Protecting our Natural Resources

STORMWATER MANAGEMENT PLAN

Prepared for:

Village of Fife Lake

FLEIS&VANDENBRINK

DESIGN. BUILD. OPERATE.

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1.0 EXECUTIVE SUMMARY

1.1 OVERVIEW

In 2014, the Village of Fife Lake received a Stormwater, Asset Management, and Wastewater (SAW) Grant from the Michigan Department of Environmental Quality (MDEQ) to provide financial assistance for the development of a Stormwater Management Plan (SWMP). This report, prepared by Fleis & VandenBrink (F&V) addresses the stormwater management plan component of these requirements.

The Village of Fife Lake is situated on Fife Lake, which is a critical and valuable natural resource. It provides vitality to the community through tourism and is the reason many full time and seasonal residents choose to live in the area. In addition to providing critical environmental value, the lake also provides important social and economic benefits to the community. Fife Lake provides habitat for wildlife and is an important part of the local hydrologic system. As a critical natural resource, the Village has opted to prepare and implement a stormwater management plan (SWMP) to guide and help protect Fife Lake and its watershed. The Fife Lake watershed encompasses several jurisdictional boundaries in Grand Traverse and Kalkaska Counties, including the Village of Fife Lake, Fife Lake Township, and Springfield Township. Although multiple municipalities share in the responsibility of protecting Fife Lake, the MDEQ SAW Grant limits the focus of this SWMP to activities within the Village of Fife Lake.

Human activities can significantly impact the natural environment, ranging from what types of fertilizer are used to treating and controlling stormwater discharged to the lake. Small changes over large periods of time, or large significant events can impact the lake and subsequently impact the environment and quality of life of Fife Lake and its residents. This Stormwater Management Plan (SWMP) outlines goals, strategies, and programs to improve water quality and protect Fife Lake. There are multiple ways of improving and protecting water quality including:

- Implementation of new best management practices
- Increase public outreach – an educated public can be one of the most effective ways of protecting water quality
- Addressing existing system capacity – Undersized storm sewers, storage basins, or other systems can overflow, flood, and cause erosion and sedimentation
- Maintain proper operation of existing infrastructure – properly maintained infrastructure including storm sewers, drainage swales, and detention/retention basins protect the watershed by intercepting pollutants
- Replacement/Rehabilitation of Infrastructure – failing infrastructure can increase the risk of water quality impacts

The goal of this SWMP is to provide guidance and a framework to protect Fife Like through proper collection, retention/detention, treatment, and discharge of stormwater in addition to increasing public awareness and involvement of the community. It describes the Village's responsibilities and authority regarding stormwater management implementation, and provides descriptions of stormwater management best management practices (BMPs).

As a part of the SWMP, capital improvements and BMPs will be recommended. Although the SAW grant does not require improvements to be implemented, it is recommended that the Village budget for implementation of future capital improvement projects (CIP) and BMPS.

2.0 INTRODUCTION

2.1 OVERVIEW OF THE STORMWATER MANAGEMENT PLAN

This Stormwater Management Plan (SWMP) follows the outline of the SWMP in Appendix D of the SAW guidance documents. It outlines goals, strategies, and programs to improve water quality, address existing system capacity, and meet a required level of service in the most cost-effective way through the proper operation, maintenance, and replacement/rehabilitation of assets to provide consistent collection, retention/detention, and discharge of stormwater.

There are six core components of this Stormwater Management Plan:

1. **Drainage System Modeling and Analysis:** This step included identification and location of each collection system asset and identifying subbasin areas and their discharge points. A hydrologic model was developed in order to analyze the existing systems stormwater capacity. This step also included identifying land use within the Village of Fife Lake's jurisdictional and watershed boundary. This step also involved identifying existing conditions and problems through working with Village staff as well as information taken from the system model. *(See Section 3.0)*

2. **Stormwater Quality Testing and Modeling:** As a part of the project, the USEPA model Spreadsheet Tool for Estimated Pollutant Load (STEPL) was used to evaluate watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD_5); and sediment delivery. F&V used existing/known data for the Village area and sub-watersheds as input into the STEPL model. To supplement and verify the model, the Village conducted stormwater sampling and testing at both Village owned outlets. *(See Section 4.0)*

3. **Desired Level of Service (LOS):** The level of service focuses the Stormwater Management Plan on providing cost effective improvements to sustain the system while providing the intended level of service to residents. *(See Section 5.0)*

4. **Improvement Recommendation Plan:** This step was developed in conjunction with the Village staff along with the LOS. *(See Section 6.0)*

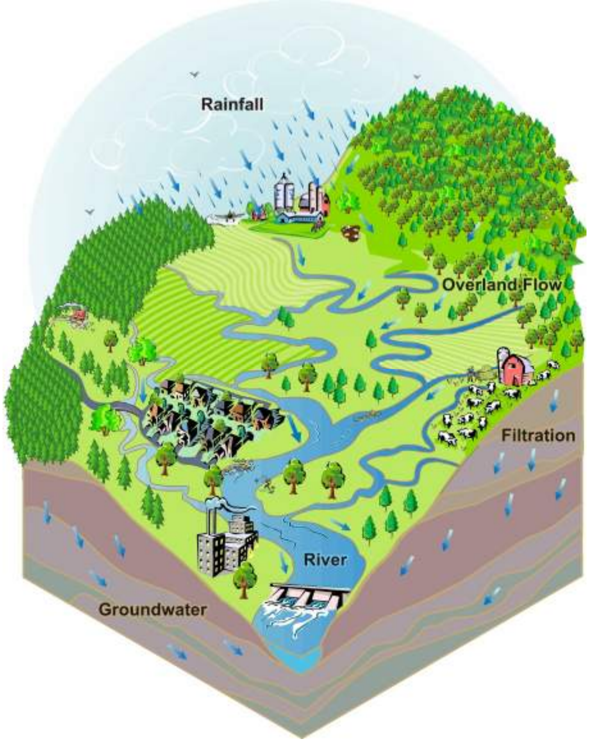


Figure 1: Schematic of Watershed

5. **General Maintenance Plan:** This step included identification and location of each component of the watershed drainage system and developing an appropriate maintenance plan. *(See Section 7.0)*

6. **Public Education Program:** This step includes developing and implementing programs to facilitate changes in public behavior. *(See Section 8.0).*

3.0 DRAINAGE SYSTEM MODELING AND ANALYSIS

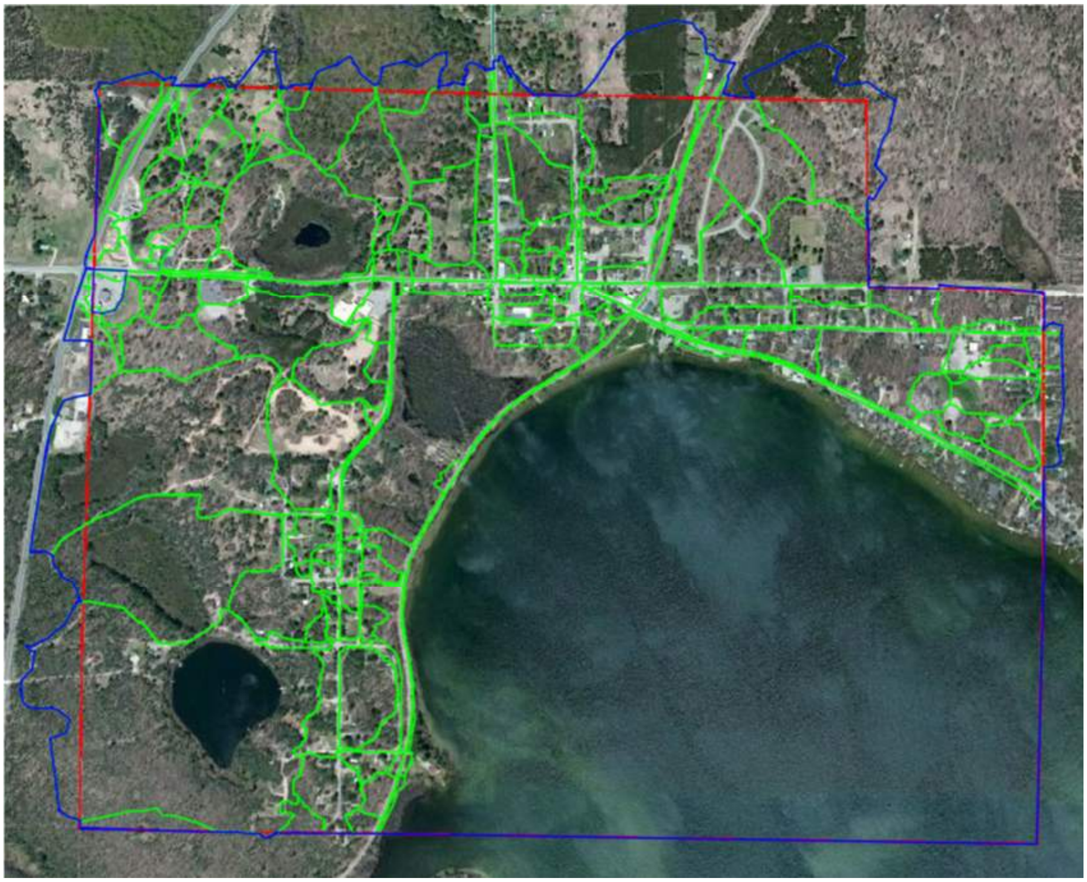
3.1 DRAINAGE AREA BOUNDARIES

3.1.1 CONTRIBUTING AREA

Using two-foot contours provided from an aerial survey, the Fife Lake watershed was analyzed. Due to the relatively large area of the Fife Lake watershed and complex terrain, AutoDesk Civil3D software was used as a tool for analysis. Civil3D features including waterdrop slope analysis, and catchment area tools were used to determine the watershed boundary and contributing area of the Village of Fife Lake. Although the Fife Lake watershed encompasses a large area spanning multiple municipalities, only the area directing stormwater runoff through the Village of Fife Lake was included in the analysis. After the Fife Lake Village drainage district was identified, the watershed was broken into individual subbasins which contribute stormwater runoff to individual outlets or storage areas. Approximately 170 subbasins were identified in the watershed, which were incorporated into the hydraulic model to calculate stormwater flow for each subbasin.

As a result of the analysis, a watershed map depicting each individual subbasin was created. In Figure 2 below, the municipal boundary of Fife Lake is shown in red, the drainage district contributing flow to the Village is shown in blue, and subbasins are shown in green. The jurisdictional boundary of Fife Lake is 749 acres, and the area of the drainage district is 805 acres. There are no recorded mapped floodplains, drainage districts, flood control facilities, or treatment components within the influence and jurisdictional boundary.

Figure 2 – Drainage Area Boundaries



3.1.2 LAND USE AND SOIL TYPE

Using high quality aerial imagery, the land use of the Fife Lake watershed was analyzed in AutoCAD Civil3D. The SCS soil maps were imported from GIS into AutoCAD Civil3D and overlaid onto the aerial imagery. For each sub-basin, areas of each land use were drawn over the corresponding Type A, B, C, or D SCS soil types. After the land use/land cover was determined for the Village, SCS curve numbers could be calculated for the subbasins in the hydraulic model. A description of the hydraulic modeling is included in section 4.0 below.

Generally, there is approximately 232 acres of residential, 204 acres of parks & open space, 22 acres of commercial use, and 302 acres of surface water within the jurisdictional boundary of the Village of Fife Lake. These land uses are represented in Figure 3 below. Because Fife Lake is largely a rural area with low population density, there is generally a large amount of undeveloped and open space which encourages stormwater infiltration and filtration. However, often times rural road sections with open ditching, gravel roads, and limited stormwater conveyance can also promote stormwater erosion and sedimentation control.

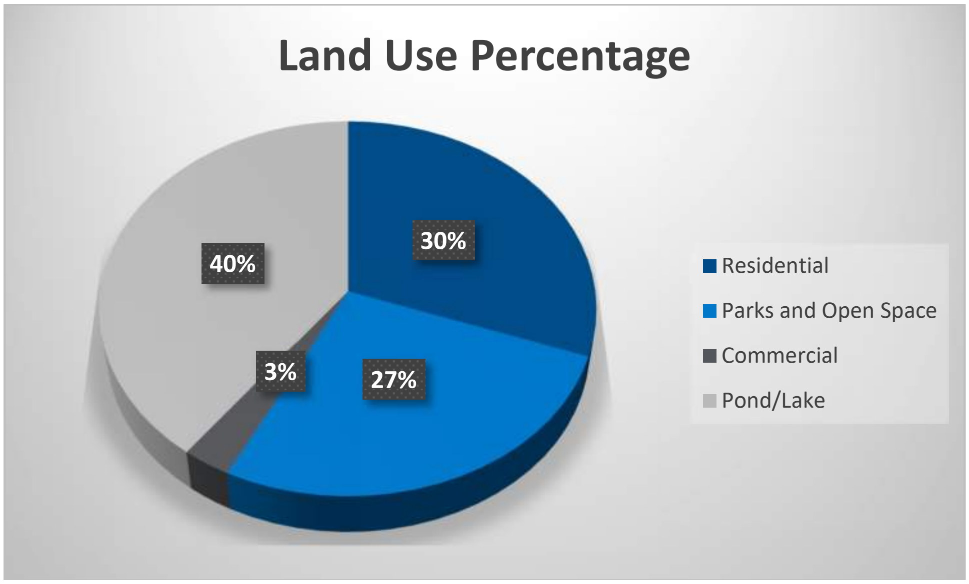


Figure 3 – Village of Fife Lake Land Use

A USGS soils map is provided in Appendix E showing the soil types in the Village of Fife Lake. The majority of the soil types are sandy which make up approximately 51.7 percent with the remaining being loamy sand, muck, and peat making up approximately 10.2 percent and surface water making up 38.1 percent. With the exception of areas adjacent to the lake, there is sufficient depth to groundwater within the Village boundary.

Soil type and depth to groundwater plays an important role in the amount of stormwater runoff. Well drained soils not only allow stormwater to infiltrate and recharge the groundwater, but also allow for filtration and improvement of stormwater quality. Because of the sandy nature of the Fife Lake soils, the size of stormwater controls including storm sewer and stormwater basins can be reduced as less runoff reaches the infrastructure. This in turn reduces initial construction costs but also reduces the amount of effort required to operate and maintain infrastructure.

3.1.3 CONVEYANCE AND COLLECTION SYSTEM

The Village stormwater collection system consists of collection, conveyance, and discharge assets. The infrastructure asset classes were defined by F&V and grouped into the following categories, as described below:

- Storm Sewers
- Culverts
- Surface Water Conveyance (ditching, curbing, etc)
- Stormwater Basins

These assets were evaluated during this study. Stormwater system assets are generally located in existing street rights-of-way or in easements dedicated for the assets use and maintenance.

Approach to Asset Inventory
The development of a stormwater system asset inventory can be challenging. In many cases, development of the asset inventory must sometimes rely on existing information and indirect assessments. The process typically includes several steps and evaluates information provided through several sources. These sources include local knowledge, community records including record drawings, field surveys, assessments, modeling and analysis of the system.

Developing a comprehensive stormwater collection system asset inventory includes a review of existing historical records (drawings, field notes, staff knowledge, etc.), supplemented with field survey and assessment work. Asset material, size and age were identified through the review of available historical record documents. Spatial orientation (pipe location), pipe depth and invert elevations were determined through a combination of review of historical records including GIS and supplemented with GPS field survey. This information is organized into a new GIS database for archiving, mapping and further evaluation purposes.

After preparing the initial GIS database and base map, a quality review process of the data was completed which included a review for missing or erroneous information and the building of a pipe network to properly connect the system operationally. Secondary field work was then performed to collect or correct information to make sure that the most accurate database was provided.

Village Assets
There is a total of 3,867 feet of storm sewer in the Village conveyance system. The predominant pipe size for the stormwater system is 12 inch, which makes up approximately 84 percent of the system piping. There are 11 manholes and 55 catch basins in the system.

A map of the Village stormwater collection system is presented in Appendix A; Figure A1.

Figure 4 provides a graphical representation of stormwater system pipes in percentage of length per size in the collection system.

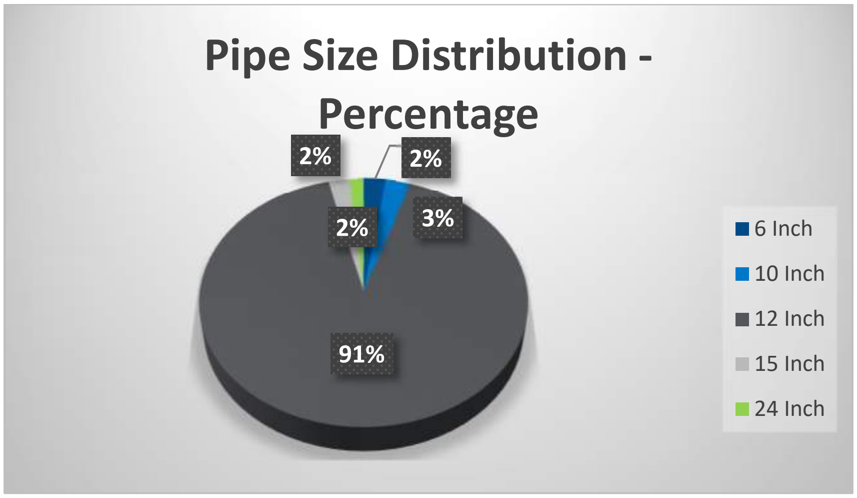


Figure 4 – Village of Fife Lake Storm System Pipe Size Distribution, Percentages

Figure 5 provides a graphical representation of stormwater system pipes in total length per size in the collection system.

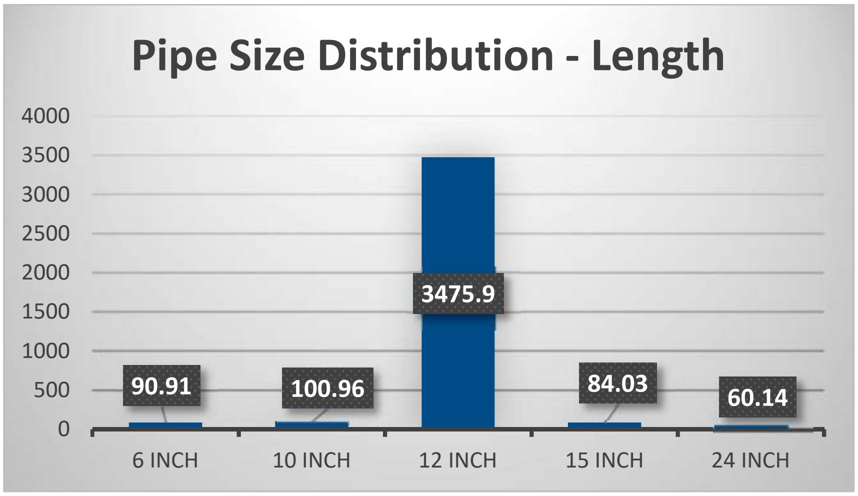


Figure 5 – Village of Fife Lake Storm System Pipe Size Distribution by Length

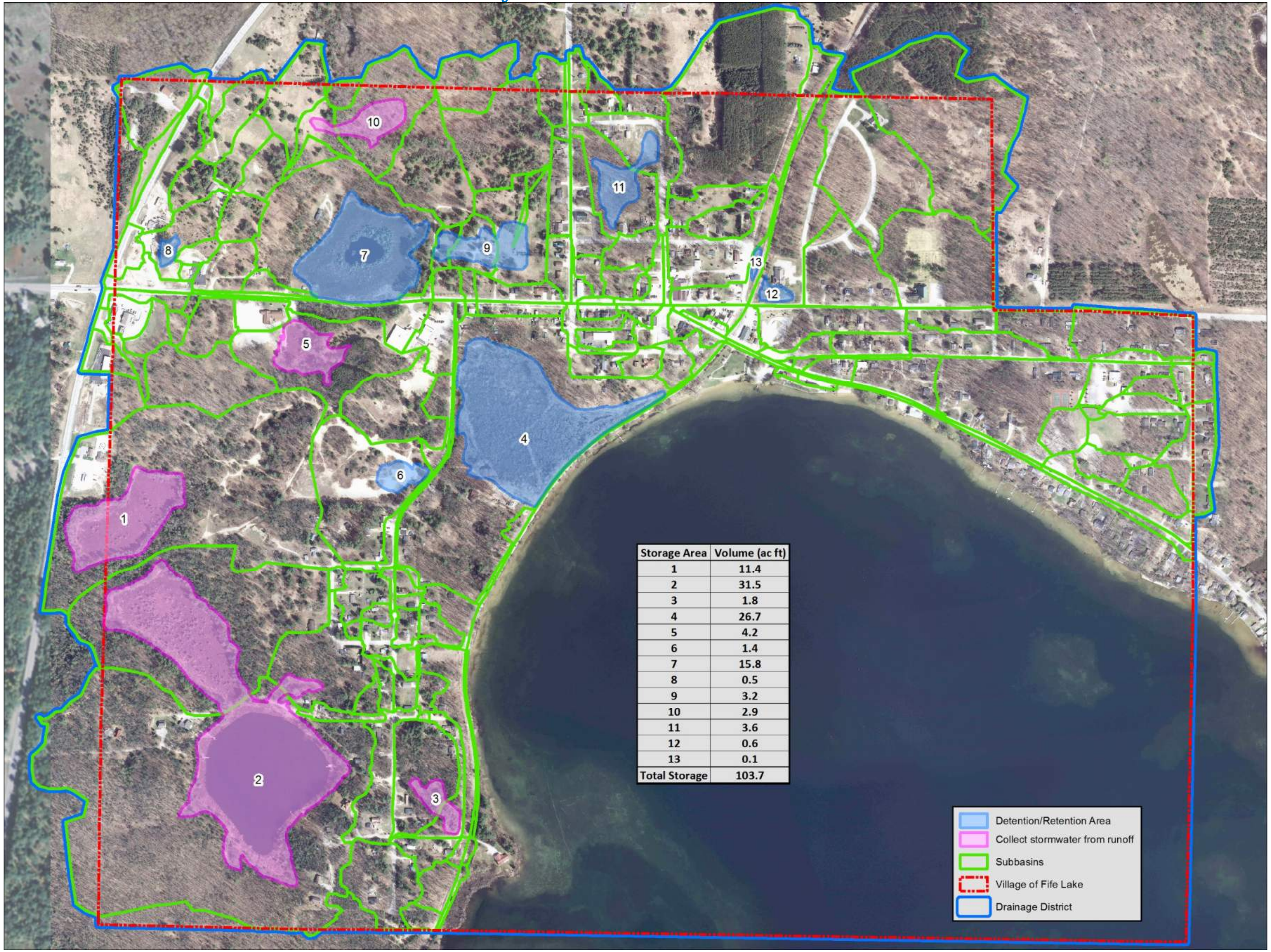
With the exception of State Street, streets do not have curb and gutter in the Village. The construction date of the original Village storm sewer system is unknown and no records for the system exist. It was designed to provide stormwater drainage and runoff management for the main business district on the main street through the center of the Village. State Street underwent an improvements project in 2003, which included improvements to the storm sewer. After the project, record drawings were provided which are included in the Village's GIS.

Although detailed field topographical mapping of ditching, curbs, and other surface water conveyance was beyond the scope of the project, these features were identified and evaluated through field inspections, visual observations, and gathering of historical information provided by Village staff.

In addition to stormwater conveyance, the Village system includes areas within the Village that act as stormwater detention or retention basins. The Village owns and operates one BMP – a stormwater infiltration basin on 4th Street adjacent to Mirror Lake. The basin was constructed in 2014 as a part of the 4th Street improvements project and significantly reduced the amount of stormwater and more importantly, sedimentation, into Mirror Lake. There is a non-engineered low area that acts as a stormwater basin across from the Post Office at the intersection of Front Street. The area is undersized however and is not maintained. In addition to the two publicly owned BMP's, there are two privately owned stormwater basins in the Village. The first is located on Merritt Street and serves the library. The second is located on State Street across from the boat launch and serves the boat launch parking lot. Neither of these engineered basins are owned or maintained by the Village.

These are largely natural features that are not maintained by the Village of Fife Lake. These areas collect runoff and provide both storage and infiltration and help to reduce peak flows in the system. Only one engineered stormwater basin exists at the Library, which is not owned or maintained by the Village. The Village of Fife Lake stormwater detention/retention areas and available storage volumes are shown graphically in Figure 6 below. Areas shown in blue have a direct outlet from the stormwater conveyance system. The storage areas are not connected hydrologically, however infiltration recharges groundwater in the watershed.

Figure 6 – Fife Lake Detention/Retention Areas



Storage Area	Volume (ac ft)
1	11.4
2	31.5
3	1.8
4	26.7
5	4.2
6	1.4
7	15.8
8	0.5
9	3.2
10	2.9
11	3.6
12	0.6
13	0.1
Total Storage	103.7

3.1.4 STORMWATER OUTLETS

There are two stormwater outlets in the Village that discharge directly into Fife Lake. The primary outlet identified as Outfall #1 collects water from the downtown area of the Village, and the secondary outlet identified as Outfall #2 drains runoff from Rebecca Street under East State Street. The outfall locations are shown on Appendix A, Figure A1.

The following photos show the stormwater outlet located near the Fife Lake Resort, identified as Outfall #1.

Outfall looking east

Outfall looking north

The following photos show the stormwater outlet located on private property, identified as Outfall #2 in. The stormwater outlet has been incorporated into landscaping, is filled with brick, and may impede flow through the storm sewer.

Outfall 2 looking south

Outfall 2 looking north east

3.2 HYDRAULIC MODELING

3.2.1 ANALYSIS AND RESULTS

F&V used Autodesk Storm and Sanitary Analysis (SSA) software for stormwater system capacity analysis. SSA includes an easy to use graphical user interface to provide an advanced graphical output. Results can be imported and exported to Excel spreadsheet reports which allows preparation of custom capacity reports. Calculations within SSA are made using the following equations:

- Manning's equation for open channel (free flowing) conditions:

$$Q = \frac{1.49}{n} AR^{\frac{2}{3}}\sqrt{S}$$

where Q = flow rate,
n = Manning roughness coefficient
A = cross-sectional area
R = hydraulic radius
S = energy slope

- Hazen-Williams equation for pressure sewer:

$$Q = 1.318CAR^{2/3}S^{1/2}$$

where:
Q = flow rate
C = Hazen-Williams C-factor, which varies inversely with surface roughness
A = cross-sectional area
R = hydraulic radius
S = energy slope

- The hydrodynamic calculation method for surcharged pipe and manhole conditions. The hydrodynamic routing method solves the complete one-dimensional Saint Venant equations consisting of continuity and momentum equation for each conduit and volume continuity equation for each node. Hydrodynamic routing method allows for pressurized flow, such as an adverse slope within the gravity collection system, and it can account for channel storage, backwater, entrance/exit losses, flow reversal, and surcharging. SSA can calculate the maximum hydraulic grade line (HGL), energy grade line (EGL), critical depth, peak flow in a sewer pipe for a given event, and maximum flow depth and velocity.

The following steps are included in the hydraulic modeling and analysis:

- Creating a network that represents the collection system assets from the GIS database.
- Verifying and editing the data.
- Calibrating and validating the model.
- Defining the analysis options and running the analysis.
- Reviewing the analysis output results.

For the Village project, F&V used the SCS TR-20 method and analyzed a 10- and 25-year storm event. Typically storm sewers are designed to accommodate a 10-year event without surcharging.

The stormwater system capacity analysis results show a majority of the system has capacity to convey the design storm event (10-year, 24-hour). However, there are 26 (43% of the system) sections of pipe that are surcharged for a duration of the design storm event. Each section of pipe is surcharged for a different amount of time, however on average they are surcharged for 34 minutes. The location of the majority of the surcharging is along E State St near Bates St and two other locations near E Morgan St and Clara St and along Oak St near E Front St. Based on the model and survey information, the pipes are surcharged due to either being undersized or pipes with uphill slope. Appendix B provides the following hydraulic model results and maps:

- Figure B1 - Map showing the location of the surcharged pipes
- Tables B1 & B2 - Detailed tabular results of the model
- Figures B2, B3 & B4 - Hydraulic profiles highlighting the surcharged pipes in the system.

3.2.2 PROBLEMS AND ISSUES

Village staff observations of historical/existing issues indicate that there are several locations that experience flooding, inundation, and erosion during rain events. These issues were confirmed by F&V during field inspections and also as a part of the hydraulic model, which showed areas of the system that backed up and surcharged during 10- or 25-year rain events. Flooding can cause erosion, in addition to collecting additional pollutants from inundated areas which can be discharged directly into the lake. Damaged infrastructure can also result in increased risk of erosion, sedimentation, and discharge of unwanted pollutants in to Fife Lake.

Below is a list of the areas of concern; Appendix C, Figure C1 shows the areas which corresponds numerically to each item below.

1. The storm sewer from the outlet at the Fife Lake Resort west to the intersection of Bates and East State Street surcharges during any rain event. This is due to outlet pipe being undersized and sloped from downstream to upstream, instead of upstream to downstream (negative grade). A hydraulic profile showing the sewer running uphill is provided in Figure B2.
2. The catch basins at East State Street near the railroad crossing backup during 10- and 25-year rain events. The catch basin in the intersection of East State Street and Oak Street is damaged and needs to be replaced.
3. The catch basins located in the intersection of West State Street and Main Street are not at elevations to drain the intersection. As a result, there is ponding at the intersection during rain events. Storm sewers at the intersection of West State and Main Street surcharge during 10 and 25-year storm events.
4. Storm Sewer at the intersection of Boyd and Morgan Street surcharge during 10- and 25 year events.
5. There is a catch basin in front of the Post Office on Oak Street with a 10-inch sewer that outlets to a low area on the other side of Oak Street. The hydraulic analysis showed that during a 10-year storm, this depression/retention area may become filled and could potentially be flooded during a larger storm.

In addition to the potential capacity issues identified, the flowing erosion, sedimentation, flooding, and structural issues were identified:

6. The alley separating Bates Street and Merritt Street washes out from Martha to Merritt during rain events. The sediment is deposited on the south side of the intersection of Lakecrest Lane and Merritt Street.
7. The shoulders of Bates Street from Martha to East State Street, and the intersection of Bates Street and Thomas Street erode during rain events.
8. There is shoulder erosion, ponding, and road damage due to surface runoff along Maple and main from Boyd to Pine Street.
9. East Front Street experiences shoulder erosion from which appears to be a result of lack of adequate shoulder paving.
10. Along Janet Street there is ponding being noticed as well as a catch basin that appears to be plugged; Janet Street erodes into the Clara Street intersection.
11. There is shoulder erosion occurring on Anthony Street from Bates Street to Merritt Street as well as along Thomas Street from Merritt Street to Bates Street.

12. Ponding, shoulder erosion, and road damage are being noticed along 5th Street from 6th Street to the Fife Lake shoreline.
13. Boyd Street is gravel and consistently washes out down the hill from Clara Street towards Morgan Street.

4.0 STORMWATER QUALITY MODELING

4.1 INTRODUCTION

A component of the SWMP involves assessing the quality of the stormwater entering Fife Lake in order to determine if water quality-related actions are required. This section can be considered a stormwater characterization report (SCR) as it details the water quality data and investigations that were undertaken.

Approximately 292-acres of the Village's jurisdictional area consists of Fife Lake itself and the remainder of the area (except for a 2.5-acre area near the northwest corner) is part of the 'Fife Lake Outlet' hydrologic unit (HUC #040601030206), the upper portion of which includes all of the land that drains to Fife Lake and is referred to in this document as the Fife Lake Watershed. The remainder of Fife Lake Watershed includes portions of Fife Lake Township and the Kalkaska County general law townships of Springfield and Boardman. The overall study area is shown in Figure 7.

4.2 WATER QUALITY / ECOLOGICAL STRESSORS

Fife Lake is extremely important to the Village and thus so is its water quality. The quality of the lake is defined by the ecological stressors that impact it; including stressors such as the pollutants in the stormwater that flow into the lake and infiltrate to the local aquifer. The area also has a shallow groundwater table and has numerous wetlands, which means that much of the hydraulic connection from stormwater runoff from uplands to the lake is through the groundwater. The stressors that are of interest are summarized in Table 1, with a more comprehensive table detailing these stressors in Appendix D.

The ecological conditions of Fife Lake as of 2001 are documented in the 2003 "Status of the Fishery Resource Report: Fife Lake" by the Michigan Department of Natural Resources. A summary of the water quality notes that:

> *…conditions in Fife Lake have been surveyed at least seven times between 1973 and 2001… The water was dark brown but clear with a Secchi disk reading of 14 feet (9 feet in 1974). Zebra mussels have colonized the lake in recent years, and their presence may enhance water clarity in the future. In the 2001 limnology survey, water temperature varied from 77°F at the surface to 59°F at 50 feet… Typically, summer oxygen levels are sufficient for fish down to a depth of 25 feet. Dissolved oxygen at 25 feet was 5.3 ppm. Below this depth there is insufficient oxygen for fish… during late summer. The water quality in 2001… [is]… consistent with [the] past.* ***Overall water quality is excellent and Fife Lake is a good environment for warm and cool water species****.*

Detailed water quality data from 2004 (associated with numerous stressors and metrics) can be found in Appendix D. Where applicable, State of Michigan surface water quality regulations are referenced and the numerical standards are shown (if applicable). Also, the stormwater sampling results obtained for the SWMP (discussed later in the report) are presented for comparative purposes. The sampling results are presented in Appendix F.

Figure 7: Stormwater Quality Study Area

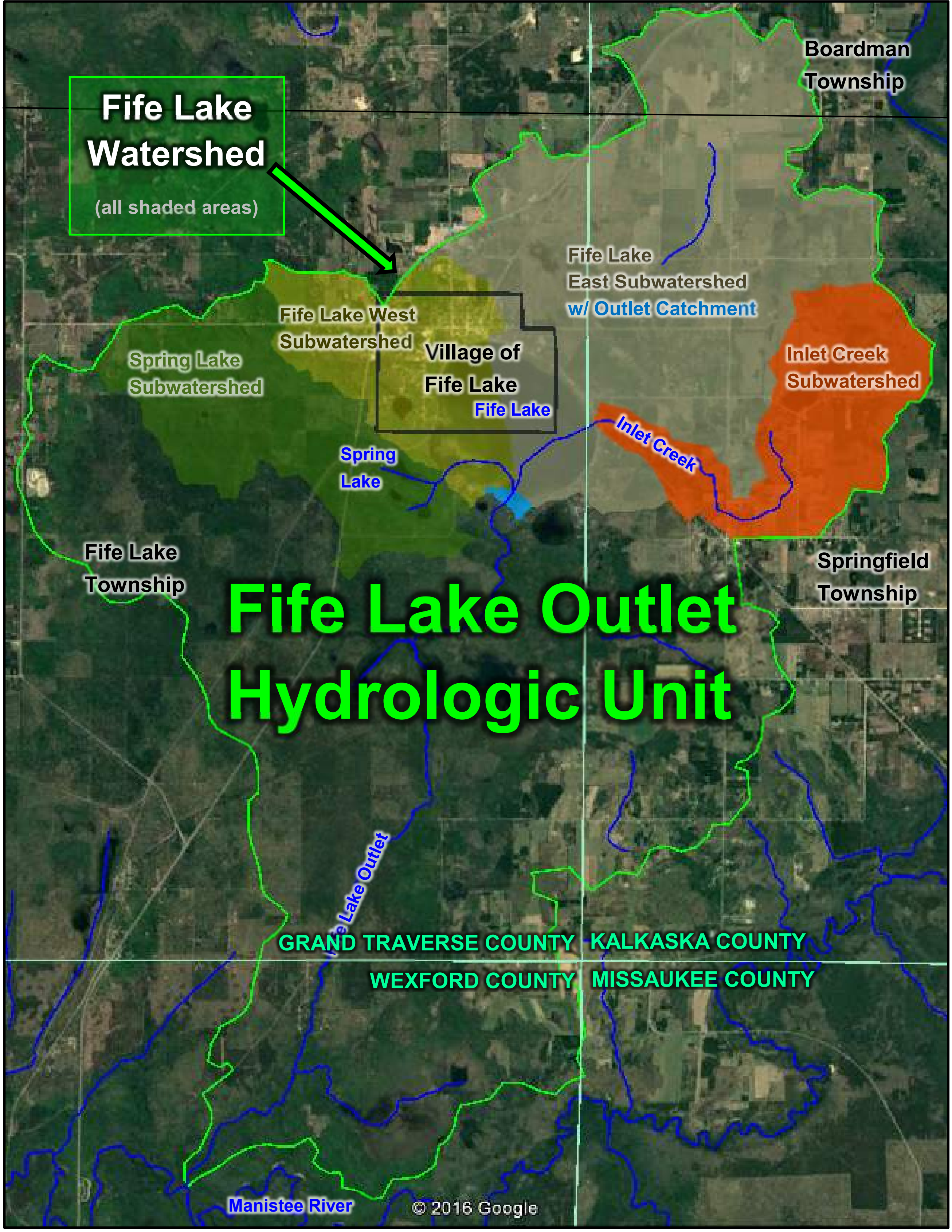


Table 1 Ecological Stressors of Interest and Water Quality Data

STRESSORS **CLASS** **Stressor Category** Specific Stressor	***Specific Measures*** *Water quality standards summarized in red italic underline text.*	**Fife Lake** Chemistry Data: 2004 Biological Data: 2013 *units: mg/l* Low - **Avg.** - High [#] *unless otherwise indicated*	**Village of Fife Lake** 2016 Stormwater Quality Data *units: mg/l* outfall: 1 | 2 *one number only if both the same value*
BIOLOGICAL **Pathogen** Fecal coliforms	*There are numerous tests to assess fecal coliform levels…* *Wastewater-related Discharges: 200 / 100 ml (30-day); 400 / 100 ml (7-day)* *…and tests to assess specific pathogens such as Escherichia coli.* *Total Body Contact = 130 / 100 ml (30 day mean); 300 / 100 ml (event)* *Partial Body Contact = 1,000 / 100 ml (event)*		E. coli: > 2,419 colonies / 100 ml
CHEMICAL **Nutrient** Nitrogen .	*Total Nitrogen* *Kjeldahl Nitrogen* *Ammonia (NH_3^-)* *(as N)* *Organic Nitrogen* *Reduced Nitrogen (e.g. NH_4^+)* *Inorganic Nitrogen:* *Nitrate (NO_3^-)* *Nitrite (NO_2^-)*	0.37 - **1.57** - 2.37 [10] 0.34 - **0.53** - 1.05 [6] 0.01 - **0.17** - 0.27 [3] 0.01 - **0.09** - 0.21 [5] 0.35 - **0.53** - 0.84 [3] 0.01 - **0.05** - 0.08 [5]	| 0.53 sum < 0.10 | 0.43 < 0.05 | 0.10
CHEMICAL **Nutrient** Phosphorus	*Total Phosphorus = 1 mg/l monthly discharge (in plant available form)*	0.02 - **0.02** - 0.03 [6]	0.06 | 0.22
CHEMICAL **Ionic Conditions** Ionic Strength	*Cl^- (chloride ion) = shall not exceed 50 mg/l (monthly) in Great Lakes / connecting waters* *Specific Conductance (µmho/cm)* *Total Dissolved Solids:* *500 mg/l monthly* *750 mg/l from controllable source* *125 mg/l monthly for public water supplies*	11 240 - **249** - 269 [24]	47 | 11
PHYSICAL **Suspended / Floating Media** Suspended Solids	*The total suspended solids measure involves weighing the sediment mass.* *The turbidity measure assesses the opacity of the water column.* *The Secchi disk depth measure is a practical assessment of turbidity in lakes, measuring the depth to which a specific disk can be seen.*	5.2 m & 6.7 m	21 | 314

4.3 HYDROLOGIC / ANALYTICAL BOUNDARIES

The Fife Lake Watershed was divided into two primary areas for the purpose of presenting results:

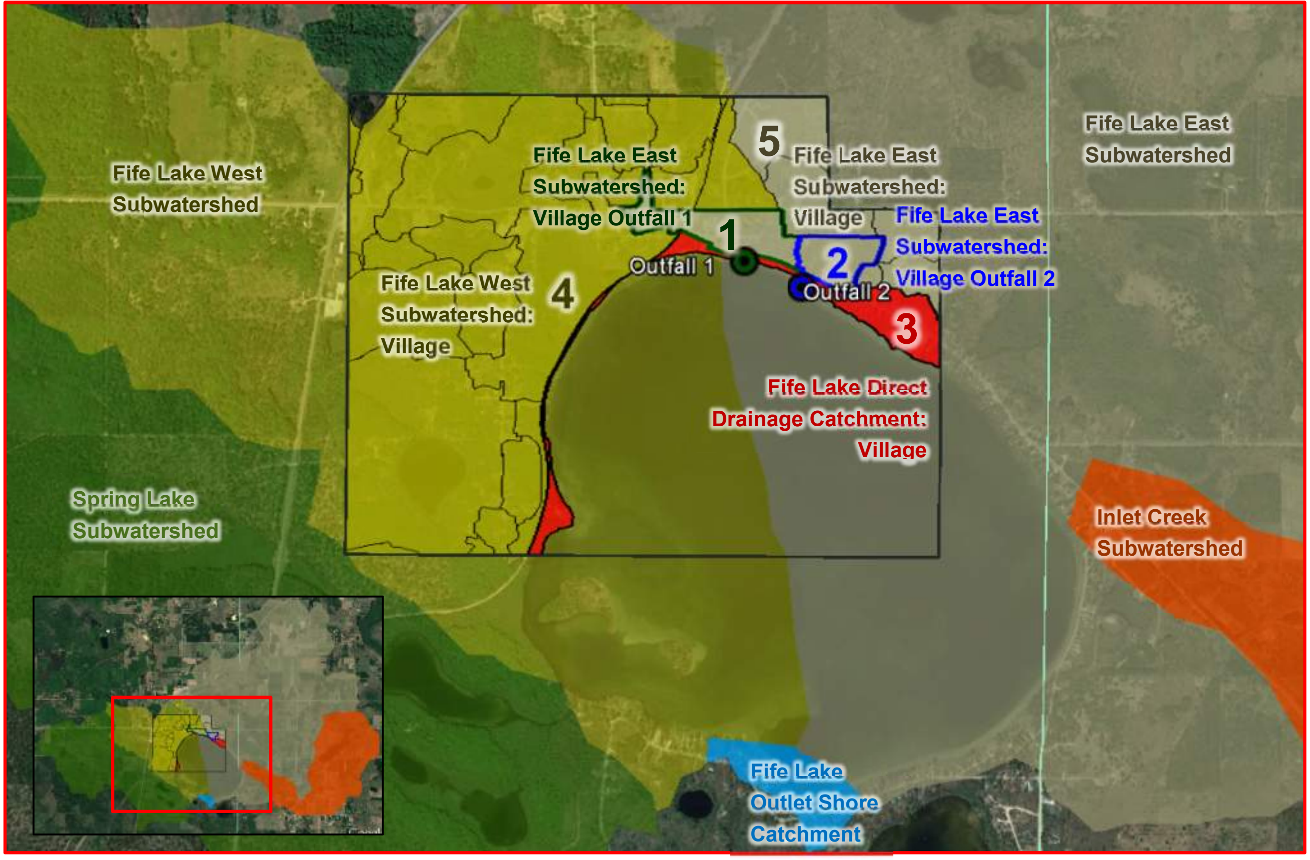
1. the Village of Fife Lake with approximately 411 acres of land that generates runoff (with parts in two different subwatersheds), and

2. Fife Lake Watershed outside of the Village (including 2,421 acres of Fife Lake Township in Grand Traverse County and 4,059 acres of Kalkaska County).

The Village is further broken down into five (5) analytical zones based on drainage patterns, sampling efforts, and contiguity between areas. These are shown in Figure (with coloration to match the subsequent map) and include:

1. The area that drains to Outfall 1,
2. The area that drains to Outfall 2,
3. The areas that drain overland directly to the lake itself,
4. The portion of the Village that is in the Fife Lake West Subwatershed (that does not drain overland to the lake), and
5. The portion of the Village that is in the Fife Lake East Subwatershed (that does not drain overland to the lake nor to Outfalls 1 or 2).

Figure 8: Detail of Fife Lake area showing STEPL model calculation area names



4.4 APPROACH

A comparative approach to assessing the pollutant loads entering Fife Lake was undertaken using the EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) model – a preferred tool for assessment and decision-making at the planning level. The STEPL model takes readily-available data (e.g. land use, hydrologic boundaries, rainfall, septic system, soil, agricultural, hydrologic, soil loss estimates, and pollutant concentration numbers) and estimates loading rates for nitrogen, phosphorus, biochemical oxygen demand (BOD), and suspended solids / sediment.

STEPL estimates for a given area are best when considered as proportional to related areas. As such the entire Fife Lake Watershed was processed through the model to help verify the results derived for the Village and to provide a comparative basis for the projected loads.

Stormwater samples from two Village outfalls were taken to provide a check on runoff concentrations in the model and to check additional parameters. These results are shown in Table 1.

4.4.1 STEPL MODEL: OVERVIEW

The STEPL model generates load estimates for nitrogen, phosphorus, biochemical oxygen demand (BOD), and sediment. The data required to run the STEPL model include[1]: land use[2,3], hydrologic boundaries, rainfall, septic system, soil, and agricultural. Other model inputs such as runoff curve numbers, soil loss equation numbers, and pollutant runoff and groundwater concentration numbers, were largely left as the default values. No best management practices were included in the model. Additional details are presented below.

4.4.2 STEPL MODEL: LAND USE DATA

The land use data throughout the Fife Lake Watershed is shown in Figure 9 with hydrologic boundaries and the Village of Fife Lake shown for reference. A summary of the land use for each analytical zone of the Village as well as a total for the rest of the watershed (and the watershed as-a-whole) are presented in Table 2.

The Village is approximately 50% developed land vs. 50% natural land. The rest of the watershed is approximately 5% developed land, 25% agricultural land, and 70% natural land.

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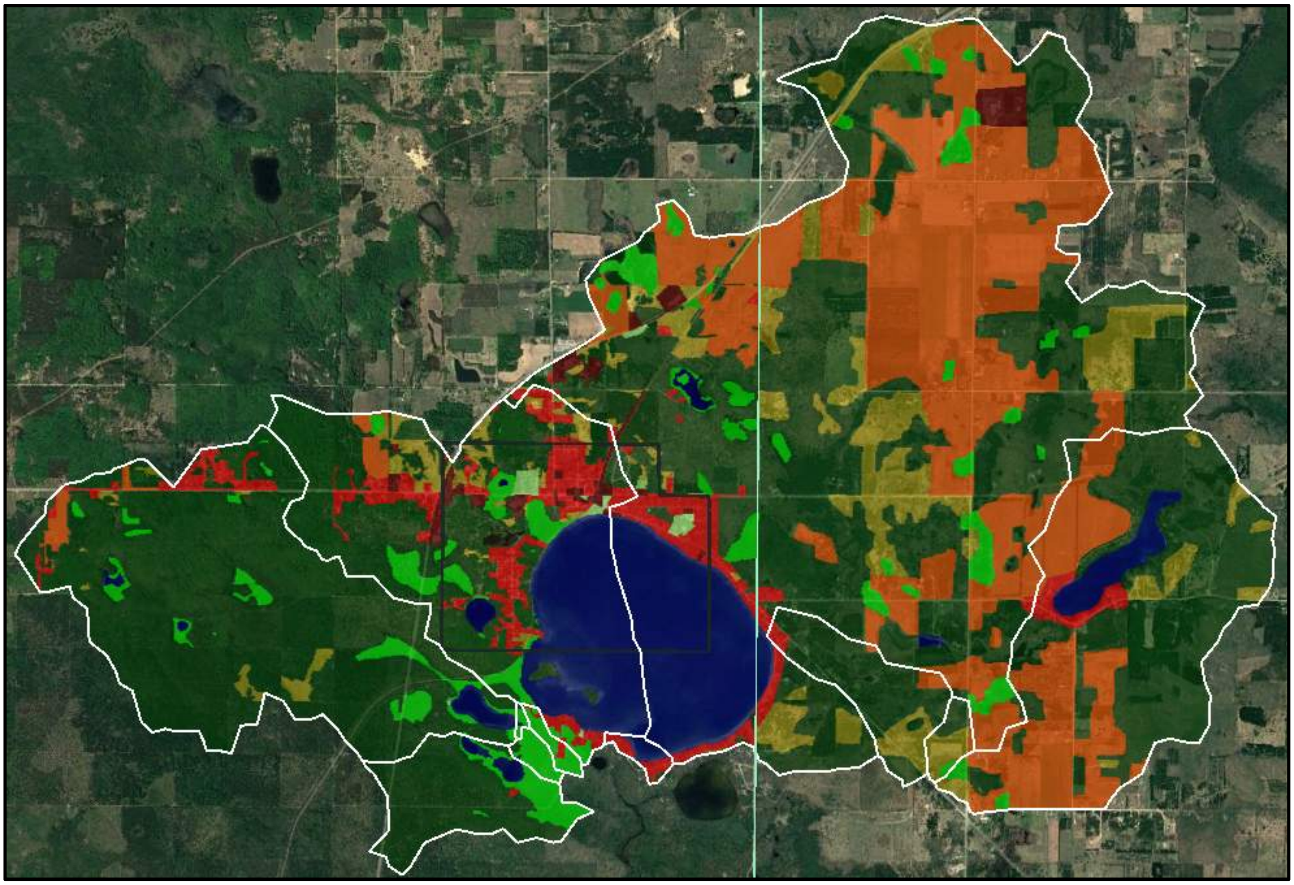
[1] Land use data for Grand Traverse County (2010) obtained from Grand Traverse County GIS Department. Land use data for the remainder of the Fife Lake Watershed was inferred from Michigan Department of Natural Resources MIRIS data (1978). Watershed boundaries were obtained from the EPA's MyWaters website. Rainfall, septic system, soil, and agricultural animal data were obtained from the STEPL online data server. The online STEPL data was provided for the entire Fife Lake Outlet HUC and was adjusted proportionally to better approximate only the watershed being studied.

[2] Land use types include: urban, cropland, pastureland, forest, and 'user defined' which was defined as a scrub-shrub land type with attributes between forest and grassland. Water and wetland areas are defined but do not contribute to pollutant loads.

[3] Urban land use types include: commercial, industrial, institutional, transportation, single-family, multi-family, cultivated, vacant, and open space.



LEGEND
Dark Green = Forest | Light Green = Wetland | Blue = Water | Orange = Cropland / Pastureland | Dark Red = Other Urban
Red = Single Family Residential (Urban) | Black = Vacant (Urban) | Light Green = Open Space (Urban) | Yellow = Scrub / Shrub

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Figure 9: Fife Lake Watershed, Drainage Areas, and Land Use

Table 2: Drainage Areas – Summarized Input Data (land use in acres)

Drainage Area	Total Contributing Area	Urban - Residential	Urban - Other	Cropland[4]	Pastureland[4]	Forest	Scrub / Shrub	Non-Contributing (e.g. water)	Total Overall Area	Est. Septic Systems	Agricultural Animals, est.
Village	410.9	141.9	55.1			186.2	28.0	343.9	754.9	17	
1	17.2	11.2	6.0						17.2		
2	9.8	5.4	0.8			3.7			9.8		
3	22.3	14.9	4.5			2.3	0.7	140.8	163.1	1	
4	312.2	90.3	36.7			161.8	23.5	203.1	515.4	15	
5	49.4	20.1	7.1			18.4	3.8		49.4	1	
Rest of Watershed	6,480.1	224.3	74.3	1,363.0	259.6	3,998.7	560.2	1,799.3	7,278.5	219	43
All	6,891.2	366.2	129.4	1,363.0	259.6	4,184.9	588.2	2,143.2	8,033.4	236	43

Note: color-coding in table matches land-use coloration shown in Figure 9.

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[4] Cropland is estimated as 84% of the agricultural land use; pastureland is estimated as 16% of agricultural land use.

4.4.3 STEPL MODEL: OTHER INPUT DATA

Additional data input into the model include:

- Annual Rain: total = 35.01 mm; days = 135; > 5mm = 77.3%; % event runoff = 29.4%
- Septic Systems: persons per = 2; failure rate = 1.14%
- Universal Soil Loss Equation Parameters: default
- Soil: hydrologic group = ‘A’; concentrations → N = 0.08%, P = 0.031%, BOD = 0.16%
- Runoff curve numbers (for A soil group): urban = 83 - default, cropland = 67 - default; pastureland = 49 - default; forest = 39 - default; scrub/shrub = 40
    - Detailed urban reference curve numbers: all default
- Nutrient concentration in shallow groundwater in mg/l (N, P, BOD): urban = 1.5, 0.63, 0; cropland & pastureland = 1.44, 0.063, 0; forest = 0.11, 0.009, 0; scrub/shrub = 0.5, 0.055, 0
- No irrigation or manure application data was provided
- No data about streambank erosion locations were available
- No data about direct wastewater discharges was provided, although it is believed that there are none
- No best management practices (BMPs) were modeled

4.4.4 STORMWATER RUNOFF NUTRIENT CONCENTRATIONS: CONSIDERATION OF STORMWATER RUNOFF SAMPLES

In addition to the amount of runoff generated, the major factor in determining runoff pollutant loads is the concentration of pollutants in the stormwater. However, the concentrations at a given outfall will be different during different seasons / conditions and also depend on the time between events and the intensity / duration / size of the event. In addition, the concentrations will fluctuate throughout an event, with values peaking very early[5]. As such, determining specific values to use in a model can be difficult.

To facilitate planning-level considerations, the STEPL model includes default values that are based on a significant number of previous studies. These are presented in Table 3.

Table 3 - Model and Measured Runoff Concentrations

Land Use -------------------------------- Drainage Area Sample	Nitrogen	Phosphorus	BOD	Total Suspended Solids (TSS)
Cropland (low density)	1.9	0.3	4	
Pastureland	4.0	0.3	13	
Forest	0.2	0.1	0.5	
Scrub/Shrub	1.09	0.28	3	
Urban - Residential	2.2	0.4	10	100
Urban - Other[6]	1.5 – 3.0	0.15 – 0.50	4 – 10	67 - 150
Outfall 1 (urban land uses)	0.53	0.22		21
Outfall 2 (urban land uses)	< 0.15	0.06		314
Average	**0.34**	**0.14**		**167.5**

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[5] Also, the concentrations of biological stressors and reactive pollutants will fluctuate due to biological and chemical activities that are, in turn, dependent on numerous environmental conditions (e.g. temperature, pH).

[6] Levels generally increase based on level of development (e.g. open space / vacant → transportation).

Because only one sample was taken at each outfall, these samples were used as spot checks to help ensure that the stormwater runoff from the Village is of a quality consistent with the parameters used in the model. The outfall drainage areas are urban and the monitoring results are near expected values. However, based on the limited sampling and without runoff quality numbers from the other land use types, it is prudent to use only the numbers provided in the model. This increases the likelihood that the results are comparable between the different drainage areas (i.e. there is a high confidence in stating the pollutant loads from one area are higher than another) although additional study would be needed to develop quantified pollutant load estimates with a high level of confidence.

4.4.5 CONSIDERATIONS IMPACTING MODEL PERFORMANCE

A large portion of the watershed drains either: 1) through smaller lakes, ponds, and/or wetlands that subsequently flow to Fife Lake; or 2) to smaller lakes, ponds, and/or wetlands that have no obvious surface water connection to Fife Lake and are likely hydraulically connected by the shallow groundwater table.

There is no information on any BMPs deployed in the watershed. It is likely that there are some management practices being implemented in the agricultural areas outside of the Village limits that would reduce the modeled pollutant loads from those that presented in this report. Similarly, BMPs may also be employed at various locations throughout the urban areas.

4.5 MODELING RESULTS AND DISCUSSION

The results of the STEPL model are presented in this section. In addition, those stressors that were sampled for but were not included in the model are discussed.

The results of the sampling along with summarized loading results from the STEPL model are presented in Table 4. Detailed STEPL model results are presented in Table 5

Table 4 - Summary of Results.

Land Use -------------------------------- Drainage Area Sample	Nitrogen	Phosphorus	BOD	Total Suspended Solids (TSS)	E. coli	Chloride	Oil and Grease
STANDARDS →		1.00			1,000		
SAMPLING	mg/l	mg/l	mg/l	mg/l	col/100 ml	mg/l	mg/l
Outfall 1 (urban land uses)	0.53	0.22		21	> 2,419	47	< 5
Outfall 2 (urban land uses)	< 0.15	0.06		314	> 2,419	11	< 5
MODEL URBAN RUNOFF →	1.5 – 3.0	0.15 – 0.50	4 - 10	67 - 150			
MODEL LOAD RESULTS	lb/acre/yr	lb/acre/yr	lb/acre/yr	lb/acre/yr			
Average	**2.3**	**0.29**	**2.4**	**173.9**			
Village of Fife Lake	2.2	0.24	4.1	54.2			
Rest of Watershed	2.3	0.29	2.3	181.6			

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Table 5 – Pollutant Load Estimates by Drainage Area

Drainage Area	Nitrogen			Phosphorus			BOD			TSS		
	Urban (lb/yr)	Total (lb/yr)	Total (lb/acre/year)	Urban (lb/yr)	Total (lb/yr)	Total (lb/acre/year)	Urban (lb/yr)	Total (lb/yr)	Total (lb/acre/year)	Urban (lb/yr)	Total (lb/yr)	Total (lb/acre/year)
Village	**366**	**924**	**2.2**	**57**	**98**	**0.24**	**1,567**	**1,665**	**4.1**	**15,954**	**22,285**	**54.2**
1	**37**	**71**	**4.1**	**5**	**6**	**0.4**	**168**	**168**	**9.8**	**1,526**	**1,526**	**88.8**
2	**8**	**24**	**2.5**	**1**	**2**	**0.2**	**35**	**36**	**3.6**	**360**	**402**	**40.8**
3	**30**	**77**	**3.5**	**5**	**7**	**0.3**	**132**	**135**	**6.0**	**1,296**	**1,422**	**63.6**
4	**255**	**634**	**2.0**	**40**	**71**	**0.2**	**1,074**	**1,158**	**3.7**	**11,152**	**16,535**	**53.0**
5	**36**	**118**	**2.4**	**6**	**12**	**0.2**	**158**	**168**	**3.4**	**1,620**	**2,400**	**48.6**
Rest of Watershed	688	14,866	2.3	101	1,906	0.29	3,040	14,653	2.3	29,254	1,176,740	181.6
Total	**1,054**	**15,790**	**2.3**	**158**	**2,005**	**0.29**	**4,607**	**16,318**	**2.4**	**45,209**	**1,199,027**	**173.9**
Ag. Land		4,450			1,032			9,749			1,017,439	
Natural		695			271			1,681			136,469	

The STEPL model pollutant loads contributed by the Village of Fife Lake (based primarily on land use) are significantly smaller – based on total loads – than those contributed by the rest of the watershed. This is not surprising based on the respective total contributing drainage areas.

It is more appropriate to compare the per acre loading rates between the entire Fife Lake watershed and the Village because this provides anormalized assessment that takes drainage area into account. A comparison of the total watershed loading and the Village per acre contribution is summarized below. This comparison also includes a discussion of the Village stormwater sample data.

4.5.1 NITROGEN

The average total watershed loading contribution per acre for nitrogen is 2.3 lbs/year which is similar to the Village's rate of 2.2 lbs/year.

Nitrate / nitrate (inorganic nitrogen) was not detected at Outfall 1 but the levels detected at Outfall 2 were approximately 10 times higher than the concentration documented in the lake.

4.5.2 PHOSPHORUS

The average watershed per acre contribution of phosphorus is 0.29 lbs/year compared to the Village's rate of 0.24 lbs/year.

The phosphorus concentrations in the samples from both outfall locations are significantly below the 1 mg/l water quality standard (although levels at Outfall 2 were nearly 4 times those at Outfall 1). The concentrations in the stormwater samples are higher than the levels that were documented in the lake.

4.5.3 BIOCHEMICAL / LOGICAL OXYGEN DEMAND (BOD)

The average watershed BOD per acre contribution is 2.4 lbs/year compared to the Village's rate of 4.1 lbs/year. This indicates proportionally more BOD is contributed to the lake from the Village than on average from the watershed as a whole.

4.5.4 TOTAL SUSPENDED SOLIDS (TSS) / SEDIMENT

The average watershed per acre contribution of TSS is 173.9 lbs/year compared to the Village's rate of 54.2.

The TSS concentration in the sample from Outfall 1, at 21 mg/l, was significantly less than the range expected based on the STEPL model inputs (67 – 150 mg/l). On the other hand, the concentration in the sample from Outfall 2 (314 mg/l) was more than twice the maximum of this range.

4.5.5 ADDITIONAL STRESSORS

Despite not being modeled and with only one sampling event, some comments can be made about other monitored parameters.

E. coli was detected in the samples from both outfalls. The concentration was determined to be above the detection limit of 2,419 colonies / 100 ml for both samples. These concentrations are well above the surface water quality standard of 1,000 colonies/100 ml for partial body contact and the lower threshold for total body contact. However, it should be noted that the water quality standards are based on results from multiple samples, and the single samples collected for this study simply indicate a potential issue.

Chloride was detected in the samples from Outfall 1 and Outfall 2. The concentration in the Outfall 2 sample was equal to the concentration of chloride in the lake, however the concentration in the Outfall 1 sample was more than 4 times as great.

Oil and Grease was not detected in either of the samples. Since the analytical test had a detection limit of 5 mg/l, the actual concentration is below this level.

4.6 CONCLUSIONS

Key conclusions are summarized as follows:

1. Nutrients in the Village's stormwater runoff appear to be in concentrations that are on the low end of the expected range. This is intuitive based on the low-density nature of the Village's urban areas. Chloride and oil and grease also appear to be at acceptable concentrations.

2. Sediment in the Village's stormwater runoff appears to be generally in the range that would be expected. However, variability between the samples highlights the need for additional investigation.

3. E. coli in the Village's stormwater runoff appears to be significantly higher than the relevant water quality standards. Additional investigation is recommended to identify specific sources including annual additional testing. The Village has agreed to conduct additional testing to determine if e. coli is a consistent pollutant within the Village's watershed.

   Although E. coli is typically a difficult pollutant to mitigate with Best Management Practices, BMP's such as infiltration basins, rain gardens, bioswales, and pet waste management programs may help to reduce E. coli levels. As a part of the capital improvements plan, several infiltration basins are proposed to be constructed upstream of the existing stormwater outlets. Also, a stormwater treatment chamber is proposed for the existing outlet near the Fife Lake Resort. These BMP's are discussed in more detail in Section 6.2 of the report and shown on the maps in Appendix C. Both the treatment chamber and the infiltration basins will promote removal of pollutants including e. coli and will improve stormwater quality in the Village.

4. Estimated nutrient and sediment loadings to Fife Lake from the Village are below the average for the entire watershed. The rate of BOD loading, however, appears to be significantly higher than average. Similar to #3 above, construction of multiple infiltration basins upstream of the stormwater outlets and the addition of an end-of-pipe treatment chamber at the stormwater outlet near the Fife Lake Resort will assist in reducing BOD loading.

5. The largest land-use contributor of pollutants to Fife Lake is estimated to be agricultural land located outside of the Village limits. It should be noted that no best management practices were incorporated into the model and that if such practices are being implemented, the actual loads may be lower than the model estimates.

Refer to Appendix D for additional information including a detailed stressor framework with lake and stormwater data. Appendix F summarizes the stormwater testing results.

5.0 DESIRED LEVEL OF SERVICE

The Level of Service (LOS) defines the way in which the utility stakeholders want the utility to perform over the long term. The LOS includes any technical, managerial, or financial components the Village wishes, as long as all regulatory requirements are met. The LOS is an important component of the development of your Stormwater Management Plan and will become a fundamental part of how the utility is operated. The LOS for the Village of Fife Lake stormwater system is stated as follows:

To provide appropriate stormwater collection, diversion, and conveyance at a minimum cost, consistent with applicable environmental regulations. To achieve this the following Level of Service (LOS) goals are proposed for the Village of Fife Lake:

- Provide adequate collection system and conveyance capacity for all service areas.
- Implement and fund a capital improvements plan to address system deficiencies.
- Improve water quality by installing BMPs
- Actively maintain collection and conveyance system assets in reliable working condition.
- Provide rapid and effective emergency response services to customers.
- Department of Public Works (DPW) staff are properly certified as Stormwater Operators
- Health and Safety of DPW staff will be addressed at least annually to determine if any changes or additional resources are needed.

6.0 STRUCTURAL BMPS AND CAPITAL IMPROVEMENT PLAN

Once the Village's desired LOS was established a rehabilitation plan was developed, including a 5-year Capital Improvement Plan (CIP) and list of recommended structural BMPs. As the Village is preparing a stormwater management plan and not an asset management plan, detailed field condition assessments of the storm sewer, catch basins, and manholes were not performed. However, field conditions were observed and noted as a part of field investigation.

6.1 BEST MANAGEMENT PRACTICES TOOLBOX

A critically important part of a stormwater management plan is evaluation and implementation of structural BMPs. Structural BMPs address stormwater quality concerns including erosion and sedimentation, removing pollutants including oil, grease, and other biological contaminates including E. coli and fecal coliforms.

Generally, it is good practice to design capital improvements that incorporate BMPs described below.

Mitigate Existing Impervious Surfaces

By managing runoff from impervious surfaces before it enters the storm sewer system or nearby waterbody, peak flow rates, total volume runoff, and pollutant concentrations can be reduced.

The Village may consider the following to mitigate existing impervious surfaces:

- Vegetated parking lot islands;
- Vegetated road medians;
- Green roofs;
- Pervious pavement / pavers;
- Rain barrels and cisterns (only with timely usage or interim draining protocols being followed);

BMPs related to mitigating existing impervious surfaces are best implemented in those areas that are already developed.

Infiltration Techniques

Using infiltration techniques to manage runoff reduces peak flow rates, total volume runoff, and pollutant concentrations that would otherwise enter the storm sewer system and impact a nearby waterbody. Infiltration techniques refer to practices which promote groundwater recharge and where the soils are conducive for infiltration.

The Village may consider the following to reduce stormwater impacts through infiltration:

- Rain gardens / tree boxes / bioretention;
- Infiltration basins;
- Infiltration trenches;
- Porous pipe and underground infiltration systems;
- Water spreading.

Infiltration BMPs can be implemented where soil conditions allow and where groundwater contamination is not a concern.

Filtration Techniques

Filtration techniques are similar to infiltration techniques in that they reduce peak flow rates, total volume runoff (if bio-filtration is used), and pollutant concentrations. They differ in that filtration is usually used in areas where the soils are not appropriate for infiltration. Subsequently, filtration techniques bring in an alternative filtering media, such as sand, and use an underdrain to direct the treated water to a storm sewer system or waterbody.

The Village may consider the following to reduce stormwater impacts through filtration:

- Sand/ organic / media filters (surface and underground);
- Pocket filters;
- Intermittent filters;
- Recirculating filters;
- Filter strips; and
- Perimeter sand filters.

The best areas to implement filtration practices include those where water quality improvements are desired but soil conditions prohibit infiltration.

Vegetative Buffers & Natural Conveyance

Using vegetative conveyance to manage runoff reduces peak flow rates, pollutant concentrations, and in some cases total volume runoff that would otherwise enter the storm sewer system or nearby waterbody.

The Village may consider the following to reduce stormwater impacts through vegetative buffers and natural conveyance:

- Herbaceous and forested riparian buffers;
- Wet and dry swales; and
- Vegetated channels.

The best areas for these practices include previously developed areas with amenable topographical conditions.

Retention and Detention

Using retention and detention to manage runoff reduces peak flow rates, pollutant concentrations, and total volume runoff that would otherwise enter the storm sewer system or nearby waterbody.

The Village may consider the following to reduce stormwater impacts by controlling peak flow rates:

- Detention / retention ponds;
- Pond/wetland systems;
- Extended detention wetlands;
- Shallow wetlands; and
- Submerged gravel wetlands.

Paving and Surfacing

When there are areas with steep slopes or difficult terrain, paving or placing aggregate surfaces resistant to erosion may be required. These surfaces can increase the amount of stormwater runoff, but provide the benefit of eliminating the potential of soil erosion and sedimentation. If paving and surfacing is required, it is important to design other green infrastructure alternatives along with the project including infiltration basins, drainage swales, or rain gardens to mitigate the increased stormwater runoff. Potential surface treatments include:

- Asphalt Pavement
- Concrete Pavement
- Porous Pavement
- Crushed Concrete or Asphalt

6.2 PROPOSED CAPITAL IMPROVEMENTS

In order to create the rehabilitation plan for structural deficiencies in the system, each asset identified with a deficiency was assigned a rehabilitation strategy. A number of asset rehabilitation techniques are available which include:

- Pipe replacement; either through direct bury or trenchless construction.
- Pipe rehabilitation; options include cleaning and CIPP lining or pipe bursting.

- Manhole replacement
- Manhole rehabilitation; options include cleaning, rim adjustment, point repair and lining.
- CCTV Inspections; includes CCTV inspection for remaining pipelines with limited assessment information, or re-inspection of suspect pipelines.
- CCTV Inspection Plus; includes CCTV inspection and a yearly allocation for rehabilitation for older pipelines with limited assessment information.

Assets are prioritized into a proposed rehabilitation year based on the LOS established to develop a full rehabilitation plan. The overall rehabilitation plan is the foundation in which the Capital Improvement Plan (CIP) is developed.

The next step is to calculate replacement, rehabilitation and preventative maintenance costs for system assets. A database for typical costs was prepared and used to determine budgetary estimates and schedules. Construction cost (2017 dollars) values were based on an informal survey of Michigan utilities in recent years based on region. Rehabilitation costs were specific to pipe size and pipe material as well as manhole size and material. Costs also assume basic construction practices, including imported sand bedding and backfill, compaction, pavement removal, hauling, shoring, trench excavation and testing.

Based on the hydraulic model, field observations, input from Fife Lake Village staff, and the water quality modeling, the proposed capital improvements are recommended in addition to the structural BMPs discussed above to address stormwater quality, erosion & sedimentation, and capacity concerns in the Village of Fife Lake. Projects are broken in to the following categories for recommended rehabilitation projects and timing.

Assets Requiring Rehabilitation in the Short Term (1-5 Years)
Assets or infrastructure that are at the highest risk or impact stormwater quality on a regular basis should be considered for short term rehabilitation. These projects include areas of frequent erosion, washouts, flooding that impacts the environment or residents, or infrastructure that is in immediate danger of failure. These projects focus on paving and installing stormwater controls, and should be addressed in the short term to prevent negative impacts to the environment, and it is recommended that they be addressed in the 5-year CIP.

Assets Requiring Rehabilitation in the mid Term (5 to 10 Years)
Assets with a medium risk or do not frequently impact the environment include areas with less significant flooding, areas that experience erosion where sediment does not impact water quality, or infrastructure that is reaching the end of its useful life. It is recommended that these assets be rehabilitated in the 5 to 10-year CIP.

Assets Requiring Rehabilitation in the Long Term (6-20 Years)
The rehabilitation of assets with the lowest risk ratings recommending improvements or repair may be considered in a long-term rehabilitation plan. These assets are of a condition or age that will require attention in the future but specific timelines for rehabilitation cannot be accurately determined based on available information, or include areas that do not cause immediate or significant harm to the environment.

<u>Proposed 1 to 5-year CIP – Appendix C, Figure C2</u>

1. Remove and replace approximately 620 feet of existing storm sewer from the outlet near the Fife Lake Resort west towards the intersection of Bates and East State Street and install a stormwater treatment chamber. Larger pipe needs to be installed with correct downhill slope. Larger pipe will reduce surcharging of the sewer and flooding of East State Street. The project includes half width reconstruction of State Street, new curb and gutter, replaced sidewalk, and improved road grades to promote drainage.
   Estimated Construction Cost: $445,000

1. Remove, replace, and upsize the storm sewer in front of the Post Office on Oak Street. Increase the size of the low area on the east side of Oak Street and create a stormwater basin to accommodate a 10-yr design storm. This includes removal and replacement of the HMA pavement through the intersection and replacing the aged catch basin with grading to efficiently drain the intersection.
   Estimated Construction Cost: $177,600

2. Pave approximately 630 feet of the alley between Bates Street and Merritt Street, pave HMA curb, spillways, and a construct a stormwater basin. This will reduce the amount of erosion and sedimentation and allow stormwater to infiltrate into sandy soils
   Estimated Construction Cost: $82,000

3. Repave approximately 1065 feet of Maple and Main Street to Pine Street with HMA curb, install spillways, a culvert, and a stormwater infiltration basin at the low area on Main Street. This will prevent stormwater from eroding the shoulders, encourage pavement longevity, and provide a means for stormwater to infiltrate into sandy soils.
   Estimated Construction Cost: $598,500

4. Repave East Front Street from Main Street to Oak Street with HMA curb and spillways. This project will include construction of a stormwater basin to store and infiltrate runoff. The improved roadway will capture runoff and prevent erosion of the shoulder and depositing sediment at the Front Street and Oak Street intersection.
   Estimated Construction Cost: $164,100

5. Pave approximately 280 feet of 5th Street from Howard Street to the railroad right of way. The project will include re-grading the roadway to promote runoff capture in a roadside ditch lined with riprap down the hill to dissipate runoff velocities and ultimately end at the railroad right of way where a stormwater infiltration basin will capture runoff to prevent erosion and promote infiltration before the sediment laden runoff reaches Fife Lake.
   Estimated Construction Cost: $121,600

<u>Proposed 5 to 10-year CIP – Appendix C, Figure C3</u>

1. Remove and Replace the damaged catch basin and approximately 100 feet of undersized storm sewer to address flooding at the State Street and Oak Street intersection. The project includes a new culvert discharge at the ditch along the railroad right of way.
   Estimated Construction Cost: $92,400

2. Pave approximately 200 feet of Boyd Street from the top of the hill at the Clara Street intersection, north to Morgan Street, install HMA curb and spillway and infiltration basin as necessary to prevent continuous erosion of the existing gravel. This will also include re-grading the roadway to capture stormwater runoff from the roadway and direct it away from the intersection of Boyd Street and Morgan Street.
   Estimated Construction Cost: $46,600

3. Paving on Anthony Street, from Bates Street to Merritt Street, repaving Thomas Street from Bates Street to Merritt Street, and Merritt Street from Thomas Street to Martha Street. These areas will be repaved with HMA curb and spillways where necessary. Construct stormwater infiltration basins on Merritt and near the Merritt/Thomas Street intersections. Grading improvements to the roadway and within the right of way will prevent ponding water on the road and promote pavement longevity. Additionally, the drainage improvements, HMA curb, and infiltration basins will control runoff and promote infiltration in sandy soils while protecting the shoulder.
   Estimated Construction Cost: $313,500

4. Repave approximately 725 feet of Bates Street from Martha to East State Street, with HMA curb and install spillways and stormwater infiltration basins to control surface water and promote infiltration and prevent erosion and sedimentation.
   Estimated Construction Cost: $196,500

<u>Proposed 10 to 20-year CIP – Appendix C, Figure C4</u>

1. Reconstruct and re-grade the intersection of West State Street and Main Street and adjust manhole elevations to allow stormwater to drain the intersection, remove and replace existing 12” storm sewer with 18” storm sewer to address flooding and surcharging of the storm sewer.
   Estimated Construction Cost: $449,000

2. Remove and replace the storm sewer system at the Boyd Street and Morgan Street intersection with larger diameter pipe. The intersection will be completely reconstructed with new grading to better intercept and control runoff. Larger diameter storm pipe will be sized to efficiently convey runoff to the current discharge location, the right of way west of the intersection, for infiltration in the sandy soils.
   Estimated Construction Cost: $155,600

3. Full reconstruction of Janet Street with grading drainage improvements, HMA paving with HMA curb and paving of the Janet Street and Clara Street intersection. This will prevent erosion of Janet Street down the hill into the Clara Street intersection. Additionally, reconstructing Janet street will include grading improvements to better control and route stormwater to ditching and storm sewer to protect the roadway and shoulders from erosion.
   Estimated Construction Cost: $121,700

7.0 MAINTENANCE PLAN

A preventative maintenance program to systematically clean and CCTV inspect pipelines to NASSCO-certified standards is critical for a healthy collection system. The process of cleaning and CCTV inspection of pipelines either with equipment owned by the community or contracted is a relatively inexpensive maintenance effort when compared to the rehabilitation efforts described in section 6.1. Currently, the Village of Fife Lake has two public works employees that operate and maintain the Village assets. As with many small communities, the Village staff perform many duties from plowing snow in the winter to mowing grass in the summer. Due to the large amount of work and limited number of staffing hours, often times maintenance is reactionary instead of being proactive. As such, it is recommended that the Village implement a regularly scheduled cleaning program for the Village storm sewer. As a rule of thumb, all pipelines should be cleaned and televised every five years, or that 20% of the system be cleaned and televised annually. Available budget will dictate the frequency or size of yearly projects. Also, the collection system should be visually inspected after rain events that produce more than 0.5 inches of rainfall.

It is recommended that the Village clean and CCTV inspect 774 ft or 20 percent per year of the stormwater collection system over the next five years so that 100% of the collection system will been inspected at the completion of the 5-Year CIP, thereby providing full “baseline” assessment data for the entire collection system. In addition to CCTV and cleaning of the sewer lines, regular cleaning of catch basins in the stormwater system is recommended. It was observed during site visits that several of the catch basins were filled with a significant amount of sediment. Some catch basins were filled to the point where storm sewer pipes were pugged and could not convey stormwater. It is important to remove sediment from the sumps of storm catch basins; not only does it allow stormwater to continue to be efficiently conveyed through the system, but pollutants will be removed prior to being discharged into surface water bodies.

Beyond the initial 5-Year CIP, the Village is encouraged to develop an ongoing preventative maintenance program for cleaning and CCTV inspection meeting NASSCO-certified standards. Pipelines should be cleaned and CCTV inspected on a periodic basis to assure that proper operating conditions exist and to plan proactive maintenance where needed. Table 6 below provides anticipated annual costs to clean and televise the existing storm sewer.

Properly maintaining the stormwater collection system will help reduce the risk of flooding due to system failure, improve the level to which pollutants are effectively removed, reduce the likelihood that sediment will need to be disposed of as hazardous waste, and reduce chances of small problems developing into big costly problems.

In addition to maintaining stormwater conveyance systems, maintaining roadways, ditching, existing infrastructure within the Village boundaries is also a critical feature of a stormwater management plan. A recommended list of maintenance activities is provided in the following section.

Road and Ditch Stabilization

Road and ditch erosion is of critical concern because the eroded soil may directly enter the storm sewer system or a nearby waterbody (through runoff or by wind action) and may also cause a public safety concern. The Village may take the following steps to stabilize roads and ditches:

- Repair failing paved roads, pave or stabilize dirt roads, and stabilize ditches and embankments on public land and contact private landowners to encourage repair;
- Researching the possibility for instituting corrective action on private lands through various enforcement mechanisms; and
- Implementing enforcement mechanism if possible, and correct eroding roads and ditches on private lands.

Bare Soil Repair

Areas of bare soil have the potential to erode and load sediment into waterbodies. The most problematic bare soil areas are those near waterbodies or those near impervious surfaces. The Village may take the following steps to repair bare soil areas:

- Repair soil problem areas on public land and contact private landowners to encourage repair;
- Researching the possibility for instituting corrective action on private lands through various enforcement mechanisms; and
- Implementing enforcement mechanism if possible, and correct bare soil problems on private lands.

Efforts to repair bare soil include grass or native vegetation planting, sod placement, or the use of containing structures, retaining walls, or terracing. Steep slopes which contribute to the problem may be mitigated with stabilization structures, including vegetation, and grade breaks.

Streambank / Shoreline Maintenance

Streambank and outfall erosion are of critical concern because the eroded soil directly enters a waterbody. The Village may take the following steps to stabilize streambanks:

- Repair eroding streambanks in accessible locations;
- Seek access to problematic locations through interactions with appropriate stakeholders and repair streambanks when access issues are resolved.

Specific Site Control

Certain sites in the sub-watershed, such as certain types of business or construction sites, have the potential to generate large amounts of sediment that may unintentionally enter the stormwater drainage system either on-site or by being transported off-site and deposited on impervious surfaces. The Village may consider the following to minimize pollution from sensitive sites:

- Developing appropriate procedures or structural modifications to implement at these sites and working with the sites to realize the improvements (i.e. on-site vehicle washing for vehicles dealing with sediment generating substances); and
- Installing appropriate structures in the public right-of-way (i.e. rock entrances designed to dislodge sediment from vehicle tires).

Maintenance of BMP’s

Existing and proposed BMP’s will need to be maintained to ensure proper operation. Maintenance of existing and proposed infiltration basins is critical to ensure that filtration and sediment removal takes place in addition to preventing debris from passing through the basins. Stormwater treatment basins also need to be maintained according to manufacturer’s recommendations to ensure proper operation.

- Inspect stormwater basins a minimum of twice per year
- Remove debris and excess sediment from stormwater basins as necessary
- Regularly maintain vegetation in infiltration basins, rain gardens, and swales
- Clean stormwater treatment basins according to manufacturer’s recommendations and at a frequency as to prevent trapped pollutants from being discharged from the BMP.

Table 6 below outlines a recommended 5-year budget to implement proper operations and maintenance of the stormwater conveyance system and other BMP’s within the Village of Fife Lake. The cost for stormwater basin maintenance increases in the proposed budget due to the assumption that 5 additional stormwater basins will be constructed within the 1 to 5-year CIP.

Table 6. 5-Year Collection System Maintenance Summary Table

Maintenance Action	Total Cost	Year 1	Year 2	Year 3	Year 4	Year 5
CCTV	$4,100	$775	$800	$800	$850	$875
Storm Structure Cleaning	$13,750	$2,750	$2,750	$2,750	$2,750	$2,750
Stormwater Basin Maintenance	$6,250	$750	$1,000	$1,250	$1,500	$1,750
Annual Road Sweeping & Cleaning	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500
General Erosion Control and bare Soil Repair	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500
	$28,100	**$8,275**	**$8,550**	**$8,800**	**$9,100**	**$9,375**

8.0 NON-STRUCTURAL BMPS RECOMMENDATIONS

Stormwater management has evolved over the past several decades from focusing on flood control and reducing peak storm volumes to improving water quality as well. Improving water quality in a watershed is a joint effort between government, watershed groups, land users (such as farmers), the public, and other stakeholders. Section 6.0 of this SWMP lists several BMPs to consider and implement. This section of the report will focus on other, non-structural practices that can be employed to assist in reducing stormwater pollution and improving water quality.

The following BMPs are derived from the US EPA MS4 stormwater program for small communities. Although the Village is not urbanized enough to require an MS4 stormwater permit, these minimum measures can be voluntarily implemented to help improve water quality in the Fife Lake watershed.

8.1 MINIMUM MEASURE #1 PUBLIC EDUCATION AND OUTREACH (PE)

8.1.1 GOAL

Minimum Measure #1’s goal is to influence public behavior in ways that will improve stormwater quality through educational programs for adults, children(schools), and businesses.

8.1.2 GOAL OVERVIEW

Minimum Measure #1’s goal overview is to develop effective programs to educate the public with meaningful information while catering to the Village’s attitudes and needs.

8.1.3 GOAL STRATEGY

Develop and implement a program to reach adults, children, and businesses that results in improved stormwater discharges on water bodies. Efforts should target specific audiences, be sustainable given Village resources, and include benchmarks to evaluate its effectiveness so that the program can adapt and improve.

The Village should to identify staff members responsible for developing an outreach program to commercial businesses, a second for residences, and a third for schools. They should target a specific audience and provide detailed guidance for each effort. There should also be coordination with local watershed council/drain commissions to identify schools interested in participating and key topics related to stormwater and water quality protection.

Some Public Education and Outreach program examples are as follows:
- Riparian Education
- Pet Waste Management
- Storm Drain Plaque
- Classroom Education
- Outreach for Commercial Businesses
- Alternatives to Pesticides and Herbicides
- Chlorinated Water Pool and Hot Tub Discharge
- Landscaping and Lawn Care
- Pest Control
- Proper Disposal of Household Hazardous Wastes
- Residential Car Washing
- Trash and Debris Management
- Water Conservation Practices for Homeowner
- Automobile Maintenance

- Pollution Prevention for Businesses
- Alternatives to Toxic Substances

8.1.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as setting a percentage of school children who have received education on stormwater or water quality topics, completion of targeted plan for each outreach, or the number of volunteers who are involved in cleanup or other volunteer work related to the outreach program.

8.2 MINIMUM MEASURE #2 PUBLIC INVOLVEMENT AND PARTICIPATION (PIP)

8.2.1 GOAL

To encourage active citizen participation in the stormwater program development and implementation of pollution reduction strategies. Public participation may include serving as citizen representatives on a local stormwater management panel, attending public hearings, assisting in program coordination with other pre-existing programs, or participating in volunteer monitoring efforts.

8.2.2 GOAL OVERVIEW

Public involvement is an integral part of the Village's stormwater program. The public must be involved in stormwater issues and solutions if the program is to be effective. The pollutants addressed by the public involvement goal depend on the target audience. Many of the involvement activities do not target specific pollutants, but instead promote environmental stewardship, pollution prevention, and water quality protection.

8.2.3 GOAL STRATEGY

Implement public involvement and stewardship activities that will raise awareness, foster community stewardship, and promote pollution prevention.

Village staff along with local non-profit and volunteer organizations can assist homeowners with stream bank and riparian habitat care along waterways through grant funded projects, utilize citizen scientists (science classes, retired experts) to monitor water quality and help find solutions, and work with local groups to label stormwater drains to warn people not to dump anything into storm drains.

Some Public Education and Outreach program examples are as follows:
- Train Students in River Enhancement, Assessment, and Monitoring
- Invasive Species Removal
- Pilot Projects Installation
- Stormwater Advisory Team
- Develop a Stormwater Speakers Bureau
- Create Stormwater Public Service Announcements
- Design a Stormwater Display
- Hold Governed Body Meetings
- Adopt-A-Stream
- Reforestation
- Stream Cleanup and Monitoring
- Volunteer Monitoring
- Wetland Plantings

- Attitude Surveys
- Stakeholder Meetings
- Watershed Organizations

8.2.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as setting a percentage of school children who have received training on river enhancement, assessment, and monitoring, number of adopt-a-streams, or the number of volunteers who are involved in cleanup or other volunteer work related to the outreach program.

8.3 MINIMUM MEASURE #3 ILLICIT DISCHARGES CONTROLS (IDDE)

8.3.1 GOAL

To identify, investigate, and, if appropriate, control/eliminate illicit discharges and non-stormwater discharges to the storm water system.

8.3.2 GOAL OVERVIEW

Illicit discharges are generally any discharge into a storm drain system this is not composed entirely of stormwater. Illicit discharges may be the result of illegal activity (i.e. dumping materials into a storm drain or connecting a wastewater pipe into the storm drain system) or ignorance (i.e. a car washing fundraiser held in a public parking lot). These illicit discharges are prohibited under various state and local laws. The exceptions include water from firefighting activities and discharges from facilities already approved by DEQ.

Illicit discharges are a problem, because unlike wastewater which flows to a wastewater treatment plant, stormwater generally flows to waterways without any additional treatment. Illicit discharges often include pathogens, nutrients, surfactants, and various toxic pollutants. The best way to prevent illicit discharges is to prevent material from entering the storm drain system. This is done through education, enforcing dumping prohibition ordinances, and controlling spills.

The Village’s activities under the illicit discharges controls goal address most pollutants commonly found in urban runoff. The type and amount of pollutants addressed depend on the pollutant source(s). For example, eliminating an illicit wash water discharge would address detergents (surfactants, phosphorus and nitrogen), solids, and oil and grease. Pollutants addressed by controlling non-stormwater discharges (such as discharges from flushing of water systems, pumped groundwater, or air conditioner condensate) include chlorine, phosphorus, and metals.

8.3.3 GOAL STRATEGY

Identify, investigate, control, and/or eliminate illicit discharges (illicit connections, illegal dumping, and spills) to the storm water system. Maintain an up-to-date storm sewer system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls. Inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

Some Public Education and Outreach program examples are as follows:

- Waste Pick Up and Removal Services

- Implement Ordinance to Prohibit Non-Stormwater Discharges
- Detect and Address Non-Stormwater Discharges
- Conduct Field Inspections
- Spill Response Plan
- Plan for Enforcement Actions
- Illicit Discharge Detection and Elimination
- Used Oil Recycling
- Illegal Dumping Control
- Trash and Debris Management
- Preventing Septic System Failure
- Illicit Discharge Training
- Community Hotlines

8.3.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as setting a limit of minimal to zero illicit discharges into the municipal stormwater system, continual training of staff and re-training as needed, and tracking the number of spills or illicit connections found each year.

8.4 MINIMUM MEASURE #4 CONSTRUCTION SITE RUNOFF CONTROL (CS)

8.4.1 GOAL

To control erosion, sediment, and pollutant discharges and other water quality impacts from active construction sites associated with new development and redevelopment during construction.

8.4.2 GOAL OVERVIEW

The design and construction of new development and redevelopment can have significant impacts on water quality. If not properly managed, ground-disturbing construction can result in erosion and the discharge of sediment and other pollutants into storm drains and local water bodies.

The main pollutants addressed by the construction erosion and sediment control goal are total suspended solids (TSS) and pollutants (such as metals and mercury) that bind to TSS. Construction site controls also reduce the discharge of floatable litter and debris, concrete washwater, bacteria, slurry, and paints and other toxic building materials into the stormwater system.

8.4.3 GOAL STRATEGY

Enact an ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance. Implement and refine stormwater management requirements for construction site operators to implement appropriate waste, erosion and sediment control BMPs. Enhance procedures for site plan review, which incorporate consideration of potential water quality impacts.

Some Public Education and Outreach program examples are as follows:

- Develop Code Erosion and Sediment Control Section

- NPDES 1200-C Permit
- Development Code Surface Waters and Drainage
- Erosion Prevention and Sediment Control Manual Booklet
- Construction Sequencing
- Construction Site Operator BMP Inspection and Maintenance
- Land Grading
- Preserving Natural Vegetation
- Site Design Review
- Construction Phase Plan Review
- Municipal Construction Inspection Program
- Training for Plan Reviewers and Field Inspectors

8.4.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as adopting and enforcing erosion prevention and sediment control ordinance, Village staff member identified as 1200-C permit enforcing officer, and tracking the number of plans that are reviewed for adequate erosion and sediment controls.

8.5 MINIMUM MEASURE #5 POST-CONSTRUCTION STORMWATER MANAGEMENT (CS)

8.5.1 GOAL

To protect water quality by addressing stormwater runoff from new development and redevelopment projects as defined by the municipal code that discharge into the Village's storm water system. Applicable controls could include preventive actions, such as protecting or restoring sensitive natural resource areas or the use of structural controls such as grassed swales or porous pavement or oil water separators that prevent pollutants from entering into and discharging from the municipal storm water system.

8.5.2 GOAL OVERVIEW

Development alters the natural landscape by increasing impervious surfaces, compacting soils in landscape areas, and introducing pollutants, which are then transported in stormwater runoff. The natural stormwater management provided by vegetation includes: filtering pollutants, slowing down flow, and providing shade. Preserving and restoring vegetation, streamside buffers, and pervious areas can help restore these critical functions. Land use changes impact stormwater in primarily two ways: by increasing stormwater flow (quantity) and the pollutants available to be transported in stormwater runoff (quality).

Increases in stormwater quantity can result in downstream flooding, stream bank erosion, and decreases in infiltration or recharge of groundwater. The impacts on water resources caused by increased impervious surfaces have been well documented, with a generally linear relationship between increased imperviousness and decreased water quality. Even when runoff is treated on-site before being released, stream bank erosion downstream of the site may make meeting TMDL goals challenging.

Development also impacts water quality by introducing pollutant loads into stormwater runoff. Oils, grease, litter and toxic substances collect on impervious and semi-pervious surfaces like lawns and run off into waters of the U.S. Studies have shown a direct correlation between total impervious area and in-stream aquatic habitat for salmonid species. Other studies have shown that up to 10 times more pesticides, herbicides, and fertilizers may run off of lawns than farmland.

The main pollutants addressed by these BMPs are total suspended solids (TSS) and pollutants (such as metals and bacteria) that bind to TSS. Post-construction site controls also reduce the discharge of floatable litter and debris, concrete washwater, bacteria, slurry, and paints. The main pollutants addressed by PCSM-4 are nutrients (phosphorus and nitrogen), temperature, total suspended solids (TSS), and pollutants that bind to TSS, herbicides, and pesticides.

8.5.3 GOAL STRATEGY

Use ordinances or other regulatory mechanisms to require BMPs for post-construction runoff from new development and redevelopment projects to reduce pollutants in discharges into and from the municipal storm water system. Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs). Ensure adequate long-term operation and maintenance of BMPs.

Some Public Education and Outreach program examples are as follows:
- Develop Code Post-Construction Runoff Control Section
- Land Use and Zoning Tools
- Park and Open Space Land Acquisition and Protection
- Stormwater Facility Land Acquisition
- Stormwater Design and Maintenance Manual (SWDMM)
- Site Plan Review for Post-Construction BMPs
- Implement Non-Structural BMPs for Site Plans
- Post-Construction BMPs Staff Training
- Post-Construction BMPs Maintenance
- Inspections of Structural Post-Construction BMPs

8.5.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as keeping records of enforcement using a computer program, staff training at least once per year on BMP design, maintenance, and inspection, and tracking the number of stormwater site plans and permanent stormwater control plans that are reviewed.

8.6 MINIMUM MEASURE #6 POLLUTION PREVENTION (PP)

8.6.1 GOAL

To prevent or reduce pollutant runoff from municipal operations.

8.6.2 GOAL OVERVIEW

It is important that a municipality's own operations minimize contamination of stormwater discharges and serve as a model for the entire regulated area. Preventing pollution is easier and more cost-effective than cleaning up pollution "after the fact". Municipal operations can contribute significant amounts of pollutants to stormwater. Examples of municipal operations that can negatively impact stormwater runoff – and ultimately water quality – include:

- Landscaping and maintaining parks, golf courses, and other municipal open spaces (e.g., sidewalks and plazas). These areas can contribute pesticides, herbicides, fertilizers, litter, and sediment to the storm drainage system if they are not properly maintained, or if municipal staff does not carry out maintenance activities in an efficient manner.

- Phosphorus is most often the limiting nutrient in aquatic systems, phosphorus concentrations in fertilizers and consequently in runoff from lawns has a dramatic impact in the watershed. Studies have shown that runoff from residential lawns comprise a small portion of stormwater volume and runoff into surface waters, but can contribute more than half of the phosphorous loading
- Washing, repairing, and fueling municipally-owned vehicles and equipment. Spills and leaks not contained during repairs and fueling can contribute gasoline, oil, and grease to the storm drainage system.
- Maintaining city surfaces, including streets, parking lots, and buildings. Roads and other paved areas collect pollutants such as heavy metals, oil and grease, sediment, leaves and other organic material, and litter from vehicles and motorists. Sand for deicing operations can also enter the storm drainage system. Another avenue for pollutants to enter the storm drainage system is from power washing or sand blasting buildings. These materials collect and wash into the storm drainage system during the “first flush” of a rain event. Many municipalities have street sweeping programs in place for aesthetic, safety, and public health reasons. These programs, if implemented properly, can reduce the amount of pollutants entering the storm drainage system.
- Waste and materials storage, particularly in uncovered areas. Given all the activities that a municipality conducts, there is a vast array of materials and wastes stored outdoors at municipally-owned facilities. If spills or leaks of these materials occur or where materials are exposed to rain, water is likely to scour pollutants and carry them to the storm drainage system.
- Construction activities and other land disturbances. Like any other type of construction activity, those initiated by the municipality can contribute sediment and other pollutants associated with construction equipment to stormwater runoff.

By implementing pollution prevention procedures, employees can ultimately reduce stormwater pollutants and save the municipality money over time. Preventing litter and other debris from entering the system can reduce damage to the system and reduce the need for expensive, time-consuming repairs and maintenance.

The main pollutants addressed by the pollution prevention and good housekeeping goal are stream and river water temperature increases, total suspended solids (TSS) and pollutants that bind to TSS, horticultural chemicals, metals, nutrients (phosphorus and nitrogen), petroleum hydrocarbons, oil and grease, floatables (debris and litter), pathogens, and chlorine from water system flushing. The goal’s strategies ensure that Village staff have the proper training to effectively implement the SWMP.

Municipal operations to be addressed:

- Maintenance of Park and Open Space, Stormwater System, Roads, Highways, and Parking Lots, and Vehicle and Equipment Washing
- New Construction and Land Disturbances
- Dust Control Practices
- Open Channel and Structural Stormwater Controls
- Flood Management Projects
- Employee Training on O&M Plan Implementation
- Stormwater Plans for Municipal Facilities
- Pursue an ordinance prohibiting fertilizers containing phosphorous to be applied within the Village limits.

Note: This pollution prevention/good housekeeping program only applies to site and facilities maintained within the municipality’s urban growth boundary.

8.6.3 GOAL STRATEGY

Develop and implement an operation and maintenance (O&M) plan with a focus on pollution prevention that addresses municipal operations. Development and implement a training program for municipal employees.

Some Public Education and Outreach program examples are as follows:

- Municipal Stormwater Operations and Maintenance Plan
- Roadway and Bridge Maintenance
- Storm Drain System Cleaning
- Hazardous Materials Storage
- Materials Management
- Spill Response and Prevention
- Integrated Pest Management
- Municipal Stormwater Operations and Maintenance Training
- Municipal Employee Training and Education
- Municipal Activities
- Municipal Landscaping
- Municipal Vehicle Fueling
- Municipal Vehicle and Equipment Washing and Maintenance
- Parking Lot and Street Cleaning
- Road Gravel Application and Storage

8.6.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as implementing dust control procedures on all public projects, inspect and maintain catch basins and other stormwater system facilities based on a schedule described in the O&M plan, or tracking the number of pollution prevention plans developed each year.

8.7 MINIMUM MEASURE #7 PROGRAM MANAGEMENT (PM)

8.7.1 GOAL

To ensure effective program management, coordination, and reporting.

8.7.2 GOAL OVERVIEW

A key focus of the Village is to provide sound program management, coordination, and reporting to ensure effective implementation of the Stormwater Management Plan (SWMP) and compliance with permit conditions. This effort involves multiple Village departments.

The program management goal does not in itself reduce pollutants; rather, it facilitates pollutant reduction by ensuring that the SWMP is effectively implemented.

8.7.3 GOAL STRATEGY

Conduct program management, coordination, and reporting.

Some Public Education and Outreach program examples are as follows:

- Village Management and Coordination
- Partnership with Federal, State, and County Agencies

- TMDL Annual Compliance Report
- Adaptive Management of TMDL Program Goals, Strategies, and Benchmarks

8.7.4 EDUCATION AND OUTREACH BENCHMARKING

The Public Education and Outreach must be set against benchmarks which will help in achieving goals in a timeline manner. Each program will need a benchmark that can be used to measure the effectiveness of the program such as continue to provide overall program management through CDD and to work with other Village departments as necessary to implement the SWMP, continue to coordinate with federal, state, and county agencies as necessary to implement the SWMP, and continue to submit annual reports by April 30th of each year to DEQ's Basin Coordinator.

APPENDIX A
STORMWATER COLLECTION SYSTEM
ASSET INVENTORY MAP

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 26, 2017

FLEIS&VANDENBRINK
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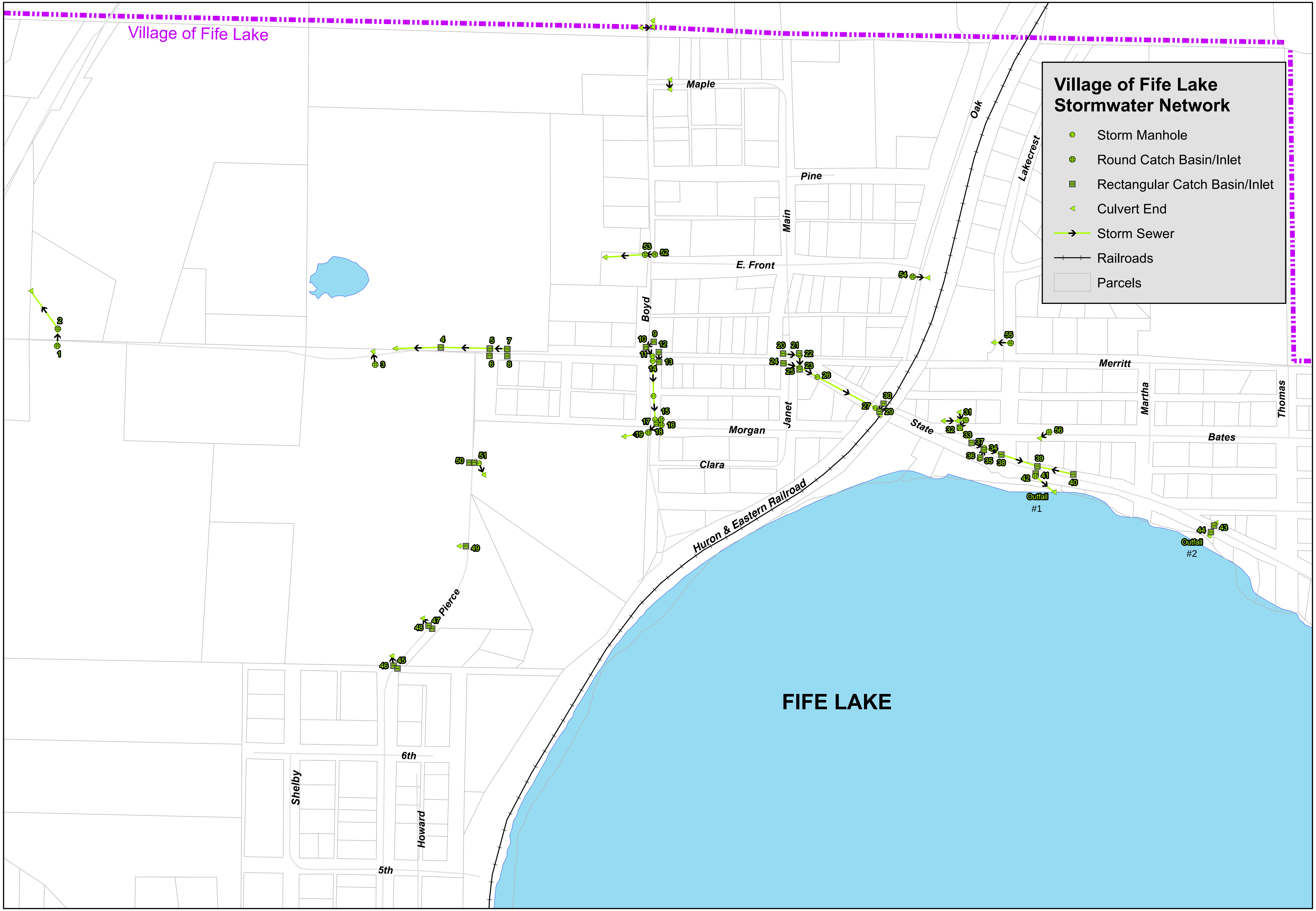

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VILLAGE OF FIFE LAKE

STORMWATER COLLECTION SYSTEM ASSET INVENTORY

GRAND TRAVERSE & KALKASK COUNTY, MICHIGAN

DRAWN BY	DATE
MEK	5/25/2017
PROJECT NO.	SCALE
816717	1:4,200
FILE LOCATION	
SOURCES	

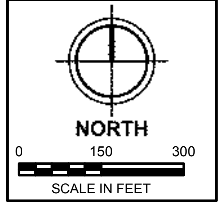

FIGURE
A1

APPENDIX B
HYDRAULIC MODELING ANALYSIS

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 2017

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LEGEND

Storm Structures

Structure Type

- ⊙ Round Catch Basin
- ▣ Square Catch Basin
- ● Storm Manhole
- △ Storm Outfall
- ● Overflowing Structures

Flow Capacity - Based on "Q"

Gravity Sewer - % of Full Capacity

- → 0- 25%
- → 25-50%
- → 50-75%
- → 75-100%
- → Greater than 100%
- ▭ Existing Stormwater Basin

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VILLAGE OF FIFE LAKE PEAK HOUR
10 YR STORM SEWER CAPACITY ANALYIS

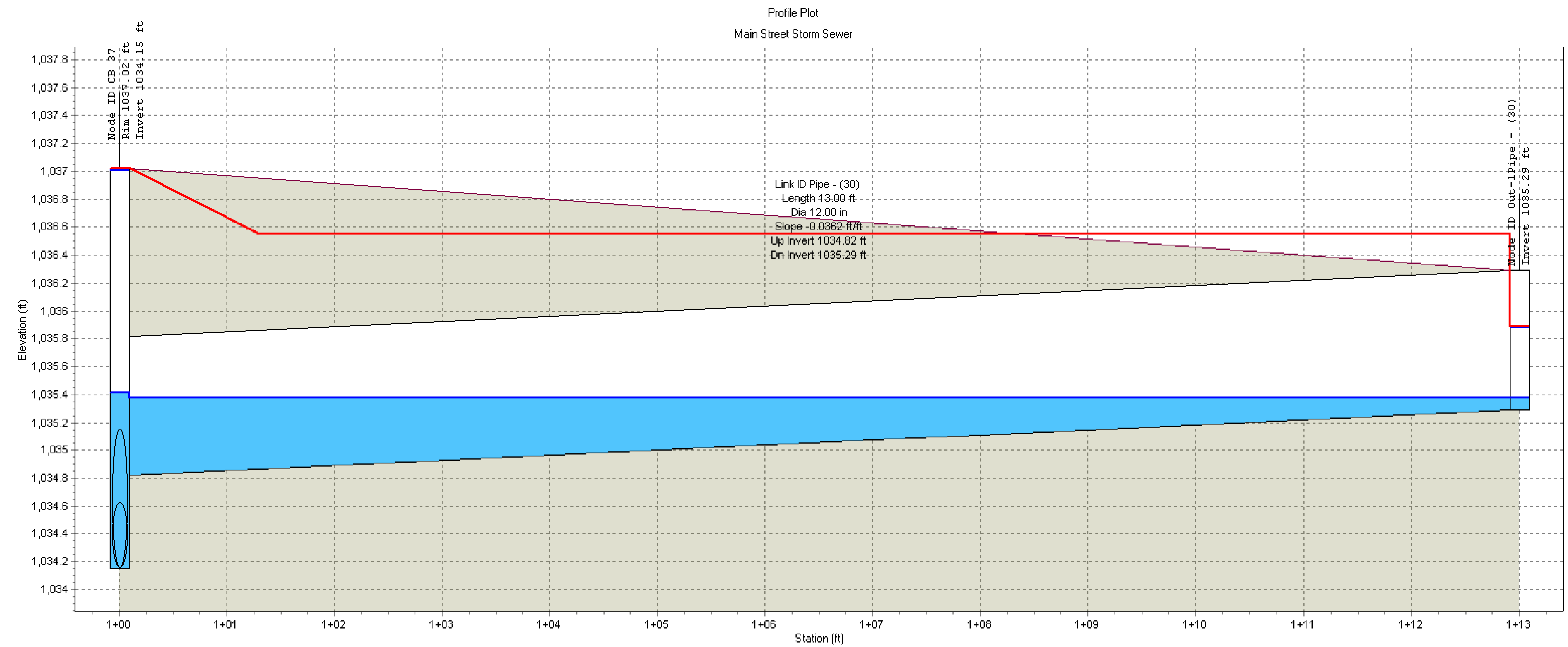
GRAND TRAVERSE COUNTY, MICHIGAN

DRAWN BY MEK	DATE 8/14/2017
PROJECT NO. 816710	SCALE 1:3,600
FILE LOCATION	
SOURCES	

NORTH
0 130 260
SCALE IN FEET

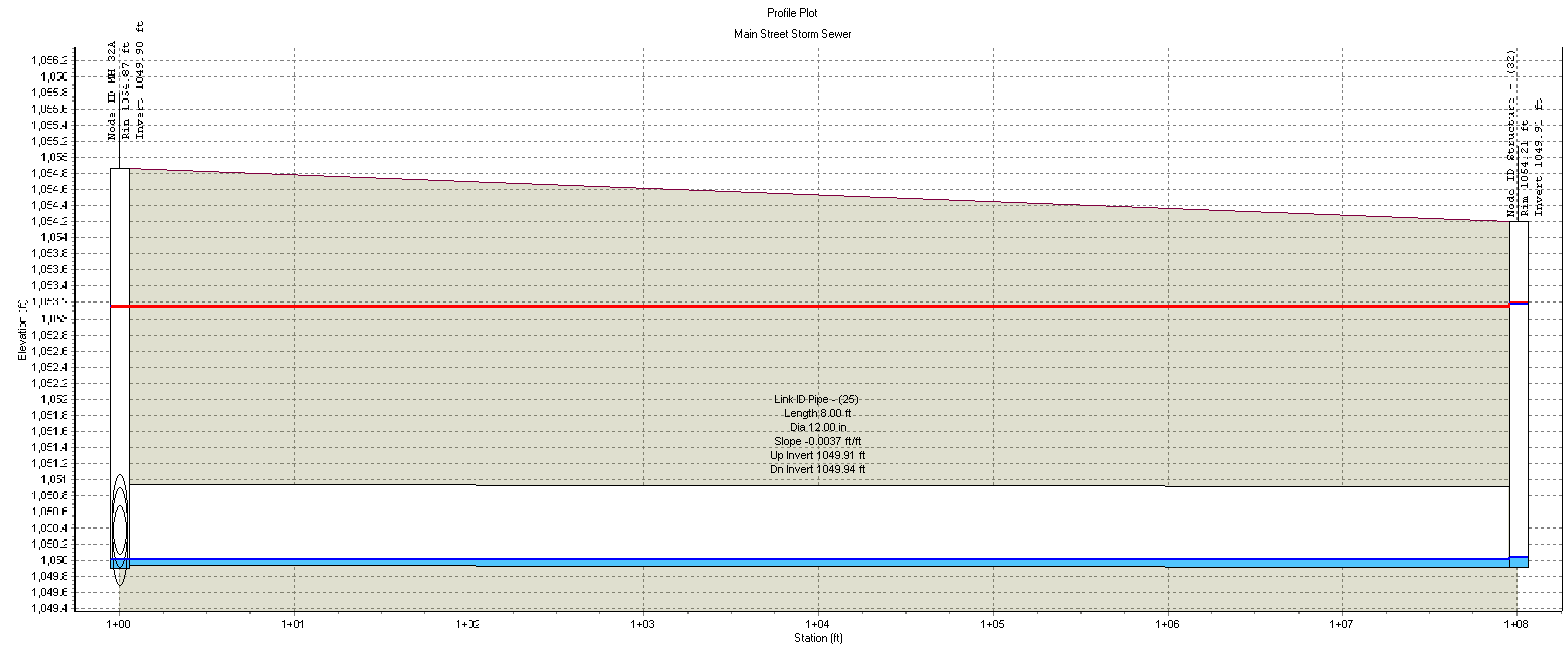
PAGE
B1

Figure B2: Hydraulic Profile - Surcharged Manholes/Pipe CB37 to Out1Pipe30 (sloped backwards)



Node ID:	CB 37		Out-1Pipe - (30)
Rim (ft):	1037.02		
Invert (ft):	1034.15		1035.29
Min Pipe Cover (ft):	1.20		
Max HGL (ft):	1037.02		1036.29
Link ID:		Pipe - (30)	
Length (ft):		13.00	
Dia (in):		12.00	
Slope (ft/ft):		-0.0362	
Up Invert (ft):		1034.82	
Dn Invert (ft):		1035.29	
Max Q (cfs):		18.91	
Max Vel (ft/s):		48.15	
Max Depth (ft):		0.80	

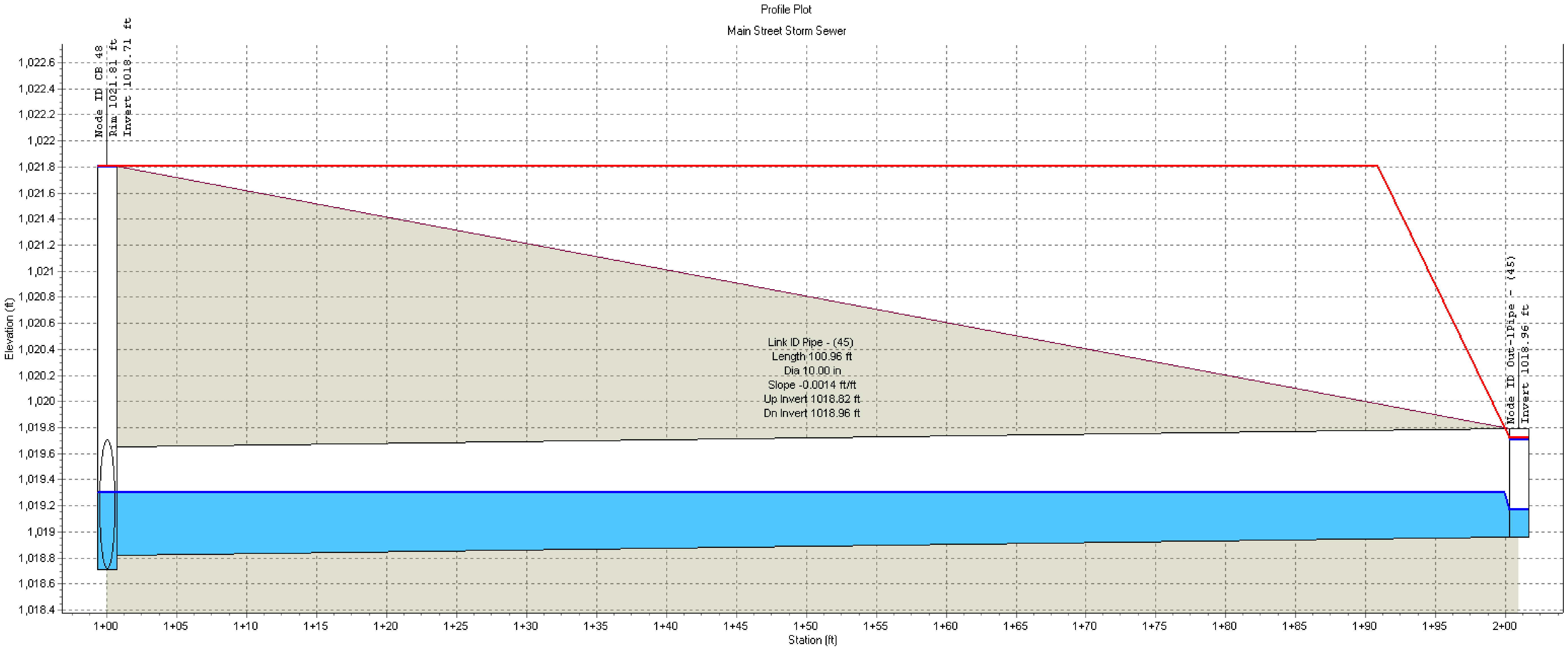
Figure B3: Hydraulic Profile - Surcharged Manholes/Pipe MH32A to MH32 (sloped backwards)



Node ID:	MH 32A	Structure - (32)
Rim (ft):	1054.87	1054.21
Invert (ft):	1049.90	1049.91
Min Pipe Cover (ft):	3.81	3.30
Max HGL (ft):	1053.15	1053.20

Link ID:	Pipe - (25)
Length (ft):	8.00
Dia (in):	12.00
Slope (ft/ft):	-0.0037
Up Invert (ft):	1049.91
Dn Invert (ft):	1049.94
Max Q (cfs):	1.37
Max Vel (ft/s):	1.75
Max Depth (ft):	1.00

Figure B4: Hydraulic Profile - Surcharged Manholes/Pipe CB48 to Out1Pipe45 (sloped backwards)



Node ID:	CB 48	Out-1Pipe - (45)
Rim (ft):	1021.81	
Invert (ft):	1018.71	1018.96
Min Pipe Cover (ft):	2.10	
Max HGL (ft):	1021.81	1019.72

Link ID:	Pipe - (45)
Length (ft):	100.96
Dia (in):	10.00
Slope (ft/ft):	-0.0014
Up Invert (ft):	1018.82
Dn Invert (ft):	1018.96
Max Q (cfs):	3.14
Max Vel (ft/s):	5.85
Max Depth (ft):	0.80

APPENDIX C
STORMWATER CONCERNS AND CIP RECOMMENDATIONS

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 2017

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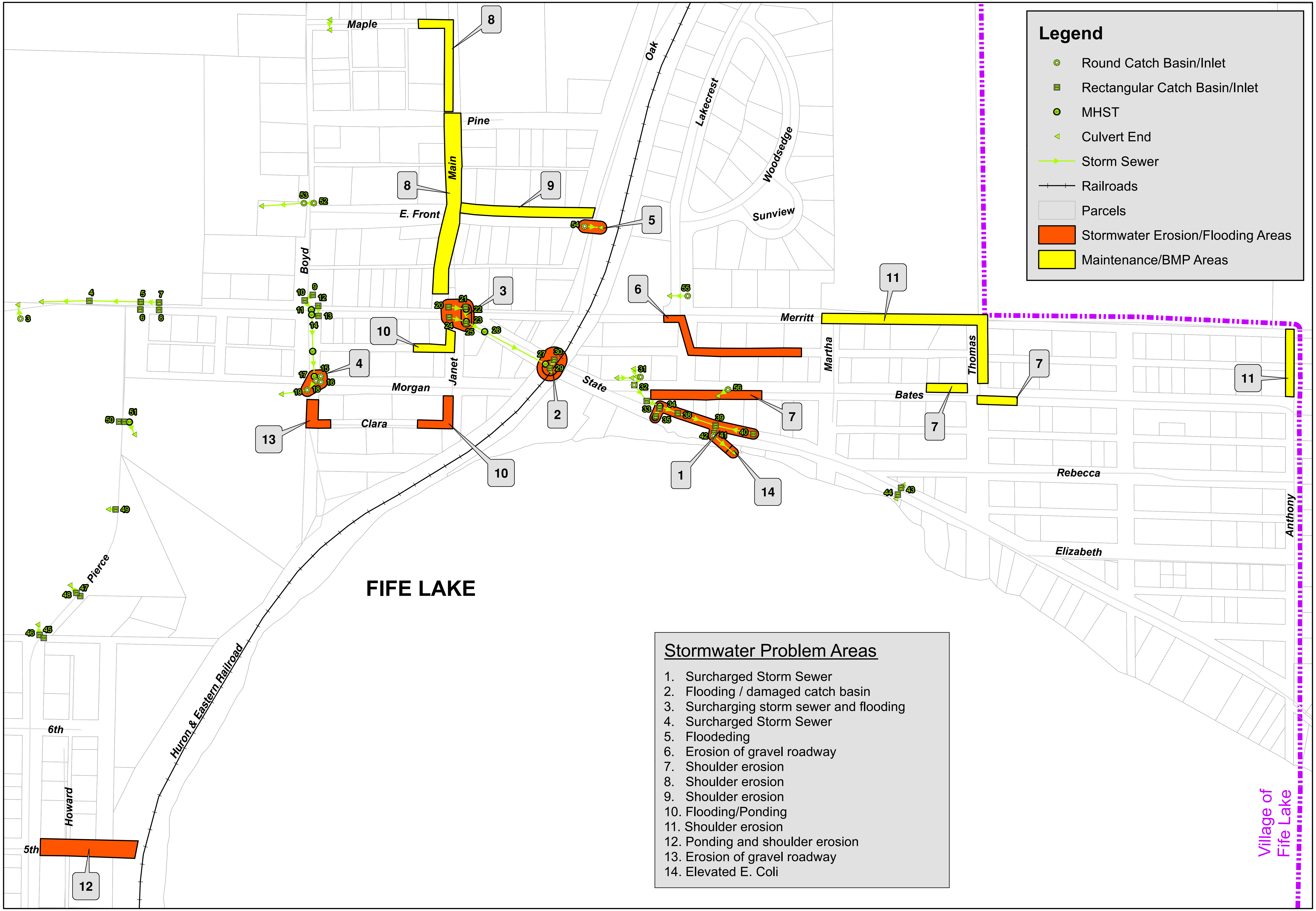

Legend

- ⊚ Round Catch Basin/Inlet
- ▣ Rectangular Catch Basin/Inlet
- ● MHST
- ◄ Culvert End
- ➝ Storm Sewer
- ┼┼ Railroads
- ☐ Parcels
- 🟥 Stormwater Erosion/Flooding Areas
- 🟨 Maintenance/BMP Areas

Stormwater Problem Areas

1. Surcharged Storm Sewer
2. Flooding / damaged catch basin
3. Surcharging storm sewer and flooding
4. Surcharged Storm Sewer
5. Floodeding
6. Erosion of gravel roadway
7. Shoulder erosion
8. Shoulder erosion
9. Shoulder erosion
10. Flooding/Ponding
11. Shoulder erosion
12. Ponding and shoulder erosion
13. Erosion of gravel roadway
14. Elevated E. Coli

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VILLAGE OF FIFE LAKE
AREAS OF STORMWATER CONCERNS

GRAND TRAVERSE COUNTY, MICHIGAN

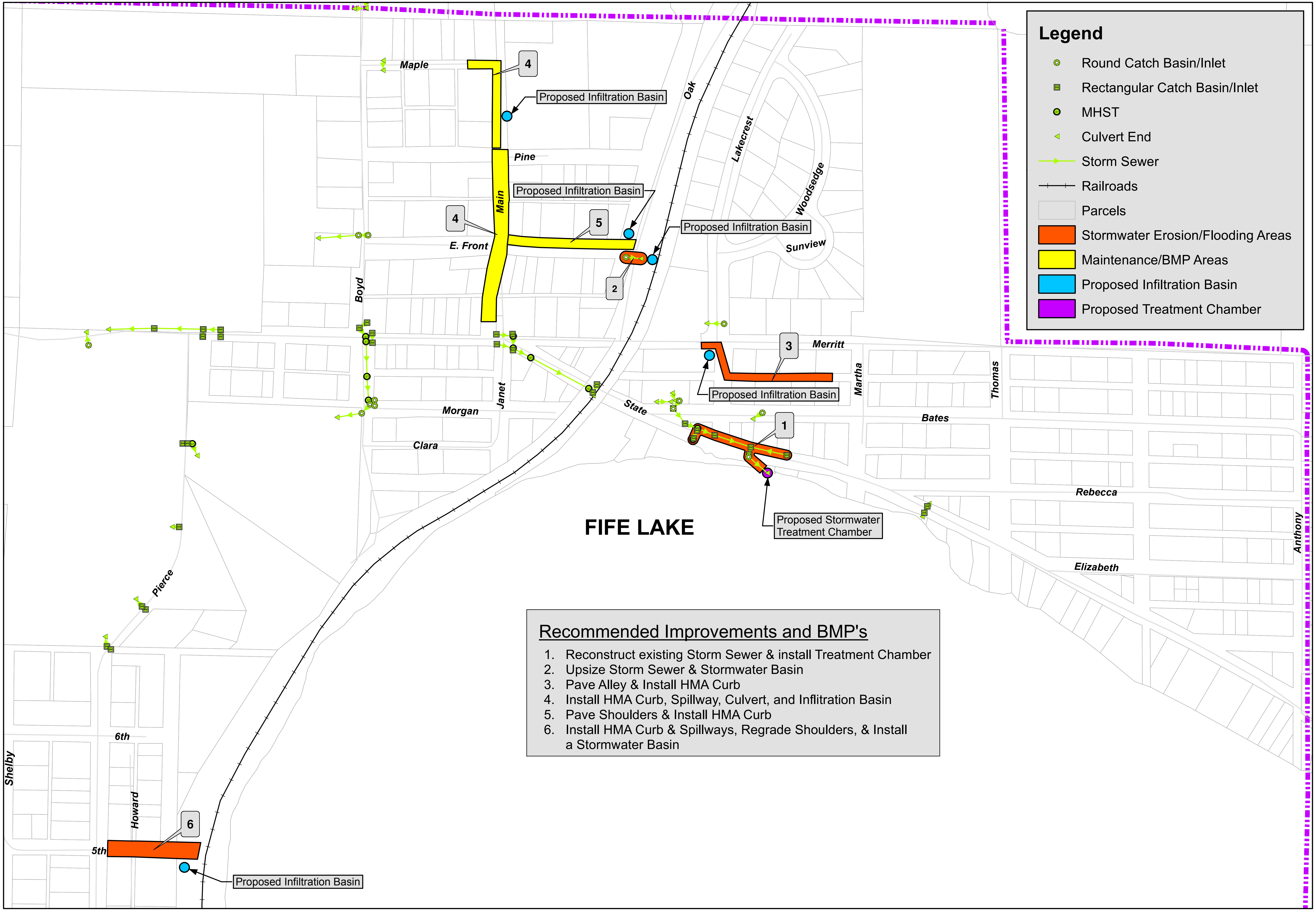
DRAWN BY	DATE
MEK	6/23/2017
PROJECT NO.	SCALE
816710	1:4,000

FILE LOCATION

SOURCES

NORTH
0 150 300
SCALE IN FEET

PAGE
C1



Legend

⊛	Round Catch Basin/Inlet
▣	Rectangular Catch Basin/Inlet
●	MHST
◄	Culvert End
—►—	Storm Sewer
─┼─┼─	Railroads
▭	Parcels
🟧	Stormwater Erosion/Flooding Areas
🟨	Maintenance/BMP Areas
🟦	Proposed Infiltration Basin
🟪	Proposed Treatment Chamber

Recommended Improvements and BMP's

1. Reconstruct existing Storm Sewer & install Treatment Chamber
2. Upsize Storm Sewer & Stormwater Basin
3. Pave Alley & Install HMA Curb
4. Install HMA Curb, Spillway, Culvert, and Inflitration Basin
5. Pave Shoulders & Install HMA Curb
6. Install HMA Curb & Spillways, Regrade Shoulders, & Install a Stormwater Basin

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DESIGN. BUILD. OPERATE.

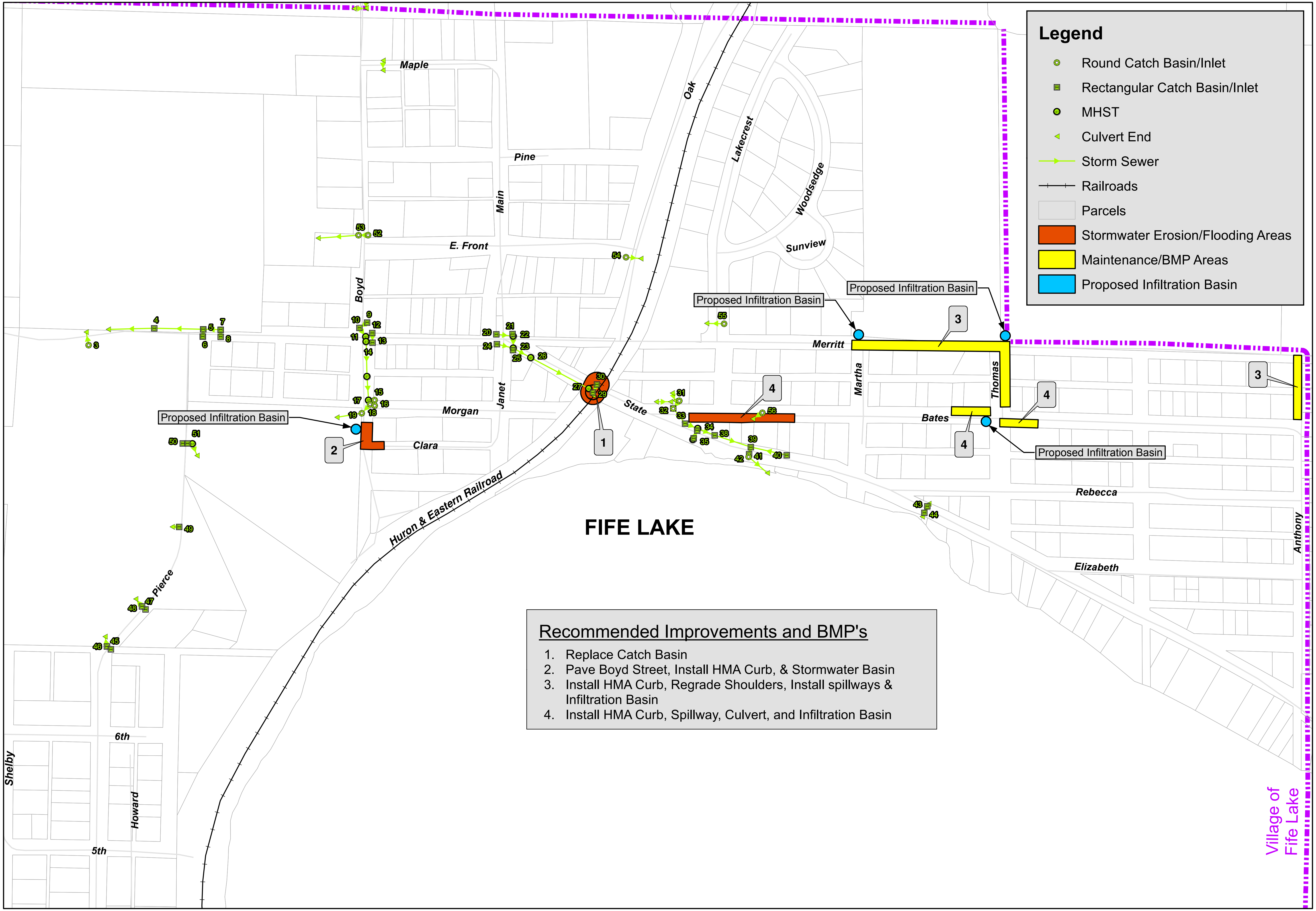
VILLAGE OF FIFE LAKE
1-5 YEAR RECOMMENDED IMPROVEMENTS

GRAND TRAVERSE COUNTY, MICHIGAN

DRAWN BY MEK	DATE 8/23/2017
PROJECT NO. 816710	SCALE 1:4,200
FILE LOCATION	
SOURCES	

NORTH
0 150 300
SCALE IN FEET

PAGE
C2



Legend

- ⚙ Round Catch Basin/Inlet
- ▣ Rectangular Catch Basin/Inlet
- ● MHST
- ◄ Culvert End
- → Storm Sewer
- ┼ Railroads
- ⬜ Parcels
- 🟧 Stormwater Erosion/Flooding Areas
- 🟨 Maintenance/BMP Areas
- 🟦 Proposed Infiltration Basin

Recommended Improvements and BMP's

1. Replace Catch Basin
2. Pave Boyd Street, Install HMA Curb, & Stormwater Basin
3. Install HMA Curb, Regrade Shoulders, Install spillways & Infiltration Basin
4. Install HMA Curb, Spillway, Culvert, and Infiltration Basin

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VILLAGE OF FIFE LAKE
5-10 YEAR RECOMMENDED IMPROVEMENTS

GRAND TRAVERSE COUNTY, MICHIGAN

DRAWN BY MEK	DATE 8/23/2017
PROJECT NO. 816710	SCALE 1:4,200
FILE LOCATION	
SOURCES	

NORTH
0 150 300
SCALE IN FEET

PAGE
C3

VILLAGE OF FIFE LAKE
6-20 YEAR RECOMMENDED IMPROVEMENTS

GRAND TRAVERSE COUNTY, MICHIGAN

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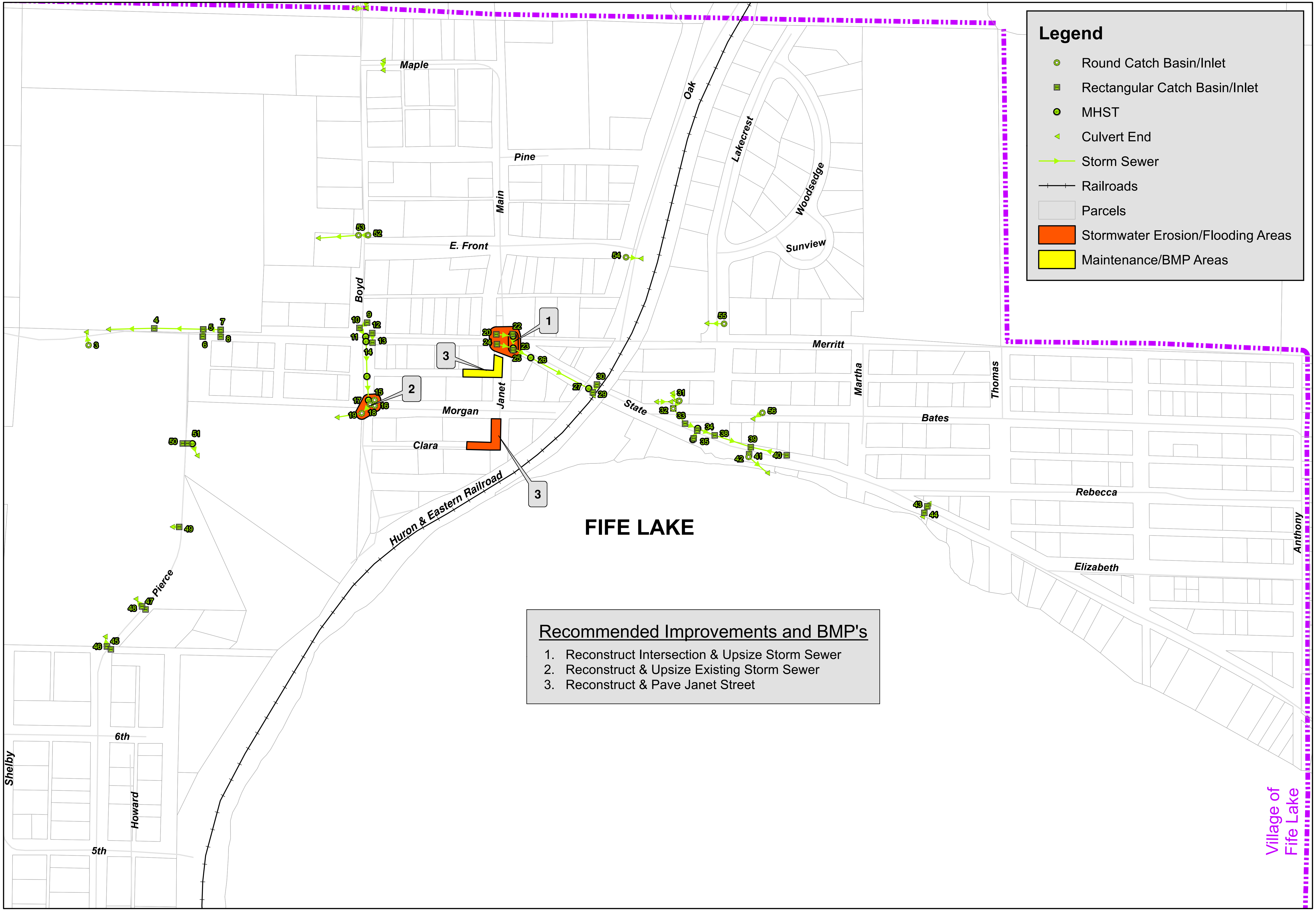

Legend

- ⊚ Round Catch Basin/Inlet
- ▣ Rectangular Catch Basin/Inlet
- ● MHST
- ◁ Culvert End
- → Storm Sewer
- ┼ Railroads
- ▭ Parcels
- 🟥 Stormwater Erosion/Flooding Areas
- 🟨 Maintenance/BMP Areas

Recommended Improvements and BMP's

1. Reconstruct Intersection & Upsize Storm Sewer
2. Reconstruct & Upsize Existing Storm Sewer
3. Reconstruct & Pave Janet Street

DRAWN BY MEK	DATE 6/23/2017
PROJECT NO. 816710	SCALE 1:4,200
FILE LOCATION	
SOURCES	

NORTH

0 150 300
SCALE IN FEET

PAGE
C4

APPENDIX D
STEPL MODELING DATA

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 2017

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

Table A-1. Stressor Framework with Lake and Stormwater Sample Data.

STRESSOR CLASS **Stressor Category** Specific Stressor*	**Details and *Specific Measures*** *Measures listed in red have designated-use based water quality standards.* *Numeric water quality standards are red and underlined.* ** *Other general standards listed at end of table.* *** ← Some details presented in left-hand column to preserve space	**Fife Lake** Chemistry Data: 2004 Biological Data: 2013 *units: mg/l* Low - **Avg.** - High [#] *unless otherwise indicated*	**Village of Fife Lake** 2016 Stormwater Quality Data *units: mg/l* outfall: 1 | 2 *one number only if both the same value*
BIOLOGICAL	**The presence of certain organisms is beneficial while some can negatively impact humans and desirable / native organisms.**		
Species' Community Structure & Behavior	Ecological health relies on healthy food web dynamics. *Measures of biotic health include: the Index of Biotic Integrity, the Invertebrate Community Index, and fishery studies.*	2001 and 2013: Fishery surveys conducted	
Invasive Species	Non-native species have the potential to significantly disturb the native ecology.	Zebra Mussels first identified in 2000	
Primary Production / Algae Blooms	Primary production forms the base of the aquatic food chain but excessive activity, e.g. algal blooms, can negatively impact the ecology. *Measuring chlorophyll provides an estimate of photosynthetic organisms while there are numerous indirect measures of primary production.*		
Pathogens	Organisms that negatively impact humans and possibly other organisms.		
Fecal coliforms Elevated levels indicate the presence of human-disease causing organisms.	*There are numerous tests to assess fecal coliform levels…* *Wastewater-related Discharges: 200 / 100 ml (30-day); 400 / 100 ml (7-day)* *…and tests to assess specific pathogens such as Escherichia coli.* *Total Body Contact = 130 / 100 ml (30 day mean); 300 / 100 ml (event)* *Partial Body Contact = 1,000 / 100 ml (event)*		E. coli: > 2,419 colonies / 100 ml
CHEMICAL	**Proper chemical conditions are necessary to sustain life including the presence of energy sources and absence of hazardous conditions.**		
Dissolved Oxygen Coldwater: 7 mg/l Warmwater & other: 5 mg/l	As oxygen is necessary for life, low levels can negatively impact organisms. -- *Dissolved oxygen in water is generally measured directly.*	-------------------------------- shallow: **9.6;** deep: **1.0**	
Bio- / Chemical-Oxygen Demand	*Bio/chemical oxygen demand (B/COD) is a measure of the amount of oxygen the water will consume.*		
Nutrients Essential to biological processes of aquatic life.	They are naturally occurring but limited. Changes in nutrient concentrations can have dramatic impacts. The ratio of N to P in a healthy lake system is typically 10:1. *Limited to level restricting stimulation of injurious growth*		
Nitrogen The cycling of nitrogen is extremely important for the production of proteins and nucleic acids. It is a complex cycle involving multiple compounds, some of which can be problematic to certain organisms.	*Total Nitrogen* *Kjeldahl Nitrogen* *Ammonia (NH_3^-)* *(as N)* *Organic Nitrogen* *Reduced Nitrogen (e.g. NH_4^+)* *Inorganic Nitrogen:* *Nitrate (NO_3^-)* *Nitrite (NO_2^-)*	0.37 - **1.57** - 2.37 [10] 0.34 - **0.53** - 1.05 [6] 0.01 - **0.17** - 0.27 [3] 0.01 - **0.09** - 0.21 [5] 0.35 - **0.53** - 0.84 [3] 0.01 - **0.05** - 0.08 [5]	| 0.53 (sum) < 0.10 | 0.43 < 0.05 | 0.10
Phosphorus Phosphorus is important for the storage of energy and creation of nucleotides.	It is typically the limiting nutrient, meaning small increases can have dramatic impacts. Typically bound to sediment in aquatic environments. -- *Total Phosphorus | 1 mg/l monthly discharge (in plant available form)*	-------------------------------- 0.02 - **0.02** - 0.03 [6]	------------------------ 0.06 | 0.22
Carbon Carbon is the substrate of and major energy source for all life. It is ingested during photosynthesis & predation.	Enters aquatic systems through runoff, air, and sediments / decomposition. -- *Dissolved organic carbon (DOC) is an indicator of the amount of organic matter entering a waterbody and its availability for cycling. The bioavailability of toxic compounds decreases with increasing DOC.*		
Ionic Conditions	The ionic conditions in an aquatic environment heavily influence the performance of biochemical processes.		
pH (hydrogen ion) 6.5 to 9.0 (generally)	*pH is the logarithmic measure of hydrogen ion concentration (i.e. acid-base scale) ranging from 0 (acid) to 14 (base). A pH of 7 is considered neutral.*	7.3 – **8.0** – 8.3 [22]	
Ionic Strength Ionic strength refers to the level of other ions present in the water and influences and is influenced by many other chemical and physical stressors. *Conductivity, salinity, and total dissolved solids are common measures of aggregate ionic strength. Others are available, as well as the measurement of individual*	*Hardness (cations associated with):* *Carbonate [& bicarbonate], e.g. associated with CO_3^{2-} & HCO_3^-* *major: Na^+, Ca^{2+}, Mg^{2+}, K^+ (measured values listed in same order →)* *minor: e.g. Fe^{2+}, Sr^{2+}, Mn^{2+}* *Non-carbonate, e.g. associated with other anions* *Gran Acid Neutralizing Capacity: Alkalinity + acid buffering of particulates* *Alkalinity (acid buffering ions): CO_3^{2-}, HCO_3^-, OH^-, $B(OH)_4^-$, $SiO(OH)_3^-$, $MgOH^+$, HPO_4^-, PO_4^-* *Other anions :* *Cl^- & SO_4^{2-} (contributes to alkalinity under proper conditions); chlorides shall not exceed 50 mg/l (monthly) in Great Lakes / connecting waters* *Specific Conductance (µmho/cm)* *Total Dissolved Solids: 500 mg/l monthly / 750 mg/l from controllable source*	 108 45.2 = 6+30.9+7.5+0.8 12.1 0.096 11 & 4 240 - **249** - 269 [24]	Cl^-: 47 | 11
Hazardous (e.g. toxic) Substances ** Often partition to suspended / bottom sediments.	There is an indefinite number of compounds that adversely impact aquatic life. The three major classes are heavy metals, organic chemicals, and inorganic chemicals. Pesticides, industrial compounds, pharmaceuticals, and personal care products are typical origins of such pollutants.		
Heavy Metals	Individual metals are typically measured by chromo/spectral analysis.		
Organic Chemicals	Organic pollutants are typically measured by chromo/spectral analysis.		
Inorganic Chemicals	Methods vary by chemical properties.		

Table A-1. Stressor Framework with Lake and Stormwater Data (continued).

STRESSOR CLASS **Stressor Category** Specific Stressor*	**Details and *Specific Measures*** *Measures listed in red have designated-use based water quality standards.* *Numeric water quality standards are red and underlined. *** *Other general standards listed at end of table. **** ← Some details presented in left-hand column to preserve space	**Fife Lake** Chemistry Data: 2004 Biological Data: 2013 *units: mg/l* Low - **Avg.** - High [#] *unless otherwise indicated*	**Village of Fife Lake** 2016 Stormwater Quality Data *units: mg/l* outfall: 1 | 2 *one number denotes same value*
PHYSICAL There are extremely complex interdependencies between most physical stressors through geomorphology and between stressors in other classes.	**Physical stressors include manmade and natural substances and features at all scales (e.g. shoreline conditions, dams, debris, sediment, temperature).** Geomorphological conditions are defined by: waterbody size / dimensions; channel gradient / slope; substrate type / size; vegetative cover / habitat complexity; and riparian zone interaction. In conjunction with the water, these define the energy of a waterbody and changes in one lead to changes in others to re-establish a balance between competing forces. Some concepts are primarily related to flowing waters,		
Temperature A measure of the thermal energy. Includes temporal and spatial temperature distribution & movement of heat through the environment	Plays an important role in many other biological, chemical, and physical stressors. -- *Temperature is measured in degrees Fahrenheit (°F) or Celsius (°C).* *Temperature maximums are defined for each month for the Great Lakes, and numerous classes of waterbodies. Temperature changes due to discharges are also restricted.*	-------------------------------- 10 - **13.4** - 23.5 °C	------------------------
Suspended / Floating Media (e.g. floating solids, foams)	Pollutants that are suspended on the surface of or within the water column, typically having visible aesthetic impacts, and causing physical degradation to the ecosystem.		
Trash & Debris Macro-scale solid waste.	Solid waste in the water can directly injure organisms / reduce habitat, alter and obstruct flow, exacerbate flooding, break down into harmful constituents (e.g. chemical stressors), and lead to other problems.		
Oils & Grease / Immiscible Liquids Macro- & micro-scale liquid pollutants.	Non-aqueous phase liquids will accumulate/partition to the water surface, suspended and/or bottom sediments, and structures. This physically injures organisms and reduces habitat and the substances are many times also chemical stressors (e.g. oil films).		< 5.0
Suspended Solids Micro-scale suspended solids / sediment in the water column. Many hazardous pollutants partition appreciably to sediments. This generally includes settleable solids.	Excessive sediments in the water column: reduce photosynthesis and predation, physically damage organisms (e.g. fouled gills, scouring), and increase heat absorption. Insufficient sediment levels can impact nutrient transport, production/predation (e.g. visibility, filter feeding), and habitat. -- *The total suspended solids measure involves weighing the sediment mass.* *The turbidity measure assesses the opacity of the water column.* *The Secchi disk depth measure is a practical assessment of turbidity in*	-------------------------------- Secchi = 5.2 m & 6.7 m	------------------------ 21 | 314
Habitat Changes to physical habitat (as a stressor) does not include other physico- or chemical attributes (e.g. oxygen levels, temperature, clarity, quantity). Specific habitats can be identified for comparison to those expected.	Habitat is broken down into four major zones, each with specific stressors. These are: open water / limnetic zone (primarily impacted by other stressors classes and/or categories), channel banks and shorelines / littoral zone, riparian / flood zone, and bottom sediments / benthic zone, There is also a difference in lentic habitats (slow moving water, e.g. lakes) and lotic habitats (fast moving water, e.g. streams) and the hydraulic disconnection between upstream and downstream areas impacts habitat along the flow direction. *Stream order, geometrical data, and climate information are used to determine the baseline habitat conditions for comparison.*		
Littoral Zone Changes This zone includes the submerged areas where vegetation grows and extends to the regular high flow limits where submergence tolerant vegetation is dominant. Stressors include man-made and natural changes	This area provides complex physical habitat and flow mitigating factors from: channel/shoreline sinuosity, small pools and riffles / shallows, substrate structure (e.g. live trees / roots and deadfall), cover / obstructions (e.g. bank overhang, boulders, plant / tree canopy). *Typical stressors include erosion and sedimentation, engineered armoring (or occasional structures – e.g. stormwater outfalls) and straightening, near-shore vegetation removal / species cultivation (e.g. removing woody species, growing turf grass lawns. Stressors to the littoral zone directly impact organisms; reduce oxygen absorption, filtering of chemical stressors, and sediment in runoff; lead to increased heat absorption (temperature); and increase the rate of flow to the waterbody.*		
Riparian / Flood Zone Changes Riparian stressors related to water quality and flow changes have more acute impacts on lower order streams while those related to flooding and water surface elevations are more impactful on higher order waterbodies.	This area provides specialized habitat (species tolerant of / requiring occasional submergence), has a large impacts on water quality (as discussed above), and is extremely important in mitigating impacts of extreme flood events. High water levels allow for transport of required materials between waterbody, nearby wetlands, and upland areas and are extremely important for watercourse geomorphology. *Typical stressors include: floodplain disconnection (e.g. dykes, floodwalls), reduction of floodplain volume (e.g. construction), impervious land cover and vegetation reduction, and storm sewers. Stressors to the riparian zone have similar impacts as those described to the littoral zone. Bank incision characteristics, riparian land uses*		

Table A-1. Stressor Framework with Lake and Stormwater Data (continued).

STRESSOR CLASS **Stressor Category** Specific Stressor*	**Details and *Specific Measures*** *Measures listed in red have designated-use based water quality standards.* *Numeric water quality standards are red and underlined. *** *Other general standards listed at end of table. **** ← Some details presented in left-hand column to preserve space	**Fife Lake** Chemistry Data: 2004 Biological Data: 2013 *units: mg/l* Low - **Avg.** - High [#] *unless otherwise indicated*	**Village of Fife Lake** 2016 Stormwater Quality Data *units: mg/l* outfall: 1 | 2 *one number denotes same value*
Benthic Zone Stressors This zone the submerged bottom areas of a waterbody. The desired composition of this zone (i.e. substrate and organisms) is largely dependent on the surrounding geology in addition to climate and stream morphological conditions.	At the bottom of a waterbody, the substrate size, density, and adhesion influence the ability to attach/burrow in different conditions (e.g. different velocities). Determined not only by geology but also plant stalk and root structures and deadfall (e.g. decaying trees). This variability (e.g. riffles / shallows and pools) provide diverse cover for different organisms at varying stages to survive a variety of changing depth and flow velocity conditions. The stability of the benthic zone is highly dependent on the state of the geomorphological processes in a given reach. The inherent roughness also defines the hydraulic roughness of the overall waterbody, influencing the capacity of the channel and the depth of flow associated with different rates. *Typical stressors include erosion / dredging of the substrate, deposition of sediment into the substrate (filling the spaces in the substrate), engineered channels, and contamination (impacting benthic species). The composition of the benthic environment (e.g. substrate) is often measured directly and the bed stability calculated. Biotic indexes are also used as a proxy to*		
Hydraulic Disconnection & Other Changes The ability of water to flow naturally and for organisms to move about is an important ecological function.	Hydraulic disconnection segments habitats, isolates / restrict species, and can influence other characteristics. *The most common hydraulic stressor is a dam. Many dams segment populations upstream and downstream, change flow regimes, accumulate sediment upstream, and increase temperatures of ponded waters. Culverts / enclosures don't restrict normal flows (although they may not be able to handle extreme flow rates) but if too long, aquatic life will not traverse the enclosed section. Gradient changes when water is re-routed also have impacts beyond the immediate area as the energy balance of the waterbody is adjusted. Channel slope / water gradient, channel sinuosity, and obstruction characteristics are used to*		
Runoff / Discharge / Water Surfaces The flow amounts and frequencies (e.g. extremely high and extremely low levels) plays an important role in the quality of habitat (independent of other stressors) and also largely defines the geomorphological conditions that control erosion, meander-	The erosive potential of a stream is reflected as 'stream power' or the capacity to move materials. As described under the other stressors, this is a function of slope/gradient, cross-section, hydraulic roughness, and flow. This category is largely about modifications to flow that are a manifestation of changes to the catchment that supplies runoff to a particular waterbody, primarily in the form of land development (e.g. impervious cover). Generally, runoff characteristics and quality change in numerous ways and this stressor category focuses on the flow aspect. *The changes are often quantified through statistical analyses and/or modeling of: water surface elevation changes, flow changes, and the relationship between the two.*		
Reduced Base Flow *Base flow is measured during dry seasons when runoff contributions to waterbody flow are at a minimum.*	Many waterbodies in urbanizing areas experienced reduced levels during the dry season. This is because much of the water that used to percolate into the ground and sustain subsurface hydraulic connections now simply runs off over the impervious surfaces. This results in a stream with less physical habitat, higher concentrations of chemical stressors, and higher temperatures (in turn impacting dissolved oxygen).		
Runoff Hydrograph Changes *Changes in runoff hydrographs are investigated through statistical analyses of stream gage data.*	Urbanization (e.g. impervious surfaces and storm sewer systems) increases the percent of rainfall that becomes runoff and routes it to the nearby waterbody much faster than under natural conditions. This means that flow rates rise quickly, peak at higher rates / water levels, and stay at the higher, more erosive levels for longer periods of time. *Actively undercut streambanks are in indirect sign that flow in a waterbody has become 'flashier'.*		
Flood Event Discharges / Water Elevations	Because of increases in rainfall runoff, the discharge and water surface elevations associated with particular storm events both increase with exacerbated flooding being the ultimate impact.		
RADIOLOGICAL	Natural and man-made radioactive materials can negatively impact humans and other organisms. *Refer to federal agency standards.*		

* The specific stressors listed are only some of the examples important in the State of Michigan. It is not feasible to enumerate all possible specific stressors.

** The standards presented are simplifications to facilitate general assessments. Many standards define multiple specific conditions and many standards can be modified on a case-by-case basis to account for unanticipated special environmental conditions.

*** Other water quality standards include: taste / odor causing substances (for water supplies or where impacting fish palatability); a complicated assessment of toxicity (explicitly noted are arsenic, cadmium, chromium III and VI, copper, cyanide, dieldrin, endrin, lindane, mercury, nickel, parathion, pentachlorophenol, zinc) with DDT and metabolites, methylmercury, all PCBs, and 2,3,7,8-TCDD listed for protection of wildlife, along with numerous other bioaccumulative chemicals of concern and human exposure values for benzene, chlordane, chlorobenzene, cyanides, DDT, dieldrin, 2,4-dimethlyphenol, 2,4-dinitrophenol, hexachlorobenzene, hexachloroethane, lindane, mercury (+ methyl-), methylene chloride, 2,3,7,8-TCDD, toluene, PCBs in general, toxaphene, and trichloroethylene.

APPENDIX E
FIFE LAKE AREA SOIL MAP

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 2017

FLEIS&VANDENBRINK
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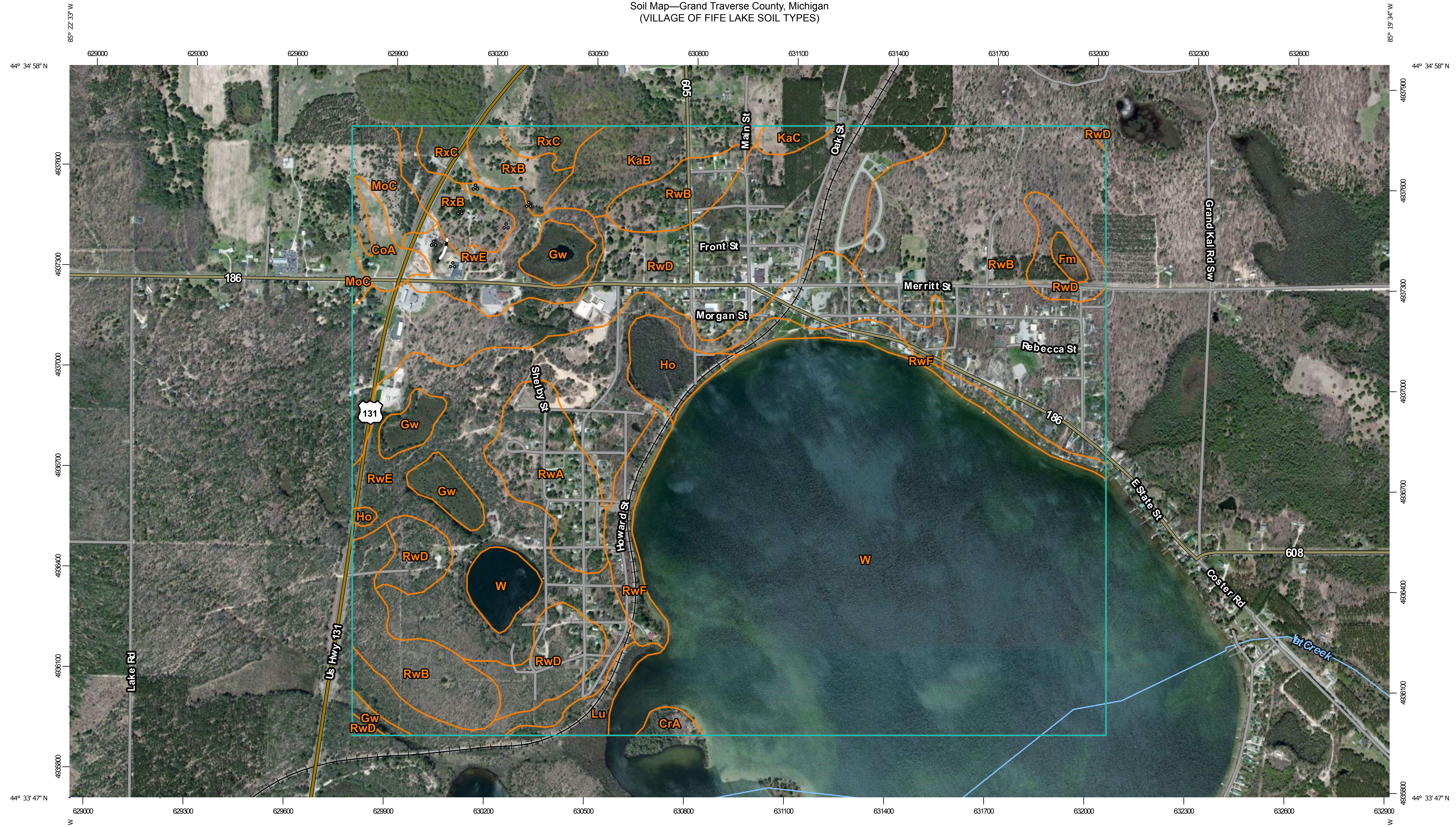
Soil Map—Grand Traverse County, Michigan
(VILLAGE OF FIFE LAKE SOIL TYPES)



Map Scale: 1:10,700 if printed on B landscape (17" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- □ Soil Map Unit Polygons
- Soil Map Unit Lines
- ■ Soil Map Unit Points

Special Point Features
- Blowout
- ☒ Borrow Pit
- Clay Spot
- ◇ Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- ◎ Perennial Water
- Rock Outcrop
- + Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- △ Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand Traverse County, Michigan
Survey Area Data: Version 10, Sep 21, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Grand Traverse County, Michigan (MI055)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
CoA	Croswell loamy sands, 0 to 2 percent slopes, overwash	8.1	0.8%
CrA	Croswell-Rubicon sands, 0 to 2 percent slopes	2.9	0.3%
Fm	Fresh water marsh	2.2	0.2%
Gw	Greenwood peat	21.5	2.1%
Ho	Houghton muck, 0 to 1 percent slopes	14.0	1.4%
KaB	Kalkaska loamy sand, 2 to 6 percent slopes	21.1	2.1%
KaC	Kalkaska loamy sand, 6 to 12 percent slopes	3.5	0.3%
Lu	Carlisle muck, 0 to 2 percent slopes, cool	7.8	0.8%
MoC	Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes	14.0	1.4%
RwA	Rubicon sand, 0 to 2 percent slopes	28.7	2.8%
RwB	Rubicon sand, 0 to 6 percent slopes	158.6	15.6%
RwD	Rubicon sand, 6 to 18 percent slopes	146.3	14.4%
RwE	Rubicon sand, 18 to 25 percent slopes	163.9	16.1%
RwF	Rubicon sand, 25 to 45 percent slopes	28.6	2.8%
RxB	Rubicon-Menominee loamy sands, 2 to 6 percent slopes	23.2	2.3%
RxC	Rubicon-Menominee loamy sands, 6 to 12 percent slopes	11.7	1.1%
W	Water	363.2	35.6%
Totals for Area of Interest		**1,019.3**	**100.0%**

APPENDIX F

STORMWATER TESTING RESULTS

PREPARED FOR:
VILLAGE OF FIFE LAKE

PROJECT NO. 816710
MAY 2017

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

SOS ANALYTICAL

4125 Cedar Run Road, Suite B
Traverse City, MI 49684

Phone: (231) 946-6767 Fax: (231) 946-8741
Email: shanna@sosanalytical.com www.sosanalytical.com

CUSTODY TRANSFER RECORD

SOS Project ID #: 165336

Cooler Temp (°C) 17.4°C Page ____ of ____

Quote # :
PO # :

Miscellaneous Information :
FIFE LAKE STORM OUTLET #1 & #2
7 0.1 INCH OF RAIN

Client / Company Name : FLEIS & VANDENBRINK
Site Address : VILLAGE OF FIFE LAKE
Project # / WSSN # : ~~B16990~~ B15360
Sampling Company : FLEIS & VANDENBRINK
Sampler's Name : IAN NEERKEN
Send Results To : DAVID CAPSER
Address : 603 BAY ST FIRST FLOOR, TCMI 49684
Phone : 231-932-2600 Fax / E-mail : DCAPSER@FVENG.COM
Invoice To : F&V – ATTN DAVID CAPSER
Address : 603 BAY ST FIRST FLOOR – TCMI 49684

Analysis Information

Sample Identification	Collection Information Date	Collection Information Time	# of Containers	Matrix DW, WW, GW, Soil, Oil, Sludge	Comments / Other Analysis	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH E coli	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH TSS NO$_3$ NO$_2$ Li TPhos	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH FOG	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	HCL HNO$_3$ H$_2$SO$_4$ NaOH MEOH	RUSH Due : Call To Schedule
1 ~~STORM~~ FIFE LAKE STORM #1	10/12/16	14:55 AM [✓ PM]	4	STORM W [✓ Grab] Comp		X	X	X							
2 FIFE LAKE STORM #2	10/12/16	14:50 AM [✓ PM]	4	STORM W [✓ Grab] Comp		X	X	X							
3		AM PM		Grab Comp											
4		AM PM		Grab Comp											
5		AM PM		Grab Comp											
6		AM PM		Grab Comp											
7		AM PM		Grab Comp											
8		AM PM		Grab Comp											
9		AM PM		Grab Comp											
10		AM PM		Grab Comp											
11		AM PM		Grab Comp											
12		AM PM		Grab Comp											
13		AM PM		Grab Comp											
14		AM PM		Grab Comp											
15		AM PM		Grab Comp											

Relinquished by: Date: 10/12/16 Time: 1650 AM [✓ PM]
Received by: Date: Time: AM PM

Relinquished by: Date: Time: AM PM
Received in lab by: C. Gerhard Date: 10/12/16 Time: 4:50 AM [✓ PM]

SOS ANALYTICAL

4125 Cedar Run Rd., Suite B
Traverse City, MI 49684
Phone 231-946-6767
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COMPANY: VILLAGE OF FIFE LAKE
NAME: FLEIS & VANDENBRINK
PROJECT NO: 815360
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:
FIFE LAKE
MI
COUNTY:
TWP:

SOS PROJECT NO: 165336
SAMPLED BY: IAN NEERKEN
DATE SAMPLED: 10/12/2016
TIME SAMPLED: 2:55 PM
SAMPLE MATRIX: STORM WATER OUT
DATE RECEIVED: 10/12/2016
TIME RECEIVED: 4:50 PM

INORGANICS/WET CHEMISTRY

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: FIFE LAKE STORM #1							
1	CHLORIDE EPA 300.0	47	2	mg/L (PPM)	KMJ	10/14/2016	
1	E.COLI SM9223-B MPN	> 2419		Colonies/100 mL	KMJ	10/13/2016	
1	NITROGEN, NITRATE - EPA 300.0	ND	0.1	mg/L (PPM)	KMJ	10/14/2016	
1	NITROGEN, NITRITE - EPA 300.0	ND	0.05	mg/L (PPM)	KMJ	10/14/2016	
1	OIL&GREASE EPA 1664A	ND	5.0	mg/L (PPM)	FT	10/21/2016	
1	PHOSPHORUS-TOTAL EPA 365.4M	0.06	0.05	mg/L (PPM)	KMJ	10/13/2016	
1	RESIDUE, NON-FILTERABLE(TSS)/SM2540D	21	1	mg/L (PPM)	AD	10/13/2016	
SAMPLE ID: FIFE LAKE STORM #2							
2	CHLORIDE EPA 300.0	11	2	mg/L (PPM)	KMJ	10/14/2016	
2	E.COLI SM9223-B MPN	> 2419		Colonies/100 mL	KMJ	10/13/2016	
2	NITROGEN, NITRATE - EPA 300.0	0.43	0.10	mg/L (PPM)	KMJ	10/14/2016	
2	NITROGEN, NITRITE - EPA 300.0	0.10	0.05	mg/L (PPM)	KMJ	10/14/2016	
2	OIL&GREASE EPA 1664A	ND	5.0	mg/L (PPM)	FT	10/21/2016	
2	PHOSPHORUS-TOTAL EPA 365.4M	0.22	0.05	mg/L (PPM)	KMJ	10/13/2016	
2	RESIDUE, NON-FILTERABLE(TSS)/SM2540D	314	10	mg/L (PPM)	AD	10/13/2016	

ND = NOT DETECTED
LOD = LIMIT OF DETECTION
SMCL = FEDERAL NON-ENFORCEABLE LIMIT
MCL = MAXIMUM CONTAMINANT LEVEL
s.u. = STANDARD pH UNITS REPORTED AT 25 C
DISS = DISSOLVED

APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER