Bostwick Creek 9 Key Elements Plan

La Crosse County

Department of Land Conservation

September 2018

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1.0 Introduction

1.1 Bostwick Creek Setting

The Bostwick Creek Watershed (BL04) is located entirely within the County of La Crosse, Wisconsin. It is situated on the western edge of the State known as the Driftless Region.

It was untouched by the most recent glacial advance but was highly dissected by the glacial melt water created 12,000 years ago by the retreating glacier, leaving behind steep, incised valleys and narrow to broad ridge tops. The Bostwick Creek Watershed is situated ½ mile south of the Village of West Salem and 5 miles east from the center of the City of La Crosse. The Towns of Greenfield, Washington, Barre, Bangor and Hamilton lie within its borders.

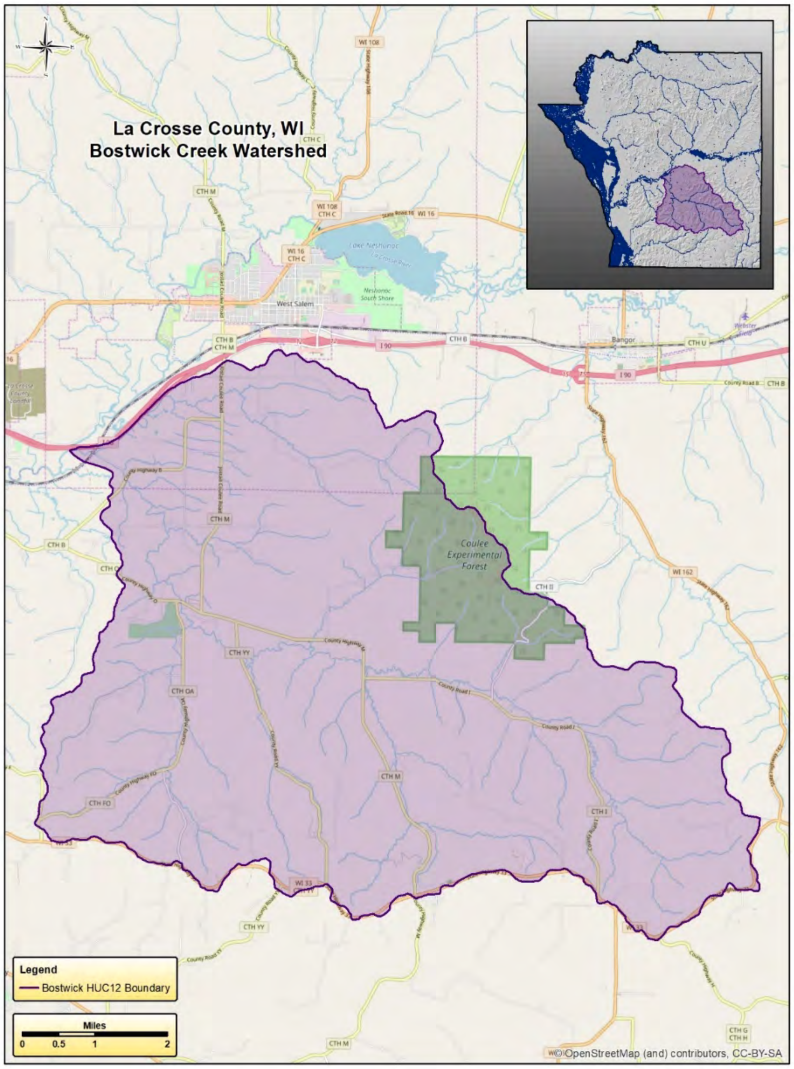

Figure 1 Bostwick Creek Watershed Map

It is a sub-watershed of the Lower La Crosse River Watershed (BL06). The Bostwick Creek Watershed drains 29,965 acres of land and is composed of 50% woodland and 46% agricultural land. The remaining 4% is classified as urban land use.

Bostwick Creek is a cold water stream that flows in a northwesterly direction. It stretches 13.2 miles from its headwaters to its mouth at the La Crosse River below Lake Neshonoc. It supports both Brook Trout and Brown Trout for much of its length.

It is designated as an exceptional resource water by the Wisconsin Department of Natural Resources from near its headwaters and extending for 12.4 miles downstream. However, the last 4 miles of Bostwick Creek is degraded, primarily from agricultural land uses, and is designated by the Wisconsin Department of Natural Resources as an impaired waterbody.

1.2 The Driftless Region

The Driftless Region of Wisconsin is a unique landscape comprised of deep valleys and steep bluffs. This area was bypassed by the most recent glacial advance but was highly dissected by the glacial melt water when the glaciers receded over 12,000 years ago.

The ridges and valleys created by the melt water were named coulees (gulches or ravines) by early French settlers resulting in this area becoming known as the "Coulee Region". This area of the upper Midwest is also called the Driftless Area due to the lack of recent glacial activity and absence of glacial drift material.

The Driftless Area has thousands of miles of coldwater streams that are primarily fed by groundwater seeps and springs. The network of coldwater streams supports rare species of aquatic plants, pollution-intolerant invertebrates as well as nongame fish and native brook trout.

Figure 2 Driftless Area Map – Courtesy of Trout Unlimited

Many of the Driftless Area streams are classified as trout waters and are prized by trout anglers. A 2017 report by University of Wisconsin – La Crosse economics professor, Donna Anderson, states that recreational trout fishing adds $952 million a year to the local economies in the Driftless Area.

1.3 Purpose

Bostwick Creek in La Crosse County is typical of cold water streams found in the Driftless Region however, years of agriculture activity has diminished the quality of its streams and fisheries. Excessive sedimentation and nutrient loading in Bostwick Creek has degraded aquatic insect and fish habitats and suppresses its recreational potential. Changes in farming practices, increased rainfall and snowmelt runoff rates have led to excessive in-stream sedimentation and degraded water quality.

Sediment from eroding streambanks and nearby croplands have changed the dynamics of Bostwick Creek. It has impacted its water quality, especially from Barre Mills to its mouth at the La Crosse River. In 2014, this stretch of Bostwick Creek has been listed as an impaired waterbody by the Wisconsin Department of Natural Resources due to excess phosphorus loads. This nonpoint pollutant load is deposited in the La Crosse River (also listed as an impaired water) and negatively impacts the La Crosse Marsh/Mississippi River complex. The purpose of this project is to reduce the sediment and phosphorus loads to Bostwick Creek, restore fish habitat and improve overall water quality.

1.4 US EPA Plan Requirements

The 1987 amendments to the Clean Water Act (CWA) established the Section 319 Nonpoint Source Management Program Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts. Under Section 319, states, territories and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects.

Clean Water Act Section 319(h) funds are provided only to designated state and tribal agencies to implement their approved nonpoint source management programs. State and tribal nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Each year, EPA awards Section 319(h) funds to states in accordance with a state-by-state allocation formula that EPA has developed in consultation with the states.

The nine elements from the USEPA Nonpoint Source Program and Grants guidelines:

1. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan
2. An estimate of the load reductions expected for selected management measures.
3. A description of the NPS management measures that will need to be implemented to achieve the load reductions and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement the plan.
4. 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 the plan.
5. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.
6. A schedule for implementing the NPS management measures identified in the plan.
7. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards.
9. A monitoring component to evaluate the effectiveness of the implementation efforts

1.5 Climate

La Crosse County lies within the Western Coulees and Ridges Ecological Landscape. It has a continental climate with cold winters and warm summers. The mean annual temperature is 43.7 degrees with a winter average temperature of 18.3 degrees and a summer average temperature of 70.9 degrees. The average daily minimum temperature is 9.5 degrees and an average daily maximum temperature of 81.9 degrees. The average annual total precipitation is 30.54 inches with an average seasonal snowfall of 41.5 inches. The prevailing wind is from the west to northwest during December through April and from the south during all other months. Average wind speeds are highest in March and April at around 11 miles per hour. The average relative humidity in midafternoon is about 61 percent. The sun shines 66 percent of the time in summer and 45 percent in winter. The mean growing season in the Western Coulees and Ridges Ecological Landscape is 145 days, which is favorable for growing agricultural row crops, small grains and pastures.

1.6 Geology and Landforms

La Crosse County lies within a unique landform known as the “Driftless Area”. The Driftless Area is also found in southeast Minnesota, northeast Iowa and northwest Illinois. Wisconsin has almost half of the Driftless Area within its borders. No glacial features are found in this region other than outwash sediments carried by rivers from glaciers to the north and east.

Glaciers have not been active in this area for at least 2.4 million years. Any glacial features since this time has been removed by erosion. The landscape left behind after the last glacial period in Wisconsin is characterized by deeply incised, steep-walled valleys and thin-soiled ridgetops with cold water streams in the valley floors. Geomorphic processes including sheet and gully erosion as well as soil creep shaped the hillslopes and transported soil material and debris to adjacent streams.

A thin to thick mantle of loess (wind deposited silty soil particles) covers most of the landscape with the thickest deposits on the ridges and closer to the Mississippi River. Much of the loess was moved downslope by erosion and has been incorporated into floodplain deposits. Stream cutting and deposition formed floodplains, terraces, swamps, sloughs and marshes along streams and rivers on valley floors.

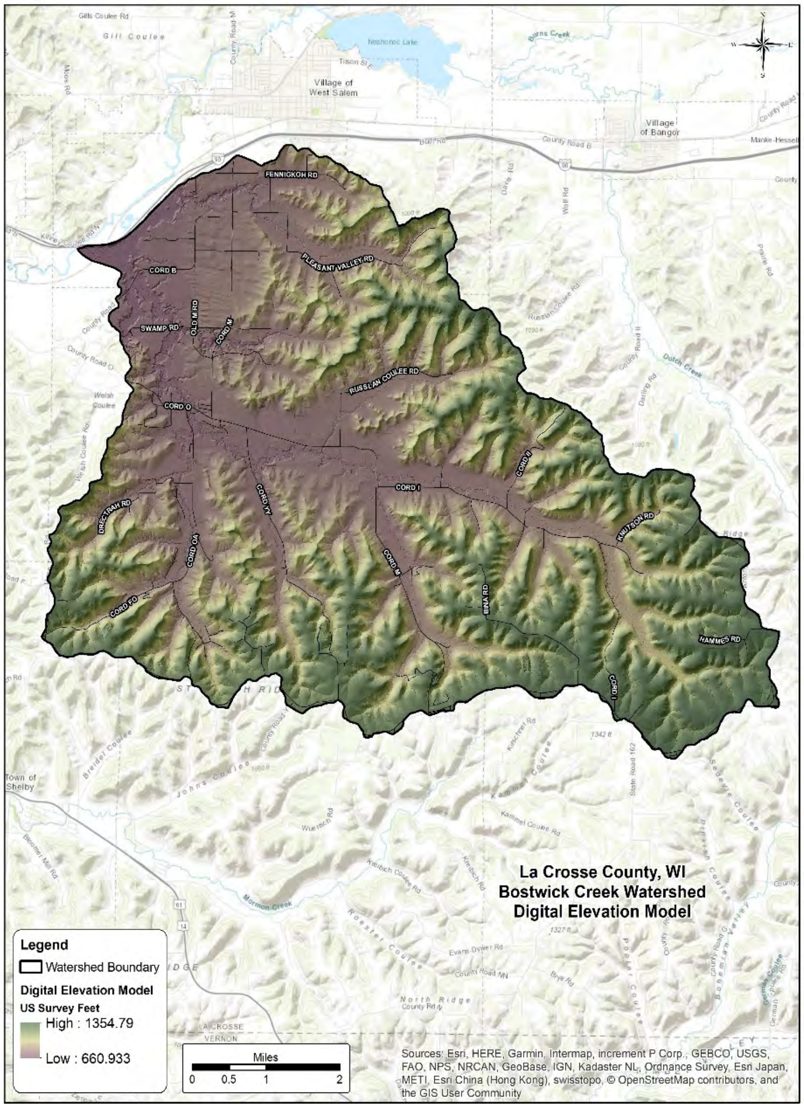

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Figure 3 Bostwick Creek Watershed Digital Elevation Model

The geologic makeup of La Crosse County varies from south to north as well as from west to east. To the south are broad, flat uplands developed on erosion-resistant Ordovician dolomite of the Prairie du Chien Group. These uplands contrast with narrow ridges in the north, which are capped by erosional remnants of dolomite from the Prairie du Chien group and interspersed with rolling lowlands and occasional bluffs formed by sandstone.

The Mississippi River forms the west boundary of La Crosse County. This area is characterized by extensive marsh lowlands along Lake Onalaska and the Mississippi backwater areas and flat, broad terraces adjacent to the east. Other rock types found throughout La Crosse County include sandstone, siltstone, shale, silty and sandy dolomite and dolomite with and without significant amounts of chert.

1.7 Soils

Soil characteristics in La Crosse County are the products of the resulting geology, landforms, relief, climate and natural vegetation in the area. The soils on bluff tops and side slopes are formed predominantly in loess, loamy to clayey residuum and loamy colluvium over limestone or sandstone.

They range from well-drained to moderately well-drained and typically have silt loam to sandy loam surface textures, moderate permeability and moderate available water capacity. The broader valleys usually contain stream terraces formed due to outflow from glaciation and have soils formed in outwash sands. The more narrow valleys are comprised of silty and loamy residuum and alluvium. They range from well drained to very poorly drained soils and have areas subjected to periodic flooding.

Soils data used for the analysis of the Bostwick Creek watershed nonpoint pollution models were provided by the USDA-Natural Resources Conservation Service (SSURGO) database.

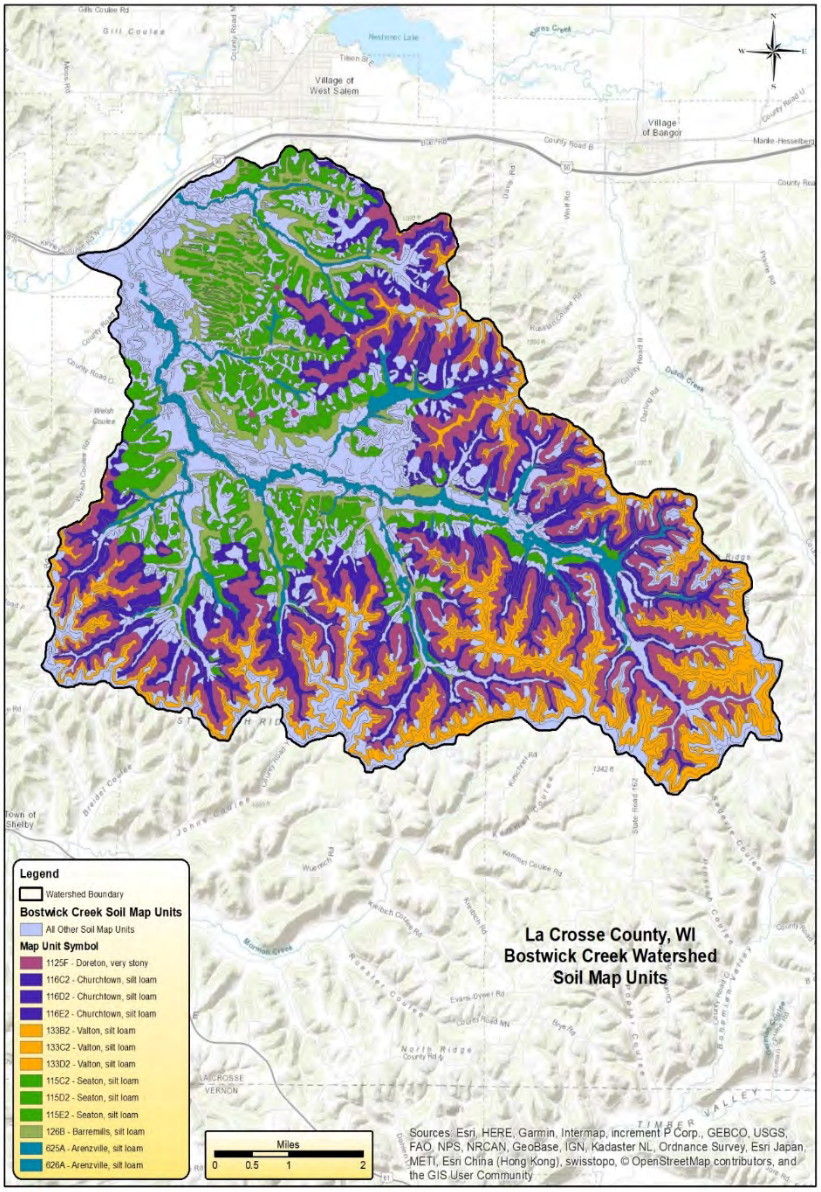

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Figure 4 Bostwick Creek Watershed Soil Map Units

Table 1 Soil Types

Doreton	**very stony**	**30 to 60 percent slopes**	**(17.3 %)**
Churchtown	**silt loam**	**6 to 30 percent slopes**	**(16.1%)**
Valton	**silt loam**	**2 to 20 percent slopes**	**(13.9%)**
Seaton	**silt loam**	**6 to 30 percent slopes**	**(12.1%)**
Barremills	**silt loam**	**1 to 6 percent slopes**	**(5.7%)**
Arenzville	**silt loam**	**0 to 2 percent slopes**	**(4.6%)**
All Others			**(30.3%)**

Land Capability Classes

Land capability classes are practical groupings of soil limitations based on such characteristics as erosion hazard, droughtiness, wetness, stoniness and response to management. Land classes are designated using roman numerals I through VIII.

Class I land has the widest range of use with the least risk of being damaged. Land in this class can be cultivated with almost no risk of erosion. It is nearly level, well-drained and productive. Class II land has slight limitations as compared to Class I land. It can be cultivated but may be gently sloping and need moderate erosion control practices to maintain productivity.

Class II land may also be slightly droughty, slightly wet or somewhat limited in depth. Class III land can be cropped but usually requires extensive use of conservation practices to control erosion or provide drainage. Class IV land has limitations that restricts cultivation and requires intense conservation measures.

Generally it is best adapted for pastures and woodlots. Class IV land is not suited for cultivation because it is too wet or too stony or because the growing season is too short. It can produce good pastures and forests. Class VI or VII land use is severely limited because of erosion hazards. Under careful management, it can be used for pasture. Class VIII land is not suited to farming. Usually it is severely eroded or is extremely sandy, wet, arid, rough, steep or stony.

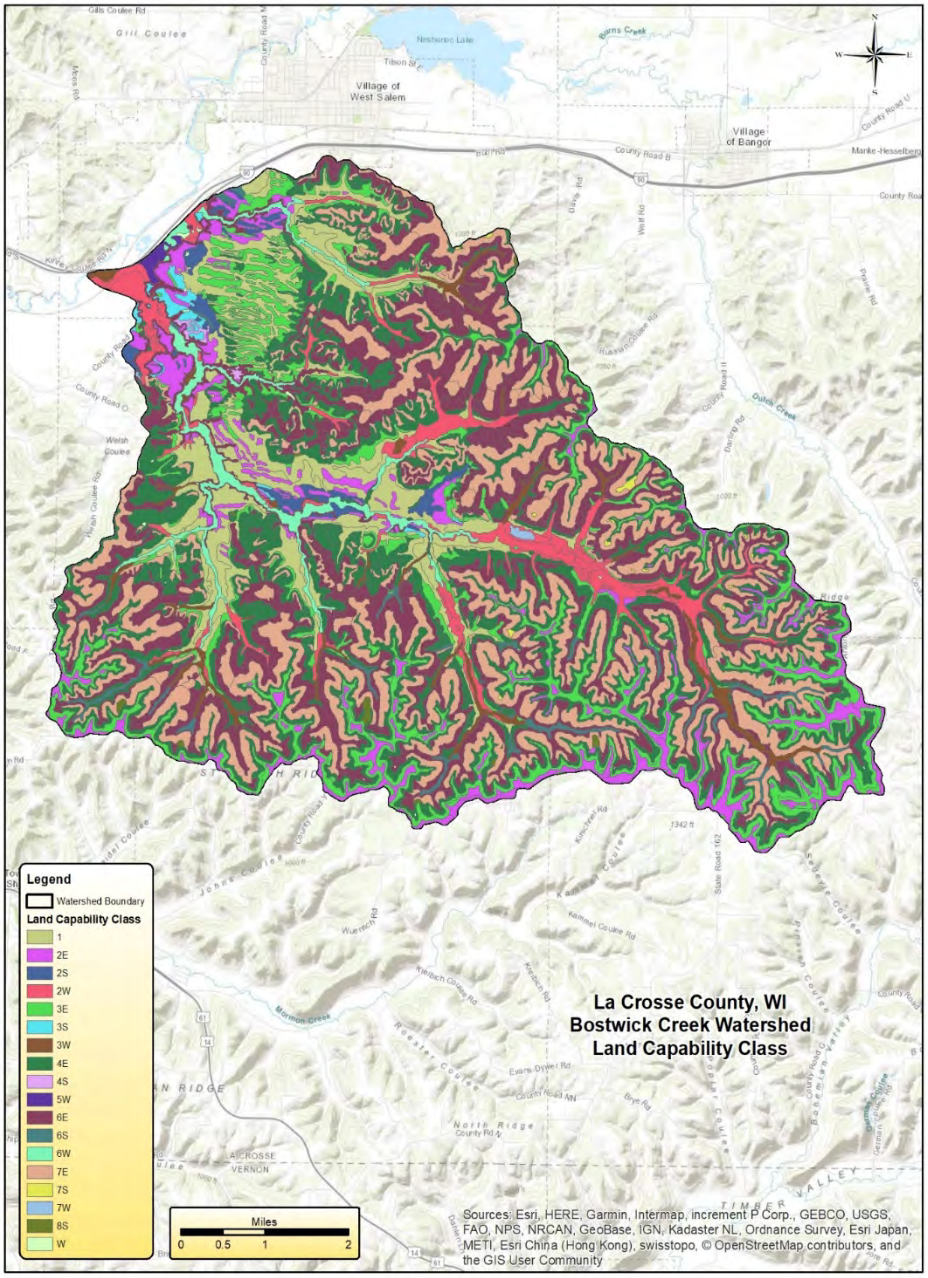

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Figure 5 Bostwick Creek Watershed Land Capability Class Map

Hydrologic Soil Group

Soils are classified into hydrologic soil groups to indicate the minimum rate of infiltration obtained for a bare soil after prolonged wetting. The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. Hydrologic soil group also indicates the transmission rate – the rate at which the water moves within the soil. This rate is controlled by the soil profile. Along with land use, management practices and hydrologic conditions, the hydrologic soil group determines a soil's associated runoff curve number. Runoff curve numbers are used to estimate direct runoff from rainfall. Soil scientists have defined 4 hydrologic soil groups. They are as follows;

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission.

Group B soils have moderate rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission.

Group D soils have a high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

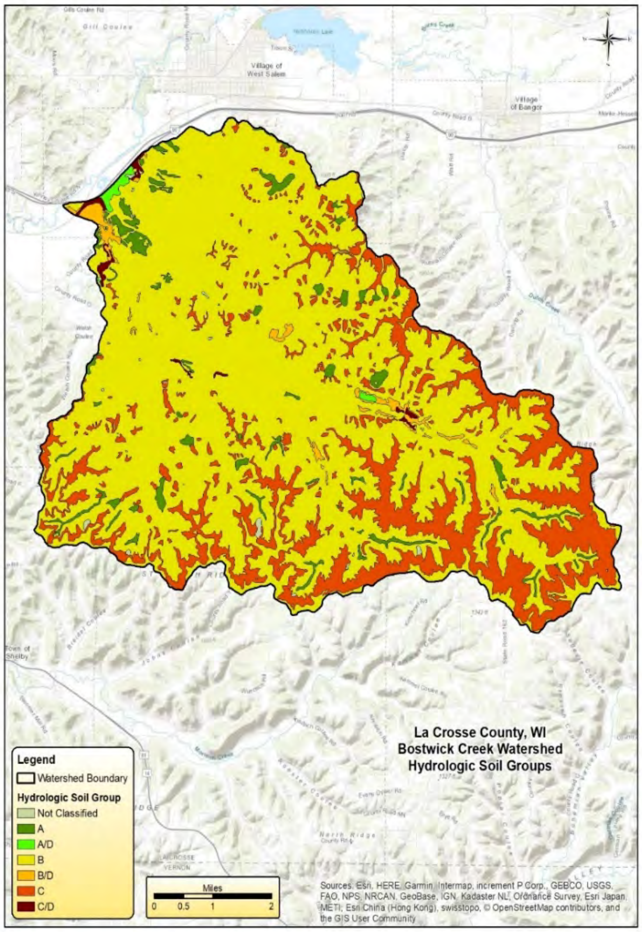

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Figure 6 Bostwick Creek Watershed Hydrologic Soil Groups Map

Table 2 Hydrologic Soil Group

Hydrologic Soil Group	Acres	Percent
A	**833.3**	**2.8**
A/D	**90.9**	**0.3**
B	**17,981.8**	**59.9**
B/D	**319.2**	**1.0**
C	**6,230.0**	**20.7**
C/D	**123.0**	**0.4**

Soil Erodibility

Soil erodibility is an indicator of a soil's susceptibility to raindrop impact, runoff, and other erosive processes. Each soil type has inherent physical and chemical properties that make it more or less resistant to erosional forces by wind and water.

Soils high in clay content are less susceptible to erosion because they are more resistant to soil particle detachment whereas coarse textured soils, such as sandy soils, are easily detached but have larger particle size and higher infiltration rates.

Soils having a high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff.

Soil Scientists at the USDA Natural Resources Conservation Service have assigned erodibility values for all soil types. This value is known as the K factor.

The K factor value is one of six factors used in the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of erosion by sheet and rill erosion in tons/acre/year. The K factor values for soils in Bostwick Creek range from .02 to .64. The majority of soils in Bostwick Creek, nearly two thirds, have K factors between .43 and .55 placing them in the high end of erodibility values.

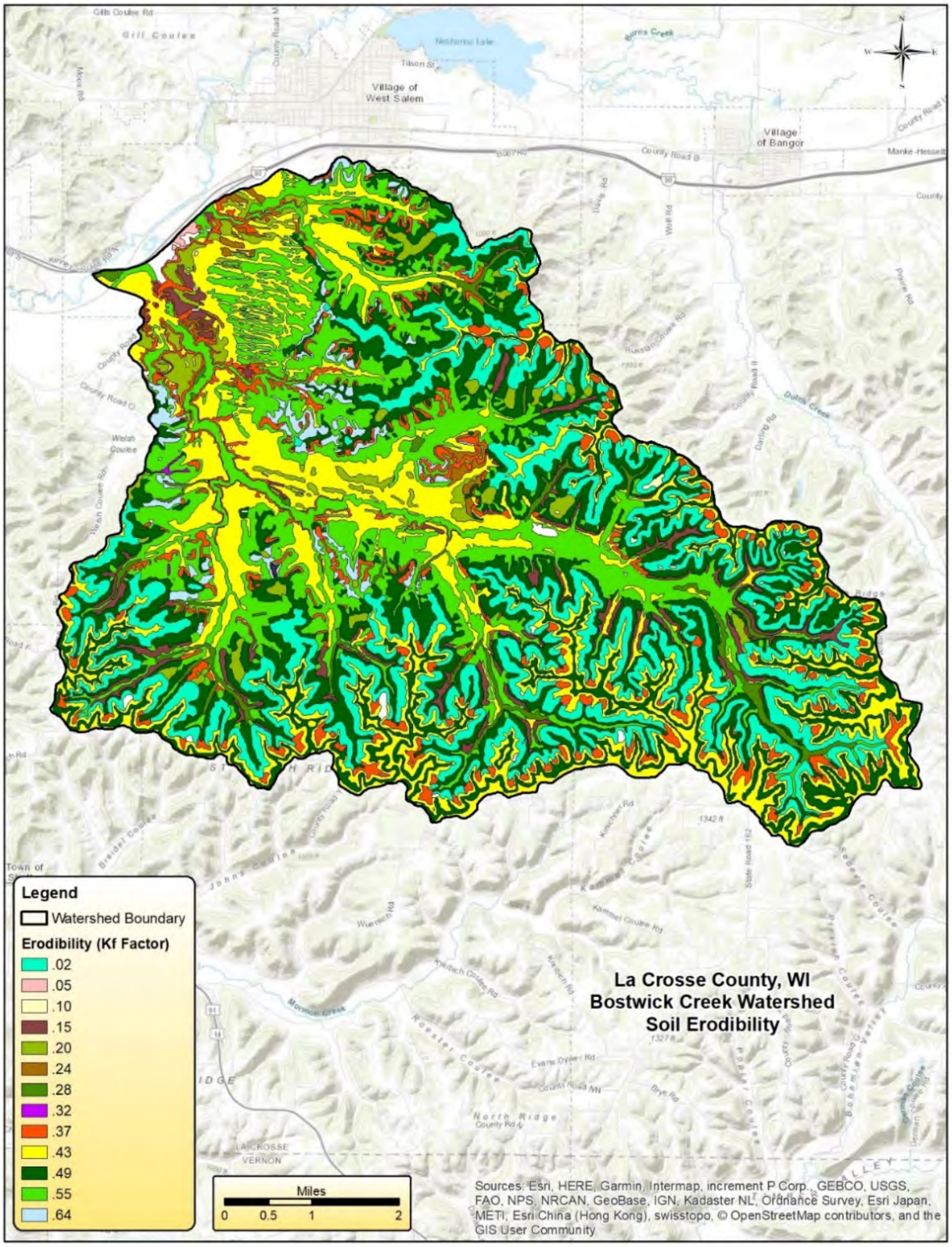

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Figure 7 Bostwick Creek Watershed Soil Erodibility Map

2.0 Watershed Jurisdictions and Demographics

2.1 Demographics

County wide, agriculture and forest lands make up for 70.3 percent of the County's land area. Residential lands make up approximately 6.4 percent of the County's acreage.

La Crosse County's population has grown between 10 and 15 percent each of the past several decades. The estimated population of La Crosse County in 2016 stands at 118,122 people. Certain parts of the county have large amounts of growth, including the Town of Holland, the Village of Holmen, and the Village of West Salem. These areas of the county are projected to grow throughout the next 30 years.

Other places in La Crosse County, including the Town of Shelby and the Town of Medary, are projected to see their declining populations stabilize over the next thirty (30) years. La Crosse County has an overall density of 236 people and 107 homes per square mile. The County's municipalities (La Crosse, Onalaska, Holmen, West Salem, Bangor, and Rockland) have an average density of 1,600 people and 664 homes per square mile. The County's urban communities have a density of nearly 700 homes per square mile. Some of the County's more rural Towns, including Washington, Burns, and Bangor have less than 10 homes per square mile.

2.2 Watershed Jurisdictions

The Bostwick Creek Watershed is located entirely within La Crosse County, Wisconsin. It contains sections of the Towns of Barre, Greenfield, Washington, Bangor and Hamilton. Portions of the Department of Natural Resources Experimental Forest are also within the Bostwick Creek Watershed boundary.

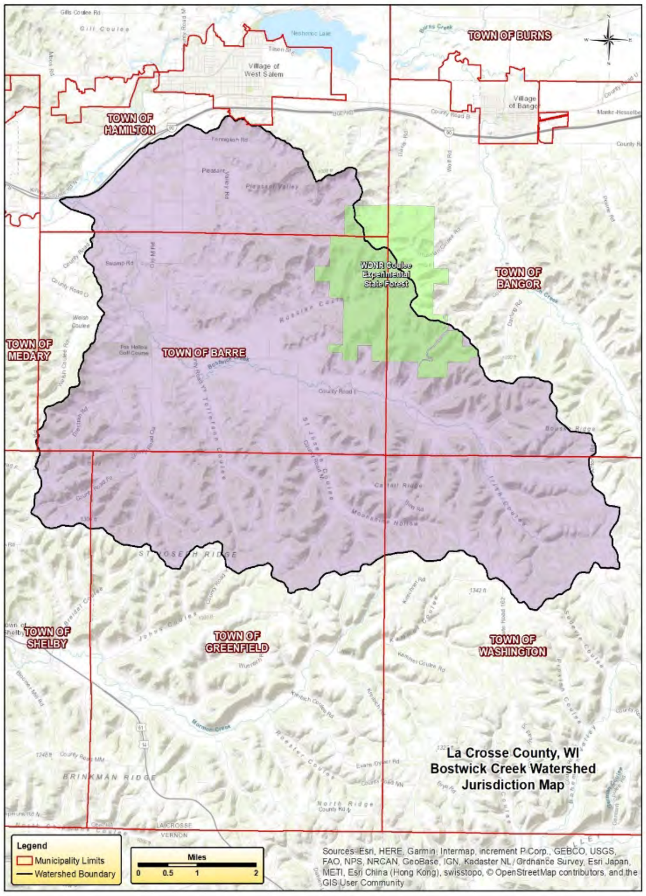


Figure 8 Bostwick Creek Watershed Jurisdiction Map

2.3 Jurisdictional Roles and Responsibilities

La Crosse County revised its Comprehensive Plan in 2016. In conjunction with other local municipalities, the county has developed a model for future land uses that protect the vast natural resources of La Crosse County while providing for controlled growth and development. All of La Crosse County Towns within the Bostwick Creek Watershed have adopted the County's Zoning Code to protect public health, safety and general welfare of its citizens. La Crosse County has enacted the following ordinances for environmental protection purposes; Flood Plain Zoning, Shoreland Zoning, Erosion Control/Land Disturbance, Animal Waste Management, Post Construction Storm Water Management, Comprehensive Plan 2007-2027 and Farmland Preservation. La Crosse County Department staff works with other local units of Government to implement and enforce the adopted ordinances.

3.0 Land Use/Land Cover

The Bostwick Creek Watershed is rural in character as the vast majority of the land use is agriculture and woodlands. Agricultural land use makes up 46% of all land in the watershed at 11,066 acres with forests covering 50% of the landscape at 13,195 acres. There is minimal development in the Bostwick Creek Watershed with only 1,200 acres classified as urban. There are no incorporated villages or cities within the watershed boundaries.

3.1 Agricultural land Use

Agriculture in La Crosse County generated $86.5 million in farm receipts in 2012 according to the US Department of Agriculture. Crop production, primarily corn, soybeans and hay, made up $38.7 million in sales while milk from cows produced $34.5 million. Agricultural products sold in 2012 generated a 42% increase over the 2007 census of agriculture. However, the number of farms has decreased by 11% during that time and remains at 748. The average size of farms has risen by 8% from 196 acres in 2007 to 212 acres in 2012. The average age of farm operators in La Crosse County is 59.2 years.

Agricultural land use in the Bostwick Creek Watershed exceeds 11,000 acres or 46% of the land cover. If we were to include forest acres as an agricultural land use, we would add an additional 13,000 acres to the count. These two land cover types account for 96% of the land use in the watershed. Much of the woodland acreage is also owned by farm operators as they occur on soils that are too steep for crop production. Much of the wooded acres are left unmanaged for timber production and see occasional harvests as a means of generating revenue rather than for forest health. One exception would be the Department of Natural Resources Coulee Experimental State Forest of which a major portion lies within the Bostwick Creek Watershed.

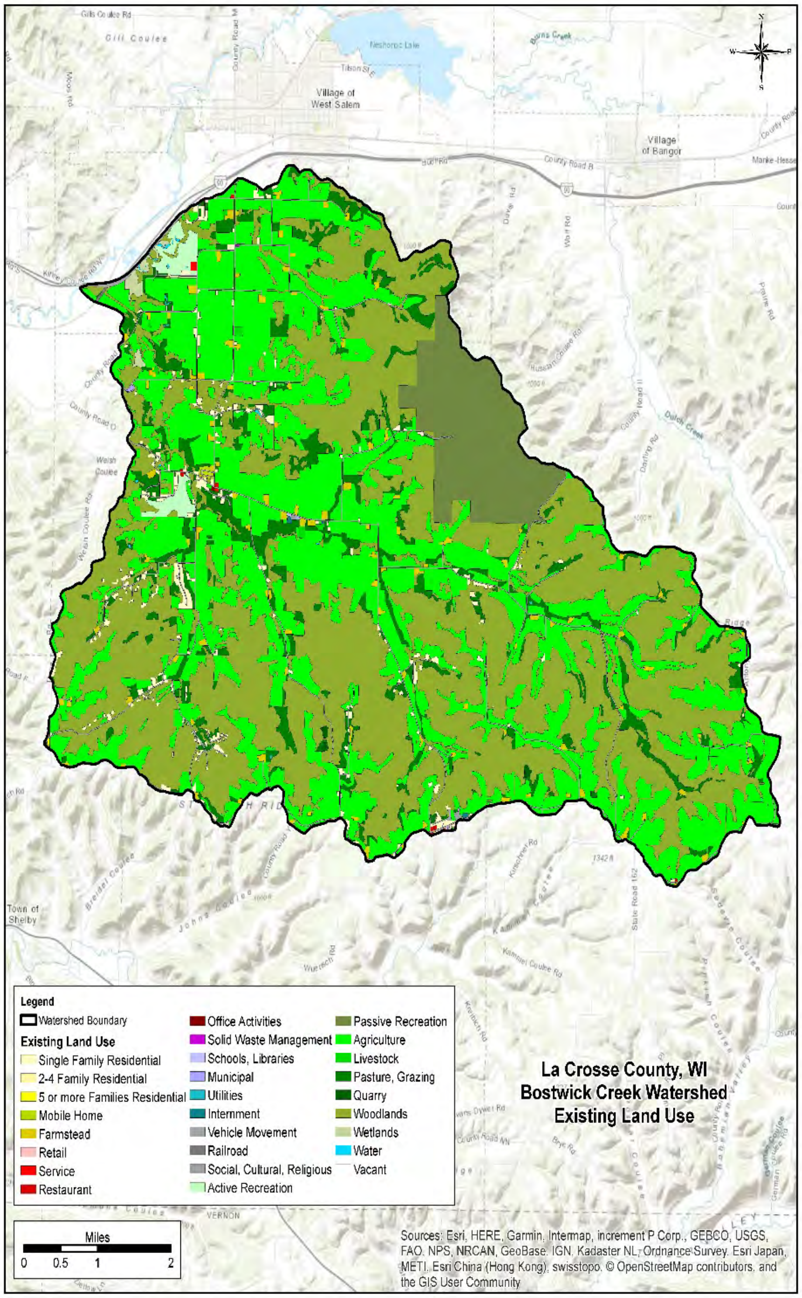


Figure 9 Bostwick Creek Watershed Existing Land Use

Crop rotations in Bostwick Creek Watershed is mixed between dairy rotations and cash grain production. Dairy rotations consist of 31.4% of the agricultural land use while cash grain makes up 25%. The remaining agriculture land use is divided among pastureland and hay ground at 40.2% and continuous corn production at 3.4%. See Table 3

Table 3 Rotation

Rotation	Acres	% of Total	% of Ag
No Agriculture	**17,163**	**57**	**0**
Pasture	**2,020**	**6**	**18**
Dairy	**4,025**	**13**	**31.4**
Cash Grain	**3,024**	**11**	**25**
Hay	**3,124**	**10**	**22.2**
Continuous Corn	**431**	**1.4**	**3.4**
Vegetable/Grain	**0.2**	**0**	**0**

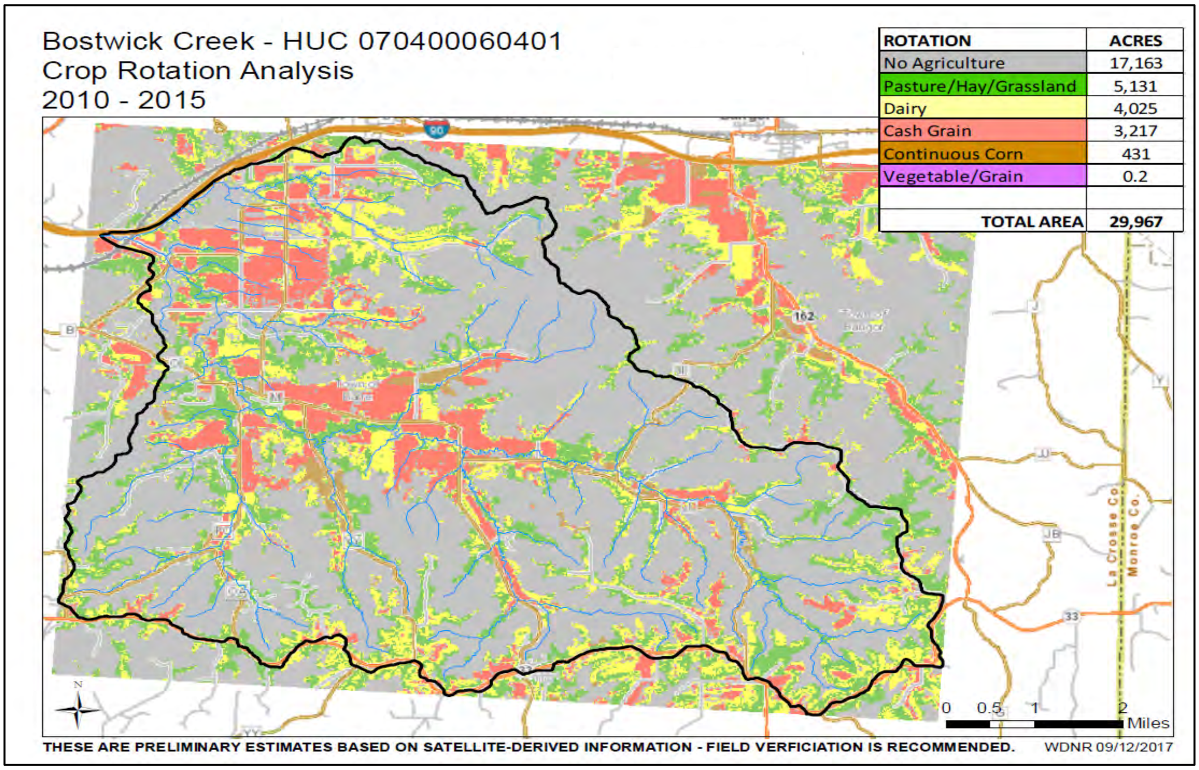


Figure 10 Bostwick Creek Watershed Crop Rotations

Cropping practices in The Bostwick Creek Watershed also include the use of supporting conservation practices. Approximately 65% of the cropped acres are tilled using some form of a reduced tillage system that leaves 30% to 80% crop residue on the soil surface. These systems are designed to reduce soil loss by increasing water infiltration and reducing erosion from rainfall and snow melt events.

4.0 Water Quality

Under the federal government's EPA Clean Water Act, every state must adopt water quality standards to protect, maintain and improve the quality of our nation's surface waters. These standards set the appropriate level of protection by:

- determining the types of activities and uses the water should support
- developing water quality criteria to protect these uses from excess pollution
- establishing an antidegradation policy to maintain & protect existing uses and high quality waters
- identifying general policies to implement these protection levels in point source discharge permits

Water quality standards also support efforts to achieve and maintain protective water quality conditions, including:

- The development of reports that document current water quality conditions
- The establishment of permit limits for wastewater discharges to protect the State's waters
- The development of Total Maximum Daily Load (TMDL) analyses which determine how much pollutant reduction is needed in a watershed to protect water quality.
- The development of water quality management plans which prescribe the regulatory, construction and management activities necessary to meet the water body goals

4.1 Designated Use and Impairments

Under the Clean Water Act, Wisconsin waters are each assigned four "uses" that carry with them a set of goals: Fish and Aquatic Life, Recreation, Public Health and Welfare, Wildlife. The use designation process involves evaluation of the resource and its natural characteristics to determine the water's highest 'attainable' use according to its potential.

For the purpose of this plan, the designated use for fish and aquatic life are of primary concern regarding water quality conditions in Bostwick Creek. The Wisconsin Department of Natural Resources Surface Water Inventory evaluates Bostwick Creek in three segments:

#1: Mouth to Barre Mills – 3.65 miles

#2: Barre Mills to CTH M – 4.13 miles

#3: CTH M to Headwaters – 8.26 miles

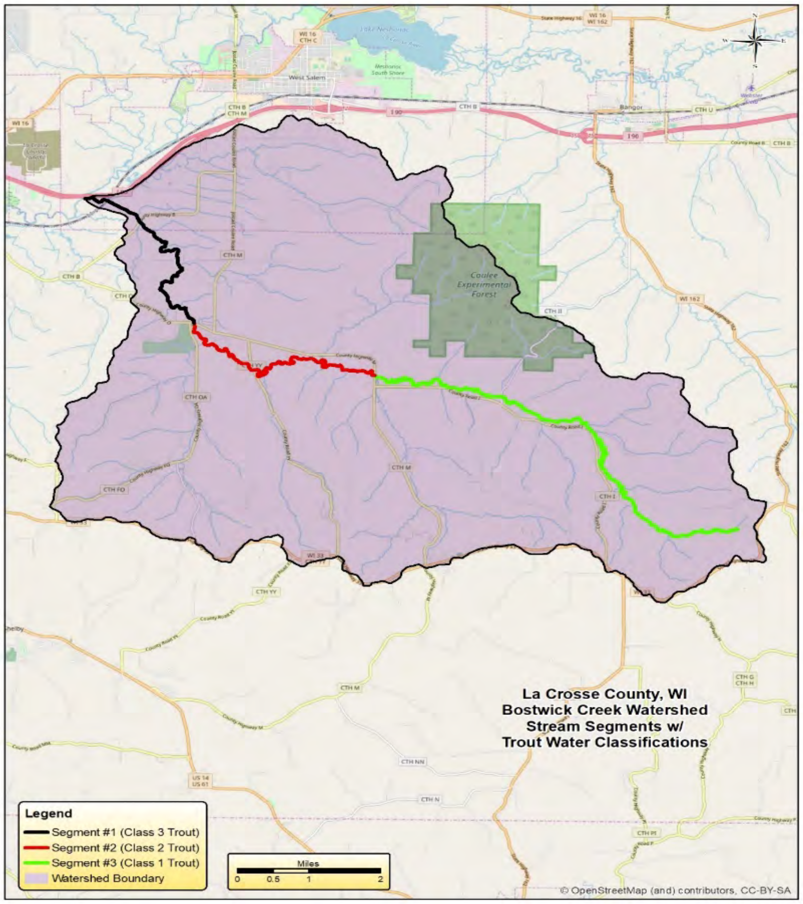


Figure 11 Bostwick Creek Watershed Trout Water Classifications Map

The surface water inventory lists each of the segments of Bostwick Creek as “cold water” for fish and aquatic life as the *current use* and *designated use*. All segments of Bostwick Creek are found to support trout populations with the upper portions having natural reproduction and good winter survival. The lower portion of Bostwick Creek contains limited in-stream cover for adult fish primarily due to sedimentation.

Segment #3 is classified as Class I Trout Waters (high quality fishery with natural reproduction). Whereas Segment #2 is classified as Class II Trout Waters (good quality fishery supported through stocking). Segment #1 is classified as Class III Trout Waters (marginal trout habitat with no natural reproduction occurring).

Wisconsin has designated many of the state’s highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORW and ERW status identifies waters that the State of Wisconsin has determined warrant additional protection from the effects of pollution.

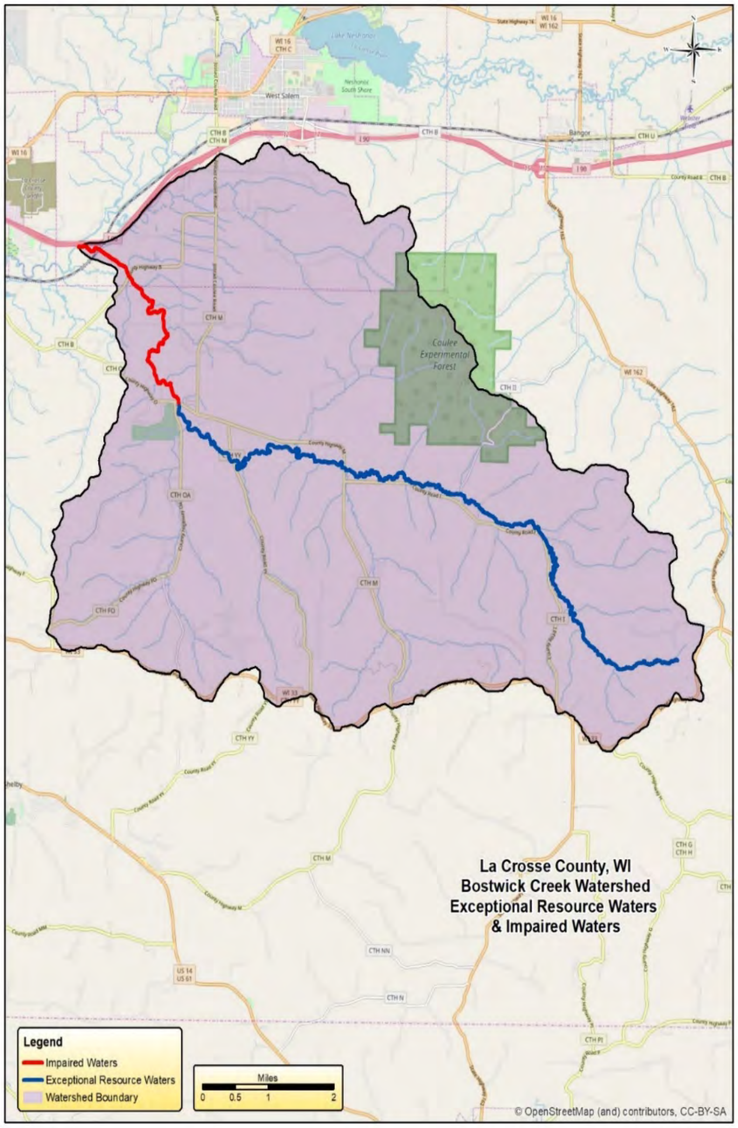


Figure 12 Bostwick Creek Watershed Exceptional & Impaired Waters Map

These designations are intended to meet federal Clean Water Act obligations requiring Wisconsin to adopt an “antidegradation” policy that is designed to prevent any lowering of water quality – especially in those waters having significant ecological or cultural value.

Every two years, DNR publishes a list of surface waters that are negatively impacted by pollutants and are not meeting their designated uses. These water bodies are reported to the EPA as required by Clean Water Act (CWA) Section 303(d). These surface waters are classified as *Impaired Waters* and may not support fishing, swimming, recreating or public health and welfare.

Bostwick Creek has the distinction of having both exceptional resource waters and impaired waters designations by the Department of Natural Resources. The headwaters of Bostwick Creek downstream to Barre Mills is classified as Exceptional Resource Waters (12.4 miles). From Barre Mills downstream to its mouth (3.65 miles), Bostwick Creek quickly degrades to an impaired water. The Department of Natural Resources states that total phosphorus is the primary impairment.

Portions of the main stem of Bostwick Creek lie within the DNR's La Crosse Area Comprehensive Fishery Area. The area is managed by the DNR to protect the public trust, enhance coldwater fishery and provide outdoor recreational opportunities. There are approximately 6.5 miles of public access in this area for angling opportunities through the purchase of easements under the Knowles-Nelson Stewardship – Streambank Protection Program.

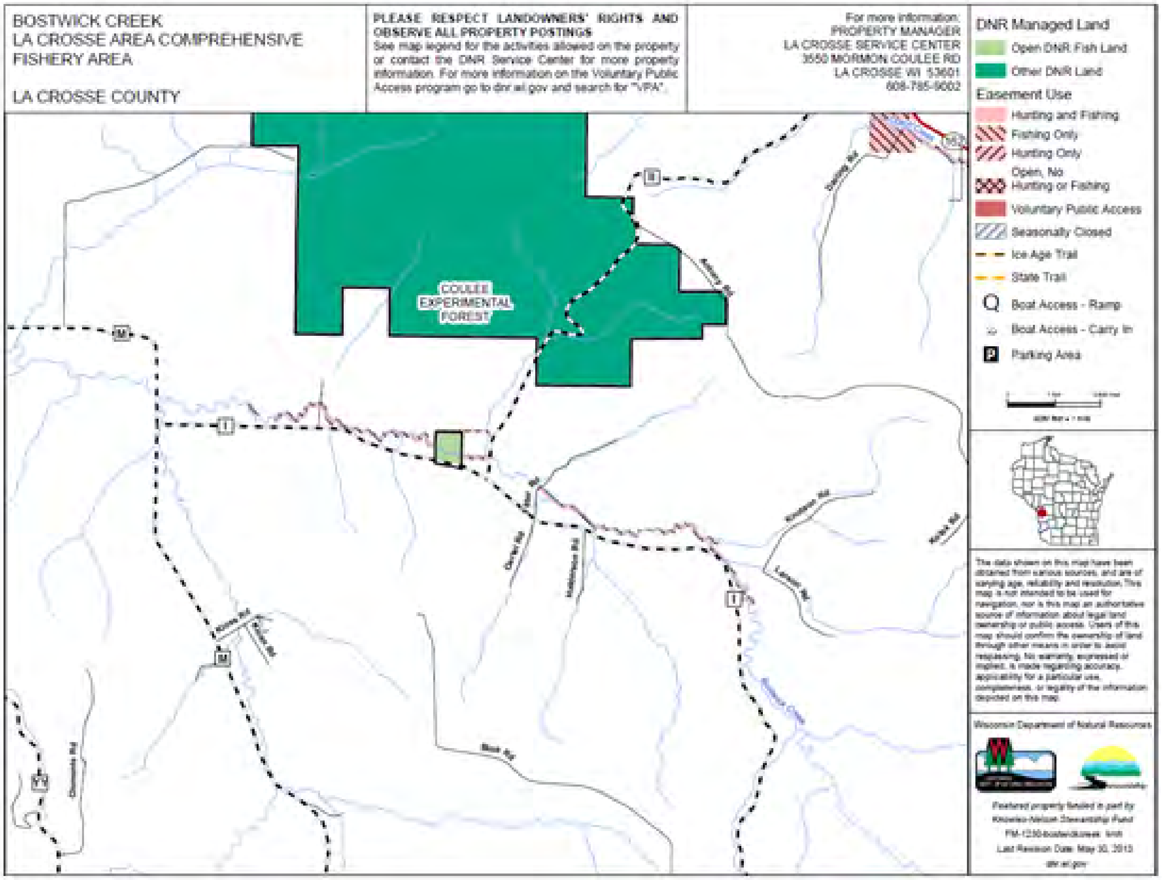


Figure 13 Bostwick Creek DNR Easement Map

4.2 Point Source Pollution

Point sources of pollution are discharges to the waters of the state that come from a pipe or a specific source that is easily identifiable. The Wisconsin Department of Natural Resources regulates these types of pollution discharges and enforces pollution control measures. Municipal waste treatment plants, manufacturing plants and storm sewer systems are examples of point sources of pollution. Through the Wisconsin Pollution Discharge Elimination System (WPDES), the Department of Natural Resources permits, monitors and enforces rules that regulate point source discharges.

There are two WPDES permitted facilities in the Bostwick Creek Watershed. The Bostwick Valley Mobile Home Park Waste Treatment Facility and the Maple Grove Estates Sanitary District are currently operating under a WPDES permit in the watershed. The Bostwick Valley Mobile Home Park Waste Treatment Facility discharges to Bostwick Creek with a design flow of 0.0200 million gallons per day whereas the Maple Grove Estates Sanitary District discharges to Pleasant Valley Creek at 0.0350 million gallons per day.

4.3 Nonpoint Source Pollution

Nonpoint sources of pollution, unlike point sources, are much more diffuse and can be difficult to locate. When rain water or snow melt runoff flows over the landscape, it carries with it soil, fertilizers, pesticides, animal manures and other pollutants that find their way into streams, lakes and groundwater. The Bostwick Creek Watershed is comprised almost exclusively by agricultural land uses and forestland. Cash grain, dairy and beef operations are the primary sources of nonpoint pollution in this watershed. Uncontrolled grazing of beef and dairy livestock along stream corridors and eroding streambanks are common sites throughout the watershed and is the leading cause of stream sedimentation and loss of fish habitat. The recent decline of dairy operations in the watershed has also increased the acres of cash grain farming and continuous row crops of corn and soybeans. These additional acres of cash grains has increased soil loss rates in the watershed.

4.4 Water Quality Monitoring

The La Crosse County Department of Land Conservation has implemented a water quality monitoring program since 1995 when a monitoring station was installed in Dutch Creek. It is located just 1.3 miles from eastern border of the Bostwick Creek Watershed. Dutch Creek Watershed is relative in size to Bostwick Creek Watershed with similar land uses. The water quality monitoring station is a 24/7 system capable of pulling water samples from Dutch Creek during runoff events as they occur whether during the day, at night or weekends and holidays. Water samples are taken to the La Crosse County Environmental Health Laboratory to be analyzed for total phosphorus, total suspended solids and E.coli bacteria. The station also records dissolved oxygen, water temperature, rain fall amounts and stream flow volumes.

The La Crosse County Department of Land Conservation also began a County-wide water quality monitoring program for all 27 subwatersheds within the County. The County-wide sampling program was developed to determine if the streams in La Crosse County were meeting water quality standards set by the La Crosse County Planning, Resources and Development Committee (PR&D), a sub-committee of the La Crosse County Board. The water quality standards are also the goals set forth in the La Crosse County

Land and Water Resource Management Plan 2016-2019. The PR&D Committee has set the following water quality standards for all streams in La Crosse County:

- Total Phosphorus not to exceed 0.05 mg/L.
- Fecal Coliform Bacteria not to exceed 1,000 colonies per 100 ml.
- Dissolved Oxygen to be no less than 5 mg/L at any time; no less than 6 mg/L for all trout waters; and no less than 7 mg/L during trout spawning season.
- All surface waters attain their full fishery potential.

The protocol used for the County-wide sampling program involves the collection of grab samples at the confluence of each stream in the County. The samples are collected within a 2 hour time span and taken to the La Crosse County Environmental Health Laboratory to be analyzed for total phosphorus, total suspended solids and E.coli bacteria. These samples are collected twice a year, typically early summer and fall when the streams are in a steady state.

The water quality in Bostwick Creek has been of special interest to the Department of Land Conservation and the Department of Natural Resources since it is considered to have the greatest potential to improve water quality and extend the Class I and Class II fisheries further downstream.

To determine the level of water quality in Bostwick Creek, Department staff have been taking weekly grab samples at four locations since 2015. The samples are collected from April 1st through October 30th. The locations of those grab sample sites can be seen on Figure 14.

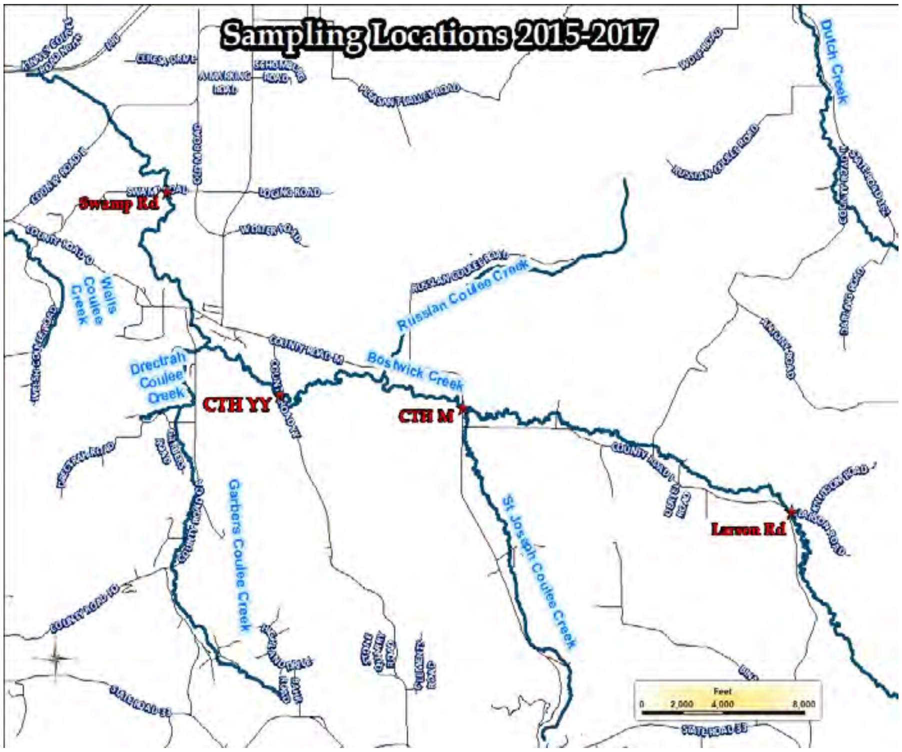
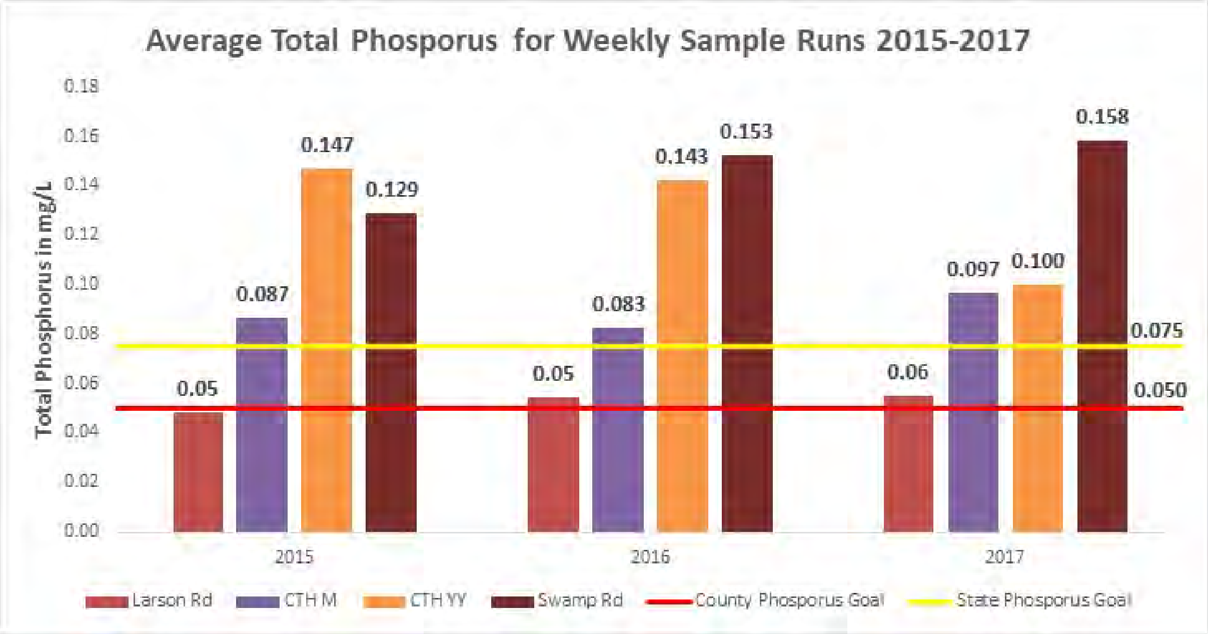


Figure 14 Bostwick Creek Watershed Grab Sample Map

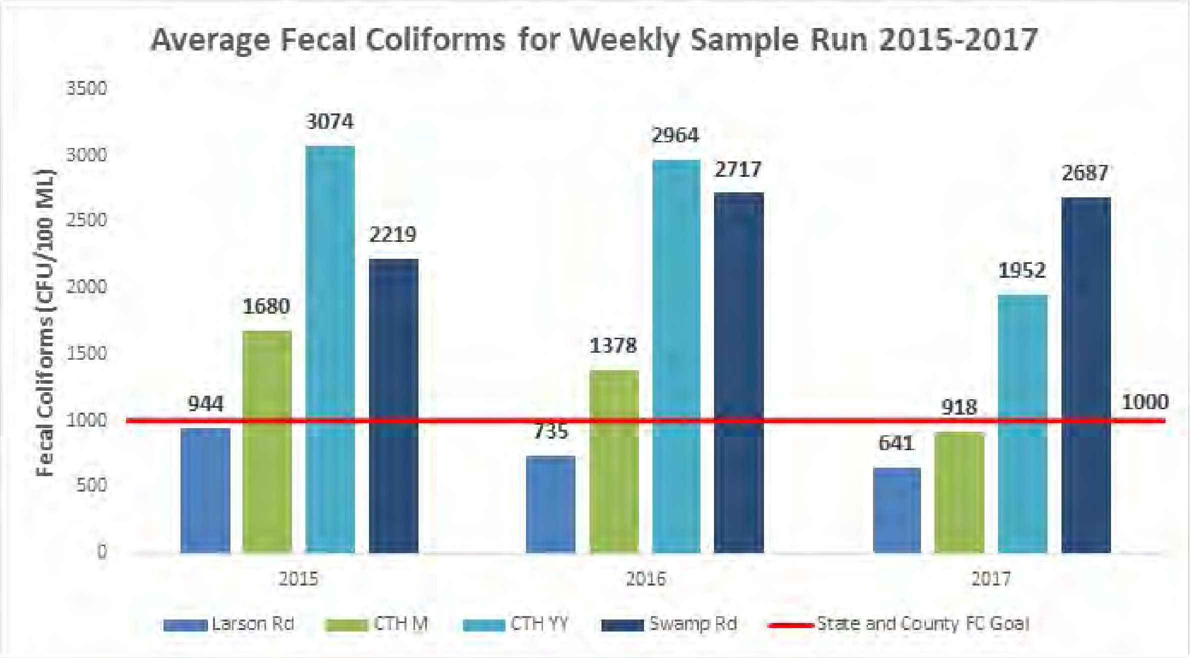
The grab samples were analyzed for concentrations of total phosphorus and E.coli bacteria by the La Crosse County Environmental Laboratory.

Below are graphs which show the results of the weekly grab samples for total phosphorus and fecal coliform bacteria from 2015-2017.

Graph 1. Average total Phosphorus weekly samples 2015-2017



Graph 2. Average weekly bacteria counts 2015-2017



Both graphs indicate that the water quality in Bostwick Creek degrades as the stream flows downstream. Both total phosphorus and E.coli bacteria quickly exceed the water quality goals set by the Department of Land Conservation at 1,000 colonies of bacteria and 0.05 mg/L of total phosphorus.

The Department of Land Conservation has also included the use of water quality monitoring sondes that measure dissolved oxygen levels and water temperature. These sondes are very portable and can be placed throughout the County to determine water quality conditions at specific sites or to better measure water quality over the length of a selected stream. The Department currently utilizes three water quality monitoring sondes as part of its water quality monitoring program.

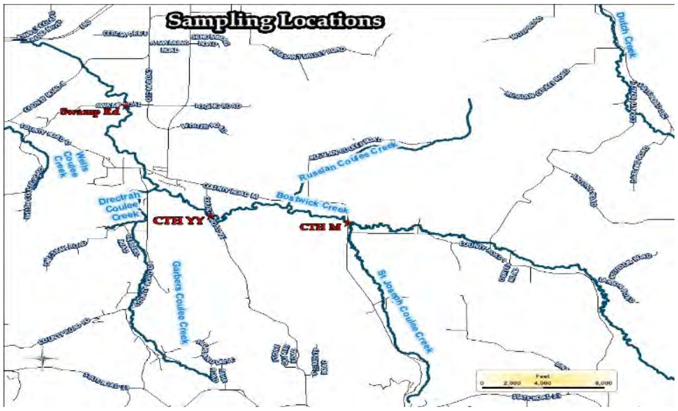


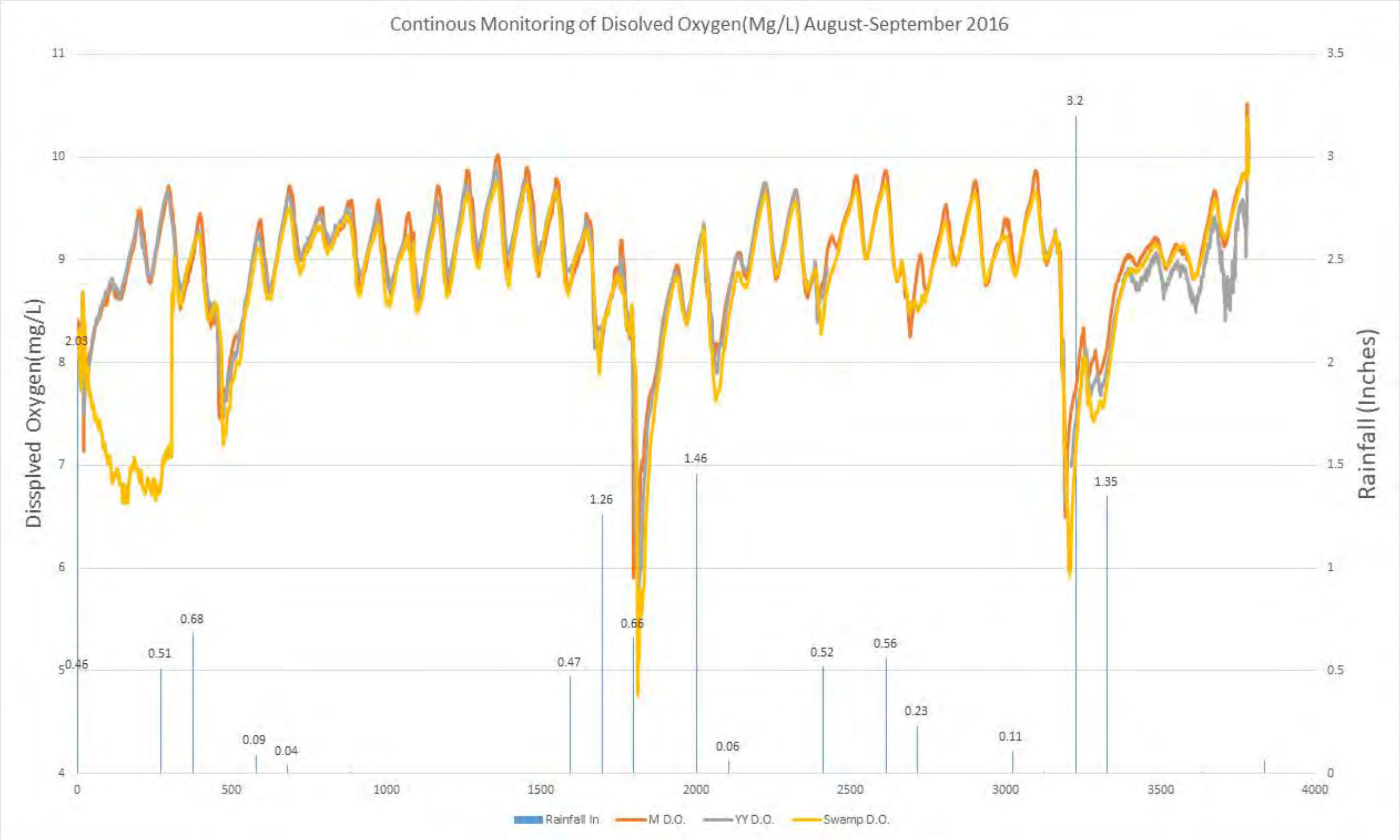
Figure 15 Bostwick Creek Watershed Sonde Sampling Map

The three sondes have been deployed in Bostwick Creek since 2015 to assess the water quality conditions in the watershed. See Figure 15 for the locations of the three sondes.

The data collected from the sondes indicates that dissolved oxygen levels remain steady throughout the watershed during rainfall events of less than 0.5 inch but drop dramatically when rainfall exceeds 1 inch.

The graph below shows dissolved oxygen fluctuations during August and September of 2016.

Graph 3. Dissolved oxygen levels August and September 2016



For current DNR survey of water quality information, refer to Appendix A.

5.0 Pollutant Loading Model

The La Crosse County Department of Land Conservation utilized the **Spreadsheet Tool for Estimating Pollutant Load** (STEPL) to calculate nutrient and sediment loads in Bostwick Creek. The STEPL model incorporates land use distribution and landowner management practices to calculate watershed surface runoff, nutrient loads, biological oxygen demand and sediment delivery. The STEPL model also allows the user to apply land use management strategies to determine the effectiveness of reducing pollutants through the implementation of Best Management Practices (BMP's).

For this plan, the Bostwick Creek Watershed was divided into 8 sub basins to define common land types and land uses (Figure 16).

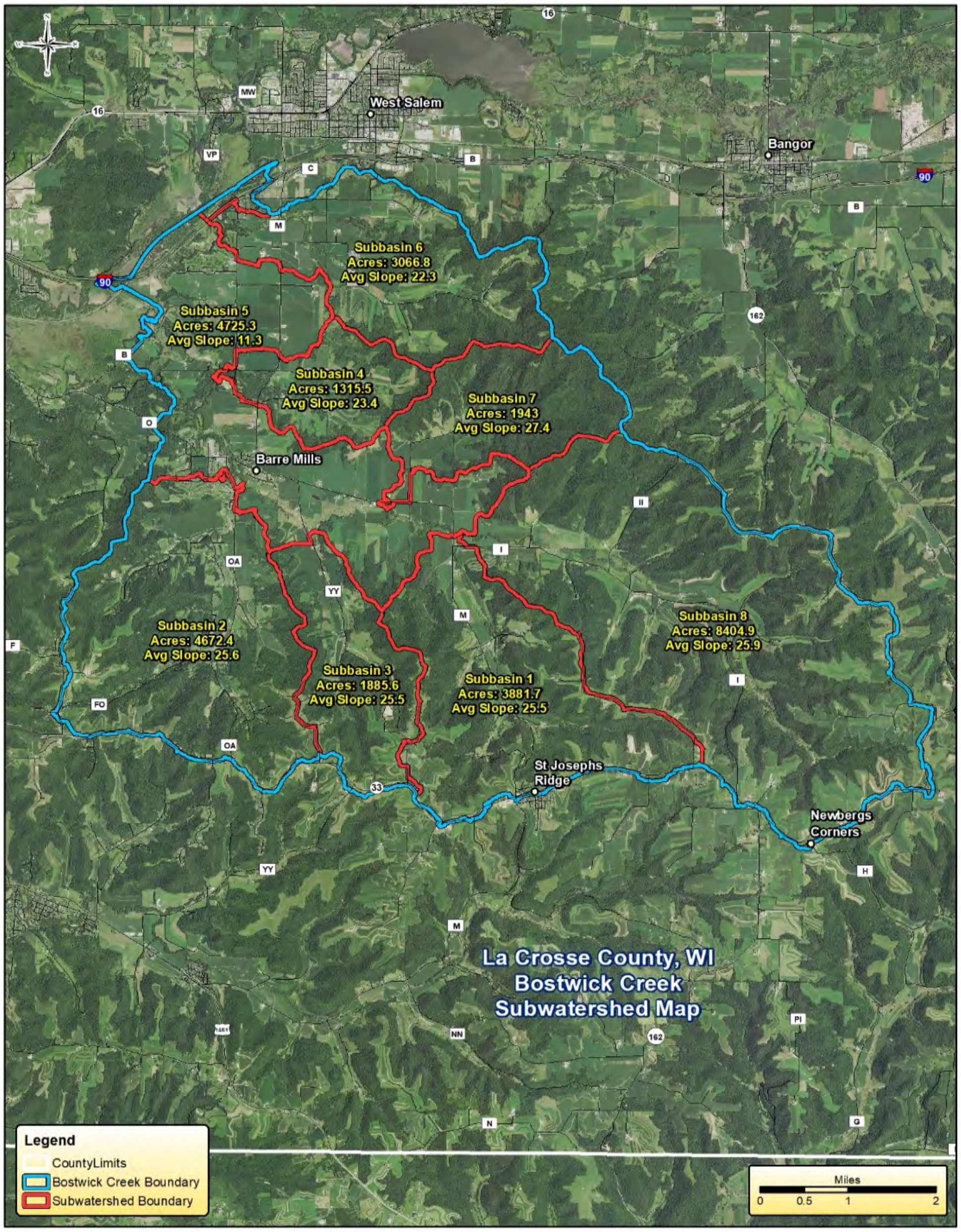


Figure 16 Bostwick Creek Subwatershed Map

Tables 4 & 5 below show the current annual nutrient, BOD, and sediment loads for each subbasin with and without BMP's as calculated using STEPL. Land use data collected by the Department of Land Conservation staff was used to populate the model.

Table 4 Current Total Loads (No BMP's)

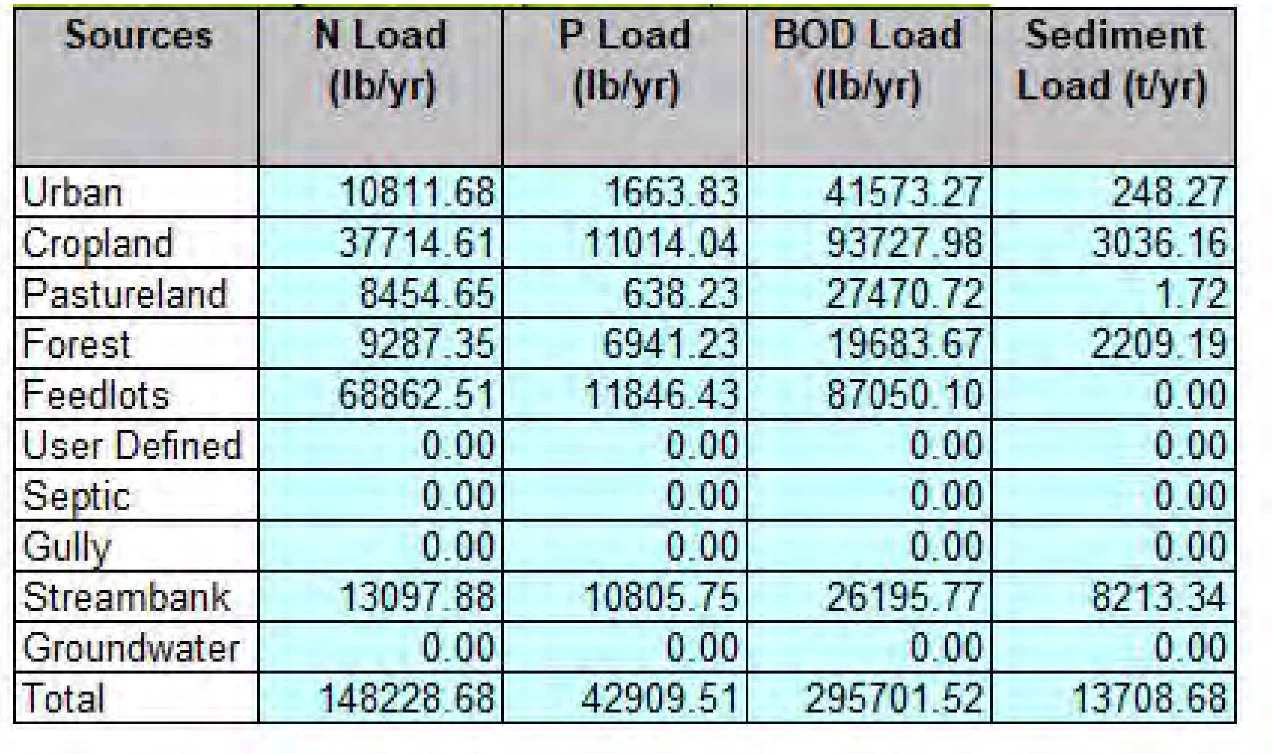
Watershed	N Load (no BMP) lb/year	P Load (no BMP) lb/year	BOD Load (no BMP) lb/year	Sediment Load (no BMP) t/year	N Reduction lb/year	P Reduction lb/year	BOD Reduction lb/year	Sediment Reduction t/year
W1	28113.7	7117.6	44549.5	1444.4	3433.5	2215.3	4102.8	641.1
W2	18616.0	5892.0	40913.2	1342.7	2973.7	1961.0	3652.4	570.7
W3	8761.8	3149.0	17633.5	741.7	2153.6	1351.7	2373.3	370.8
W4	6985.2	2042.5	13755.7	395.3	1046.0	703.8	1284.7	200.7
W5	35364.9	9682.8	67069.7	1659.7	4764.8	3131.6	5631.9	880.0
W6	18664.5	4885.6	33024.1	925.6	1886.4	1157.1	1775.1	277.4
W7	4622.5	1581.2	9194.6	362.5	480.8	320.4	563.9	88.1
W8	39505.6	14222.2	73310.8	3301.1	8760.7	5627.3	10551.4	1648.7
W9	13097.9	10805.8	26195.8	8213.3	0.0	0.0	0.0	0.0
W10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**173732.0**	**59378.8**	**325647.0**	**18386.4**	**25499.4**	**16468.2**	**29935.4**	**4677.4**

Table 5 Current Total Loads (With BMP's)

Watershed	N Load (with BMP) lb/year	P Load (with BMP) lb/year	BOD Load (with BMP) lb/year	Sediment Load (with BMP) t/year	N Reduction %	P Reduction %	BOD Reduction %	Sediment Reduction %
W1	24680.2	4902.3	40446.7	803.4	12.2	31.1	9.2	44.4
W2	15642.4	3931.1	37260.8	772.0	16.0	33.3	8.9	42.5
W3	6608.1	1797.3	15260.3	370.8	24.6	42.9	13.5	50.0
W4	5939.2	1338.7	12471.0	194.6	15.0	34.5	9.3	50.8
W5	30600.1	6551.2	61437.8	779.8	13.5	32.3	8.4	53.0
W6	16778.2	3728.5	31249.0	648.2	10.1	23.7	5.4	30.0
W7	4141.7	1260.8	8630.7	274.4	10.4	20.3	6.1	24.3
W8	30744.9	8594.9	62759.5	1652.5	22.2	39.6	14.4	49.9
W9	13097.9	10805.8	26195.8	8213.3	0.0	0.0	0.0	0.0
W10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**148232.6**	**42910.6**	**295711.5**	**13709.0**	**14.7**	**27.7**	**9.2**	**25.4**

Table 6 shows total pollutant loads with BMP’s by land use type.

Table 6 Current Pollutant Loading Results



Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	10811.68	1663.83	41573.27	248.27
Cropland	37714.61	11014.04	93727.98	3036.16
Pastureland	8454.65	638.23	27470.72	1.72
Forest	9287.35	6941.23	19683.67	2209.19
Feedlots	68862.51	11846.43	87050.10	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	0.00	0.00	0.00	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	13097.88	10805.75	26195.77	8213.34
Groundwater	0.00	0.00	0.00	0.00
Total	148228.68	42909.51	295701.52	13708.68

6.0 Watershed Inventory

6.1 Barnyard Inventory Results

Animal feedlots and barnyards were inventoried by using existing GIS based tracking data, air photo interpretation and windshield surveys. The La Crosse County Department of Land conservation has developed a farm operator tracking data base to compile management strategies implemented by landowners within the County. Data was collected from farm operators who participate in the Wisconsin Farmland Preservation Program and the County's Nutrient Management Program. The Farmland Preservation Program participants operate up to 40% of the cropland acres within the Bostwick Creek Watershed and an additional 20% of non-FPP participants have implemented a nutrient management plan.

The animal types in the Bostwick Creek Watershed are diverse with a significant number of hobby farms scattered throughout the landscape. Dairy cows and beef animals are prevalent with pigs, horses and sheep also present in lesser numbers.

Table 7 Animal Numbers

Animal	#
Dairy Cows	1,066
Dairy Heifers	765
Dairy Calves	322
Beef Steers	1,102
Beef Calves	324
Pigs	2,300
Horses	202
Chickens	174
Sheep	238

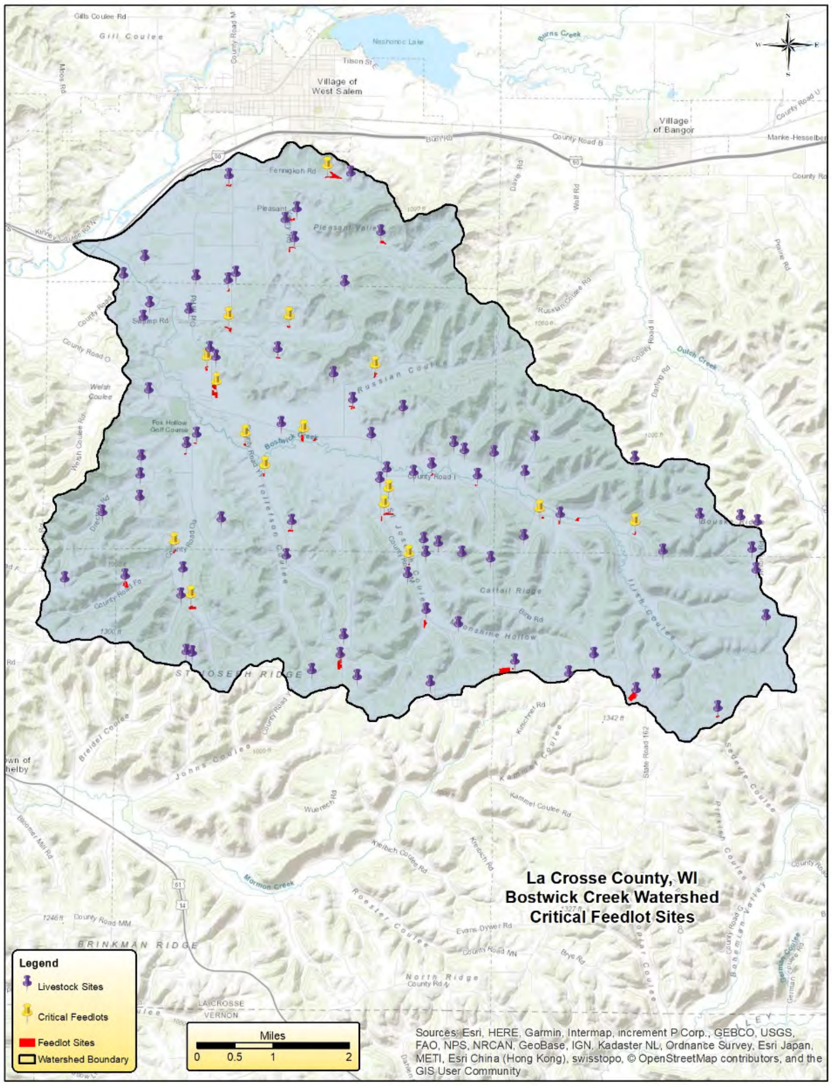


Figure 17 Bostwick Creek Watershed Critical Feedlot Sites

6.2 Streambank Inventory Results

In the summer of 2017, the main stem of Bostwick Creek was inventoried to determine the location and extent of streambank erosion. Two Department staff measured each eroded site from Larson Road down to County Highway M. Measurements included the height, length and recession rate of each eroded site. Streambank erosion on tributaries to Bostwick Creek were estimated by rating the size of the tributaries watershed with the inventoried main stem. With the aid of the County's Lidar data, streambank erosion was estimated by comparing the 2008 Lidar flight with the 2017 flight. This provided staff with a fairly accurate prediction of the streambank erosion rates on the tributaries to Bostwick Creek.

Figure 18 Streambank Erosion Photo

Streambank erosion is a common problem in the Driftless Region of Wisconsin. The steep, incised valley bottoms often contain several feet or more of deposited sediments from upland erosion. These streams meander extensively through these deposits as it flows down gradient. When intense rainfall events occur, the streams quickly swell and the force of the rushing water easily erodes the sediments from the streambanks. The STEPL model estimates that streambank erosion accounts for 8,213 tons of sediment per year and 10,806 pounds of phosphorus per year. The presence of cattle and unmanaged grazing practices along the streambanks also contributes to the acceleration of eroding sites. Eroding streambanks is the primary cause of excessive in-stream sedimentation that degrades fish habitat and other aquatic biota. See Figure 18.

Figure 19 Bostwick Creek Watershed Streambank GPS Survey

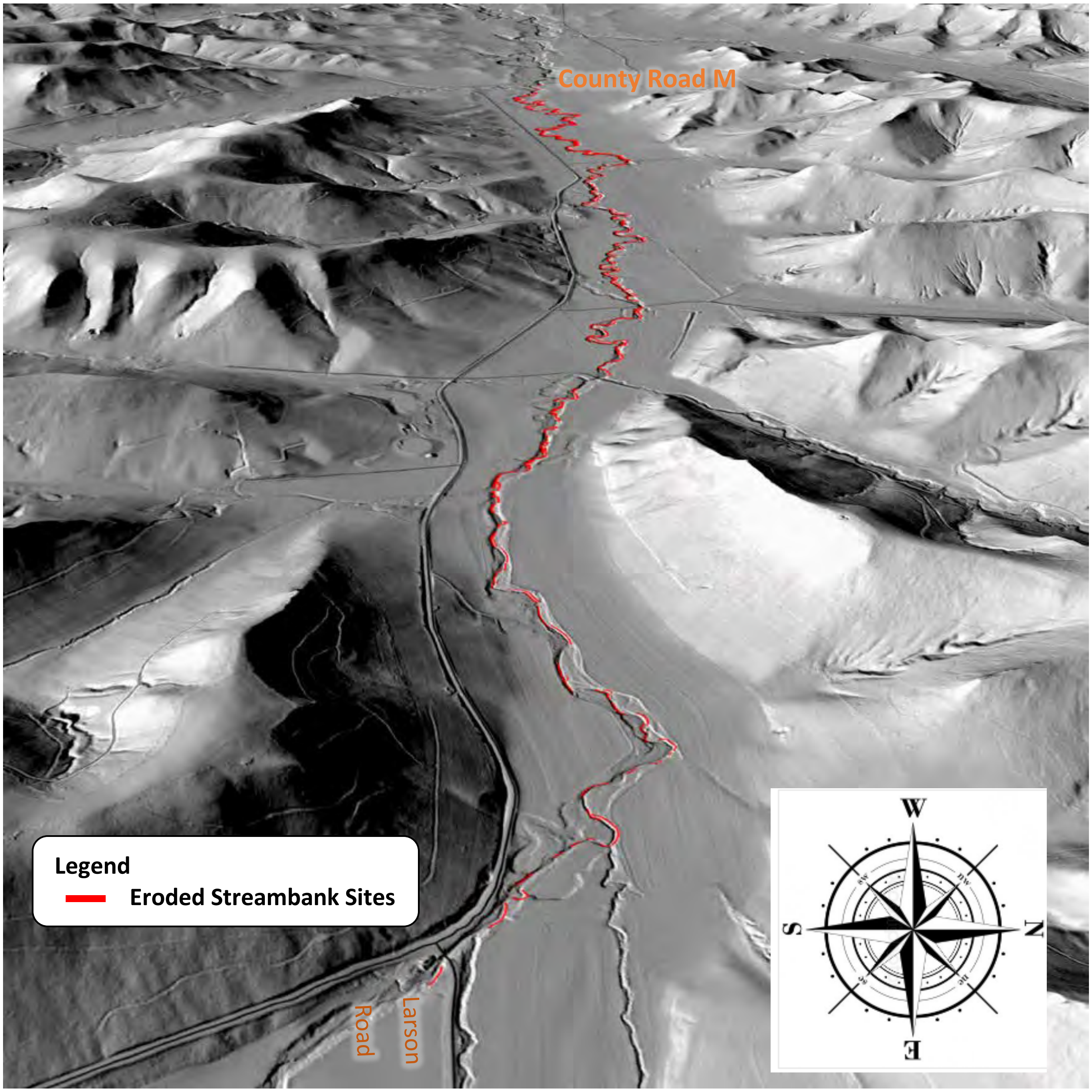


Figure 20 Bostwick Creek Watershed Streambank Erosion Inventory - Larson Rd to County Hwy M

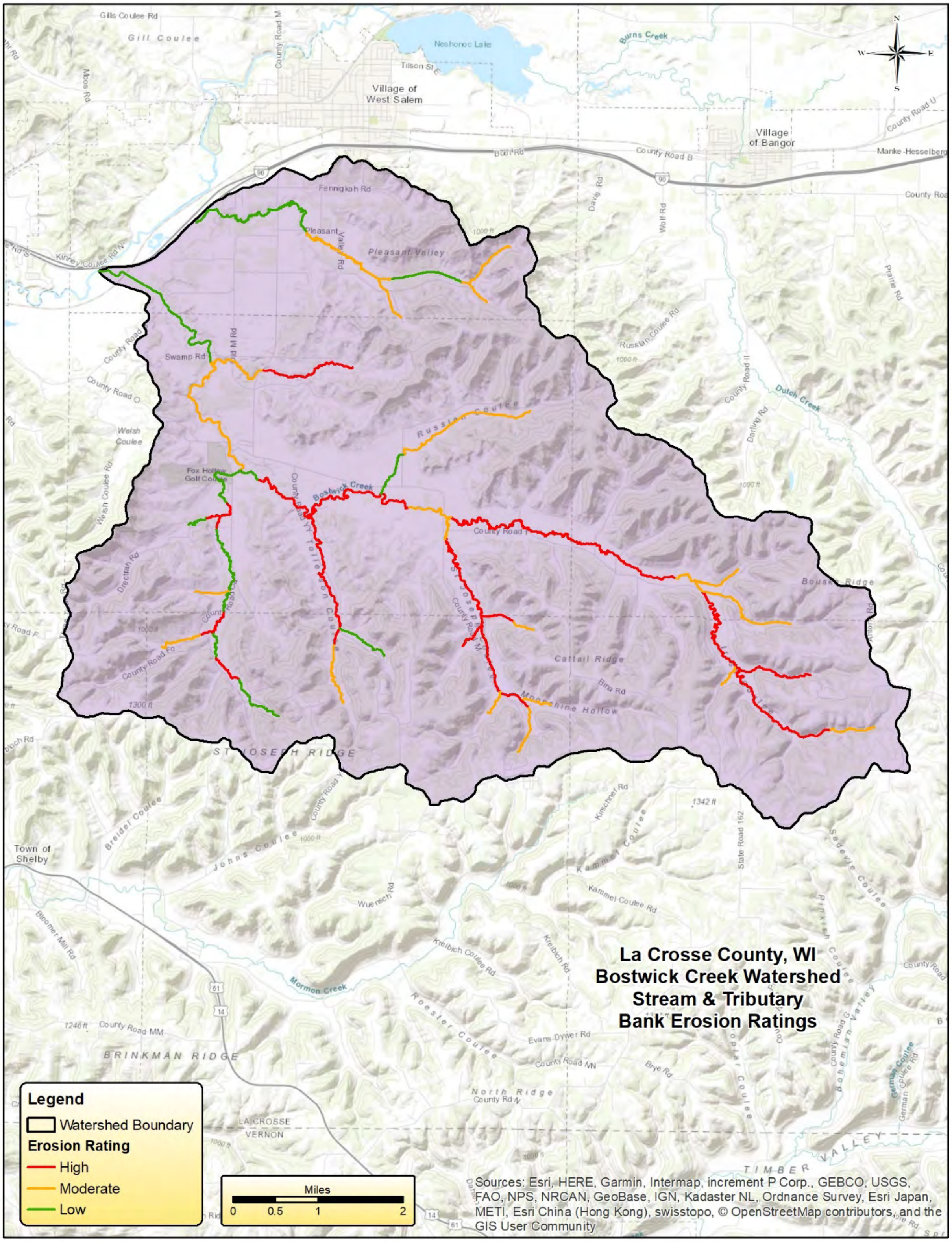
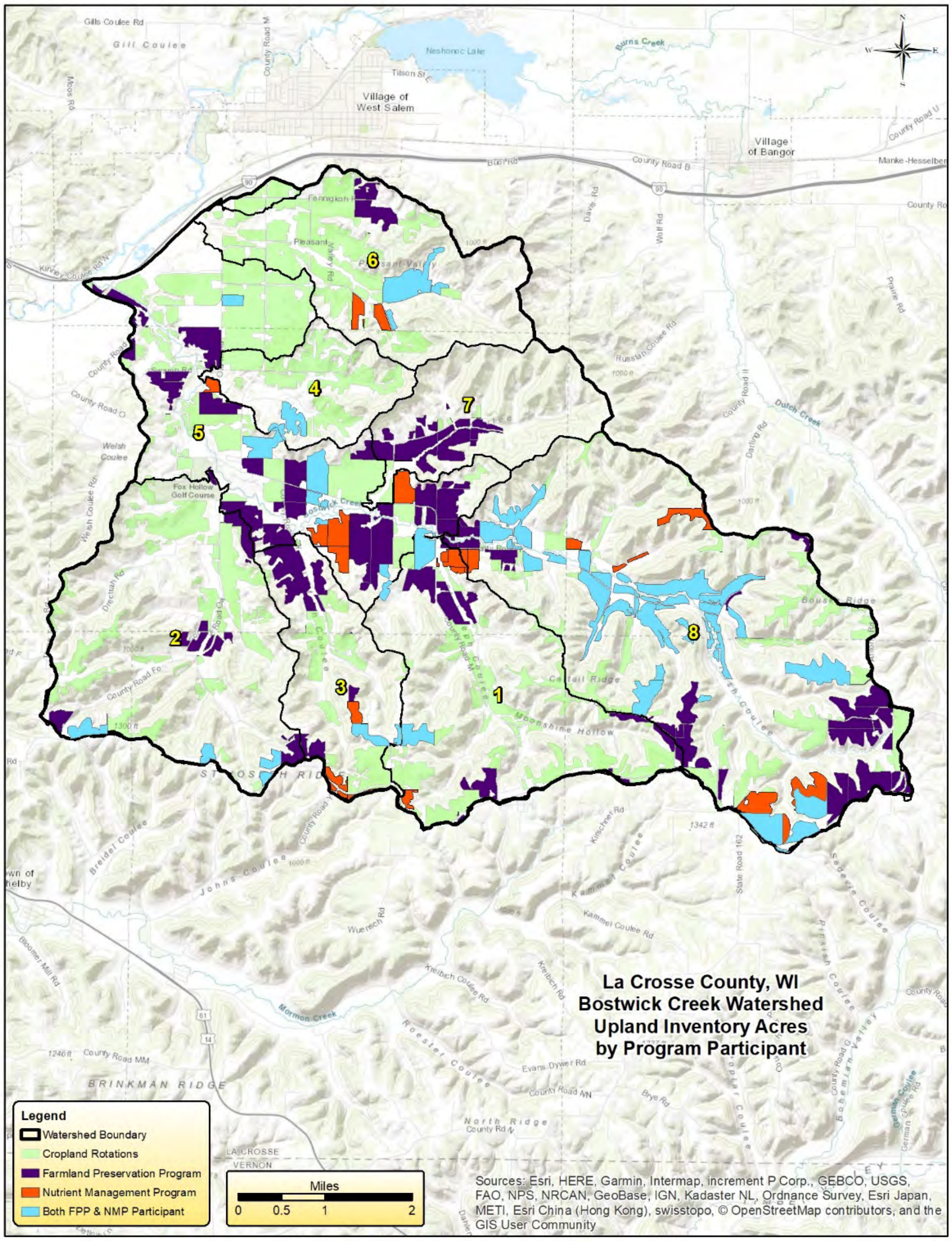


Figure 21 Bostwick Creek Watershed Stream & Tributary Bank Erosion Ratings

6.3 Upland Inventory

The upland inventory for agricultural practices was obtained through data from the Department of Land Conservation's GIS based farm tracking program. Farm operators who participate in the State Farmland Preservation Program and the County's Nutrient Management Program have provided cropping information and livestock numbers to the Department as a way of tracking compliance with program soil and water conservation requirements. Nearly 60% of the farm operators in the Bostwick Creek Watershed participate in one or more programs where this data is collected.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

Figure 22 Bostwick Creek Watershed Upland Inventory Acres by Program Participant

Department staff also used air photography and conducted a windshield survey to identify cropping practices for farm operations that currently do not participate in the Farmland Preservation Program or the Nutrient Management Program.

The dominate crop rotation in the Bostwick Creek Watershed is dairy based. Nearly 32% of the cropland or 4,025 acres is used to feed dairy animals. Two years of corn silage followed by four years of alfalfa hay is the typical dairy rotation in the watershed. Cash grains, primarily corn and soybeans, make up 25% of the cropland or 3,204 acres. Hay ground, 3,124 acres (22.2%) and pastureland, 2,020 acres (18%) make up the remaining cropland acres.

Much of the tillage in the Bostwick Creek Watershed is considered to be reduced tillage, leaving a minimum of 30% crop residue after planting crops. In order to meet program requirements and save soil, many farm operators in the watershed utilize a no-till planting system or a chisel-disk system. There are few moldboard plow systems in the watershed and they are used intermittently to control weed infestations.

In-field conservation practices such as grassed waterways, contour strip cropping and diversions are effective measures for preventing rill and gully erosion in croplands. They provide a means of conveying runoff water from ridge top fields to valley bottoms while preventing excessive soil erosion. Most of the dairy operations in the Bostwick Creek Watershed utilize a combination of these practices to control soil erosion on their farmland. However, as dairy farming decreases in La Crosse County, many of these conservation practices are disappearing from the landscape as cash grain operations replace them. Cash grain farmers typically operate larger equipment than dairy farmers and the size of their equipment does not lend itself well to contour strip cropping. The cash grain farmers rely on no-till systems to help them meet the soil loss tolerance levels and maintain compliance with soil and water conservation requirements. The conservation practices currently installed throughout Bostwick Creek has reduced upland sediment loads by 24% to as high as 53% according to the STEPL model.

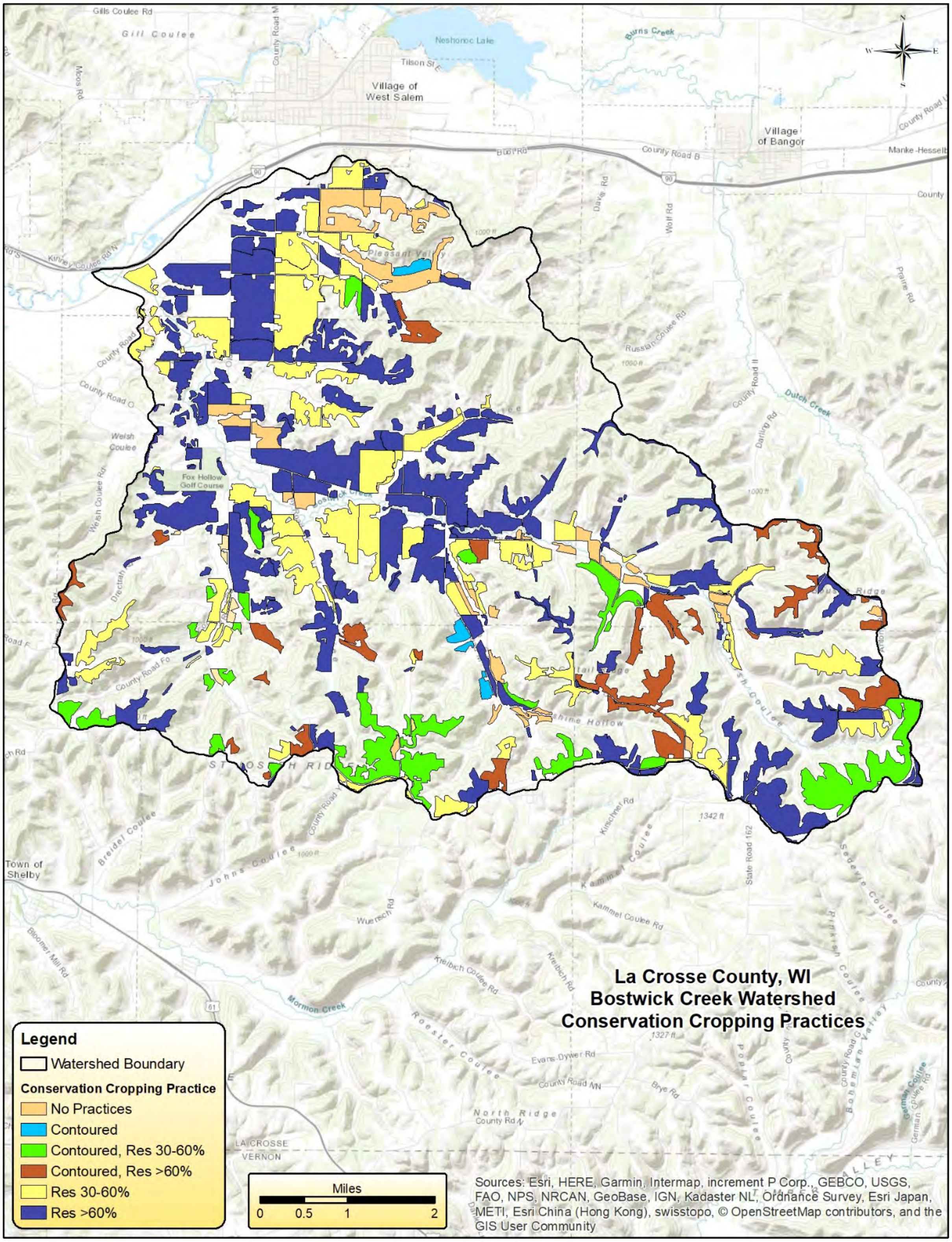
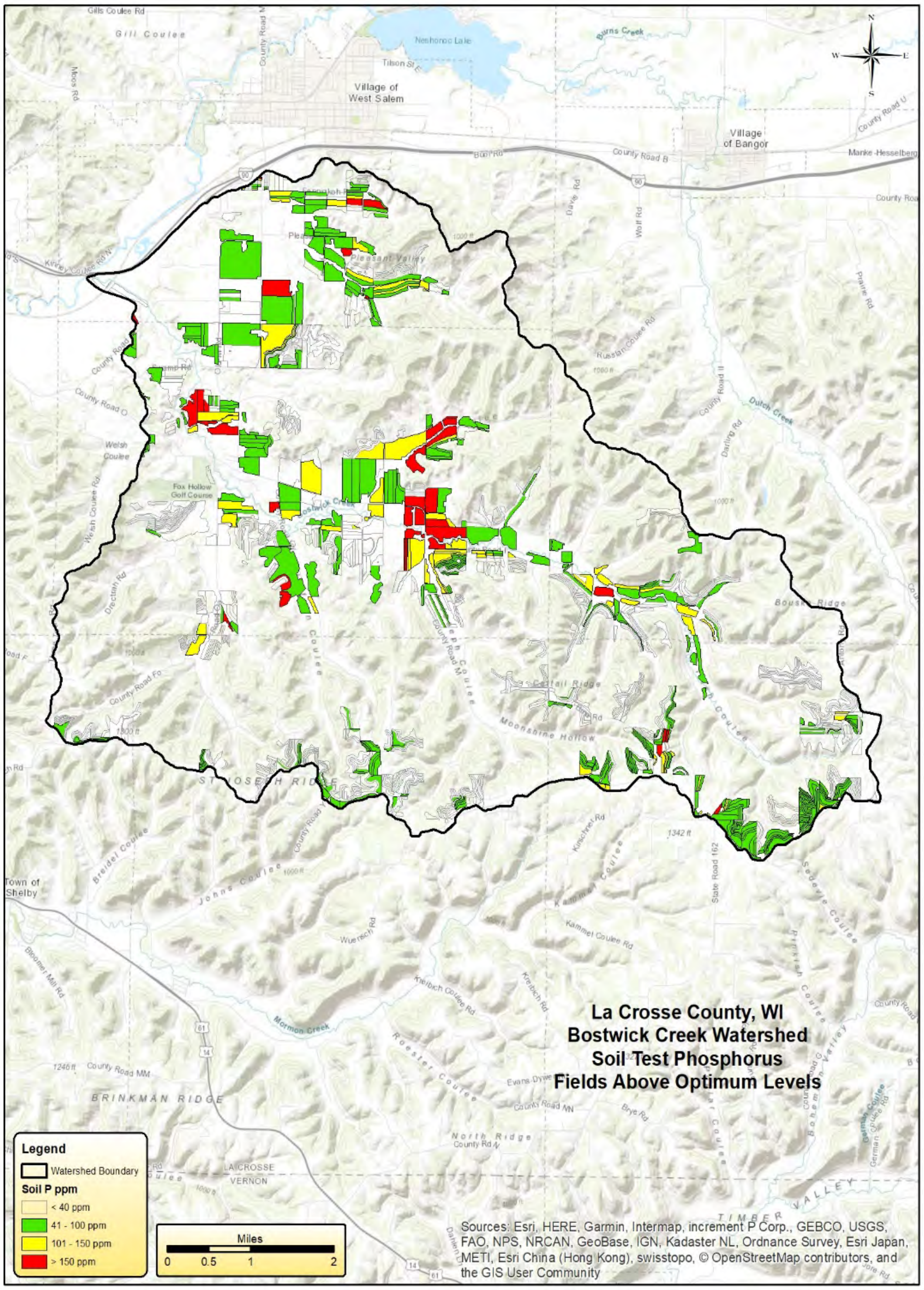


Figure 23 Bostwick Creek Watershed Conservation Cropping Practices Map

6.4 Nutrient Management Planning

Nutrient management planning is a method of utilizing and applying animal manures and commercial fertilizers to meet cropland nutrient needs without over-application of those nutrients. The primary nutrients in animal manure and commercial fertilizer is nitrogen (N), phosphorus (P) and potassium (K).



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

Figure 24 Bostwick Creek Watershed Soil Test Phosphorus Fields Above Optimum Levels

These primary nutrients are essential to plant growth and when applied at optimum rates helps achieve expected crop yields.

If these primary nutrients are under-applied or unavailable to the plants, crop yields are reduced and animal feed quality is jeopardized. To the contrary, if these nutrients are over applied, they are lost to the environment and become pollutants of groundwater and surface water resources.

Nutrient management planning attempts to balance the nutrient needs of crops while protecting water resources from excessive nutrient runoff.

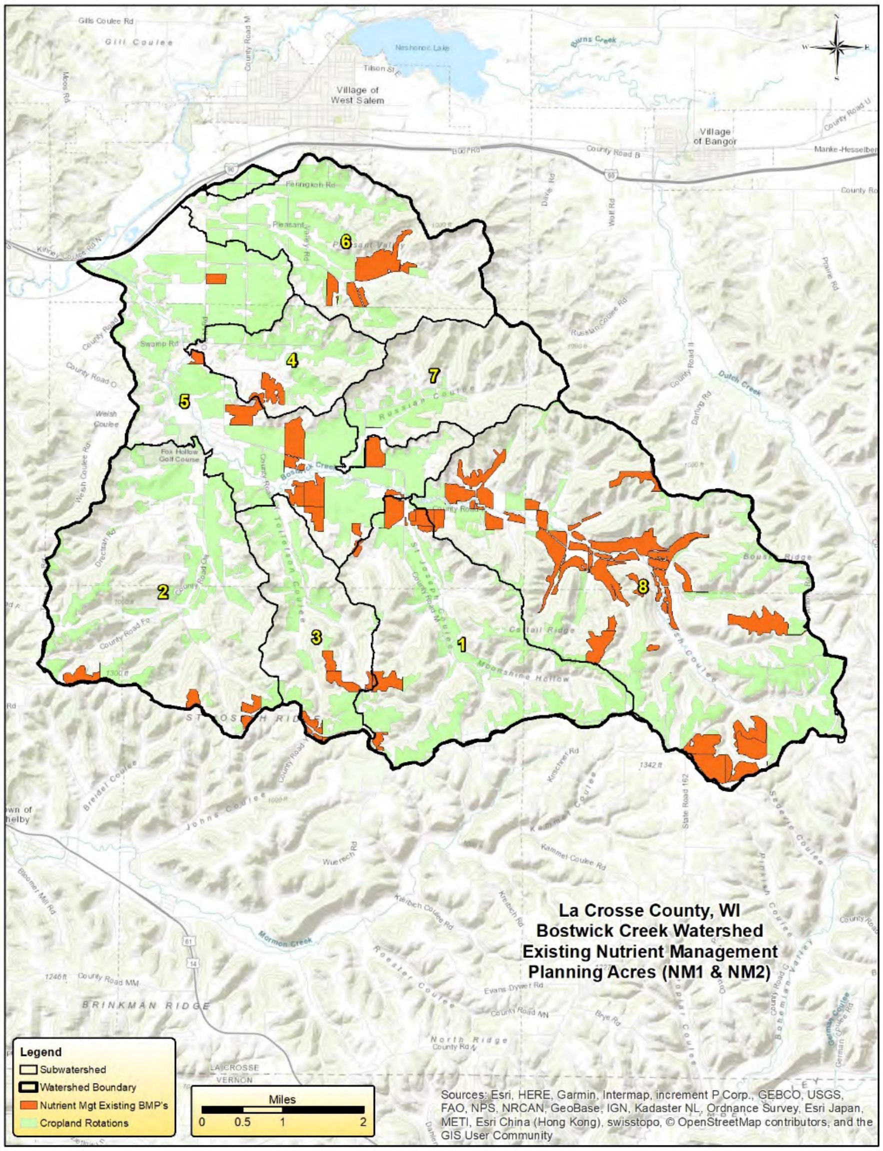


Figure 25 Bostwick Creek Watershed Nutrient Management BMPs

The La Crosse County Department of Land Conservation has developed and implemented a farmer nutrient management planning program since 1995. Department staff, along with staff from UW-Extension and the USDA Natural Resources Conservation Service, conduct annual workshops that assist farmers in developing their nutrient management plans. To date, La Crosse County has 150 farmers and 49,000 acres under a nutrient management plan. That represents 66% of the total cropland in La Crosse County.

The Bostwick Creek Watershed has 15 farmers and 2,108 acres operating under an approved nutrient management plan. This represents 20% of the cropland in the Bostwick Creek Watershed.

6.5 Grazing/Pastureland

Animal grazing in Bostwick Creek Watershed varies greatly from farm to farm. Dairy farm operators in the valley bottoms generally utilize stream corridors as pastureland since most farms were historically located close to water sources. Ridge top dairy operations must provide a source of drinking water for their animals and therefore keep them close to the farm buildings on exercise lots or free-stall buildings. Beef cattle operators often utilize available land that is not under crop production. This includes stream corridors as well as upland forests.

Stream corridor grazing by both dairy and beef cattle is of major concern regarding the water quality in Bostwick Creek. Overgrazing by cattle removes vegetation from streambanks and destabilizes the slopes, making them much more susceptible to sloughing and erosion. Cattle access to streams also creates high E.coli bacteria counts that exceed health standards set by the La Crosse County Environmental Health Department at a concentration of 1,000 colonies/100 ml.

The La Crosse County Comprehensive Plan indicates that there are 2,115 acres of pastureland in the Bostwick Creek Watershed. This number fluctuates as the number of small beef cattle operations varies from year to year based on markets. The STEPL model shows that pastureland generates only 1.72 tons of sediment per year to Bostwick Creek.

6.6 Gully Erosion

Gully erosion in the Driftless Region of Wisconsin usually occurs in two forms. One type of gully formation occurs after heavy rainfall or snowmelt events and are referred to as ephemeral gullies. These can be seen in crop fields where erosion control practices failed to provide adequate protection against the erosive forces of a runoff event. These types of gullies often cause sedimentation to occur at field edges and road ditches. Often times this sediment is carried to nearby streams and degrades water quality. These gullies are typically repaired by the farm operator after crops have been harvested and may not reappear for years. See Figure 26

Figure 26 In-field Gully Formation Photo

Another type of gully is referred to locally as “dry runs”. These gullies are often deep and narrow with boulder strewn channels. Runoff water from the ridge top fields is collected by naturally formed drainage patterns and swiftly escorted down the sides of steep bluffs to the valley bottoms below. These drainage patterns have formed since the retreat of the last glaciers some 12,000 years ago.

Under normal runoff events, these gullies are not considered to be active but rather serve as a conveyance system for runoff water from the uplands to the valley bottoms below. Under extreme runoff events, such as those that occurred in 2007, 2008 and 2017, these dry run gullies become raging torrents of water capable of transporting large boulders, rock and rubble downslope. These events can result in the littering of crop fields and stream beds with rock and rubble that have permanently redirected stream channels. See Figure 27

Figure 27 Dry Run Gully Deposits Photo

Determining soil loss from active gully erosion in crop fields can be calculated, when they form, by using a width x length x depth formula. Since field gully erosion occurs at sporadic events in the Bostwick Creek Watershed, calculating their contribution to sediment loading of streams is difficult at best.

Dry run gullies are numerous throughout the watershed and their contribution to sediment loading under normal runoff events is questionable. During extreme runoff events, these gullies transport material at rates that exceed soil loss calculation models. Utilization of conservation practices on ridge top crop fields that promote infiltration and slows runoff rates are important to reducing the downslope impacts from dry run gullies.

6.7 Wetlands

Wetland acres make up only a small percentage of land cover in the Bostwick Creek Watershed. Data from the La Crosse County Comprehensive Plan indicates that there are 61 acres of wetlands in the watershed. Much of these exist in the upper third of Bostwick Creek and are classified as riparian wetlands. They exist as oxbow formations. Some of these wetlands are lightly pastured.

6.8 Forests and Woodlands

Wooded acres in the Bostwick Creek Watershed make up a significant portion of the land cover. There are 13,195 acres of woodlands in the watershed. Nearly all of the woodland is privately owned except for approximately 2,000 acres of the Coulee Experimental Forest that is owned and operated by the Wisconsin Department of Natural Resources. The Coulee Experimental Forest was dedicated in 1960 for the purpose of research of the effects of land use and steep land management and its impacts on soil erosion and stream sedimentation. The Forest also studies the adaptability of various tree species and planting stock on different site locations to assist landowners with their tree planting programs. The Coulee Experimental Forest also provides outdoor recreation opportunities such as hiking, skiing, horseback riding and hunting.

Nearly all of the wooded acres in the Bostwick Creek Watershed are located on steep bluff sides that are not farmed due to steepness or thin soils over bedrock. The primary tree species consist of northern red oak, white oak, red maple, shagbark hickory and black cherry. These woodland acres are not extensively managed for timber production and are used primarily for recreational purposes and grazing. The STEPL model predicts that 2,208 tons of sediment per year are produced from forested land and only 6,940 pounds of phosphorus per year.

7.0 Watershed Goals and Management Objectives

The goals of the Bostwick Creek Watershed Project will be to;

1. Reduce in-stream phosphorus levels & sedimentation
2. Improve the trout fishery
3. Reduce flooding
4. Achieve County surface water quality standards

To achieve these goals, a number of water resource concerns must be identified before objectives can be defined. The Wisconsin Department of Natural Resources and the La Crosse County Department of Land Conservation have determined that the following sources are having negative impacts on the Bostwick Creek Watershed:

1. Total Phosphorus from manure and commercial fertilizer applications
2. Sedimentation from upland and streambank erosion
3. E.coli bacteria from animal feedlot runoff and cattle access to streams

The objectives for the Bostwick Creek Watershed Project will include the following:

1. Reduce total phosphorus and E. coli from croplands and feedlots
2. Reduce sedimentation from uplands and eroding streambanks
3. Increase water infiltration on cropland
4. Increase in-stream trout habitat

8.0 Management Measures Implementation

The following implementation schedule utilizes a 10 year plan horizon in an attempt to achieve the goals and objectives of the Bostwick Creek Watershed plan. The plan assumes that both staffing and financial resources will be sufficiently available to implement the activities as listed. It also assumes favorable landowner attitude and participation in the watershed project.

8.1 Management Measures Needed

The following Best Management Practices (BMP's) are deemed to be the most appropriate conservation measures to reduce total phosphorus, sedimentation and improve the trout fishery in Bostwick Creek;

- Barnyard Runoff Control Systems
- Access Road
- Contour Farming
- Cover and Green Manure Crop
- Critical Area Stabilization
- Diversions
- Filter Strips
- Grade Stabilization Structures
- Livestock Fencing
- Livestock Watering Facilities
- Nutrient Management for Cropland
- Relocating or Abandoning Animal Feeding Operations
- Residue Management
- Riparian Buffers
- Roofs
- Roof Runoff System
- Sediment Basins
- Streambank and Shoreline Protection
- Stream Crossing
- Strip-cropping
- Water and Sediment Control Basins
- Waterway Systems

8.2 Implementation Schedule

The following implementation schedule is a general outline of the planned activities for the installation of BMP's over a 10 year period.

Table 8 Implementation Schedule

Objective	*Activity*	*Milestones/Timeline*			*Funding Sources*	*Implementation*
		0-3 years	*3-7 years*	*7-10 years*		
Reduce total Phosphorus & E.Coli bacteria from cropland	Plant 1200 acres of cover crops	300 acres	400 acres	500 acres	DATCP, NRCS	NRCS, DLC
	Plan 1200 acres of nutrient management	300 acres	400 acres	500 acres	DATCP	NRCS, DLC, UW Extension
Reduce total Phosphorus & E.Coli Bacteria from animal feedlots	Install 3 roofed barnyards	1 unit	1 unit	1 unit	DNR-TRM, DATCP	DLC
	Install 1500 feet livestock fencing	500 feet	500 feet	500 feet	DNR-TRM, DATCP	DLC
	Install 10 roof runoff systems	2 systems	3 systems	5 systems	DNR-TRM, NRCS	DLC, NRCS
Reduce sedimentation from uplands and eroding stream banks	Plan 500 acres of Cons. Tillage	100 acres	200 acres	200 acres	DATCP	DLC
	Install 200 acres of contour farming	40 acres	60 acres	100 acres	DATCP, NRCS	NRCS, DLC
	30,000 feet of stream stabilization	5,000 feet	10,000 ft.	15,000 ft.	DNR-TRM, NRCS	NRCS, DLC
	10,000 feet livestock exclusion fence	1,000 feet	3,000 feet	6,000 feet	DNR-TRM, NRCS	NRCS, DLC
	Install 50 acres of riparian buffers	10 acres	20 acres	20 acres	DNR-TRM, NRCS	NRCS, DLC
	Install 30 stream crossings	10 units	10 units	10 units	DNR-TRM, NRCS	NRCS, DLC
Increase water infiltration on croplands	Plant 1200 acres of cover crops	300 acres	400 acres	500 acres	DNR-TRM, NRCS	NRCS, DLC
	Plan 500 acres of Cons. Tillage	100 acres	200 acres	200 acres	DATCP	DLC
Increase in-stream fish habitat	Place in-stream fish structures	TBD	TBD	TBD	Trout Unlimited	TU, DLC

9.0 Pollutant Load Reductions

Current pollutant loads from agricultural sources were estimated by applying the STEPL model (Spreadsheet Tool for Estimating Pollutant Loading) to known land use and management conditions in the Bostwick Creek Watershed. The STEPL model was also used to estimate pollutant reduction levels with applied Best Management Practices (BMP's). The BMP's selected and the quantities applied were based on the potential to attain La Crosse County water quality standards as well as anticipated landowner participation rates. The following Tables 9 & 10 show the estimated future load reductions for each sub basin based on selected management scenarios using the STEPL model.

Table 9 Future Pollutant Total Load Reductions (No Bmp's)

Watershed	N Load (no BMP) lb/year	P Load (no BMP) lb/year	BOD Load (no BMP) lb/year	Sediment Load (no BMP) t/year	N Reduction lb/year	P Reduction lb/year	BOD Reduction lb/year	Sediment Reduction t/year
W1	28113.7	7117.6	44549.5	1444.4	3927.0	2718.2	4410.5	689.1
W2	18616.0	5892.0	40913.2	1342.7	3119.6	2386.0	3652.4	570.7
W3	8761.8	3149.0	17633.5	741.7	2317.8	1394.2	2373.3	370.8
W4	6985.2	2042.5	13755.7	395.3	1223.5	1024.0	1401.9	219.0
W5	35364.9	9682.8	67069.7	1659.7	6185.4	4815.0	6545.2	1022.7
W6	18664.5	4885.6	33024.1	925.6	3153.4	1969.0	2606.6	407.3
W7	4622.5	1581.2	9194.6	362.5	497.5	323.3	564.7	88.2
W8	39505.6	14222.2	73310.8	3301.1	9738.1	7152.2	11294.6	1764.8
W9	13097.9	10805.8	26195.8	8213.3	4212.5	3475.3	8425.0	2647.7
W10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**173732.0**	**59378.8**	**325647.0**	**18386.4**	**34374.7**	**25257.1**	**41274.3**	**7780.4**

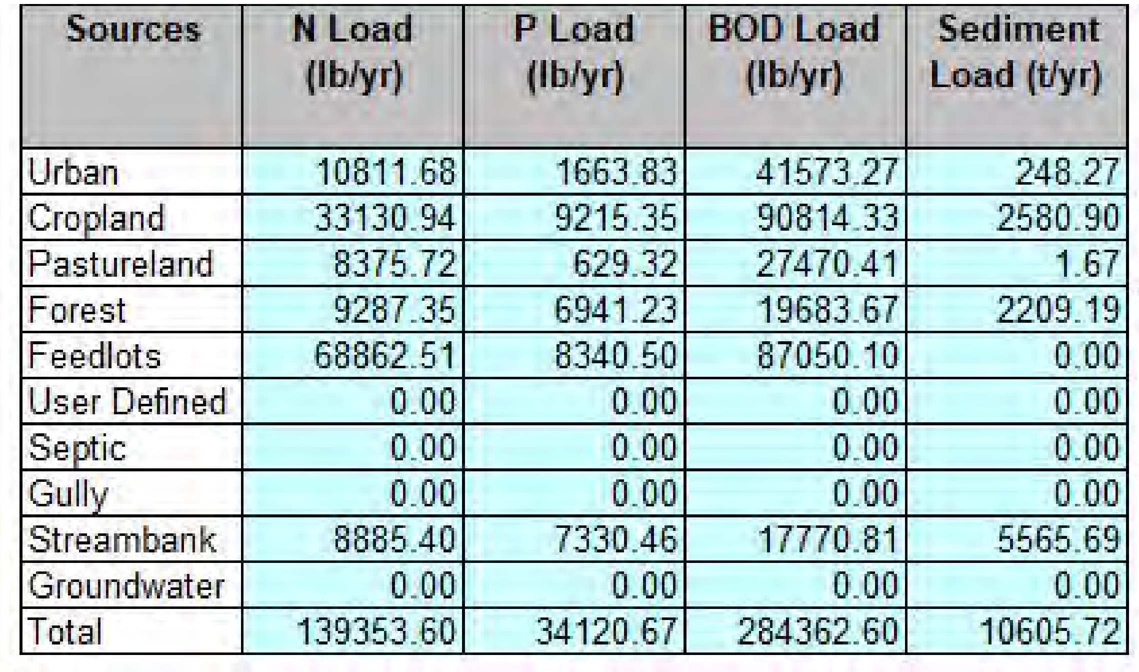
The application of selected BMP's and the resulting reductions can be seen in Table 10.

Table 10 Future Pollutant Total Load Reductions (With BMP's)

Watershed	N Load (with BMP) lb/year	P Load (with BMP) lb/year	BOD Load (with BMP) lb/year	Sediment Load (with BMP) t/year	N Reduction %	P Reduction %	BOD Reduction %	Sediment Reduction %
W1	24186.7	4399.4	40139.0	755.3	14.0	38.2	9.9	47.7
W2	15496.4	3506.1	37260.8	772.0	16.8	40.5	8.9	42.5
W3	6444.0	1754.8	15260.2	370.8	26.5	44.3	13.5	50.0
W4	5761.6	1018.5	12353.8	176.3	17.5	50.1	10.2	55.4
W5	29179.4	4867.9	60524.5	637.0	17.5	49.7	9.8	61.6
W6	15511.2	2916.7	30417.5	518.3	16.9	40.3	7.9	44.0
W7	4125.0	1257.9	8629.8	274.3	10.8	20.4	6.1	24.3
W8	29767.6	7070.0	62016.2	1536.3	24.6	50.3	15.4	53.5
W9	8885.4	7330.5	17770.8	5565.7	32.2	32.2	32.2	32.2
W10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**139357.3**	**34121.7**	**284372.6**	**10606.0**	**19.8**	**42.5**	**12.7**	**42.3**

The pollutant reductions of primary concern for the Bostwick Creek Watershed are phosphorus and sediment from agricultural sources. The BMP's selected for the STEPL Model were intended to target these pollutants at critical sites. Below is the expected total reductions of phosphorus and sediment by pounds per year.

Table 11 Future Pollutant Loading Reductions after BMP Installations by Land Use



Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	10811.68	1663.83	41573.27	248.27
Cropland	33130.94	9215.35	90814.33	2580.90
Pastureland	8375.72	629.32	27470.41	1.67
Forest	9287.35	6941.23	19683.67	2209.19
Feedlots	68862.51	8340.50	87050.10	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	0.00	0.00	0.00	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	8885.40	7330.46	17770.81	5565.69
Groundwater	0.00	0.00	0.00	0.00
Total	139353.60	34120.67	284362.60	10605.72

Current Phosphorus Load

Total Current Annual Agriculture Phosphorus Load (Table 6)

Agriculture =	Cropland + 11,014.04	Pasture + 638.23	Feedlot + 11,846.43	Streambank 10,805.75	= 34,304.45 lbs/yr

Total Phosphorus Reduction from Cropland after BMP Installation

Table 6 total 11,014.04 -	Table 9 total 9,215.35	= 1,798.69 lbs/year

Total Phosphorus Reduction from Streambanks after BMP Installation

Table 6 total 10,805.75 -	Table 9 total 7,330.46	= 3,475.29 lbs/year

Total Phosphorus reduction from Feedlots after BMP Installation

Table 6 total 11,846.43 -	Table 9 total 8,340.50	= 3,505.93 lbs/year

Total Phosphorus Reduction from Pastureland after BMP Installation

Table 6 total 638.23 -	Table 9 total 629.32	= 8.91 lbs/year

Total Agriculture Total Phosphorus Reduction = 8,788 lbs/year

Percent Reduction 8,788 lbs/year ÷ 34,304 lbs/year = 25.6%

Current Sediment Load

Total Current Annual Agriculture Sediment Load (Table 6)

Agriculture =	Cropland + 3,036.16	Streambank 8,213.34	= 11,250 t/yr

Total Sediment Reduction from Cropland after BMP Installation

Table 6 total 3,036.16 -	Table 9 total 2,580.90	= 455.26 t/year

Total Sediment Reduction from Streambanks after BMP Installation

Table 6 total 8,213.34 -	Table 9 total 5,565.69	= 2,647.65 t/year

Total Agriculture Sediment Reduction = 3,103 t/year

Percent Reduction: 3,103 t/year ÷ 11,250 t/year= 27.6%

9.1 Critical Sites

Land use in the Bostwick Creek Watershed is dominated by forestland (50%) and agriculture (46%). As can be expected, agricultural activities contribute the highest levels of phosphorus pollutant loading to Bostwick Creek. Agriculture also produces the second highest sediment pollutant loading levels to Bostwick Creek, just behind streambank erosion. The sources of agricultural pollutant loading is varied and scattered throughout the watershed and locating the primary sources will involve the use of a process that combines inventory data with water quality assessments.

The La Crosse County Department of land Conservation will use a systematic approach to define critical sites at existing farm operations. By utilizing the Department's Geographic Information System, current inventory data will be combined to create map layers that visually locates farm operations that have potentially severe or multiple sources of pollutant loading levels. Ranking the sub basins by pollutant loading (phosphorus and sediment) found in Table 4 will be the first filter applied to screen for critical sites. See Table 12. Inventory data for feedlots, streambanks, cropland, nutrient management and pastures will be combined to generate a map layer that should better define the location of critical sites.

Table 12 Sub Basin Ranking by Phosphorus and Sediment Loading

Sub Basin	Phosphorus lb/yr	Rank	Sediment t/y	Rank
W9	10,805	2	8,213	1
W8	14,222	1	3,301	2
W5	9,683	3	1,660	3
W1	7,118	4	1,444	4
W2	5,892	5	1,343	5
W6	4,886	6	926	6
W3	3,149	7	742	7
W4	2,043	8	395	8
W7	1,581	9	362	9

Critical sites for phosphorus runoff from animal feedlots has been inventoried and located in the watershed as shown in Figure 17. These critical sites have direct runoff to surface waters or are located within 300 feet of a navigable stream.

The streambank erosion inventory results are depicted in Figure 21. Erosion rates are listed as High, Moderate and Low.

Critical sites for streambank erosion will include the following conditions:

1. High erosion rates with cattle access
2. High erosion rates with adjacent cropland with no BMPs

Critical Sites for cropland will include the following existing conditions:

1. Fields with soils that have high erodibility indexes with no BMPs.
2. Fields with BMPs that exceed the tolerable soil loss rate.

Nutrient Management critical sites will include the following existing conditions:

1. Fields with soil test phosphorus levels greater than 40 ppm and no nutrient management plan.
2. Livestock operations with no nutrient management plans.

Pastureland critical sites will include the following existing conditions:

1. Pastured streambanks with inadequate sod cover to prevent erosion.
2. Pastures adjacent to streambanks with no vegetative buffer.

Department staff will conduct individual, on-site farm visits to determine actual field conditions and assess whether a critical sites designation is warranted. Map layers will be updated as field conditions are verified.

10.0 Information and Education

The intent of the proposed information and education program will be to raise landowner awareness of agricultural pollution sources and their effects on surface water quality. Emphasis will be placed on agricultural pollution impacts on the local fishery. It will also serve as a means to introduce farm operators to conservation measures that they have been reluctant to adopt due to a lack of understanding or misinformation.

The La Crosse County Department of Land Conservation has developed a working relationship with nearly 60% of the landowners in Bostwick Creek Watershed. Through conservation programs such as the State Farmland Preservation Program and the County's Nutrient Management Farmer Education program, we have been engaged with the majority of the landowners on an annual basis. The goal of this information and education program will be to engage the 40% of landowners that do not work with our Department on a regular basis and may not be applying soil and water conservation measures.

Objectives

- Determine level of landowner commitment to stewardship through a watershed-wide survey
- Develop educational materials to target various levels of landowner involvement
- Conduct Town Hall meetings to educate landowners about the project and allow them to give feedback
- Create landowner awareness of current water quality issues in their watershed
- Increase landowners adoption of conservation measures

The following Table 13 Shows the proposed information and education plan implemented over a ten year period and associated costs.

Table 13 Information and Education Plan Implementation Activities

Activity	Timeline		
	0-3 year	3-7 year	7-10 year
Issue a County-wide survey	60 surveys	30 surveys	
Issue a post-project survey to measure project success			50 surveys
Develop a project wide newsletter	3 newsletters	2 newsletters	2 newsletters
Develop fact sheets for NR 151	60 fact sheets	30 fact sheets	30 fact sheets
Develop BMP fact sheets	120 fact sheets	100 fact sheets	80 fact sheets
Project kickoff meeting to introduce project	2 meetings		
Annual "Progress to Date" meeting	1 meeting	3 meetings	3 meetings
Project wrapup meeting			1 meeting
Plan "field day" to demonstrate need for erosion control practices	2 field days	2 field days	2 field days
DNR fisheries stream shocking event	2 events	2 events	2 events
Develop demonstration plots for nutrient management, conservation tillage	3 events	3 events	2 events
Conduct one-on-one landowner meetings to encourage soil and water comservation plan development	20 meetings	20 meetings	40 meetings

11.0 Plan Implementation Costs

Projected costs for implementing the Bostwick Creek Watershed Plan is based on current estimated practice costs. Commonly used conservation practices have an estimated per unit cost that staff from La Crosse County Department of Land Conservation and the USDA-Natural Resources Conservation Service use to determine pre-construction costs or to determine final payment, as is the case with NRCS paid practices. Landowners that participate in the implementation of the Bostwick Creek Watershed Plan will be required to operate any installed conservation for a minimum of 10 years except for those practices that are installed to meet the conservation requirements of NR 151 where the standard must be maintained in perpetuity. Total cost to implement the 9 Key Elements Plan for Bostwick Creek is estimated at $2,929,250.00.

Table 14 Implementation Costs Summary

Item	Cost
Information and Education	$ 47,750
Water Quality Monitoring	$ 107,000
BMP Installation	$ 2,774,500
Total	**$ 2,929,250**

Table 15 Estimated Best Management Practice Installation Costs.

Practice		Quantity	Cost/Unit ($)	Total Cost ($)
Upland Best Management Practice	Cover Crops (ac.)	1,200	$50	$ 60,000
	Conservation Tillage (ac.)	500	$20	$ 10,000
	Nutrient Management (ac.)	1,200	$15	$ 18,000
	Contour Farming (ac.)	200	$10	$ 2,000
	Riparian Buffers (ac.)	50	$4,000	$ 200,000
Animal Waste Management Practice	Barnyard Roof Runoff System (units)	10	$6,500	$ 65,000
	Roofed Barnyards (units)	3	$130,000	$ 390,000
	Livestock Fencing (feet)	500	$7.00	$ 3,500
Streambank Stabilization and Protection Practices	Streambank Shaping and Sloping (ft.)	30,000	$5	$ 130,000
	Rock Rip Rap (lin. Ft.)	25,000	$38	$ 950,000
	Livestock Exclusion Fence (ft.)	10,000	$5	$ 50,000
	Stream Cattle Crossings (ft.)	1,400	$15	$ 21,000
Technical Assitance	Technical Assitance (hours)	25,000	$35	$ 875,000
			Total Cost	$2,774,500

Table 16 Water Quality Monitoring Estimated Costs

Water Quality Monitoring Activity	Costs ($)
Collect Weekly Water Samples From 4 Locations in Bostwick Creek Watershed for Analysis of Total Suspended Solids, Total Phosphorus and E. coli Bacteria. 10 year schedule April through October each year.	$55,000
Deploy Water Quality Monitoring YSI Sondes at four bridge locations in Bostwick Creek Watershed to measure Dissolved Oxygen and Temperature. 10 year schedule April through October annually.	$40,000
Coordinate with DNR Biologists to collect water quality indicators such as aquatic invertebrates and fish surveys on an annual basis.	$12,000
Total Cost	$107,000

12.0 Funding Sources

The implementation of the Bostwick Creek Watershed Project will utilize available Federal, State and County financial resources to provide cost share assistance to participating landowners. The following programs are expected to be the primary funding sources for project implementation.

USDA-Natural Resources Conservation Service – Environmental Quality Incentives Program (EQIP). This program provides financial and technical assistance to cooperating landowners who install conservation measures that address resource concerns. Participants receive a flat-rate payment for conservation practices that are designed and installed in accordance with USDA-NRCS standards and specifications.

USDA-Farm Service Agency – Conservation Reserve Enhancement Program (CREP). A federal program that provides funding to eligible landowners for installation of filter strips, buffer strips, wetland restoration, tall grass prairie, oak savanna restoration, grassed waterways and permanent native grasses. The program also offers conservation easements with a 15 year contract or a perpetual easement.

Wisconsin Department of Natural Resources – Targeted Runoff Management Grant (TRM). A State funded competitive grant program that provides local units of government with funding to control nonpoint sources of pollution. Grants are issued for both agricultural related and urban sources of nonpoint pollution. Cost share rates under this program are 70% of eligible construction costs.

Wisconsin Department of Agriculture, Trade and Consumer Protection – Soil and Water Resource Management Grant (SWRM). A state program that helps fund county soil and water conservation staff and support expenditures, as well as landowner conservation projects. Cost share rates to landowners who install eligible conservation measures can receive up to 90% reimbursement of installation costs.

County of La Crosse – Environmental Fund. This is a cost share program funded by La Crosse County to provide financial assistance to Landowners who install conservation measures that may not be funded though other conservation programs. These funds are usually targeted for watersheds that are of special concern to La Crosse County.

USDA-Natural Resources Conservation Service in Partnership with Trout Unlimited – Regional Conservation Partnership Program. NRCS and its partners assist landowners and farm operators install and maintain conservation activities in selected project areas. The Jo Daviess Conservation Foundation and its partners will target areas in the Driftless Area where land restoration and land protection will have the most positive impact on water quality by implementing permanent conservation practices that reduce pollution and sediment runoff into streams. RCPP funding will provide a new comprehensive, targeted regional approach to restoring cold-water streams and their riparian areas for the benefit of the many at-risk species. The project will assist landowners reduce pollution and sediment runoff through the adoption of key conservation practices. Agricultural Conservation Easement Program funding will purchase agricultural conservation easements to install permanent conservation practices such as riparian buffers and filter strips.

13.0 Plan Implementation Progress

The proposed implementation schedule for the Bostwick Creek Watershed Project will require 10 years of BMP planning, design and installation. Over this time span, individual farms will be assessed to determine the location and efficiency of existing BMPs, current management practices and potential critical sites of pollution. The farm operations will also be assessed to determine whether they are in compliance with the State of Wisconsin's agriculture performance standards in accordance with the Department of Natural Resources Chapter NR 151.

All BMPs that are contracted under the Bostwick Creek Watershed Project will be planned, designed and installed by certified staff with the appropriate USDA Natural Resources Conservation Service Engineering Job Approval Authority or the Wisconsin Department of Agriculture, Trade and Consumer Protection Conservation Engineering Practitioner Certification. For nutrient management planning and conservation tillage practices, plan approval must be by a Certified Crop Advisor (CCA) or a person with a higher level of accreditation. This rule ensures that qualified staff are involved in the decision-making process and insures that selected BMPs and their application is appropriate for the existing conditions.

When a farm operator has agreed to the installation of a BMP, they will be required to sign an operation and maintenance agreement for that BMP prior to engaging in a cost-share assistance agreement. This ensures that the farm operator understands their responsibility for the proper and continued operation of the BMP.

As the Bostwick Creek Watershed Project progresses, it will be important to monitor the functionality of all BMPs after their installation. Over time, BMPs can become less efficient at achieving designed pollutant reductions due to several factors. According to the U.S. Environmental Protection Agency, natural variability, lack of proper maintenance and unforeseen consequences are primary causes of BMP depreciation. See Appendix B.

To ensure that installed BMPs are reaching their designed life expectancy, the La Crosse County Department of Land Conservation will monitor and verify the condition and efficiency of the conservation practice. This will be accomplished by recording the location, type and installation date of each contracted BMP using the Department's Geographic Information System (GIS). The recording of the BMP will occur after certification of practice installation and has been determined that the practice is functioning according to design standards and specifications.

Periodic BMP inspections will be conducted, especially after significant weather events, to determine if the practices are continuing to function properly. Visual inspections and other methods of verification as described in the U.S. Environmental Protection Agency Technical Memorandum #1, Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, will be utilized during BMP inspection. See Appendix B.

There are several key indicators of the Bostwick Creek Watershed plan that will be carefully tracked and monitored to determine if sufficient progress is being made and milestones are being achieved. Those indicators include:

- Landowner participation rates are not hitting targets by year 3 of implementation
- The number of conservation measures installed are not meeting milestones by year 3
- The type of conservation measures requested from landowners differ from Department proposed measures
- In-stream water quality is not responding to conservation measures by year 5

The La Crosse County Department of Land Conservation will take the lead responsibility of monitoring plan implementation progress by tracking the following plan components:

1. Information and education activities and participation
2. Pollution reduction levels from installed BMP's
3. In-stream water quality monitoring
4. Administrative review

With assistance from our cooperating partners, USDA-NRCS and UW-Extension Services, an annual review meeting will be conducted to assess the following activities:

1. Information and education
    a. Number of landowners/operators contacted
    b. Number of one-on-one landowner contacts
    c. Number of group meetings and attendance
    d. Number of cost share agreements signed

2. BMP installation, performance and pollution reduction
    a. That BMP design is in accordance with NRCS standards and specifications
    b. That BMP's are installed according to standards and specifications
    c. Inspect BMP's every 4 years to determine level of efficiency
    d. Conduct BMP operation and maintenance spot checks
    e. Rerun STEPL Model when BMP efficiency has changed to determine effects on pollutant loads

3. Water Quality Monitoring
    a. Results of Phosphorus, Total Suspended Solids and E.coli bacteria from weekly grab samples
    b. Results of Dissolved Oxygen and temperature from YSI sondes
    c. Results from Dutch Creek monitoring station
    d. DNR aquatic biota survey review

4. Administrative Review
    a. Grant source and application review
    b. Grant allocations for cost share assistance review
    c. Review practices and dollar amounts per cost share agreement
    d. Track and review staff expenses and support costs
    e. Review all other expenses related to the project
    f. Determine if milestones are sufficiently attained

There are many variables that may change the present land use in Bostwick Creek and therefore the effectiveness of the implementation plan. Dairy operations are declining at an accelerating pace due to 4 continuous years of low milk prices. As in the past, these retired dairy operations will rent out their cropland to cash grain farmers or replace the dairy herd with beef animals. This may or may not have a significant impact on water quality in Bostwick Creek.

The La Crosse County Department of Land Conservation, along with our cooperating partners will annually evaluate and monitor these potential changes in land use and prepare to refocus the implementation plan accordingly. Utilizing an adaptive management strategy in evaluating project progress will assist in meeting watershed goals.

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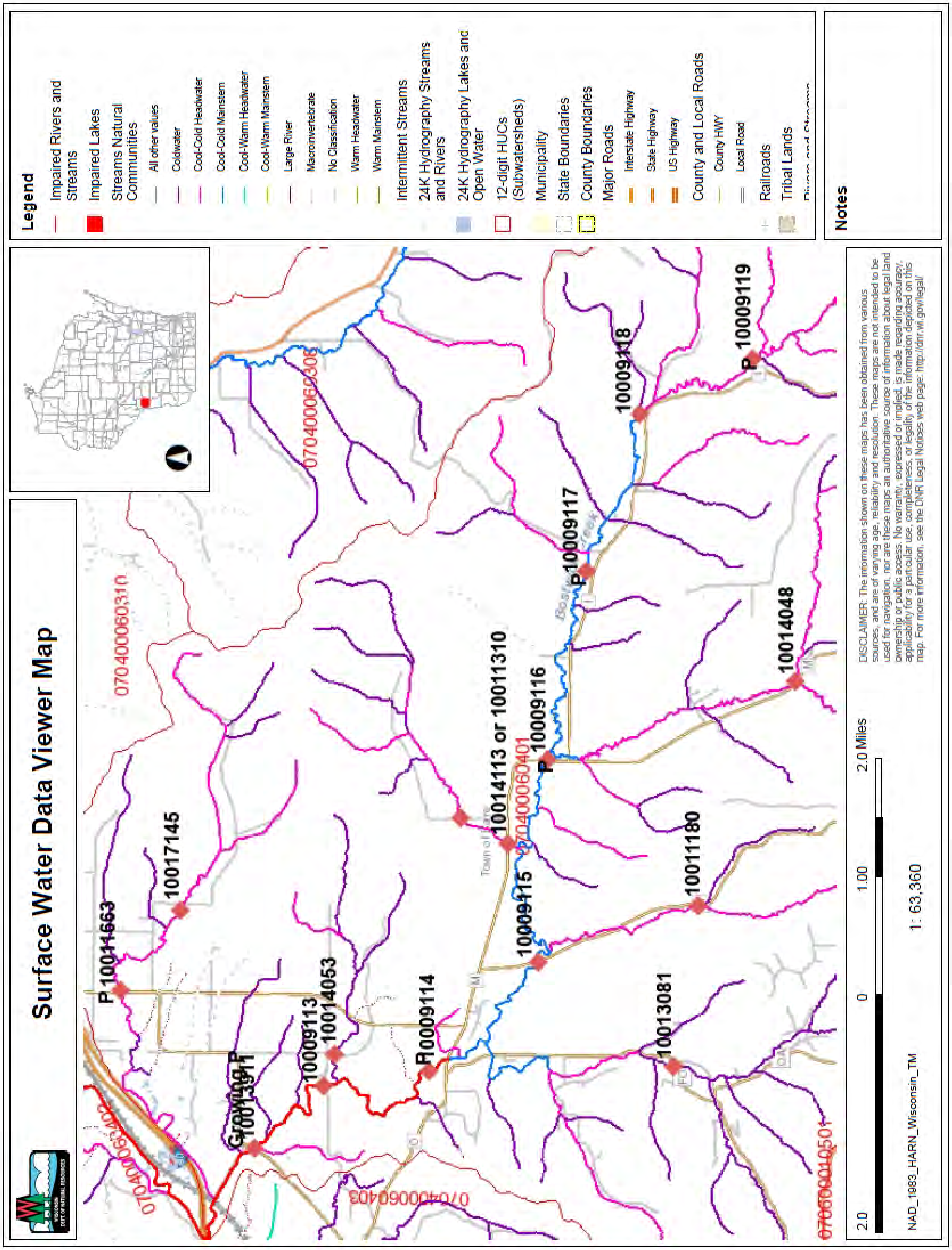
Appendix

A. Bostwick Creek Department of Natural Resources Water Quality Survey 2018



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Summary of the Bostwick Creek Watershed

Station Name: Bostwick Creek #7 – Field Rd. Crossing on Tremaine Property**Swims:** 10009119

Habitat: Stream runs through a disturbed pasture with livestock occupying the pasture. There was little to no riparian buffer width throughout this station. Overall, the stream had a nice complex of riffles, pools, and runs. Bank erosion was limited and was primarily along bends and in areas where cattle heavily use the stream. Substrate varied throughout the stream and consisted of fines (sand, silt, and clay) in pools and deeper runs; and rubble, cobble, and gravel in the riffles. The stream had a fair amount of fish habitat which consisted of undercut banks, root wads, overhanging vegetation, and deep pools. Native vegetation such as bull rush was present along the stream corridor, but the stream is also home to invasive species such as Forget Me Not.

Fish: The only fish species present in this stream were brown trout. In the 100 meters we shocked and measured 52 brown trout. Adult brown trout lengths varied from 7.0 inches to 13.4 inches, and only one young of the year was present.

Station Name: Bostwick Creek #6- Lower Field Rd. Crossing on Schomberg Farm **Swims:** 10009118

Habitat: Entire stream flows through a pasture area with cattle. There was little to no riparian buffer width along this station. Banks were eroded from heavy cattle use. The stream complex consisted of pools, riffles, and runs. Fine sediments covered most of the stream surfaces. Fish cover consisted of woody debris (log jams and treefalls), overhanging vegetation, submerged macrophytes, pools and boulders. Aquatic invasive species noted in this stream were Forget Me Not and Rusty Crayfish.

Fish: The only fish species present in this stream were Brown Trout. In the 100 meters we shocked and measured 37 brown trout. Adult Brown Trout lengths varied from 5.0 inches to 11.6 inches, and 2 young of the year were present.

Station Name: Bostwick Creek #5- 300 Meters Downstream from Cty II Bridge **Swims:** 10009117

Habitat: Stream was filled with downed trees, log jams, and woody debris. Good riffle, run, and pool complexes. Fine sediments, mainly silt and clay, were extensive in all habitats. Erosion was extensive. Stream showed evidence of being a very flashy system (ripped up trees, high banks, etc.). In some areas the station buffer appeared wide and vegetated with trees and shrubs, other areas had a small buffer with adjacent row crops.

Fish: The only species present is Brown Trout. In a 175-meter length station we shocked approximately 300 trout. 220 of those fish were adults ranging from 4.2 inches to 15.2 inches. The other 80 trout were young of the year fish under 4 inches.

Station Name: Unnamed (St. Joseph Coulee Creek) at CTH I Bridge Crossing **Swims:** 10014106

Habitat: Stream complex was mostly runs, with no riffles, and a few short pools. Substrate consisted of all sand and silt, with very few areas of gravel. The riparian zone was well protected and relatively undisturbed. Bank erosion was present in some areas along the stream, but not extensive. Woody debris, small pools, and over hanging vegetation provided fish cover. The aquatic invasive species Forget Me Not was present in this stream.

Fish: The only species present in this stream are brown trout. In 135-meter length station 27 brown trout were present. Of the 27, 26 are adults and 1 is a young of the year.

Station Name: Bostwick Creek #4- Bridge on Cty M **Swims:** 10009116

Habitat: Stream substrate was entirely sand but was very stable. Some areas below the sand were clay. Riparian buffer width was narrow with row crops on the left side and old pasture on the right side beyond the small buffer width. The banks were fairly stable and vegetated with heavy reed canary grass and other meadow species, although there was more extensive erosion on the right bank. Stream complexes were predominantly runs with a few small pools and bends, but no riffles. Fish cover was composed of overhanging vegetation, some woody debris, and a couple of pools. Aquatic invasive species were found and consisted of curly leaf pondweed.

Fish: The only species present in this section of stream are Brown Trout. In a 140 meter segment 229 browns were captured. 192 of those fish were adults ranging from 5.5 inches to 18.5 inches. Another 37 juvenile young of the year trout were also present in the stream.

Station Name: Unnamed (Russian Coulee Creek) At Cth M Bridge Crossing **Swims:** 10014113

Habitat: Buffer width was wide and wooded. Past the buffer width the land use was agriculture and a few houses on the right bank and start of town on left bank. Limited bank erosion. All runs, no pools or riffles in station length. Two slight bends present in stream. Substrate is primarily sand, silt, and clay, but small patches of gravel were present. Fish cover limited to woody debris, scraps (metal pipes and tires) and some overhanging vegetation. Sewage smell 10 meters below bridge, visible liquid seeping from bank into stream.

Fish: Both Brown Trout and a Brook Trout are present in this stream. 6 Brown Trout were captured ranging from 3.5 inches to 8.0 inches. Only one Brook Trout was captured, and it measured 7.6 inches.

Station Name: Unnamed Creek (Tollefson Coulee Creek) - Beginning at Confluence with Bostwick Creek

Swims: 10011179

Habitat: Riparian buffer width was less than 1 meter and stream flowed through a pasture area. Bank erosion was moderate in this station length. The stream was dominated by runs, but riffle areas and bends did exist. Fine sediments were common in the mid channel and present in riffles. Cover for fish was common, but not extensive and generally limited to overhanging vegetation and undercut banks.

Fish: In this stream both Brown Trout and Brook Trout were present. 13 Browns were captured ranging from 3.1 inches to 10.4 inches. Only one 8.2 inch Brook Trout was captured, and it had gill lice.

Station Name: Bostwick Creek #3 - Cty Rd YY **Swims:** 1009115

Habitat: In this segment, buffer width was less than 1 meter and stream flowed through a large pasture area with cattle present. Erosion was extensive and very eroded to the crest of the stream, although the bank was more stable. Within the stream complex runs were dominant and riffles and bends were present. Fine sediments were extensive throughout the stream. Cover for fish was common (woody debris and undercut banks).

Fish: This segment of Bostwick had more diversity. We shocked 36 White Suckers, 11 Johnny Darters, Brook Trout and Brown Trout. We shocked 6 Brook Trout ranging from 7.7 inches to 9.9 inches. 4 of these Brook Trout also had gill lice. We also shocked 102 Brown Trout ranging from 5.3 inches to 14.1 inches.

Station Name: Garber's Coulee Creek - Starts at Cth Oa Bridge Crossing **Swims:** 10014115

Habitat: Stream showed signs of previous flooding. Woody debris and downed trees were abundant in this portion of the stream. Fines were the dominate substrate type (sand, silt, and clay) and in some areas these fines were 2-3 feet deep. Stream was comprised of mainly runs, except for a riffle below the bridge. Bank erosion was major in some areas, but overall the station length was only moderately eroded. Iron bacteria present in back water areas and pockets along the stream bank. Cover for fish was abundant due to the amount of woody debris and overhanging vegetation in the stream. Riparian buffer width was good in most parts of the stream (trees and shrubs), but the segment started below a golf course and is adjacent to a few smaller row crop fields. One aquatic invasive species of concern that we noted was Japanese knot weed.

Fish: We shocked 175 meters upstream. In that section we shocked 11 Brown Trout ranging from 7.0 inches to 11.6 inches, 4 Brook Trout 7.4 inches to 9.4 inches, 2 of those also had gill lice. We also shocked 1 11.3-inch Northern Pike.

Station Name: Pleasant Valley – Bridge on Cth M **Swims:** 10011663

Habitat: The riparian buffer width was wide and well vegetated. Erosion was limited throughout the stream. Pools were rare overall but were located along bends which occurred throughout the segment. Riffles were generally well developed, but runs were the dominant habitat type. The stream was generally deep and narrow. Substrate was mainly silt and sand, although pockets of gravel existed in the riffles. Fish cover was limited to mainly overhanging vegetation (Reed Canary) and woody debris.

Fish: The only species present in the section of stream were Brook Trout. We captured 1 10.0 inch, and 2 8.9 inch Brook Trout. Two Brooks also had gill lice.

Station Name: Bostwick Creek – Cth B Bridge **Swims:** 10013911

Habitat: Riparian buffers were wide, although row crops were present beyond the buffer area. Erosion was limited along stream banks. Stream was very wide and sandy, and displayed few other substrate types. Log jams and woody debris were present along the station length and provided fish cover. Stream complex was not well developed and consisted mostly of runs. Fish diversity consisted of both warm-water and cold-water species which may have been influenced by the distance to the La Crosse River.

Fish: This Station yielded a diverse group of fish, 11 species in total. The non-game species we captured were; 20 White Suckers, 2 Banded Darters, 9 Johnny Darters, 1 Central Mud Minnow, 10 Longnose Dace, and 3 Western Blacknose Dace. The game species we captured were; 1- 8.0 inch Musky, 1- 2.6 inch Yellow Perch, 90 Brown Trout ranging from 13.7 inches to 3.2 inches, 1- 7.5 inch Brook Trout, and 2- 3 inch Small Mouth Bass.

Station Name: Bostwick Creek #1 – Bridge on Swamp Rd. **Swims:** 10009113

Habitat: Has not been surveyed yet.

Fish: At this site we shocked 240 meters upstream. That yielded 1 Lamprey Ammocoete, 14 White Suckers, 11 Longnose Dace, 5 Johnny Darters, 91 Brown Trout ranging in length from 3.6 inches – 15.9 inches, and 2 Brook Trout 7.5 inches and 9.9 inches.

Station Name: Unnamed Creek 20 – Old CTH M Bridge Crossing **Swims:** 10014053

Habitat: Riparian buffer greater than 10 Meters on both sides and consisted of forest and meadows. Substrate was sandy with a few gravel patches. Only one small riffle area with no pools and predominately runs. Some bank erosion on the right bank. Some woody debris in the stream, but not deep enough to provide fish cover. Culvert under road is perched and blocks fish movement upstream.

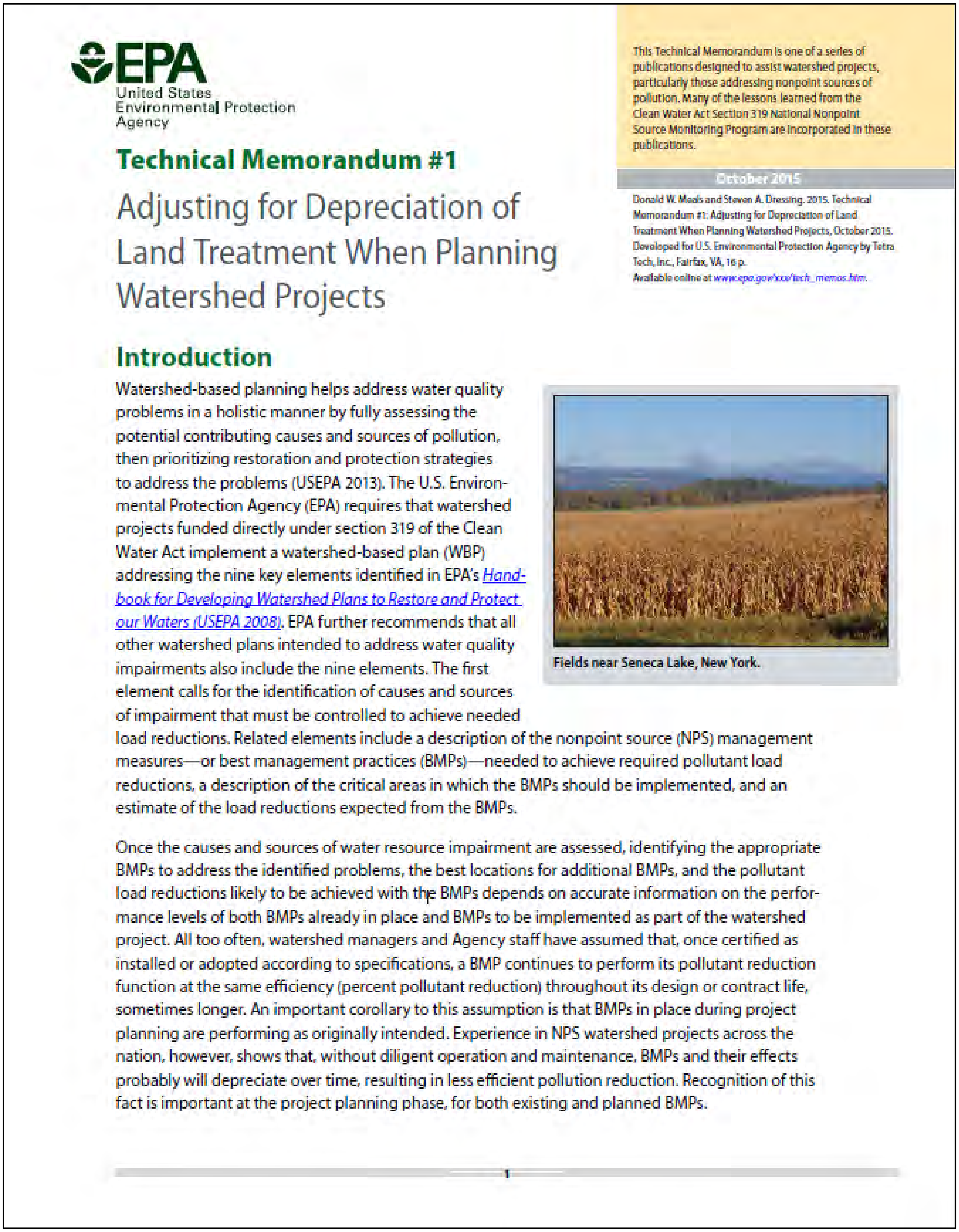
Fish: We started shocking 105 meters downstream of the culvert and then shocked upstream 100 meters. In that station length we captured 1 Brook Stickleback, 2 Brook Trout 7.3 and 9.1 inches (one with gill lice), and 3 Brown Trout 3.5, 7.1 and 7.7 inches.

Station Name: Bostwick Creek #2 – 320 Meters Downstream from CTY O Bridge. **Swims:** 1009114

Habitat: Has not been surveyed yet

Fish: In 220 Meters we shocked 4 species. 17 White Suckers, 3 Longnose Dace, 3 Brook Trout ranging from 6.6 to 12.2 inches (2 with gill lice), and 86 Brown Trout which measured 3.6 inches to 17.3 inches.

B. EPA Technical Memorandum #1 – Adjusting for Depreciation of Land Treatment When Planning Watershed Projects



United States
Environmental Protection
Agency

Technical Memorandum #1

Adjusting for Depreciation of Land Treatment When Planning Watershed Projects

This Technical Memorandum is one of a series of publications designed to assist watershed projects, particularly those addressing nonpoint sources of pollution. Many of the lessons learned from the Clean Water Act Section 319 National Nonpoint Source Monitoring Program are incorporated in these publications.

October 2015

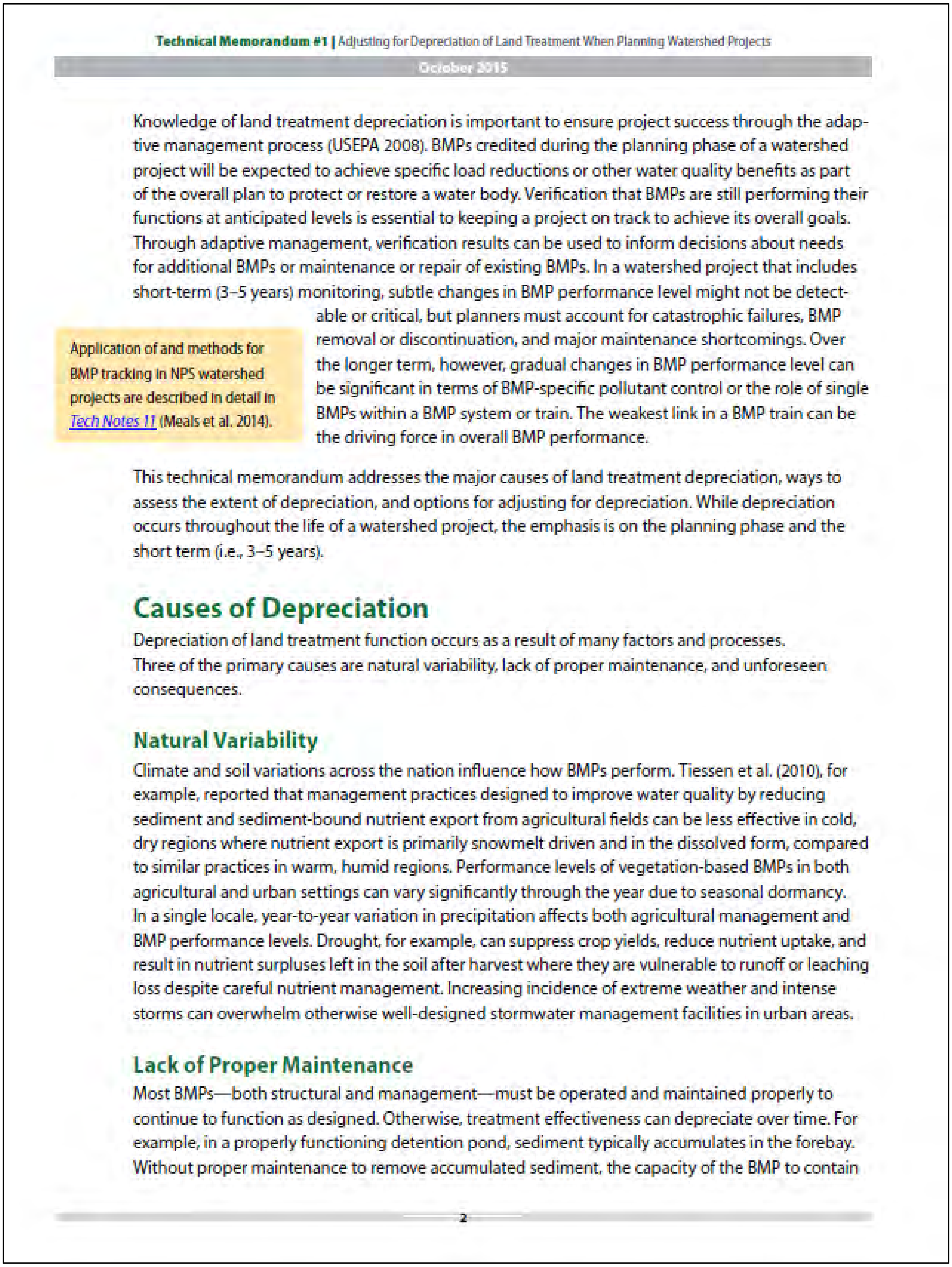
Donald W. Meals and Steven A. Dressing. 2015. Technical Memorandum #1: Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, October 2015. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 16 p.
Available online at *www.epa.gov/xxx/tech_memos.htm*.

Introduction

Watershed-based planning helps address water quality problems in a holistic manner by fully assessing the potential contributing causes and sources of pollution, then prioritizing restoration and protection strategies to address the problems (USEPA 2013). The U.S. Environmental Protection Agency (EPA) requires that watershed projects funded directly under section 319 of the Clean Water Act implement a watershed-based plan (WBP) addressing the nine key elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters (USEPA 2008)*. EPA further recommends that all other watershed plans intended to address water quality impairments also include the nine elements. The first element calls for the identification of causes and sources of impairment that must be controlled to achieve needed load reductions. Related elements include a description of the nonpoint source (NPS) management measures—or best management practices (BMPs)—needed to achieve required pollutant load reductions, a description of the critical areas in which the BMPs should be implemented, and an estimate of the load reductions expected from the BMPs.

Fields near Seneca Lake, New York.

Once the causes and sources of water resource impairment are assessed, identifying the appropriate BMPs to address the identified problems, the best locations for additional BMPs, and the pollutant load reductions likely to be achieved with the BMPs depends on accurate information on the performance levels of both BMPs already in place and BMPs to be implemented as part of the watershed project. All too often, watershed managers and Agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.



Knowledge of land treatment depreciation is important to ensure project success through the adaptive management process (USEPA 2008). BMPs credited during the planning phase of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track to achieve its overall goals. Through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planners must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train. The weakest link in a BMP train can be the driving force in overall BMP performance.

Application of and methods for BMP tracking in NPS watershed projects are described in detail in *Tech Notes 11* (Meals et al. 2014).

This technical memorandum addresses the major causes of land treatment depreciation, ways to assess the extent of depreciation, and options for adjusting for depreciation. While depreciation occurs throughout the life of a watershed project, the emphasis is on the planning phase and the short term (i.e., 3–5 years).

Causes of Depreciation

Depreciation of land treatment function occurs as a result of many factors and processes. Three of the primary causes are natural variability, lack of proper maintenance, and unforeseen consequences.

Natural Variability

Climate and soil variations across the nation influence how BMPs perform. Tiessen et al. (2010), for example, reported that management practices designed to improve water quality by reducing sediment and sediment-bound nutrient export from agricultural fields can be less effective in cold, dry regions where nutrient export is primarily snowmelt driven and in the dissolved form, compared to similar practices in warm, humid regions. Performance levels of vegetation-based BMPs in both agricultural and urban settings can vary significantly through the year due to seasonal dormancy. In a single locale, year-to-year variation in precipitation affects both agricultural management and BMP performance levels. Drought, for example, can suppress crop yields, reduce nutrient uptake, and result in nutrient surpluses left in the soil after harvest where they are vulnerable to runoff or leaching loss despite careful nutrient management. Increasing incidence of extreme weather and intense storms can overwhelm otherwise well-designed stormwater management facilities in urban areas.

Lack of Proper Maintenance

Most BMPs—both structural and management—must be operated and maintained properly to continue to function as designed. Otherwise, treatment effectiveness can depreciate over time. For example, in a properly functioning detention pond, sediment typically accumulates in the forebay. Without proper maintenance to remove accumulated sediment, the capacity of the BMP to contain and treat stormwater is diminished. Similarly, a nutrient management plan is only as effective as its implementation. Failure to adhere to phosphorus (P) application limits, for example, can result in soil P buildup and increased surface and subsurface losses of P rather than the loss reductions anticipated.

Jackson-Smith et al. (2010) reported that over 20 percent of implemented BMPs in a Utah watershed project appeared to be no longer maintained or in use when evaluated just 5 years after project completion. BMPs related to crop production enterprises and irrigation systems had the lowest rate of continued use and maintenance (~75 percent of implemented BMPs were still in use), followed by pasture and grazing planting and management BMPs (81 percent of implemented BMPs were still in use). Management practices (e.g., nutrient management) were found to be particularly susceptible to failure.

Practices are sometimes simply abandoned as a result of changes in landowner circumstances or attitudes. In a Kansas watershed project, farmers abandoned a nutrient management program because of perceived restrictive reporting requirements (Osmond et al. 2012).

In the urban arena, a study of more than 250 stormwater facilities in Maryland found that nearly one-third of stormwater BMPs were not functioning as designed and that most needed maintenance (Lindsey et al. 1992). Sedimentation was a major problem and had occurred at nearly half of the facilities; those problems could have been prevented with timely maintenance.


Abandoned waste storage structure.

Hunt and Lord (2006) describe basic maintenance requirements for bioretention practices and the consequences of failing to perform those tasks. For example, they indicate that mulch should be removed every 1–2 years to both maintain available water storage volume and increase the surface infiltration rate of fill soil. In addition, biological films might need to be removed every 2–3 years because they can cause the bioretention cell to clog.

In plot studies, Dillaha et al. (1986) observed that vegetative filter strip-effectiveness for sediment removal appeared to decrease with time as sediment accumulated within the filter strips. One set of the filters was almost totally inundated with sediment during the cropland experiments and filter effectiveness dropped 30–60 percent between the first and second experiments. Dosskey et al. (2002) reported that up to 99 percent of sediment was removed from cropland runoff when uniformly distributed over a buffer area, but as concentrated flow paths developed over time (due to lack of maintenance), sediment removal dropped to 15–45 percent. In the end, most structural BMPs have a design life (i.e., the length of time the item is expected to work within its specified parameters). This period is measured from when the BMP is placed into service until the end of its full pollutant reduction function.

Unforeseen Consequences

The effects of a BMP can change directly or indirectly due to unexpected interactions with site conditions or other activities. Incorporating manure into cropland soils to reduce nutrient runoff, for example, can increase erosion and soil loss due to soil disturbance, especially in comparison to reduced tillage. On the other hand, conservation tillage can result in accumulation of fertilizer nutrients at the soil surface, increasing their availability for loss in runoff (Rhoton et al. 1993). Long-term reduction in tillage also can promote the formation of soil macropores, enhancing leaching of soluble nutrients and agrichemicals into ground water (Shipitalo et al. 2000). Stutter et al. (2009) reported that establishment of vegetated buffers between cropland and a watercourse led to enhanced rates of soil P cycling within the buffer, increasing soil P solubility and the potential for leaching to watercourses.

Despite widespread adoption of conservation tillage and observed reductions in particulate P loads, a marked increase in loads of dissolved bioavailable P in agricultural tributaries to Lake Erie has been documented since the mid-1990s. This shift has been attributed to changes in application rates, methods, and timing of P fertilizers on cropland in conservation tillage not subject to annual tillage (Baker 2010; Joosse and Baker 2011). Further complicating matters, recent research on fields in the St. Joseph River watershed in northeast Indiana has demonstrated that about half of both soluble P and total P losses from research fields occurred via tile discharge, indicating a need to address both surface and subsurface loads to reach the goal of 41 percent reduction in P loading for the Lake Erie Basin (Smith et al. 2015).

Several important project planning lessons were learned from the White Clay Lake, Wisconsin, demonstration projects in the 1970s, including the need to accurately assess pollutant inputs and the performance levels of BMPs (NRC 1999). Regarding unforeseen consequences, the project learned through monitoring that a manure storage pit built according to prevailing specifications actually caused ground water contamination that threatened a farmer's well water. This illustrates the importance of monitoring implemented practices over time to ensure that they function properly and provide the intended benefits.

Control of urban stormwater runoff (e.g., through detention) has been widely implemented to reduce peak flows from large storms in order to prevent stream channel erosion. Research has shown, however, that although large peak flows might be controlled effectively by detention storage, stormflow conditions are extended over a longer period of time. Duration of erosive and bankfull flows are increased, constituting channel-forming events. Urbonas and Wulliman (2007) reported that, when captured runoff from a number of individual detention basins in a stream system is released over time, the flows accumulate as they travel downstream, actually increasing peak flows along the receiving waters. This situation can diminish the collective effectiveness of detention basins as a watershed management strategy.

Assessment of Depreciation

The first—and possibly most important—step in adjusting for depreciation of implemented BMPs is to determine its extent and magnitude through BMP verification.

BMP Verification

At its core, BMP verification confirms that a BMP is in place and functioning properly as expected based on contract, permit, or other implementation evidence. A BMP verification process that documents the presence and function of BMPs over time should be included in all NPS watershed projects.

At the project planning phase, verification is important both to ensure accurate assessment of existing BMP performance levels and to determine additional BMP and maintenance needs. Verification over time is necessary to determine if BMPs are maintained and operated during the period of interest.

Documenting the presence of a BMP is generally simpler than determining how well it functions, but both elements of verification must be considered to determine if land treatment goals are being met and whether BMP performance is depreciating. Although land treatment goals might not be highly specific in many watershed projects, it is important to document what treatment is implemented. Verification is described in detail in *Tech Notes 11* (Meals et al. 2014). This technical memorandum focuses on specific approaches to assessing depreciation within the context of an overall verification process.

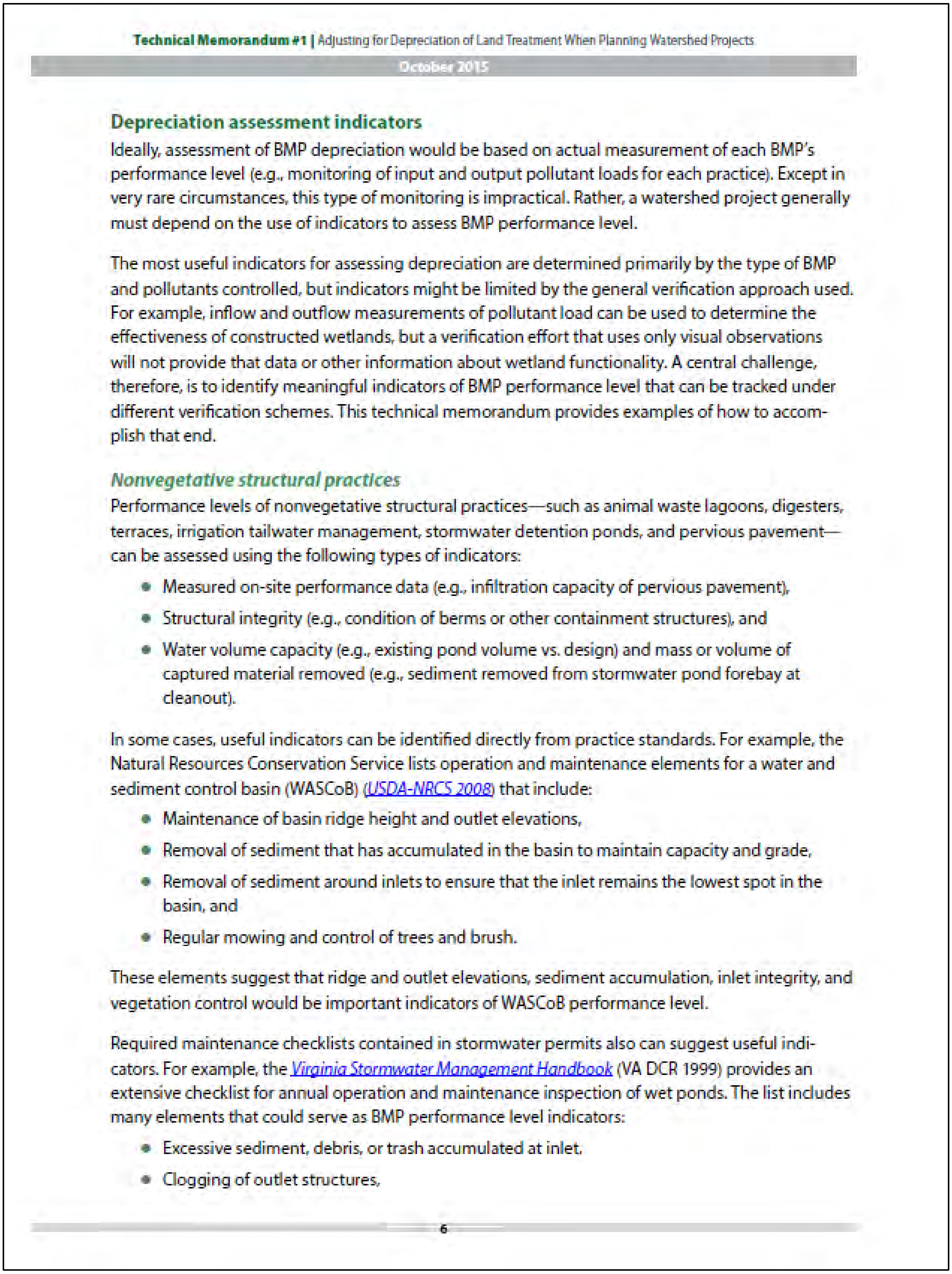
Methods for Assessing BMP Presence and Performance Level

Whether a complete enumeration or a statistical sampling approach is used, methods for tracking BMPs generally include direct measurements (e.g., soil tests, onsite inspections, remote sensing) and indirect methods (e.g., landowner self-reporting or third-party surveys). Several of these methods are discussed in *Tech Notes 11* (Meals et al. 2014). Two general factors must be considered when verifying a BMP: the presence of the BMP and its pollutant removal efficiency. Different types of BMPs require different verification methods, and no single approach is likely to provide all the information needed in planning a watershed project.

Certification

The first step in the process is to determine whether BMPs have been designed and installed/adopted according to appropriate standards and specifications. Certification can either be the final step in a contract between a landowner and a funding agency or be a component of a permit requirement.

Certification provides assurance that a BMP is fully functional for its setting at a particular time. For example, a stormwater detention pond or water and sediment control basin must be properly sized for its contributing area and designed for a specific retention-and-release performance level. A nutrient management plan must account for all sources of nutrients, consider current soil nutrient levels, and support a reasonable yield goal. A cover crop must be planted in a particular time window to provide erosion control and/or nutrient uptake during a critical time of year. Some jurisdictions might apply different nutrient reduction efficiency credits for cover crops based on planting date. Some structural BMPs like parallel tile outlet terraces require up to 2 years to fully settle and achieve full efficiency; in those cases, certification is delayed until full stability is reached. Knowledge that a BMP has been applied according to a specific standard supports an assumption that the BMP will perform at a certain level of pollutant reduction efficiency, providing a baseline against which future depreciation can be compared. Practices voluntarily implemented by landowners without any technical or financial assistance could require special efforts to determine compliance with applicable specifications (or functional equivalence). Pollution reduction by practices not meeting specifications might need to be discounted or not counted at all even when first installed.



Depreciation assessment indicators

Ideally, assessment of BMP depreciation would be based on actual measurement of each BMP's performance level (e.g., monitoring of input and output pollutant loads for each practice). Except in very rare circumstances, this type of monitoring is impractical. Rather, a watershed project generally must depend on the use of indicators to assess BMP performance level.

The most useful indicators for assessing depreciation are determined primarily by the type of BMP and pollutants controlled, but indicators might be limited by the general verification approach used. For example, inflow and outflow measurements of pollutant load can be used to determine the effectiveness of constructed wetlands, but a verification effort that uses only visual observations will not provide that data or other information about wetland functionality. A central challenge, therefore, is to identify meaningful indicators of BMP performance level that can be tracked under different verification schemes. This technical memorandum provides examples of how to accomplish that end.

Nonvegetative structural practices

Performance levels of nonvegetative structural practices—such as animal waste lagoons, digesters, terraces, irrigation tailwater management, stormwater detention ponds, and pervious pavement—can be assessed using the following types of indicators:

- Measured on-site performance data (e.g., infiltration capacity of pervious pavement),
- Structural integrity (e.g., condition of berms or other containment structures), and
- Water volume capacity (e.g., existing pond volume vs. design) and mass or volume of captured material removed (e.g., sediment removed from stormwater pond forebay at cleanout).

In some cases, useful indicators can be identified directly from practice standards. For example, the Natural Resources Conservation Service lists operation and maintenance elements for a water and sediment control basin (WASCoB) (*USDA-NRCS 2008*) that include:

- Maintenance of basin ridge height and outlet elevations,
- Removal of sediment that has accumulated in the basin to maintain capacity and grade,
- Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the basin, and
- Regular mowing and control of trees and brush.

These elements suggest that ridge and outlet elevations, sediment accumulation, inlet integrity, and vegetation control would be important indicators of WASCoB performance level.

Required maintenance checklists contained in stormwater permits also can suggest useful indicators. For example, the *Virginia Stormwater Management Handbook* (VA DCR 1999) provides an extensive checklist for annual operation and maintenance inspection of wet ponds. The list includes many elements that could serve as BMP performance level indicators:

- Excessive sediment, debris, or trash accumulated at inlet.
- Clogging of outlet structures,

- Cracking, erosion, or animal burrows in berms, and
- More than 1 foot of sediment accumulated in permanent pool.

Assessment of these and other indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Vegetative structural practices

Performance levels of vegetative structural practices—such as constructed wetlands, swales, rain gardens, riparian buffers, and filter strips—can be assessed using the following types of indicators:

- Extent and health of vegetation (e.g., measurements of soil cover or plant density),
- Quality of overland flow filtering (e.g., evidence of short-circuiting by concentrated flow or gullies through buffers or filter strips),
- On-site capacity testing of rain gardens using infiltrometers or similar devices, and
- Visual observations (e.g., presence of water in swales and rain gardens).

Parking lot rain garden.

As for non-vegetative structural practices, assessment of these indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Nonstructural vegetative practices

Performance levels of nonstructural vegetative practices—such as cover crops, reforestation of logged tracts, and construction site seeding—can be assessed using the following types of indicators:

- Density of cover crop planting (e.g., plant count),
- Percent of area covered by cover crop, and
- Extent and vitality of tree seedlings.

These indicators could be assessed by on-site inspection or, in some cases, by remote sensing, either from satellite imagery or aerial photography.

Management practices

Performance levels of management practices—such as nutrient management, conservation tillage, pesticide management, and street sweeping—can be assessed using the following types of indicators:

- Records of street sweeping frequency and mass of material collected,
- Area or percent of cropland under conservation tillage,

- Extent of crop residue coverage on conservation tillage cropland, and
- Fertilizer and/or manure application rates and schedules, crop yields, soil test data, plant tissue test results, and fall residual nitrate tests.

Illustration of line-transect method for residue.

Assessment of these indicators would generally require reporting by private landowners or municipalities, reporting that is required under some regulatory programs. Visual observation of indicators such as residue cover, however, can also be made by on-site inspection or windshield survey.

Data analysis

Data on indicators can be expressed and analyzed in several ways, depending on the nature of the indicators used. Indicators reporting continuous numerical data—such as acres of cover crop or conservation tillage, manure application rates, miles of street sweeping, mass of material removed from catch basins or detention ponds, or acres of logging roads/landings revegetated—can be expressed either in the raw form (e.g., acres with 30 percent or more residue cover) or as a percentage of the design or target quantity (e.g., percent of contracted acres achieving 30 percent or more of residue cover). These metrics can be tracked year to year as a measure of BMP depreciation (or achievement). During the planning phase of a watershed project, it might be appropriate to collect indicator data for multiple years prior to project startup to enable calculation of averages or ranges to better estimate BMP performance levels over crop rotation cycles or variable weather conditions.

Indicators reporting categorical data—such as maintenance of detention basin ridge height and outlet elevations, condition of berms or terraces, or observations of water accumulation and flow—are more difficult to express quantitatively. It might be necessary to establish an ordinal scale (e.g., condition rated on a scale of 1–10) or a binary yes/no condition, then use best professional judgment to assess influence on BMP performance.

In some cases, it might be possible to use modeling or other quantitative analysis to estimate individual or watershed-level BMP performance levels based on verification data. In an analysis of stormwater BMP performance levels, Tetra Tech (2010) presented a series of BMP performance curves based on monitoring and modeling data that relate pollutant removal efficiency to depth of runoff treated (Figure 1). Where depreciation indicators track changes in depth of runoff treated as the capacity of a BMP decreases (e.g., from sedimentation), resulting changes in pollutant removal could be determined from a performance curve. This type of information can be particularly useful during the planning phase of a watershed project to estimate realistic performance levels for existing BMPs that have been in place for a substantial portion of their expected lifespans.

The performance levels of structural agricultural BMPs in varying condition can be estimated by altering input parameters in the *Soil and Water Assessment Tool* (SWAT) model (Texas A&M University 2015a); other models such as the *Agricultural Policy/Environmental eXtender* (APEX) model (Texas A&M

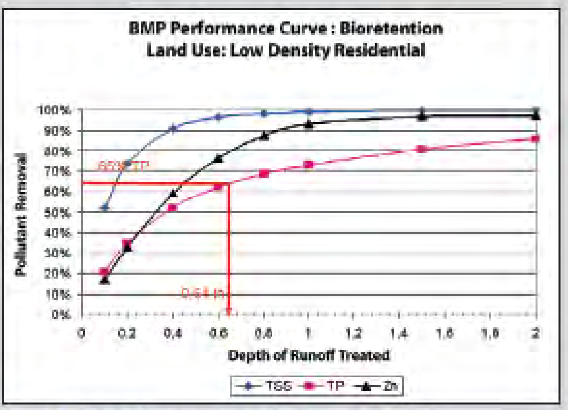


Figure 1. BMP Performance Curve for Bioretention BMP (Tetra Tech 2010).

University 2015b) also can be used in this way (including application to some urban BMPs). For urban stormwater, engineering models like HydroCAD (HydroCAD Software Solutions 2011) can be used to simulate hydrologic response to stormwater BMPs with different physical characteristics (e.g., to compare performance levels under actual vs. design conditions). Even simple spreadsheet models such as the Spreadsheet Tool for Estimating Pollutant Load (STEPL) (USEPA 2015) can be used to quantify the effects of BMP depreciation by varying the effectiveness coefficients in the model.

Data from verification efforts and analysis of the effects of depreciation on BMP performance levels must be qualified based on data confidence. "Confidence" refers mainly to a quantitative assessment of the accuracy of a verification result. For example, the number of acres of cover crops or the continuity of streamside buffers on logging sites determined from aerial photography could be determined by ground-truthing to be within +10 percent of the true value at the 95 percent confidence level. Confidence also can refer to the level of trust that BMPs previously implemented continue to function (e.g., the proportion of BMPs still in place and meeting performance standards). For example, reporting that 75 percent of planned BMPs have been verified is a measure of confidence that the desired level of treatment has been applied.

While specific methods to evaluate data confidence are beyond the scope of this memo, it is essential to be able to express some degree of confidence in verification results—both during the planning phase and over time as the project is implemented. For example, an assessment of relative uncertainty of BMP performance during the planning phase can be used as direct follow-up to verification efforts to those practices for which greater quantification of performance level is needed. In addition, plans to implement new BMPs also can be developed with full consideration of the reliability of BMPs already in place.

Adjusting for Depreciation

Information on BMP depreciation can be used to improve both project management and project evaluation.

Project Planning and Management

Establishing baseline conditions

Baseline conditions of pollutant loading include not only pollutant source activity but also the influence of BMPs already in place at the start of the project. Adjustments based on knowledge of BMP depreciation can provide a more realistic estimate of baseline pollutant loads than assuming that existing land treatment has reduced NPS pollutant loads by some standard efficiency value.

Establishing an accurate starting point will make load reduction targets—and, therefore, land treatment design—more accurate. Selecting appropriate BMPs, identifying critical source areas, and prioritizing land treatment sites will all benefit from an accurate assessment of baseline conditions. Knowledge of depreciation of existing BMPs can be factored into models used for project planning (e.g., by adjusting pollutant removal efficiencies), resulting in improved understanding of overall baseline NPS loads and their sources.

While not a depreciation issue per se, when a BMP is first installed—especially a vegetative BMP like a buffer or filter strip—it usually takes a certain amount of time before its pollutant reduction capacity is fully realized. For example, Dosskey et al. (2007) reported that the nutrient reduction performance of newly established vegetated filter strips increased over the first 3 years as dense stands of vegetation grew in and soil infiltration improved; thereafter, performance level was stable over a decade. When planning a watershed project, vegetative practices should be examined to determine the proper level of effectiveness to assume based on growth stage. Also, because of weather or management conditions, some practices (e.g., trees) might take longer to reach their full effectiveness or might never reach it. The Stroud Preserve, Pennsylvania, section 319 National Nonpoint Source Monitoring Program (NNPSMP) project (1992–2007) found that slow tree growth in a newly established riparian forest buffer delayed significant NO_3–N (nitrate) removal from ground water until about 10 years after the trees were planted (Newbold et al. 2008).

The performance of practices can change in multiple ways over time. For example, excessive deposition in a detention pond that is not properly maintained could reduce overall percent removal of sediment because of reduced capacity as illustrated in Figure 1. The relative and absolute removal efficiencies for various particle size fractions (and associated pollutants) also can change due to reduced hydraulic retention time. Fine particles generally require longer settling times than larger particles, so removal efficiency of fine particles (e.g., silt, clay) can be disproportionally reduced as a detention pond or similar BMP fills with sediment and retention time deteriorates. Expert assessment of the condition and likely current performance level of existing BMPs, particularly those for which a significant amount of pollutant removal is assumed, is essential to establishing an accurate baseline for project planning.

Adaptive watershed management

Watershed planning and management is an iterative process; project goals might not all be fully met during the first project cycle and management efforts usually need to be adjusted in light of ongoing changes. In many cases, several cycles—including mid-course corrections—might be needed for a project to achieve its goals. Consequently, EPA recommends that watershed projects pursue a dynamic and adaptive approach so that implementation of a watershed plan can proceed and be modified as new information becomes available (USEPA 2008). Measures of BMP implementation commonly used as part of progress assessment should be augmented with indicators of BMP depreciation. Combining this information with other relevant project data can provide reliable progress assessments that will indicate gaps and weaknesses that need to be addressed to achieve project goals.

BMP design and delivery system

Patterns in BMP depreciation might yield information on systematic failures in BMP design or management that can be addressed through changes to standards and specifications, contract terms, or permit requirements. This information could be particularly helpful during the project planning phase when both the BMPs and their implementation mechanisms are being considered. For example, a cost-sharing schedule that has traditionally provided all or most funding upon initial installation of a BMP could be adjusted to distribute a portion of the funds over time if operation and maintenance are determined to be a significant issue based on pre-project information. Some BMP components, on the other hand, might need to be dropped or changed to make them more appealing to or easier to manage by landowners. Within the context of a permit program, for example, corrective actions reports might indicate specific changes that should be made to BMPs to ensure their proper performance.

Project Evaluation

Monitoring

Although short-term (3–5 year) NPS watershed projects will not usually have a sufficiently long data record to evaluate incremental project effects, data on BMP depreciation might still improve interpretation of collected water quality data. Even in the short term, water quality monitoring data might reflect cases in which BMPs have suffered catastrophic failures (e.g., an animal waste lagoon breach), been abandoned, or been maintained poorly. Meals (2001), for example, was able to interpret unexpected spikes in stream P and suspended sediment concentrations by walking the watershed and discovering that a landowner had over-applied manure and plowed soil directly into the stream.

Longer-term efforts (e.g., total maximum daily loads[1]) might engage in sustained monitoring beyond individual watershed project lifetime(s). The extended monitoring period will generally allow detection of more subtle water quality impacts for which interpretation could be enhanced with information on BMP depreciation. While not designed as BMP depreciation studies, the following two examples illustrate how changes in BMP performance can be related to water quality.

In a New York dairy watershed treated with multiple BMPs, Lewis and Makarewicz (2009) reported that the suspension of a ban on winter manure application 3 years into the monitoring study led to dramatic increases in stream nitrogen and phosphorus concentrations. First and foremost, knowledge of that suspension provided a reasonable explanation for the observed increase in nutrient levels. Secondly, the study was able to use data from the documented depreciation of land treatment to determine that the winter spreading ban had yielded 60–75 percent reductions in average stream nutrient concentrations.

The Walnut Creek, Iowa, Section 319 NNPSMP project promoted conversion of row crop land to native prairie to reduce stream NO_3-N levels and used simple linear regression to show association of two monitored variables: tracked conversion of row crop land to restored prairie vegetation and stream NO_3-N concentrations (Schilling and Spooner 2006). Because some of the restored prairie was plowed back into cropland during the project period—and because that change was

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[1] "Total maximum daily loads" as defined in §303(d) of the Clean Water Act.

documented—the project was able to show not only that converting crop land to prairie reduced stream NO_3-N concentrations but also that increasing row crop land led to increased NO_3-N levels (Figure 2).

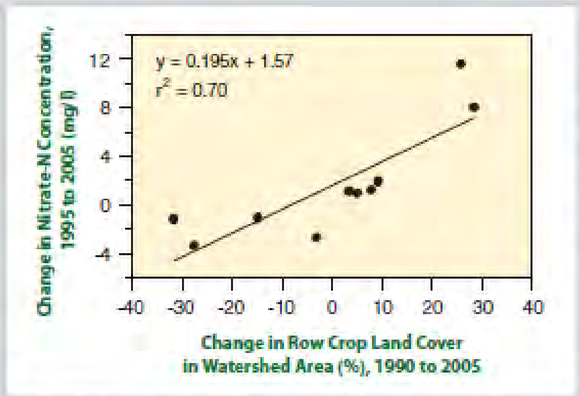


Figure 2. Relating Changes in Stream Nitrate Concentrations to Changes in Row Crop Land Cover in Walnut Creek, Iowa (Schilling and Spooner 2006)).

Modeling

When watershed management projects are guided or supported by modeling, knowledge of BMP depreciation should be part of model inputs and parameterization.

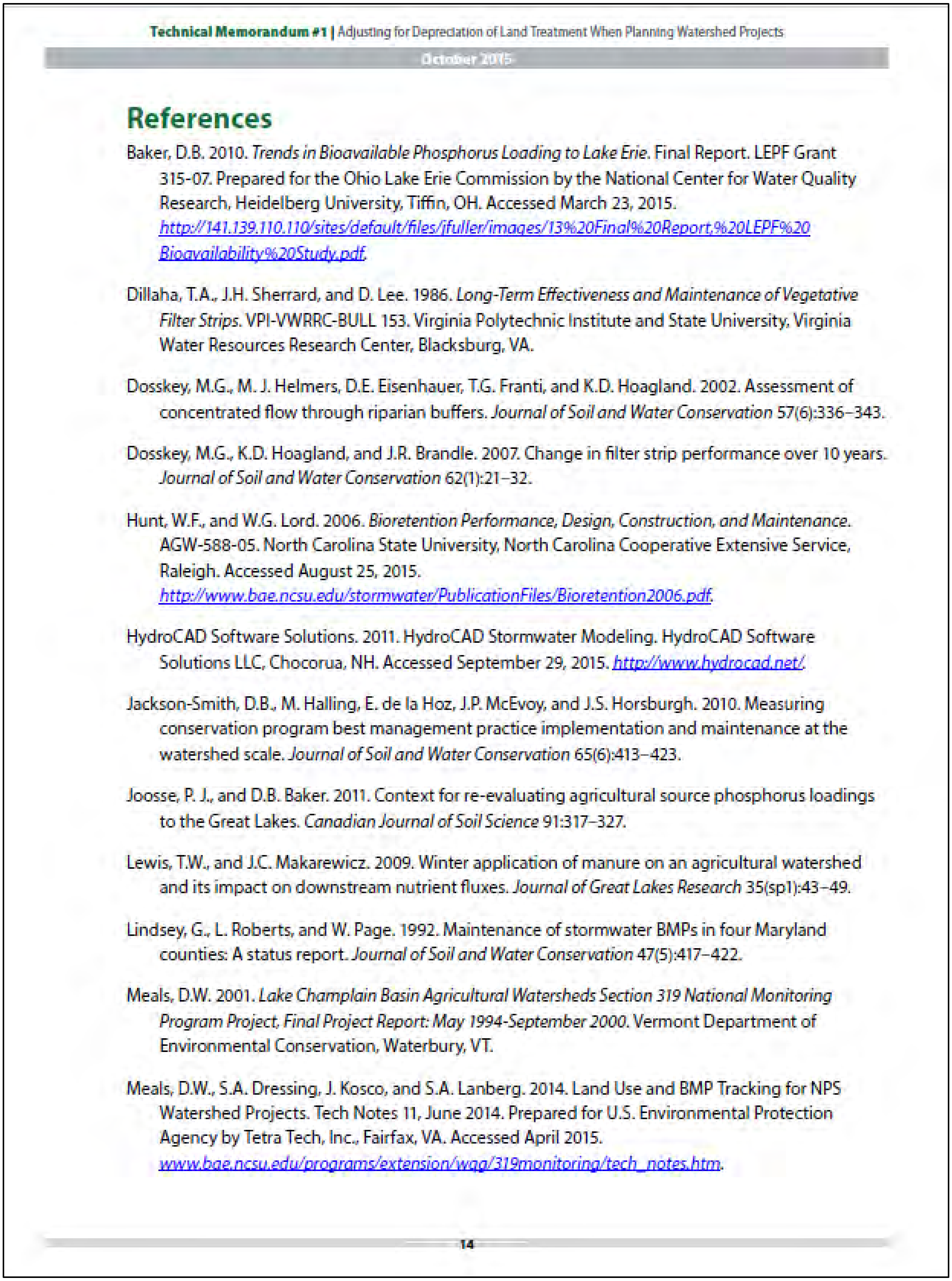
The magnitude of implementation (e.g., acres of treatment) and the spatial distribution of both annual and structural BMPs should be part of model input and should not be static parameters. Where BMPs are represented by pollutant reduction efficiencies, those percentages can be adjusted based on verification of land treatment performance levels in the watershed. Incorporating BMP depreciation factors into models might require setting up a tiered approach for BMP efficiencies (e.g., different efficiency values for BMPs determined to be in fair, good, or excellent condition) rather than the currently common practice of setting a single efficiency value for a practice assumed to exist. This approach could be particularly important for management practices such as agricultural nutrient management or street sweeping, in which degree of treatment is highly variable. For structural practices, a depreciation schedule could be incorporated into the project, similar to depreciating business assets. In the planning phase of a watershed project, multiple scenarios could be modeled to reflect the potential range of performance levels for BMPs already in place.

Recommendations

The importance of having accurate information on BMP depreciation varies across projects and during the timeline of a single project. During the project planning phase, when plans for the achievement of pollutant reduction targets rely heavily on existing BMPs, it is essential to obtain good information on the level of performance of the BMPs to ensure that plan development is properly informed. If existing BMPs are a trivial part of the overall watershed plan, knowledge of BMP depreciation might not be critical during planning. As projects move forward, however, the types of BMPs implemented, their relative costs and contributions to achievement of project pollutant reduction goals, and the likelihood that BMP depreciation will occur during the period of interest will largely determine the type and extent of BMP verification required over time. The following recommendations should be considered within this context:

- For improved characterization of overall baseline NPS loads, better identification of critical source areas, and more effective prioritization of new land treatment during project planning, collect accurate and complete information about:
    - Land use,

  - Land management, and
  - The implementation and operation of existing BMPs. This information should include:
    - Original BMP installation dates,
    - Design specifications of individual BMPs,
    - Data on BMP performance levels if available, and
    - The spatial distribution of BMPs across the watershed.
- Track the factors that influence BMP depreciation in the watershed, including:
  - Variations in weather that influence BMP performance levels,
  - Changes in land use, land ownership, and land management,
  - Inspection and enforcement activities on permitted practices, and
  - Operation, maintenance, and management of implemented practices.
- Develop and use observable indicators of BMP status/performance that:
  - Are tailored to the set of BMPs implemented in the watershed and practical within the scope of the watershed project's resources,
  - Can be quantified or scaled to document the extent and magnitude of treatment depreciation, and
  - Are able to be paired with water quality monitoring data.
- After the implementation phase of the NPS project, conduct verification activities to document the continued existence and function of implemented practices to assess the magnitude of depreciation and provide a basis for corrective action. The verification program should:
  - Identify and locate all BMPs of interest, including cost-shared, non-cost-shared, required, and voluntary practices;
  - Capture information on structural, annual, and management BMPs;
  - Obtain data on BMP operation and maintenance activities; and
  - Include assessment of data accuracy and confidence.
- To adjust for depreciation of land treatment, apply verification data to watershed project management and evaluation by:
  - Applying results directly to permit compliance programs,
  - Relating documented changes in land treatment performance levels to observed water quality,
  - Incorporating measures of depreciated BMP effectiveness into modeling efforts, and
  - Using knowledge of treatment depreciation to correct problems and target additional practices as necessary to meet project goals in an adaptive watershed management approach.



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