General Assembly passed the Conservation 2000 bill providing $100 million in funding over a 6-year period for the promotion of conservation efforts. In 1999, legislation was passed to extend the program through 2009. In 2008, House Bill 1780 was signed into law as Public Act 95-0139, extending the program to 2021 as Partners for Conservation. The Partners for Conservation Program funds programs at Illinois Department of Natural Resources, Illinois Department of Agriculture, and IEPA.

Conservation Practices Program

The Conservation Practices Cost Share Program provides monetary incentives for conservation practices implemented on land eroding at one and one-half times or more the tolerable soil loss rate. Payments of up to 60 percent of initial costs are paid through the local conservation districts. The program will cost share cover crops, filter strips, grassed waterways, no-till systems, and pasture planting, amongst other BMPs. Other sediment control options such as contour farming and installation of stormwater ponds are also covered. Practices funded through this program must be maintained for at least 10 years.

Streambank Stabilization Restoration Program

Conservation 2000 also funds a streambank stabilization and restoration program aimed at restoring highly eroding streambanks. Research efforts are also funded to assess the effectiveness of vegetative and bioengineering techniques.

Sustainable Agriculture Grant Program

The Sustainable Agricultural Grant Program funds research, education, and outreach efforts for sustainable agricultural practices. Private landowners, organizations, educational, and governmental institutions are all eligible for participation in this program.

5.5 Nonpoint Source Management Program

IEPA receives federal funds through section 319(h) of the Clean Water Act to help implement Illinois' Nonpoint Source Pollution Management Program. The purpose of the program is to work cooperatively with local units of government and other organizations toward the mutual goal of protecting the quality of water in Illinois by controlling nonpoint source pollution. The program emphasizes funding for implementing cost-effective corrective and preventative BMPs on a watershed scale; funding is also available for BMPs on a non-watershed scale and the development of information/education nonpoint source pollution control programs.

The maximum federal funding available is 60 percent, with the remaining 40 percent coming from local match. The program period is two years unless otherwise approved. Funding is directed toward activities that result in the implementation of appropriate BMPs for the control of nonpoint source pollution or to enhance the public's awareness of nonpoint source pollution.

Projects or activities carried out to comply with the MS4 six minimum control measures are not eligible for section 319 funding. However, there may be some activities that promote opportunities to implement the watershed approach that are eligible for section 319 funding that could indirectly address the six minimum measures as well as nonpoint source projects. For more information: http://www.epa.state.il.us/water/watershed/nonpoint-source.html.

5.6 Agricultural Loan Program

The Agricultural Loan Program offered through the Illinois State Treasury office provides low-interest loans to assist farmers who implement soil and water conservation practices. These loans will provide assistance for the construction, equipment, and maintenance costs that are not covered by cost share programs.

5.7 Illinois Conservation and Climate Initiative

The Illinois Conservation and Climate Initiative is a joint project of the State of Illinois and the Delta Pollution Prevention and Energy Efficiency (P2/E2) Center that allows farmers and landowners to earn carbon credits when they use conservation practices. These credits are then sold to companies or agencies that are committed to reducing their greenhouse gas emissions. Conservation tillage earns 0.5 metric tons (1.1 US ton) of carbon per acre per year (mt/ac/yr), grass plantings (applicable to filter strips and grassed waterways) earn 0.75 mt/ac/yr, and trees planted at a density of at least 250 stems per acre earn somewhere between 3.5 to 5.4 mt/ac/yr, depending on the species planted and age of the stand. Current exchange rates are available online at http://chicagoclimatex.com. Administrative fees of $0.14/mt plus 8 percent are subtracted from the sale price. Program enrollment occurs through the P2/E2 Center which can be found online at http://p2e2center.org/. The requirements of the program are verified by a third party before credits can be earned.

5.8 Illinois Green Infrastructure Grants

Grants have been made available in 2011 and 2012 by the IEPA to local units of government and other organizations to implement green infrastructure BMPs to control stormwater runoff for water quality protection in Illinois. Projects must be located within a MS4 combines sewer overflow area. Competitive grants are available in three categories 1) CSO rehabilitation ($300,000 - $3,000,000); 2) stormwater retention and infiltration category ($100,000 - $750,000); and 3) green infrastructure small projects category ($15,000 - $75,000). This grant program is reviewed annually, and therefore may not be available in the future. For more information: http://www.epa.state.il.us/water/financial-assistance/igig.html.

5.9 Illinois American Water Grants

Established in 2005, the Environmental Grant Program offers funds for innovative, community-based environmental projects that improve, restore or protect the watersheds, surface water and/or groundwater supplies. Competitive grants are offered to community partners in areas which are served by Illinois American Water. For more information: http://www.amwater.com/ilaw/ensuring-water-quality/environmental-grants-program.html.

6. Monitoring and Measuring Success

An important component of the TMDL implementation process is follow-up monitoring. Monitoring will help determine whether the implementation actions have improved water quality. In addition, monitoring will help determine the effectiveness of various BMPs and indicate when adaptive management should be initiated. The goal of the monitoring plan is to assess the effectiveness of source reduction strategies for attaining water quality standards and designated uses.

6.1 Water Quality Monitoring

The 2009 Regional Stormwater Plan for Peoria, Tazewell, and Woodford Counties identified a great need for localized data collection on water quality of surface waters of the region. In response to this need, TCRPC has partnered with Bradley University, Illinois Central College, the Heart of Illinois Sierra Club, and the National Great Rivers Research and Education Center (River Watch program) to form the IL River Action League program that aims to engage citizens of various capabilities in water quality monitoring. This program is currently in its infancy and is in need of funding; however, local partners thus far have developed protocol and assembled monitoring kits to launch a test run of citizen-based data collection with both Girl Scout organizations and middle school teachers. This program will continue to evolve as partners find resources for implementation. Partners anticipate that this program will serve as a mechanism to provide long term data collection where data are publically available via internet mapping platforms.

In order to establish baseline conditions in the North Farm Creek and Dry Run Tributary subwatersheds, water quality and flow monitoring should be conducted throughout the watersheds. At a minimum, a monitoring station located near the outlet of the watershed should be established. The smaller tributaries could also be monitored to determine their contribution and to isolate any sources stemming from those tributaries. Water quality grab samples and flow measurements should be collected on a bi-weekly or monthly basis from April to October. Water quality samples should be analyzed for the following parameters: nitrate nitrogen, total phosphorus, total suspended solids, chlorides (in North Farm Creek subwatershed only), and fecal coliform bacteria. Baseline condition modeling should be conducted for a minimum of two years to account for various weather conditions.

Once baseline conditions are established, the monitoring program will then be in place to measure improvements in water quality over time.

6.2 BMP Effectiveness Monitoring

Multiple BMPs will be needed to address the water quality impairments found in the Middle Illinois River watershed. There are limited data on the effectiveness of many BMPs, therefore monitoring the results of programs and representative practices are critical. Best management practice monitoring can including water quality and flow monitoring, visual monitoring, vegetation monitoring, and monitoring of behaviors. A monitoring program should be put in place as both structural and nonstructural BMPs are implemented to 1) measure success and 2) identify changes that could be made to increase effectiveness.

USEPA provides a manual for conducting water quality monitoring and reporting data that are useful for assessing the effectiveness of stormwater BMPs at: http://water.epa.gov/scitech/wastetech/guide/stormwater/monitor.cfm.

7. Adaptive Management

To ensure management decisions are based on the most recent knowledge, the implementation plans follow the form of an adaptive and integrated management strategy and establish milestones and interim goals for evaluation of the implementation program.

USEPA recognizes that the processes involved in watershed assessment, planning, and management are iterative and that actions might not result in complete success during the first or second cycle (USEPA 2008). For this reason, it is important to remember that TMDL/LRS implementation will be an iterative process, relying upon adaptive management.

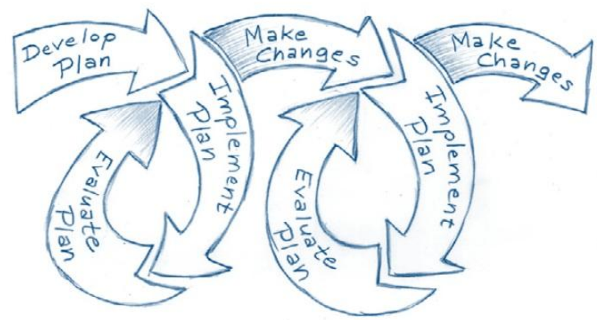

Figure 26. Adaptive management iterative process (USEPA 2008).

Adaptive management is a strategy commonly used since a problem in natural resource management involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system (DOI 2009). As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process, depicted in Figure 26, enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time, and management can be improved (DOI 2009).

In addition to focusing future management decisions, with established assessment milestones, adaptive management can include a re-assessment of the TMDL. Re-assessment of the TMDL is particularly relevant when completion of key studies, projects or programs result in data showing load reductions or the identification/quantification of alternative sources. Reopening/reconsidering the TMDL may include refinement of the TMDL or recalculation of load reductions and allocations. For instance, if special studies can quantify wildlife loading, the load allocations can be refined and wasteload adjusted accordingly. Similarly, if implementation efforts are successful in reducing MS4 loads, then required reductions shall be refined.

Table 21 and Table 22 summarize the pollutant load reduction goals based on the TMDL/LRS study for each pilot watershed and the expected load reductions that could be achieved by proposed implementation activities. Not all sources and reductions are quantified at this time. As baseline data are collected, these estimates can be refined. In addition, these tables include the monitoring targets for each pollutant that will determine if water quality is meeting the TMDL/LRS. Monitoring is an essential component of adaptive management, the refinement of management strategies, and reopening of the TMDL. Consequently, this implementation plan stresses the importance of continued water quality monitoring and evaluation of implementation performance to assess effectiveness in the short- and long-terms (Section 6).

Table 21. North Farm Creek subwatershed pollutant load summary

Target Pollutant		Suspended Solids	Nitrogen	Phosphorus	Pathogens	Chloride
Target Pollutant Reduction %		88	17 - 63	21 - 73	68-79	75
Target Pollutant Concentration		50-60 mg/L	1.798 mg/L	0.072 mg/L	200 #/100 mL [c]; 400 #/100 mL [b]	500 mg/L
Structural Practice	**Source Load Addressed**	**Expected Load Removed by Implementation**				
Conservation Tillage	Agricultural Stormwater Runoff	28	ukw	26	ukw	ukw
Green Infrastructure Retrofitting	Urban Stormwater Runoff	31	27	28	33	ukw
Salt Management Plan	Urban Stormwater Runoff	ukw	ukw	ukw	ukw	10-40
Total Pollutant Removal Quantified (%)		59	27	54	33	10-40
Additional Removal Needed (%)		29	36	19	46	35-65

Notes
ukw - unknown
a. Fecal coliform standards are for the recreation season only (May through October)
b. Standard shall not be exceeded by more than 10 percent of the samples collected during a 30 day period
c. Geometric mean based on minimum of 5 samples taken over not more than a 30 day period

Table 22. Dry Run Tributary subwatershed pollutant load summary

Target Pollutant		Suspended Solids	Nitrogen	Phosphorus	Pathogens
Target Pollutant Reduction %		96	20 - 65	32 - 76	97 - 100
Target Pollutant Concentration		50-60 mg/L	1.798 mg/L	0.072 mg/L	200 #/100 mL [c]; 400 #/100 mL [b]
Structural Practice	**Source Load Addressed**	**Expected Load Removed by Implementation**			
Green Infrastructure Retrofitting	Urban Stormwater Runoff	35	35	42	45
Total Pollutant Removal Quantified (%)		35	35	42	45
Additional Removal Needed (%)		61	23	31	55

Notes
a. Fecal coliform standards are for the recreation season only (May through October)
b. Standard shall not be exceeded by more than 10 percent of the samples collected during a 30 day period
c. Geometric mean based on minimum of 5 samples taken over not more than a 30 day period

The adaptive management process for this implementation plan will follow a phased-implementation approach. Three implementation phases, associated milestones, and associated goals are as follows:

Phase 1: Implementation of Nonstructural BMPs (Years 0-3)
Phase 1 will focus on nonstructural BMPs, such as educational programs and ordinance development. This phase will also include planning for any needed point source controls and establishment of a monitoring program to determine baseline conditions. Stabilization of gullies, ravines, and steep slopes is a focus area.

Phase 2: Structural BMP Implementation (Years 3-10)
Phase 2 will focus on implementation of recommended BMPs such as green infrastructure retrofitting and streambank stabilization.

5-Year Milestone: All nonstructural management opportunities should be in place. Planning related to point source control should be completed. BMP demonstration projects should be underway. Agricultural BMP implementation is a focus area.

Milestone Goal: 15 percent reduction in pollutant loads

10-Year Milestone: Nonstructural management opportunities continue to be implemented and enhanced. Demonstration projects are completed and monitoring programs are in place to determine effectiveness. Structural management opportunities are being implemented throughout the watershed. Urban BMP implementation and point source controls are the focus areas. Water quality conditions in streams are evaluated and the TMDL/LRSs and implementation plan are modified as needed.

Milestone Goal: 30 percent reduction in pollutant loads

Phase 3: Monitoring and Adaptive Management (Years 10-20)
Phase 3 will include additional BMP implementation and studies to show the effectiveness of BMPs. The implementation plan should be re-evaluated at Year 10.

15-Year Milestone: Nonstructural management opportunities continue to be implemented and enhanced. Structural management opportunities continue to be implemented watershed-wide. Monitoring data continue to be collected and implementation plan adjusted as needed.

Milestone Goal: 50 percent reduction in pollutant loads

20-Year Milestone: All implementation activities will be in place addressing all sources of pollutants.

Milestone Goal: 75 – 90 percent reduction in pollutant loads, depending on pollutant.

The implementation phases, milestones, and goals will guide the adaptive management process, helping to determine the type of monitoring and implementation tracking that will be necessary to gauge progress over time. Evaluation for adaptive management can include a variety of evaluation components to gain a comprehensive understanding of implementation progress. An implementation evaluation determines if non-structural and structural activities are put in place and maintained by implementation partners according to schedule; this is often referred to as an output evaluation. An outcome evaluation focuses on changes to behaviors and water quality as a result of implementation actions. This type of evaluation looks at changes in stakeholder behavior and awareness (i.e., non-structural BMP effectiveness), structural BMP performance, and changes to ambient water quality. Table 23 provides a summary of the adaptive management process by phase, highlighting evaluation tools and triggers for potential implementation plan modifications over time.

Table 23. Adaptive management by phase

Implementation Activity/Focus	Milestones	Goal	Evaluation Tools	Modification Necessary If…
Phase I (Years 0-3)				
Nonstructural BMPs (e.g., educational programs and ordinance development, planning related to woodland management and salt management)	None specified until Year 5	None specified until Year 5	Focus on implementation evaluation to determine if nonstructural BMPs are implemented occurring according to schedule. Identify evaluation measures and instruments for nonstructural BMPs, including behavioral change/awareness surveys.	Funding or partner support isn't adequate to implement nonstructural BMPs according to schedule
Planning for any needed point source controls in North Farm Creek subwatershed			Focus on implementation evaluation to determine if planning is occurring according to schedule	Planning isn't occurring according to schedule
Stabilization of gullies, ravines, and steep slopes			Implementation evaluation against schedule. Outcomes evaluation including visual monitoring and water quality monitoring.	Planning and implementation isn't occurring according to schedule
Phase 2 (Years 3-10)				
Recommended structural BMPs (e.g., green infrastructure retrofitting and streambank stabilization)	5 year milestone: All nonstructural management opportunities in place. Planning related to point source control complete. BMP demonstration projects underway.	15 percent load reduction	Continue implementation evaluation against schedule. Conduct evaluation for nonstructural BMPs using identified measures and instruments to determine behavior change and awareness. Identify evaluation measures and monitoring approaches for structural BMPs, including BMP effectiveness monitoring, visual monitoring, and ambient water quality monitoring	Nonstructural and structural BMPs are not implemented according to schedule. Nonstructural BMPs not resulting in behavior changes or increased awareness.
	10-year milestone: Continued nonstructural management implementation. Determine effectiveness of completed demonstration projects. Continued structural management implementation.	30 percent load reduction	Continue implementation evaluation against schedules. Conduct comprehensive implementation plan evaluation to identify necessary modifications for Phase 3 of implementation.	Nonstructural and structural BMPs are not implemented according to schedule. Nonstructural BMPs not resulting in behavior changes or increased awareness. BMP effectiveness data don't align with expected BMP performance. Water quality conditions not improving.
Phase 3 (Years 10-20)				
Adapt structural and non-structural BMPs based on 10-year evaluation data/information Implement new structural or non-structural BMPs as determined necessary during evaluation process	15-year milestone: Nonstructural management opportunities continue to be implemented and enhanced. Structural management opportunities continue to be implemented watershed-wide. Monitoring data continue to be collected and implementation plan adjusted as needed.	50 percent load reduction	Implementation evaluation against schedules. Outcomes evaluation for structural and nonstructural BMPs including BMP performance, visual monitoring, BMP inspections, and water quality monitoring.	Nonstructural and structural BMPs are not implemented according to schedule. Nonstructural BMPs not resulting in behavior changes or increased awareness. BMP effectiveness data don't align with expected BMP performance. Water quality conditions not improving.
	20-year milestone: All implementation activities in place and fully functioning based on 10-year evaluation. Conduct comprehensive implementation plan evaluation with focus on water quality outcomes.	75-90 percent load reduction		

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Appendix A

North Farm Creek Technical Appendix

Appendix A: North Farm Creek Technical Appendix

A multi-scale modeling approach was used for the North Farm Creek watershed and consisted of a watershed-wide pollutant loading and low impact development (LID) model, followed by a detailed, neighborhood level model of LID effectiveness on various storm events.

The North Farm Creek watershed was modeled using Long Term Hydrologic Impact Analysis (L-THIA LID; available at https://engineering.purdue.edu/~lthia/) to generate annual pollutant loads (sediment and nutrients) and model the effectiveness of various levels of BMP implementation. L-THIA is a simple web-based model which evaluates annual hydrology and pollutant loadings, and can also be used to determine the effect of BMPs such as bioretention and porous pavement using the Low Impact Development spreadsheet (L-THIA LID). L-THIA LID is only applicable to developed areas. A baseline condition is run in L-THIA and compared to a BMP scenario using L-THIA LID which includes implementation of lot scale BMPs including bioretention, rain barrels, permeable pavement, swales, green roofs, and impervious disconnection. The model results show the effectiveness of implementing different BMPs on a watershed scale by demonstrating the potential reductions of nitrogen, phosphorus, sediment, and bacteria loads.

Model Inputs

There are only four required inputs to L-THIA including:

- State
- County
- Land use/land cover
- Soil hydrologic soil group

Land use/land cover and soil hydrologic group data can be obtained directly from the L-THIA website, however since newer land cover data exists in the North Farm Creek watershed; these data were obtained from the 2006 National Land Cover Database (NLCD). Hydrologic soil group data are available from the Natural Resource Conservation Service's Soil Survey Geographic Database (SSURGO) for Tazewell County. Since land use categories from NLCD do not match completely with the available land covers in L-THIA, conversions and aggregations were performed. Table 1 presents the results of this process, while Table 2 shows the NLCD definitions used to convert developed land uses.

Table 1. NLCD 2006 land cover conversion into L-THIA land uses

NLCD land cover categories	L-THIA land uses
Water	Water/Wetlands
Woody Wetland	
Bare Rock/Sand/Clay	Grass/Pasture
Grassland/Herbaceous	
Developed, Open Space	
Pasture/Hay	
Developed, Light Intensity	Low Density Residential
Developed, Medium Intensity	High Density Residential
Developed, High Intensity	Commercial/Industrial
Deciduous Forest	Forest
Cultivated Crops	Agriculture

a. Commercial and industrial land uses were coded by interpretation of aerial imagery.

Table 2. L-THIA Land uses and associated NLCD classes

L-THIA land use	NLCD land use	NLCD definition
High Density Residential	Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.
Low Density Residential	Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.
Commercial & Industrial	Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

Hydrologic soil groups (HSGs) are graded from type A, which are primarily sandy or loamy and have a high capacity for water infiltration, to type D, which have high clay content or are heavily compacted with a low infiltration capacity. The majority of the North Farm Creek watershed consists of type B soils (Figure 1), which have moderately good infiltration and drainage properties. However, isolated patches of land are classified as B/D, which indicates type D soils that have the potential to achieve type B properties if properly drained. Urban lands are unclassified in the database and do not have any information associated with them. A HSG B was assigned to all of these urban soils.

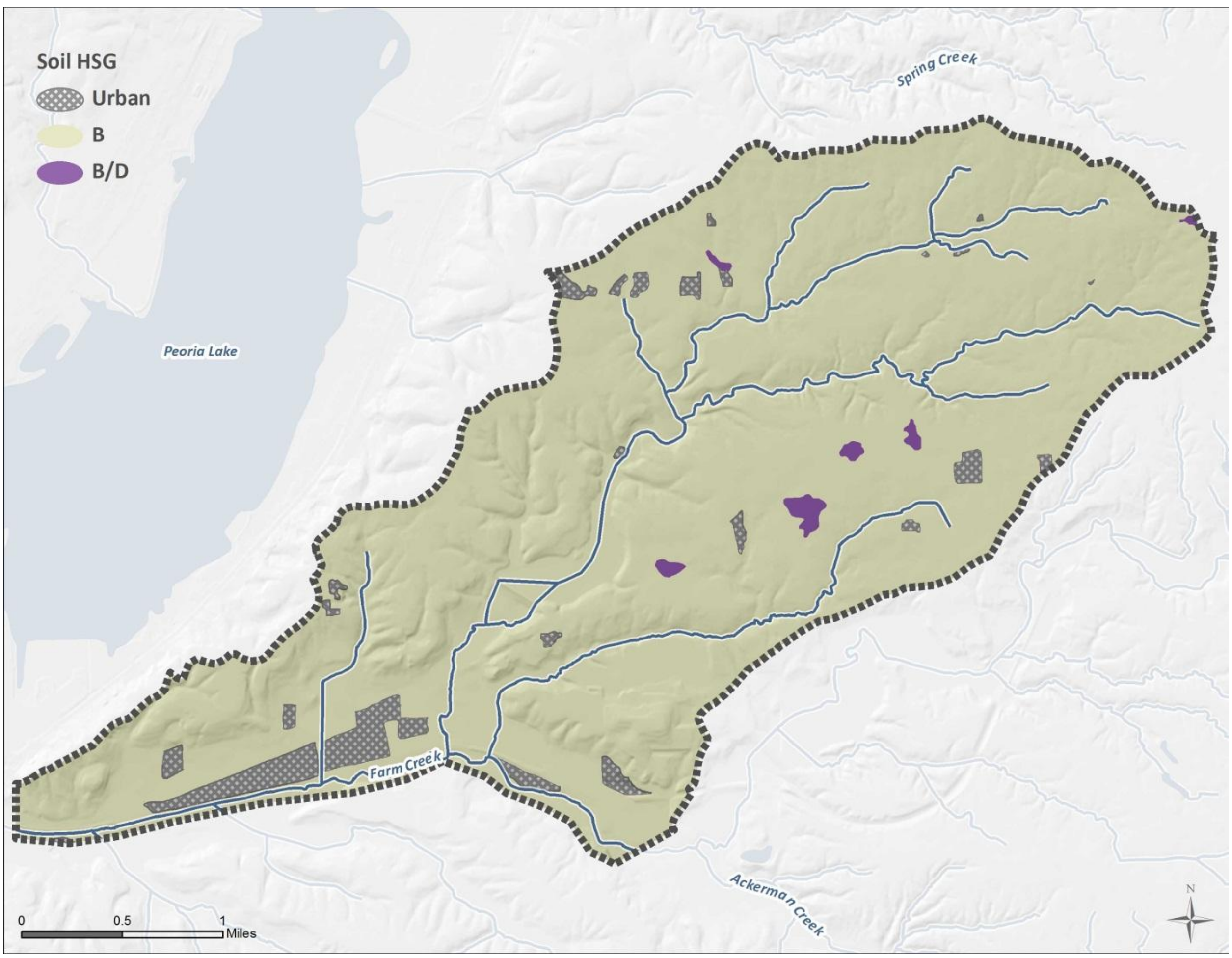

Figure 1. Hydrologic soil groups in the North Farm Creek watershed.

Existing Conditions Model Results

The L-THIA model was run to simulate average annual runoff and pollutant loadings from the North Farm Creek watershed under existing conditions. The L-THIA model has been left uncalibrated. Researchers have noted that predicted runoff is often less than runoff derived from streamflow records (Muthukrishnan et al. 2006). This is due mainly to L-THIA only representing surface runoff while ignoring baseflow contributions to the stream. Other factors including actual antecedent moisture conditions, evapotranspiration, generalized land-cover data, surface topography, and spatial and temporal variability of rainfall can also account for differences in L-THIA predicted runoff and streamflow records. Because the purpose of this study is to evaluate the effect of green infrastructure on pollutant loadings, the relative difference between the predicted current conditions and future conditions with BMPs should not be affected.

Table 3 summarizes the results, while Figure 2 displays the spatial distribution of land cover along with their relative contributions to total area, average annual runoff volume, fecal coliform load, nitrogen load, phosphorus load, and suspended solids load.

Table 3. Summary of area, runoff volume, and pollutant loadings by land cover

Land cover	Area (Acres)	Runoff volume (acre-ft)	Nitrogen (pounds)	Phosphorus (pounds)	Suspended solids (pounds)	Pathogens (millions of coliform)
High Density Residential	588	349	1,729	541	38,953	86,370
Low Density Residential	1,815	359	1,777	556	40,052	88,807
Commercial	76	83	303	72	12,555	7,095
Industrial	99	76	262	58	12,607	9,188
Agriculture	843	240	2,875	849	69,934	77,242
Grass/Pasture	1,542	156	297	4	425	386
Forest	1,282	80	152	2	217	197
Total	**6,245**	**1,343**	**7,395**	**2,082**	**174,743**	**269,285**

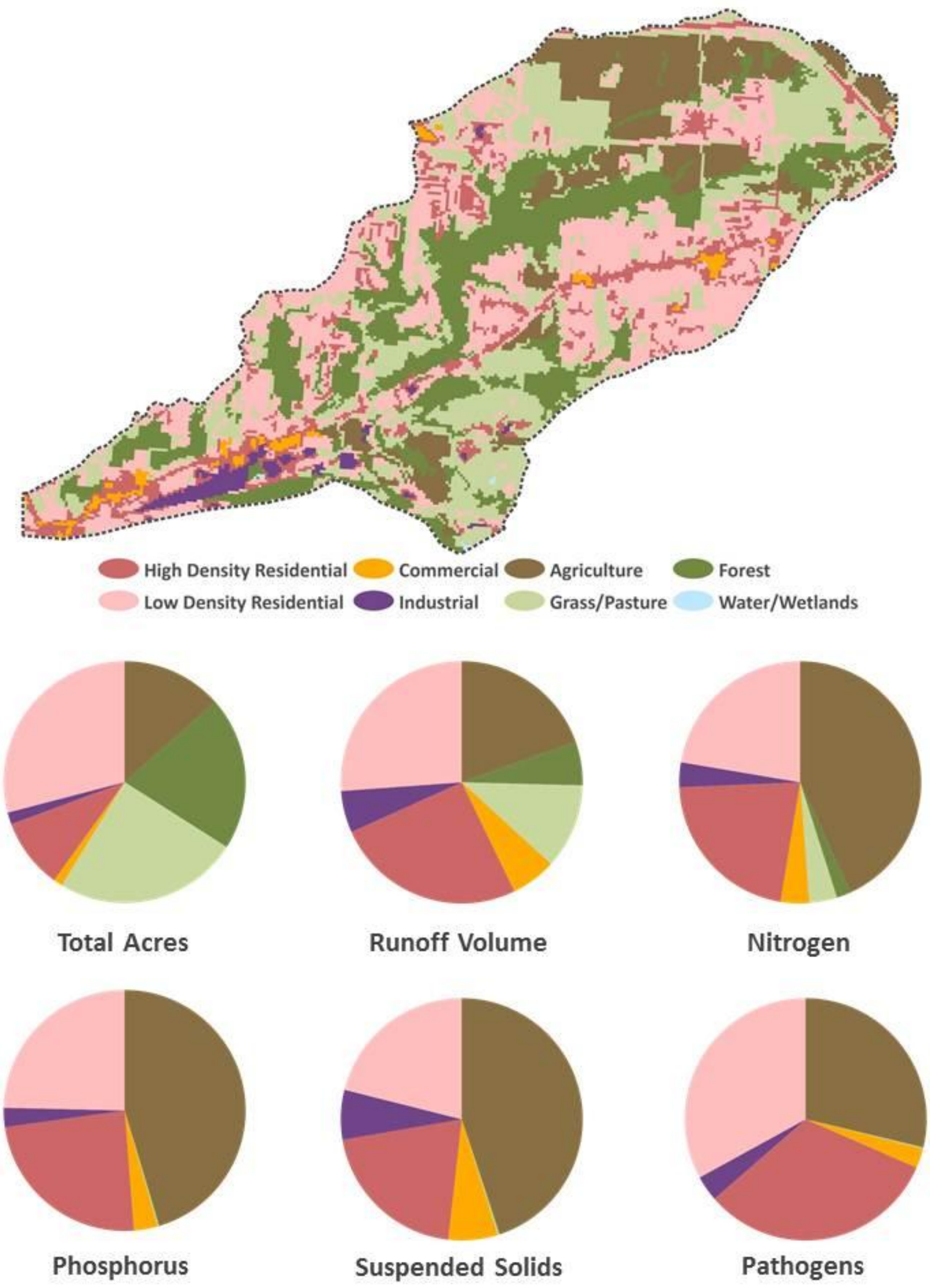

Figure 2. Land cover and total contribution under existing conditions.

Best Management Practices

The L-THIA model is capable of simulating the effects of BMPs on surface runoff for developed land uses using the LID spreadsheet version of the model, L-THIA LID. Green infrastructure BMPs are designed to capture stormwater runoff and allow for its infiltration, storage, and treatment, thereby reducing nonpoint source pollution. The following green infrastructure practices are included in the L-THIA LID model:

- Bioretention (e.g., rain garden)
- Cisterns
- Curb and gutter with porous pavement
- Green roofs
- Natural resource conservation
- Parking with porous pavement
- Rain barrels
- Sidewalks with porous pavement
- Swales
- Swales with porous pavement

A sensitivity analysis was conducted to determine the effectiveness of each BMP within the L-THIA LID model. Hypothetical watersheds of 1,000 acres were modeled for each unique HRU assuming 50 percent of the watershed was converted to LID (Figure 3). Each practice was modeled separately to determine the change in curve number associated with the BMP. The results were compared and the results lead us to the selection of the most effective green infrastructure practices found in Table 4. It should be noted that while parking with porous pavement was the most effective green infrastructure practice for high density residential areas, it was not selected since there are no parking lots in these residential areas. Residential areas with parking lots, such as apartment complexes, are considered part of commercial areas in this analysis.

LID Effectiveness: Low		Medium		High
B type Soils	Curve Number			
LID Practice	HDR	LDR	COM	IND
Nothing	**85**	**70**	**92**	**88**
Curb and gutter & porous pavement	81	68	92	87
Swales	82	69	92	87
Swales and porous pavement	80	68	92	87
Rain Barrels	84	70	91	87
Cisterns	83	69	89	85
Green Roofs	83	69	89	85
Sidewalks with porous pavement	83	70	92	87
Parking with porous pavement (Low)	81	69	80	78
Parking with porous pavement (Medium)	80	69	75	73
Parking with porous pavement (High)	78	69	70	69
Bioretention/raingarden	82	63	91	85
Natural resource conservation	84	69	92	87

Figure 3. Sensitivity analysis - LID effectiveness on B type soils as reduction in curve number.

Table 4. LID practices selected for use in L-THIA LID

L-THIA land use	Most effective green infrastructure practice(s)
High Density Residential	Bioretention/rain garden and Streets with swales with porous pavement
Low Density Residential	Bioretention/rain garden
Commercial	Parking with porous pavement
Industrial	Parking with porous pavement

Note: LID = low impact development.

L-THIA LID Model Results

Four scenarios were used to derive the percentage of LID application in developed areas required to achieve hypothetical target reductions of 10, 20, and 40 percent for runoff volume, sediment, and nutrients. These scenarios model the effects of applying green infrastructure practices to 25, 50, 75, and 100 percent of the developed watershed, ignoring any reductions on agricultural lands. The results of applying green infrastructure practices to the developed land uses within the North Farm Creek watershed if all developed land uses were converted to a LID scenario (Figure 4 through Figure 8); these figures do not include the load associated with non-developed land uses. Table 5 summarizes the maximum runoff volume and pollutant load reductions modeled.

Table 5. Maximum runoff volume or pollutant removal

	Runoff volume (acre-ft)	Nitrogen (pounds)	Phosphorus (pounds)	Suspended solids (pounds)	Pathogens (millions of coliform)
Baseline	867	4,071	1,227	104,167	191,460
100% LID Application	434	2,101	647	49,987	102,704
Percent Reduction from Baseline	50%	48%	47%	52%	46%

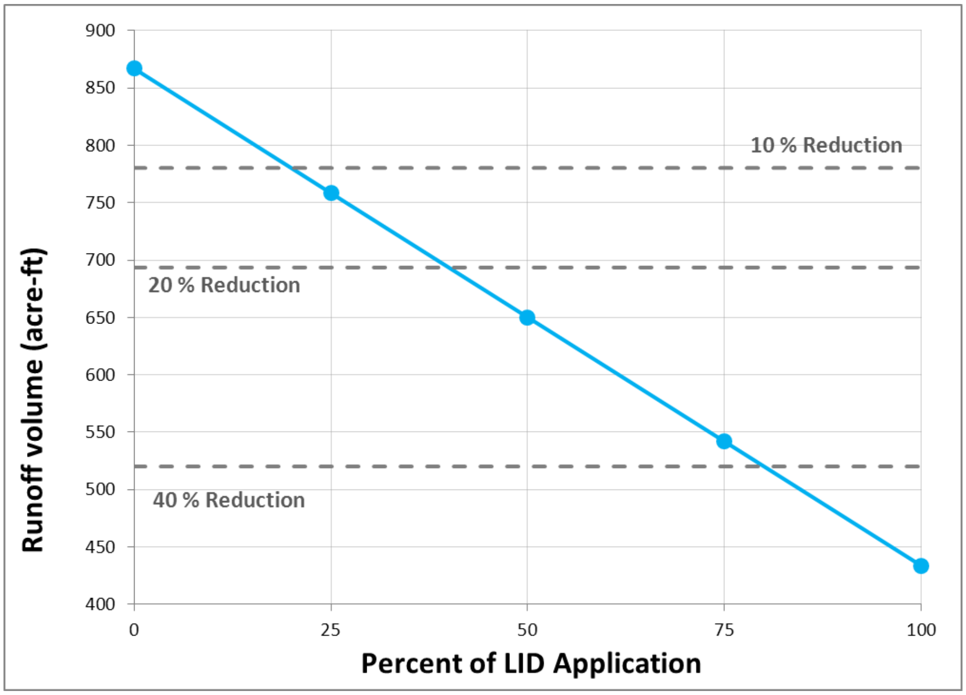

Figure 4. Potential runoff volume reduction at various percentages of LID application.

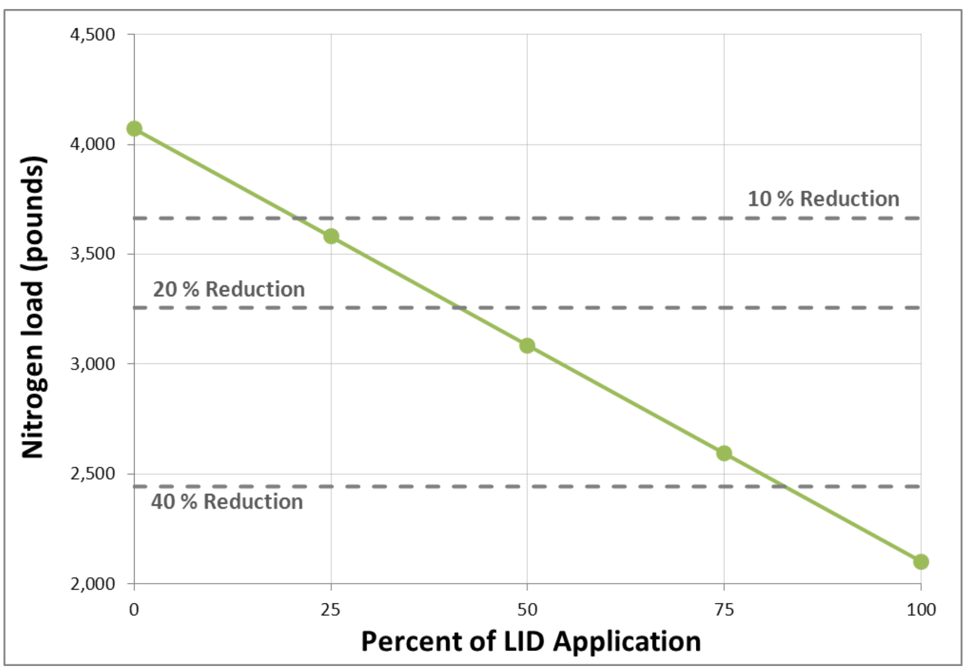

Figure 5.Potential nitrogen load reduction at various percentages of LID application.

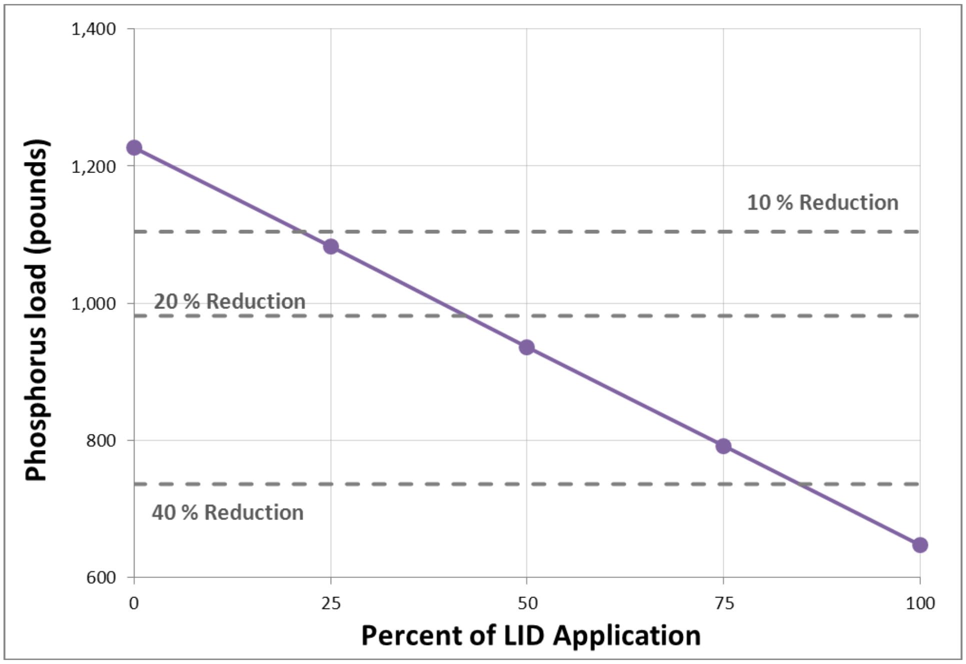

Figure 6. Potential phosphorus load reduction at various percentages of LID application.

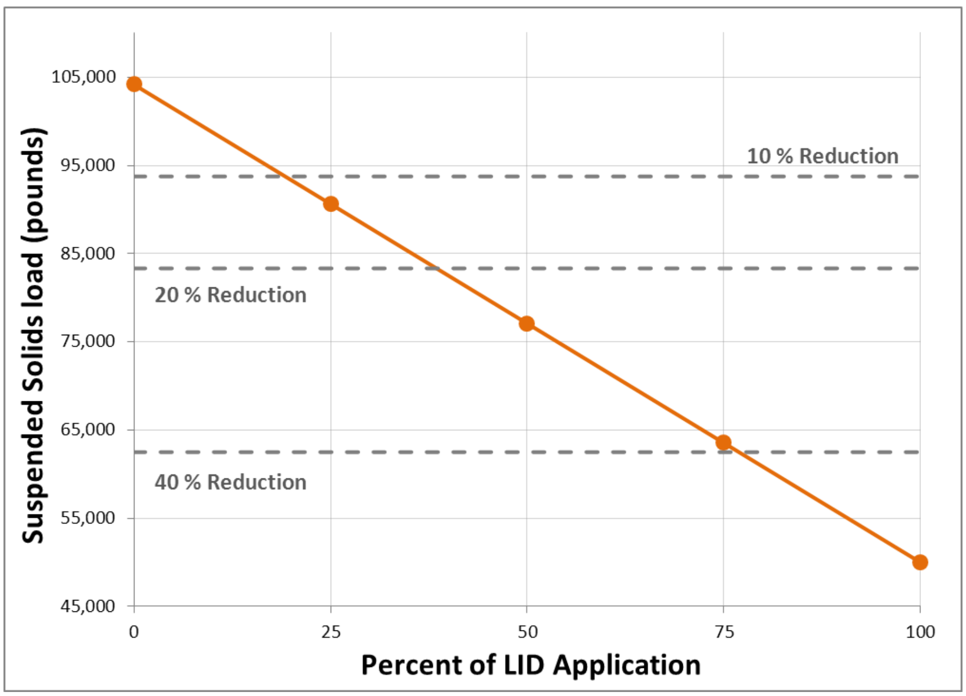

Figure 7. Potential suspended solids load reduction at various percentages of LID application.

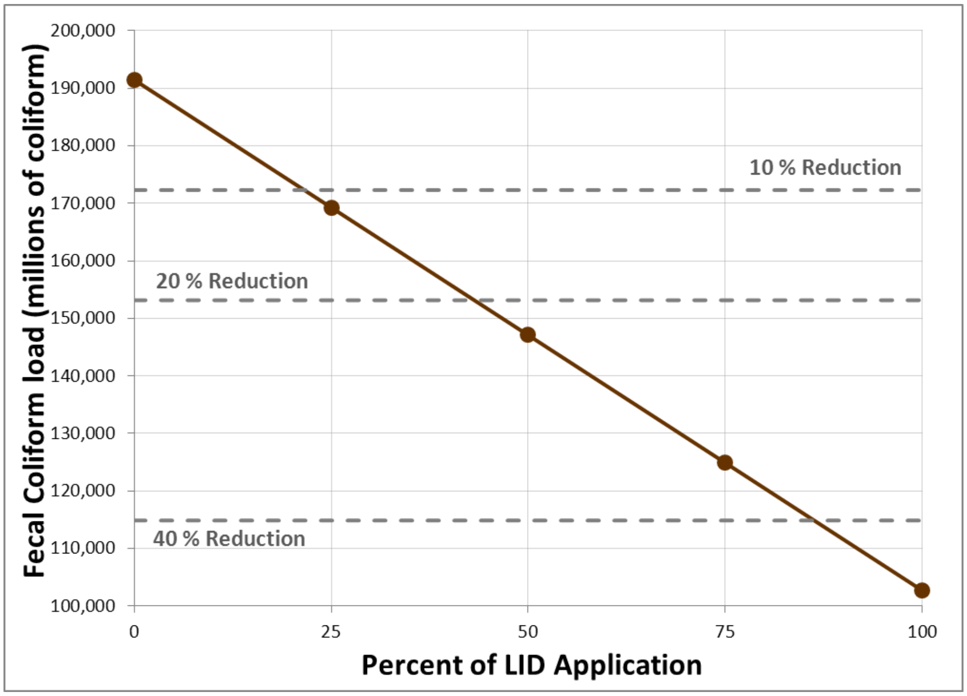

Figure 8. Potential fecal coliform load reduction at various percentages of LID application.

Watershed BMP Costs

The modeling results from L-THIA suggest that LID practices should be applied to the entire North Farm Creek watershed. L-THIA does not provide the size nor the quantity of BMPs assumed for each modeled scenario, however, estimates of various types of impervious cover can be derived from L-THIA. For example, parking lots are assumed to account for 53 percent of commercial land uses, while 26 foot wide streets account for 22 percent of high density residential areas. These values were used to determine the extent of impervious cover types, but the extent of LID practices applied to them were based on the following assumptions:

- Porous pavement is applied to 60 percent of the parking lot area in commercial and industrial areas.
- High density residential streets include two four foot wide porous pavement strips.
- Bioswales are present along 30 percent of the high density residential streets at a width of ten feet and a ponding depth of 0.5 feet. An amended soil is assumed.
- Bioretention/rain garden areas are sized to treat 1-inch of runoff from impervious surfaces with a ponding depth of 12 inches.

BMP lifecycle costs are presented as net present worth in 2012 dollars and include the probable construction costs, annual operation and maintenance, and repair and replacement costs. The lifecycle period was defined as 20-years to take into account costs for replacing some BMPs. No land, administration, demolition, or legal cost factors were defined for any costs.

The following sources were reviewed when defining the lifecycle costs:

- BMP and Low Impact Development Whole Life Cost Models Version 2.0. Water Environment Research Foundation (WERF 2009).
- Lake County Stormwater Management Commission. 2012. Central Permit Facility Fact Sheet.
- Long-Term Hydrologic Impact Analysis Low Impact Development Version - 2.0.

- National Green Values Calculator, Center for Neighborhood Technology (Center for Neighborhood Technology 2009).
- The Cost and Effectiveness of Stormwater Management Practices, University of Minnesota (Weiss et al. 2005).
- Low Impact Development for Big Box Retailers. Prepared for U.S. Environmental Protection Agency (Low Impact Development Center 2005).

Additional Tetra Tech projects and best professional judgment were also considered when defining the range of lifecycle unit costs. Table 6 summarizes the potential costs based on the assumptions above, averaging $31,640 per developed acre. The costs are linear related to the percent of application in the watershed; therefore if 50 percent of the watershed is converted to LID, the cost estimate would be between $33 and $49 Million.

Table 6. Cost estimates for BMP application to 100 percent of the North Farm Creek watershed

Land use	BMP	BMP size (acres)	Lifecycle cost (2012 $/ft^2)	Total cost (2012 $)
Commercial	Parking with porous pavement	24.1	$9 to $13	$9,459,556 to $13,663,804
Industrial	Parking with porous pavement	25.6		$10,041,345 to $14,504,165
High Density Residential	Streets with Porous Pavement	39.8		$15,614,394 to $22,554,125
	Streets with swales	29.9	$8 to $12	$10,409,596 to $15,614,394
	Bioretention/Rain garden	21.1		$7,347,177 to $11,020,766
Low Density Residential	Bioretention/Rain garden	37.8		$13,176,550 to $19,764,825
			TOTAL	**$66 to $97 Million**

Appendix B

Dry Run Tributary Technical Appendix

Appendix B: Dry Run Tributary Technical Appendix

Effective implementation planning starts with a review of baseline conditions and watershed-scale factors that contribute to documented water quality problems. An understanding of the basic hydrology of the watershed is necessary to establish baseline conditions. The water cycle is a natural, continuous process that can be generalized as the movement of rainfall from the atmosphere to the land, then back to the atmosphere. The balanced water cycle of precipitation, evapotranspiration, infiltration, groundwater recharge, and stream base flow is a key part of sustaining fragile water resources (Figure 1). When identifying and establishing baseline conditions, a critical part of the analysis involves an assessment of watershed characteristics that affect the resultant runoff. Source areas and delivery mechanisms that will be the focus of targeted BMPs are driven by watershed response to precipitation.

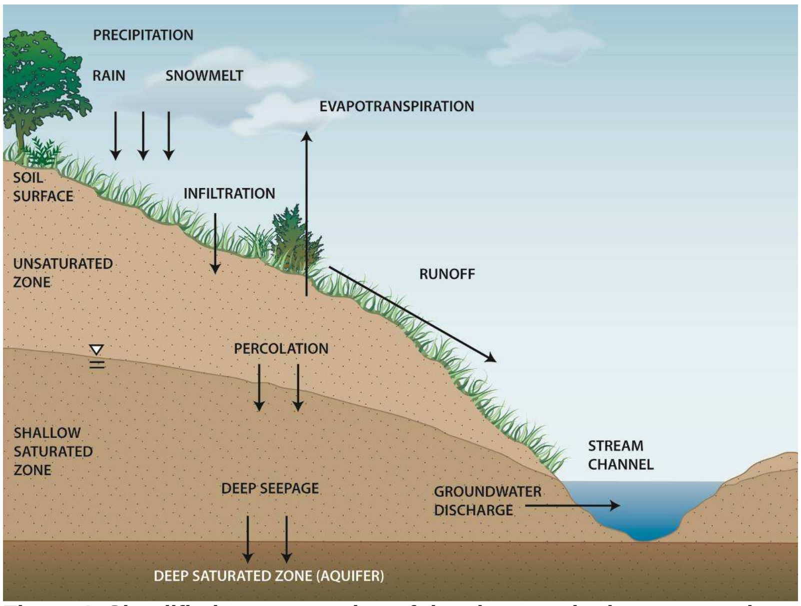

Figure 1. Simplified representation of the elements in the water cycle.

Modeling was used to help establish baseline conditions. Watershed models use site-specific spatial and temporal elements to characterize the rainfall runoff response. The watershed model time series represent the existing condition (or baseline conditions), which serves as the reference point from which stormwater improvement will be measured.

Baseline Conditions

There are a wide variety of models available that have been used to assist stormwater management activities with describing runoff patterns. Modeling approaches can range from simple to complex. The Dry Run Tributary watershed was modeled and evaluated using the Best Management Practice Decision Support System (BMPDSS). BMPDSS was developed by Tetra Tech for Prince George's County, Maryland and is the pre-cursor to the EPA's System for Urban Stormwater Treatment and Analysis Integration (*SUSTAIN*) model. The BMPDSS system is a decision-making tool for placing BMPs at strategic locations in urban watersheds on the basis of integrated data collection and hydrologic, hydraulic, and water quality modeling. BMPDSS can be applied to analyze the overall performance of multiple BMPs and find an optimal solution for their implementation. BMPDSS can provide assessment of both distributed (including LID-type) and centralized BMPs in combinations and can support selection of the optimum plan that maximizes benefits and leads to significant cost savings. This quantitative approach can provide assurance to stormwater managers and regulators that goals or TMDL reduction requirements are achievable and practicable, thereby ensuring that investments in selected BMPs are justified. Hourly rainfall runoff time series are required as input to BMPDSS and were generated using Loading Simulation Program in C++ (LSPC). LSPC is a re-coded version of the Hydrologic Simulation Program in Fortran (HSPF) watershed model. LSPC provides a comprehensive watershed and receiving water quality modeling framework that is generally considered one of the most advanced available. The current version of LSPC is version 3.1 and is available for download at http://www.epa.gov/athens/wwqtsc/html/lspc.html.

The Dry Run Tributary watershed has been delineated into subwatersheds and land uses have been further classified (Figure 2 and Figure 3).

Runoff and Pollutant Load Timeseries

The BMPDSS model requires unit-area runoff and pollutant load time series for each hydrologic response unit (HRU) represented in the model. These time series are input from standard ASCII text files and can be generated by a number of publically available rainfall-runoff or watershed models including Storm Water Management Model (SWMM), Hydrologic Simulation Program FORTRAN (HSPF), Loading Simulation Program C++ (LSPC), Urban Catchment Model Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds (P8-UCM), and Soil and Water Assessment Tool (SWAT) as well as a numerous proprietary models which are often used by municipal entities. Using the external ASCII file format provides the flexibility for output from any existing rainfall-runoff, watershed, or other model to be pre-processed and used as a foundation for BMP simulation within the BMPDSS framework. A primer on watershed models, including pros and cons, can be found in EPA's *Compendium of Watershed-Scale models for TMDL Development.*

For the Dry Run Tributary watershed pilot, the LSPC watershed model was used to generate these runoff and pollutant loading time series. LSPC uses many of the algorithms found in HSPF with several key structural updates to enhance organization, results post-processing, and output visualization. This section discusses the development of runoff and pollutant loading time series that will be used to drive the BMPDSS model. The time series development process includes the steps of:

- Climate data representation (precipitation, temperature, evapotranspiration, etc.)
- Hydrology simulation
- Water quality representation

Unit-area time series are processed which represent the runoff and pollutant loading from four HRUs including (1) urban pervious (2) non-residential urban impervious (3) residential urban impervious and (4) forest.

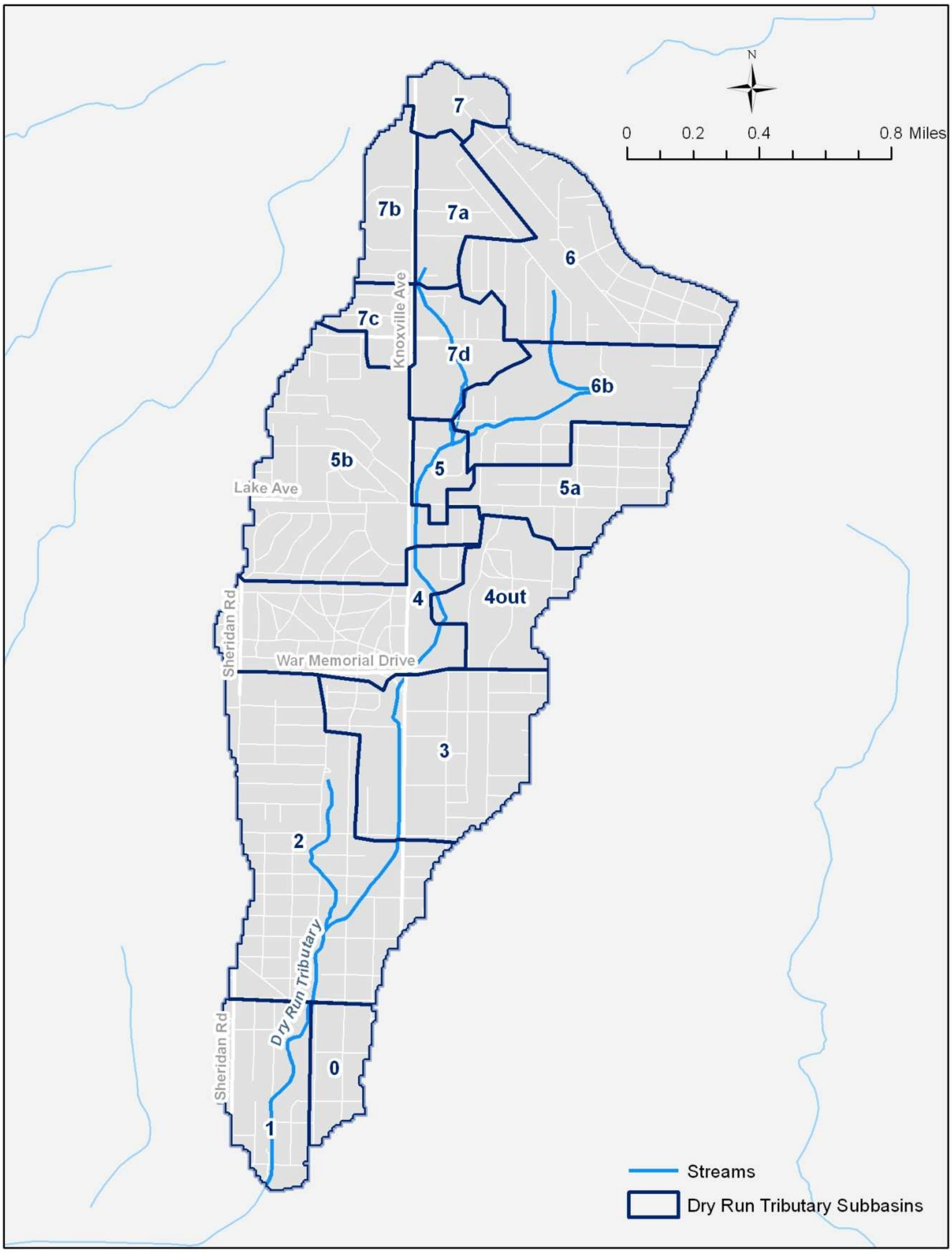

Figure 2. Dry Run Tributary subwatersheds.

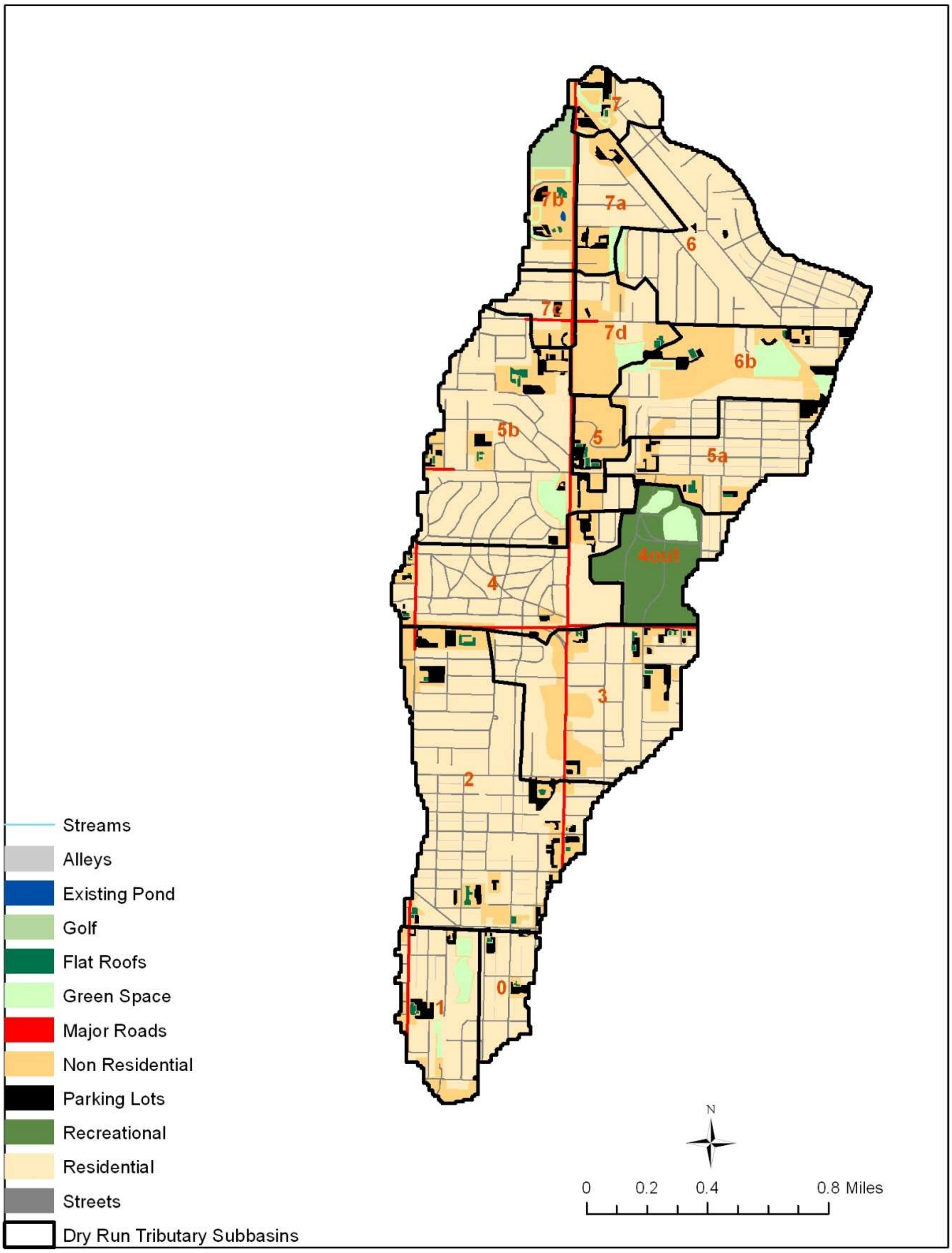

Figure 3. Dry Run Tributary watershed land uses.

Climate Representation

The LSPC model is driven by precipitation and other meteorological data including air and dew point temperature, potential evapotranspiration, cloud cover, wind speed, and solar radiation. Of these, the most critical inputs are precipitation, air temperature, and potential evapotranspiration. These data were represented on an hourly time-step to allow the model to better predict hydrologic responses. A variety of meteorology data from various sources are available for the Peoria metropolitan area. A summary of the available data used for this study area presented in Table 1. Precipitation and daily temperature used for this study are collected at the Peoria GTR Airport (COOPID 116711). Hourly temperature and the remaining parameters listed in Table 1 are available at the Rockford Greater Rockford Airport (WBAN 14842).

Table 1. Summary of available climate parameters by source

(●) - Primary data source **(♦) - Computed from primary data** **(-) - Not available**	**Precipitation**	**Temperature**	**Dew point**	**Wind speed**	**Cloud cover**	**Potential evaporation**	**Solar radiation**
NCDC Summary of Day (SOD)	●	●	-	-	-	-	-
NCDC Unedited Web	●	●	●	●	●	♦	♦
NCDC Surface Airways [a]	●	●	●	●	●	♦	♦

a. Available from the EarthInfo, Inc. data product through 2005.

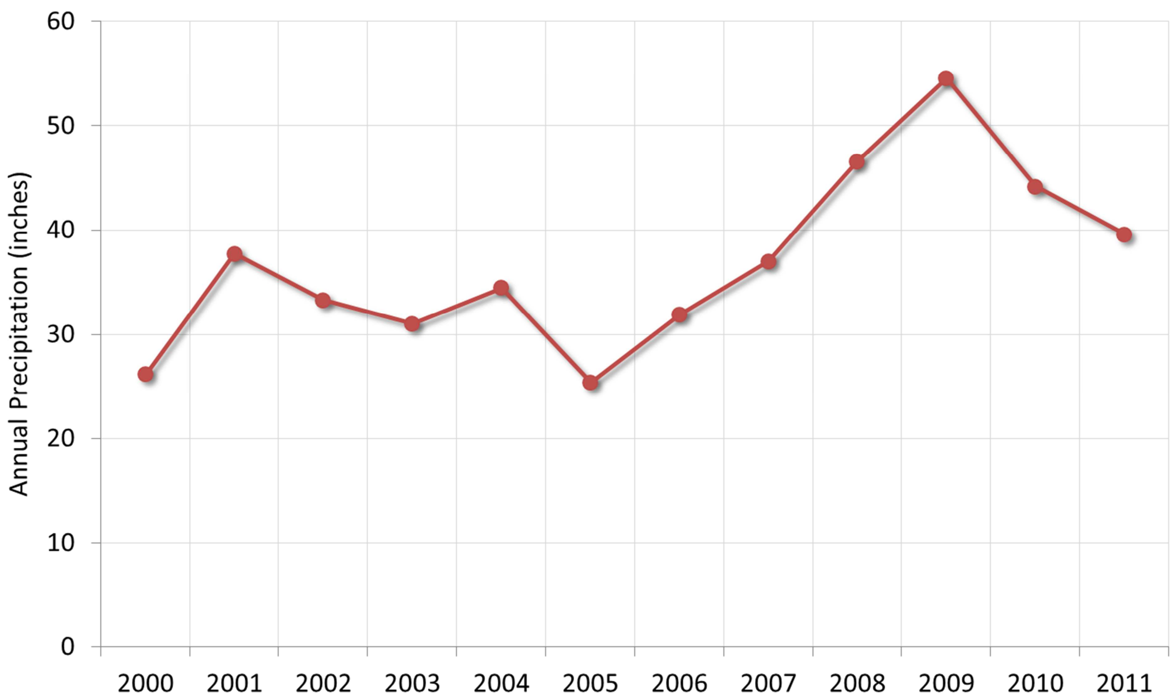

Figure 4. Total Precipitation at PEORIA GTR PEORIA AP (116711), 1990-2011.

Runoff and Water Quality Time Series Development

In the absence of site-specific monitoring data, the ability to perform a model calibration in the traditional sense is lost; however, with guidance from spatial datasets and other local studies a series of reasonable assumptions can be made which make the model realistic and provides for valuable insight of the physical system. For the Dry Run Tributary LSPC pilot model, hydrology will be assessed for each HRU by calculating a runoff coefficient. Water quality representation will be assessed by comparing modeled annual loads against locally-cited literature values of export coefficients. A 10 year modeling period of October 1, 2001 through September 30, 2011 was used to provide a distribution of dry, average and wet years for model evaluation.

To assess the relative magnitude of model assumptions, a set of six, 1 acre subwatersheds were modeled using a mix of urban pervious, urban impervious (residential and non-residential), and forest land uses as presented in Table 2.

Table 2. Model land use compositions used for time series development and evaluation (USDI 2012)

Land use description	Urban impervious (non-residential)	Urban impervious (residential)	Urban pervious	Forest
Parking Lot	100%	0%	0%	0%
Commercial	90%	0%	10%	0%
Medium Density Residential	0%	50%	50%	0%
Low Density Residential	0%	20%	80%	0%
Parks	10%	0%	60%	30%
Forest	0%	0%	0%	100%

Hydrology

In the LSPC watershed model, runoff is controlled by parameters representing the surface and subsurface characteristics of land segments. These parameters describe physical features of the land such as topography, slope, and hydrologic soil group. The most sensitive parameters include the infiltration index (INFILT), interception storage (CEPSC), slope (SLSUR), roughness coefficient (NSUR). INFILT controls the rate at which water moves from the surface to the subsurface. CEPSC is the depth of water that is captured on the land surface and made available for evaporation. SLSUR is the average slope of the land surface which affects the magnitude of peak runoff. NSUR describes the roughness, (resistance to flow) of the land surface and is a function of the type of cover. Several other parameters are sensitive when modeling pervious and other natural conditions; however, the parameters discussed above are dominant in urban settings.

For calibration purposes, four land use categories were configured in LSPC representing (1) urban pervious (2) residential urban impervious (3) non-residential urban impervious, (4) and forest. Each of these land use categories was parameterized in LSPC to reflect the range of typical surface and subsurface characteristics (USEPA 2000). Annual average runoff over the period from October 1, 2001 through September 30, 2011 was then summarized and compared to the annual average precipitation over the same period for the land uses presented in Table 2. The results of this analysis are presented below as Figure 5.

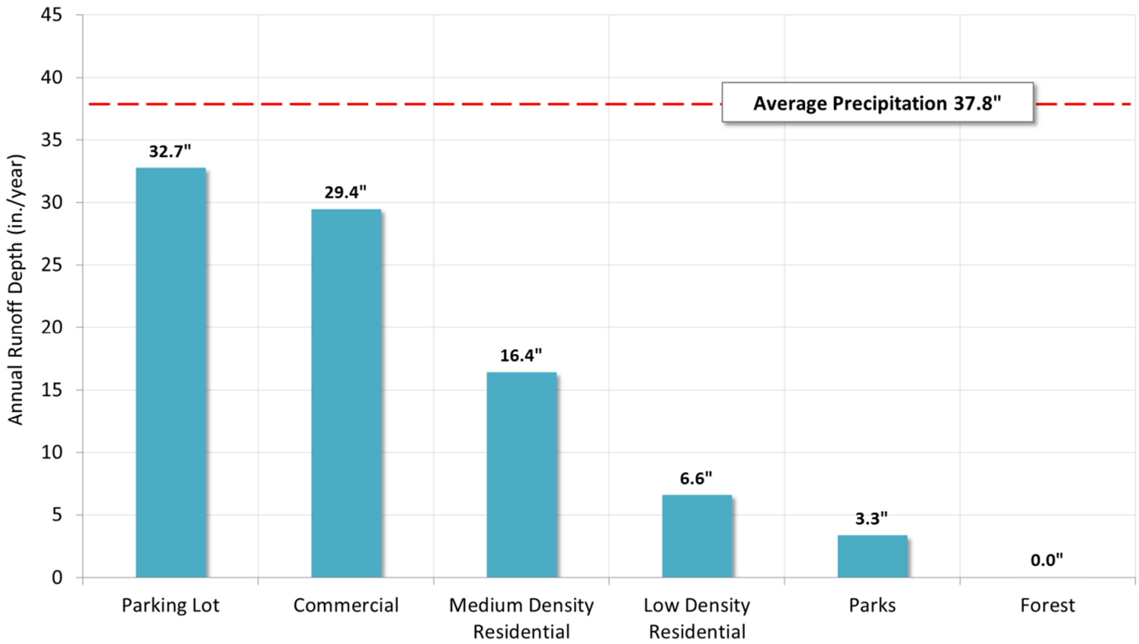

Figure 5. Summary of average annual runoff depth by land use category (10/1/2001 through 9/30/2011).

While no site-specific flow data is available for formal calibration, Figure 5 shows the relative magnitude of runoff off the six land uses presented in Table 2 which included a varying mixes of pervious and impervious land.

Water Quality

Water quality was represented within the LSPC model by land use using a set of event mean concentration (EMC) values for total suspended sediment (TSS), total phosphorous (TP), total nitrogen (TN) and Fecal Coliform indicator bacteria. During model simulation, EMCs are applied only during periods with surface flow from the respective land use. The EMC values used in the LSPC model are presented in Table 3 and were derived from the L-THIA application.

Table 3. Event mean concentrations by land use (derived from L-THIA model)

Constituent	Residential	Commercial	Forest
TSS (mg/l)	41.0	55.5	57.9
TP (mg/l)	0.57	0.32	0.35
TN (mg/l)	1.82	1.34	1.57
Fecal Coliform (#/100 ml)	15,161	8,680	3,28

The model's ability to represent pollutant loading of various constituents was evaluated by comparing annual average modeled loads against locally-derived export coefficients Using the previously discussed hydrology representation and EMCs presented in Table 3. A literature review was performed that summarized literature-based export coefficients for TSS, TN, TP which are expressed as pounds/acre/year. Target export coefficient values by land use were used to validate the annual average model export coefficients based on simulations from 10/1/2001 through 9/30/2011 (Burton 2002). Plots of modeled vs. literature based export coefficients by land use are presented in Figure 6 through Figure 8. The modeled unit-area loads compare well with export coefficients found during literature review and follow the relative distribution across land uses similar to the runoff coefficients presented in Figure 5.

The water quality results are further summarized as unit-area loads and mapped spatially by subwatershed to identify 'hot spots' or other areas of increased pollutant generation (Figure 9).

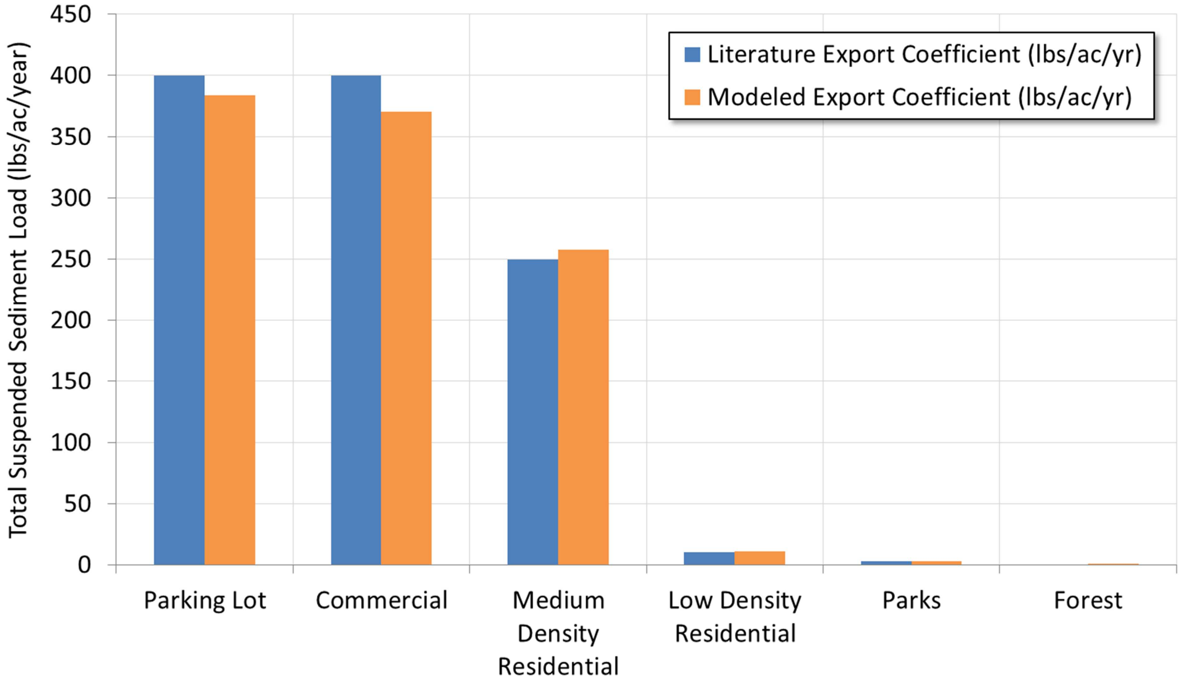

Figure 6. Modeled vs. literature based Total Suspended Sediment export coefficients by land use (10/1/2001 through 9/30/2011).

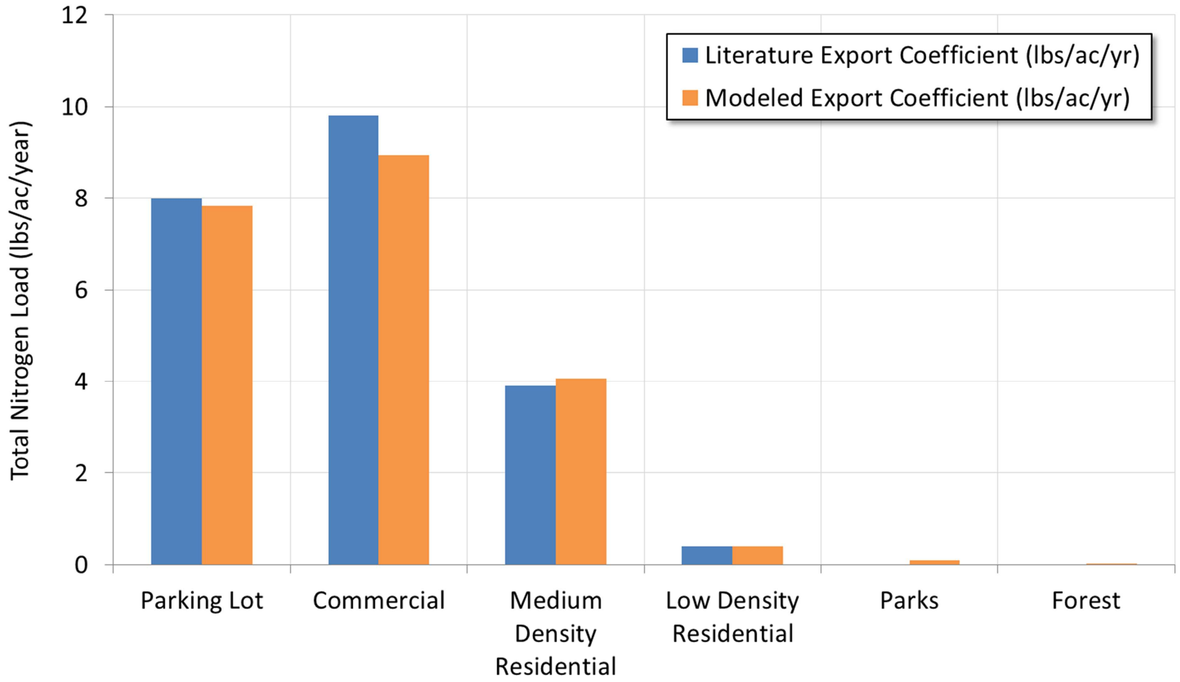

Figure 7. Modeled vs. literature based Total Nitrogen export coefficients by land use (10/1/2001 through 9/30/2011).

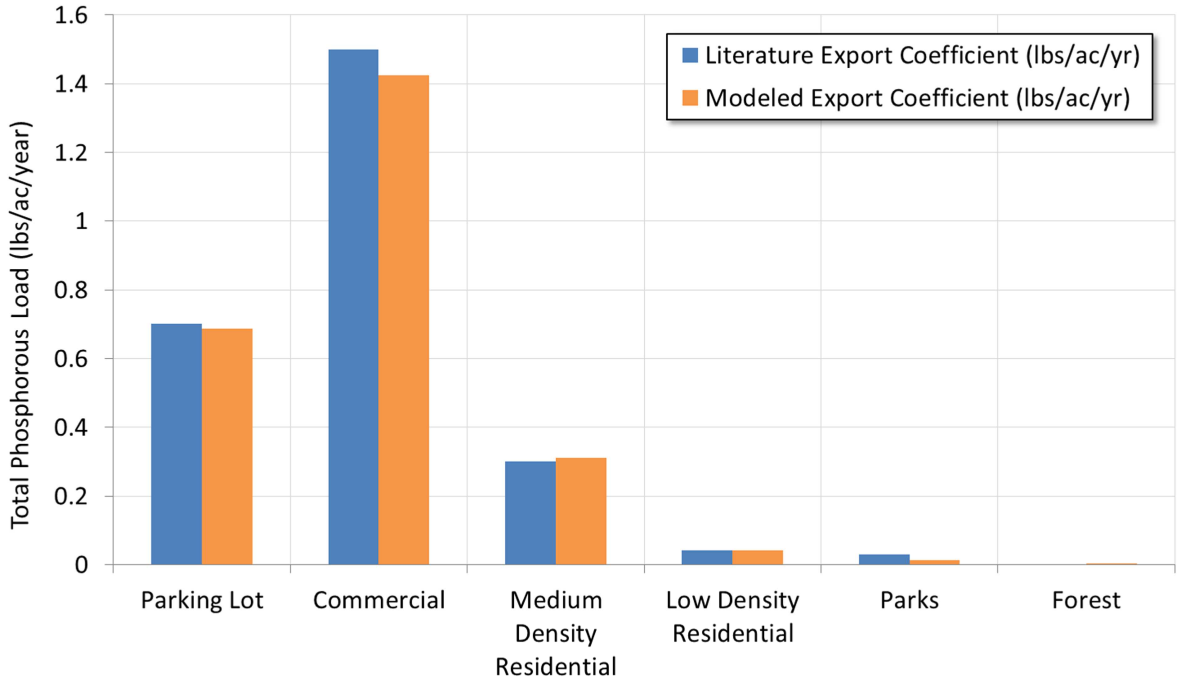

Figure 8. Modeled vs. literature based Total Phosphorous export coefficients by land use (10/1/2001 through 9/30/2011).

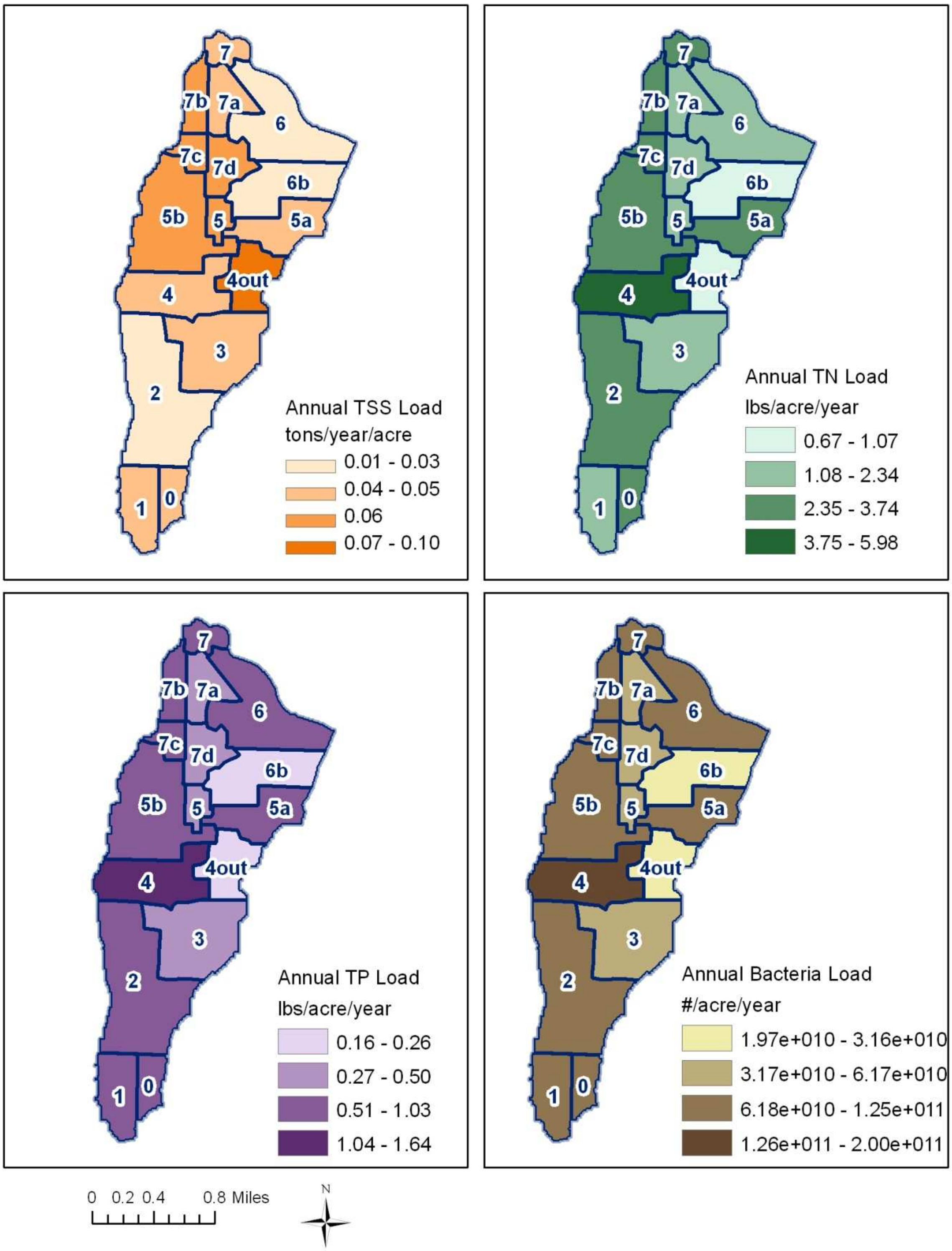

Figure 9. Water quality model results.

Best Management Practices

BMPs for the Dry Run Tributary pilot area were selected based upon the characteristics of the watershed, land uses, and soils conditions. The selection of BMPs is dependent upon the suitability of the BMPs for each area based upon site conditions and performance goals. Soils in this watershed are assumed to be fairly permeable, therefore practices which promote infiltration were included. Examples of some of the BMPs that can be modeled in BMPDSS include bioretention, rain barrels, ponds, porous pavement, and green roofs.

The following BMPs were considered for this pilot area:

- Bioretention (bioswale/pond)
- Rain garden
- Porous pavement
- Rain barrel
- Green roof

Each of the BMPs was evaluated for applicability in the pilot area on the basis of a review of aerial imagery and field reconnaissance. Candidate locations were selected according to available land area and proximity to sources of runoff and pollutants. Design assumptions for the BMPs were compiled from various design manuals and based on experience. Lifecycle costs, including operation and maintenance, were used to evaluate the economics of the various BMPs.

Bioretention

Bioretention facilities are designed to capture and retain runoff from local paved roads, driveways, and the front half of parcels as well as commercial areas. Bioretention facilities can be linear features constructed adjacent to roadways, small ponding areas in the form of curb bump outs, or larger ponding areas. Potential locations for bioretention were identified through aerial imagery analysis. There are limited areas within the residential areas to place bioretention due to small front yards. The area modeled for bioretention facilities includes one street in each modeled subbasin, with an average width of four feet. In addition, bioretention facilities are included in most of the commercial and institutional properties.

Figure 10. Linear bioretention example.

Bioretention facilities are sized according to the available land area and are assumed to encompass up to 25 acres of the watershed. Bioretention facilities are designed for one-half to one foot of ponded depth and 1.5 feet of plant and soil media. The BMPs can treat up to 93 acres of impervious and 102 acres of pervious surfaces.

Rain Garden

Rain garden areas are assumed to be located in front yards of residential areas and are designed to serve runoff from the surrounding area throughout all residential areas. One-half of the roof and one-half of the front yard are assumed to be routed to each rain garden. Driveways are also routed to rain gardens through a trench drain at the bottom of the driveway, thereby capturing this impervious area prior to discharging into the road.

Rain gardens are assumed to be constructed and maintained by the homeowner with little costs associated with design. A two foot soil amendment is assumed with no underdrain. Front yard size was considered when setting the rain garden area (150 square feet). It is assumed that a maximum of 25 percent of homes in the residential area could be served by rain gardens in combination with a rain barrel. A total of 256 acres (200 impervious acres and 56 pervious acres) could be treated by rain gardens.

Porous Pavement

Porous pavement was assumed to be applicable throughout the pilot area for both roads in the residential areas and parking lots in commercial areas. The modeled porous pavement design for streets includes two strips of porous pavement, each four feet wide and located along both sides of the curb (Figure 11). An underdrain is included two feet below the pavement. The contributing drainage area includes the pavement itself, driveways, and contributing roof and urban lawn areas. Porous pavement would treat up to 106 acres in the watershed (11 pervious acres, 95 impervious acres). It is assumed that the front yards of residential areas drain to the street. Roads are delineated using GIS, and driveway areas are estimated using a representative number of homes in each of the residential BMP areas.

Figure 11. Porous pavement example.

Porous pavement can also be used effectively in parking lots. Sixty percent of each paved parking lot was considered for porous pavement installation, which assumes that driving lanes remain asphalt or concrete and the parking spots are made permeable. All parking lots are assumed to have underdrain systems. The drainage area is represented by the entire parking lot area.

Rain Barrel

Rain barrels provide for storage of runoff. Following rainfall events, the water stored in rain barrels and cisterns can be used for irrigating vegetation. Rain barrels are typically applied in residential areas. It was assumed that up to 25 percent of homes in the residential area could be retrofitted with up to two rain barrels. All homes that contain a rain garden are assumed to have a rain barrel. The rain barrel capacity at any point during the simulation is a function of the amount of water released after a previous event. If rain barrels are filled to capacity, back-to-back precipitation events can show bypass, with no rain barrel benefit. During cold-weather conditions, the rain barrels are assumed to be disconnected from rooftop downspouts. The standard size of rain barrels used in this analysis is 55 gallons, with a maximum of two units per home. The drainage area to each rain barrel is assumed to be equal to one-quarter of the roof area (326 square feet).

Figure 12. Rain barrel example.

Green Roof

Green roofs can typically be placed on any flat roof surface, assuming the roof can support the additional weight. Potential green roof locations were identified throughout the watershed using aerial photography.

It was assumed that flat roofs would have the structural support necessary to carry a green roof, which results in an overestimation of the maximum potential area suitable for green roofs. The drainage area to green roofs is assumed to include the entire roof surface. An extensive green roof was assumed.

BMP Configuration and Performance

BMPs are simulated in BMPDSS according to design specifications, with the performance modeled using a unit-process parameter-based approach. That contrasts with and has many advantages over most other techniques that simply assign a single percent effectiveness value to each type of practice. BMPDSS predicts BMP performance as a function of its physical configuration, storm size and associated runoff intensity and volume, and moisture conditions in the BMP.

The objective of this effort was to identify combinations of practices that maximize runoff volume reduction while minimizing the lifecycle cost of the associated group of BMPs. The analysis assumes that all rain gardens and rain barrels are implemented. To run the optimization analysis, a set of decision variables was identified to explore the best possible combinations of the various BMP practices. For this analysis, the decision variables consisted of the surface area of bioretention, porous pavement, and green roof.

Because the decision variable values can range anywhere between zero to a maximum number or size, it is possible for one component to never be selected if it is not cost-effective toward achieving the objective. Table 4 summarizes the maximum extent of each practice determined through aerial photography analysis, field reconnaissance and on the basis of best professional judgment. Those values define the upper boundary of the optimization search space. Figure 13 illustrates the maximum spatial distribution of potential BMPs modeled in the watershed and Figure 14 further defines the possible BMP placement within an example subwatershed. The location of BMPs is used as a guide only to determine their applicability; actual implementation will need to take into account many other variables including property ownership. The physical configuration data and infiltration parameters for each BMP component are listed in Table 5.

Table 4. Maximum extent of BMPs

BMP	Maximum BMP extent (unit or acre)	Maximum drainage area (acres)
Rain Garden (unit)	1,022 (3.5 acres)	256
Rain Barrel (unit)	2,044	15
Bioretention (acres)	25	195
Porous Pavement Roads (acres)	3	45
Porous Pavement Parking Lots (acres)	37	61
Green Roof (acres)	10	10

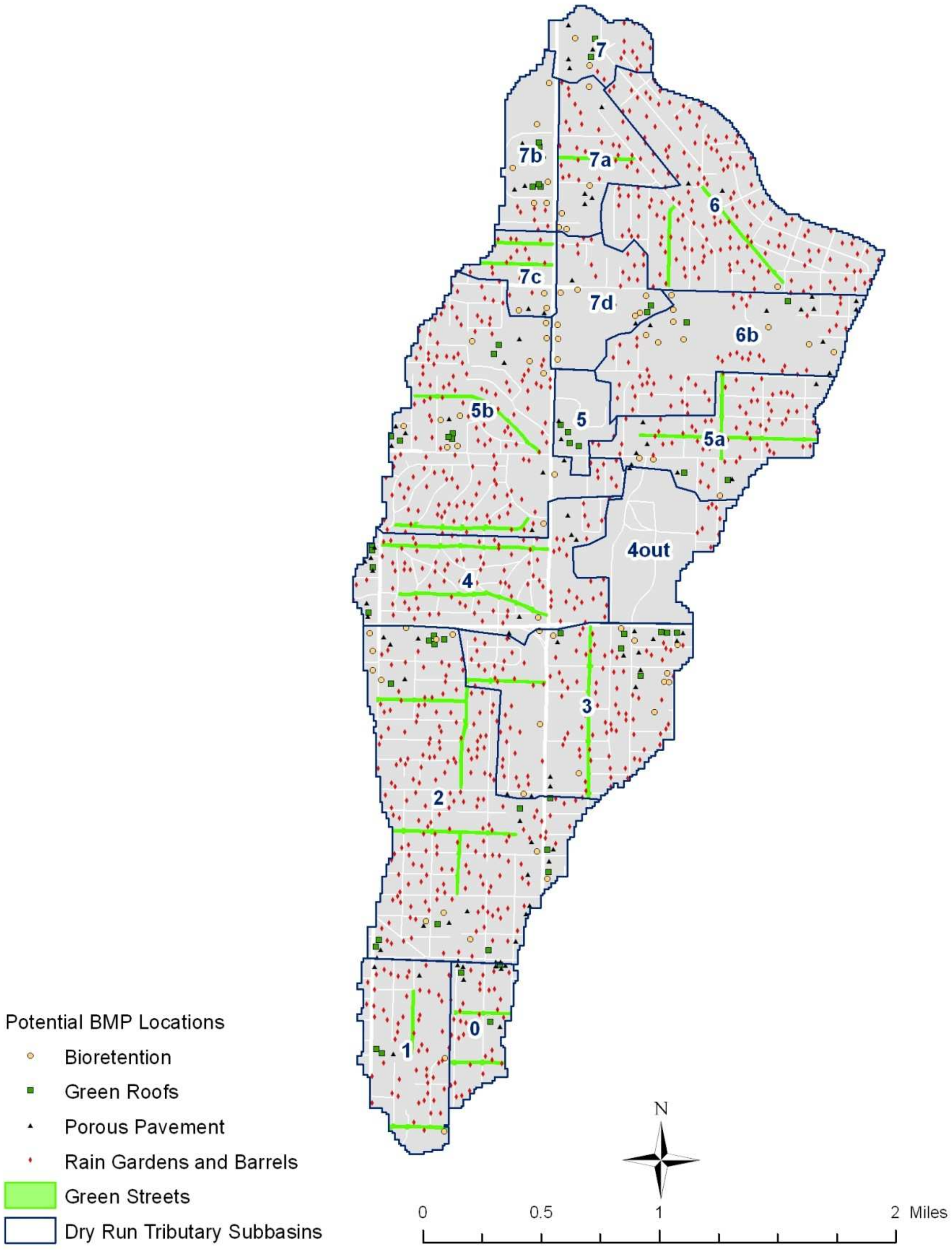

Figure 13. Modeled BMPs.

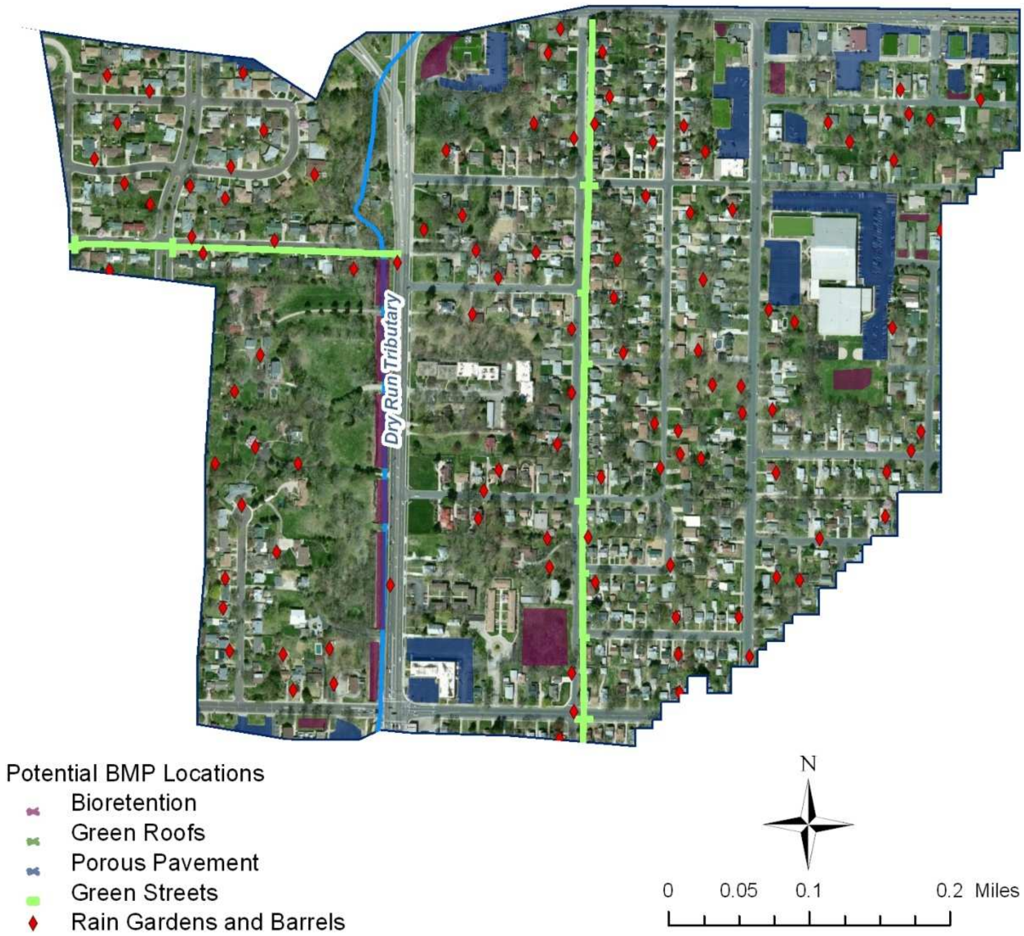

Figure 14. Subwatershed 3, conceptual BMP placement.

Table 5. BMP configuration parameters

Parameter	Rain barrel (unit)	Rain garden (unit)	Bioretention (acres)	Porous Pavement Parking Lots (acres)	Green Roof (acres)
Physical Configuration					
Unit size	55 gal	150 ft2	N/A	N/A	N/A
Design drainage area (square feet)	326	493 Pervious, 1,717 Impervious	N/A	N/A	N/A
Substrate depth (ft)	N/A	1.5	1.5	2	0.67
Underdrain storage depth (ft)	N/A	N/A	NA	2	0.1
Ponding depth (ft)	N/A	0.5	0.5 - 1	0.1	0.1
Infiltration					
Substrate layer porosity	N/A	0.4	0.4	0.45	0.4
Substrate layer field capacity	N/A	0.25	0.25	0.055	0.4
Substrate layer wilting point	N/A	0.1	0.1	0.05	0.1
Underdrain gravel layer porosity	N/A	NA	NA	0.5	0.5
Vegetative parameter, A	N/A	1	1	1	0.6
Background infiltration rate (in/hr)	N/A	0.5	0.5	0.5	N/A
Media final constant infiltration rate (in/hr)	N/A	0.5	0.5	1	1
Net Present Worth LIFECYCLE COSTS ($/sq foot or $/unit)	$165	$1,500	$10	$11	$45

Infiltration parameters were determined on the basis of the assumed soil substrate. The background infiltration rate refers to the infiltration rate of the native soils below the engineered media and varies dependent upon the predominant hydrologic soil group within each subwatershed. The vegetative parameter, or the percent vegetative cover, and wilting point values were provided by Tetra Tech, Inc. (2001). Wilting point is defined as the minimal soil moisture required to prevent vegetation wilting.

BMP lifecycle costs are presented as net present worth in 2012 dollars and include the probable construction costs, annual operation and maintenance, and repair and replacement costs. The lifecycle period was defined as 20-years to take into account costs for replacing some BMPs. No land, administration, demolition, or legal cost factors were defined for any costs.

The following sources were reviewed when defining the lifecycle costs:

- *BMP and Low Impact Development Whole Life Cost Models Version 2.0*. Water Environment Research Foundation (WERF 2009).
- Lake County Stormwater Management Commission. 2012. *Central Permit Facility Fact Sheet*.
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- National Green Values Calculator. (Center for Neighborhood Technology 2009).

- *The Cost and Effectiveness of Stormwater Management Practices*, University of Minnesota (Weiss et al. 2005).
- *Low Impact Development for Big Box Retailers. Prepared for U.S. Environmental Protection Agency* (Low Impact Development Center 2005).
- *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (USEPA 2003).

Additional Tetra Tech projects and best professional judgment were also considered when defining the range of lifecycle unit costs.

BMPDSS Model Results

The objective of the Dry Run Tributary BMPDSS model run was to evaluate feasible reductions in annual flow volume using the previously described suite of management practices and evaluate the secondary benefits of pollutant reduction (TSS,TN, TP and bacteria) with respect to the Middle Illinois River watershed TMDL and LRS study. In assessing the study objectives, this analysis will:

- Represent the maximum implementation of residential rain barrels and rain gardens
- Develop a trade-off curve of cost and average annual volume reduction evaluating opportunity for four additional BMP types by subwatershed
- Identify solution(s) of interest on the trade-off curve from which to evaluate specific BMP selections by practice and subwatershed
    - Solution #1 - Maximum implementation of rain barrels and rain gardens (Table 4)
    - Solution #2 – Inflection point of the BMP trade-off curve (includes bioretention, porous pavement, and green roofs)
    - Solution #3 – Inclusive of both Solution #1 and Solution #2

Runoff and pollutant loading time series generated with the LSPC watershed model, described previously, were used as the boundary condition for the BMPDSS model. Rather than just producing a single model simulation, BMPDSS employs a scatter search algorithm to gather information from a series of model runs to arrive at a near-optimal set of solutions. For the sake of efficiency, it is often prudent to limit the modeling scope to a period of time representative of a critical condition (ie. low flow, high flow, average precipitation). For this study, a simulation period of October 1, 2005 through September 30, 2008 was selected to represent a sequence of below average, average, and above average precipitation years (see Figure 4).

Trade-off Curve

Figure 15 shows the average annual stormwater runoff volume reduction trade-off curve for the Dry Run Tributary watershed as a result of running the BMPDSS model for the three year representative period. In this figure, the small points represent all solutions that were evaluated during the scatter search, while the larger points shown in clusters along the left-and-upper-most perimeter represent least cost options identified by the scatter search with respect to achieving annual volume reduction. The maximum achievable volume control through the use of all potential trade-off curve practices (excluding rain barrels and rain gardens) within the study area is just over 28 percent; however, there is clearly a point(s) above which the marginal costs of additional controls increases dramatically. One solution resembling an inflection point (Solution #2 near 25 percent reduction) was selected for detailed performance evaluation with respect to flow and pollutant load reduction. This solution was selected to demonstrate possible management options in support of TMDL compliance.

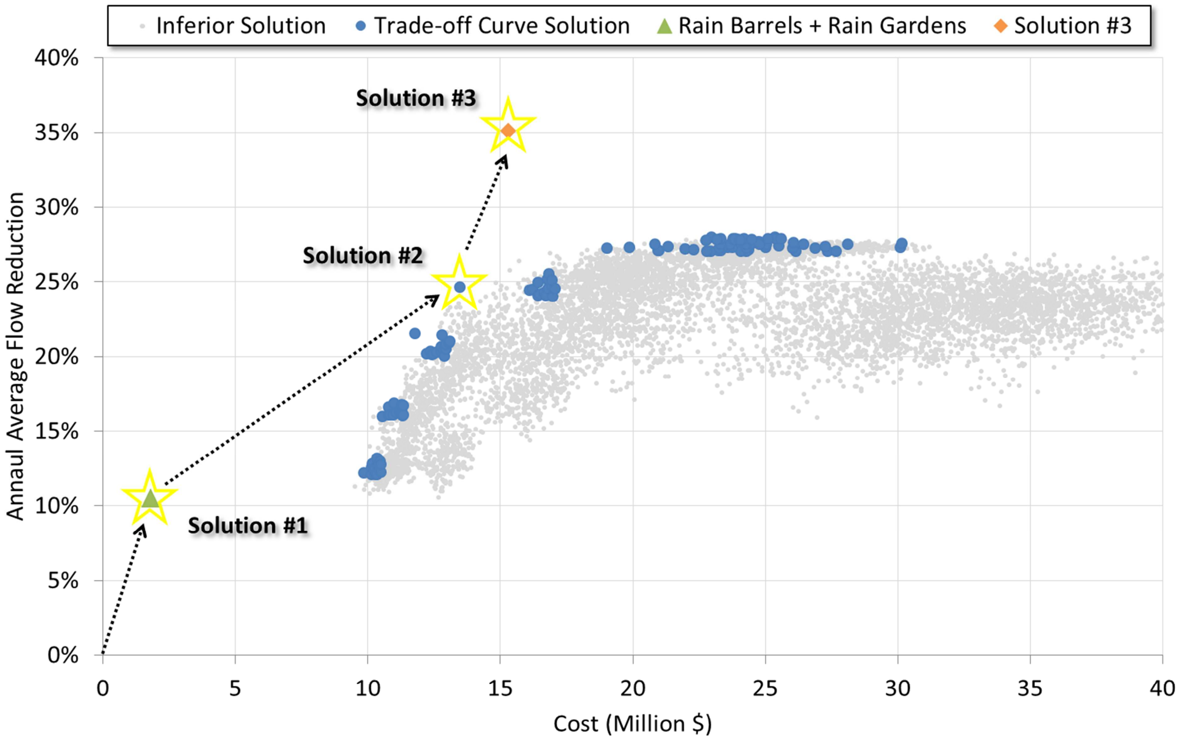

Figure 15. Trade-off curve for Dry Run Tributary management scenarios inclusive of rain barrel & rain garden boundary condition.

The solution associated with a 35 percent flow reduction is inclusive of the boundary condition which represents implementation of all residential rain barrels and rain gardens. These features are typically much cheaper than other BMP types, and therefore it is reasonable to expect that they would be selected first and implemented in full for achieving a volume control objective. Past experience modeling urban stormwater BMPs in several Midwest watersheds has demonstrated this trend. Making this simplification in the model reduced the overall number of BMPs evaluated using scatter search algorithm. This resulted in a tremendous computational cost savings when using a non-linear search technique.

Table 6. Summary of trade-off curve solutions

Solution	Description	Flow Volume Reduction (%)	Cost (Million $)
1	Rain Barrels & Rain Gardens Only	10.5%	1.8
2	Trade-off curve BMPs (no Rain Barrels & Rain Gardens)	24.6%	13.5
3	Composite of Solution #1 & #2	35.1%	15.3

Trade-off Curve BMP Implementation

To investigate the efficiency of treatment in the Dry Run Tributary pilot area, percent utilization of each of the four BMP types evaluated during development of the trade-off curve was summarized by subwatershed. The percent utilization was calculated by comparing the selected BMP size to the maximum selectable size configured in the model. The results of this calculation for Solution #2 are presented by BMP and subwatershed in Figure 16. While percent utilization compares the model selected implementation of a BMP relative to its own potential, this gives no measure of the physical size or volume of the BMP. Treatment capacity (static BMP volume) was also calculated by BMP and subwatershed for Solution #2 and is presented as Figure 17.

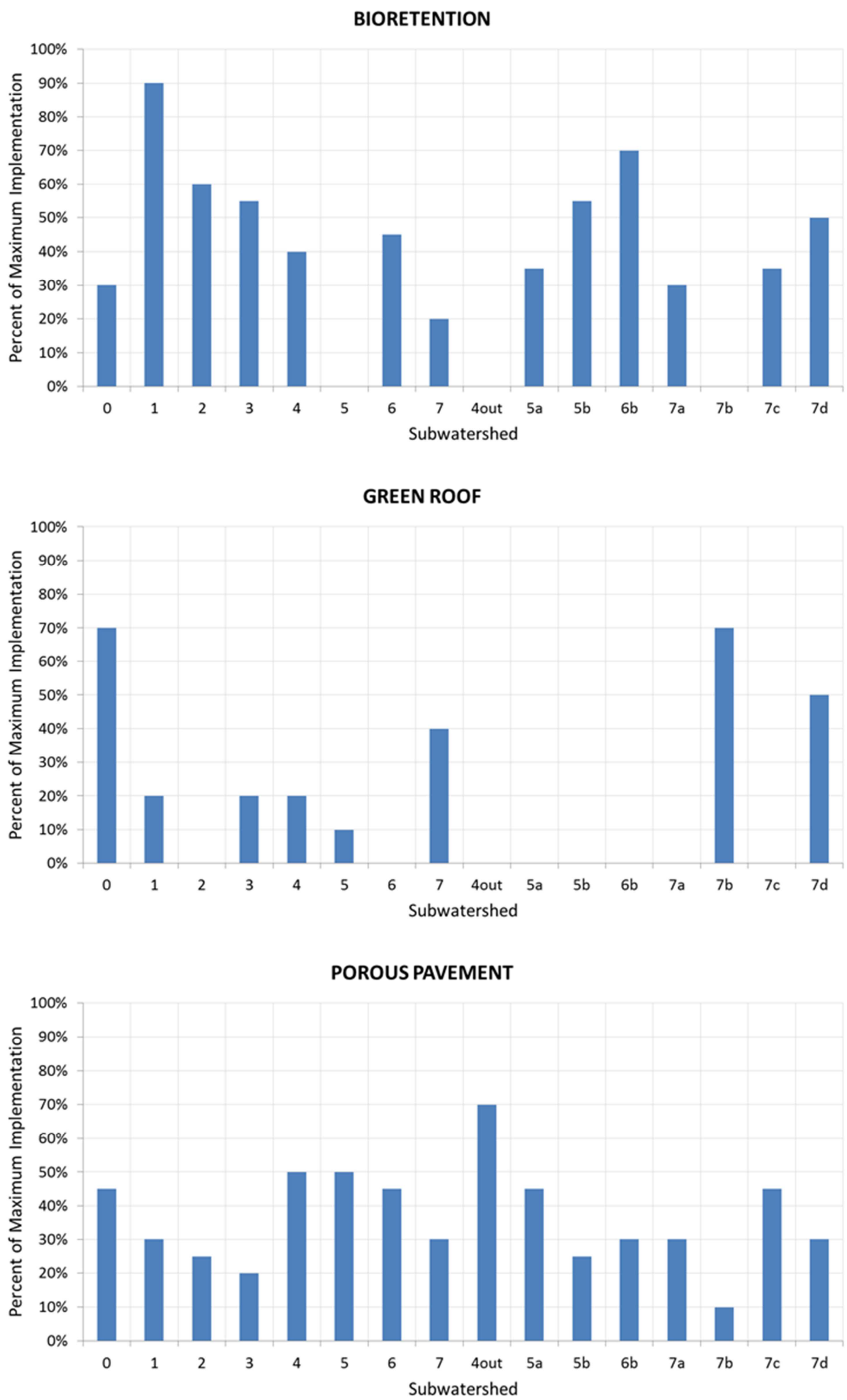

Figure 16. Trade-off curve solution percent of maximum implementation by subwatershed (Solution #2).

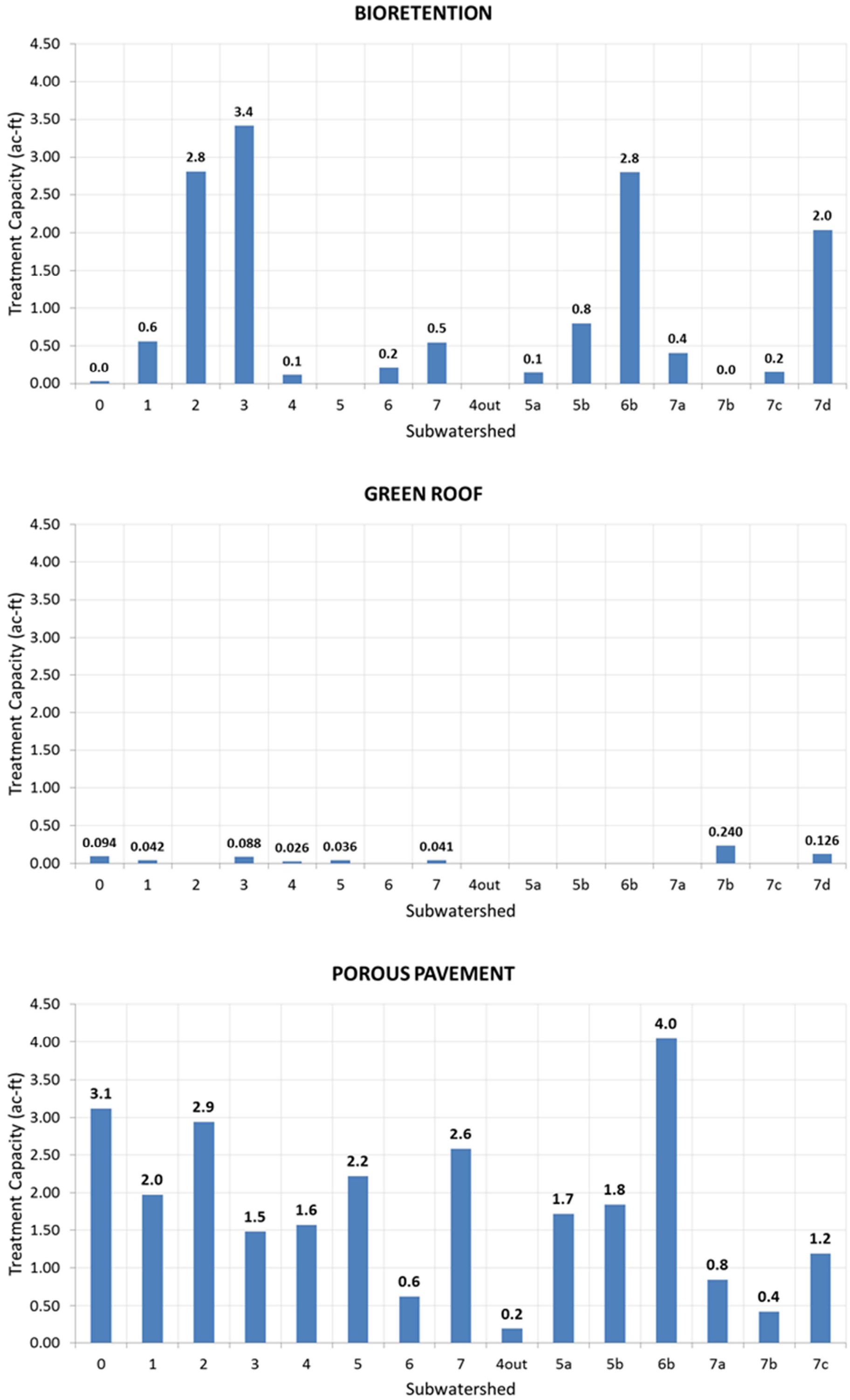

Figure 17. Trade-off curve solution treatment capacity by subwatershed (Solution #2).

Although the objective shown on the BMP trade-off curve was annual average flow reduction, the highlighted solutions presented in Table 6 can also be evaluated in terms of their associated pollutant load removal capacity. Figure 18 presents a plot organized by subwatershed of the annual average sediment load removal achieved for four scenarios (1) baseline condition without any BMPs (2) implementation of residential rain barrels and rain gardens only (3) trade-off curve BMPs only, and (4) all BMPs includes of rain barrels, rain gardens and selected trade-off curve BMPs.

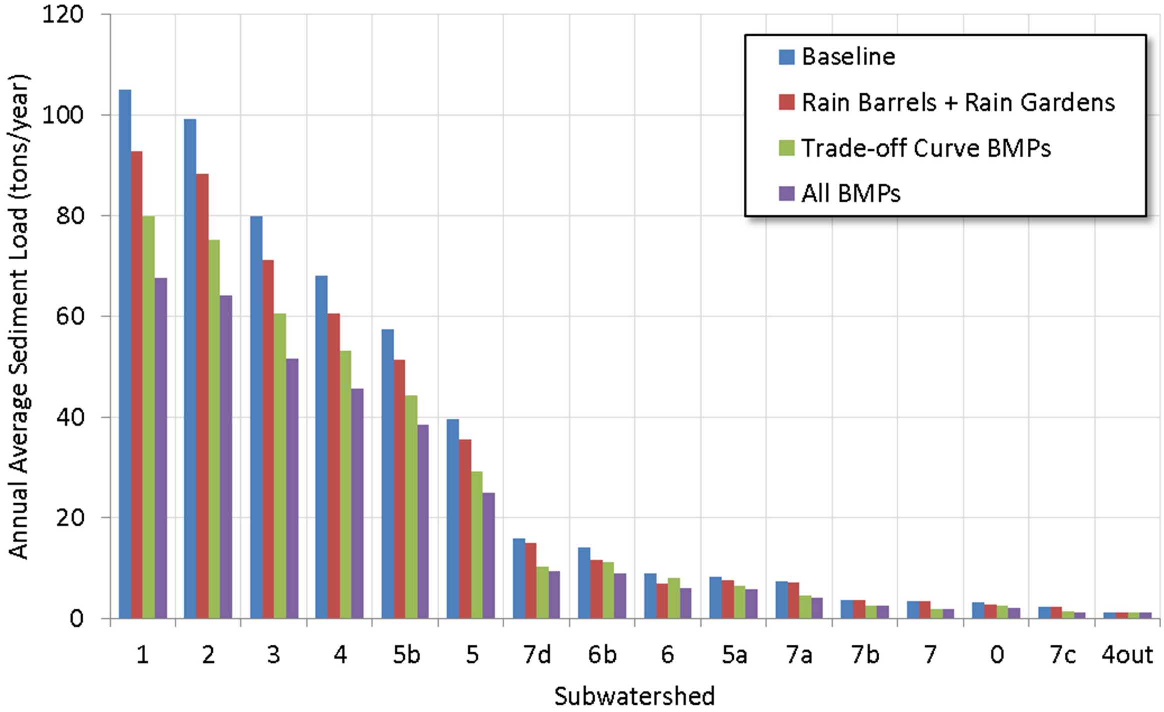

Figure 18. Annual average sediment load by subwatershed for the baseline condition and three BMP scenarios.

The results of this analysis presented in Figure 18 clearly show the increasing level of sediment reduction with increased BMP implementation. The values by subwatershed are presented as tons per year providing a clear linkage to TMDL style analysis that evaluate actual load.

Pollutant Load Reduction

Figure 19 presents the annual average pollutant reduction for TSS, TN, TP, and bacteria from all three scenarios presented in Table 6 which include (1) implementation of residential rain barrels and rain gardens only (2) trade-off curve BMPs only, and (2) all BMPs includes of rain barrels, rain gardens and selected trade-off curve BMPs.

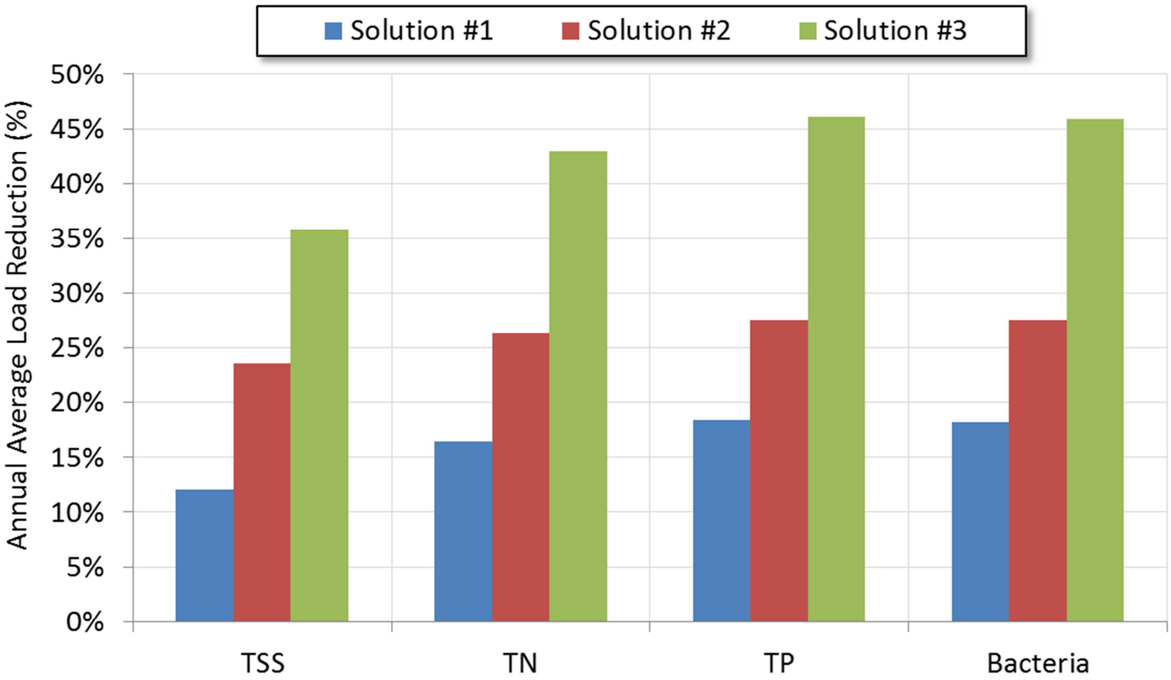

Figure 19. Annual average percent load reduction for three BMP scenarios (10/1/2005 through 9/30/2008).

The annual average TSS reduction presented in Table 6 tracks closely with the annual average flow reduction while the other three constituents show noticeably higher percent load reductions. This is attributed mainly to the heavy focus of treatment on residential areas through the Dry Run Tributary pilot area. The residential EMC values used for TN, TP, and bacteria were the highest among the modeled land uses while the EMC for TSS was lower than both non-residential impervious and forest (Table 3).

Results Discussion

This modeling analysis has presented the results of three solutions of increasing cost and level of implementation for achieving an annual average flow reduction in the Dry Run Tributary pilot watershed. Along with the modeled flow volume reduction, pollutant load reduction for TSS, TN, TP and bacteria was also summarized to inform implementation strategies in support of the TMDL/LRS. The following are a summary of observations form the previously presented analyses:

- The combination of residential rain barrels and rain gardens (modeled with a fixed maximum implementation) had a smaller marginal cost ($/benefit) than the other BMPs evaluated using the scatter search algorithm
    - This was a modeling simplification that was made to increase efficiency of the model
    - The results presented in Figure 15 appear to validate this simplification
- Selection of green roofs was isolated to specific subwatersheds
    - Although these were selected in some instances for as much as 70 percent of maximum implementation, the overall treatment capacity provided by green roofs is a fraction of what is available through other practices
    - Green roofs were likely selected in areas where treatment through other practices was more limited
- Bioretention appears to have preferentially selected some subwatersheds over others
- Porous pavement was selected the most consistently and for Solution #2 is included in every subwatershed

  - This BMP treats the highest proportion of direct non-residential impervious contributing area relative to bioretention and green roofs making it especially effective for a flow reduction objective
- Annual average sediment load reduction tends to follow annual average flow reduction moving from Solution #1 to Solution #3 while other constituents tends to have slightly higher annual average load reductions
  - In the Dry Run Tributary pilot watershed treatment tends to focus mostly on residential opportunities since this is the dominant land use
  - Residential impervious has the lowest EMC for sediment but the highest EMC for TN, TP and bacteria
- These results are constrained by the maximum BMP numbers and sizes identified in Table 4
  - Additional BMP opportunities may exist that were not included in this analysis
  - There may also be opportunity for centralized BMP(s) at our near the outlet of the pilot watershed which could change the implementation strategy

The results presented in Figure 16 and Figure 17 are intended to guide implementation of BMPs throughout the watershed for achieving an annual average flow reduction. The treatment capacities are not prescriptive or absolute as site assessments and field verification are still necessary to account for the nuances of urban hydrology and other site-specific conditions not represented in the model. A change in model objective (ie. maximize sediment removal rather than flow volume reduction) would likely result in a different distribution of BMP selections that may or may not be inclusive of the results presented in this analysis.