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Dobbins Creek Nine Key Element Plan

Federal Clean Water Act Section 319 Small Watersheds Focus Grant Workplan

MINNESOTA POLLUTION CONTROL AGENCY

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Executive summary

The Dobbins Creek Nine Key Element Plan (Plan) was developed to fulfill the requirements set forth by the U.S. Environmental Protection Agency (EPA) for recipients of grants appropriated by Congress under Section 319 of the Clean Water Act (EPA 2013). The requirements emphasize the use of watershed-based plans that contain the nine minimum elements documented in the guidelines and EPA's Handbook for Developing Watershed Plans to Restore and Protect our Waters (EPA 2008).

This Plan builds on the foundation of many levels of planning efforts, water quality conditions, implementation goals and activities and an evaluation approach for the watershed. With the EPA approval of the Plan, the Plan will set the stage to further the previous and current restoration activities and continue efforts to achieve the water quality goals in the watershed.

1. Introduction

The Dobbins Project started as a local priority over 25 years ago, and has since gained momentum and support, and has become a project of regional and statewide significance. Local leadership of staff and elected local government personnel, along with landowner engagement are two key aspects that make the Dobbins Project successful.

The primary water quality challenges are derived from ideal agricultural row crop opportunities. The land is productive, drained, and cultivated on nearly all the landscape with exception to the riparian areas along the streams. The intense agriculture provides landowners with an opportunity to grow crops on nearly all of the land. In addition, the limited riparian areas that are seeded to perennial vegetation are also being grazed. Flooding and high runoff speed is also a concern and challenge for managing a healthy stream system in the Dobbins Watershed. These factors result in land use that is stressing the water quality in Dobbins Creek.

1.1 Document overview

The intent of this document is to concisely address the nine elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA 2008) that are critical to preparing effective watershed plans to address nonpoint source pollution. The EPA emphasizes the use of watershed-based plans containing the nine elements in Section 319 watershed projects in its guidelines for the Clean Water Act Section 319 program and grants (EPA 2013).

This Plan's foundation is the data collection, analysis, and development of plans from multiple sources and scales. Most of the monitoring and planning efforts sponsored by the state (Intensive Watershed Monitoring (IWM), Assessments, total maximum daily loads (TMDL), watershed restoration and protection strategies (WRAPS), One Watershed One Plan (1W1P), etc.) are conducted and report on as hydrological unit code (HUC) 8 watersheds. These foundational efforts provide the support and understanding to develop the very targeted and detailed Focus Grant Workplans for small watersheds. Instead of broad, strategies, this Focus Grant Workplan will delve into specific and targeted actions to achieve water quality goals in the Dobbins Creek Watershed.

This Grant Workplan is intended to be a living document. Through the initial development, first steps of implementation, and the final data collection, this road map is intended to change, react, and correct the course of watershed implementation in the Sand Creek Watershed. This is only the first step along the path to water quality goals in the Dobbins Creek Watershed.

The intent of the nine elements and the EPA watershed planning guidelines is to provide direction in developing a sufficiently detailed plan at an appropriate scale so that problems and solutions are targeted effectively. The nine elements are listed in Table 1 along with the section of this report in which each nine element can be found.

Table 1. Nine elements

Section 319 Nine Element	Applicable Report Section
a. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.	Section 3.4 Pollutant source assessments Section 3.5 TMDLs
b. An estimate of the load reductions expected from management measures.	Section 6 Identification of management strategies
c. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this Plan.	Section 6 Identification of management strategies
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this Plan.	Section 6
e. An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Section 6: included in milestone tables Section 8 Public participation
f. Schedule for implementing the nonpoint source management measures identified in this Plan that is reasonably expeditious.	Section 6: milestone, goals, and assessment tables for each strategy
g. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 6: milestone, goals, and assessment tables for each strategy
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.	Section 6: milestone, goals, and assessment tables for each strategy
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Section 7: Monitoring

1.2 Planning purpose and process

The 2015-2018 Section 319 grant project, Effectiveness of Targeted Dobbins Creek BMPs, set the stage for the Dobbins Creek Section 319 Small Watersheds Focus Program project. The project provided the watershed a benchmark in the history of water resource work in Dobbins Creek and the Cedar River. The grant set out to accelerate project development and begin an advanced monitoring network that would provide feedback for initial project results and establish anchor sites to begin a long-term data set for tracking project development over several years.

The grant project involved several partners. The Cedar River Watershed District (CRWD) provided local project levy funding and staffing resources to address the goal areas. The Minnesota Board of Water and Soil Resources (BWSR) provided key grant funding through the Clean Water Fund. The Minnesota Department of Natural Resources (DNR) assisted with stream bank technical assistance work and permitting. The federal United States Department of Agriculture partners assisted with key program assistance to implement practices on the landscape through the Mississippi River Basin Initiative and National Water Quality Initiative. The Minnesota Pollution Control Agency (MPCA) was key to the grant formation and assistance with establishing the project. The project also had a unique partner in the Hormel Foundation. The foundation funding support reflected local interest from the community for waterway improvement in Austin and the surrounding area. Other agencies and community also supported the project through various levels.

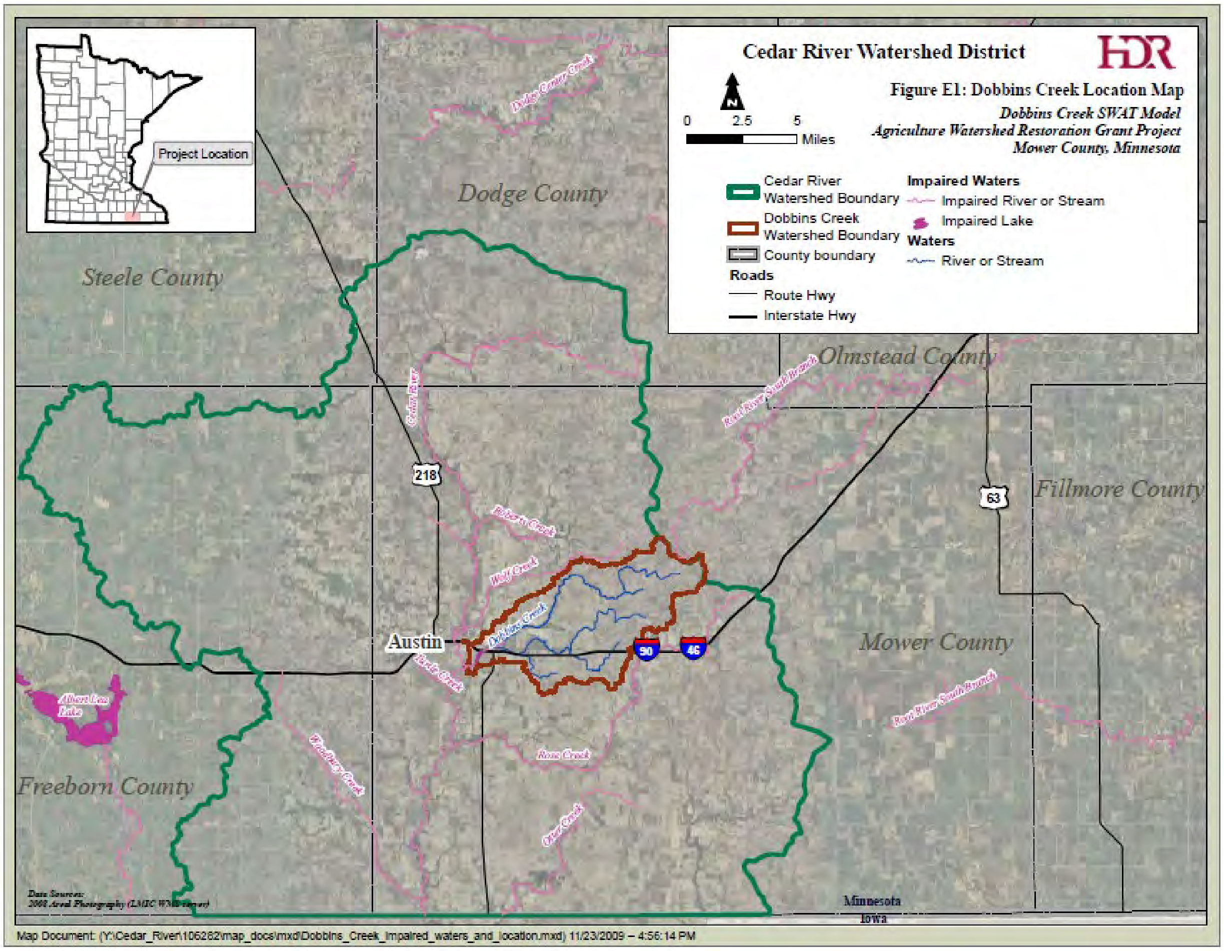
The overarching goal was to develop systems that approached watershed management at a manageable scale and implemented practices that could influence change in the overall quality of the stream. The monitoring period needs to be extended to better understand the effects of those practices. The Dobbins Creek partners also discovered that the scale of those projects also needed to be reduced, if actual and meaningful changes were going to be observed. The entire watershed did not get addressed through the window of the project. However, the best management practices (BMPs) adoption that occurred in the focus areas was significant and almost unprecedented for this area in the past. Adoption rates were high and the landowners were engaged in adopting practices and being a part of the project. The project success lies in the total and comprehensive work that many partners contributed to create opportunity for voluntary BMPs on private lands.

The Section 319 Focus Grant Workplan provides the opportunity to continue building the framework of the small watershed approach in Minnesota along with continuing the implementation work to achieve the water quality goals for the watershed. The foundation of this plan was written by compiling and synthesizing the information describing previous and current work in the watershed, quantifying current sources and pollutant loads, determining load reductions needed to meet the water quality goals, and identifying the management measures and levels of implementation needed to achieve the reductions. Through this process, gaps in the existing planning efforts have been identified and will be addressed. Efforts will be focused in various levels throughout the watershed in critical areas. As the work continues, critical areas will be refined. Critical area selection includes physical science influence, such as critical loading areas, but also will take into account social aspects such as citizens' priorities and landowner willingness to participate.

2. Watershed description

Dobbins Creek Watershed is part of the CRWD located in southern Minnesota (Figure 1). The watershed is in and to the northeast of the city of Austin, Minnesota and is entirely contained in Mower County. The watershed is a Hydrological Unit Code (HUC)-12 watershed in the Middle Cedar River subwatershed (HUC-10) and is approximately 38 square miles (24,550 acres). The creek is approximately 26 miles long divided into three branches: North Branch, South Branch, and Unnamed Branch. The creek ranges in width of approximately 13 to 16 feet (CRWD 2008) and empties into East Side Lake, which then drains to the Cedar River near Austin, Minnesota.

Figure 1. Dobbins Creek Watershed (from HDR 2010)



2.1 Geology

The following is an excerpt from the *Cedar River Watershed District Watershed Management Plan* (Barr Engineering 2009a):

> The bedrock underlying the CRWD is part of the Upper Devonian and Upper Ordovician Series, which formed 375–450 million years ago. The Cedar Valley Group underlies the southern portion of the watershed district. The Wapsipinicon Group and Maquoketa and Dubuque Formations are mostly found in the northern portion of the watershed district. These groups

and formations are composed of mainly limestone, dolostone and shale. More information about geology is available in the *Geologic Atlas of Mower County* from the Minnesota Geological Survey.

The terminal moraine of the Wisconsin Glaciation forms a north-south boundary approximately in the center of the watershed called the Bemis moraine. Approximately 8 percent of wells tap into glacial deposits, according to the USGS's 1975 report, *Water Resources of the Cedar River Watershed, Southeastern Minnesota*. East of the Bemis moraine, pre-Wisconsin Kansas drift of Leverett underlies most of the surface, and less than 3 percent of wells tap into thin glacial deposits. Near the Cedar River, surficial aquifers are categorized by glacial outwash and alluvium of sand and gravel and are at or near the land surface. The vast majority of wells tap into the Cedar Valley-Maquoketa- Dubuque-Galena Aquifer that underlies the entire watershed.

Most of the municipalities in the CRWD rely on groundwater from bedrock aquifers for their drinking water supply.

Geology in southeast Minnesota is characterized by karst features. The Cedar River Watershed is located in the western edge of Minnesota's karst geography, in a transition zone ranging from covered karst to active karst. These geologic features occur where limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution release points to drinking water wells or surface water.

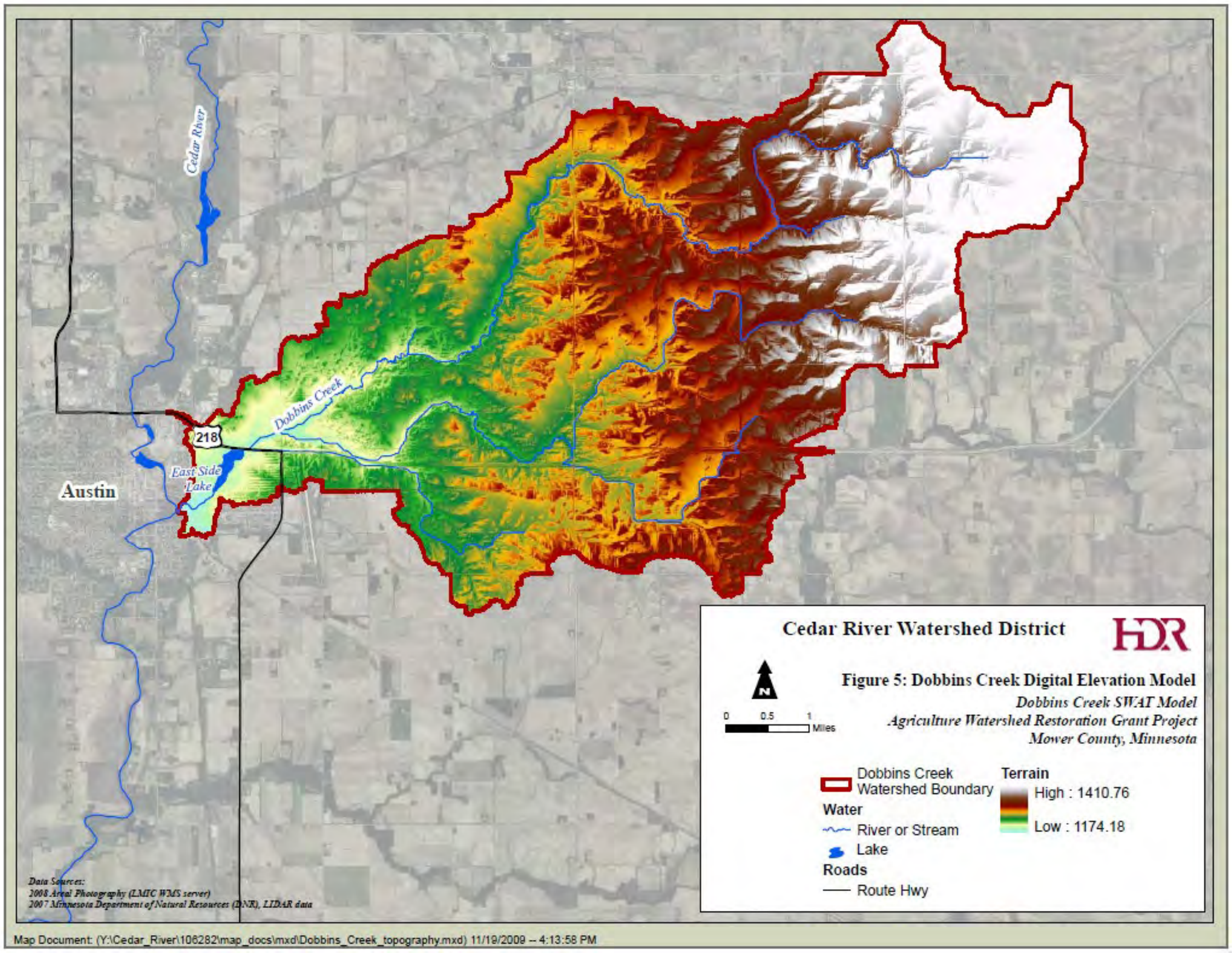
Karst aquifers are difficult to protect from activities at the ground surface. Pollutants are quickly transported to drinking water wells or surface water, thus conventional hydrogeologic tools such as monitoring wells are of limited usefulness. The best strategy is pollution prevention from common sources like septic systems, abandoned wells, and animal feedlot operations.

Bedrock in Mower County is covered by glacial sediments as thick as 275 feet, with bedrock exposed in only a few places such as along the Cedar River. The County is underlain by limestone and dolostone karst aquifers, which are formed by solution processes.

2.2 Topography/elevation data

The topography of the Dobbins Creek Watershed is gently rolling. The lowest point in the watershed is 1,174 feet above mean sea level and the highest point in the watershed is 1,411 feet above mean sea level (Figure 2).

Figure 2. Dobbins Creek digital elevation model (from HDR 2010)



2.3 Wetlands

There are approximately 509 acres of wetlands in the Dobbins Creek Watershed (National Wetlands Inventory Circular 39). Approximately 74% of the wetlands are classified as seasonally flooded basin or flat, 12% as shallow marsh, 8% as shallow open water, 4% as shrub swamp, and 1% as wooded swamp.

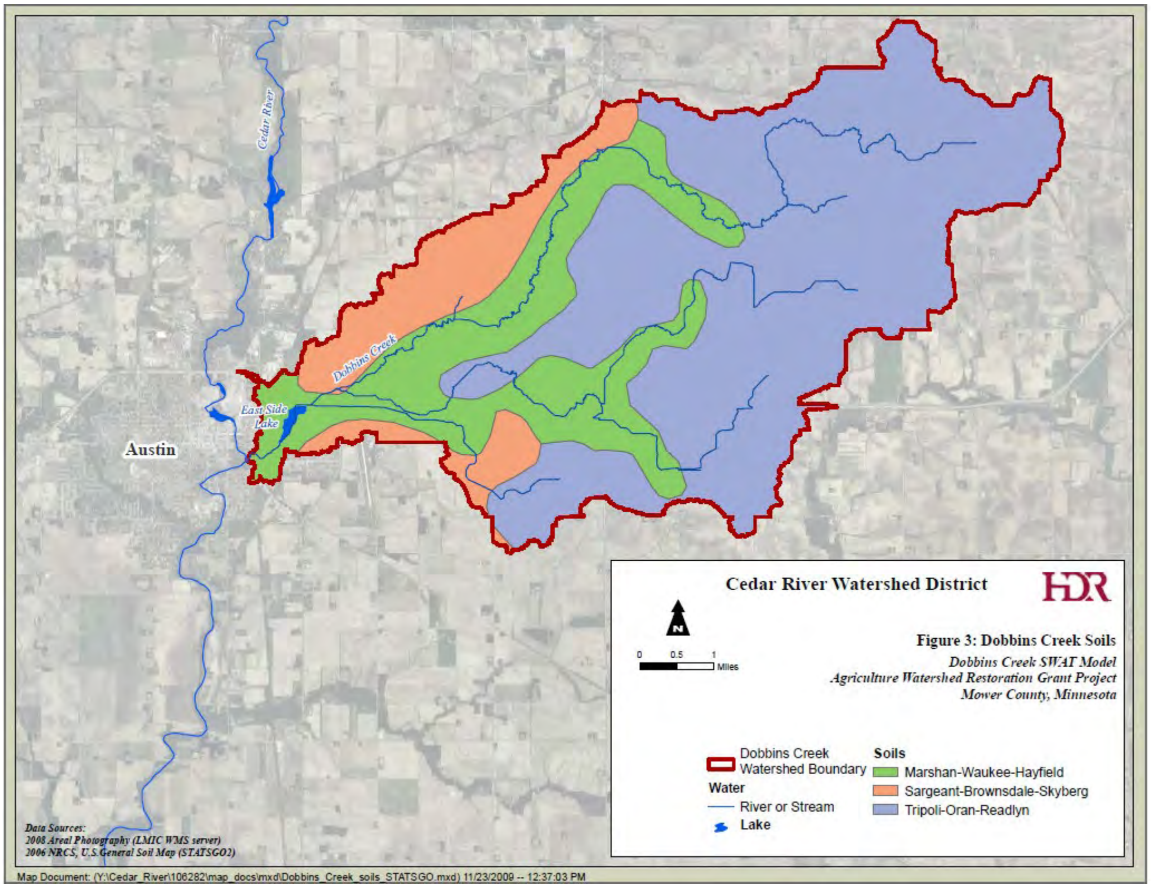
2.4 Soils

The following is an excerpt from the *Dobbins Creek – SWAT Model: Agricultural Watershed Restoration Grant Project* (HDR 2010):

> There are three predominant soil associations in the Dobbins Creek Watershed: Marchan-Waukee- Hayfield, Sargeant-Brownsdale-Skyberg and Tripoli-Oran-Readlyn. Soils within the watershed are generally poorly to somewhat poorly drained. Small patches of sand loam and clay loam soils are present within the central and northeast parts of the watershed, which are moderately to poorly drained, respectively. Similarly, most of the soils have medium to low infiltration.
>
> As stated in the Mower County Soil Survey, soils in the area were formed as silty sediment overlaying glacial till, sandy glacial till, recent alluvium or thin loamy sediment overlaying weathered limestone bedrock (Carroll R Carlson (Soil Conservation Service), 1989).

These prevailing soils associations were captured in the Natural Resources Conservation Service (NRCS) U.S. General Soil Map (STATSGO2) database and are presented on Figure 3 [see Figure 3 of this report below]. Until 2006, these data were referred to as the State Soil Geographic (STATSGO) database. It consists of a broad based inventory of soils and non-soil areas. STATSGO2 provides a general overview of the soils in the project area.

Figure 3. Dobbins Creek soils (map from HDR 2010)



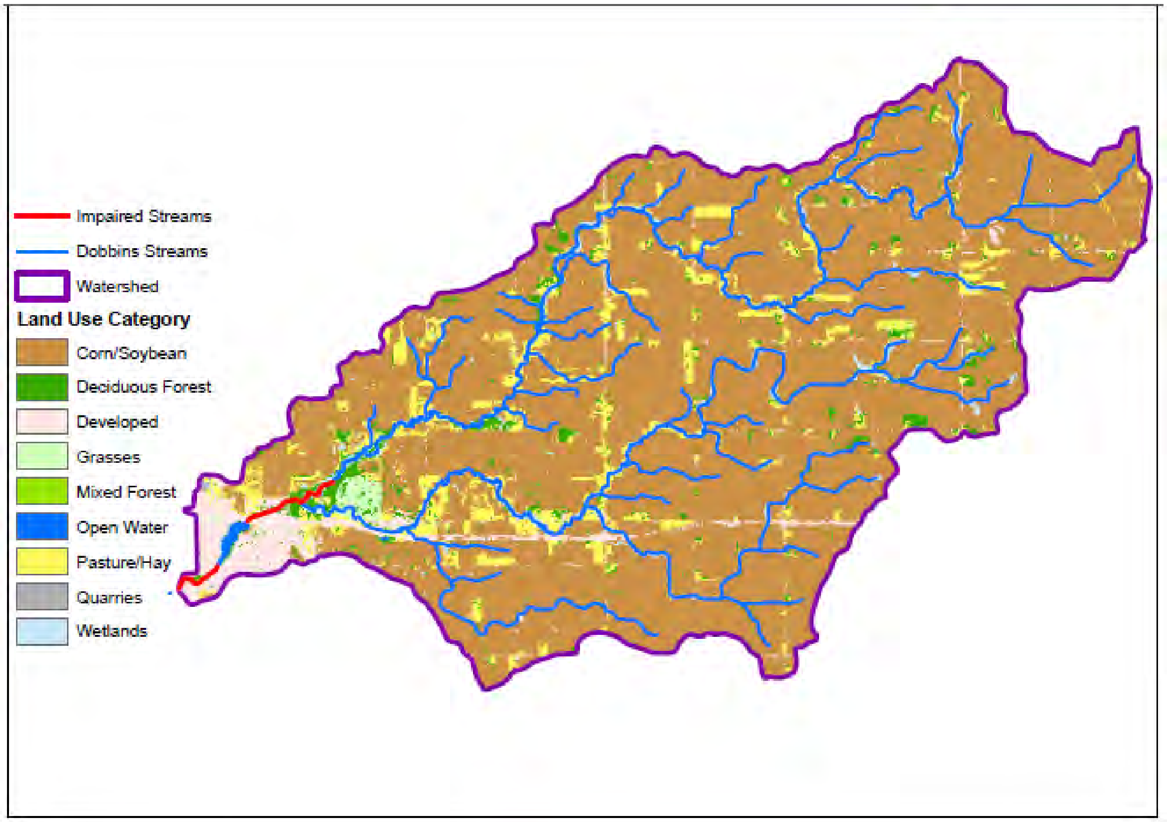
2.5 Land cover

Land cover in the Dobbins Creek Watershed is primarily agricultural (82%). 11% of the watershed is developed, focused in and around the city of Austin (Table 2, Figure 4). Cropland is primarily corn and soybeans.

Table 2. Land cover summary of the Dobbins Creek Watershed (NLCD 2011 data)

Land Cover	Area (%)
Agriculture	82%
Developed	11%
Natural (forest, shrub, grassland)	6%
Open water and wetlands	1%

Figure 4. Land cover in the Dobbins Creek Watershed

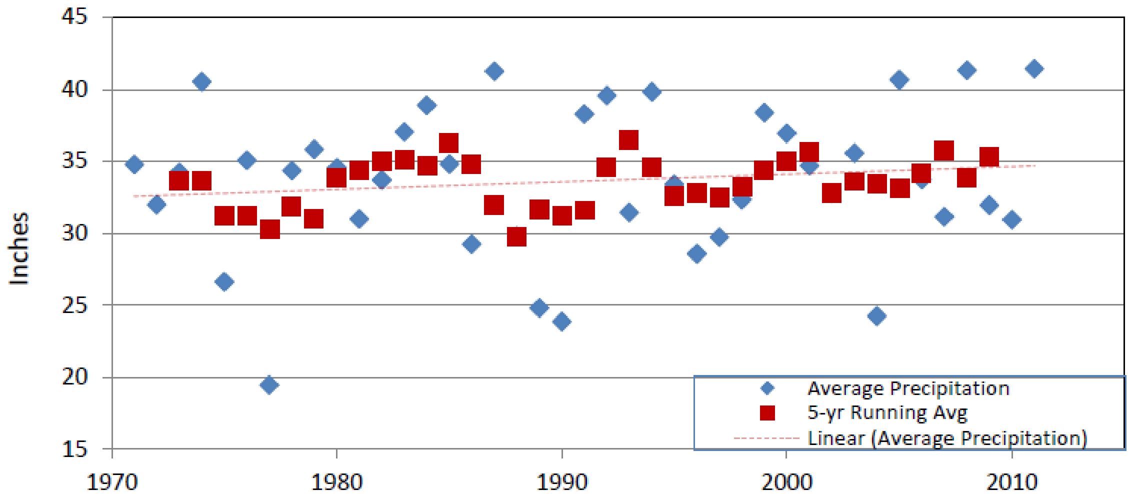


2.6 Climate and precipitation

The region has a continental climate, marked by warm summers and cold winters. The mean annual temperature for Minnesota is 43.2° F. Mean monthly temperatures vary from 10.9°F in January to 70.0°F in July (1971–2000). Extreme temperatures recorded were a high of 100°F on June 21, 1988, and a low of -42°F on January 15, 1963, and January 19, 1970. For the period 1971–2000, the average date for latest occurrence of freezing temperatures is May 2, while the average date for the first autumn frost is September 29. The average frost-free period (growing season) is approximately 150 days (Barr Engineering 2009a).

Precipitation is the source of almost all water inputs to a watershed. In southeastern Minnesota, deep bedrock aquifers also conduct water from recharge zones hundreds of miles distant, allowing discharge of groundwater into local watersheds. Precipitation in the Cedar River Watershed averages 32 inches per year (see Figure 5 for southeast Minnesota data).

Figure 5. Precipitation trends in southeast Minnesota (1960–2010) with five year running average (figure from MPCA 2012)



3. Water quality and quantity

3.1 Water quality standards and beneficial uses

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses — identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria — amounts of specific pollutants allowed in a body of water and still protects it for the beneficial uses
- Narrative criteria — statements of unacceptable conditions in and on the water
- Antidegradation protections — extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric, and narrative criteria, and antidegradation protections provide the framework for achieving Clean Water Act goals.

Minnesota's water quality standards are provided in Minnesota Rule (Minn. R.) ch. 7050. All current state water rules administered by the MPCA are available on the Minnesota water rules page (https://www.pca.state.mn.us/water/water-quality-rules).

3.1.1 Beneficial uses

The beneficial uses for public waters in Minnesota are grouped into one or more classes as defined in Minn. R. ch. 7050.0140. The classes and beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The aquatic life use class now includes a tiered aquatic life uses (TALU) framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses.

All surface waters are protected for multiple beneficial uses.

3.1.2 Numeric criteria and state standards

Narrative and numeric water quality criteria for all uses are listed for four common categories of surface waters in Minn. R. ch. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, also protected for drinking water: classes 1B; 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat, also protected for drinking water: classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, 3C, or 3D; 4A and 4B or 4C; and 5
- Limited resource value waters: classes 3C; 4A and 4B; 5; and 7

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. ch. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. ch. 7050.0150.

The MPCA assesses individual waterbodies for impairment for class 2 uses—aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish, and associated aquatic life and their habitats. Both class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming.

Protection for aquatic recreation entails the maintenance of conditions safe and suitable for swimming and other forms of water recreation. In streams, aquatic recreation is assessed by measuring the concentration of *Escherichia coli* (*E. coli*) in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreational activities, its trophic status is evaluated using total phosphorus (TP), Secchi depth, and chlorophyll-*a* as indicators. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biological integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by water body type and use subclass (exceptional, general, and modified).

General use waters harbor “good” assemblages of fish and macroinvertebrates that can be characterized as having an overall balanced distribution of the assemblages and with the ecosystem functions largely maintained through redundant attributes. Modified use waters have been extensively altered through legacy physical modifications, which limit the ability of the biological communities to attain the general use. Currently the modified use is only applied to streams with channels that have been directly altered by humans (e.g., maintained for drainage, riprapped).

The ecoregion standard for aquatic recreation protects lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

3.1.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

A. Existing uses and the level of water quality necessary to protect existing uses shall be maintained and protected.
B. Degradation of high water quality shall be minimized and allowed only to the extent necessary to accommodate important economic or social development.
C. Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters shall be maintained and protected.
D. Proposed activities with the potential for water quality impairments associated with thermal discharges shall be consistent with section 316 of the Clean Water Act, United States Code, title 33, section 1326.

3.1.4 Standards and criteria

The stream and lake in the watershed are designated as class 2B waters. The water quality standards and criteria used in assessing the streams and lakes in the planning area include the following parameters:

- *E. coli* – not to exceed 126 organisms per 100 milliliters (org/100 mL) as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31.
- Dissolved oxygen (DO) – daily minimum of 5 milligrams per liter (mg/L).
- pH – to be between 6.5 and 9.0 pH units.
- Total suspended solids (TSS) – 65 mg/L not to be exceeded more than 10% of the time between April 1 and October 31.
- Chloride
  - Chronic: 230 mg/L
  - Maximum standard: 860 mg/L
  - Final acute value: 1,720 mg/L
- Stream eutrophication – based on summer average concentrations for the South River Nutrient Region
  - TP concentration less than or equal to 150 micrograms per liter (µg/L) and
  - Chlorophyll-*a* (seston) concentration less than or equal to 35 µg/L or
  - Diel DO flux less than or equal to 4.5 mg/L or
  - Five-day biochemical oxygen demand (BOD) concentration less than or equal to 3.0 mg/L.
  - If the TP criterion is exceeded and no other variable is exceeded, the eutrophication standard is met.
- Lake eutrophication – based on summer average values for shallow lakes in the western corn belt plains ecoregion
  - TP concentration less than or equal to 90 µg/L and
  - Chlorophyll-*a* concentration less than or equal to 30 µg/L or
  - Secchi disk transparency not less than 0.7 meter.
- Biological indicators – The basis for assessing the biological community are the narrative water quality standards and assessment factors in Minn. R. 7050.0150. Attainment of these standards is measured through sampling of the aquatic biota and is based on impairment thresholds for IBI that vary by use class. Appendix 4.1 in the Cedar River Watershed Monitoring and Assessment Report (MPCA 2012) provides the IBI numeric thresholds.

3.2 Impairments

The Clean Water Act, Section 303(d) requires TMDLs to be developed for surface waters that do not meet applicable water quality standards necessary to support their designated uses. A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards and allocates allowable pollutant loads to various sources needed to meet water quality standards.

There are three impairments in the planning area (Table 3). The impairments affect aquatic consumption, aquatic life, and aquatic recreation uses based on mercury in fish tissue, turbidity, and fecal coliform concentrations.

Table 3. Impairments in the planning area

Resource of Concern	Description	Waterbody Identification (WID)	Use Class	Year Added to List	Impairment	TMDL Status
Dobbins Creek	T103 R18W S36, east line to East Side Lake	07080201-535	2Bg, 3C	2012 2006	Aquatic life: turbidity Aquatic recreation: fecal coliform	Approved
East Side Lake	–	50-0002-00	2B, 3C	1998	Aquatic consumption: mercury in fish tissue	Approved
Dobbins Creek	East Side Lake to Cedar River	07080201-537	2Bg, 3C	2006 2006	Aquatic life: turbidity Aquatic recreation: fecal coliform	Approved

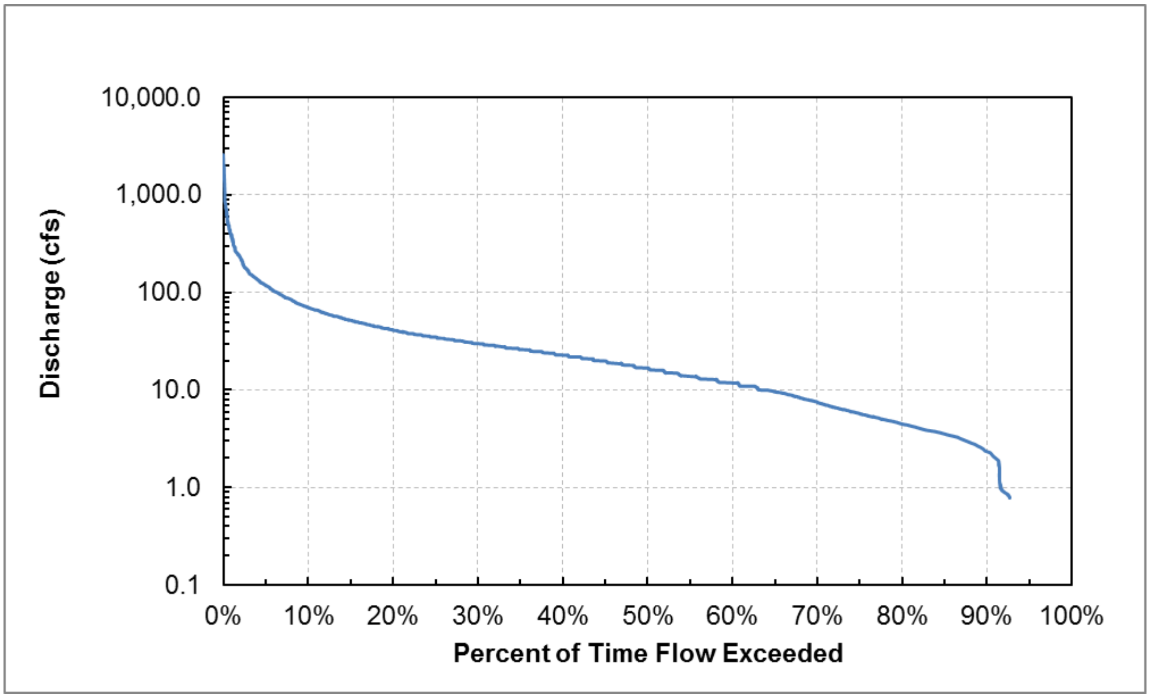
Although the fish and macroinvertebrate assemblages in Dobbins Creek were not assessed for impairment in the Cedar River Watershed Monitoring and Assessment Report (MPCA 2012), fish and macroinvertebrate IBI scores from 2014 and 2017 are near the aquatic life impairment thresholds (CRWD 2018).

3.3 Flow and water quality summary

The CRWD, Mower County Soil and Water Conservation District (SWCD), DNR, and MPCA have completed various monitoring activities in the watershed. The summary of data below is taken from various reports that characterize the impairments for the Dobbins Creek Watershed.

Stream flow data are available from DNR gauge 48005001 (Dobbins Creek at Austin County Road 61) located 1.7 miles upstream of the confluence with Cedar River. Daily flow data are available from 1998 through 2016; however, several gaps in the data are present. The gage site was not operated through the winter given the difficulties of frozen conditions. Data is also not present for 2008, 2011 to 2014, and parts of other years. Data from 2017 through the present are only available as 15-minute interval flows until the data is finalized. Discharge is calculated based on a stage-discharge relationship. A flow duration curve of the daily flow data is shown in Figure 6. Daily average stream flows in Dobbins Creek are less than 2.4 cubic feet per second (cfs) more than 90% of the time and only 10% of the flows exceed 71 cfs. The median daily streamflow is about 17 cfs.

Figure 6. Flow duration curve for the period of record for Dobbins Creek (1998-2016).



3.3.1 Total suspended solids and turbidity

The two stream reaches of Dobbins Creek have monitoring sites where TSS and turbidity data has been assessed for impairment. The number of TSS samples and number with concentrations greater than the numeric criteria for the standard during the 2000-2010 assessment period for the 2012 303(d) list are summarized in Table 4. The lower reach (downstream of East Side Lake) had no concentrations greater than 65 mg/L TSS. The upper reach had 20 out of 128 samples with TSS concentrations greater than 65 mg/L. The reaches were listed as impaired for the turbidity water quality standard where greater than 10% of the available data for both reaches exceeded the turbidity standard of 25 NTU. The turbidity standard was replaced with the TSS standard in 2015, so standard evaluations are completed for TSS.

Median TSS concentrations in the upstream impaired reach were similar during May, June, July, and September, with the highest concentrations observed in April (Table 5). TSS concentrations are on average lower at the downstream impaired site (Table 6).

In the impaired Dobbins Creek reach that is upstream of East Side Lake, exceedances of the TSS standard were observed in all flow zones except low flows (Figure 7). The greatest number and magnitude of the exceedances were under high flows. A similar pattern was seen in the reach downstream of East Side Lake (Figure 8).

Table 4. Summary of TSS monitoring data on impaired Dobbins Creek reaches (Barr Engineering 2019a)

Listed Water Body Name	WID	WQ Station ID(s)	# samples	# Samples > 65 mg/L
Dobbins Creek – T103 R18W S36, east line to East Side Lk	07080201-535	S003-065, S005-282, S008-963	128*	20
Dobbins Creek – East Side Lk to Cedar R	07080201-537	S003-066	26	0

* Sample concentrations from multiple sites on the same day were averaged to one value.

Table 5. TSS summary statistics by month at Dobbins Creek upstream reach (WID -535), 2000–2018

All TSS data are in mg/L.

Month	Count	average	Median	Maximum	90th percentile
Apr	13	123	8	1,120	226
May	23	29	19	83	62
Jun	29	61	22	332	141
Jul	27	48	25	196	152
Aug	23	12	8	87	19
Sep	15	55	26	380	96
Oct	14	20	4	107	75

Table 6. TSS summary statistics by month at Dobbins Creek downstream reach (WID -537), 2000–2001

All TSS data are in mg/L.

Month	Count	average	Median	Maximum	90th percentile
May	2	35	35	45	43
Jun	7	29	31	44	41
Jul	9	29	30	42	42
Aug	8	15	17	20	19

* Sample concentrations from multiple sites on the same day were averaged to one value.

Figure 7. Dobbins Creek (WID -535) TSS load duration curve (Barr Engineering 2019a)

Data include turbidity data that were transformed to the TSS-equivalent.

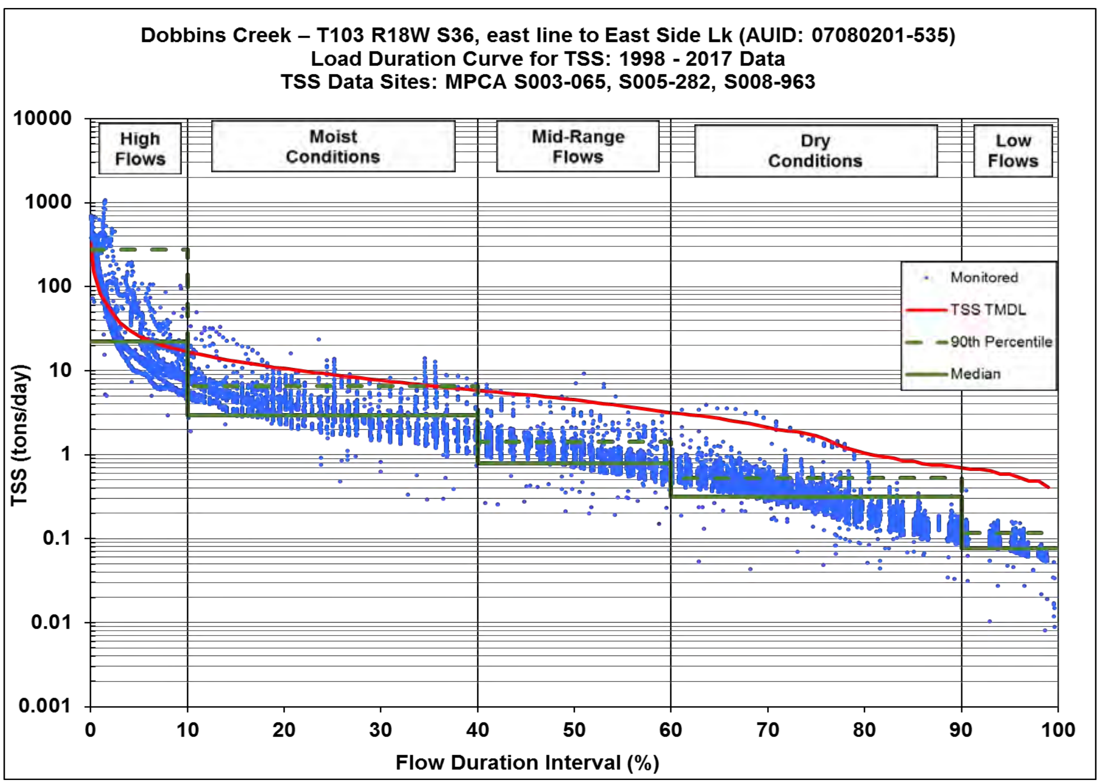
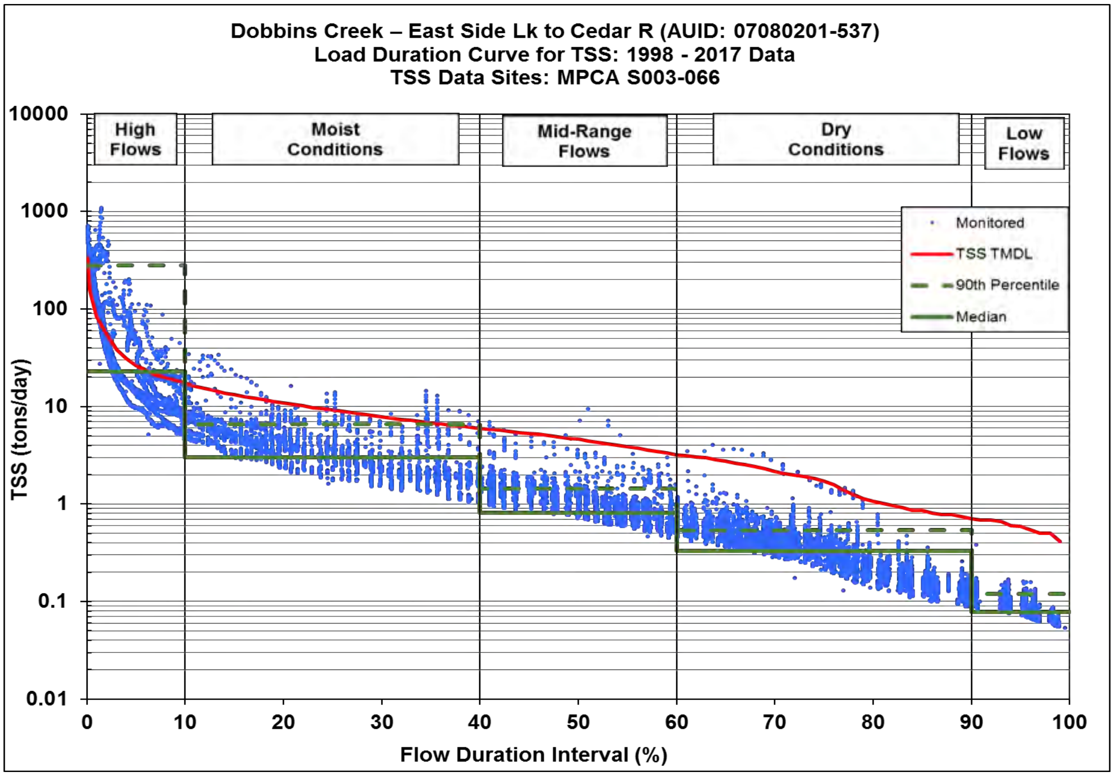


Figure 8. Dobbins Creek (WID -537) TSS load duration curve (Barr Engineering 2019a)
Data include turbidity data that were transformed to the TSS-equivalent.



TSS loads at four monitoring sites in the Dobbins Creek Watershed were estimated with monitoring data and the Flux 32 load estimation software (Table 7; CRWD 2018). Uncertainty in the estimates was greatest at the smallest, flashiest site, 250th. These estimated annual loads are meant to provide baseline data to allow for change over time to be shown in the future. Flows at site N8 may have been overestimated, leading to artificially high load estimates. Future work in the watershed should include the refinement of the rating curve used to calculate flows at this site.

Table 7. Estimated annual loads

Site	Drainage Area (acres)	TSS (tons/yr)
Outlet	25,700	4,654.51
Golf Course	10,872	1,291.23
N8	6,350	4,410.85
250th	464	351.09

3.3.2 Fecal coliform and *E. coli* bacteria

On the upstream impaired reach, 28% of the *E. coli* samples exceeded the maximum standard (1,260 org/100 mL), and none of the 31 samples from the downstream reach exceeded the standard (Table 8). All of the monthly geometric means from June through August exceeded the standard (126 org/100 mL) except for one month on the downstream reach (Table 8).

Table 8. Summary of *E. coli* monitoring data on impaired Dobbins Creek reaches (2011–2018)*

Reach Name	Number of Exceedances of Maximum Standard	*E. coli* Geometric Mean (sample size), org/100 ml		
		June	July	August
Dobbins Creek (Upper Reach, 07080201–535)	19 of 68 (28%)	907 (9)	517 (15)	524 (12)
Dobbins Creek (Below East Side Lake, 07080201–537)	0 of 31 (0%)	117 (7)	139 (12)	133 (10)

*Maximum standard = 1,260 org/mL, monthly geometric mean standard = 126 org/100 mL. For reach 07080201-537, fecal coliform data were converted to *E. coli* equivalents in Barr Engineering (2019a).

In the impaired Dobbins Creek reach that is upstream of East Side Lake, *E. coli* concentrations greater than 126 org/100 mL were observed in all flow zones (Figure 9). The greatest number and magnitude of the exceedances was under high flows. A similar pattern was seen in the reach downstream of East Side Lake (Figure 10). Concentrations on average were lower in the downstream reach than in the upstream reach.

Figure 9. Dobbins Creek (WID -535) *E. coli* load duration curve (Barr Engineering 2019a)

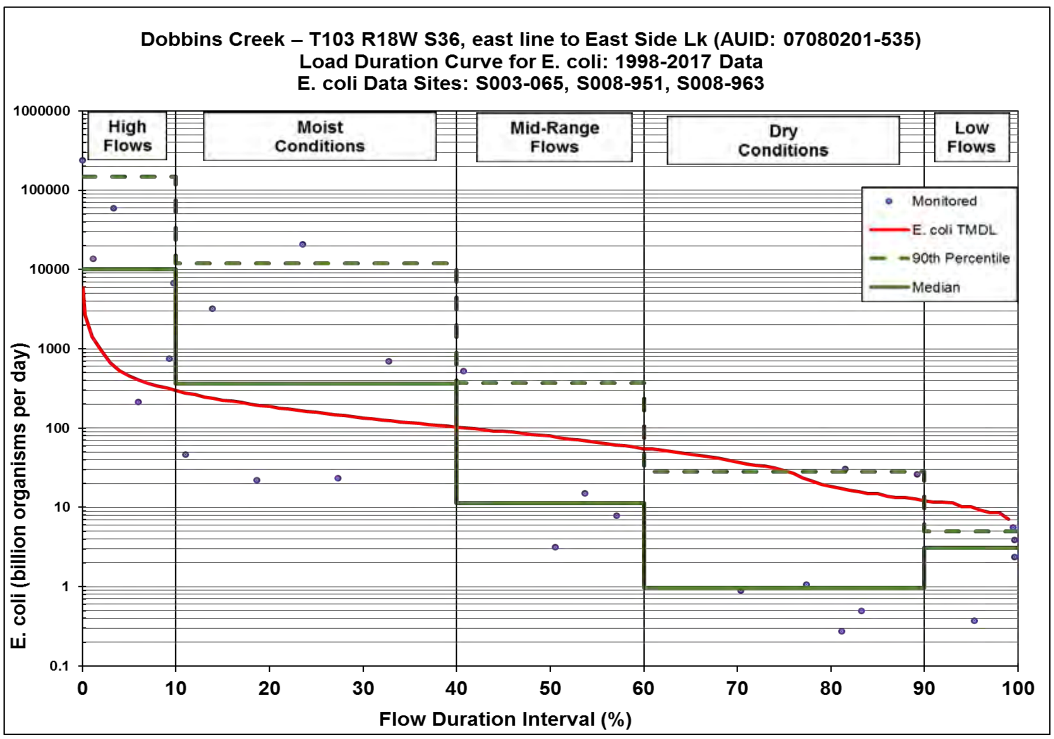
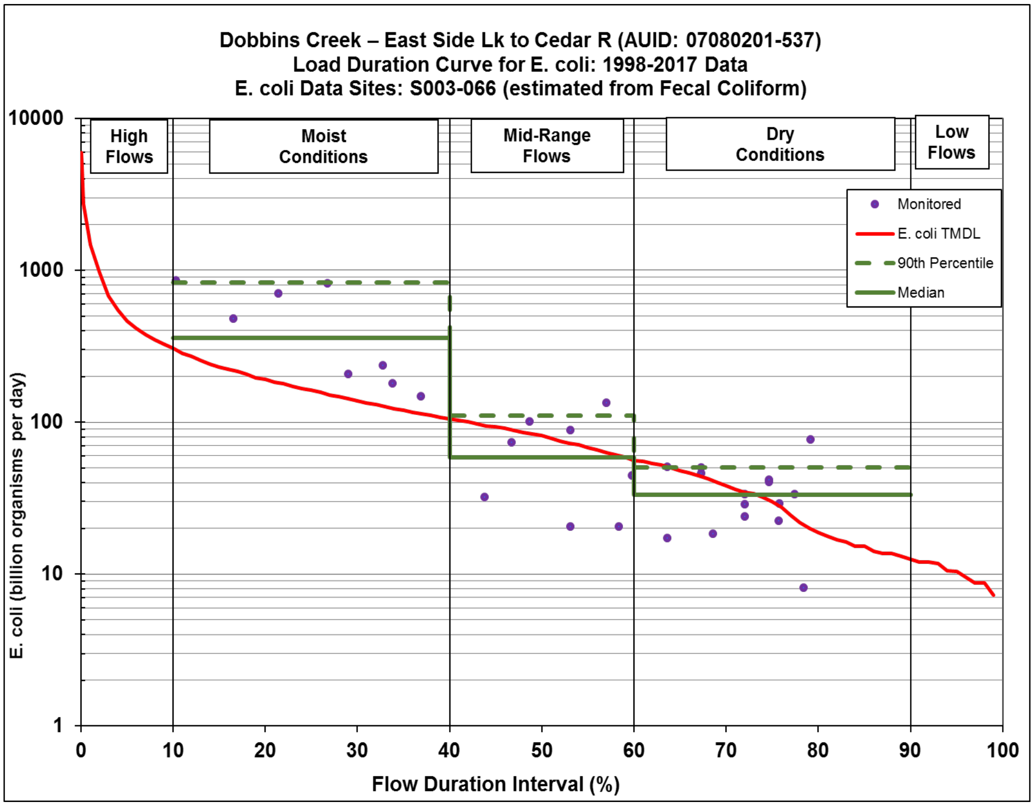


Figure 10. Dobbins Creek (WID -537) *E. coli* load duration curve (Barr Engineering 2019a)



3.3.3 Fish and macroinvertebrates

Over the past few years, the MPCA has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, IBI scores are calculated, which provides a measure of overall community health. If biological impairments are found, stressors to the aquatic community must be identified.

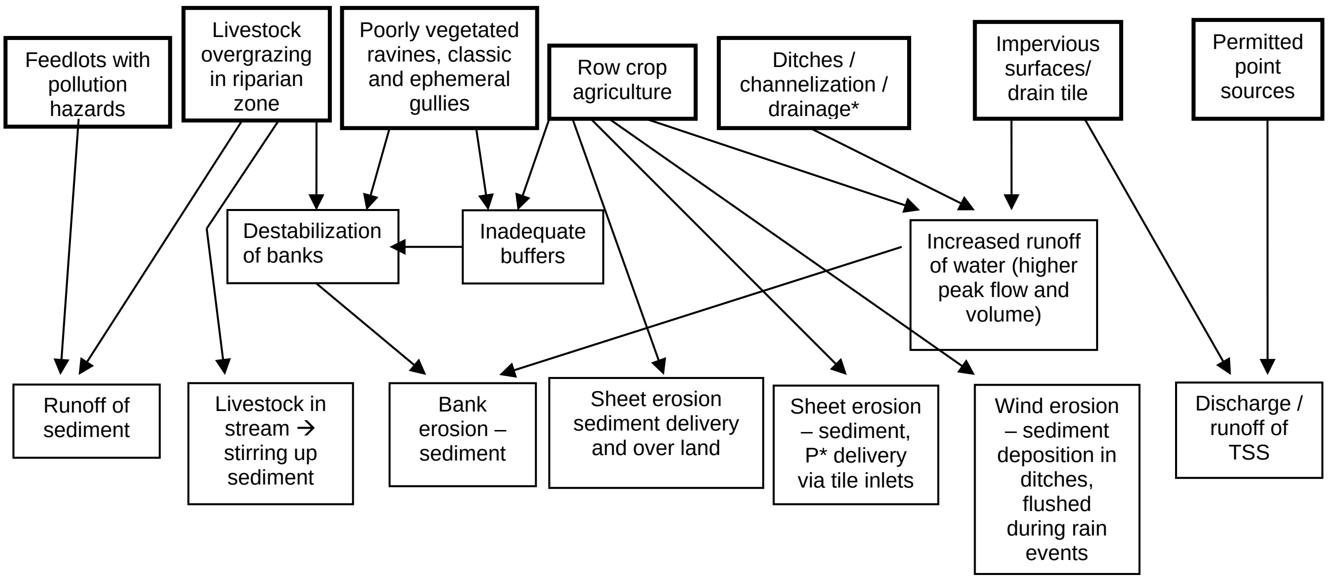
Fish and macroinvertebrates were sampled using MPCA protocols. The sampling took place in the north and south branches of Dobbins Creek over three years (2015, 2016, 2017) by University of Minnesota and Mower SWCD staff. Additionally, MPCA staff sampled fish and macroinvertebrates at four of these stations in 2014. Stream classification and IBIs were calculated by MPCA staff. Although fish and macroinvertebrate IBIs were near the impairment thresholds for their respective stream classes they have not been assessed for impairment by MPCA. The Dobbins Creek Watershed Partners have determined that macroinvertebrate IBI and fish IBI stressors should be addressed.

3.4 Pollutant source assessments

3.4.1 Total suspended solids

A simplified conceptual model/diagram for sediment in the Cedar River Watershed is presented in Figure 11, which shows several possible sources. This figure illustrates potential sediment sources, types of erosion, and pathways for sediment. Both "external" and "internal" sources of TSS are illustrated in this figure. Most point and nonpoint sources are typically considered external in that they are located in the watershed, but outside of the stream channel itself. TSS contribution from point sources is more easily quantified, while the nonpoint source sediment loads are harder to measure, model, and define. Internal sources typically encompass processes that occur within the channel (including the bed and banks) or the floodplain of a waterway, stream, or river. Such processes include channel and floodplain erosion or scour, stream bank erosion, and bank slumping. These internal sediment sources are primarily due to changes in total runoff volumes, higher peak flows, and stream channel geomorphology.

Figure 11. Simplified conceptual model for sediment (Barr Engineering 2019a)



TSS sources in the Dobbins Creek Watershed are varied and include row crop agriculture, poorly vegetated ravines, overgrazing in the riparian zone, drain tile, impervious surfaces, and bank erosion. High turbidity and suspended sediment can occur when heavy rains fall on unprotected soils, dislodging soil particles that are transported by surface runoff into the rivers and streams. The soil may be unprotected for a variety of reasons, such as construction, agriculture, or insufficiently vegetated pastures. Decreases in bank stability and altered hydrology can also lead to sediment loss from the stream banks and stream channels. A 1993 study found that almost all of the Dobbins Creek stream banks are somewhat eroded, and areas with direct traffic from livestock are the most eroded (Bednar 1993). A variable mix of perturbations in the landscape are involved, such as channelization of waterways, agricultural drainage, riparian land cover alteration, loss of water storage, and increases in impervious surfaces. Approximately 40% of the stream sediment in Dobbins Creek is derived from in-channel sources (MPCA 2019), predominantly the stream banks.

TSS concentration is often a function of the land use and crop covers in the watershed and the type and timing of a given storm event. Higher inorganic suspended sediment concentrations are often seasonal, with peaks occurring in the spring before a crop canopy is established. Heavier rainfalls onto soils that are wet can result in erosion and suspended sediment transport when the crops are actively growing (June– August).

In previous work in the Dobbins Creek Watershed (CRWD 2018), there were a number of areas showing advancing headcut gullies with a loss of cropland acreage (Figure 12), slumping and eroding gullies (Figure 13), and actively eroding stream banks (Figure 14) that were transporting sediment from headwater streams and both branches in the Dobbins Creek Watershed. The watershed is also challenged with surface flow that runs across the landscape with little storage; surface flow coming into the stream is at a high velocity. The result is that nearly 50% of sediment is delivered to surface waters, based on modeling estimates from the TMDL process. Because of this, a variety of land treatment methods are critical for driving improvement in the stream. Soil and Water Assessment Tool (SWAT) modeling for Dobbins Creek showed that the majority of sediment was derived from contributions of sediment coming from the North Branch. This study also suggested that BMPs should be targeted for the North Branch, as it would provide the most efficient treatment for the watershed.

The permitted sources of TSS in the Dobbins Creek Watershed are stormwater runoff from the city of Austin's municipal separate storm sewer system (MS4), construction stormwater, and industrial stormwater. Loading from the developed area associated with the city of Austin is at the downstream portion of the Dobbins Creek Watershed. Loads from permitted construction and industrial stormwater are expected to be minor relative to other sources. It is assumed pollutant loads from permitted point sources meet the waste load allocations for the entities and no further reductions are required.

A watershed water quality model was developed by the MPCA with Hydrologic Simulation Program–FORTRAN (HSPF) to evaluate pollutant loading in the Cedar River Watershed (RESPEC 2014). HSPF is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Model documentation contains additional details about the model development and calibration (RESPEC 2014). TSS loads in the Dobbins Creek Watershed were estimated with the HSPF model. Cropland contributes almost half of the load, developed areas contribute approximately 36%, and loads from bed and bank sources represent approximately 13% of the load (Table 9).

Table 9. TSS loads by source (1996–2012 average)

Summary from HSPF model (RESPEC 2014)

Source	TSS Load (%)
Bed and Bank	13%
Cropland	49%
Developed	36%
Feedlot	<1%
Natural	<1%

Figure 12. Field erosion in Red Rock Township in the Dobbins Creek Watershed

Figure 13. Gully erosion in Dexter Township before a targeted Dobbins project

Figure 14. Streambank erosion on Tapp property in Red Rock Township in the Dobbins Creek Watershed

3.4.2 *E. coli*

The watershed sources of *E. coli* include livestock facilities and pastures, fields with applied manure, failing subsurface sewage treatment systems (SSTS), stormwater runoff from developed areas, and wildlife. The source assessment in the Cedar River WRAPS (MPCA 2019) references information from the larger scale source assessment in the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006). Cedar River Watershed was included in the Lower Mississippi River Regional TMDL. During wet periods, *E. coli* sources from animal agriculture that are runoff-related (e.g., feedlots and surface applied manure) are the dominant sources to surface waters. Dobbins Creek Watershed has few pastured animals and few registered feedlots, indicating that livestock operations are likely not a contributor to the *E. coli* impairment. During dry periods, sources such as failing SSTS and pasture adjacent to waterways that directly contribute *E. coli* to surface waters dominate. Additional information on these sources is provided below.

3.4.2.1 Livestock

E. coli loads from livestock can be directly from runoff from feedlot facilities or from livestock manure that is stockpiled and applied to nearby agricultural fields for fertilizer.

Animal feeding operations (AFOs) under 1,000 animal units and those that are not federally defined concentrated animal feeding operations (CAFOs) do not operate with permits; however, the requirements under Minn. R. ch. 7020, 7050 and 7060 still apply. Manure may accumulate in AFOs, and vegetative cover cannot be maintained due to the density of animals. In Minnesota, feedlots with greater than 50 animal units, or greater than 10 animal units in shoreland areas, are required to register with the state. Facilities with fewer animal units are not required to register with the state. It is assumed pollutant loads from permitted point sources meet the waste load allocations for the entities and no further reductions are required.

Of the 38 active, registered feedlots in the Dobbins Creek Watershed, there is one permitted operation and two feedlots in shoreland areas. The non-CAFOs feedlots are registered for up to approximately 2,400 animal units with most being swine, followed by beef cattle (data from MPCA statewide feedlots database). It is expected that compliance with state feedlot guidance, that registered feedlots are not contributors to *E. coli*.

3.4.2.2 Wildlife

Waste from mammals (e.g., deer, beaver, and raccoon) and birds are natural background sources of *E. coli* that minimally contribute to *E. coli* concentrations in surface waters. In natural settings, wildlife is scattered, and such a small fraction of wild animal waste is deposited in waterways that natural background sources are not enough to cause an impairment. In certain locations, wildlife concentrates near a waterway and can be a more substantial *E. coli* source. Birds and waterfowl congregate at locations that provide favorable habitat and food.

3.4.2.3 Septic systems

Septic systems that discharge untreated sewage to the land surface or directly to streams are considered imminent threats to public health and safety (ITPHS) and can contribute *E. coli* to surface waters. Approximately 5% of septic systems in Mower County are considered to be an ITPHS (based on 2016 data). Mower County will be conducting a compliance inventory in Dobbins Creek Watershed for regulatory enforcement. The Dobbins Creek Watershed partners have targeted SSTS upgrades and replacements to substantially reduce *E. coli* loads.

3.4.2.4 NPDES permitted sources

Stormwater runoff from the city of Austin's MS4 is a permitted source of *E. coli*. Approximately two square miles of the city's MS4 is in the Dobbins Creek Watershed. Impervious areas such as roads, driveways, and rooftops can directly connect the location where *E. coli* is deposited on the landscape to points where stormwater runoff carries *E. coli* into surface waters. For example, there is a greater likelihood that uncollected pet waste in an urban area will reach surface waters through stormwater runoff than it would in a rural area with less impervious surface. Wildlife, such as birds and raccoons, can be another source of *E. coli* in urban stormwater runoff.

There is one National Pollutant Discharge Elimination System (NPDES)-permitted animal feeding operation in the Dobbins Creek Watershed. This CAFO is registered for up to approximately 1,300 swine. NPDES-permitted feedlots are designed to contain all manure from the facility with the exception of manure storage basin overflows due to extreme climatic events. Manure application to cropland is to be managed by a manure management plan, but is not directly regulated. It is assumed that compliant and permitted CAFOs are not significant contributors to *E. coli* loading.

There are no permitted wastewater treatment facilities in the Dobbins Creek Watershed.

3.5 Total maximum daily loads

TMDLs were developed in the *Cedar River Watershed Total Suspended Solids, Lake Eutrophication, and Bacteria Total Maximum Daily Load* Report (Barr Engineering 2019a) for the impairments in the Dobbins Creek Watershed. The TMDL tables for the two TSS and two *E. coli* impairments can be found in Table 10 to Table 13.

Table 10. TSS TMDL for Dobbins Creek (-535)

	Flow Zone				
	High	**Moist**	**Mid**	**Dry**	**Low**
	Tons/day				
TOTAL DAILY LOADING CAPACITY	25.78	9.03	4.53	1.66	0.58
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0.00	0.00	0.00	0.00	0.00
Austin City MS4	0.79	0.28	0.14	0.05	0.02
Construction and Industrial Stormwater	0.01	0.004	0.002	0.0007	0.0003
Load Allocation	22.40	7.85	3.94	1.44	0.50
Margin of Safety	2.58	0.90	0.45	0.17	0.06
	Percent of total daily loading capacity				
TOTAL DAILY LOADING CAPACITY	100%	100%	100%	100%	100%
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0%	0%	0%	0%	0%
Austin City MS4	3.1%	3.1%	3.1%	3.1%	3.1%
Construction and Industrial Stormwater	0.05%	0.05%	0.05%	0.05%	0.05%
Load Allocation	87%	87%	87%	87%	87%
Margin of Safety	10%	10%	10%	10%	10%

Table 11. TSS TMDL for Dobbins Creek (-537)

	Flow Zone				
	High	**Moist**	**Mid**	**Dry**	**Low**
	Tons/day				
TOTAL DAILY LOADING CAPACITY	26.40	9.25	4.64	1.70	0.59
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0.00	0.00	0.00		0.00
Austin City MS4	1.33	0.47	0.23	0.09	0.03
Construction and Industrial Stormwater	0.01	0.004	0.002	0.0008	0.0003
Load Allocation	22.42	7.86	3.94	1.44	0.50
Margin of Safety	2.64	0.92	0.46	0.17	0.06
	Percent of total daily loading capacity				
TOTAL DAILY LOADING CAPACITY	100%	100%	100%	100%	100%
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0%	0%	0%	0%	0%
Austin City MS4	5.0%	5.0%	5.0%	5.0%	5.0%
Construction and Industrial Stormwater	0.05%	0.05%	0.05%	0.05%	0.05%
Load Allocation	85%	85%	85%	85%	85%
Margin of Safety	10%	10%	10%	10%	10%

Table 12. *E. coli* TMDL for Dobbins Creek (-535)

	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion Organisms/day				
TOTAL DAILY LOADING CAPACITY	453.31	158.84	79.74	29.17	10.21
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0.00	0.00	0.00	0.00	0.00
Communities Subject to MS4 NPDES Requirements	13.88	4.86	2.44	0.89	0.31
Load Allocation	394.10	138.09	69.32	25.36	8.87
Margin of Safety	45.33	15.88	7.97	2.92	1.02
	Percent of total daily loading capacity				
TOTAL DAILY LOADING CAPACITY	100%	100%	100%	100%	100%
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0%	0%	0%	0%	0%
Communities Subject to MS4 NPDES Requirements	3.1%	3.1%	3.1%	3.1%	3.1%
Load Allocation	87%	87%	87%	87%	87%
Margin of Safety	10%	10%	10%	10%	10%

Table 13. *E. coli* TMDL for Dobbins Creek (-537)

	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion Organisms/day				
TOTAL DAILY LOADING CAPACITY	464.19	162.65	81.65	29.87	10.45
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0.00	0.00	0.00	0.00	0.00
Communities Subject to MS4 NPDES Requirements	23.34	8.18	4.11	1.50	0.53
Load Allocation	394.43	138.21	69.38	25.38	8.88
Margin of Safety	46.42	16.27	8.17	2.99	1.05
	Percent of total daily loading capacity				
TOTAL DAILY LOADING CAPACITY	100%	100%	100%	100%	100%
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0%	0%	0%	0%	0%
Communities Subject to MS4 NPDES Requirements	5.0%	5.0%	5.0%	5.0%	5.0%
Load Allocation	85%	85%	85%	85%	85%
Margin of Safety	10%	10%	10%	10%	10%

For the purposes of this Plan, it has been determined that a 73% reduction in *E. coli* is needed to meet the TMDL

4. Watershed goals

4.1 Management objectives and indicators

The next formal assessment round by MPCA is planned for 2020 that may inform the current condition of Dobbins Creek for delisting for Aquatic Recreation (bacteria) and/or Aquatic Life (TSS). If the reaches are not delisted, the water quality data will be evaluated for change with the cumulative implementation efforts within the watershed and are working toward the end goal of delisting Dobbins Creek for the current as well as possible future impairments (i.e., fish and macroinvertebrate IBIs). The CRWD is actively pursuing other grant sources to build upon the monitoring that has already been completed.

The CRWD, in partnership with the Board of Water and Soil Resources (BWSR), undertook the application of a SWAT model to model the Dobbins Creek Watershed system. The scope of this project was to use SWAT to simulate hydrologic and sediment dynamics on a continuous simulation to identify potential system changes or BMPs needed to meet TSS water quality standards in the Dobbins Creek Watershed. Using the calibrated SWAT model, five broad scenarios were evaluated to determine their ability to reduce peak flows and TSS transported through the Dobbins Creek system. The primary focus of this project was sediment reduction; however, BMPs selected for implementation under these scenarios also considered their ability to reduce peak flow.

The goal of these scenarios is to meet applicable TSS state surface water quality standards. Dobbins Creek is a class 2B stream with a numeric criteria of 65 mg/l TSS. Dobbins Creek reaches were examined using the calibrated model to determine if those reaches were meeting current water quality standards based on monthly averages of TSS concentrations over a 10-year period (1999-2008).The focus of BMP implementation is the North Branch of Dobbins Creek. There are five scenarios which are summarized below, these scenarios were developed and chosen to get the creek back to standards or as closely as possible.

A. Existing Condition: This scenario called for CRWD, residents and stakeholders to maintain existing practices (crop rotations, land management, and fertilizer application). This scenario documented no improvement to infrastructure, farming practices, or the main/tributary channels. As a result, North Branch and Unnamed Branch do not meet TSS water quality standards.

B. Temporary Distributed Storage: This scenario implements seven wetland restoration sites identified by CRWD, 2 sites from Flood Reduction Feasibility Studies, and 17 temporary storages sites from the Upper Cedar River Surface Water Management Plan (WMP). The principal goal of this scenario was to reduce the continuous simulated peak flows (for the 10-year period) by 10%. Again, the focus of this goal was not to meet the water quality standard but to reduce peak flows by 10%. Implementing this scenario provided a 10% reduction in continuous simulated peak flows from Scenario A. TSS concentrations reduced by 4-5% in some months and in others by 50 – 70%. Although there were reductions in TSS concentrations, they were not enough to meet water quality standard. The cost to implement this scenario would be approximately $2.1 million. The primary challenge to implementing this scenario is financial and public perception. The flood reduction sites and the wetland restoration sites will require a substantial capital investment from CRWD to acquire properties, design and construct. Public perception surrounding downsizing culverts to manufacture temporary storage areas has not been favorable. The scale of the WMP was so large that stakeholders were unwilling to consider the temporary storage identified in the WMP. However, the reduced magnitude presented here may be more palatable.

C. Perennial Vegetation: The goal of this scenario was for the watershed to meet TSS water quality standards. To meet TSS water quality standards, 100% of the agricultural land in the North Branch subwatershed was converted from corn or soybean crops to switchgrass. The cost to implement that conversion would be about $4 million/year. Results from a farmer survey indicated that farmers in this region are not likely to convert from corn or soybeans to switchgrass/perennials. In addition, the programming cost necessary to offset the annual loss in revenue is high relative to the CRWD 2010 – 2018 average annual operating budget of $880,444 (CRWD, 2009)

D. Erosion Control: This scenario implements conservation tillage and stream bank restoration to meet the TSS water quality standard. Conservation tillage was employed over 100% of agricultural land draining to the North Branch. In addition, streambanks within the North Branch would be restored though revetment projects along the entire 1,014 m (3,328 ft) length of the channel from East Side Lake. Then, Newberry Rock Riffles were implemented in stream sections (1, 7, 10, 12, 17, 22, and 25) to control grade, reduce velocity and trap sediment. The cost of implementation is about $790,311. As with Scenario B, the implementation challenge is financial. CRWD would need funds to pay for engineering design and construction services associated with the Newberry Rock Riffles; and to buy the items need for the riparian restoration/streambank stabilization.

E. Combination: The practices considered in this scenario were based on responses received from the surveys; the ability of these practices to meet TSS water quality standards, reduce peak flows by 10%; and the availability of grant programs to offset the financial burden. Using that as a basis, the following practices were used in Scenario E:

- Flood Reduction Sites
- Wetland Restoration Sites
- Phase 1- Temporary Storage Sites (Table 10)
- Conservation Tillage

Over the 10-year period of record, monthly average TSS concentrations values were reduced by 34%, which will result in meeting the TSS water quality standard. Peak flow readings were reduced by 23%. The cost to implement this scenario is about $2 million. Although, the price tag is high, there are several grants and funding mechanisms available to CRWD to offset the cost. This scenario is practical because it builds on previous studies, it has support from stakeholder and it addresses both water quality and quantity concerns. It is feasible because the BMPs suggested here and the results of this report provide CRWD the framework and evidence needed to gain financial support.

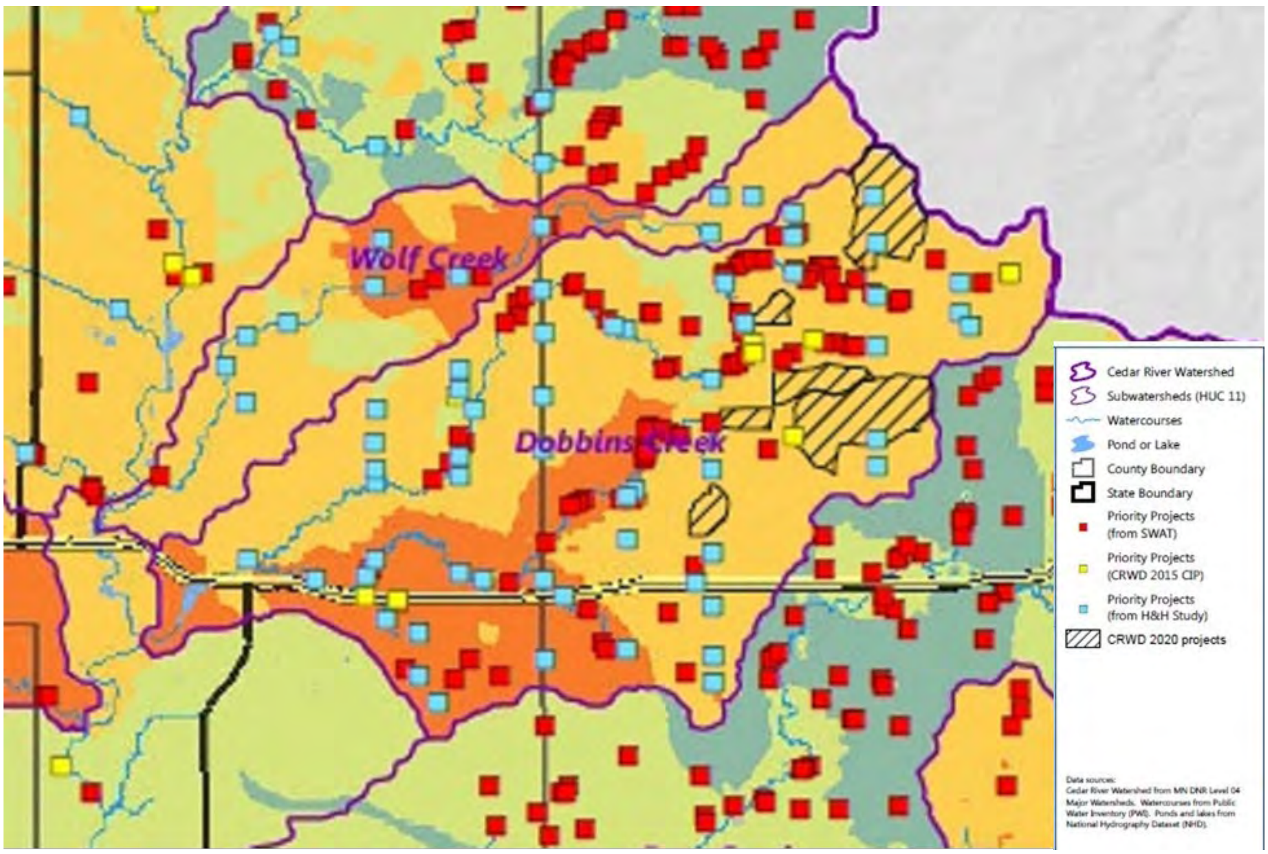
The goal for this watershed is to meet water quality standards with a combination of implementation practices in the combination (E) scenario. It is expected that the management strategies discussed in Section 6 will achieve water quality standards in the reaches. Prioritization was determined by focusing on the headwaters area of Dobbins Creek to embrace the approach of working from the top down. For further implementation in the watershed, priority will be given to practices to address TSS impairments and those to address the potential biota impairments. Results from evaluation/effectiveness monitoring will be used to adapt the practices and approaches to attain water quality standards.

5. Critical areas

Critical areas were identified with various tools in the Dobbins Creek Watershed as part of the overall Cedar River Basin Watershed analysis. Tools included digital terrain analysis to compute stream power index (SPI) and compound topographic index values, stream geomorphic analysis including the BANCS model, and watershed models including HSPF/SAM, SWAT, XP-SWMM, and GSSHA.

With the critical areas identified, priority implementation sites were selected for Dobbins Creek, along with other subwatersheds in the Cedar Basin.

Figure 15. Priority project implementation sites in Dobbins Creek Watershed (excerpted from 1W1P Figure 6-5)



The targeted locations of the priority project implementation sites were developed based on the results of the digital terrain analysis and SWAT water quality modeling. The geographic prioritization was completed to focus the efforts of the watershed partnerships over the next 10 years. The locations include subwatershed outlets where field practices (e.g., filter strips, water and sediment control basins) could likely be implemented. Additional analyses will be completed within the spatial priority areas to identify field-scale critical areas, ground-truth, and prioritize individual project targeting and opportunities.

The Dobbins Creek Watershed partners have field-scale level BMPs identified for Dobbins Creek; however, due to privacy concerns these will not be published as part of the Plan.

6. Identification of management strategies

The following suites (e.g. soil health practices, controlling water, etc.) of BMPs will be applicable to Dobbins Creek in most areas of the watershed. It is the priority of the watershed to implement in identified critical areas, to areas with listed impairments. Habitat concerns are also a high priority for the Dobbins Creek partners and will continue to be addressed. It is expected that with full adoption of these BMPs that water quality standards for TSS and *E. coli* will be met over the long-term.

Management strategies for Dobbins Creek Watershed were developed using several tools, models, and strategizing and planning approaches. These approaches included specific focus on Dobbins Creek as a small watershed as well as its position in the Cedar River HUC 8 Watershed. The CRWD and partners identified the following areas as focal points to achieve water quality standards for Dobbins Creek.

Prioritizing reductions to work toward reaching overall Minnesota Nutrient Reduction Strategy (NRS) goals and to address impairments in Dobbins Creek Watershed determined that soil health practices adopted anywhere in Dobbins Creek will have a positive effect on water quality. Strategies are prioritized in higher load, higher erodible areas through various models and tools (e.g., SPI) and identified high priority areas. Implementation will be targeted to the critical areas (highest pollutant loading), with a focus on impaired waters. Plans to continue the prioritization process, ensure effectiveness of the practices, and milestones and goals, are included in Table 14.

The potential pollutant load reductions and BMP costs for TSS, TP, and total nitrogen (TN) from the priority implementation sites were estimated through a combination of the water quality modeling outputs and digital terrain analysis. Unit area TN and TP loading rates were estimated in the HSPF modeling. Unit area sediment loading rates were estimated in the SWAT modeling. The average unit area loading rates were used for the planning level estimates of project benefits in this plan as described in the Cedar River Basin 1W1P. A total of 94 potential BMP locations were identified with one or more specific BMPs that could be implemented. The BMP locations have an overall contributing drainage area of 3,930 acres. Given that specific practices will be selected with individual landowners, an estimated average pollutant removal efficiency was used for each pollutant based on the group of BMPs most likely to be implemented.

A 46% reduction in TSS loads is needed to meet the Dobbins Creek water quality standard of 65 mg/L TSS. This is based on the 90th percentile of monitored TSS concentrations (April-September, 2009-2018) along reach 535, which is 119 mg/L TSS, compared to the water quality standard (65 mg/L). The 2016-2018 average load in Dobbins Creek was 4,655 ton/yr TSS (Barr 2019); therefore, the load reduction goal in Dobbins Creek is 2,121 ton/yr TSS.

It is assumed that 50% of the total load to Dobbins Creek originates in the critical areas. The planned BMPs in the critical areas are estimated to achieve a 60% reduction in TSS load in those critical areas, or 1,397 ton/yr. The remaining load reduction needed to achieve the load reduction target in Dobbins Creek is 724 ton/yr. This will be achieved by continuing to implement the BMPs to promote soil health and agricultural BMPs described below.

BMP implementation completed to date with the FFY 2014 Effectiveness in Dobbins Creek Section 319 grant are estimated to have provided a reduction of 10 to 30% in sediment and nutrient loads. The targeted efforts will get over halfway to meeting the TSS and *E. coli* water quality standards.

Additional work will continue to implement the practices necessary to achieve water quality standards as described in the following sections using an adaptive management approach. It is expected that a same or similar suite of BMPs will be used past the initial ten years and that through the continued implementation of these BMPs and practices, Dobbins Creek Watershed will meet water quality standards.

The target reductions for TN and TP are based on the NRS goals. The reaches in Dobbins Creek are not impaired for eutrophication or nitrate. The goals for this are found in Table 18.

While Dobbins Creek is fully supportive of aquatic life, during the assessment it was noted that each AUID had potential issues, which if not addressed, could potentially lead to the stream reach becoming impaired in the future. Dobbins Creek was identified as a specific protection area for aquatic life IBIs in the Cedar River WRAPS. The partners have demonstrated the goal to incorporate habitat protection into water quality projects. It is expected that many of the altered hydrology and agricultural BMPs will address this issue.

Prioritized and focused implementation increases the likelihood of achieving measurable water quality improvements. Dobbins Creek Watershed partners have identified areas in the short term to take steps to further identify critical BMP placement and prioritize their work and are mostly planned to occur in the next couple years. These activities include targeted monitoring, updating models, and field verification of high-priority BMP sites.

Projected activities over the next 10 years in Dobbins Creek Watershed including project development, construction, staff time, technical assistance, and outreach will likely exceed $18,500,000. To achieve water quality standards, it is estimated that it will cost approximately $28,500,000.

Table 14. Goals, milestones, and assessments for effectiveness activities for Dobbins Creek Watershed

Treatment Groups	Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10-year goals	Long term goals	Assessment
Prioritization	Perform field verification of very high priority and high priority project sites identified through SWAT modeling and GIS terrain analyses to verify problem areas and evaluate feasibility	10 site verifications	10 site verifications	10 site verifications	10 site verifications	10 site verifications	Total of 50 high priority sites verified	Implement projects on verified sites in the critical loading areas	# of sites verified
	Perform HSPF-SAM/GSSHA modeling to improve estimates of nutrient, sediment, and volume reduction benefits of field-verified priority project sites			Verify reduction estimates			Verify reduction estimates	Get Estimates of nutrient sediment, and volume reduction in very high and high priority project areas	Estimates run every 5 years
	Update existing hydrologic and hydraulic modeling using most current precipitation data						Run outputs as needed; approximately 10-yr precipitation updates	Maintain an up-to-date model	Model updated
	Establish work group to incorporate GSSHA, H&H, and other modeling into updates of watershed-wide hydrologic model	Establish the team	Completed	Assess progress from the modeling effort(s)			Evaluate the future needs of this work group	Continue to use accurate and applicable models in the watershed	Models incorporated/collaboration occurs in work group
	Develop and maintain inventory to quantify and track extent of soil health practices and land use changes used in the watershed (e.g., cover crops, perennial vegetation)	X	X	X	X	X	Clear understanding of utilization of all soil health practices in watershed		Inventory maintained

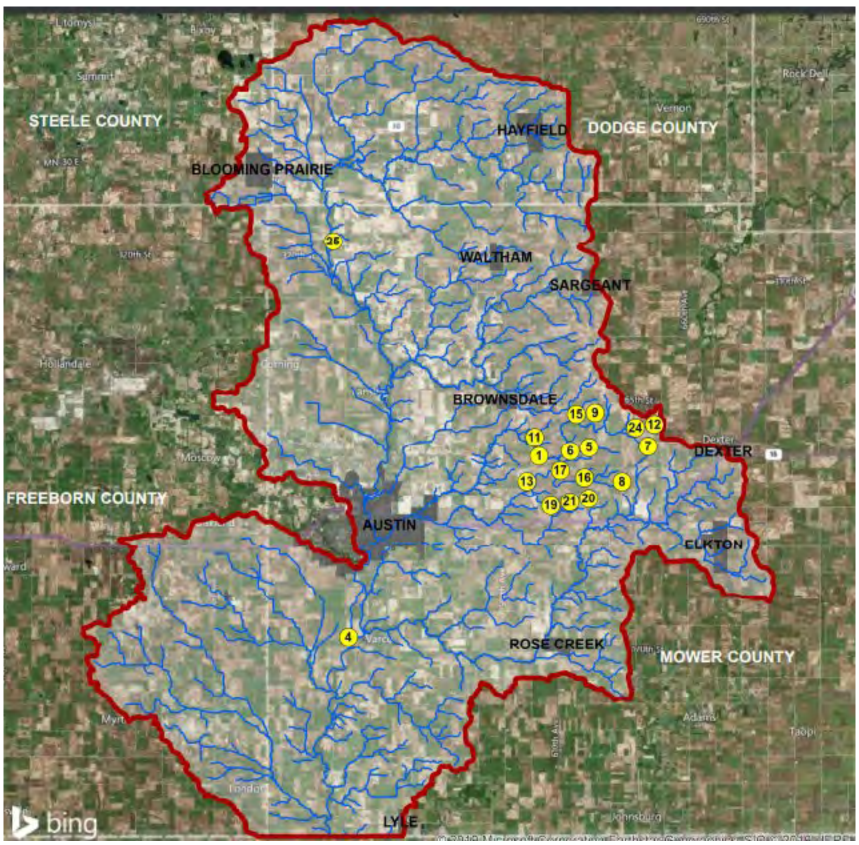
Treatment Groups	Treatment type	Milestones					10-year goals	Long term goals	Assessment
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Effectiveness	Develop monitoring plan focusing on effects of the stressors on the fish and macroinvertebrate IBIs	Critical area monitoring plan completed						Focus on FIBI and MIBI monitoring	FIBI and MIBI monitoring plan completed
	Conduct FIBI monitoring	Monitoring annually	Monitoring annually	Monitoring annually	Monitoring annually	Monitoring annually	Annual monitoring continues	Accurate picture of the stream FIBI and MIBI-- how the BMPs are effecting these metrics over long term	FIBI and MIBI monitoring completed
	Conduct MIBI monitoring	Monitoring annually	Monitoring annually	Monitoring annually	Monitoring annually	Monitoring annually			FIBI and MIBI monitoring completed
	Trend and data analysis of IBIs and metrics			Analysis completed		Analysis completed	Data analysis completed every four years	Monitoring data utilized	Data analysis completed
	Monitoring the water quality of select waterbodies focusing on critical stressors downstream of project locations/implementation			Data summary		Data summary	Every four years data summary completed	Understanding and response to critical stressors downstream of implementation	Monitoring completed
	Evaluate effectiveness of installed BMPs	compile and analyze collected data		Using data gathered make plan changes to utilize more effective BMPs		Using data gathered make plan changes to utilize more effective BMPs	Identify effectiveness of work completed	Determine effectiveness and lag times of improvement	Evaluation monitoring completed Results used for adaptation

6.1 Altered hydrology mitigation strategies

Flooding is a concern for the Dobbins Creek Watershed as it enters the city of Austin, Minnesota. The CRWD has done a lot of work to mitigate flooding and flood damages through flood reduction studies, storage identification, and implementation of practices. Many of the water quality practices in this plan also provide increased water storage that address altered hydrology in the stream and downstream flooding.

While these practices may also protect infrastructure, the primary goal of these practices will be to correct the altered hydrology of the system that has a negative effect on habitat and system as a whole. These practices primarily reduce sediment and nutrient loadings. Specific practices that address the altered hydrology will be streambank restoration and other high cost practices. The Cedar River Watershed has identified these as capital improvement projects (CIPs). Figure 16 shows the 25 planned CIPs for 2019-2020 for the Cedar River Watershed, with a heavy concentration of these projects happening within the Dobbins Creek Watershed, demonstrating the WD's commitment to prioritizing Dobbins Creek Watershed.

Figure 16. CIPs planned for the Cedar River Watershed, with majority prioritized in the Dobbins Creek Watershed



The projects are estimated to reduce flow by 10% at the Cedar River-Dobbins confluence. The CIPs represent a treatment train approach to flood reduction by targeting critical areas and stacking practices to maximize the benefits. Table 15 summarizes all Cedar River Watershed CIPs that are currently being constructed or have completed in 2019 (Phase 1). The majority of these practices are in the Dobbins Creek Watershed. The priority number is used to identify locations in Figure 16. Elements of these projects include grassed waterways, rock riffles, streambank revitalization, berms/impoundments, and ravine stabilization.

Table 15. CRWD CIP 2019 projects that have been completed or currently underway, expected reductions, and estimated costs

Project Priority	Watershed Project Name	Projected Completion	Flow Reduction From Site	Reduction TP**	Reduction TSS***	Estimated Construction Cost
PHASE I - 2017-2019						
1	Dbbn 15- #2-16	COMPLETE	54%	54%	82%	$65,000
2	Cedar 20- #4-16	COMPLETE	33%	53%	81%	$175,000
3	Cedar 20- #5-16	COMPLETE	N/A	53%	81%	$25,000
4	Cedar 20- #5-16	COMPLETE	N/A	53%	81%	$50,000
5	Dbbn 13- #1-16	COMPLETE	82%	54%	83%	760,000
6	Dbbn 13- #1-16	COMPLETE	82%	59%	87%	$760,000
7	Dbbn 1—#15-18	90% COMPLETE	90%	55%	79%	$230,000
8	Dbbn 32- #8-17	90% COMPLETE	85%	48%	71%	$290,000
9	Dbbn 8- #13-18	COMPLETE	85%	49%	72%	270,000
10	Dbbn 33- #12-18	2019	90%	51%	70%	$775,000
11	Dbbn 14- #7-16	2019	86%	50%	72%	$900,000
Pollution Reduction Metrics ** TP: Total phosphorus / ***TSS: Total suspended solids				**TOTAL PHASE I COST**		**$4,300,000**

Phase 2 began in 2019 and some projects are currently underway and are listed in Table 16.

Table 16. Phase 2 CIP projects 2019-2021

Project Priority	Watershed Project Name	Projected Completion	Flow Reduction From Site	Reduction TP**	Reduction TSS***	Estimated Construction Cost
PHASE II PROJECTS CONSTRUCTION IN 2019-2020						
12	Dbbn 3-#18-18	2019	80%	65	87%	$425,000
13	Dbbn 46- #20-19	2019	88%	48%	67%	$325,000
14	Dbbn 2- #17-18	2019	85%	54%	71%	$275,000
15	Dbbn 8- #16-18	2019	80%	20%	31%	$150,000
16	Dbbn 33- #19-18	2020	85%	54%	82%	$1,300,000
17	Dbbn 34- #10-18	2020	2019-'20	48%	75%	$250,000
18	Dbbn 13- #11-18	2020	2019-'20	54%	82%	$350,000
19	Dbbn 35	2020	2019-'20	56%	85%	$325,000
20	Dbbn 37	2020	2020	54%	82%	$175,000
21	Dbbn 37	2020	2020	53%	81%	$300,000
22	Dbbn 11	2020	2019-'20	55%	84%	$300,000
23	Dbbn 2	2020	2019-'20	55%	84%	$175,000
24	Dbbn 3	2020	2019-'20	55%	84%	$175,000

Project Priority	Watershed Project Name	Projected Completion	Flow Reduction From Site	Reduction TP**	Reduction TSS***	Estimated Construction Cost
25	Cedar River-93	2021	2019-’20	54%	83%	$175,000
			2019-’20	**TOTAL PHASE II COST**		**$4,700,000**
Pollution Reduction Metrics ** TP: Total phosphorus / ***TSS: Total suspended solids				**TOTAL CIP COST**		**$9,000,000**

The CRWD has partnered with the Hormel Foundation and will be utilizing state Clean Water Funds and bonding dollars to secure funding for this undertaking as described in Table 17.

Table 17. Summary of partners and funding sources for Phase 1 and 2 CIPs

Bonding Proposal Summary of Costs and Partnering Contributions

PHASE	Hormel Foundation	CRWD	Clean Water Fund	State Bonding	Total
I	$1,350,000	$800,000	$450,000	$1,700,000	$4,300,000
II	$1,850,000	$500,000	$2,350,000		$4,700,000
Total	**$3,200,000**	**$1,300,000**	**$4,500,000**		**$9,000,000**

Funding for the CIPs described above will not include Section 319 funds. However, the partners may seek funding for effectiveness monitoring for these projects through the Section 319 program. Effectiveness monitoring milestones, goals, and assessments are included in Table 19.

6.2 Soil health practices

The watershed partners, and the nation as a whole, have determined that improving soil health is critical to improving water quality. The practices that improve and maintain soil health decrease water runoff, and TSS and nutrient loss from cropland. Reductions in runoff, along with increased infiltration and water holding capacity, provide benefits to watershed hydrology. This provides benefits to watershed hydrology that address streambank erosion and increase stream stability. With this recognition, the watershed partners have identified soil health practice implementation as a priority in Dobbins Creek Watershed.

Soil health, according the Minnesota Soil Health Coalition (https://mnsoilhealth.org/technical-information/), has five main functions: regulating water, sustaining life (plants and soil organisms), filtering and buffering, cycling nutrients, and physical support. Soil health practices include residue management, utilizing cover crops, crop rotations, managing nutrient application, and other practices that generally increase the soil structure to retain water and nutrients on the landscape. The practices also decreases the amount of sediment runoff. For full lists and greater descriptions, see https://mnsoilhealth.org/technical-information/. These adaptions to farming practices represents a significant change to what is commonly practiced on farms. A sizeable chunk of this suite of practices is managing the change in behavior. Through the use of peer-to-peer coaching/mentoring, specific and targeted education/outreach, and demonstrations, the watershed partners hope to make this change with the producers.

Soil health practices work toward achieving Minnesota’s Nutrient Reduction Strategy goals, as well as addressing the TSS impairment in Dobbins Creek. Initial work is focused in the headwaters portion of the watershed, with the philosophy of working from the top down in the Dobbins Creek Watershed. In the headwaters area of Dobbins Creek, the critical areas (highest loading areas) will be the priority area for implementation.

The adoption of these practices amount to a cultural change in this area. While reductions from implementing the practices are important, the Dobbins Creek Watershed partners are also focusing on facilitating the cultural change to encourage the adoption of these practices. These activities include targeted education events, including field trials, events, and peer-to-peer learning. The partners offer Cover Crops 101 classes to watershed landowners to help provide technical information and how-to information. Even more importantly, the partners are facilitating a “coach-the-coach” program to utilize the known peer effect on adoption. Table 18 describes the activities, milestones, and assessment measures for soil health adoption and promotion.

Table 18. Goals, milestones, and assessments of soil health practices for Dobbins Creek Watershed

Treatment type	Milestones					10 year goals	Long-Term Goals	Assessment
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Soil health						Implement structural and non-structural projects and practices to reduce watershed sediment loading by 18 tons/year in Dobbins Creek	Reduce TSS concentrations to <10% of samples exceeding 65 mg/L (April 1 – September 30) by reducing TSS loading in the watershed by 15%	Reductions measured through SWAT/DTM modeling
Cover Crop Field Days	Annual field day/ with 10 participants	Annual field day with additional 5 participants	Evaluate/reassess effectiveness	Implement improvements	Annual field day with additional 5 participants	Start to effect cultural change to adopt soil health practices Conduct field day with 20 participants	Facilitate cultural change to adopt soil health practices Maximizing participation by producers, renters, consultants, retailers, etc.	# of field day participants
Cover Crop 101 Workshops	Connect with 5 new farmers (1 implementation)	Connect with 5 new farmers (1 implementation)	Evaluate/reassess effectiveness	Implement improvements	Connect with 5 new farmers (5 implementations)	Make 15 new farmer connections Facilitate 7 new cover crop implementations	Connections made with 100% of farmers in watershed Cover crops implemented on 75% of all cropland	# of farmer connections # of farms implementing cover crops
Outreach education stories: news articles, social media	10 stories/articles released and 40 social media posts	10 stories/ articles released and 40 social media posts	10 stories/articles released and 40 social media posts	10 stories/articles released and 40 social media posts	10 stories/articles released and 40 social media posts	Create a social message about soil health practices and benefits 50 stories/articles and 200 social media posts	Ongoing outreach via stories, news articles, and social media posts	# of news stories, articles, posts completed
Public/Private collaborative education efforts	Ongoing – involve 1 new business in partnership programs	Ongoing – involve 1 new business in partnership programs	Ongoing – involve 1 new business in partnership programs	Ongoing – involve 1 new business in partnership programs	Ongoing – involve 1 new business in partnership programs	5 businesses involved in partnership program	Joint message across public and private spheres Robust business involvement in partnership programs	# of businesses involved in partnership programs

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
Peer-to-Peer Coaching	Identify willing landowners as coaches; 1 peer-to-peer coaching contacts	Coaching with 2 new participants	Coaching with 2 new participants	Coaching with 2 new participants	Coaching with 2 new participants	Provide the peer based support to achieve cultural change; 9 coaching contacts	Normalize soil health practices among producers through peer-to-peer coaching	# of coaching contacts
Coach-the-coach training/ support	Conduct 1 training/support event; train 1 coach	Conduct training/support event; train original and 1 new coach	Conduct training/support event; train original and 1 new coach	Conduct training/support event	Conduct training/support event	Training for 3 peer-to-peer coaches; 5 training/support events	Strong and supportive coaches for new producers/producers considering adoption	# of coaches # of training/support events
Technical assistance, facilitating contracts (EQIP, across the counter, etc.)	Provide technical assistance to 10 landowners	Provide technical assistance to 10 landowners	Provide technical assistance to 10 landowners	Provide technical assistance to 10 landowners	Provide technical assistance to 10 landowners	Provide technical assistance to 10 landowners every two years	Adequate technical assistance to ensure use of EQIP for implementation	# of landowners receiving technical assistance
Watershed partner (LGU) meetings	5 meetings	5 meetings	5 meetings	5 meetings	5 meetings	Unify and collaborate message and outreach efforts; 25 meetings	Systematic and cohesive approach among local entities	# of watershed partner meetings
All soil health practices	74 acres adopting soil health practices	110 acres adopting soil health practices	170 acres adopting soil health practices	270 acres adopting soil health practices	330 acres adopting soil health practices	1154 acres using soil health practices	6,000 acres of agricultural land practicing soil health	# acres using soil health practices
Cost share assistance for soil health crop management (e.g., cover crops, tillage, etc.)	2 projects funded	2 projects funded	2 projects funded	2 projects funded	2 projects funded	10 projects funded	Ongoing cost share assistance sought for a minimum of 1 annually	# projects funded
Provide educational materials regarding the Minnesota Agricultural Water Quality Certification Program	1 certified farmer	1 certified farmer	1 certified farmer	1 certified farmer	1 certified farmer	Five farmers in the MAWQC program	Maximize the participation of farmers in the MAWQCP in the Dobbins Creek Watershed	# of certified farmers

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
Precision agriculture specialist on staff to assist public/private certifications	Precision agriculture specialist assisting public/private certifications	Evaluate effectiveness of the position	Identify funding sources to continue position			Determine effectiveness of precision ag specialist and source of funding to continue position, if effective	Build relationships with private providers and producers to assist on becoming certified	Staff position funded Staff position evaluated Funding source identified
Conservation planner position at the CRWD to conduct field walkovers, tech support, kitchen-table meetings	5 site visits	5 site visits	5 site visits	5 site visits	5 site visits	25 site visits	CRWD is a credible source of implementation and information to landowners	# of site visits
Work with agriculture retailers and crop consultants on workshops / field days / other outreach activities	2 outreach events	2 outreach events	2 outreach events	2 outreach events	2 outreach events	10 outreach events; Develop relationships and collaboration with private sector	Strong established relationships with private sector and increased credibility of CRWD	# of outreach events
Reduce fertilization rates to UMN rates	5% adoption rate	5% adoption rate	5% adoption rate	5% adoption rate	5% adoption rate	25% of corn/soybean acres adopting UMN rates	50% of corn/soybean acres adopting UMN rates	% of corn/soybean acres adopting UMN rates
Support and expand gridded soil testing coop programs	10% adoption rate	10% adoption rate	10% adoption rate	10% adoption rate	10% adoption rate	50% of cropland acres adopting soil testing program	80% of cropland acres adopting testing	% of cropland acres adopting soil testing program
Adopt spring N application	5% adoption rate	5% adoption rate	5% adoption rate	5% adoption rate	5% adoption rate	25% of corn/soybean acres adopting spring N application	50% of corn/soybean acres adopting spring N application	% of corn/soybean acres adopting spring N application

6.3 Agricultural best management practices

Section 6.2 describes the efforts specific to soil health. This section will describe management activities and practices that apply to agriculture, but are not directly tied to soil health. The goal of the practices in this section is to control the amount of water coming from above and below the surface of the fields and to manage drainage. These practices help reduce the amount of nutrient and TSS loading. Some of the BMPs include controlled drainage, wetland restorations, water retention BMPs, ditch maintenance, two-stage ditches, stream restoration, and buffers. Table 19 outlines the short term goals and actions to implement agricultural BMPs in high-priority and critical areas.

The Dobbins Creek partners have been working with partners to develop a program that addresses the multiple opportunities that storage related projects may have to improve the resource concerns listed above. The partners support the development of storage projects that will provide an opportunity to develop criteria for targeting, design, and program administration to be replicated in other areas around the state. Agricultural BMPs will achieve multiple benefits including improving habitat and reducing altered hydrology concerns.

Table 19. Goals, milestones, and assessments of agricultural BMPs for Dobbins Creek Watershed

	Milestones							
Treatment type	**2-year (2023)**	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**	**10 year goals**	**Long-Term Goals**	**Assessment**
Evaluation of water retention BMPs funded as CIPs Figure 16		Monitor and measure the impact of installed CIPs				Determine the effectiveness of CIPs projects implemented in 2019 through 2021	Effective water retention BMPs	Monitoring data demonstrates appropriate pollutant reductions
WASCOBs	2 WASCOBs installed	2 WASCOBs installed	2 WASCOBs installed	2 WASCOBs installed	2 WASCOBs installed	10 WASCOBs installed	WASCOBs implemented in all appropriate critical areas	# of WASCOBs
Increase public awareness and promote the use of vegetated buffers and runoff reduction practices through education and outreach	Conduct public awareness efforts in conjunction with outreach efforts in Table 18; conduct 20 field or road surveys, add or improve buffers at 1 site	Conduct public awareness efforts in conjunction with outreach efforts in Table 18; conduct 20 field or road surveys, add or improve buffers at 1 site	Conduct public awareness efforts in conjunction with outreach efforts in Table 18; conduct 20 field or road surveys, add or improve buffers at 1 site	Conduct public awareness efforts in conjunction with outreach efforts in Table 18; conduct 20 field or road surveys, add or improve buffers at 1 site s	Conduct public awareness efforts in conjunction with outreach efforts in Table 18; conduct 20 field or road surveys, add or improve buffers at 1 site	100 road or field surveys completed and vegetated buffers added or improved at 5 sites	Preserve all natural features	% compliance
Two-stage ditches				Design project	1 two-stage ditch	1 two-stage ditch	Increase use of two-stage ditch designs in ditch management	# of two-stage ditches
Grassed waterways	2 grassed waterways installed	2 grassed waterways installed	2 grassed waterways installed	2 grassed waterways installed	2 grassed waterways installed	10 grassed waterways installed	Increase use of grassed waterways where needed	# of waterways
Filter strips	5 acres of filter strips installed	5 acres of filter strips installed	5 acres of filter strips installed	5 acres of filter strips installed	5 acres of filter strips installed	25 acres of filter strips installed		# of acres of filter strips

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
Incorporate practices to improve fish and macroinvertebrate habitat into projects that address surface water quality	Incorporate habitat improvement activities into 2 implementation projects	Incorporate habitat improvement activities into 2 implementation projects	Incorporate habitat improvement activities into 2 implementation projects	Incorporate habitat improvement activities into 2 implementation projects	Incorporate habitat improvement activities into 2 implementation projects	Incorporate habitat improvement activities into 10 implementation projects	Protect and improve fish and macroinvertebrate habitat	# of projects with habitat improvement component

6.4 Reducing *E. coli* loading

There are two stream impairments for bacteria measured as fecal coliform in Dobbins Creek. *E. coli* has replaced fecal coliform as the bacteria water quality standard. The 10-year goal is to implement both structural and non-structural practices to reduce loading. The primary practices will include encouraging upgrading and replacing SSTS and feedlot program guidance[1]. It is estimated the activities outlined to be completed in the 10 year implementation schedule (Table 20) will reach water quality standards; however, due to the lag time involved measurable results may not be shown for a time after implementation is completed. *E. coli* issues are primarily being addressed through regulatory measures at the county level, through septic and feedlot permits.

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used to estimate sediment and *E. coli* loads and reductions for the whole planning area combined as a single watershed. The BMPs identified in the 10-year target implementation tables were summed and entered as individual practices in STEPL. The default sediment reduction efficiencies were used. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the BMP list worksheet. The removal efficiencies for the treatment types and resulting watershed load reduction estimates for sediment and *E. coli* are shown in Table 21. Given large uncertainty in BMP efficiencies for bacteria and large range in annual loads, reductions are estimated to achieve the standard. Practices outlined in Section 6.4 are expected to achieve a 97% reduction in *E. coli* loading exceeding the reduction required to meet the TMDL.

[1] https://www.pca.state.mn.us/water/county-feedlot-program

Table 20. Goals, milestones, and assessments of BMPs to address *E. coli* in Dobbins Creek

Treatment Groups	Treatment type	Milestones					10 year goals	Long-Term Goals	Assessment
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
		Identify nonfunctioning SSTS and work with landowners on ways to fix/replace	Continue monitoring SSTS for malfunctions at point of sale and create action plan to mitigate	Continue monitoring SSTS for malfunctions at point of sale and create action plan to mitigate	Continue monitoring SSTS for malfunctions at point of sale and create action plan to mitigate	Continue monitoring SSTS for malfunctions at point of sale and create action plan to mitigate	Implementation of projects and practices to address nonfunctioning SSTS	All SSTS functioning	# of SSTS
Feedlot improvements	Small feedlot improvements		Design and schedule small feedlot fix with identified landowner	Implement small feedlot fix		Use fixed feedlot as a tool to convince other landowners to fix issues	1 small feedlot fix over 10 years--few feedlots	Improve feedlot operations when applicable	# of feedlots
Feedlot improvements	Manure management plans	Review and maintain 2 manure land application plans	Review and maintain 2 manure land application plans	Review and maintain 2 manure land application plans	Review and maintain 2 manure land application plans	Review and maintain 2 manure land application plans	Review and maintain 10 manure land application plans	Manure management plans in place and followed	# of manure land application plans reviewed/maintained
Feedlot improvements	Feedlot inspections	Maintain annual inspections of registered feedlots to identify and maintain compliance	Maintain annual inspections of registered feedlots to identify and maintain compliance	8 site inspections	Maintain annual inspections of registered feedlots to identify and maintain compliance	8 site inspections	Inspect all registered feedlots twice in 10 years	All registered feedlots inspected every five years	# of feedlot inspections
SSTS	SSTS upgrades		County program continues	County program continues	County program continues	County program continues	County program continues to upgrade SSTS to achieve 100% compliance	Maintain 100% compliance	% compliance
SSTS			Upgrade 20% SSTS	Upgrade 20% SSTS	Upgrade 20% SSTS	Upgrade 20% SSTS	100% of SSTS upgraded	Maintain 100% compliance	# of SSTS upgrades/ % compliance

Treatment Groups	Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
	Mower County inventory priority of Dobbins Creek Watershed	20% SSTS inventoried	20% SSTS inventoried	20% SSTS inventoried	20% SSTS inventoried	20% SSTS inventoried	100% SSTS inventoried	Maintain 100% inventory	% inventoried
	Provide educational materials regarding proper function and maintenance of SSTS systems (targeting non-compliant landowners)	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Program continues	SSTS owners educated and aware of SSTS compliance	Program continues
	Encourage the use of low impact design (LID) techniques to reduce stormwater runoff from developed areas through technical assistance to residents and developers	2 outreach events that target 5 new participants	2 outreach events that target 5 new participants	2 outreach events that target 5 new participants	2 outreach events that target 5 new participants	2 outreach events that target 5 new participants	10 outreach events conducted that target 25 participants.	LIDs normalized and used in developed areas	# of outreach events # of participants targeted

Table 21. STEPL removal efficiencies and load reduction estimates for ten-year implementation target BMPs

Treatment	Amount treated (acres)	STEPL BMP	E. coli efficiency	E. coli Reduction	E. coli reduction per unit
				Billion MPN/yr	Billion MPN/unit/yr
Soil health	6,000	Cover Crop 3	0.5	1,967	0.33
Nutrient and manure mgmt.	10,000	Nutrient Management 1	0.5	3,288	0.33
50 ac-ft water retention	2,400	Terrace	0.3	569	0.24
10 WASCOBS	400	Terrace	0.3	196	0.49
100% buffer compliance	24,550	Terrace	0.3	4,764	0.19
1 two-stage ditch	80	Two-Stage Ditch	0.3	117	1.46
10 grassed waterways	500	Terrace	0.3	196	0.39
25 acres of filter strips	25	Terrace	0.3	108	4.31
2.5 miles streambank restoration	200	Two-Stage Ditch	0.3	150	0.75
SSTS	123			274,046	
Ag. waste basin	1			0.1	
Total load reduction				285,402	
Total - percent reduction				97%	

6.5 Improving habitat (terrestrial and aquatic)

Improving the aquatic and terrestrial habitat areas are very important to the Dobbins Creek Watershed partners. There are multiple approaches to improve habitats that are and will be worked into the implementation of the BMPs in Dobbins Creek. These include the CIPs and agricultural BMPs, but also include the benefits gained from soil health practices and the resulting TSS and nutrient reductions and the changed behaviors from education events. Table 22 describes the goals, milestones, and assessment methods specifically for improving habitat.

Table 22. Goals, milestones, and assessments of BMPs and activities to address habitat protection in Dobbins Creek

	Milestones							
Treatment type	**2-year (2023)**	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**	**10 year goals**	**Long-Term Goals**	**Assessment**
Improve FIBI and MIBI scores in Dobbins Creek						Implement structural and non-structural practices to improve MIBI	Achieve applicable Macroinvertebrate Indices of Biological Integrity for streams: - Southern Forest Streams (low gradient): 43	IBIs improved
Cooperate with the DNR and other agencies in efforts to minimize the spread and/or adverse impact of aquatic and terrestrial invasive species (e.g., signage, volunteer activities)	Ongoing cooperation	Ongoing cooperation	Ongoing cooperation	Ongoing cooperation	Ongoing cooperation	Program Continues	Raise public awareness about AIS	Cooperation events occurred
CRWD outreach and education surrounding AIS (e.g., events, news releases, social media)	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Stories and news shared with the public	The public aware and engaged with limiting the spread of AIS	Stories shared
Student outreach and education about AIS (500-600 students/event)	Annually	Annually	Annually	Annually	Annually	10 student events	To engage young people and teach them the importance of healthy ecosystems	# of events
Incorporate practices to improve fish and macroinvertebrate habitat into projects that address surface water quality and/or flooding issues	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Projects address multiple benefits whenever possible	Consciously address multiple benefits to maximize effectiveness of implementation and management practices	% of projects with habitat considerations
Expand participation in the Minnesota Conservation Reserve Enhancement Program (CREP), RIM, and CRP through targeted solicitation of high-value habitat areas	Host 1 educational activities/ work with 2 new landowners and improve knowledge of programs	Host 1 educational activities/ work with 2 new landowners and improve knowledge of programs	Host 1 educational activities/ work with 2 new landowners and improve knowledge of programs	Host 1 educational activities/ work with 2 new landowners and improve knowledge of programs	Host 1 educational activities/ work with 2 new landowners and improve knowledge of programs	Host 5 educational activates/ work with 10 new landowners and improve knowledge of programs	Maximize knowledge and participation in conserving high-value habitat lands	# of educational activities
Restore priority stream reaches	1/2 mile of streambank restoration	1/2 mile of streambank restoration	1/2 mile of streambank restoration	1/2 mile of streambank restoration	1/2 mile of streambank restoration	1.5 miles of stream banks restored	Restore Dobbins Creek to a healthy stream system	# of stream miles

6.6 Groundwater protection

Dobbins Creek is identified as an area with the presence of Karst features (i.e., limestone that has been eroded, increasing groundwater conductivity), making it highly sensitive to pollution. The entire region relies on groundwater for their drinking water source causing its protection to be paramount to health and safety. A targeted approach for BMPs over groundwater sensitive Karst areas will be taken. Dobbins Creek partners will be working with Minnesota Department of Health to identify trends in nitrate concentrations in residential wells and identifying priority action areas. Developing a comprehensive strategy plan for groundwater monitoring and assessment in the watersheds will help to identify the priority areas and implement actions.

The activities for monitoring, assessment, planning, and implementation are described in Table 23 that will protect groundwater from contamination. However, most of the BMPs described in this plan will have groundwater protection features.

Table 23. Goals, milestones, and assessments of BMPs and activities to protect groundwater in Dobbins Creek

	Milestones							
Treatment type	**2-year (2023)**	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**	**10 year goals**	**Long-Term Goals**	**Assessment**
Support testing of private wells for nitrate, bacteria, and other contaminants (Mower County)	10 wells sampled	10 wells sampled	10 wells sampled	10 wells sampled	10 wells sampled	50 wells sampled	Know water quality of wells and awareness of any trends	# wells sampled
Distribute education materials increasing resident awareness of, and promoting practices to reduce, nitrate loading to groundwater in DWSMAs (e.g., radio, news articles, social media, etc.)	2 mailings, 10 news stories/articles released and 80 social media posts	2 mailings, 10 news stories/articles released and 80 social media posts	2 mailings, 10 news stories/articles released and 80 social media posts	2 mailings, 10 news stories/articles released and 80 social media posts	2 mailings, 10 news stories/articles released and 80 social media posts	Continue outreach efforts	Public is informed and engaged about nitrogen use and its effect on groundwater in the DWSMA	Outreach efforts
Provide technical assistance and cost share for sealing abandoned/unused wells	4 wells sealed	4 wells sealed	4 wells sealed	4 wells sealed	4 wells sealed	20 wells sealed	All abandoned/unused wells are sealed in Dobbins Creek Watershed	# of wells sealed

6.7 Public access to nature and engagement

Public engagement has been a priority historically for the project area. The Dobbins Creek partners have invested heavily in educating, informing, and working with the public and they have set forth plans to continue doing so. The Dobbins Creek partners' goals and milestones to achieve this engagement are listed in Table 24.

One example of this commitment to community engagement is the Hormel Foundation. The Foundation is a very active partner providing funding and land acquisition opportunities for Mower SWCD. These resources are used for various conservation projects, most notable is the 518-acre Jay C. Hormel Nature Center. The preserve was established in 1971 and is located within the city limits of Austin in the Dobbins Creek Watershed. The Nature Center features restored and remnant prairie, hardwood forest, wetlands and meandering streams. The mission is to enhance and encourage environmental education, scientific opportunities, and the enjoyment of nature for the public. The Nature Center also provides many hands-on environmental education programs to the general public at no cost.

A previous Section 319 project in Dobbins Creek led the partners to determine that one of the greatest successes of the project was their public participation. Through watershed community engagement and understanding of the work being targeted, many landowners were involved with adopting and implementing practices. Beyond landowner outreach, the partners also developed education programs for both students and adults. The partners also have targeted local news stories to highlight the work being done in the watershed and how it impacts their everyday life.

Table 24. Goals, milestones, and assessments of public engagement and accessibility activities to increase public interaction with nature in Dobbins Creek

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
Promote public interaction with nature through environmental stewardship education and outreach efforts	Host 2 stewardship events	Host 2 stewardship events	Host 2 stewardship events	Host 2 stewardship events	Host 2 stewardship events	Host 10 stewardship events	Stewardship and interaction maximized with community	# of stewardship events
Develop and maintain a list of volunteer activities/opportunities for community groups, conservation groups, and other residents, and recruit such groups to perform identified activities (e.g., river cleanup, enviro-thon, and citizen monitoring)	Add 5 new volunteers	Add 5 new volunteers	Add 5 new volunteers	Add 5 new volunteers	Add 5 new volunteers	Increase number of new volunteers by 25	Increase citizen and community engagement	# of new volunteers

6.8 Administration and regulatory activities to support this plan

The Dobbins Creek Watershed partners have also determined that attention to administrative and regulatory duties will help advance this plan. Table 25 includes the goals, milestones, and activities that will help the partners integrate the support of watershed goals in the administrative and regulatory environment. The activities in this table do not include regulatory or administrative duties that are beyond the control of the local partners (e.g., state, federal).

Table 25. Goals, milestones, and assessments of activities to build a supportive regulatory environment in Dobbins Creek

Activity	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	10 year goals	Long-Term Goals	Assessment
Update local ordinances to adopt Minimal Impact Design Standards (MIDS) for projects creating or reconstructing one acre or more of impervious area.	Review 2 zoning ordinances, review 2 land use regulations	Review 2 zoning ordinances, review 2 land use regulations	Review 2 zoning ordinances, review 2 land use regulations	Update 4 ordinances	Update remaining ordinances and regulations	Local ordinances include MIDS	MIDs used as standard	Ordinances updated
Continue to implement and enforce rules and regulatory programs required by the State of Minnesota but implemented at the local level (e.g., NPDES General Construction Stormwater Permit, Wetland Conservation Act, Buffer Law, Soil Loss)	Continue enforcement and administration	Continue enforcement and administration	Continue enforcement and administration	Continue enforcement and administration	Continue enforcement and administration	Program continues	Rules and regulations required by state to be enforced at the local level continue to be supported	Rules and regulations enforced

6.9 Mercury management

Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanoes. There are no known natural sources in the state that emit mercury directly to the atmosphere.

The long-term goal of the mercury TMDL is for the fish to meet water quality standards; the approach for Minnesota's share is mass reductions from state mercury sources. This mercury TMDL establishes that there needs to be a 93% reduction in state emissions from 1990 for the state to meet its share. Water point sources will be required to stay below 1% of the total load to the state and all but the smallest dischargers will be required to develop mercury minimization plans. Air sources of mercury will have a 93% emission reduction goal.

Almost all the mercury in Minnesota's lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota's mercury emissions are carried by wind to other states and countries. It's impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Because mercury in runoff is derived from atmospheric deposition, mercury in stormwater is accounted for in the calculation of the atmospheric load. Separate strategies for reducing nonpoint sources are not included in this plan for mercury management.

Any efforts to reduce soil erosion will tend to reduce mercury entering a lake or river from nonpoint water sources. Many of these practices are already employed for control of sediment and nutrient loading and will result in reducing mercury loading to surface waters.

7. Monitoring

The Dobbins Creek Watershed has been targeted as a high priority through various studies and modeling projects resulting in CRWD identifying it as a high priority for flow reduction and sediment and nutrient pollution reduction. Consequently, millions of dollars have been spent on BMP and other large-scale project implementation in the Dobbins Creek Watershed since 2014. The CRWD, in partnership with the University of Minnesota, has been evaluating the effectiveness of BMP implementation through discrete sampling, load monitoring, and biological monitoring. ISCO automated water samplers have been deployed at 4 different sites in the Dobbins Creek Watershed. Samples are being collected for TSS, TP, dissolved orthophosphorus, and nitrate and nitrite. The data has been tabulated into annual loads with an intention of doing long term trend analysis over time. Fish Index of Biotic Integrity (IBI) data has been collected by MPCA, CRWD, and the University of Minnesota at 13 sites across the Dobbins Creek Watershed since 2014. Macroinvertebrate IBI data has also been collected by the MPCA, CRWD, and the University of Minnesota at 5 sites since 2014. Baseline data has been collected for all of the previously mentioned parameters as BMP implementation continues. The CRWD will continue to prioritize the existing chemistry and biological monitoring sites as a high priority as more funding becomes available to continue this monitoring in the future (Barr Engineering 2019b).

There are plans to evaluate the effectiveness of the Dobbins Creek project over a 10-year timeframe to determine how well the cumulative efforts within the North and South Branch subwatersheds are working toward the end goal of delisting Dobbins Creek. At this point, the North Branch has many more installed BMPs than the South Branch. This allows us to compare the pollutant contributions from both watersheds in a paired-watershed design and as a trend analysis at the outlet station for the entire Dobbins Creek HUC-12 watershed. The CRWD hopes to leverage grant dollars to be able to continue the monitoring on Dobbins in the future.

Through additional funding and the second round of IWM in the Cedar River Watershed by the MPCA, we hope to continue to monitor both the water quality and biological quality in the mainstem of Dobbins Creek, as well the two tributaries (North and South Branches). In the near future we also hope to establish more localized water quality monitoring locations in the upper part of the watershed where BMPs have been installed as part of this Section 319 grant or are planned to be installed in the near future. Now that the locations of actual on the ground BMPs have been installed or soon will be, more localized monitoring will help communicate how well the BMPs are delivering the anticipated benefits from field to stream. These may include: a tighter nested monitoring approach of the sources of sediment and bacteria within the two tributaries as well as more targeted “end-of-field” or “end-of-pipe” monitoring of subsurface tile drainage. Additionally, at this stage, non-water quality measurements or visual monitoring of actual pollutant sources with photographs should be considered (e.g., bank erosion pins, measuring bank slumps growing, staying the same, or getting moved downstream during high flows), among others. This more targeted monitoring near the highest sources of pollutants, will hopefully provide information and feedback sooner on how well the BMPs are working with local partners to keep them invested in the process in the interim. The information gathered will also benefit watershed predictive models by providing real data on how well the BMPs are working to provide better estimations on what can be accomplished with the current BMPs and if and where more work is needed.

Citizen monitoring is an important component of the watershed monitoring approach. The MPCA coordinates two programs aimed at encouraging citizen surface water monitoring: the Citizen Lake Monitoring Program and the Citizen Stream Monitoring Program. Like the permanent load monitoring network, sustained citizen monitoring can provide the long-term picture needed to help evaluate current status and trends. The advance identification of lake and stream sites that will be sampled by the MPCA staff provides an opportunity to actively recruit volunteers to monitor those sites, so that water quality data collected by volunteers are available for the years before and after the intensive monitoring effort by MPCA staff. This citizen-collected data helps agency staff interpret the results from the intensive monitoring effort, which only occurs one out of every 10 years. It also allows interested parties to track any water quality changes that occur in the years between the intensive monitoring events. Coordinating with volunteers to focus monitoring efforts where it will be most effective for planning and tracking purposes will help local citizens/governments see how their efforts are being used to inform water quality management decisions and affect change.

The work completed to date will provide a baseline of information with which to measure and compare ongoing monitoring data for trend analysis of BMP effectiveness. The upland, near-stream, and in-stream BMPs implemented will eventually provide an improvement in the primary impairments (excess *E. coli*, sediment as TSS); however, there may be considerable lag-time needed for demonstrated improvements in Dobbins Creek.

8. Public participation and education

One of the great success stories in the watershed involves the participation of the public in previous projects. This is especially true for the landowners involved in adopting and implementing practices. Project successes are a result of watershed community engagement and understanding of the work that was being targeted.

This led to increased implementation and adoption. The community also embraced the project. We utilized education programs developed for different ages from schools, through college students and adults. This broad spectrum of outreach engaged the community and generated several local news stories on the work being done. This has resulted in good feedback from the public through public meetings, social media and interactions between staff. Due to the success of these efforts they will be continually built upon and utilized in the future.

The Hormel Foundation was committed to community improvement projects in and around the city of Austin. They committed $100,000 towards the implementation of projects. The use of those projects ranged between the practices, but were targeted in the headwaters of Dobbins Creek Watershed. This was a significant step for a private foundation to get involved like this. They were trusting in the process of watershed management and funding a project several miles away from the city of Austin, which was the target area for their funding. Since that time, the Foundation has also committed to other watershed projects in the Cedar River Watershed. The CRWD was also a funding partner, utilizing local levy for projects.

The partners recognize that public awareness and support is necessary to successfully implement this Plan and achieve meaningful progress towards Plan goals. Public input was solicited at the initial public meeting hosted as part of Plan development. Additional stakeholder input received through a diverse Advisory Committee, including local residents and business owners, was considered throughout Plan development. The education and public involvement activities are generally geared towards promoting soil, water, and natural resource stewardship through increased public understanding of priority issues and providing varying levels of technical assistance. Planned levels of engagement include:

- Site visits and site-specific technical assistance (e.g., nutrient management plans)
- Workshops (e.g., to promote implementation of soil health BMPs to agricultural producers)
- Demonstration projects/research sites
- Volunteer events (e.g., river clean-ups)
- Targeted mailings (e.g., information targeting owners of non-functioning SSTS)
- News articles/press releases (project- or initiative-specific)
- Educational flyers (e.g., information about vegetated buffers, groundwater conservation)

Plan implementation presents an opportunity to increase and optimize the existing education and public involvement roles of the partners. The partners will leverage existing relationships and public outreach methods as a foundation to implement the activities selected, further developing capacity and methods through the assistance of cooperating entities and the targeting performed as part of this Plan. Existing education and public involvement programs include:

- Public presentations in schools
- Canoe-mobile
- Hormel Nature Center 7th grade "Water Day"
- Dodge County Expo
- County fair booths

- Enviro-thon
- Riverland Technical College Cover Crop 101 classes
- Field Days
- Workshops
- Citizen Advisory Committee
- Water Planning Committee
- Template education materials (e.g., information on vegetated buffers, groundwater conservation)
- Photo contest/social media engagement
- Annual reports

The partner organizations will continue to coordinate with the Cedar River Watershed Partnership (CRWP) as it seeks to implement this Plan. The CRWP is a public-private-nonprofit collaboration that provides tools and resources to help farmers adopt farm management strategies that improve the soil, water and economic health of their farms and address water quality challenges in the watershed. The CRWP includes Environmental Initiative, Central Farm Service, Mower County SWCD, Land O' Lakes SUSTAIN, Hormel Foods and the MDA. The CRWP engages with farmers, provides information and resources on improved farming strategies, and works with them to address water quality risks through achieving certification in the Minnesota Agricultural Water Quality Certification Program. Template education and outreach materials will be developed for use within each County and be hosted online. Activities will be locally administered and implemented, with individual partners tailoring administration to the particular needs of their jurisdictions.

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Appendix A: STEPL *E. coli* assumptions and reductions

The STEPL was used to estimate *E. coli* loads and reductions for the watershed. The BMPs identified in the 10-year milestone table were summed and entered as individual practices in STEPL. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the 'BMPList' worksheet in STEPL. The practices and assumed reduction efficiencies are shown in Table 26. The BMPs with area and percent of watershed treated and assumptions made for STEPL are described in Table 27. The treatment efficiencies for the BMPs that are not in the original list of BMPs and reduction efficiencies (BMPList) in STEPL were assigned based on the similarity of the treatment processes with selected BMPList practices. STEPL output for the *E. coli* load reduction estimates for BMPs are listed in Table 28.

Table 26. Land use, BMPs and efficiencies for STEPL

Landuse	BMP and efficiency	*E. coli*
Cropland		
Cropland	0 No BMP	0
Cropland	Bioreactor	0.9
Cropland	Buffer - Forest (100ft wide)	0.9
Cropland	Buffer - Grass (35ft wide)	0.65
Cropland	Conservation Tillage 1 (30-59% Residue)	0.3
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.5
Cropland	Land Retirement	0.9
Cropland	Nutrient Management 1 (Determined Rate)	0.5
Cropland	Streambank Stabilization and Fencing	0.3
Cropland	Terrace	0.3
Cropland	Two-Stage Ditch	0.3
Pastureland		
Pastureland	0 No BMP	0
Pastureland	30m Buffer with Optimal Grazing	0.65
Pastureland	Alternative Water Supply	0.65
Pastureland	Grazing Land Management (rotational grazing with fenced areas)	0.65
Pastureland	Livestock Exclusion Fencing	0.65
Pastureland	Streambank Protection w/o Fencing	0.3
Pastureland	Streambank Stabilization and Fencing	0.65
Pastureland	Use Exclusion	0.9
Feedlots		
Feedlots	0 No BMP	0
Feedlots	Filter strip	0.3
Feedlots	Runoff Mgmt System	0.5
Feedlots	Solids Separation Basin w/Infilt Bed	0.9
Feedlots	Waste Storage Facility	0.9

Landuse	BMP and efficiency	*E. coli*
Urban		
Urban	0 No BMP	0
Urban	Bioretention facility	0.9
Urban	Extended Wet Detention	0.9
Urban	Filter Strip-Agricultural	0.3
Urban	Infiltration Basin	0.9

Table 27. Percent watershed treated and assumptions for BMPs as STEPL inputs

Acres	BMP	% watershed treated	Assumptions
Soil Health			
6,000	Soil health practices	24.44%	Assume Cover Crop 3
10,000	50% nutrient mgmt.	40.73%	Assume as Nutrient Management 1, includes manure mgmt. (0.5 of 20,000 ac cropland)
20,000	80% soil testing		Skip, only use nutrient mgmt.
Ag BMPs			
2,400	50 ac-ft water retention	9.78%	Assume 0.25 inch/acre retention, reduction efficiencies for water retention assumed to be the same as efficiencies for Terrace
400	10 WASCOBS	1.63%	Assume 40 acres treated per WASCOB, reduction efficiencies for WASCOBs assumed to be same as efficiencies for Terrace
24,550	100% buffer compliance	100.00%	Assume 100% with 35 ft width, as Terrace
80	1 two-stage ditch	0.33%	Assume 1 miles with treatment as 80 ac/mile (1/8 mile width), as Two-Stage Ditch
500	10 grassed waterways	2.04%	Assume 50 acres treated by grassed waterway, reduction efficiencies for grassed waterways assumed to be the same efficiencies for Terrace.
25	25 acres of filter strips	0.10%	Assume 25acres
E. coli			
10,000	100% compliance with feedlot program	40.73%	Assume as Nutrient management 1
	1 small feedlot fix		E. coli load from 2 ac feedlot using 'Feedlots' worksheet is 0.021556037 Billion MPN/yr
	100% manure mgmt. plan compliance		
	100% SSTS compliance - upgrade 20%/2 years		Assume 123 failing systems are all replaced, % failing systems changes from 20 to 0%
200	2.5 miles streambank restoration		Assume 1 miles with treatment as 80 ac/mile (1/8 mile width), as Two-Stage Ditch
Groundwater			
	20 wells sealed		

Table 28. STEPL output for *E. coli* load reduction estimates for BMPs

Treatment	Amount treated (acres)	% treated	STEPL BMP	*E. coli* efficiency	*E. coli* load (no BMP) (Billion MPN/year)	*E. coli* reduction (Billion MPN/year)	*E. coli* load (with BMP) (Billion MPN/year)	% *E. coli* reduction (%)
Soil health	6,000	24%	Cover Crop 3	0.5	293128.36976	1967.5	291160.9	0.7%
Nutrient and manure mgmt.	10,000	41%	Nutrient Management 1	0.5	293128.36976	3288.144282	289840.2	1.1%
50 ac-ft water retention	2,400	10%	Terrace	0.3	293128.36976	569.1610553	292559.2	0.2%
10 WASCOBS	400	2%	Terrace	0.3	293128.36976	196.2719271	292932.1	0.1%
100% buffer compliance	24,550	100%	Terrace	0.3	293128.36976	4764.163748	288364.2	1.6%
1 two-stage ditch	80	0.3%	Two-Stage Ditch	0.3	293128.36976	117.0329873	293011.3	0.0%
10 grassed waterways	500	2%	Terrace	0.3	293128.36976	196.2719271	292932.1	0.1%
25 acres of filter strips	25	0.1%	Terrace	0.3	293128.36976	107.7107591	293020.7	0.0%
2.5 miles streambank restoration	200	1%	Two-Stage Ditch	0.3	293128.36976	149.660786	292978.7	0.1%
SSTS – 10 [1]					293128.36976	274,046	19082.2	93.5%
Ag. waste basin – 1 [2]						0.02		0.0%

[1] SSTS - Assume ten failing systems are all replaced, % failing systems changes from 2% to 0%

[2] Ag. waste basin - E. coli load from 2 ac feedlot using 'Feedlots' worksheet calculated and removed

E. coli loads and subsequent reductions with replacement estimated in STEPL by assuming the average concentration (MPN/mL) of *E. coli* effluent reaching a stream from septic overcharge is 948,000 as equivalent to the BWSR SSTS tool assumption. *E. coli* efficiency and other STEPL SSTS worksheet assumptions are described in Table 29.

Table 29. SSTS STEPL worksheet and assumptions

Septic Nutrient Loads

1. Nutrient load from septic systems

Watershed	No. of SSTS	Pop per SSTS	SSTS Failure Rate %	Failing SSTS	Pop on Failing SSTS	Failing SSTS Flow gal/day	Failing SSTS Flow l/hr	N Load lb/hr	P Load lb/hr	BOD lb/hr	*E. coli*, MPN/hr
Dobbins Creek	615	2.43	20	123	299	20922	3300	0.437	0.171	1.8	3.13×10^9

2. Septic nutrient load in lb/yr except E. coli in MPN/yr) | **Load after Reduction**

Watershed	N Load lb/yr	P Load lb/yr	BOD lb/yr	*E. coli* MPN/yr	N Load lb/yr	P Load lb/yr	BOD lb/yr	*E. coli* MPN/yr	*E. coli* Billion MPN/yr
Dobbins Creek	3824	1498	15614	2.740×10^{14}	3824	1498	15614	2.740×10^{14}	274,046

Assumptions made for SSTS

The direct contribution of nutrients to a stream is mainly from failing septic systems.

Required input for calculating septic nutrient load are number of systems, failure rate, loading rate (lb/hr) and flow (cfs).

Assumption: failing septic systems are distributed evenly across the watershed based on land area.

Assume the average concentrations reaching the stream (from septic overcharge) are:

Total Nitrogen	60	mg/L (range of 20 to 100)
Total Phosphorus:	23.5	mg/L (range of 18 to 29)
Organics (BOD):	245	mg/L (range of 200 to 290)
E. coli	948000	MPN/100ml
Typical septic overcharge flow rate of:	70	gal/day/person(range of 45 to 100)

E. coli effluent # assumed to be 948,000 as equivalent from the BWSR Septic System Improvement Estimator Tool (Heger 2017) assumption

Appendix B: SWAT report

Dobbins Creek – SWAT Model

Agricultural Watershed Restoration Grant Project

Prepared For
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Project Number #106282

February 2010

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Executive Summary

Dobbins Creek watershed is part of the CRWD located in southern Minnesota. The watershed is northeast of the city of Austin, Minnesota and is entirely contained in Mower County. The Dobbins Creek watershed area is approximately 38 square miles (24,550 acres). The creek is approximately a 26-mile stream divided into three branches: North Branch, South Branch and Unnamed Branch. The creek ranges in width by of approximately 13 – 16 feet, (CRWD, 2008). The creek empties into East Side Lake, which then drains to the Cedar River.

The CRWD, in partnership with the Minnesota Board of Water and Soil Resources (BWSR), have undertaken the development of a Soil and Water Assessment Tool (SWAT) model for the Dobbins Creek watershed system. The scope of this project is to use SWAT to simulate hydrologic and sediment dynamics on a continuous simulation to identify potential system changes or Best Management Practices (BMPs) needed to meet sediment water quality standards in the Dobbins Creek Watershed, specifically in the impairment reach.

This report is a summation of the application of the SWAT model and evaluation of load reduction scenarios. The report is divided into the following sections:

<u>Executive Summary</u> – Provides an overview of the report

<u>Project Background</u> – Summarizes the historic background of the project documenting the fact that Dobbins Creek is impaired for turbidity and that the scope of this project is to simulate hydrologic and sediment dynamics on a continuous simulation to quantify the impact that potential system changes or BMPs would have on the hydrology and sediment impairment within the watershed.

<u>Watershed Characteristics</u> – Presents current information about the watershed relating to land use/ land cover, topography, soils, hydrology and farming practices.

<u>Model Selection, Development and Performance</u> – Describes the selection method used to select a SWAT model as the preferred modeling tool for this watershed; how and where data were compiled from and an assessment of the available data; and how the model was calibrated and validated.

<u>Evaluation of Load Reduction Scenarios</u> – Presents five load reduction scenarios: Existing Conditions/ Do Nothing, Temporary Distributed Storage, Perennial Vegetation, Erosion Control and a combination of BMPs used in the other scenarios. These scenarios were described, computed, water quality benefits presented, estimated cost offered and concluded with an assessment of implementation challenges.

<u>Conclusion</u> – Summarizes the project and provides recommendations.

Project/ Modeling Framework

Model Selection

To complete the project, the Hydrological Simulation Program – Fortran (HSPF), the Agricultural Non-Point Sources Pollution Model (AGNPS) and the SWAT models were evaluated for use on this project. The models were evaluated based on the following:

- Public domain/private software
- Event Based/ continuous simulation
- Empirical/physically based
- Geographical Information System (GIS) based models

After reviewing the list of available watershed data and the scope of the project, which requires a model that simulates nutrient and sediment dynamics on a continuous basis, and the intended use of the model, SWAT emerged as the most suitable model.

Model Development

The model was developed in three major steps. These steps were completed as follows and are summarized described below:

1. Compile Data
2. Model Construction
3. Perform Model Calibration and Validation

Data Assessment

Various sources of data were available for land use, soils, topography, climate, land management, stream flow, water quality and infrastructure, as described above. Stream flow and sediment data were the most limited. Stream flow data were reviewed from the Minnesota Department of Natural. Although it was documented that flow data are available from 1998 – present for gauge station DNR 48005001, only data from 2008 and 2009 were used to calibrate and validate the model due to data quality. Datasets used for sediment calibration were from July and August 2000 and July and August 2001. Although there are data gaps, the key to making the most successful use of a SWAT model for the Dobbins Creek watershed was to calibrate the model to observed, monitored flow and sediment data.

Model Construction

The model was constructed in three key steps: watershed delineation, land use, and soils integration. The watershed delineation was completed by loading the Digital Elevation Model (DEM) into SWAT. Thirty-seven (37) subbasins and the outlet to the Cedar River were defined. The land use and soil themes were defined by loading the National Land Cover Data (NLCD) land use and Soil Survey Geographic (SSURGO) soil data layers. Once each subbasin was defined they were furthered divided into Hydrologic Response Units (HRU). After the HRUs were developed, land management practices, such as fertilizer application, crop rotations, and tillage operations were added. Lastly, climate data were added and the model was executed/simulated using a model default coefficient.

Model Performance

SWAT simulated results were compared to observed data to determine whether the model simulations provide a reasonable representation of actual conditions. The model was calibrated and validated to available flow and sediment concentration data. Flow data from the DNR 48005001 were divided and used for model calibration and validation as noted below.

Calibration	Validation
April 08	May 08
June 08	July 08
August 08	September 08
October 08	November 08
April 09	

Sediment data from the J.C. Hamel Nature Center site, just upstream of East Side Lake for the 2000-1 monitoring period were divided and used. Data from July and August of 2000 were used for calibration, and data from July and August 2001 were used for validation. The SWAT model parameters adjusted to calibrate the model are presented in Table E1:

Table E1: Dobbins Creek Model Calibration Parameters

Parameter	Definition	Units	Lower Bound	Upper Bound	Default	Calibrated Model
Flow						
ALPHA_BF	Baseflow alpha factor for recession constant	days	0	1	0.048	0.7
CH_K2	Effective hydraulic conductivity in tributary channel	mm/hr	0	25	0	12
CH_N	Manning's roughness coefficient for the main channel		0.014	.024	0.014	0.019
CN2	SCS runoff curve number		-0.05	0.05	Varies	0.05
ESCO	Soil evaporation compensation factor		0	1	0	1
GW_DELAY	Groundwater delay	Days	0	31	31	16
GWQMN	Threshold depth of water in the shallow aquifer from return flow	mm	-2000	2000	0	-1457.17

Parameter	Definition	Units	Lower Bound	Upper Bound	Default	Calibrated Model
REVAPMIN	Threshold depth of water in the shallow aquifer for revap or percolation to the deep aquifer to occur	mm	-100	100	1	8.264
SMTMP	Snowmelt temperature	°C	-0.25	.25	1	-0.12
SOL_AWC	Available water capacity	m/m	-0.25	.25	Varies	0.195
SURLAG	Surface runoff lag coefficient		0	10	4	0.5
TIMP	Snow pack temperature lag factor		0	1	1	0.687
Sediment						
SPEXP	Exponent parameter for calculating sediment re-entrained in channel sediment routing		1	2	1	2

This model's performance, using a daily time step, had R^2 values of 0.7 and 0.7 for flow calibration and validation and 0.9 and 0.8 for sediment calibration and validation, respectively.

Load Reduction Scenarios

A. Existing Condition
B. Temporary Distributed Storage (Flood Reduction Sites, Wetland Restoration Sites and Temporary Distributed Storage Sites)
C. Perennial Vegetation (Converting Corn and Soybean crops to Switchgrass throughout the watershed)
D. Erosion Control (Conservation Tillage, and Newberry Rock Riffles)
E. Combination (Flood Reduction Sites, Wetland Restoration Sites and Temporary Distributed Storage Sites, and Conservation Tillage)

Conclusion

The CRWD, in partnership with BWSR, undertook the application of a SWAT model to model the Dobbins Creek watershed system. The scope of this project was to use SWAT to simulate hydrologic and sediment dynamics on a continuous simulation to identify potential system changes or BMPs needed to meet TSS water quality standards in the Dobbins Creek Watershed. Using the calibrated SWAT model, five broad scenarios were evaluated to determine their ability to reduce peak flows and TSS transported through the Dobbins Creek system. The primary focus of this project was sediment reduction; however, best management practices selected for implementation under these scenarios also considered their ability to reduce peak flow.

The goal of these scenarios, as documented by CRWD, is to meet applicable turbidity/TSS state surface water quality standards. Dobbins Creek is a class 2B stream with a turbidity limit of 25 NTUs which translated to between 30 – 40 mg/l of TSS. The three branches of Dobbins Creek, North, South and Unnamed, were examined using the calibrated model to determine if those reaches were meeting current water quality standards based on monthly averages of TSS concentrations over a 10-year period (1999-2008). The South Branch consistently meets water quality standards. While the Unnamed Branch, violates the standard by about 5 mg/l one month over the 10-year period. On the other hand, North Branch violates the water quality standard five times over the 10-year period with exceedance of the standard ranging from about 7 mg/l to 35 mg/l. As a result, the focus of BMP implementation was the North Branch of Dobbins Creek. The five (5) scenarios are summarized below.

A. Existing Condition - This scenario called for CRWD, residents and stakeholders to maintain existing practices (crop rotations, land management, and fertilizer application). This scenario documented no improvement to infrastructure, farming practices or the main/tributary channels. As a result, North Branch and Unnamed Branch do not meet TSS water quality standards.

B. Temporary Distributed Storage – This scenario implement seven wetland restoration sites identified by CRWD, two sites from Flood Reduction Feasibility Studies, and seventeen(17) temporary storages sites from the WMP. The principal goal of this scenario was to reduce the continuous simulated peak flows (for the 10-year period) by 10 percent. Again, the focus of this goal was not to meet the water quality standard but the reduce peak flows by 10 percent. Implementing this scenario provided a 10 percent reduction in continuous simulated peak flows from Scenario A. TSS concentrations reduced by 4-5 percent in some months and in others by 50 – 70 percent. Although there were reductions in TSS concentrations, they were not enough the meet water quality standards. The cost to implement this scenario would be approximately $2.1 million. The primary challenge to implementing this scenario is financial and public perception. The flood reduction sites and the wetland restoration sites will require a substantial capital investment from CRWD to acquire properties, design and construct. Also, public perception surrounding down sizing culverts to manufacture temporary storage areas has not been favorable. The scale of the WMP was so larger that stakeholders were unwilling to consider. However, the reduced magnitude presented here may be more palatable.

C. Perennial Vegetation: The goal of this scenario was for the watershed to meet TSS water quality standards. To meet TSS water quality standards, 100 percent of the agricultural land in the North Branch subwatershed was converted from corn or soybean crops to switchgrass. The cost to implement that conversion would be about $4 million. Result from the survey indicated that farmers in this region are less likely to convert from corn or soybeans to switchgrass/perennials. In addition, the programming cost necessary to offset the annual loss in revenue is high relative to the CRWD 2010 – 2018 average annual operating budget of $880,444 (Cedar River Watershed District, 2009).

D. Erosion Control: The following erosion control best management practices were implemented in this scenario to meet TSS water quality standard: conservation tillage and stream bank restoration. Conservation tillage was employed over 100 percent of agricultural land draining to the North Branch. In addition, streambanks within the North Branch would be restored though revetment projects along the entire 1,014 m (3,328 ft) length of the channel from East Side Lake. Then, Newberry Rock Riffles were implemented in stream sections (1, 7, 10, 12, 17, 22, and 25) to control grade, reduce velocity and trap sediment. The cost of implementation is about $ 790,311. As with Scenario B, the implementation challenge is financial. CRWD would need funds to pay for engineering design and construction services associated with the Newberry Rock Riffles; and to buy the items need for the riparian restoration/streambank stabilization.

E. Combination: The practices considered in this scenario were based on responses received from the surveys; the ability of these practices to meet TSS water quality standards, reduce peak flows by 10 percent; and the availability of grant programs to offset the financial burden. Using that as a basis, the following practices were used in Scenario E:

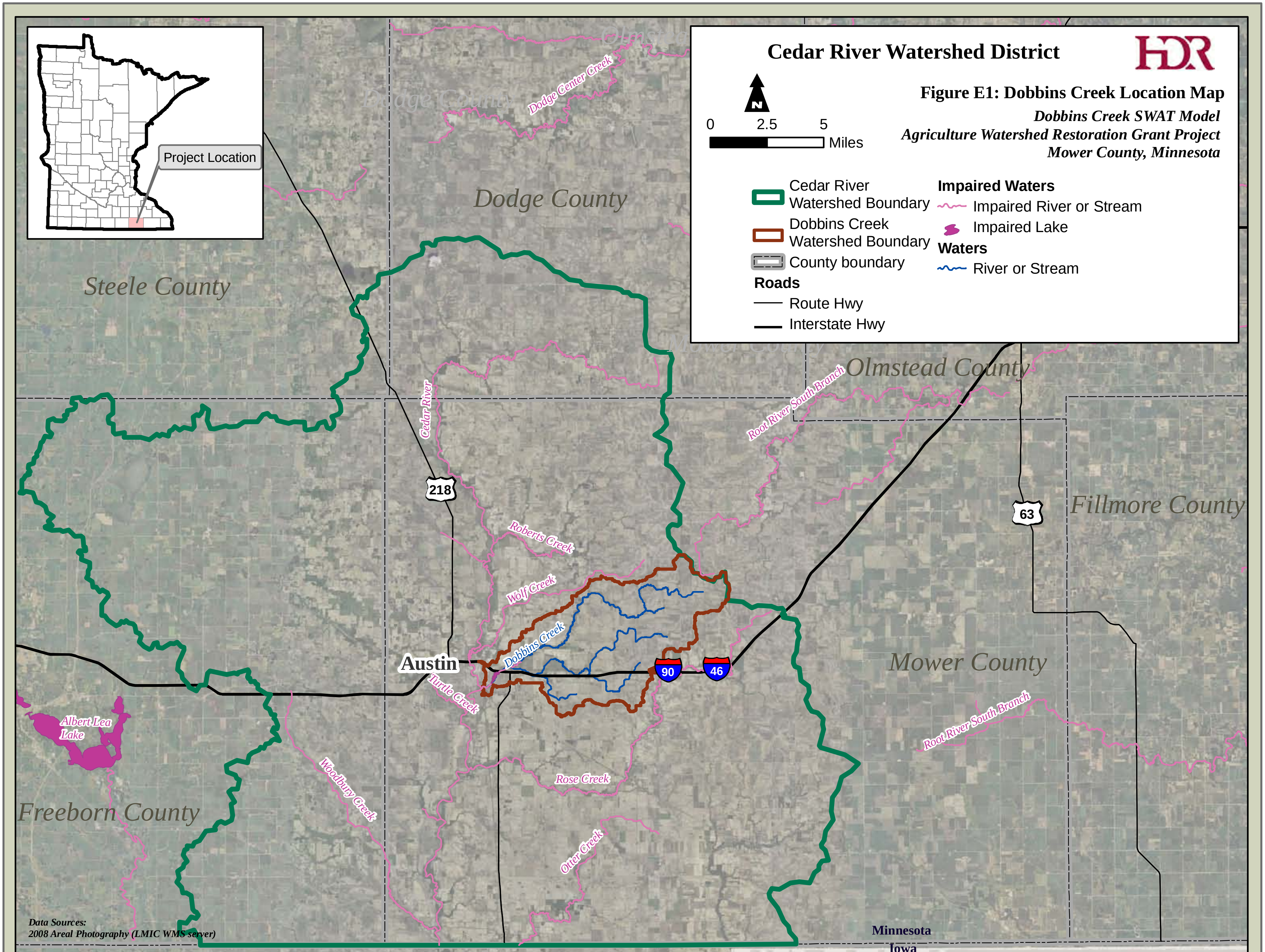
- Flood Reduction Sites
- Wetland Restoration Sites
- Phase 1- Temporary Storage Sites (Table 10)
- Conservation Tillage

Over the 10-year period of record, monthly average TSS concentrations values were reduced by 34 percent, which satisfied Minnesota Statue 7050. In addition, peak flow readings were reduced by 23 percent. The cost to implement this scenario is about $2 million. Although, the price tag is high, there are several grants and funding mechanisms available to CRWD to offset the cost. This scenario is practical because it builds on previous studies, it has support from stakeholder and it addresses both water quality and quantity concerns. It is feasible because the BMPs suggested here and the results of this report provide CRWD the framework and evidence needed to gain financial support.

Recommendations

Considering the findings presented in this report and the water quality implications to Dobbins Creek, the following actions are recommended:

- Apply for Phase 3 funding and other applicable funding to implement Scenario E. Use the funds received to
    1. Revise Site 1 and 2 Flood Reduction designs to incorporate water quality features
    2. Complete Phase 1 site assessments/feasibility studies on the seven (7) identified wetland restoration sites.
    3. Complete engineering design and construction associated with the WMP temporary storage sites incorporated in the study.
- Complete an in-depth water quality study of East Side Lake to determine nutrient and sediment budgets.
- Continue monitoring efforts and integrate procedures that will aide obtaining flow and TSS data during high flow events.
- Education and engage stakeholders to voluntarily participate in runoff reducing practices, such as, conservation tillage or no-till.



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Project Background

The Cedar River Watershed District (CRWD) is located in Steele, Dodge, Freeborn, and Mower Counties, Minnesota. The primary land mass is contained within Mower County. The CRWD drainage area is approximately 435 square miles and contains eleven stream reaches: Dobbins Creek, Lower Cedar River, Mud Lake Creek, Orchard Creek, Roberts Creek, Rose Creek, Schwerin Creek, Upper Cedar River, West Beaver Creek, Wolf Creek, and Woodbury Creek. The focus of this project is the Dobbins Creek stream reach. Dobbins Creek and its contributing watershed were selected as part of a state-wide project for agricultural watershed restoration and management focusing on hydrology and water quality. The watershed was selected because of water quality concern, the land use is predominantly agricultural, and due to its size.

The CRWD, in partnership with the Minnesota Board of Water and Soil Resources (BWSR), have undertaken the application of the Soil and Water Assessment Tool (SWAT) to model the Dobbins Creek watershed system. The scope of this project is to use the SWAT model to simulate hydrologic and sediment dynamics on a continuous simulation to identify potential system changes or Best Management Practices (BMPs) needed to meet turbidity (total suspended sediment) water quality standards in the Dobbins Creek.

The following sections describe the Dobbins Creek watershed model including: model selection, application and performance; and use for various scenarios.

Watershed Characteristics

Dobbins Creek watershed is part of the CRWD located in southern Minnesota. The watershed is northeast of the city of Austin, Minnesota and is entirely contained in Mower County. The Dobbins Creek watershed area is approximately 38 square miles (24,550 acres). The creek is approximately a 26-mile stream divided into three branches: North Branch, South Branch and Unnamed Branch. The creek ranges in width by of approximately 13 – 16 feet, (CRWD, 2008). The creek empties into East Side Lake, which then drains to the Cedar River.

According to water quality assessments completed by the MPCA, Dobbins Creek has fecal coliform water quality impairment from township 103 north, section 26, range 18 west, east line to Cedar River. The impaired section is not meeting the water quality standards set for fecal coliform which is 126 E.Coli colony forming units per 100 ml (US EPA, 2008). As a result in 2006, that section of Dobbins Creek was put on the 303 (d) list (MPCA, 2006). A total maximum daily load (TMDL) has been completed and is being implemented as part of the Lower Mississippi River Basin process (CRWD, 2008). Currently, Dobbins Creek is being assessed for turbidity impairment. The assessment process entails the MPCA calling for available data along the creek to determine if the creek is meeting the turbidity water quality standard of 25 nephelometric turbidity units (NTU) or total suspended solids (TSS) of 40mg/L (Thompson - Personal Communication, 2009). A review of available data, which will be discussed in a later section, suggests that the reach of the creek north of

East Side Lake is not meeting water quality standards for turbidity. The primary focus of this study, as previously stated, is to determine potential BMPs needed for the creek to meet turbidity/ TSS water quality standards.

Below is a brief description of the characteristics of Dobbins Creek Watershed.

Land Use/Land Cover

According to the National Land Cover Dataset (NLCD), land use within the watershed is approximately 80 percent agricultural with the remaining 20 percent divided between forest, range, wetlands, residential and industrial land uses (Figure 1) (USGS, 2001).

Topography

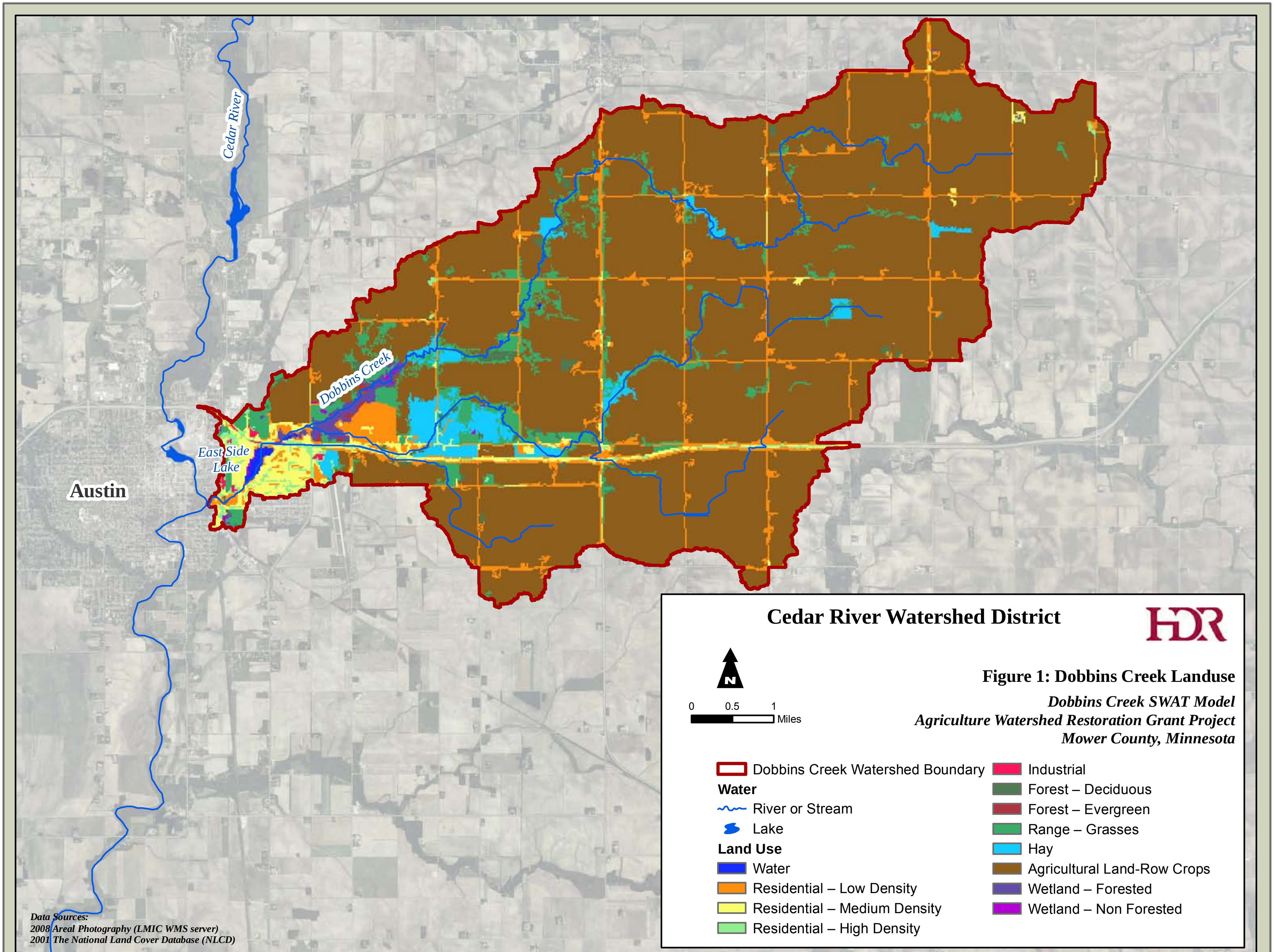
The watershed has an undulating topography. Relief in the watershed ranges from 1410 feet to 1174 feet above mean sea level (Figure 2).

Soils

There are three predominate soil associations in the Dobbins Creek Watershed: Marchan-Waukee-Hayfield, Sargeant-Brownsdale-Skyberg and Tripoli-Oran-Readlyn. Soils within the watershed are generally poorly to somewhat poorly drained. Small patches of sand loam and clay loam soils are present within the central and northeast parts of the watershed, which are moderately to poorly drained, respectively. Similarly, most of the soils have medium to low infiltration.

As stated in the Mower County Soil Survey, soils in the area were formed is silty sediment overlaying glacial till, sandy glacial till, recent alluvium or thin loamy sediment overlaying weathered limestone bedrock (Carroll R Carlson (Soil Consrevation Service), 1989).

These prevailing soils associations were captured in Natural Resources Conservation Service (NRCS) U.S. General Soil Map (STATSGO2) database and are presented on Figure 3. Until 2006, these data were referred to as the State Soil Geographic (STATSGO) database. It consists of a broad based inventory of soils and non-soil areas. STATSGO2 provides a general overview of the soils in the project area. For use on this project, the Soil Survey Geographic (SSURGO) dataset was used as discussed under Model Application.



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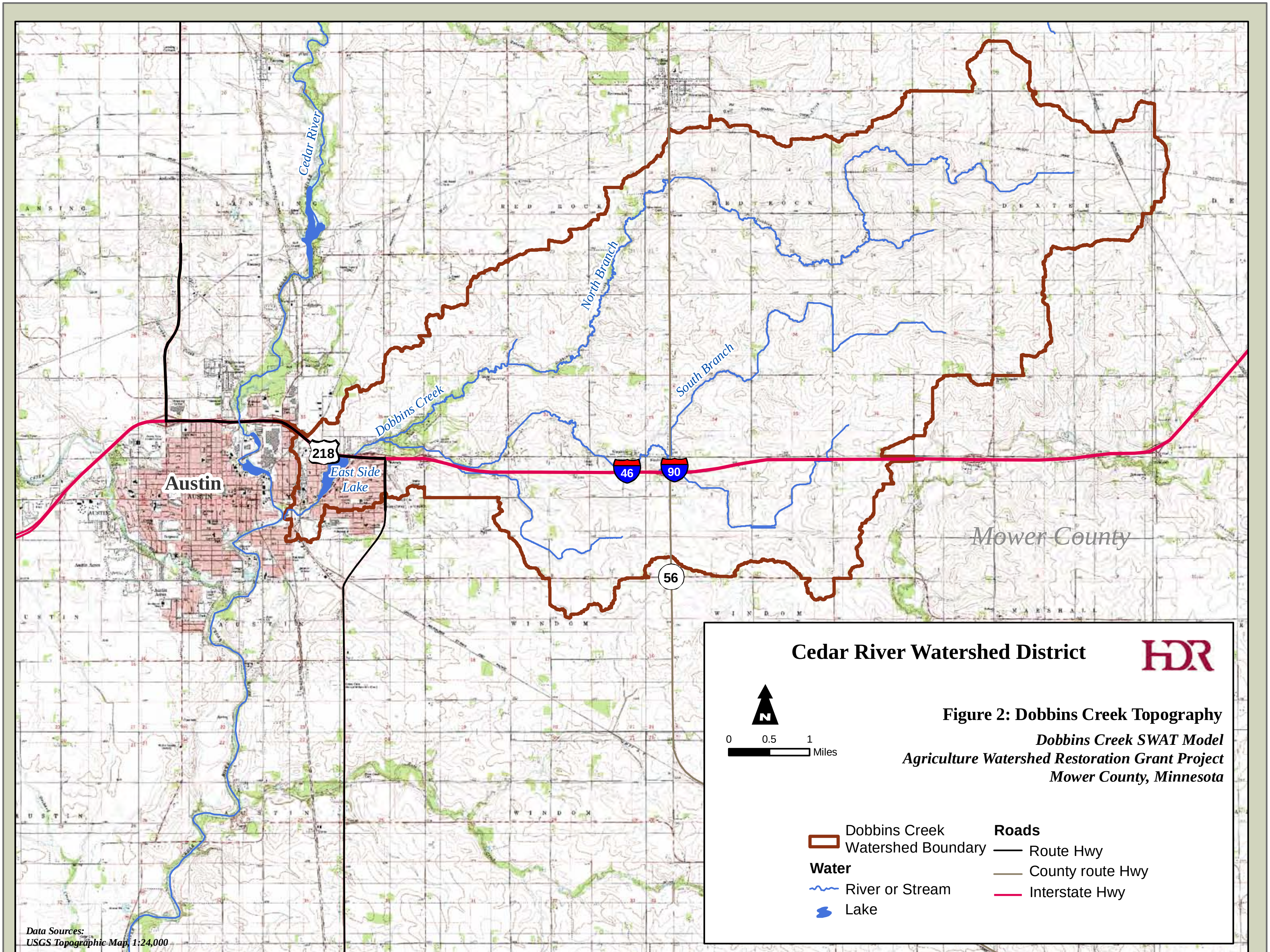

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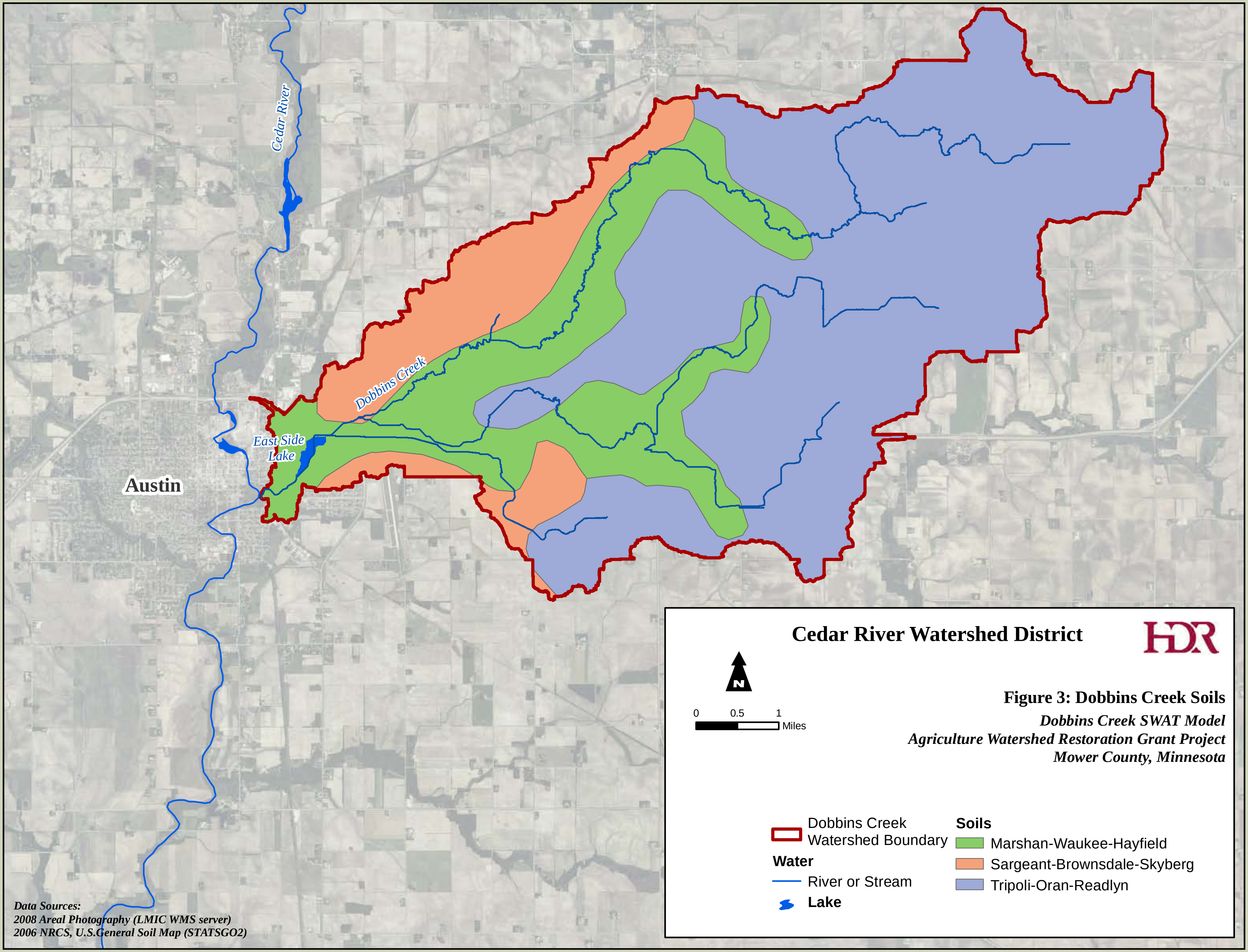

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Hydrology

The hydrology of the Dobbins Creek watershed is a flashy, complex system with a few tributaries interconnecting from surrounding agricultural areas, tile drainage and drainage ditches. The North, South and Unnamed branches of Dobbins Creek drain the northern part; and the central and southern parts of the watershed, respectively (Figure 4). Beginning at stream mile eight (8) and stream mile seven (7) northeast of the city of Austin, the North and South branches meander southwest into Austin and flow together in the J.C. Hormel Nature Center. Dobbins Creek flows about 0.5 miles before discharging to East Side Lake (Bednar, 1993).

Farming Practices

As previously mentioned, land use within the watershed is predominately agricultural. Farming practices associated with agricultural land use generally consists of a rotation of corn and soybeans. The rotations for the 2006, 2007, and 2008 growing seasons by percentage of the agricultural land use watershed area are shown in (Table 1) (United States Department of Agriculture - NASS). Table 1 illustrates, for example, that same areas of agricultural land totally 36 percent in Dobbins Creek were cropped on a corn (2006), soybean (2007), corn (2008) rotation.

Approximately 96 percent of the agricultural land use was farmed using a few different combinations of corn and soybean rotations as shown in Table 1. For the remaining four (4) percent of the agricultural land use, over 62 other crops and rotations were used. Chisel plow is the main tillage practice used throughout the watershed (Hanson, Dobbins Creek Land Management, 2009). Fertilizer (including manure) is used within the watershed; however it is typically only applied to corn crops (Table 2).

Table 1. Dobbins Creek Agricultural Land Use Crop Rotation for 2006, 2007 and 2008[1]

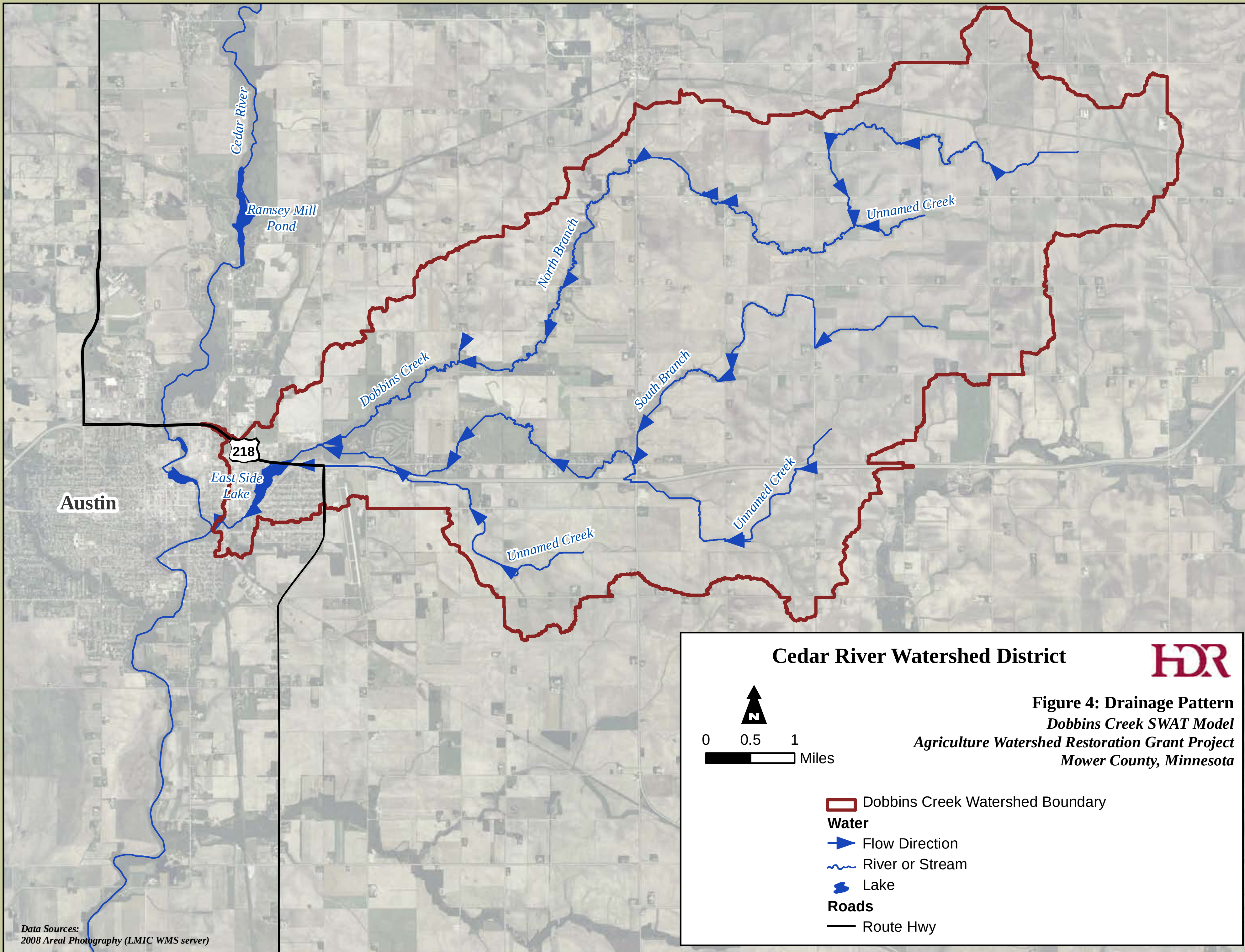
Crop Rotation by Annual Crop Type (2006-2007-2008)	Percentage of Agricultural Land Use Area
Corn-Soybean-Corn	36
Soybean-Corn-Soybean	33
Soybean-Soybean-Corn	9
Soybean-Soybean-Soybean	6
Corn-Soybean-Soybean	4
Corn-Corn-Corn	3
Corn-Corn-Soybean	3
Soybean-Corn-Corn	2
Total	**96**

[1] (United States Department of Agriculture - NASS)

Table 2. Dobbins Creek Fertilizer Application[2]

Fertilizer	Application rate (lbs/acre)	Application Area, (acre)	Annual Load (lbs)
Anhydrous Ammonia (82-0-0)	125	12,425	1,553,125
Urea (46-0-0)	20	4,142	82,840
DAP (non manure applicants)	50	16,566	828,300
Starter (at planting)	5	18,637	93,185
Pot Ash 2 (non manure applicants)	40	16,566	662,640
Manure	4,000 gal/ac	4,142	16,568,000 gal

[2] (Hanson, Dobbins Creek Land Management, 2009)


Cedar River
Ramsey Mill Pond
Dobbins Creek
North Branch
Unnamed Creek
South Branch
Unnamed Creek
Unnamed Creek
218
East Side Lake
Austin
Cedar River Watershed District
HDR
Figure 4: Drainage Pattern
Dobbins Creek SWAT Model
Agriculture Watershed Restoration Grant Project
Mower County, Minnesota
N
0 0.5 1
Miles
Dobbins Creek Watershed Boundary
Water
Flow Direction
River or Stream
Lake
Roads
Route Hwy
Data Sources:
2008 Areal Photography (LMIC WMS server)

Model Selection, Development, and Performance

Model Selection

A range of simple to detailed hydrologic and water quality models are available. Many of these are public domain models, developed and supported by various government agencies. Private models, for sale by software companies, are also available. Drawbacks with private models include the cost, technical support, and limited access to the technical underpinnings. Many of the public domain models are summarized in the Environmental Protection Agency (EPA) *Draft* Handbook for Developing Watershed TMDLs (US EPA, 2008).

While many of these models do not readily integrate geographic information system (GIS) data to calculate the loadings, most of the data needed and available to produce a defensible model and simulate a variety of scenarios are in a GIS format, or would be determined using GIS coverages. Based on the preference of using a pubic domain model and the requirement to use a tool that directly integrates GIS data, the list of potential models for selection was greatly reduced. The most promising models are Agricultural Nonpoint Sources (AGNPS), Hydrological Simulation Program - Fortran (HSPF), and SWAT. After reviewing the list of available watershed data, the scope of the project—which requires a model that simulates sediment dynamics on a continuous basis—and by evaluating the intended use of the model, SWAT emerged as the most suitable.

SWAT is a quasi-physically-based water quality simulation model that operates internally on a daily time step. It is a basin-scale model developed by United States Department Agriculture (USDA) - Agricultural Research Service (ARS), in Temple, Texas (Neitsch, Arnold, Kiniry, & Williams, 2005). SWAT was developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields in complex watersheds with varying soils, land use, and management conditions over long periods of time. The SWAT model components include: hydrology, weather, sedimentation, crop growth, nutrients, pesticides, and agricultural management. To accurately predict movement of sediment, nutrients, and pesticides, the hydrologic cycle, as simulated by the model, must conform to what is happening in the watershed.

The strength of the SWAT modeling approach is in the emphasis on landscape scale analysis of pollutant loadings with a powerful GIS-based interface. This yields a direct association between land use activities and water quality impacts to engage stakeholders in management efforts. The SWAT model also provides a focal point for a unifying assemblage of data, a detailed understanding of the source of pollutants, an ability to simulate existing and future scenarios, and a foundation for analyzing adaptive management efforts to improve water quality with time.

Model Development

The model was developed in three major steps. These steps were completed as follows and are described in more detail below:

1. Compile Data
2. Model Construction
3. Perform Model Calibration and Validation

Data Compilation

Available monitoring data are critical to constructing a watershed model which accurately simulates movement of sediment, nutrients, and the hydrologic cycle of the Dobbins Creek watershed. Data were compiled from CRWD, and various state and federal agencies as described below. These data were reviewed and evaluated for use in constructing a credible and defensible model of the watershed. The following sections summarize data compiled for the Dobbins Creek Watershed SWAT model and the respective sources for data from the 10-year period from 1999 through 2008.

Climate

Climate data were obtained from the Minnesota Climatology Historical Climate Data Retrieval system (Historical Climate Data Retrevial, 2009). Data for maximum and minimum daily air temperatures and precipitation were available for National Oceanic Atmospheric Administration (NOAA) monitoring station 210355 – Austin 3S, latitude 43.62252/longitude 93.00581. This monitoring station was selected because of its proximity to the watershed. Data acquired are discussed in a later section.

Topography

The Department of Natural Resources (DNR), on behalf of the 2007 Minnesota Recovers Task Force and its local, state and federal partners conducted a project to collect light detection and ranging (LIDAR) data across the seven counties (including Mower County) identified as federal disaster areas after the August 2007 floods in southeastern Minnesota (DNR, 2009). For this project CRWD provided LIDAR data, clipped to the Dobbins Creek watershed, in the form of a digital elevation model (DEM) raster dataset. The dataset had 2-foot contour feature class and hill shade raster within an Environmental Systems Research Institute, Inc (ESRI) file geodatabase. The data provided had a mean point density of 1.5 meters, a horizontal accuracy of less that 1 meter and a vertical accuracy of 18 centimeters or less. The LIDAR data were projected in universal transverse mercator (UTM) Zone 15 coordinate system, North American Datum of 1983 (NAD83) horizontal datum and North American Vertical Datum of 1988 (NAVD88) vertical datum (Figure 5).

Soils

The Natural Resources Conservation Service (NRCS) Division of the USDA maintains a database of soils data. This database is referred to as the Soil Survey Geographic (SSURGO) dataset (USDA-

SSURGO). The SSURGO dataset is the most detailed soil mapping produced by the NRCS. The soils coverage was projected in the NAD 1983 UTM Zone 15N (Figure 6).

Land Use/ Land Cover

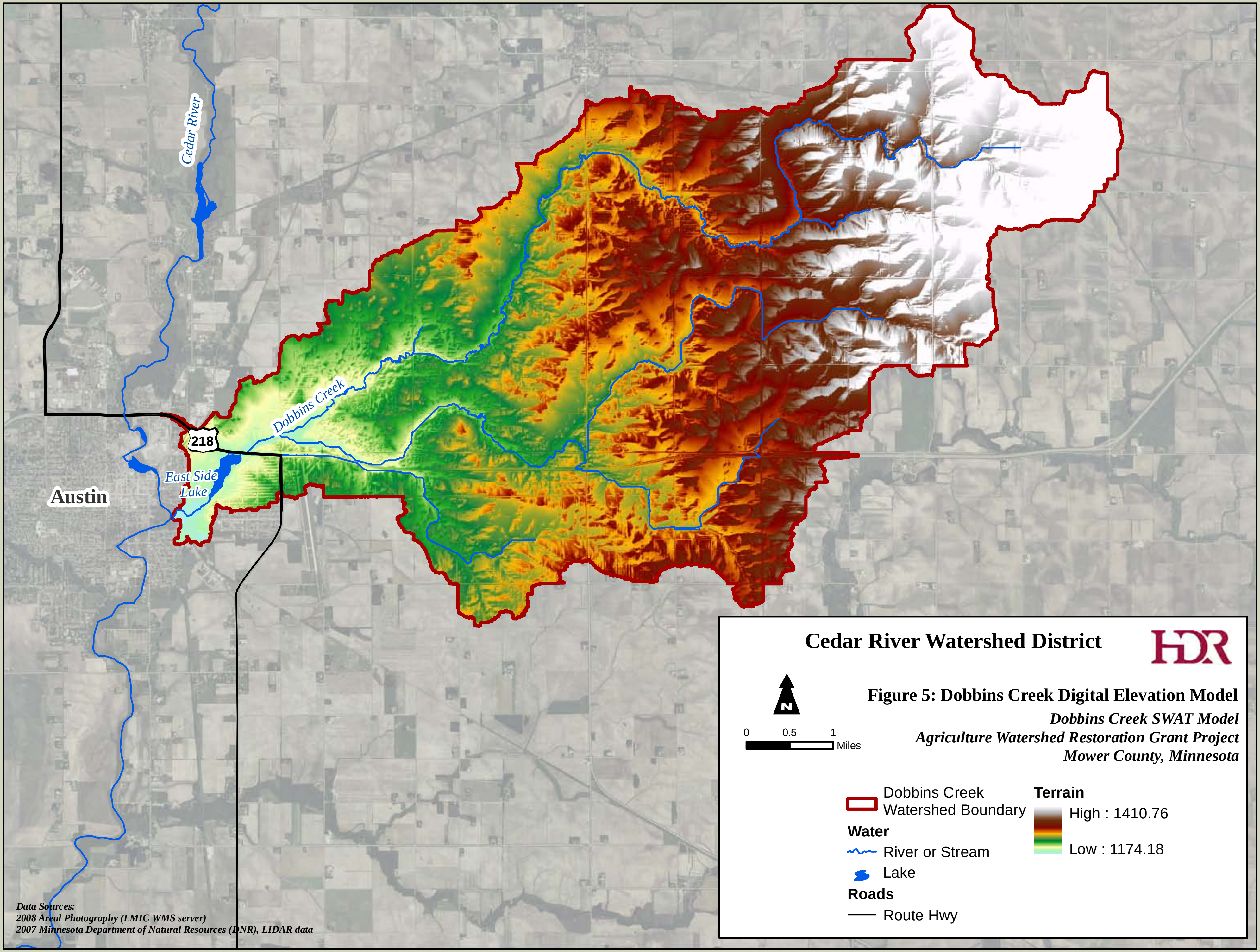
The National Land Cover Database (NLCD) coverage from 2001 was acquired from the United States Geologic Survey (USGS) Multi-Resolution Land Characteristics Consortium (MRLC) (USGS, 2001). NLCD data consists of land use and land cover classification data primarily based on interpretation of aerial photography and elevation data. Coverage for the NLCD area includes several class codes used to identify land use and land cover. The most common NLCD coverage in the Dobbins Creek watershed is agricultural. The data were projected in NAD 1983 UTM Zone 15N (Figure 1).

Land Management

Crop cover data were obtained from the National Agricultural Statistics Service (NASS) for 2006, 2007 and 2008 as a raster data file projected in the NAD 1983 UTM Zone 15N coordinate system. The vast majority of the watershed was farmed as corn or soybean (Table 1). CRWD staff interviewed local farmers, farm managers, and NRCS local conservation personnel about tillage, fertilizer, and manure applications. A summary of the results from the interviews is shown in Table 3 (Hanson, Dobbins Creek Land Management, 2009). According to the data from the Minnesota Pollution Control Agency (MPCA), there are 32 registered feedlots located within the Dobbins Creek watershed (Hanson, Dobbins Creek Land Management, 2009). Information on feedlot location, size, and livestock information are presented in Table A1 in the Appendix A and Figure 7 (Hanson, Dobbins Creek Land Management, 2009).

Table 3. Dobbins Creek Watershed Tillage and Fertilizer Application Data

Tillage Practice			
Chisel Plow	Spring Fall after harvest		
Fertilizer Application			
Name (Formula)	**Application Rate**	**Application Period**	**Crop Application**
Anhydrous Ammonia (82-0-0)	125 lbs/ac	Spring	Corn
Manure	4,000 gal/ac	Spring	Corn
Urea (46-0-0)	20 lbs/ac	Spring	Corn
DAP1(18-46-0)	50 lbs/ac	Spring (75%) Fall (25%)	Corn
Starter (10-34-0)	5 lbs/ac	Spring	Corn
Pot Ash (0-0-60)	40 lbs/ac	Spring	Corn



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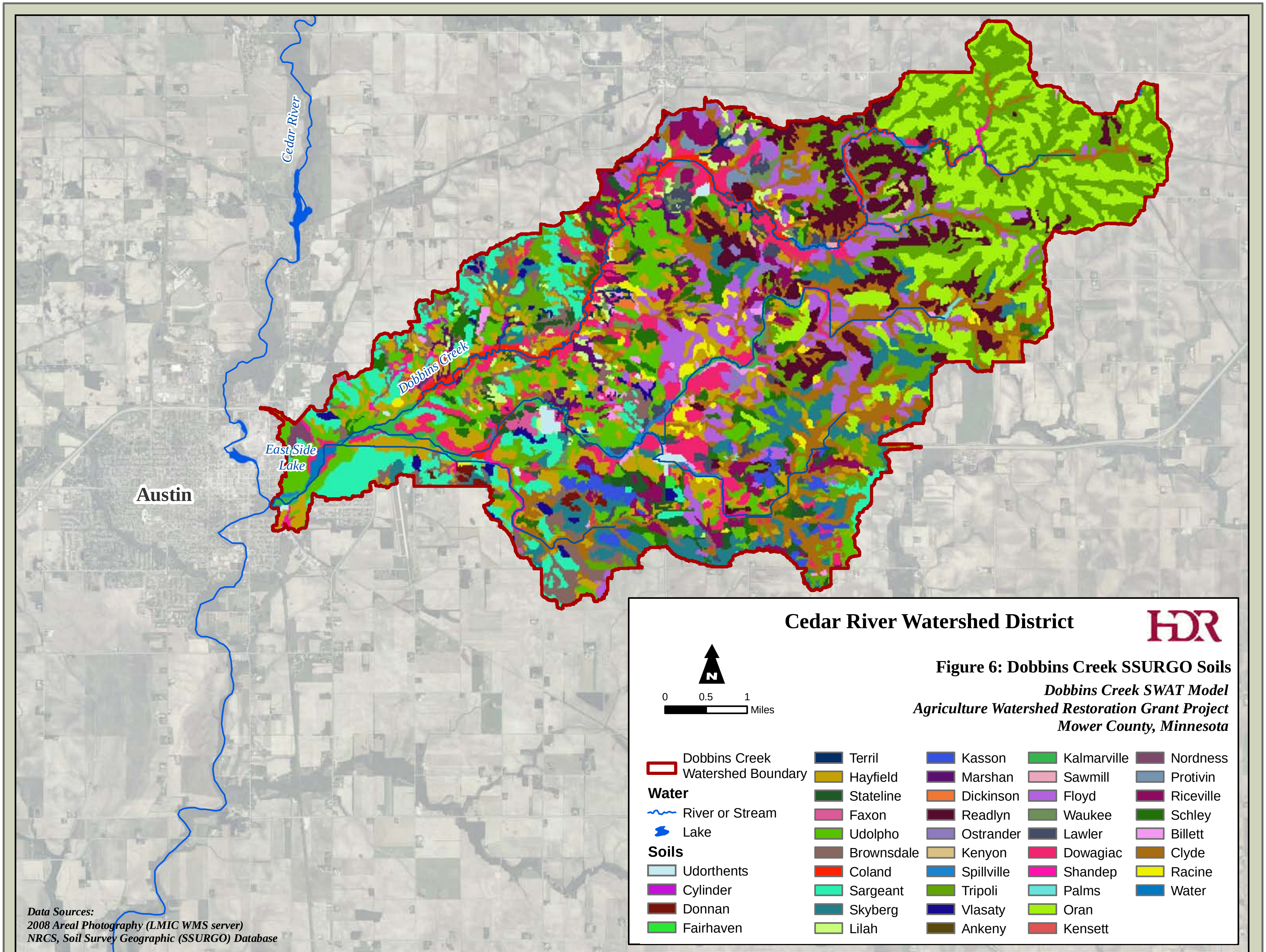

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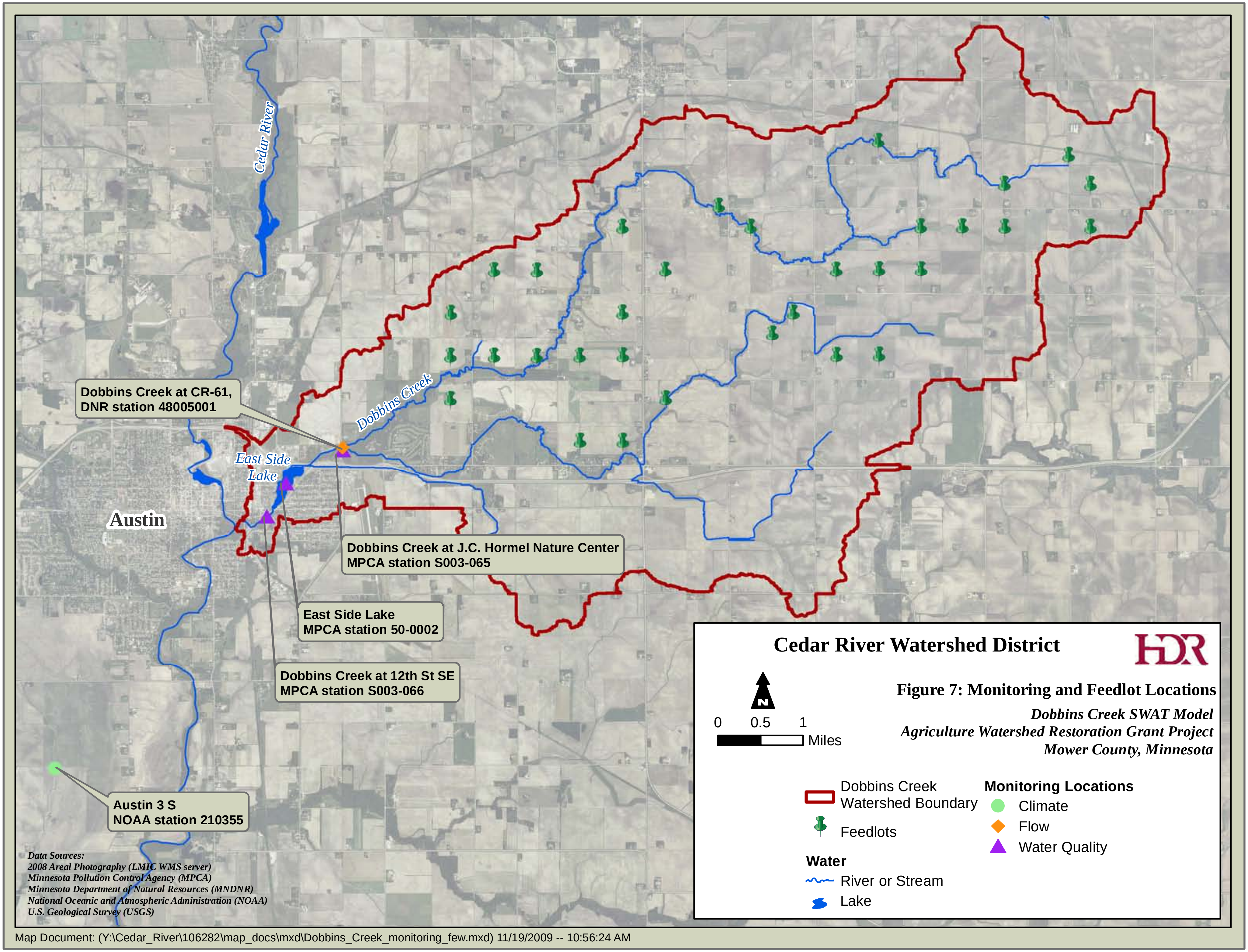

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Flow and Sediment Data

Flow Data

Stream flow data are available from gauging DNR 48005001 (Dobbins Creek at Austin County Road 61) located 1.7 miles upstream of the confluence with Cedar River (Figure 7) (CRWD, 2008). Flow data are available from 1998 to present at 15 minute intervals based on a stage-discharge relationship. A graph of the available data is provided in a later section.

Sediment/Total Suspended Solids Data

Total Suspended Solids (TSS) data records are available for Dobbins Creek watershed and surrounding area from the following locations (Figure 7):

- Dobbins Creek at 12th Street SE in the city of Austin, MN (Downstream of East Side Lake) – 2000-1.
- Dobbins Creek in the J.C. Hormel Nature Center (upstream of East Side Lake) – 2000-1, 2005 – 6, and 2008 – 9.
- East Side Lake in Austin, MN – 1981, 1989-1993 and 1994-1997.

Culverts

For this project, CRWD provided culvert data as a GIS layer file with points indicating the culvert locations and sizes. The culvert data are from the Upper Cedar River Surface Water Management Plan (WMP). The goal of that plan was to provide flood protection throughout the entire area, Dobbins Creek included, by reducing the 100-year peak flow by 20 percent (BARR Engineering Company, 2007).

Data Assessment for Modeling

As described above, various forms of data are available for land use, soils, topography, climate, land management, stream flow, water quality and infrastructure. Stream flow and sediment data are the most limited for model construction. Stream flow data were reviewed for the station DNR 48005001 since it is in the watershed and within the project boundary. Although flow data are available from 1998 through the present for station DNR 48005001, DNR quality codes for the dataset were: 32 indicating poor quality for period of 1998 through 2005 and some of 2007, 31 indicating fair quality for parts of 2007 and 2008 and 30 indicating good quality for 2008 and 2009 (Peterson, 2009). Data from 2008 and 2009 were used to calibrate the model. Sediment data were available from July and August 2000; May, June, July and August 2001; August, September, October, November 2008 and March and April 2009. Data used for sediment calibration were from July and August 2000; July and August 2001 data were used to validate the model.

Application of the SWAT Model to the Dobbins Creek watershed includes recognition and understanding of data issues and limitations. These constraints result in datasets that are generally limited both spatially and temporally. Where there are data gaps, model defaults were used to support the modeling effort, where necessary. These defaults were based on researched values in the

SWAT model, SWAT manuals and/or conclusions of literature research, and modeling experience. Although there are data gaps within the compiled data, the key to making the most successful use of a SWAT model for the Dobbins Creek watershed is to calibrate the model to observed flow and sediment data.

Model Construction

The following describes the steps to apply the SWAT model to Dobbins Creek watershed. The process is divided into three key areas; watershed, land use, and soils.

The watershed delineation was completed by loading the previously described DEM into SWAT. SWAT uses the DEM to delineate the stream location and subbasin boundaries. The delineated subbasin boundaries from the WMP were used as a guide for delineating the subbasins within SWAT (BARR Engineering Company, 2007). Thirty-seven (37) basins (Figure 8) and the outlet to the Cedar River were defined. Because of the difference in focus and the streams delineated from the DEM, some of the smaller subwatersheds from the WMP report were aggregated into larger subwatersheds during the SWAT processes reducing the total number from 59 to 37 subwatersheds (BARR Engineering Company, 2007).

The land use and soil themes were defined by loading the NLCD land use and SSURGO soil data layers. SWAT uses the land use data to determine water and nutrient runoff and infiltration capacity. Land Use/Land Cover data were then expressed in SWAT codes as shown in Table 4.

The soils data were from the SSURGO database, which included the type of soil, their infiltration capacity, water retention capacity, and other soil characteristics. These data assisted in simulating runoff, sediment transport and vegetation potential (for crop growth simulation) in SWAT. The land use, soil and slope (derived from the DEM) data were reclassified using the SWAT land cover classes, the state soil identifiers and the calculated land slopes and then superimposed in SWAT. This resulted in each watershed having subbasin of specific land use, soils and slope (e.g. corn/Oran/0-0.5%).

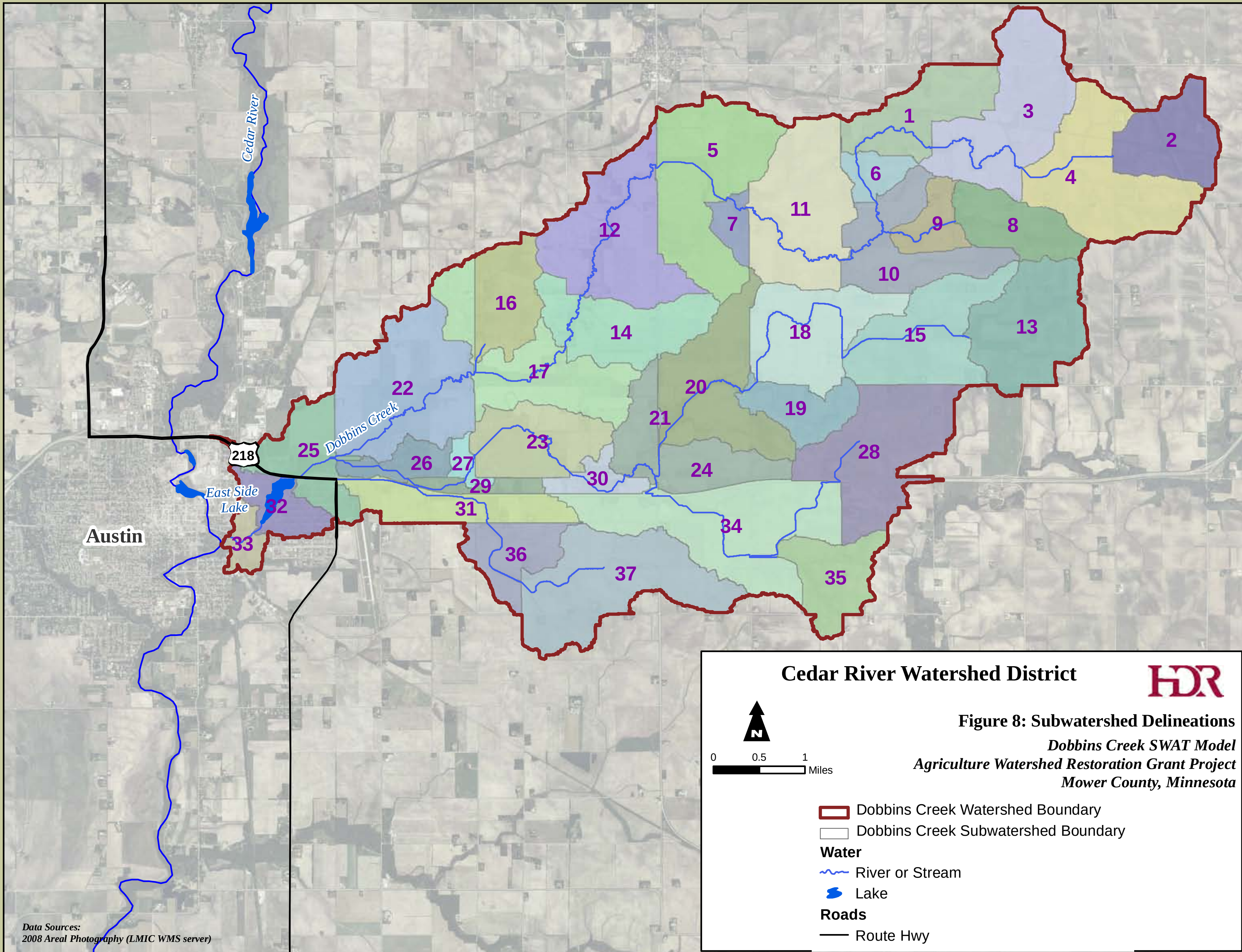
With the characteristics of each subbasin defined, the hydrologic response unit (HRU) distribution was selected. HRUs were defined using the default 'land use percentage over subbasin area' of 10 percent and 'soil class percentage over land use area' of 10 percent and 'slope class percentage over the land use area' of 10 percent. This resulted in 826 HRUs. For each HRU, water flux and transport of sediment and nutrients are simulated in the SWAT model and then routed through a subwatershed, i.e., water and chemicals are transported from one subwatershed to the next, depending on flow characteristics.

After the HRUs were developed, the land management practices data were incorporated into the model. Model defaults were used except for agricultural areas where additional land management practices were specified. For the agricultural areas, the crop rotations shown in Table 1 were used (Cedar River Watershed District, 2008). Corn was the only crop where both tillage and fertilizer practices occurred. Those practices were put in the model based on data received from the CRWD (Table 5).

After inputting watershed land use, soils, slope and land management information were completed, the SWAT View was used to enter weather data and to define the coefficients. Climate data from station NOAA 210355 – Austin 3S, along with the model databases and simulation equations, were used for the climatological data. The internal SWAT weather simulation generator (based on regional weather station data) was used for other climate parameters (e.g., solar radiation and wind speed). Default coefficients were used for the initial model simulation.

Table 4. Dobbins Creek NLCD and SWAT Codes

Land Use (NLCD, 2001)	Land Use (SWAT code)
Agricultural Land - CCSB	CCSB
Agricultural Land - Corn	CORN
Agricultural Land - CSBC	CSBC
Agricultural Land - CSBS	CSBS
Agricultural Land - SBCC	SBCC
Agricultural Land - SBCS	SBCS
Agricultural Land - SBSC	SBSC
Agricultural Land - Soybeans	SOYB
Forest – Deciduous	FRSD
Forest – Evergreen	FRSE
Hay	HAY
Pasture	PAST
Range – Grasses	RNGE
Residential – High Density	URHD
Residential – Low Density	URLD
Residential – Medium Density	URMD
Water	WATR
Wetland – Forested	WETF
Wetland – Non Forested	WETL



Cedar River Watershed District

HDR

Figure 8: Subwatershed Delineations

Dobbins Creek SWAT Model

Agriculture Watershed Restoration Grant Project

Mower County, Minnesota

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Table 5. Dobbins Creek SWAT Corn Crop Management Input

Operation	Quantity	SWAT Model Schedule (Date)
Tillage – Chisel Plow		April 27
Fertilizer		May 5
Anhydrous Ammonia	84.1kg/ha	
Urea	4.5 kg/ha	
DAP	33.6 kg/ha	
Pot Ash	35.9 kg/ha	
Manure - Dairy	83.8 kg/ha	
Manure – Beef	400.6 kg/ha	
Manure - Swine	6,102 kg/ha	
Manure - Horse	39.4 kg/ha	
Manure - Sheep	325.1 kg/ha	
Manure - Duck	34.3 kg/ha	
Plant		May 16
Fertilizer - Starter	5.0 kg/ha	May 19
Harvest and Kill		October 15
Tillage – Chisel Plow		November 15
Fertilizer - DAP	11.2 kg/ha	November 15

Model Performance

The model results were compared to observed data to determine whether the model simulations provided a reasonable representation of actual conditions. Standard SWAT calibration practices were followed for stream flow and sediment calibration and validation. A portion of the available flow and sediment dataset were reserved and used to validate the model. The remaining data were used for the SWAT sensitivity analysis and calibration procedure.

The calibration process is an iterative process of adjusting parameters specific to flow and sediment and checking the results against known observed values. SWAT comes equipped with functions that allow us to perform sensitive analysis and auto-calibration on un-calibrated models. For this project, only the sensitive analysis was used and the model was manually calibrated. To perform the sensitivity analysis, SWAT uses the Latin Hypercube Sampling (LHS) and the One factor At a Time (OAT) design to form the LHS-OAT method (Srinivasan, 2008). The model divides the parameter (s) spaces in N parts of equal probability 1/N, then takes N samples according to LHS scheme and sequentially determines the OAT sensitivity for each LHS point (Srinivasan, 2008).

Using this method affords the ability to determine the sensitivity each parameter selected has on changing the results of the model. For instance, if there are six (6) parameters that could effect change, an endless amount of time and money could be spent adjusting each parameter to calibrate the model. The sensitive analysis checks each one of the six (6) parameters by comparing the un-calibrated model to the observed results to see how those values would affect the output of the model. They results of the sensitive analysis could be presented as shown in Table 6. Table 6 shows that three (3) parameters (A, B, and C) are the most sensitive, while D – J are insensitive parameters under any spatial or temporary condition.

Table 6: Example SWAT Sensitivity Analysis Output

Parameter	Rank
A	1
B	2
C	3
D	7
E	7
F	7

The Dobbins Creek model was calibrated to flow and sediment, in that order. The model was calibrated to data from DNR 48005001 and the J.C. Hormel Nature Center for flow and sediment, respectively. Figure 7 shows monitoring station locations in relation to the s boundaries. The confluence of Cedar River and Dobbins Creek is approximately 2 miles downstream of the monitoring point, located at the outlet of subwatershed 22 (Figure 8). In the following sections, the process of calibrating the model to flow and sediment are described.

Calibration and Validation

Flow

At the start of the project, the available flow dataset from the DNR was examined. It was determined, based on data quality notes that accompanied the dataset, that only data from 2008 (April, May, June, July, August, September, October, and November) and 2009(April) were of sufficient quality to use (Peterson, 2009). Average daily flow calculated was 38 cfs, with the highest flow recorded on June 9, 2008 and lowest flow recorded on September 21, 2008 of 928 cfs and 2 cfs, respectively. The data were divided as noted below for calibration and validation which were both evaluated and checked on a monthly and daily timestep, respectively. Again, the validation data were removed (reserved) and only the data from the months noted below were used to calibrate the model.

Calibration	Validation
April 08	May 08
June 08	July 08
August 08	September 08
October 08	November 08
April 09	

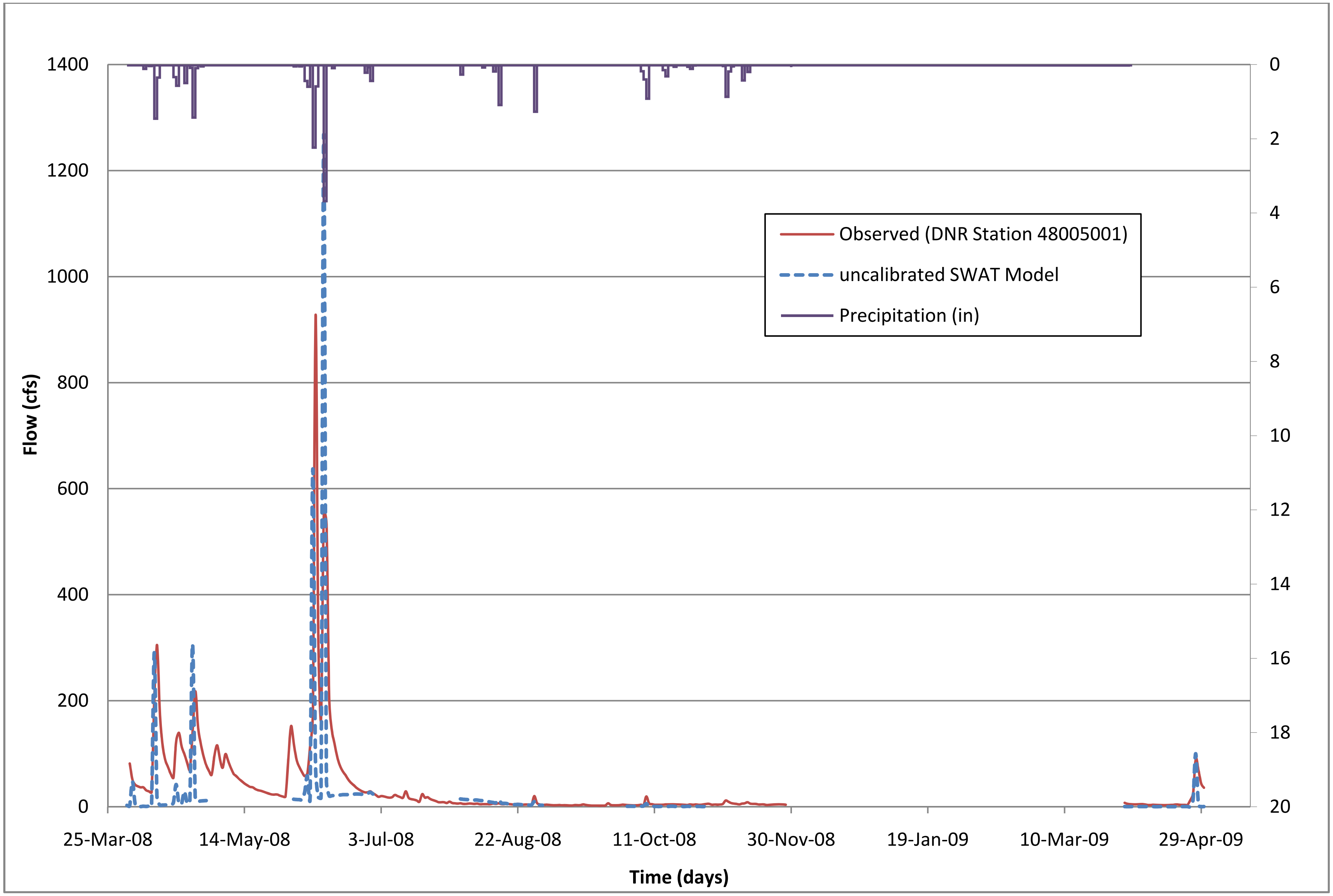
The output of the un-calibrated model to observed data are shown on Figure 9. Figure 9 illustrates that the un-calibrated model is under-predicting the total volume of runoff. However, the un-calibrated model simulated the peak magnitude and timing of the runoff hydrographs within an acceptable range. The available flow calibration parameters were reviewed and 17 parameters, specific to managing runoff and base flow, were selected for potential calibration adjustment. Using the selected 17 parameters, the SWAT sensitivity analysis was run to determine which parameters were the most or least sensitive.

The sensitivity analysis showed CN2 (Curve Number) was the most sensitive; Sftmp (Snowfall Temperature), Smfmn (Minimum Snowmelt Temperature) and Smfmx (Maximum Snowmelt Temperature) were the least sensitive/ insensitive to change, (Table 7).

Table 7. Dobbins Creek SWAT Model Sensitivity Analysis Results-Flow

Parameter	Summary	Rank
CN2	Initial SCS runoff curve number for moisture condition II.	1
ESCO	Soil evaporation compensation factor.	2
TIMP	Snow pack temperature lag factor.	3
SOL_AWC	Available water capacity of the soil layer (mm H_2O/mm soil).	4
REVAPMIN	Threshold depth of water in the shallow aquifer for revap or percolation to the deep aquifer to occur (mm H_2O).	5
ALPHA_BF	Base flow alpha factor (days).	6
GWQMN	Threshold depth of water on the shallow aquifer required for return flow to occur (mm H_2O).	7
CH_K2	Effective hydraulic conductivity in main channel alluvium (mm/hr).	8
SURLAG	Surface runoff lag coefficient.	9
SMTMP	Snowmelt temperature (°C)	10
CH_N	Manning's 'n' value for the tributary channel	11
GW_REVAP	Groundwater revap coefficient. As GW_REVAP approaches 0, movement of water from the shallow aquifer to the root zone is restricted.	12
SLOPE	Land slope (m/m)	13
SLSUBBSN	Average slope length (m).	14
SFTMP	Snowfall temperature (°C)	18
SMFMN	Melt factor for snow on December 21 (mm H_2O/°C-day).	18
SMFMX	Melt factor for snow on June 21 (mm H_2O/°C-day).	18

Figure 9. Dobbins Creek Observed Vs. Un-calibrated SWAT Daily Model



The sensitivity analysis provided a starting point for manually. Of the 17 parameters tested and ranked, the top ranked parameters were used to manually calibrate the model. After an iterative process, 12 of those parameters were adjusted to produce a flow-calibrated SWAT model of the Dobbins Creek Watershed (Table 8Figure 7).

The model was considered calibrated when the R^2 of the observed to the modeled data was 0.7 or greater for monthly flow values for the calibration period. The model was first calibrated to the monthly average flow value and then checked against daily average flow value. The calibrated flow model was predicting, at R^2, 0.9 and 0.7 for average monthly and average daily flows, respectively (see Figure 10 and Figure 11). For the validation period, the model was predicting, at R^2 of 0.9 and 0.7 for average monthly and average daily flows, respectively. Given that the model met, and in some cases exceeded, the acceptable R^2 of 0.7 or greater, the model was considered calibrated for flow.

Table 8. Dobbins Creek SWAT Model Calibration Parameters - Flow

Parameter	Units	Lower Bound	Upper Bound	Default	Calibrated Model
ALPHA_BF	days	0	1	0.048	0.7
CH_K2	mm/hr	0	25	0	12
CH_N		0.014	.024	0.014	0.019
CN2		-0.05	0.05	Varies	.05
ESCO		0	1	0	1
GW_DELAY	Days	0	31	31	16
GWQMN	mm	0	5,000	0	1457.17
REVAPMIN	Mm	-100	100	1	8.26
SMTMP	°C	-0.25	.25	1	-0.12
SOL_AWC	m/m	-0.25	.25	Varies	0.19
SURLAG		0	10	4	0.5
TIMP		0	1	1	0.68

Figure 10. Dobbins Creek Observed Vs. SWAT Model - Average Monthly Flows

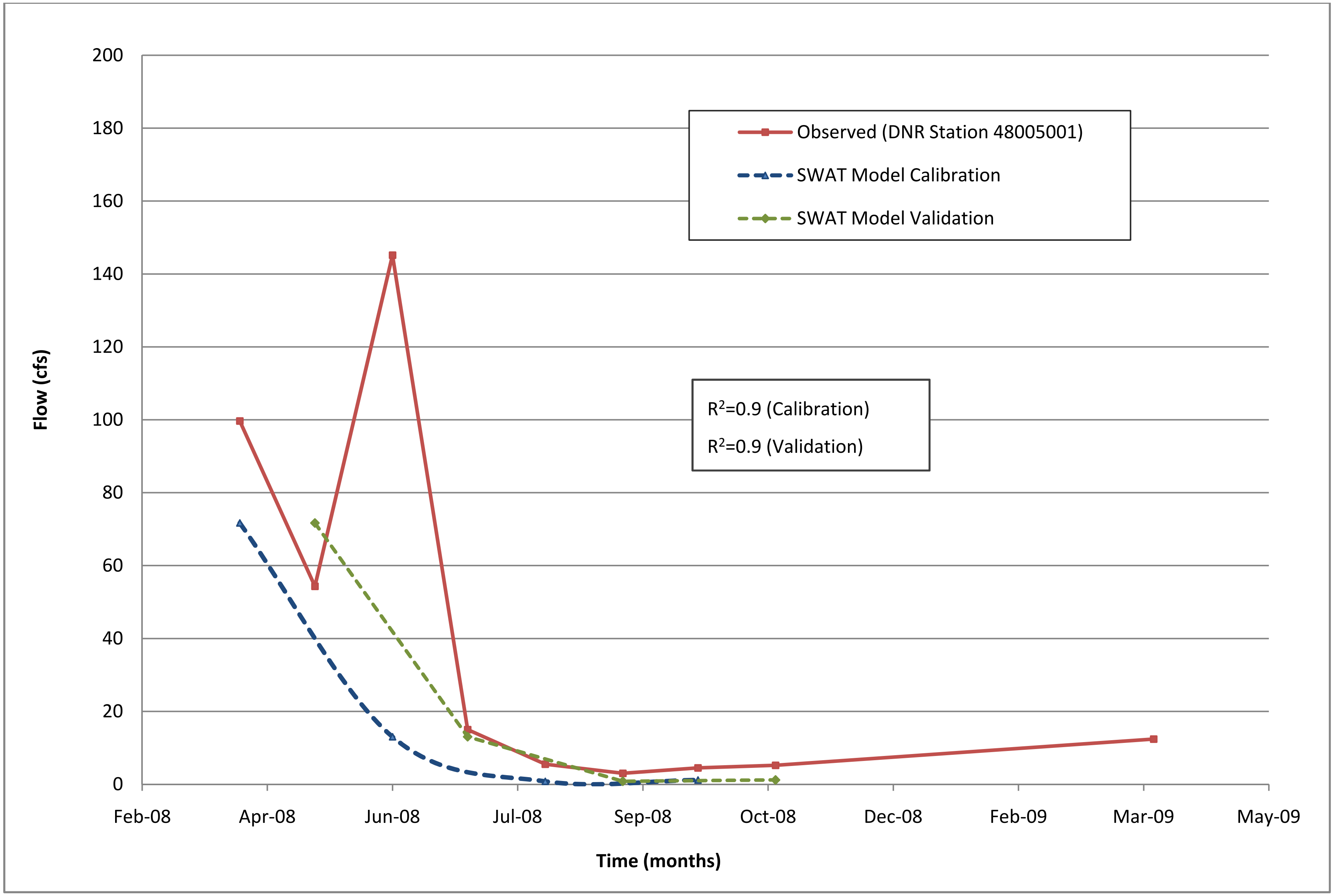


Figure 11. Dobbins Creek Observed Vs. SWAT Model - Average Daily Flows

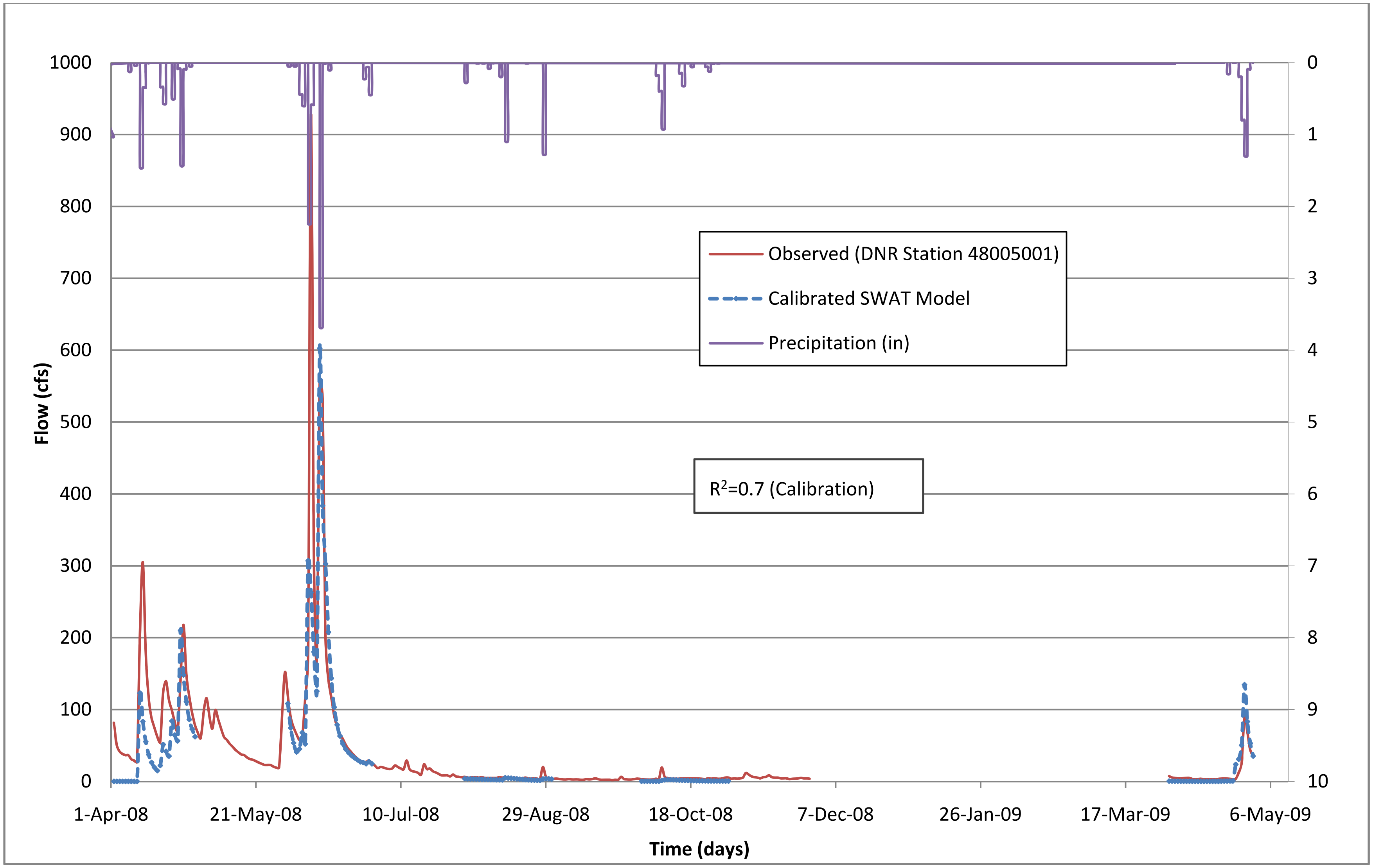


Figure 12

Total Suspended Solids

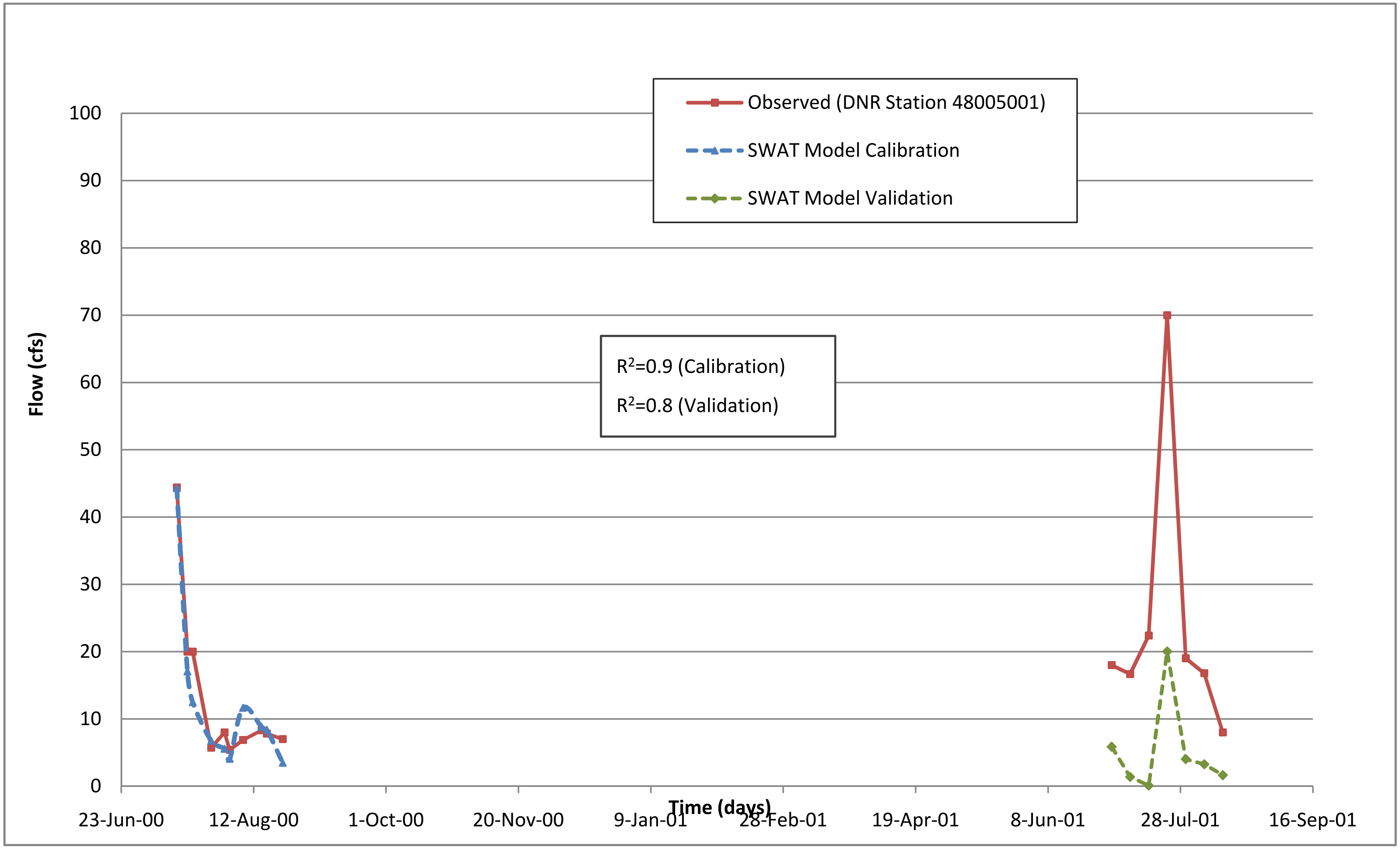
The same process used to calibrate the model to flow was used to calibrate the model to observed daily TSS data. The model was calibrated to TSS data from July and August of 2000 and validated using the July and August 2001 data. Figure 12 shows the observed data to the un-calibrated model prediction.

First, a SWAT sensitivity analysis was performed and then the internal auto-calibration function with a reduced number of parameters was employed. There were six initial parameters that were ranked for TSS, as presented in Table 9. As a result of researching land use practices and evaluating soils conditions in the watershed, the only parameter changed was SPEXP. It was changed from the default value of one (1) to two (2). The model was considered calibrated to TSS when the R^2 for calibration was 0.9 and the R^2 for validation was 0.8 (Figure 12) for available daily TSS values. At the conclusion of this process, a SWAT model calibrated to both flow and TSS for the Dobbins Creek watershed was produced.

Table 9. Dobbins Creek SWAT Model Sensitivity Analysis Results - Sediment

Parameter	Summary	Ranking
USLE_P	USLE equation support practice factor	1
SPCON	Linear parameter for calculating the maximum amount of sediment that can be re-entrained during channel sediment routing	2
USLE_C	Minimum value of USLE C factor for water erosion applicable to the land cover/plant	3
SPEXP	Exponent parameter for calculating sediment re-entrained in channel sediment routing	4
CH_COV	Channel cover factor	7
CH_EROD	Channel erodibility factor	7

Figure 12. Dobbins Creek Observed Vs. SWAT Model – Average Daily TSS Concentrations



Evaluation of Load Reduction

Using the Dobbins Creek calibrated SWAT model for flow and sediment, five broad scenarios were evaluated to determine their ability to reduce peak flows and sediment transported through the Dobbins Creek system. The primary focus of this project is sediment reduction given the turbidity assessment; however, best management practices selected for implementation in two of the scenarios also consider reducing peak flow. The five general scenarios are:

1. Scenario A - Existing Condition
2. Scenario B - Temporary Distributed Storage
3. Scenario C - Perennial Vegetation
4. Scenario D - Erosion Control
5. Scenario E - Combination

The goal of these scenarios, as documented by CRWD, is to meet applicable state surface water quality standards. Dobbins Creek is a class 2B stream with a turbidity limit of 25 NTUs which translated to between 30 – 40 mg/l of TSS (*Personal Communication with Bill Thompson, MPCA*).

The three branches of Dobbins Creek, North, South and Unnamed, were examined using the calibrated model to determine if those reaches are meeting current water quality standards based on monthly averages of TSS concentrations. As illustrated in Figure 13, the south branch consistently meets water quality standards. While the Unnamed Branch, violates the standard by about 5 mg/l one month over the 10-year period. On the other hand, North Branch violates the water quality standard five times over the 10-year period with exceedance of the standard ranging from about 7 mg/l to 35 mg/l. As a result, the focus of BMP implementation will be around the North Branch of Dobbins Creek.

Using the calibrated Dobbins Creek SWAT model, BMPs were selected and evaluated for scenarios B, C, and D based on their ability to get the stream branches to meet TSS water quality standard. In addition, Scenario B considered peak flow reduction. Scenario E, on the other hand, represented a combination of practical and feasible practices, taking into account improving water quality, reducing peak flows and optimizing capital investments. The scenarios presented here support the TSS assessment for the Dobbins Creek watershed. TSS reductions in the Dobbins Creek watershed should improve water quality conditions downstream; however, assessment of TSS, nutrient cycling and water quality issues in East Side Lake and downstream to the Cedar River are beyond the scope of this study.

The overall performance of best practices used in each of the scenarios was assessed using available climate data for the 1999-2008 (10-year) period (Figure 14). For that period, annual median and average rainfalls were 35.8 (2005) and 35.2 inches, respectively. Relatively wet and dry annual rainfalls were seen in 2004 (42.6 inches) and 2003(27.8 inches), respectively. Over that period of record, air temperature readings were 34.4°C (94°F), -28.9°C (-20°F) and 7.2°C (45°F) which represent, maximum, minimum and average readings, respectively. The scenarios are described below.

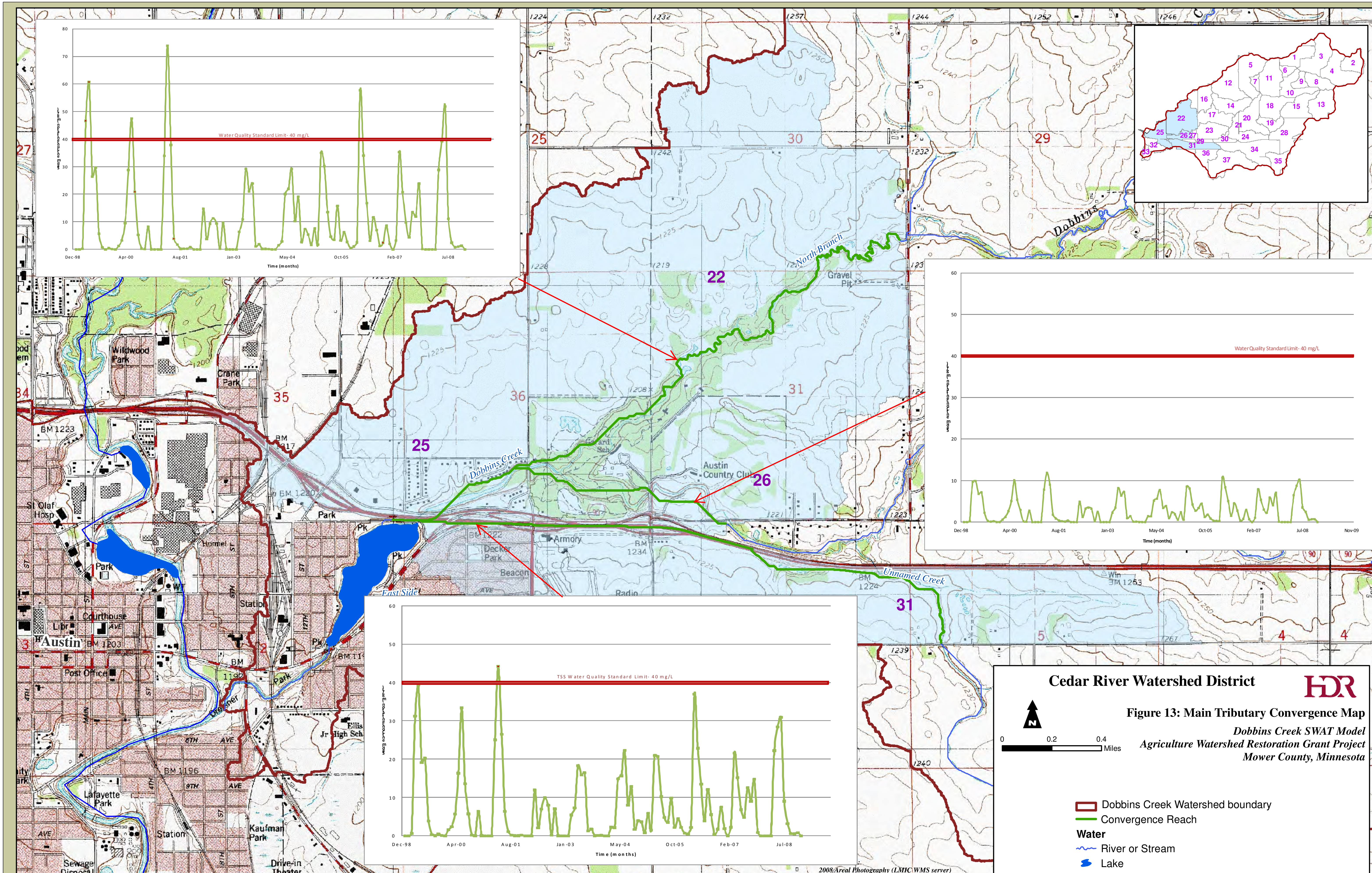


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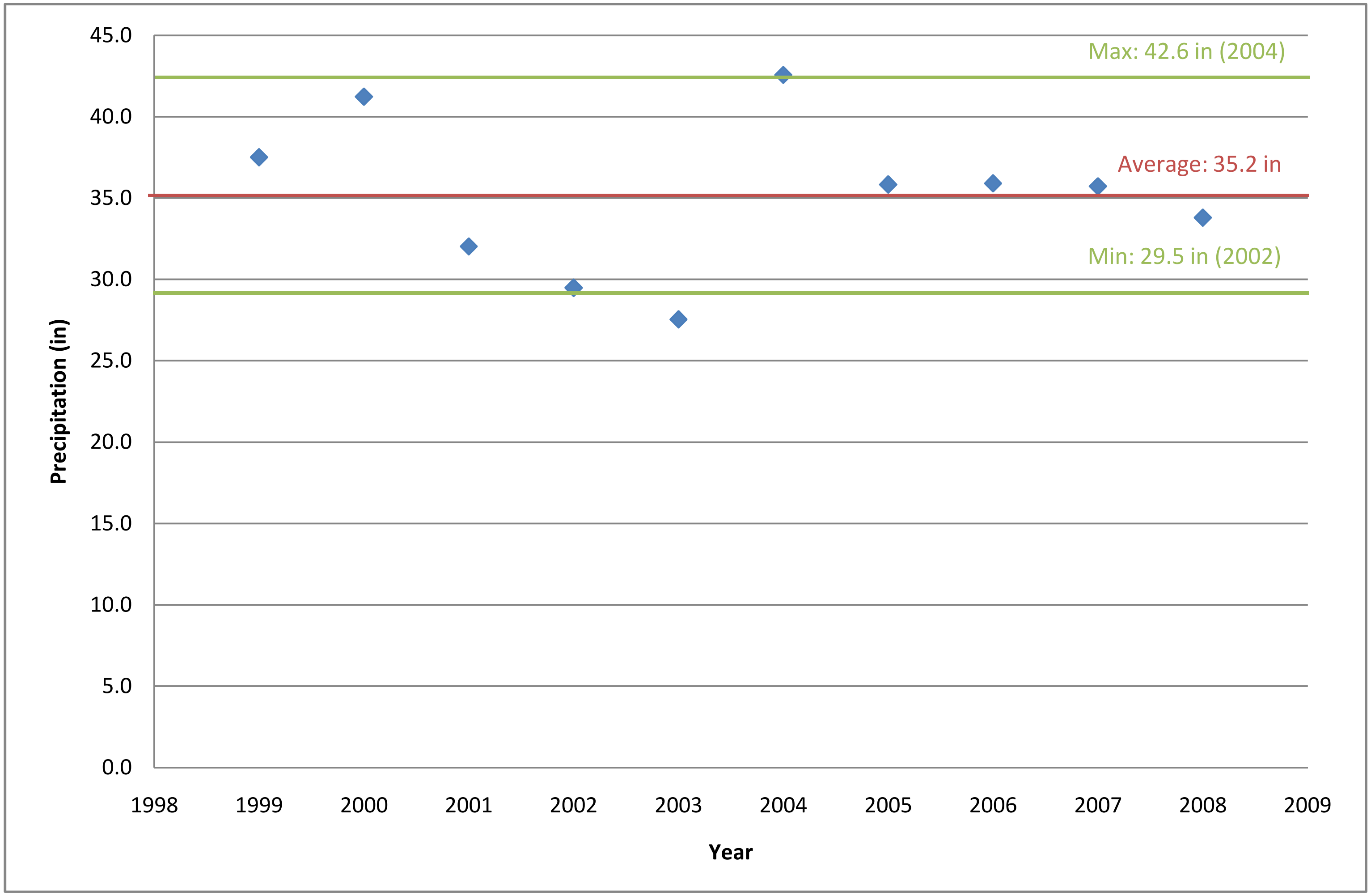
Figure 14: Annual Precipitation for the Dobbins Creek Watershed (1999 - 2008)



Scenario A - Existing Condition

Description

This scenario calls for CRWD, residents and stakeholders to maintaining existing practices as documented in previous sections. This scenario identifies no improvement to infrastructure, farming practices or the main/tributary channels.

Computed Water Quality Benefits

The Existing Condition scenario provides no water quality benefits. As previously noted, over 10-year period (1999 – 2008) North Branch and the Unnamed Branch do not meet water quality standard. Doing nothing could further degrade Dobbins Creek, and lead to additional impairments and/or more of the tributaries being impaired. Figure 15, Figure 16, and Figure 17 presents the baseline for which the other scenarios will be compared.

Estimated Cost

Since this scenario does not require any changes, the estimated cost of implementation is $0.00. However, there could be adverse impacts to other valued amenities, in both direct and indirect costs, if the water quality is not improved.

Implementation Challenges

Under section 303 (d) of the Clean Water Act (CWA), all states are required to address impaired waters that are polluted or degraded to meet their respective water quality standards. In this case, TSS water quality standards would not be met. Doing nothing would be a direct violation of Minnesota Statute 7050.

Figure 15: Dobbins Creek - Scenario A: Existing Condition Monthly Average Peak Flow Graph (1999 – 2008)

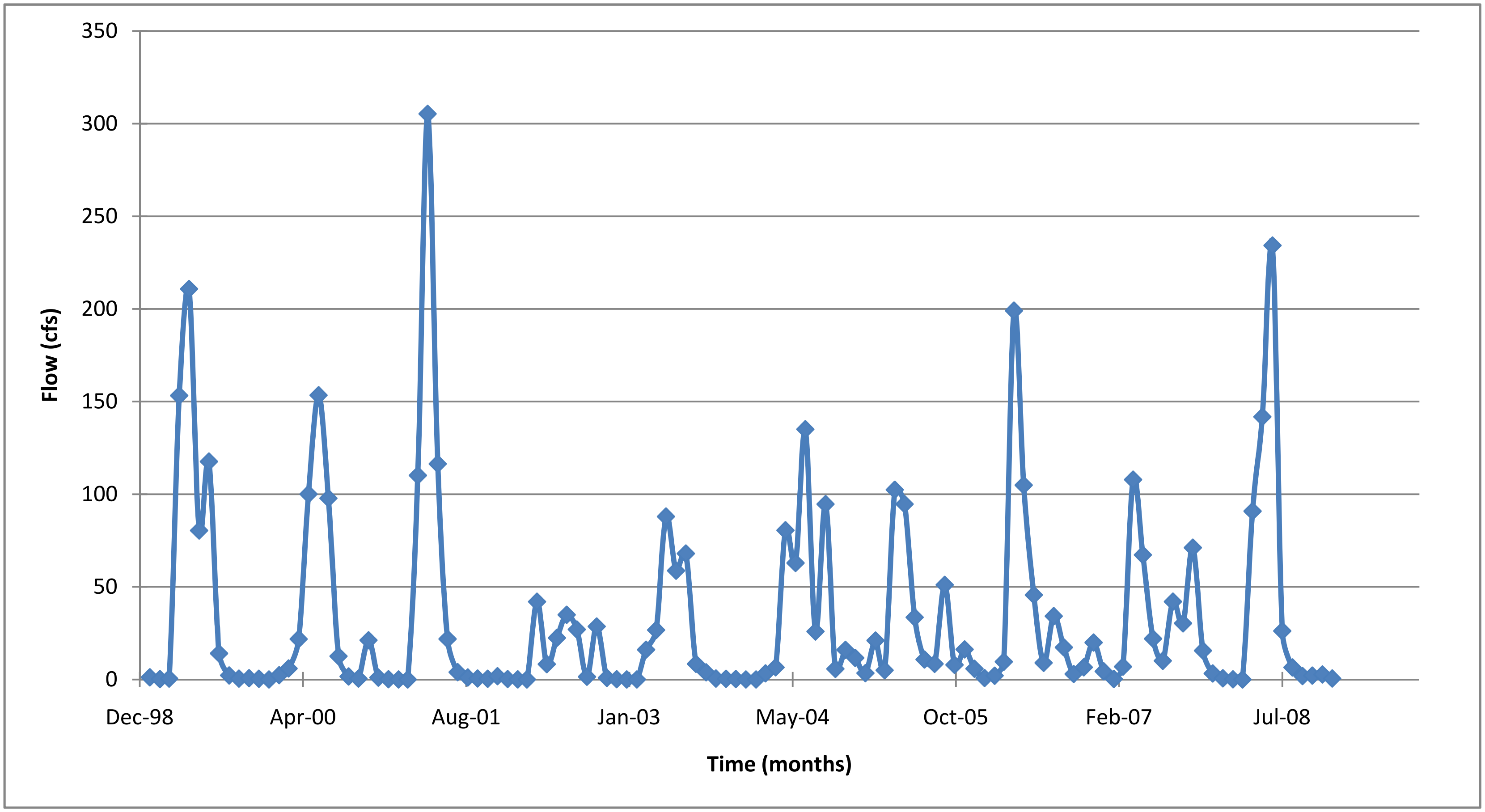


Figure 16: Dobbins Creek - Scenario A: Existing Condition Monthly Surface Runoff Graph (1999 – 2008)

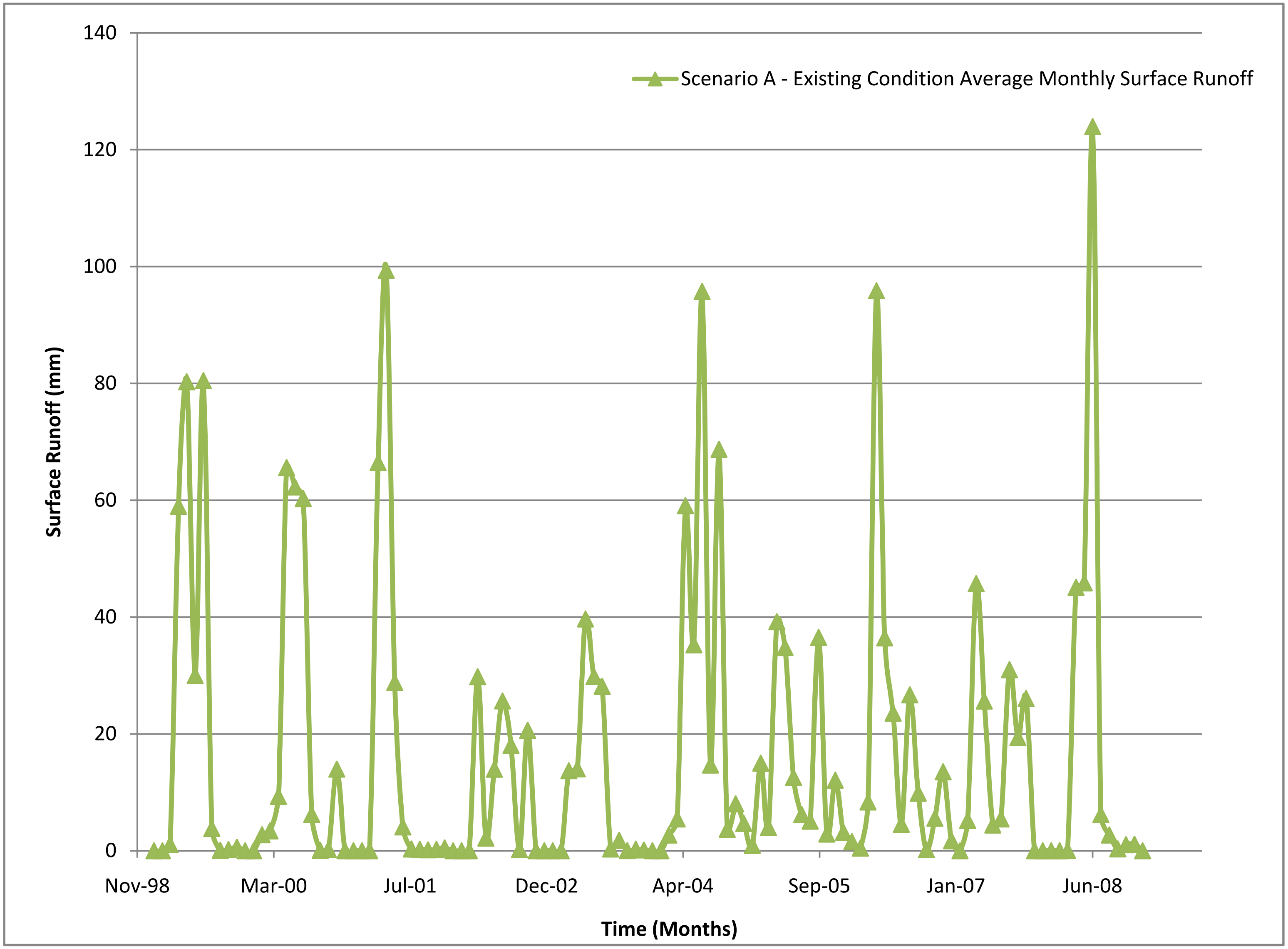
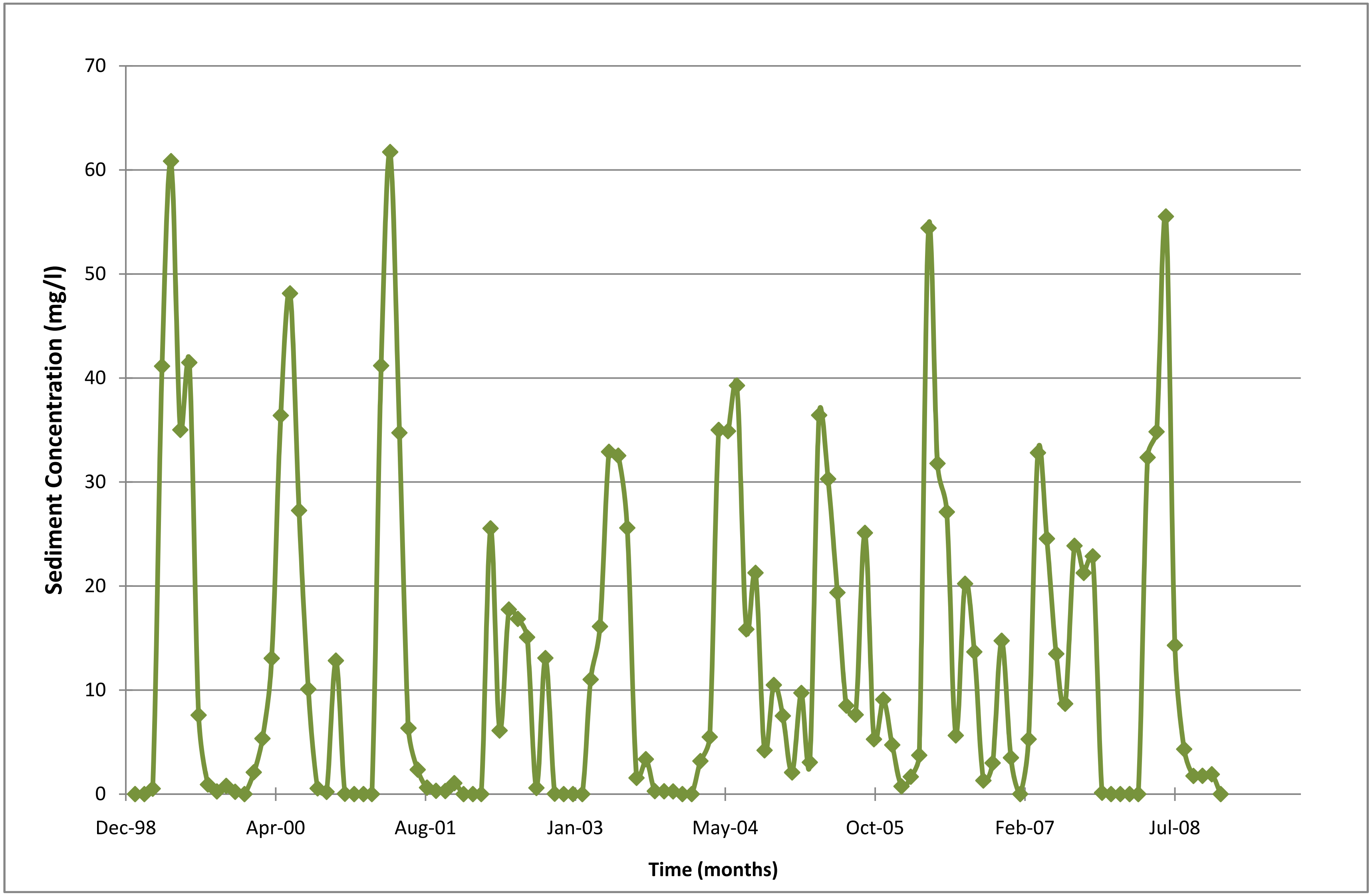


Figure 17: Dobbins Creek - Scenario A: Existing Condition Monthly Average TSS Concentration Graph (1999 – 2008)



Scenario B – Distributed Temporary Storage

Description

The CRWD identified three different storage options: wetland restoration sites, flood reduction sites and temporary storage areas (Figure 18). The wetland restoration sites have not been formally studied, however, initial discussion have taken place between CRWD and property owners. Formal studies commissioned by CRWD and other stakeholders on the flood reduction sites and temporary storage site are described below.

In September 2009, CRWD commissioned two Flood Reduction Feasibility Studies (Jones,Haugh & Smith Inc - Site 1, 2009) (Jones, Haugh & Smith Inc - Site 2, 2009). The draft reports identified two location Site 1 (Sections 7 and 18 – Dexter Township) and Site 2 (Section 28–Red Rock Township) which could be used for flood reduction sites during high flow events (Figure 16). Site 1's watershed is approximately 660 acres, which is about 60 percent of subbasin 3 and has a potential storage volume of 25 ac-ft. Site 2's watershed is approximately 280 acres, which is about 30 percent of subbasin 17 with a potential storage volume of 13 ac-ft. Those storage areas were considered in SWAT to determine their water quality benefits.

In September 2007, the Upper Cedar River Ad Hoc Committee commissioned the Upper Cedar River Surface Water Management Plan (WMP). The primary focus of the WMP was to provide flood protection and reduce the 100-year peak flows by 20 percent. The WMP documents surface areas and temporary storage volumes adjacent to culverts in the Upper Cedar River Watershed, of which Dobbins Creek is a part. Using findings of that report as a foundation, temporary storage sites' surface areas and storage volumes were identified throughout the watershed as documented in Table 10. Because North Branch and to a lesser extend Unnamed Branch were the focus of these scenarios, temporary storage sites were located in those subwatersheds.

Table 10: Dobbins Creek Temporary Storage Sites Surface Areas and Volumes

WMP Watershed No.		Area of Inundation (ac)	Detention Volume (ac-ft)	Depth of Storage (ft)	SWAT Subbasin	SWAT (ac)	SWAT Storage Depth (ft)	SWAT Detention Volume (ac-ft)
Dbbn	30	114	518.6	4.5	22/26	50	4.5	227.5
Dbbn	31	3.5	5.8	1.7	13	4	1.7	5.8
Dbbn	15	33	118.5	3.6	11	33	3.6	118.5
Dbbn	16	15.4	22.5	1.5	7	15	1.5	22.5
Dbbn	17	15.2	31	2.0	5	15	2.0	31.0
Dbbn	18	73.2	297	4.1	5	50	4.1	202.9
Dbbn	19	18.5	40.1	2.2	12	19	2.2	40.1
Dbbn	20	38.1	140	3.7	12	38	3.7	140.0
Dbbn	21	35.5	112.9	3.2	12	36	3.2	112.9
Dbbn	48	12.5	45.8	3.7	30	13	3.7	45.8
Dbbn	49	60.3	231.8	3.8	34	50	3.8	192.2
Dbbn	50	27	106.4	3.9	37	27	3.9	106.4
Dbbn	51	6.5	23.4	3.6	37	7	3.6	23.4
Dbbn	10	435	189.1	0.4	1	50	0.4	21.7
Dbbn	11	14.6	22.8	1.6	6	15	1.6	22.8
Dbbn	7	10.8	28.4	2.6	3	11	2.6	28.4

The principal goal of this scenario was to reduce the continuous simulated peak flows (for the 10-year period) by 10 percent. Again, the focus of this goal is not to meet the water quality standard but the reduce peak flows by 10 percent.

The mentioned storage options were evaluated in stages, one building off the other. Initially, flood reduction and wetland restoration sites were put into the model and the outputs checked to determine whether the 10 percent peak flow reduction had been met. Recognizing it hadn't been met, the temporary storage areas derived from the WMP was incorporated in phases as noted in Table 11. The first phase focused on the North Branch subwatershed because it did not meet water quality standard more times that any of the other branches. In addition, within the subwatershed, subbasins were ranked based on sediment yield. Subbasins in Phase 1 represented areas that had the high yields per unit area.

Table 11: Dobbins Creek Temporary Storage Phasing Plan

	SWAT Subbasins
Phase 1	3
	1
	6
	11
	7
	5
	12
	22
Phase 2	26
	13
Phase 3	37
Phase 4	30
	34
Phase 5	1
	22
	5

Computed Water Quality Benefits

The result showed a 10 percent reduction in continuous simulated average monthly peak flows from the Existing Condition (Figure 19). There would also some water quality benefits realize. TSS concentrations for the 10-year period based on using the flood reduction, wetland restoration and all phases of temporary storage sites are shown in Figure 16. This scenario generated TSS concentration reduction of 4 – 5 percent during some months and as high as 50 – 70 percent reductions in others. Although, Figure 20 illustrates positive change in TSS concentration as a result of using these storage options, water quality standard were not met.

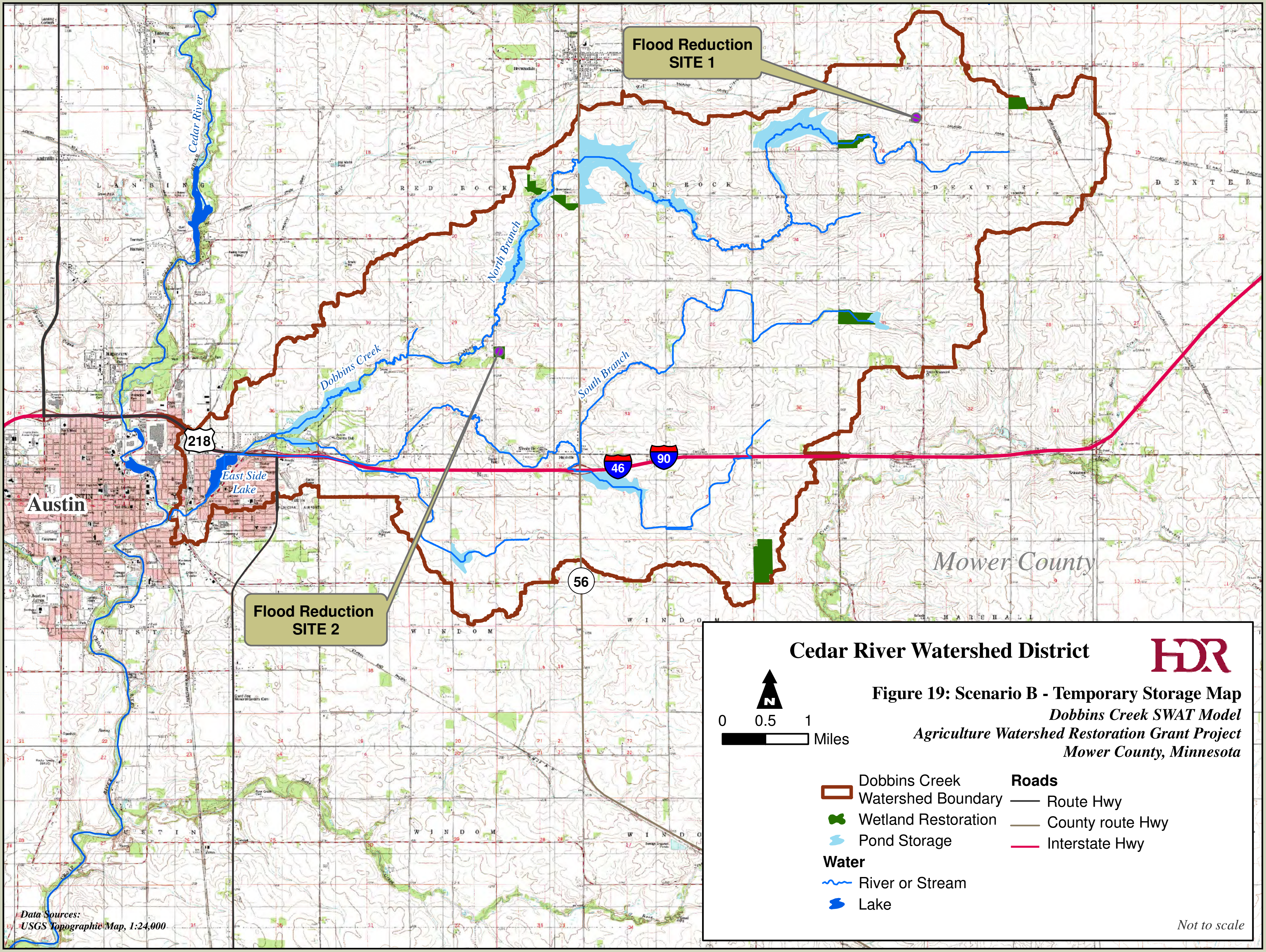


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Figure 19: Dobbins Creek - Scenario B: Temporary Distributed Storage Monthly Average Peak Flow Graph (1999 – 2008)

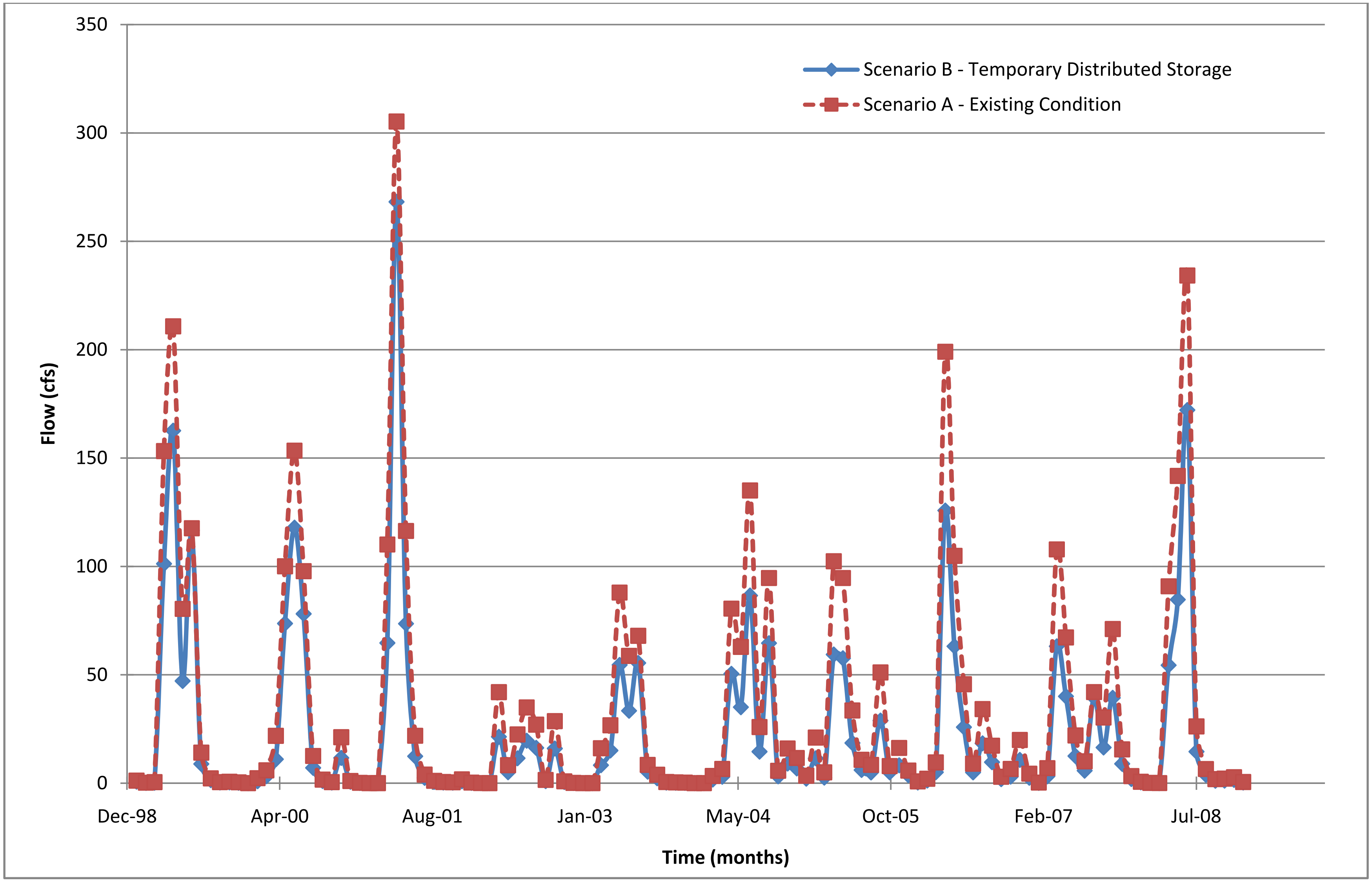
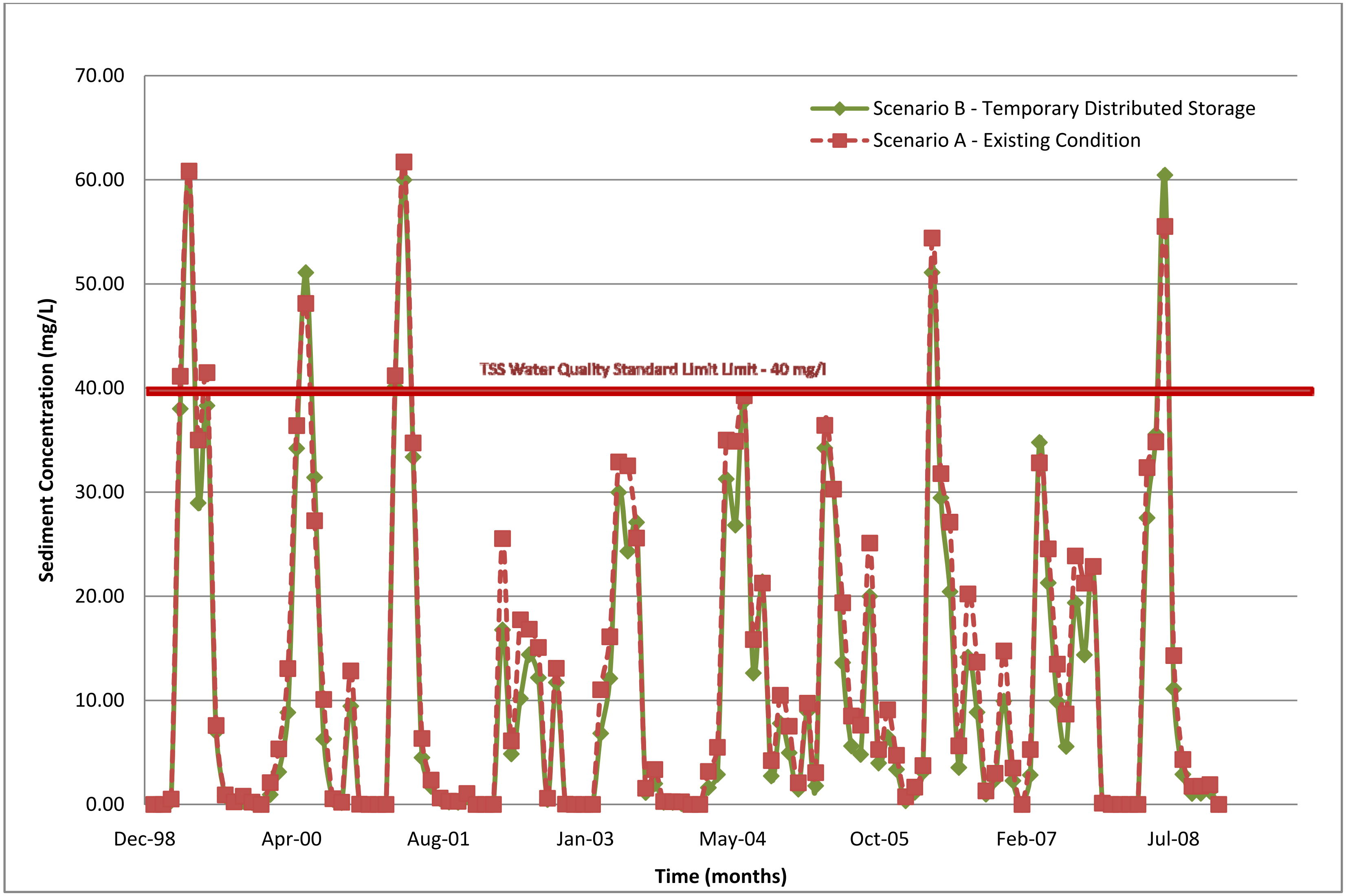


Figure 20: Dobbins Creek - Scenario B: Temporary Distributed Storage Monthly Average TSS Concentration Graph (1999 – 2008)



Estimated Cost

The estimated cost for implementing this scenario was addressed as follows:

- Costs associated with the flood reduction sites were taken for the cost data provided in the reports for the two sites.
- Cost associated with the wetland restoration sites will be based on land acquisition cost of $5,000 per acre (Burnet, 2010). It is assumed that design and construction is $3,000 per acre.
- Costs associated with the temporary storage were derived from the reconnaissance level cost estimate presented in the WMP. The information presented assumes CRWD staff would complete the engineering design and construction observation and administration.

Flood Sites

Site 1: Cost Estimate (Jones,Haugh & Smith Inc - Site 1, 2009)

Land Acquisition	$49,000
Design	$15,000
Construction	$55,640
Miscellaneous	$26,360
Total Start-Up Cost	$131,000

Site 2: Cost Estimate (Jones, Haugh & Smith Inc - Site 2, 2009)

Land Acquisition	$ 5,000
Design	$25,000
Construction	$148,000
Miscellaneous	$39,500
Total Start-Up Cost	$232,800

Wetland Restoration Sites

Land Acquisition (70ac)	$350,000
Design/Construction ($3,000/ac)	$210,000
Contingency (30%)	$168,000
Total Cost	$728,000

Temporary Storage Sites

WMP Watershed No.		SWAT Subbasin	WMP Reported Cost
Dbbn	30	22/26	$102,000
Dbbn	31	13	$10,000
Dbbn	15	11	$135,000
Dbbn	16	7	$0
Dbbn	17	5	$46,000
Dbbn	18	5	$13,000
Dbbn	19	12	$206,000
Dbbn	20	12	$7,000
Dbbn	21	12	$7,000
Dbbn	48	30	$0
Dbbn	49	34	$0
Dbbn	50	37	$9,000
Dbbn	51	37	$7,000
Dbbn	10	1	$383,000
Dbbn	11	6	$36,000
Dbbn	7	3	$21,000
		Total	**$982,000**

Total Cost

Flood Reduction Sites	$363,800
Wetland Restoration Sites	$728,000
Temporary Storage Sites	$982,000
Total	$2,073,800

Implementation Challenges

There are two transparent implementation challenges – money and public perception.

The flood reduction sites and the wetland restoration sites will require a substantial amount of capital for CRWD to acquire properties, design and construct. A phased approach would be a good way to reduce the fiscal burden of implementing this scenario. Public perception surrounding down sizing culverts to manufacture temporary storage areas has not been favorable. The scale of the WMP study required large area flooding for durations longer than stakeholders were willing to tolerate. The reduced magnitude presented in this report may be more palatable.

Scenario C – Perennial Vegetation

Description

As the price of oil increases, the United States and other nations are researching and developing alternative fuel options. These alternative fuel options have included corn-based ethanol and cellulosic ethanol. The option being considered here is cellulosic ethanol which is derived from switchgrass and other perennial vegetation.

Looking at the North Branch, switchgrass was planted on agricultural lands within that watershed. Subwatersheds contributing to the North Branch were ranked based on the sediment yield rate from the Existing Condition model (Table 12). The ranked data were then partitioned into four sections (50%, 60%, 75% and 100%) based on percentage of area draining to the North Branch (Table 12).

Table 12: Dobbins Creek North Branch Sediment Yield Ranking

<table>
<tr><th>Subbasin</th><th>Area (km2)</th><th>Sediment Yield (t/ha)</th><th>Percent of Area</th><th>Cumulative Percent of Area</th></tr>
<tr><td>9</td><td>1.051</td><td>8.56</td><td>2%</td><td rowspan="9">~ 50%</td></tr>
<tr><td>6</td><td>0.793</td><td>8.42</td><td>2%</td></tr>
<tr><td>12</td><td>4.684</td><td>7.98</td><td>9%</td></tr>
<tr><td>1</td><td>2.660</td><td>7.96</td><td>5%</td></tr>
<tr><td>7</td><td>0.638</td><td>7.76</td><td>1%</td></tr>
<tr><td>10</td><td>2.943</td><td>6.41</td><td>6%</td></tr>
<tr><td>17</td><td>3.815</td><td>6.38</td><td>8%</td></tr>
<tr><td>22</td><td>5.034</td><td>6.11</td><td>10%</td></tr>
<tr><td>2</td><td>2.373</td><td>6.06</td><td>5%</td></tr>
<tr><td>4</td><td>4.561</td><td>5.93</td><td>9%</td><td>~ 60%</td></tr>
<tr><td>8</td><td>2.036</td><td>5.88</td><td>4%</td><td rowspan="3">75%</td></tr>
<tr><td>11</td><td>4.479</td><td>5.84</td><td>9%</td></tr>
<tr><td>16</td><td>2.104</td><td>5.66</td><td>4%</td></tr>
<tr><td>3</td><td>4.629</td><td>5.64</td><td>9%</td><td rowspan="3">100%</td></tr>
<tr><td>5</td><td>4.969</td><td>4.81</td><td>10%</td></tr>
<tr><td>14</td><td>3.081</td><td>4.79</td><td>6%</td></tr>
</table>

Agricultural areas were converted to switchgrass starting with 50% of the watershed area, then 60 percent and so on until 100 percent. Each time additional area was converted to switchgrass, the output was checked to see if water quality standards were met. Water quality standards were not met until 100 percent of the area draining to the North Branch was converted (Figure 23).

Computed Water Quality Benefits

Implementing this scenario resulted in a reduction in TSS concentrations, as is illustrated in Figure 23. Over the 10-year period, all monthly average TSS concentrations were reduced to within an acceptable range, satisfying Minnesota Statue 7050. The scenario also produced reductions in runoff as shown in Figure 22.

Estimated Cost

The cost associated with implementing this scenario was derived using the crop production from SWAT model outputs for this scenario and Scenario A – Existing Conditions. Presented in Table 13 below is the expected annual revenue stream over the 10-year period for the Scenario A – Existing Condition with crops of corn and soybean and Scenario C with perennial vegetation. Converting crops from corn/soybean to switchgrass would cost growers an estimated $3,955,325, as shown on Table 13.

Table 13: Dobbins Creek Scenario C_ Perennial Vegetation Cost Estimate

Crop	Yield (bushels/ac)	Production (bushels)	Unit Price[3]	Total Revenue
Existing Conditions				
Soybeans	85	331,585	$9.65	$3,199,795
Corn	130	1,025,050	$3.40	$3,485,170
			Total	**$6,684,965**
Proposed Conditions				
Switchgrass	3.86	45,494	$ 60.00	$2,729,638
			Total	**$2,729,638**
			Difference	**$3,955,325**
Area (ac) Soybeans		3,901		
Area (ac) Corn		7,885		
Total Area(ac)		**11,786**		

[3] (USDA, 2009)

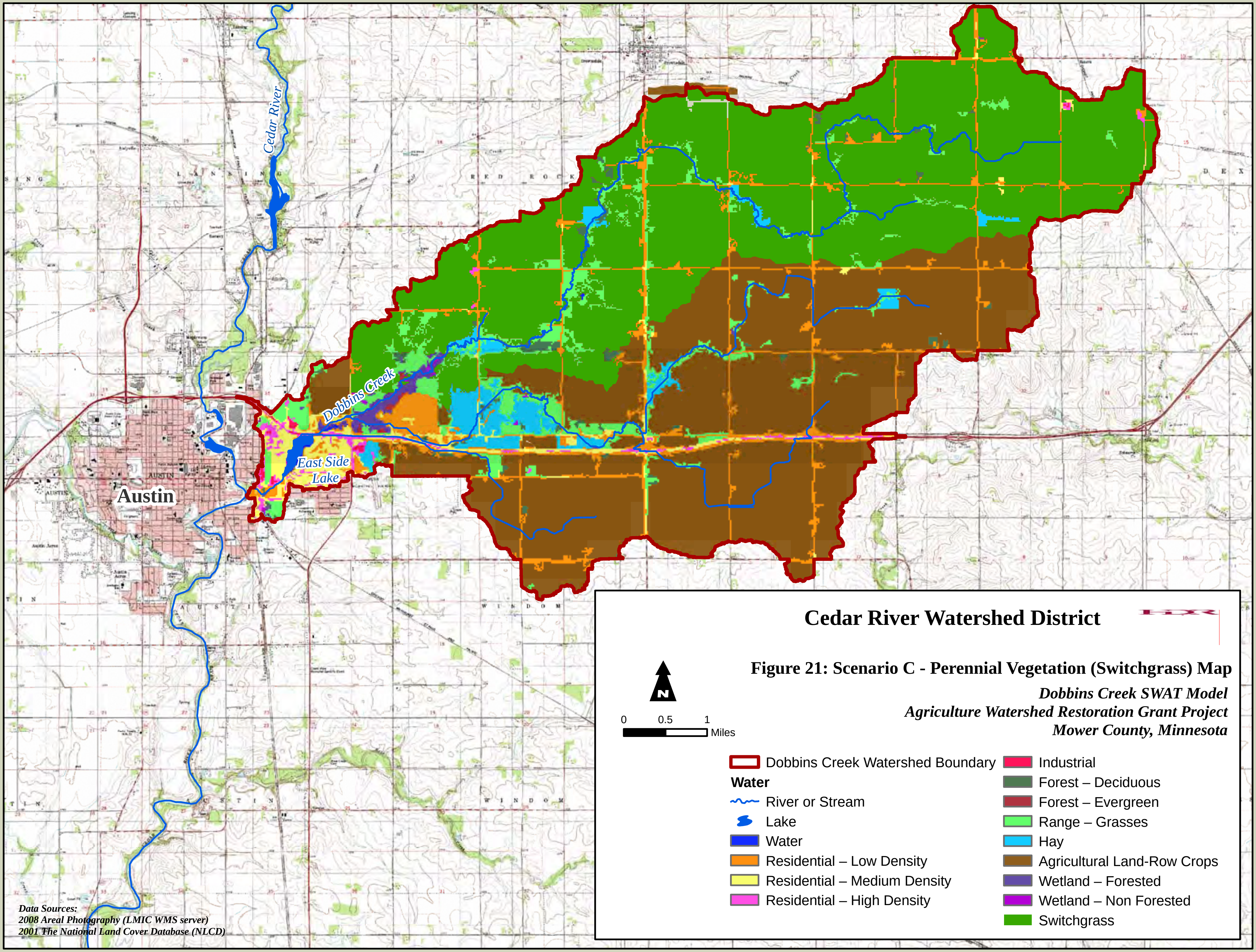


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Figure 22: Dobbins Creek - Scenario C: Perennial Vegetation Monthly Average Surface Runoff Graph (1999 – 2008)

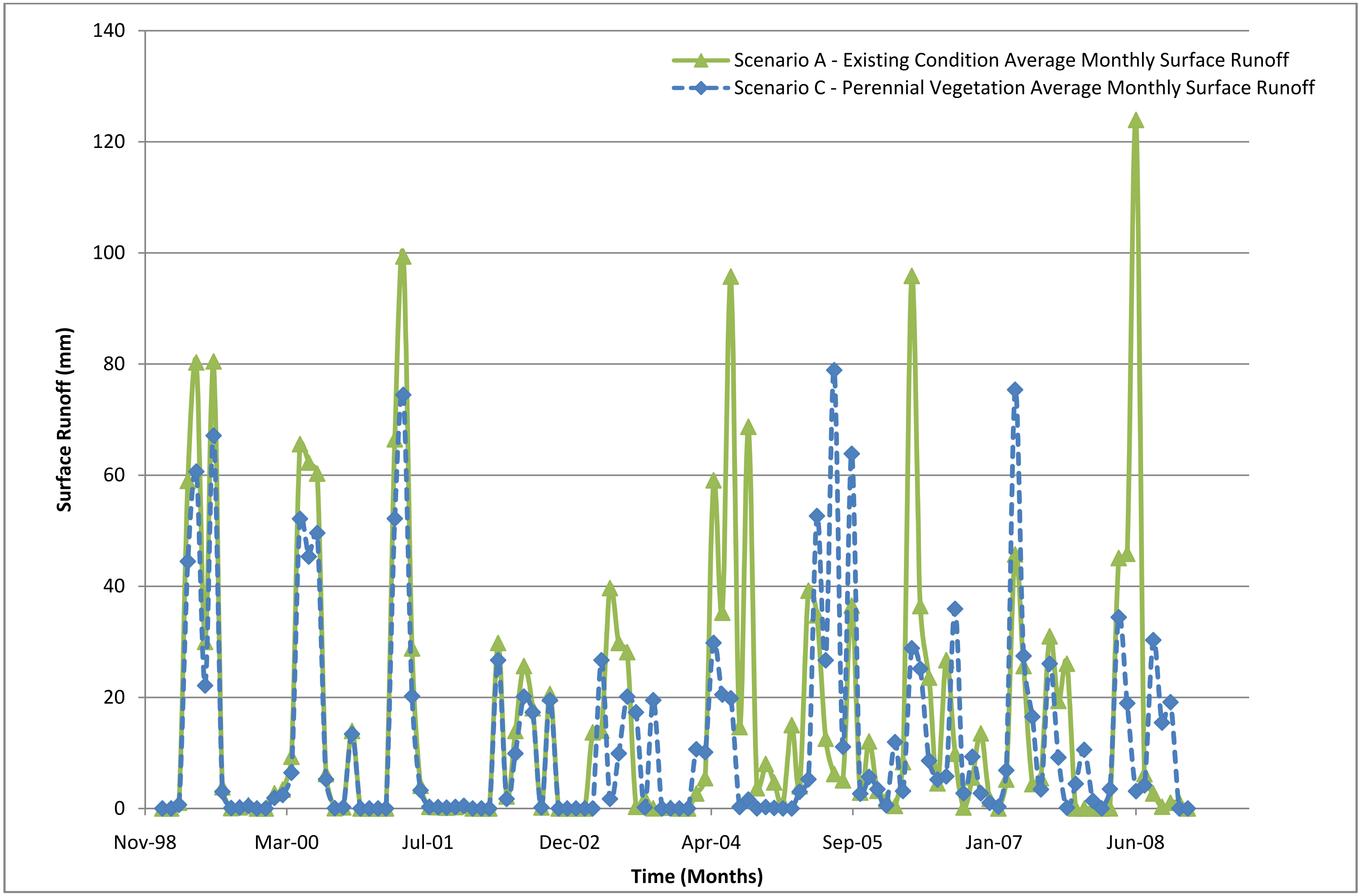
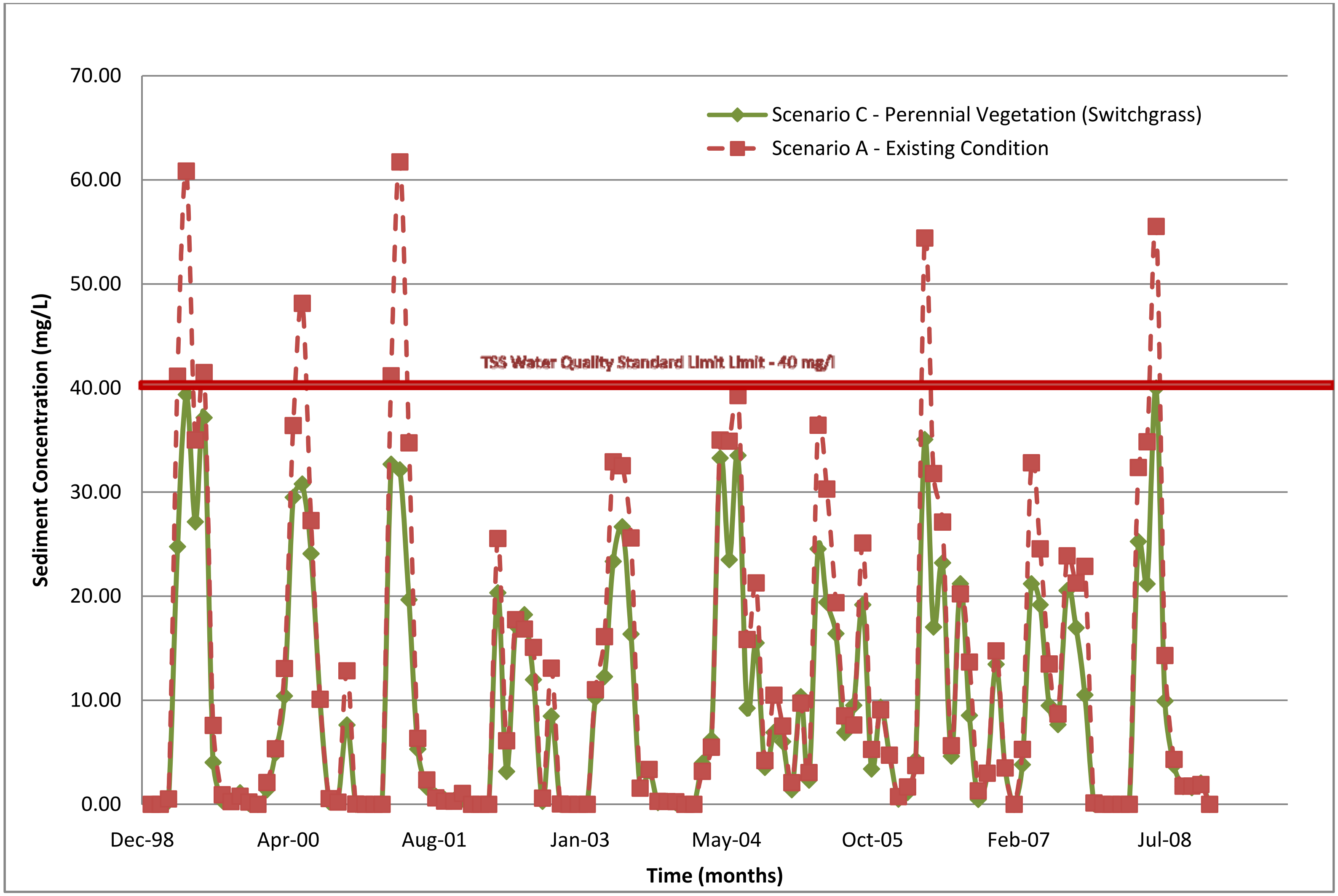


Figure 23: Dobbins Creek - Scenario C: Perennial Vegetation Monthly Average Sediment Concentration Graph (1999 – 2008)



Implementation Challenges

As a part of this project, CRWD staff conducted a survey of local farmers to determine what BMPs of land management practices would they most likely implement, if given the option and financial incentives (Appendix B). One of the options specified on the survey was converting their crops to perennial vegetation. Although the perennial vegetation option was analyzed, survey results indicated that farmers in this region are less likely to convert from corn or soybeans to switchgrass/perennials. In addition, the program cost necessary to offset the annual loss in revenue is high relative to the CRWD 2010 – 2018 average annual operating budget of $880,444 (Cedar River Watershed District, 2009).

Scenario D – Erosion Control

Description

Controlling erosion is critical to restoring water quality Dobbins Creek. Erosion control, prevention or management reduces the transport and delivery of sediment to the stream. According to the Stream Survey Report and CRWD, there are estimated 1,014 meter (3,328 lineal feet) and 98 square meters (1,050 square feet) of bank erosion along the north and south branch, respectively (Hanson - Stream Report, 2008). Bank erosion coupled with erosion from land management practices results in increased sediment deposition in tributary streams and the main channel.

In an effort to address this problem, the following erosion control best management practices were implemented in this scenario: conservation tillage and stream bank restoration. Conservation tillage was considered over 100 percent on agricultural land draining to the North Branch. In addition, streambanks within the North Branch would be restored. First, guided by CRWD staff, eroded sections of the creek would be restoring using revetment projects along the 1,014 m (3,328 ft) length of the channel upstream of East Side Lake. Then, implement Newberry Rock Riffles in selected stream sections (1, 7, 10, 12, 17, 22, and 25) to control grade, reduce velocity and trap sediment. Figure 24, provides a graphical illustration of the erosion control best management practices employed in this scenario.

Computed Water Quality Benefits

Implementing this scenario resulted in a reduction in TSS concentrations along the impaired reach of the creek as is illustrated in Figure 26. Over the 10-year period, monthly average TSS concentrations were reduced to within an acceptable range, satisfying Minnesota Statue 7050. The scenario also produced a reduction in runoff as shown in Figure 25.

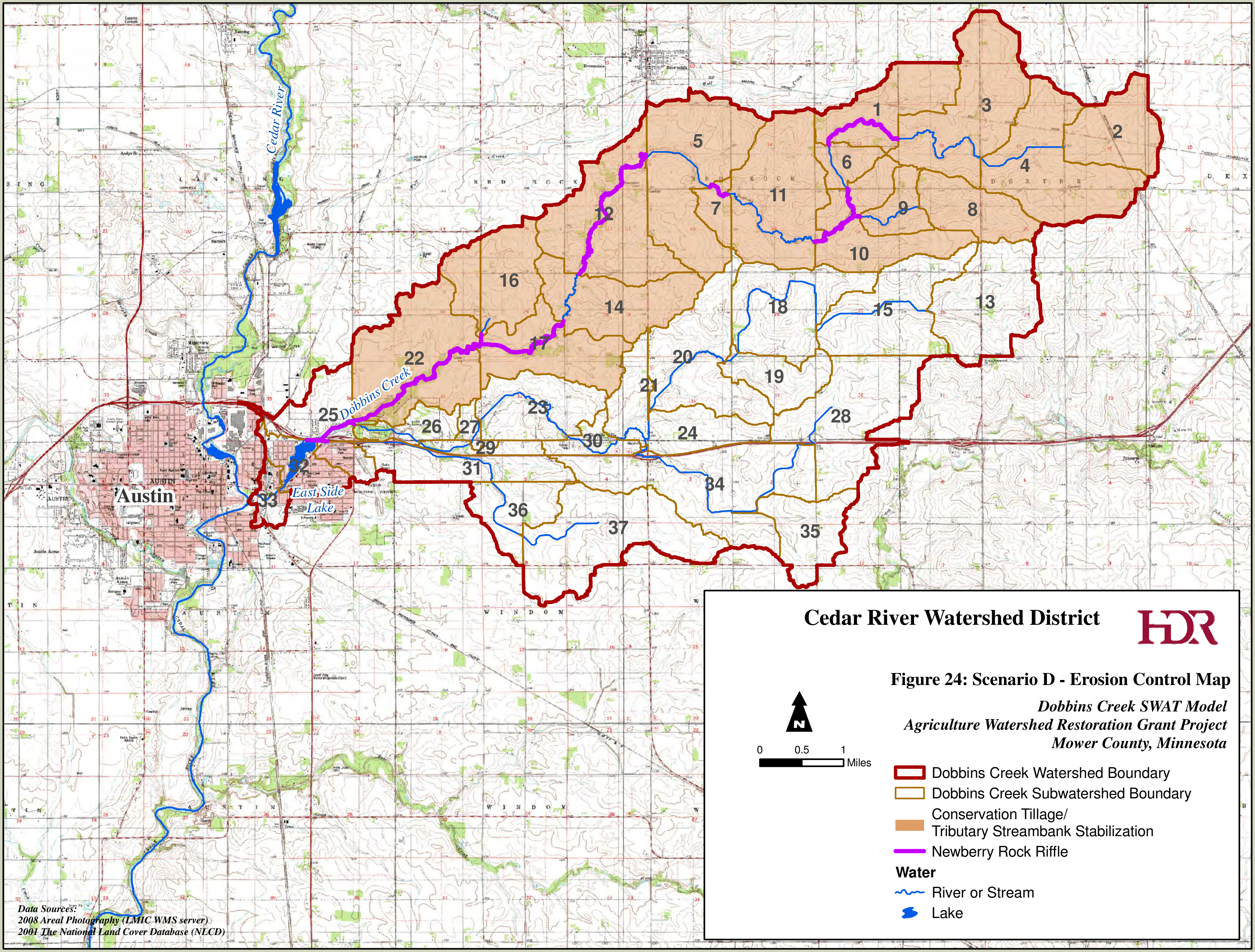


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Figure 25: Dobbins Creek - Scenario D: Erosion Control Monthly Average Surface Runoff Graph (1999 – 2008)

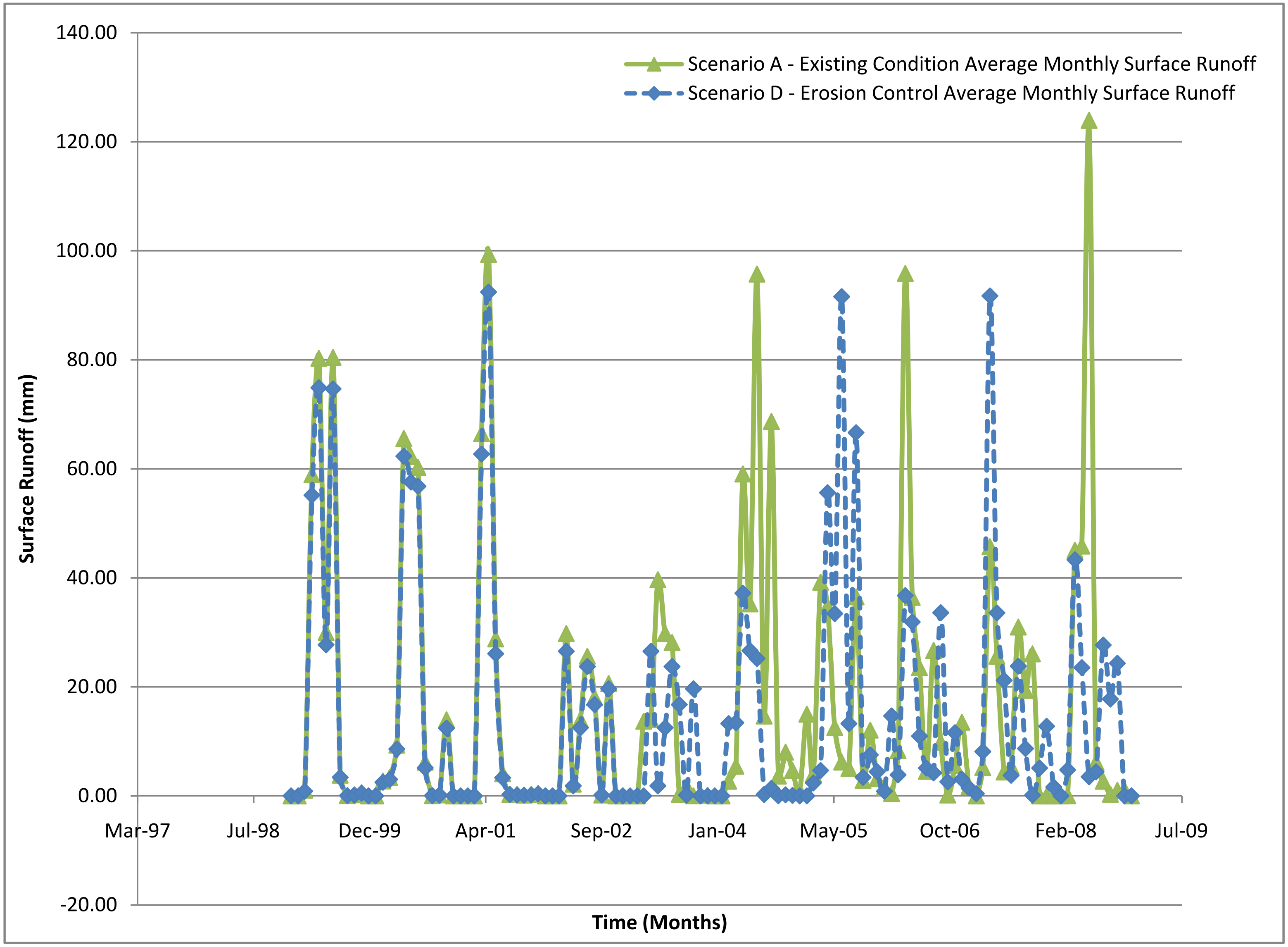

Figure 26: Dobbins Creek - Scenario D: Erosion Control Monthly Average TSS Concentration Graph (1999 – 2008)

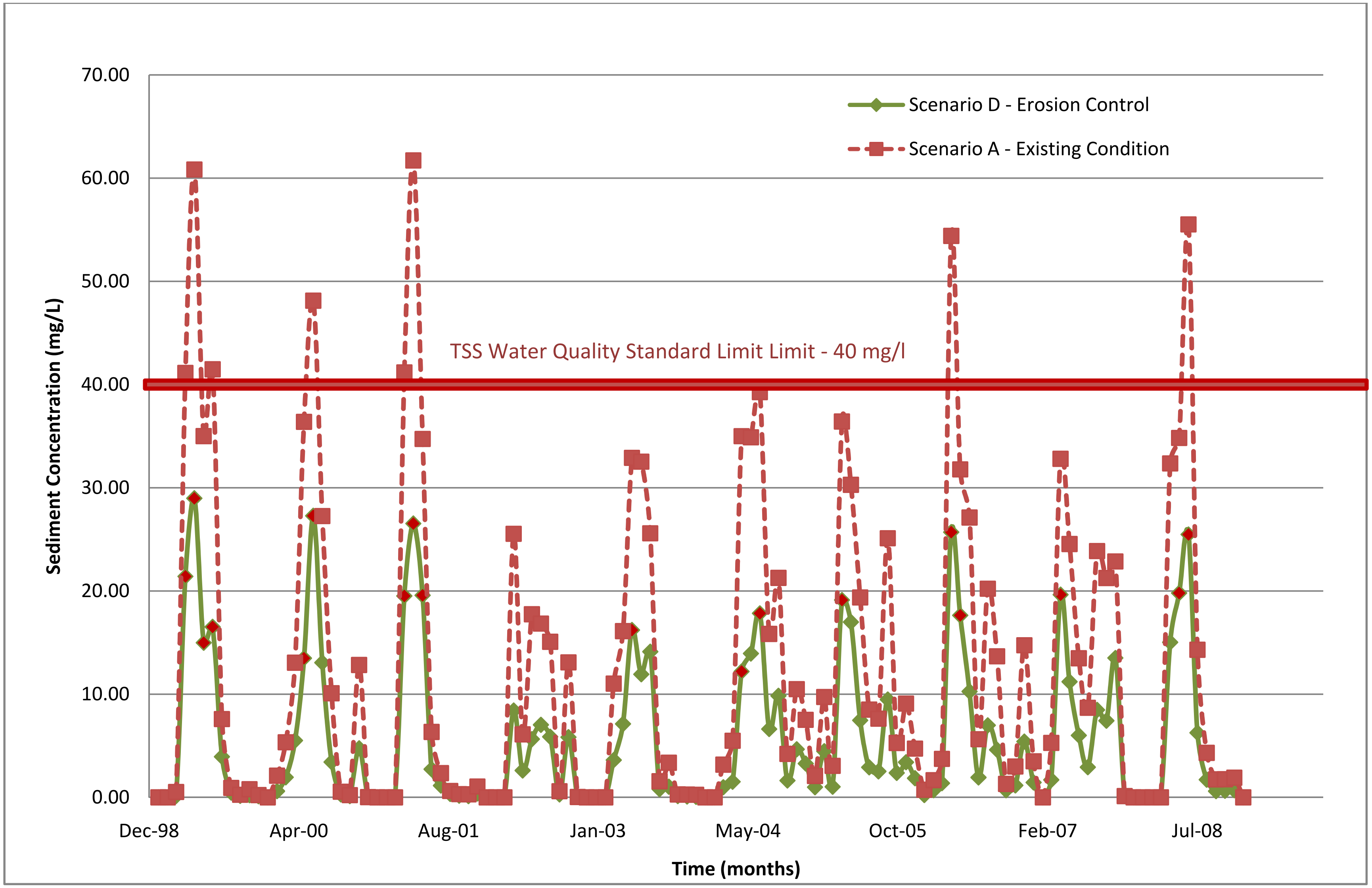

Table 14: Dobbins Creek Scenario D – Cost Estimate

North Branch				Contingencies		
Item	Quantity	U/I	Unit Price	Extended Amount	%	Contingency Amount
Grade Control and Scour Protection						
Riffles , 30'x10' – Reach 1	7	EA	$3,700	$25,900	30%	$7,770.00
Riffles , 30'x10' – Reach 7	2	EA	$3,700	$7,400	30%	$2,220
Riffles , 30'x10' – Reach 10	7	EA	$3,700	$25,900	30%	$7,770
Riffles , 50'x20' – Reach 12	7	EA	$7,070	$49,490	30%	$14,847
Riffles , 50'x20' – Reach 17	8	EA	$7,070	$56,560	30%	$16,968
Riffles , 50'x20' – Reach 22	7	EA	$7,070	$49,490	30%	$14,847
Riffles , 50'x20' – Reach 25	3	EA	$7,070	$21,210	30%	$6,363
Deflectors	75	EA	$ 870	$65,250	30%	$19,575
			Subtotal	**$301,200**		**$90,360**
Riparian Restoration						
Bank Stabilization	3,328	LF	$50	$166,400	30%	$49,920
Log/Rootward/Boulders	133.3	LF	$40	$5,332	30%	$1,599.60
Tree saplings with grow tube	15,000	EA	$ 9	$135,000	30%	$40,500
			Subtotal	**$306,732**		**$92,019.60**

Implementation Challenges

As with Scenario B, the implementation challenge is financial. CRWD would need funds to pay for engineering and construction services associated with the design and construct of the Newberry Rock Riffles and to buy the items need for the riparian restoration/streambanks stabilization.

Scenario E – Combination

Description

The CRWD created a survey for local farmers that asked what they would most likely implement, if given the options and financial incentives. The results of the survey are presented in Appendix B. The survey provided critical implementation information which allowed evaluation of practices that farmers would actually implement.

CRWD survey pool was made up of five (5) farmers and the City of Austin - Nature Center, chosen to represent the cross-section of views relating to land management in the watershed. The result of the survey suggests that:

- Approximately 20 percent of farmers would voluntarily implement conservation tillage or no-till options. If compensated, that number rises to 80 percent.
- If compensated:

- 80 percent would consider flowage easements
- 60 percent would consider flood reduction sites
- 25 percent would consider wetland restorations (include the Nature Center)
- 17 percent would consider streambank restorations

The practices measured in this scenario were based on responses received from the surveys; the ability of these practices to meet TSS water quality standards and reduce peak flows by 10 percent; and the availability to get grant to offset the financial burden. Using these as a basis, the following practices were used in Scenario E:

- Flood Reduction Sites
- Wetland Restoration Sites
- Phase 1- Temporary Storage Sites (Table 10)
- Conservation Tillage

These practices are also presented graphically on Figure 27.

Computed Water Quality Benefits

Over the 10-year period of record, monthly average TSS concentrations values were reduced by 34 percent, which satisfies Minnesota Statue 7050. In addition, peak flow readings were reduced by 23 percent. The highest average peak flow of 305 cubic feet/second (May 2001) was reduced by 10 percent. The other three notable average peak flows greater than 200 cfs were reduced by 19 – 25 percent.

Estimated Cost

The cost to implement this scenario is presented below.

Flood Reduction Sites

Site 1: Cost Estimate (Jones,Haugh & Smith Inc - Site 1, 2009)

Land Acquisition	$49,000
Design	$15,000
Construction	$55,640
Miscellaneous	$26,360
Total Start-Up Cost	$131,000

Site 2: Cost Estimate (Jones, Haugh & Smith Inc - Site 2, 2009)

Land Acquisition	$45,000
Design	$25,000
Construction	$148,000
Miscellaneous	$39,500
Total Start-Up Cost	$232,800

Wetland Restoration Sites

Land Acquisition (70ac)	$350,000
Design/Construction ($3,000/ac)	$210,000
Contingency (30%)	$168,000
Total Cost	$728,000

Temporary Storage Sites

WMP Watershed No.		SWAT Subbasin	WMP Reported Cost
Dbbn	10	1	$383,000
Dbbn	7	3	$21,000
Dbbn	17	5	$46,000
Dbbn	18	5	$13,000
Dbbn	11	6	$36,000
Dbbn	16	7	$0
Dbbn	15	11	$135,000
Dbbn	19	12	$206,000
Dbbn	20	12	$7,000
Dbbn	21	12	$7,000
Dbbn	30	22	$102,000
		Total	**$956,000**

Total Cost

Flood Reduction Sites	$363,800
Wetland Restoration Sites	$728,000
Temporary Storage Sites	$956,000
Total	$2,047,800

Implementation Challenges

A $2 million capital investment during a time when budget challenges are being seen in every arena from government to residential household presents a major hurdle. In addition, CRWD is obligated to address water quality problems affecting regulated uses of the Dobbins Creek by state and federal laws. These two items present a picture that is being seen by many other entities that are faced with unfunded mandates.

But, the feasibility and practicality of the BMPs considered in this scenario makes the task of securing funding less daunting. The water quality and quantity benefits of implementing this scenario provide the perfect framework for soliciting funding partners. Below is a list of a few funding opportunities available to CRWD to implement these BMPs:

- DNR Flood Damage Reduction Program (DNR-FDR Program, 2010): This program provides financial, planning, and technical assistance to reduce recurring flood damages by promoting the sound management and appropriate use of floodplain and riparian areas. The program requires 25 percent matching funds from local government units.
- Conservation Reserve Enhancement Program (CREP) (USDA-FSA, 2009): This is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. CREP provides payments to participants who offer eligible land.
- EPA Five- Star Restoration Program (US EPA - 5 SRP, 2009): The program provides challenge grants ($5,000 to $20,000), technical support and opportunities for information exchange to enable community-based restoration projects.
- USDA Wetland Reserve Program and BWSR Reinvest in Minnesota (RIM-WRP, 2009): The program provides funding to restore critical wildlife habitat on privately owned lands while improving water quality, reducing flood damage potential, providing economic assistance to landowners, and providing other environmental and economic benefits. In 2009, the total amount available for projects was $41 million.
- DNR Pheasant habitat improvement program (PHIP) (DNR - PHIP, 2010): This program provides cost-sharing to landowners for management practices that improve pheasant habitat through the development, restoration, and maintenance of suitable habitat for ring-necked pheasants, which includes the establishment of food plots (primarily corn or sorghum), nesting cover, woody cover and wetland restoration.
- US Fish and Wildlife Service - North American Wetland Conservation Act (USFWS, 2010): This program provides matching grants (not to exceed $75,000) to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.

In addition to the grant opportunities noted above, the state of Minnesota through BWSR provides countless other funding mechanisms including the conservation drainage program, runoff reduction grants, and clean water assistance grants.

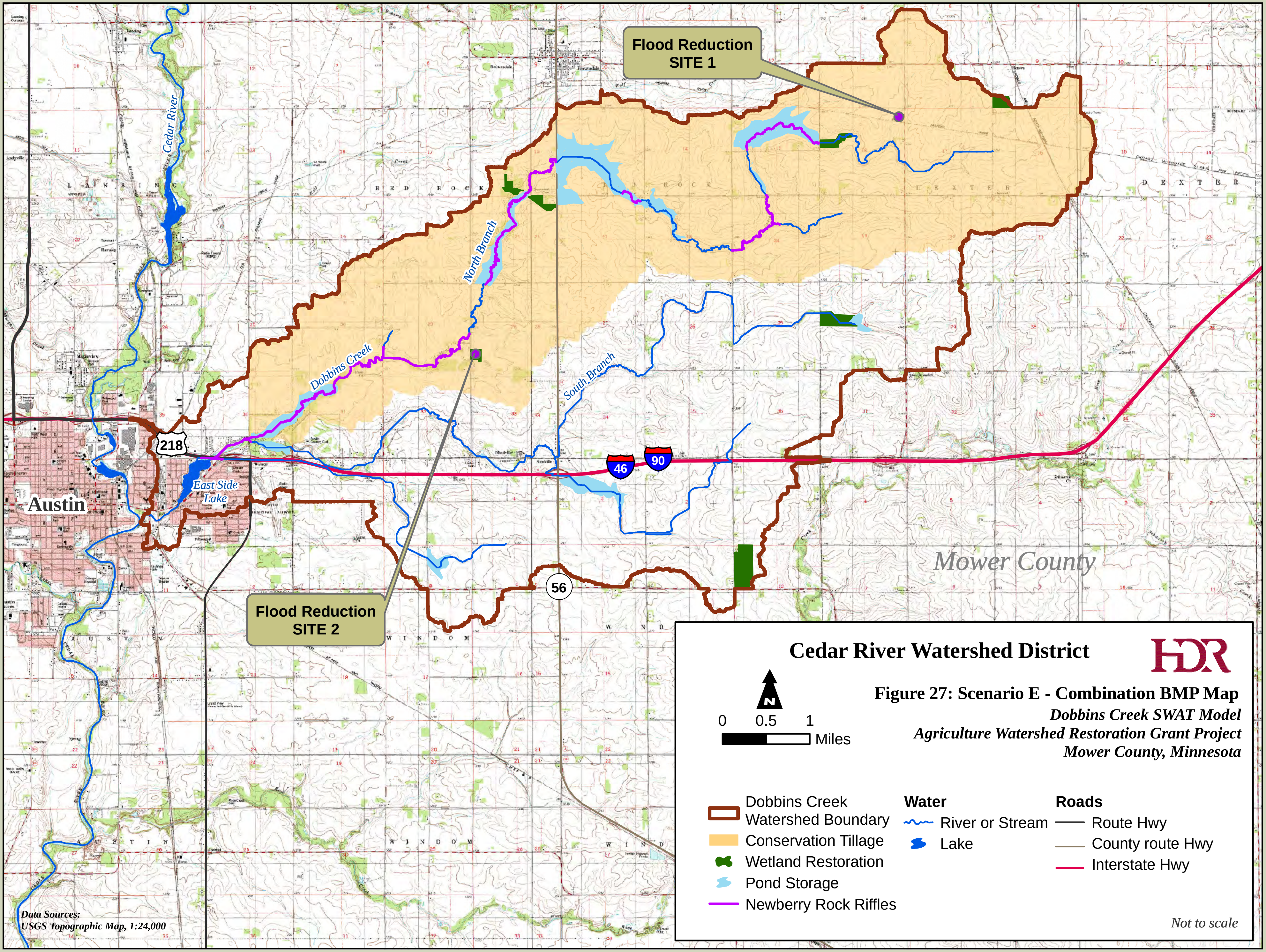

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Figure 28: Dobbins Creek - Scenario E: Combination Practices Monthly Average Peak Flow Graph (1999 – 2008)

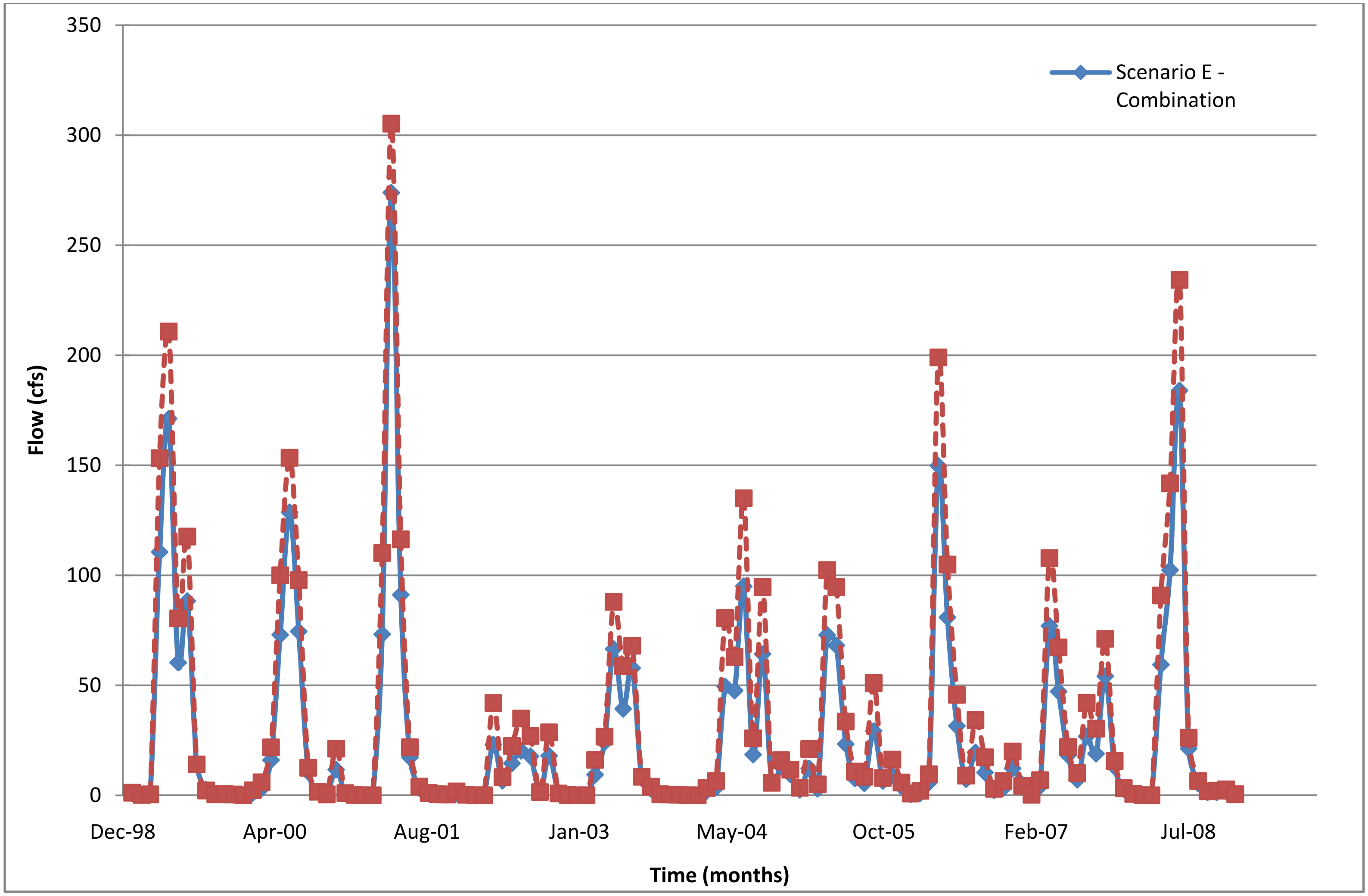
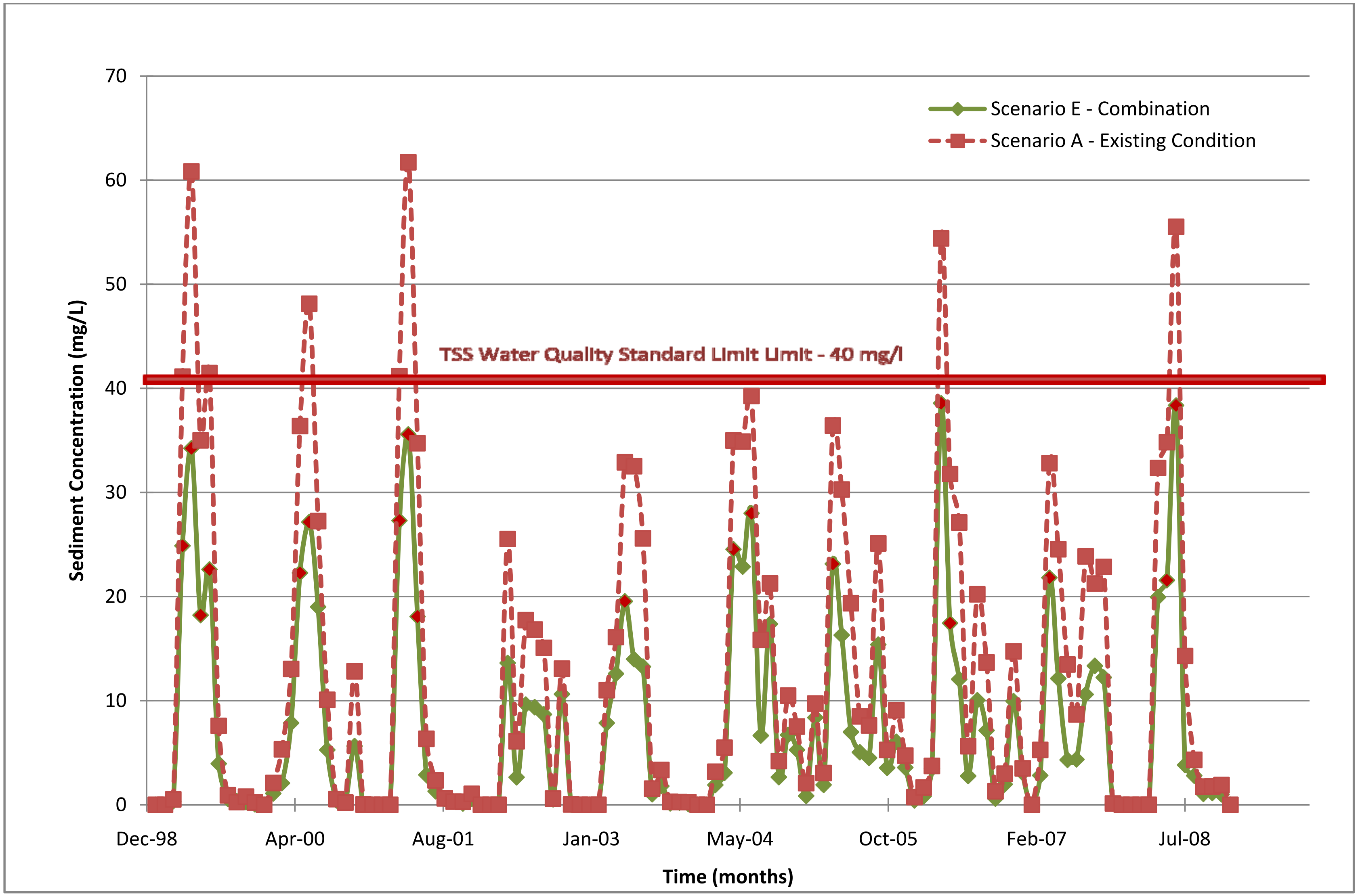


Figure 29: Dobbins Creek - Scenario E: Combination Practices Monthly Average TSS Concentration Graph (1999 – 2008)



Conclusion

The CRWD, in partnership with BWSR, undertook the application of a SWAT model to model the Dobbins Creek watershed system. The scope of this project was to use SWAT to simulate hydrologic and sediment dynamics on a continuous simulation to identify potential system changes or BMPs needed to meet TSS water quality standards in the Dobbins Creek Watershed. Using the calibrated SWAT model, five broad scenarios were evaluated to determine their ability to reduce peak flows and TSS transported through the Dobbins Creek system. The primary focus of this project was sediment reduction; however, best management practices selected for implementation under these scenarios also considered their ability to reduce peak flow.

The goal of these scenarios, as documented by CRWD, is to meet applicable turbidity/TSS state surface water quality standards. Dobbins Creek is a class 2B stream with a turbidity limit of 25 NTUs which translated to between 30 – 40 mg/l of TSS. The three branches of Dobbins Creek, North, South and Unnamed, were examined using the calibrated model to determine if those reaches were meeting current water quality standards based on monthly averages of TSS concentrations over a 10-year period (1999-2008). The South Branch consistently meets water quality standards. While the Unnamed Branch, violates the standard by about 5 mg/l one month over the 10-year period. On the other hand, North Branch violates the water quality standard five times over the 10-year period with exceedance of the standard ranging from about 7 mg/l to 35 mg/l. As a result, the focus of BMP implementation was the North Branch of Dobbins Creek. The five (5) scenarios are summarized below.

A. <u>Existing Condition</u> - This scenario called for CRWD, residents and stakeholders to maintain existing practices (crop rotations, land management, and fertilizer application). This scenario documented no improvement to infrastructure, farming practices or the main/tributary channels. As a result, North Branch and Unnamed Branch do not meet TSS water quality standards.

B. <u>Temporary Distributed Storage</u> – This scenario implement seven wetland restoration sites identified by CRWD, two sites from Flood Reduction Feasibility Studies, and seventeen(17) temporary storages sites from the WMP. The principal goal of this scenario was to reduce the continuous simulated peak flows (for the 10-year period) by 10 percent. Again, the focus of this goal was not to meet the water quality standard but the reduce peak flows by 10 percent. Implementing this scenario provided a 10 percent reduction in continuous simulated peak flows from Scenario A. TSS concentrations reduced by 4-5 percent in some months and in others by 50 – 70 percent. Although there were reductions in TSS concentrations, they were not enough the meet water quality standards. The cost to implement this scenario would be approximately $2.1 million. The primary challenge to implementing this scenario is financial and public perception. The flood reduction sites and the wetland restoration sites will require a substantial capital investment from CRWD to acquire properties, design and construct. Also, public perception surrounding down sizing culverts to manufacture temporary storage areas has not been favorable. The scale of the WMP was so larger that stakeholders were unwilling to consider. However, the reduced magnitude presented here may be more palatable.

C. <u>Perennial Vegetation</u>: The goal of this scenario was for the watershed to meet TSS water quality standards. To meet TSS water quality standards, 100 percent of the agricultural land in the North Branch subwatershed was converted from corn or soybean crops to switchgrass. The cost to implement that conversion would be about $4 million. Result from the survey indicated that farmers in this region are less likely to convert from corn or soybeans to switchgrass/perennials. In addition, the programming cost necessary to offset the annual loss in revenue is high relative to the CRWD 2010 – 2018 average annual operating budget of $880,444 (Cedar River Watershed District, 2009).

D. <u>Erosion Control</u>: The following erosion control best management practices were implemented in this scenario to meet TSS water quality standard: conservation tillage and stream bank restoration. Conservation tillage was employed over 100 percent of agricultural land draining to the North Branch. In addition, streambanks within the North Branch would be restored though revetment projects along the entire 1,014 m (3,328 ft) length of the channel from East Side Lake. Then, Newberry Rock Riffles were implemented in stream sections (1, 7, 10, 12, 17, 22, and 25) to control grade, reduce velocity and trap sediment. The cost of implementation is about $ 790,311. As with Scenario B, the implementation challenge is financial. CRWD would need funds to pay for engineering design and construction services associated with the Newberry Rock Riffles; and to buy the items need for the riparian restoration/streambank stabilization.

E. <u>Combination</u>: The practices considered in this scenario were based on responses received from the surveys; the ability of these practices to meet TSS water quality standards, reduce peak flows by 10 percent; and the availability of grant programs to offset the financial burden. Using that as a basis, the following practices were used in Scenario E:

- Flood Reduction Sites
- Wetland Restoration Sites
- Phase 1- Temporary Storage Sites (Table 10)
- Conservation Tillage

Over the 10-year period of record, monthly average TSS concentrations values were reduced by 34 percent, which satisfied Minnesota Statue 7050. In addition, peak flow readings were reduced by 23 percent. The cost to implement this scenario is about $2 million. Although, the price tag is high, there are several grants and funding mechanisms available to CRWD to offset the cost. This scenario is practical because it builds on previous studies, it has support from stakeholder and it addresses both water quality and quantity concerns. It is feasible because the BMPs suggested here and the results of this report provide CRWD the framework and evidence needed to gain financial support.

Recommendations

Considering the findings presented in this report and the water quality implications to Dobbins Creek, the following actions are recommended:

- Apply for Phase 3 funding and other applicable funding to implement Scenario E. Use the funds received to
    1. Revise Site 1 and 2 Flood Reduction designs to incorporate water quality features
    2. Complete Phase 1 site assessments/feasibility studies on the seven (7) identified wetland restoration sites.
    3. Complete engineering design and construction associated with the WMP temporary storage sites incorporated in the study.
- Complete an in-depth water quality study of East Side Lake to determine nutrient and sediment budgets.
- Continue monitoring efforts and integrate procedures that will aide obtaining flow and TSS data during high flow events.
- Education and engage stakeholders to voluntarily participate in runoff reducing practices, such as, conservation tillage or no-till.

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Appendix A: Table A1

Table A1. Dobbins Creek Feedlot Data

PREFERRED ID	Feedlot Name	Dairy	Beef	Veal	Swine	Horse	Sheep	Chicken	Duck
099-83271	Daniel Holst Farm				100				
099-83198	David A Krebsbach Farm					10			
099-83458	David Allen Farm					8			
099-83447	David Andree Farm		35		700			450	75
099-83270	David Holst Farm				596				
099-82977	Delmer Tapp Farm				560				
099-83252	Dennis Jax Farm	40			226				
099-83411	Diane Buckley Farm					3			
099-83213	Douglas Kiser Farm		15						
099-93966	Duane Anderson Farm				503				
099-83327	Francis Guiney Farm		20						
099-83230	Gary Kahler Farm						150		
099-82976	Gene Tapp Farm				328				
099-83357	George Finnegan Farm		80						
099-83067	Guy Rockwell Farm		13				230		
099-100193	Holden farms				2450				
099-83429	Jack Bergstrom Farm		14		280	2			
099-83431	Jack Bergstrom Farm		145						
099-83398	James Christian Farm		60		355				
099-83269	John Holst Farm	20							
099-93980	John Mueller Farm				247				
099-83158	Kathy & Joe Mayo Farm				375				
099-83594	Keith Ellis Farm				312				
099-83592	Keith Ellis Farm				700				
099-83026	Kenneth Schwebke Farm		5			5			
099-83428	LaVerne Bergstrom Farm				500				
099-82999	Myron Sorenson Farm		75						
099-83106	Phillip Oswald Farm		35						
099-83248	Richard Jax Farm	123	30		502				
099-82953	Richard Waldman Farm				580		300		
099-82927	Ron Wradislavsky Farm					11			
099-83082	Ronald Quill Farm		30						
099-83533	Russell M Linnett		20						
099-83440	Steven Bartelt Farm		25			40			
099-83356	Thomas Finnegan Farm		58						
099-83664	Tim Swegle Farm		7			7			
099-83057	William Rugg Farm		40						
	TOTAL	183	707	0	9314	86	680	450	75

Appendix B: Landowner Surveys

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could be used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, tryiug to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: Al Akkerman Twp. Red Rock Sec. Various

Have you ever enrolled in a cost-share program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration			
Flood Retention			
Stream Bank Restoration			
Buffer Strip			
Perennial Biofuel Crops			
Conservation Tillage		X	
Nutrient Management Incentive		X	

Have done No Till already

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	
Flood Retention	
Stream Bank Restoration	
Buffer Strip	
Perennial Biofuel Crops	
Conservation Tillage	X
Nutrient Management Incentive	X
Other	Description:

What kind of incentives would it take for you or your neighbors to incorporate some of these practices?

$20/acre incentive to switch over

Would you be open to Land Retirement Programs? YES NO

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO

More Attractive to take out of production than do Flowage Esmnt.

Are there specific sites you may have in mind if funding was made available next spring? YES NO
Examples?

If Yes, Describe Practice: Approx 2,000 acres

Location: Twp. Sec.

Other Notes: Already doing conservation tillage on his land. He thought that we could develop a program to encourage other landowners to change

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could he used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, trying to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: City of Austin - Nature Center Twp. Red Rock Sec. 30

Have you ever enrolled in a cost-share program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration		X	X
Flood Retention			
Stream Bank Restoration		X	X
Buffer Strip			
Perennial Biofuel Crops			
Conservation Tillage			
Nutrient Management Incentive			

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	X
Flood Retention	
Stream Bank Restoration	
Buffer Strip	
Perennial Biofuel Crops	
Conservation Tillage	
Nutrient Management Incentive	
Other	

Description:

What kind of incentives would it take for you or your neighbors to incorporate some of these practices? No Comment on Neighbors Needs for cost-Share

Would you be open to Land Retirement Programs? YES NO

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO NA

Are there specific sites you may have in mind if funding was made available next spring? Examples? YES NO

If Yes, Describe Practice: Wetland Restoration

Location: SW 1/4 Twp. Red Rock Sec. 30

Other Notes: Land is in agreement to be incorporated into Existing Nature Center over next year . . . or two

Site #1
Feasibility Study

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could be used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, trying to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: Les Tapp Twp. Dexter Sec. 7, 18

Have you ever enrolled in a cost-share program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration			
Flood Retention			
Stream Bank Restoration			
Buffer Strip	X		
Perennial Biofuel Crops			
Conservation Tillage	X		
Nutrient Management Incentive			

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	
Flood Retention	X
Stream Bank Restoration	
Buffer Strip	X
Perennial Biofuel Crops	
Conservation Tillage	X
Nutrient Management Incentive	
Other	

Description:

What kind of incentives would it take for you or your neighbors to incorporate some of these practices? No Comment Made

Would you be open to Land Retirement Programs? YES NO

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO

Are there specific sites you may have in mind if funding was made available next spring? YES NO
Examples?

If Yes, Describe Practice: Flood Retention

Location: Dexter Twp. Sec. 7, 18

Other Notes: Would like to do large scale retention project. open and willing to discuss Dobbins Creek Flood Feasability Study site #2

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could be used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, trying to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: Wayne DieKrager Twp. Red Rock Sec. 30

Have you ever enrolled in a cost-share program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration	X		
Flood Retention			
Stream Bank Restoration			
Buffer Strip	X		
Perennial Biofuel Crops			
Conservation Tillage			
Nutrient Management Incentive			

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	
Flood Retention	
Stream Bank Restoration	
Buffer Strip	
Perennial Biofuel Crops	
Conservation Tillage	
Nutrient Management Incentive	
Other	X

Description: Suggested alternative crops such as Walnut tree Plantings and incentives to promote

What kind of incentives would it take for you or your neighbors to incorporate some of these practices?

Did not think he had sites that would fit these criteria

Would you be open to Land Retirement Programs? YES NO — YES

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale — Easements

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO — NO

Are there specific sites you may have in mind if funding was made available next spring? YES NO — NO
Examples?

If Yes, Describe Practice:

Location: Twp. Sec.

Other Notes: Very active, conservation minded landowner. He would not likely participate in the land he owns within the Dobbins Creek area

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could be used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, trying to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: Gene Tapp Twp. Red Rock Sec. Various

Have you ever enrolled in a cost-share program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration			
Flood Retention			
Stream Bank Restoration			
Buffer Strip			
Perennial Biofuel Crops			
Conservation Tillage	X		Expire in '09
Nutrient Management Incentive	X		

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	
Flood Retention	X
Stream Bank Restoration	X
Buffer Strip	
~~Perennial Biofuel Crops~~	
Conservation Tillage	X
Nutrient Management Incentive	
Other	

Description:

What kind of incentives would it take for you or your neighbors to incorporate some of these practices?

"High enough monetary incentives"

Would you be open to Land Retirement Programs? YES NO

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO

Are there specific sites you may have in mind if funding was made available next spring? YES NO
Examples?

If Yes, Describe Practice: Conservation Tillage, Stream Bank, Flood Retention

Location: Various Twp. Sec.

Other Notes:

Site #2
Feasibility Study

Dobbins Creek Landowner Survey

The CRWD is working on a study to evaluate land use practices in the Dobbins Creek area. There have been extensive studies in this area which show that there are concerns with the level of sediment getting into Dobbins creek. There are also resource concerns involved with numerous flood events. Dobbins is a very flashy watershed. In the past, it has been hit with heavy rain events which move very quickly over the land with a great deal of velocity. These events result in a variety of flood damage issues. We have unique opportunity to review the watershed in detail and look at specific best management practices could be used to alleviate some of the water quality and flood damage a problems. I will be asking a series of questions, trying to get an understanding of what BMP practices you may be interested in incorporating into your operation. We will have an excellent opportunity to offer a "taylor made" cost-share program to fit the needs of the producers in this area.

Name: Joseph Guiney Twp. Red Rock Sec. 28

Have you ever enrolled in a ~~cost-share~~ Conservation Program program for the following practices?

	Cost Share	On Own	Current Practice?
Wetland Restoration	X		
Flood Retention			
Stream Bank Restoration			
Buffer Strip			
Perennial Biofuel Crops			
Conservation Tillage			
Nutrient Management Incentive			

Which practice would you consider putting on your farm (if appropriately compensated)

Wetland Restoration	
Flood Retention	
Stream Bank Restoration	
Buffer Strip	
Perennial Biofuel Crops	
Conservation Tillage	X
Nutrient Management Incentive	
Other	

Description: Native Cost-Share Program Perenial Hay Crop

What kind of incentives would it take for you or your neighbors to incorporate some of these practices?

~~[illegible]~~ Not sure what incentives would be needed for others.

Would you be open to Land Retirement Programs? YES NO

If Yes – Would you prefer Easements or Land Sale? Easements Land Sale

Would you be open to Flowage Easements to temporarily impound water on a small area of land? YES NO

Are there specific sites you may have in mind if funding was made available next spring? YES NO
Examples?

If Yes, Describe Practice: ~~[illegible]~~ Flood Retention, Conservation Tillage

Location: ___ Twp. Red Rock Sec. 28

Other Notes:

East - of proposed site in "Site #2" Landowner may be interested in additional retention Areas.

Appendix C: HSPF-SAM model

Watershed: Cedar River Basin (Winnebago, Shell Rock, Upper Cedar)
Delivery date: 9/30/14
Modeler(s): Cindie McCutcheon, Paul Senne, Adam Rutz
Reviewer(s): Megan Burke, Cindie McCutcheon

The QA/QC procedure outlined below was performed on the HSPF Model Application developed for the above listed watershed(s).
The following components have been reviewed:

Component	Modeler	Reviewer
UCI file	CMM	MPB
WDM file	AJR	MPB
Hydro Calibration	CMM	MPB
WQ Calibration	CMM	MPB
GenScn Project	CMM	SJK
Other Deliverables	CMM	CMM

QAQC for UCI and Model Development

Item	Notes
Files	All files called/created correctly, correct HBNs being writing to correct files
Simulation Flags	All correct flags turned on for complete hydro WQ simulation
Parameters	All possible PERLNDS, IMPLNDS, RCHRES operations accounted for in all parameter blocks
Opn Sequence	All operations in schematic are called out in opn sequence, rch to rch connections are correct
F-Tables	Correct slope used, all Ftable values are consistent and reasonable, lake areas match
SCHEMATIC BLOCK	
Total Area	No major difference between GIS areas and schematic areas
Landuse Area	Less than 1% difference between GIS model landuse area and Schematic Landuse areas
Subwatershed Area	Less than 0.3 % difference in any given subwatershed areas.
LU Area by Sub	No major difference between GIS areas and schematic areas
Feedlot Areas	Total feedlot areas match GIS. Data applied correctly
Tillage Data	Tillage percentages applied correctly
MASS LINK BLOCK	
Operations	All valid constituents from Land routed to Reaches
Soils	Not enough difference in soils so only 1 PERLND mass link
Factors	All factors are the standards currently being used
Feedlots	Separate Mass Links for MN Feedlots >1000 AU and Feedlots < 1000
Special cases	MS4 area have separate mass links, Gener to add interflow sediment, springs added to Cedar model
EXT SOURCES BLOCK	
Met	PREC changed on BASINS based hydrozones to nearby HIDEN hydrozone PREC
Ag Detached Sed	Detached sediment applied correctly to low and high till cropland
Point Sources	Factors applied constitantly and correctly
Atm Deposition	Correct stations used; correct member #s applied to operations
Boundary Condidtions	No boundary condidtions

QAQC for Hydrologic and Water Quality Calibration

Item	
Water Balance	Logical
Hydro Stats	Daily and monthly rank "good" for primary calibration sites
Hydro Validation	No change with 2006 SCHEMATIC - very little change with split sample
Source Allocation	Constituents loads for each landuse are reasonable
Upstream/Local Conc	Upstream and local load loads/concentrations are reasonable

QAQC for Deliverables

Item	Notes
Model	Run when copied to C:drive
GenScn	NA
Memos	Describes what was modeled and has been reviewed
Geodatabase	Contains all features and layers used for model development and calibration

September 30, 2014

Dr. Charles Regan
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155

Dear Dr. Regan:

RE: Cedar River/Little Cedar River and Shell Rock River/Winnebago River HSPF Model Application Development

The methodology for developing the User Control Input (UCI) and Watershed Data Management (WDM) files for the project area, which includes the Cedar River, Little Cedar River, Shell Rock River, and Winnebago River, is summarized in this memorandum. The methodology includes the following:

- Subwatershed delineation and primary reach selection
- Reach/subwatershed numbering scheme
- Lake and stream function table (F-table) development
- Time-series development
- Pervious land (PERLND) and impervious land (IMPLND) category development.

Each of these items is discussed below.

SUBWATERSHED DELINEATION AND PRIMARY REACH SELECTION

Two separate UCI files were set up for this project. One file represents the Cedar River and Little Cedar River Watersheds, and the other represents the Shell Rock River and the Winnebago River watersheds. The procedures followed for delineating subwatersheds and selecting primary reaches to be explicitly modeled in the Cedar River/Little Cedar River and the Shell Rock River/Winnebago River HSPF model applications are described in this section. Methods for developing each UCI were the same. A Geographic Information System (GIS) geodatabase was created containing the following data layers: Minnesota Department of Natural Resources (MN DNR) Level 7 and Level 8 watersheds, National Hydrography Dataset (NHD) flowlines and waterbodies, Minnesota Pollution Control Agency (MPCA) 2012 draft impaired streams and waterbodies, 2010 Minnesota assessed streams and waterbodies, monitoring site locations, a Digital Elevation Model (DEM), and an imagery basemap. These data were used to delineate the model subwatersheds and define the primary reach networks for the Cedar River/Little Cedar River HSPF and the Shell Rock River/Winnebago River HSPF model applications.

The MN DNR Level 7 watersheds were used as the basis for the HSPF model subwatersheds layer. In the model application, each subwatershed typically corresponds to only one reach (stream segment or lake), and subwatersheds were defined to consider the drainage network, locations of impaired streams and assessment waterbodies, and available monitoring data. The MN DNR Level 7 watersheds were used rather than the United States Geological Survey (USGS) Hydrologic Unit Code-12 (HUC12) watersheds because they were more defined and minimized further processing. When a discharge or water-quality data station or an impaired waterbody endpoint occurred within a Level 7 watershed boundary, the watershed was divided into two subwatersheds using the MN DNR Level 8 watersheds where available or a combination of the DEM and imagery basemap.

Reach length and slope are required to determine physically based parameters in the model application, as well as for developing function tables (F-tables), which are described later in this memorandum. Reach length and slope were calculated using ArcGIS for all nonlake reaches.

REACH AND SUBWATERSHED NUMBERING SCHEME

This section describes the numbering scheme used for the watershed drainage networks for the Cedar River/Little Cedar River UCI and the Shell Rock River/Winnebago River UCI, as illustrated in Figure 1. Reach I.D.s consist of one to three numeric digits. Mainstem reaches were given I.D.s that end in zero (##0). Reaches were assigned an odd 10s place (middle number) if they represented a stream segment (e.g., 110, 130, 150, and 190 in Figure 1) and an even 10s place if they represented a lake (e.g., 120 and 160 in Figure 1). Tributaries were assigned an odd reach I.D. for the 1s place (end number) if they represented a reach (e.g., 141, 143, and 153 in Figure 1) and an even number if they represented a reservoir (e.g., 142 in Figure 1). The 10s place of the tributary reach I.D.s correspond with the downstream mainstem reach I.D. (e.g., 111 and 113 flow into 120).

Overall, subwatersheds and reaches were numbered in order, beginning with low I.D. numbers upstream and ending with high I.D. numbers downstream. The schematic structure allows for five tributary reach segments per mainstem reach I.D. If more than five tributary reaches contribute to the mainstem reach at any given point, the next chronological downstream mainstem reach I.D. was not used and the downstream reach was given the next largest mainstem reach I.D. For example, downstream of Mainstem Reach 160 in the sample schematic in Figure 1, a combination of seven tributary reaches (e.g., 171, 173, 175, 177, 179, 182, and 183) contribute to Mainstem Reach 190. Each subwatershed typically contains only one reach and was given the I.D. of the corresponding reach. Final reach (and subwatershed) I.D.s are illustrated in Figure 2.

LAKE AND STREAM FUNCTIONTABLE DEVELOPMENT

This section describes the development of F-tables, which are used by the HSPF model to route water through each modeled reach (lake or stream). An F-table summarizes the hydraulic and geometric properties of a reach and is used to specify functional relationships among surface area, volume, and discharge at a given depth. F-tables can be thought of as extended rating curves for lakes and streams. Data for lake F-table calculations included surface area and volume at a variety of water elevations (depths), overflow information (spillway width and runout elevation), and discharge, if applicable.

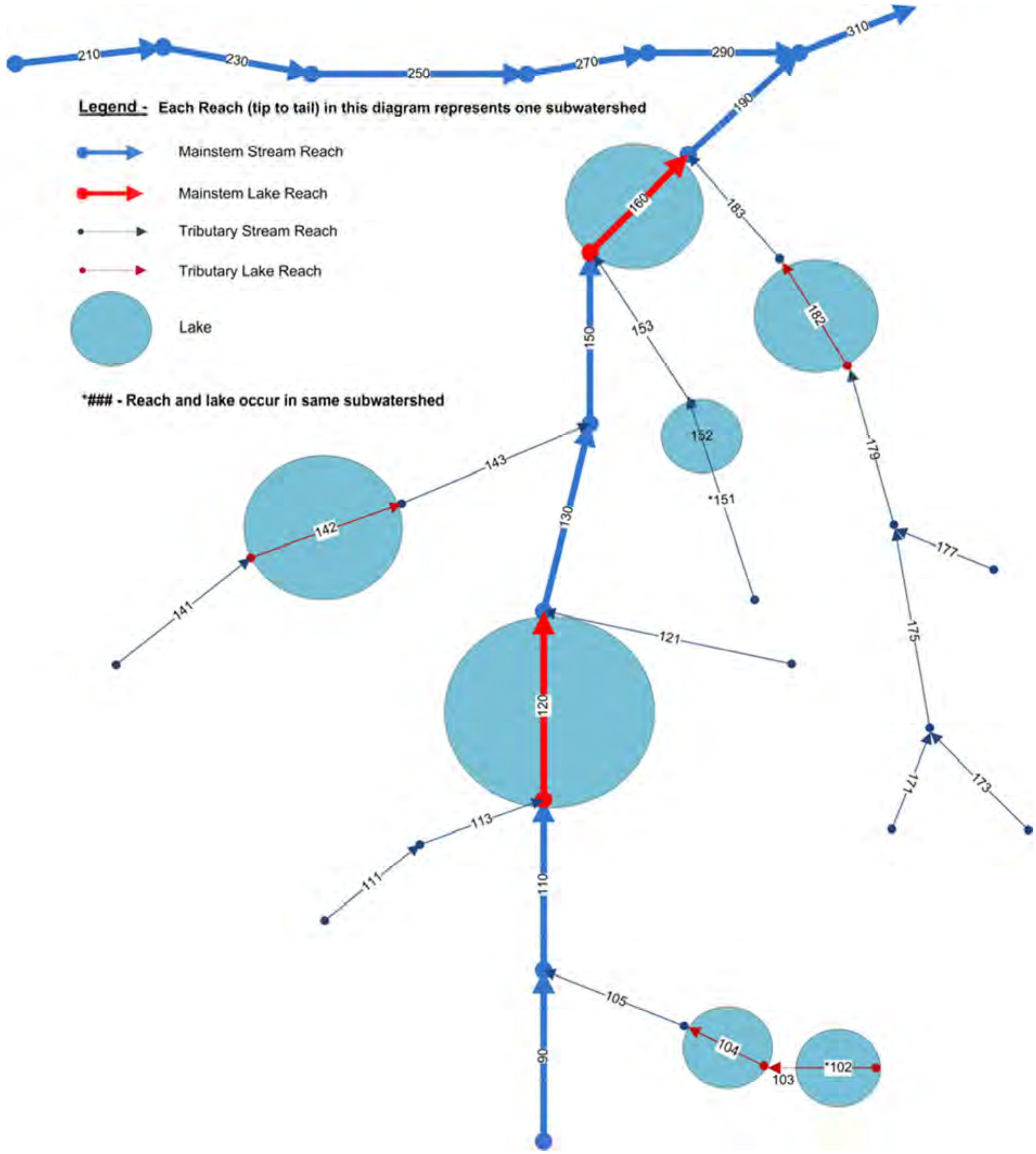

Figure 1. Example Reach Numbering Schematic.

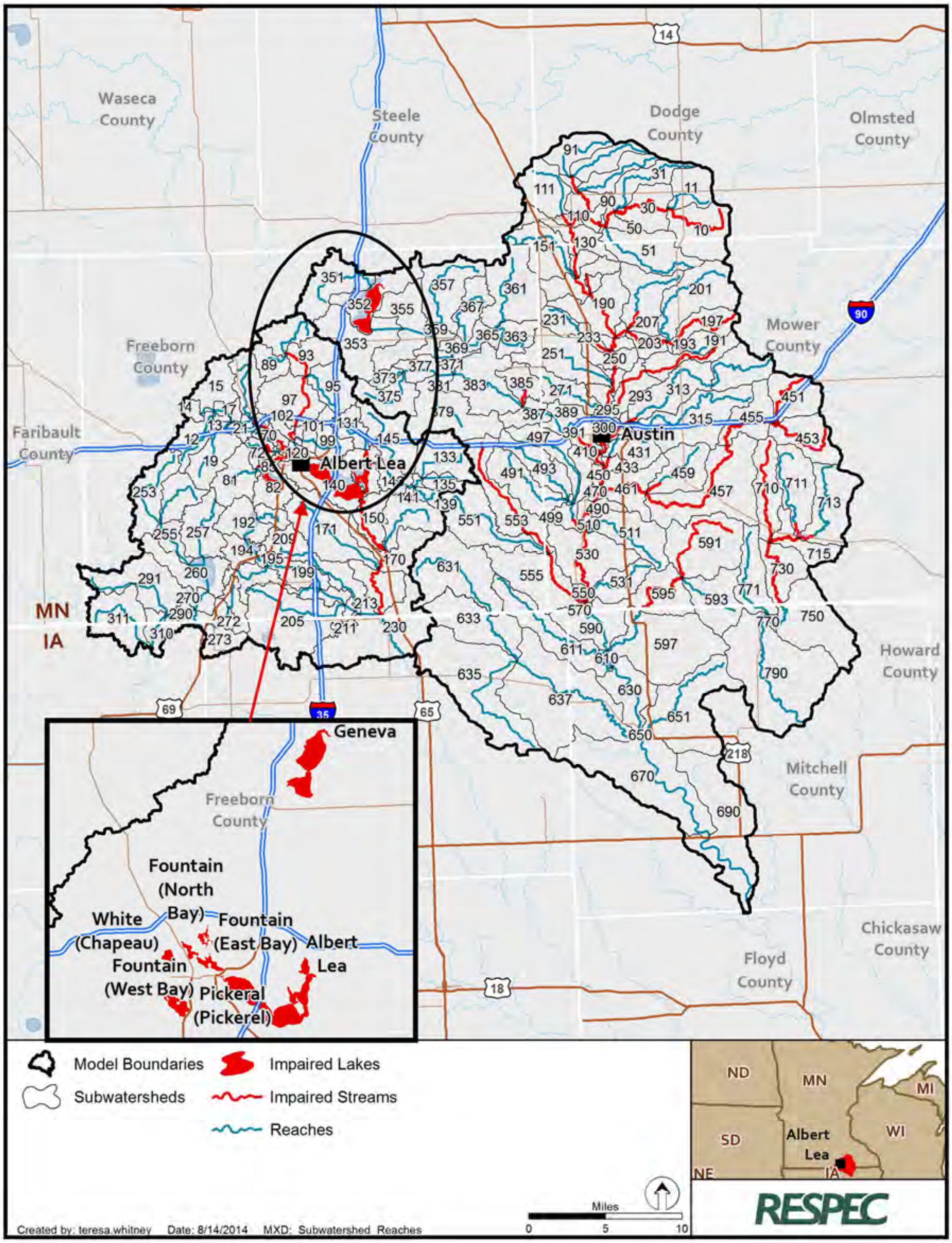

Figure 2. Cedar River/Little Cedar River and the Shell Rock River/Winnebago River Reach and Subwatershed I.D.s.

The equations used to calculate lake outflows at different water elevations, as well as assumptions made, are discussed below. For simplicity and because of the lack of overflow data, the equation of discharge for overflow spillways was used to calculate discharge from lakes (Equation 1). Because of the large scale of this project, coefficient correction factors for all overflow calculations were not used, and side contractions of the overflow, as well as approach velocity were negligible, so the equation could be used in its simplest form:

$$Q = C \times L_e \times H^{1.5} \tag{1}$$

where:

$$Q = \text{discharge } (\text{cubic feet per second } (\text{cfs}))$$

$$C = \text{variable coefficient of discharge}$$

$$L_e = \text{effective length of crest } (\text{feet})$$

$$H = \text{water depth above weir } (\text{head } (\text{feet})).$$

The total head (H) used in the equation was calculated at variable water levels as the difference between the water surface and outlet elevations. The outlet was assumed to be at the maximum recorded depth (if available) or the maximum contour depth. Effective length of the crest (L_e) was derived from spillway length obtained either the National Inventory of Dams dataset or the MN DNR State Dam Inventory. At lake depths below the outlet, L_e was set equal to the spillway length. At lake depths above the outlet, L_e varied as a function of depth and was increased, assuming a 0.02 flood plain slope at each end of the crest.

The variable coefficient of discharge ((C)) was calculated by using an empirical relationship derived by the U.S. Bureau of Reclamation by plotting *x*-*y* points along a basic discharge coefficient curve for a vertical-faced section with atmospheric pressure on the crest (Equation 2):

$$C = 0.1528 \times \text{In}\left(\frac{P}{H_d}\right) + 3.8327 \tag{2}$$

where:

$$P = \text{crest Height (feet)}$$

$$H = \text{head (feet)}.$$

Crest height (P) was assumed to be the height above sill, which was available from the MN DNR dam dataset. Head (H_d) varied with the water surface and was calculated as described previously.

The MN DNR provided lake contours for all lakes except Albert Lea and Fountain Lakes. The Shell Rock River Watershed District provided more detailed Triangular Irregular Networks (TINs) for Albert Lea and Fountain Lakes. The Albert Lea and Fountain Lake TINS were converted to 1 foot lake contours. After all available data were collected and compiled, F-tables were developed by calculating the surface area, volume, and discharge over a range of depths. The F-tables were created using the depths, surface areas, and volumes calculated from lake contours with the Bathymetry Volume and Surface Area ArcGIS ModelBuilder tool. This tool created separate TINs for the lakes on which a “Surface Volume” tool was used to calculate the area and volume below specified depths. The highest contour, if available, or maximum depth, was assumed to be the outlet. Depths were added incrementally above the outlet until the discharge shown in the F-table exceeded the maximum observed discharge levels. The surface area and volume above the outlet were calculated by using conical geometry with an assumed floodplain slope of 0.02. Discharge at each height above the outlet was calculated by using Equations 1 and 2. The discharge values at depths at or below the outlet were zero. The assumed value of the floodplain slope is arbitrary and can be easily adjusted during the calibration process.

Data requirements for stream F-table development include cross-section and discharge measurements. Cross-section measurements were obtained from MPCA geomorphic studies and XP_SWMM survey data, in addition to Shell Rock River Watershed District and USGS stream gaging locations. When more than one cross section was available within the same reach, typically the cross section from the furthest downstream site was assigned to the entire reach (depending on the quality of the data).

In reaches where measured cross sections were unavailable, the main reach was examined to determine if it was an intermittent reach. If so, a 1-meter LiDAR (Light Detection and Ranging)-derived DEM was used to obtain the most representative cross section using 3D Analyst in ArcGIS. Several intermittent ditch cross sections were available in the project area, which were compared with the cross sections that were generated from the LiDAR DEM; the cross-section profiles were nearly the same. The intermittent reaches that lack survey cross sections were determined to be best represented through LiDAR-derived cross sections rather than from cross-sectional data from nearby channels. Visual analyses of aerial photography, in addition to referencing MN DNR stream types, were used to determine when to use a LiDAR cross section. Reaches that were not intermittent were not assigned cross sections in this manner because LiDAR does not penetrate surface water. Mainstem reaches for which cross-sectional data were unavailable or unattainable via LiDAR were assigned a representative cross section using best engineering judgment. Representative cross sections were assigned based on the nearest available downstream mainstem cross section because cross-section areas generally increase from upstream to downstream. Similarly, tributary reaches for which cross-sectional data were unavailable were assigned a representative tributary cross section based on proximity and drainage area similarities. Cross sections used in developing the Cedar River/Little Cedar River and the Shell Rock River/Winnebago River model applications are illustrated in Figure 3.

Once each reach was assigned the most appropriate channel cross section based on location and drainage area, discharge was calculated for each reach by using length, slope, and cross-sectional data with the Manning’s equation shown in Equation 3. Channel slope (S) for each reach was calculated by dividing the difference between the maximum and minimum elevations by the reach length.

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2} \tag{3}$$

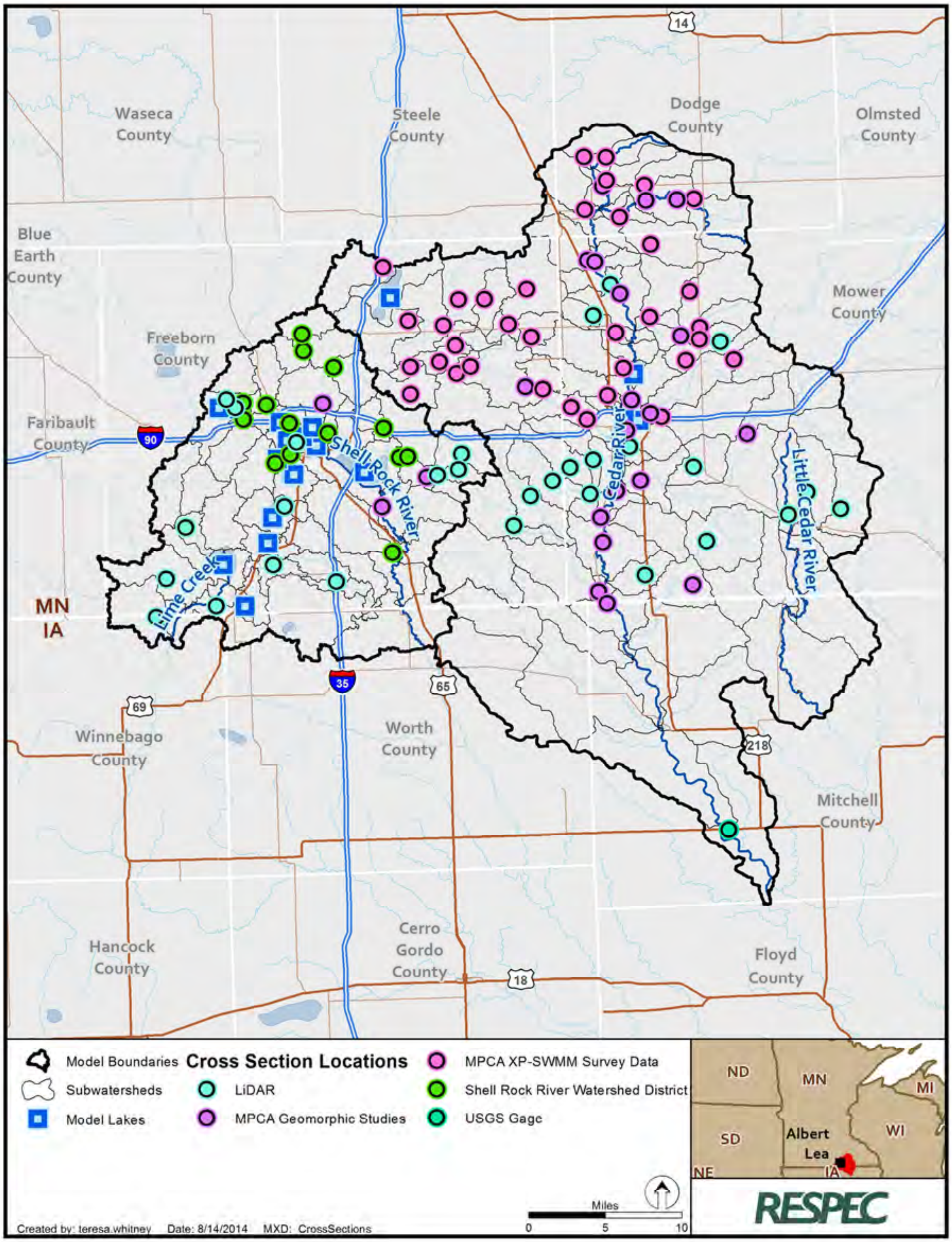

Figure 3. Location of and Cross-Sectional Data Used to Develop Model F-Tables.

where:

$$Q = \text{discharge } (\text{cfs})$$
$$n = \text{Manning's roughness coefficient}$$
$$A = \text{cross-sectional area } (\text{square feet})$$
$$R = \text{hydraulic radius } (\text{feet})$$
$$S = \text{channel slope.}$$

Manning's roughness coefficients (n) of 0.035 and 0.045 were used for the channel and floodplain, respectively. The values for the floodplain slope, channel slope, Manning's roughness coefficient, and horizontal bank extension length were set based on local topography and by using best engineering judgment; the values are easily adjusted during the calibration process. After all required data were collected and compiled, an F-table was developed for each reach by calculating the surface area, volume, and discharge over a range of depths. To allow the F-table to handle large storm flows, the cross section was extended 1,000 feet horizontally beyond each bank. The floodplain slope of 0.05 was estimated using best engineering judgment. The volume and surface area were calculated with the cross sections and stream segment lengths.

TIME-SERIES DEVELOPMENT

This section describes the procedures used to create the WDM files accessed directly by HSPF during a model simulation. Meteorological data to drive the HSPF model application were obtained from the U.S. Environmental Protection Agency's (EPA) BASINS system, and extensive supplementary HIDEN (HIgh spatial DENsity, daily observations) precipitation data were provided by MPCA. Point-source data from facilities discharging within the watershed were used to account for additions to stream flow and were provided by MPCA. Observed discharge time series were obtained for all available gaging stations within the watershed to compare simulated discharge during model calibration. Separate WDM files were created for meteorological time series and point sources discharging within the watershed (i.e., added flow time series).

Precipitation data were provided through 2012; however, BASINS time-series datasets are available through 2009. To append the BASINS datasets through 2012, supplementary hourly and daily time-series datasets were provided via the Midwestern Regional Climate Center (MRCC). The MRCC stations used to extend the BASINS constituents through 2012 were selected based on proximity to the nearest BASINS station. The BASINS system provides all meteorological time-series data in a WDM file that is specific to each station and constituent, including air temperature (ATEM), cloud cover (CLOU), dew point temperature (DEWP), precipitation (PREC), potential evapotranspiration (PEVT), solar radiation (SOLR), and wind movement (WIND). These data were preprocessed into hourly time series by AQUA TERRA Consultants for the BASINS stations selected for the model application. PREC and PEVT are the minimum requirements to drive the model; however, hydrologic processes to be represented within the model applications require all of the time-series data listed above. Hourly Penman Pan Evaporation was obtained by loading hourly time-series data from selected BAINS stations into WDMutil and aggregating these data to calculate daily PEVT as a function of minimum and maximum daily ATEM, mean daily DEWP, total daily WIND, and total daily SOLR. The data were then disaggregated back to hourly time-series (Figure 4). Penman Pan Evaporation is converted to potential evapotranspiration in the external sources block of the UCI (where model inputs are called and distributed) by using a pan factor of 0.70, which was derived from the National Oceanic and Atmospheric Administration (NOAA) Evaporation Atlas. Additionally, the hydrologic processes within the project area are greatly influenced by the snow accumulation and melt. Two options are available when simulating snow with HSPF: the energy-balance method and the degree-day method. The energy balance method uses ATEM, DEWP, WIND, SOLR, and CLOU to calculate snow processes, while the degree-day method uses only ATEM. Both methods were evaluated, and the method that resulted in the best snow and hydrology calibrations was ultimately chosen.

PREC time-series data were obtained through a combination of BASINS and HIDEN stations selected to provide comprehensive spatial coverage of the project area. The watershed was divided into hydrozones to account for the precipitation distribution within the subwatersheds and was based on locations of available data. HIDEN stations were selected based on proximity to the subwatersheds while BASINS stations were chosen primarily to fill spatial precipitation data gaps based on location and period of record (Figure 4). Preference was given to HIDEN stations with a complete period of record and minimal missing data. Stations with an incomplete period of record were extended through the entire modeling period by using available data from the nearest station. Missing data and accumulated values from the HIDEN stations were filled or disaggregated by using data from the closest available station, including the BASINS stations. In the project area, the HIDEN precipitation data were used as the primary precipitation sites in 18 hydrozones. The remaining four hydrozones were developed by using datasets from four BASINS stations located within the watershed. Daily HIDEN PREC time series were loaded into a WDM file and disaggregated into hourly time series with WDMutil using the daily precipitation distributions of the three closest BASINS stations. If the daily totals of the hourly PREC of any of the BASINS stations were within 90 percent of the daily PREC of the station to be disaggregated on a given day, then the station's daily PREC was disaggregated according to the hourly distribution of the nearest BASINS station. If the data tolerance of 90 percent was not upheld, then the station's daily PREC total was disaggregated by using a triangular distribution with the peak in the middle of the day. A data tolerance of 90 percent was used to maximize the availability of hourly PREC data for the triangular distribution method. The disaggregated/filled HIDEN daily PREC time series allowed for using 39 unique stations to provide comprehensive spatial coverage for 22 hydrozones within the watershed (Figure 4).

The point-source time-series data (flow addition) were processed in a similar manner, while the discharge (calibration) time-series data required minimal processing. The total monthly discharge data were provided by the MPCA for two major point-source facilities and 28 minor point-source facilities within the watershed. Monthly discharge time-series datasets for these permitted facilities were processed into daily time series by distributing the total discharge from each source throughout the month. Each time series was then assigned to its corresponding reach and loaded into a WDM file to be called by the model in the external sources block of the UCI. Observed discharge data for calibration purposes were obtained as daily time series from the USGS and Shell Rock River Watershed District stream gaging locations. Daily discharge data for the entire simulation period (1995–2012) were available at only one gage within the project area (S000-001, Cedar River 1.5 miles south of Austin,

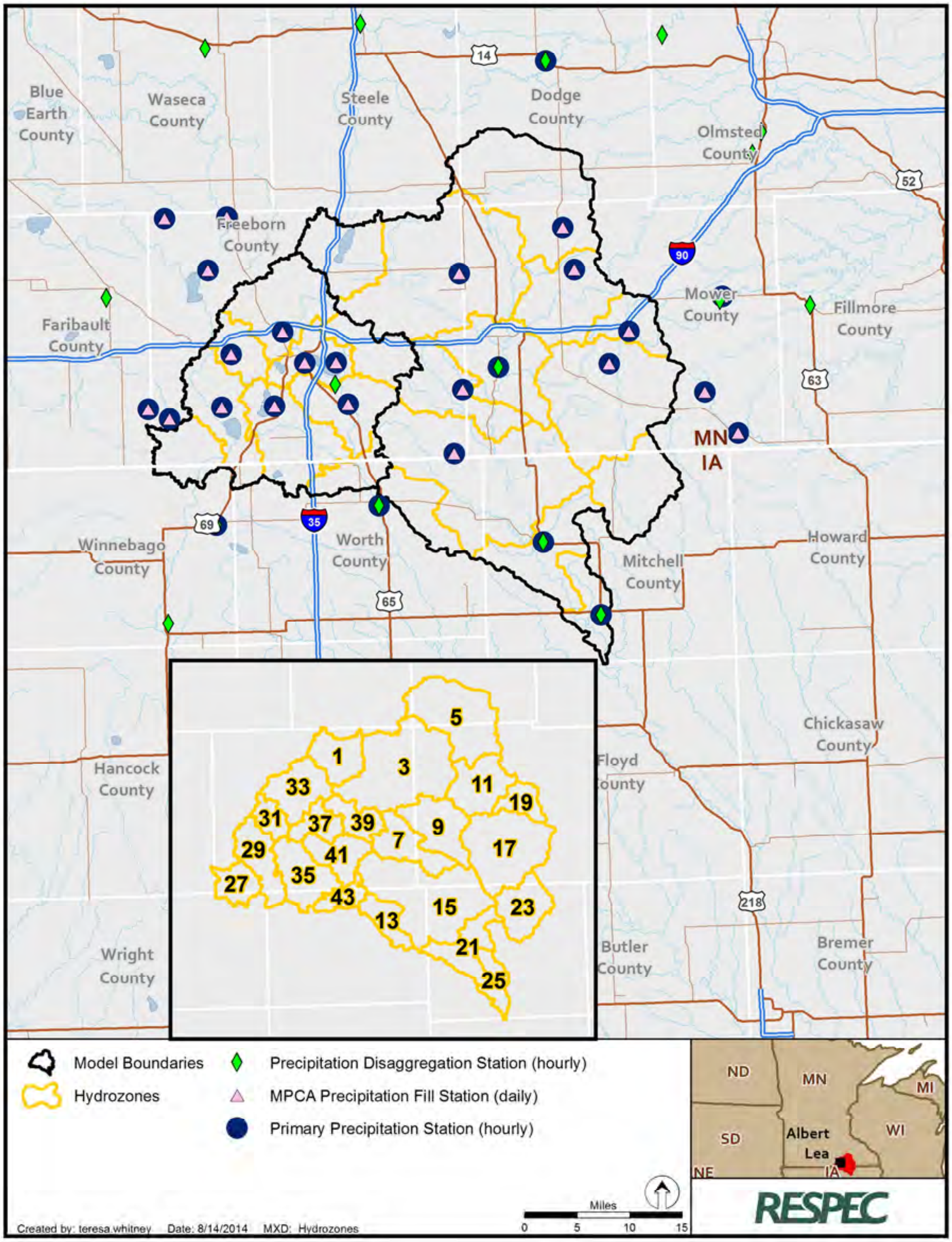

Figure 4. BASINS and the Minnesota Pollution Control Agency Meteorological Stations.

Minnesota [Reach 410]). Table 1 displays all available gaging locations within the watershed, the model reach where they are located, the 8-digit HUC they reside in, and their respective periods of record. Each calibration discharge time series was assigned to its corresponding reach and loaded into the WDM file and developed to store observed and model output time series to facilitate model calibration.

Table 1. Stream Gaging Locations Within the Project Area

Stream Flow Gage	Model Reach I.D.	Hydrologic Unit Code (HUC) 8	Period of Record
S004-121	50	07080202	3/20/09–11/6/13
S004-117	81	07080202	3/20/09–11/6/13
S004-114	87	07080202	3/25/09–11/6/13
S004-120	97	07080202	3/19/09–11/6/13
S004-118	101	07080202	3/20/09–8/15/13
S004-116	131	07080202	3/20/09–11/13/13
S004-119	140	07080202	3/18/09–11/6/13
S005-772	141	07080202	6/19/09–8/15/13
S005-773	145	07080202	9/12/09–11/13/13
S004-113	150	07080202	3/19/09–11/13/13
S000-084	190	07080202	12/31/10–6/18/14
S000-137	230	07080201	4/14/01–6/18/14
S003-065	317	07080201	6/13/98–6/18/14
S004-432	387	07080201	1/10/02–6/18/14
S000-001	410	07080201	1/1/52–8/12/14
USGS 05457505	690	07080201	4/16/10–8/12/14

In the Cedar/Little Cedar model application, flow and water quality constituents from Todd Park Spring (Reach 293) and Seven Springs (Reach 389) were represented. Flow was represented as continuous and was less than 2cfs for each spring. Water quality concentrations were derived from nearby well data.

PERVIOUS LAND AND IMPERVIOUS LAND CATEGORY DEVELOPMENT

This section describes the methodology in determining the pervious and impervious land (PERLND and IMPLND) cover categories selected for explicit representation in the model applications. The PERLND and IMPLND blocks of the UCI file contain the majority of the parameters that describe the way that water flows over and through the watersheds; therefore, the objective of this task was to separate the watershed into unique land segments by using spatial watershed characteristics to effectively represent the variability of hydrologic and water-quality responses in the watershed. The primary watershed characteristics selected for PERLND and IMPLND categorization included drainage patterns, meteorological variability, land cover, soil properties, and agricultural practices.

Delineating model subwatersheds based on drainage patterns allowed for the contributing area of each uniquely represented pervious or impervious land segment within each subwatershed to be linked to the appropriate reach section in the schematic block of the UCI file. Aggregating the subwatersheds into hydrozones based on meteorological variability and station distribution provided initial boundaries for the land segments and allowed hydrologic processes to be accurately represented while reducing computational demands. As with the reaches and subwatersheds, a numbering scheme was developed to identify unique pervious and impervious land segments. The PERLND and IMPLND operation numbers in HSPF are limited to three digits and can range from 1 to 999. The 10s place of each PERLND or IMPLND category was selected to reflect the hydrozone in which the unique land segment was located. The 1s place of each PERLND or IMPLND corresponded to land cover, soil, and agricultural characteristics. These characteristics were systematically classified and combined to create unique pervious and impervious land segment categories to diversify and manage model parameterization. Procedures for determining the PERLND and IMPLND categories within each hydrozone are described below.

The National Land Cover Database (NLCD) was the source of the land cover distribution data. Water movement through the system (e.g., infiltration, surface runoff, and water losses from evaporation or transpiration) is significantly affected by the land cover and associated characteristics. In addition, anthropogenic practices (e.g., manure application, tillage, and artificial drainage) that clearly impact the accumulation of pollutants such as sediment, bacteria, and nutrients can be represented within land cover classes. Because of the simulation period length (1995–2012), it was preferable to represent the changes into land cover over time by incorporating both the NLCD 2006 and NLCD 2011 in the PERLND and IMPLND development process. NLCD 2011 was used for calibration during the entire modeling period (1995–2012), and NLCD 2006 was used for validation during the early portion of the simulation period (1995–2004). The number of operations (e.g., PERLND, IMPLND, RCHRES, PLTGEN, and COPY) that are allowed in one HSPF model application is limited; consequently, the 15 categories represented within the modeled area in the NLCD 2006 and 2011 (Table 2) were aggregated into relatively homogeneous model categories (Figure 5 and Figure 6). Developed land and cropland are the predominant land cover classes in the project area. Cropland was further segmented to represent distinct soil properties and agricultural practices within the watershed, which are discussed later in this memorandum. The remainder of the project area is composed of forested land, grassland, pasture, and wetland areas.

Impervious areas were represented by using the NLCD 2006 and NLCD 2011 Percent Developed Imperviousness from the Multi-Resolution Land Characteristics Consortium (MRLC). The data represent mapped impervious area (MIA) and were used to determine the effective impervious area (EIA) using the following equation from Sutherland [1995]:

$$\mathrm{EIA} = 0.1\left(\mathrm{MIA}\right)^{1/2} \tag{4}$$

The term “effective” implies that the impervious region is directly connected to a local hydraulic conveyance system (e.g., gutter, curb drain, storm sewer, open channel, or river); consequently, the resulting overland flow does not have the opportunity to infiltrate along its respective overland flow path before reaching a stream or waterbody. The percent EIA was used to separate the urban land cover class into urban pervious and impervious categories.

Table 2. Summary of 2006 and 2011 National Land Cover Database Categories

NLCD Category	Percent of Watershed 2006	Percent of Watershed 2011
Developed, Open Space	6.72	6.26
Developed, Low Intensity	1.57	1.78
Developed, Medium Intensity	0.37	0.56
Developed, High Intensity	0.12	0.14
Barren Land	0.04	0.04
Shrub/Scrub	0.00	0.00
Grassland/Herbaceous	4.92	4.87
Deciduous Forest	1.71	1.71
Evergreen Forest	0.01	0.01
Mixed Forest	0.00	0.00
Pasture/Hay	1.71	1.65
Cultivated Crops	79.10	79.26
Woody Wetlands	1.19	1.19
Emergent Herbaceous Wetlands	1.19	1.20
Open Water	1.34	1.33

Soil properties within the project area were also examined in conjunction with land cover to guide PERLND categorization because soil type can significantly affect hydrologic processes such as infiltration, surface runoff, interflow, groundwater storage, and deep groundwater losses. A GIS analysis was conducted by using soil data obtained from the Soil Survey Geographic (SSURGO) database and the Natural Resources Conservation Service (NRCS) Soil Data Viewer to investigate the soil distribution within the watershed and determine runoff potential (Figure 7). Maps were created to identify the spatial extent of the primary hydrologic soil groups (HSG) (A, B, C, and D), which represent well-drained to poorly drained soil (Figure 7). Some soils within the watershed received a dual classification (e.g., A/D, B/D, or C/D) to imply that the soil will respond like the poorly drained soil group (e.g., D) if the soil is not adequately drained (Figure 7). Soils were reclassified to explicitly represent runoff potential, where A and B soils were combined to define the low runoff potential class and C soils were combined with D soils to define the high runoff potential class. Soils with a dual classification were given the class of the lower runoff potential soil (e.g., A for A/D soils) because they were primarily located in the cropland land cover class, where it was assumed that producers work to maintain ideal soil moisture conditions through practices such as irrigation, artificial drainage, tillage, and manure application. Soils that were classified as “not rated” were grouped with the high runoff potential soils because they typically represent open water or urban areas. The

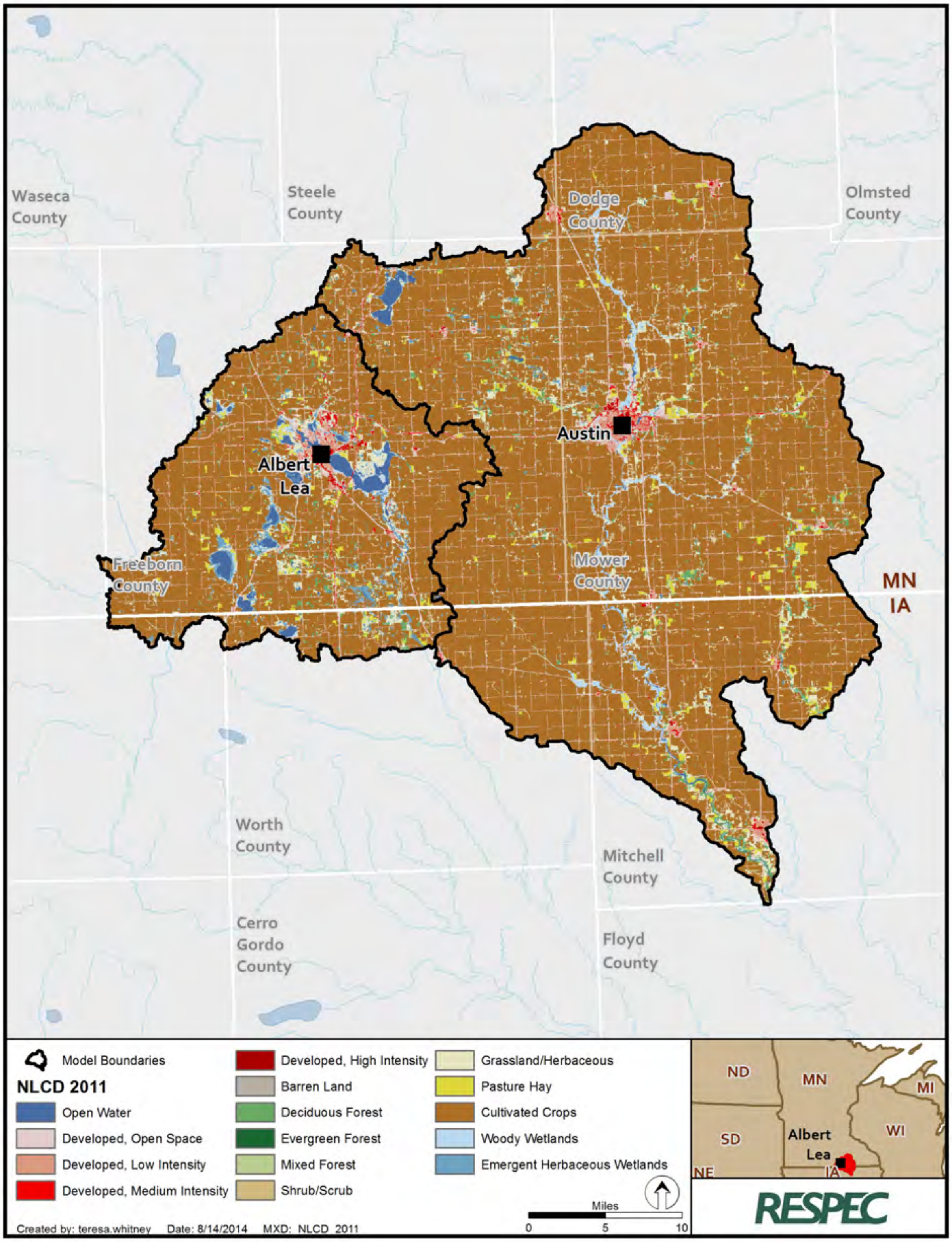

Figure 5. National Land Cover Database 2011 Used to Develop Model Land-Cover Categories.

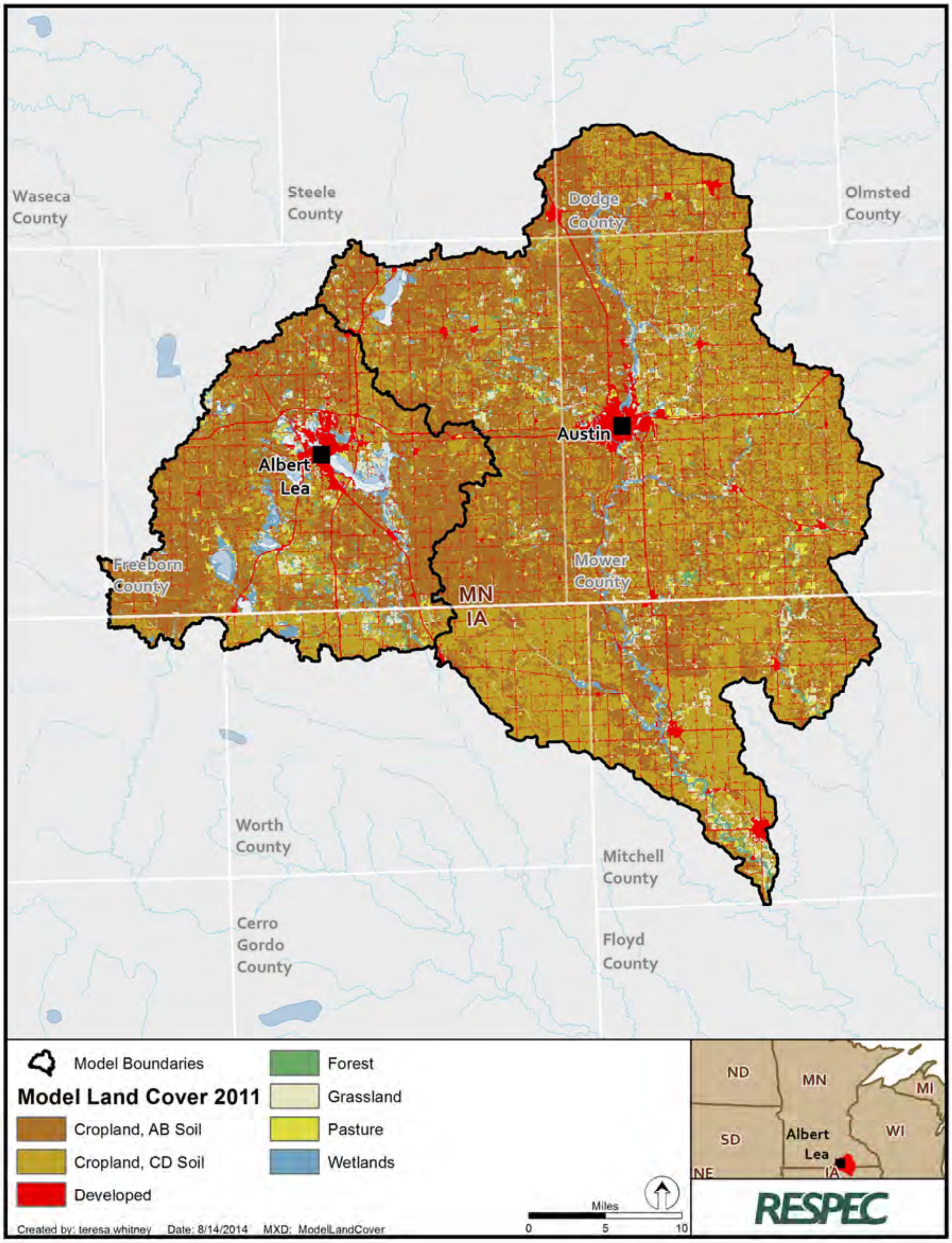

Figure 6. Aggregated Land-Cover Categories Used in the Model Applications.

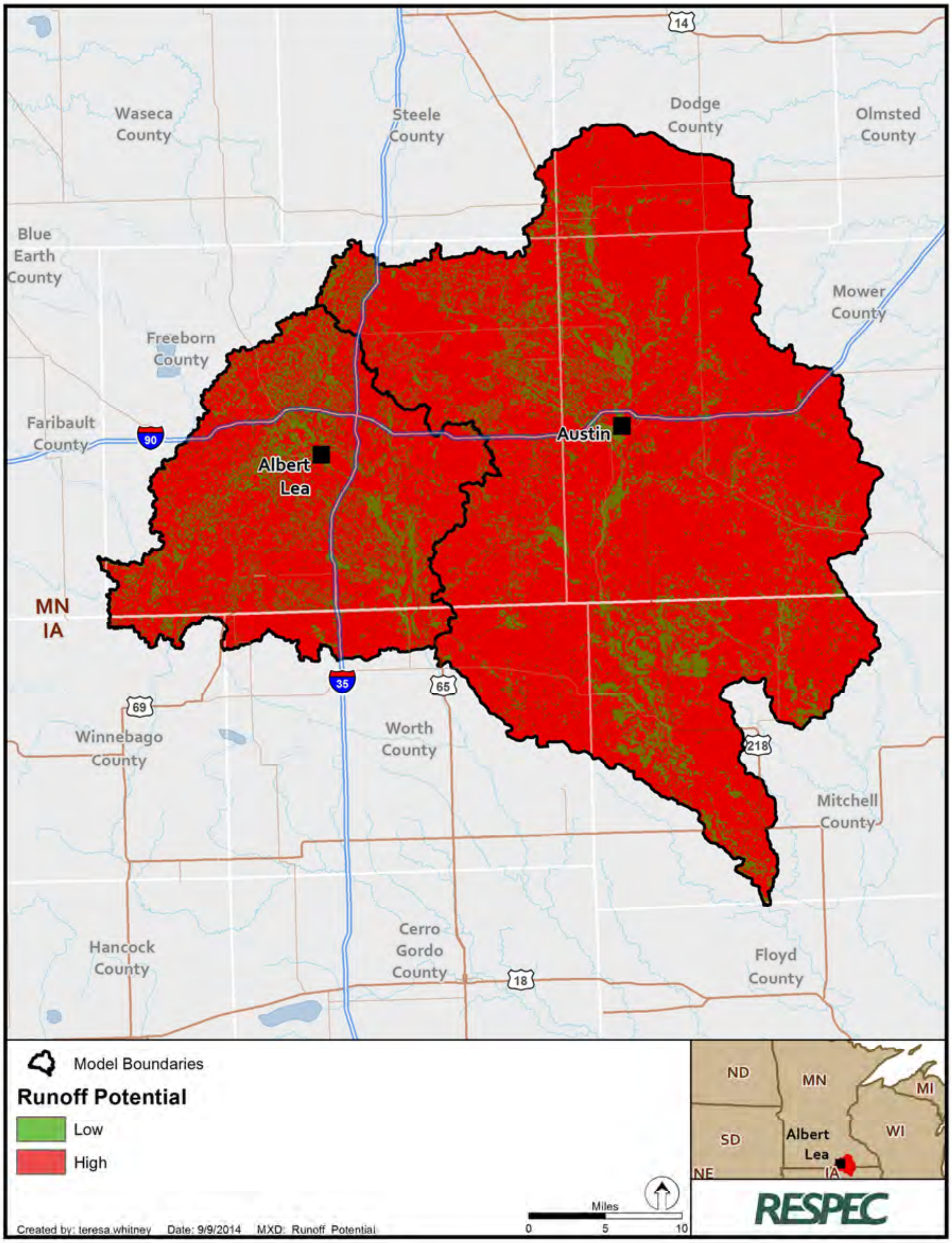

Figure 7. Distribution of Hydrologic Soil Group and Runoff Potential.

cropland land cover class was segmented to represent cropland areas on A/B soils and cropland areas on C/D soils. Because forest, grassland, pasture, wetland, and urban areas make up a very small portion total watershed area, HSG was not represented on these land uses.

Cropland makes up a majority of the total project area. Therefore, representing agricultural practices within the model application was necessary. Agricultural practices incorporated in the PERLND development procedures include tillage and animal feedlot operations (AFOs). These practices were selected for explicit representation, not only for their influence on hydrologic and water-quality processes, but also for their future use in modeling management scenarios. The project area is heavily channelized and subsurface drainage is likely present; however, artificial drainage was not explicitly represented as a unique PERLND class because artificial drainage can be more effectively represented through implicit model parameterization.

Tillage data applied within the project area stemmed from the Minnesota Tillage Transect Survey Data Center, which provides 2007 data available by county, as well as data that were collected in tillage studies conducted through the MPCA for 1999, 2009, 2010, 2011, and 2012 within the bounds of the project area. The Minnesota Tillage Transect Survey Data Center tillage surveys include total farmed area, total conventional tillage area, and total conservation. tillage area. Conventional tillage is categorized by 30 percent or less residue remaining on the field and includes intensive-till and reduced-till practices. Conservation tillage is categorized by greater than 30 percent of residue remaining on the field and includes no-till, ridge-till, and mulch-till practices. Leaving residue on the fields can increase the upper zone storage capacity, which can decrease runoff and impact sediment and water-quality processes. Tillage data were processed in ArcGIS to estimate weighted area fractions of conventional tillage versus conservation tillage for each subwatershed (Figure 8).

An estimated 1,115 AFOs are within the project area (Figure 9). AFOs represent a small percentage of the total watershed area but are important to represent because of their potential to significantly impact water quality. The primary pollution source from AFOs is manure, which introduces oxygen-demanding substances, ammonia, nutrients, solids, and bacteria into the surrounding waterbodies through accumulation and wash-off processes. Also, reduction in vegetation and densely packed subsurface soils that result from concentrated animal grazing can lower infiltration rates and increase sediment erosion. Spatial location and animal data (e.g., type and count) for the AFOs were obtained from the MPCA. For modeling purposes, an area for each AFO was estimated based on the typical design specification of 300 square feet per animal unit [Murphy and Harner, 2001]. The individual calculated areas were shifted from the land category where each AFO is located to the feedlot category.

The cities of Albert Lea and Austin have regulated Municipal Separate Storm Sewer Systems (MS4s); therefore, additional model formulations were developed to track flow and load from the MS4 area of these two cities in separate mass links.

SUMMARY

The Cedar River/Little Cedar River and the Shell Rock River/Winnebago River were delineated into subwatersheds for two separate UCIs, and a reach network was defined to represent drainage properties within each UCI. A numbering scheme was developed, and the

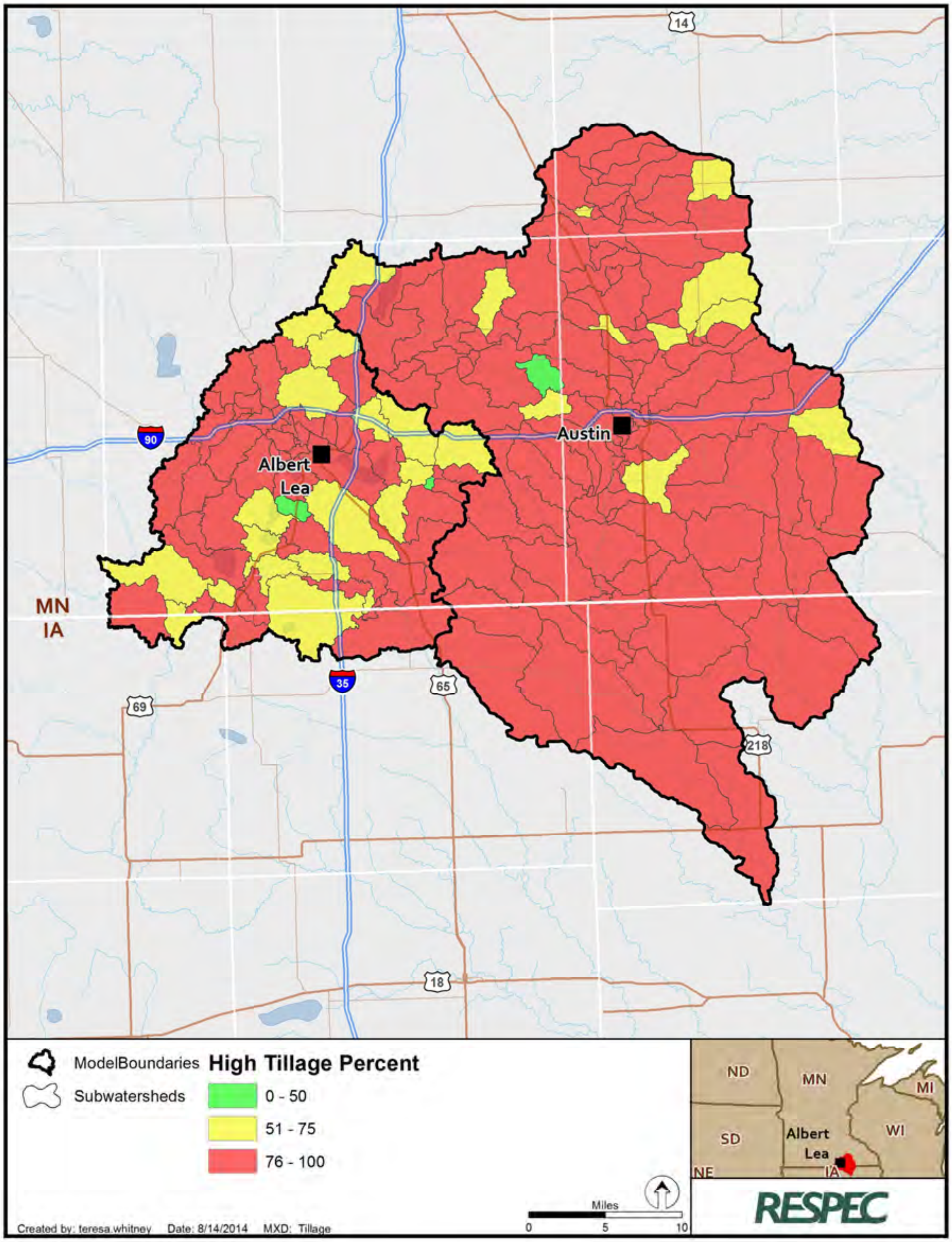

Figure 8. High Tillage Estimates Within Each Subwatershed.

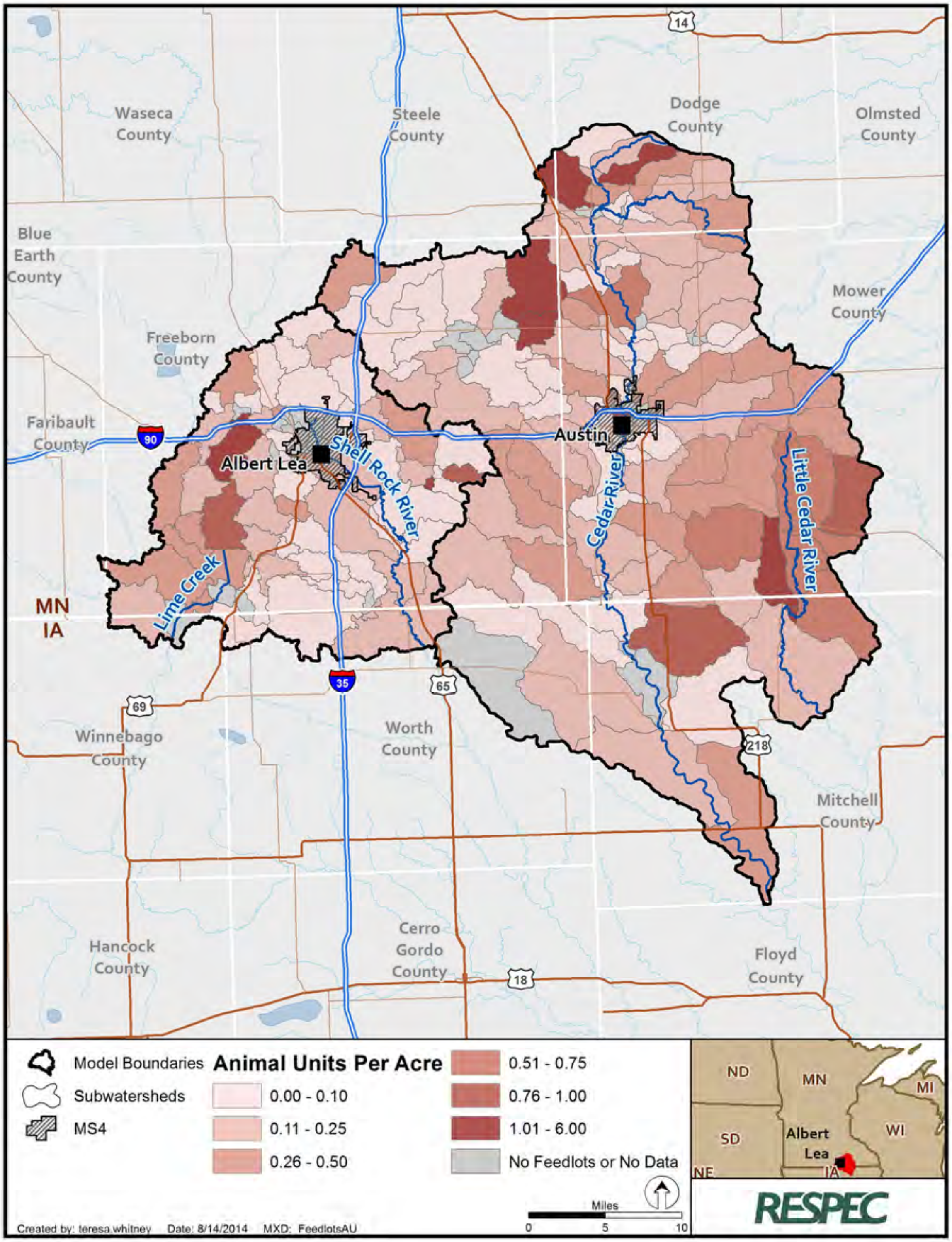

Figure 9. Feedlot Locations Within the Project Area.

physical properties of model reaches and subwatersheds were calculated and entered into the UCI. F-tables were developed by using lake and reach properties to allow the model to route water effectively through the system. Twenty-two unique hydrozones were created to maximize using available meteorological time-series data. These data were processed and loaded into WDM files to supply model inputs, including PREC, PEVT, ATEM, CLOU, DEWP, SOLR, and point sources, as well as discharge data for calibration purposes. Unique pervious and impervious classifications were developed based on watershed characteristics (Figure 10). The 22 hydrozone zones, combined with the 10 land characteristic classifications, created a total of 220 possible land segment operations in two separate UCIs. Initial parameters were based on existing model applications in nearby watersheds. Finally, PERLND and IMPLAND land segments were linked to corresponding reaches in the model schematic, which resulted in two completed model applications representing hydrology within the Cedar River, the Little Cedar River, the Shell Rock River, and the Winnebago River Watersheds.

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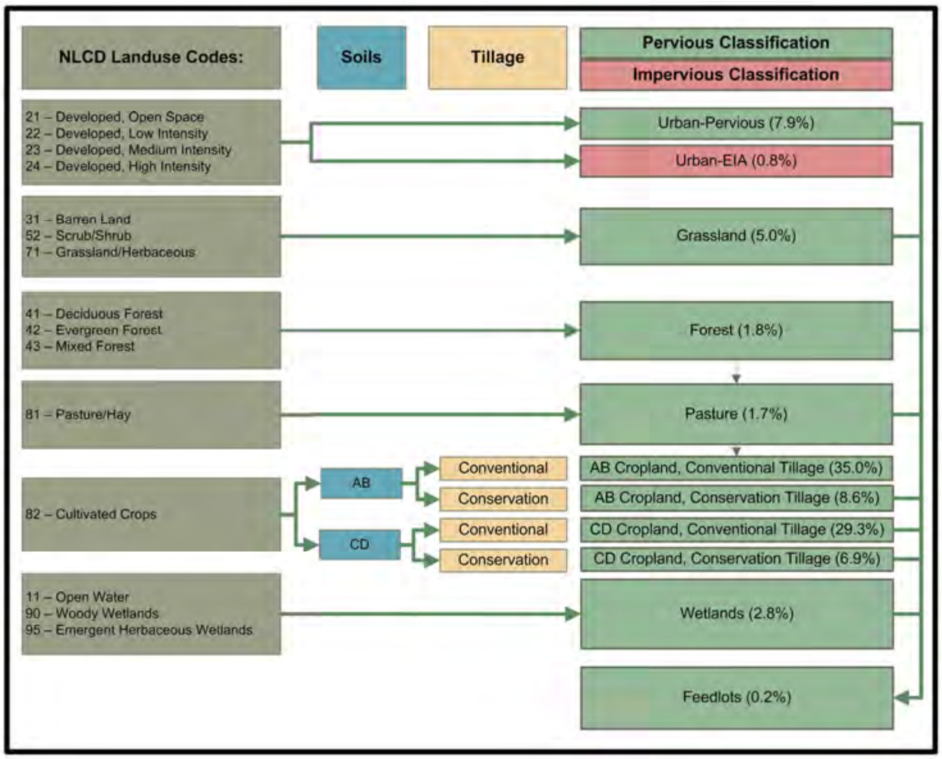

Figure 10. Final Model PERLND and IMPLND Categories.

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Thank you for your time in reviewing the methods for developing the UCI and WDM files for the Cedar River/Little Cedar River and the Shell Rock River/Winnebago River HSPF model applications. If you have any questions or need more information, please contact me by telephone (605.394.6400) or email (c*indie.mccutcheon@respec.com*).

Sincerely,

Cindie McCutcheon
Staff Engineer

CMM:amk

cc: Project Central File 2428 — Category A

September 30, 2014

Dr. Charles Regan
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155

Dear Dr. Regan:

RE: Hydrology and Water-Quality Calibration of the Cedar River/Little Cedar and the Shell Rock/Winnebago HSPF Watershed Model Applications

Please review the following methodology and results for the hydrologic and water-quality calibration and validation of the Cedar River/Little Cedar and the Shell Rock/Winnebago HSPF watershed model applications.

Hydrologic calibration is critical to parameter development for an HSPF model application, particularly for parameters that cannot be readily estimated by watershed characteristics. Calibrating hydrology is also necessary to form the basis for a sound water-quality calibration. Calibrating an HSPF model is a cyclical process that involves making parameter changes, running the model, producing graphical and statistical comparisons of simulated and observed values, and interpreting the results. Observed data for hydrology calibration includes continuous stream flow (collected at gaging stations) obtained from reputable sources. Calibration is typically evaluated with visual and statistical performance criteria and validating the model performance that is separate from the calibration effort.

HYDROLOGIC CALIBRATION DATA

Continuous, observed stream flow data required for calibration are available at 16 gaging locations within the project area, which are illustrated in Figure 1. Table 1 lists these gages and their respective periods of record to support calibration and validation of the HSPF model applications. A higher emphasis was given to the calibration at gages with the longer periods of record and larger drainage areas. The primary flow calibration gage in the Shell Rock/Winnebago HSPF watershed model application was MN49009001 at Reach 190, and the primary flow calibration gage in the Cedar River/Little Cedar HSPF watershed model application was MN48020001 at Reach 410.

Typically, calibration is performed over at least a 5-year period with a range of hydrologic conditions from wet to dry. Two User Control Inputs (UCIs) were created for each model application, and the model calibration UCIs were developed by using land-cover data derived from the National Land Cover Database (NLCD) in 2011, which were used to calibrate throughout the entire modeling period from 1995 to 2011. The other UCI, developed by using the NLCD in 2006, was used for model validation, which was run from 1995 through 2011. Additionally, the model application's ability to maintain a high-quality calibration at multiple gages that represent the variability of the watershed while maintaining consistent parameters throughout the watershed is, in itself, a form of validation. For both calibration and validation, the initial year (1995) was simulated to let the model adjust to existing conditions.

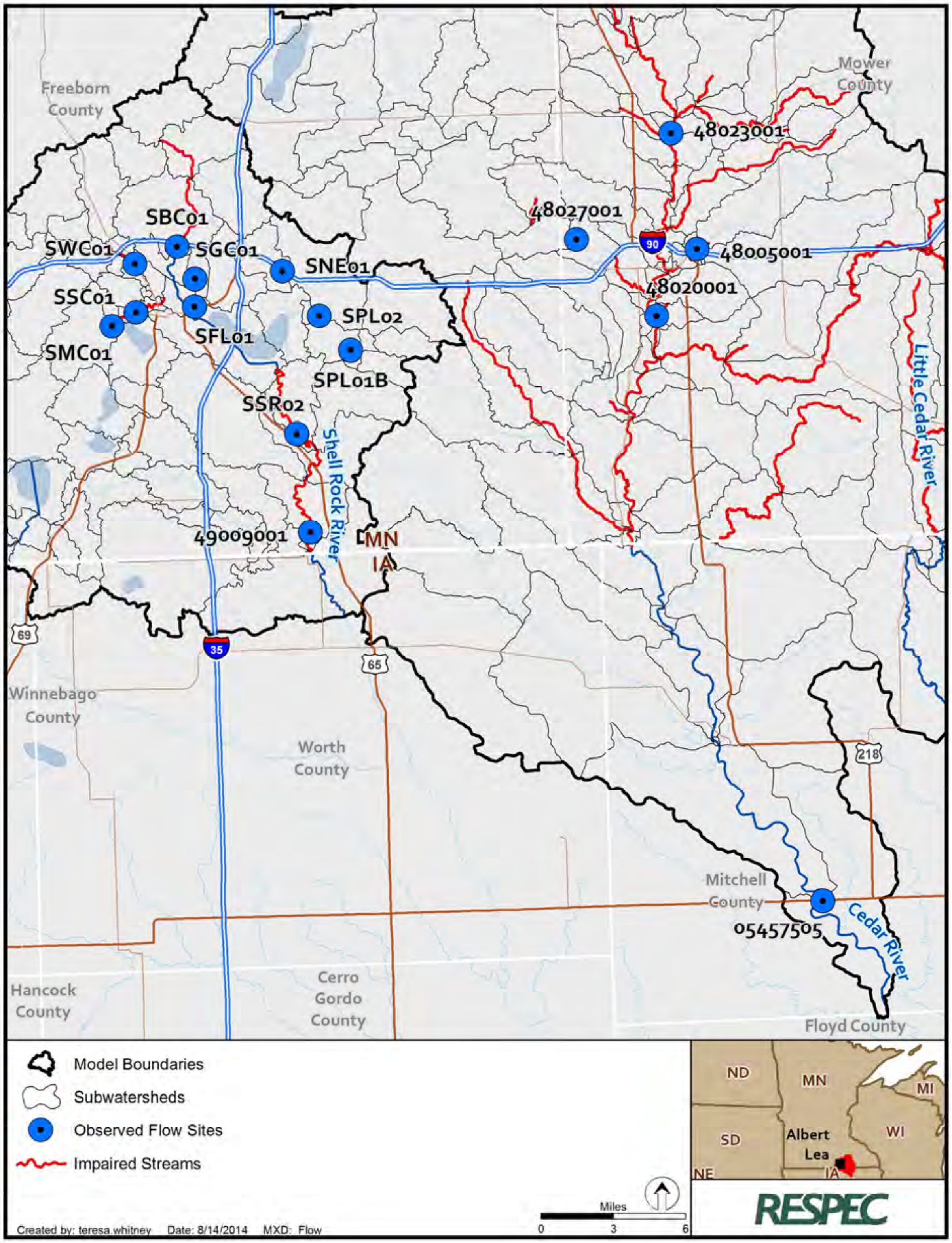

Figure 1. Flow Calibration Gages.

Table 1. Stream Flow Gages

Gage	Model Application	Gage Location/ Description	Calibration Gage Type	HSPF Reach I.D.	Drainage Area (mi^2)	Modeling Period Data Availability
SWC01	Shell Rock/Winnebago	Wedge Creek off of state Hwy 13 near Albert Lea, MN	Secondary	50	34.0	2009–2012
SMC01	Shell Rock/Winnebago	Mud Creek at County Road 71, 2 miles west of Albert Lea, MN	Secondary	81	7.5	2009–2012
SSC01	Shell Rock/Winnebago	Schoff Creek at Lake Chapeau Drive in Albert Lea, MN	Secondary	87	15.2	2009–2012
SBC01	Shell Rock/Winnebago	Bancroft Creek at Plaza Street in Albert Lea, MN	Secondary	97	34.2	2009–2012
SGC01	Shell Rock/Winnebago	Goose Creek on Bridge Ave in Albert Lea, MN	Secondary	101	6.8	2009–2012
SFL01	Shell Rock/Winnebago	Fountain Lake outlet to Albert Lea Lake	Secondary	120	97.5	2009–2012
SNE01	Shell Rock/Winnebago	Northeast Creek at I-90 rest stop, 4 miles northeast of Albert Lea, MN	Secondary	131	4.2	2009–2012
SPL01	Shell Rock/Winnebago	Peter Lund Creek at 185th Street, 2 miles southeast of Hayward, MN	Secondary	141	15.2	2009–2012
SPL02	Shell Rock/Winnebago	County Ditch 32 at 200th Street, 0.5 miles southwest of Hayward, MN	Secondary	145	10.1	2009–2012
SSR02	Shell Rock/Winnebago	Shell Rock River at Main Street in Glenville, MN	Secondary	150	151.5	2010–2012
MN49009001	Shell Rock/Winnebago	Shell Rock River, 1 miles west of Gordonsville, MN	Primary	190	190.4	2008–2012
MN48023001	Cedar/Little Cedar	Cedar River, 0.5 mile east of Lansing, MN	Secondary	230	159.9	2001–2012
MN48005001	Cedar/Little Cedar	Dobbins Creek at the Nature Center in Austin, MN	Secondary	317	37.0	1998–2012
MN48027001	Cedar/Little Cedar	Turtle Creek at 43rd Street bridge, 2 miles northwest of Austin, MN	Secondary	387	145.8	2002–2012
MN48020001	Cedar/Little Cedar	Cedar River, 1.5 miles south of Austin, MN	Primary	410	401.7	1995–2012
USGS 05457505	Cedar/Little Cedar	Cedar River at Osage, IA	Secondary	670	839.3	2010–2012

STANDARD HYDROLOGIC CALIBRATION

The standard hydrologic calibration is an iterative process intended to match simulated flow to observed flow by methodically adjusting model parameters. Water-quality simulations depend highly on hydrology processes; therefore, water-quality calibration cannot begin until the hydrology calibration is considered acceptable. The standard HSPF hydrologic calibration is divided into the following four sequential phases of adjusting appropriate parameters to improve the performance of their respective components of watershed hydrology simulation:

- **Establish an annual water balance.** This phase consists of comparing the total annual simulated and observed flows (in inches) and is governed by meteorological inputs (rainfall and evaporation). It is also governed by the listed parameters LZSN (lower zone nominal storage), LZETP (lower zone evapotranspiration parameter), DEEPFR (deep groundwater recharge losses), and INFILT (infiltration index), and the factor applied to pan evaporation to calculate potential evapotranspiration.
- **Make seasonal adjustments.** Differences in the simulated and observed total flow over summer and winter are compared to determine if runoff (defined for calibration purposes as total stream discharge) needs to be shifted from one season to another. These adjustments are generally accomplished by using seasonal (monthly variable) values for the parameters CEPSC (vegetal interception), UZSN (upper zone storage), and LZETP. LZETP will vary greatly by land use, especially during summer months, because evapotranspiration differs. KVARY (variable groundwater recession), BASETP (baseflow evapotranspiration index), snow accumulation, and snow melt parameters are also adjusted.
- **Adjust low flow/high flow distribution.** This phase compares high- and low-flow volumes by using flow percentile statistics and flow-duration curves. Parameters typically adjusted during this phase include INFILT, AGWRC (groundwater recession), and BASETP.
- **Adjust storm flow/hydrograph shape.** Storm flow, which is largely composed of surface runoff and interflow, is evaluated by using daily and hourly hydrographs. Adjustments are made to the UZSN, INTFW (interflow parameter), and IRC (interflow recession). INFILT may also be adjusted slightly.

Monthly variation of the CEPSC and LZETP parameters was initially applied to all pervious land (PERLND) categories. Monthly variations in UZSN, NSUR, INTFW, and IRC parameters were applied, as necessary, to improve model performance.

By iteratively adjusting specific calibration parameter values within accepted ranges, the simulation results were improved until an acceptable comparison of simulated results and measured data was achieved. The procedures and parameter adjustments involved in these phases are more completely described in Donigian et al. [1984] and in the HSPF hydrologic calibration expert system (HSPEXP) [Lumb et al., 1994].

Land cover and soil properties typically control most of the variability in the hydrologic responses of a watershed; thus, they were the basis for estimating initial hydrologic parameters. The land cover characteristics primarily affect water losses from evaporation or transpiration by vegetation. Water movement through the system is also affected by vegetation cover and associated characteristics (e.g., type, density, roughness). Soil properties primarily affect infiltration, interflow, and soil storage parameters. HSPF model categories were developed based on aggregating the existing land-use and hydrologic soil group classifications into representative hydrologic areas.

INITIAL SNOW ACCUMULATION AND MELT CALIBRATION

Snow accumulation and melt are significant elements of hydrology in Minnesota; thus, snow simulation is an integral part of the hydrology calibration (especially during the winter and spring). The snow accumulation and melt calibration is generally completed early in the calibration process in addition to the seasonal phase of the standard calibration procedure. Snow is simulated in HSPF with meteorological time-series data (precipitation, air temperature, solar radiation, wind, and dew-point temperature) with a suite of adjustable parameters. As discussed in the model development letter, two options are available when simulating snowmelt with HSPF (the energy balance method and the degree-day method). Both methods were evaluated, and the energy balance method was chosen because it resulted in a better hydrologic calibration. Initial values for the wet bulb air temperature below which precipitation occurs as snow under saturated conditions (TSNOW), the factor to adjust the rate of heat transfer from the atmosphere to the snowpack because of condensation and convection (CCFACT), the maximum rate of snowmelt by ground heat (MGMELT), the maximum snowpack at which the entire pervious land segment will be covered with snow (COVIND), monthly values of the degree-day factor (MON-MELT-FAC), a catch-efficiency factor (SNOWCF), a reference temperature (TBASE), the factor to adjust evaporation/sublimation from the snowpack (SNOEVP), and the maximum snowmelt rate by ground heat (MWATER) were attained from previous HSPF applications in Minnesota and were adjusted as necessary. The initial snow-parameter calibration was supported by comparing observed and simulated snowfall and snow depth data to verify a reasonable representation of snow accumulation and melt processes. A more detailed calibration of snow parameters was based heavily on comparisons of observed and simulated flow data during the standard hydrologic calibration process. Observed snow data were available from the Minnesota Climatology Working Group website (http://climate.umn.edu/HIDradius/radius.asp) for multiple locations within and in close proximity to the project area (Figure 2). Primary snow calibration sites were near Austin in the Cedar/Little Cedar model application and near Albert Lea in the Shell Rock/Winnebago model application. Calibration figures were constructed to compare observed snowfall to simulated snowfall (Figure 3, top) and observed snow depth to simulated snow levels (Figure 3, bottom). Air temperature is included on the snowfall figure to help estimate parameters such as TSNOW and to verify the accuracy of the snowfall data.

WEIGHT-OF-EVIDENCE APPROACH

Model performance was evaluated by using a weight-of-evidence approach described by Donigian [2002]. This type of approach uses both visual and statistical methods to best define the performance of the model. The approach was integrated into the hydrologic calibration to continuously evaluate model results to efficiently improve calibration performance until there was no apparent improvement from further parameter adjustments. This process was performed at each flow gage by adjusting parameters for land segments upstream. Moreover, greater weight was applied to the performance of the model at gages where there is a larger

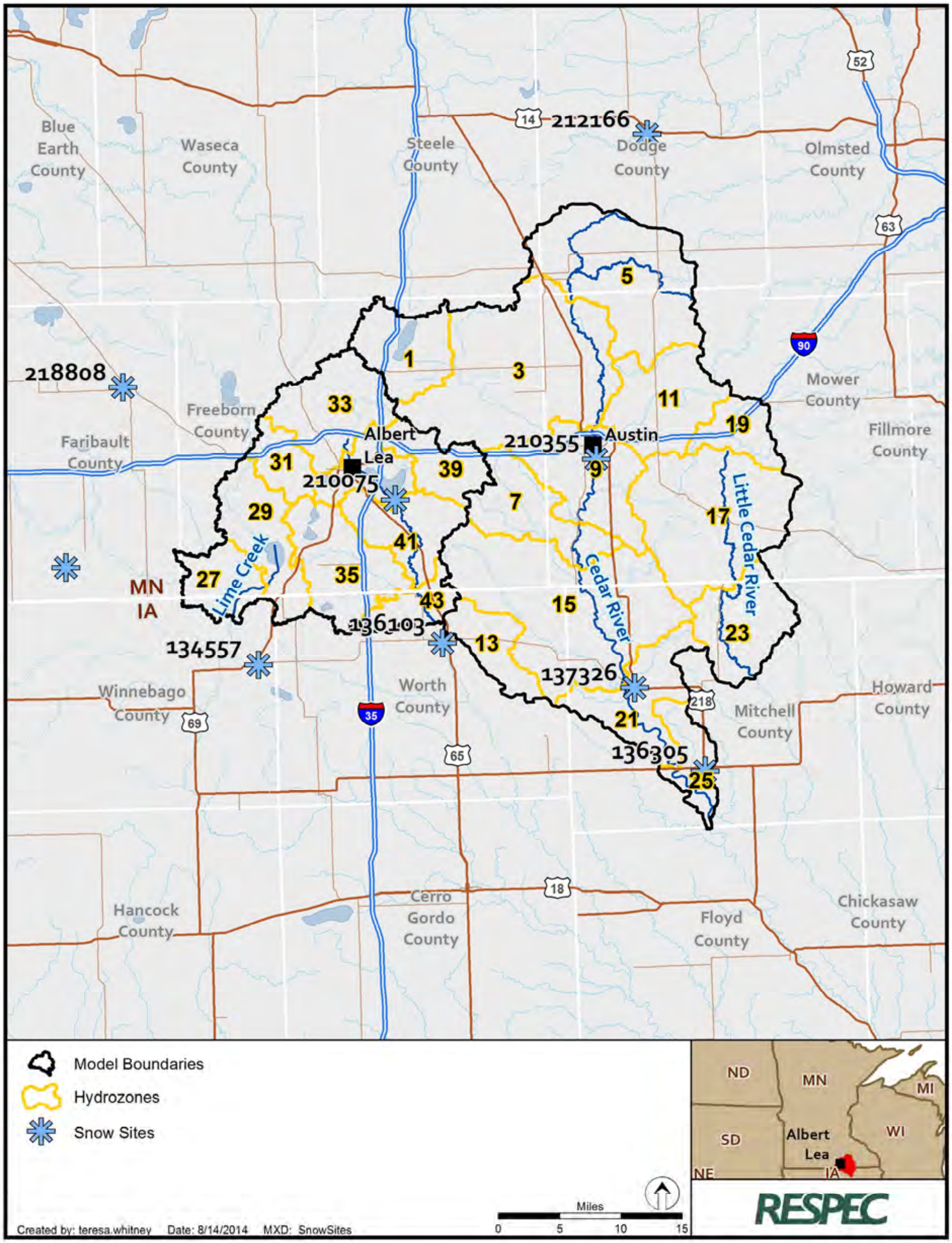

Figure 2. Meteorological Stations With Snow Data Used for Calibration.

contributing area and a longer period of record. Maintaining comparable parameter values and intraparameter variations for each land-segment category throughout the watershed is also preferred. The following specific model-data comparisons of simulated and observed values for the calibration period are grouped with their associated phase of the standard hydrologic calibration:

- **Establish an Annual Water Balance**
  - Total runoff-volume errors for calibration/validation period
  - Annual runoff-volume errors
- **Make Seasonal Adjustments**
  - Monthly runoff-volume errors
  - Monthly model-fit statistics
  - Summer/winter runoff-volume errors
  - Summer/winter storm-volume errors.
- **Adjust Low Flow/High Flow Distribution**
  - Highest 5 percent, 10 percent, and 25 percent of flow-volume errors
  - Lowest 5 percent, 10 percent, 15 percent, 25 percent, and 50 percent of flow-volume errors
  - Flow frequency (flow duration) curves.
- **Adjust Storm Flow/Hydrograph Shape**
  - Daily/hourly flow time-series graphs to evaluate hydrograph shape
  - Daily model-fit statistics
  - Average storm peak-flow errors
  - Summer/winter storm-volume errors.

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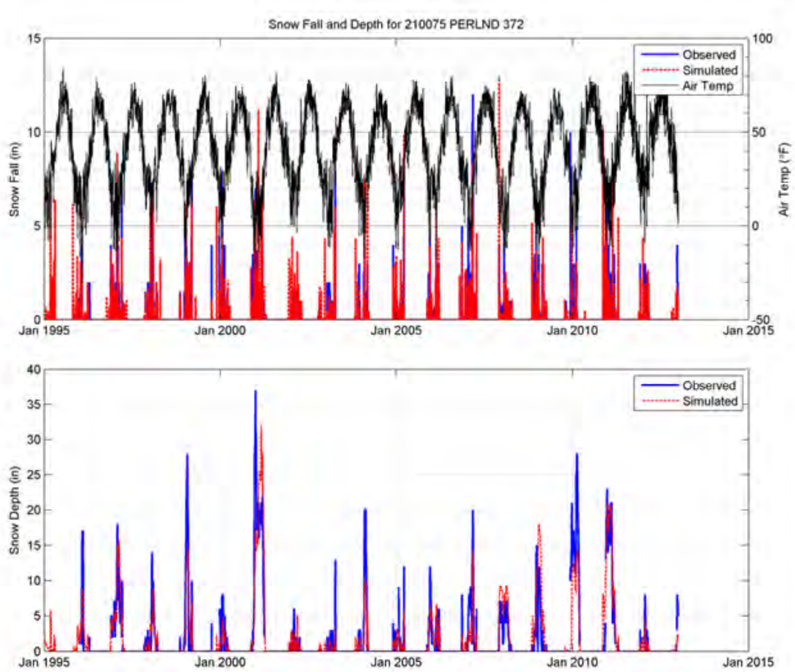

Figure 3. Snowfall (Top) and Snow Depth (Bottom) Calibration Figures for PERLND Land-Use Category # 2, Which Represents Cropland.

Common model-fit statistics used for evaluating hydrologic model applications include a correlation coefficient (*r*), a coefficient of determination (r^2), Nash-Sutcliffe efficiency (NSE), mean error, mean-absolute error, and mean-square error. Statistical methods help provide definitive answers but are still subject to the modeler's best judgment for the overall model performance.

Annual and monthly plots were used to visually compare runoff volumes over the contributing area. This method includes transferring the amount of flow measured at each calibrated gage to a volume of water, which is measured in inches and spread over the entire contributing area, to normalize the data for the drainage area. Monthly plots help verify the model's ability to capture the variability in runoff among the watersheds and that the snowfall and snowmelt processes are simulated accurately. Average yearly plots help to verify that the annual water balances are reasonable and allow trends to be considered. Flow-frequency distributions, or flow-duration curves, present measured flow and simulated flow versus the corresponding percent of time the flow is exceeded. Thus, the flow-duration curves provide a clear way to evaluate model performance for various flow conditions (e.g., storm events or baseflow) and determine which parameters to adjust to better fit the data. Daily flow time-series plots allow for the analyzing individual storm events, snow accumulation and snowmelt processes, and baseflow trends. Examples of the daily flow time-series plots, monthly plots, annual plots, and flow-duration curves from model Reach 410 used for the calibration/validation process in the Cedar River/Little Cedar River model application are illustrated in Figures 4 through 7, respectively.

In addition to the aforementioned comparisons, the water-balance components of watershed hydrology were reviewed. This involved summarizing outflows from each individual land-use and soil group classification for the following hydrologic components:

- **Precipitation**
- **Total Runoff (Sum of the Following Components)**
  - Overland flow
  - Interflow
  - Baseflow
- **Potential Evapotranspiration (ET)**
- **Total Actual ET (Sum of the Following Components)**
  - Interception ET
  - Upper zone ET
  - Lower zone ET
  - Baseflow ET
  - Active groundwater ET
- **Deep Groundwater Recharge/Losses.**

Although observed values are not available for each of the water-balance components previously listed, the average annual values must be consistent with expected values for the region and for the individual land-use and soil group categories.

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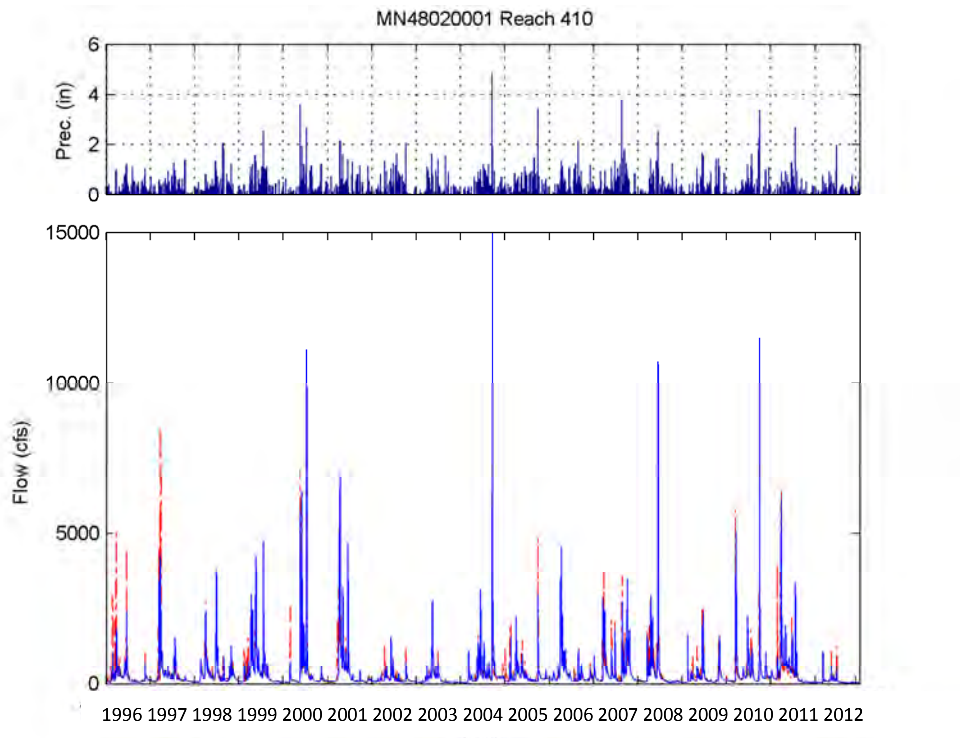

Figure 4. Daily Flow Time-Series Plot Example.

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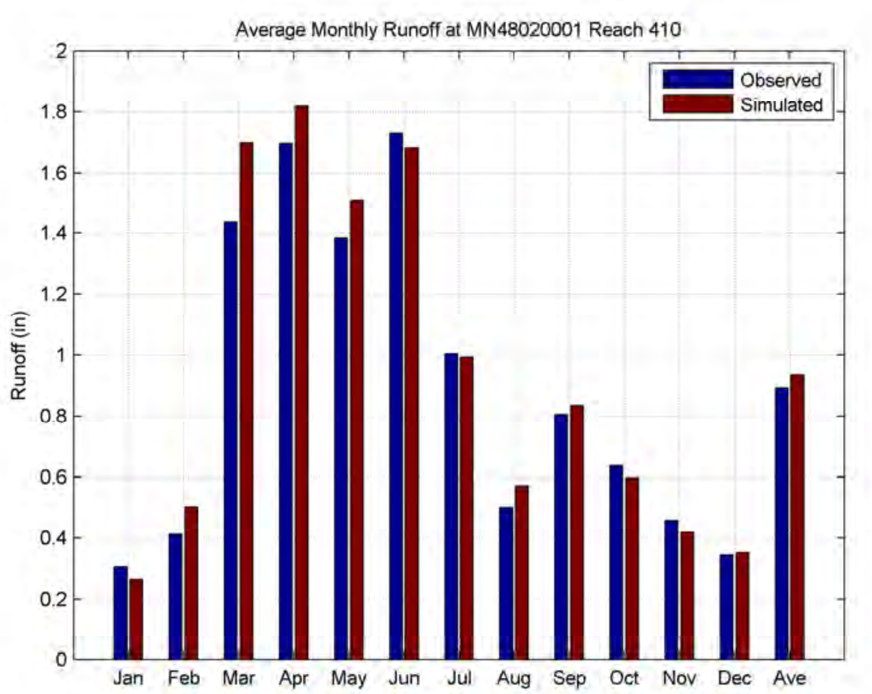

Figure 5. Average Monthly Runoff Plot Example.

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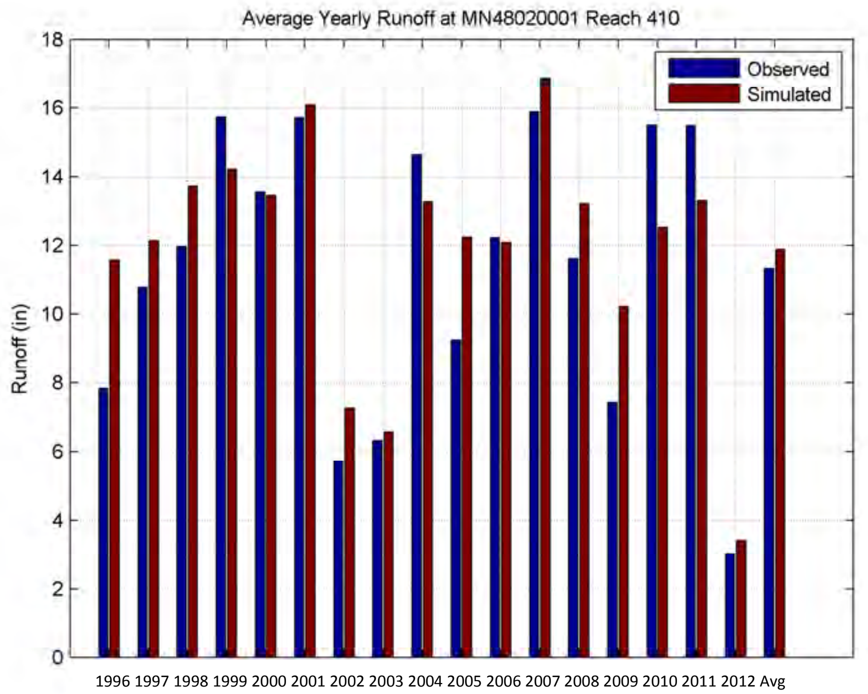

Figure 6. Average Yearly Runoff Plot Example.

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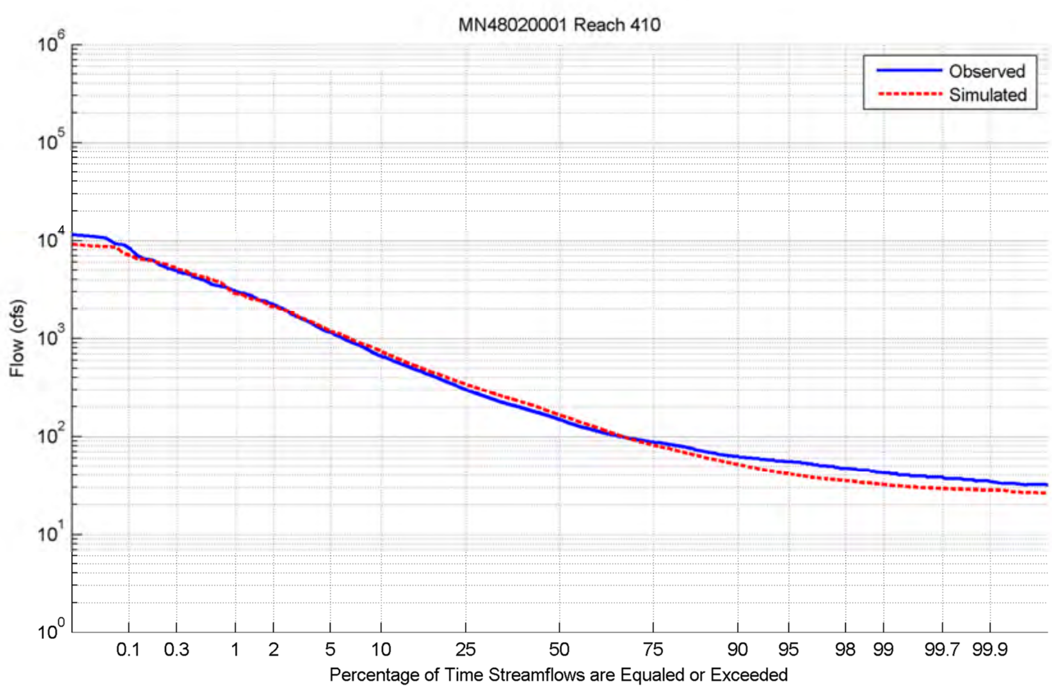

Figure 7. Flow-Duration Curve Example.

MODEL PERFORMANCE CRITERIA

The calibration parameters were adjusted to improve the model performance until the preferred performance criteria were met or there was no apparent improvement from parameter refinement. The graphical plots were visually evaluated to objectively assess the model performance, and the statistics were compared to objective criteria developed from 20 years of experience with **HSPF** applications. The percent-error statistics were evaluated with the hydrology criteria in Table 2. The correlation coefficient (*r*) and the coefficient of determination (r^2) were compared with the criteria in Figure 8 to evaluate the performance of the daily and monthly flows. These measures allow the user to assess the quality of the overall model application performance in descriptive terms to aid in deciding to accept or reject the model application. The developed performance criteria are explained in detail in Donigian [2002].

Table 2. General Calibration/Validation Targets or Tolerances for HSPF Applications

	Difference Between Simulated and Recorded Values (%)		
	Fair	**Good**	**Very Good**
Hydrology/Flow	15–25	10–15	<10

Caveats: Relevant to monthly and annual values; storm peaks may differ more
Quality and detail of input and calibration data
Purpose of model application
Availability of alternative assessment procedures
Resource availability (i.e., time, money, and personnel).

Source: Donigian [2000].

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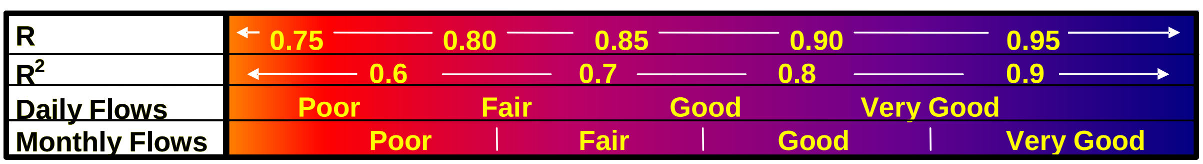

Figure 8. General Calibration/Validation *R* and R^2 Targets for HSPF Applications.

CALIBRATION RESULTS

The calibration was performed by using the primary downstream mainstem gage for each model application. The secondary upstream and tributary gages helped to calibrate parameters for less influential land-segment categories as well as to provide insight into the influence of the numerous channelized tributaries and controlled impoundments within the watershed; however, the focus of this hydrology calibration was the primary gage. The calibration results for the Cedar/Little Cedar primary gage (Reach 410) and the Shell Rock/Winnebago primary gage (Reach 190) rate good with respect to daily and monthly calibration targets (Figure 8). Parameters for tributary gages were set to achieve a balance between the best possible results at the upstream and tributary gages and the best possible results at the primary gages. Table 3 provides the results for the primary gages used in the model applications, with the most downstream mainstem reaches (Cedar/Little Cedar Reach 410 and Shell Rock/Winnebago Reach 190) in bold. Table 4 summarizes the weighted water-balance components at the outlet of the model applications. Attachment A contains hydrologic calibration figures for all calibration gages in the project area.

WATER-QUALITY CALIBRATION

The water-quality constituents that were modeled include total suspended solids (TSS), temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), and nutrients. The methods described in the following section provide RESPEC with the ability to estimate turbidity, temperature, DO, and nutrient loads; calculate contributions from point, nonpoint, and atmospheric sources where necessary; and provide a means of evaluating the impacts of alternative management strategies to reduce these loads and improve water-quality conditions.

The water-quality calibration was completed on the entire modeling period (1995 through 2012) and was based on the NLCD 2011 land-use data. Ideally, calibration parameters of each land-use category should remain fairly consistent throughout the watershed unless there is a specific reason for a deviation.

TURBIDITY APPROACH

Turbidity impairments exist on ten assessment reaches within the project area. TSS was used as a surrogate for turbidity, based on an observed, strong correlation between the two. A regression analysis could be completed to determine the relationship of TSS and turbidity to allow the model TSS predictions to support future total maximum daily load(TMDL) studies. The calibration focus was at locations where TSS concentration data are available. TSS concentration data are widely available from the Minnesota Pollution Control Agency (MPCA), and suspended sediment concentrations (SSC) are more limited. The model application is capable of identifying sources of sediment and the processes that drive sediment erosion, delivery, and transport in the watersheds, as well as point-source sediment contribution.

The sediment parameter estimation and calibration was performed according to guidance from the U.S. Environmental Protection Agency (EPA) [2006]. The steps for sediment calibration included estimating model parameters, adjusting parameters to represent estimated landscape erosion loading rates and delivery to the stream, adjusting parameters to represent in-stream transport and bed behavior, and analyzing sediment budgets for landscape and in-stream contributions. Initial sediment parameters were estimated from nearby models, when appropriate, and adjusted iteratively to match observations. Observed local data are rarely sufficient to accurately calibrate all parameters for all model land uses for each stream and waterbody reach. Therefore, the majority of the calibration is based on sites with observed data. Simulations in all parts of the watershed were reviewed to ensure that the model results are consistent with congruent analyses, field observations, historical reports, and expected behavior from past experience. This was especially critical for sediment modeling because the behavior of sediment erosion and transport processes is extremely dynamic [U.S. EPA, 2006].

Table 3. Summary Statistics for Primary Calibration Gages

Observed Flow Gage	Model Application	HSPF Reach I.D.	Total Runoff Volume			Monthly			Daily			Storm % Error	
			Observed (in)	Simulated (in)	% Δ	*R*	R^2	NSE	*R*	R^2	NSE	Volume	Peak
MN48020001	Cedar/Little Cedar	410	11.33	11.89	4.92	0.95	0.90	0.90	0.86	0.74	0.73	4.50	–3.49
MN49009001	Shell Rock/ Winnebago	190	8.86	8.41	–4.99	0.93	0.86	0.86	0.83	0.68	0.65	–6.69	6.61

Table 4. Summary of Water Balance Components

Water Balance Component	Water Balance Component Description	Water Supply (%)
SURO	Surface outflow	2.3
IFWO	Interflow outflow	13.6
AGWO	Active groundwater outflow	17.2
IGWI	Inflow to inactive groundwater	0.0
CEPE	Evaporation from interception storage	19.3
UZET	Evapotranspiration from upper zone	16.9
LZET	Evapotranspiration from lower zone	29.8
AGWET	Evapotranspiration from active groundwater storage	0.3
BASET	Evapotranspiration from active groundwater outflow (baseflow)	0.5

Sediment erosion, delivery, and in-stream transport were represented in the sediment model application. Parameters predicting sediment erosion from the landscape and delivery to the stream were estimated and compared with results from the Revised Universal Soil Loss Equation (RUSLE). RUSLE provides an estimate of the average soil loss in tons per acre, based on numerical factors developed from spatial soil and land-use characterization data, slope, and rainfall and runoff intensity estimates. A detailed procedure for RUSLE analysis is described by the U.S. EPA [2006]. A sediment delivery ratio (SDR) based on watershed area and slope was applied to the average soil loss because RUSLE provides gross erosional estimates that are greater than the sediment load that is actually delivered to the stream. HSPF landscape erosion-loading rates represent the predicted sediment load delivered to the stream from the landscape. The annual sediment loads per acre, predicted by the model on a subwatershed scale, were compared to RUSLE loading rates, adjusted with the SDR by using appropriate parameterization. Model sediment loading rates were also compared to typical ranges of expected erosion rates from literature for applicable land-use categories (Table 5) and to surficial geology and soils maps for information on particle-size distribution.

The primary calibration parameters involved in landscape erosion simulation are the coefficients and exponents from three equations representing different soil detachment and removal processes. KRER and JRER are the coefficient and exponent, respectively, from the soil detachment from rainfall impact equation; KSER and JSER are the coefficient and exponent, respectively, from the soil washoff or transport equation; and KGER and JGER are the coefficient and exponent, respectively, from the matrix soil equation, which simulates gully erosion. KRER was estimated as the soil-erodibility coefficient from the RUSLE equation, which can be estimated from the Soil Survey Geographic (SSURGO) spatial soils database. Landscape fractionation of sand, silt, and clay were represented by using data from the SSURGO spatial soils database. The remaining parameters were initially given a combination of the recommended initial values from the U.S. EPA [2006] and values from previously developed model applications from nearby watersheds.

Table 5. Typical Ranges of Expected Erosion Rates [U.S. Environmental Protection Agency, 2006]

Land Use	Erosion Rates (Tons/Acre)
Forest	0.05–0.4
Pasture	0.3–1.5
Conventional Tillage	1.0–7.0
Conservation Tillage	0.5–4.0
Hay	0.3–1.8
Urban	0.2–1.0
Highly Erodible Land	> ~ 15.0

After landscape sediment erosion rates were adjusted to provide the expected loading to the stream channel, calibration was continued by adjusting parameters governing the processes of deposition, scour, and transport of sediment within the stream. Calibration was performed on a reach-by-reach basis from upstream to downstream because downstream reaches are influenced by upstream parameter adjustments. Bed behavior and sediment budgets were analyzed at each reach to ensure that the results are consistent with field observations, historical reports, and expected behavior from past experience. The initial composition of the channel beds was estimated by using available particle-size distribution data.

The primary parameters that were involved in calibrating in-stream sediment transport and bed behavior include critical shear stresses for deposition and scour for cohesive sediment (silt and clay) and the coefficient and exponent in the noncohesive (sand) transport power function. TAUCD and TAUCS are the critical deposition and scour shear stress parameters, respectively. They were initially estimated as the 25^{th} percentile of the simulated bed shear stress for TAUCD and the 75^{th} percentile for TAUCS and iteratively adjusted until predicted sediment concentrations matched the observed data. Cohesive sediment is transported when the bed shear stress is higher than TAUCD, and it settles and deposits when the bed shear stress is lower than TAUCD. Sediment is scoured from the bed when the shear stress is greater than TAUCS. The erodibility parameter (M) for silt and clay determines the intensity of scour when it is occurring. KSAND and EXPSAND are the coefficient and exponent of the sand transport power function, respectively.

A significant amount of tile drainage exists in the project area. This artificial drainage is being implicitly represented in HSPF using a shallow subsurface flow component called interflow. HSPF does not inherently simulate sediment in interflow so sediment concentrations were added to interflow from cropland land-use categories using the GENER module. Interflow was given a concentration based on the simulated concentration multiplied by a reduction factor to account for the settling of sediment before it enters the artificial drainage network.

Detached sediment storage (DETS) in HSPF represents the sediment on the surface that is available to wash off. To represent agricultural practices on cropland, DETS was increased at four different days of the year to simulate the increases in sediment available to wash off from plowing, planting, cultivating, and harvesting practices. Cropland classified as high-till was given higher increases in DETS than cropland classified as low-till.

TEMPERATURE, DISSOLVED OXYGEN, BIOCHEMICAL OXYGEN DEMAND DYNAMICS, AND NUTRIENT APPROACH

The HSPF model application simulates in-stream temperature (using HTRCH), organic and inorganic nitrogen, total ammonia, organic and inorganic phosphorus (using NUTRX), dissolved oxygen and biochemical oxygen demand (using OXRX), and algae (using PLANK). The adsorption/desorption of total ammonia and orthophosphate to sediment was also simulated. The modeled output can be used to support the MPCA's activities for TMDL development, in-stream nutrient criteria compliance testing, and support for point-source permitting. Initial calibration parameters were estimated from nearby calibrated models.

The overall sources considered for nutrients included point sources such as water treatment facilities, nonpoint sources from the watershed, atmospheric deposition (nitrate, ammonia, and phosphorus), subsurface flow, and soil-bed contributions. Point-source facility contributions were explicitly modeled for future permitting purposes. Nonpoint sources of total ammonia, nitrate and nitrite, orthophosphate, and BOD were simulated through accumulation, depletion/removal and a first-order washoff rate from overland flow. Atmospheric deposition of nitrogen and ammonia was applied to all of the land areas and provides a contribution to the nonpoint-source load through the buildup/washoff process. Atmospheric deposition onto water surfaces was represented in the model as a direct input to the lakes and river systems. Subsurface flow concentrations were estimated on a monthly basis for calibration.

Loadings from individual sewage treatment systems (ISTS) were estimated by using 2013 permit data provided by Dodge, Mower, and Freeborn Counties in Minnesota; MPCA's February 2004 ISTS report for Steele and Faribault Counties in Minnesota [2004]; and census data for the Iowa portion of the model application. Where 2013 permit data were available, the number of residences served by ISTS within each county was summed from the provided permit data per township and the total number of ISTS was then determined based on the percent of each subwatershed within its respective county. The average number of individuals per household was used to estimate the number of persons served by ISTS per subwatershed. The number of people served on ISTS for Steele and Faribault Counties in Minnesota was estimated based on the 2004 ISTS report regarding system count data per county. The total number of residences served by ISTS per county was obtained from this report and the number of persons served by ISTS per subwatershed was then estimated as previously described. For the portion of the model application that is within Iowa, county and city population data were used to determine ISTS loadings. The total number of residences served by ISTS per county was estimated by subtracting the city population from the county population. The number of persons per subwatershed served by ISTS was then estimated in the same aforementioned manner.

Loading rates were developed for ammonia, nitrate, orthophosphate, carbonaceous biochemical oxygen demand ultimate (CBODU), and water on a per capita basis and were applied to each reach through a mass link.

Biochemical reactions that affect DO were represented in the model application. The overall sources considered for BOD and DO include point sources such as water treatment facilities, nonpoint sources from the watershed, interflow, and active groundwater flow. The model application addresses BOD accumulation, storage, decay rates, benthic algal oxygen demand, settling rates, and reaeration rates. The model also represents respiration, growth, settling rates, density, and nutrient requirements of benthic algae and phytoplankton.

AMBIENT WATER-QUALITY DATA AVAILABLE

A watershed model application that represents nutrients, DO, and BOD dynamics, and primary production requires observed values of temperature, DO, BOD, nitrogen species (nitrate/nitrite, ammonia, and Kjeldahl nitrogen), phosphorus species (total and inorganic phosphorus), organic carbon, and chlorophyll *a* (representing phytoplankton) throughout the watershed to compare simulated results. Observed ambient water-quality data were obtained from the MPCA. Table 6 provides stream and lake data availability of applicable constituents within the project area. These sites are also illustrated in Figure 9. Sites in bold in Table 6 were chosen as primary calibration sites for this round of modeling based on the number of samples in the reach, reach impairment, and location of the site in the calibration reach. TSS, water temperature, DO, BOD, chlorophyll *a*, ammonia, Kjeldahl nitrogen, nitrate/nitrate, orthophosphate, and total phosphorus ambient water-quality monitoring data are available throughout the watershed for both lakes and streams.

Total nitrogen is not available in the ambient water-quality datasets, but it can be calculated by summing concurrent samples of nitrate, nitrite, and Kjeldahl nitrogen. Similarly, organic nitrogen can be calculated as the difference between concurrent samples of Kjeldahl nitrogen and ammonia-nitrogen. Organic phosphorus was also unavailable in the ambient water-quality data, but it can be calculated as the difference between concurrent samples of total phosphorus and orthophosphate-phosphorus.

Table 6. Sample Counts for any Applicable Constituent at Ambient Water-Quality Monitoring Sites. (Page 1 of 5)

Monitoring Site I.D.	Model Application	Reach I.D.		Number of Samples									
			BOD[a]	DO[b]	Suspended Solids	TAM[c]	Water Temperature	TKN[d]	NO2+NO3[e]	T-ORTHO[f]	T-P[g]	CHLOR-A[h]	Total
S000-789	Cedar/Little Cedar	30	0	0	0	0	15	0	0	0	0	0	15
S006-604	Cedar/Little Cedar	53	0	5	5	0	5	0	5	0	4	0	24
S000-804	Cedar/Little Cedar	70	0	60	43	40	60	43	42	43	43	2	376
S006-105	Cedar/Little Cedar	70	0	0	0	0	30	0	0	0	0	0	30
S000-805	Cedar/Little Cedar	99	0	35	34	0	35	0	40	35	41	0	220
S006-870	Cedar/Little Cedar	99	0	1	0	1	1	0	1	1	1	0	6
S006-872	Cedar/Little Cedar	111	0	1	0	1	1	0	1	1	1	0	6
S007-067	Cedar/Little Cedar	113	0	5	0	0	5	0	5	0	5	0	20
S000-803	**Cedar/Little Cedar**	**130**	**0**	**73**	**84**	**42**	**74**	**62**	**75**	**69**	**75**	**0**	**554**
50-0016-00-201	Cedar/Little Cedar	150	0	1	0	1	1	0	1	1	1	0	6
S000-060	Cedar/Little Cedar	150	0	0	29	0	0	0	0	0	0	0	29
S003-069	**Cedar/Little Cedar**	**151**	**0**	**71**	**86**	**42**	**72**	**65**	**73**	**72**	**73**	**0**	**554**
S007-068	Cedar/Little Cedar	171	0	5	0	0	5	0	5	0	1	0	16
S000-802	Cedar/Little Cedar	190	0	4	0	0	4	0	4	0	4	0	16
S001-188	Cedar/Little Cedar	193	0	3	0	0	3	0	4	0	4	0	14
S000-749	Cedar/Little Cedar	197	0	4	0	0	4	0	4	0	4	0	16
S000-746	Cedar/Little Cedar	203	0	5	0	0	5	0	5	0	5	0	20
S000-807	Cedar/Little Cedar	203	0	0	29	0	0	0	0	0	0	0	29
S007-065	Cedar/Little Cedar	205	0	5	0	0	5	0	5	0	5	0	20
S001-182	Cedar/Little Cedar	209	0	60	43	40	66	43	43	43	43	1	382
S000-137	**Cedar/Little Cedar**	**230**	**20**	**131**	**100**	**68**	**133**	**17**	**131**	**58**	**112**	**20**	**790**
S007-119	**Cedar/Little Cedar**	**230**	**0**	**2**	**0**	**0**	**2**	**0**	**4**	**0**	**4**	**0**	**12**
S003-077	**Cedar/Little Cedar**	**233**	**0**	**0**	**17**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**17**
S003-078	**Cedar/Little Cedar**	**233**	**0**	**76**	**73**	**41**	**77**	**62**	**75**	**69**	**75**	**0**	**548**
S004-869	**Cedar/Little Cedar**	**251**	**0**	**70**	**54**	**39**	**71**	**60**	**68**	**67**	**68**	**0**	**497**
S006-533	**Cedar/Little Cedar**	**251**	**0**	**13**	**0**	**0**	**14**	**14**	**14**	**14**	**14**	**0**	**83**
S006-534	Cedar/Little Cedar	251	0	20	7	0	20	18	21	20	21	0	127
S000-227	Cedar/Little Cedar	260	0	4	0	0	4	0	6	0	6	0	20
S004-867	Cedar/Little Cedar	271	0	45	43	40	45	43	43	43	43	0	345
S003-064	Cedar/Little Cedar	293	0	45	72	41	45	44	44	44	44	0	379
S000-225	Cedar/Little Cedar	300	0	0	0	0	0	0	1	0	1	0	2
S005-357	Cedar/Little Cedar	300	0	4	0	0	4	0	4	0	4	0	16
S007-118	Cedar/Little Cedar	310	0	4	0	0	4	0	4	0	4	0	16

Table 6. Sample Counts for any Applicable Constituent at Ambient Water-Quality Monitoring Sites. (Page 2 of 5)

Monitoring Site I.D.	Model Application	Reach I.D.	Number of Samples										
			BOD[a]	DO[b]	Suspended Solids	TAM[c]	Water Temperature	TKN[d]	NO2+NO3[e]	T-ORTHO[f]	T-P[g]	CHLOR-A[h]	Total
S005-095	Cedar/Little Cedar	311	0	32	33	0	32	0	33	34	34	0	198
S005-282	Cedar/Little Cedar	313	0	0	0	0	93	0	0	0	0	0	93
S007-236	Cedar/Little Cedar	313	0	12	12	0	12	4	12	11	12	0	75
S003-065	**Cedar/Little Cedar**	**317**	**0**	**56**	**72**	**0**	**57**	**17**	**56**	**57**	**56**	**0**	**371**
S003-066	Cedar/Little Cedar	322	0	0	28	0	0	0	0	0	0	0	28
S005-613	Cedar/Little Cedar	330	0	18	10	10	18	10	10	0	10	0	86
S006-461	Cedar/Little Cedar	330	0	4	0	0	80	0	5	0	5	0	94
24-0015-00-201	**Cedar/Little Cedar**	**352**	**0**	**4**	**1**	**0**	**4**	**1**	**1**	**0**	**2**	**2**	**15**
24-0015-00-202	**Cedar/Little Cedar**	**352**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
24-0015-00-203	**Cedar/Little Cedar**	**352**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
24-0015-00-204	**Cedar/Little Cedar**	**352**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**2**
24-0015-00-207	**Cedar/Little Cedar**	**352**	**0**	**2**	**0**	**2**	**3**	**1**	**2**	**2**	**3**	**1**	**16**
24-0015-00-101	Cedar/Little Cedar	352	0	19	11	0	20	11	11	0	13	11	96
24-0015-00-205	Cedar/Little Cedar	352	0	0	0	0	1	0	0	0	1	0	2
24-0015-00-206	Cedar/Little Cedar	352	0	0	0	0	1	0	0	0	1	0	2
S004-430	Cedar/Little Cedar	359	0	4	69	2	4	0	71	71	71	0	292
S004-429	Cedar/Little Cedar	369	0	2	74	0	2	0	74	73	74	0	299
S004-431	Cedar/Little Cedar	381	0	3	71	0	3	0	72	71	72	0	292
S004-432	Cedar/Little Cedar	387	0	6	77	0	6	1	78	77	78	0	323
S006-860	Cedar/Little Cedar	387	0	2	0	2	2	0	2	2	2	0	12
S000-230	**Cedar/Little Cedar**	**391**	**0**	**19**	**38**	**10**	**370**	**10**	**11**	**0**	**11**	**0**	**469**
S000-809	**Cedar/Little Cedar**	**391**	**0**	**3**	**3**	**0**	**79**	**0**	**3**	**0**	**3**	**0**	**91**
S000-001	**Cedar/Little Cedar**	**410**	**0**	**219**	**231**	**75**	**271**	**211**	**248**	**243**	**250**	**4**	**1,752**
S007-066	Cedar/Little Cedar	433	0	5	0	0	5	0	5	0	0	0	15
S006-863	Cedar/Little Cedar	451	0	1	0	1	1	0	1	1	1	0	6
S006-375	Cedar/Little Cedar	457	0	12	12	0	12	4	12	11	12	0	75
S006-858	Cedar/Little Cedar	457	0	1	0	1	1	0	1	1	1	0	6
S005-094	Cedar/Little Cedar	459	0	36	37	0	36	0	38	33	38	0	218
S000-229	Cedar/Little Cedar	461	0	85	83	41	86	61	70	68	70	0	564
S000-808	Cedar/Little Cedar	461	0	1	0	1	1	0	1	1	1	0	6
S000-136	Cedar/Little Cedar	470	15	75	63	62	74	0	66	2	39	15	411
S003-067	Cedar/Little Cedar	499	0	45	70	39	45	43	43	43	43	0	371
S000-222	Cedar/Little Cedar	530	0	8	3	0	8	0	4	0	4	0	27
S000-231	Cedar/Little Cedar	555	0	0	28	0	0	0	0	0	0	0	28

Table 6. Sample Counts for any Applicable Constituent at Ambient Water-Quality Monitoring Sites. (Page 3 of 5)

Monitoring Site I.D.	Model Application	Reach I.D.	Number of Samples										
			BOD[a]	DO[b]	Suspended Solids	TAM[c]	Water Temperature	TKN[d]	NO2+NO3[e]	T-ORTHO[f]	T-P[g]	CHLOR-A[h]	Total
S004-868	Cedar/Little Cedar	555	0	45	45	41	46	45	45	45	45	0	357
S000-059	Cedar/Little Cedar	590	0	22	11	10	22	11	15	1	15	0	107
S006-869	Cedar/Little Cedar	591	0	1	0	1	1	0	1	0	1	0	5
S003-068	Cedar/Little Cedar	595	0	0	26	0	0	0	0	0	0	0	26
S005-787	Cedar/Little Cedar	595	0	4	3	3	4	0	3	0	3	0	20
S006-873	Cedar/Little Cedar	710	0	1	0	1	1	0	1	1	1	0	6
S000-793	Cedar/Little Cedar	711	0	5	0	0	5	0	5	0	1	0	16
S000-730	Cedar/Little Cedar	713	0	5	0	0	5	0	5	0	5	0	20
S005-614	Cedar/Little Cedar	730	0	18	11	11	18	11	11	0	11	0	91
S006-871	Cedar/Little Cedar	730	0	1	0	1	1	0	0	1	1	0	5
S006-864	Cedar/Little Cedar	771	0	1	0	1	1	0	1	1	1	0	6
S005-008	Shell Rock/Winnebago	10	0	14	13	0	14	10	11	3	13	10	88
24-0037-00-201	Shell Rock/Winnebago	12	0	0	0	0	1	0	0	0	1	0	2
24-0038-00-201	Shell Rock/Winnebago	14	0	24	26	0	25	0	0	26	27	26	154
24-0038-00-202	Shell Rock/Winnebago	14	0	0	0	0	1	0	0	0	1	0	2
S005-009	Shell Rock/Winnebago	17	0	14	13	0	14	10	11	3	13	10	88
S005-010	Shell Rock/Winnebago	19	0	12	13	0	12	10	11	3	13	10	84
24-0040-00-201	Shell Rock/Winnebago	32	0	20	21	0	21	0	0	21	22	21	126
S004-121	Shell Rock/Winnebago	50	0	201	185	0	203	52	64	147	182	86	1,120
24-0024-00-201	Shell Rock/Winnebago	72	0	41	37	0	62	0	0	56	58	56	310
24-0018-02-201	Shell Rock/Winnebago	80	0	233	23	0	261	0	0	65	65	58	705
S004-117	Shell Rock/Winnebago	81	0	79	85	0	80	0	15	85	85	0	429
24-0025-00-201	Shell Rock/Winnebago	82	0	237	71	0	263	0	14	108	108	98	899
24-0025-00-202	Shell Rock/Winnebago	82	0	0	0	0	1	0	0	0	2	0	3
24-0025-00-203	Shell Rock/Winnebago	82	0	0	0	0	1	0	0	0	1	0	2
24-0025-00-204	Shell Rock/Winnebago	82	0	0	0	0	1	0	0	0	1	0	2
24-0025-00-205	Shell Rock/Winnebago	82	0	0	0	0	0	0	0	0	1	0	1
24-0025-00-206	Shell Rock/Winnebago	82	0	0	0	0	1	0	0	0	2	0	3
24-0068-00-201	Shell Rock/Winnebago	84	0	0	0	0	0	0	0	0	1	0	1
24-0068-00-202	Shell Rock/Winnebago	84	0	0	0	0	1	0	0	0	1	0	2
S004-114	Shell Rock/Winnebago	85	0	79	87	0	80	16	20	87	87	58	514
S005-006	Shell Rock/Winnebago	89	0	16	15	0	16	12	13	3	14	12	101
S005-007	Shell Rock/Winnebago	91	0	15	15	0	15	12	13	3	14	12	99
S006-536	Shell Rock/Winnebago	91	0	3	0	3	3	0	3	3	3	0	18
S006-537	Shell Rock/Winnebago	91	0	3	0	3	3	0	3	3	3	0	18

Table 6. Sample Counts for any Applicable Constituent at Ambient Water-Quality Monitoring Sites. (Page 4 of 5)

Monitoring Site I.D.	Model Application	Reach I.D.	Number of Samples										
			BOD[a]	DO[b]	Suspended Solids	TAM[c]	Water Temperature	TKN[d]	NO2+NO3[e]	T-ORTHO[f]	T-P[g]	CHLOR-A[h]	Total
S005-005	Shell Rock/Winnebago	95	0	15	15	0	15	12	13	3	14	12	99
S004-120	**Shell Rock/Winnebago**	**97**	**0**	**119**	**111**	**0**	**120**	**43**	**50**	**83**	**112**	**53**	**691**
S006-535	Shell Rock/Winnebago	97	0	3	0	3	3	0	3	3	3	0	18
S004-118	Shell Rock/Winnebago	101	0	67	69	0	68	12	15	69	69	44	413
24-0018-00-205	Shell Rock/Winnebago	102	0	17	11	0	17	0	11	11	11	11	89
24-0018-01-201	**Shell Rock/Winnebago**	**120**	**0**	**79**	**40**	**0**	**79**	**0**	**10**	**40**	**40**	**37**	**325**
24-0018-01-204	**Shell Rock/Winnebago**	**120**	**0**	**365**	**60**	**0**	**374**	**0**	**10**	**98**	**98**	**93**	**1,098**
S000-142	**Shell Rock/Winnebago**	**120**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**
S004-119	**Shell Rock/Winnebago**	**120**	**0**	**79**	**85**	**0**	**80**	**14**	**18**	**85**	**85**	**55**	**501**
S004-116	Shell Rock/Winnebago	131	0	72	76	0	74	12	24	76	76	13	423
24-0014-00-104	**Shell Rock/Winnebago**	**140**	**0**	**240**	**58**	**0**	**232**	**0**	**11**	**95**	**96**	**90**	**822**
24-0014-00-207	**Shell Rock/Winnebago**	**140**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
24-0014-00-239	**Shell Rock/Winnebago**	**140**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**2**
24-0014-00-205	**Shell Rock/Winnebago**	**140**	**0**	**216**	**60**	**0**	**218**	**0**	**13**	**98**	**98**	**87**	**790**
S000-002	**Shell Rock/Winnebago**	**140**	**0**	**58**	**56**	**3**	**58**	**0**	**9**	**59**	**61**	**31**	**335**
S005-772	**Shell Rock/Winnebago**	**141**	**0**	**44**	**46**	**0**	**46**	**12**	**22**	**46**	**46**	**12**	**274**
S005-773	**Shell Rock/Winnebago**	**145**	**0**	**47**	**49**	**0**	**49**	**14**	**23**	**49**	**49**	**14**	**294**
S004-115	**Shell Rock/Winnebago**	**147**	**0**	**33**	**36**	**0**	**33**	**0**	**5**	**36**	**36**	**1**	**180**
24-0014-00-206	**Shell Rock/Winnebago**	**148**	**0**	**190**	**59**	**0**	**193**	**0**	**11**	**99**	**100**	**90**	**742**
S004-113	**Shell Rock/Winnebago**	**150**	**0**	**81**	**90**	**0**	**84**	**0**	**8**	**89**	**93**	**62**	**507**
S005-117	**Shell Rock/Winnebago**	**150**	**0**	**4**	**2**	**1**	**4**	**1**	**4**	**1**	**4**	**2**	**23**
24-0082-00-201	**Shell Rock/Winnebago**	**170**	**0**	**3**	**0**	**3**	**3**	**0**	**3**	**3**	**3**	**0**	**18**
S001-011	**Shell Rock/Winnebago**	**170**	**0**	**3**	**2**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**8**
S007-148	**Shell Rock/Winnebago**	**170**	**0**	**2**	**0**	**0**	**2**	**0**	**2**	**0**	**2**	**2**	**10**
S005-096	**Shell Rock/Winnebago**	**171**	**0**	**50**	**54**	**0**	**52**	**0**	**13**	**54**	**55**	**0**	**278**
S000-084	**Shell Rock/Winnebago**	**190**	**24**	**247**	**251**	**90**	**254**	**143**	**215**	**189**	**261**	**77**	**1,751**
S006-538	**Shell Rock/Winnebago**	**190**	**0**	**3**	**0**	**3**	**3**	**0**	**3**	**3**	**3**	**0**	**18**
S006-770	**Shell Rock/Winnebago**	**190**	**0**	**3**	**1**	**0**	**3**	**0**	**4**	**0**	**4**	**3**	**18**
24-0031-00-201	**Shell Rock/Winnebago**	**192**	**0**	**34**	**23**	**0**	**51**	**0**	**0**	**42**	**43**	**41**	**234**
24-0031-00-202	**Shell Rock/Winnebago**	**192**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
24-0027-00-100	**Shell Rock/Winnebago**	**194**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**5**
24-0027-00-201	**Shell Rock/Winnebago**	**194**	**0**	**32**	**22**	**0**	**40**	**0**	**0**	**39**	**41**	**39**	**213**
24-0027-00-202	**Shell Rock/Winnebago**	**194**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**3**
S005-615	**Shell Rock/Winnebago**	**211**	**0**	**18**	**13**	**11**	**18**	**13**	**13**	**0**	**13**	**0**	**99**
24-0028-00-201	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**7**	**6**	**14**

Table 6. Sample Counts for any Applicable Constituent at Ambient Water-Quality Monitoring Sites. (Page 5 of 5)

Monitoring Site I.D.	Model Application	Reach I.D.	Number of Samples										
			BOD[(a)]	DO[(b)]	Suspended Solids	TAM[(c)]	Water Temperature	TKN[(d)]	NO2+NO3[(e)]	T-ORTHO[(f)]	T-P[(g)]	CHLOR-A[(h)]	Total
24-0028-00-202	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**22**	**15**	**0**	**0**	**24**	**22**	**83**
24-0028-00-203	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**4**
24-0028-00-204	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
24-0028-00-205	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**2**
24-0028-00-208	**Shell Rock/Winnebago**	**260**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**2**
24-0030-00-203	Shell Rock/Winnebago	272	0	0	0	0	1	0	0	0	1	0	2
24-0030-00-204	Shell Rock/Winnebago	272	0	0	0	0	4	4	0	0	4	4	16

(a) BOD = Biochemical Oxygen Demand
(b) DO = Dissolved Oxygen
(c) TAM = Total Ammonia
(d) TKN = Total Kjeldahl Nitrogen
(e) NO2 + NO3 = Nitrate Nitrite
(f) T-ORTHO = Total Orthophosphate
(g) T-P = Total Phosphorus
(h) CHLOR-A = Chlorophyll *a*, Corrected

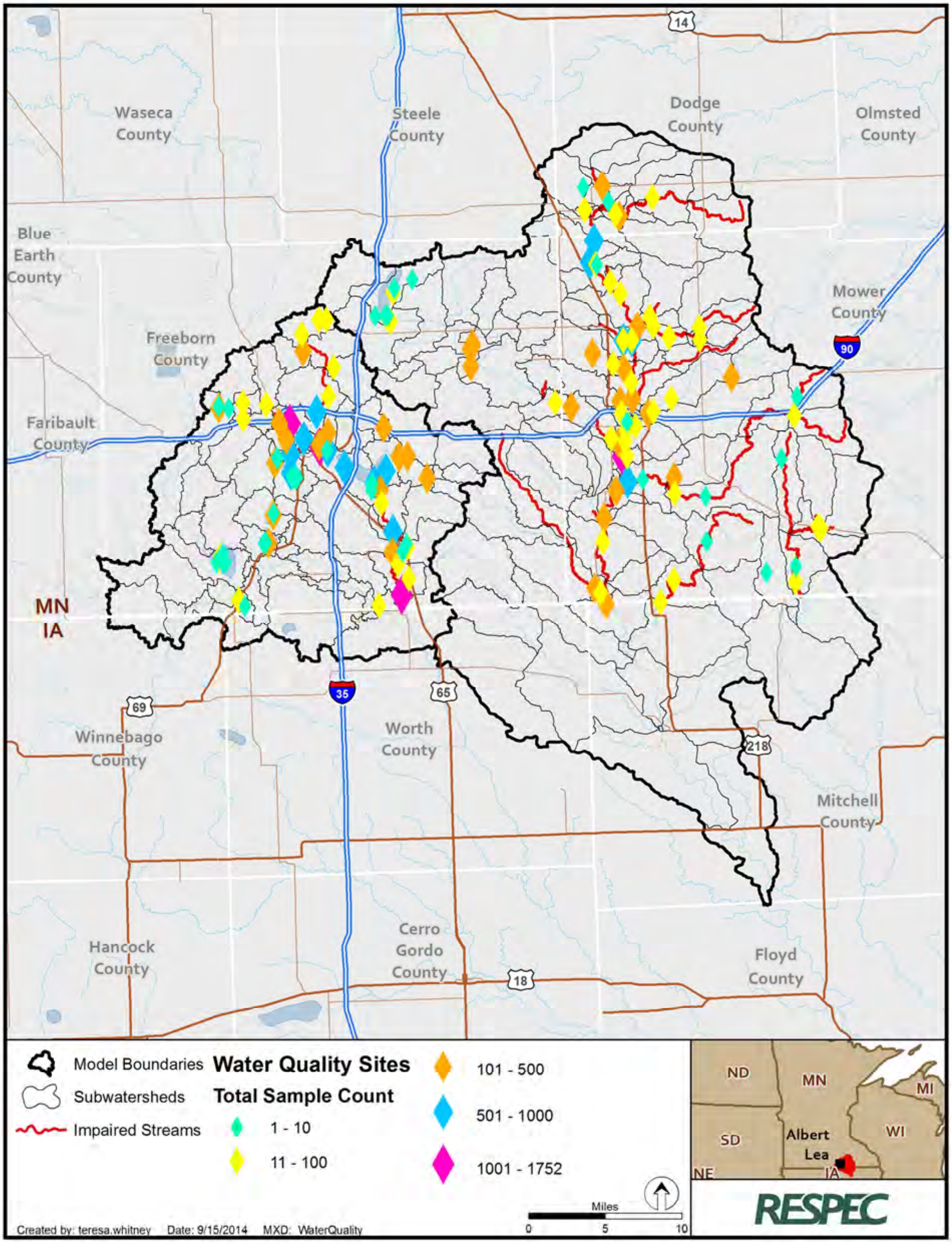

Figure 9. Ambient Water-Quality Monitoring Sites.

ATMOSPHERIC DEPOSITION DATA AVAILABLE

Atmospheric deposition of nitrate and ammonia was explicitly accounted for in the model applications by input of separate wet and dry deposition fluxes. Wet atmospheric deposition data were downloaded from the National Atmospheric Deposition Program (NADP). The NADP sites that represent the Cedar River Watershed wet deposition were Lamberton (MN27) and Perkinstown (PRK134). Wet deposition includes deposition of pollutants from the atmosphere that occur during precipitation events. Thus, nitrate and ammonia wet deposition was applied as concentrations (milligrams per liter [mg/L]) to the precipitation input time series.

Dry atmospheric deposition data were downloaded from the EPA's Clean Air Status and Trends Network (CASTNet). The CASTNet site chosen to represent the Cedar River Watershed dry deposition was Perkinstown (PRK134). Dry deposition does not depend on precipitation; therefore, nitrate and ammonia dry deposition data (originally in kilograms/hectare [kg/ha]) were applied in the model application by using a pound-per-acre approach. Both the wet and dry atmospheric deposition sites are illustrated in Figure 10.

Original dry deposition data were supplied at a weekly time step in kg/ha. To transform the data into daily time series, they were divided by the number of days in the sampling period. Similarly, the wet deposition data were obtained at a weekly time-step, plus or minus multiple days. Because wet deposition was in units of concentration, it did not need to be divided by the number of days in the sampling period. Instead, the concentration was assigned to each day of the sampling period. Once transformed to daily time-series data, missing dry and wet deposition data were patched by using interpolation between the previous and later dates when fewer than 7 days occurred between values (rare with this dataset) and by using monthly mean values when more than 7 days occurred between values (likely scenario).

AVAILABLE POINT-SOURCE DATA

Two major point sources (the Albert Lea and Austin waste-water treatment plants) and 28 minor point sources with discharge data are located in the project area and shown in Figure 11. The minor point sources are a combination of municipal and industrial facility types and vary in current operational status. Seven industrial facilities are currently inactive within the project area, but discharge data are available during the model simulation period. Minor point sources generally discharge intermittently for variable lengths of time, and data for the sites were provided as a combination of monthly volumes and monthly average flow. If a controlled pond was missing monthly discharge, it was assumed that the pond did not release effluent to the surface water during that month. An estimate number of discharge days was supplied by the MPCA and was incorporated by using the following logic supplied by Henningsgaard [2012]:

1. If only a few discharge days are followed by a month with only a few discharge days, or if the first month has only a couple and the next month has up to approximately 10 discharge days, they should be placed at both the end and beginning of the 2 months.
2. If over 6 discharge days are in a month, but fewer than approximately 18, they can be placed anywhere consecutively.
3. If there are over approximately 18 discharge days, one-half should be placed in the first half of the month and one-half should be placed in the second half of the month.

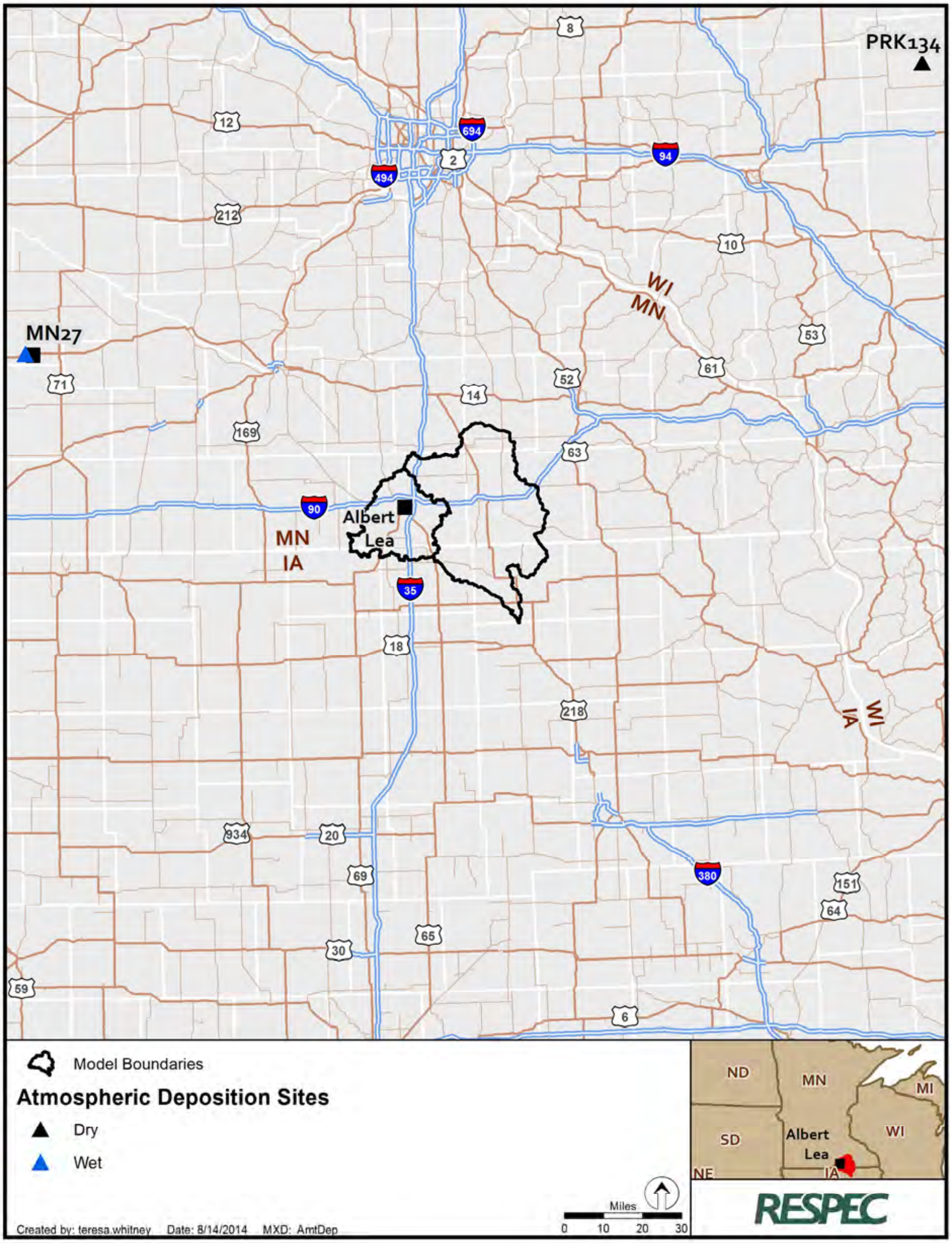

Figure 10. Wet and Dry Atmospheric Deposition Sites.

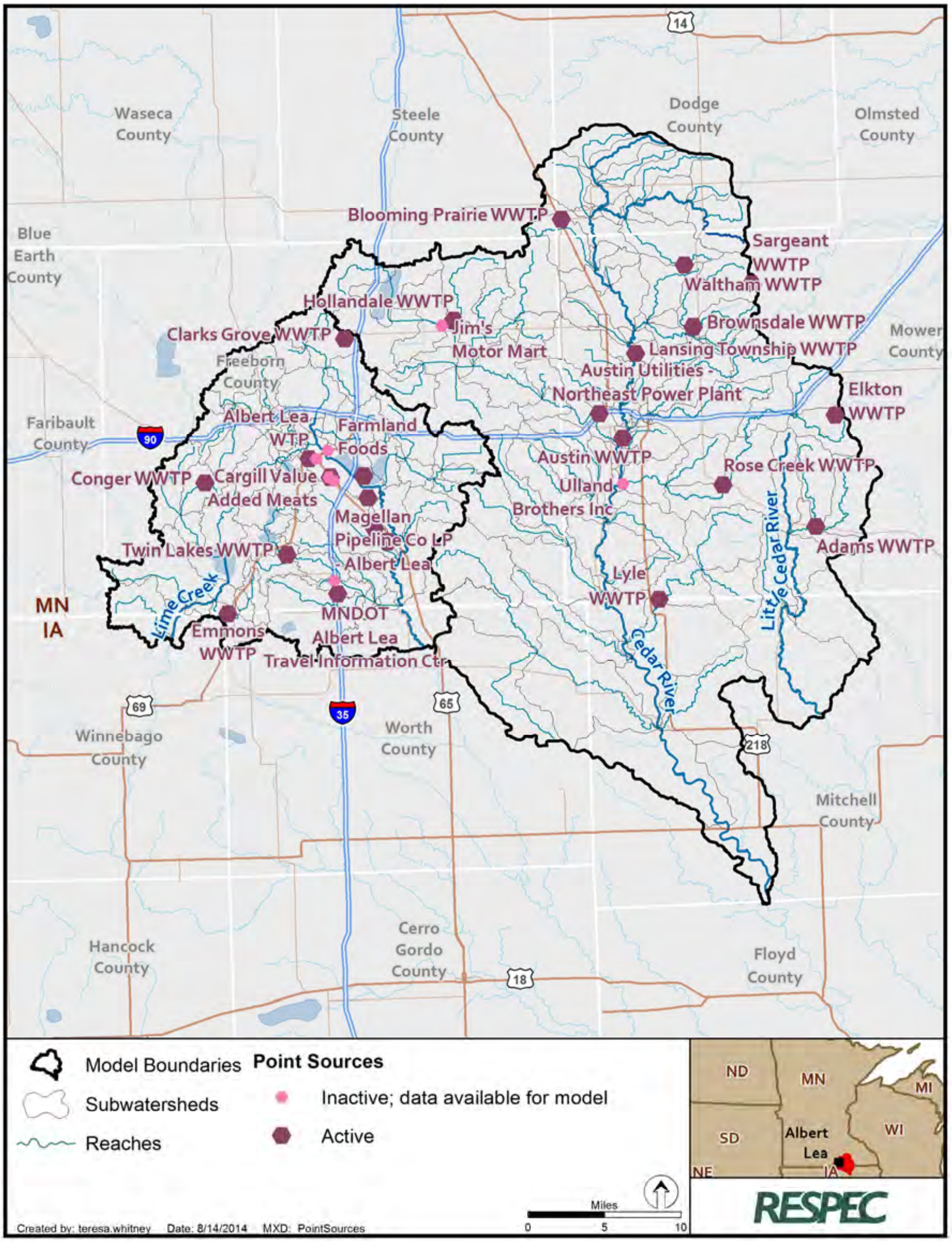

Figure 11. Minor Point Sources.

For each facility, data availability throughout the period of record was assessed. Available constituents from point sources that are applicable for modeling purposes include carbonaceous 5-day biochemical oxygen demand (CBOD5), TSS, total phosphorus (TP), and DO. Point-source water-quality data were filled by using monthly mean values. Where monthly means were unavailable, interpolation was used. The available effluent water-quality parameters vary by site, but in general, most parameters were available from wastewater treatment facilities (WWTF).

Nitrogen species data and orthophosphate-phosphorus were unavailable in many of the minor point-source datasets provided. Classes for each point source located in the Cedar River Watershed are provided in Table 7 [Weiss, 2012a]. Point-source loads for nitrogen species were calculated by using numbers supplied by Weiss [2012b] and are provided in Table 8. Methods for estimating other phosphorus species from point sources were derived from methods used in the Minnesota River model application [Tetra Tech, 2009]. The nutrient portions of the Cedar River Watershed external sources blocks contain estimates where nutrient data were unavailable. Temperature data were derived from a minor wastewater treatment facility located in the Missouri River Watershed and were adjusted for differences in temperature between the two watersheds. All available data for model inputs have been uploaded into the project Watershed Data Management (WDM) file, and all available data used for comparison to model simulations are in an observed data Microsoft Excel file.

Besides temperature, the concentrations of all available constituents, including BOD as CBODU (converted from CBOD5 using Equation 1 [Chapra, 1997]), were converted from concentration (mg/L) to load (lb/day), using a conversion factor of 8.34. Temperature was converted from degrees F to a heat load in British Thermal Units (BTU) per day (temperature × discharge × a conversion factor of 8,339,145).

$$L_0 = \frac{y_5}{1 - e^{-k_1(5)}} \tag{1}$$

where:

$L_0 = \mathrm{CBOD}_u$

$y_5 = \mathrm{CBOD}_5$

$k_1 = 0.10$, minimum value after primary treatment.

Estimated daily time series were then imported into the binary WDM files, and loads were applied to the corresponding stream reach in the external sources block in the model input file.

The final results from the most data-intensive downstream reaches of the Cedar/Little Cedar (Reach 410) and the Shell Rock/Winnebago model applications (Reach 190) are included in Appendix B and Appendix C, respectively. Three figures are included for each available water-quality constituent at each location. The figures illustrate comparisons of observed data (blue) and model simulations (red) and include a concentration duration curve, a monthly average plot, and a time-series plot for each site. The results at additional water-quality monitoring sites are included in the deliverable results folder.

Table 7. Concentration Categories Assigned to Point Sources Within the Cedar River Watershed [Weiss, 2012a]

Name	Site I.D.	Type
Adams WWTP	MN0021261	B
Albert Lea WTP	MNG640002	WTP
Albert Lea WWTP	MN0041092	A
Austin Utilities–Northeast Power Plant	MN0025810	POWER
Austin WWTP	MN0022683	A
Blooming Prairie WWTP	MN0021822	B
Brownsdale WWTP	MN0022934	D
Cargill Value Added Meats	MNG255077	NCCW
Clarks Grove WWTP	MNG580067	D
Conger WWTP	MN0068519	D
Elkton WWTP	MNG580013	D
Emmons WWTP	MN0023311	C
Farmland Foods	MN0000124	NCCW
Glenville WWTP	MN0021245	D
Hollandale WWTP	MN0048992	D
Holsum Foods	MNG250024	NCCW
Jim's Motor Mart	MNG790111	O
Lansing Township WWTP	MN0063461	B
Lou Rich Inc.	MN0000086	NCCW
Magellan Pipeline Co LP– Albert Lea	MNG790110	O
MDNR Myre Big Island State Park	MN0033740	D
MNDOT Albert Lea Travel Information Center	MNG580065	D
POET Bio refining– Glenville	MN0065692	T
Rose Creek WWTP	MN0024651	D
Sargeant WWTP	MNG580214	D
Schweigert Foods	MN0000175	NCCW
Twin Lakes WWTP	MNG580042	D
Ulland Brothers Inc.	MN0061450	GW
Waltham WWTP	MN0025186	D

Table 8. Categorical Concentration Assumptions (mg/L) [Weiss, 2012b]

Category	General Description	TN[(a)]	NOx[(b)]	TKN[(c)]	NHx[(d)]
A	Class A municipal—large mechanical	19	15	4	3
B	Class B municipal—medium mechanical	17	10	7	4
C	Class C municipal—small mechanical/pond mix	10	7	3	1
D	Class D municipal—mostly small ponds	6	3	3	1
O	Other—generally very low volume effluent	10	7	3	2
PEAT	Peat mining facility—pump out/drainage from peat	10	7	3	2
T	Tile line to surface discharge	10	7	3	3
P	Paper industry	10	7	3	2
NCCW	Noncontact cooling water	4	1	3	2
POWER	Power industry	4	1	3	2
WTP	Water treatment plant	4	3	1	1
GRAV	Gravel mining wash water	2	1	1	1
GW	Industrial facilities—primarily private groundwater well	0.25	0.25	0	0

(a) TN = Total Nitrogen
(b) NOx = Nitrate + Nitrite
(c) TKN = Total Kjeldahl Nitrogen
(d) NHx = Ammonia.

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Thank you for your time in reviewing the methods for the development of the UCI and WDM files for the Cedar/Little Cedar and Shell Rock/Winnebago HSPF model applications. If you have any questions or need additional information, please contact me by telephone (605.394.6400) or email (*cindie.mccutcheon@respec.com*).

Sincerely,

Cindie M. McCutcheon
Staff Engineer

CMM:amk

cc: Project Central File 2428 — Category A

APPENDIX A

PRIMARY GAGE HYDROLOGY CALIBRATION RESULTS FOR THE CEDAR RIVER/LITTLE CEDAR RIVER AND THE SHELL ROCK RIVER/WINNEBAGO RIVER WATERSHED MODELS

RSI-2428-14-011

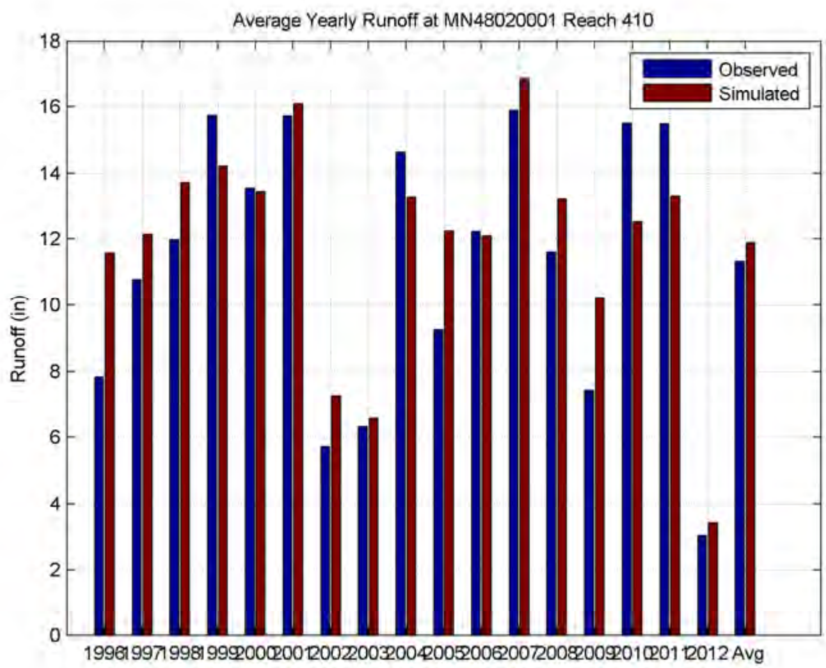

Figure A-1. Average Yearly Runoff at Reach 410 (Cedar/Little Cedar).

RSI-2428-14-012

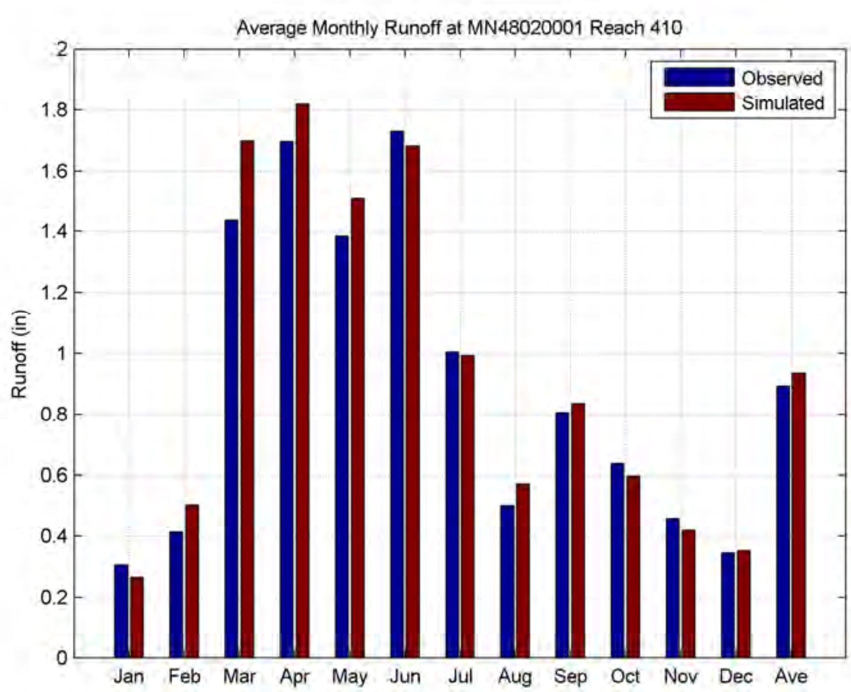

Figure A-2. Average Monthly Runoff at Reach 410 (Cedar/Little Cedar).

RSI-2428-14-013

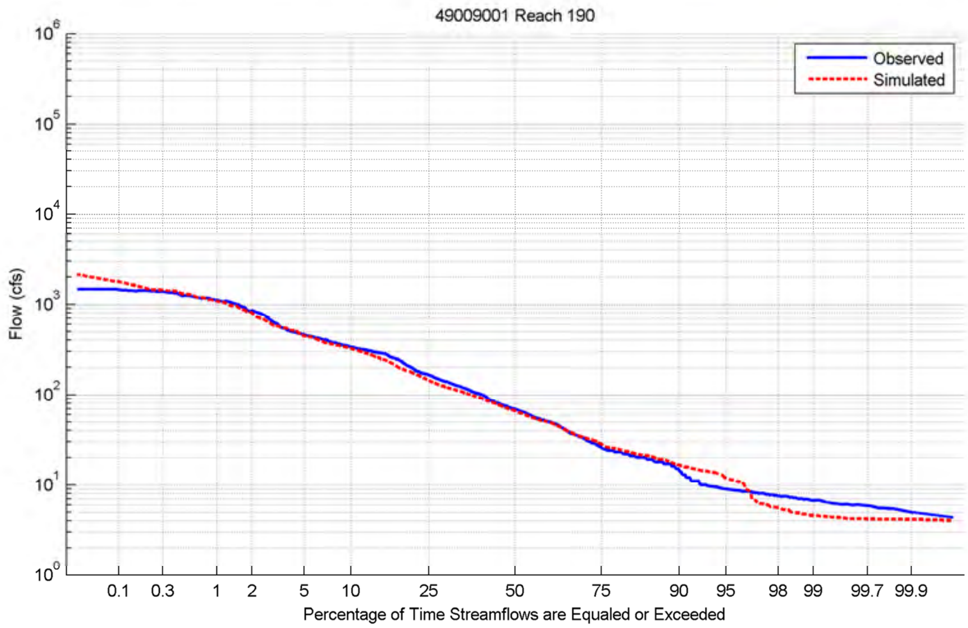

Figure A-3. Flow Duration Plot for Reach 410 (Cedar/Little Cedar).

RSI-2428-14-014

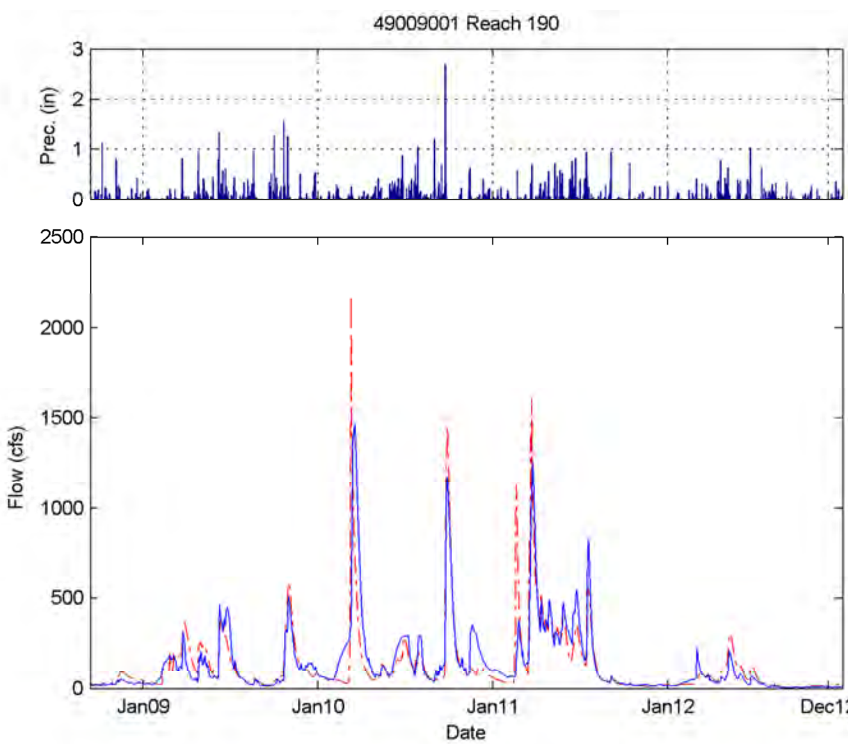

Figure A-4. Daily Hydrographs for Reach 410 (Cedar/Little Cedar).

RSI-2428-14-015

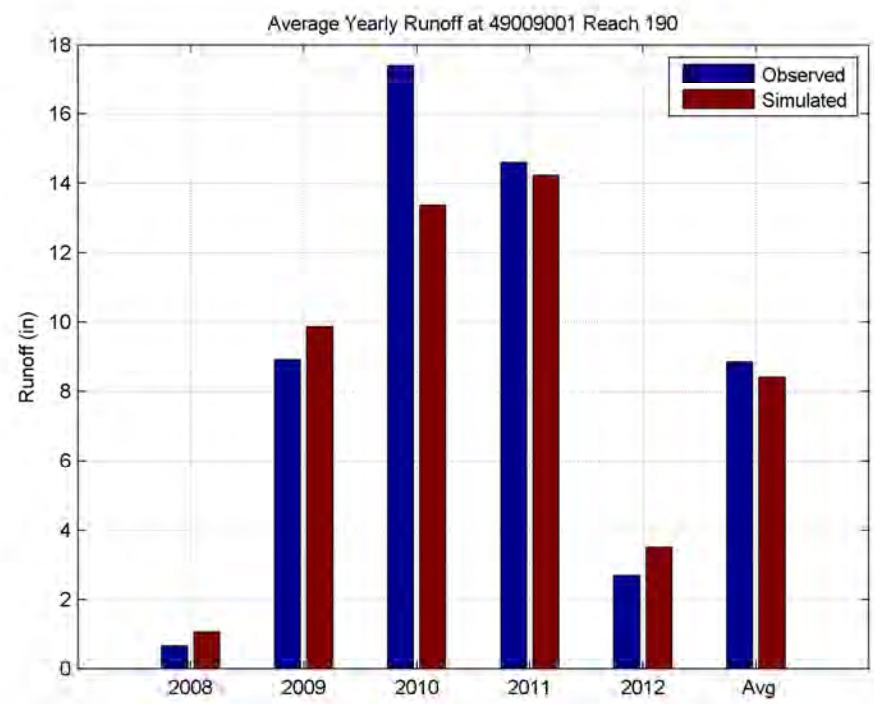

Figure A-5. Average Yearly Runoff at Reach 190 (Shell Rock/Winnebago).

RSI-2428-14-016

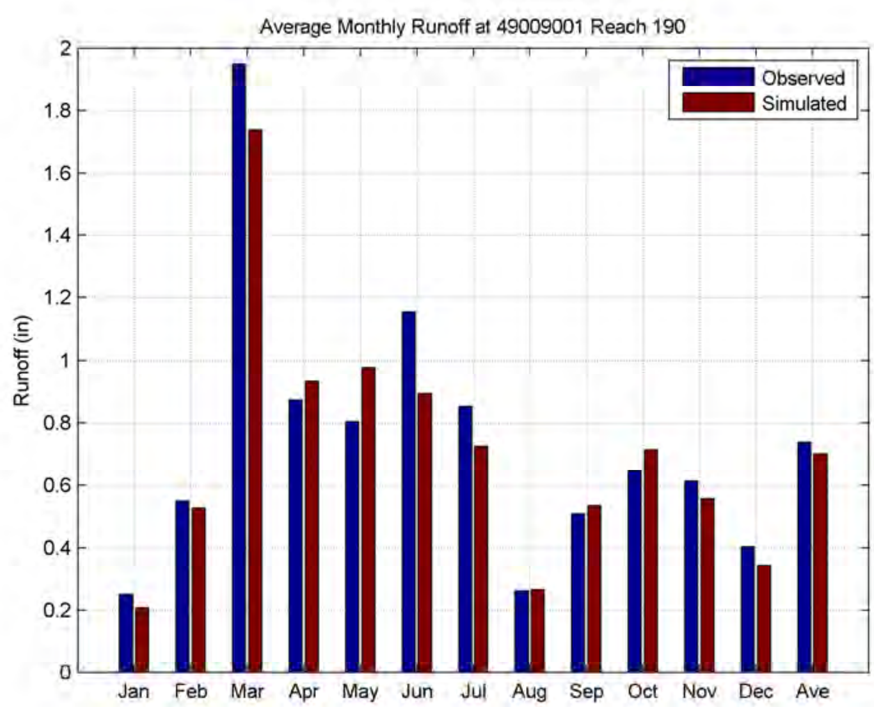

Figure A-6. Average Monthly Runoff at Reach 190 (Shell Rock/Winnebago).

RSI-2428-14-017

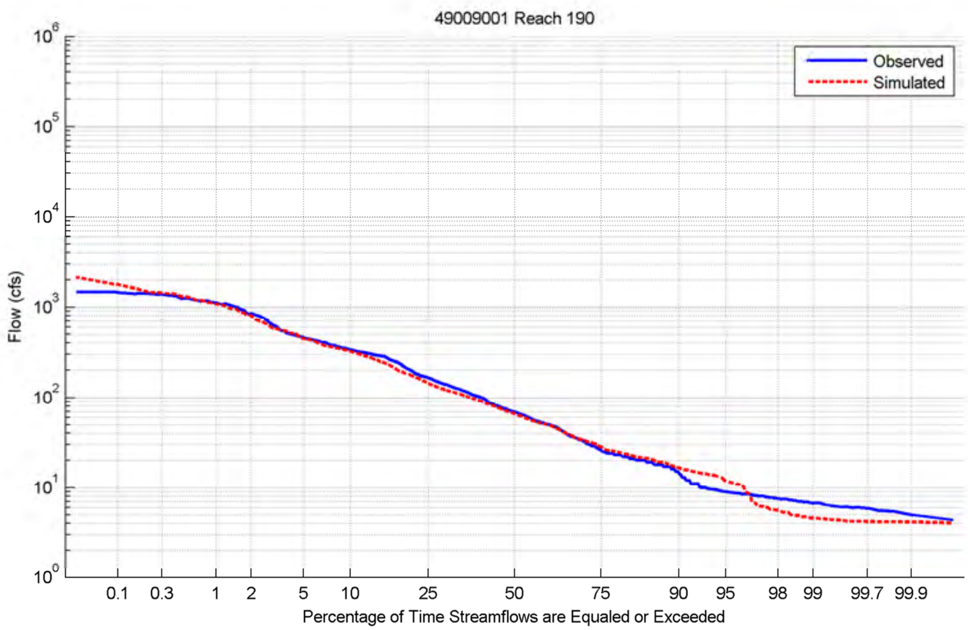

Figure A-7. Flow-Duration Plot for Reach 190 (Shell Rock/Winnebago).

RSI-2428-14-018

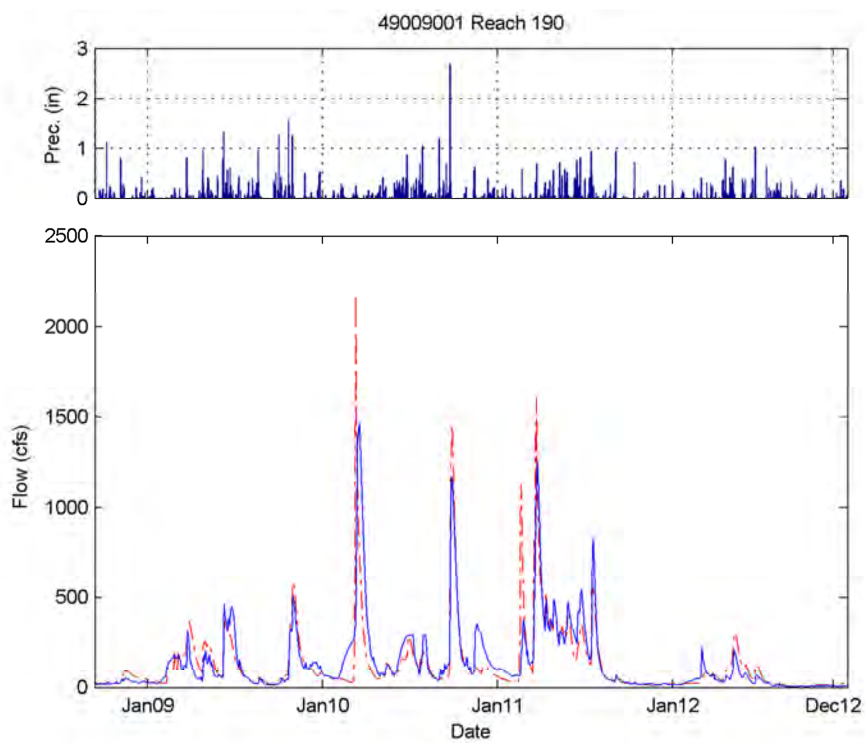

Figure A-8. Daily Hydrographs for Reach 190 (Shell Rock/Winnebago).

APPENDIX B

CEDAR RIVER/LITTLE CEDAR RIVER
WATER-QUALITY CALIBRATION FIGURES

RSI-2428-14-019

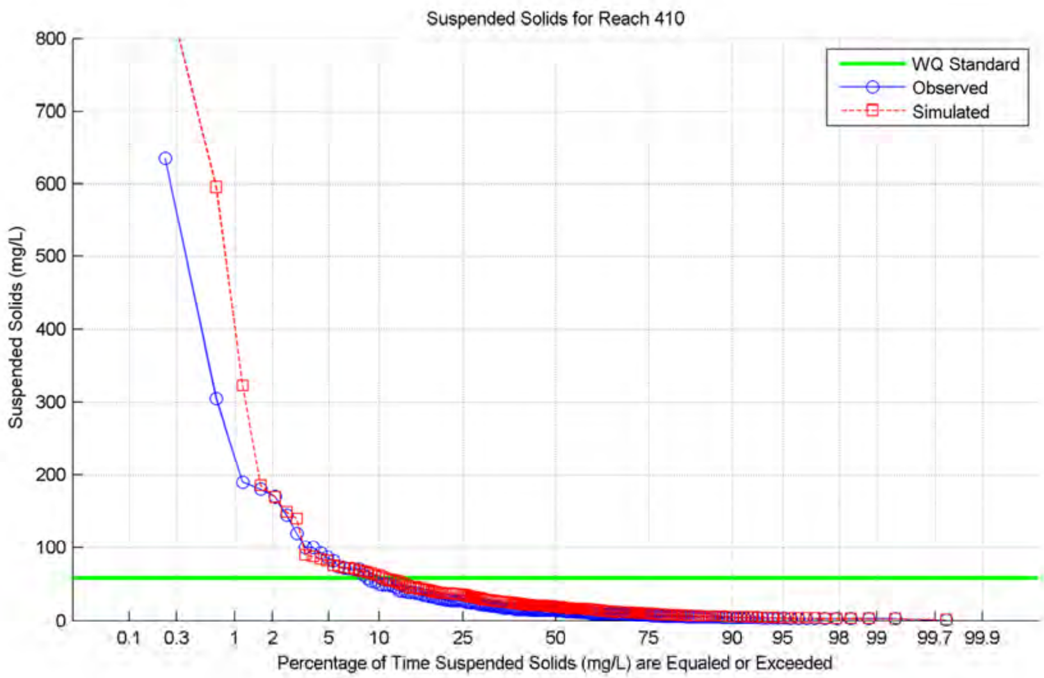

Figure B-1. Suspended Solids Concentration Duration Curve at Reach 410.

RSI-2428-14-020

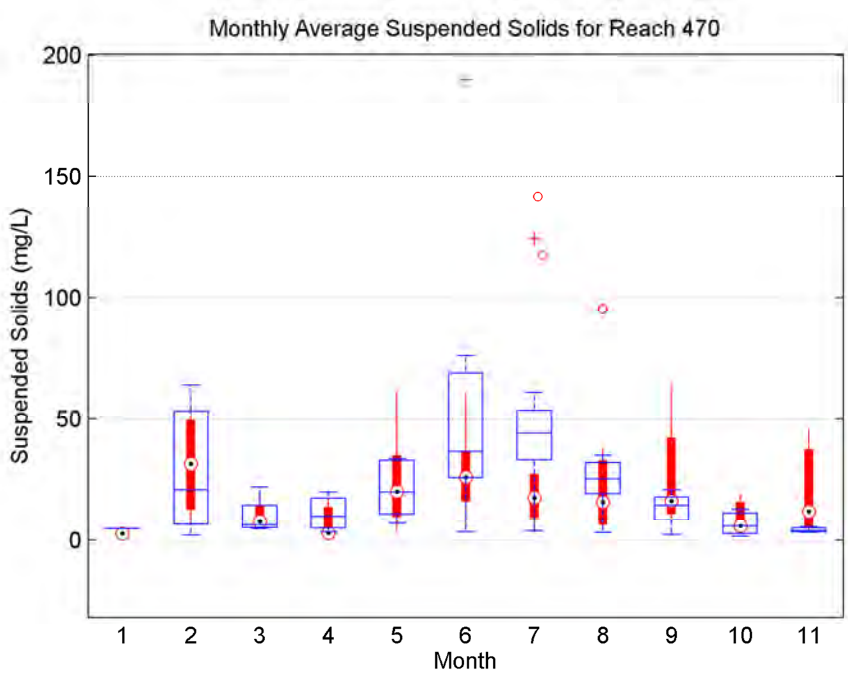

Figure B-2. Suspended Solids Monthly Averages at Reach 410.

RSI-2428-14-021

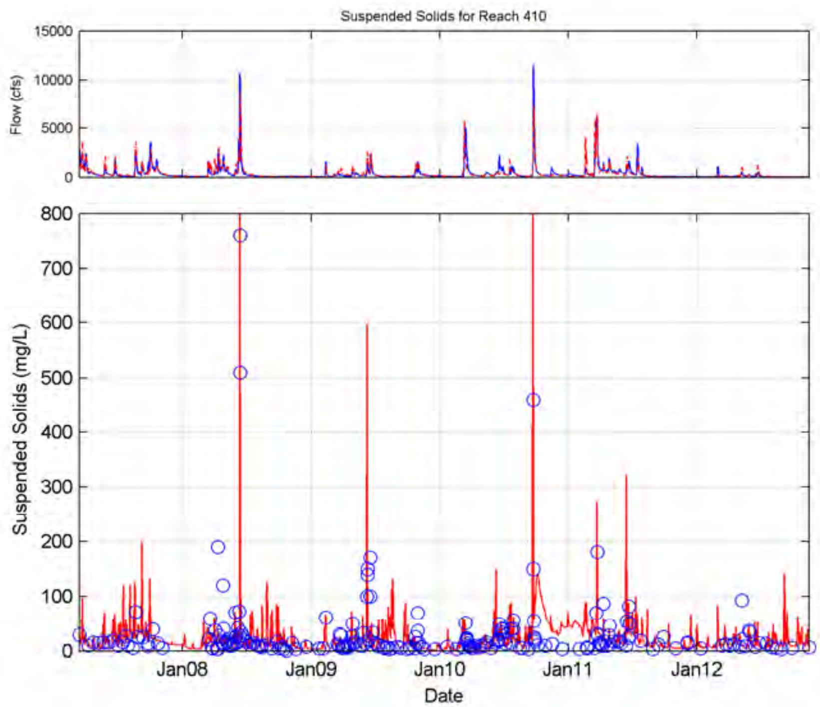

Figure B-3. Suspended Solids Daily Time Series at Reach 410.

RSI-2428-14-022

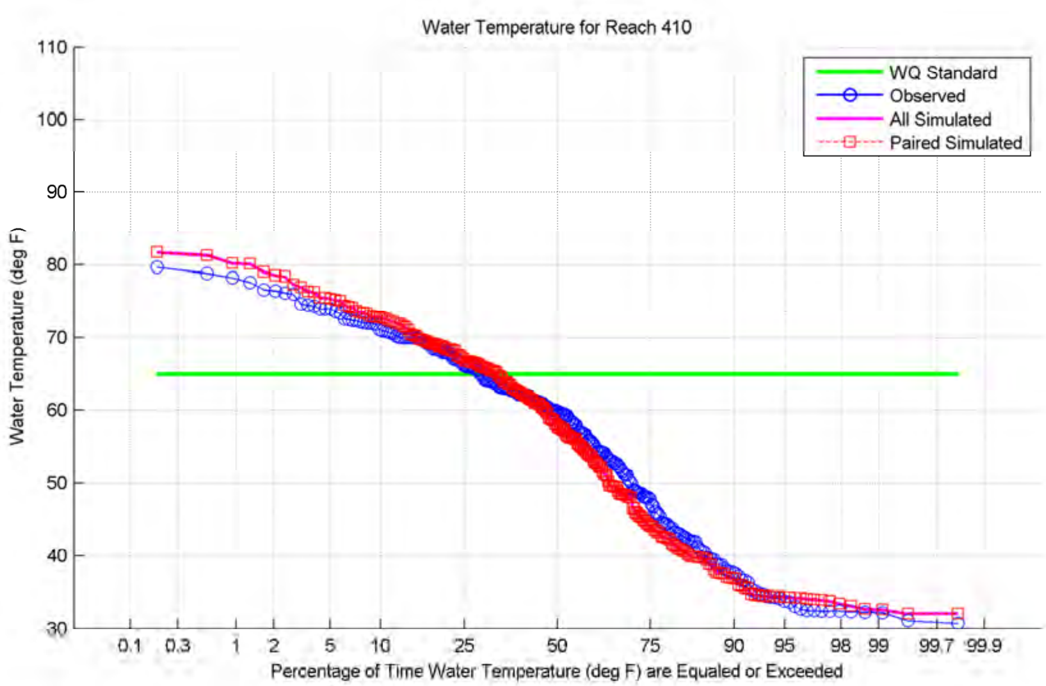

Figure B-4. Water Temperature Concentration Duration Curve at Reach 410.

RSI-2428-14-023

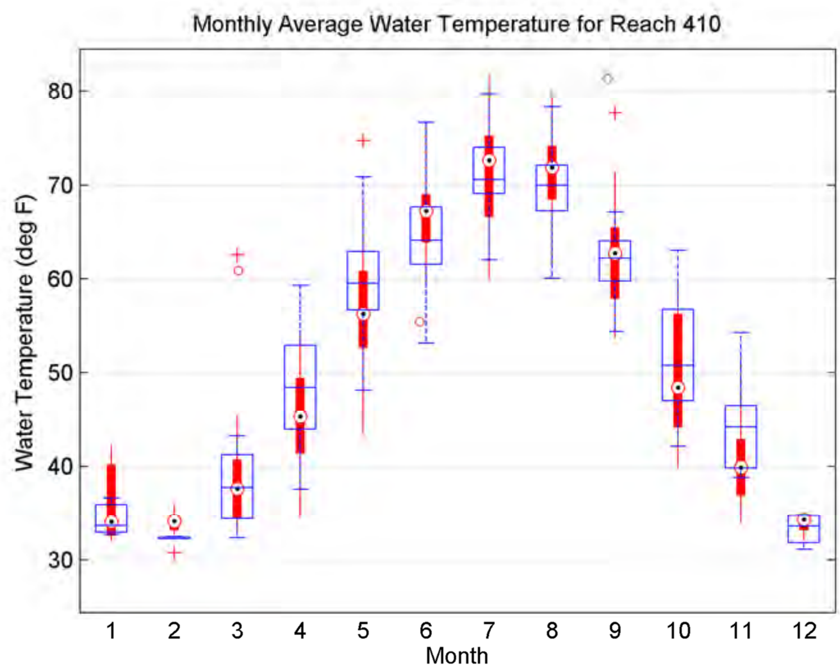

Figure B-5. Water Temperature Monthly Averages at Reach 410.

RSI-2428-14-024

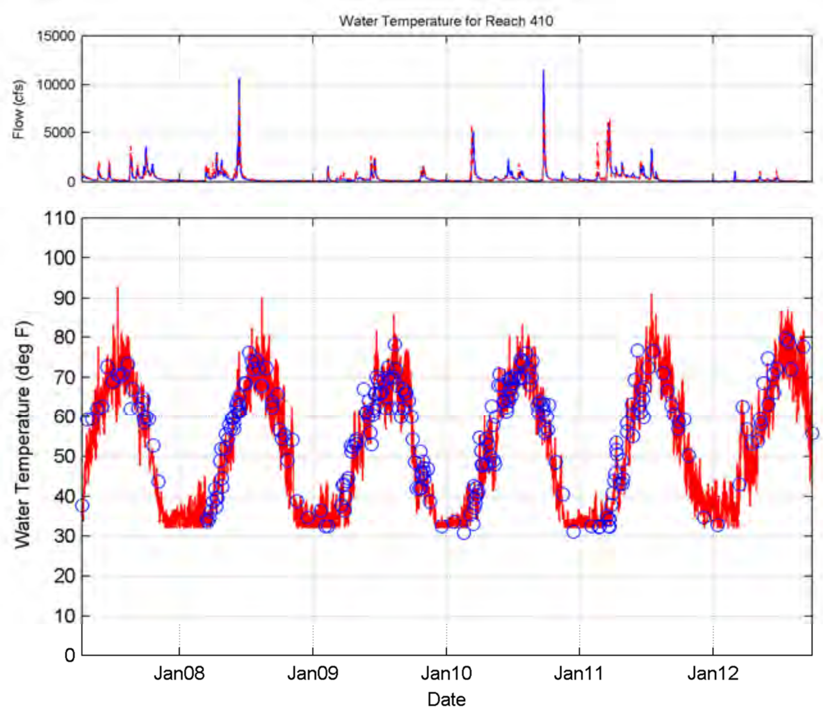

Figure B-6. Water Temperature Hourly Time Series at Reach 410.

RSI-2428-14-025

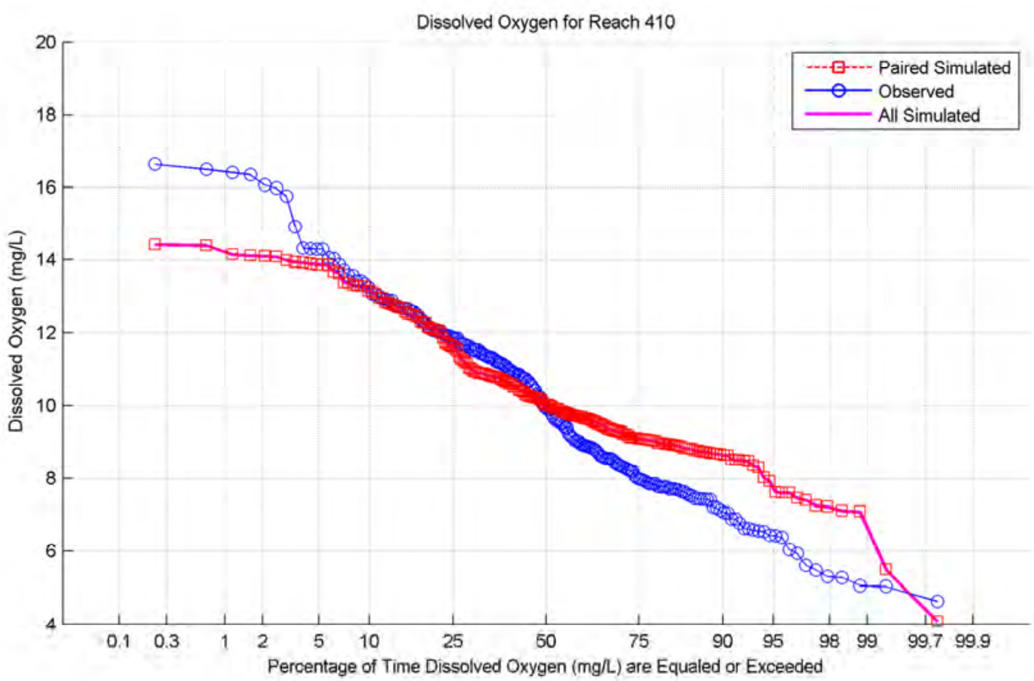

Figure B-7. Dissolved Oxygen Concentration Duration Curve at Reach 410.

RSI-2428-14-026

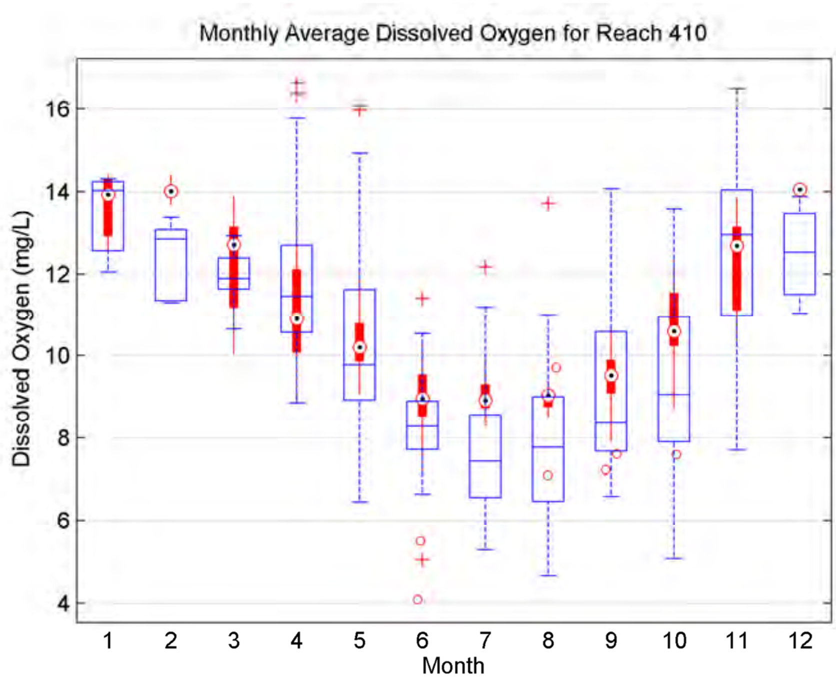

Figure B-8. Dissolved Oxygen Monthly Averages at Reach 410.

RSI-2428-14-027

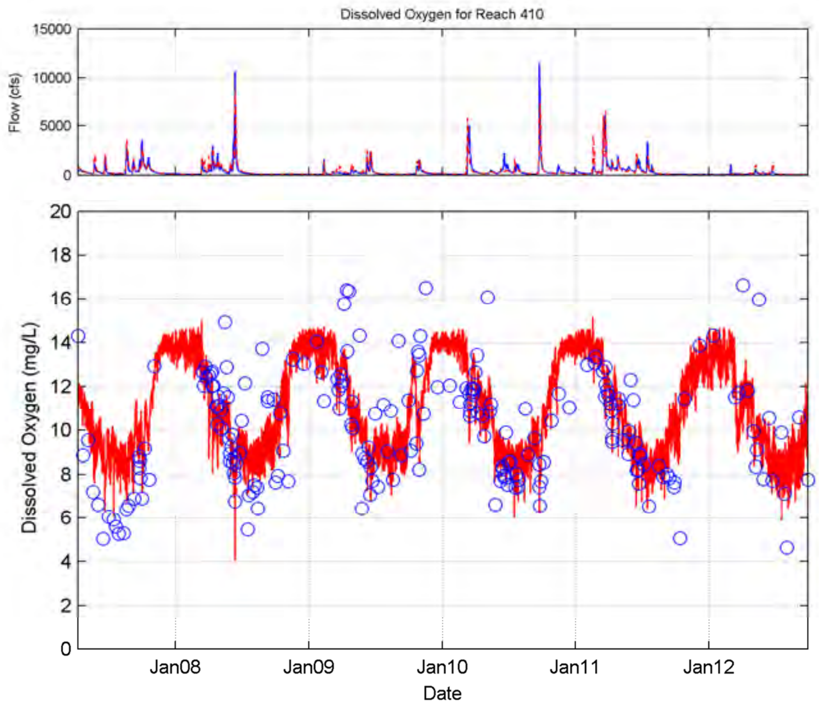

Figure B-9. Dissolved Oxygen Hourly Time Series at Reach 410.

RSI-2428-14-028

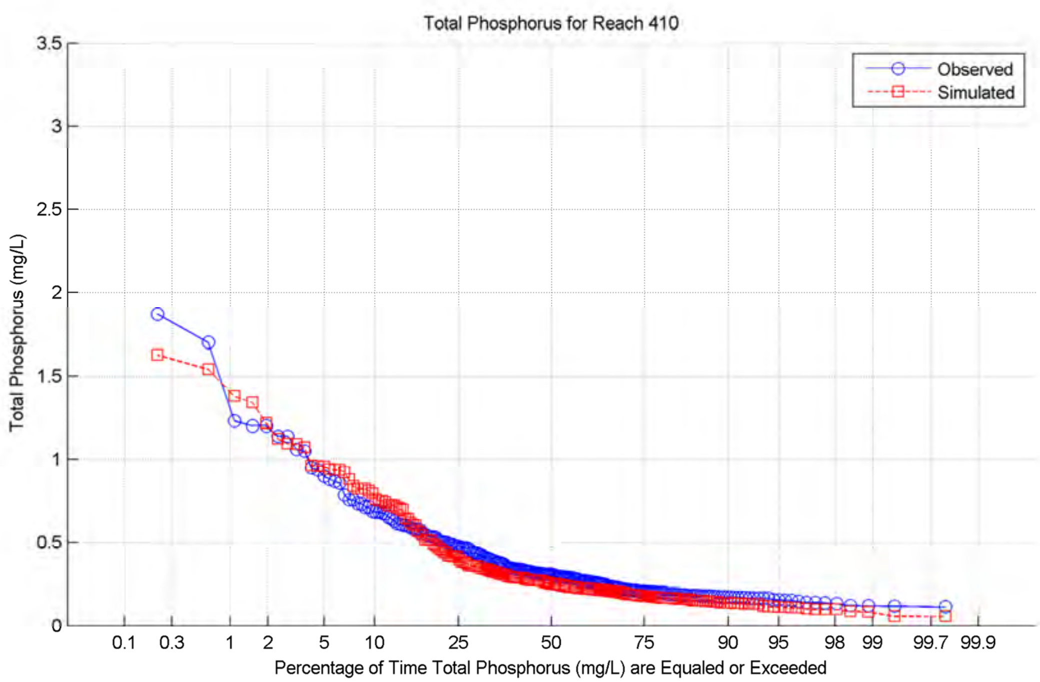

Figure B-10. Total Phosphorus Concentration Duration Curve at Reach 410.

RSI-2428-14-029

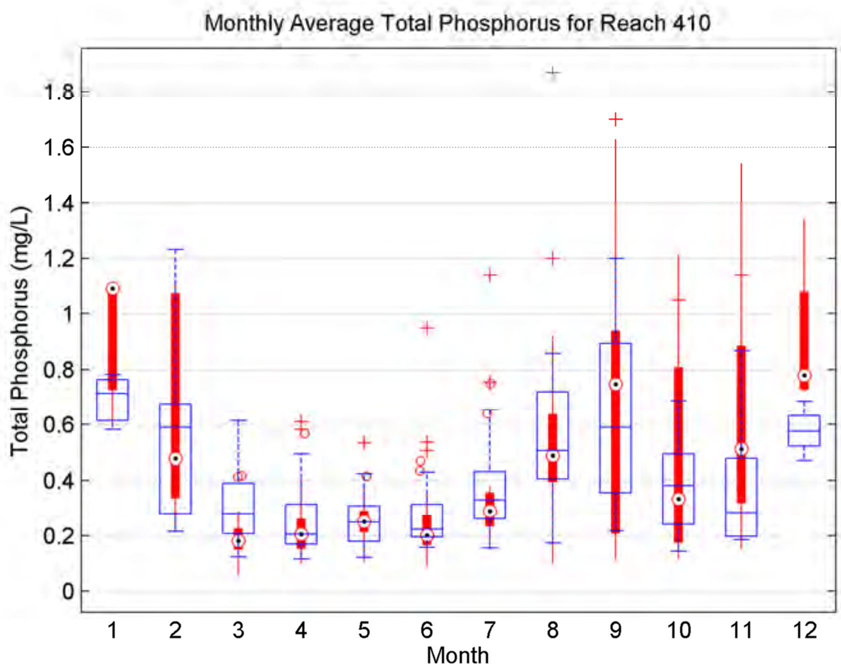

Figure B-11. Total Phosphorus Monthly Averages at Reach 410.

RSI-2428-14-030

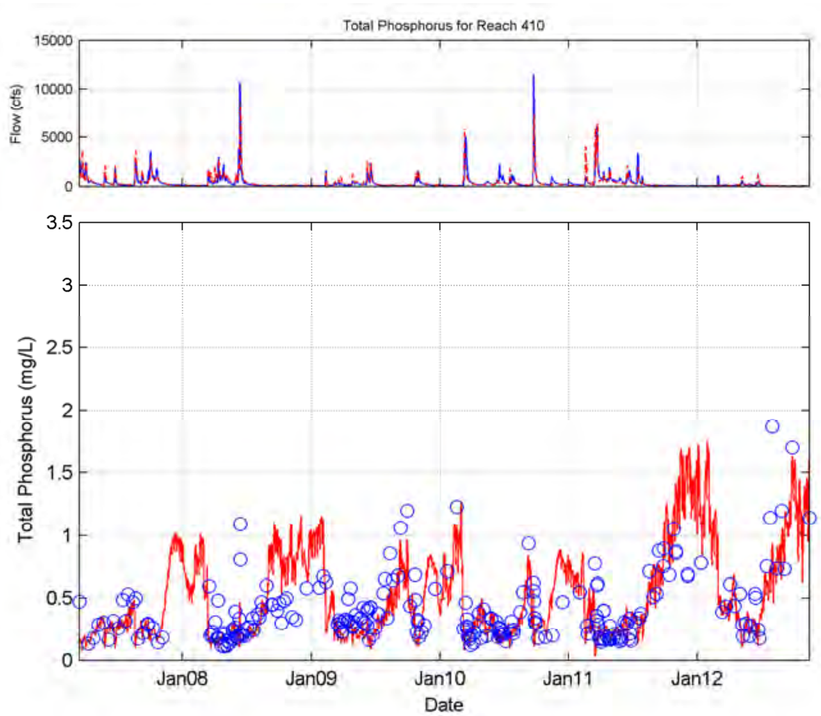

Figure B-12. Total Phosphorus Daily Time Series at Reach 410.

RSI-2428-14-031

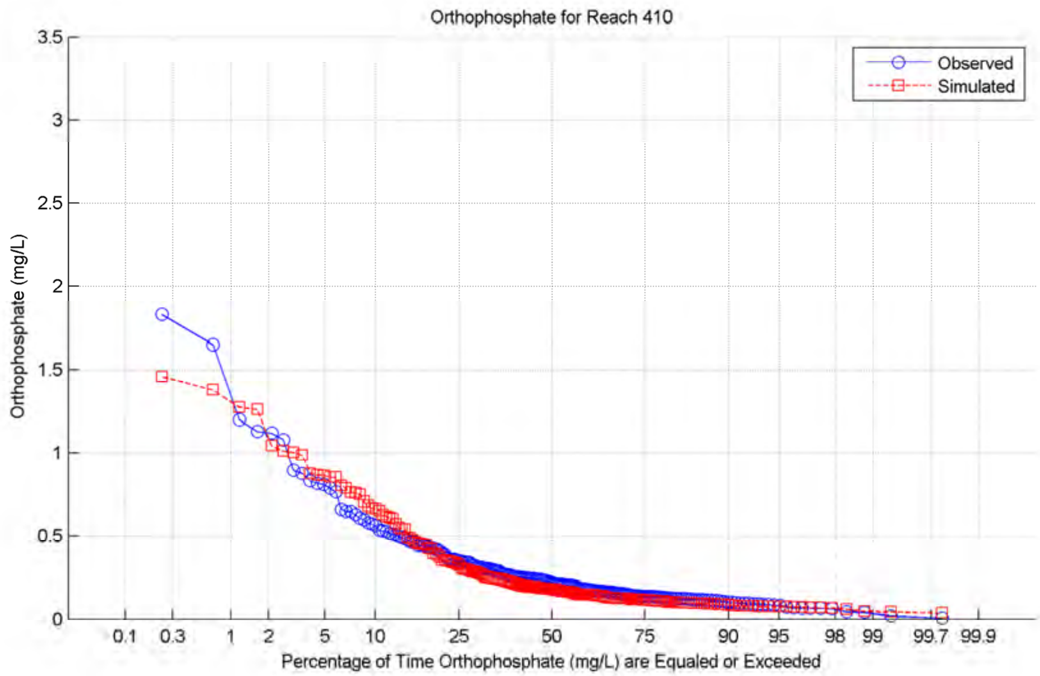

Figure B-13. Total Orthophosphate Concentration Duration Curve at Reach 410.

RSI-2428-14-032

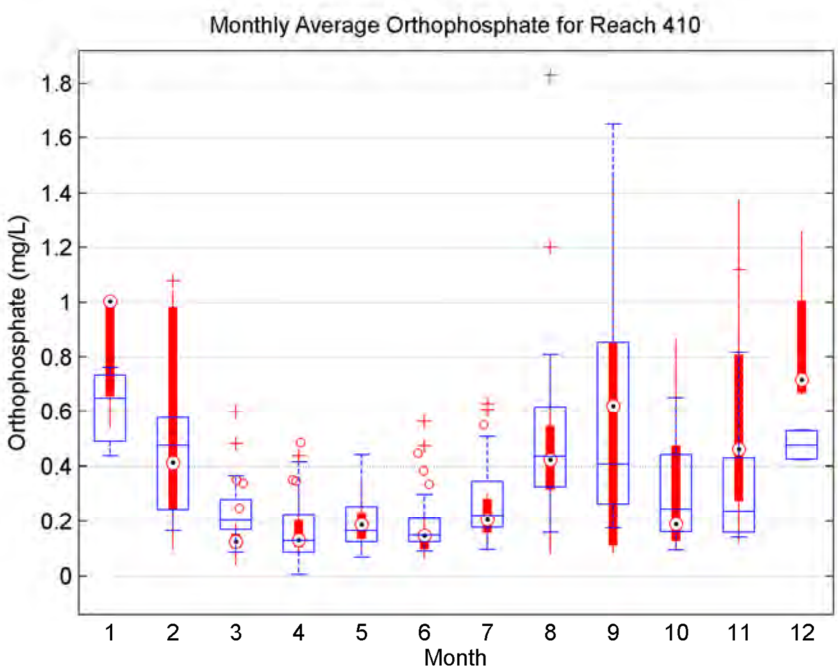

Figure B-14. Total Orthophosphate Monthly Averages at Reach 410.

RSI-2428-14-033

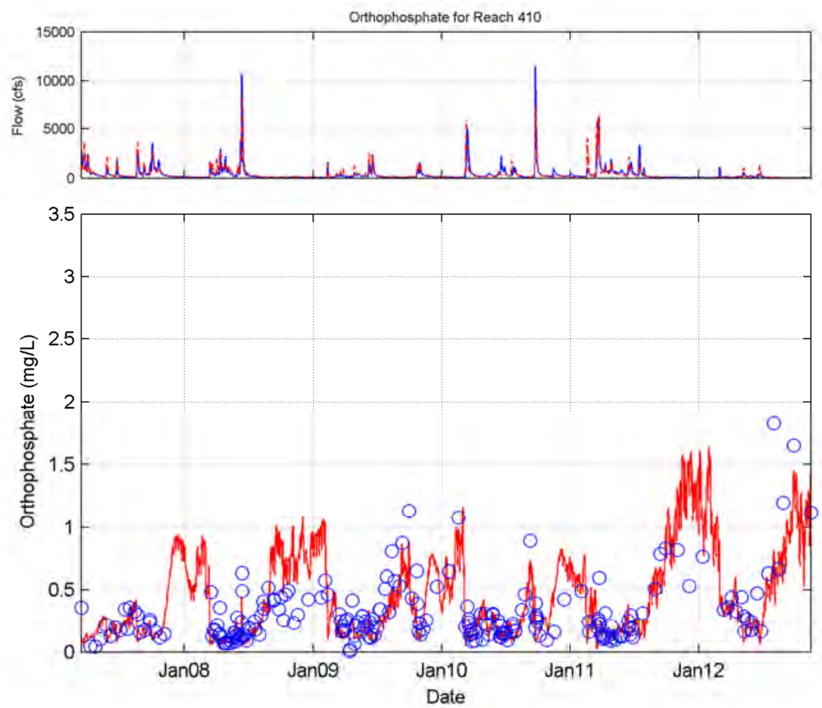

Figure B-15. Total Orthophosphate Daily Time Series at Reach 410.

RSI-2428-14-034

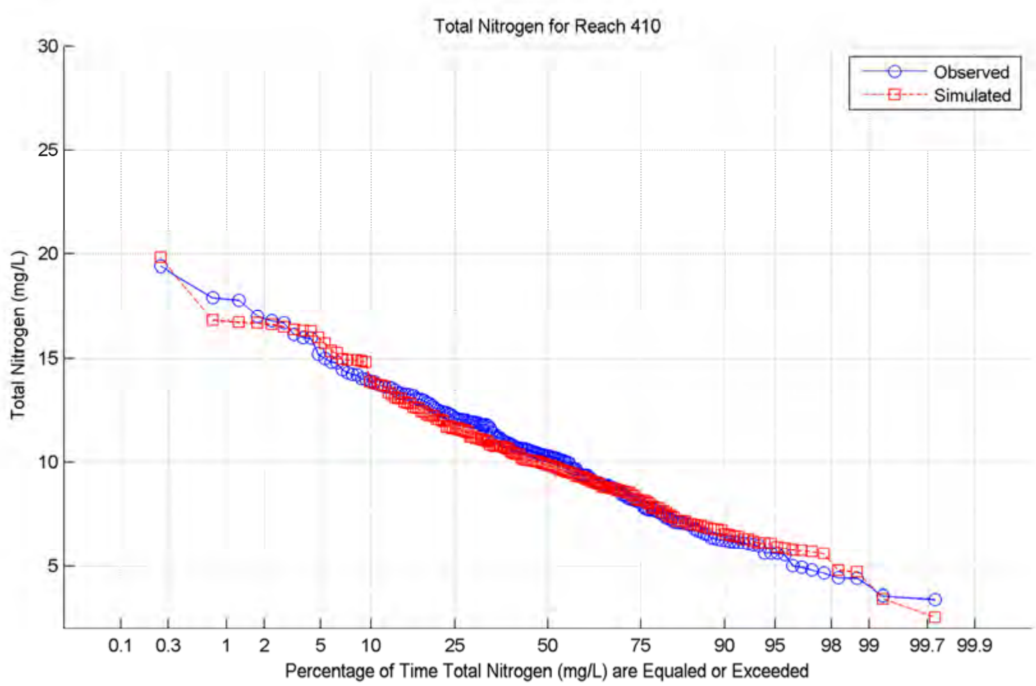

Figure B-16. Total Nitrogen Concentration Duration Curve at Reach 410.

RSI-2428-14-035

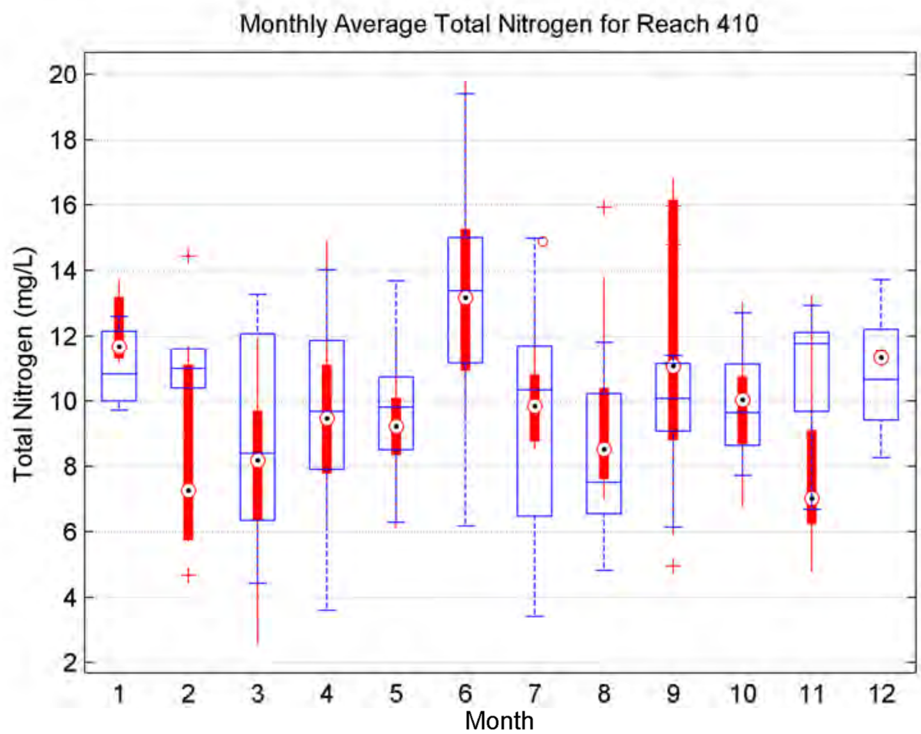

Figure B-17. Total Nitrogen Monthly Averages at Reach 410.

RSI-2428-14-036

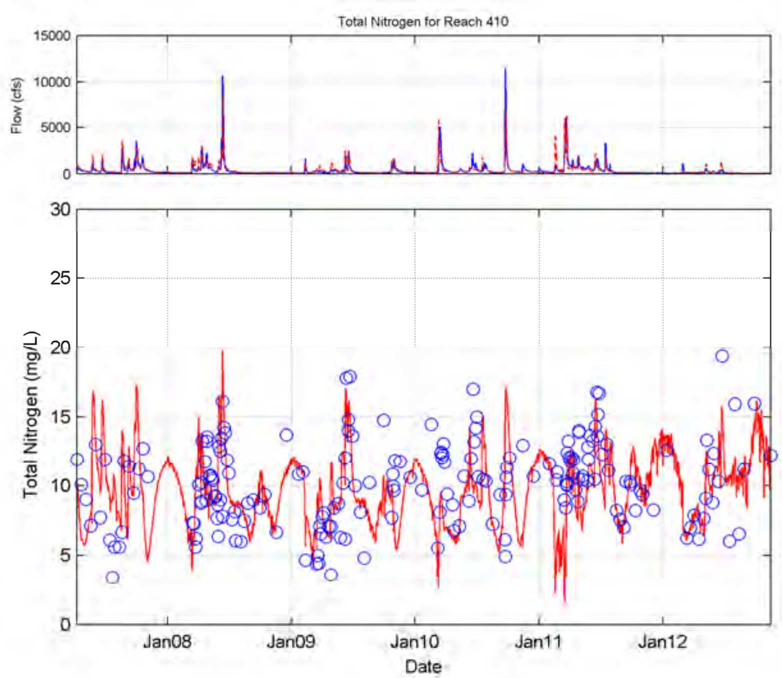

Figure B-18. Total Nitrogen Daily Time Series at Reach 410.

RSI-2428-14-037

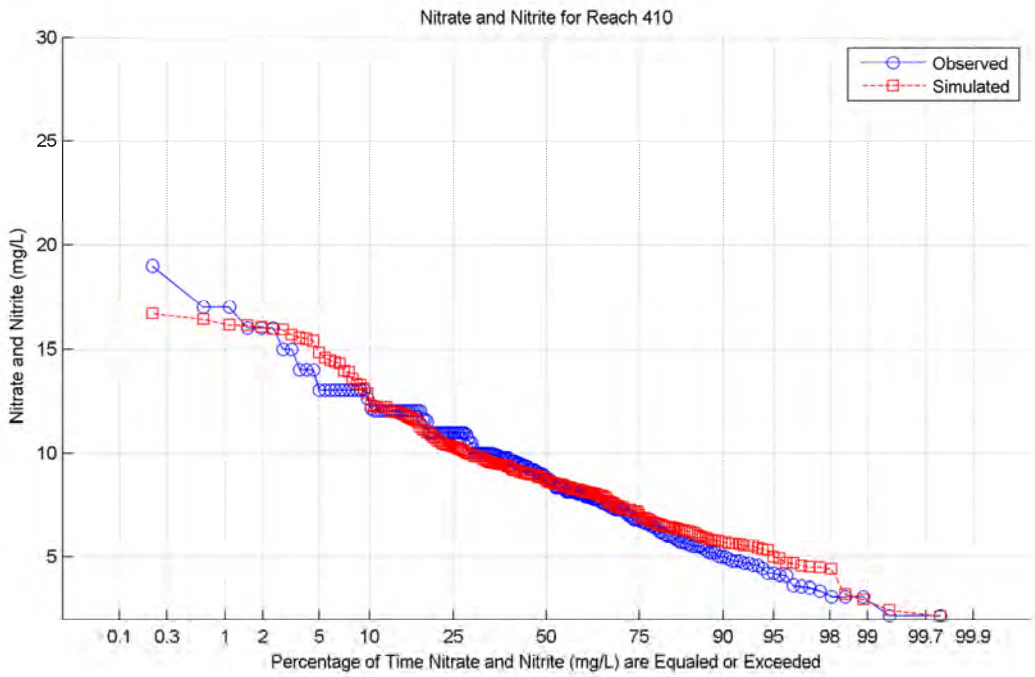

Figure B-19. Nitrate and Nitrite Concentration Duration Curve at Reach 410.

RSI-2428-14-038

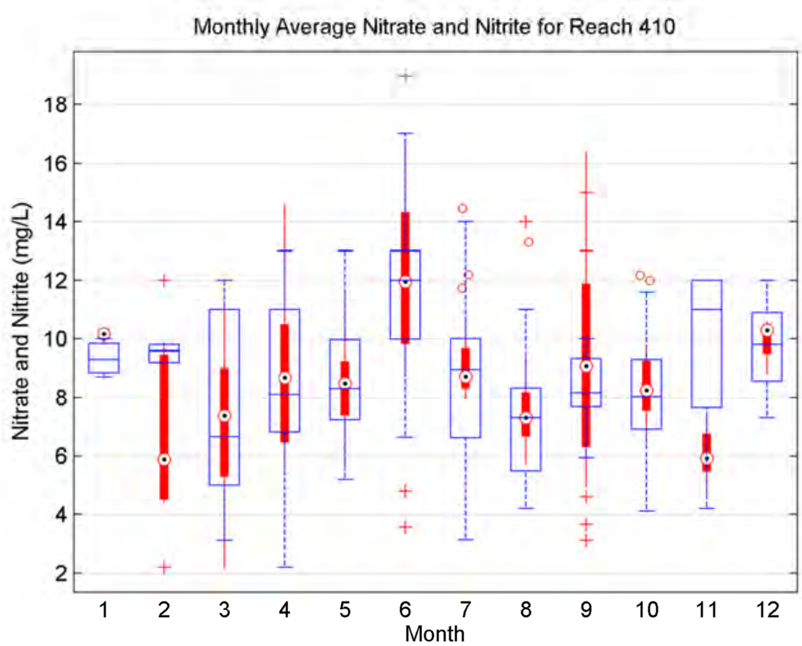

Figure B-20. Nitrate and Nitrite Monthly Averages at Reach 410.

RSI-2428-14-039

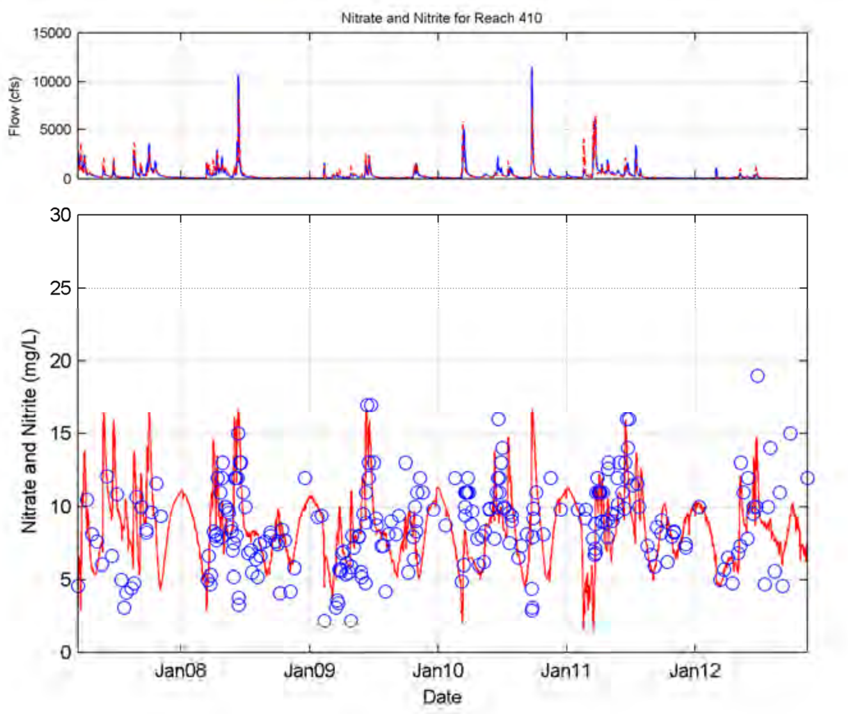

Figure B-21. Nitrate and Nitrite Daily Time Series at Reach 410.

RSI-2428-14-040

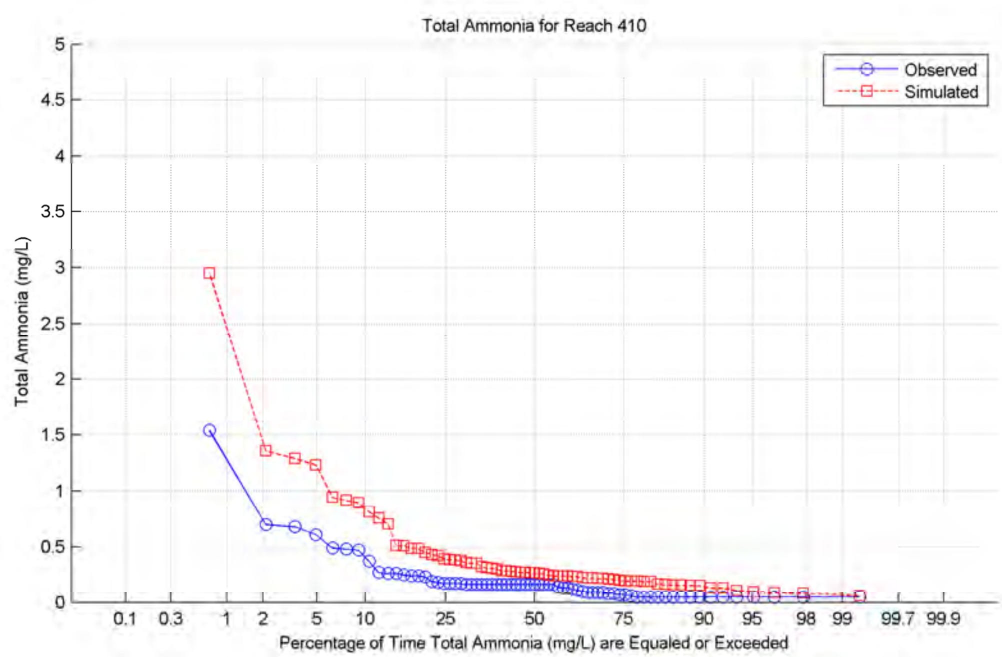

Figure B-22. Total Ammonia Concentration Duration Curve at Reach 410.

RSI-2428-14-041

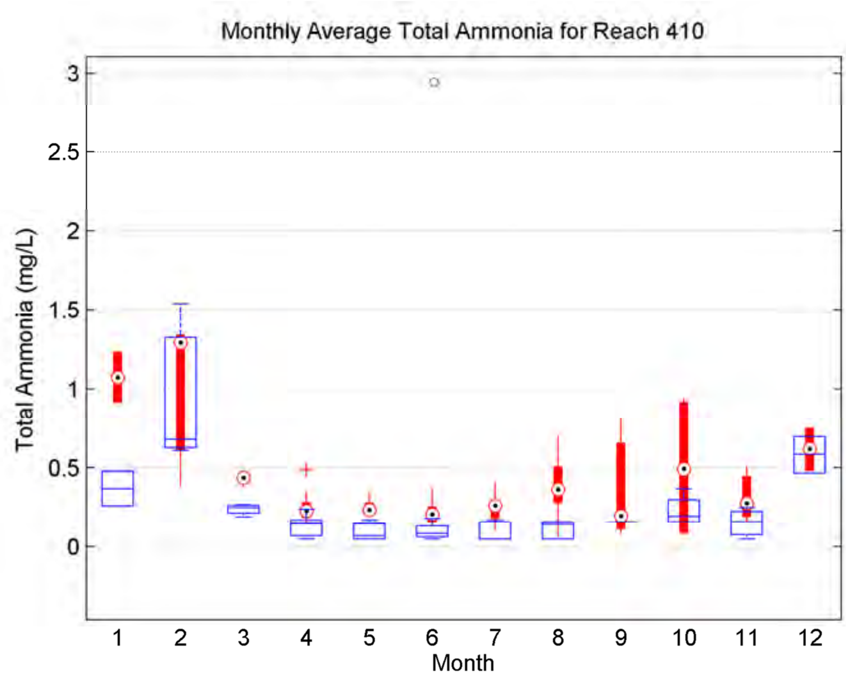

Figure B-23. Total Ammonia Monthly Averages at Reach 410.

RSI-2428-14-042

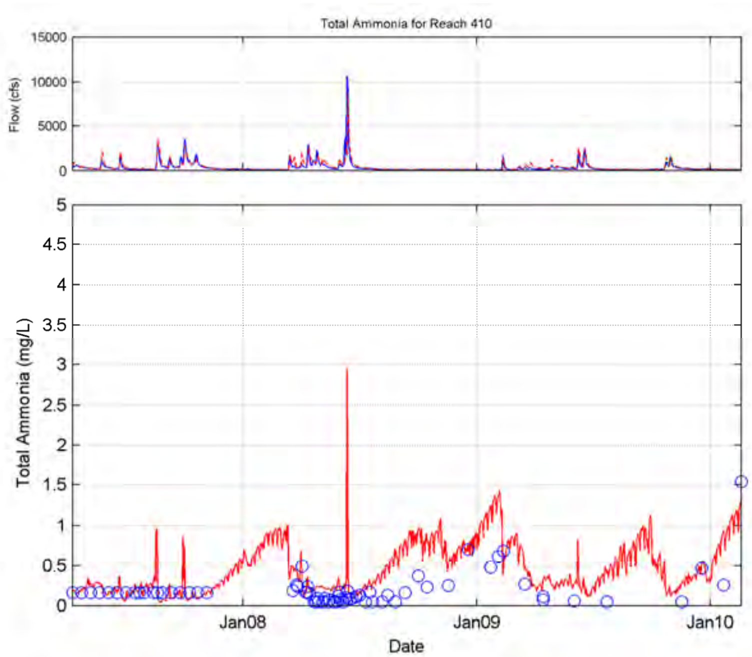

Figure B-24. Total Ammonia Daily Time Series at Reach 410.

RSI-2428-14-043

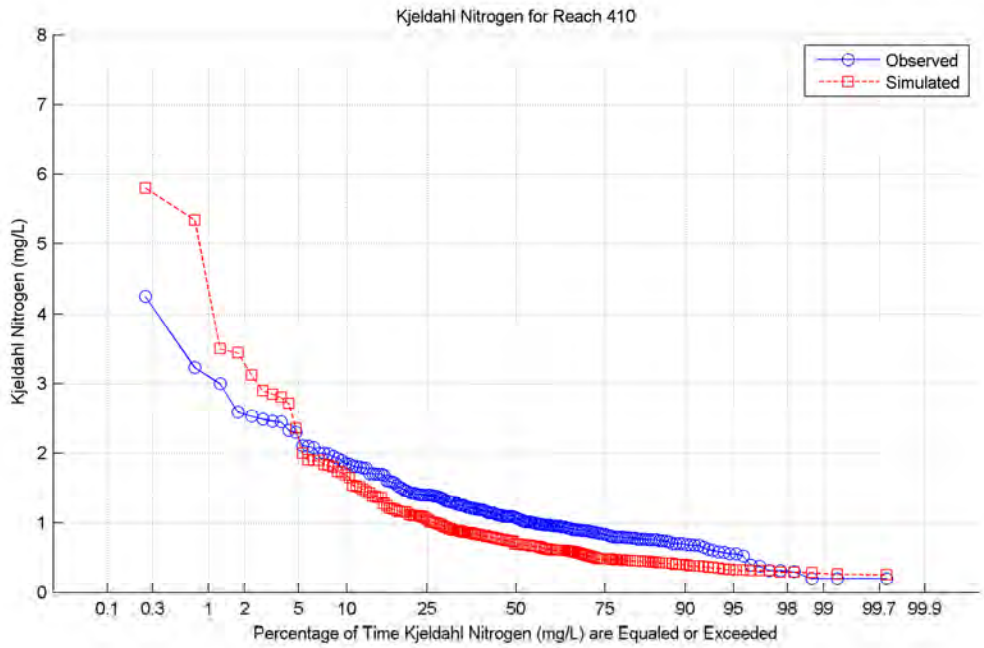

Figure B-25. Kjeldahl Nitrogen Concentration Duration Curve at Reach 410.

RSI-2428-14-044

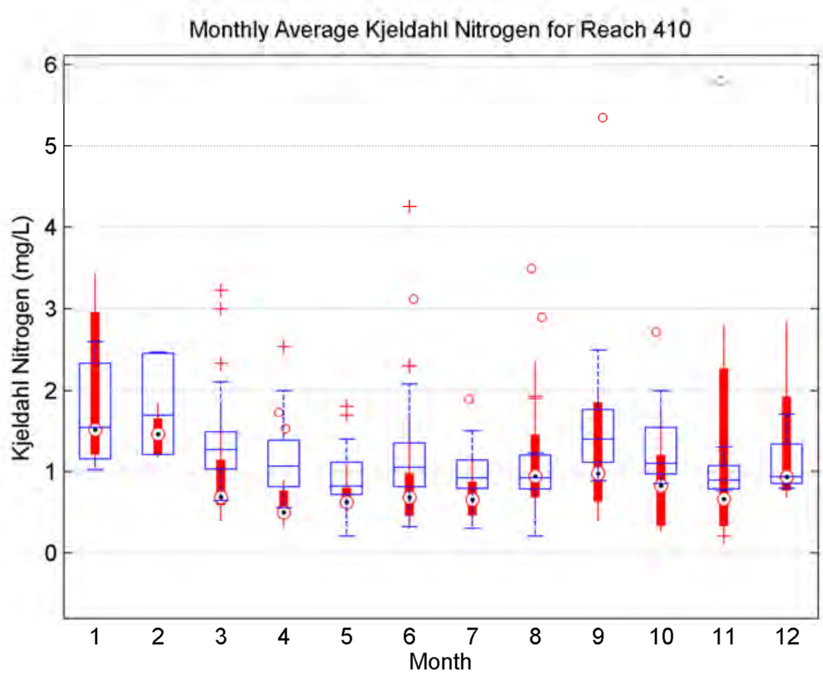

Figure B-26. Kjeldahl Nitrogen Monthly Averages at Reach 410.

RSI-2428-14-045

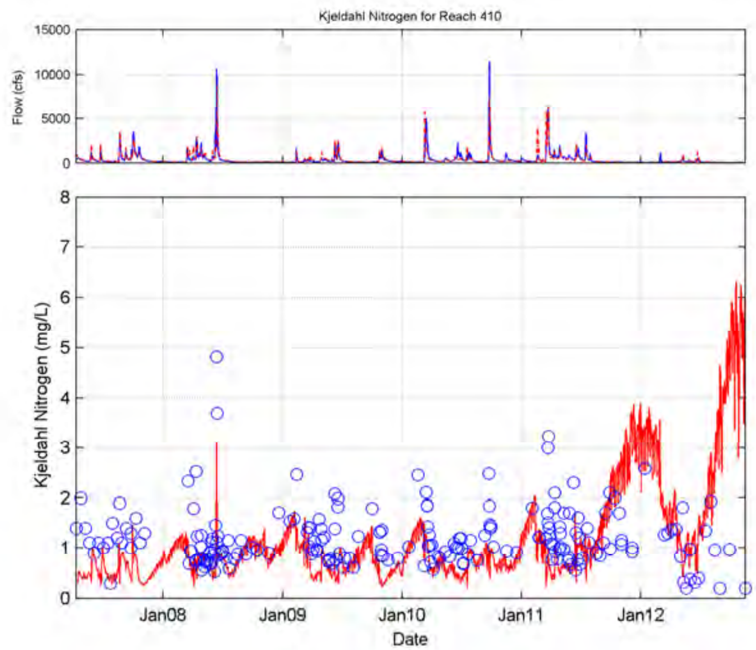

Figure B-27. Kjeldahl Nitrogen Daily Time Series at Reach 410.

RSI-2428-14-046

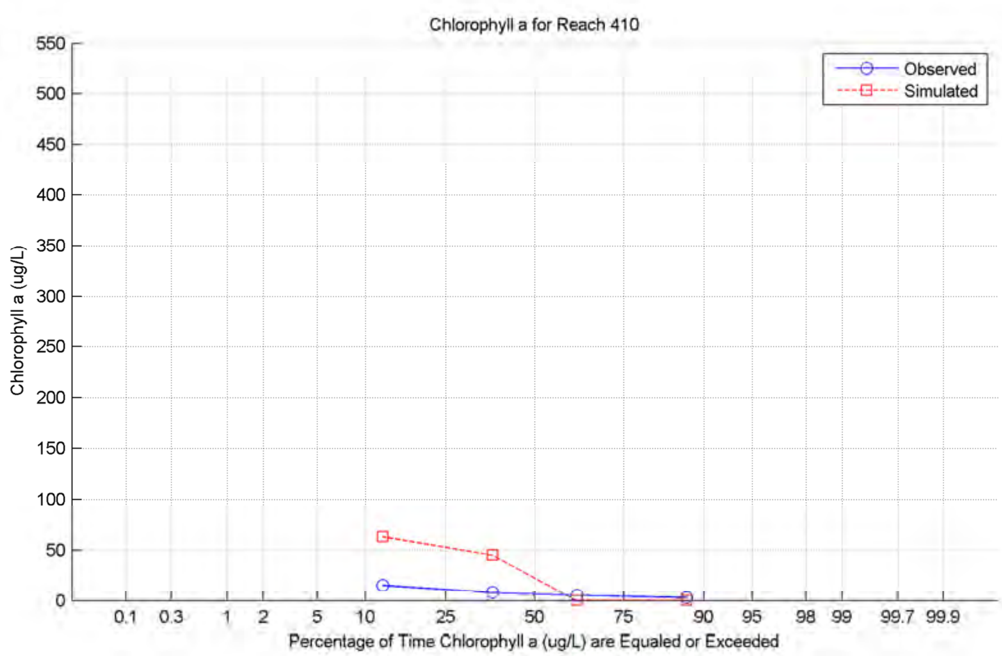

Figure B-28. Chlorophyll *a* Concentration Duration Curve at Reach 410.

RSI-2428-14-047

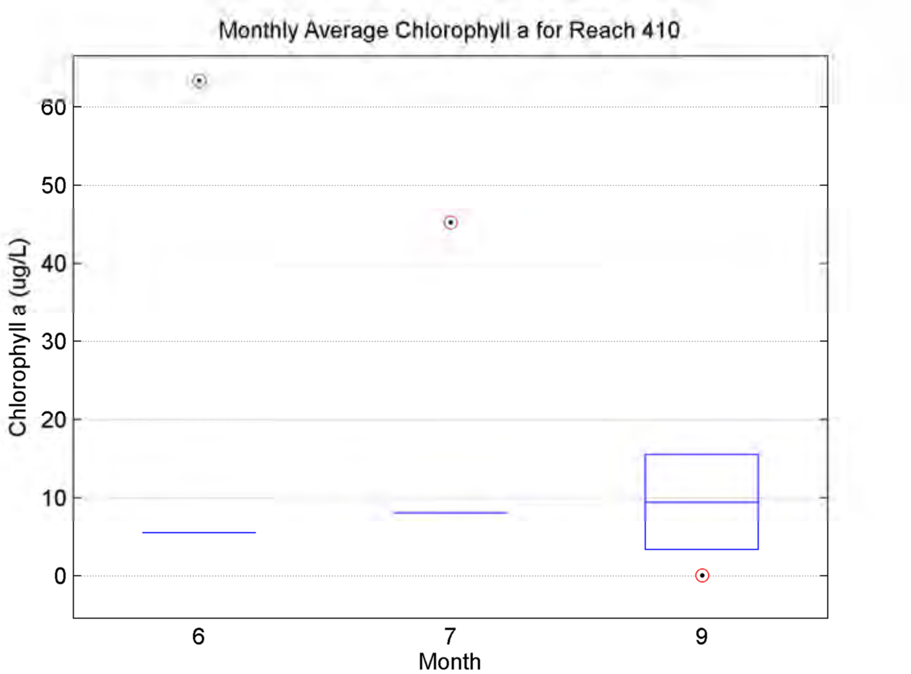

Figure B-29. Chlorophyll *a* Monthly Averages at Reach 410.

RSI-2428-14-048

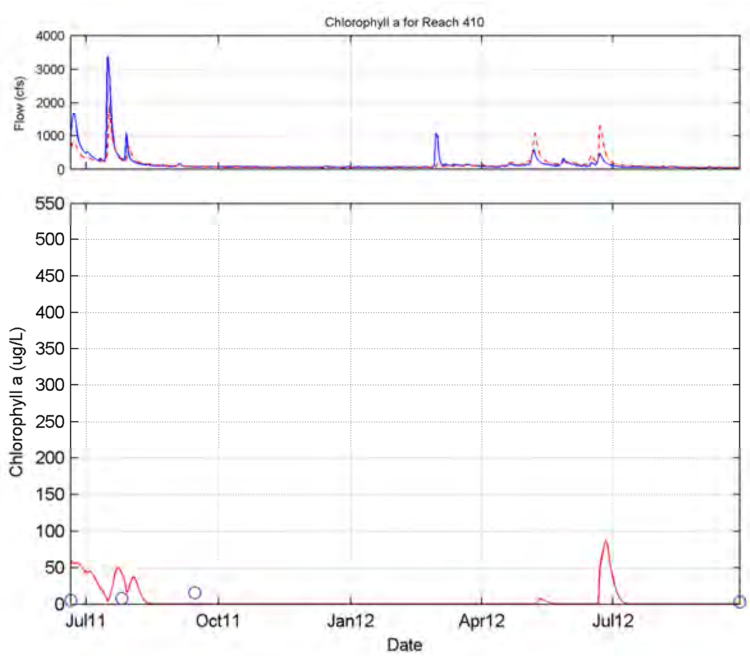

Figure B-30. Chlorophyll *a* Daily Time Series at Reach 410.

APPENDIX C

SHELL ROCK RIVER/WINNEBAGO RIVER WATER-QUALITY CALIBRATION FIGURES

RSI-2428-14-049

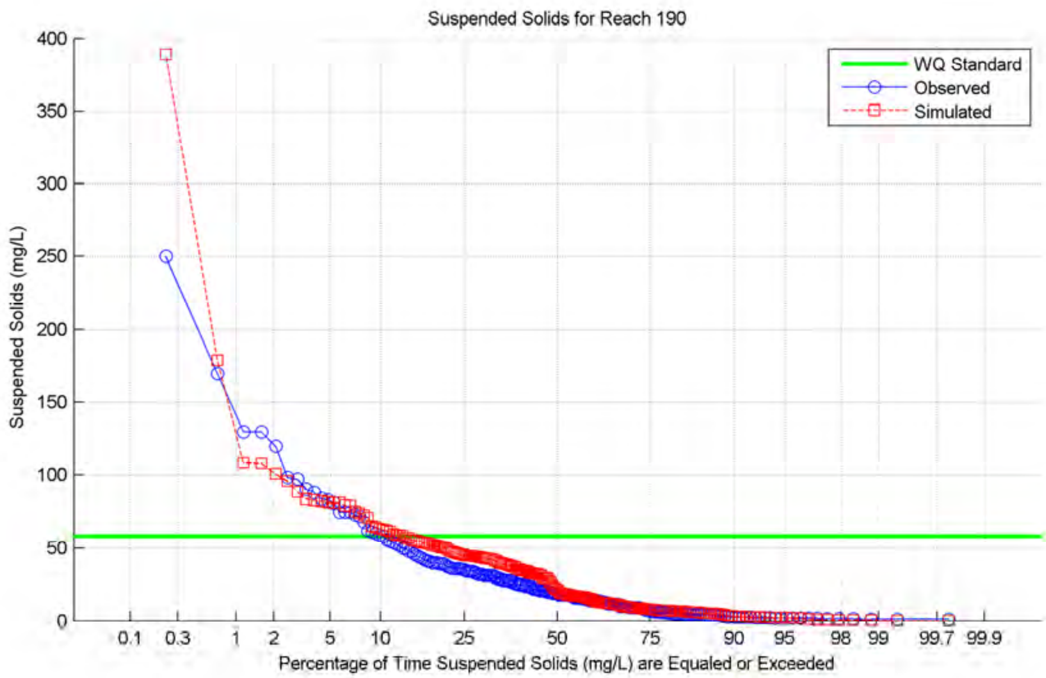

Figure C-1. Suspended Solids Concentration Duration Curve at Reach 190.

RSI-2428-14-050

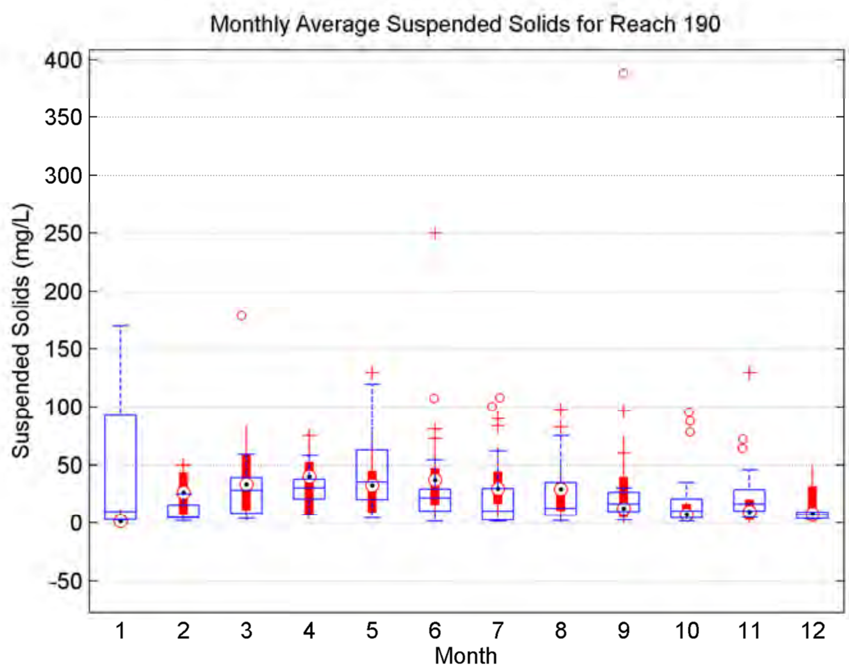

Figure C-2. Suspended Solids Monthly Averages at Reach 190.

RSI-2428-14-051

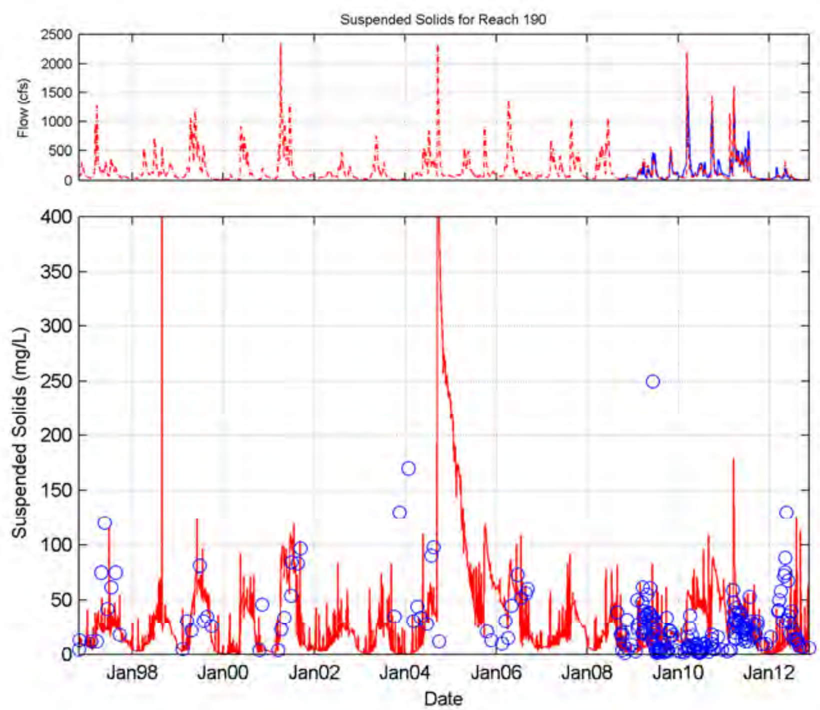

Figure C-3. Suspended Solids Daily Time Series at Reach 190.

RSI-2428-14-052

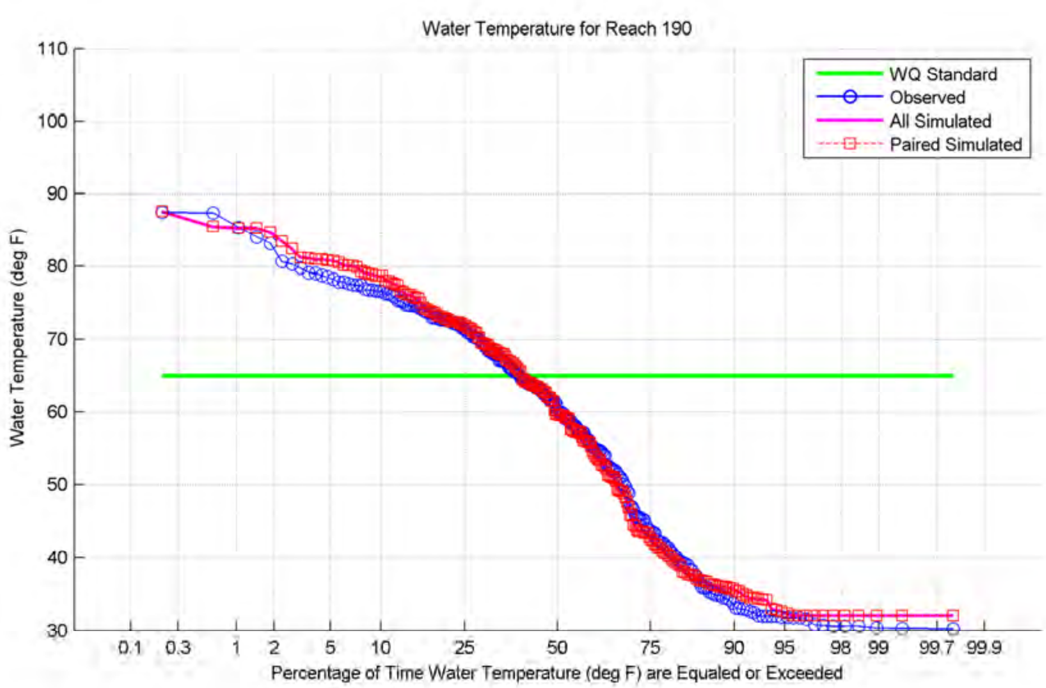

Figure C-4. Water Temperature Concentration Duration Curve at Reach 190.

RSI-2428-14-053

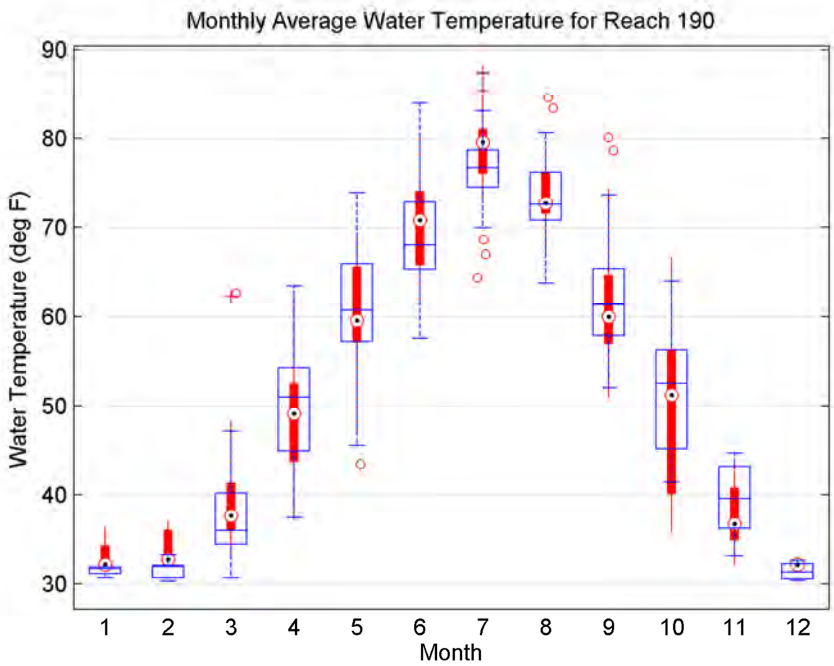

Figure C-5. Water Temperature Monthly Averages at Reach 190.

RSI-2428-14-054

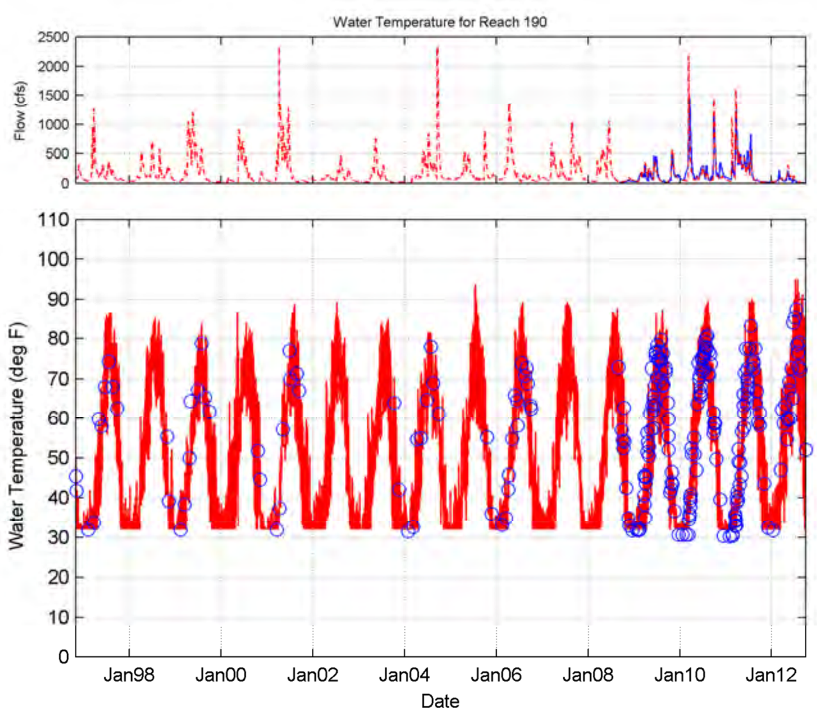

Figure C-6. Water Temperature Hourly Time Series at Reach 190.

RSI-2428-14-055

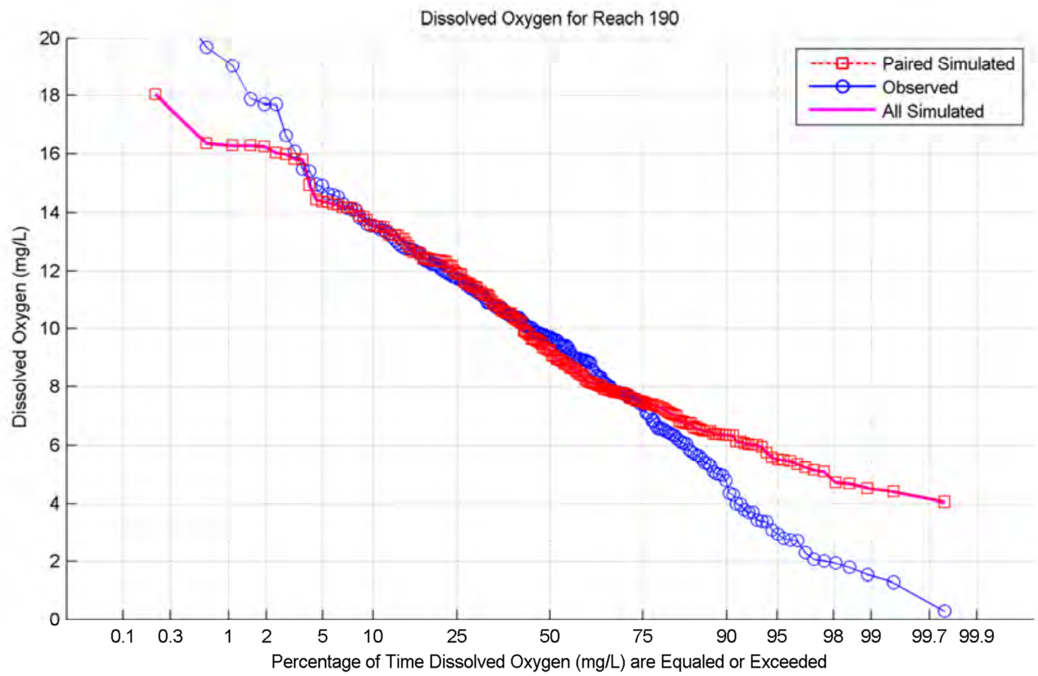

Figure C-7. Dissolved Oxygen Concentration Duration Curve at Reach 190.

RSI-2428-14-056

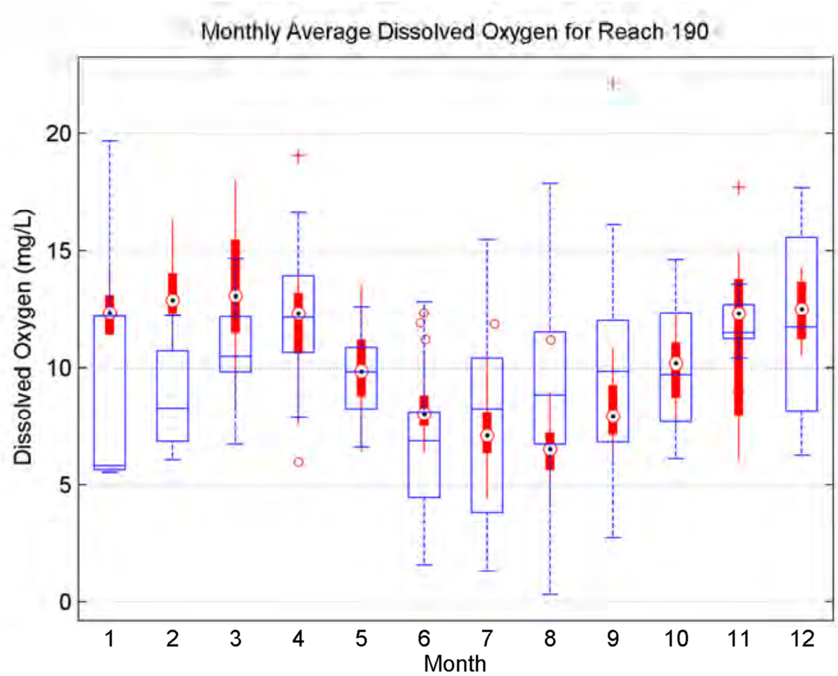

Figure C-8. Dissolved Oxygen Monthly Averages at Reach 190.

RSI-2428-14-057

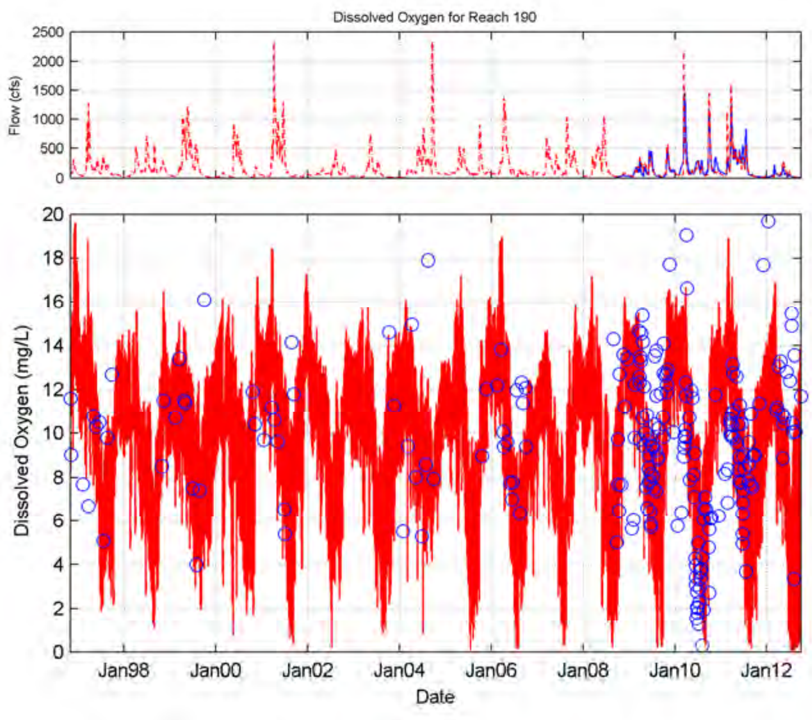

Figure C-9. Dissolved Oxygen Hourly Time Series at Reach 190.

RSI-2428-14-058

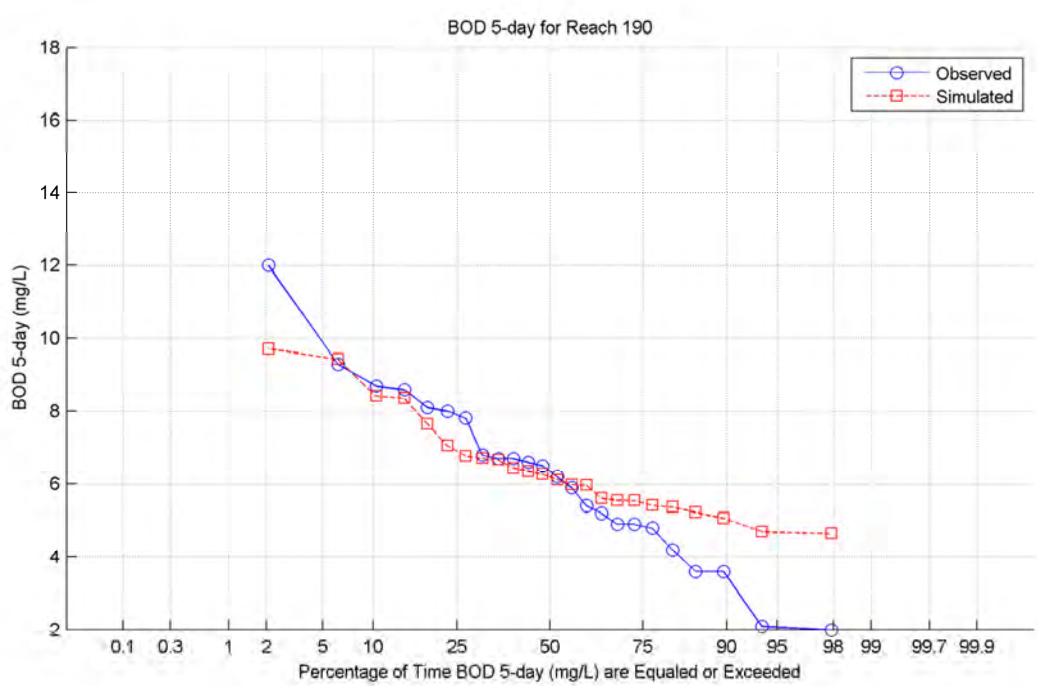

Figure C-10. 5-day Biochemical Oxygen Demand Concentration Duration Curve at Reach 190.

RSI-2428-14-059

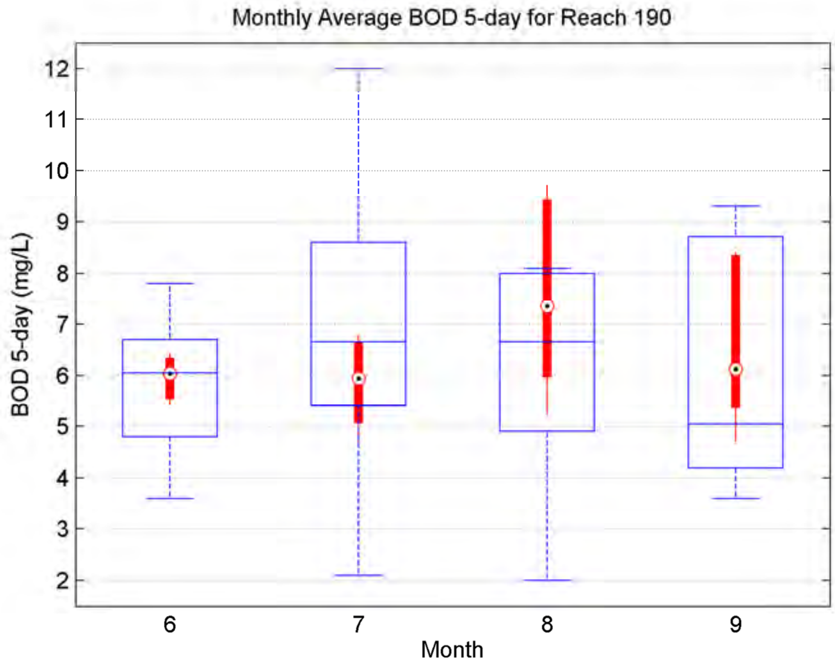

Figure C-11. 5-day Biochemical Oxygen Demand Monthly Averages at Reach 190.

RSI-2428-14-60

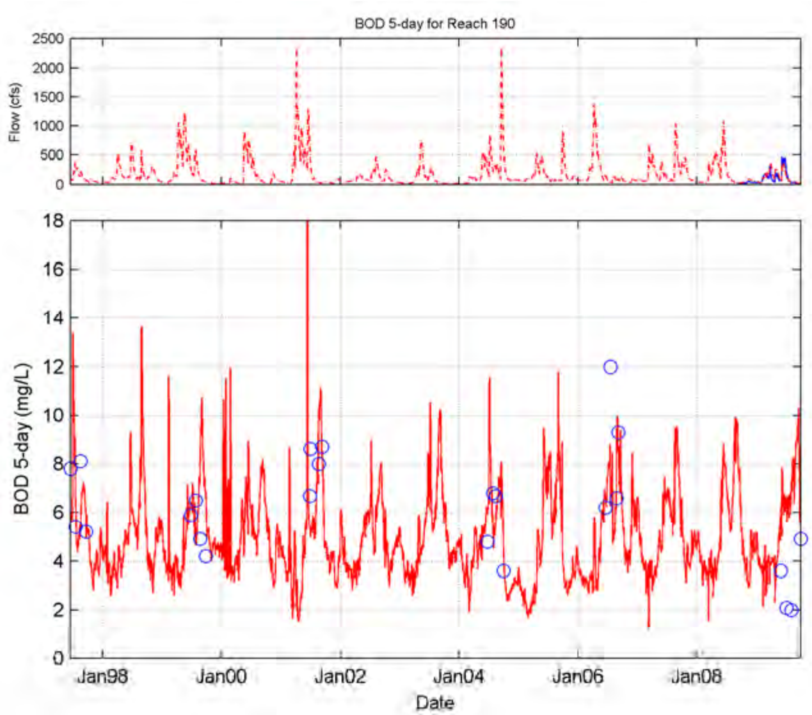

Figure C-12. 5-day Biochemical Oxygen Demand Hourly Time Series at Reach 190.

RSI-2428-14-61

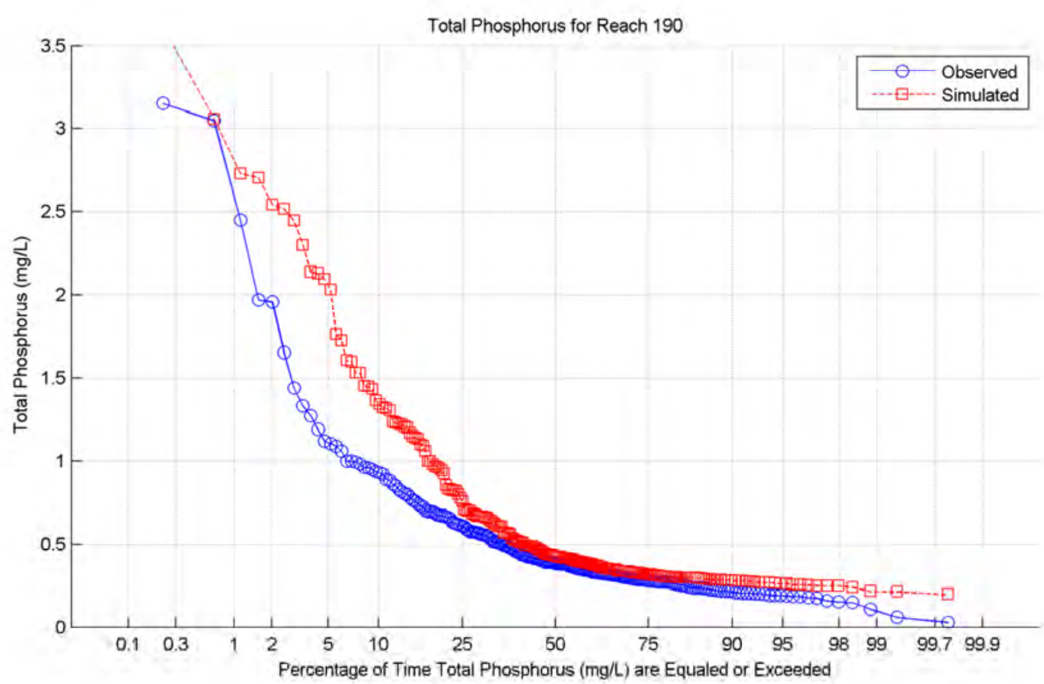

Figure C-13. Total Phosphorus Concentration Duration Curve at Reach 190.

RSI-2428-14-62

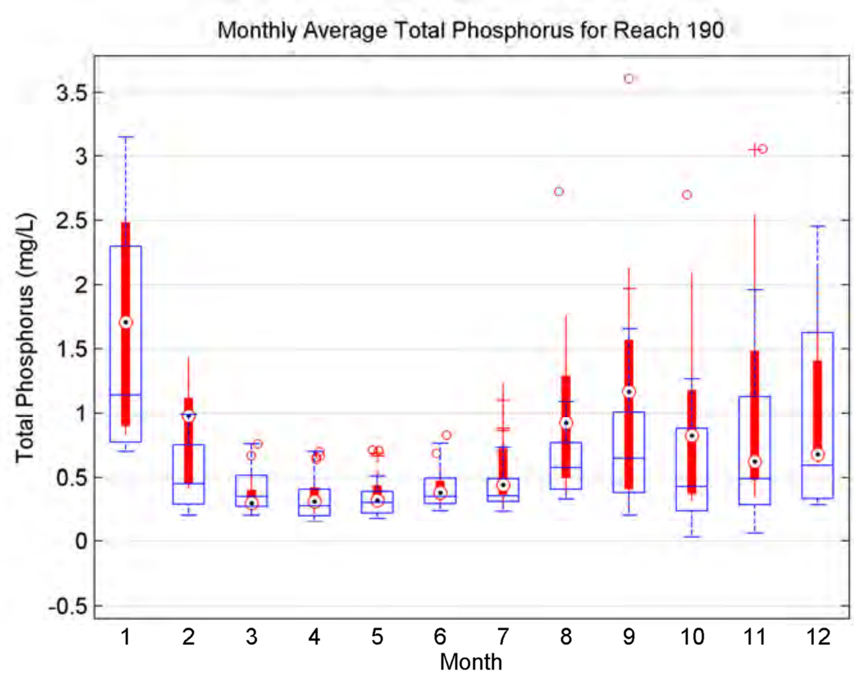

Figure C-14. Total Phosphorus Monthly Averages at Reach 190.

RSI-2428-14-63

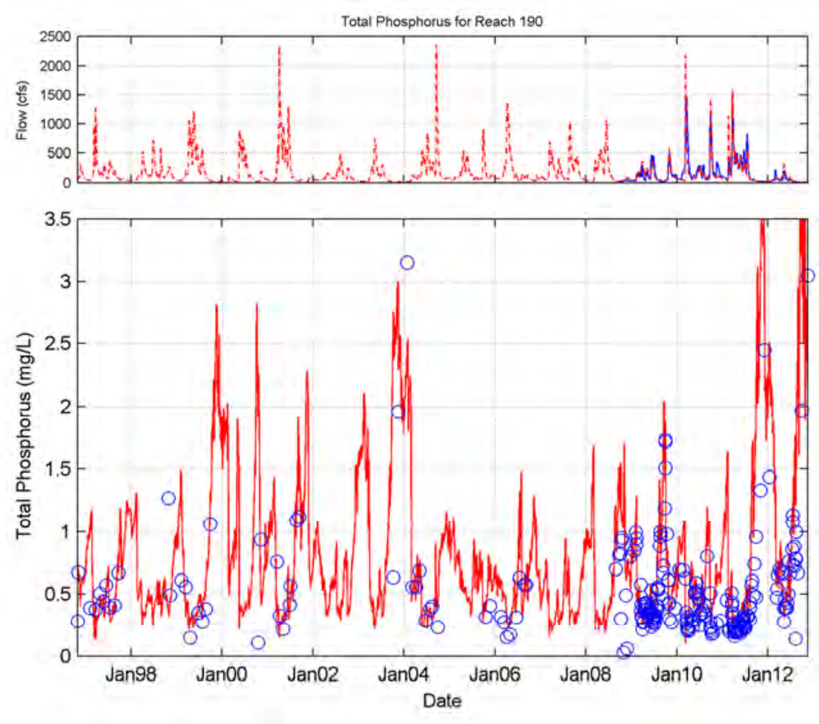

Figure C-15. Total Phosphorus Daily Time Series at Reach 190.

RSI-2428-14-64

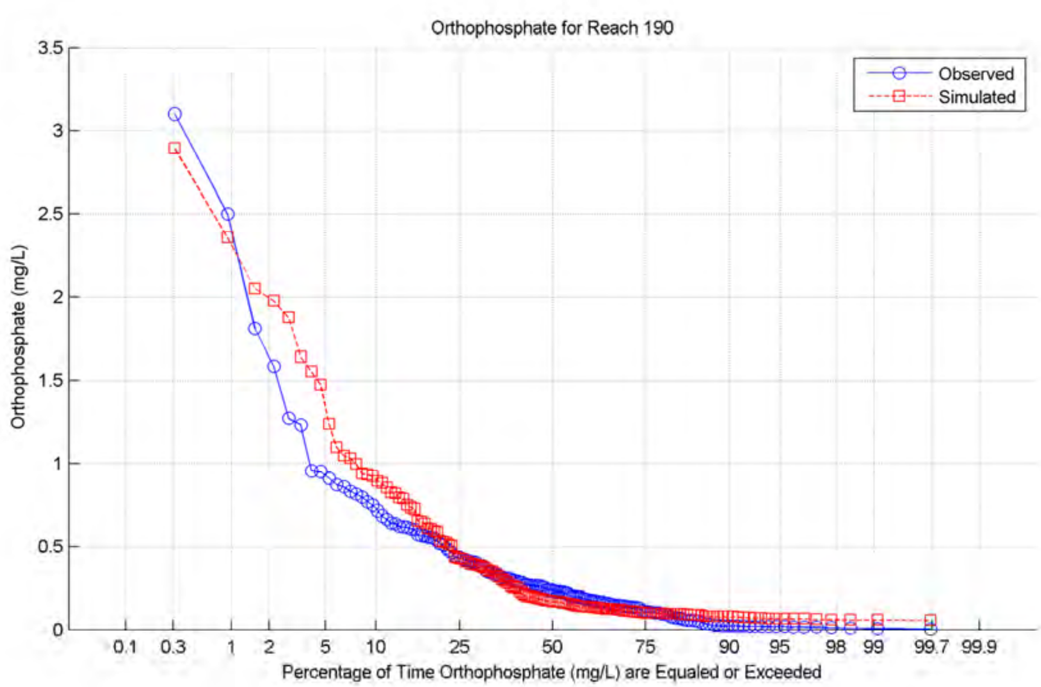

Figure C-16. Total Orthophosphate Concentration Duration Curve at Reach 190.

RSI-2428-14-65

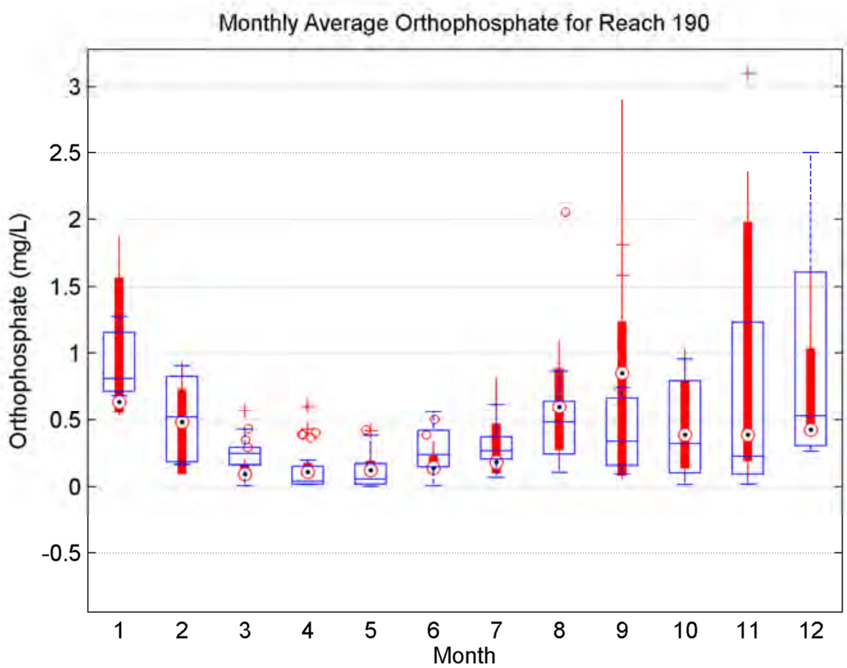

Figure C-17. Total Orthophosphate Monthly Averages at Reach 190.

RSI-2428-14-66

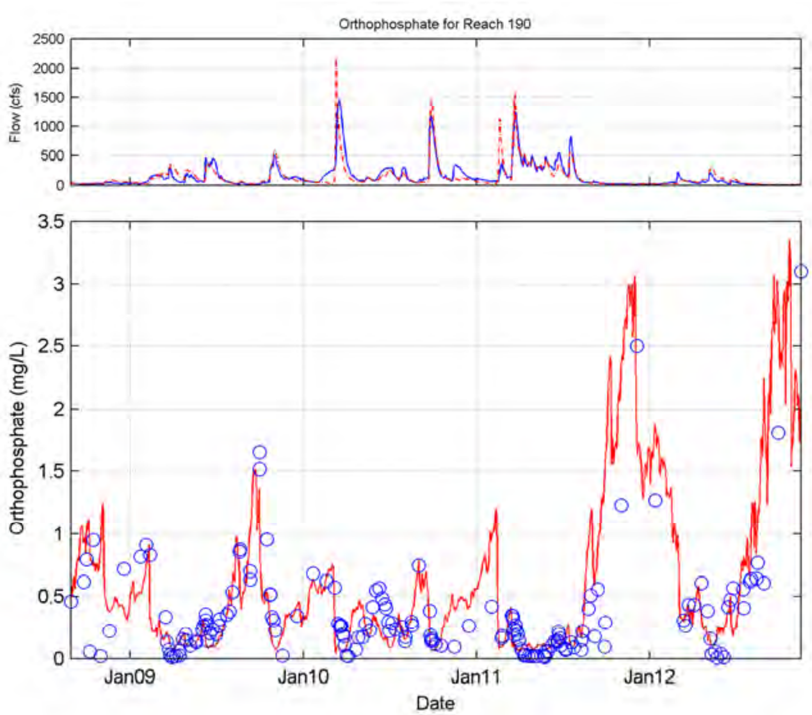

Figure C-18. Total Orthophosphate Daily Time Series at Reach 190.

RSI-2428-14-67

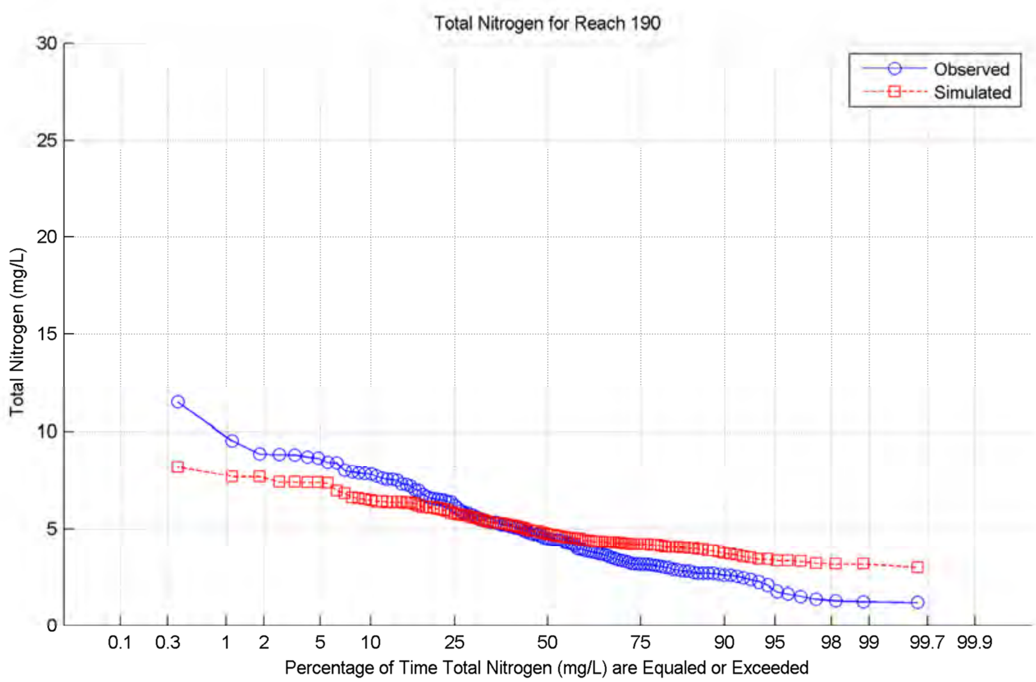

Figure C-19. Total Nitrogen Concentration Duration Curve at Reach 190.

RSI-2428-14-68

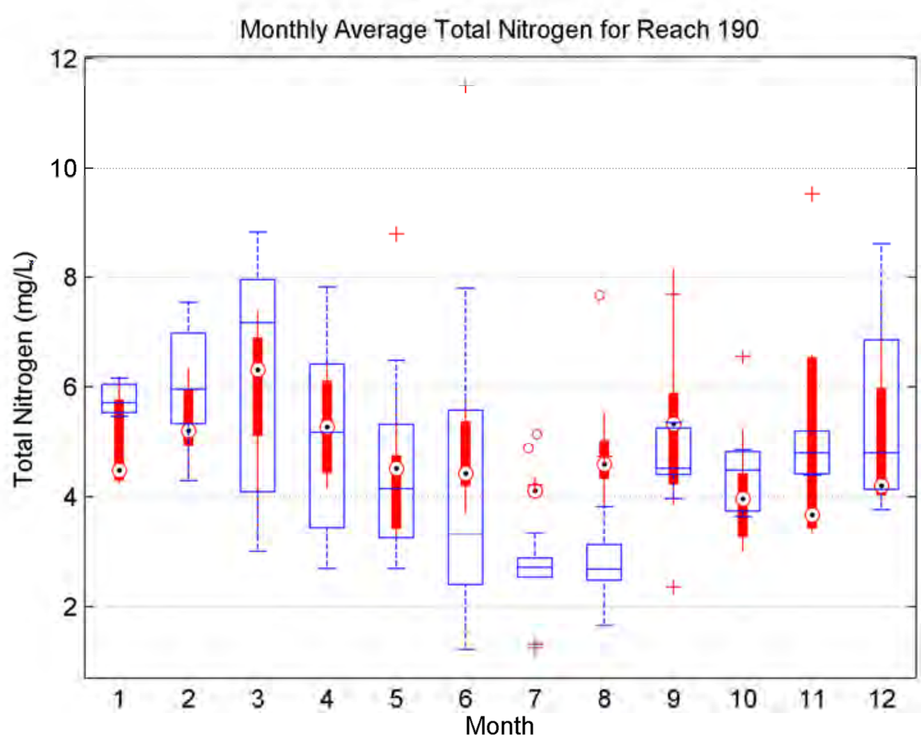

Figure C-20. Total Nitrogen Monthly Averages at Reach 190.

RSI-2428-14-69

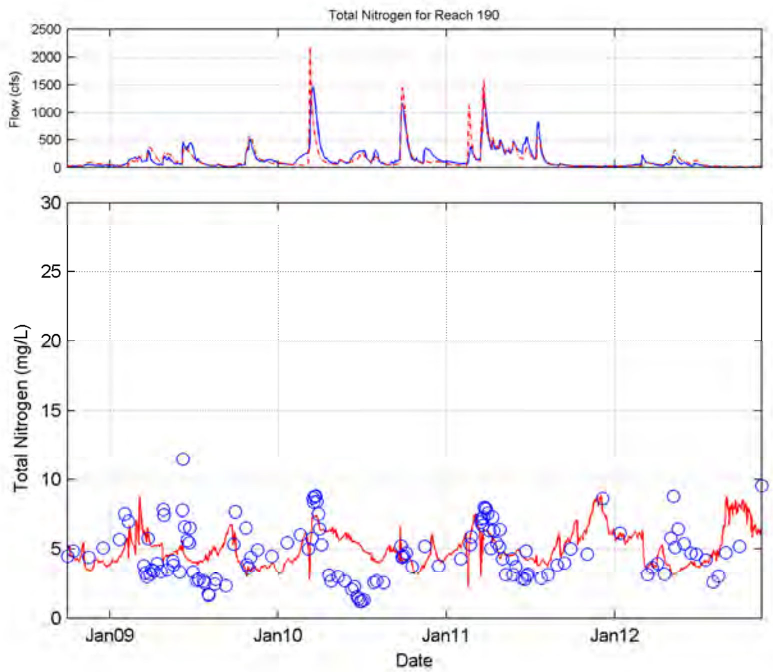

Figure C-21. Total Nitrogen Daily Time Series at Reach 190.

RSI-2428-14-70

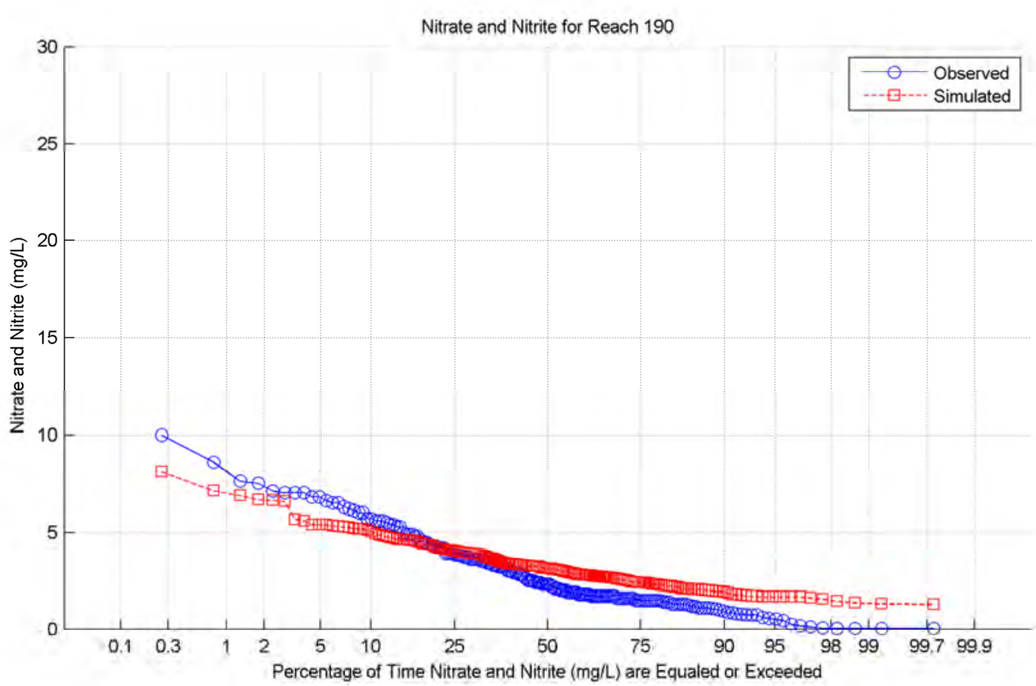

Figure C-22. Nitrate and Nitrite Concentration Duration Curve at Reach 190.

RSI-2428-14-71

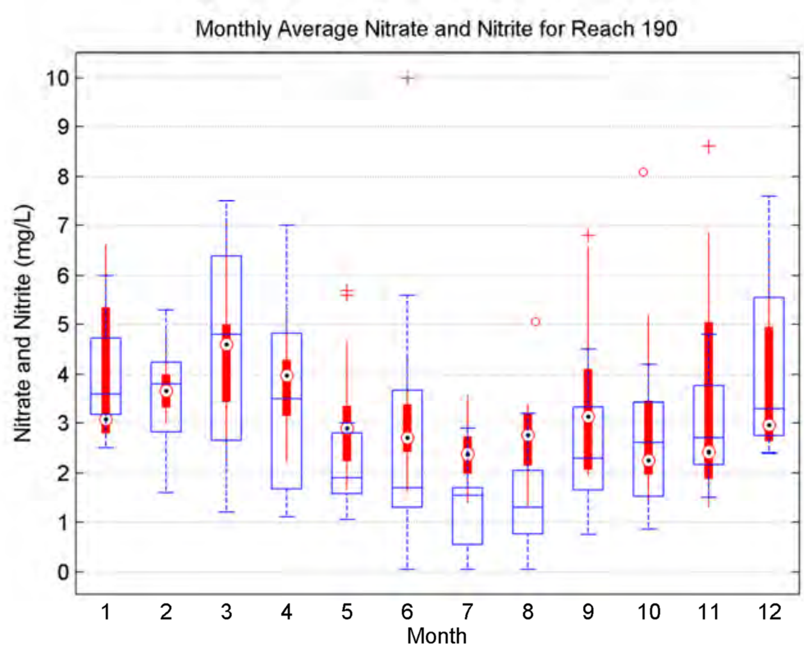

Figure C-23. Nitrate and Nitrite Monthly Averages at Reach 190.

RSI-2428-14-72

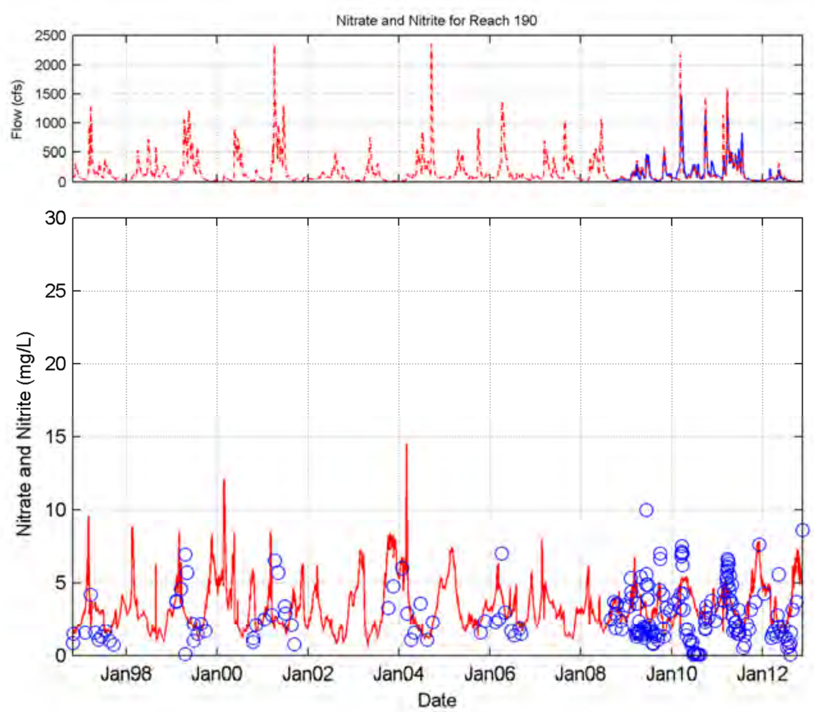

Figure C-24. Nitrate and Nitrite Daily Time Series at Reach 190.

RSI-2428-14-73

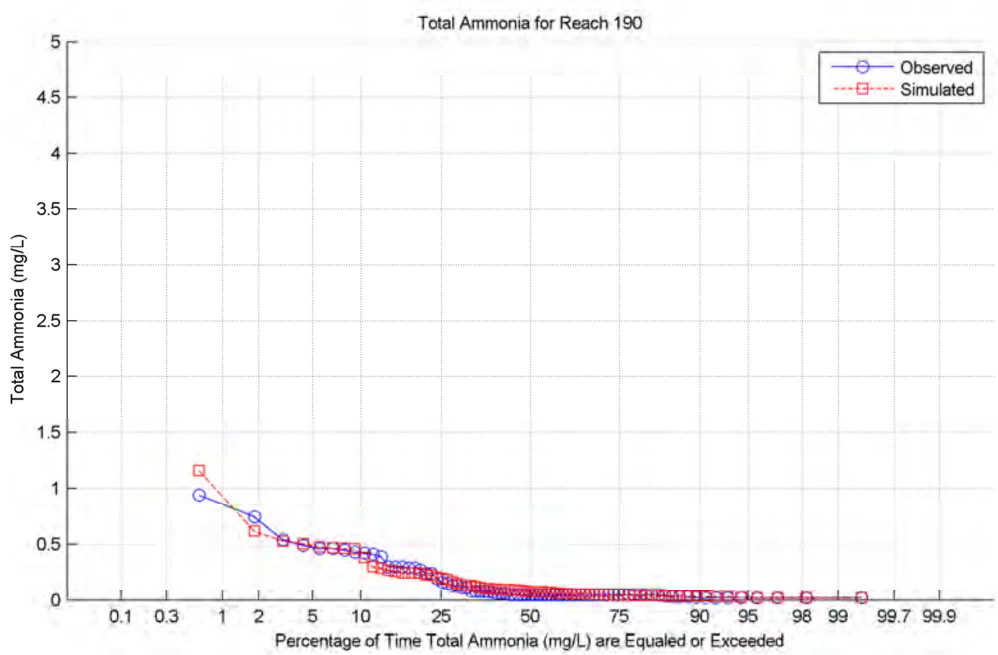

Figure C-25. Total Ammonia Concentration Duration Curve at Reach 190.

RSI-2428-14-74

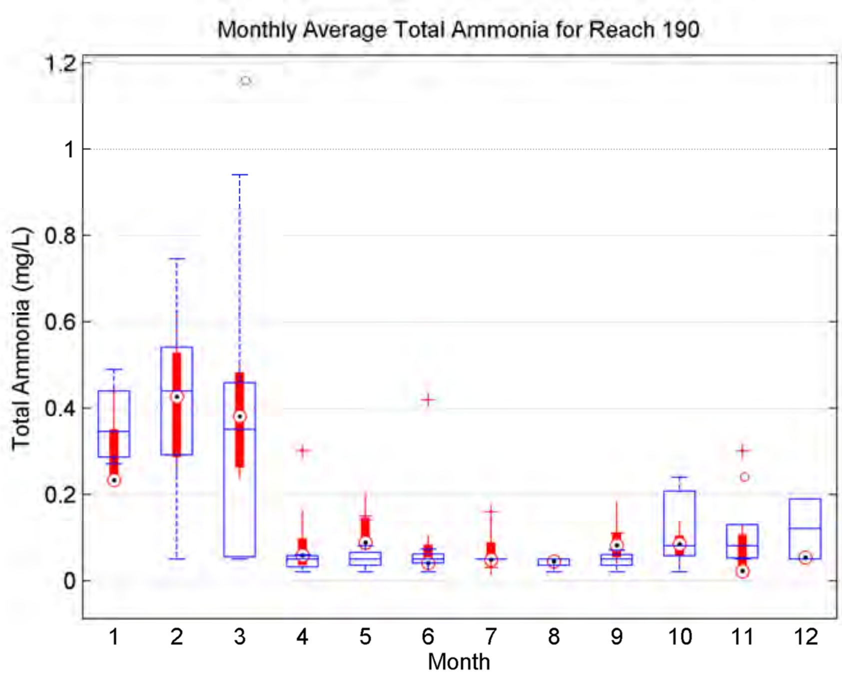

Figure C-26. Total Ammonia Monthly Averages at Reach 190.

RSI-2428-14-75

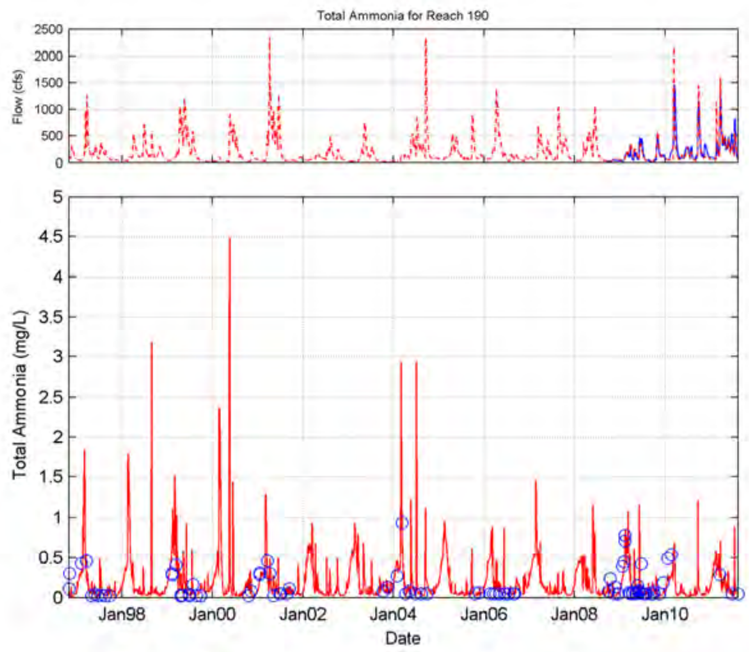

Figure C-27. Total Ammonia Daily Time Series at Reach 190.

RSI-2428-14-76

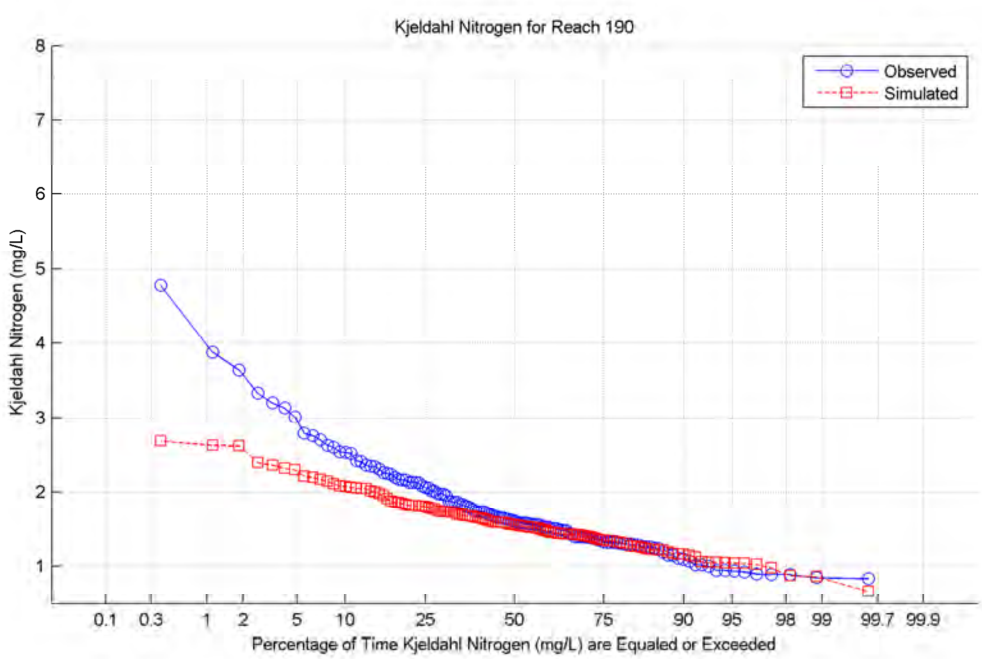

Figure C-28. Kjeldahl Nitrogen Concentration Duration Curve at Reach 190.

RSI-2428-14-77

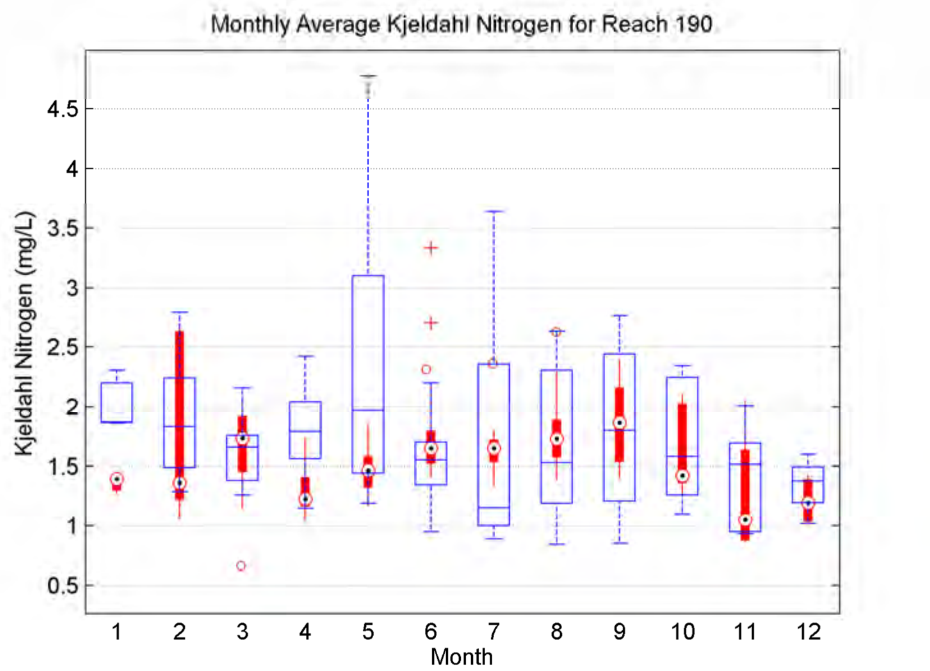

Figure C-29. Kjeldahl Nitrogen Monthly Averages at Reach 190.

RSI-2428-14-78

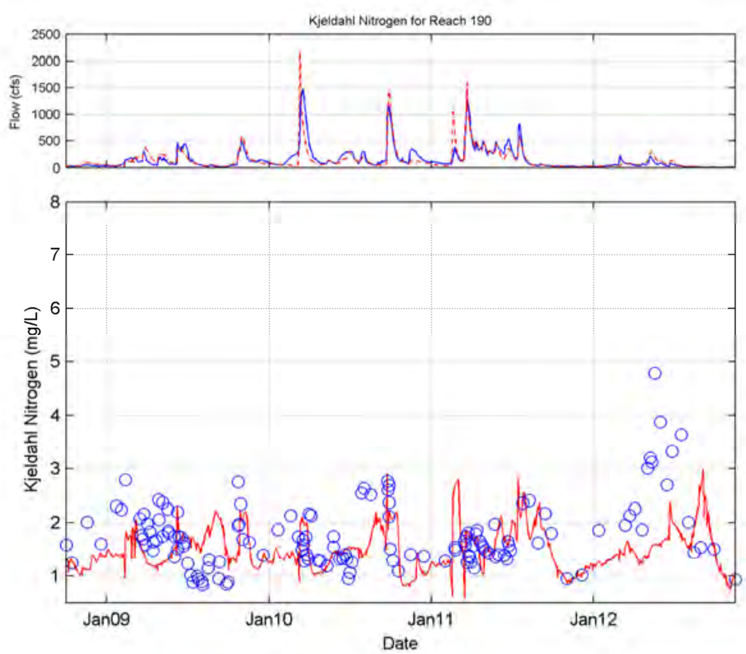

Figure C-30. Kjeldahl Nitrogen Daily Time Series at Reach 190.

RSI-2428-14-79

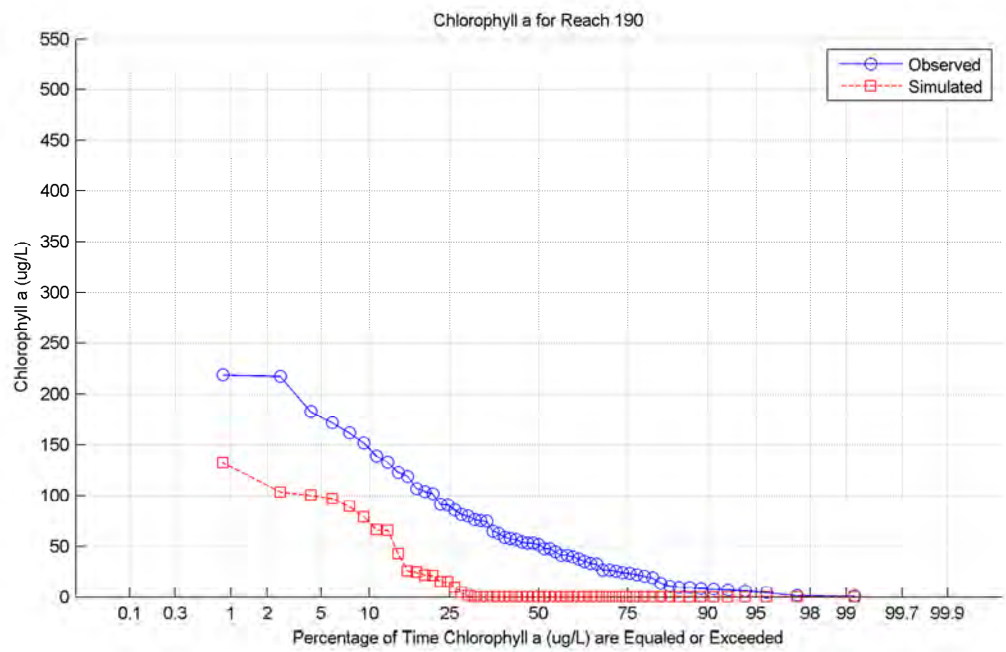

Figure C-31. Chlorophyll *a* Concentration Duration Curve at Reach 190.

RSI-2428-14-80

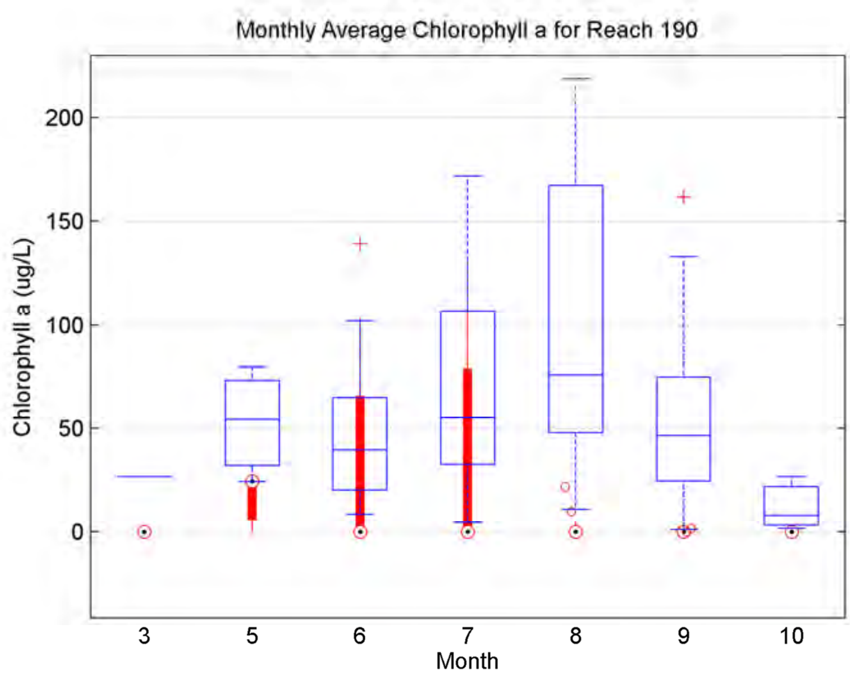

Figure C-32. Chlorophyll *a* Monthly Averages at Reach 190.

RSI-2428-14-81

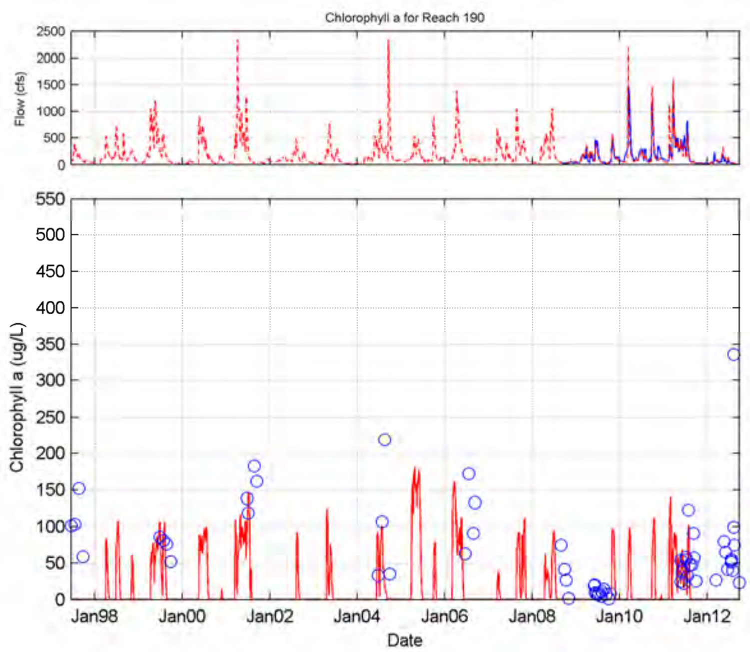

Figure C-33. Chlorophyll *a* Daily Time Series at Reach 190.