CRUCIAL CREEKS MASTER'S PROJECT

Tannery Creek (Little Traverse Bay): A Scale-Appropriate Watershed Management Plan

Authors: Elizabeth Lillard, Diana Portner, Julie Riggio, Bo Williams, and Leah Zimmerman

Client: Tip of the Mitt Watershed Council

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ABSTRACT

Tannery Creek is one of the main tributaries leading into Little Traverse Bay, which is located adjacent to Petoskey, Michigan. The creek lies within the jurisdiction of the Little Traverse Bay Watershed Protection Plan. The client, Tip of the Mitt Watershed Council (the Watershed Council), asked the project team to research and prepare a watershed management plan for Tannery Creek that would be amended to the Little Traverse Bay plan. The project included an assessment of Tannery Creek's water quality, a watershed analysis using GIS tools, and a thorough public outreach campaign. For the stream assessment, the project team compiled historical data and conducted sampling at five sites over the course of 2012. For the watershed analysis, the team utilized to primary tools: a land cover model and the Long Term Hydrologic Impact Analysis model. In addition to a description of these activities and their results, the watershed management plan itself includes goals and objectives and a detailed implementation plan.

EXECUTIVE SUMMARY

Tip of the Mitt Watershed Council (the Watershed Council), located in Petoskey, Michigan, requested a master's project team from the University of Michigan (UM) School of Natural Resources and Environment (SNRE) to write a watershed management plan for Tannery Creek, which flows into Little Traverse Bay. Over 16 months in 2012 and 2013, the SNRE team conducted the necessary research and analysis to write a robust scale-appropriate plan for Tannery, a plan that focuses on both restoration and protection in the Tannery Creek watershed.

This document firstly contains the primary product from this project: a watershed management plan, which will be submitted by the client to the Department of Environmental Quality for approval. The plan includes a description of the current state of the watershed based on a stream assessment and watershed analysis, the public outreach efforts conducted in conjunction with the plan's development, and a full set of management recommendations. These management recommendations include goals and objectives, prioritized implementation tasks, and a discussion of how to evaluate progress toward the plan's goals.

Following the watershed management plan, this document contains a description of methodologies for the stream assessment, watershed analysis, and public outreach conducted by the project team (beginning on page 102). Finally, for future reference, this report also contains the raw data and public outreach materials developed in the process of designing the watershed management plan.

Stream Assessment. Thanks to previous monitoring efforts by the Watershed Council and the Little Traverse Bay Bands of Odawa Indians (the Tribe), there exists some historical data on the water quality and biological communities of Tannery Creek. To augment and fill in the gaps in this data, the SNRE team conducted a full stream assessment in summer 2012, expanding efforts to include several new sites. The team sampled at five total sites that are representative of the creek's entire reach: headlands, middle areas with prevalent road–stream crossings, and the creek mouth, which is located in a more developed commercial area. The SNRE team then used an analysis of the historical and newly gathered data to inform management recommendations for the creek. For the most part, the water quality and terrestrial and aquatic habitats of Tannery Creek are in good condition. Primary concerns include debris/litter and altered hydrology, which results in occasional flooding in the lower portion of the creek. The SNRE team recommends a management approach that prioritizes protection efforts.

Watershed Analysis. To better understand the current state of Tannery Creek, the SNRE team conducted an assessment of the full watershed utilizing Geographic Information Systems (GIS) and two specific modeling tools, namely Impervious Land Cover and Long Term Hydrologic Impact Assessment (L-THIA). To aid in this analysis, the SNRE team divided the Tannery Creek Watershed into three distinct sub-watersheds: West Branch, East Branch, and the Lower Watershed. The Impervious Land Cover tool evaluates impervious surface percentages and revealed current problems in the Lower Watershed. The L-THIA model estimates runoff, recharge, and nonpoint pollution for a given area. The team used zoning information from the Bear Creek Township Master Plan to create a "build-out" scenario that projects future runoff volumes for the Tannery Creek watershed. Based on this build-out scenario, it is clear that the East Branch and West Branch portions of the watershed may experience negative impacts of runoff in the future due to development pressures and increased impervious surface levels.

Public Outreach. The SNRE team conducted extensive public outreach and education both to inform the stream assessment and watershed analysis described above and to begin the process of achieving buy-in from local residents and businesses for management recommendations. The team conducted a survey of residents and businesses to explore uses and impressions of the creek. In addition to one-on-one conversations with many residents and business owners, the team conducted two Community Forum meetings in March 2013 to further engage those who live and work in the Tannery Creek watershed.

Recommendations. Though current threats to Tannery Creek are primarily from debris/litter and altered hydrology, the watershed analysis suggests future threats from development activities that may include thermal pollution, nutrient loading, sedimentation, and the addition of heavy metals, pesticides, and pathogens to the watershed. The management plan firstly recommends continued monitoring to assess the addition of these threats. The plan also recommends a robust education and outreach program and specific protection measures to avoid these potential problems. To determine specific recommended tasks and actions, the SNRE team utilized GIS to identify priority areas and parcels for protection as well as critical areas—namely the Lower Watershed—for immediate attention. The team also designed an education strategy and outreach materials to be used by the Watershed Council in the future.

Tannery Creek is a small, but important creek to Little Traverse Bay, which is in turn important to Lake Michigan. The SNRE team and the Watershed Council recognize that even the smallest creeks are critical to the health of broader watersheds. Effective stewardship begins on a local community level and the SNRE team hopes that the Tannery Creek Watershed Management Plan will be an important contribution to the Watershed Council's ongoing efforts to restore and protect the vibrant watersheds of Northern Michigan.

TANNERY CREEK
WATERSHED MANAGEMENT PLAN

APRIL 2013

Prepared for Tip of the Mitt Watershed Council
by Elizabeth Lillard, Diana Portner, Julie Riggio, Bo Williams, and Leah Zimmerman

In partnership with the University of Michigan
School of Natural Resources and Environment

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We are grateful to the Michigan Department of Environmental Quality, Tip of the Mitt Watershed Council, the Little Traverse Bay Bands of Odawa Indians, and the Petoskey Historical Society for providing historical data and critical information about Tannery Creek.

Finally, thank you to our SNRE master's project advisors, David Allan and Allen Burton, two of the country's foremost freshwater ecologists whose advice was invaluable in the research and writing process.

The Tannery Creek Watershed Management Plan is available online at www.watershedcouncil.org.

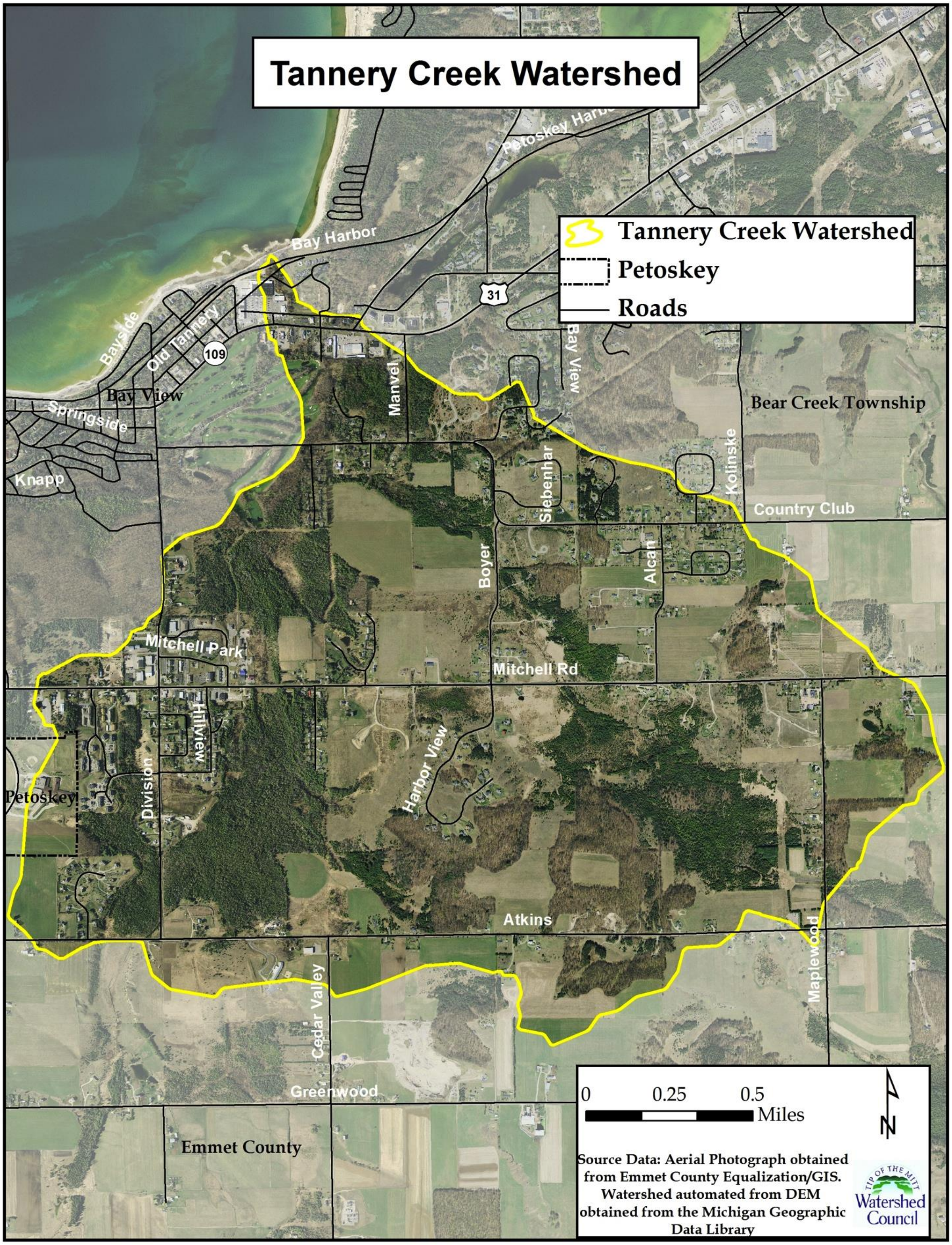


FIGURE 1: TANNERY CREEK WATERSHED BOUNDARIES. BEAR CREEK TOWNSHIP, MI.

INTRODUCTION

Tannery Creek is located just north of the City of Petoskey and is a small, but important creek both to the region and to Little Traverse Bay. The City of Petoskey covers four square miles and has approximately 6,000 year-round residents. The town's population swells in summer months and future development activity poses a potential threat to the quality of Tannery Creek. The creek has five official designated uses: navigation, industrial water supply, agriculture, indigenous aquatic life and wildlife, and cold water fishery.[1] For bodies of water, the State of Michigan determines "dedicated uses" which are then used to guide relevant management decisions.

Historically and presently, the region is home to Odawa Native Americans, who have lived around Little Traverse Bay since about 1400. The Odawa used the creek and watershed for fishing, tanning hides, and also likely trapping animals and burying their dead. Tannery Creek drains into Little Traverse Bay, which is the fourth largest bay in Lake Michigan and itself has tremendous ecological and recreational value. Forests and agriculture dominate the upper parts of Tannery Creek, while the lower reaches contain more developed commercial and residential areas.

Streams, rivers, and lakes are the lifeblood of the Great Lakes region. Every body of water is intimately tied to its watershed, which can be defined as the area of land that drains into the water body. Watersheds can be demarcated at many different scales and are nested within each other. For example, all groundwater and water that falls within the Tannery Creek watershed eventually flows into the Little Traverse Bay, which means that the Tannery Creek watershed is one of several sub-watersheds of the Little Traverse Bay watershed. The Little Traverse Bay watershed is, in turn, a sub-watershed of the Lake Michigan watershed. Though the creek itself can be considered relatively healthy, stream ecosystems like Tannery Creek are influenced by broader regional trends and activity within the watershed. Therefore, to assess stream health, it is also important to assess the overall watershed health by evaluating the surrounding area.

Watershed Management Plan and Public Outreach

The primary means for managing watersheds on a local level is through watershed management plans. Early watershed management efforts in the United States (US) were largely human-centered and focused on flood control. Today, watershed managers strike to take a more holistic approach, incorporating broader ecosystem considerations and community concerns. Various government agencies now share responsibility for watershed governance—including local, state, and federal agencies—but non-governmental organizations also play a key role in engaging stakeholders, developing watershed management plans, and facilitating implementation of management plans.

Watershed management plans are often produced for large-scale watersheds where much remediation and restoration is necessary. Tannery Creek offers a unique opportunity for the development of a scale-appropriate plan with a focus on both protection and restoration. Tip of the Mitt Watershed Council (the Watershed Council) has been working to protect watersheds in northern Michigan for more than 30 years. The Watershed Council has extensive experience conducting restoration projects, surveys, and monitoring in other areas of the Little Traverse Bay watershed and in nearby watersheds. In Fall 2011, the Watershed Council approached the University of Michigan's (UM) School of Natural Resources and Environment (SNRE) with a "Crucial Creeks Project" request to generate a watershed management plan for Tannery Creek. The primary goal of this watershed management plan is to preserve its current high environmental quality, thereby protecting Tannery Creek from future degradation as development progresses.

This Tannery Creek Watershed Management Plan (TC Plan) is designed to fit within the existing Little Traverse Bay Watershed Protection Plan (LTB Plan), which was approved in 2007. A committee of leaders representing important stakeholders, including residents, government agencies, and the Little Traverse

Bay Bands of Odawa Indians (the Tribe), coordinates implementation of the LTB Plan. The Watershed Council developed the LTB Plan, facilitates the LTB Plan Committee, and has extensive collective experience implementing watershed management plans. A sub-committee of the LTB Plan Committee will guide implementation of the TC Plan.

Locally, zoning ordinances will be key to the success of this plan. Emmet County zoning ordinances and other regulations apply to the creek as the watershed falls almost exclusively within Bear Creek Township, and the Emmet County office of Planning and Zoning acts as the zoning administrator for Bear Creek Township. The township still plays an important role, however, in that it makes recommendations for zoning amendments through its Master Plan, reviews zoning permits submitted from within township borders, and makes recommendations to the county.

The TC Plan is designed to adhere to the US Environmental Protection Agency's (EPA) nine elements, which must be included in a watershed plan for it to be eligible for funding under the Clean Water Act (Section 319). These elements are designed to insure the plan is developed appropriately and implemented effectively. Examples of requirements include identifying sources of pollution, engaging stakeholders, and planning for monitoring of progress toward goals. The TC Plan is intended to adhere to not only the EPA standards, but also to guidelines published by Michigan's Department of Environmental Quality (MDEQ). See Appendix A for a full description of EPA requirements and Michigan's state-specific requirements.

In the Great Lakes region, significant federal and state resources are available for the restoration of degraded water bodies, while fewer resources are devoted to protecting those that remain intact. Protection is necessary to avoid significant future restoration and remediation costs. This plan highlights areas within the Tannery Creek watershed where restoration is necessary, but it also provides a model for other similar rivers in Northern Michigan where protection is also a significant need.

To achieve public input and buy-in for this watershed management plan, the SNRE team conducted interviews with residents familiar with the creek and distributed a survey to riparian residents and businesses located within the watershed. The results of this survey are discussed in Chapter 7 and the full results can be found in Appendix E. The goals of this survey were to gather additional data about stream conditions, riparian land management/activities, and to involve local residents and businesses in the development of this plan. Key local organizations, residents, and businesses vetted this plan at a series of Community Forum meetings held in Petoskey in March 2013.

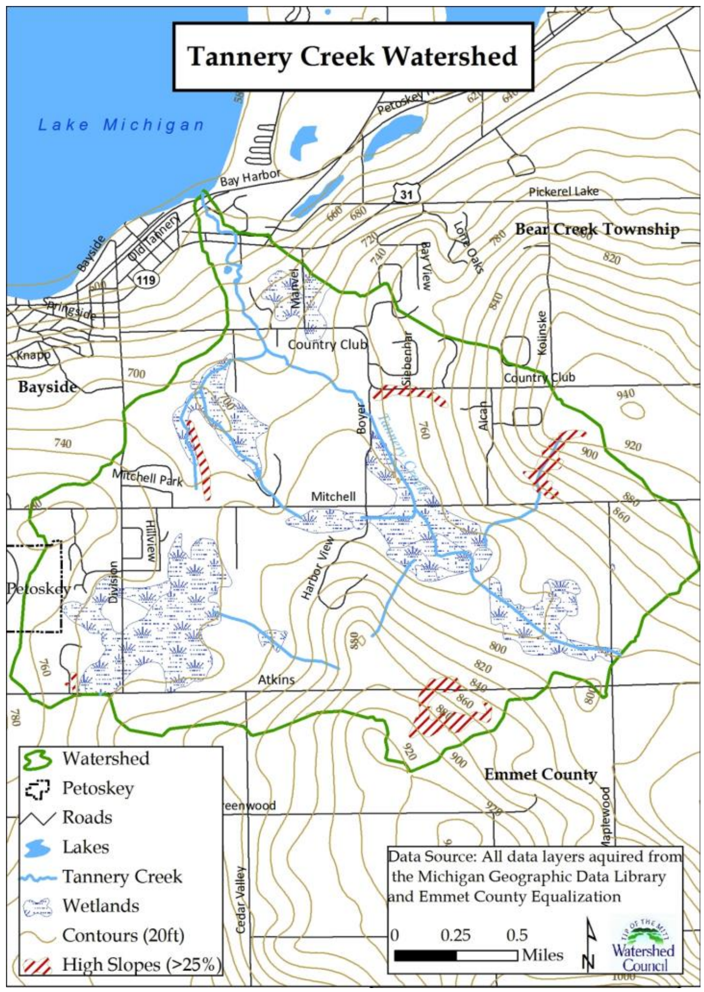


FIGURE 2: ELEVATIONAL CONTOURS OF TANNERY CREEK WATERSHED

Stream Assessment and Sampling Sites

To generate this plan, a team of graduate students at SNRE conducted a stream assessment by gathering water quality data from the Watershed Council, the Tribe, and MDEQ and generated additional data on water chemistry, biological communities, and riparian conditions. Sampling occurred at five sites, labeled TC1-TC5 (Figure 3). On one occasion, the team sampled the headwaters of the stream (TCHW) at the allowance of a property owner. The sample sites were chosen, in part, because of their accessibility, but more so to provide a representative sample of water quality and habitat throughout the creek.

TC1 is located on the west tributary to Tannery Creek where it crosses Mitchell Rd. The remaining sites are on the creek's mainstem. TC2 is located approximately a half mile west of TC1 at Mitchell Rd. TC3 is at the Boyer Road stream crossing. TC4 is further downstream at the Country Club Drive stream crossing. TC5 is the most downstream site, located where the creek passes under the Little Traverse Wheelway. TCHW is located a quarter mile northeast of the intersection of Maplewood Drive and Atkins Road.

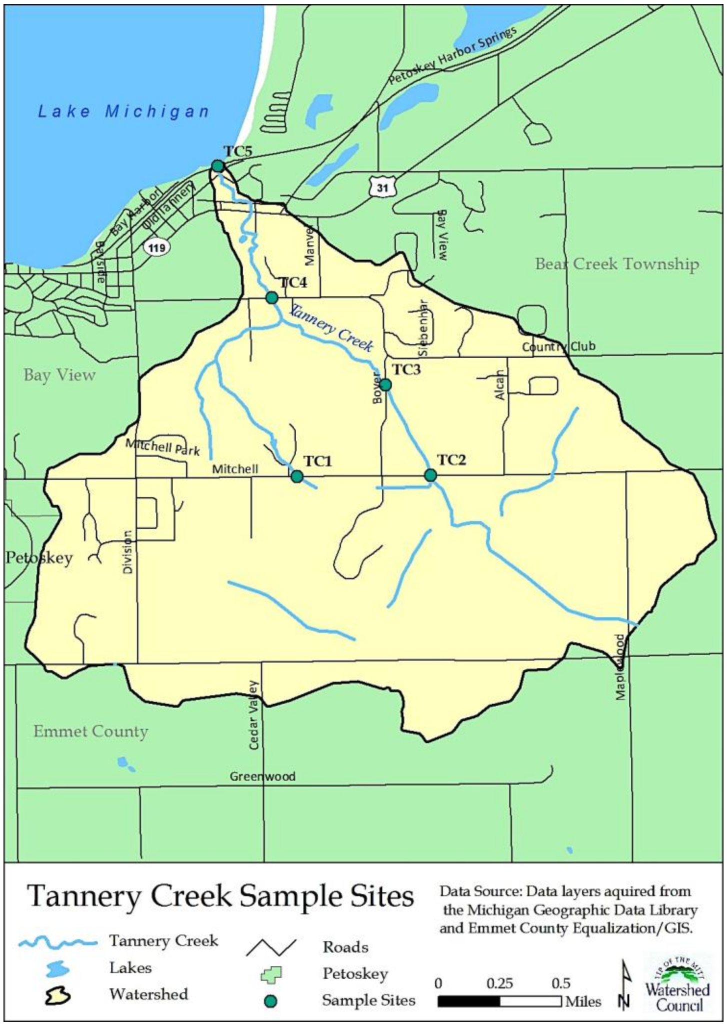


FIGURE 3: SITES SAMPLED BY STUDY TEAM

Watershed Delineation and Analysis

The SNRE team divided the watershed into three distinct hydrologic units, or sub-watersheds, each part of the greater Tannery Creek watershed. This breakdown allows for comparisons across sub-watersheds—particularly useful when historical water quality data was lacking—and for examination of relative development trends, sensitive natural features, hydrology, sources and causes of contamination, vulnerabilities, and land use suitability using geographic units that minimize landscape variation. As such, management recommendations can be tailored to the specific needs identified for each sub-watershed and the watershed as a whole. Sub-watershed descriptions are included in Chapter 5. The three sub-watersheds are the West Fork Watershed, East Fork Watershed, and Lower Watershed.

When including tributaries and intermittent channels, Tannery Creek has 9.8 miles of stream reach. The creek has two distinct branches that each start in the glacial hillsides overlooking Little Traverse Bay and transected by Atkins road, flowing downhill and north by northwest before emptying into Little Traverse Bay. The East Branch, the larger of the forks (also referred to as the Mainstem), has its genesis in its headwaters near the intersection of Atkins and Maplewood road, where, as a base flow trickle it fans out across an extensive wetland and eventually coalesces into a defined channel. This headwaters wetland complex maintains the flow and quality of Tannery Creek by gradually discharging cool, clear water that provides enough flow in summer months to support cold-water fish, including trout. The East Fork picks up flow, hugging the steep, forested hillside adjacent to Boyer Road, before meeting the West Fork at Surrey

Lane, just east of County Club Road. The East Fork has 2.1 miles of surface water and loses roughly and 100 feet of elevation before combining with the West Fork.

The surface waters of the West Fork stream emerge southeast of Mitchell Road in a large wetlands area, extending both east and west from Division Road. This branch travels a short distance through neighborhoods and farmland before flowing into the East Fork (Mainstem) at Surrey Lane, where the creek enters the final sub-watershed, the Lower Watershed. Here the creek keeps to the edges of the Petoskey Bay View Country Club before winding its way through Pirate Cove, under the Highway 31 corridor, and past the Wheelway where it finds Little Traverse Bay.

The SNRE team utilized the Impervious Cover Model and the Long Term Hydrologic Impact Assessment (L-THIA) Model to provide information on the current and future conditions of the creek and to present a framework for viewing development and changes in the watershed. The team combined the results from these tools with stream assessments, surveys, Geographic Information Systems (GIS) analyses, and personal accounts determine areas for protection, restoration, and retrofitting and to provide additional management recommendations

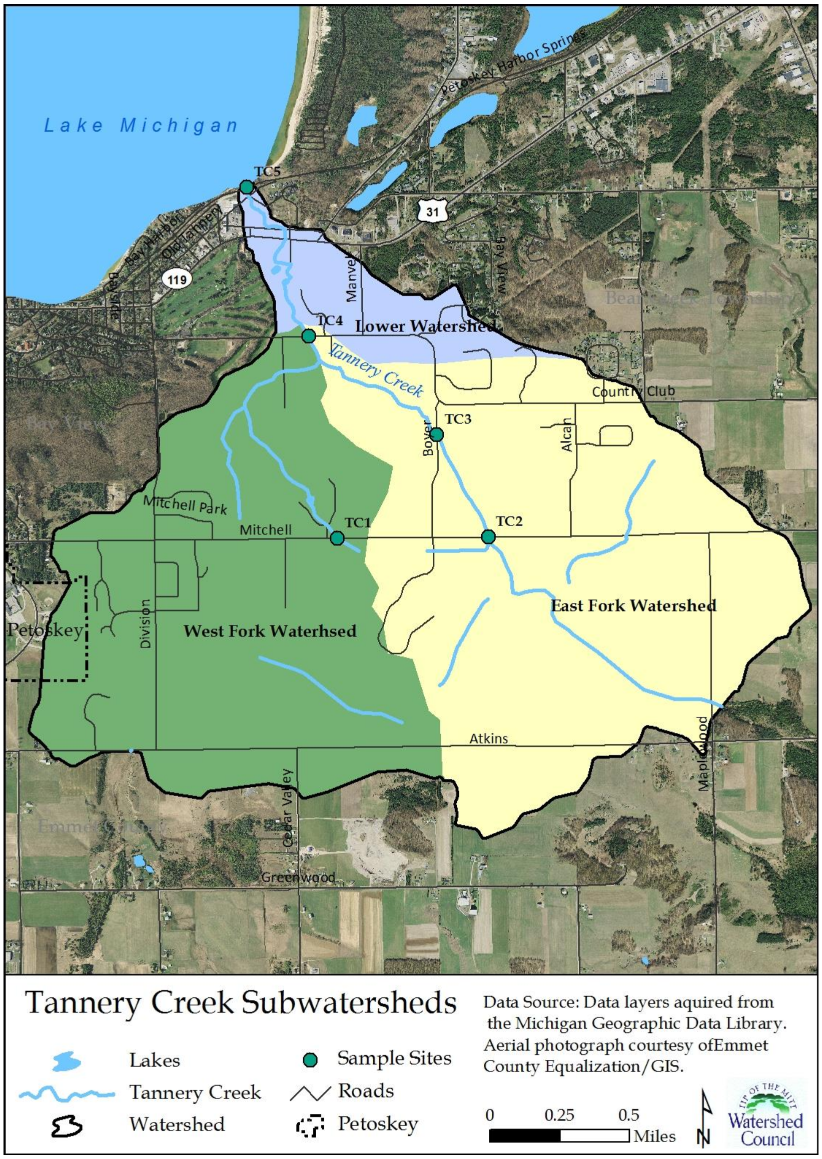


FIGURE 4: TANNERY CREEK SUB-WATERSHEDS

CHAPTER 1: CHARACTERIZATION OF THE WATERSHED

REGIONAL PROFILE

Historical, demographic, and socioeconomic information is particularly useful for identifying trends and conditions that could influence land use decisions, future development patterns, and economic and recreational activities. The Tannery Creek watershed falls within the jurisdictional and census block units of Bear Creek Township, The City of Petoskey, Emmet County, and the State of Michigan. At the census block group level, the majority of Tannery Creek's watershed area falls within Census Block 9706.[2]

Odawa Native Americans have lived around Little Traverse Bay since about 1400. The Odawa's residence around the bay was disrupted during war with the Iroquois, which lasted from 1640-1701, but they returned to the Straits of Mackinac in 1670, and have lived at Little Traverse Bay since 1742 without interruption. Nine bands of Odawa villages made up the Little Traverse Bay Bands, one of which was the Bear River band. Although many people in this band lived near the Bear River, some had to spread out along the Bay to better access and utilize resources. Kegomic, a village meaning "fish-town," on Tannery Creek was where some people moved, using the creek for fishing and tanning hides. During the time of the village, the creek boasted a larger wetland and may have flowed more strongly, which would better allow it to support a fishery and tanning. The Odawa have always buried their dead by water and, in fact, burials have been found in other places along the Bay where the Odawa settled (for instance, modern-day Wequetonsing and Harbor Point along the north edge of the Bay and Petoskey and Bay Shore on the south edge). It is highly probable that since the Odawa lived in Kegomic, they also buried their dead there. As a tributary of Little Traverse Bay, Tannery Creek was probably also used for trapping animals. This history of the Tribe at Tannery Creek comes from Eric Hemenway, an Anishnaabe/Odawa who, as the Repatriation and Archives Department Director for the Little Traverse Bay Bands of Odawa, conducts historical and cultural research for the Tribe.

Missionaries and other European settlers began to arrive in Bear River in the mid-19th century. The town was founded in 1879 and named after an Odawa chief, Pe-to-se-ga. With a railroad running south to Grand Rapids, Petoskey became a bustling town. In 1885, William Wirt Rice built a tannery just north of Petoskey in Kegomic at the mouth of a creek. This creek became known as Tannery Creek. The tannery was built on 180 acres, which today is divided between the Petoskey State Park and a commercial district along US Highway 31 (US-31). At its peak, the tannery employed approximately 200 individuals and processed over 1000 hides—primarily buffalo—per day. Pollution from the tannery severely impacted Little Traverse Bay and swimmers were reported to have avoided the area around the mouth of the creek for many years. Given this history and the possibility of legacy contamination, the stream assessment conducted for this report included a sediment analysis at the mouth of the creek.

Over the past 40 years, the area's population has grown significantly, with the fastest period of growth occurring between 1990 and 2000. See Table 1 below for population change statistics. Much of this growth can be attributed to the abundant recreational and tourism opportunities offered by Lake Michigan and the attractive rural and wooded landscapes of the surrounding areas. As such, the region is greatly influenced by seasonal population fluctuations. According to census data for housing characteristics, nearly 22.5 percent of Bear Creek Township's housing units are seasonal, recreational, or occasional use homes.[3] Consequently, the region's residential population increases dramatically in the summer months and this is further influenced by proximity to Petoskey State Park, which boasts 170 campsites. The Petoskey Regional Chamber of Commerce estimates that roughly 1.1 million visitors journey to the Petoskey area each year.[4]

Reflecting this character, the Tannery Creek watershed is primarily covered by low-density single-family homes and farms with higher density residential and commercial areas abutting the lake, Petoskey, and Bay

View, which is a seasonal resort community. Bear Creek Township and the City of Petoskey have a high percentage of renter-occupied housing units (35.4 and 47.2 percent, respectively).[5] Since 1990, further growth in the popularity of Petoskey as a tourist and recreation destination has expedited growth in Tannery Creek watershed. The overall population density in Bear Creek Township increased from 133 persons per square mile in the year 2000 to 156.6 persons per square mile in 2010. The population density of the City of Petoskey, however, decreased from 1,842 persons per square mile in 2000 to 1,718 in 2010. This is perhaps due to the relatively recent trend towards declining family size and the number of persons per household. Another possibility is a greater emphasis on commercial activity within the Petoskey city limits, which has driven residents into neighboring areas, such as the Tannery Creek watershed. Shifting housing structure characteristics in Bear Creek Township support these explanations: the availability of 2- to 9-unit structures in Bear Creek Township has increased greatly in the past decade, from 13.1 percent of total housing type to 16.5, while the number and percentage of single-unit detached housing structures decreased by 3.8 percent.[6]

Building and growth rates for the region did, in fact, slow from 2000 to 2010 as compared to 1990-2000. In Bear Creek Township, the average number of new single-family homes built per year dropped from 45.7 to 37.8 between 2000 and 2010 (see building permit activity in Table 3 below). This trend is representative of the economic health of the community and perhaps reflects economic conditions precipitated by the recession beginning in 2008. As the economy recovers, the areas adjoining Petoskey and in close proximity to Little Traverse Bay, including the Tannery Creek watershed, are likely to further develop denser commercial and residential zones. Indeed, recent house sales and property values have increased in the Traverse City area. Bear Creek Township has shifted zoning ordinances to prepare for and direct these developments. Further discussion of predicted land use and land use trends is included in the Build-out analysis description in Chapter 3.

TABLE 1: HISTORICAL POPULATION OF BEAR CREEK TOWNSHIP: 1970-2012; FROM US CENSUS DATA

			Change 1970-1980			Change 1980-1990			Change 1990-2000			Change 2000-2010	
Location	1970	1980	Total	%	1990	Total	%	2000	Total	%	2010	Total	%
Bear Creek Township	2,450	3,287	837	34.2	3,469	182	5.5	5,259	1,800	51.9	6,201	932	17.7
City of Petoskey	6,432	6,097	-336	-5.2	6,056	-41	-.07	6,080	24	4	5,670	-410	-6.7
Emmet County	18,331	22,992	4,661	25	25,040	2,048	9	31,437	6,397	26	32,694	1,257	4.0
State of Michigan	8,881,826	9,262,078	380252	4.3	9,295,297	33,219	0.4	9,938,444	643,147	7	9,883,640	54,804	-0.6

TABLE 2: DEVELOPMENT IN BEAR CREEK TOWNSHIP: 2005-2010; FROM TOWNSHIP DATA

Year	2005	2006	2007	2008	2009	2010	Total
Single Family (includes duplexes)	50	30	21	13	5	6	125
Multifamily	23	7	2	1	0	0	33
Total	73	37	23	14	8	6	158

TABLE 3: BEAR CREEK TOWNSHIP HOUSING STRUCTURE: 2000-2010; FROM US CENSUS DATA

Unit Type	2000		2010		Change 2000-2010	
	Number	Percent	Number	Percent	Number	Percent
1 unit detached	2,120	70.6	2,385	66.8	265	12.5
1 unit attached	48	1.6	124	3.5	76	158.3
2-9 unit structures	394	13.1	590	16.5	196	49.7
10 or more units structures	212	7.1	382	10.7	170	80.2
Mobile home or trailer	230	7.6	87	2.4	-143	-62.2
Total	3,004	100	3,568	100	564	18.8

HYDROLOGY

Stream flow is one of the most important variables that ensure biological integrity of a stream ecosystem. Watershed development typically has negative impacts on the natural hydrology, resulting in alterations in stream flow that degrade habitat and aquatic life. More development typically means more impervious surfaces—such as road networks, parking lots, and roofs of homes and buildings—which do not allow precipitation to percolate into the groundwater. Degraded aquatic communities are commonly found in watersheds with as little as 2% impervious area, but are common when levels are 10-16% or higher.[7] Impervious surfaces, often with accompanying drains and piping, act as funnels for water to travel directly over the land surface into waterways, such as Tannery Creek. This makes it easier for surface water to pick up sediments, nutrients, and other pollutants on its way to the stream. It also decreases ground infiltration and the amount of time it takes for water to reach the waterway, which can result in dramatically increased flows in short periods of time (referred to as "flashiness"). Impacts resulting from flashy flows include scouring and erosion of the stream bottom and banks, sedimentation of interstitial spaces where macroinvertebrates typically live and thrive, homogenization of habitat due to sedimentation, washing downstream of debris and habitat, and washing downstream of macroinvertebrates and other stream fauna.[8]

Tannery Creek is a relatively flat stream, with some steeper gradients in the headwaters. It gains velocity and gradient as it winds its way to the bay, but still remains a low gradient stream. The substrate is mostly sand and pebbles, with some areas consisting of more gravel and cobble.

Currently, the flow of Tannery Creek is relatively unimpeded, but there are exceptions. A small dam on the Bay View Golf Course was removed in 2004 as a Watershed Council project,[9] which necessitated the installation of a sea lamprey weir at the mouth of the creek, downstream of site TC5. As of the writing of this plan, the Watershed Council is working on a project to install a clear span bridge in place of the current culvert and weir to restore the hydrologic connectivity between the upstream and downstream portions of Tannery Creek at this site. The Watershed Council is also facilitating riparian restoration in the form of re-vegetation. In addition to this culvert, there are several road–stream crossings where the creek flows through culverts. Because culverts are typically straight, narrow, and made of metal, they increase the velocity of the stream. This can hinder fish and other aquatic species' passage and degrade habitat directly downstream.

Several groups have collected flow measurements since 2007, including the Tribe, the Watershed Council, and the SNRE study team (see Appendix B for historical flow data). The collection of flow data requires a flow meter to measure depth and velocity at a point and a measuring tape to measure stream width. Without a wading rod and flow meter, velocity measurements can be taken at sites along the stream using a neutrally buoyant object and cross-sectional depth and width measurements can be taken with a measuring tape and meter stick. Measurements taken by the SNRE team using a neutrally buoyant object, a meter stick and a meter tape. All other measurements were taken using a flow meter and meter tape.

During times of high flow and storm events, there is severe flooding upstream of US-31. Tannery Creek flows over its western bank, a few hundred feet upstream of Pirate's Cove, into the parking lot behind McDonald's and Fast Eddie's and onto the Bay View Golf Course. A flooding analysis was conducted by the Watershed Council and the organization has begun talks with relevant parties and stakeholders to find a solution to this problem so the businesses and their patrons can enjoy the creek without this unnecessary burden, which leads to habitat destruction and pollutant loadings.[10]

GROUNDWATER

Groundwater is critically important for the water quality and ecosystem integrity of the Tannery Creek watershed, including its wetlands and aquatic habitats. Increasingly used for human purposes, including potable water supply, agriculture and livestock and industrial uses, groundwater constitutes approximately 96% of all freshwater in the United States, holding nearly 50 times the volume of surface waters.[11] Almost half of Michigan and nearly all of Emmet County use groundwater as their sole source of drinking water.[12] In the Tannery Creek watershed, over 60 wells provide residents, businesses, and visitors with their daily water needs. Groundwater infiltration and recharge areas in the Tannery Creek watershed warrant protection to safeguard against surface water pollution from excessive stormwater runoff.

Groundwater refers to the saturated and unsaturated layers extending below the land surface to a depth where solid rock does not permit further movement of water.[13] An aquifer is the spatial unit of rock, sand and other materials where groundwater occurs. The deeper, saturated portion is referred to as the "water table." Groundwater is recharged or replenished vertically from the surface infiltration of rainfall or other atmospheric precipitation, or from water bodies, including lakes, rivers, wetlands, and estuaries. The proportion of precipitation to reach the water table is determined by watershed-specific processes that depend on variables of precipitation, land cover, soil composition, surficial geology, and other factors.

The movement of groundwater, a natural process in the hydrological cycle, greatly affects water-dependent ecosystems that are wholly or partly dependent on groundwater, such as stream, lake, and pond habitats. Rates of recharge and discharge—naturally regulated by a landscape's soils, vegetative cover, geology, and topography—sustain groundwater dependent ecosystems and surface water ecosystems by providing significant portions of the water requirements, sustaining flow through dry periods via base-flow, and contributing to the chemical composition and temperature key to the survival of native aquatic species.[14]

Discharge areas are locations in a watershed where groundwater leaves the aquifer and flows to/along the surface, such as steep slope areas and regions in the upper watershed. Seeps and springs are observable discharge areas that often flow into surface water bodies, such as streams and lakes. Because water flow is largely dictated by the force of gravity (though pressure gradients and the physical

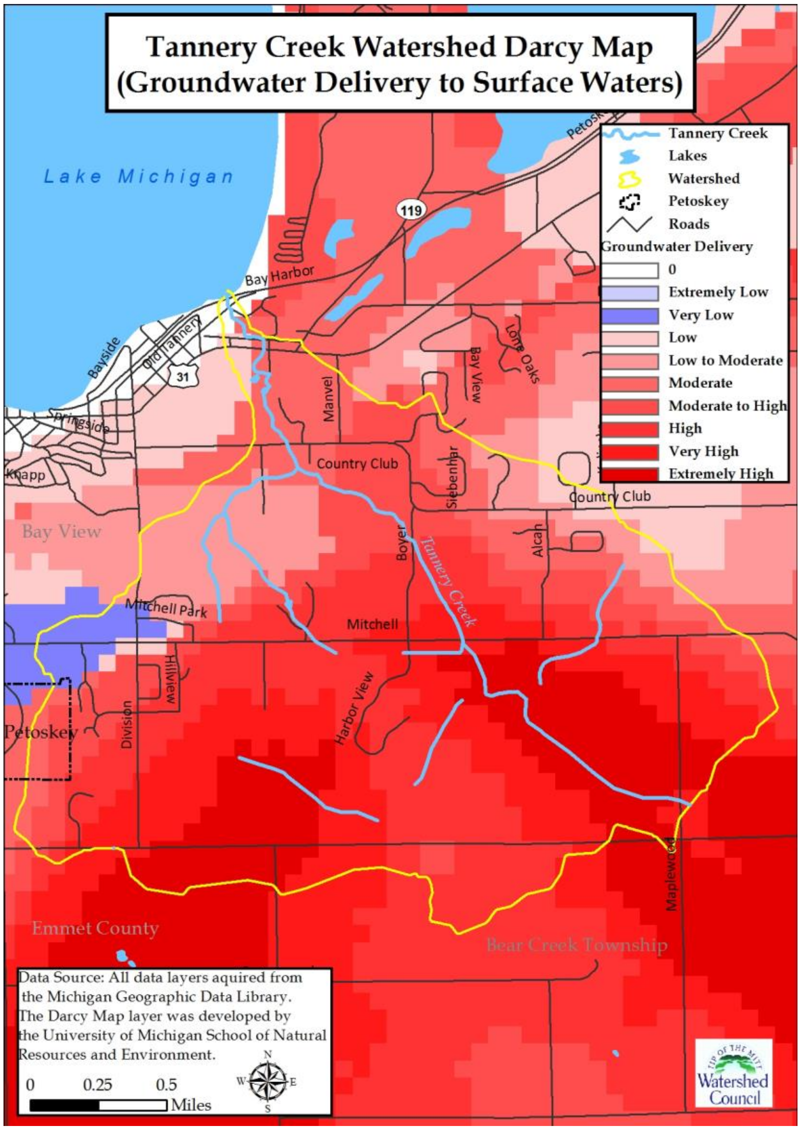


FIGURE 5: GROUNDWATER DELIVERY TO SURFACE WATERS IN TANNERY CREEK WATERSHED

properties of water can cause water to flow against gravity), higher elevation areas, such as hills, are typically where groundwater is recharged, while low-lying areas are generally discharge areas. The probable degree to which groundwater contributes to stream and other surface waters in the Tannery Creek watershed is illustrated in The Darcy Map (Figure 5), developed by UM and the Michigan Department of Natural Resources (MDNR).

Expanding development, such as road and house construction, replaces natural land cover with impervious surfaces, impeding groundwater recharge and increasing the proportion of water that runs off over the surface. Altering the hydrologic balance can have a number of consequences for a surface water ecosystem's biological, chemical, and physical attributes.[15] Importantly, Tannery Creek's resident trout and spawning salmon populations rely on steady flows of cool water provided by subsurface waters.

Protecting natural areas that facilitate surface water infiltration to deeper groundwater areas can also help limit the detrimental effects of excessive runoff. Unimpeded runoff can also alter the natural hydrology and flow regime of surface waters, causing creeks to 'flash' during storm events and causing pollution as runoff picks up whatever pollutants and contaminants are present at the surface, such as nutrients, oils, and sediments, and deposit them into surface waters. A discussion of soil infiltration rates can be found in the Geology/Soils section below.

Groundwater resources are also impacted when recharge areas are compromised. Threats to recharge areas are less critical than threats from runoff in the Tanner Creek watershed, but should still be monitored. Efforts to protect groundwater resources should address both the potential for pollutants to reach and contaminate groundwater and the unintentional reduction of groundwater recharge due to development. A discussion of soil types and groundwater recharge areas can be found in the Geology/Soils section below.

Ways to Protect Groundwater

Fortunately, there are a number of measures communities can take to protect groundwater resources, promote groundwater recharge, and realize the benefits of cleaner water, which include more open space, less stormwater to manage, maintenance of base flow to preserve ecological communities, and flood mitigation. Preservation of open spaces with natural vegetation and site designs that utilize Low Impact Developments (LID) and Best Management Practices (BMPs), such as rain gardens, porous pavement, and vegetative swales, are effective measures landowners, developers, and resource planners can take to protect groundwater.

There are also a number of policy and planning standards and ordinances being used by communities to protect groundwater and limit runoff including the following: designating an area as a groundwater recharge area, designating aquifer recharge areas as environmentally sensitive, classifying aquifers based on their use or susceptibility to contamination, setting groundwater recharge performance standards, setting impervious surface performance standards, and restricting land use activities which involve materials that could contaminate an aquifer. Identification of critical recharge areas is based on surface soil permeability, wellhead protection zones (areas within one-year water movement travel zone of larger wells), and areas with high concentration of private domestic wells (locations where the number of wells within half-mile radius is 36 or more). Contaminants to consider include microbial (septic systems, flooding, livestock), organic compounds (paint thinner, solvents, gasoline, preservatives, lubricants), and inorganic compounds (septic systems, animal waste, agricultural activities). Impervious surface standards are most important and necessary for Tannery Creek.

A characterization of the geology and soils found in the Tannery Creek watershed is critical to understanding the current state of the watershed and future threats given the above groundwater infiltration and runoff discussions. The most recent glaciation in Michigan's history, the Wisconsonian, shaped the landscape of today's Tannery Creek watershed. This was the most recent advance of the Laurentide ice sheet, which lasted from approximately 110,000 to 10,000 years ago. The glacier shifted and completely buried what is now the state of Michigan.[16] As the glacier retreated, it left behind a mix of rock material of all sizes, commonly referred to as till.

The surficial geology of the upper and northern portions of watershed—areas of higher elevation—is comprised primarily of course textured glacial till, which is drift material eroded from the Earth's surface and deposited by glaciers. These areas are commonly known as moraines, or accumulations of unconsolidated glacial debris.[17] Emmet and Leelanau series soils, consisting of deep, well-drained soils formed in sandy loam till on end moraines and ground moraines, generally overlap with the underlying glacial till geology in the upper watershed.[18] Within these overlapping areas of higher elevation, coarse textured soils and surficial geology, and level surfaces, water is most likely to infiltrate the surface to replenish the water table below. Emmet Series soils below 18 percent slope, with moderate permeability, moderate available water capacity, and moderate surface runoff rates, are the most productive farming soils in the region and cover most of the Tannery Creek watershed.

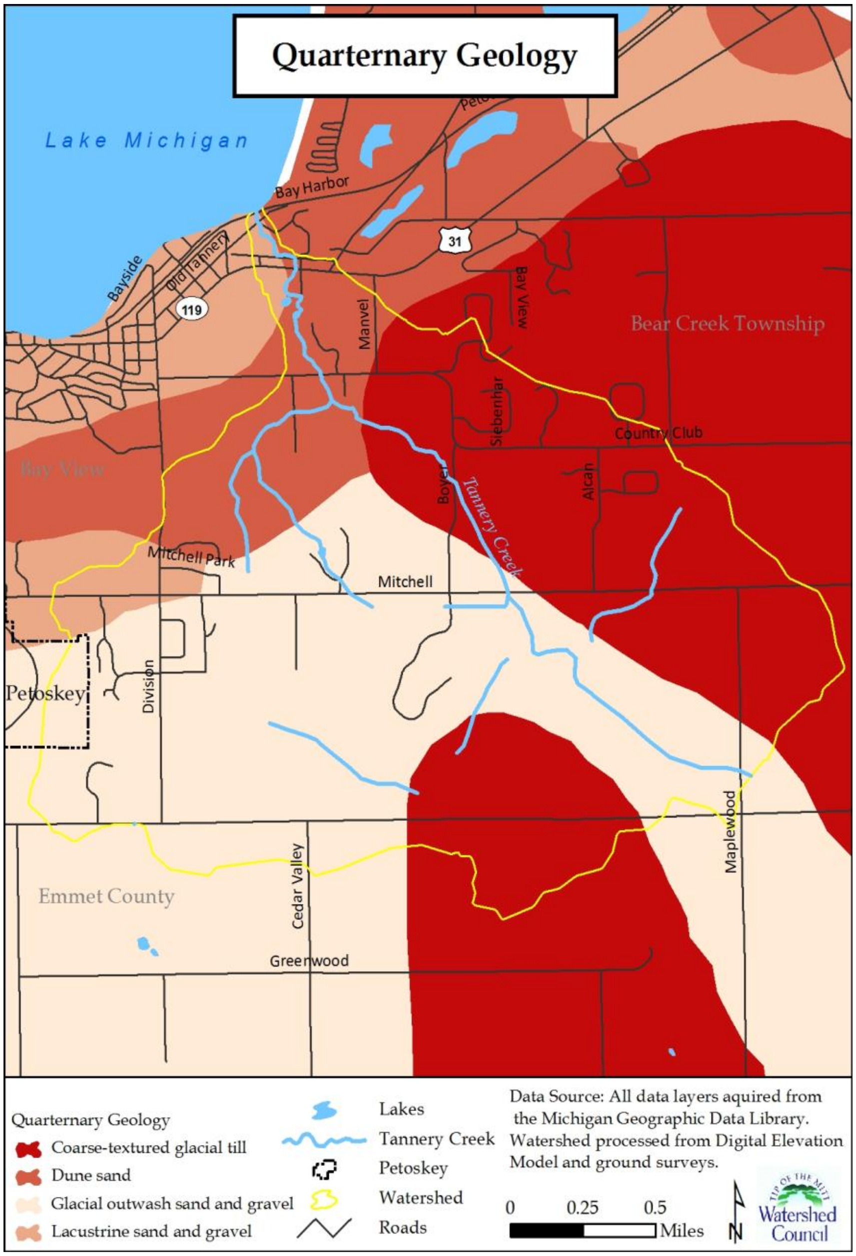


FIGURE 6: SURFICIAL GEOLOGY IN TANNERY CREEK WATERSHED

Moving down the catchment, surficial geology dominated by glacial till gradually gives way to a topography characterized by glacial outwash sand and gravel and post-glacial alluvium, products of weathering and deposits from Tannery Creek and from glacial sediments deposited from glacial meltwater outwash. This geology spans the lower-lying portions of the middle watershed, south to the catchment ridgeline and the border of Petoskey, and north to steeper topography that indicates the margins of the moraine geology. As the topography levels, the water table interacts with the surface, discharging to form Tannery Creek as a surface stream. The underlying soil association also transitions from sand, gravel, and loam—areas of high water infiltration—to poorly drained soils formed in sandy, silty fluvial deposits, such as Carbondale Muck and Charlevoix series soils. These areas are location to significant wetlands, which dominate the southern fork sub-watershed.

As the creek picks up flow and the catchment narrows (near Country Club Lane), the geology transitions to dune sand and lacustrine sand, while the predominant soil structure transitions to a loamy and sandy loam series, which is common at edges of moraines and in low-lying lake regions.

The lowest portion of watershed is underlain with dune sand before transitioning to lacustrine sand and gravel near the creek's exit point to Little Traverse Bay. Soils here are a mix of outwash plain—as represented by the Rubicon series—and sandy deposits dominated by the Deer park soil series, which is so prevalent in the Great Lakes region. Below is a description of the major soil associations in the Tannery Creek watershed (Table 4) and a map of their locations within the watershed (Figure 7).

TABLE 4: SOIL ASSOCIATION BY ACREAGE IN TANNERY CREEK WATERSHED[19]

Soil Association	Description	Area (acres)
Carbondale Muck	Very deep, very poorly drained soils formed in organic deposits	317
Charlevoix	Deep, somewhat poorly drained soils formed sandy loam till	106
Deer Park	Very deep, well drained soils in sandy deposits	25
East Lake	Very deep, somewhat well drained soils that formed in sandy/gravelly out wash plains	21
Emmet	Very deep, well drained soils formed in sandy loam till	1476
Ensley	Very deep, poorly drained soils formed in loamy till	19
Kalkasa	Very deep, somewhat well drained soils formed in sandy deposits	7
Leenlanau	Very deep, well drained soils	214
Linwood Muck	Very deep, very poorly drained soils formed in highly decomposed woody, organic materials	90
Mancelona	Very deep, somewhat well drained soils formed in sandy and gravelly outwashes	42
Rubicon	Very deep, well drained soils formed in sandy deposits	2
Tawas Muck	Very deep, very poorly drained organic soils	1
Water		
Wet Alluvial Land		24

Source: USDA NRCS

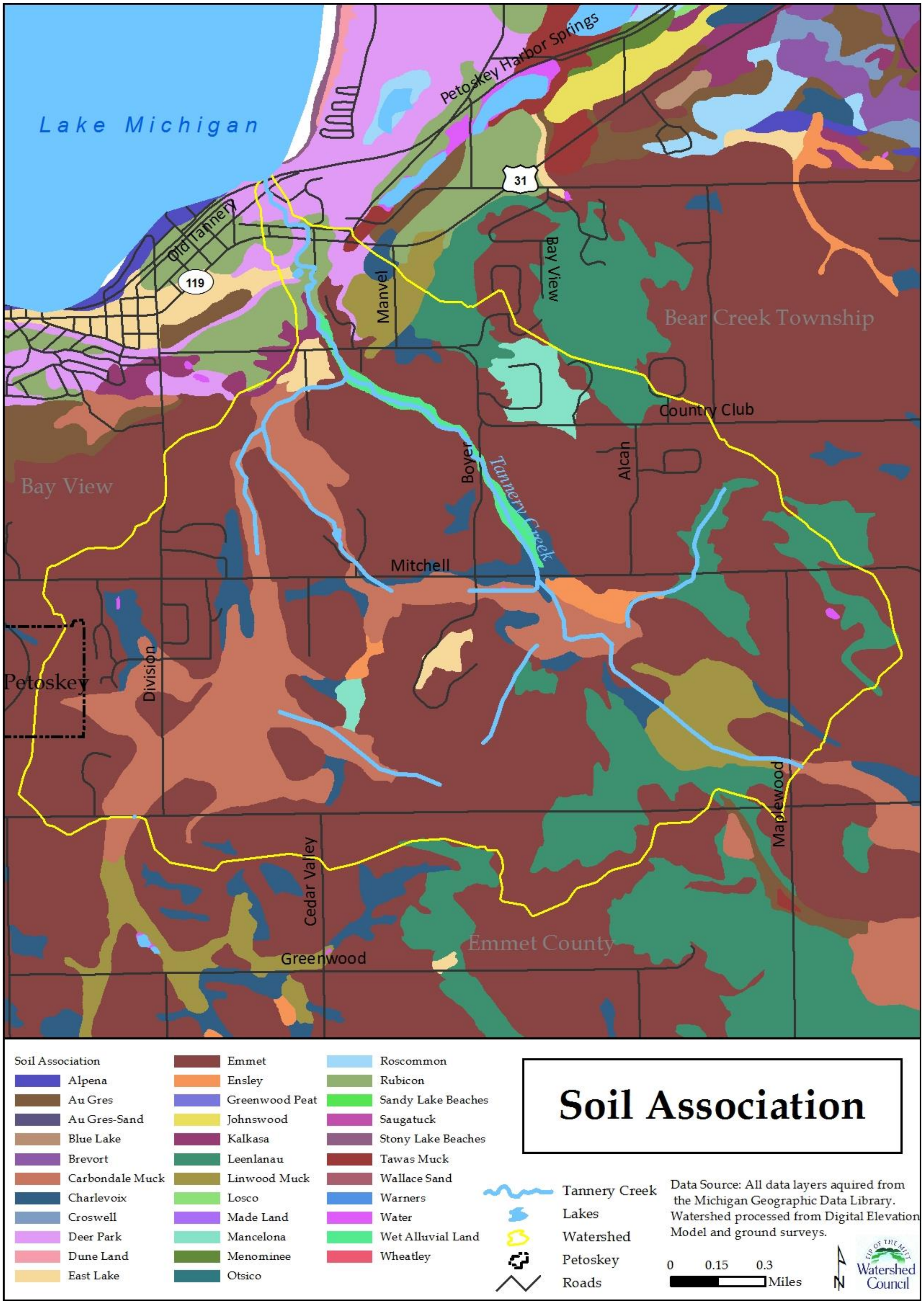


FIGURE 7: TANNERY CREEK BY NATURAL RESOURCE CONSERVATION SERVICE (NRCS) SOIL ASSOCIATIONS

Hydrologic Soil Groups and Soil Infiltration

Soils are classified into hydrologic soil groups (A-D) to indicate the minimum rate of *water infiltration and transmission* after prolonged wetting. These soil groups are utilized as inputs to the L-THIA model used to project impacts from build-out scenarios in Chapter 3. The soil groups are also used as a variable in determining soil infiltration rates, which are critical to understanding both runoff rates and groundwater recharge areas. A soil infiltration rate is the rate at which water enters the soil at the surface and the transmission rate is the rate at which the water moves downward within the soil. Infiltration and transmission rate classifications are a factor of soil saturated hydraulic conductivity.[20]

Most of the groupings are based on the premise that soils found within a climatic region that are similar in depth, transmission rate of water, texture, structure, and degree of swelling when saturated, will have similar runoff responses. The classes are based on the following assumptions: unfrozen soil, bare soil surface, maximum swelling of expansive clays, and intake and transmission of water under the conditions of maximum yearly wetness.

Soil permeability is based on rates of infiltration as described in hydrological soil group classifications. It is important to consider that rates of infiltration and transmission to groundwater largely depend on surface cover and associated runoff rates. Hydrological soil groups do not account for effects that natural cover, slope, and anthropogenic land cover changes have on infiltration and transmission rates. Built and natural impervious surfaces can greatly alter infiltration and transmission and therefore consideration of groundwater recharge rates and runoff amounts should include potential effects of impervious surfaces or other altering forces.

Group A: Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission (greater than 0.30 in/hr). USDA: (greater than 5.67 inches per hour).

Group B: Soils having moderate infiltration rates when thoroughly wetted and consisting of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). USDA: (1.42-5.67 inches per hour)

Group C: Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes the downward movement of water or soils with moderately-fine to fine texture. These soils have a slow rate of water transmission (0.05-0.15 in/hr). USDA: (0.14-1.42 inches per hour)

Group D: Soils having very slow infiltration rates when thoroughly wetted and consisting 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 slow rate of water transmission (0.0-0.05 in/hr). USDA (0.0-0.14 inches per hour)

TABLE 5: ANNUAL INFILTRATION RATES BY HYDROLOGIC SOIL GROUP

NRCS hydrologic soil group (HSG)	Annual base infiltration rate - I_B (inches)
A	18
B	12
C	6
D	3

Source: Horsley, 1996

In the Tannery Creek watershed, the prevailing sandy soils (Deer Park Sand, East Lake Loamy Sand, Kalkaska Sand, Leelanau Loamy Sand, Mancelona Loamy Sand, and Rubicon Sand) that facilitate groundwater recharge and facilitate groundwater transport to surface waters also present a potential threat to its aquifer and wetland habitats. Although soils are a natural filtration medium, pollutants associated with agricultural activity (e.g., pesticides, herbicides, nutrients, pathogens) and the urban or residential environment (e.g., metals, automotive fluids, nutrients,) can regardless be transported through the ground and contaminate either drinking water supplies or local surface waters fed by groundwater. Some of the major potential sources of contaminants present in the Tannery Creek watershed are storage tanks, septic systems, and the widespread use of road salts, fertilizers, pesticides, and other chemicals such as inorganic chemicals or solvents from automotive industry.[21]

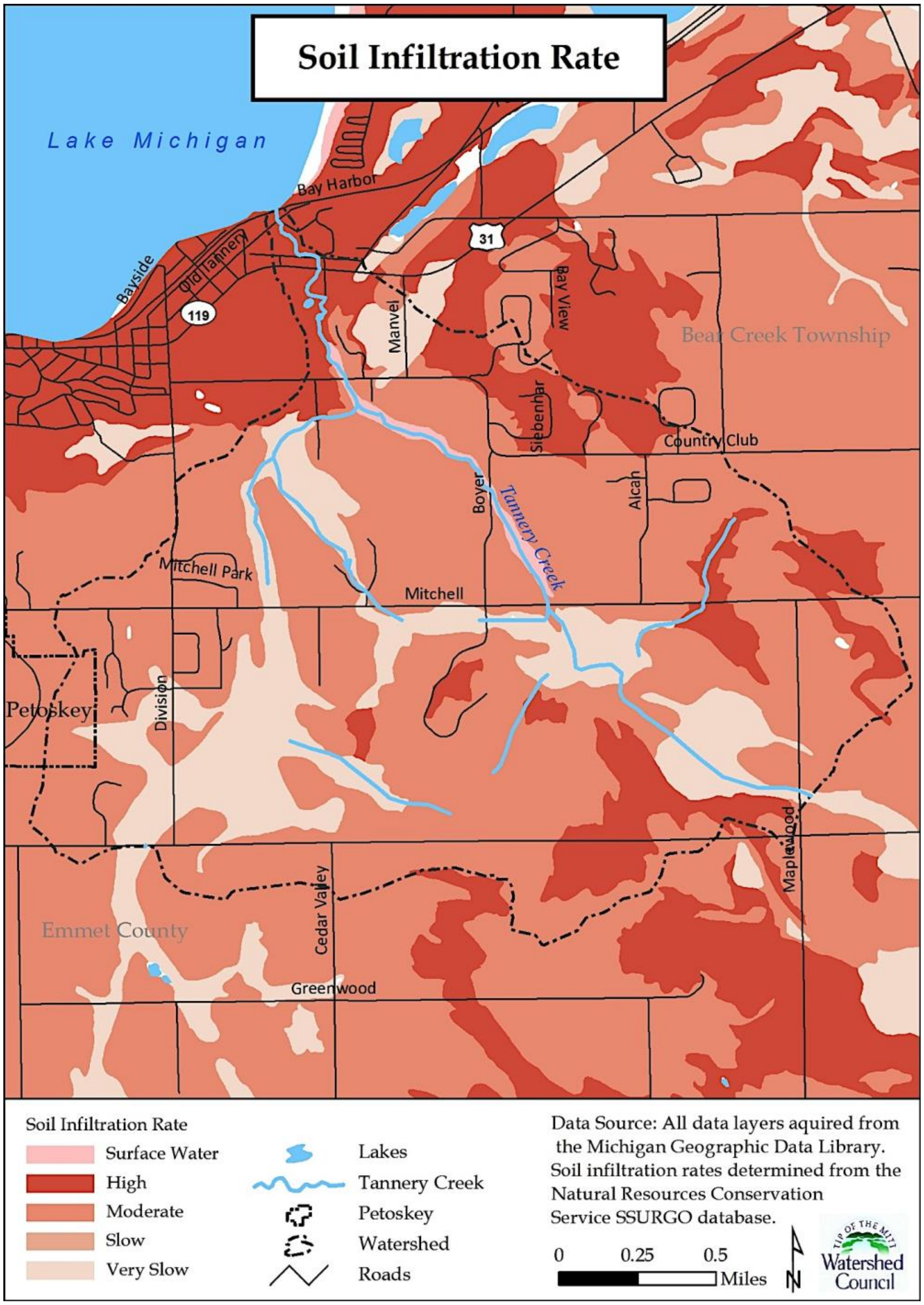


FIGURE 8: SOIL INFILTRATION RATES FOR TANNERY CREEK WATERSHED

Soil Erodibility

Soil erodibility is a measure used to identify key parcels for protection in Chapter 5. The soil erodibility depicted in Figure 9 below is based on ratings by NRCS. These ratings are a product of slope and soil k-factor, which indicates how likely a soil is to erode. High erodibility indicates higher priority for protection.

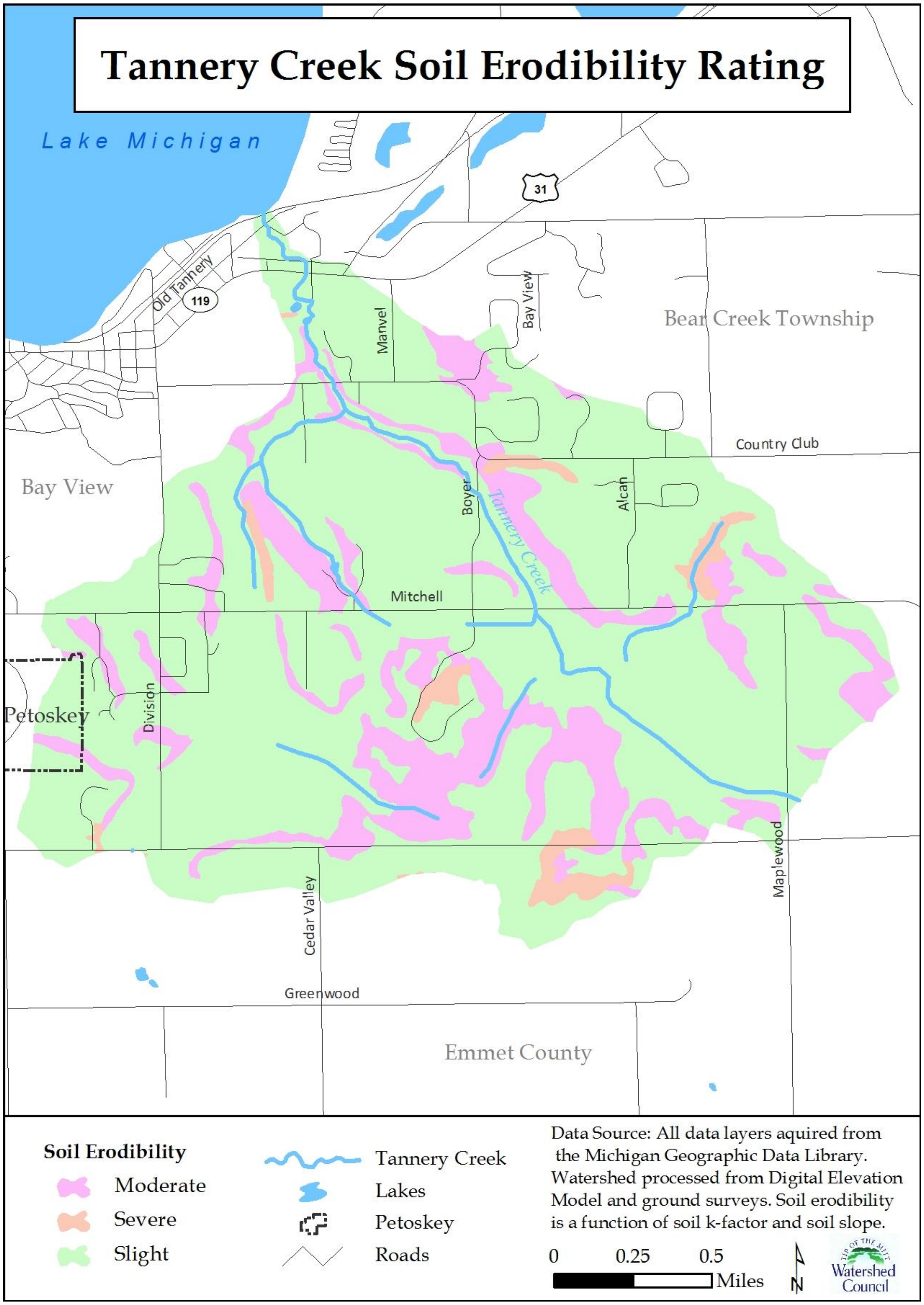


FIGURE 9: ERODIBILITY OF SOILS IN TANNERY CREEK WATERSHED

LOCAL CLIMATE

The local climate for the Tannery Creek watershed is typical for Northern Michigan: mild summers and cold, snowy winters. Climate is a major determinant of a watershed's hydrology; however it is important to recognize the combined influence that climate, land cover, land use, soils, geology, topography, and other factors have on a watershed's hydrology. Table 6 includes data for the City of Petoskey, which encompasses a portion of the watershed. In-depth climate data at National Oceanic And Atmospheric Administration (NOAA) National Climate Data Center: http://www.ncdc.noaa.gov/

TABLE 6: CITY OF PETOSKEY HISTORICAL CLIMATE DATA[22]

Average Annual Rainfall	31.45 in
Average Annual Snowfall	109.1 in
Minimum Average Monthly Precipitation	February (1.37 in)
Maximum Average Monthly Precipitation	September (3.77 in)
Winter Average Precipitation	5.84 in
Spring Average Precipitation	7.02 in
Summer Average Precipitation	8.99 in
Fall Average Precipitation	9.61 in
Annual Average Minimum Temperature (F)	36.7°F
Annual Average Maximum Temperature (F)	52.9°F
Average Temperature	44.8°F
Days above 90°F/32°C	2.9
Days below 0°F/-18°C	9.2
Average Warmest Month	July
Highest Recorded Temperature	99°F in 1955
Average Coolest Month	January
Lowest Recorded Temperature	-25 ° in 1979

FISHERIES

Limited data are available for fish populations of Tannery Creek. Tannery Creek is, however, designated as a cold-water fishery. Brook trout have been identified in the creek by residents and fisheries biologists in the area. From the data provided, it is evident that brook trout across a range of sizes can be found in the creek, but the overall health of the brook trout population is uncertain. Evidence of a reproducing population would augment this limited census data, and could be obtained from periodic surveys in mid-autumn to look for individuals in spawning colors and young of the year.

MDNR does not currently survey Tannery Creek because of its small size and unknown impact on the larger trout fishery in the area. If surveys were conducted, beyond the one performed by the MDEQ in Table 7 below, MDNR would have a sense of the productivity of the creek and if further monitoring is warranted.

Overall, the temperature, substrate, dissolved oxygen, and aquatic macroinvertebrate data all support that a self-sustaining brook trout population is possible for Tannery Creek. The temperature is cool enough, the substrate of the correct size for spawning, the dissolved oxygen sufficiently high, and macroinvertebrates are abundant as a food source for the trout in the creek.[23]

TABLE 7: COUNTS OF BROOK TROUT IN TANNERY CREEK: 2008 (TC4 AND TC5)

Size (in)	TC5	TC4
1	0	5
2	3	11
3	0	7
4	4	8
5	11	10
6	9	4
7	9	6
8	4	2
9	1	2
10	1	0

Data collected based on electrofishing surveys in 2008 by the MDEQ. This study was conducted to assess the health of the fishery after a dam removal in 2004 by the MDNR Fisheries Division.[24]

NATURAL FEATURES AND WILDLIFE

Over the last few centuries, the Tannery Creek watershed landscape has changed considerably. What is now a patchwork of farms, forests, homes, and commercial zones, was once mostly undulating forests, grasslands, and dunes intermixed with sprawling wetlands in low-lying valleys (see Figure 10 for historical vegetation). Understanding where these landscapes historically occurred—knowledge of the type, location, and ecological context of the native vegetation and wildlife—can help planners, resource managers, and landowners choose effective land management goals and techniques that account for the underlying habitat.

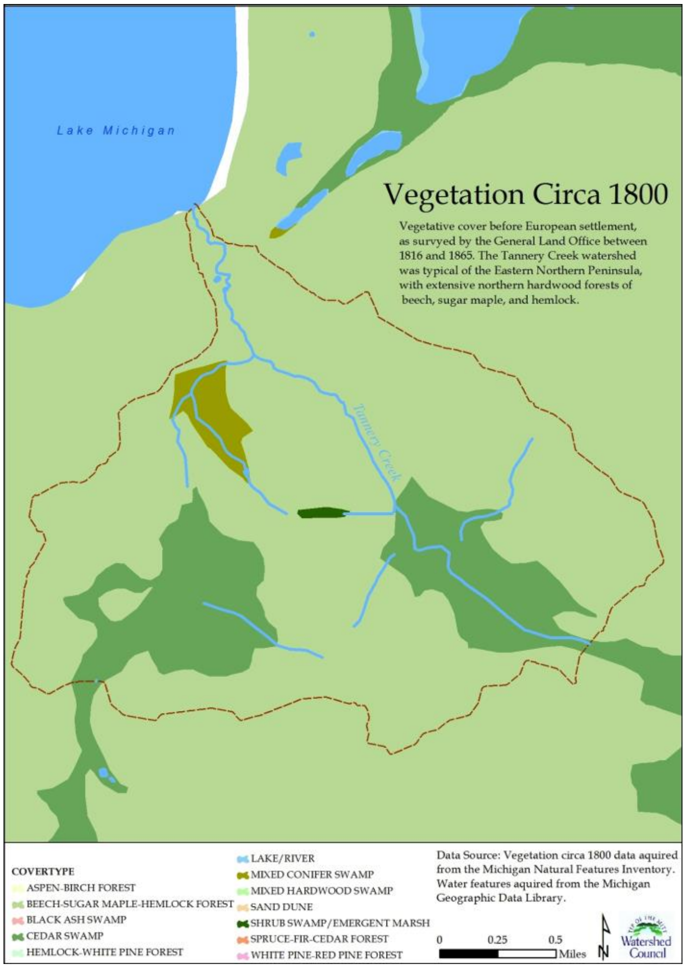


FIGURE 10: HISTORICAL VEGETATIVE COVER, CIRCA 1800, IN TANNERY CREEK WATERSHED
Source: MNFI

Ecoregion

The US EPA, state resource agencies, universities, and conservation organizations have all used the concept of "ecoregions" to classify regional landscape ecosystems by taking into account the interrelated effects that geology, climate, soils, and landforms have on ecological characteristics. MDNR describes the ecoregion encompassing Tannery Creek as such:

The Eastern Upper Peninsula (Northern Lacustrine-Influenced Upper Michigan) Ecoregion (Section VII) is characterized by extensive, sandy outwash plains and large moraines. Although the climate of the ecoregion is strongly moderated by the Great Lakes, the interior portions experience the greatest temperature extremes in Lower Michigan. Historically, the ecoregion supported extensive northern hardwood forests of sugar maple, American beech, eastern hemlock and white pine. In addition, the ecoregion supported large areas of fire-dependent ecosystems such as jack pine barrens, oak-pine barrens, and white pine-red pine forest. A diversity of wetland natural communities, including bog, northern fen, northern wet meadow, hardwood-conifer swamp and rich conifer swamp, continues to thrive. Today, much of the ecoregion remains forested by northern hardwood, aspen, oak, pine plantations, and lowland conifer.[25]

The sub-ecoregion under this classification is Vanderbilt Moraines, sub-section VII.2.3. The Tannery Creek Watershed falls into the Northern Lakes and Forests Ecoregion (Level III Ecoregions), according to the US EPA.[26]

Endangered Species

The region encompassing the Tannery Creek watershed is ecologically and biologically diverse with numerous plant and animal species inhabiting the region's abundant high-quality wetlands, rivers, streams, upland forests, and inland lakes. Though the Tannery Creek watershed is mostly cleared of its original vegetation—exclusive of its protected wetland areas—it is historically a habitat to a number of endangered and threatened species. The collective efforts made by natural resource agencies, universities, and other institutions such as the Michigan Natural Features Inventory (MNFI) to identify and protect rare, threatened, and endangered species are critical. Endangered, rare, and threatened species are protected in Michigan under the US Endangered Species Act, administered by the US Fish and Wildlife Service, the NOAA Fisheries Service, and the Michigan Natural Resources and Environmental Protection Act. Article III. Chapter 1. Part 365.[27] The rare, threatened, and endangered species present in the Tannery Creek watershed are listed in the table below.

TABLE 8: PROTECTED SPECIES FOUND WITHIN THE TANNERY CREEK WATERSHED

Scientific Name	Common Name	Federal	State
Amerorchis rotundifolia	Small round-leaved orchid		E
Bromus pumpellianus	Pumpelly's bromegrass		T
Buteo lineatus	Red-shouldered hawk		T
Calypso bulbosa	Calypso or fair-slipper		T
Charadrius melodus	Piping plover	LE	E
Cirsium pitcheri	Pitcher's thistle	LT	T
Cypripedium arietinum	Ram's head lady's-slipper		SC
Dalibarda repens	False violet		T
Drosera anglica	English sundew		SC
Haliaeetus leucocephalus	Bald Eagle		SC
Microtus pinetorum	Woodland Vole		SC
Mimulus michiganensis	Michigan Monkey Flower	LE	E
Senecio congestus	Marsh fleabane		X
Tanacetum huronense	Lake Huron tansy		T
Trimerotropis huroniana	Lake Huron locust		T
Woodsie obtusa	Blunt-lobed woodsia		T

Federal Protection Status Codes: *LE–Listed Endangered, LT–Listed Threatened*
State Protection Status Codes: *SC–Special Concern, T–Threatened, E–Extirpated*

Biological Rarity Index

MNFI developed a probability model and a rarity index model to describe the probability of occurrence of a rare species or high-quality natural communities and to help prioritize the known occurrence areas for conservation.[28] The models are based in the MNFI database of known sightings of threatened, endangered, or special concern species and high-quality natural communities. This dataset provides only a cursory explanation (results are displayed in 40 acre blocks) of the distributions of threatened, endangered, or special concern species and high-quality habitats and should be viewed as supplement to the expert opinion of local natural resource professionals. Still, the probability and rarity models are valuable for prioritizing species and habitat protection and can help ensure coordinated resource management and protection efforts (between landowners, resource agencies, planners, and developers.) The rare species or high-quality natural communities probability map generated by MNFI is provided in Figure 11 below.

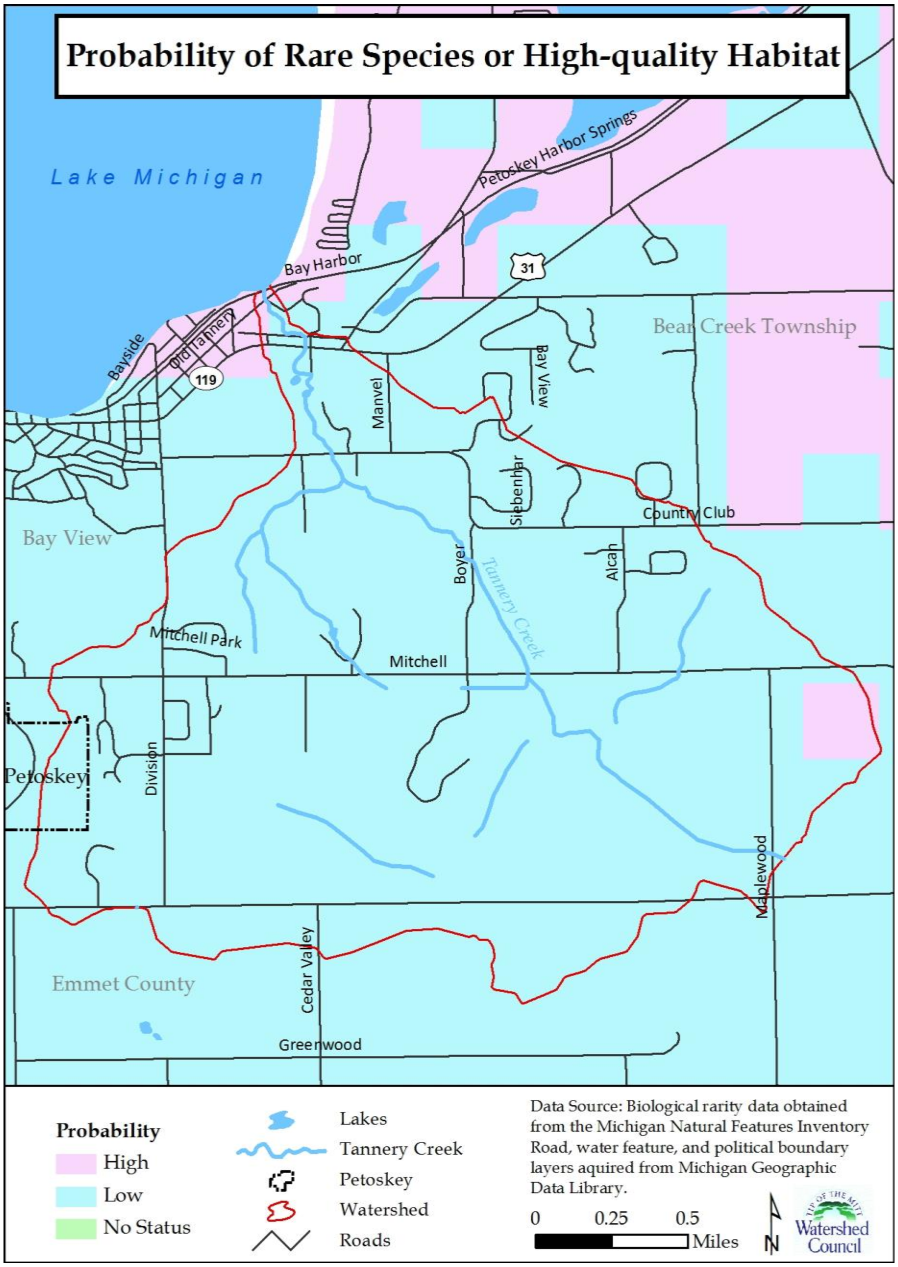


FIGURE 11: PROBABILITY OF RARE SPECIES OR HIGH-QUALITY HABITAT IN TANNERY WATERSHED

Wetlands

The Tannery Creek watershed encompasses nearly 101 acres of wetlands (4.2% of the total watershed area), as determined by the MDEQ wetlands inventory. All of these wetland areas are classified as Palustrine, which are "non-tidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 parts per thousand."[29] Though these wetlands are spread throughout the watershed, most are found in low-lying, flat, poorly drained zones of the middle watershed. A large area of forested wetlands is located east and south of the intersection of Division and Atkins roads and is characterized by needle conifers, such as white pine.[30] Another large area of mostly emergent, riparian wetlands can be found near the intersection of Boyer and Mitchell roads. Emergent wetlands are characterized by a vast array of grass-like plants such as sedges, cut grass, and cattails, and are usually saturated with water year round. [31]

Wetlands are an important resource in the Tannery Creek watershed. Wetlands help maintain and improve water quality and quantity, provide erosion control, retain sediments, prevent flooding, help recharge groundwater supplies, support biological diversity, and offer certain recreation and aesthetic values.[32] Wetlands preserve water quality by intercepting and filtering runoff from the land that may contain harmful pollutants before reaching groundwater or open water, such as Tannery Creek or Little Traverse Bay.[33] As detailed in the groundwater section above, wetlands also act as reservoirs for the watershed, retaining runoff from precipitation, snowmelt, surface waters, and groundwater; regulating the water balance within the watershed; and acting as a natural buffer against changing water levels. This ecological function supports multiple services, including protection of riparian properties from excess runoff and flooding, retention to slow groundwater recharge, and pollutant detention.[34] In addition, stream riparian wetlands, by virtue of their place in the landscape, protect shorelines and streambanks against erosion. Wetland plants hold the soil in place with their roots and reduce the velocity of stream currents.[35] Diverse species of plants, mammals, amphibians, birds, insects, and fish depend on wetlands for habitat, food and shelter. According to MDNR, wetlands acre-for-acre, '"produce more wildlife and plants than any other Michigan habitat type."[36] As the watershed develops further, managing wetlands effectively and sustainably will be important for maintaining these vital services and values.

Michigan has formally recognized the importance of protecting and preserving wetland habitats through its wetlands statute, Part 303–Wetlands Protection of the Natural Resources and Environmental Protection Act, 1991 PA 451. Part 303 defines wetlands as "land characterized by the presence of water at a frequency and duration sufficient to support, and under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp, or marsh."[37] This statute protects wetlands from any activity that would cause detrimental impacts and requires permit application for any activity that falls under those listed by the state (e.g. dredging, draining, filling maintained use or development, etc.). MDEQ reviews all Part 303 permits.

Importantly, as one of two states approved by the EPA to administer the federal Section 404 Permit Program under the Clean Water Act (1972), wetlands permits in Michigan satisfy both state and federal application requirements.

In order to allow MDEQ to make a decision on a proposed activity within a wetland, proper identification of the location of wetlands that may be impacted is required. The process for identifying wetlands depends on the level of activity and may require a site review. Pursuant to Part 303, MDEQ has conducted wetland inventories, identifying wetlands and creating maps on a county-by-county basis. These maps indicate areas that would require wetlands construction permits (note: wetlands requiring permits are not limited to areas depicted in DEQ wetland maps; a more thorough wetland identification may be necessary).[38] The wetland inventory in Figure 12 below is based on data from the following sources:

1. The National Wetland Inventory conducted by the US Fish and Wildlife Service through interpretation of topographic data and aerial photographs;
2. Land Cover, as mapped by the Michigan Department of Natural Resources' Michigan Resource Inventory System (MIRIS), through interpretation of aerial photographs; and
3. Soils, as mapped by the US Department of Agriculture, Natural Resource Conservation Service.

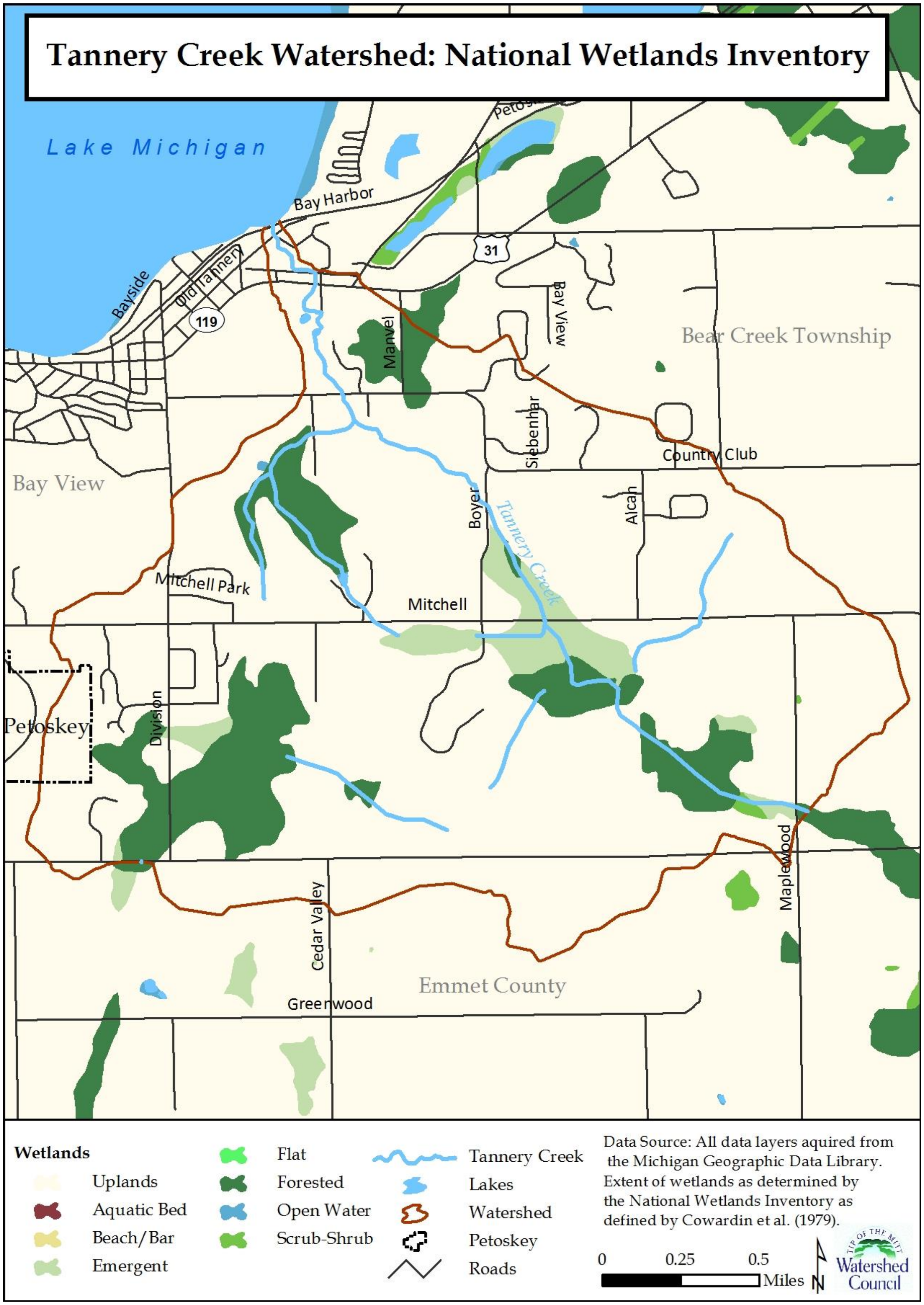


FIGURE 12: WETLANDS IN TANNERY CREEK WATERSHED

INVASIVE SPECIES

Invasive species, also known as exotic species, are plants, animals, or other organisms that are not native to the area they inhabit; for the purposes of this analysis, invasives are further identified as those having adverse effects on ecological, economic, social, or public health systems.[39] Examples in the Tannery Creek watershed range from sea lamprey to Japanese knotweed. Typically, humans are the cause of invasive species introduction or migration to a region. These species become problematic when they have the ability to outcompete the native species of a region, for example, the ability to grow under harsh conditions, such as low access to light, water, nutrients, food, or habitat.

Some invasive plant species are also designated as *noxious weeds,* which are plants designated as harmful to agriculture, ecosystems, humans, or livestock. There is a federal noxious weed list and state-specific lists in 46 states. In Michigan, certain species are prohibited or restricted by the Natural Resources and Environment Protection Act and the Noxious Weed Act of 1941, created with the goal of controlling and even eradicating certain noxious weeds. Under this law, it is the duty of property owners to remove, destroy, and prevent the regrowth of noxious weeds found on their property.[40] Noxious weeds are categorized as either prohibited or restricted species. While prohibited species are not allowed to be grown or sold in the state, restricted species may be grown in the state, but are considered detrimental. Noxious weeds are further restricted under the Michigan Seed Law. Seeds offered for sale must not contain any seeds of prohibited species under this act. Likewise, the occurrence of seeds of restricted species is limited, set at a level of 1 in 4000 seeds.[41]

The study team and staff at the Watershed Council found the following plant species of concern in the Tannery Creek watershed:

- Autumn Olive (*Elaeagnus umbellata*)
- Common Buckthorn (*Rhamnus cathartica*)
- Crown Vetch (*Coronilla varia*)
- Garlic Mustard (*Alliaria petiolata*)
- Giant Knotweed (*Fallopia sachalinensis, syn. Polygonum sachalinense* and *Reynoutria sachalinensis*)
- Goutweed (*Aegopodium podagraria*)
- Multiflora Rose (*Rosa multiflora*)
- Narrow-leaved Cattail (*Typha angustifolia L.*)
- Purple Loosestrife (*Lythrum salicaria*)
- Reed Canary Grass (*Phalaris arundinacea*)
- Spotted Knapweed (*Centaurea maculosa*)

See Appendix G for a full description of these riparian invasive species.

LAND USE INVENTORY

The land cover of the Tannery Creek watershed has changed considerably since Europeans first arrived several hundred years ago. Much of the uplands in the watershed were covered in beech, sugar maple, and hemlock forest, while lowland areas were (and mostly still are) cedar and mixed-conifer swamps (see Table 9 below for historical land cover types).[42] In recent centuries, the watershed has experienced a number of transformations including logging in the upper parts and construction of the tannery and subsequent urbanization in the lower watershed.

TABLE 9: TANNERY CREEK HISTORICAL LAND COVER TYPES, CIRCA 1800.

Beech-Sugar Maple-Hemlock Forest	1847	78%
Mixed Conifer Swamp	57	2%
Cedar Swamp	462	19%
Shrub Swamp/Emergent Marsh	5	1%

Source: MNFI

The current landscape of the Tannery Creek watershed can be accurately assessed through remote sensing using satellite imagery and analysis. Data gathered from the National Land Cover Database 1992, 2001, and 2006 editions show that a significant portion of the watershed has been developed or altered by humans.

Human population increases in the watershed and the consequent conversion of natural land cover types to agricultural, residential, and urban uses invariably impact water resources. Sediments washed from these areas choke the gills of fish, smother spawning beds, reduce habitat, increase water temperatures, and reduce dissolved oxygen levels.[43] Nutrient pollution from fertilizers, animal waste, and sewage can cause eutrophication, resulting in excessive algae blooms that affect water quality and ecosystem integrity.[44]

Other contaminants found in stormwater runoff from agricultural and urban areas, including herbicides, pesticides, oil, lead, arsenic, cadmium, mercury, and zinc, can affect natural communities of lakes, rivers, and wetlands.[45] Stormwater runoff can also cause thermal pollution; waters heated by pavement and from urban areas can elevate water temperatures, which lowers dissolved oxygen counts.[46] For a cold water stream such as Tannery Creek, this can have negative consequences on native fish and plant life.

TABLE 10: CURRENT LAND USES IN TANNERY CREEK WATERSHED

Land Cover Type	Area (acres)	Percent
Developed Open Space	165.2	7.0%
Developed Low Intensity	186.8	8.0%
Developed Medium Intensity	43.3	1.8%
Developed High Intensity	18.2	0.7%
Barren Land	2.8	0.1%
Deciduous Forest	308.2	13.0%
Evergreen Forest	109.6	4.5%
Mixed Forest	31.8	1.3%
Scrub/Shrub	20.2	0.8%
Grasslands/Herbaceous	181.9	7.6%
Pasture/Hay	281.1	11.7%
Cultivated Crop	634.4	26.5%
Woody Wetlands	365.6	15.3%
Emergent Herbaceous Wetland	36.9	1.5%
Total	2386.5	100.0%

Local governments' master plans and zoning ordinances have great potential to positively or negatively impact water quality. Zoning ordinances affect land development in a region and have control over site design and access. Ordinances are used to regulate permitted uses of the land; for example, setting minimum/maximum lot sizes and setback requirements (from neighbors, roads, water bodies) or reducing residential street widths and lengths. Overall, zoning ordinances are enacted to protect the use of a property and ensure the public's safety, health, and welfare. How communities manage their land use has a direct impact on water resources. Since protecting water quality requires looking at what happens on land, zoning, master plans, subdivision and construction codes, and stand-alone ordinances can be extremely important watershed management tools. Benefits of zoning include: increased local control/autonomy over land use decision making; communicating clear expectations with developers based on community needs; and creating an opportunity for the residents to design the type of community in which they want to live—one that respects their unique cultural, historic, and natural resource values. Generally, local governments may enact zoning laws that are more stringent than the next highest-ranking form of government, but not less. In any case, all applicable State and Federal laws must be followed.

The primary tool to manage land use in the Tannery Creek watershed is zoning. As the watershed is almost entirely within the Bear Creek Township, Emmet County Zoning Ordinances apply because the county is Zoning Administrator for the Township. Bear Creek Township has an independent Master Plan; therefore amendments to the codes for the township are recommended through the Master plan. The township also reviews building permits within the township borders and makes recommendations to Emmet County on courses of action.

The Watershed Council developed a Local Ordinance Gaps analysis for Emmet County and local governing bodies within the county. This guide evaluate ordinances and development rules that affect water quality, highlighting areas that need improvement while offering recommendations and suggested actions to help local government officials understand and strengthen these areas. To view the full Emmet County Local Ordinance Gaps Analysis, please visit www.watershedcouncil.org.

WATER CHEMISTRY

The Watershed Council and the Tribe have monitored the water quality of Tannery Creek regularly since 2002. Although there has been some variability by year, season, and location in the watershed, water quality has remained relatively high. The Watershed Council has sampled consistently at two sites along the stream since 2007: Boyer Road (TC3) and a location near the mouth of the creek, just upstream of where the creek enters Little Traverse Bay (TC5). The SNRE team conducted extensive sampling in the summer 2012. The water quality parameters analyzed include conductivity, temperature, dissolved oxygen, pH, phosphorus, nitrogen, and total suspended solids. The study team chose these parameters because they offer a comprehensive view of water quality in the stream. The findings presented here should be regarded as a very general view of stream health due to the small number of data points.

Conductivity

Conductivity is a measure of a body of water's ability to pass an electrical current and increases with the amount of dissolved ions present.[47] Conductivity varies with natural geology, but research has shown that conductivity also serves as an appropriate surrogate indicator of overall water quality when human activities increase dissolved ion concentrations. These ions are frequently derived from salts or metals, which can enter a waterway due to human activity such as use of road salt and fertilizers. Chloride is one of the most common ions contributing to elevated conductivity and though it can be abundant in natural waters, it is also elevated by human activity. Conductivity provides a good indicator of groundwater inputs and upwellings (higher values than surface waters) and also shows a peak during the first flush of urban runoff events. The conductivity peaks during first flush are related to elevated loadings of inorganics and have been related to toxicity.[48]

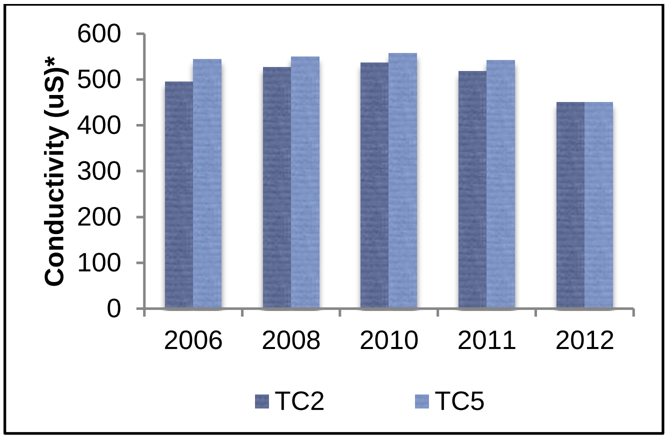


FIGURE 13: TANNERY CREEK AVERAGE CONDUCTIVITY: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
** uS = microsiemens; n = 21*

TABLE 11: CONDUCTIVITY FOR FIVE SAMPLING SITES: JUN-AUG. 2012

	TC1	TC2	TC3	TC4	TC5
Average	510.1	401.8	416.0	456.3	450.6
Min	389.9	283.0	293.4	349.0	356.3
Max	643.3	505.3	514.2	568.4	560.6

n=15

The average conductivity of Tannery Creek in 2012—averaged across sample sites—was between 401-510 microsiemens. The overall range for samples taken in 2012 was 283-634.3 microsiemens. Conductivity is almost always higher at TC5. Though there is no perfect comparison in the region, it is useful to look at nearby Bear River. The table below shows average conductivity for the Bear River from 2000-2008. The Bear River has significantly lower conductivity with averages between 300-400 microsiemens.

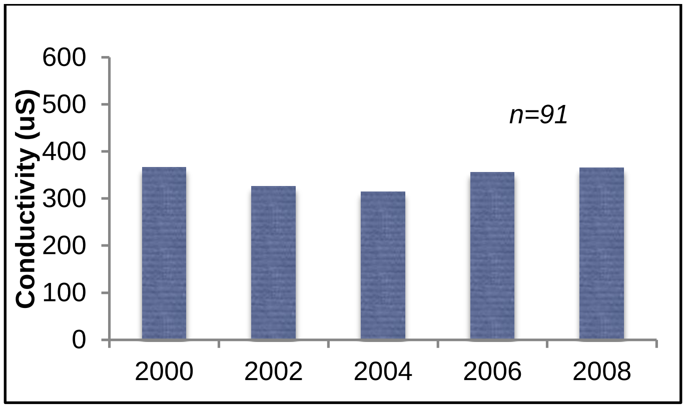


FIGURE 14: BEAR RIVER AVERAGE CONDUCTIVITY: 2000-2008
Averaged historical data gathered from the Watershed Council and LTTB.
uS = microsiemens

Temperature

Water temperature impacts physical, biological, and chemical characteristics of a freshwater aquatic system. Temperature affects the amount of oxygen that can be dissolved in the water, the rate of photosynthesis, the metabolic rate of aquatic organisms, and the sensitivity of organisms to toxic wastes, among other things.

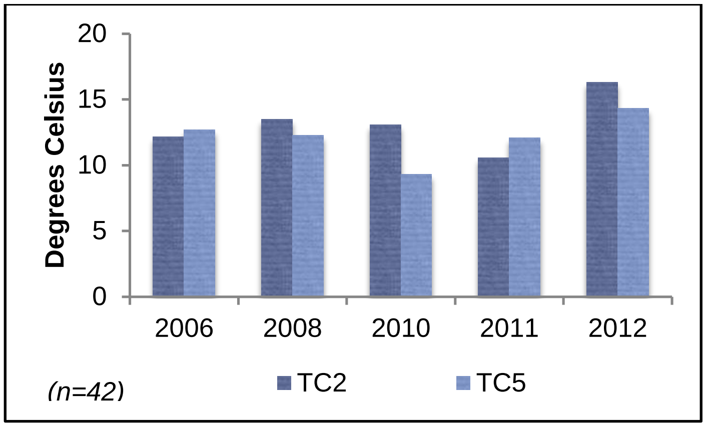


FIGURE 15: AVERAGE TEMPERATURE FOR TANNERY CREEK: 2006-2012
Data collected twice a year, spring and fall at two sites, every two years by the Watershed Council.

Thermal pollution is one reason that stream temperatures rise. Thermal pollution is the discharge of heated water from industrial operations, dams, or stormwater runoff from hot pavement or other impervious surfaces. Tannery Creek is designated a cold-water fishery that maintains a brook trout population as well as other sensitive organisms. Research by the US Fish and Wildlife Service shows that 11-16°C is best for growth and survival for cold-water fisheries.[49] Between 0-5°C and 16-19° C are tolerable but not ideal conditions for cold-water fish such as brook trout. Table 12 shows that temperature maximums observed during the study period.

TABLE 12: TEMPERATURE AT FIVE SITES: JUN-OCT 2012

	TC1	TC2	TC3	TC4	TC5
Average	12.71	13.42	14.13	13.58	13.26
Minimum	7.71	7.65	7.69	7.80	7.87
Maximum	16.00	16.32	18.70	18.30	17.60

The average temperature of the creek during the summer and early fall of 2012 was between 14° and 16° C; however, ore data are required to truly determine a trend. Given the limited data available it would appear that there has been a slight increase in temperature over time. This trend could be due to an increase in stormwater runoff, which can carry higher temperatures from streets and parking lots, or warmer than normal temperatures.[50] The lower half of the watershed has a considerable amount of impervious surface, which would contribute to runoff and therefore temperature changes.

Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen contained in water. It is essential for fish, aquatic macroinvertebrates, and other aquatic plants and organisms because it is critical to photosynthesis, mineral solubility, and decomposition of organic matter.[51] Oxygen is a by-product of photosynthesis, but also dissolves into water from the atmosphere. The amount of DO that water can hold varies with water temperature and cold water holds more oxygen than warm water;[52] however, in Michigan even at the warmest temperatures, DO will be greater than 8mg/L, and is never limiting due to temperature influence. Table 13 shows the solubility of oxygen given different temperatures. The summer maximum temperature in 2012 was around 18° C, which corresponds to 9.46mg/L oxygen at saturation. Different organisms require different amounts of oxygen depending on species and life stage. The State of Michigan DO standard states that "surface water designated as a cold water fishery must meet a minimum standard of 7 milligrams per liter. [53]

TABLE 13: SOLUBILITY OF OXYGEN IN WATER IN RELATION TO TEMPERATURE[54]

Temperature (°C)	Oxygen (mg/L)
0	14.6
5	12.8
10	11.3
15	10.1
18	9.5

DO concentrations in Tannery Creek have increased since 2006, except for in 2012. Average DO concentrations for Tannery Creek in 2012 were between 8.4mg/L and 12.9mg/L, which are above the State of Michigan DO standard. However, the stream is likely always at 100% saturation, and the variation found in measurements is due to sampling at different water temperatures. DO at site TC2 is slightly lower than the other sites. The reason for this is unclear and warrants close attention in the future.

TABLE 14: DISSOLVED OXYGEN AT SAMPLE SITES (FULL DATA RANGE): JUN-AUG. 2012

	TC1	TC2	TC3	TC4	TC5
Average	9.40	7.20	9.36	10.31	10.30
Minimum	8.84	6.77	8.40	9.45	9.75
Maximum	9.43	8.67	9.62	12.9	11.25

n=15

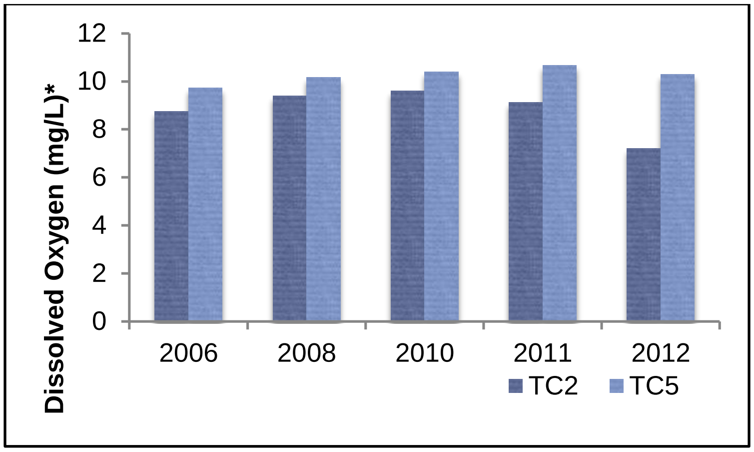


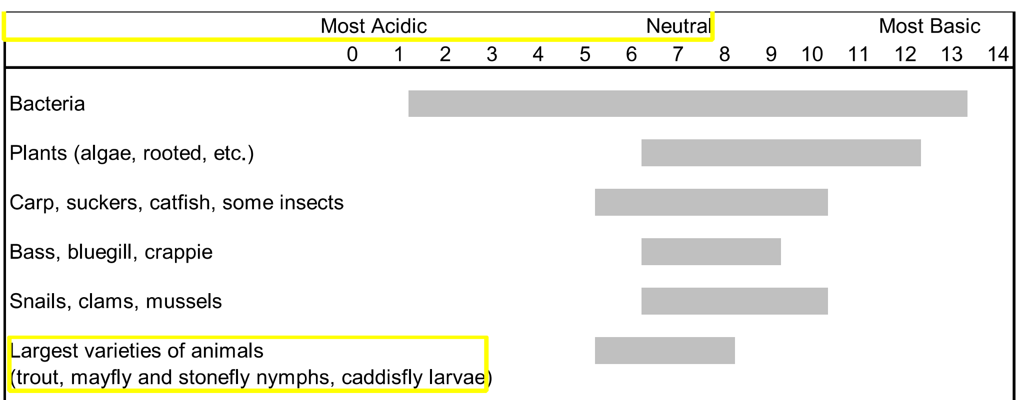
FIGURE 16: TANNERY CREEK AVERAGE DISSOLVED OXYGEN: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
**mg/L = micrograms per liter; n=26*

pH

pH measures the hydrogen ion activity in water and can influence the solubility of various substances. It also regulates biological processes in freshwater systems. pH is measured on a scale from 0 to 14, with 0-6 indicating acid, and 8-14 indicating base. Every one unit change in pH corresponds with a roughly ten-fold change in acidity or alkalinity. Pure water has a pH of 7 and is considered "neutral." Natural water has a pH between 6.5 and 8.5, which is optimal for most organisms. Rule 53 of the Michigan Water Quality Standards states that pH should be maintained within the range of 6.5 to 9.0 in all waters.

Rapidly growing algae and vegetation can remove carbon dioxide from the water, which can result in a significant increase in pH. While there are some natural variations in pH, many fluxes in pH are due to human influences, especially in the form of nonpoint source pollution. Acid rain, industrial wastes, agricultural runoff, and other activities all can cause fluctuations in pH.

The average pH of Tannery Creek in 2012 was between 7.48 and 8.04. These values are within the pH range considered optimal for most freshwater organisms. pH has remained relatively constant over the period of measurement from 2006 to the present.



Source: W. Stapp, and M. Mitchell. Field Manual for Low Cost Water Quality Monitoring, 11th Edition.

FIGURE 17: PH RANGES THAT SUPPORT FRESHWATER BIOLOGY

TABLE 15: PH LEVELS AT FIVE SITES, JUNE-AUG. 2012

Site	TC1	TC2	TC3	TC4	TC5
Average	8.0	7.5	7.7	7.8	7.8
Min	7.9	6.8	6.9	7.1	7.0
Max	8.2	8.0	8.1	8.2	8.4

n=15

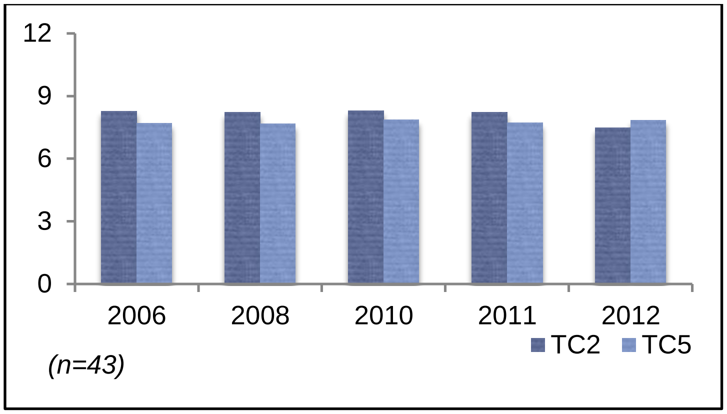


FIGURE 18: TANNERY CREEK AVERAGE PH LEVELS: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
n = 43

Phosphorus

Phosphorus is an essential nutrient required for plant growth and metabolic reactions in plants and animals. Phosphorus is typically the limiting nutrient in freshwater systems, meaning once all phosphorus has been used plant growth will cease regardless of how much nitrogen is available. As a result, too much phosphorus can lead to eutrophication and algal blooms. The State of Michigan does not have a numeric standard for phosphorus, but rather a narrative standard that applies to all nutrients. This standard states that "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state."[55] However a numeric standard can be found in the EPA Northern Michigan Ecoregion Nutrient Recommendations for Rivers and Streams, which suggests an average of 10 micrograms/liter.[56]

Phosphorus enters aquatic systems from point and nonpoint sources. Wastewater treatment plans are the primary point sources of phosphorus. Sources of the nutrients in wastewater include commercial products such as toothpaste, detergents, and pharmaceuticals.

Nonpoint source pollution is pollution from diffuse sources, such as agricultural runoff. Nonpoint sources of phosphorus include natural, human, and animal sources. Natural sources include phosphate rich deposits and rocks, which releases phosphorus during weathering and erosion. For non-natural sources, eroded sediments from mining and agricultural areas carry phosphorus-containing soil to surface waters, a process that can be exacerbated by precipitation and storm events. Inefficient and failing septic systems and septic leakage can also introduce phosphorus to the system. Agricultural erosion and faulty piping are the most likely sources to impact Tannery Creek. There is some agriculture adjacent to the creek. There is also a golf course near the creek, which is another likely contributor. Additionally there is more piping infrastructure, including sewer lines and stormwater drainage pipes, in the lower half of the watershed, all of which could impact the creek's phosphorus level.

Site averages of Total phosphorus concentrations for Tannery Creek in 2012 ranged from 4.1 ug/L to 16.7ug/L (Table 16 below). Total phosphorus has fluctuated somewhat within a narrow range in the last six years. This could be related to yearly differences in rainfall patterns, weather preceding the sampling event, or seasonal differences from year to year. Overall the phosphorus values are relatively low. Average total phosphorus values for the nearby Bear River are displayed in Figure 20 below. The Bear River values are in the same range as Tannery Creek.

TABLE 16: TOTAL PHOSPHORUS AT FIVE SITES: JUN-OCT. 2012

	TC1	TC2	TC3	TC4	TC5
Average	16.7	5.1	4.1	8.2	7.1
Minimum	2.9	1.0	1.0	2.3	2.2
Maximum	29.2	8.3	7.2	15.3	13.4

n=25. All values are in micrograms per liter.

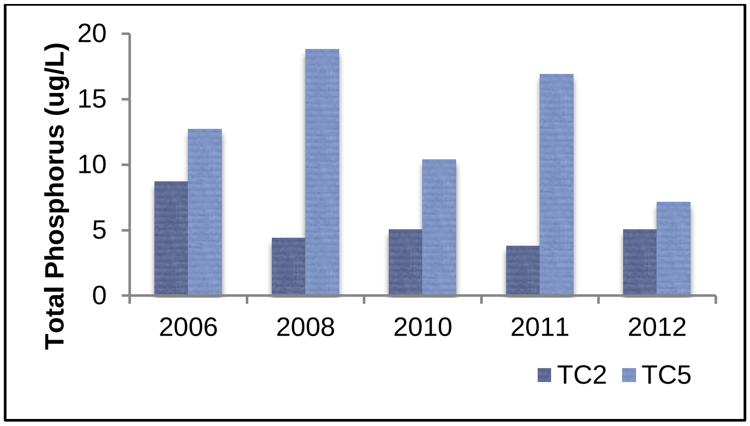


FIGURE 19: TANNERY CREEK AVERAGE TOTAL PHOSPHORUS LEVELS: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
** ug/L = micrograms per liter; n=42; one data point omitted due to measure error*

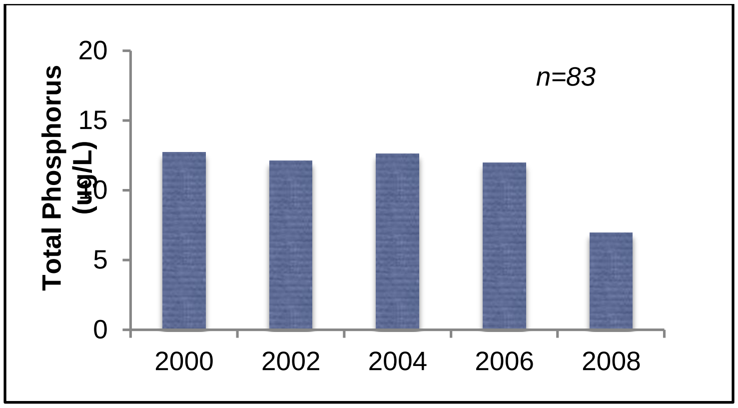


FIGURE 20: BEAR RIVER AVERAGE TOTAL PHOSPHORUS: 2000-2008
Averaged historical data gathered from the Watershed Council and LTTB.

Nitrogen

Nitrogen is a component of all plant and animal matter that is abundant in most lakes and streams and is required for plant and algae growth. Nitrogen levels are important for determining whether the system is nitrogen limited relative to phosphorus; however it is rarely a limiting agent in streams in the region. Similar to phosphorus, no statewide numeric standard exists for nitrogen. The same narrative nutrient standard stated above applies to nitrogen. The EPA Northern Michigan ecoregion recommendations also suggest a standard for nitrogen of 0.38 milligrams per liter.[57]

Since 2006 there appears to have been an overall decrease in nitrogen. Average total nitrogen concentrations for Tannery Creek in 2012 were between 0.73 and 0.86 mg/L. These readings are somewhat high for the region, particularly as compared to the EPA ecoregion standard and could be tied to fertilizer use. The Bear River total nitrogen average is 0.47mg/L from 2008. This is markedly lower than the Tannery Creek values.

TABLE 17: TOTAL NITROGEN AT FIVE SITES: JUN–OCT 2012

	TC1	TC2	TC3	TC4	TC5
Average	0.86	0.78	0.73	0.74	0.81
Minimum	0.48	0.56	0.53	0.48	0.53
Maximum	1.44	1.13	1.03	1.10	1.21

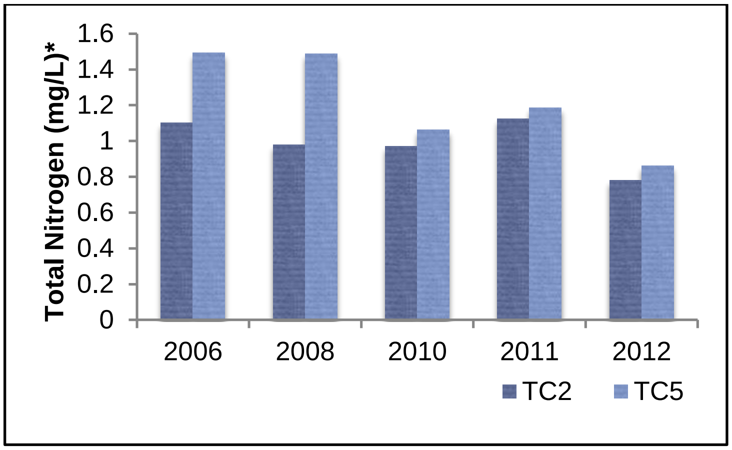


FIGURE 21: TANNERY CREEK TOTAL NITROGEN: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
**mg/L = milligrams per liter; n=42*

Total Suspended Solids (TSS)

Turbidity is a measure of the relative clarity of water and is the result of suspended solids and dissolved solids in the water that reduce the transmission of light. Total Dissolved Solids includes anything present in water other than the water molecule and dissolved constituents such as minerals, salts, metals, cations, or anions dissolved in water. TSS measures all particles suspended in water that will not pass through a fine filter (typically 0.45 um). Suspended solids range from clay, silt, and plankton to industrial wastes and sewage. Mineral formation such as calcite can also cloud a stream. Suspended solids can block fish gills, reduce growth rates, and result in habitat loss. Suspended solids can increase water temperature because the particles can absorb energy from sunlight. This in turn can reduce DO levels.[58] It is important to note TSS concentrations vary considerably with stream discharge. The impact of storm events should be taken into consideration when identifying long term suspended solids trends.

Michigan Water Quality Standards identify water with TSS levels less than 20mg/L as clear, water with levels between 40 and 80 mg/L as cloudy, and water with levels above 150mg/L water as dirty.

TSS levels in Tannery Creek have been fairly constant with the exception of 2006 and 2008. These data are skewed due to collection occurring after significant storm events. The average TSS level for Tannery Creek in 2012 was between 3.63 and 12.33mg/L. The Bear River has similar averages to Tannery Creek, with a range of 3.5-11mg/L.

TABLE 18: TOTAL SUSPENDED SOLIDS FOR FIVE SITES: JUN-OCT. 2012

	TC1	TC2	TC3	TC4	TC5
Average	6.95	4.63	3.62	8.18	3.20
Minimum	2.00	1.20	1.20	3.00	2.00
Maximum	17.00	25.00	9.00	23.00	30.00

n= 25. All values are in milligrams per liter.

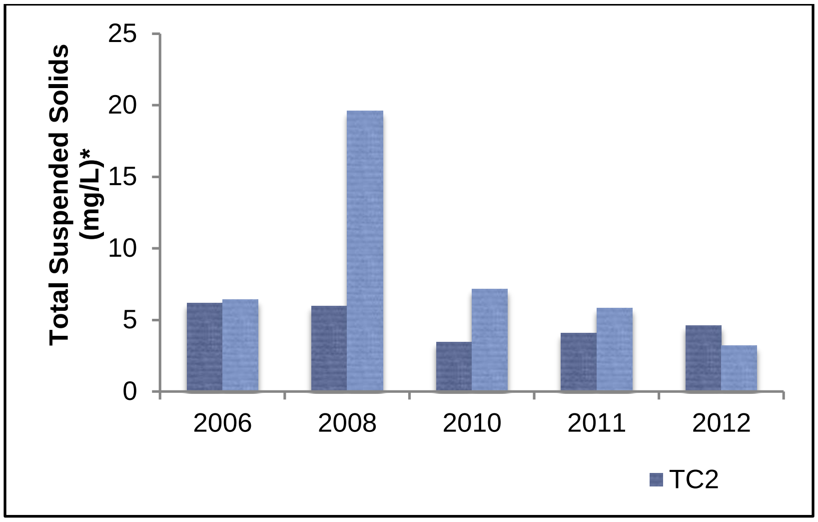


FIGURE 22: TANNERY CREEK TOTAL SUSPENDED SOLIDS: 2006-2012
Averaged historical data gathered from the Watershed Council and LTTB.
**mg/L= milligrams per liter; n=40; several values omitted because they were taken after extreme storm events and misleadingly skewed the data.*

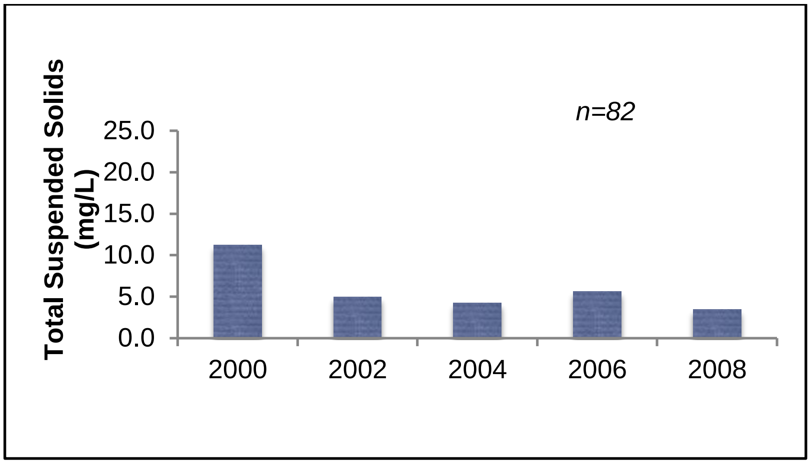


FIGURE 23: BEAR RIVER TOTAL SUSPENDED SOLIDS: 2000-2008
Averaged historical data gathered from the Watershed Council and LTTB.

Benthic Macroinvertebrates

Benthic macroinvertebrates are aquatic insects and other organisms living on a creek bed, on a lake bottom, or in association with vegetation, wood, or other debris found in aquatic environments. The life cycles of invertebrates vary, but typically last one to two years. They are a primary food source for fish. The macroinvertebrate community is made up of functional feeding groups, which represent a range of differing feeding habitats. Absences of one of these groups or excessive abundance of one type could indicate deviation from good water quality. Certain species are able to respond fairly quickly to changing environmental conditions; however, the composition of the overall benthic community may take several years to change.

Benthic macroinvertebrate monitoring is widely used as a tool to assess water quality because of several advantages associated with invertebrate populations.[59] Namely, they are sedentary, abundant in smaller order streams, easy to identify to taxonomic order using the naked eye, and relatively easy for volunteers to identify using taxonomic keys. Also, some have specialized gill structures that are sensitive to nonpoint source pollution and altered hydrology, making them useful indicators of water quality.

A number of biotic indices can be used to evaluate water quality with benthic macroinvertebrates. Total number of taxa and percent composition of Ephemeroptera/mayflies, Plecoptera/stoneflies and Trichoptera/caddisflies (EPT) taxa are both widely used metrics and require identification to the family level. Total number of taxa is a measure of the diversity within the macroinvertebrate community at each site; it refers to total number of families found. In general, higher diversity indicates higher water quality. Using percent composition of EPT families is a good way to assess a number of water quality indicators because most EPT families are sensitive to changes in stream flow (hydrology), temperature, dissolved oxygen, and substrate.[60] Many macroinvertebrate populations, not just those of the EPT families, can also be negatively affected by nonpoint sources of pollution.

The Watershed Council has collected biological data at two sites, TC3 and TC5, since 2007. Table 19 indicates that the Boyer Rd site consistently has higher diversity of taxa. This suggests that this site also has higher water quality, more diverse and better habitat, or both. Table 19 shows the relationships between water quality at the two sample sites during different times of the year. In general, macroinvertebrate collections are most diverse during the late winter and early spring months. Sampling during the summer will not typically yield results similar to those found in the spring and fall because many taxa are present only as eggs or very small larval forms.

TABLE 19: TOTAL TAXA AT TC3 AND TC5, TANNERY CREEK.

	Total Taxa		EPT Taxa	
Date	**TC3**	**TC5**	**TC3**	**TC5**
22-Sep-07	21	8	8	3
17-May-08	24	11	9	3
20-Sep-08	15	7	7	2
16-May-09	12	15	8	5
22-May-10	15	11	7	3
18-Sep-10	24	17	9	4

Family level identification was performed and accounts for the total number of taxa. Sample collection performed by volunteers from the Watershed Council.

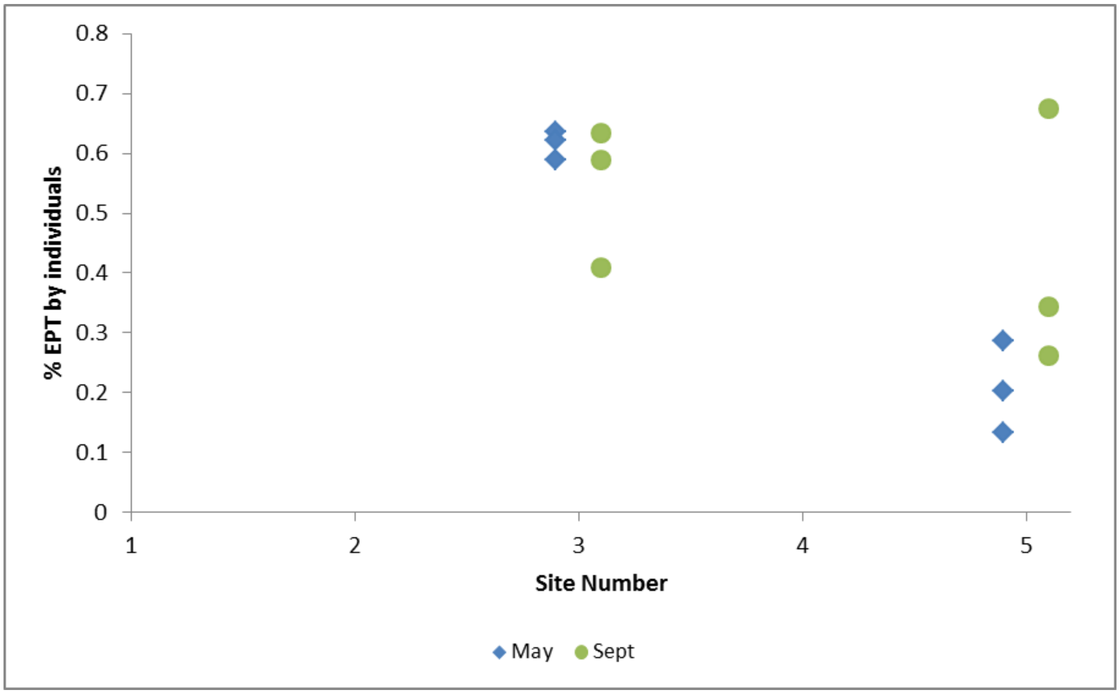


FIGURE 24: PERCENT EPT AT TC3 AND TC5

Samples taken twice per year, May and September, by Watershed Council volunteers and staff.

For previous sampling efforts, the Watershed Council used the Hilsenhoff Family Biotic Index, which rates the water quality of a stream based on macroinvertebrate sensitivity. It is specifically calibrated to the Midwest region and weights non-sensitive organisms more heavily so the resulting family-biotic index score will be higher and indicate poorer quality when more pollution tolerant organisms are present in a sample.

Table 20 outlines the scoring criteria used to determine water quality using the Hilsenhoff Method. Figure 25 depicts the scores for TC3 and TC5 and indicates their water quality status. TC3 achieved a score of excellent based both on May and September samples, indicating that organic pollution is very low at this site. TC5 achieved an excellent score for its September monitoring but not for the May sample dates. A score of 'good' indicates that, at this time of the year, the creek experiences some organic pollution at TC5.

TABLE 20: HILSENHOFF FAMILY-LEVEL BIOTIC INDEX FOR EVALUATING WATER QUALITY

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very Good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly Poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very Poor	Severe organic pollution likely

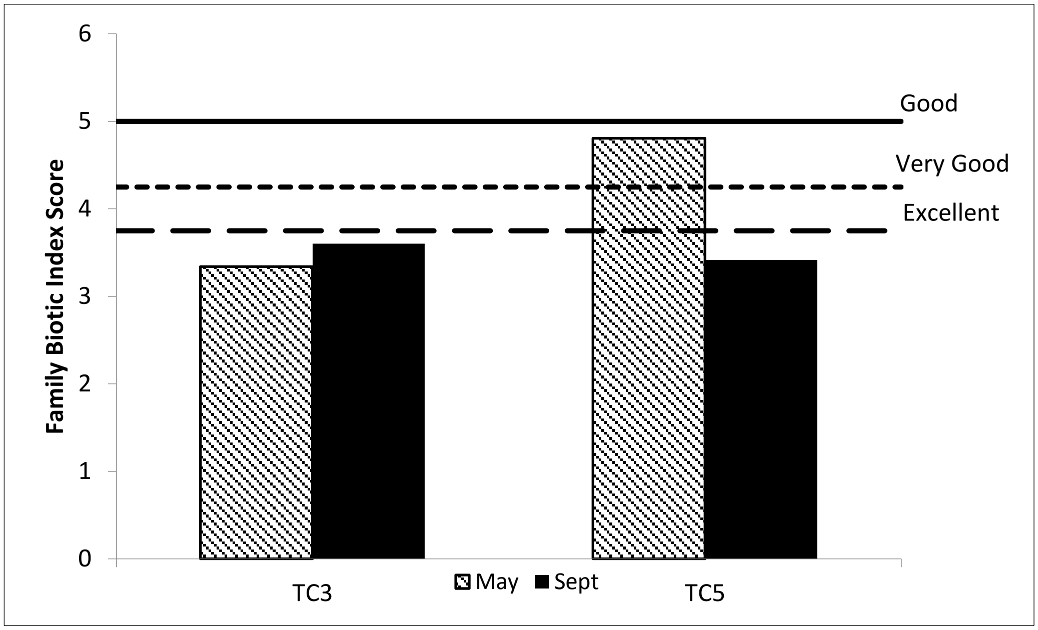


FIGURE 25: AVERAGE FAMILY-LEVEL BIOTIC INDEX SCORES FOR TC3 AND TC5
Scores for each site and month were averaged across three years (n=3 for each column). All indicate excellent water quality except for the Glens May score, which averages a score of good. Lower scores indicate higher water quality. See Appendix C for raw data.

Another classification system based on order level identification and used by the Michigan Clean Water Corps (MiCORPS), a group that fosters volunteer monitoring efforts. To determine whether biotic metrics for Tannery Creek are typical for the region, two similarly sized streams located near Tannery Creek were compared using the percent EPT by individual counts. The authors chose Mullett Creek and Stover Creek for comparison because their geographic location, stream and watershed size, land use patterns, and overall conditions are similar to Tannery Creek. Geographic location is important because the soils and topography of a region can affect water chemistry and the way a stream flows through the landscape. Both Mullett and Stover Creeks are roughly as long as Tannery Creek, approximately 1.71 miles. According to the Watershed Council's Volunteer Monitoring Report,[61] Mullett Creek received a grade of A-, Stover Creek a C, and Tannery Creek a C. Additional details on the MiCORPS method can be found in Appendix D

Figures 26 and 27 show the percent EPT composition of Tannery Creek is nearly the same as the comparison streams, which suggests these streams have similar water quality. Based on this analysis, it would be expected that the quality of Tannery Creek would be slightly less than that of Mullett but slightly greater than that of Stover. These figures indicate that the water quality of Tannery Creek is close to what is expected for streams in the area.

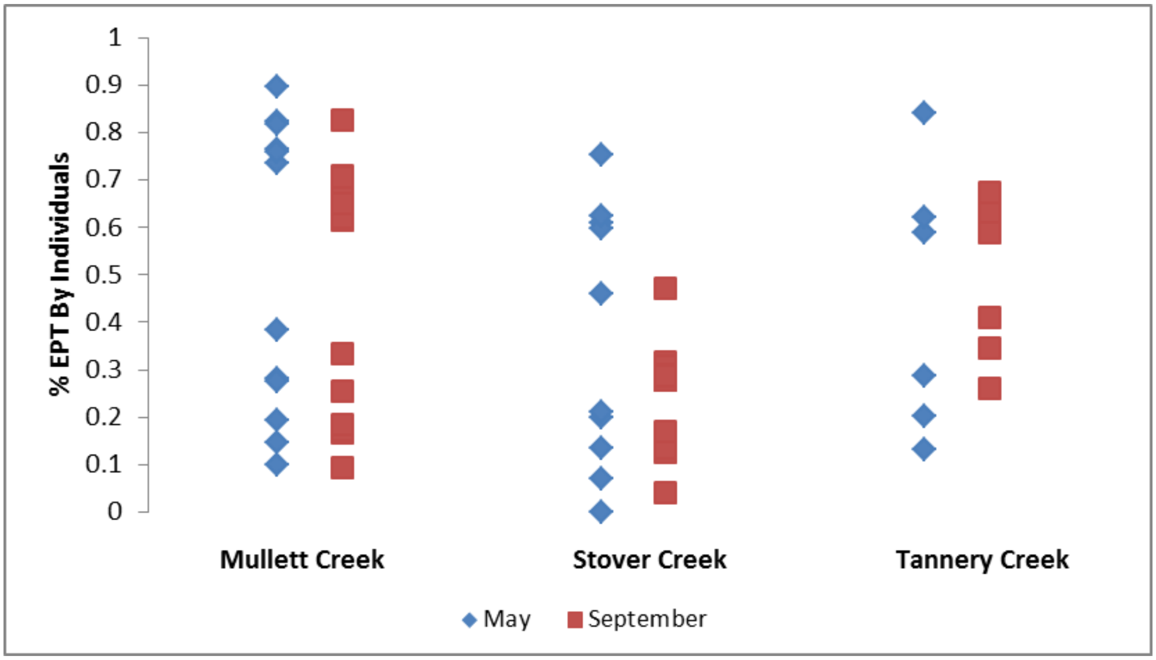


FIGURE 26: PERCENT EPT FOR COMPARISON CREEKS; MULLETT AND STOVER
Data collected by Tip of the Mitt Watershed Council between 2007-2011.

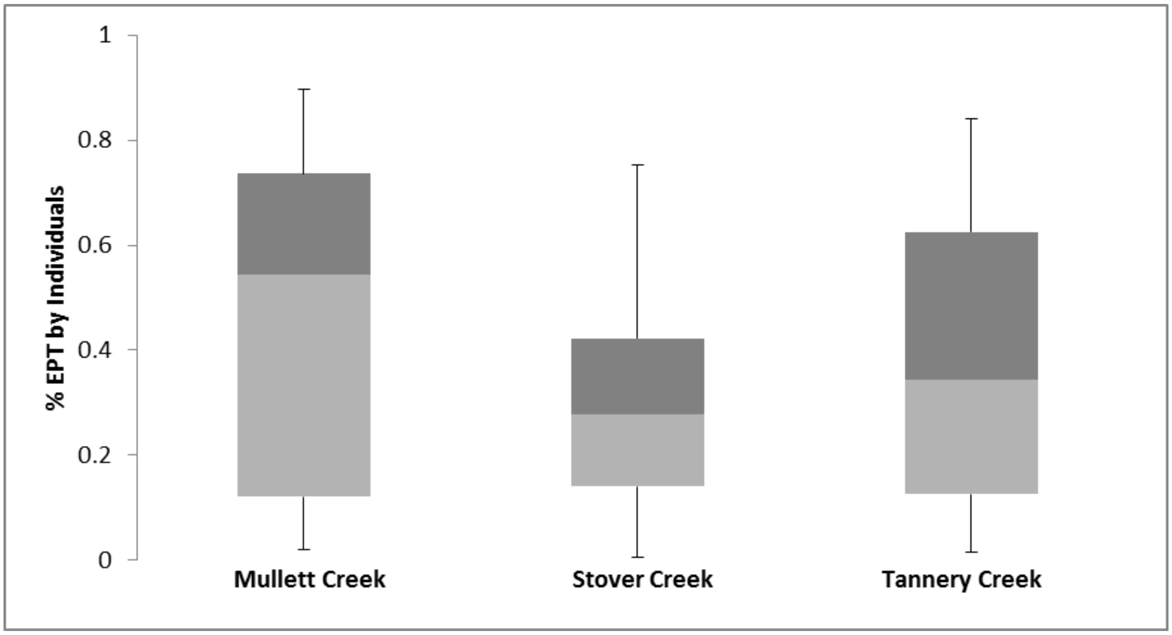


FIGURE 27: PERCENT EPT FOR COMPARISON CREEKS (MIN/LOWER QUARTILE/AVG/UPPER QUARTILE/MAX)

RIPARIAN CONDITIONS

Road–Stream Crossings

At locations where roads cross over streams, road–surface runoff from rainstorms or snowmelt washes sediments and pollutants associated with vehicles into the waterway. Increased sedimentation degrades habitat, reduces fish cover, changes stream velocity, and alters water temperatures.[62] Roads also result in changes to the natural stream hydrology as new surface paths are formed and cause surface runoff to wash directly into the stream.[63] Increased surface runoff results in greater peak discharges, which scour the stream channel, destroy habitat, and displace or expose smaller aquatic organisms. Furthermore, culverts, commonly installed to route streams under roads, have been shown to reduce trout standing stocks.[64]

The Watershed Council completed a road–stream crossing inventory of Tannery Creek in 2002 as part of LTB Plan development. The SNRE team recommends that an updated inventory be completed as part of TC Plan implementation. The purpose of the initial inventory was to identify all road–stream crossings on the stream and assess potential impacts and problems. The study focuses on seven sites; however, this list is neither complete nor exhaustive, as there are other smaller crossings within the watershed. Data collected at each site includes information about location, road characteristics (width, shoulder, drainage, surface), culvert condition, and erosion and runoff problems. The inventory also includes basic stream characteristics such as depth, width, and substrate. The inventory identifies all surveyed road–stream crossings as moderately impacted and provides a series of treatments and recommendations with costs estimated by the Watershed Council for each project.

TABLE 21: TANNERY CREEK ROAD-STREAM CROSSING SURVEY RECOMMENDATIONS: 2002

Site	Recommendations	Estimated Cost
E. Mitchell Rd.	Need to control runoff from road through use of diversion culverts	$ unknown
Boyer Rd.	Re-vegetate roadside bank, control erosion from the road and along ditches.	$2,000
Surrey Lane	Re-vegetate at culvert inlet and outlet; Lengthen and re-position culvert.	$5,000
Country Club Rd.	No action needed	None
US 131	Install larger culvert	$ unknown
Chase Bank Driveway	Install larger culvert	$6,500
Behind Glen's	Outlet needs to be revegetated; fencing to keep people from trampling the embankment would be useful to prevent further erosion. Management of invasive species is necessary to keep them out of upper watershed.	$10,500

Since the inventory was completed in 2002 a number of improvements have been made or proposed for Tannery Creek. First, the Road Commission replaced the culvert at the Mitchell Rd. crossing. Next, the recommended re-vegetation for the Boyer Road site was completed by Watershed Council volunteers. Lastly, a clean span bridge was proposed as an alternative to the culvert at the Little Traverse Wheelway. The Watershed Council is currently facilitating completion of this project, which is expected to cost approximately $200,000.

Instream and Riparian Conditions

The Watershed Council previously monitored two sites for chemical and biological water quality parameters. As described above, the SNRE study team chose three additional sites to capture natural variation within the watershed and to provide a more complete picture of what is happening within the catchment. In choosing new sites, the SNRE study team and the Watershed Council focused on road–stream crossings because of their accessibility and also because they are typically more heavily impacted by human activity than unimpeded areas. The headwaters sample site represents a pristine site, while sample sites and road/stream crossings further downstream represent more impacted sites, with TC5 representing the most impacted site.

Initial site assessments took place on June 9-10, 2012, following a large storm event. These assessments were performed during high flow conditions. The headwaters site was also surveyed following a rain event on one occasion, October 16, 2012.

The study team used the EPA rapid bioassessment protocols to conduct in-stream and riparian habitat evaluations and collected the following data at each site:[65] (See Appendix F for example data sheet.)

Physical Characterization: weather conditions, stream characterization, watershed features, riparian vegetation (18 meter buffer), in-stream features, large woody debris, aquatic vegetation, water quality, sediment/substrate, inorganic substrate components, organic substrate components

Habitat Assessment in Sampling Reach: epifaunal substrate/available cover, pool substrate characterization, pool variability, sediment deposition, channel flow status

Habitat Assessment Beyond Sampling Reach: channel alteration, channel sinuosity, bank stability (left and right bank), vegetative protection (left and right bank), riparian vegetative zone width (left and right bank riparian zone)

It is important to note that assessment scores can be brought down from the optimal to suboptimal range due to the absence or degraded quality of just a few characteristics. For example, a site with little to no available cover could lose ten points up front, automatically bringing its in-reach score down to suboptimal. When averaged with beyond reach characteristics, however, the site may still score optimal.

TCHW-TC5 Riparian Descriptions and Assessments (See Figure 3 on page 8 above for site map)

The Headwaters SITE (TCHW): Maplewood Drive just north of Atkins Rd.

This is the most upstream site sampled during the study period. The property was previously owned by a logging company and was logged twice. It has been in possession of the current owner's family for approximately 30 years, and the owners allowed the property to succeed back to a typical northern Michigan hardwood forest. The family uses the property for vacationing and has left it, for the most part, untouched.

This area is considered the headwaters of the stream. The stream here appears from groundwater seeps and runs through a wet, marshy area before forming into Tannery Creek. The banks and bed appear to be in very good condition upon initial assessment. There is little erosion present on the banks and in the channel and the streambed is varied in habitat type, i.e. riffles, pools, and runs. The amount of sand present in the stream here is low, which is indicative of good fish spawning habitat and low erosion in the surround land area. Substrate consisted of 20% woody debris, 50% rock and gravel, and 30% sand. Vegetation on the banks consisted mostly of cedar trees, other native hardwoods, native perennials such as milkweed, and other common wetland vegetation. The study team also observed two small brook trout during a site visit.

Initial Assessment:
In-stream habitat score: 80 – Optimal
Riparian habitat score: 98 – Optimal

SITE TC2: Mitchell Rd at mainstem crossing (downstream of culvert)

The Mitchell Road site is located just downstream of the Mitchell Road/Tannery Creek road–stream crossing. The stream comes through a cylindrical metal culvert as it crosses under the road. This culvert was replaced two year before this plan was written; however, there are still some lingering issues resulting from the previously existing undersized culvert. The poor design of the old culvert allowed for scouring of the substrate beneath it and the formation of a plunge pool. Plunge pools are habitats of low oxygen and low biological quality. This is not ideal, but is very typical of road–stream crossing culverts. The hope is that the installation of the new culvert will allow this problem to heal itself naturally over time.

There is also a concern here regarding thermal pollution. There is not much overhead cover at this site from mid-size and overstory trees or other riparian vegetation, which means increasing temperatures during warm summer months could cause the stream to warm, possibly past the tolerance level for brook trout. This is likely the result of a broad floodplain and riparian wetlands in the area. Temperature should be monitored closely at this site as well as dissolved oxygen. Monitoring conducted by the study team showed these two parameters to be higher than other sites.

The habitat at this site is categorized as suboptimal. There is good presence of aquatic vegetation and the stream banks appear stable. There is sufficient vegetation in place to keep banks from eroding. Woody debris is lacking, likely due to the lack of trees along the banks. A monoculture of the invasive grass *phalaris* may contribute to lack of tree cover in this area. The stream bottom consists of pebbles, possibly from the road above, and some sand and silt, which could be indicative of erosion within the watershed above this site. A high diversity of macroinvertebrate fauna was found here, which indicates good water quality.

Initial Assessment:
In-stream habitat score: 64 – Suboptimal
Riparian habitat score: 95 – Optimal

SITE TC3: Boyer Rd at mainstem crossing (upstream of culvert)

The Boyer Road site is just upstream of the Boyer/Tannery road crossing. The creek follows the road for approximately 35-40 feet before going through the culvert. There is concern here that such lengthy exposure to the roadside has adverse effects on creek water quality. Biannual macroinvertebrate sampling has not supported this, nor does this habitat assessment. There also does not appear to be any siltation of the stream due to its position next to the road. This site should continue to be monitored closely into the future.

The creek here is downhill of a single family home, approximately 50 feet away, which could possibly result in nutrient inputs to the creek from fertilization applications on the lawn or salt from the driveway, which is directly next to the creek at the bottom of the hill. A number of other homes are slated to be built in the Horizon Heights subdivision, located behind the existing riparian's home, as the economy recovers. There is, however, a good vegetative buffer 6-8 feet wide, consisting of small shrubs and young trees, between the creek and the owner's manicured yard. This buffer should not only prevent fertilizer from getting into the stream, but also provides adequate shading. On the road's side of the stream bank there are bank stabilization efforts occurring in the form of re-vegetation. This means there have been past erosion problems here that are being corrected.

Macroinvertebrate fauna were diverse when sampled by the study team. Highly varied habitat (including submerged vegetation, undercut banks, and woody debris) and stream bottom type, along with high water quality, indicate that this should be the case.

Initial Assessment:
In-stream habitat score: 73 – Suboptimal
Riparian habitat score: 71 – Suboptimal

The West Tributary SITE TC1: Mitchell Rd crossing at Southwest Tributary (upstream of culvert)

This site was not previously sampled =by the Watershed Council or the Tribe. This point drains the extensive wetlands in the southwestern portion of the watershed where the primary land use is residential. Development of this area into single-family homes is likely following an economic upturn.

From here, the stream winds through a heavily forested area before emerging into an open marshy area covered predominantly by reed canary grass. It is narrow, less than two meters across. It is also the deepest of the sites sampled. The substrate is mucky, predominantly silts and clays with little to no cobble. The survey revealed bank undercutting on both banks, which measured as much as one meter in some places. The study also indicated an absence of riffle, run, and pool sequences but the stream does not appear to have been altered or channelized in any way.

This site has some woody debris present that could be used as cover by fish. One small trout fry was caught during macroinvertebrate sampling. The macroinvertebrate sample was dominated by order Amphipoda, but others were observed, including Odonata (rare), Hemiptera (common), Coleoptera (rare), Ephemeroptera (rare), and Trichoptera (rare). These are typically regarded as pollution tolerant species, which could indicate some sources of organic pollution in the headwaters of this sub-watershed. This is supported by water chemistry data collected at the site showing it had consistently higher levels of phosphorus than others further downstream. It should also be noted that this assemblage could be naturally occurring due to lack of quality macroinvertebrate habitat here. Potential sources of nonpoint source pollution include agricultural lands upstream, residential areas, and runoff from the road.

Initial Assessment:
In-stream habitat score: 71 – Suboptimal
Riparian habitat score: 85 – Optimal

SITE TC4: Country Club Drive at mainstem crossing (downstream of culvert)

This site is located just downstream of the Country Club/Tannery Creek road–stream crossing. The situation here is similar to that at Mitchell Road, in that a plunge pool occurs just downstream of the culvert, though this pool is larger and deeper. The slope of the stream here is greater than at Mitchell Rd., which is the likely factor causing the deeper scour and larger pool formation. This is likely a result of an undersized and poorly designed culvert, which should be corrected in the future.

Stream habitat here is otherwise of an acceptable condition. The stream bottom consists of boulders, pebbles, and some sand and silt. Higher stream velocities and gradients here expose these heavier substrate types and carry small sands and silts downstream to flatter areas where they then deposit out. There is good shading from trees here, which have also provided adequate woody debris for the use of fish and invertebrates. The macroinvertebrate community was highly varied and consistent with good habitat and high water quality. Stream banks are stabilized by well-established hardwood vegetation. There is some concern about the volume and velocity of water moving through the stream during high flow conditions here due to the presence of exposed tree roots on the banks.

Initial Assessment:
In-stream habitat score: 61 – Suboptimal
Riparian habitat score: 88 – Optimal

SITE TC5: Little Traverse Wheelway (upstream of Wheelway culvert/directly downstream of Glen's parking lot)

Similar to TC3, this site has been monitored by the Watershed Council since 2007. This site is by far the most impacted, as it is downstream of a large commercial area with extensive impervious surface area from parking lots, roads, and buildings. Streambanks are obviously impacted by occasional high flows. There are exposed roots and they are void of perennial vegetation. This may be the result of large amounts of impervious surfaces and watershed development directly upstream of the sample site. The creek bottom is composed mainly of sand, which is typical of streams in the region. The underlying geological makeup of the area is glacial outwash and dune sand, which supports this finding. There is also a trash issue here and remnant debris from the old tannery including a concrete channel bottom, sluiceway, and pipes. Historically, this portion of the stream was modified and partially channelized for use by the tannery.

Woody debris and larger pebble and cobble substrate provide some habitat for macroinvertebrates, but overall the low aquatic macroinvertebrate diversity documented by volunteers and the study team suggests poorer in-stream habitat than at other stream sites.

Further upstream from this site there are noticeable issues. Just north of the Glen's parking lot, there is a large area infested with Japanese knotweed, an invasive shrub. The knotweed is right on the banks of the river and is providing far fewer benefits to the stream than that a traditional riparian area consisting of native vegetation would provide (i.e. nutrients, habitat diversity). Also, after the creek flows under US-31 and around Chase Bank, the riparian buffer is non-existent. The landscaping practices here include mowing up to the creeks edge, which does not provide for any shade or buffer from harmful chemical elements.

The figure below compares the samples sites to each other in terms of overall habitat scores. The graph shows separate bars for instream and riparian habitat, each with a maximum score of 100. Overall, any one individual site can receive up to 200 points total. The horizontal lines indicate habitat quality, as described by the EPA Rapid Bioassessment Protocols for stream habitat characterization. The results show that upstream sites are of a better quality than downstream sites, especially the Glen's site.

Initial Assessment:
In-stream habitat score: 52 – Suboptimal
Riparian habitat score: 71 – Suboptimal

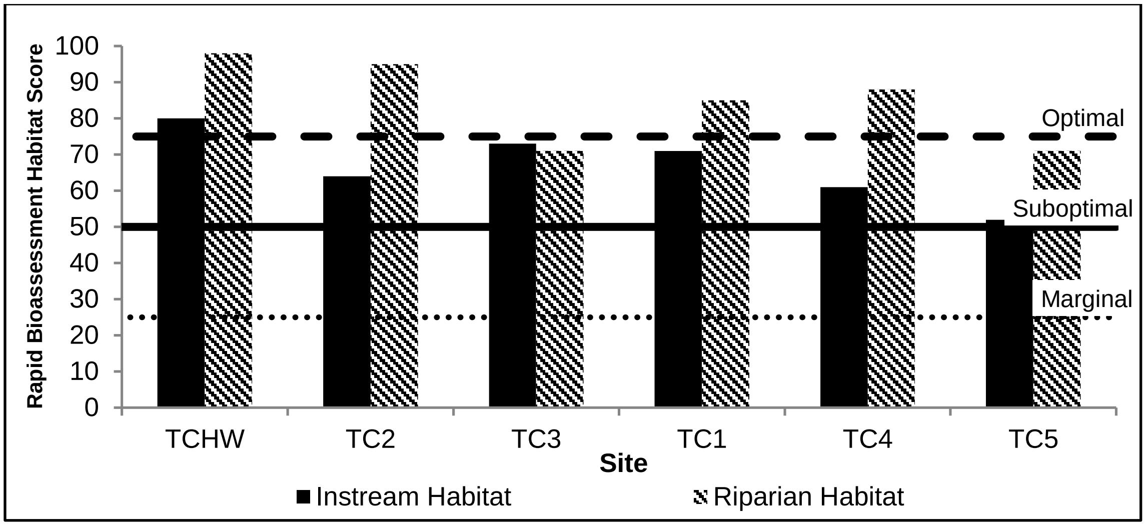


FIGURE 28: RAPID BIOASSESSMENT HABITAT SCORES

Rapid bioassessment habitat scores (maximum = 100 per bar or 200 per pair) for six sites on Tannery Creek, Petoskey, MI. Sites are named from upstream to downstream with the exception of Tributary. This site is the West Tributary to Tannery Creek. Data were collected in June, with the exception of the Maplewood site, which was collected in October of 2012. EPA Rapid Bioassessment Protocols were followed. Higher scores indicate more desirable and/or pristine habitat conditions (i.e. above 80 individual or 160 total points earns an optimal categorization).*

CHAPTER 3: WATERSHED ANALYSIS

The SNRE planning team employed land use planning and watershed analysis tools and scientific-based frameworks to provide information useful for making comparisons across Tannery Creek's sub-watersheds. These planning tools, when combined with other observations, are powerful aids for visualizing where the causes of pollutants in the watershed occur and could potentially occur, determining what management methods should be employed to address these issues, and selecting which areas should be protected (e.g. wetlands, steep slopes, groundwater recharge areas) to minimize future pollution. The two primary tools utilized are the Impervious Cover Model and the L-THIA model. The Impervious Cover Model is a conceptual framework that classifies levels of stream degradation according to percent impervious surface coverage. The L-THIA model is a computer-based program that uses the Soil Conservation Service (SCS) curve number (CN) method to provide estimates of runoff, recharge, and nonpoint pollution for a particular area. The results of the models were combined with other factors—resource inventories, GIS layering, field reports, etc.—to aid in the identification of critical areas for pollution mitigation and priority areas for protection within the watershed. This chapter details the results of the watershed analysis and makes recommendations for priority restoration and protection areas.

THE IMPERVIOUS COVER MODEL

The effects of agricultural and urban land use on surface waters are well documented. For many years, impervious surfaces have been considered an indicator of the intensity of urban development.[66] Increasing urbanization has led to increased amount of impervious surfaces and decreases in natural surfaces—forests, wetlands, and other open space areas that filter and slow precipitation runoff. Impervious surfaces prevent precipitation from infiltrating into the ground, instead funneling water along the surface directly into rivers and streams. Unnaturally high volumes of surface runoff can alter the hydrological balance of watershed, leading to scouring and eroding stream channels and generally degraded stream systems.

As such, impervious surface coverage in a watershed have become a powerful indicator of stream health and are often used by planners to project impacts future developments will have on watershed systems. Land use planners use density categories based in zoning restrictions—allowable lot coverage, road standards, and parking lot requirements—to conduct "build-out" analyses. These analyses are used to estimate impervious surface cover ratios, i.e. the amount of a watershed covered in impervious surfaces relative to the total watershed. With this information, planners can better prepare for growth by directing expansion to less impactful areas, limiting impervious surfaces through promotion and inclusion of LID methods, such as rain gardens and bio-sales, and adjusting the zoning ordinance to adhere with Better Site Design principles, as proposed by the Center for Watershed Protection's Better Site Design Manual.[67]

Research compiled by the Chesapeake Stormwater Network in consortium with the Center for Watershed Protection indicates that as impervious surfaces increase in a watershed natural stream elements are lost at certain intervals. While every watershed is unique, generally when a watershed nears the 10% threshold, the impacts of increases in surface runoff noticeably affect stream habitat and life. As the amount of these surfaces increase in a watershed the velocity, volume and pollution of surface runoff increases, so too do impacts on aquatic habitats. The impervious cover model provides a framework for viewing impervious surface increases in a watershed and the potential affects they may have on water quality and general stream health.

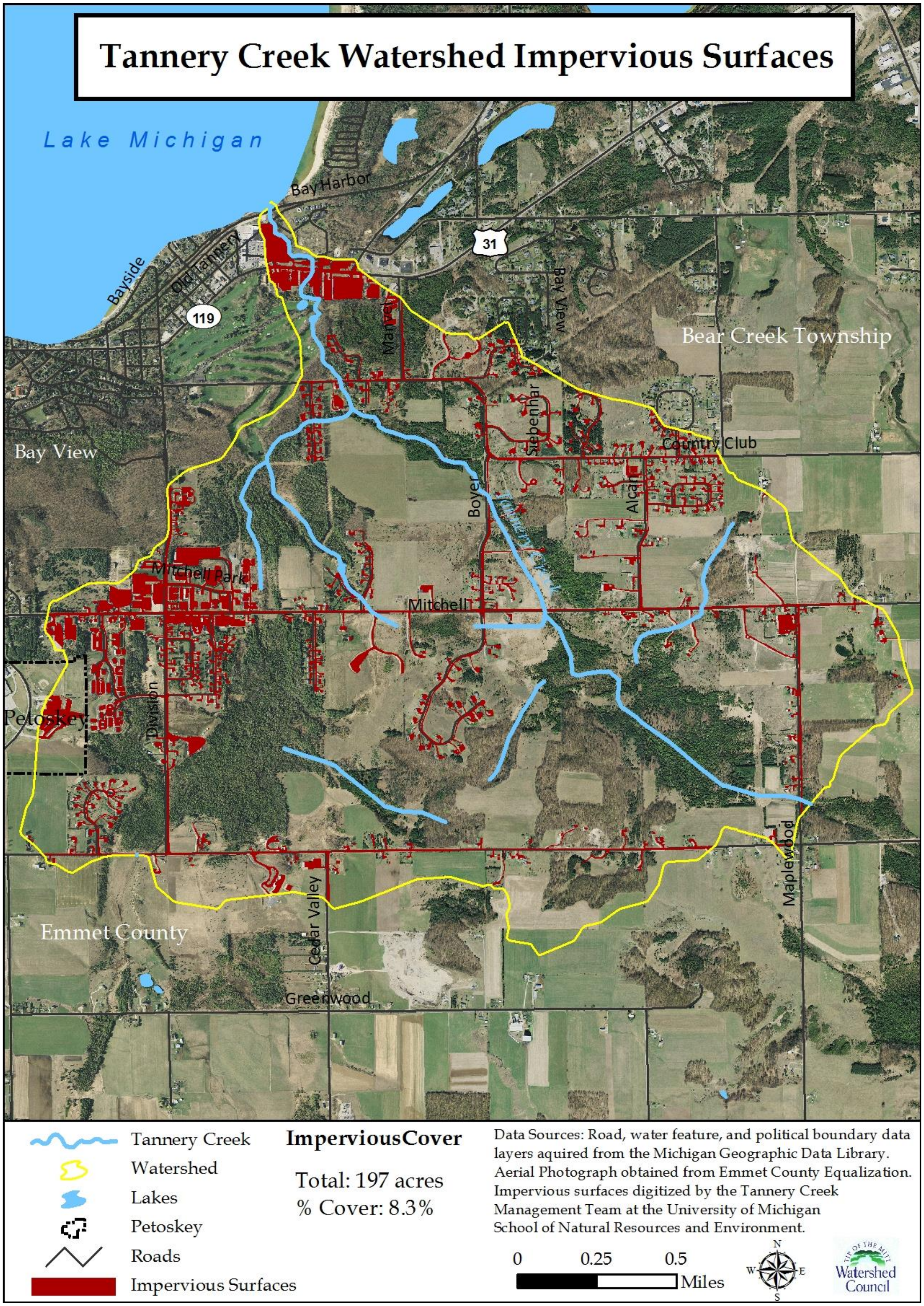
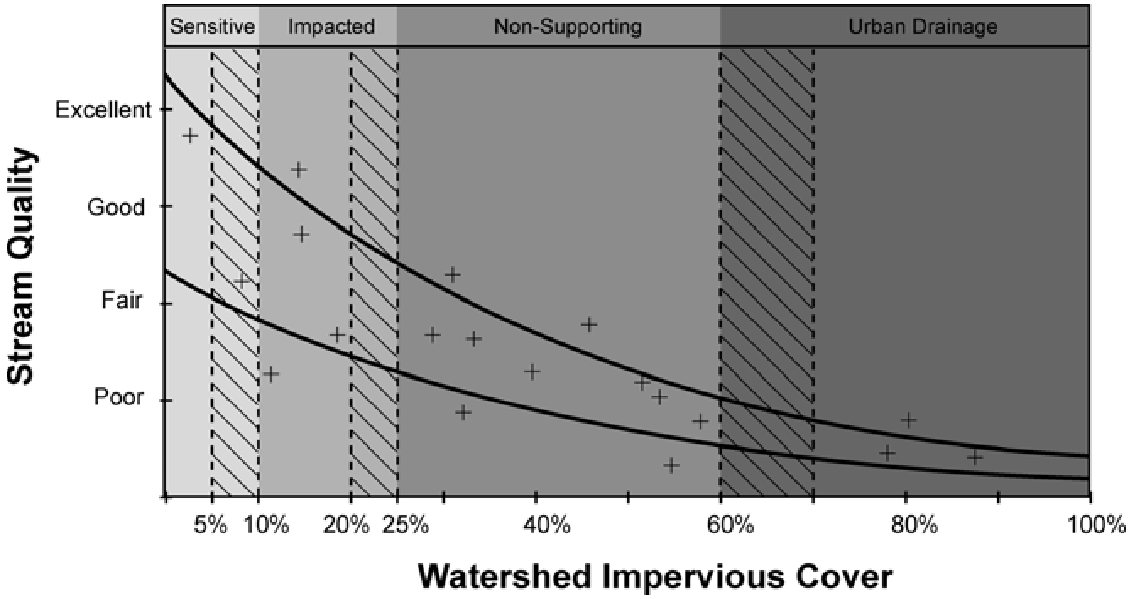


FIGURE 29: IMPERVIOUS SURFACES IN TANNERY CREEK WATERSHED

The classification system proposed by the Impervious Cover Model is presented below:

- **SENSITIVE Streams.** These streams typically have a watershed impervious cover of zero to 10 percent. Consequently, sensitive streams are of high quality and are typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects. Since impervious cover is so low, these streams do not experience frequent flooding and other hydrological changes that accompany urbanization. It should be noted that some sensitive streams located in rural areas may have been impacted by prior poor grazing and cropping practices that may have severely altered the riparian zone, and consequently, may not have all the properties of a sensitive stream. Once riparian management improves, however these streams are often expected to recover.
- **IMPACTED Streams.** Streams in this category possess a watershed impervious cover ranging from 11 to 25 percent, and show clear signs of degradation due to watershed urbanization. The elevated storm flows begin to alter stream geometry. Both erosion and channel widening are clearly evident. Streams banks become unstable, and physical habitat in the stream declines noticeably. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
- **NON-SUPPORTING Streams.** Once watershed impervious cover exceeds 25%, stream quality crosses a second threshold. Streams in this category essentially become conduits for conveying stormwater flows, and can no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, down-cutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water recreation is no longer possible due to the presence of high bacterial levels. Sub-watersheds in the non-supporting category will generally display increases in nutrient loads to downstream receiving waters, even if effective urban BMPs are installed and maintained. The biological quality of non-supporting streams is generally considered poor and is dominated by pollution tolerant insects and fish.



Source: Schuler et al

FIGURE 30: IMPACT OF IMPERVIOUS SURFACES ON STREAM QUALITY

TABLE 22: INVENTORY OF TANNERY CREEK IMPERVIOUS SURFACES

Sub-watershed	Actual Total Area (acres)	Actual Impervious Area (acres)	%	L-THIA Total Area (acres)	L-THIA Impervious Area (acres)	%
Mainstem Watershed	1199	45.00	3.7	1195	39.2	3.2
Lower Watershed	169	46.31	27.4	163	31.0	19.0
West Fork Watershed	1003	106.60	10.6	996	60.8	6.1
Total	2371	197.90	8.3	2354	131.0	5.5

The SNRE team determined current impervious surface rates from aerial photographs obtained from Emmet County. Impervious surfaces—roads and buildings—within the watershed boundaries were put into digital form using GIS. The planning team also calculated current impervious surface area with values used by the L-THIA model to then compare this ratio with impervious surface ratios for future land use scenarios using same L-THIA classifications.[68] The study team used the Impervious Cover Model as a conceptual basis for presenting potential conditions of the stream given plausible impervious cover amounts under these land use scenarios.[69] As a whole watershed, the extent of impervious surface in the Tannery Creek watershed is below the 10% threshold, indicating a stream relatively un-impacted by imperviousness. However, the Lower Watershed is covered by 27% impervious surfaces, indicating relatively impactful effects from imperviousness in this area. This diagnosis is consistent with stream habitat and water quality survey results that show a relatively lesser quality for this area. The Lower Watershed comprises only about 8% of the total watershed.

It is important to note that the Impervious Cover Model framework provides an oversimplified prescription for determining the impacts on stream health from impervious cover. The Impervious Cover Model does not distinguish between connected and unconnected impervious surfaces or account for either the effects of topographical characteristics or positive effects from urban stormwater management systems. Nevertheless, the Impervious Cover Model provides a reasonable and widely used system for estimating the negative effects on stream systems from development.

L-THIA AND BUILD-OUT ANALYSIS

The L-THIA model is a watershed analysis tool that provides estimates of runoff, recharge, and nonpoint source pollution for a particular area.[70] A joint project of Purdue University and the EPA, L-THIA was developed and integrated with GIS to estimate direct runoff from inputs of yearly rainfall averages, land uses, and hydrologic soil groups. The model utilizes the SCS CN method, which is a widely used and simple empirical method for determining the approximate amount of runoff from either a single event or for average annual runoff, given certain conditions (no routing, unfrozen ground, and antecedent moisture conditions).[71] The model also employs standard nonpoint pollution (P, N, SS, etc.) coefficients to determine pollution loading.

The SCS CN method combines factors of soil hydrologic group, land cover, precipitation, and antecedent runoff condition to calculate CN values, from which direct runoff can be determined. Soil hydrologic groups are classified according to minimum infiltration rate, which is a product of soil permeability and surface intake rates. Hydrologic soil group A has the highest minimum infiltration rate, while D has the lowest (see soils section for HSG infiltration rates and descriptions). Each land cover type is assigned an impervious surface cover percentage (e.g. Commercial: 85%) and this value is used in calculating CN values. Rainfall data is gathered from local municipal sources available online.

The L-THIA model therefore is a useful and readily available tool for estimating runoff volumes for past or proposed land use scenarios. For the Tannery Creek watershed project, the planning team utilized GIS to create the following four land use scenarios: Current, Build-out, Conservation 50, and Conservation 100. The team then ran these through the ArcView GIS L-THIA application to produce runoff and nonpoint pollution volumes for each scenario. The goals of this exercise were to gather information on the watershed's current hydrology, evaluate potential effects of land use change, identify best locations for particular land uses, and generate a visual way to identify potential problem areas. The Current land use grid represents current land use/land cover conditions. The Build-out scenario includes land use/land cover according to zoning designations and location of significant natural features. The Conservation 50 and Conservation 100 scenarios use the same land use grid as the Build-out scenario but CN values are altered at intervals according to reductions in impervious surfaces for developments that use of LID techniques, such as rain gardens or thinner driveways.

TABLE 23: RUNOFF PROJECTIONS BY SCENARIO

Scenario	Runoff (cm)	N(kg)	P(kg)	Mean CN value
Current (NLCD 2001)	8232	107.4	26.1	49.0
Build-out	28,916	405.7	112.4	58.3
Conservation 100	12,495	166.6	44.0	52.0
Conservation 50	16,925	228.6	61.5	55.0

TABLE 24: RUNOFF PROJECTIONS BY SCENARIO AND SUB-WATERSHED

Sub-Watershed	Current	Build-out	Conservation 100	Conservation 50
East Fork Watershed	0.72	3.01	1.41	1.84
West Fork Watershed	1.87	6.15	2.58	3.58
Lower Watershed	3.02	8.85	3.43	5.10

Future development of the watershed will significantly influence water quality. While it is difficult to accurately predict development within the watershed, it is still quite useful to conduct a build-out analysis to project how the watershed may develop and how these changes could affect stream conditions. With this information we can better direct management recommendations for maintaining the generally high stream quality and ecological conditions of Tannery Creek. The build-out scenario was developed to a) provide a visual representation of plausible future land cover and land uses, b) to estimate the potential amount of impervious surface cover in the watershed given the current zoning designation, and c) to produce land use grids for processing in the L-THIA model so that impacts of future land use scenarios on runoff and nonpoint pollution amounts could be estimated and compared to current conditions.

The study team considered a number of factors in designing the build-out scenario. The current zoning code, administered by Emmet County, is a strong indicator of how and where the community wishes to see the area develop. Given zoning information, the team assumed that a build-out scenario is one where the community realizes the full definitions of the zoning code through development. Impervious surfaces were estimated from density restrictions and lot coverage set by the zoning code and translated into L-THIA-specific land cover classes. Land cover from the Current land cover scenario was overlain with these new land cover classifications and translated as such. However, it is not accurate to assume that ever acre of land would be developed, as construction is restricted by the presence of natural feature protected by law (i.e. wetlands and riparian areas), plots with growth restrictions or under easement, and areas with prohibitive conditions (i.e. steep slopes, unsafe soils, etc.). Therefore, the planning team assumed certain natural features would not transfer to new land cover classifications, retaining the original land cover defined in the Current scenario land cover grid. These areas include wetlands, high slope areas (>25%), areas with known development restrictions (easements and preserves), and riparian areas (one 30x30 grid cell buffer around stream polyline).

Critical Areas

Critical areas in the Tannery Creek watershed are the areas in which management measures need to be implemented to achieve load reduction identified in the plan. Critical areas refer to locations where actions are needed to address known and potential sources of these pollutants. The process of identifying critical areas relies upon combination of methods including resource inventories, GIS layering, field reports, L-THIA model results, and reports from resource managers and others familiar with a particular aspect of the watershed. The critical areas identified reflect current pollution and community concerns about potential future pollution; the primary sources of nonpoint pollution considered were agriculture, urban stormwater, shoreline management, hydrologic manipulation (impervious surfaces and groundwater), invasive species, and road–stream crossings.

Critical areas are shown at two levels: general critical areas and acute critical areas. General critical areas indicate a particular region contributing presumed higher levels of nonpoint pollution. Acute critical areas include specific priority locations known to contribute nonpoint pollution and that should receive directed efforts. General critical areas are classified under broader, less location specific concerns such as impervious surfaces, agricultural runoff, urban stormwater, litter/blight, and thermal pollution. Categories addressed as acute critical areas include invasive species, stormwater (retrofit), road–stream crossings, litter control, and streambank restoration. Designated general and acute critical areas and recommendations to address these concerns are included under individual sub-watershed implementation chapters.

Priority Conservation Areas

Priority conservation areas are considered the areas within the watershed with features that are most vulnerable to development and other land uses and that provide valuable environmental services. Protecting these features—including steep slope areas (particularly those with highly erodible soils riparian areas, groundwater recharge areas, wetlands, and forestlands—will provide long-term protection of water quality in the watershed. The planning team used a combination of on-the-ground surveys and a GIS process to evaluate conservation areas based on ecological criteria, vulnerability, and other factors and selected priority conservation areas based on these evaluations. Features considered in the selection process include the following:

- **Steep Slopes:** Areas with steep slopes and highly erodible soils (k factor) are at risk of erosion and exaggerated runoff when developed. To prevent sedimentation of surface waters and negative effects of excess runoff, areas with steep slopes should be protected. Areas with 25% or greater slope are considered most vulnerable. These areas are identified in the soils section (see Figure 9 on page 20 for the soil erosion potential map).
- **Riparian Areas:** Riparian areas, or lake shorelines and streambanks, are the critical interface between land and water, where human activity has a significant potential for degrading water quality. Developing riparian properties for residential, commercial, or other uses typically alters the riparian ecosystem and invariably has negative impacts on the stream system. Preserving natural shorelines and streambanks is essential to protecting water quality. The Emmet County Zoning Ordinance requires a 60 ft shoreline buffer in residential areas and a 30 ft. shoreline buffer in commercial zones.
- **Groundwater Recharge Potential:** Groundwater discharge is essential for maintaining healthy cold water fisheries. Land with highly permeable soils (see map in Figure 8 on page 19 above) allows precipitation to percolate relatively quickly through the ground, slowing runoff and recharging groundwater supplies.

- **Wetlands:** Wetlands provide a variety of important function that contribute to the health of a watershed, including fish and wildlife habitat, water quality protection, flood control and erosion prevention. The study team used digital GIS layers containing results of the National Wetlands Inventory to determine the presence of wetlands on individual parcels.

Priority Parcels for Protection

Protected lands owned by state, local, and tribal governments, land conservancies, and private landowners are scattered throughout the Tannery Creek watershed. Nevertheless, there remain land parcels in sensitive areas that should be protected to safeguard the watershed's wildlife habitat, groundwater, and stream quality. To this end, the planning team conducted a priority parcel analysis—a GIS process that evaluates individual land parcels based on multiple ecological criteria and ranks parcels accordingly. The final product provides a tool to land conservancies, governmental entities, and others to assist in prioritizing land protection efforts in a manner that provides the greatest benefit to local ecosystems while also complementing existing land protection efforts. The planning team studied every parcel in the watershed analyzed and selected and ranked priority parcels according to the presence of priority conservation features as described above. The team also considered parcel size and adjacency to protected lands. The criteria used to determine priority parcels for protection include:

- **Parcel Size:** Larger blocks of contiguous land typically have higher ecological value due to their potential to harbor greater diversity of habitat types and species. Larger parcels are also more time and cost effective to protect than smaller parcels. The selection threshold for parcel size was ten acres.
- **Protected Land Adjacency:** Properties adjacent to protected lands such as state forests or conservancy lands have a high ecological value because they provide a buffer to pre-existing protected lands and increase the contiguous protected area, which expands the biological corridor for species migration and interaction. Protected lands include properties owned by the federal government, tribal governments, State of Michigan, local governments, land conservancies, and private owners (conservation easements).

Conservation Areas and Priority Parcels are identified and further detailed in sub-watershed characterization and implementation chapters below.

CHAPTER 4: CURRENT CONCERNS AND FUTURE THREATS TO THE WATERSHED

This chapter contains a description of the current and potential threats to the watershed. As revealed through the stream assessment discussed above and through an analysis of community concerns (discussed in Chapter 7 below), the perceived current threats to the creek include litter and debris, altered hydrology, and development impacts in the lower watershed. Given land use trends and potential future impacts of climate change, other threats include thermal pollution, sedimentation, nutrient loading, and the addition of heavy metals and pathogens to the creek.

COMMUNITY CONCERNS

During the fall of 2012, the study team surveyed residents, business owners, and managers located along Tannery Creek and within the broader watershed. One main goal of the survey was to determine the current perceptions of water quality of Tannery Creek among community members. In addition, the survey assessed the current concerns of this population.

In general, community members reported the creek to be good condition overall (Figure 31 below). 75% of survey respondents (n=31) perceived the creek to be in good or excellent condition, while only 6% indicated that the creek was in poor condition. One resident agreed, “It appears to be in excellent condition on my land.” Other long-time residents proclaimed the creek to be in stable condition for 10 and even 28 years. There was a slight difference between businesses and residents in their responses: while 46% of residents rated the creek in excellent condition (n=24), no business respondents (n=7) rated the condition this highly. The majority of business respondents (82%) were located in the lower watershed (n=17) while the residents were more evenly distributed between regions of the watershed (n=26). However, due to the small sample size, there was no significant difference between the two groups nor was there a significant difference based on location of respondents.

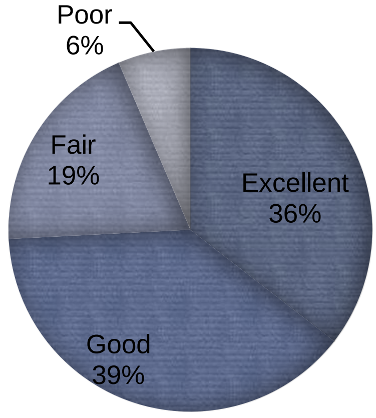


FIGURE 31: CURRENT CONDITIONS OF TANNERY CREEK AS PERCEIVED BY RESIDENTS

When given a list of potential water quality concerns in Tannery Creek, community members rated pooling and flooding as the highest current issue of concern for the creek, followed closely by trash and litter (Figure 31). 41% of respondents (n=27) identified pooling and flooding as a concern. While some businesses reported that this flooding has had little impact on their business activity, others disclosed that customers find it to be offensive, and at times it even reduces the number of customers during flooding periods. Trash and litter was a major concern of 37% of survey respondents (n=27), including the appearance of old concrete, rusted barrels and broken glass. However, one resident admitted to regularly removing the trash found within the creek. The next issue of concern included invasive species with 26% of responses (n=27) citing this as a concern. Reed canary grass and purple loosestrife were two invasive species listed as present in the watershed by residents. Community members were also concerned about erosion, discoloration, and unpleasant odor coming from the water, particularly during storm events and times of flooding. During these times, the creek appears to be muddy with high silt content, but typically returns to a clear state shortly thereafter. In addition to the abovementioned areas of concern, community members also discussed concerns regarding native species depletion; this includes the lowered number of wildlife and fish populations, in addition to, dying ash trees in the riparian areas.

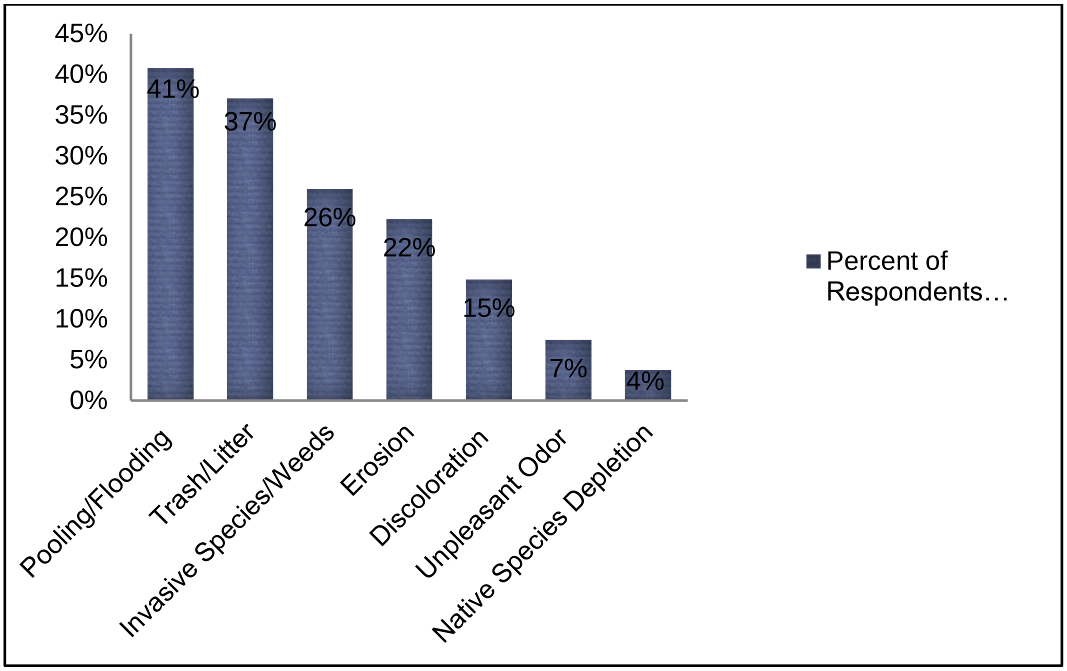


FIGURE 32: CURRENT CONCERNS OF TANNERY WATERSHED RESIDENTS

Community Land Management Practices

Property management practices within the watershed have direct impacts on the health of Tannery Creek. This includes landscaping practices and parking lot management. For this reason, the study team surveyed community members about current land management practices.

When asked about landscaping practices, many businesses reported the use of landscaping service (72%, n=13). The majority of survey respondents (72%, n=39) reported mowing their lawn on a weekly or as-needed basis, with the remainder mowing on a less frequent basis. 100% of survey respondents (n=34) reported that when mowing, that they did not mow directly to the creek edge. 75% of residents (n=19) reported that these riparian areas, or buffer strips, consisted of at least 50 feet of area next to the creek. These regions included trees and shrubs, tall grass, and herbaceous plants and flowers.

Residents and businesses alike utilized both fertilizer and pesticides in landscaping practices. Fertilizer was used by 45% of respondents (n=19), while pesticides were used by 26% (n=11). When considering fertilizer use, residents were questioned on whether the fertilizer included phosphorous in its ingredients. While the response rate for this question was low (n=7), 71% of respondents reported using phosphorous-free fertilizer.

The study team also inquired about landscape management in the winter, specifically regarding snow removal and salt application. 89% of businesses (n=16) utilize a snow removal service, with the snow typically being deposited somewhere on-site. A similarly high percentage of businesses (94%, n=16), acknowledged using salt on parking lots and sidewalks during the winter months. In contrast, only 44% of residents (n=11) utilize salt.

In addition to landscaping, the surveys included questions regarding waste management. 80% of businesses surveyed (n=12) do not currently have an established liquid waste management plan in place. Of those reporting an established plan, the examples included rain barrels to conserve water, and the disposal of liquid volatile organic compounds (VOC's) through a waste management company. 62% of the households surveyed in Tannery Creek watershed (n=16) have septic systems in place, over half of which are over 20 years old (n=10). However, residents reported that many of these systems were serviced within the past three years (n=10). In relation to the creek, the drainage fields of these systems were reported to be over 200 feet away (87%, n=13).

Current management practices, such as those described above, are important to be aware of in order to plan for the future of Tannery Creek. This knowledge helps to set a baseline understanding of the current impacts on the creek from residential and business sources.

PERCIEVED CURRENT THREATS

Debris and Litter

Debris and litter in aquatic ecosystems are defined as any manufactured or anthropogenic solid waste that enters the aquatic environment from any source.[72] Sources of debris and litter include roads, residential areas, and urban areas. People who litter, landfills, and storm drains also contribute. The presence of debris and litter decreases the aesthetic value of the stream and negatively impacts both water quality and aquatic wildlife. Habitat destruction is a common problem associated with litter, which can cover critical habitat such as the streambed when submerged.[73] Debris can add toxic chemicals to the water posing a threat to water quality. Physical litter can harmful to aquatic animals through ingestion and entanglement. Debris and litter is primarily a problem in the lower watershed of Tannery Creek, mainly in the section above the mouth near US-31. Litter from the road as well as poorly managed trash receptacles are the most likely to contribute to this problem.

Altered Hydrology/Flooding

Directly connected impervious landscapes pose a significant problem to hydrology. An example is a rooftop connected to a driveway via a downspout that is then connected to the street where stormwater can ultimately flow directly into the creek. In less developed areas, mitigation of the effect of impervious surfaces often utilizes the preservation of natural features, incorporating detention ponds, infiltration basins, or other on-site stormwater control systems. In developed areas, managing this flow is difficult, since there is usually limited land on which to build a detention pond or other on-site management system. In urban areas, underground storage systems and smaller on-site systems such as residential rain barrels can be used to control flow. Currently, the flow of Tannery Creek is mostly unimpeded. There is a sea lamprey weir just downstream of the TC5 sampling site, which is the main obstacle in the stream. This weir will soon be replaced by a clear span bridge, which will restore a more natural flow to the creek.

Riparian and Terrestrial Invasive Species

Invasive species are non-native species that pose a threat to ecosystem health. Though many non-native species are benign, the species considered invasive are those aggressive species that have the ability to cause major changes to the ecosystems in which they inhabit. Through quick and extensive growth and reproduction, these plants have the ability to crowd out the native species of a region, resulting in reduced native flora and fauna of the ecosystem.[74] In addition, they have the ability to damage native habitat and reduce the sources of sustenance for native species.[75] The abundance of a single species reduces biodiversity of a region, which has direct impacts on the overall health of an ecosystem.

There are currently 11 invasive species of concern in the Tannery Creek watershed. Removal of these species and restoration of native plant species is important to restoring and enhancing overall ecosystem health. For a complete listing and description of these invasive species see Appendix G.

Elevated Water Temperature

Water temperature directly affects many physical, biological, and chemical characteristics of a river. Temperature affects the amount of oxygen that can be dissolved in the water; the rate of photosynthesis by algae and larger aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases. These factors limit the type of macroinvertebrate and fish communities that can live in a stream. This threat is particularly noticeable at the TC2 site where overhead vegetation is lacking and the stream is relatively shallow. Water tends to be cooler farther upstream. It is especially concerning at this site because it is the most upstream site that has been consistently monitored. Further detail is provided in the water chemistry section above.

Sediment

While some sedimentation in a river is natural, as the streambank in one area erodes, the river then deposits the soil downstream. Impacts of soil erosion and sedimentation on downstream resources include a decrease of aesthetic quality with an increase in turbidity, decreased light penetration and decreased plant growth, and degraded aquatic habitat. Aquatic habitat degrades due to increased sediment islands that block fish migration and sediment that covers and clogs the gills of fish and aquatic insects. In addition, nutrients and other pollutants often bond with soil particulates, increasing the detrimental impact of sedimentation on water resources.

Increased stormwater flows lead to high sediment loadings for a variety of reasons. Stormwater picks up soil particulates as it flows over roads, through ditches, and off of bridges into surface waters. Increased flows from stormwater runoff have enough energy to scour soils and destabilize stream banks, carrying bank sediments downstream. In addition, runoff from some construction sites can be a source of sediment if proper soil erosion and sedimentation controls are not in place. Sediment enters the water at bridges as a result of inadequate construction and maintenance practices, and via road ditches, which convey sediment from unpaved roads into the stream. Other sources of community concern regarding sediment include sediments washed off of paved streets and parking lots.

Nutrients

A certain amount of nutrients occur naturally in freshwater systems. In excess, nutrients can cause aquatic ecosystems to become out of balance, favoring certain organisms over other and changing the intrinsic function, use, and appearance of a water body. Phosphorus (P) is the primary nutrient of concern for Michigan’s aquatic ecosystems because it is a common limiting growth factor for algae and other nuisance plants. When excess P enters waterways from excess fertilizer or other sources, it encourages the accelerated growth of plants and algae.

Decomposing plants and algae reduce the dissolved oxygen and light entering the water and create an environment where it is difficult for most fish and aquatic insects to live. High nutrient concentrations interfere with recreation and aesthetic enjoyment of water bodies by causing reduced water clarity, unpleasant swimming conditions, foul odors, and algal blooms. Sources of phosphorus can include fertilizers from lawns, golf courses, and croplands; failing septic systems; and waste from pets, livestock, and wildlife. Eroded soils can serve as a main source of phosphorus to the creek because the nutrient binds to particulates in the soil. Nutrients are not currently a problem at this time.

Pesticides

Pesticides are often used on agricultural lands, gardens, and lawns to repel pests. Most pesticides can contain chemicals that are harmful to humans and aquatic ecosystems. These chemicals can travel into ground water or surface water and contaminate a waterway.[76] Though pesticides are not suspected be a significant problem in Tannery Creek, further investigation would be beneficial as development progresses.

Heavy Metals

Heavy metals such as lead, copper, and mercury can have adverse effects on water systems. These metals disrupt the physiology of aquatic organisms and accumulate in their tissues.[77] Heavy metals are a by-product of manufacturing, but are also common in agricultural and road runoff. The study team suspected possible legacy contamination from the tannery and tested for heavy metals at the mouth of Tannery Creek in August 2012. As of the writing of this plan, heavy metal concentrations are low and are not causing any sediment toxicity problems, but may cause problems in the future.

Pathogens

It is not currently known if pathogens are a concern in Tannery Creek. The study team did not sample for pathogens due to the lack of potential sources—including human contact and livestock. Pathogens are tiny organisms, typically bacteria and protozoa that are agents for disease.[78] They usually originate from fecal matter resulting from sewage discharges, leaking septic tanks, and livestock. Contamination from pathogens can occur though both drinking water and non-drinking water activities such as swimming and wading.[79] Major sources of pathogens include failing septic systems and illegal discharges of sanitary waste into storm sewers. Pet, livestock, and wildlife wastes are also sources of pathogens, but it is very difficult to measure the impact of these sources compared to those above. In the Tannery Creek watershed failing septic and sewer systems are the mostly likely cause of any future pathogen activity.

TABLE 25: POTENTIAL THREATS TO TANNERY CREEK AND THEIR CAUSES

Threats	Source	Rank	Cause (listed in priority order by source)
Nutrients (Phosphorous and Nitrogen)	Urban Stormwater	1	Inadequate treatment of stormwater that may contain pet waste, oils, grease, heavy metals, salts, etc.
			Incomplete stormwater management plan/ inadequate stormwater site design (eg. McDonalds and golf course)
	Landscape and Lawn Care/ Riparian property management	2	Use of phosphorous fertilizer
			Over-application of fertilizer
			Lack of native vegetation buffer strip in riparian areas
	Road–stream Crossings	3	Undersized and short culverts
			Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside
	Golf Course	4	Heavy application of phosphorous-rich fertilizer and pesticides
			Lack if native vegetation buffer strip in riparian areas
	Agriculture	5	Heavy use of pesticides and chemical fertilizers
			Over-application of fertilizer
			Inadequate testing of soil properties
			Inadequate soil erosion control measures
	Septic Systems	6	Outdated, poorly maintained and improperly designed septic systems
Sediment	New Development and Construction	1	Lack of proper erosion control and retention measures, and stormwater management measures
			Riparian development and removal of native riparian vegetation
			Inadequate riparian buffer strips
	Urban/ Residential Stormwater	2	Sand used in winter for traffic safety, construction and general runoff
			Inadequate landscape or vegetative cover
	Road–stream Crossings	3	Undersized and short culverts
			Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside
	Streambank Use and Condition	4	Inadequate buffer strips in riparian areas

			Wear from stream recreation activities and access
Oils, Grease, and heavy metals	Urban/Residential Stormwater	1	Inadequate treatment of stormwater that may contain pet waste, oils, grease, heavy metals, salts, etc.
			Incomplete stormwater management plan/ inadequate stormwater site design (eg. McDonalds and golf course)
			Inadequate buffer strips in riparian areas
			Lack of awareness of proper car care, landscape and property maintenance, etc.
	Road–stream Crossings	2	Undersized and short culverts
			Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside
Hydrologic/ Flow Disturbance	Urban/ Residential Stormwater	1	Incomplete stormwater management plan/ inadequate stormwater site design (eg. McDonalds and golf course)
			Lack of awareness of proper car care, landscape and property maintenance, etc.
			Development in Recharge areas, wetlands, and high slope areas
			Excessive impervious surfaces and lack of low impact development site design and sustainable development strategies
	Road–stream Crossings	2	Undersized and short culverts
			Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside
	Streambank Use and Condition	3	Inadequate buffer strips in riparian areas
			Wear from stream recreation activities and access
Pesticides	Lawn care/ riparian property management	1	Misuse and over use of pesticides, and improper choice of pesticides
	Golf Course	2	Misuse and over use of pesticides, and improper choice of pesticides
	Agriculture	3	Misuse and over use of pesticides, and improper choice of pesticides
Pathogens	Urban/ Residential Stormwater	1	Pet and wildlife waste
	Septic Systems	2	Outdated, poorly maintained and improperly designed septic systems
	Agriculture	3	Animal waste
Thermal Pollution	Urban/ Residential Stormwater	1	Pooling and stagnation of stormwater
			Incomplete stormwater management plan/ inadequate stormwater site design (eg. McDonalds and golf course)
			Industrial uses and diversions of surface water (golf course)
			Lack of native vegetation buffer strip in riparian areas
	Lawn care/ riparian property management	2	Lack of native vegetation buffer strip in riparian areas
			Lack of awareness of proper landscape management and maintenance techniques and designs
			Lack of bank vegetated cover
			Flow alteration from sedimentation and altered hydrology causing unnatural pooling
	Road–stream Crossings	3	Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside
Debris Trash	Urban/ Residential Stormwater	1	Inadequate treatment of stormwater that may contain debris, trash and other waste.
			Incomplete stormwater management plan/ inadequate stormwater site design (eg. McDonalds and golf course)
			Inadequate buffer strips in riparian areas
			Lack of awareness of proper car care, landscape and property maintenance, etc.
			Lack of efficient recycling and trash management programs (eg. Glen's parking lots)
			Lack of or improper use of waste receptacles in public spaces
	Road–stream Crossings	2	Lack of runoff diversions
			Inadequate fill on road surface
			Lack of vegetation on roadside

To better understand the needs of the Tannery Creek watershed, this plan breaks the watershed into three sub-watersheds: West Branch, East Branch, and the Lower Watershed. This chapter includes a description of each sub-watershed and Chapter 8 below outlines implementation plans for each sub-watershed.

WEST BRANCH SUB-WATERSHED

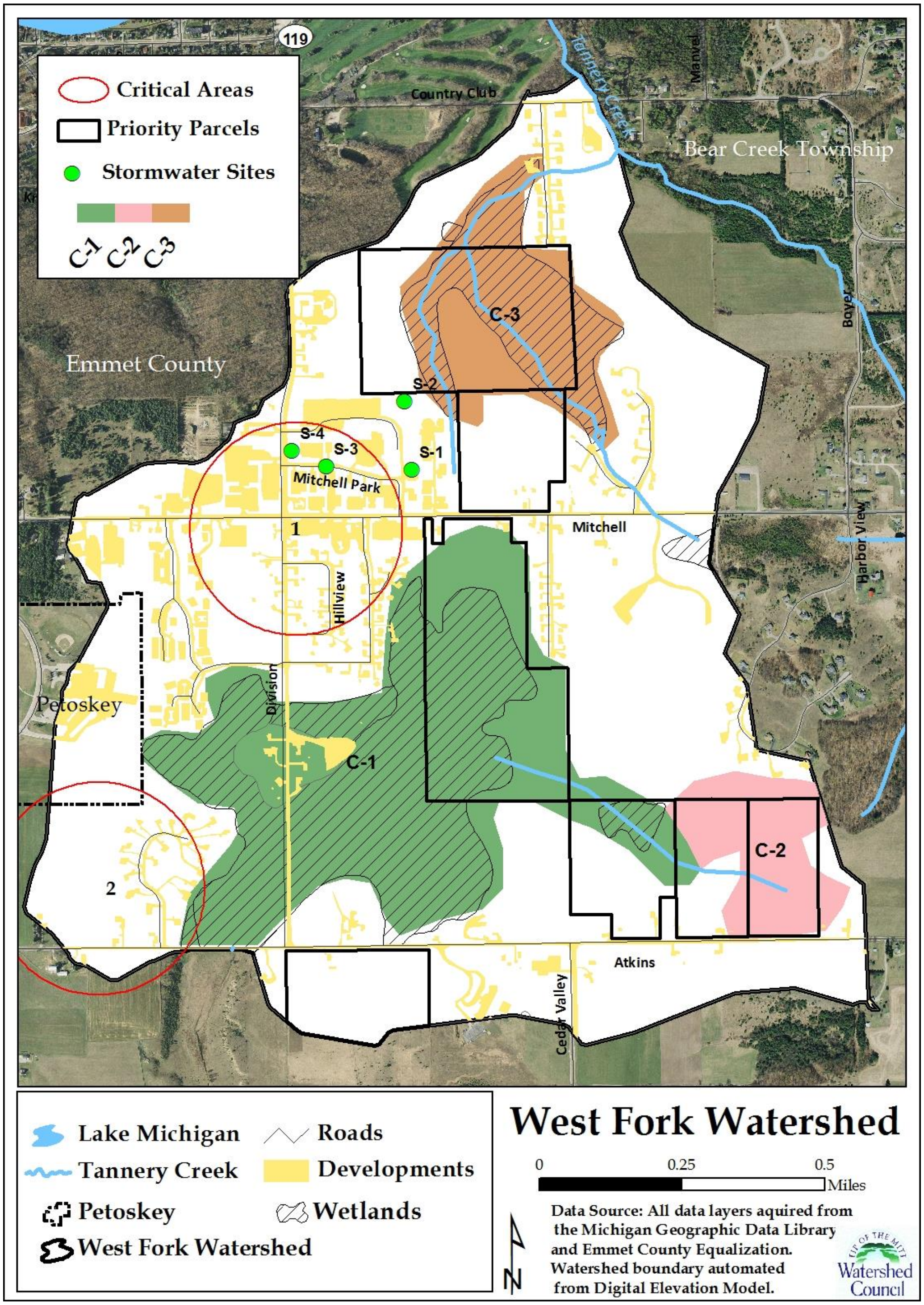


FIGURE 33: MAP OF WEST BRANCH SUB-WATERSHED, DRAINAGE AREA: 1300 ACRES

The West Branch sub-watershed is currently classified as IMPACTED using the Impervious Cover Model and could shift to NON-SUPPORTING if the remaining developable area (excluding wetlands, slopes >25%, lands under easement, and stream/riparian buffer areas) in the watershed is built out according to the current zoning. The West Branch sub-watershed contains a 135-acre swath of forested needle-leaved evergreen wetlands (C-1) in its upper reaches—the largest and (mostly) intact wetland in the entire watershed. The lowest portion of the watershed contains a large intact scrub/shrub wetland (C-3) abutting the Petoskey Bay View Country Club. The southeast corner is another environmentally important area and is characterized by steep slopes, moderately permeable soils, coarse-textured surficial geology conducive to groundwater recharge, and soils with a moderate erodibility factor (C-3). This sub-watershed is primed for the most development in the Tannery Creek watershed because it abuts the City of Petoskey, is easily accessible, is partially connected to the municipal sewer system, and is currently zoned for more dense development. County and township planners have identified this area for growth, which is reflected in higher density zoning designations (B-1, B-2, R-2, R-2B, R-2C), particularly at the intersection of Division and Atkins roads.

TABLE 26: IMPERVIOUS SURFACES IN THE WEST FORK SUB-WATERSHED

	Total (acres)	Percentage	ICM Sub-watershed Category
Actual Impervious surface area	106.6	10.60%	IMPACTED
L-THIA: Land Use Designations	60.8	6.10%	SENSITIVE
NLCD 2001 Median Impervious	63.6	6.38%	SENSITIVE
L-THIA: Future Impervious Cover (with build-out)	235.0	24%	IMPACTED

As this area is primed for new growth and already experiences a high rate of runoff, the TC Plan firstly recommends actions that promote use of Better Site Design and LID tools, stormwater management retrofitting, and other techniques for stormwater mitigation. The SNRE team also recommends directing development away from critical natural areas—particularly wetlands that slow and filter runoff—to preserve the important services they provide. While this sub-watershed is home to extensive wetland complexes, it has areas that are well suited for more dense development. Development should be directed towards these areas and away from wetlands and other more sensitive areas.

TABLE 27: WEST BRANCH SUB-WATERSHED CURRENT LAND USE, L-THIA CATEGORIES

Land Use	Area (acres)
Low Density Residential	138
High Density Residential	30
Commercial	8
Forest	156
Grass/Pasture	444
Wetland/Water	220
Total	996

Source: 2001 National Land Cover Database (NLCD 2001), L-THIA categories

TABLE 28: WEST BRANCH SUB-WATERSHED CURRENT LAND USE, NLCD 2001

Land Use	Area (acres)	Percent
Developed Open Space	49	5
Developed Low Intensity	89	9
Developed Medium Intensity	30	3
Developed High Intensity	6	0.9
Barren Land	3	0.4
Deciduous Forest	93	9
Evergreen Forest	52	5
Mixed Forest	11	1
Scrub/Shrub	7	0.9
Grassland/Herbaceous	48	5
Pasture/Hay	93	9
Cultivated Crop	296	30
Woody Wetland	212	21
Emergent Herbaceous Wetland	8	0.8
Total	997	100

Source: 2001 National Land Cover Database (NLCD 2001)

TABLE 29: WEST BRANCH SUB-WATERSHED PRIORITY CONSERVATION AREAS

Priority Conservation Areas in West Branch Sub-watershed	
Conservation Area	**Description**
C-1	135 acres of mostly undisturbed forests wetlands adjacent and immediately downslope of densely developed area.
C-2	Area of northern hardwoods, steep slopes, moderately erodible soils, moderate soil permeability and groundwater recharge potential. Contiguous to C-1 wetland area.
C-3	47 acre forested wetland immediately upslope of Petoskey Bay View Country Club.

TABLE 30: WEST BRANCH SUB-WATERSHED CRITICAL AREAS

Critical Area Type and Location	Concerns
General Critical Areas (see Figure 33 above)	
1, 2	Surfaces
Acute Critical Areas (see Figure 33 above) and Priority Stormwater Retrofit Areas	
S-1	Stormwater retention pond possibly in need of retrofitting
S-2	Extensive network of stormwater retention ponds to contain/slow water flowing from Mitchell Park development. Ponds are in need of retrofitting should more development occur in the area. Ponds are location to invasive species--cattail, spotted knapweed-- that threaten nearby wetland area.
S-3	Mitchell Park Road has storm water running along road surface. Retrofitting along roadways to slow runoff
S-4	Pooling in parking lots

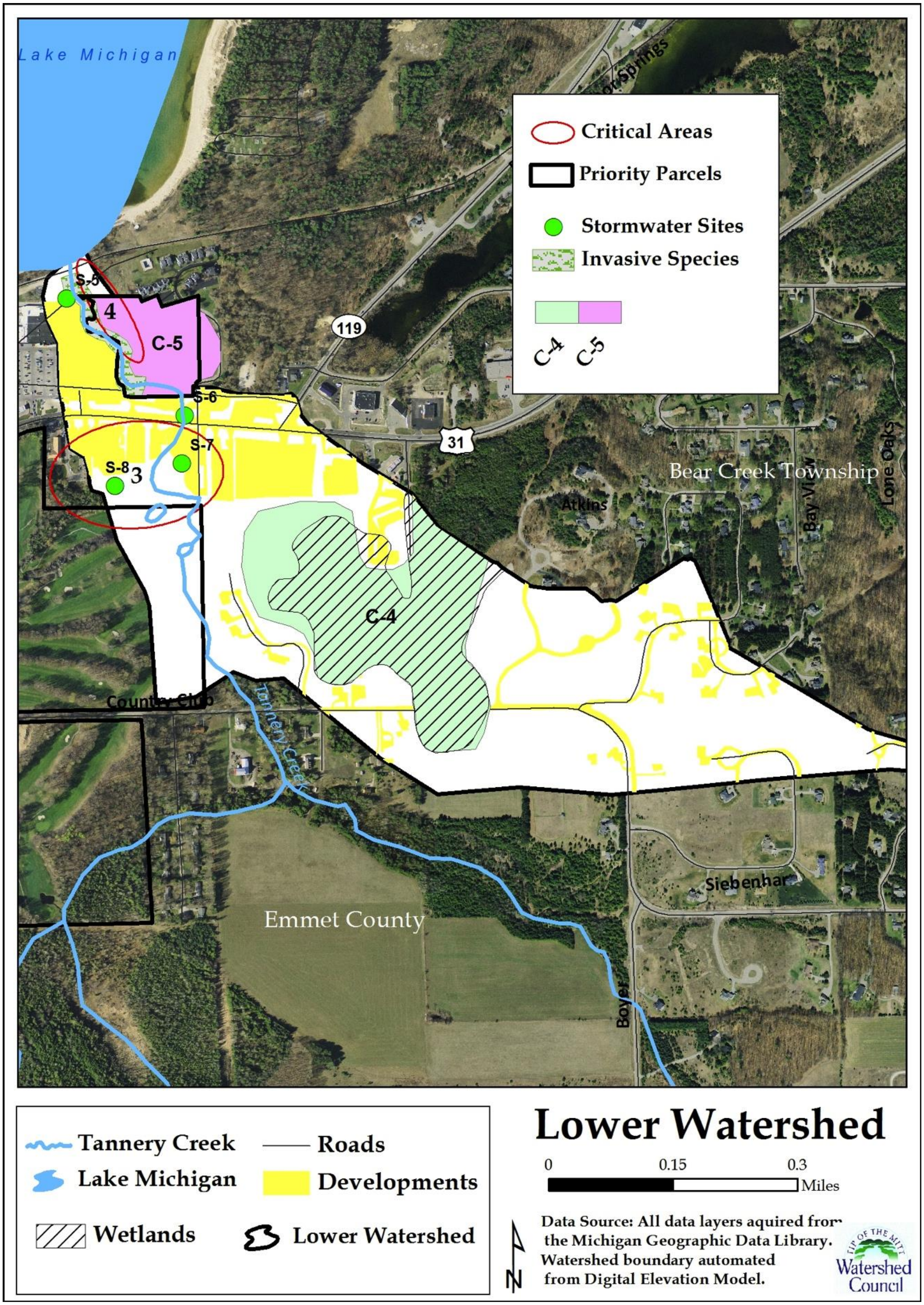


FIGURE 34: LOWER WATERSHED, DRAINAGE AREA 169 ACRES

The Lower Watershed is currently classified as NON-SUPPORTING. The Lower Watershed encompasses a relatively small portion of the overall watershed that includes Tannery Creek's exit point into Little Traverse Bay. Transected by the US-31 commercial corridor and bounding Petoskey Bay View County Club, it is the most developed and impacted sub-watershed in the Tannery Creek watershed. There is, however, little developable area remaining. A 38-acre forested needle-leaf evergreen wetland remains intact directly upslope from the US-31 corridor. Ditching, channel alteration, rerouting, stormwater ponds, an inadequate road–stream crossing (undersized culvert), buffer removal, invasive species, and stormwater runoff have resulted in degraded steam conditions. Importantly, businesses have built into the floodplain, resulting in continual flooding and pooling in back lots and parking lots and routing water out of the watershed. Invasive species—particularly *Japanese Knotweed*—dominate a sizeable portion of the shoreline on the lake side of the US-31 corridor. Litter from roadways and parking lots in riparian zones also pose a threat to stream water and habitat quality.

The consensus recommendation is to mitigate the effects of further development on stream quality by reengineering and retrofitting stormwater management systems (ponds and drains), promoting LID practices in new developments, seeking road–stream crossing improvements, controlling litter blight, removing invasive species, and preserving priority conservation areas and parcels. The primary goal should be to improve urban stormwater management by retrofitting stormwater systems and improving the road–stream crossing at US-31.

TABLE 31: LOWER WATERSHED IMPERVIOUS SURFACES

Category	Total (acres)	Percent	ICM Category
Actual Impervious Surface Area	46.31	27%	NON-Supporting
L-THIA Land Use Designations	31.00	19%	IMPACTED
NLCD 2001 Median Impervious	29.00	18%	IMPACTED
L-THIA: Future Impervious Cover (with build-out)	54.00	33%	NON-Supporting

TABLE 32: LOWER WATERSHED CURRENT LAND USE, NLCD 2001

Land Use	Area (acres)	Percent
Developed Open Space	27.35	17
Developed Low Intensity	20.91	13
Developed Medium Intensity	12.68	8
Developed High Intensity	12.23	7
Barren Land	0.00	0
Deciduous Forest	17.79	11
Evergreen Forest	7.56	5
Mixed Forest	4.00	2
Scrub/Shrub	1.33	1
Grassland/Herbaceous	2.89	2
Pasture/Hay	14.01	9
Cultivated Crop	12.23	7
Woody Wetland	29.80	18
Emergent Herbaceous Wetland	0.00	0
Total	162.79	100

TABLE 33: LOWER WATERSHED LAND USE, L-THIA CATEGORIES

Land Use	Area (acres)	Percent
Low Density Residential	48	29
High Density Residential	13	9
Commercial	12	8
Forest	30	18
Grass/Pasture	30	18
Wetland/Water	30	18
	163	100

Source: NLCD 2001, L-THIA Categories

TABLE 34: LOWER WATERSHED NONPOINT SOURCE POLLUTION CONCERNS

General Critical Areas	Critical Concerns
3	Urban Stormwater, Impervious Surfaces,
4	Urban Stormwater, Invasive Species, Litter

TABLE 35: LOWER WATERSHED PRIORITY STORMWATER MANAGEMENT AREAS

Priority Stormwater Areas	Description	Priority Level
S-5	Stormwater exit point that drains directly in to Tannery Creek. Outflow has eroded away streambank and led to secondary channel	Medium
S-6	Under-sized culvert immediately downstream of larger culvert under US 31	High
S-7	Pooling stormwater in back lots and parking lots	Low
S-8	Outwash from Tannery Creek combines with groundwater seeps to cause considerable flooding, especillay during storm events. Retrofitting of stormwater management systems, with focus on amending berms and strengthening communication between businesses	High

TABLE 36: LOWER WATERSHED PRIORITY CONSERVATION AREAS

Priority Conservation Areas in Lower Watershed	
Region	Description
C-4	38 acre cedar swamp that buffers Tannery Creek from developments in US 31 corridor
C-5	Riparian buffer that connects with Wheel Way owned by Michigan Department of Natural Resources

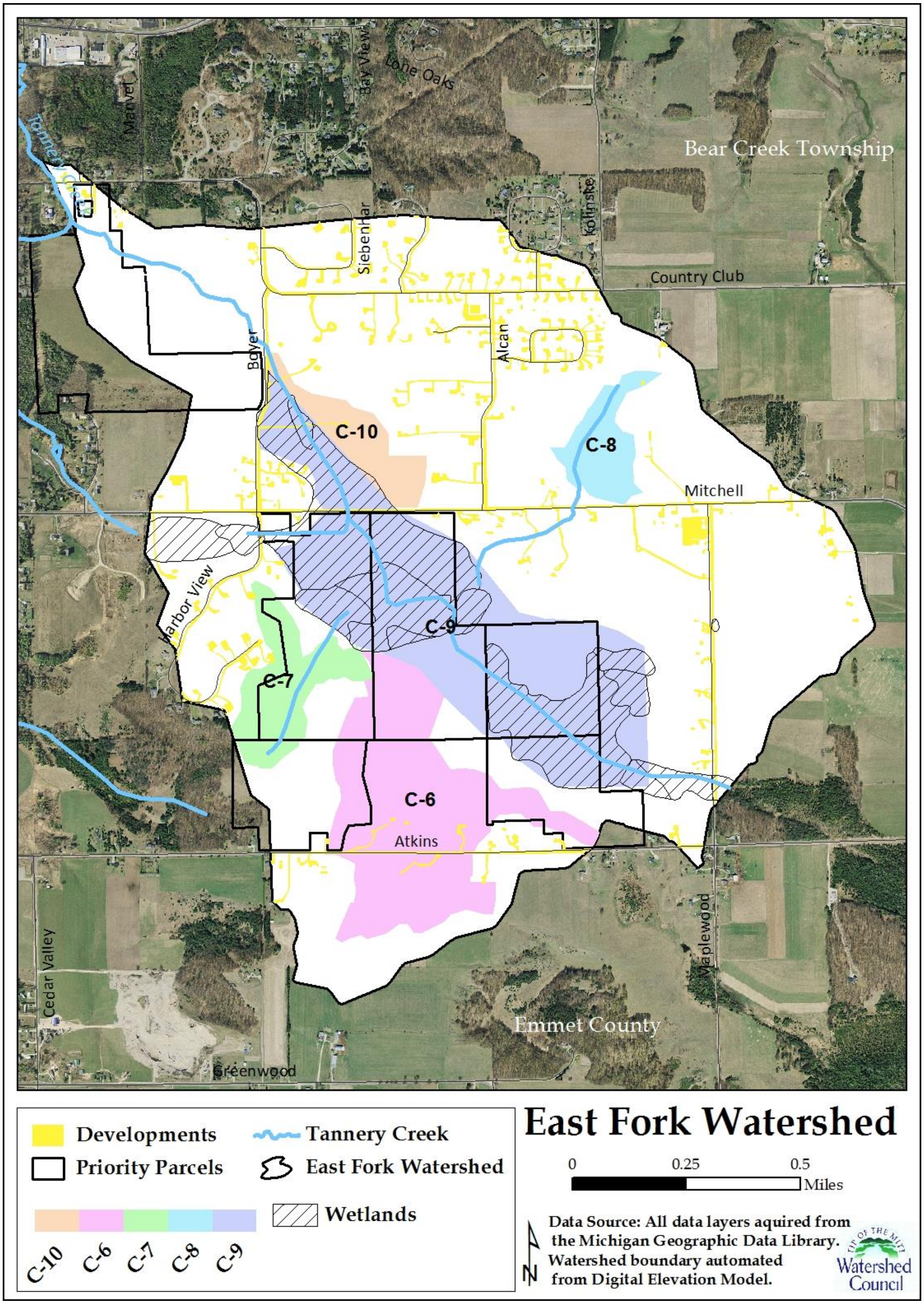


FIGURE 35: EAST FORK SUBWATERSHED, DRAINAGE AREA 1195 ACRES

The East Branch (mainstem) watershed is currently classified as SENSITIVE and could shift to IMPACTED if the remaining developable area in the watershed is built out according to current zoning designations. The East Branch watershed is the largest of the three Tannery Creek watersheds (1195 acres) and is the least developed. This sub-watershed is characterized by sweeping views, historical farmland, extensive wetland complexes, hardwood and cedar forests, loose-textured surficial geology, highly permeable and erodible soils, and steep hillsides. A 100-acre nearly intact emergent and forested wetland area extends from the creek's headwaters near the intersection of Maplewood and Atkins roads to the creek's crossing at Boyer Road. Hardwood and cedar forests cover steep slope areas in the upper watershed and along riparian areas. The southwest corner of the East Branch sub-watershed is the highest point in the Tannery Creek watershed and is an important environmental area. This portion of the watershed is characterized by steep slopes and highly erodible soils and has significant groundwater recharge potential. Two historical farms, important cultural resources, cover the eastern corner of the East Branch sub-watershed, a region with high groundwater recharge potential and steep slopes.

The East Branch sub-watershed is an environmentally significant and sensitive area. The TC Plan firstly recommends actions that facilitate conservation of this region's important natural features, such as land preservation, open space trading, buffer protections, and other methods for open space preservation. The authors recommend directing development away from the upper portions of the watershed (areas of high elevation and steep slopes) to less sensitive areas further downstream and closer to existing developments. Several historical farmlands found in the eastern portion of the sub-watershed are also important to protect as cultural resources and open space areas.

TABLE 37: EAST BRANCH (MAINSTEM) SUB-WATERSHED IMPERVIOUS SURFACES

	Total	%	ICM Category
Actual Impervious Surface Area	45	3.7	SENSITIVE
L-THIA Land Use Designations	39.25	3.2	SENSITIVE
NLCD 2001 Median Impervious	34.25	2.9	SENSITIVE
L-THIA Future Impervious Cover	193	16.1	IMPACTED

TABLE 38: EAST BRANCH (MAINSTEM) SUB-WATERSHED LAND USE, L-THIA CATEGORIES

NLCD 2001: L-THIA	
Land Use	Area (acres)
Low Density Residential	157
High Density Residential	0
Commercial	0
Forest	259
Grass/Pasture	626
Wetland/Water	153
Total	1195

TABLE 39: EAST BRANCH (MAINSTEM) SUB-WATERSHED LAND USE

NLCD 2001 Categories	
Land Use	Area (acres)
Developed Open Space	82.73
Developed Low Intensity	73.84
Developed Medium Intensity	0.00
Developed High Intensity	0.00
Barren Land	0.00
Deciduous Forest	193.26
Evergreen Forest	49.82
Mixed Forest	16.46
Scrub/Shrub	12.23
Grassland/Herbaceous	129.88
Pasture/Hay	166.80
Cultivated Crop	317.36
Woody Wetland	123.65
Emergent Herbaceous Wetland	29.36
Total	1195.37

TABLE 40: EAST FORK CONSERVATION PRIORITIES

Priority Conservation Areas in the East Fork Watershed	
Priority Conservation Area	Description
C-6	108 acres encompassing headwaters, primary growth forest, highly erodible soils on greater than 25% slopes, high groundwater recharge potential, and immediately upslope from headwaters wetland complex
C-7	Area of hardwood forests characterized by high slopes (25%-45%), erodible soils, and high groundwater recharge potential.
C-8	Historic farmland with highly erodible soils and high groundwater recharge potential, encompassing important headwater riparian area.
C-9	Large intact wetland complex that encompasses primary headwater area.
C-10	High slope riparian area populated mainly by cedar.

CHAPTER 6: GOALS AND OBJECTIVES

The project team developed the below goals based on the stream assessment, watershed analysis, and public outreach efforts described above. Given the identified needs and on the goals identified in the LTB Plan, the project team designed below objectives to meet overarching goals. The implementation plan in Chapter 8 is designed to address each of these objectives and the evaluation plan in Chapter 9 provides a roadmap for assessing progress toward the goals and objectives.

GOAL 1: PROTECT AQUATIC AND TERRESTRIAL HABITATS

Objectives

1.1 Protect and restore critical habitat including in-stream habitats, riparian areas, headwater areas, springs, groundwater recharge areas, wildlife corridors, and wetlands.
1.2 Remove and protect against terrestrial and aquatic invasive species and promote desirable native plant growth.
1.3 Protect and restore natural hydrology and flow regime to ensure adequate fish passage and natural ecosystem function.
1.4 Conduct regular inventories of natural features, aquatic species, invasive species, and sensitive areas.

GOAL 2: PROTECT, RESTORE, AND ENHANCE THE QUALITY OF WATER RESOURCES IN TANNERY CREEK WATERSHED

Objectives

2.1 Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *residential sources* (chemical, fertilizer, invasive species, pet waste, etc.).
2.2 Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *agricultural sources* (fertilizer, pesticides, manure, etc.).
2.3 Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *urban and developed areas* (road/stream crossings, storm water, etc.).
2.4 Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *recreational impacts*.
2.5 Reduce and protect against hydrological alteration by protecting groundwater recharge areas, maintaining natural riparian corridors, protecting wetland areas, and improving in-stream morphology.
2.6 Reduce thermal pollution by maintaining riparian vegetation, controlling stormwater inputs, etc.
2.7 Conduct monitoring of physical, chemical, and biological water quality parameters to bolster the body of existing data.

GOAL 3: MAINTAIN AND ENHANCE RECREATIONAL OPPORTUNITIES

Objectives

3.1 Improve fish habitat to better support fisheries.
3.2 Provide safe and open access to stream at public access points.
3.3 Remove and protect against terrestrial and aquatic invasive species in the creek and in riparian areas.

GOAL 4: PRESERVE AND PROTECT THE RURAL, NATURAL CHARACTER AND HERITAGE OF TANNERY CREEK WATERSHED

Objectives

4.1 Protect significant viewsheds throughout watershed.
4.2 Protect the rural character of the watershed (open spaces, historical farms, woodlands, etc.).
4.3 Protect valuable lands that are critical to water quality, fisheries, and wildlife.
4.4 Educate landowners on opportunities and incentives available for land preservation and conservation, including conservation easements.
4.5 Decrease blight, trash, and debris in commercial areas and riparian corridors.

GOAL 5: PROMOTE SUSTAINABLE AND HEALTHY WATERSHED MANAGEMENT PROGRAMS AND PRACTICES

Objectives

5.1 Promote watershed protection practices—such as permanent land protection and LID techniques—among watershed stakeholders.
5.2 Work with units of local government to develop strategies and implement programs that protect water quality and natural resources.
5.3 Work cooperatively watershed stakeholders to leverage funds, pool resources and skills, broaden outreach, and implement projects of the TC Plan.
5.4 Inform future zoning and planning processes including new road approval.

GOAL 6: DEVELOP EFFECTIVE EDUCATION AND COMMUNICATION EFFORTS TO SUPPORT AND PROMOTE WATERSHED PROTECTION

Objectives

6.1 Increase the number of involved stakeholders and deepen their engagement through innovative communications strategies.
6.2 Forge strategic collaborations with businesses, residents, and local government officials.
6.3 Convey current watershed issues and their potential impact on local resources to wider audience(s) in the region.
6.4 Further develop educational and reference materials for business owners and residents.
6.5 Improve awareness of and adherence to ecologically sensitive recreation practices to prevent stream bank erosion, habitat loss, invasive species propagation, etc.
6.6 Ensure all communications are integrated, accurate, on message, and consistent.
6.7 Increase hands-on participation in watershed stewardship.

Education is essential to the successful implementation of any watershed management plan. Local landowners, residents, business owners and managers, and elected officials all play important roles in the management of water resources. It is critical to increase awareness of the watershed among key stakeholders, communicating how their actions affect the watershed and how alternative behaviors can improve the quality of the watershed.

Effective education and outreach is key to the successful implementation of the TC Plan. Education and outreach activities will be designed and implemented in four separate, but interconnected stages: connect, educate, motivate, and activate. The concept is to start with connecting stakeholders with the creek and with each other and to build on those relationships over time through education and motivation to arrive at a place of active engagement

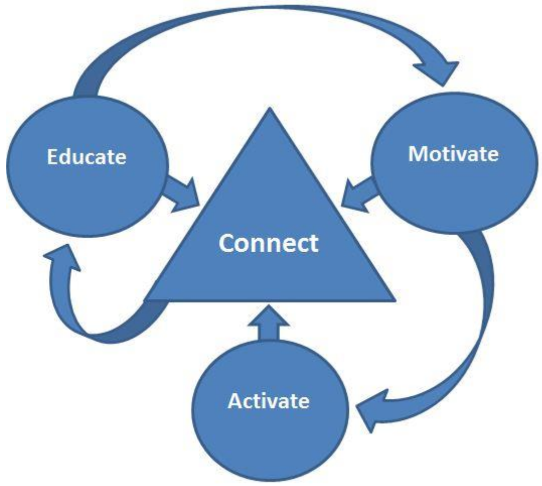


FIGURE 36: EDUCATION STRATEGY FLOW DIAGRAM

Connect

The first stage in a successful outreach campaign involves connecting the audience with the resource to be preserved and connecting stakeholders with each other. This includes promoting awareness and offering opportunities for interaction with the resource. The process of connecting began for many Tannery Creek residents and business owners during the process of researching and writing the TC Plan.

When surveyed during summer of 2012, 100% of the 27 residential survey respondents were aware that Tannery Creek flows near their property. Similarly, 71% of the 18 business respondents reported this awareness. While awareness of the creek itself is important, it is not sufficient for considering the watershed as a whole. In general, many citizens of the United States are not aware of the watershed concept.[80] Therefore, it is important to not only increase awareness of the creek itself, but also the three square mile watershed that surrounds Tannery Creek.

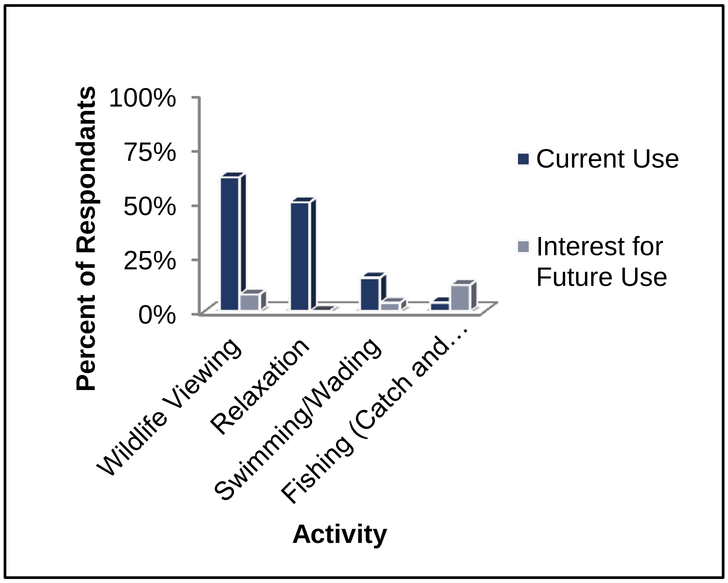


FIGURE 37: COMMON USES OF TANNERY CREEK

The goal of the outreach plan is to increase awareness of Tannery Creek and its surrounding watershed among all residents and business owners, beyond those that responded to the surveys. Connecting is more than simply awareness, but also allowing for opportunities to interact with the resource. When surveyed, residents were asked about their current uses of the creek as well as what future activities they would be interested in pursuing. Wildlife viewing and relaxation were rated high among residents. While these categories are not direct uses of the creek, it is important to spread the awareness of opportunities for indirect interactions with the creek.

Also, the TC Plan development process included individual conversations and a group Community Forum meeting in March 2013, where residents and business interacted for the first time to discuss the future of the creek. The intent is to build upon these connections in the future, knowing that the more people feel connected not just to the resource, but also to each other as a community, the more motivated they will be.

Educate

After connecting, the next step in outreach is education. During this step it is critical to provide educational materials and interactive workshops regarding the importance of preserving water quality and the actions that significantly affect water quality, both positively and negatively. Many citizens are not aware of the connection between individual actions, stormwater runoff, and the effects on water quality.[81] It will be essential to utilize multiple media sources to ensure that the information reaches as many segments of the population as possible. Often educators rely on brochures or fliers to disseminate information regarding watershed health. However, other forms of media exposure, such as television, radio, and newspaper, tend to be much more effective than the traditional methods. With an audience consisting of diverse ages and backgrounds, a mixed media approach will likely meet a higher proportion of the population. In addition to media campaigns, intensive trainings or workshops are a complementary approach to watershed education.[82] This allows opportunities for hands-on and interactive learning. Demonstration or model landscape designs, such as vegetative buffers or rain gardens in public areas can serve as an additional mode of education.

Regardless of the mode of delivery, consistency and simplicity in messaging are critical to a successful outreach campaign.[83] Repetition strengthens a message and increases awareness, which in turn strengthens the understanding of the connection between individual action and ecosystem health. Thus, the process of education further connects citizens to Tannery Creek, reinforcing the first connection stage in the process.

Motivate

The assumption that knowledge will lead to awareness of the environment and therefore result in positive behavior change is a traditional foundation of environmental education. However, research into environmental behavior has revealed the problematic nature of these linear assumptions.[84] Educating citizens about the importance of preserving water quality and the relationship with individual action is important, but is not sufficient to creating direct action. Therefore, after connecting and educating, it will be essential to provide incentives and increase motivation for residents and business owners to take action.

Rather than utilizing extrinsic motivators—such as monetary incentives—for behavior change, a more effective method focuses on intrinsic motivation. Encouraging small stages of change can allow watershed residents to explore options and learn new skills. This process of exploration and understanding, resulting in new-found competence, is rewarding in and of itself. Similarly, encouraging sharing of ideas among community members creates a social atmosphere that is engaging and intrinsically motivating due to the creation and development of social relationships.[85]

In the business sector, it is important to link pro-watershed behaviors with positive reinforcement. As a sub-watershed of the Little Traverse Bay watershed, businesses in the Tannery Creek watershed will have the opportunity to participate in a new program designed to recognize businesses that follow BMPs for watershed protection. Catering to specific business sectors, this program will encourage watershed protection through specific actions that improve water quality. Through publicity and recognition for their positive actions, these businesses will realize increased sales and a widened and more loyal customer base.[86]

As motivation and the willingness to take action increase, awareness of the creek and its surrounding watershed will also increase, further strengthening the connection initiated in the first stage.

Activate

With high levels of awareness, knowledge, and motivation achieved, the next and final stage is Activate. At this stage, it is necessary to provide tangible and accessible opportunities for direct action. This may come in the form of volunteer activities, such as invasive species or trash removal, fundraising, or stream-bank restoration. Encouraging BMPs and celebrating successes, however small, among all citizens is an important way to promote meaningful action. The watershed recognition program for businesses, mentioned above, also provides opportunities for employees to become involved in the creek on an individual level. To be involved at a higher level, citizens of Tannery Creek watershed have the opportunity to join the sub-committee of the Little Traverse Bay watershed committee responsible for the implementation of the TC Plan.

CHAPTER 8: IMPLEMENTATION TASKS

This chapter outlines specific implementation tasks and recommendations designed to achieve the goals and objectives outlined in Chapter 6 above. The first section below outlines implementation tasks by focus area (ie. zoning/land use planning, stormwater, etc.). Next are separate sections dedicated to each of the three sub-watersheds. Finally, the implementation of the education and outreach program receives special attention, though education and outreach is meant to support all of the outlined implementation tasks.

The following baseline assumptions serve as a foundation for the designed implementation tasks:

1. Development of necessary reliable financial and organizational resources to fulfill the goals and objectives. This is achieved largely by amending the TC Plan to the LTB Plan; however, the LTB Committee and the Watershed Council should carefully consider the financial and organizational resources required for full implementation.
2. Continuation and expansion of a comprehensive and collaborative monitoring and inventory program for Tannery Creek that builds upon existing monitoring practices to include inventories of natural features, water quality, flow, road–stream crossings, invasive species, and springs and seeps. Data should be carefully managed and regularly compiled together with new data from the Watershed Council, the Tribe, and MDEQ.

With these baseline conditions established, the SNRE team recommends the implementation parameters and tasks included in the tables below for the preservation and improvement of the Tannery Creek watershed. Each task and action identifies the following:

Category: M (monitoring), A (Advocacy), R (Restoration), E (Education)

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors: urgency to correct or reduce an existing problem; need to enact a specific task or action before a problem develops; availability of funds, partner(s) or program(s) ready to implement; and the overall need to balance low, medium, and high priorities over the course of then years.

Unit Cost/Cost estimate: An estimated unit cost is provided when applicable. An estimated total cost is provided when applicable and calculable.

Milestones: Milestone(s) are identifiedto establish an interim, measurable benchmark for determining progress of a specific task or action.

Potential Partners: The potential partners specified are those who have the interest or capacity to implement the task or action. They are not obligated to fulfill the task or action. It is expected that they will consider pursuing funds to implement the task or action, work with other identified potential partners, and communicate any progress with the Little Traverse Bay Watershed Advisory Council. Partner acronyms: TOMWC (Watershed Council), LTBB (the Tribe), LTC (Little Traverse Conservancy), NRCS (Natural Resources Conservation Service), MSUE (Michigan State University Extension)

Potential Funding Sources: To be completed at a future date by the Watershed Council. Potential funding sources for each task or action include, but are not limited to: private foundation (PF), state grant (SG), federal grant (FG), local government (LG), partner organization (PO), revenue generated (RG), private cost-share (CS), and local businesses (LB).

Objectives Addressed: Each task and action supports one or more of the objectives detailed in Chapter 6.

Timeline: To be completed at a future date by the Watershed Council.

		Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Zoning and Land Use Planning								
	Support allowance/use of cluster developments, open space trading, easements, and purchase (PDR), transfer (TDR), or donation of development rights (DDR) for land preservation.	M	N/A	$10,000	Initiate in Year 1	TOMWC, Little Traverse Conservancy, Bear Creek Township		5.1; 5.2
	Generate materials clearly outlining innovative programs and mechanisms that incentivize greener developments and low impact design	M	N/A	$5,000	Materials distributed within 2 years	TOMWC, Little Traverse Conservancy		
	Encourage changing impervious surface lot coverage limits in residential zoning districts to 15% impervious surfaces of total lot (now 35%)	L	N/A	$5,000	Meeting within Year 1 between local government officers	TOMWC, Bear Creek Township, Emmet County		5.2
	Encourage flexible lot coverage standards to allow for reduction of impervious surfaces. This includes A) relaxing side yard setbacks and frontages to reduce driveways lengths and B) promoting Planned Use Development zoned areas under section 1901 of the Emmet County Zoning Ordinance	M	N/A	$5,000	Inclusion in Emmet County Zoning Ordinance within 5 years	TOMWC, Bear Creek Township, Emmet County		5.1; 5.3
	Promote explicit inclusion and allowance of LID methods—including bio-retention, rain gardens, filter strips and swales—in required setback areas in Zoning Ordinance	M	N/A	$5,000	Inclusion in Emmet County Zoning Ordinance within 5 years	TOMWC, Bear Creek Township, Emmet County		5.1
	Encourage a streamlined permitting process to provide cost-effective and incentive-based regulation for "green" developments, open-space trading, and buffer protections for wetlands	L	N/A	$5,000	To be determined	TOMWC		5.2
	Conduct ongoing reviews of future development projects and rezoning requests.	M	$2,500	$20,000	To be determined	TOMWC		5.4
	Promote awareness among community members regarding the impact of current and future zoning	M	N/A	$10,000	Education materials distributed in 2 years	TOMWC, Little Traverse Conservancy		5.3
	Encourage shorter driveways and shared driveways via education efforts	M	N/A	$10,000	Demonstration project within 2 years	TOMWC		5.3

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Stormwater								
M	Monitor stormwater discharge	H	$3,000	$6,000	Conduct annual monitoring of stormwater discharge issues, two sample sites	TOMWC, MDEQ, Emmet County, Bear Creek Township		2.7; 5.3
R	Retrofit priority stormwater management systems, offering technical and/or financial support	H	$50,000	$50,000	Complete timeline for stormwater retrofits by Year 4. Retrofit by Year 10	TOMWC, Emmet County, Bear Creek Township		2.3; 2.6; 5.2
A	Evaluate whether or not to promote adoption of a stormwater utility for the Tannery Creek watershed. The utility would charge residents and businesses a monthly or quarterly charge based on impervious surface coverage	L	n/a	n/a	Compile information and recommendation on utilities for local governments by Year 7	TOMWC		2.3; 2.6; 5.2
M/A	Develop stormwater management plans for local municipalities (Petoskey, Emmet Co., and Bear Creek Twp.) in conjunction with local resources agencies	M	n/a	$5,000	Develop model stormwater plan by Year 3	TOMWC, Emmet County, Bear Creek Township		2.3; 2.6; 5.2
A/E	Support adoption of alternative stormwater management techniques (by education of residents, businesses, and developers) that aim to reduce stormwater via conservation of natural areas, reduction of direct connections between impervious surfaces, and inclusion of better site design techniques	H	n/a	$2,000	Develop and distribute educational materials by Year 4	TOMWC, Emmet County, Bear Creek Township		2.3; 2.6; 5.2
A	Promote addition of required review of stormwater BMPs to the Site Plan Review in Emmet County	L	n/a	$2,000	Stormwater BMPs added to Review section by Year 5	TOMWC, Emmet County, Bear Creek Township		2.3; 2.6
A/E	Promote stormwater runoff retention techniques in curb and gutter areas	H	n/a	$1,500	Develop and distribute educational materials by Year 2	TOMWC, Emmet County, Bear Creek Township		2.3; 2.6
M	Update stormwater infrastructure and impervious surface maps	M	$1,500	$1,500	Complete updates by Year 2	TOMWC, Emmet County, Bear Creek Township		5.2
E	Provide residents with information about proper disposal of household/yard hazardous waste. Provide accessible locations for proper disposal	M	n/a	$2,000	Develop and distribute educational materials by Year 3	TOMWC		6.3

STREAMBANKS AND BUFFERS

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Streambanks and Buffers								
M	Document and monitor in-stream and streambank habitat (including erosion) every five years	H	$10,000	$20,000	Complete survey every five years	TOMWC		1.4
A	Promote buffer zones in all riparian areas with a minimum width of 75 feet, extending riparian buffer area definitions to wetland areas (at least 25' buffer). Develop incentive programs that may include tax credits, awards, vouchers, discounts on landscape supplies and services, etc.	H	n/a	$3,000	Discussions with 50% of riparian businesses and residents by Year Three	TOMWC		1.1; 2.5; 2.6; 6.5
R	Restore priority riparian invasive species-impaired sites with native vegetation	M	$100/LF	$10,000	Restore 50 LF/YR	TOMWC		1.1
E	Install demonstration rain gardens and vegetation buffers in key public locations with clearly marked and easily viewed educational signage	H	$5,000	$5,000	One demonstration constructed in watershed	TOMWC		6.3; 6.5
E	Develop and install signs and clear demarcation for key road–stream crossings and public access points	L	$500	$3,000	Install signs at 100% of road–stream crossings	TOMWC		6.5

LAND PRESERVATION AND MANAGEMENT

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Land Preservation and Management								
E	Promote Michigan Agriculture Environmental Assurances Program (MAEAP) to encourage BMPs and farmstead verification	M	n/a	$5,000	Achieve 2 verifications in the watershed by Year 5	TOMWC, NRCS, MSUE		4.2
E	Connect with landowners in sensitive and critical preservation areas to encourage land protection. Assist in efforts to preserve historical and cultural resources (historical farms) and sites as committed lands or via contingency plans	H	n/a	$1,000	Conduct annual community forums, connect individually with at least 5 landowners per year	TOMWC		4.4
E	Support local land conservancies in distribution of education materials regarding conservation easements and facilitate acquisition of easements and other development rights	H	n/a	$1,000	One priority parcel with easement by Year 3	TOMWC, Little Traverse Conservancy		4.4

WETLANDS

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Wetlands								
A	Recommend adoption by Emmet County of minimum streambank lot frontage and wetland setback (at least 25')	M	n/a	n/a	Regulation adopted by Year 5	TOMWC, Emmet County		1.1; 2.5; 5.2
M	Identify and evaluate wetlands for habitat value, water quality benefits, and flood control contributions	M	n/a	$5,000	Compile results and distribute by Year 5	TOMWC		1.4; 4.3
R	Identify restorable wetlands, develop restoration plans, and restore wetlands. Work with private property owners to facilitate restoration and protection of valuable wetlands; seek funding on their behalf to implement restoration projects	H	$2,000	$10,000	Complete restoration plans for one wetland by Year 8	TOMWC		1.1; 4.3; 4.4
E	Educate citizens and landowners about the benefits of wetlands protection and restoration. Develop and distribute appropriate education materials.	M	$1,000	$1,000	Develop materials and conduct a workshop on wetlands for local residents by Year 3	TOMWC		1.1; 6.1; 6.3

FLOODPLAINS AND STEEP SLOPES

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Floodplains and Steep Slopes								
M	Create a 100-year flood hazard map for Tannery Creek for inclusion/recognition under FEMA's National Flood Insurance Program	M	n/a	$5,000	Map created and distributed by Year 8	TOMWC, Emmet County, Bear Creek Township		1.3; 2.5
E	Produce and distribute education materials on steep-slope protection and management to landowners, residents, and businesses in priority steep-slope and vulnerable erosion areas	H	$1,000	$3,000	Materials produced and distributed by Year 2	TOMWC		6.1 – 6.4

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Groundwater and Wellhead Protection (Hydrology)								
A	Recommend inclusion of sensitive groundwater recharge area locations in county and township master plans, or as overlay district	H	n/a	n/a	Priority sensitive areas identified in master plans (as addendums?) by Year 4	TOMWC, Emmet County, Bear Creek Township		1.1; 5.2; 5.4
A	Protect groundwater from potential contamination by requiring Pollution Incident Prevention Plans for storage of hazardous materials in coordination with Local Emergency Planning Committee efforts	L	n/a	n/a	Pollution	TOMWC, Emmet County, Bear Creek Township		1.1; 2.1; 2.2; 2.3
A	Recommend that Emmet County restrict—via ordinance or a site review process—high-risk land use activities in wellhead protection zones or sensitive aquifer recharge areas	H-M	n/a	$2,000	Ordinance or site review process approved by Year 3	TOMWC, Emmet County		5.2; 5.4
A/E	Develop and distribute maps of priority groundwater discharge and recharge areas to local governments and organizations	H	n/a	$1,500	Distribute maps by Year 3	TOMWC		5.2; 6.4
M/E	Inventory and summarize the status of wellhead protection plans and provide this inventory to local governments to inform future planning	M	n/a	$5,000	Compile by Year 4	TOMWC		5.2; 6.4
M	Monitor changes in areas with important recharge and runoff retention zones (wetlands)	L	$500	$2,500	Conduct annual monitoring of runoff retention zones	TOMWC		1.1; 4.3
A	Limit impervious surfaces in high groundwater recharge areas, working with local governments to develop and adopt ordinances	L	n/a	$2,000	One local government to adopt ordinance by Year 5	TOMWC		2.1; 2.3; 5.2; 5.4
E	Work with area business and property owners to encourage proper maintenance and monitoring of underground fuel storage tanks and other potential hazards	M	n/a	$2,000	Initiate discussions with all relevant businesses by Year 3	TOMWC		5.2; 5.3; 6.7

ROAD–STREAM CROSSINGS

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Road-Stream Crossings								
M	Conduct road–stream crossing inventories every five years to determine if priorities remain the same and to document newly installed BMPs or improvements	H	$1,000	$2,000	Complete inventory by Year 5, Year 10	TOMWC		2.3; 2.5; 2.7
R	Provide financial and technical support for replacement and/or repair of culverts as needed	M	Tbd	Tbd	Provide support as needed.	TOMWC		5.2; 5.3
R	Perform re-vegetation of banks at road–stream crossings as needed	M	Tbd	Tbd	Provide support as needed.	TOMWC		1.1; 2.5; 4.5
E	Create and carry out volunteer ecological restoration work days to address areas/issues of concern at road-stream crossings (i.e., invasive species, erosion, trash/litter, etc.). Engage citizens and businesses to attempt to carry out similar projects on private properties	M	n/a	$1,000	Conduct two work days per year	TOMWC		6.1-6.4; 6.7

HABITAT, FISH, AND WILDLIFE

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Habitat, Fish, and Wildlife								
M	Perform initial assessment of Tannery Creek fish community to establish baseline	H	n/a	$1,000	Conclude baseline assessment by Year 2	TOMWC, LTBB		2.7; 3.1; 4.3
M	Document in-stream and streambank habitat of Tannery Creek every two years using EPA Habitat Rapid Bioassessment Protocol; identify trends, compile, and distribute results	H	$1,000	$5,000	Assessments conducted every two years	TOMWC		1.4; 2.7
E	Promote the use of large woody debris (LWD) by riparian property owners through print materials, media, and other methods	L	n/a	$5,000	Educational materials developed and distributed to residents	TOMWC		1.3; 3.1; 6.1-4; 6.7

WATER QUALITY MONITORING

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Water Quality Monitoring								
M	Continue comprehensive water quality monitoring at TC3 and TC5 sites each spring and fall	H	n/a	n/a	Continue monitoring as currently conducted	TOMWC, TLBB		1.4; 2.7
M	Expand established Watershed Council monitoring sites to include West Tributary site (TC1W) and one additional site on the Tannery Creek mainstem. Establish new monitoring sites as needed. Update and maintain database for all water quality data and maintain annually	M	$500	$1,000	Monitoring conducted 2x per year at appropriate sites	TOMWC		1.4; 2.7
M	Collect discharge at each monitoring site so that pollutant loadings may be calculated	H	$500	$2,500	Conduct monitoring 2x per year at appropriate sites	TOMWC		2.7
E	Incentivize businesses to follow BMPs in regards to water quality and quantity preservation (i.e., watershed protection award)	H	n/a	$2,000	Implementation of Aqua Stars business recognition program	TOMWC, Petoskey Area Chamber of Commerce		6.1-4; 6.7
E	Continue to encourage and expand volunteer participation in water quality monitoring efforts; develop incentives for participation	H	n/a	$1,000	Recruitment of new volunteers each year	TOMWC		6.1; 6.7

INVASIVE AND ENDANGERED SPECIES

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Invasive and Endangered Species								
R	Develop a comprehensive invasive species management strategy based on the results of ongoing monitoring efforts	H	n/a	$2,000	Strategy developed by Year 3	TOMWC		1.2; 1.4; 3.3
M	Develop volunteer-based invasive and endangered species monitoring program for all of Tannery Creek; expanding on the existing report of invasive species in the Lower Watershed	M	n/a	$2,000	Conduct monitoring at key sites annually	TOMWC		1.4; 6.1-5; 6.7
E	Develop educational materials regarding invasive species, endangered species, and native and drought resistant plants. Disseminate species- and location-specific materials to landowners	M	n/a	$1,000	Develop and distribute materials by Year 3	TOMWC		1.2; 3.3; 6.1-7

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Education and Outreach Program								
E	Utilize an integrated multiple media approach to community outreach. Draw attention to Tannery Creek through newsletters, e-news, websites, and other published updates	M	n/a	$5,000	Educational materials developed and distributed to resident; newspaper articles and TV/radio public service announcements created	TOMWC		6.1-6.7
E	Conduct field trips to explore and learn about local natural resources	L	$500	$1,000	Conduct two field trips by Year 7	Petoskey Public School District, North Central Michigan College		6.1; 6.2; 6.7
E	Create a Tannery Creek sub-committee of the Little Traverse Bay Watershed Advisory Council	H	n/a	n/a	Form committee and conduct first meeting by Year 1	LTB Watershed Advisory Committee		6.1; 6.2; 6.7
E	Connect with and engage youth by partnering with local schools and utilizing age-appropriate education strategies	M	n/a	$2,000	To be determined	TOMWC, Petoskey Public and Private Schools		6.1; 6.2; 6.7
E	Survey/interview businesses to determine barriers to implementing BMPs. Identify resources (funding and otherwise) to assist with overcoming these barriers	H	n/a	$1,000	Surveys completed and disseminated; survey results analyzed.	Petoskey Area Chamber of Commerce		6.2
E/R	Involve local citizens in trash clean-up and restoration events in the Lower Watershed	H	$200	$1,000	Conduct annual litter clean-up days	TOMWC		6.1-3; 6.5; 6.7
E	Educate residents and businesses with septic systems on proper septic maintenance and scheduled check-ups	M	n/a	$2,000	Identify key targets and conduct outreach by Year 5	TOMWC, Septic tank servicing companies		6.1-3; 6.7
E	Educate residents and businesses about watershed friendly landscaping and property management techniques	M	n/a	$2,000	Identify key targets and conduct outreach by Year 5	TOMWC, Local landscaping companies		6.1-4; 6.7

In addition to the implementation tasks listed above, what follows is a list of recommended site-specific activities. Refer to Figure 33 on page 60.

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Land Conservation								
A	Seek easements or other land protections on large parcels overlying priority conservation areas (see parcel priority) and contiguous to existing conservation lands (Bear Creek Township owns a parcel on Mitchell abutting C-2)	H	n/a	$1,000,000	2 large parcels protected by year 10	Little Traverse Conservancy		4.4; 5.2; 5.3
E	Produce and distribute education materials on steep slope protection and management to landowners, residents, and businesses in priority steep-slope and vulnerable erosion areas (C-2)	M	n/a	$5,000	Materials distributed by Year 2	TOMWC		6.1-4
A	Seek protection for the Petoskey Bay View Country Club (PBVCC), as it is a semi-public entity that encompasses an important region of the watershed. Note: Bear Creek Township identified PBVCC as an important cultural and historical site	M	n/a	$25,000	To be determined	Petoskey Bay View Country, Little Traverse Conservancy		4.2; 5.1-3
A	Promote cluster developments (or PUD) in less impactful areas—those abutting City of Petoskey and east of conservation area C-1—to preserve wetland areas C-1 and C-3 and the conservation area C-2	M	n/a	$10,000	To be determined	TOMWC, Bear Creek Township, Emmet County		5.1-2
A	Promote open space trading to direct denser growth in areas of this watershed suited for growth, in exchange for land conservation in more sensitive areas, such as the wetland areas or the sensitive East Fork sub-watershed	L	n/a	$10,000	To be determined	TOMWC		4.3; 4.4; 5.2
A	Promote extending riparian buffer definition to wetland areas (with minimum 25' buffer) to protect sensitive wetland areas from degradation and encroachment from new developments in the West Branch sub-watershed	L	n/a	$10,000	Adoption of ordinance within year 10	Emmet County, Bear Creek Township, MDEQ		1.1; 4.3; 5.2
Habitat/Streambank								
R	Remove invasive species covering retention pond area S-2 and abutting wetlands. Replant with native vegetation	M	$10,000	$10,000	Removal and restoration by year 3	TOMWC, Little Traverse Conservancy		1.2; 3.3

See Figure 35 on page 66 for a map of priority conservation and key restoration areas.

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Land Conservation								
A	Seek easements or other land protections on large parcels overlying priority conservation areas (see parcel priority) and contiguous to existing conservation lands	H	n/a	$50,000	1 large parcels protected by year 5	Little Traverse Conservancy		4.4; 5.2; 5.3
E	Produce and distribute education materials on steep slope protection and management to landowners, residents, and businesses in priority steep-slope and vulnerable erosion areas (C-2)	L	n/a	$5,000	Materials distributed by Year 2	TOMWC		6.1-4
A	Seek protection, if not already in place, for the historic farms in the eastern portion of the East Barnch Sub-watershed	L	n/a	$10,000	To be determined	LTC		4.2; 5.1-3
A	Promote cluster developments (or PUD) in less impactful areas—those lower in the watershed and close to current developments, particularly along Country Club Road—to preserve important and sensitive features	L	n/a	$10,000	To be determined	TOMWC		5.1-2
Land Preservation								
E	Promote Michigan Agriculture Environmental Assurances Program (MAEAP) to encourage BMPs and farmstead verification	L	n/a	$5,000	Achieve 1 verification by Year 5	TOMWC, NRCS, MSUE		1.2; 3.3

Category	Task	Priority	Unit Cost	Estimated Total Cost	Milestones	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Stormwater Management								
R	Seek restoration and retrofitting of priority stormwater management areas	H	$25,000	$250,000	Completion of 1 retrofitting by year 5	MDEQ, Emmet County, TOMWC, Bear Creek Township		1.3; 2.5
R	Facilitate action towards retrofitting of priority stormwater management sites by offering technical or financial support	H	N/A	N/A	Completion of 1 retrofitting by year 5	TOMWC, MDEQ		5.2; 5.3
E/A	Promote better stormwater management and adoption of BMP's via regular evaluation and education and outreach efforts	M	N/A	$15,000	Materials by year 2	TOMWC, MDEQ, Emmet County		6.1-4; 6.7
Road-Stream Crossings								
R	Develop a project plan schedule and fundraising plan to restore priority road/stream crossing site at Chase Bank and US Highway 31	H	$10,000	$10,000	Plan completed by year 2	TOMWC, MDEQ, Emmet County		5.2; 5.3; 6.2
Habitat/Streambanks								
R	Restore priority riparian invasive species impaired sites with native pre-development vegetation	H	$15,000	$15,000	2 restoration events within 2 years	TOMWC		1.1; 1.2; 2.6
E	Seek planting of native vegetation along all possible riparian sites, particularly along buffer areas without significant vegetation	M	N/A	$10,000	Planting by 1 local business	TOMWC, MDEQ		1.1; 1.2; 2.6
R/E	Seek solution to litter problem (mostly during summer months) in Glen's parking lot and other areas contributing litter	H	N/A	$10,000	Litter management system improved by year 2	TOMWC		4.5; 6.1; 6.3
R	Restore erosion sites lake-side of US 31 corridor	M	$20,000	$40,000	Restoration of 1 site	TOMWC, MDEQ		1.1; 5.2; 5.3
Monitoring								
M	Document in-stream and streambank habitat in lower reaches to establish baseline conditions and to monitor effectiveness of actions taken	H	$2,500	$20,000	Monitoring conducted 2x per year at appropriate sites	TOMWC, LTBBOI		1.4; 2.7
M	Continue comprehensive water quality monitoring at TC3 and TC5 each spring	H	$2,500	$20,000	Monitoring conducted 2x per year at appropriate sites	TOMWC, LTBBOI		2.7
M	Collect discharge at each monitoring site so that pollutant loadings may be calculated	H	$500	$2,000	Monitoring conducted 2x per year at appropriate sites	TOMWC, LTBBOI		2.7
Land Conservation								
A	Seek easements or other land protections on parcel overlying priority conservation areas (see parcel priority) and contiguous to existing conservation lands	H	N/A	$1,000,000	1 parcel protected by year 5	TOMWC, Little Traverse Conservancy		4.1-4

CHAPTER 9: EVALUATION

Key to the success of the TC Plan is integration of a clear monitoring and evaluation process to determine both the effectiveness of planned activities and progress toward the plan's goals and objectives. TC Plan monitoring and evaluation should also provide critical feedback—in the form of lessons learned—to inform future watershed management plans. The Tannery Creek sub-committee of the Little Traverse Bay Committee together with the Watershed Council will be responsible for evaluating progress toward the Plan's goals.

The success of the TC Plan will be evaluated by determining the following:

- Progress in completing the recommended tasks and actions (implementation)
- Effectiveness in improving and protecting water quality and habitat in watershed

Progress should be measured using a number of interim metrics, including measuring water quality as well as activities and changed behavior. Table 41 below outlines possible metrics to be used to evaluate progress toward the TC Plan's goals.

To measure water quality, a straightforward, routine monitoring program will be sufficient to provide the necessary data to make informed management decisions. The suggested approach is to measure dissolved oxygen, temperature, conductivity, and turbidity at two to three sites once per month, or as often as allows. Measuring nitrogen and phosphorus at the same sites two to three times per year is sufficient to provide adequate chemical data. Flow measurements should also be taken at base flows as often as possible and when nitrogen and phosphorus samples are collected.

The volunteer sampling effort to assess the biological community of Tannery Creek to date has been outstanding. To maintain knowledge of the biological community, it is suggested that, in addition to monitoring in May and September, the volunteers perform an index of biotic integrity once a summer at two or three sites using the EPA Rapid Bio-assessment Protocol. It is also recommended that habitat measurements be taken concurrently and evaluated using Qualitative Habitat Evaluation Indices.

"Water quality" in Table 41 below refers to the following set of measurements:

- Total phosphorus concentrations remain below 10 micrograms/liter. [87]
- Total nitrogen concentrations remain below 0.38 milligrams/liter. [88]
- Dissolved oxygen remains high.
- Average temperature does not consistently exceed 16 degrees F in summer months. [89]
- No significant increases in the presence of suspended solids, heavy metals or pathogens.
- Maintained or increased aquatic macroinvertebrate abundance and diversity.
- Maintained or improved riparian habitat.
- No increase in invasive species or blue green algae (cyanobacteria)

TABLE 41: EVALUATION METRICS FOR PLAN IMPLEMENTATION

Goal	Objective	Evaluation Metrics
Protect aquatic and terrestrial habitats	Protect and restore critical habitat including in-stream habitats, riparian areas, headwater areas, springs, groundwater recharge areas, wildlife corridors and wetlands	• Water quality • Abundance and diversity of fish • Abundance and diversity of terrestrial wildlife
	Remove and protect against terrestrial and aquatic invasive species and promote desirable native plant growth.	• Percent and volume by mass invasive species • Diversity and health of native plants
	Protect and restore natural hydrology and flow regime to ensure adequate fish passage and natural ecosystem function.	• Water quality • Stream–road crossing effectiveness
	Conduct regular inventories of natural features, aquatic species, invasive species, and sensitive areas.	• Number and frequency of inventories • Frequency and accuracy of trend analysis
Protect, restore, and enhance the quality of water resources in Tannery Creek watershed	Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *residential sources.*	• Water quality • Average residential riparian buffer • Amount and frequency of fertilizer application • Number residents engaged in Plan
	Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *agricultural sources.*	• Water quality • Size of active agricultural lands, number of livestock • Number agricultural land owners engaged in Plan
	Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *urban and development impacts.*	• Water quality • Percent impervious surface • Number business owners engaged in Plan, number involved in business recognition award
	Reduce nutrient, sediment, and pathogen inputs to surface waters and groundwater from *recreational impacts.*	• Water quality
	Reduce and protect against hydrological alteration by protecting groundwater recharge areas, maintaining natural riparian corridors, protecting wetland areas, and improving in-stream morphology.	• Water quality • Total wetland acreage • Number and size of erosion areas
	Reduce thermal pollution by maintaining riparian vegetation, controlling stormwater inputs, etc.	• Water quality • Percent impervious surfaces • Number and size of rain barrels, rain gardens, etc. • Average riparian buffer width
Maintain and enhance recreational opportunities	Improve fish habitat to better support fisheries.	• Abundance and diversity of fish • Streambed composition
	Provide safe and open access to stream at public access points.	• Signage at road–stream crossings and other key points
	Remove and protect against terrestrial and aquatic invasive species in the creek and in riparian areas.	• Percent and volume by mass invasive species • Diversity and health of native plants
Preserve and protect the rural, natural character and heritage of Tannery	Protect significant viewsheds.	• Resident and business owner opinion of the creek (surveys, interviews)

Creek watershed	Protect the rural character of the watershed.	• Resident and business owner opinion of the creek (surveys, interviews)
	Protect valuable lands that are critical to water quality, fisheries, and wildlife.	• Number and size of conservation easements and other protections • Total acreage of wetlands
	Educate landowners on opportunities and incentives available for land preservation and conservation.	• Number and quality of educational materials and events • Number landowners attending and actively engaged
	Decrease blight, trash, and debris in commercial areas and riparian corridors.	• Volume trash removed by volunteer crews • Resident and business owner opinion
Promote sustainable and healthy watershed management programs and practices	Promote watershed protection practices among stakeholders.	• Number and quality of educational materials and events • Number and size of rain barrels, rain gardens, etc. • Public service announcements and articles in local publications
	Work with units of local government to develop strategies and implement programs that protect water quality.	• New or improved water protection programs • Number of government representatives involved in Plan • Number and frequency of connections between local government reps and other stakeholders
	Inform future zoning and planning processes.	• Number of public meetings attended and comments made by Tannery stakeholders during zoning processes
		•
	Increase the number of involved stakeholders and deepen their engagement through innovative communications strategies.	• Number and quality of educational materials and events Number landowners and business owners attending and actively engaged
Develop effective education and communication efforts to support and promote watershed protection	Forge strategic collaborations with businesses, residents, and local government officials.	• Number of government representatives involved in Plan • Number and frequency of connections between local government reps and other stakeholders
	Convey current watershed issues and their potential impact on local resources to wider audiences in the region.	• Public service announcements and articles in local publications • Number of non-residents and non-business owners involved in direct or indirect implementation projects
	Further develop educational and reference materials for business owners and residents.	• Number and quality of educational materials and events • Number of materials distributed to stakeholders
	Improve awareness of and adherence to ecologically sensitive recreation practices.	• Resident and business opinions of creek (surveys, interviews)
	Increase hands-on participation in watershed stewardship.	• Number of volunteers involved in inventories and water quality monitoring • Number of stakeholders attending public meetings

APPENDIX A: EPA NINE ELEMENTS AND MDEQ REQUIREMENTS[90]

DEQ CMI Required Elements (NPS)	EPA Minimum Elements (319)	Michigan's Phase II Minimum Requirements	Content requirements meeting all 3
1. The *geographic scope* of the watershed. • Watershed boundaries are appropriate. • Plan includes a watershed map that clearly shows the watershed boundaries and the location of surface waters. • Plan provides a description of the watershed, including such information as land use information, predominant soil types, significant natural features, and hydrology information.		*The boundaries of the watershed plan are required to be identified as an element of the Application and included in the Certificate of Coverage (the boundary must make hydrologic sense and should not be based on political boundaries).*	• Watershed boundaries must be hydrologically based and delineated on a map. • The watershed description should include such information as: ○ Hydrology ○ Geology ○ Ecology ○ Land Use.
2. The *designated uses and desired uses* of the watershed. • Plan includes the designated uses that are being met. • Plan includes a list of desired uses, including restoring and/or protecting designated uses.		• An assessment of the nature and status of the watershed ecosystem to the extent necessary to achieve the purpose of the Watershed Management Plan (WMP). • *The purpose of the WMP shall be to resolve water quality concerns including those related to a TMDL, which are caused by wet-weather discharges from separate storm water drainage systems.* • *An Illicit Discharge (to storm sewers) Elimination Plan is required and*	• Include designated and desired uses of the watershed.
3. The *water quality threats and/or impairments* in the watershed. • Plan identifies the water quality threats. • Plan identifies the water quality impairments, if applicable, including the designated uses that are not being met.			• Include water quality impairments and threats.
4. The known or suspected cause of each threat or impaired use, including specific *pollutants*.	a. 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 this watershed-based plan.	*specifically targets this source.*	• Include the sources and causes of the threats and impairments including a quantification or estimate of the magnitude of each source or cause and a prioritization of the sources and causes.
5. The *sources of the pollutants* causing the impairments or threats and those that are critical to control in order to meet water quality standards or other water quality goals. • The plan includes the sources of pollutants. • The method used to inventory sources is included. • An inventory has been completed to identify priority areas. • The sources have been prioritized. • The prioritization method is included.			• *DEQ includes designation of critical areas tied to sources – EPA includes designation of critical areas tied to BMPs. These are equivalent requirements and described below.*
6. A clear statement of the *water quality improvement or protection goals* of the watershed plan. • Plan identifies water quality improvement goals, including restoring designated uses. AND/OR • Plan identifies water quality protection goals, including protecting designated uses.	b. An estimate of the load reductions expected for the management measures described in element (c) below.	• Long-term goals for the watershed (which shall include both protection of designated uses and attaining compliance with any TMDL established within the watershed).	• Plan identifies water quality improvement goals, including restoring designated uses. AND/OR • Plan identifies water quality protection goals, including protecting designated uses. • Plan identifies an estimate of the load reduction needed to attain the water quality goal. AND/OR • Plan identifies an estimate of the maximum allowable load to protect water quality.

7. The *tasks* that need to be completed to prevent or control the critical sources of pollution or address causes of impairment, including as appropriate: · Plan identifies specific tasks to accomplish the identified goals, the responsible party and the anticipated products. · Tasks include one or more of the following: o Best management practices needed, including physical improvements. o Revisions needed or proposed to local zoning ordinances and other land use management tools. o Information and educational activities. o Activities needed to institutionalize watershed protection.	c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated in element (b) above, and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.	· Determination of the actions needed to achieve the short-term objects · Determination of the actions needed to achieve the long-term goals	A description of the tasks and activities that will need to be implemented to achieve the water quality goals and tied to the estimated loads. The description must describe the critical area for each task and activity.
8. Estimated *cost* of implementation activities, by category (such as BMP implementation, land use management activities, information/education activities, etc.).	d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan.	· Assessment of the benefits and costs of the actions (a cost/benefit analysis is not required).	· An estimate by category of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon. · Assessment of the benefits and costs of the actions.
10. Summary of the *public participation process*: · Plan included an opportunity for public comment. · Plan identifies how public input and comment were solicited. · Plan identifies the partners that were involved in the development of the plan, and their roles and responsibilities. · Plan involved a wide variety of agencies and interests, including those most affected by the plan and/or able to help implement the plan.	e. 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.	· *A Public Education Plan (PEP) is required as detailed in Part I Section A.3.b. of the permit□ □The PEP shall promote, publicize, and facilitate watershed education for the purpose of encouraging the public to reduce the discharge of pollutants in storm water to the maximum extent practicable□ The PEP shall describe a method for determining the effectiveness of the various public education activities.* · *Watershed Partners (both permitted and voluntary must be identified in the permit application.* · *There must be a process to involve the watershed jurisdictions and the public in the development of the WMP.*	· Phase II has specific requirements including a stormwater P2 element.
9. The estimated period of *time needed to complete each task* and the proposed *sequence of task completion*.	f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.	· Commitments, identified by specific permittee or others, to implement actions by specified dates necessary to achieve the short-term objectives *and to initiate achievement of the long term goals.*	· NPS and 319 are equivalent and do not require specific dates only a plan year or range. · Phase II requires specific dates for completion.
	g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.	· Short-term measurable objectives	Establish measurable interim milestones for water quality improvement and progress on implementation efforts.

11. A description of the process that will be used to *evaluate the effectiveness* of implementing the plan and achieving its goals.	h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised.	· Methods for evaluation of progress, which may include chemical or biological indicators, flow measurements, erosion indices, and public surveys.	Establish a process and criteria for evaluating the effectiveness of the plan and the resulting changes in water quality. The monitoring component should include required project specific needs, the measurable interim milestones, local monitoring efforts and it should also be tied to the State water quality monitoring efforts (i.e. environmental, social, administrative, and water quality elements).
	i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.		

Column 1 DEQ CMI Required Elements Excerpted from the watershed plan approval checklist.
Column 2 EPA Minimum Elements Excerpted from the FY03 Section 319 Guidance.
Column 3 Michigans Phase II Minimum Requirements Excerpted from Section 1.B.1. of the WatershedPermit. Information in this column that is in *italics* is not a requirement for the WMP but comes from other portions of the permit or permit process.
Column 4 Elements needed for a plan to be consistent with all three programs.

APPENDIX B: HISTORICAL STREAM FLOW DATA

			Cross-Sectional			Discharge	
Site	**Date**	**Group**	**Width (m)**	**Area (m2)**	**Velocity (m/s)**	**cms**	**cfs**
TC2	Mar-10	LTBB	--	--	--	0.068	2.40
TC2	May-10	LTBB	--	--	--	0.057	2.00
TC2	Jul-10	LTBB	--	--	--	0.007	0.25
TC2	Jun-10	LTBB	--	--	--	0.021	0.75
TC2	Aug-10	LTBB	--	--	--	--	--
TC2	Sep-10	LTBB	--	--	--	--	--
TC2	Oct-10	LTBB	--	--	--	0.016	0.55
TC3	Feb-07	TOMWC	1.52	0.133	0.125	0.017	0.59
TC 5	Feb-07	TOMWC	2.97	0.411	0.189	0.078	2.74
TC5	Mar-10	LTBB	--	--	--	0.082	2.90
TC5	May-10	LTBB	--	--	--	0.119	4.20
TC5	Jun-10	LTBB	--	--	--	0.067	2.35
TC5	Jul-10	LTBB	--	--	--	0.014	0.48
TC5	Aug-10	LTBB	--	--	--	0.023	0.80
TC5	Sep-10	LTBB	--	--	--	0.017	0.60
TC5	Oct-10	LTBB	--	--	--	0.071	2.50
TC 5	Jun-11	TOMWC	1.93	0.151	0.221	0.033	1.18
TC5	Jan-13	TOMWC	1.45	0.432	0.937	0.405	14.30

TCT-UM = Tannery Creek Team from Unviersity of Michigan – Ann Arbor
LTBB = Little Traverse Bay Band of Odawa Indians
TOMWC = Tip of the Mitt Watershed Council

APPENDIX C: RAW DATA FOR BIOTIC INDEX VALUES

The below table presents Hilsenhoff family-biotic index values and stream condition for TC3 (upstream of human impact) and TC5 (downstream of human impact). Data were collected in Tannery Creek, Petoskey, MI by the Watershed Council in conjunction with volunteers. Higher FBI scores indicate poorer water quality conditions.

TABLE 42: HILSENHOFF FAMILY BIOTIC INDEX VALUES (RAW DATA)

Date	Location	FBI Score	Condition
Sept. 22, 2007	TC3	3.10	Excellent
	TC5	3.62	Excellent
May 17, 2008	TC3	3.49	Excellent
	TC5	4.65	Good
Sept. 20, 2008	TC3	4.41	Very good
	TC5	3.53	Excellent
May 16, 2009	TC3	2.91	Excellent
	TC5	3.94	Very good
May 22, 2010	TC3	3.62	Excellent
	TC5	5.83	Fairly poor
Sept. 18, 2010	TC3	3.30	Excellent
	TC5	3.10	Excellent

APPENDIX D: MICORPS STREAM RATING SYSTEM

Tip of the Mitt Watershed Council has been using the MiCOPRS water quality evaluation system to score streams in their service area. Using the MiCORPS system we can translate the data collected during the rapid bioassessment into characterizations of water quality. It uses insect orders and places them into three categories, sensitive, somewhat-sensitive, and tolerant, based on their pollution tolerance levels. It should be noted, however, that two streams of identical chemical water quality and different habitat could yield different assessments of water quality using this index.

Stream quality scores are calculated via the following procedure:
R (rare) = 1-10 individuals found, **C** (common) = 11 or more individuals found

Group 1	Group 2	Group 3
____# R's * 5.0 =____	____ # R's * 3.0 =____	____ # R's * 1.1 =____
____# C's * 5.3 =____	____ # C's * 3.2 =____	____ # C's * 1.0 =____
Group 1 Total ____	Group 2 Total____	Group 3 Total____

Total stream quality score (*round to nearest whole number)* ____

Assessment of quality: **Excellent** (>48), **Good** (34-48), **Fair** (19-33), **Poor** (<19)

TABLE 43: TANNERY CREEK WATER QUALITY CHARACTERIZATIONS (MICORPS)

Date	Site	Score	Assessment
June 9, 2012	TC4	18	Poor
	TC5	25	Fair
June 10, 2012	TC1	18	Poor
	TC2	25	Fair
	TC3	16	Poor

APPENDIX E: BUSINESS/RESIDENT SURVEY RESULTS

Businesses		Residents	
Surveys sent	75	Surveys Sent	61
Responses Received	18	Responses	27
Response Rate	24%	Response Rate	44%

Before receiving this survey, were you aware that Tannery Creek flows near the property of your business?

Businesses

	Response	%
Yes	12	71%
No	5	29%
Total	17	100%

Residents

Answer	Response	Percent
Yes	26	100%
No	0	0%
Total	26	100%

How do you currently use Tannery Creek? Please indicate the frequency you engage in the following activities:

Residents

	Never	Never, but would like to	Rarely (1-3 times per year)	Sometimes (1-3 times per month)	Often (once a week or more)	Total
Fishing (Catch and Release)	22	3	1	0	0	26
Fishing (For Consumption)	24	0	0	0	0	24
Swimming/Wading	21	1	2	1	1	26
Relaxation	13	0	0	4	8	25
Wildlife Viewing	8	2	1	4	11	26
Other*	3	0	1	0	1	5

How would you rate the condition of the creek as viewed from your property?

Businesses

Answer	Response	%
Very Good	0	0%
Good	3	43%
Fair	3	43%
Poor	1	14%
Total	7	100%

Residents

Answer	Response	%
Excellent	11	46%
Good	9	38%
Fair	3	13%
Poor	1	4%
Total	24	100%

When looking at the creek, do you notice any of the following? Please check all that apply.

Businesses

Answer	Response
Trash/Litter	4
Invasive Species/Weeds	2
Erosion	2
Unpleasant Odor	0
Discoloration	2
Other	6

Residents

Answer	Response	%
Trash/Litter	6	32%
Invasive Species/Weeds	5	26%
Pooling/Flooding	5	26%
Erosion	4	21%
Discoloration	2	11%
Native Species Depletion	1	5%
Unpleasant Odor	1	5%
Other	9	47%

Have you noticed any pooling or flooding on your property after a large rainstorm?

Answer	Response	%
Yes	6	38%
No	10	63%
Total	16	100%

What percentage of your property is paved? (This includes parking lots, driveways, sidewalks and any other paved surfaces.)

Businesses

< 5%	3	18%
5 - 25%	4	24%
25 - 50%	5	29%
50 - 75%	3	18%
> 75%	2	12%
Total	17	100%

Does your business have an established liquid waste management plan?

Answer	Response	%
Yes	3	20%
No	12	80%
Total	15	100%

In the winter, do you apply salt or other deicers to your driveway, parking lot, and/or sidewalks?

Businesses

Answer	Response	%
Yes	16	94%
No	1	6%
Total	17	100%

Residents

Answer	Response	%
Yes	11	44%
No	14	56%
Total	25	100%

How frequently is the lawn mowed?

Businesses

Answer	Response	%
Weekly/As Needed	11	69%
Bi-weekly	3	19%
3x per Month or less	1	6%
Unknown	1	6%
Total	16	100%

Residents

Answer	Response	%
Weekly	17	74%
Bi-weekly	2	9%
Every 3 Weeks	2	9%
Monthy	1	4%
Never/None	1	4%
Total	23	100%

Is the lawn mowed directly to the creek edge?

Businesses

Answer	Response	%
Yes	0	0%
No	9	100%
Total	9	100%

Residents

Answer	Response	%
Yes	0	0%
No	25	100%
Total	25	100%

Please indicate the type of vegetation or material adjacent to the creek on your property:

Residents

Answer	Response	%
Trees/Shrubs	18	86%
Tall Grass	17	81%
Herbaceous Plants/Flowers	10	48%
Rock Wall/Cement	2	10%
Other	3	14%

Is fertilizer applied to the lawn or garden?

Businesses

Answer	Response	%
Yes	7	41%
No	6	35%
Unknown	4	24%
Total	17	100%

Residents

Answer	Response	%
Yes	12	48%
No	12	48%
Unknown	1	4%
Total	25	100%

Does the fertilizer contain phosphorus? (This information can be found on the packaging of your fertilizer.)

Residents

Answer	Response	%
Yes	2	29%
No	5	71%
Total	7	100%

Are pesticides applied?

Businesses

Answer	Response	%
Yes	4	24%
No	10	59%
Unknown	3	18%
Total	17	100%

Residents

Answer	Response	%
Yes	7	28%
No	17	68%
Unknown	1	4%
Total	25	100%

Does your home have a septic system?

Residents

Answer	Response	%
Yes	16	62%
No	10	38%
Total	26	100%

APPENDIX F: RAPID BIOASSESSMENT SCORES

Below are rapid bioassessment scores[91] for all sample sites on Tannery Creek in Petoskey, MI. The assessment was performed June 10, 2012 by UM project team. This assessment is meant to account for the instream and riparian habitat conditions at each sample site. The results can be used, in conjunction with water chemistry and biological data, to make conclusions about overall site health and to inform management recommendations. It is conducted by a simple visual evaluation of each parameter listed in the table below.

TABLE 44: RAPID BIOASSESSMENT SCORES FOR TANNERY CREEK 2012

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
Epifaunal substrate/available cover	17 Optimal	11 Suboptimal	17 Optimal	10 Poor	13 Suboptimal	4 Poor
Pool substrate characterization	15 Suboptimal	12 Suboptimal	17 Optimal	11 Suboptimal	16 Optimal	4 Poor
Pool variability	10 Marginal	6 Marginal	1 Poor	14 Marginal	5 Poor	7 Marginal
Sediment deposition	18 Optimal	17 Optimal	19 Optimal	16 Suboptimal	11 Suboptimal	12 Suboptimal
Channel flow status	20 Optimal	18 Optimal	19 Optimal	20 Optimal	16 Optimal	18 Optimal
SUBTOTAL	**80 Optimal**	**64 Suboptimal**	**73 Suboptimal**	**71 Suboptimal**	**61 Suboptimal**	**52 Suboptimal**

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
Channel alteration	20 Optimal	17 Optimal	18 Optimal	13 Suboptimal	20 Optimal	14 Suboptimal
Channel sinuosity	20 Optimal	19 Optimal	13 Suboptimal	16 Optimal	20 Optimal	11 Suboptimal
Bank stability (L)	9 Optimal	10 Optimal	7 Suboptimal	10 Optimal	7 Suboptimal	7 Suboptimal
Bank stability (R)	9 Optimal	10 Optimal	5 Marginal	10 Optimal	7 Suboptimal	7 Suboptimal
Vegetative protection (L)	10 Optimal	10 Optimal	9 Optimal	10 Optimal	8 Suboptimal	7 Suboptimal
Vegetative protection (R)	10 Optimal	10 Optimal	9 Optimal	10 Optimal	8 Suboptimal	7 Suboptimal
Riparian vegetative zone width (L)	10 Optimal	10 Optimal	1 Poor	8 Suboptimal	9 Optimal	9 Optimal
Riparian vegetative zone width (R)	10 Optimal	10 Optimal	9 Optimal	8 Suboptimal	9 Optimal	9 Optimal
SUBTOTAL	**98 Optimal**	**95 Optimal**	**71 Suboptimal**	**85 Optimal**	**88 Optimal**	**71 Suboptimal**

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
OVERALL TOTAL	**178 Optimal**	**159 Optimal**	**144 Suboptimal**	**156 Optimal**	**149 Suboptimal**	**116 Suboptimal**

Overall scoring key:
150-200 = optimal
100-149= suboptimal
50-99 = marginal
0-49 = poor

Autumn Olive

[92]Autumn Olive is a tree that originated in East Asia, introduced in the United States as a landscaping plant and for road-bank stabilization.[93] It can grow to be approximately 20' tall, with dark-green, alternate leaves.[94] One defining characteristic of Autumn Olive is the silver-white color of the underside of the leaves. It produces yellow flowers along the twigs, followed by the production of abundant reddish-pink berries. The main mode of reproduction is through bird foraging and seed dispersal. In addition to abundant seed production, Autumn Olive has the ability to adapt to many environments, and grows rapidly, thereby suppressing native plant species. In addition, the tree is a nitrogen-fixing plant, which alters the soil chemistry, disrupting the ability of certain species to grow.[95]

Common Buckthorn

[96]Common buckthorn is a tree that originated in Eurasia, often utilized in the United States as a hedgerow or fence-line plant. If left untreated, the plant will grow into a large tree, up to 25' tall.[97] It may also be found growing as a dense shrub, with multiple intertwined branches. You can identify the shrub by the sub-alternate branching, glossy dark-green leaves, dark blue berries, and dark grey bark. Representative of its name, you may find a thorn located at the tips of branches, between the terminal buds. In addition, just under the surface of the bark, buckthorn is bright orange in color. Buckthorn produces its leaves earlier in the spring than many native species and loses its leaves later in the fall, thereby gaining a competitive advantage by shading out other species. It reproduces through abundant, bird-dispersed berries, but may also regenerate through root and stump sprouts. Buckthorn is prevalent along Tannery Creek, with dense stands found along the lower portion of the creek, and extending along the shoreline of Little Traverse Bay.

Crown Vetch

[98]Crown Vetch is a perennial plant in the legume (pea) family, originating in Eurasia. You can identify this plant by its purple to white flowers, and leaves resembling that of a pea plant. In many areas in the United States, the plant was introduced as a method for controlling and preventing erosion.[99] The plant spreads extensively, able to cover an area of over 100 square feet in just a few years' time.[100] It spreads mostly by rhizomes that can individually grow up to 10 feet in length. In addition, it has the ability to reproduce through seeds. Due to its ability to quickly spread and cover large areas, crown vetch will shade out native herbaceous species. Partially hidden by taller vegetation, crown vetch exists in a small area along Tannery Creek, behind a bend in the creek where it flows through the town of Petoskey.

Garlic Mustard

[101]Garlic mustard is a cool-season biennial plant, originally from Eurasia.[102] The plant grows in dense patches along the forest floor, crowding out native wildflowers and herbaceous plants. Garlic mustard has an additional advantage by being alleopathic.[103] In other words, it releases chemicals that inhibit the growth of other plants. Garlic mustard can be identified by its heart-shaped leaves, which will grow in rosettes close to the ground during its first year. In the spring of its second year, the plant will grow to a height of 1-4 feet. The most notable identifier of garlic mustard is the strong garlic-like odor. Garlic mustard reproduces in the second year of its growth cycle, with bunches of small white flowers at the top of the stems. The plant produces erect, slender seed pods, ultimately releasing thousands of seeds per plant.[104] The plant stores

enough energy in its tap root to produce seeds, even after being removed from the soil. These seeds can then stay viable in the seed bank for up to 5 years. There is a large patch of garlic mustard near the mouth of Tannery Creek, with patches extending into the wooded area.

Giant Knotweed

[105]Giant knotweed is an herbaceous perennial plant originating in Japan. It was introduced in the United States for ornamental gardening and erosion control.[106] Its relative, Japanese Knotweed, is recognized as a prohibited plant species in the state of Michigan.[107] Giant Knotweed grows hollow stalks, reaching up to 12 feet in height. It has large, alternate leaves, each 6-14 inches long. It grows in thick stands and spreads aggressively through rhizomes which can extend 23 feet or more from the plant. Relying primarily on its rhizomes for reproduction, the plant produces few viable seeds. However, it can also sprout from broken stems. Dense stands of knotweed can quickly crowd out native vegetation, leading to increased erosion on stream banks. In addition, it is capable of clogging small waterways, thereby reducing riparian habitat.[108] There is a large stand of giant knotweed on the bank of the lower portion of Tannery Creek.

Goutweed

[109]Goutweed, also known as Snow-on-the-Mountain or Bishop's Weed, is a perennial groundcover plant from Europe and Northern Asia. The plant is often used as a low-maintenance ground cover. Wild varieties of the plant have leaves of a medium-green color. In contrast, some varieties, originally introduced for their ornamental value, have bluish-green leaves that are outlined in white. Due to its long, branching rhizomes, Goutweed form dense patches that are able to exclude the growth of other herbaceous species. In particularly dense populations, it may even have the ability to preclude the growth of tree species.[110] There is a small patch of goutweed in the wooded area of the lower reaches of the creek, near the mouth.

Multiflora Rose

[111]Multiflora rose is an ornamental plant, originating in Eastern Asia. It was originally introduced as a rootstock for ornamental roses, and later was used for erosion control, as a fence-line plant in agricultural regions, and for wildlife cover. It has even been planted on highway medians to serve as crash barriers and reduce the visual disturbance of oncoming traffic headlights. The plant usually occurs as a shrub, but can also be a climbing vine. As is common in the rose family, it has thorns along its stems, and showy, fragrant flowers, typically white to pinkish. It reproduces through rose hips that are distributed widely by a variety of bird species, with a single plant producing millions of seeds annually.[112] Multiflora rose grows in dense thickets, excluding the growth of other herbaceous plant species. In addition, it has the ability to interfere with native bird nesting.[113] There is a thicket of Multiflora rose downstream of the Little Traverse Wheelway and along the walking path near the mouth.

Narrow-leaved Cattail

[114]Narrow-leaved Cattail is an aquatic perennial, originating in Eurasia. It grows 3 to 6 feet erect, with narrow, flat leaves reaching 2 to 5 feet long. Its flowers, the source of the plant's name, are cigar shaped and velvety brown in color. The flowers eventually release up to 250,000 seeds, to be wind-dispersed and remain viable for up to 100 years. In addition, the plant has the ability to reproduce via rapidly spreading and densely growing rhizomes,

prohibiting the growth of other species. Narrow-leaved Cattail poses a threat to wetland areas due to its ability to rapidly spread, thereby limiting native plant growth and biodiversity of the ecosystem, eventually resulting in a monoculture stand.[115]

Purple Loosestrife

[116]Purple Loosestrife is a perennial herb, originating in many parts of Europe and Asia. It is recognized as a restricted plant species in the state of Michigan.[117] It can grow 4 to 10 feet high, with a square woody stem, often covered in fine hairs, with opposite or whirled leaves.[118] Its most notable characteristic is the showy magenta-purple flowers that grow along the tip of the stalk for an extended season lasting most of the summer. Each plant can produce more than 2 million seeds per year.[119] In addition, it reproduces through stems that emerge from the rootstock. Purple loosestrife has the ability to adapt to a variety of wetland conditions, both natural and disturbed. Once established, the plant can displace native grasses, sedges, and other native wetland plant species, ultimately affecting waterfowl habitat.[120] There are established stands of purple loosestrife along the mouth of Tannery Creek, and the species also poses a threat to the wetlands of the watershed.

Reed Canary Grass

[121]Reed Canary Grass is a perennial grass, originating in Europe, Asia, and even North America. It was vastly planted in the United States for forage and erosion control.[122] Its invasive nature is thought to be due to selective cultivation, which encouraged vigorous growth.[123] Its stalk grows 2 to 6 feet tall with leaf blades that extend 3 ½ to 10 inches long with a coarse texture and rough edges. The compact flowers occur in dense clusters near the tip of the stalk, green to purple in color, eventually changing to a brown or beige color later in the season. It grows and spreads rapidly, making it highly competitive with other plants. Due to this rapid growth and its ability to inhibit growth of other species, it causes a serious threat to wetlands and stream banks. It can also spread to drier soils of upland and woodland habitats.[124]

Spotted Knapweed

[125]Spotted knapweed, native to central Europe and Russia, is a short-lived perennial flowering plant. The plant was first introduced as a contaminant in domestic alfalfa seed[126]. It is recognized as a prohibited noxious weed in the state of Michigan[127]. In its first year, it grows as a ground-level rosette and flowers in its subsequent years. It is hairy in appearance with alternative leaves, a deep taproot and flowering stems that can grow 8 to 50 inches tall. The flowers are purple to pink, with up to 35 flowers per head, growing in clusters of two or three. Spotted knapweed has the ability to outcompete native plants by releasing a toxin in the soil that hinders the growth of other species, resulting in decreased species diversity. It produces up to 4000 seeds per square foot, which remain viable in the soil up to 8 years. In addition, it can affect soil and water quality through erosion and surface runoff.[128]

METHODOLOGIES, DATA, AND OUTREACH MATERIALS

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WATER QUALITY RESEARCH METHODOLOGIES

Water Chemistry

The study team sampled the Creek at five different locations. Sampling dates were June 9, June 13, July 7, August 20, and October 15, 2012. (On the October sampling trip a location was added on the Bachelor Property at the headwaters of the Creek.)

TABLE 45: SITE LOCATIONS ALONG TANNERY CREEK, BEAR CREEK TOWNSHIP, MI. SAMPLED BY STUDY TEAM IN 2012

Site Label	Location Description	Samples Collected
TCHW	Headwaters – Bachelor Property	1
TC1	West Tributary at Mitchell Rd	5
TC2	Boyer Rd	5
TC3	Mitchell Rd	5
TC4	Country Club Dr.	5
TC5	Little Traverse Wheelway	5

The physical parameters measured were temperature, pH, dissolved oxygen, specific conductivity, flow and turbidity. With the exception of turbidity and flow all physical parameters were measured using a Hydrolab provided by the Watershed Council. Turbidity was measured using a nephalometer provided by the Allen Burton laboratory at the School of Natural Resources and Environment. Turbidity data was only collected during the June 9th trip, because data appeared inaccurate. It is unclear if fault lies with the nephalometer or operator error. Flow data was qualitative and collected based on the study team's observations. Physical data was only collected on June 9, August 20, and October 15.

The study team also collected chemical data during the same time frame mentioned above and taken to the University of Michigan Biological Station for testing. Samples were tested for the following: phosphate (PO_4), Ammonium (NH_4), Nitrate (NO_3), Chloride (Cl), Sulfate (SO_4), total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS).

To look for long-term trends, and to more accurately characterize the watershed, the study team obtained data previously collected by the Little Traverse Bay Band of Odawa Indians. The Tribe collected both physical and chemical data at two sites, TC2 and TC5. In terms of chemical data, the tribe only collected data for chloride, total phosphorus, total nitrogen, and total suspended solids.

Hydrology

In order to collect discharge measurements, the study team chose a simple field method utilizing a meter tape, a meter stick, and an orange peel. To calculate discharge[129], the measurements collected were put into the equation:

$$Q = Av$$

Where Q is discharge, in cubic meters per second (cms), A is the cross-sectional area of the stream channel at the chosen transect in square meters, and v is the mean velocity at the chosen transect, in m/s. Calculations are often also reported in cubic feet per second (cfs).

To calculate cross-sectional area, two measurements must be taken: stream channel width and stream depth. This is achieved using the meter tape and meter stick. First, the width of the stream is measured at the location of the wetted width. This is simply the edge of the water at the left and right banks. Once this location is determined, the meter tape is stretched across the channel to find the overall width of the stream. That width is then divided into equal sections. The depth is measured at each interval. The depth at a given interval is multiplied by the interval width to provide cross-sectional area for that sub-section.

To measure mean velocity a neutrally buoyant object, the orange peel, was placed in the stream and allowed to travel 2 meters. The time it took for the peel to travel was recorded and divided by two to get the velocity. This was repeated four times and an average was taken to find the mean velocity of the stream. The cross-sectional area at each sub-section was then multiplied by mean velocity to find discharge for that sub-section. Summing the discharges for all intervals gives the overall discharge of the stream at the chosen transect.

Biological Community

Benthic macroinvertebrates were collected at each site according to EPA Rapid Bioassessment Protocols. [130] The multi-habitat approach with a D-frame dip net was followed as outlined in the protocol manual, excepting two modifications. The study team sampled during a fifteen minute time period at each site in different habitat types and noted the percentage of time sampled in each type on the field data sheet. Also, samples were processed and identified in the field, not in a laboratory setting. Invertebrates were identified by a trained team member. Field data sheets from Appendix A-3 were utilized to record findings.[131]

Physical and Riparian Conditions

An inventory of the physical and riparian conditions at each site was taken according to EPA Rapid Bioassessment Protocols.[132] The protocol sets out different instream and riparian habitat parameters that are scored from 0-20 or 0-10 depending on the parts of the stream each parameter addresses. For example, when scoring stream cover, a maximum of 20 points is available. Conversely, when observing bank stability, a maximum of 10 points is available for each bank. This data was collected by visual observation and entered into field data sheets from Appendix A-1.[133]

The L-THIA model is a watershed analysis tool that provides estimates of runoff, recharge and non-point pollution for a particular area.[134] A joint project of Purdue University and the EPA, L-THIA was developed and integrated with ArcGIS to estimate direct runoff from inputs of yearly rainfall averages, land uses, and hydrologic soil groups. The model utilizes the SCS CN method, which is a widely used and simple empirical method for determining the approximate amount of runoff from either a single event or for average annual runoff, given certain conditions (no routing, unfrozen ground, and antecedent moisture conditions), for a particular area. The model also employs standard non-point pollution (P, N, SS, etc.) coefficients to determine pollution loading amounts.

The SCS CN method combines factors of soil hydrologic group, land cover, precipitation, and antecedent runoff condition to calculate CN values, from which direct runoff can be determined. [135] The general equation for the SCS CN method is as follows:

(1) $Q = \frac{(P-I_a)^2}{(P-I_a)+S}$

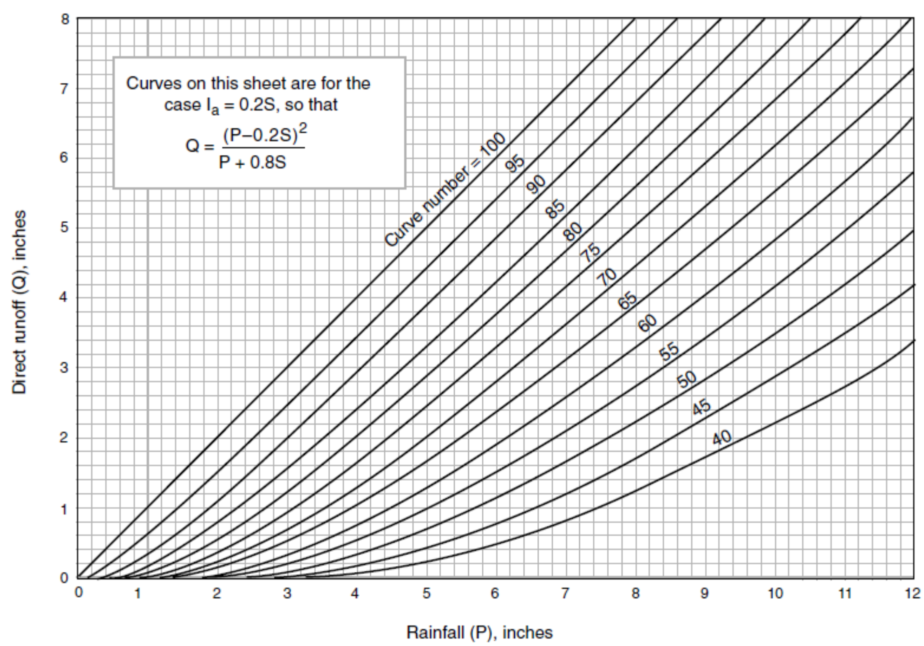
Q= runoff (in)

P= rainfall (in)
S= Potential maximum retention after runoff begins
I_a = initial abstractions

(2) $I_a = 0.2S$

(3) $Q = \frac{(P-0.2S)^2}{(P+0.8S)}$

(4) $S = \frac{100}{CN} - 10$



Source: USDA TR-55

FIGURE 38: URBAN HYDROLOGY FOR SMALL WATERSHEDS

Soil hydrologic groups are classified according to minimum infiltration rate, which is a product of soil permeability as well as surface intake rates. Hydrologic soil group A has the highest minimum infiltration rate, while D has the lowest (see soils section for HSG infiltration rates and descriptions). Each land cover type is assigned an impervious surface cover percentage (e.g. Commercial: 85%) and this value is used in calculating CN values. Rainfall data is gathered from local municipal sources available online.

The L-THIA model therefore is a useful and readily available tool for estimating runoff volumes for past or proposed land use scenarios. For the Tannery Creek watershed project, the team utilized GIS to create several land use/land cover scenarios—“Current”, “Build-out”, “Conservation 50”, Conservation 100”-- for the watershed and then ran these through the ArcView GIS L-THIA application to produce runoff and non-point pollution volumes for each scenario. The goals of this exercise were to gather information on the watershed’s current hydrology, evaluate potential effects of land use change on water quality and stream condition, identify best location for a particular land use and locations suited for preservation, and to generate community awareness of these potential problems through a visual medium. The “Current” land use grid represents current land use conditions; the “Build-out” includes land use according to a full realization of zoning designations (i.e. full development as allowed by the zoning code) and location of significant natural features; the “Conservation 50” and “Conservation 100” scenarios use the same land use grid as the “Build-out” scenario but CN values are altered at intervals according to reductions in impervious surfaces for developments that utilize Low Impact Development techniques, such as rain gardens or thinner driveways.

Methods

The first step in preparing data for processing in L-THIA was to delineate Tannery Creek’s watershed from a Digital Elevation Model (DEM), obtained from the Michigan Geographic Data Library, utilizing ArcGIS hydrology extension tools. The team verified the watershed boundary through several visits to the watershed to ensure that any man-made surfaces did not alter the course of water at the boundaries and, if so, adjusted the boundary accordingly to account for these changes.

The “Current” land use grid was developed from land use/land cover data provided by the National Land Cover Database (NLCD) 2001. The L-THIA GIS model only recognizes 8 land use classes (Water/Wetland, Commercial, Agricultural, HD Residential, LD Residential, Grass/Pasture, Forest, Industrial) and for each it applies a particular impervious surface count. As such, after clipping the NLCD 2001 to the watershed’s extent, the team reclassified the NLCD land use classes to those recognized by L-THIA, using impervious cover as converter. Table 16 illustrates this process.

The “Build-out” land use grid was created so that the team could present how development could potentially impact watershed hydrology and stream conditions. The current zoning code, administered by Emmet County, is a strong indicator of how and where the community wishes to see the area develop. Zoning codes set restrictions for the type of land use that can occur in a certain area (e.g. commercial or residential) and the density for these developments (usually set by number of units per acre and/or in percent total coverage in built surfaces per acre and/or per lot). Given this information, the team assumed that a “build-out” scenario is one where the community realizes the full definitions of the zoning code through development. Impervious surfaces were estimated from density restrictions and lot coverage set by the zoning code and translated into L-THIA-specific land cover classes (see Table 17). Land cover from the “Current” land cover scenario was overlain with these new land cover classifications and translated as such. However, it is not accurate to assume that ever acre of land would be developed, as construction is restricted by the presence of natural feature protected by law (i.e. wetlands and riparian areas), plots with growth restrictions or under easement, and areas with prohibitive conditions (i.e. steep slopes, unsafe soils, etc.). Therefore, the team assumed certain natural features would not transfer to new land cover classifications, retaining the original land cover defined in the “Current” scenario land cover grid. These areas include: wetlands, high slope areas (>25%), areas with known development restrictions (easements, preserves), and riparian areas (one 30x30 grid cell buffer around stream polyline).

The "Conservation 50" and "Conservation 100" scenarios were developed to show the positive effects Low Impact Developments have on limiting runoff from developed areas. These scenarios have the same land cover as the "Build-out" but impervious surface counts and consequently CN values were altered to reflect inclusion of LID methods. Reductions in impervious surfaces and CN outputs were extracted from the L-THIA online model, which presents standardized reduction values for given LID techniques (e.g. bio swales, rain gardens, sidewalk thinning). The "Conservation 100" land cover scenario assumes adoption of every LID technique (at least those calibrated/catalogued in the L-THIA online model) and CN values were reduced by the maximum amount, or 100%. The "Conservation 50" assumes 50% of possible CN reductions.

Hydrologic soul group data was extracted from the national Resources Conservation Service SSURGO soils database and transformed into raster grid format using ArcGIS tools. Precipitation data was downloaded from the L-THIA online database.

Community outreach and stakeholder engagement were vital to the watershed management plan formulation. The researchers utilized a mixed-media approach, consisting of surveys, one-on-one interviews and meetings, press releases, mailings and announcements. The main goals of community outreach were increasing awareness among the community and utilizing local knowledge to inform the plan process.

To determine relevant stakeholders, the study team utilized GIS data to delineate watershed boundaries, including all parcel data within the watershed. All businesses within the entire watershed were included, while only those residents with riparian properties were included. Throughout the process, the team updated contact information, and removed certain businesses from the list when on-site assessment revealed the properties to fall outside of watershed boundaries. In addition to residents and business owners, the team contacted local government officials, such as city and county planners, the local Native American tribe, the land conservancy, and the historical museum. Initial conversations with stakeholders revealed further contacts, such as property owners and managers.

Since this portion of the research involved human subject participation, the team completed the University of Michigan Health Sciences and Behavioral Science Institutional Review Board (IRB) process. Each team member completed training regarding the ethical implications of the use of human subjects in research. In addition, they submitted an application regarding proposed survey and interview methodologies. The IRB deemed the research exempt status, and therefore free from additional monitoring and oversight by the IRB.

The Process

The study team began the process of stakeholder engagement in June 2012, with an introductory postcard. The purpose of the postcard was to introduce residents and businesses to the project and team members. (See Public Outreach Materials for a copy of Introductory Postcard). Accompanying the postcard was an introductory press release in the Petoskey News-Review, written by reporter Morgan Sherburne, providing an overview of the project and the team.

In August 2012, the study team produced and distributed surveys to businesses and residents in Tannery Creek Watershed. Questions and methods of delivery differed based on survey recipient category (i.e., riparian resident, riparian business, general business). The following categories of questions were included: Awareness, Current Interactions, Perceptions of Water Quality, Concerns, Property Information, Recipient Demographics, Property and Landscape Management, and Follow-Up Preferences. (See Resident/Business Survey Data for the full survey and results.) All riparian residents received the survey via mail, with an introductory letter and self-addressed, stamped envelope included. The study team hand-delivered surveys to all businesses in the watershed in 'outreach folders'. Besides housing the survey, the folders included information regarding the Watershed Council, study team and project, as well as, self-addressed, stamped return envelopes. Prior to in-person delivery, the team called each business to announce the visit, determine proper business contacts, and schedule meeting times.

To encourage greater survey return rates, the team mailed reminder postcards to all survey recipients (found in Public Outreach Materials) and personally called all business contacts to offer in-person survey collection. In October 2012, members of the survey team visited priority businesses and residents for in-person survey collection, to discuss specific water quality concerns, and to strengthen stakeholder relationships. The study team determined priority contacts based on level of responsiveness during initial meetings, personal communication following survey disbursement, suggestion of other contacts, proximity to the waterway, and potential for impact. Through this process, the team identified community members that could serve as potential allies for protection of the creek. Following the October visit, the team, in conjunction with Morgan Sherburne at the Petoskey News-Review, released a second press release. This article described the initial results of water quality analysis, and quotes from community members. It also included a URL address to complete the survey online.

In March 2013, the study team hosted a town hall style community meeting, the Tannery Creek Community Forum, to present research results regarding survey, water quality, and GIS data. In addition, the team announced future methods of involvement for the community, including volunteer opportunities, upcoming meetings, and the potential for serving on a sub-committee of the Little Traverse Bay Watershed Advisory Committee. To encourage attendance, the team sent Save the Date announcements and formal invitations to all residents and businesses in the watershed. (See Public Outreach Materials for a copy of the forum invitation.) The team also called every riparian resident and high priority business. Morgan Sherburne of Petoskey News-Review wrote a press release announcing the meeting, released the week prior to the meeting. The team also called and emailed key contacts such as city planners and representatives of the Little Traverse Bay Band of Ottawa Indians.

The team chose to offer two times for the community forum, in order to accommodate the schedules of businesses and community members. This tactic proved successful, with approximately 15 community members and business representatives in attendance at each meeting. In addition, the team secured donations from local businesses to provide refreshments for the meetings. In addition to the presentation, the study team distributed general information regarding the watershed, including a map of the watershed, and information about future involvement in Tannery Creek Watershed protection, including a schedule of events and contact information. Meeting attendees were thoughtful and engaged, asking many questions regarding the water quality of the creek and effects of development. The team received positive feedback from the meeting attendees and several individuals discussed interest in continuing involvement and volunteer opportunities. (See Community Forum Evaluation Results for full survey and responses.)

The Tannery Creek Community Forum served as the formal method of handing-off management of the watershed and community involvement from the study team to the client, the Watershed Council. Staff members from the Watershed Council were present to answer questions and assist community members with future involvement. Morgan Sherburne of Petoskey News-Review attended the forum and wrote a final press release regarding the project. The article detailed the main themes of the meeting and included information about how to be involved in future management of the creek.

Future Outreach and Community Engagement

The relationships built during the process of creating the watershed management plan will be essential to implementation of the plan. The team presented residents and businesses with opportunities for future involvement, including information regarding upcoming meetings, volunteer opportunities, and the option to form a sub-committee of the Little Traverse Bay Watershed Advisory Committee. In addition, the team created a special opportunity for businesses of the watershed to become involved in watershed protection through participation in a business recognition program, entitled *Aqua-Stars*. The purpose of this program is to publicly recognize businesses that complete Best Management Practices (BMPs) for watershed protection as part of their business activities. The program will be available for all businesses in the greater Little Traverse Bay watershed. For a complete program description, see Public Outreach Materials.

WATER QUALITY RAW DATA

Physical and Chemical Data

TABLE 46: PHYSICAL WATER QUALITY RAW DATA ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: JUNE-OCT 2012. COLLECTED BY STUDY TEAM

Site	Date	Flow	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductivity (uS)	Turbidity (NTU)
TC1	6/9/12	High	16.00	--	8.84	506.0	--
TC2	6/9/12	High	16.30	6.78	8.67	417.0	2.92
TC3	6/9/12	High	18.70	6.92	9.36	440.5	0.58
TC4	6/9/12	High	18.30	7.06	9.45	451.6	10.51
TC5	6/9/12	High	17.60	7.02	9.75	435.00	5.49
TCW1	8/20/12	Low	16.01	8.08	9.62	514.2	--
TC2	8/20/12	Low	16.32	7.62	6.77	505.3	--
TC3	8/20/12	Low	14.42	7.88	9.40	634.3	--
TC4	8/20/12	Low	14.65	8.19	10.31	568.4	--
TC5	8/20/12	Low	14.32	8.38	10.30	560.6	--
TCHW	10/15/12	Peak	7.78	8.19	8.93	300.0	--
TC1	10/15/12	Peak	7.69	8.05	8.40	293.4	--
TC2	10/15/12	Peak	7.65	8.03	7.20	283.0	--
TC3	10/15/12	Peak	7.71	8.00	9.43	383.9	--
TC4	10/15/12	Peak	7.80	8.06	12.9	349.0	--
TC5	10/15/12	Peak	7.87	8.14	11.25	356.3	--

TABLE 47: CHEMICAL WATER QUALITY DATA ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: JUN-OCT 2012 COLLECTED BY STUDY TEAM

Site	Date	Phosphate (ug/L)	Ammonium (ugN/L)	Nitrate (ug N/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (ug P/L)	Total Nitrogen (mg N/L)	Total Suspended Solids (mg/L)
TC1	6/9/12	17.44	27.4	108.60	46.0	<1	29.2	0.482	17.0
TC2	6/9/12	2.24	21.6	288.50	16.0	<1	8.3	0.566	25.0
TC3	6/9/12	2.09	23.9	236.30	17.0	<1	5.1	0.531	9.0
TC4	6/9/12	7.44	8.4	184.75	33.0	<1	15.3	0.493	23.0
TC5	6/9/12	6.32	7.5	231.40	30.0	<1	13.4	0.528	30.0
TC1	6/13/12	20.71	4.8	1053.90	49.0	11.0	20.1	1.079	6.0
TC2	6/13/12	2.61	4.3	837.92	17.0	11.0	6.6	0.903	4.0
TC3	6/13/12	1.82	5.5	816.32	18.0	11.0	3.0	0.843	3.0
TC4	6/13/12	3.95	4.2	773.76	32.0	12.0	7.3	0.843	3.0
TC5	6/13/12	1.73	7.5	765.12	32.0	12.0	6.6	0.870	34.0
TC1	7/7/12	2.90	25.6	378.90	18.6	7.4	2.9	0.794	94.0
TC2	7/7/12	1.80	18.8	1050.30	13.5	9.4	1.0	1.133	85.3
TC3	7/7/12	1.40	29.2	909.60	16.6	9.6	1.0	1.032	87.3
TC4	7/7/12	1.70	4.7	1043.70	21.7	10.5	7.4	1.101	94.0
TC5	7/7/12	1.40	103.8	901.60	19.2	9.0	5.9	1.213	96.7
TCW1	8/20/12	15.00	<1	1240.40	41.4	10.6	17.7	1.442	2.0
TC2	8/20/12	2.80	4.5	436.80	17.6	10.9	2.6	0.732	8.7
TC3	8/20/12	2.60	1.4	425.90	19.6	11.2	4.1	0.703	1.3
TC4	8/20/12	3.20	1.7	552.60	35.5	11.2	2.3	0.796	2.7
TC5	8/20/12	2.60	1.4	627.80	35.1	10.6	2.2	0.883	2.0
TCHW	10/15/12	2.70	8.8	355.80	11.1	--	4.5	0.802	3.2
TC1	10/15/12	11.10	8.6	94.20	39.1	--	13.8	0.504	2.8
TC2	10/15/12	3.70	10.8	48.10	12.0	--	6.8	0.565	1.2
TC3	10/15/12	3.80	12.8	28.70	17.4	--	7.2	0.559	1.2
TC4	10/15/12	5.40	8.4	57.40	29.5	--	8.9	0.482	4.0
TC5	10/15/12	4.30	9.1	108.90	47.1	--	7.6	0.537	4.4

TABLE 48: PHYSICAL WATER QUALITY DATA FOR SITE TC2 ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: 2006-2011. DATA PROVIDED BY THE LITTLE TRAVERSE BAY BANDS OF ODAWA INDIANS.

Date	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductivity (uS)	Turbidity (NTU)
5/11/06	10.42	7.40	8.07	343.7	--
6/15/06	11.70	7.70	9.4	513.9	--
7/18/06	15.70	7.80	8.99	520.6	--
8/9/06	14.00	7.80	8.75	541.3	--
9/13/06	11.90	7.90	8.83	524.0	--
10/11/06	9.22	7.60	8.55	530.6	--
5/8/08	13.57	7.40	9.92	512.0	2.07
6/10/08	12.93	7.52	8.57	535.5	4.07
7/8/08	13.60	7.56	8.54	528.8	--
8/7/08	16.97	7.89	9.16	550.0	0.58
9/4/08	12.39	7.91	9.70	500.4	3.20
10/2/08	11.42	7.66	10.46	536.3	0.94
2/10/10	2.82	8.01	12.38	499.6	0.13
5/14/10	--	--	10.48	--	--
6/7/10	13.29	7.78	9.65	528.5	--
7/20/10	15.88	7.91	9.40	543.1	--
8/9/10	14.46	7.98	8.78	534.4	1530.00
9/9/10	14.27	7.91	9.21	539.2	--
10/5/10	7.43	7.69	10.09	535.2	--
1/31/11	1.22	6.28	12.13	531.3	--
5/2/11	6.39	7.53	9.66	471.6	--
7/20/11	14.10	7.79	7.98	535.0	--
10/3/11	11.20	7.82	9.71	546.0	--

TABLE 49: CHEMICAL WATER QUALITY DATA FOR SITE TC2 ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: 2006-2011. DATA PROVIDED BY THE LITTLE TRAVERSE BAY BANDS OF ODAWA INDIANS.

Date	Chloride (mg/L)	Total Phosphorus (ug/L)	Total Nitrogen (mg/L)	TSS (mg/L)
5/11/06	17.08	27.2	1.25	15.9
6/15/06	17.48	12.1	1.09	3.0
7/18/06	18.10	7.6	1.02	4.4
8/9/06	16.92	9.1	1.23	8.3
9/13/06	16.14	4.4	1.06	2.3
10/11/06	20.68	10.3	0.95	3.1
5/8/08	24.20	2.5	0.65	24.2
6/10/08	21.68	3.5	0.83	3.3
7/8/08	20.64	6.2	0.89	1.6
8/7/08	21.00	7.7	1.13	3.7
9/4/08	16.93	4.7	1.18	0.8
10/2/08	17.79	1.8	1.18	2.3
2/10/10	22.17	1.9	0.63	2.6
5/14/10	20.40	5.6	0.65	3.6
6/7/10	18.52	5.2	0.65	2.5
7/20/10	19.73	4.3	0.96	3.5
8/9/10	21.08	4.8	1.60	1.6
9/9/10	23.66	6.2	0.83	8.5
10/5/10	19.01	4.2	1.15	1.1
1/31/11	17.30	3.7	1.38	2.8
5/2/11	19.60	4.2	1.27	1.1
7/20/11	19.00	4.6	0.99	9.6
10/3/11	23.08	2.6	1.12	1.6

TABLE 50: PHYSICAL WATER QUALITY DATA FOR SITE TC5 ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: 2006-2011. DATA PROVIDED BY THE LITTLE TRAVERSE BAY BANDS OF ODAWA INDIANS.

Date	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductivity (uS)	Turbidity (NTU)
5/7/02	9.94	7.78	11.39	437.5	--
6/4/02	10.11	8.46	8.98	510.2	--
9/24/02	--	--	--	--	--
10/15/02	7.7	8.13	11.52	556.8	--
5/4/04	5.27	8.04	12.08	482.8	--
6/8/04	9.48	8.11	9.48	555.0	--
7/6/04	13.56	8.35	9.90	489.6	--
8/11/04	13.80	8.31	9.56	483.1	--
9/16/04	15.65	8.45	8.30	476.8	--
5/11/06	10.90	7.90	10.50	445.6	--
7/18/06	17.70	8.32	8.80	527.4	--
8/9/06	18.10	8.32	8.74	555.4	--
9/13/06	13.40	8.30	9.80	537.3	--
10/11/06	9.43	8.21	10.82	555.0	--
8/7/08	17.42	8.23	9.15	551.1	7.88
9/4/08	14.24	8.18	9.83	547.7	1.06
10/2/08	10.31	8.24	11.50	551.4	0.00
3/8/10	2.60	8.93	13.49	576.9	4.76
5/14/10	9.06	8.27	11.27	589.4	--
6/7/10	11.64	8.19	11.39	487.8	--
7/2/10	18.14	8.35	9.15	557.0	--
8/9/10	18.67	8.40	8.77	528.9	1529.00
9/9/10	13.74	8.29	9.99	621.2	--
10/5/10	7.16	8.31	11.84	593.2	--
5/2/11	6.50	8.23	11.86	525.5	--
7/20/11	20.53	8.14	8.72	495.0	--
10/3/11	9.22	8.26	11.44	605.2	--

TABLE 51: CHEMISTRY WATER QUALITY DATA FOR SITE TC5 ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: 2006-2011. DATA PROVIDED BY THE LITTLE TRAVERSE BAY BANDS OF ODAWA INDIANS.

Date	Chloride (mg/L)	Total Phosphorus (ug/L)	Total Nitrogen (mg/L)	TSS (mg/L)
5/7/02	31.5	21.8	0.85	9.5
6/4/02	17.7	8.9	1.24	4.1
9/24/02	31.4	10.6	1.84	14.6
10/15/02	28.4	2.7	0.82	0.5
5/4/04	35.4	11.3	1.40	3.5
6/8/04	30.0	9.0	1.30	4.4
7/6/04	19.0	21.0	1.40	11.1
8/11/04	40.0	23.6	1.18	7.0
9/16/04	20.0	11.0	1.54	14.8
5/11/06	28.0	152.0	2.38	117.4
7/18/06	20.9	15.4	1.39	8.4
8/9/06	24.2	9.2	1.41	5.4
9/13/06	20.5	9.2	1.23	5.2
10/11/06	30.5	14.6	1.05	6.8

8/7/08	26.7	28.5	1.60	30.6
9/4/08	20.6	21.4	1.55	21.0
10/2/08	32.6	6.5	1.32	7.3
3/8/10	48.3	14.2	1.29	9.7
5/14/10	42.0	9.7	1.00	4.4
6/7/10	41.7	8.9	0.67	5.6
7/2/10	26.3	14.7	1.20	15.8
8/9/10	24.4	14.9	1.67	11.5
9/9/10	40.9	7.7	0.71	2.8
10/5/10	34.5	6.6	1.13	2.8
5/2/11	36.9	10.1	1.38	4.8
7/20/11	23.1	30.3	1.12	9.6
10/3/11	40.3	10.4	1.06	3.1

Hydrology

TABLE 52: DISCHARGE DATA FOR FIVE SITES ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI. COLLECTED BY STUDY TEAM: JUNE 9-10, 2012.

Site	Total Width (m)	Cross-Sectional Area (m^2)	Velocity (m/s)	L/s	cfs
TC1	1.1	0.456	0.11	51.4	1.8
TC2	1.5	0.264	0.28	73.7	2.6
TC3	1.5	0.191	0.37	71.4	2.5
TC4	3.5	0.405	0.78	314.0	11.1
TC5	5.6	2.073	0.33	693.4	24.5

TABLE 53: RAW HYDROLOGY DATA FOR FIVE SITES ON TANNERY CREEK. BEAR CREEK TOWNSHIP, MI: JUNE 9-10, 2012. COLLECTED BY STUDY TEAM

Site	Transect Distance (m)	Width (m)	Depth (m)	Cross-Sectional Area (m2)	Velocity (m/s)	L/s	cfs
TC1	0	0.1	0.48	0.048	0.11	5.4	0.19
TC1	0.1	0.1	0.42	0.042	0.11	4.7	0.17
TC1	0.2	0.1	0.49	0.049	0.11	5.5	0.19
TC1	0.3	0.1	0.48	0.048	0.11	5.4	0.19
TC1	0.4	0.1	0.46	0.046	0.11	5.2	0.18
TC1	0.5	0.1	0.45	0.045	0.11	5.1	0.18
TC1	0.6	0.1	0.38	0.038	0.11	4.3	0.15
TC1	0.7	0.1	0.38	0.038	0.11	4.3	0.15
TC1	0.8	0.1	0.47	0.047	0.11	5.3	0.19
TC1	0.9	0.1	0.31	0.031	0.11	3.5	0.12
TC1	1.0	0.1	0.24	0.024	0.11	2.7	0.09
		Total W = 1.1m		**A = 0.456**		**Discharge = 51.4**	**1.8**
TC2		0.15	0.04	0.006	0.28	1.7	0.06
TC2	0.15	0.15	0.16	0.024	0.28	6.7	0.24
TC2	0.30	0.15	0.175	0.026	0.28	7.3	0.26
TC2	0.45	0.15	0.19	0.029	0.28	8.0	0.28

TC2	0.60	0.15	0.205	0.031	0.28	8.6	0.30
TC2	0.75	0.15	0.23	0.035	0.28	9.6	0.34
TC2	0.90	0.15	0.22	0.033	0.28	9.2	0.33
TC2	1.05	0.15	0.21	0.032	0.28	8.8	0.31
TC2	1.20	0.15	0.19	0.021	0.28	8.0	0.28
TC2	1.35	0.15	0.14	0.021	0.28	5.9	0.21
		Total W = 1.5m		**A = 0.264**		**Discharge = 73.7**	**2.6**
TC3		0.15	0.09	0.014	0.37	5.1	0.18
TC3	0.15	0.15	0.15	0.023	0.37	8.4	0.30
TC3	0.30	0.15	0.17	0.026	0.37	9.6	0.34
TC3	0.45	0.15	0.15	0.023	0.37	8.4	0.30
TC3	0.60	0.15	0.16	0.024	0.37	9.0	0.32
TC3	0.75	0.15	0.15	0.023	0.37	8.4	0.30
TC3	0.90	0.15	0.12	0.018	0.37	6.7	0.24
TC3	1.05	0.15	0.14	0.021	0.37	7.9	0.28
TC3	1.20	0.15	0.11	0.017	0.37	6.2	0.22
TC3	1.35	0.15	0.03	0.005	0.37	1.7	0.06
		Total W = 1.5m		**A = 0.194**		**Discharge = 71.4**	**2.5**
TC4	0	0.5	0	0	0.78	0.00	0.00
TC4	0.5	0.5	0.06	0.030	0.78	23.3	0.82
TC4	1.0	0.5	0.17	0.085	0.78	65.9	2.33
TC4	1.5	0.5	0.20	0.100	0.78	77.5	2.74
TC4	2.0	0.5	0.15	0.075	0.78	58.1	2.05
TC4	2.5	0.5	0.13	0.065	0.78	50.4	1.78
TC4	3.0	0.5	0.10	0.050	0.78	38.8	1.37
		Total W = 3.5m		**A = 0.405**		**Discharge= 314.0**	**11.1**
TC5	0.0	0.5	0.00	0.000	0.33	0.0	0.00
TC5	0.5	0.5	0.04	0.018	0.33	5.9	0.21
TC5	1.0	0.5	0.80	0.400	0.33	133.8	4.73
TC5	1.5	0.5	0.75	0.375	0.33	125.5	4.43
TC5	2.0	0.5	0.60	0.300	0.33	100.4	3.54
TC5	2.5	0.5	0.50	0.250	0.33	83.6	2.95
TC5	3.0	0.5	0.10	0.050	0.33	16.7	0.59
TC5	3.5	0.5	0.18	0.090	0.33	30.1	1.06
TC5	4.0	0.5	0.35	0.175	0.33	58.6	2.07
TC5	4.5	0.5	0.23	0.113	0.33	37.6	1.33
TC5	5.0	0.5	0.49	0.245	0.33	82.0	2.89
TC5	5.5	0.5	0.12	0.058	0.33	19.2	0.68
		Total W = 5.6m		**A = 2.074**		**Discharge = 693.4**	**24.5**

Biological Communities

TABLE 54: MACROINVERTEBRATE SAMPLES FROM SITE TC5, TANNERY CREEK BEAR CREEK TOWNSHIP, MI: 2007-2010. DATA COLLECTED BY WATERSHED COUNCIL VOLUNTEERS.

Stream Name: Tannery Creek							
Sampling location: Glen's							
Type of Collection: Volunteer							
		# of Individuals collected					
Order	**Family**	**22-Sep-07**	**17-May-08**	**20-Sep-08**	**16-May-09**	**22-May-10**	**18-Sep-10**
Amphipoda	Gammaridae	9	4	3	5	4	4
Amphipoda	Hyallelidae	0	0	0	0	0	0
Bivalvia	Sphaeriidae	0	0	0	0	0	0
Coleoptera	Chrysomelidae	0	0	0	0	0	0
Coleoptera	Curculionidae	0	0	0	0	0	0
Coleoptera	Dryopidae	0	0	0	0	0	0
Coleoptera	Dytiscidae	0	0	0	0	0	1
Coleoptera	Elmidae	0	2	0	1	1	1
Coleoptera	Gyrinidae	0	0	0	0	0	0
Coleoptera	Haliplidae	0	1	0	0	0	0
Coleoptera	Hydrophilidae	0	0	0	0	0	0
Coleoptera	Lampyridae	0	0	0	0	0	0
Coleoptera	Psephenidae	0	0	0	0	0	0
Coleoptera	Staphylinidae	0	0	0	0	0	0
Collembola		0	0	0	0	0	0
Decapoda	Cambaridae	0	0	0	0	0	0
Diptera	Athericidae	0	0	0	0	0	0
Diptera	Ceratopogonidae	0	0	0	0	0	0
Diptera	Chironomidae	0	22	0	8	12	5
Diptera	Dixidae	0	0	0	0	0	0
Diptera	Dolichopodidae	0	0	0	0	0	0
Diptera	Empididae	0	0	0	0	0	0
Diptera	Ephydridae	0	0	0	0	0	0
Diptera	Muscidae	0	0	0	0	0	0
Diptera	Psychodidae	0	0	0	0	0	0
Diptera	Ptychopteridae	0	0	0	0	0	0
Diptera	Sciomyzidae	0	0	0	0	0	0
Diptera	Simuliidae	0	18	0	1	2	2
Diptera	Stratiomyidae	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0
Diptera	Tipulidae	1	0	3	1	0	1
Ephemeroptera	Baetidae	0	3	0	2	9	5
Ephemeroptera	Baetiscidae	0	0	0	0	0	0
Ephemeroptera	Caenidae	0	0	0	0	0	0

Ephemeroptera	Ephemeridae	0	0	0	0	0	0
Ephemeroptera	Ephemerellidae	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	2	0	4	2	0	1
Ephemeroptera	Isonychiidae	0	0	0	0	0	0
Ephemeroptera	Leptohyphidae	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	0	0	0	1	0	0
Ephemeroptera	Metrotopodidae	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	0	0	0	0	0	0
Gastropoda	Ancylidae	0	0	0	0	0	0
Gastropoda	Hydrobiidae	0	0	0	0	0	0
Gastropoda	Lymnaeidae	0	0	0	1	1	0
Gastropoda	Physidae	0	5	0	4	3	3
Gastropoda	Planorbidae	0	0	0	0	0	0
Gastropoda	Pleuroceridae	0	0	0	0	0	0
Gastropoda	Valvatidae	0	0	0	0	0	0
Gastropoda	Viviparidae	0	0	0	0	0	0
Heteroptera	Belostomatidae	0	0	0	0	0	0
Heteroptera	Corixidae	0	0	0	0	0	0
Heteroptera	Gerridae	0	0	0	1	0	0
Heteroptera	Hebridae	0	0	0	0	0	0
Heteroptera	Mesoveliidae	0	0	0	0	0	0
Heteroptera	Nepidae	0	0	0	0	0	0
Heteroptera	Notonectidae	0	0	0	0	0	0
Heteroptera	Pleidae	0	0	0	0	0	0
Heteroptera	Saldidae	0	0	0	0	0	0
Heteroptera	Veliidae	0	0	0	0	0	1
Hirudinea		0	0	0	0	0	0
Hydracarina		0	0	0	0	0	1
Isopoda	Asellidae	3	0	0	2	42	2
Lepidoptera	Pyralidae	0	0	0	0	0	0
Megaloptera	Corydalidae	0	0	1	0	0	2
Megaloptera	Sialidae	0	0	0	0	0	2
Nematoda	Round worm	0	0	0	0	0	0
Nematomorpha	Horsehair worms	0	0	0	0	0	0
Odonata	Aeshnidae	0	1	1	0	0	0
Odonata	Calopterygidae	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0
Odonata	Cordulegastridae	1	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	0	0
Odonata	Gomphidae	0	0	0	0	0	0
Odonata	Lestidae	0	0	0	0	0	0
Odonata	Libellulidae	0	0	0	0	0	0

Oligochaeta		5	2	5	1	4	6
Pelecypoda	Dreissenidae	0	0	0	0	0	0
Pelecypoda	Sphaeridae	0	0	0	0	0	0
Plecoptera	Capniidae	0	0	0	0	0	2
Plecoptera	Leuctridae	1	0	0	0	0	0
Plecoptera	Nemouridae	0	1	0	0	0	0
Plecoptera	Perlidae	0	0	0	0	0	0
Plecoptera	Perlodidae	0	0	0	0	0	0
Plecoptera	Pteronarcyidae	0	0	0	0	0	0
Plecoptera	Taeniopterygidae	0	0	0	0	0	0
Trichoptera	Brachycentridae	0	0	0	0	0	0
Trichoptera	Glossosomatidae	0	0	0	0	0	0
Trichoptera	Goeridae	0	0	0	0	0	0
Trichoptera	Helicopsychidae	0	0	0	0	0	0
Trichoptera	Hydropsychidae	7	10	23	3	2	3
Trichoptera	Hydroptilidae	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	0	0	0	0	0	0
Trichoptera	Leptoceridae	0	0	0	0	0	0
Trichoptera	Limnephilidae	0	0	0	2	0	0
Trichoptera	Molannidae	0	0	0	0	0	0
Trichoptera	Odontoceridae	0	0	0	0	0	0
Trichoptera	Philopotamidae	0	0	0	0	0	0
Trichoptera	Phryganeidae	0	0	0	0	0	0
Trichoptera	Polycentropodidae	0	0	0	0	0	0
Trichoptera	Psychomyiidae	0	0	0	0	0	0
Trichoptera	Rhyacophilidae	0	0	0	0	0	0
Trichoptera	Uenoidea	0	0	0	0	3	0
Turbellaria		0	0	0	0	0	0
	Total Taxa	8	11	7	15	11	17
	EPT Families	3	3	2	5	3	4
	TOTAL # of specimens	29	69	40	35	83	42

TABLE 55: MACROINVERTEBRATE SAMPLES FOR SITE TC3, TANNERY CREEK BEAR CREEK TOWNSHIP, MI: 2007-2010. DATA COLLECTED BY WATERSHED COUNCIL VOLUNTEERS.

Stream Name: Tannery Creek							
Sampling location: Boyer							
Type of Collection: Volunteer							
		# of Individuals collected					
Order	**Family**	**22-Sep-07**	**17-May-08**	**20-Sep-08**	**16-May-09**	**22-May-10**	**18-Sep-10**
Amphipoda	Gammaridae	30	28	5	2	3	4
Amphipoda	Hyallelidae	0	0	0	0	0	0

Bivalvia	Sphaeriidae	0	0	0	0	0	0
Coleoptera	Chrysomelidae	0	0	0	0	0	0
Coleoptera	Curculionidae	0	0	0	0	0	0
Coleoptera	Dryopidae	0	0	0	0	0	0
Coleoptera	Dytiscidae	0	1	0	0	1	0
Coleoptera	Elmidae	9	0	0	0	0	5
Coleoptera	Gyrinidae	0	0	0	0	0	0
Coleoptera	Haliplidae	0	0	0	0	0	0
Coleoptera	Hydrophilidae	1	1	0	0	0	0
Coleoptera	Lampyridae	0	0	0	0	0	0
Coleoptera	Psephenidae	0	0	0	0	0	0
Coleoptera	Staphylinidae	0	0	0	0	0	0
Collembola		0	0	0	0	0	0
Decapoda	Cambaridae	0	0	0	0	0	0
Diptera	Athericidae	0	0	0	0	0	0
Diptera	Ceratopogonidae	0	0	0	0	0	0
Diptera	Chironomidae	2	6	1	0	1	6
Diptera	Dixidae	9	0	0	0	1	0
Diptera	Dolichopodidae	0	0	0	0	0	0
Diptera	Empididae	0	0	0	0	0	0
Diptera	Ephydridae	0	0	0	0	0	0
Diptera	Muscidae	0	0	0	0	0	0
Diptera	Psychodidae	0	0	0	0	0	0
Diptera	Ptychopteridae	0	0	0	0	0	0
Diptera	Sciomyzidae	0	0	0	0	0	0
Diptera	Simuliidae	4	7	5	1	2	2
Diptera	Stratiomyidae	0	0	0	0	0	0
Diptera	Tabanidae	0	0	1	0	0	1
Diptera	Tipulidae	2	2	0	0	0	3
Ephemeroptera	Baetidae	6	9	7	7	6	9
Ephemeroptera	Baetiscidae	0	0	0	0	0	0
Ephemeroptera	Caenidae	0	0	0	0	0	0
Ephemeroptera	Ephemeridae	0	0	0	0	0	0
Ephemeroptera	Ephemerellidae	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	12	25	15	5	5	3
Ephemeroptera	Isonychiidae	0	0	0	0	0	0
Ephemeroptera	Leptohyphidae	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	5	44	5	4	0	1
Ephemeroptera	Metrotopodidae	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	0	0	0	0	0	0
Gastropoda	Ancylidae	0	0	0	0	0	0
Gastropoda	Hydrobiidae	0	0	0	0	0	0
Gastropoda	Lymnaeidae	0	0	0	0	0	0
Gastropoda	Physidae	0	1	0	0	0	3
Gastropoda	Planorbidae	3	1	0	0	0	0
Gastropoda	Pleuroceridae	0	0	0	0	0	0
Gastropoda	Valvatidae	0	0	0	0	0	0
Gastropoda	Viviparidae	0	0	0	0	0	0
Heteroptera	Belostomatidae	0	0	0	0	0	0

Heteroptera	Corixidae	0	0	0	0	0	0
Heteroptera	Gerridae	0	2	1	2	0	0
Heteroptera	Hebridae	0	0	0	0	0	0
Heteroptera	Mesoveliidae	0	0	0	0	0	0
Heteroptera	Nepidae	0	0	0	0	0	0
Heteroptera	Notonectidae	0	0	0	0	0	0
Heteroptera	Pleidae	0	0	0	0	0	0
Heteroptera	Saldidae	0	0	0	0	0	0
Heteroptera	Veliidae	1	1	0	0	0	3
Hirudinea		0	0	0	0	0	0
Hydracarina		3	0	0	0	0	1
Isopoda	Asellidae	0	5	1	2	1	2
Lepidoptera	Pyralidae	0	0	0	0	0	0
Megaloptera	Corydalidae	0	2	0	0	0	0
Megaloptera	Sialidae	0	0	0	0	3	0
Nematoda	Round worm	0	0	0	0	0	0
Nematomorpha	Horsehair worms	0	0	0	0	0	0
Odonata	Aeshnidae	1	6	4	0	0	2
Odonata	Calopterygidae	1	4	7	0	0	2
Odonata	Coenagrionidae	0	0	0	0	0	0
Odonata	Cordulegastridae	1	1	0	0	2	2
Odonata	Corduliidae	0	0	0	0	0	0
Odonata	Gomphidae	0	0	0	0	0	0
Odonata	Lestidae	0	0	0	0	0	0
Odonata	Libellulidae	0	0	0	0	0	0
Oligochaeta		0	0	1	0	0	3
Pelecypoda	Dreissenidae	0	0	0	0	0	0
Pelecypoda	Sphaeridae	0	0	0	0	0	0
Plecoptera	Capniidae	0	0	0	0	0	0
Plecoptera	Leuctridae	0	0	0	0	0	0
Plecoptera	Nemouridae	0	3	0	1	1	2
Plecoptera	Perlidae	0	0	0	0	0	0
Plecoptera	Perlodidae	2	0	0	0	0	0
Plecoptera	Pteronarcyidae	0	0	0	0	0	0
Plecoptera	Taeniopterygidae	0	0	0	0	0	0
Trichoptera	Brachycentridae	0	0	0	0	0	0
Trichoptera	Glossosomatidae	0	0	0	0	0	4
Trichoptera	Goeridae	0	0	0	0	0	0
Trichoptera	Helicopsychidae	0	0	0	0	0	0
Trichoptera	Hydropsychidae	32	10	3	8	2	2
Trichoptera	Hydroptilidae	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	0	0	0	0	0	0
Trichoptera	Leptoceridae	0	0	0	0	0	0
Trichoptera	Limnephilidae	0	2	1	2	0	1
Trichoptera	Molannidae	0	0	0	0	0	0
Trichoptera	Odontoceridae	0	0	0	0	0	0
Trichoptera	Philopotamidae	8	1	0	0	6	2
Trichoptera	Phryganeidae	0	0	1	0	0	0
Trichoptera	Polycentropodidae	0	2	13	0	1	0

Trichoptera	Psychomyiidae	26	0	0	0	0	0
Trichoptera	Rhyacophilidae	5	1	0	1	2	3
Trichoptera	Uenoidea	0	0	0	9	0	0
Turbellaria		0	0	0	0	0	0
	Total Taxa	21	24	15	12	15	24
	EPT Families	8	9	7	8	7	9
	TOTAL # of specimens	163	165	71	44	37	66

Physical and Riparian Conditions

TABLE 56: INVENTORY OF PHYSICAL AND RIPARIAN CONDITIONS (PER EPA RAPID BIOASSESSMENT PROTOCOLS) AT 6 SITES ON TANNERY CREEK, BEAR CREEK TOWNSHIP, MI. JUNE 9-10 AND OCT 15, 2012. COLLECTED BY STUDY TEAM.

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
Epifaunal substrate/available cover	17 Optimal	11 Suboptimal	17 Optimal	10 Poor	13 Suboptimal	4 Poor
Pool substrate characterization	15 Suboptimal	12 Suboptimal	17 Optimal	11 Suboptimal	16 Optimal	4 Poor
Pool variability	10 Marginal	6 Marginal	1 Poor	14 Marginal	5 Poor	7 Marginal
Sediment deposition	18 Optimal	17 Optimal	19 Optimal	16 Suboptimal	11 Suboptimal	12 Suboptimal
Channel flow status	20 Optimal	18 Optimal	19 Optimal	20 Optimal	16 Optimal	18 Optimal
SUBTOTAL	**80 Optimal**	**64 Suboptimal**	**73 Suboptimal**	**71 Suboptimal**	**61 Suboptimal**	**52 Suboptimal**

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
Channel alteration	20 Optimal	17 Optimal	18 Optimal	13 Suboptimal	20 Optimal	14 Suboptimal
Channel sinuosity	20 Optimal	19 Optimal	13 Suboptimal	16 Optimal	20 Optimal	11 Suboptimal
Bank stability (L)	9 Optimal	10 Optimal	7 Suboptimal	10 Optimal	7 Suboptimal	7 Suboptimal
Bank stability (R)	9 Optimal	10 Optimal	5 Marginal	10 Optimal	7 Suboptimal	7 Suboptimal
Vegetative protection (L)	10 Optimal	10 Optimal	9 Optimal	10 Optimal	8 Suboptimal	7 Suboptimal
Vegetative protection (R)	10 Optimal	10 Optimal	9 Optimal	10 Optimal	8 Suboptimal	7 Suboptimal
Riparian vegetative zone width (L)	10 Optimal	10 Optimal	1 Poor	8 Suboptimal	9 Optimal	9 Optimal
Riparian vegetative zone width (R)	10 Optimal	10 Optimal	9 Optimal	8 Suboptimal	9 Optimal	9 Optimal
SUBTOTAL	**98 Optimal**	**95 Optimal**	**71 Suboptimal**	**85 Optimal**	**88 Optimal**	**71 Suboptimal**

Habitat Parameter	TCHW	TC2	TC3	TC1	TC4	TC5
OVERALL TOTAL	**178 Optimal**	**159 Optimal**	**144 Suboptimal**	**156 Optimal**	**149 Suboptimal**	**116 Suboptimal**

Overall scoring key:
150-200 = optimal
100-149= suboptimal
50-99 = marginal
0-49 = poor

TABLE 57: ROAD-STREAM CROSSING DATA FOR TANNERY CREEK, BEAR CREEK TOWNSHIP, MI: 2002 COLLECTED BY THE WATERSHED COUNCIL.

Date	Site ID	Stream Name	Road Name	Culvert Type	ACTION?	Other treatment	Reason for Treatment Recommendation	Severity
8-Nov-02	TC 1	Tannery	E. Mitchell Rd	twin	FALSE	--	Need to control some of the runoff originating from the road through diversion outlets.	Moderate
8-Nov-02	TC 2	Tannery	Boyer Rd.	twin	FALSE	Revegetation	Erosion occurring from the road and along ditches.	Moderate
26-Nov-02	TC 3	Tannery	Surrey Lane	triple	FALSE	Revegetation at inlet and outlet.	Lengthen and re-position culvert.	Moderate
8-Nov-02	TC 4	Tannery	Country Club	single	TRUE	--	--	Moderate
8-Nov-02	TC 5	Tannery	US 31	single	FALSE	--	Undersized culvert	Moderate
26-Nov-02	TC 6	Tannery	Chase Bank	single	FALSE	--	Undersized culvert	Moderate
26-Nov-02	TC 7	Tannery	Glen's	single	FALSE	--	Keep exotic species out of the upper reaches of Tannery creek. Erosion at the outlets embankment needs to be revegetated. Fencing needed to keep people from trampling the embankment, Erosion around plunge pool should be controlled.	Moderate

Runoff volume and non-point pollution results for each scenario run through the L-THIA model are presented in Table 14 below. Runoff volume maps are presented below.

TABLE 58: RUNOFF AND NONPOINT SOURCE POLLUTION SCENARIOS (L-THIA) FOR TANNERY CREEK WATERSHED BEAR CREEK TOWNSHIP, MI: 2012. CONDUCTED BY STUDY TEAM

Scenario	Runoff (cm)	N(kg)	P(kg)	Mean CN value
Current (NLCD 2001)	8232	107.4	26.1	49
Build-Out	28916	405.7	112.4	58.3
Conservation 100	12495	166.6	44	52
Conservation 50	16925	228.6	61.5	55

TABLE 59: RUNOFF SCENARIOS BROKEN DOWN BY SUBWATERSHED. TANNERY CREEK WATERSHED, BEAR CREEK TOWNSHIP, MI: 2012 CONDUCTED BY STUDY TEAM

Sub-Watershed	Runoff volume per acre (in)			
	Current	Build Out	Conservation 100	Conservation 50
East Fork Watershed	0.72	3.01	1.41	1.84
West Fork Watershed	1.87	6.15	2.58	3.58
Lower Watershed	3.02	8.85	3.43	5.10

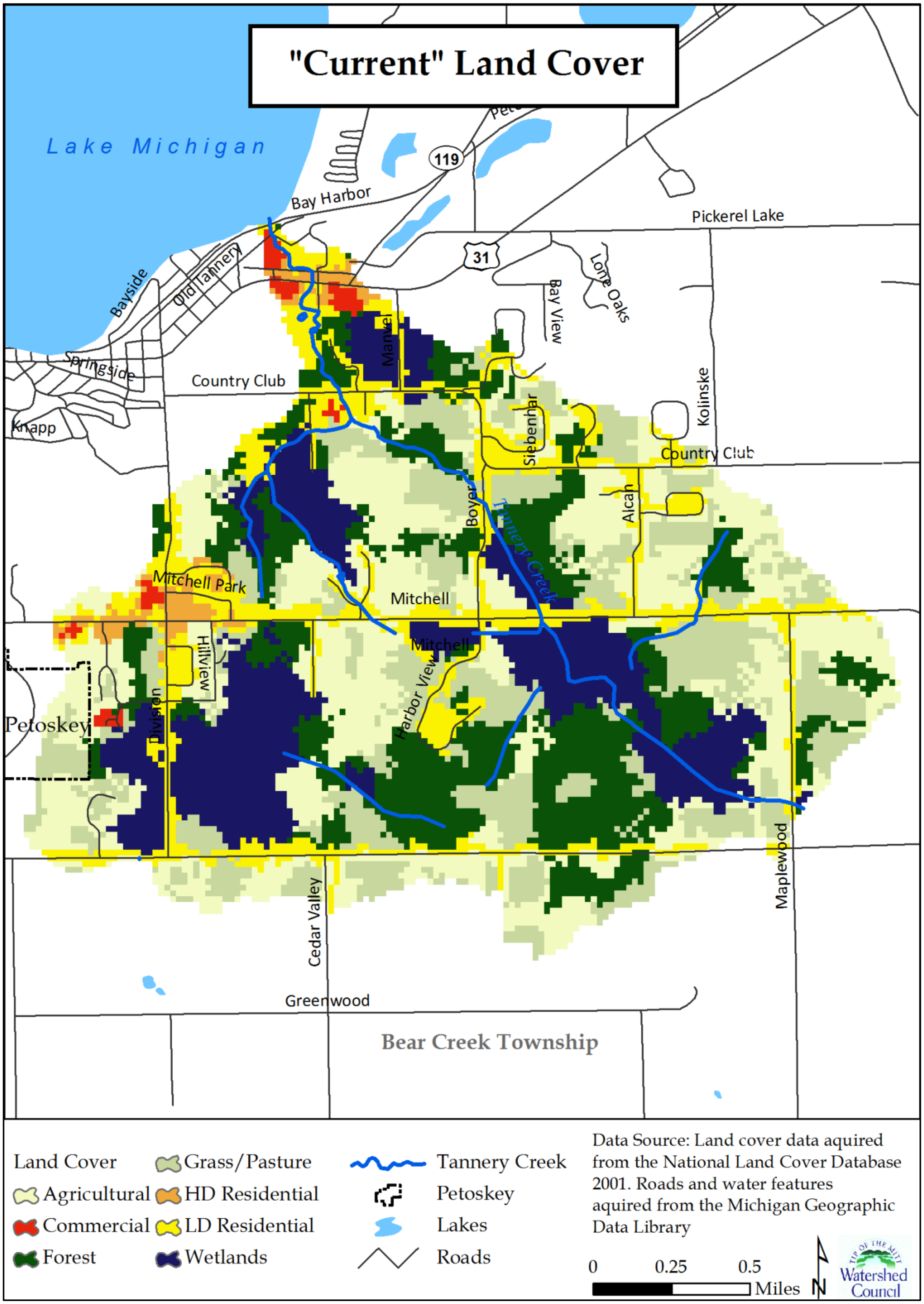


FIGURE 39: CURRENT SCENARIO LAND COVER IN TANNERY CREEK WATERSHED, BEAR CREEK TOWNSHIP, MI.

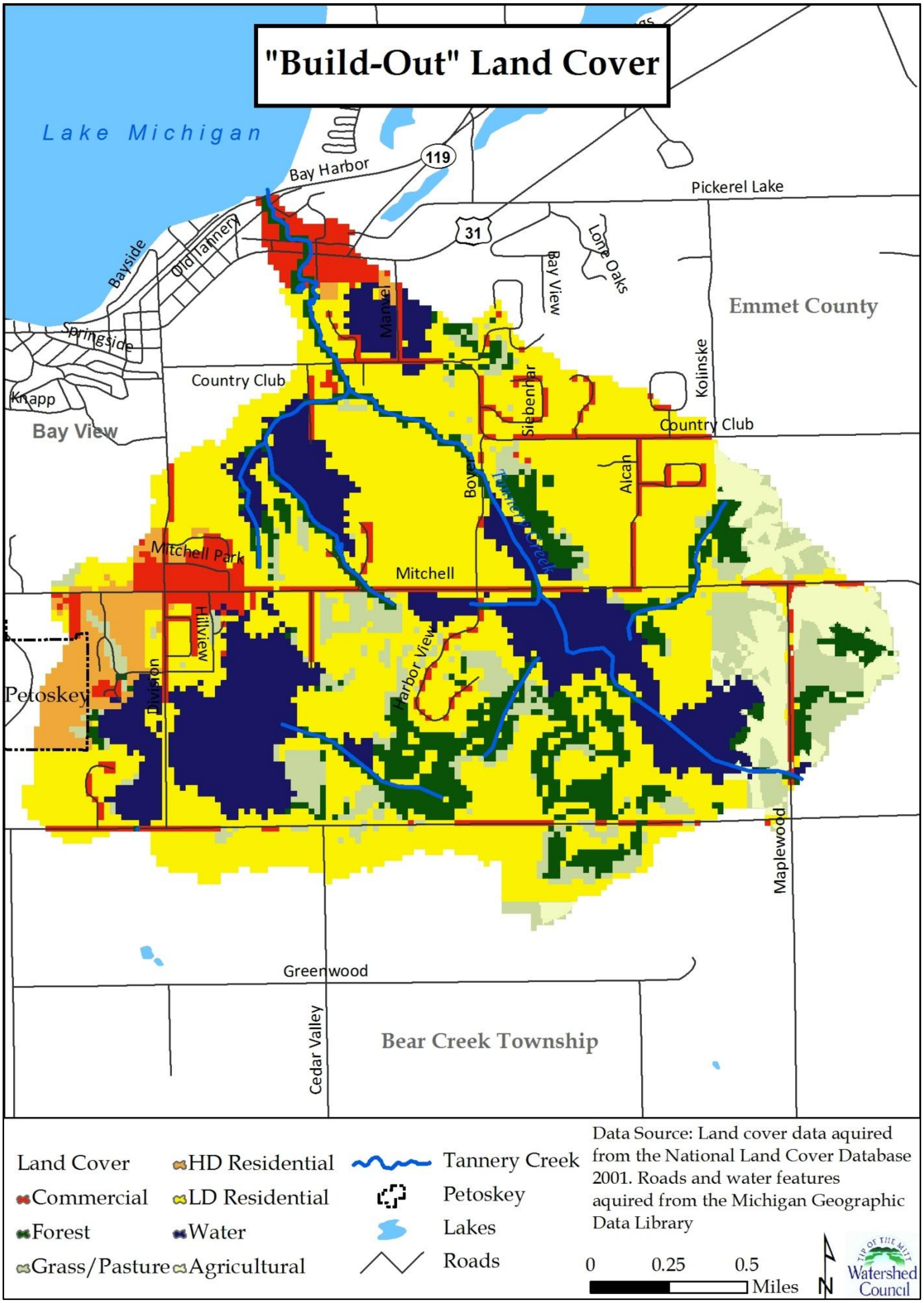


FIGURE 40: BUILD-OUT SCENARIO LAND COVER FOR TANNERY CREEK WATERSHED, BEAR CREEK TOWNSHIP, MI

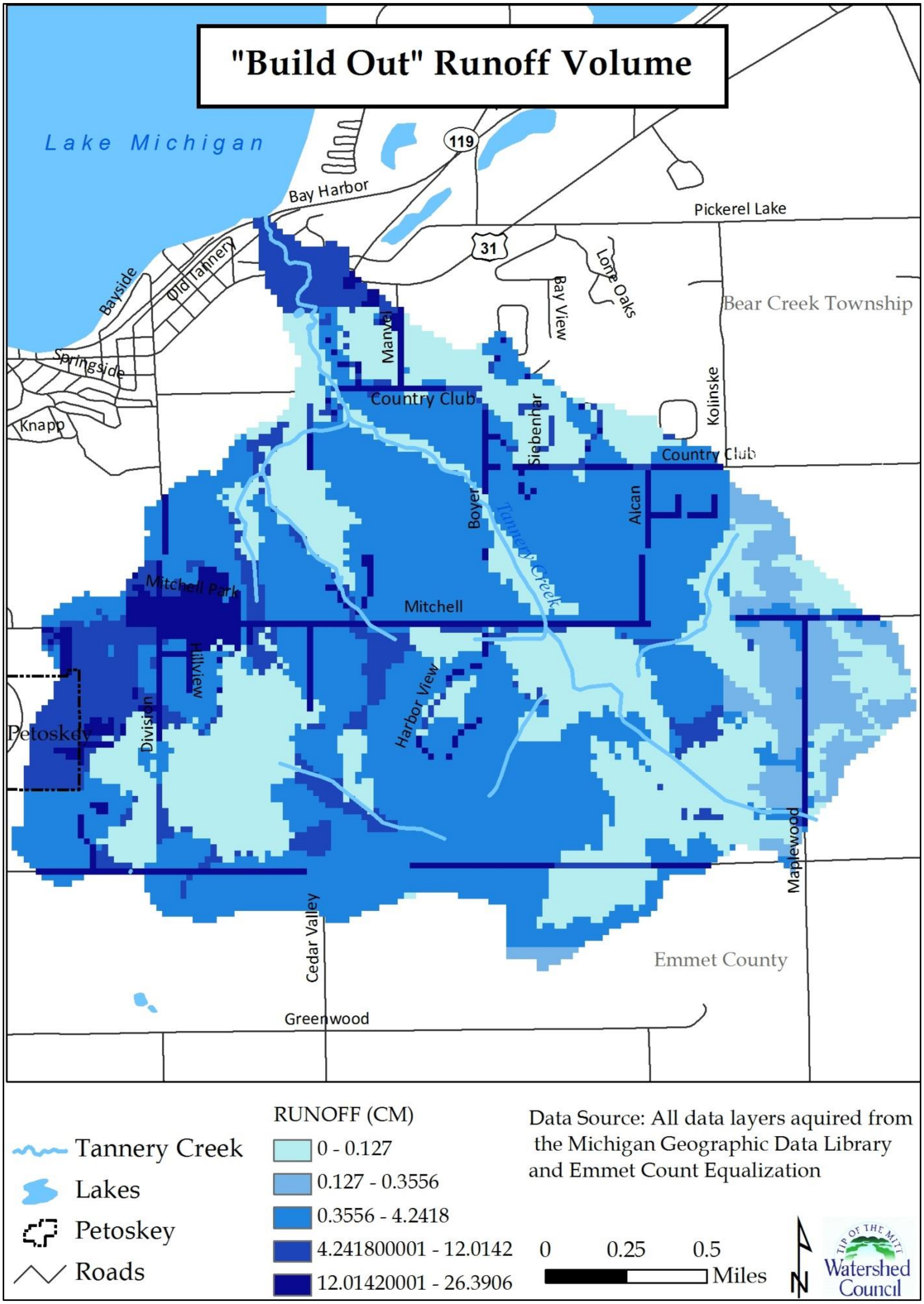


FIGURE 41: BUILD-OUT SCENARIO RUNOFF VOLUME FOR TANNERY CREEK WATERSHED, BEAR CREEK TOWNSHIP, MI.

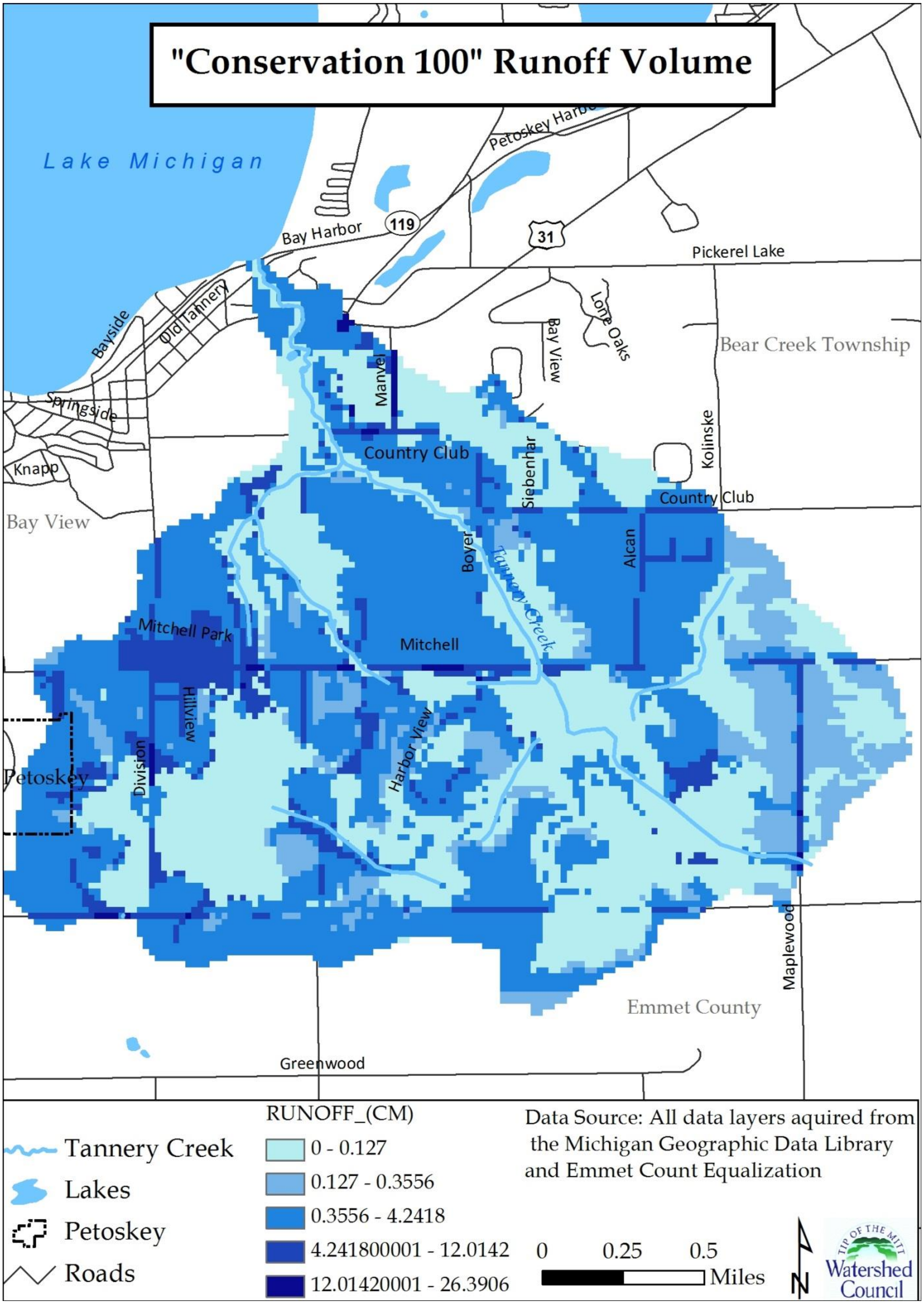


FIGURE 42: 100% CONSERVATION RUNOFF VALUE FOR TANNERY CREEK WATERSHED, BEAR CREEK TOWNSHIP, MI.

TABLE 60: NATIONAL LAND COVER DATABASE 2001 LAND COVER CLASSES CONSERVSION TO L-THIA LAND COVER CLASSES

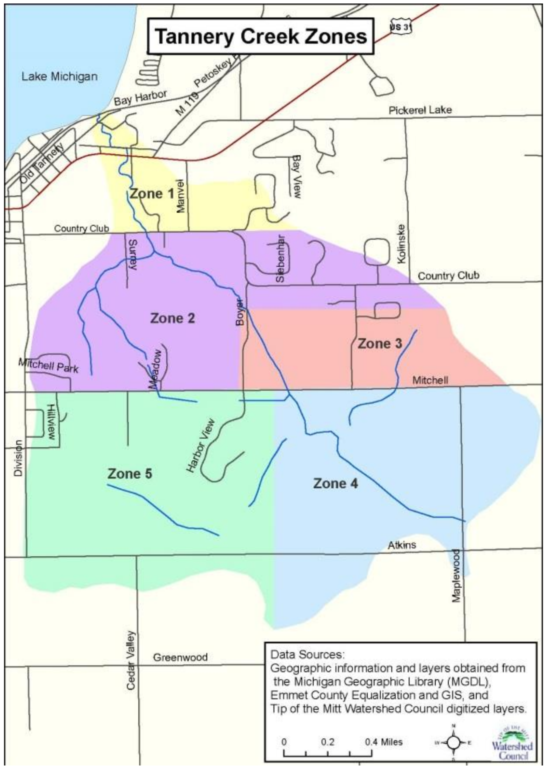
NLCD 2001 Land Cover Classes (Impervious %)		L-THIA Land Cover Classes (Impervious %)
21- Developed, Open Space (20)	→	Low-Density Residential (25%)
22-Developed, Low Intensity (20-49)		
23- Developed, Medium Intesity (50-79)	→	High-Density Residential (65%)
24-Developed, High Intensity (80-100)	→	Commercial (85%)
31-Barren Land		
41-Deciduous Forest	→	Forest
42-Evergreen Forest		
43-Mixed Forest		
52-Shrub/Scrub	→	Grass/Pasture
71-Grassland/Herbaceous		
81-Pasture/Hay		
82-Cultivated Crop	→	Agricultural
90-Woody Wetlands	→	Water/Wetland
95-Emergent Herbaceous Wetlands		

TABLE 61: ZONING CODE TRANSLATION TO L-THIA MODEL LAND COVER CLASSES

Zoning Code Density Conversion			
Zoning District	Net Density in Units per Acre		L-THIA Land Cover Classes (Impervious %)
R-1A, R-1B & R-1C One Family Residential	1.98	→	Low Density Residential (25%)
R-2A, R-2B & R-2C General Residential	5.125-10.890	→	High-Density Residential (65%)
RR-1 & RR-2 Recreation Residential	1.452	→	Low-Density Residential (25%)
B-1 Local Tourist Business	-	→	Commercial (85%)
B-2 & B-3 General Business	-	→	Commercial (85%)
FF-1 Farm Forest	1	→	Grass/Pasture

RESIDENT/BUSINESS SURVEY DATA

RESIDENT SURVEY RESULTS



Surveys Sent	61
Responses	27
Response Rate	44%

1. Before receiving this survey, were you aware that Tannery Creek runs through or borders your property?

Answer	Response	Percent
Yes	26	1
No	0	0
Total	26	1

2. Do you know where the creek flows between your property and Little Traverse Bay?

Answer	Response	Percent
Yes	26	0.96

No	1	0.04
Total	27	1

3. Where does the creek flow after it leaves your property?

flows NW to the bay
from East Mitchell to Tannery by Glenns
Northwest through woods, fields, residential, golf course, and commercial area
in my backyard
I have the 40 acre parcel that is basically the headwaters of the creek - I know its route all the way to the lake
under Mitchell Road 1/2 mile east of Division
between Boyer & Mitchel Rd
We knew where it was - did not know the name.
backyard
some private property, country club, glens
in the 10 acres area, we have a small section that goes through a naturally marshy area
It starts out as a spring on my property
I own 2.3 acres it flows through - behind #16 golf hole of Petoskey Bay View Golf course
to country club rd, behind the meat mkt. under US 31, passed the condo into the bay
less than 100' North
south boundary straight to the bay
meanders as drawn on zone 1 at the back (west) of my house - I can hear it out of my bedroom window every night
It flows on 4 acres of unused land not connected to my home property
it does not run through or near my property - 2/3 of a mile away
Begins on our property. Flows to adjacent Bachelor property.
at the rear of our property

4. How do you currently use Tannery Creek? Please indicate the frequency with which you engage in the following activities:

	Never	Never, but would like to	Rarely (1-3 times per year)	Sometimes (1-3 times per month)	Often (once a week or more)	Total
Fishing (Catch and Release)	22	3	1	0	0	26
Fishing (For Consumption)	24	0	0	0	0	24
Swimming/Wading	21	1	2	1	1	26
Relaxation	13	0	0	4	8	25
Wildlife Viewing	8	2	1	4	11	26
Other*	3	0	1	0	1	5

Other responses:
education
beekeeping; star gazing; sunsets

5. Additional Comments

the portion of property is a seasonal creek from "wetlands" (zone 5)
would like it stocked with trout. there was a salmon run last fall

beautiful stony bed - I've realigned stones for falls & water noise
Since it was declared swamp land I have no way of using it
Not enough water for wading, fishing or swimming

6. How would you rate the condition of the creek?

Answer	Response	%
Excellent	11	0.46
Good	9	0.38
Fair	3	0.13
Poor	1	0.04
Total	24	1

7. Why did you rate it this way? What concerns you about the water quality?

as a kid I fished it. It is but a shell of what it was in the 60's

8. When looking at the creek, do you notice any of the following? Please check all that apply:

Answer	Response	%
Trash/Litter	6	0.32
Invasive Species/Weeds	5	0.26
Pooling/Flooding	5	0.26
Erosion	4	0.21
Discoloration	2	0.11
Native Species Depletion	1	0.05
Unpleasant Odor	1	0.05
Other	9	0.47

Invasive Species/Weeds. (If known, please list species below.)

reed canary grass
loose strif

Native Species Depletion (If known, please list the species that you used to see, but no longer do.)

trout

Unpleasant Odor (Please describe below.)

after upstream neighbor was bulldozing yard into stream in March & April 2011

Discoloration (Please describe below.)

same as above comment
muddy after a hard rain but then gets clear, normally the water is clear

Other

creek has been stable for at least 10 years
it was wider and deeper
appears to be in excellent condition on my land
I clean up any trash/litter; ducks land on it
seems to be the same for 28 yrs
foam after some storms
I have only been there once in the last year.
portion in zone 3 is dried up

abandoned tree forts and piles of old boards neighbor kids built and moved away; dying ash trees

9. Please take a look at the map above. In which region is your property located?

Answer	Response	%
Zone 1	5	0.19
Zone 2	7	0.27
Zone 3	5	0.19
Zone 4	4	0.15
Zone 5	5	0.19
Total	26	1

10. How long have you owned your property?

Answer	Response	%
< 1 year	0	0
1 - 3 years	0	0
3 - 5 years	4	0.15
5 - 10 years	2	0.08
10 + years	20	0.77
Total	26	1

11. How large is your property (acres)?

Answer	Response	%
< 1/2 acre	2	0.08
1/2 - 1 acre	4	0.15
1 - 2 acres	2	0.08
2 - 5 acres	6	0.23
5 + acres	12	0.46
Total	26	1

12. Is this your primary residence?

Answer	Response	%
Yes	23	0.88
No	3	0.12
Total	26	1

13. How often do you use the property?

10x pr yr
never
weekly

14. If seasonally, please note which season(s):

Answer	Response
Spring	1
Summer	1
Fall	1
Winter	1

15. What is your age?

Answer	Response	%
18 - 25	1	0.04
26 - 35	0	0
36 - 50	4	0.15
51 - 65	7	0.27
66 +	14	0.54
Total	26	1

16. How frequently do you mow your lawn?

Text Response	Code
1 every 3 weeks	3
2 weeks	2
1 time/month	4
as needed/weekly	1
weekly	1
weekly	1
weekly	1
once a week	1
1/week	1
weekly	1
once/week	1
weekly 7-10 days	1
weekly	1
no mow - all wild	0
weekly when needed	1
once/week	1
once a week	1
2 weeks	2
every seven days	1
1 per week	1
when necessary	1
3 wk	3
once per week	1

Coding	Answer	Response	%
1	Weekly	17	0.739130435
2	Bi-weekly	2	0.086956522
3	Every 3 Weeks	2	0.086956522
4	Monthy	1	0.043478261
0	Never/None	1	0.043478261
	Total	23	1

17. Is the lawn mown directly to the creek edge?

Answer	Response	%
Yes	0	0
No	25	1
Total	25	1

18. Please indicate the type of vegetation or material adjacent to the creek on your property:

Trees/Shrubs (If known, please indicate species below.)
black spruce, red pine
all kinds (maple, cedar, pine, birch, ash, oak)
cedar, birch, maple trees
cedars
bush (unknown)
locus, mountain ash, pine
ash, maple, cedar, boxwood, walnut
mostly cedar

Herbaceous Plants/Flowers (If known, please indicate species below.)
ferns, jack in the pulpet, trillium, myrtle
lady slipper
weeds w/ flowers
unknown
spotted knapweed, orchard grass
all completely wild and untouched
dead limbs

Other
lots of round stones in creek

Answer	Response	%
Trees/Shrubs	18	0.86
Tall Grass	17	0.81
Herbaceous Plants/Flowers	10	0.48
Rock Wall/Cement	2	0.1
Other	3	0.14

19. What is the approximate distance between the mown area and the creek?

Text Response	Feet	Code
500 ft	500	4
1 mile	5280	5
300 + ft	300	3
20 yards	60	2
1/2 mile	2640	5
5 - 10 ft	5 to 10	1
200 ft	200	2
150 feet	150	2
20 feet	20	1
50 feet	50	2
50 ft	50	2
3 + acres	624	5
200 yards	600	4
no mowed area	unlimted	5
5' to 20'	5 to 20	1
property does not border creek	n/a	n/a
100 ft	100	2

Coding	Answer	Response	Percent
n/a	n/a	1	0.041666667
1	<50 ft	5	0.208333333
2	50-200 ft	9	0.375
3	201-350 ft	1	0.041666667
4	351-600	3	0.125
5	>600 ft	5	21%
	Total	24	100%

100 ft on property owned by Jakubiak	100	2
200'	200	2
2-6 feet	2 to 6	1
150 yards	450	4
1/16 mile	330	3
50 yds	150	2
250 yards	750	5

20. Is fertilizer applied to the lawn and/or garden?

Answer	Response	%
Yes	12	48%
No	12	48%
Unknown	1	4%
Total	25	100%

21. Does the fertilizer contain phosphorus? (This information can be found on the packaging of your fertilizer.)

Answer	Response	%
Yes	2	29%
No	5	71%
Total	7	100%

22. How frequently is fertilizer applied?

Text Response	Code
once a year	1
Greenlawn North applies twice per summer (lawn); organic fertilizer only and as needed (garden)	2
3 time/yr	3
once a yr	1
2x/year just started this year	2
twice yearly	2
up to last year - 3x yr evergreen lawncare; not this year	3
4 times year	4
once or twice/year; usually milogranite	1
3 times per year; company does the fertilizers	3
spring and fall (twice yearly)	2
spring and fall - lawn; spring - garden	2

Coding	Answer	Response	%
1	Annually	3	25%
2	Bi-annually	5	42%
3	3x per year	3	25%
4	Quarterly	1	8%
	Total	12	100%

23. Are pesticides applied to the lawn and/or garden?

Answer	Response	%
Yes	7	28%
No	17	68%
Unknown	1	4%
Total	25	100%

24. Please note the type of pesticide used:

Text Response
some spray type to kill grubs
Trimec Weed Control
weed killer
Grub control; weed control

25. How frequently are pesticides applied?

Text Response	Code
1 time in June 2012	1
2x/year	2
twice yearly	2
up to last year - 3x yr - not this yr	3
once per year	1
Spring & Fall; Early summer	2

Coding	Answer	Response	%
1	Annually	2	33%
2	Bi-annually	3	50%
3	3x per year	1	17%
	Total	6	100%

26. Are there any plants, other than mown lawn, that would stop storm water from flowing into the street (i.e., a rain garden)?

Number	Answer	Bar	Response	%
1	Yes	0	0	0%
2	No	1	1	100%
	Total		1	100%

27. Please indicate what is planted there.

No responses

28. In the winter, do you apply salt or other deicers to your driveway and/or sidewalks?

Answer	Response	%
Yes	11	44%
No	14	56%
Total	25	100%

29. How frequently is salt applied?

Text Response	Code
as needed, by hand - the pet friendly kind	3
1 - 2 / mo	2
occasionally	3
as needed after snowfall	3
use sand	4
small amount on stoop	3
rarely	4
maybe twice a winter	4
10 times a year. Applied > 100 ft from stream. Less than 3 gallons of crystal salt used per year	2

Coding	Answer	Response	Percent
1	Daily - Weekly	1	10%
2	Bi-weekly-Monthly	2	20%
3	Occassionally/As Needed	4	40%
4	Rarely/Never	3	30%
	Total	10	100%

once per day or as needed	1

30. Does your home have a septic system?

Answer	Response	%
Yes	16	62%
No	10	38%
Total	26	100%

31. When was it installed?

Text Response	Age of Septic	Code
1978	35	4
1980	33	4
1983	30	3
80's	24-33	3
1999-2000	13	2
20 yrs	20	2
2005	8	1
1993	20	2
1989	24	3
1983	30	3
1967	46	5
30 yrs ago	30	3
2001	12	2
50 year ago	50	5
Nov-85	28	3

Coding	Answer	Response	%
1	<10 yr old	1	7%
2	10-20 yr old	4	27%
3	21-30 yr old	6	40%
4	31-40 yr old	2	13%
5	>40 yr old	2	13%
	Total	15	100%

32. When was it last serviced?

Text Response	Yrs since service	Code
2011	2	2
2012	2	2
2011	3	2
2011	3	2
never	n/a	5
2012	1	2
yearly	1	2
2 years	2	2
Jun-12	0.5	1
several yr ago	3 to 7	3
60 months ago	5	3
?	n/a	5
each year	1	2
Sep-12	0.5	1

Coding	Answer	Response	%
1	<1 yr ago	2	14%
2	1-3 yr ago	8	57%
3	4-10 yr ago	2	14%
4	>10 yr ago	1	7%
5	unknown	1	7%
	Total	14	100%

33. Approximately how far is the drainage field located from the creek?

Answer	Response	%
0 - 50 ft	0	0%
50 - 100 ft	0	0%
100 - 200 ft	1	7%
> 200 ft	13	87%
Unknown	1	7%
Total	15	100%

34. How would you prefer to learn about the results of this survey?

Answer	Response	%
Mail	19	79%
Phone	0	0%
One-on-One Meeting	1	4%
Small Group Meeting	1	4%
Town Hall Meeting	3	13%
Total	24	100%

35. What day/time is best for you for a meeting?

Answer	Response	%
Weekday Evening	3	75%
Weekday Lunch	1	25%
Weekday Morning	0	0%
Weekend	0	0%
Total	4	100%

BUSINESS SURVEY RESULTS

Surveys sent	75
Responses Received	18
Response Rate	24%

1. Before receiving this survey, were you aware that Tannery Creek flows near the property of your business?

	Response	%
Yes	12	71%
No	5	29%
Total	17	100%

2. Do you know where rainwater drains off your property?

	Response	%
Yes	12	67%
No	6	33%

Total	18	100%

3. Where does it drain?

Text Response
culvert near Division Rd.
to retention pond
it shoots up out of our front lawn - geyser! - culvert is not operable
follows eaves around buildings 2202 mitchell park dr & 2206 mitchell park dr. water flows into french drain created 2011.
detention & retention ponds on next lot
street
Running downhill (west to east) across the property with the majority of runoff that is consolidated coming from a ditch on Mitchell Park Dr & summit
high sandy soil very little run off. mostly absorbed & then downhill
some into township sewers, some into Tannery Creek
most all stays on our property. we absorb a lot from other property, roads and Tannery Creek
retention area n. side
most flows to drains located on side of the highway lower lot drains into creek. lower lot is not paved

4. How would you rate the impact of Little Traverse Bay on the income of your business? (1= Little Traverse Bay does not impact my business --> 5 = My business would not exist without the Bay)

Answer	Response	%
1	2	11%
2	1	6%
3	7	39%
4	8	44%
5	0	0%
Total	18	100%

5. Does your business rely on seasonal tourism?

Answer	Response	%
Yes	10	56%
No	8	44%
Total	18	100%

6. Which season(s) do you experience the greatest increase in business?

Answer	Response
Spring	1
Summer	9
Fall	2
Winter	1

7. Have you noticed any pooling or flooding on your property after a large rainstorm?

Answer	Response	%
Yes	6	38%
No	10	63%

Total	16	100%

8. How has this affected your business?

Text Response
It doesn't!
offensive to customers
little impact
minimally brief buildup in drainage ditch
reduces the amount of customers

9. Have you noticed any odor coming from the flooded water?

Answer	Response	%
Yes	1	17%
No	5	83%
Total	6	100%

10. Please take a look at the map above. In which zone is your business located?

Answer	Response	%
Zone 1	6	35%
Zone 2	8	47%
Zone 3	0	0%
Zone 4	1	6%
Zone 5	2	12%
Total	17	100%

11. How long has your business operated at its current location?

Answer	Response	%
< 1 year	0	0%
1 - 3 years	0	0%
3 - 5 years	0	0%
5 - 10 years	3	18%
10 + years	14	82%
Total	17	100%

12. How large is your property (acres)?

Answer	Response	%
< 1/2 acre	4	25%
1/2 - 1 acre	5	31%
1 -2 acres	2	13%
2 - 5 acres	2	13%
5 + acres	3	19%
Total	16	100%

13. What percentage of your property is paved? (This includes parking lots, driveways, sidewalks and any other paved surfaces.)

Answer	Response	%
< 5%	3	18%

5 - 25%	4	24%
25 - 50%	5	29%
50 - 75%	3	18%
> 75%	2	12%
Total	17	100%

14. Does your business have an established liquid waste management plan?

Answer	Response	%
Yes	3	20%
No	12	80%
Total	15	100%

15. Please describe the established protocols.

Text Response

all liquid V.O.C.'s are disposed of through a waste management company

rain barrells

16. Does your business use a snow removal service for parking lots and sidewalks?

Answer	Response	%
Yes	16	89%
No	2	11%
Total	18	100%

17. Where is the removed snow deposited?

Text Response
back and side of property
in the yard
on-site
back of building
piled on south end of parking lots (upper and lower lot) and slow drains across blacktop (2-3 wks)
on site off of paved lots
behind building
moved to parking lot edges
adjacent to creek at edge of parking lot, in field on opposite side of creek
snow plowing in house and piled on property approx 30% will melt and go to bay through storm drains
on my grass
corners of parking lot
west side of building

18. Does your business apply salt in the parking lot and/or sidewalks?

Answer	Response	%
Yes	16	94%
No	1	6%
Total	17	100%

19. How frequently is salt applied?

Text Response	Code
just to sidewalks	2
rarely - only when absolutely necessary, and then just in the patients walking area	3
very sporaticly - go through maybe 1 bag/year (it wrecks carpets)	3
daily	1
Too frequently in my opinion. To prevent lawsuits is reason for application.	1
as needed to prevent slips and falls	2
as needed	2
"ice melt" - sidewalks, in high traffic areas frequently - once or twice per season applied to overall lot	1
very rarely & small amounts	3
as needed	2
depends on snowfall	2
as needed on sidewalks for ice	2
hand spread, only @ door	3
daily during winter	1
ask landlord (leased property)	4

Coding	Answer	Category	Total	Percent
1	Daily-Weekly	Frequently/Daily	4	27%
2	Occassionally/As Needed	Occassionally/As Needed	6	40%
3	Rarely/Sparingly	Rarely/Sparingly	4	27%
4	Unknown	Unknown	1	7%
		Total	15	100%

20. Does your business use a landscaping service?

Answer	Response	%
Yes	13	72%
No	5	28%
Total	18	100%

21. What company/landscaping service do you employ?

Text Response
Green Thumb Gardening
Mark Beadet
Bodette's & Hoffmans
Green Thumb
Evergreen
Property Management Co. (Jack VanTreese & Assoc.)
P.C. Lawn Care
4 Seasons (?)

22. How frequently is the lawn mowed?

Text Response	

	Coding	Answer	Response	%

once every two weeks	2
as needed	1
1/wk	1
3x/mo	3
weekly	1
1-2 weeks	1
weekly	1
biweekly	2
weekly	1
once/week	1
weekly	1
varies by area, 1-7 days/wk	1
bi-weekly	2
1 per week	1
weekly in summer	1
ask landlord	4

1	Weekly/As Needed	Weekly/As Needed	11	69%
2	Bi-weekly	Bi-weekly	3	19%
3	3x per Month or less	3x per Month or less	1	6%
4	Unknown	Unknown	1	6%
		Total	16	100%

23. Is the lawn mowed directly to the creek edge?

Answer	Response	%
Yes	0	0%
No	9	100%
Total	9	100%

24. Is fertilizer applied to the lawn?

Answer	Response	%
Yes	7	41%
No	6	35%
Unknown	4	24%
Total	17	100%

25. Are pesticides applied?

Answer	Response	%
Yes	4	24%
No	10	59%
Unknown	3	18%
Total	17	100%

26. Do your employees interact with the creek in any way, such as an outdoor employee break area?

Answer	Response	%
Yes	0	0%
No	1	100%
Total	1	100%

27. Does your business use any of its outside property as a storage site?

Answer	Response	%
Yes	2	12%
No	15	88%
Total	17	100%

28. Please describe the outdoor storage use.

Text Response
metal storage bin - old shipping container
owners store recreational vehicles

29. How would you prefer to learn about the results of this survey?

Answer	Response	%
Mail	12	75%
Phone	1	6%
One-on-One Meeting	0	0%
Small Group Meeting	2	13%
Town Hall Meeting	1	6%
Total	16	100%

30. What day/time is best for you for a meeting?

Answer	Response	%
Weekday Morning	5	56%
Weekday Lunch	0	0%
Weekday Evening	4	44%
Weekend	0	0%
Total	9	100%

31. Do you know where the creek flows after it leaves your property?

Answer	Response	%
Yes	6	35%
No	2	12%
n/a	9	53%
Total	17	100%

32. Where does it flow after leaving your property?

Text Response
to adventure golf property
to the creek by highway
into Little Traverse Bay
vacant property, pirate's cove, bank, condos, bay
into Little Traverse Bay
east of business

33. How would you rate the condition of the creek as viewed from your property?

Answer	Response	%

Very Good	0	0%
Good	3	43%
Fair	3	43%
Poor	1	14%
Total	7	100%

34. When looking at the creek, do you notice any of the following? Please check all that apply.

Answer	Response
Trash/Litter	4
Invasive Species/Weeds	2
Erosion	2
Unpleasant Odor	0
Discoloration	2
Other	6

Invasive Species/Weeds (If known, please list species below.)

occasional algae growth - otherwise nice and clear

Unpleasant Odor (Please describe below.)

Discoloration (Please describe below.)

high iron in water - stains sink and stool

only after a big rain - silty, muddy

Other:

cannot see creek from
property

no drinkable

decrease in wildlife in and near creek over past 10-15 years

I do not see any moving water; we try to keep ditch area clean, but there is some old concrete/etc.

rusted barrels/broken glass

been a lot of construction, so water is polluted; do not see it from the office

For the following items, please rate whether or not you agree with the statement.
(1=Strongly Disagree, 5 = Strongly Agree)

The information presented was clear and easy to understand.

Mean Response: 4.56
Total Respondents: 18

The information presented was relevant to me.

Mean Response: 4.06
Total Respondents: 18

The presenters were knowledgeable about the subjects presented.

Mean Response: 4.78
Total Respondents: 18

I felt comfortable asking questions and giving feedback.

Mean Response: 4.53
Total Respondents: 17

My questions were answered thoroughly.

Mean Response: 4.54
Total Respondents: 13

I have a greater understanding of the watershed now than when I arrived.

Mean Response: 4.61
Total Respondents: 18

I am aware of how to continue being involved in the management of Tannery Creek.

Mean Response: 4.89
Total Respondents: 18

What was the most interesting/important piece of information that you gained at today's meeting?

Where my property is located in the watershed. Happy to hear all the efforts to protect the creek.
Stats on percentage of impervious surface vs. water quality degradation
Flood control
When the plan will be finished
Zoning
That there was a creek there.
Water quality
Quality of water
How big the Tannery Creek watershed is.
How important it is.
Learning about the watershed
How many surveys are actually done to Tannery Creek watershed.
How widespread the watershed actually is
The info about the quality of the water
The quality of the water is good.

Are there any concepts unclear and/or is there any information that you would have liked to be covered in more detail?

Tribal uses and traditional knowledge
Land management possibilities in the watershed

Manipulation, i.e., ponds, dams, etc.

Pretty well covered

You did a great job.

Are all the women in environmental studies so cute?

Would have liked to hear info on water levels.

Do you have any specific concerns regarding Tannery Creek that yo uwant us to be aware of?

Stormwater fluxes of pollutants - creek also dries up occasionally

Preservation as is well-addressed

Additional Comments/Feedback:

Great work

Thank you for the pizza & drinks. Overall, I really enjoyed your presentation.

What is your association with the watershed?

Answer	Response	%
Business owner/manager	2	11%
Resident	3	17%
Landowner	3	17%
Student	8	44%
Other*	2	11%
Total	18	100%

*Other: Tribal Government; TOMWC volunteer

How did you learn about this meeting?

Answer	Response
Postcard Invitation	4
Phone Call	2
Newspaper Article	5
Radio Announcement	0
Other*	7

*Other: Email invite; Teacher; Class

PUBLIC OUTREACH MATERIALS

AQUA-STARS BUSINESS RECOGNITION PROGRAM

Background

For more than a century, Little Traverse Bay has proven essential to the economy of the surrounding communities. Annually, its beauty attracts tourists from around the nation, serving as a place of respite for a variety of travelers. Ironically, the management practices of the businesses in the region pose a threat to the quality of the water resources that make the region attractive.

To specifically address the issues facing Little Traverse Bay and its surrounding watershed, the Watershed Council created the Little Traverse Bay Watershed Management Plan, which was completed in December 2005 and approved by the Michigan Department of Environmental Quality and US Environmental Protection Agency in June 2007. An Advisory Committee composed of representatives from a diverse set of organizations and local government agencies provided input to the Plan and prioritized its recommendations. The overarching goal of the Plan is to protect and enhance the water quality and ecosystem integrity of Little Traverse Bay and its tributaries.[136]

Tip of the Mitt aims to increase its efforts at protecting Little Traverse Bay through the reduction of non-point source pollution entering the bay. Non-point source pollution is any pollution that cannot be traced directly to one specific source; rather, its origins are many and diffuse. Much of the non-point source pollution that affects the Bay is storm-water runoff, or rainwater that runs off the land before entering surface water sources, such as Little Traverse Bay and its tributaries. The increased amount of paved, or impervious, surfaces in the developed urban areas surrounding the Bay add further threats to this problem. Rather than allowing rainwater to percolate through the ground before entering water bodies, the water flashes across these impervious surfaces, bringing with it substances such as dirt, fertilizers, chemicals, trash, and bacteria that cause a serious threat to the health of the aquatic communities of the Bay. In addition to these contaminants, the speed of this flowing water causes erosion along stream banks and shorelines, increasing the amount of sediment flowing into the Bay.

In a community with a tourist-based economy, such as those surrounding Little Traverse Bay, restrictions on water recreation due to water quality degradation would be devastating. In a recent survey of businesses located in a sub-watershed of Little Traverse Bay, 83% of survey respondents (n=18) recognized the importance of the Bay on the economic vitality of their business, with responses recognizing the moderate impact of the Bay on the survival of their businesses. Over half of the businesses also admitted their reliance on seasonal tourism. With the potential for severe impacts on these tourism resources due to water degradation, prevention is the key to protecting the water resources that these communities have come to rely on for over a century.

To reduce the effects of non-point source pollution, efforts must be spread across a broad spectrum of audiences. Recognizing that non-point source pollution is a community effort, this program will reach one such audience, the business community at large, ultimately reaching over 75 businesses in the region. *Aqua-Stars* is a program designed to recognize significant commitment to, and actions by, a business to improve water quality in Little Traverse Bay and its tributaries. Since urban storm water is a significant threat, the focus is on businesses located throughout the Little Traverse Bay watershed. (See Figure 43 below for a map of the Little Traverse Bay watershed.) By encouraging the implementation of best management practices for water quality protection, the program will achieve reduced non-point source pollution, ultimately improving and protecting the water resources of the Little Traverse Bay watershed.

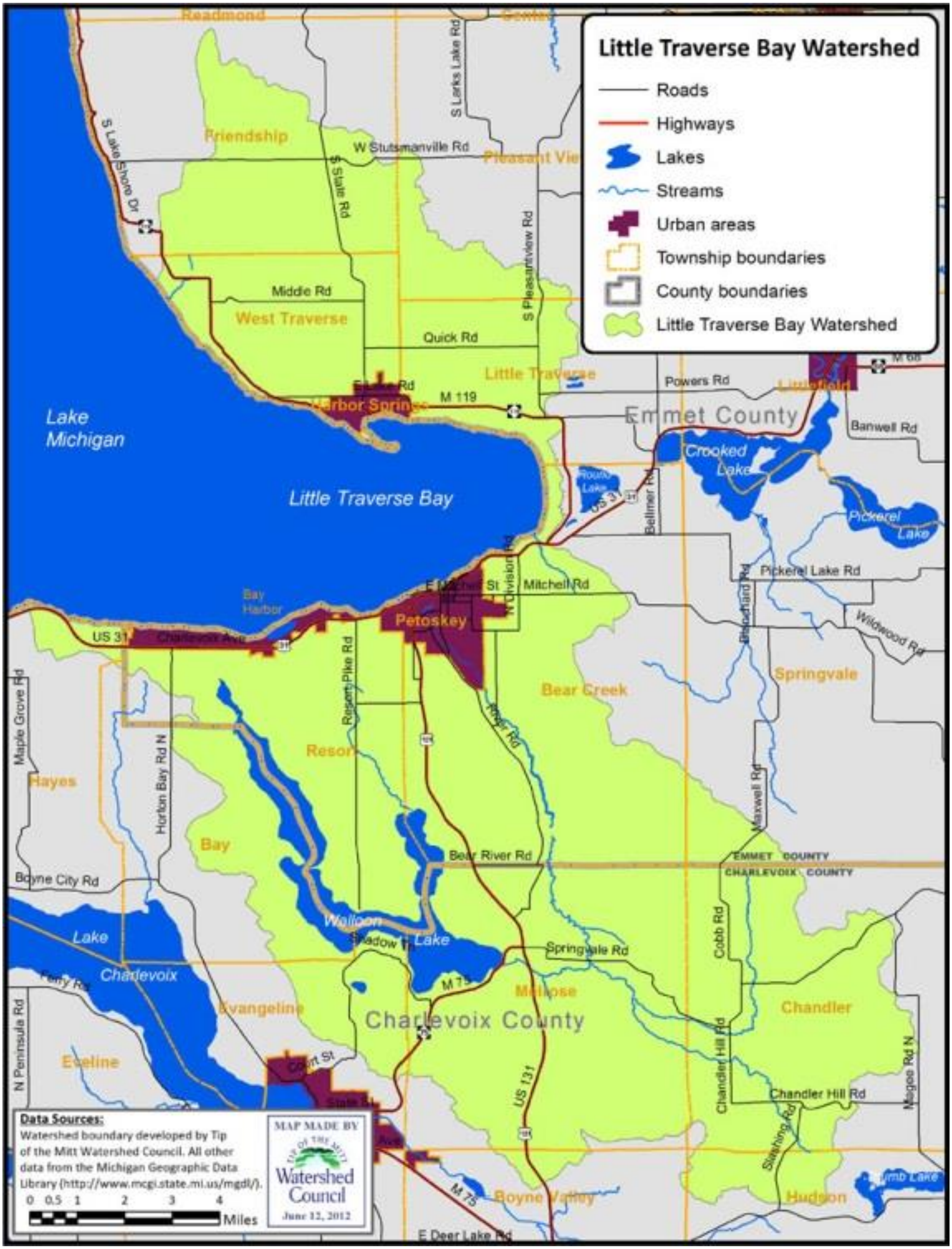


FIGURE 43: MAP OF LITTLE TRAVERSE BAY WATERSHED

Program Description

The purpose of this program is to publicly recognize businesses that protect the water quality of Little Traverse Bay through the implementation of practices that keep non-point source sediments, nutrients, or toxic pollutants from entering the Bay. The program seeks to reach all businesses in the Little Traverse Bay watershed; however, considerable focus will be directed to the business categories with the potential for the largest impact on watershed health. These business categories include auto repair, landscaping, restaurants, and golf courses. Each business will receive a list of best management practices (BMPs), specific to the corresponding business category. All other businesses will be placed in the general business category, receiving the general list of actions. (See Tables 63-67 for action lists.) Businesses also have the option to include other actions in the list, which may be meaningful actions for water quality protection, yet not included in the list.

The Program has four tiers of recognition, with the base level representing a pledge to protect water quality, and higher levels representing a more significant commitment and continuing record of best management practices (BMPs), making a positive contribution to water quality in Little Traverse Bay and/or its tributaries. The first level, Aqua-Starters, will receive a single star, and is designed to be accessible to any business. This level represents public commitment by a business to implement five of the listed BMPs within a year's time. This pledge will be signed and posted in a public place, as a symbol of the business's commitment to watershed protection. The second level, represented by two stars, is designed to be the next step in watershed protection. It represents the implementation of a number of BMPs to reduce or eliminate pollution of the Bay, as a result of that business's operations. The third level, represented by three stars, requires a higher level of commitment. It recognizes successful implementation of BMPs mentioned above, plus some extra effort. Recipients recognized at the 3-star level add further key practices and a commitment to carry out future efforts to reduce adverse impacts of its operations on water quality. The highest level of recognition, 4-stars, will be awarded to a business that fully and continuously implements the range of BMPs applicable to its operations. Recipients receiving 4-stars will also make additional contributions to achieving the goals of the Little Traverse Bay Watershed Protection Plan, such as serving on management committees, sponsoring environmental events, or providing volunteer service. (See Participation Requirements below for specific requirements for each level.)

A business desiring to participate in *Aqua-Stars* will submit an online application to the Watershed Council. Through an on-line, interactive format, the business owner or manager will be guided through the application process, making the process simple and accessible. Applicants will be expected to answer questions regarding business type, current management practices, including those listed as BMPs in the action lists, and the willingness and commitment to enact further BMPs in the future. The application will indicate actions the business has taken, or commits to undertake, in support of this recognition.

All applications will be reviewed by a review committee composed of volunteers from local business, government, and non-profit organizations. During the selection process, the panel will review documentation and determine the level of recognition to be awarded. To continue to participate and be recognized under the program, a business will re-apply each year to share actions it has taken, lessons learned from its experience, and the additional (if any) actions it has taken or plans to take in the following year. The panel will then oversee annual implementation reviews and the recertification of participating businesses.

Once approved by the review panel, a business qualifying for recognition under the Program would be eligible for a variety of benefits, including visible signs of public recognition such as a window decal or plaque, recognition at public meetings, and listings in newsletters, websites, and brochures. Partnerships with local media will give additional opportunities for recognition through newspaper advertisements and articles, and radio and television announcements. Based on the level of recognition, eligible businesses will receive corresponding benefits. Only those businesses recognized at the highest level will receive all of the possible benefits. (See Recognition Benefits below for more details.)

Recognition Benefits

Aqua-Starters – 1-Star Recognition

Businesses participating at the *Aqua-Starters* level will receive the following benefits:

- Receive a window decal for use at place of business
- Permission to use recognition/level in marketing materials

2-Stars Recognition

Businesses qualifying for 2-Star Recognition status will receive all the above benefits in addition to the following:

- Annual newspaper articles/advertisements listing all businesses qualifying under the program.
- A brochure listing qualified businesses produced and made available widely, including through the Chamber of Commerce.

3-Stars Recognition

Businesses receiving the 3-Stars level of recognition will receive all of the above benefits and the following:

- Attractive plaque/trophy/framed certificate (or something like that) with level and year of award
- Listed on the Little Traverse Bay Watershed Protection Plan Advisory Committee webpage as an Aqua-Star business.
- Listed in the Watershed Council's annual report and recognized at TOMWC annual meetings and Little Traverse Bay Watershed Protection Plan Advisory Committee meetings.

4-Stars Recognition

Businesses receiving the highest level of recognition will receive all of the above benefits and the following:

- Invitation to annual recognition dinner, to be hosted by a partnership of the Watershed Council and the local Chamber of Commerce
- Radio announcements and press releases detailing the story of the business's commitment to watershed protection
- Business included as a "success story" in the marketing of Aqua-stars
- Recognized at and invited to the annual Chamber of Commerce Breakfast for Champions award ceremony.

Participation Requirements

To be eligible for each level of recognition, a business must complete the following actions. Previously participating businesses are eligible for annual renewal and/or increase in recognition status by increasing the actions completed each year. (See Appendices A-E for complete action lists.)

Aqua-Starters – 1-Star Recognition

- Publicly pledge to complete at least 5 actions from the list below within the first year of participation in the program.

2-Stars Recognition

- Complete or commit to complete within a specified timeframe at least 10
- actions from the lists below.

3-Stars Recognition

- Complete or commit to complete within a specific time at least 20 actions from the list below.
- Hold at least one training program per year for all employees related to these actions, and incorporate into the training of new staff.
- If business has previously participated in the Program, have fully carried out the actions from previous year(s) and submitted annual report.

4-Stars Recognition

- Complete or commit to complete within a specific time at least 25 actions listed.
- Hold at least one training program per year for all employees related to these actions, and incorporate into your training of new staff
- Fully carry out the actions from at least one previous year in the program and submit annual report(s)
- Make additional contributions to achieving the goals of the Little Traverse Bay Watershed Protection Plan. Examples of this include: sponsoring events or providing volunteers for water quality/watershed management activities; making business facilities available to water quality/watershed management activities; providing leadership within the business community on water quality issues; contributing to the LTB Fund; or otherwise actively promoting water quality actions in LTB.

Implementation and Evaluation

The success of the program will rely heavily on partnerships with the local media and Chamber of Commerce. Advertising and marketing during the initial phase of the project will include one-on-one meetings with local business owners and Tip of the Mitt staff, in addition to newspaper and radio advertisements. As businesses begin to participate in the program, recognized businesses will provide testimonials for the program, thereby increasing its local credibility. Finally, businesses that are publicly recognized will receive advertising through local media sources and the environmentally friendly status associated with the *Aqua-Stars* brand.

The program has three major phases: initial development and marketing, implementation and promotion, and review and recognition. The first phase will be a one-time event, while the other two will repeat annually through the life of the program. (See Appendix F for a timeline of the major milestones for the first year of the program.)

As a new program, most associated program expenses are one-time expenses, such as the hire of a Program Development Intern, the development of a web-based application, and significant promotional costs. The majority of the budget is made possible by generous in-kind contributions from Tip of the Mitt staff and board members, community volunteers, and local media.

The ultimate goal of impacting the water quality of Little Traverse Bay cannot be completed without effective program implementation. A quantitative evaluation of the number of participating businesses and the number of best management practices implemented by each, will give a sense of the efficiency of the program, in terms of level of participation. To determine the number of actions that were completed due to the program, a survey will be included in the application process. Participants will be asked to acknowledge which actions were completed prior to participation in the program, and which actions were completed due to program participation. In addition, to assess the success of advertising methods, the application will include questions regarding the method in which each business learned of the program. Finally, there will be a question assessing the application process itself, regarding ease of understanding and completion.

During subsequent years of participation, businesses will be questioned about the perceived effectiveness and benefits of the program. Businesses that re-apply will receive this questionnaire during the application process; those that choose not to re-apply will receive a mailed survey. Especially during the initial years of program implementation, Tip of the Mitt will frequently elicit feedback from the businesses regarding the program. This information will be used to adapt and adjust the program accordingly.

Flexibility and the ability to adapt will prove essential to program success. Initially, if business response is lacking, Tip of the Mitt will need to be prepared to dedicate further resources to program promotion. For example, the organization may offer on-site assessments for businesses to recommend realistic action steps for each business to complete. This one-on-one interaction with business owners and managers will increase awareness of the program. More importantly, this will assist businesses by providing the procedural knowledge of specific actions that are achievable.

In addition, by including an “other” option on the action lists, this will allow for the lists of Best Management Practices to evolve over time upon realization that certain actions are meaningful yet missing from the lists. A review of these lists will need to be conducted bi-annually to ensure that they are reflective of current BMPs.

TABLE 62: AQUA-STARS IMPLEMENTATION TIMELINE

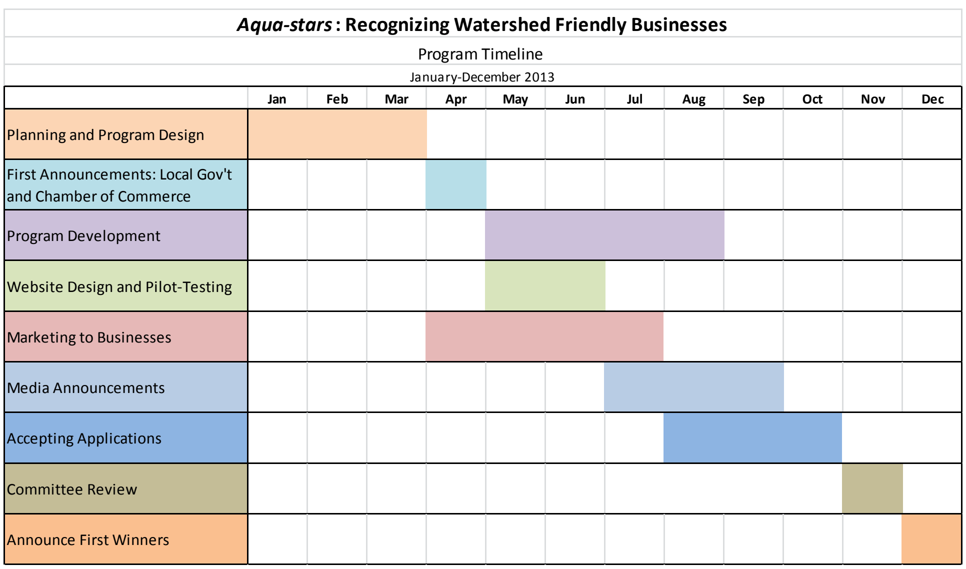


TABLE 63: AQUA-STARS ACTIONS, GENERAL BUSINESSES

⊗	Action	Date Completed	Date to be Completed
	Post Best Management Practices in general view of all employees and customers. Provide customers with information on water pollution.		
	Place signs reminding customers and employees to conserve water and report leaks.		
	Regularly clean litter and debris surrounding all sides of your business.		
	Install pet waste bag dispensers and signs to encourage visitors to pick up pet waste.		
	Keep receiving areas and dumpsters clear of litter. Empty dumpsters regularly and increase pick-up frequency if needed to avoid overflow. Inspect dumpsters for leaks and ensure that dumpsters are always secured with tight fitting lids.		
	Cover/contain materials stored outside to prevent rainwater contamination and runoff into storm drains		
	Dispose of hazardous waste properly. This includes e-waste, fluorescent bulbs, motor oil, and other chemicals.		
	Ensure that all storm drains remain clear of debris and litter. Mark all storm drains with "no dumping" message. Never use salt to clear ice-covered storm drains.		
	Determine current water consumption levels and monitor the water bill monthly to detect problems. Keep a water-saving log.		
	Use and document water saving strategies for cleaning. Train employees about water-saving techniques.		
	Regularly check water system for leaks, and promptly repair leaks in toilets, faucets, and pipes if found. (Dye tablets can be used to check for toilet leaks. All other leaks can be detected through visual inspection.)		
	Use environmentally preferable cleaning products, such as those with a Green Seal or EcoLogo certification. Use and dispose of cleaning products and other chemicals with care. Use them completely or take them to a hazardous waste disposal facility. Never mix chemicals with regular trash, pour down drains or dump on ground.		
	Follow proper snow and ice removal techniques. This includes closing areas that are not frequently traveled; initiating night time snow removal crews; training snow removal crews in effective salt and sand application; alternative de-icing products; anti-icing techniques, proper storage of salt/sand, piling snow where it will be possible to recover solids after melting.		
	Establish a plan for oil or chemical spillage cleanup and follow it every time. Train all employees the proper methods for carrying out the plan.		
	Dispose of wastewater properly – reuse for watering vegetation if free of contaminants or pour into sanitary drain. Never pour into storm drains. Route dirty cleaning water to sanitary sewers, not storm drains/gutters/streets.		
	Use ground cover or mulch around plants to prevent evaporation.		
	Utilize landscaping to minimize bare soil eroding into storm drains.		
	Use the highest acceptable mowing height for grasses, typically 2 ½ to 3 inches. Compost or leave grass clipping		

⊗	Action	Date Completed	Date to be Completed
	on mowed turf rather than sending them to the landfill. Never direct clippings into bodies of water. Remove any clippings that have blown onto impervious surfaces.		
	Ensure that hazardous cleaning materials are used sparingly, and according to manufacturer's directions. Store all chemical products in their original containers and properly labeled secondary containers with tight fitting lids. Chemical products should be stored in secure, controlled areas, away from storm-water runoff.		
	Regularly inspect and maintain all vehicles, with a particular focus on leaking fluids. Wash cars, equipment, floor mats and other items in area with floor drains leading to sanitary sewers, or direct water to landscaped areas. Do not wash where runoff water flows into the storm drain.		
	Direct downspouts into landscaping areas instead of into the storm sewer system, streets, or parking lots.		
	Use a cistern or rain barrels to collect and recycle rain water for irrigation or other purposes.		
	Water on an as-needed basis rather than a set schedule. Use rain gauges and soil moisture probes to determine necessity of irrigation. When irrigating, water in early mornings to minimize evaporation. Adjust sprinklers for even coverage of grass, avoid pavement, and repair defective lines and sprinkler heads.		
	Minimize fertilizer use and avoid products containing Phosphorous. Follow proper application procedures according to instructions. Never fertilize when heavy rain is expected.		
	Use pesticides sparingly. Use pest- and disease-resistant plants in landscaping. Never apply pesticides during rain or when a heavy rain is expected.		
	Use drip devices in lieu of sprinklers and install automatic hose shut-off nozzles for hand watering.		
	Install a rain garden or bio-swale to treat runoff from roof or parking lot.		
	Install pervious pavement to increase storm-water infiltration.		
	Install low flow lavatory faucet aerators (1.5 gpm or less) or motion-sensitive faucets.		
	Other:		
	Other:		
	Other:		

TABLE 64: AQUA-STARS ACTIONS: AUTO REPAIR AND CAR WASH BUSINESSES

⊗	Action	Date Completed	Date to be Completed
	Post Best Management Practices in general view of all employees and customers. Provide customers with information on water pollution.		
	Place signs reminding customers and employees to conserve water and report leaks.		
	Regularly clean litter and debris surrounding all sides of your business.		
	Cover/contain materials stored outside to prevent rainwater contamination and runoff into storm drains		
	Ensure that all storm drains remain clear of debris and litter. Mark all storm drains with "no dumping" message. Never use salt to clear ice-covered storm drains.		
	Establish a plan for oil or chemical spillage cleanup and follow it every time. Train all employees the proper methods for carrying out the plan.		
	Check all vehicles for leaks as they arrive. Use drip pans or plastic tarps to catch leaking fluid.		
	Train employees regularly on how to respond to spills, and proper product and waste storage techniques. Check employee performance to ensure adherence to these practices.		
	Provide employee incentives to reduce liquid waste, including contaminated oil, antifreeze, and/or solvent.		
	Follow proper snow and ice removal techniques. This includes closing areas that are not frequently traveled; initiating night time snow removal crews; training snow removal crews in effective salt and sand application; alternative de-icing products; anti-icing techniques, proper storage of salt/sand, piling snow where it will be possible to recover solids after melting.		
	Ask vendors to provide alternatives to hazardous products.		
	Store hazardous waste in tightly-sealed containers that are compatible with the waste they hold; kept inside or under cover; not in direct contact with soil or located over a drain; and clearly marked with the name and description of waste and its hazards.		
	Properly dispose of all hazardous waste: either treated so that it is no longer hazardous or is sent to a permitted recycling company, moderate risk waste facility, or treatment, storage and disposal facility. Never dispose of hazardous waste down sanitary, storm, or septic system drains, or garbage.		
	Dispose of wastewater properly – reuse for watering vegetation if free of contaminants or pour into sanitary drain. Never pour into storm drains. Route dirty cleaning water to sanitary sewers, not storm drains/gutters/streets.		
	Wash vehicles in a covered, contained bay. Collect and recycle the wash/rinse water. Never discharge wash water into storm drains.		
	Inspect your drains and discover where they drain. Ensure that floor drains from work and cleaning areas connect to the sanitary sewer system and not into the storm sewer. Never pour waste liquids into floor drains, sinks, outdoor storm inlets, or other connections to storm or sanitary water. Label drains or post a diagram for employees in a visible location.		
	When changing oil, flushing radiators, or changing other fluids, always drain and replace fluids in a designated		

⊗	Action	Date Completed	Date to be Completed
	area isolated from storm sewers.		

	Collect used oil and fluids in a labeled container for proper disposal. Dispose of used motor oil, other fluids, and their containers properly, recycling whenever possible. Never discharge fluids or oil to the ground or storm sewer. If your shop services air conditioners, you must use special equipment to catch the Freon or other refrigerant.		
	In order to reduce spills, use spigots, pumps, catch pans, and funnels when dispensing and transferring liquids instead of freely pouring them.		
	Use the "dry shop" principle: Keep a drip pan or container under all dripping/leaking fluids, and/or whenever removing parts that may leak fluids. Do not leave drip pans or open containers unattended. When a spill occurs, use absorbent materials like kitty litter, or absorbent pads to soak up the spill, then sweep the area with a broom. Larger spills must be contained before being cleaned up. Refer to your hazardous material response plan for larger spills.		
	Keep solid wastes in a covered dumpster. Empty dumpsters regularly and increase pick-up frequency if needed to avoid overflow. Inspect dumpsters for leaks and ensure that dumpsters are always secured with tight fitting lids.		
	Cover outdoor work and storage areas with a roof, cover or tarpaulin. Do not let rainwater contact old parts, scrap metal, tires or other waste. Keep any liquid storage on impermeable pavement and covered.		
	If vehicles are to be stored long-term, always drain gasoline, oil, and other fluids first.		
	Use shop cloths to wipe as much brake dust as possible from the rotors and drums before using brake cleaner fluid. Do not hose down brake pads, rotors, or drums with water.		
	Provide receptacles for and accept used fluids and materials from the public to be recycled.		
	Store cracked batteries in secondary containment to avoid water contamination. If a battery is dropped, treat as if cracked.		
	Clean parts without liquid cleaner whenever possible. When using liquid solvents, used solvents must be disposed of as hazardous waste. Never pour used solvents down storm or sanitary drains, even those marked as "biodegradable".		
	Use the highest acceptable mowing height for grasses, typically 2 ½ to 3 inches. Compost or leave grass clipping on mowed turf rather than sending them to the landfill. Never direct clippings into bodies of water. Remove any clippings that have blown onto impervious surfaces.		
	Install pervious pavement to increase storm-water infiltration.		
	Other:		

TABLE 65: AQUA-STARS ACTIONS: LANDSCAPING AND NURSERY BUSINESSES

⊗	Action	Date Completed	Date to be Completed
	Post Best Management Practices in general view of all employees and customers. Provide customers with information on water pollution.		
	Place signs reminding customers and employees to conserve water and report leaks.		
	Mandate participation of key staff in at least one seminar focused on the effects of landscaping practices on water and best practices for conserving water and protecting water quality.		
	Use composted materials.		
	Regularly clean litter and debris surrounding all sides of your business.		
	Cover/contain materials stored outside to prevent rainwater contamination and runoff into storm drains		
	Dispose of hazardous waste properly. This includes e-waste, fluorescent bulbs, motor oil, and other chemicals.		
	Ensure that all storm drains remain clear of debris and litter. Mark all storm drains with "no dumping" message. Never use salt to clear ice-covered storm drains.		
	Determine current water consumption levels and monitor the water bill monthly to detect problems. Keep a water-saving log.		
	Use environmentally preferable cleaning products, such as those with a Green Seal or EcoLogo certification. Use and dispose of cleaning products and other chemicals with care. Use them completely or take them to a hazardous waste disposal facility. Never mix chemicals with regular trash, pour down drains or dump on ground.		
	Dispose of wastewater properly – reuse for watering vegetation if free of contaminants or pour into sanitary drain. Never pour into storm drains. Route dirty cleaning water to sanitary sewers, not storm drains/gutters/streets.		
	Regularly inspect and maintain all vehicles, with a particular focus on leaking fluids. Wash cars, equipment, floor mats and other items in area with floor drains leading to sanitary sewers, or direct water to landscaped areas. Do not wash where runoff water flows into the storm drain.		
	Use drip devices in lieu of sprinklers and install automatic hose shut-off nozzles for hand watering.		
	Utilize landscaping to minimize bare soil eroding into storm drains.		
	Develop and implement a quality Integrated Pest Management or Organics policy or program.		
	Train employees on the company's IPM/Organics program, including pest identification and pesticide selection techniques. Always choose the product most appropriate for the problem/pest.		
	When applying pesticides, mix only the quantity needed. Read and follow all label directions. Properly dispose of any remaining chemicals. Never pour leftover chemicals into storm or sanitary drains.		
	Apply or suggest that customers apply spot treatments of pesticides only after specific diagnosis of a pest or disease problem—as opposed to calendar-based broadcast applications—and only after offering the customer a non-pesticide solution.		
	For customers with waterfront property, leave a buffer between mowed lawn and the edge of the water to trap		

	pollutants, sized according to the individual characteristics of the site. Inspect buffer areas for sediment accumulation after all major storm events.		
	Encourage customers to choose native and/or drought resistant plants and regularly grow and/or stock these plants. Avoid invasive or exotic species.		
	Soil test customers' lawns to reduce the amount of fertilizer used. Use mulch and compost instead of chemical fertilizers when possible. When using fertilizer, use slow-release fertilizers and avoid fertilizers containing phosphorous.		
	Encourage customers to use rain water harvesting to collect water for irrigation and help them install these devices.		
	Learn to install and encourage installation of rain gardens for customers.		
	Utilize sustainable sources of irrigation water such as reusing grey water and wastewater, harvested/stored rainwater, and surface runoff. Train staff to utilize these methods.		
	Mow lawns high (2 ½ - 3 inches) to encourage a deeper, more drought- and pest-tolerant root system.		
	Direct downspouts into landscaping areas instead of into the storm sewer system, streets, or parking lots.		
	Create and distribute educational packages on shoreline protection and restoration for shoreline property clients.		
	Install pervious pavement to increase storm-water infiltration.		
	Install low flow lavatory faucet aerators (1.5 gpm or less) or motion-sensitive faucets.		
	Other:		
	Other:		
	Other:		

TABLE 66: AQUA-STARS ACTIONS: RESTAURANTS AND FOOD SERVICE BUSINESSES

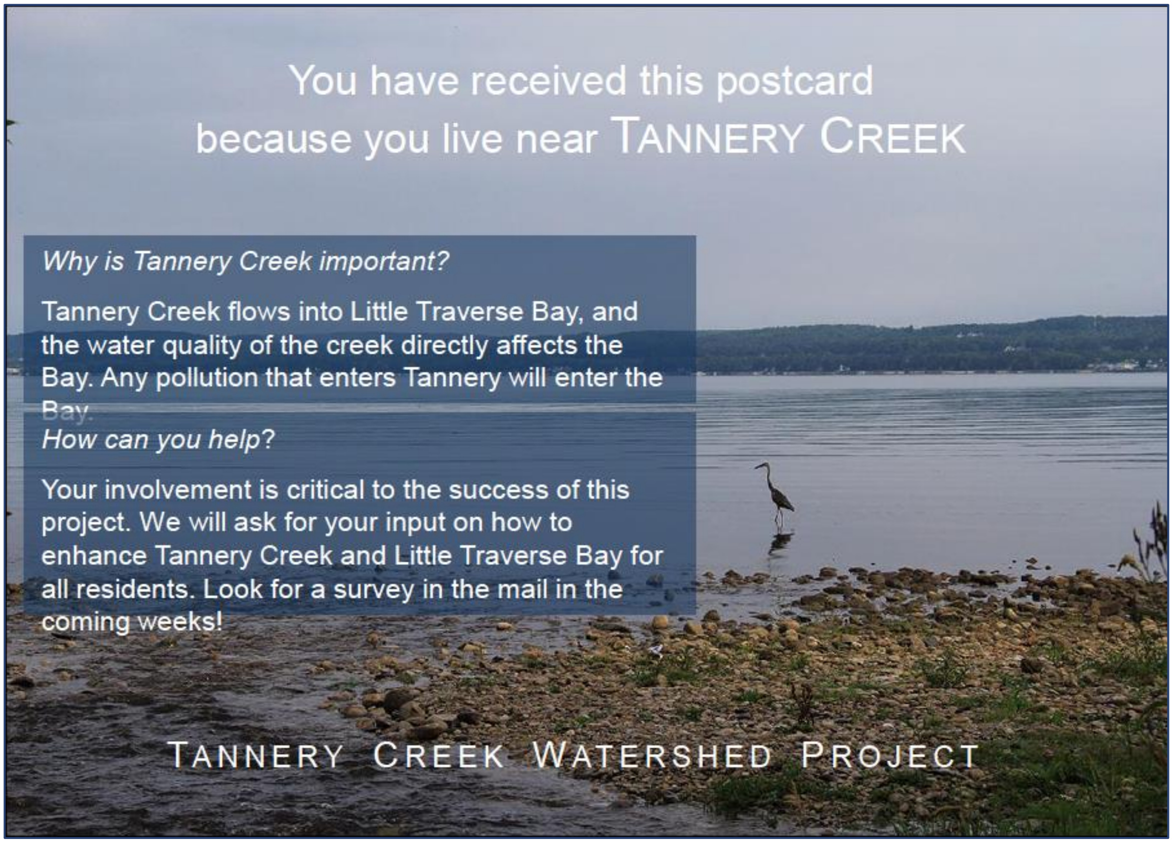
⊗	Action	Date Completed	Date to be Completed
	Post Best Management Practices in general view of all employees and customers. Provide customers with information on water pollution.		
	Regularly clean litter and debris surrounding all sides of your business.		
	Post signs reminding employees to dispose of oil and grease properly.		
	Inspect and clean grease traps at least once a week and keep a maintenance log. Keep exhaust hoods clean and free of grease and inspect roof for signs of grease buildup.		
	Minimize food scraps and grease going down the drain by scraping plates and dry wiping pots and pans to remove food and grease before washing.		
	Use garbage grinders sparingly to avoid blockage and buildup in the sewer collection system.		
	Put all garbage and recyclables in designated, covered leak-proof bins		
	Recycle grease and oil. Never pour it into sinks, floor drains, or onto a parking lot or street.		
	Keep receiving areas and dumpsters clear of litter. Empty dumpsters regularly and increase pick-up frequency if needed to avoid overflow. Inspect dumpsters for leaks and ensure that dumpsters are always secured with tight fitting lids.		
	Ensure that all storm drains remain clear of debris and litter. Mark all storm drains with “no dumping” message. Never use salt to clear ice-covered storm drains.		
	Clean floor mats, filters, and garbage cans in a mop sink or over a floor drain. Do not wash them in a parking lot, alley, sidewalk, or street where the wash water could pollute storm runoff.		
	Determine current water consumption levels and monitor the water bill monthly to detect problems. Keep a water-saving log.		
	Use and document water saving strategies for cleaning. Train employees about water-saving techniques.		
	Regularly check water system for leaks, and promptly repair leaks in toilets, faucets, and pipes if found. (Dye tablets can be used to check for toilet leaks. All other leaks can be detected through visual inspection.)		
	Use dry methods (absorbent material and/or sweeping) for oil and grease spill cleanup before mopping.		
	Follow proper snow and ice removal techniques. This includes closing areas that are not frequently traveled; initiating night time snow removal crews; training snow removal crews in effective salt and sand application; alternative de-icing products; anti-icing techniques, proper storage of salt/sand, piling snow where it will be possible to recover solids after melting.		
	Install pet waste bag dispensers and signs to encourage visitors to pick up pet waste.		
	Use environmentally preferable cleaning products, such as those with a Green Seal or EcoLogo certification. Use and dispose of cleaning products and other chemicals with care. Use them completely or take them to a hazardous waste disposal facility. Never mix chemicals with regular trash, pour down drains or dump on ground.		
	Buy the least toxic products available. Look for "nontoxic," "non-petroleum based," "free of ammonia,		

	phosphates, dye or perfume," or "readily biodegradable" on the label. Avoid chlorinated compounds, petroleum distillates, phenols and formaldehyde. Use water-based products.		
	Ensure that hazardous cleaning materials are used sparingly, and according to manufacturer's directions. Store all chemical products in their original containers and properly labeled secondary containers with tight fitting lids. Chemical products should be stored in secure, controlled areas, away from storm-water runoff.		
	Dispose of wastewater properly – reuse for watering vegetation if free of contaminants or pour into sanitary drain. Never pour into storm drains or onto a parking lot, alley, sidewalk, or street. Route dirty cleaning water to sanitary sewers, not storm drains/gutters/streets.		
	Use ground cover or mulch around plants to prevent evaporation.		
	Utilize landscaping to minimize bare soil eroding into storm drains.		
	Direct downspouts into landscaping areas instead of into the storm sewer system, streets, or parking lots.		
	Use a cistern or rain barrels to collect and recycle rain water for irrigation or other purposes.		
	Store excess materials and liquid waste inside a building or build a covered area that is paved and designed to prevent runoff from entering storm drains. Place materials inside rigid, durable, water- tight and rodent-proof containers with tight fitting covers. Storage containers should be regularly inspected and kept in good condition.		
	Install pervious pavement to increase storm-water infiltration.		
	Install low flow lavatory faucet aerators (1.5 gpm or less) or motion-sensitive faucets.		
	Install low flow toilets and urinals.		
	Other:		
	Other:		
	Other:		

TABLE 67: AQUA-STARS ACTIONS, GOLF COURSES AND CLUBS

⊗	Action	Date Completed	Date to be Completed
	Post Best Management Practices in general view of all employees and customers. Educate staff and customers about the importance of water conservation		
	Mandate participation of key staff in at least one seminar focused on the effects of landscaping practices on water and best practices for conserving water and protecting water quality.		
	Put all garbage and recyclables in designated, covered leak-proof bins.		
	Keep receiving areas and dumpsters clear of litter. Empty dumpsters regularly and increase pick-up frequency if needed to avoid overflow. Inspect dumpsters for leaks and ensure that dumpsters are always secured with tight fitting lids.		
	Determine current water consumption levels and monitor the water bill monthly to detect problems. Keep a water-saving log.		
	Use and document water saving strategies for cleaning. Train employees about water-saving techniques.		
	Regularly check water system for leaks, and promptly repair leaks in toilets, faucets, and pipes if found. (Dye tablets can be used to check for toilet leaks. All other leaks can be detected through visual inspection.)		
	Use composted materials.		
	Control erosion. Choose the right place, size and plants for buffer strips.		
	Use native and/or drought resistant plants; avoid invasive or exotic species.		
	Use environmentally preferable cleaning products, such as those with a Green Seal or EcoLogo certification. Use and dispose of cleaning products and other chemicals with care. Use them completely or take them to a hazardous waste disposal facility. Never mix chemicals with regular trash, pour down drains or dump on ground.		
	Buy the least toxic products available. Look for "nontoxic," "non-petroleum based," "free of ammonia, phosphates, dye or perfume," or "readily biodegradable" on the label. Avoid chlorinated compounds, petroleum distillates, phenols and formaldehyde. Use water-based products.		
	Ensure that hazardous cleaning materials are used sparingly, and according to manufacturer's directions. Store all chemical products in their original containers and properly labeled secondary containers with tight fitting lids. Chemical products should be stored in secure, controlled areas, away from storm-water runoff.		
	Dispose of wastewater properly – reuse for watering vegetation if free of contaminants or pour into sanitary drain. Never pour into storm drains or onto a parking lot, alley, sidewalk, or street. Route dirty cleaning water to sanitary sewers, not storm drains/gutters/streets.		
	Regularly inspect and maintain all vehicles and other equipment, with a particular focus on leaking fluids. Wash cars, golf carts, equipment, floor mats and other items in area with floor drains leading to sanitary sewers, or direct water to landscaped areas. Do not wash where runoff water flows into the storm drain.		
	Know when and where to irrigate. Use drip devices in lieu of sprinklers and install automatic hose shut-off nozzles for hand watering.		

	Minimize fertilizer and pesticide inputs to land management.		
	Develop and implement a quality Integrated Pest Management or Organics policy or program.		
	Train employees on the company's IPM/Organics program, including pest identification and pesticide selection techniques. Always choose the product most appropriate for the problem/pest.		
	When applying pesticides, mix only the quantity needed. Read and follow all label directions. Properly dispose of any remaining chemicals. Never pour leftover chemicals into storm or sanitary drains.		
	Store, handle, apply, and dispose of chemicals and other hazardous substances properly and in legal compliance.		
	Contribute to the natural function of the aquatic ecosystem and watershed by focusing drainage on the green only, increasing naturalized areas surrounding the green, including restoring floodplains and wetlands.		
	Collect, cleanse, store, and reuse storm-water through installation of swales, ditches, waterways (streams/ponds) and restored wetlands.		
	Utilize sustainable sources of irrigation water such as reusing grey water and wastewater, harvested/stored rainwater, and surface runoff. Train staff to utilize these methods.		
	Incorporate water-saving technologies such as motion sensors and low pressure fitments.		
	Direct downspouts into landscaping areas instead of into the storm sewer system, streets, or parking lots.		
	Install pervious pavement to increase storm-water infiltration.		
	Install low flow lavatory faucet aerators (1.5 gpm or less) or motion-sensitive faucets.		
	Install low flow toilets and urinals.		
	Other:		
	Other:		
	Other:		



We are graduate students from the University of Michigan School of Natural Resources and Environment. In collaboration with Tip of the Mitt Watershed Council, we are working to ensure that Tannery Creek and Little Traverse Bay continue to be a healthy part of your community.

If you have any questions please contact us at: crucial-creeks@umich.edu or 231-347-1181

Tip of the Mitt Watershed Council
426 Bay St | Petoskey, MI 49770

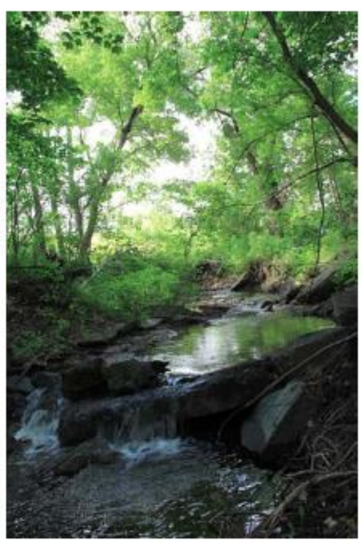
TANNERY CREEK WATERSHED PROJECT

FIGURE 44: INTRODUCTORY POSTCARD

GREETINGS RESIDENTS OF TANNERY CREEK WATERSHED!

If you have already filled out the survey sent by us regarding Tannery Creek, thank you! If you haven't yet completed the survey, you may now do so online: http://tinyurl.com/clbnolt.

Please also be on the lookout for an announcement about a town hall meeting regarding Tannery Creek in early January 2013. We are in the process of researching and determining a watershed management plan for the creek. We will discuss your ideas and thoughts at the town hall meeting, but for more information in the meantime, you can reach us at crucial-creeks@umich.edu.



Thank you for caring about Tannery Creek--this project can only be successful with your help!

Sincerely,
The Tannery Creek Watershed Team
Diana, Julie, Elizabeth, Leah, and Bo

FIGURE 45: SURVEY FOLLOW-UP POSTCARD

Tip of the Mitt Watershed Council
426 Bay St.
Petoskey, MI 49770

PLEASE
PLACE
STAMP
HERE

Your feedback is important to us!

Please join **Tip of the Mitt Watershed Council** and the Tannery Creek Watershed Team for a Community Forum to discuss the watershed management plan for Tannery Creek.

Monday March 4, 2013
9am or 7pm
Bear Creek Township Hall
373 N. Division Rd.

Refreshments provided!

Please RSVP
via email: tannery-creek@umich.edu
or phone: 231-347-1181

«Name»

«Address»

«City», «State» «Zip»

FIGURE 46: FORUM INVITATION POSTCARD

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