# STORMWATER MANAGEMENT PLAN





May 2017

### City of Traverse City Engineering Department

### City of Traverse City Guide for Water Quality

IN COLLABORATION WITH



## Stormwater Management Plan

### CITY OF TRAVERSE CITY ENGINEERING DEPARTMENT

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## EXECUTIVE SUMMARY

Stormwater runoff has been identified as one of the threats impacting water quality of the watershed of Grand Traverse Bay. The City of Traverse City was awarded funding from the MDEQ for the development of a Stormwater Management Plan to investigate existing infrastructure conditions and assess options to improve the quality of stormwater runoff. The objectives of the Report were to:

- Identify the baseline conditions
- Evaluation of open channels and shoreline
- Capacity analysis of open channels
- Determination of water quality considerations
- Creation of an updated Capital Improvement Plan

These five objectives are presented as their own sections in the report and are expanded upon in the appendices. These sections are explained as follows:

- Identify Baseline Conditions
  - Historical information such as previous reports, technical data, utility records, plans and mapping
  - o Outcomes of public meetings
- Asset Evaluation—Open Channels and Shoreline
  - o Identified key drainage courses
  - o Kids Creek and tributaries streambank inventory
  - o Channel cross section survey
  - o Boardman Lake shoreline inspection
  - Stream data transferred to GIS
- Capacity Analysis
  - o Capacity Level of Service
  - o Hydrologic and hydraulic modeling of Kids Creek
- Water Quality Considerations
  - o Identified key subwatersheds of concerns
  - Stakeholder meetings
  - Proposed capital improvements to address water quality problems
- Capital Improvement Plan (CIP)
  - Update to Grand Traverse Bay Watershed Protection Plan
  - o Stormwater Management Plan
  - Coordination of the CIP with the Stormwater Asset Management Plan

#### STORMWATER MANAGEMENT PLAN

### MINIMUM CONTROL MEASURES

- Public Education and Outreach
- Public Participation
   and Involvement
- Illicit Discharge
   Detection and
   Elimination
- Construction Site
   Runoff Control
- Post-Construction
   Runoff Control
- Pollution
   Prevention/Good
   Housekeeping

### **Plan Highlights**

- Match resident flooding survey to the XP-SWMM modeling and confirm if the Kid's Creek and Cedar Street area as are the primary locations for folding concerns in the City
- City purchase of the XP-SWMM software for analysis of all drainage areas within the City Limits
- Calibration of the XP-SWMM model using actual storm events in order to confirm the model results are within 15% of actual stormwater runoff volumes and 20% of actual peak flow rates
- City to continue monitoring water quality
- Regular updating of the Stormwater Control Ordinance Guidelines to meet current best management practices and incorporation of the guidelines into the City's stormwater ordinance, including the regulation of open loop geothermal systems
- It is recommended that the stormwater guideline of 0.78 inches for the 90% design storm be incorporated into the City stormwater ordinance for water quality considerations
- Document locations where water quality devices have been installed and tabulate investments for various treatments
- Determine water quality treatments for remaining City storm sewers and estimate required investment
- Coordinate with the Stormwater Asset Management Plan for determining a system wide level of investment
- TWC applied to EPA Great Lakes Restoration Initiative for \$500,000 for improving the outfall to the 14<sup>th</sup> Street drain
- TWC applied to National Fish and Wildlife Foundation Sustain Our Great Lakes for \$537,000 to improve natural stream function and in stream habitat on Kids Creek between 7<sup>th</sup> Street and Silver Lake Road
- Appendices
  - Appendices A, B, C and D
    - The contributing drainage area map, hydraulic capacity of storm sewers and the field data sheet for the majority of the points of entry. Some of the points of entry did not have data for storm sewers available and/or could not be field located.
  - o Appendix E
    - Runoff calculations for the contributing drainage areas for the points of entry. The calculations include drainage area in acres, surface type by land use, and determination of the potential runoff volume and discharge rates.
  - o Appendix F
    - Current City ordinance and guidelines for stormwater runoff control. It also includes a copy of PA 507 of 2002 which enables local health officials to test, monitor and report beach area water quality.

- o Appendix G
  - Maps showing Stormwater Treatment locations and details.
- o Appendix H
  - Bibliography, resource documents, Flooding Survey, and referenced materials.
- o Appendix I
  - Prince-Lund Engineering's "Drainage Analysis and Comparison: An Analysis and Comparison of Hydrologic Runoff Models" from April 2017.
- o Appendix J
  - TWC's proposed updates to the Grand Traverse Bay Watershed Protection Plan specific to the City's SAW grant



## SECTION 1: IDENTIFY BASELINE CONDITIONS

In order to determine a starting point for assessing the current and future conditions of the City's stormwater system, baseline conditions needed to be established. These baseline conditions were determined by reviewing historical documents, conducting a flooding survey, and holding a number of public meetings. The review of historical documents included the review and update of the 2007 Stormwater Management Report, the Grand Traverse Bay Watershed Protection Plan, and the Boardman Lake Watershed Study, to bring them up to current standards and to make them applicable in 2017.

### 1.1 Review of Historical Information

It is necessary to review the historic information and technical data that is available to begin the process of identifying points of stormwater entry into Grand Traverse Bay and its watershed within the city limits of Traverse City. The following reports and documents were reviewed and key information about existing stormwater systems compiled.

**Report on Sewage Disposal (1931)** - This identified the need to eliminate all the direct sewage discharges into the Boardman Lake, Boardman River and Tributaries and the Grand Traverse Bay. It recommended a centralized sewage treatment facility at the present site of the sewage treatment plant to comply with a court order. It also recommended the main intercepting sewer and retaining wall along the river ending at a Front Street Lift Station; an east side intercepting sewer heading east on Front Street; a south side intercepting sewer serving the area south and west of the Oak Street and connected to the new sewer at the Hospital; a Bay Street Sewer System with a pump station at Bay Street and Maple Street; An Oak Street Trunk Sewer; and a Cass Street Trunk Sewer.



**Report on One Year Operation of Sewage Disposal System (1933)** - This report focused on the success of the first year of operation of the City's sewage collection and treatment system including storm sewers.

**Report on Sewerage and Drainage (1945)** - This comprehensive report provided the basis of design and general plans for much of the City Storm and Sanitary Sewer system. This report references a 13 year frequency for the basis of design for stormwater infrastructure.

**Report on Water Supply Improvements for City of Traverse City (1956)** - This report provided the basis of design for the relocation of the City water supply from West Grand Traverse Bay to East Grand Traverse Bay due to water quality concerns in West Grand Traverse Bay. The new water treatment plant and intake was completed in November 1965 and put into service in 1966.

*Water Quality Models for Total Coliform Bacteria in Grand Traverse Bay (1967)* - This study provided significant water quality data for the West Grand Traverse Bay and references the transfer of the City water supply intake to East Grand Traverse Bay in 1966 as a result of water quality concerns which affected public health.

*Report on Algal Nutrients in the Boardman River (1968)* - This report provided significant water quality data for the Boardman River and discussed eutrophication of West Grand Traverse Bay.

Sanitary Sewerage and Water Supply Systems (1970) - This report focused on the regional sanitary sewer and water supply and states; "The problems of combined sewers are evident in Traverse City" and; "A program to separate these flows should be taken as soon as possible, particularly in view of the fact that during periods of high run off substantial amounts of overflow are discharged directly into the Boardman River, including significant amounts of Raw Sewage."

"The problems of combined sewers are evident in Traverse City." —Sanitary Sewerage and Water Supply Systems (1970)

**Boardman River Natural River Plan (1976) (revised 2002)** - This plan and its updates are the guidelines for stewardship of the Boardman River. Our river care champion, The Grand Traverse County Soil Conservation District, maintains this plan as part of their Boardman River Project.

*Infiltration/Inflow Analysis (1978)-* This report focused on infiltration in the Sanitary sewer system and includes the reference "The Traverse City sewerage system was completely separated in 1973 when the last combined sewers were eliminated."

"The Traverse City sewerage system was completely separated in 1973 when the last combined sewers were eliminated."

—Infiltration/Inflow Analysis (1978)

*Greilickville Storm Water Plan (1979)* - This report provided the basis of design including a 10 year frequency for stormwater systems and 100 year frequency for flood protection with recommendations for stormwater management for the area between M-72 and Grand View Road in Elmwood Township and the City.

*Stormwater Management, An Experiment and Demonstration in Traverse City (1980)-* This study was a follow up to "Grand Traverse Bay Water Quality Investigations (1974)"which documented water quality concerns at municipal beaches. The report verified that these two BMP's are highly effective in reducing stormwater pollution to Grand Traverse Bay:

- Citizen Education- This best management practice (BMP) included the education of citizens as to how pollutants build up on streets, sidewalks, and lawns to reduce stormwater pollution at its source.
- Street and Catchment Maintenance- This BMP consisted of intensifying the regular street sweeping and catch basin cleaning in the study area.

Currently, the City has partnered with the Watershed Center Grand Traverse Bay to continue the water quality awareness of our citizens and implementation of water quality projects.

*Eastern Avenue Drainage Basin Study (1987)*- This study examined solutions to drainage issues resulting from September 1986 storm event in the north east part of the City. The initial study was followed by several updates and plans for an area retention basin situated on Eastern Avenue in the vicinity of the water treatment plant.



*Tributary A of Kid's Creek Drainage Basin Study (1988)* - This study examined solutions to flooding along Tributary A to Kid's Creek in the vicinity of Grand Traverse Commons and the hospital.

*Kid's Creek Stormwater Management Plan (1988)* - This comprehensive plan addressed existing and future flooding and water quality concerns of Kid's Creek in the City and Garfield Township. The plan served as a catalyst for stormwater management ordinance and regulation in region.

### City of Traverse City Code of Ordinances Chapter 1068 Ground-Water Protection and Storm-Water Runoff Control

(1991)- The purpose of this chapter is to aid in the prevention of surface and ground-water contamination, to regulate and control the construction and use of storm-water runoff facilities, to control

discharges to the public storm drain system, to protect the public health, safety and general welfare and to prevent the pollution, impairment or destruction of a natural resource and the environment of the City and the State. The current version is included in **Appendix F** along with the Guidelines currently used by the City for regulating stormwater runoff.

*Mitchell Creek Watershed Protection Strategy (1995)*- This study was an effort to balance preservation of the natural resource base while encouraging reasonable local economic development initiatives for the Mitchell Creek Watershed including the tributaries to Mitchell Creek.

*Various Wastewater Treatment Facility Reports-* Subsequent years to the initial 1933 operational sewage treatment plant have produced many additional reports focused on the wastewater treatment plant and the extent of sewage treatment has evolved to the current facility, a nationally recognized sewage treatment facility completed in 2004, producing highly effective sewage treatment.

*The Grand Traverse Bay Watershed Protection Plan (2003) (Updated 2005)-* The Grand Traverse Bay Watershed Protection Plan provides a description of the watershed (including such topics as bodies of water, population, land use, municipalities, and recreational activities), summarizes each of the nine sub-watersheds to Grand Traverse Bay, and outlines current water quality conditions in the bay. Within the initial two-year development phase of the protection plan, water quality threats were identified and efforts to address these issues were researched, developed, and prioritized. The plan was prepared by The Watershed Center Grand Traverse Bay, a private non-profit organization, founded in 1990 and devoted to the protection and enhancement of Michigan's Grand Traverse Bay and surrounding watershed through research, education and collaboration with partners (see **Appendix H**).



*The Boardman Lake Watershed Study (2003)-* This study identified the physical, biological, and built infrastructure resources of the Boardman Lake watershed and evaluated them for potential impacts to the long term water quality of Boardman Lake and the lower reaches of the Boardman River. This study complemented previous and ongoing watershed management plans within the region.

*Stormwater Source Identification (2001)-* This study quantified mass loading of nutrients and fecal contaminants via urbanized tributaries and stormwater discharges to Grand Traverse Bay.

*Public Act 507 (2002)* - This Public Act enables local health officials to test, monitor and report beach area water quality. The current version is included in **Appendix F** 

*Grand Traverse Region Stormwater Management Toolkit (2006)* - The Watershed Center Grand Traverse Bay put together a toolkit for local governments and other involved organizations for learning about options for stormwater management. The toolkit is a mix of online resources, books, electronic reports, and articles and information relating to stormwater management and best management practices.

*New Designs for Growth Development Guidebook (2006)* - The *"Guidebook"* represents a continuation of efforts to demonstrate how development can occur while protecting natural resources. It is designed for appointed and elected officials and developers within the five county Grand Traverse Region.

*Stormwater Management Report (2007)* - Traverse City completed an analysis of its stormwater collection system in 2007. The objectives of that study were to determine system capacity through hydrologic and hydraulic modeling, delineate drainage area boundaries, review the condition of outfalls and other drainage components, and identify water quality projects that could be constructed to protect the Grand Traverse Bay from stormwater.

*Kids Creek Watershed Hydrologic Study (2010)* – This study was conducted to better understand the hydrologic characteristics of the Kids Creek Watershed. The evaluation of the hydrologic characteristics of the watershed helped to determine the watershed's critical areas and provided a basis for stormwater management ordinances.

*Stormwater Asset Management Plan (2017)* – This plan refined the existing inventory and condition rating of the City's Stormwater System assets. It analyzed the flow capacity of underground pipes and identified long term operation and maintenance strategies. It also examined funding needs and funding gaps and offered suggestions for future funding for this critical infrastructure.

### 1.2 Water Quality Milestones

The City, from its conception to 1931, directly discharges wastewater into the Boardman River and Grand Traverse Bay. In 1931 the City built its first wastewater treatment plant (WWTP) and until 1973, when the City had completed the separation of its storm and waste water sewer systems, the City had a combined storm and waste water sewer system which overflowed into the bay during large storm events. In 1976, the Boardman River Natural Plan was developed, followed by numerous plans and studies which continue to this day and will continue into the future, to help improve water quality. In 1991 the City created the City of Traverse City Code of Ordinances Chapter 1068 Ground-Water Protection and Storm-Water Runoff Control and became a Municipal Enforcing Agency for stormwater and soil erosion. In 2003 the Regional WWTP was upgraded with state of the art integrated membrane bioreactor technology. In 2007 the first large scale stormwater BMP project, which made stormwater quality improvements to 7 locations, was implemented, followed by numerous stormwater BMP projects in the following years and into the future, both public and private. More detailed information about the City's Water Quality Milestones can be found in the timeline on the following page.

# Traverse City Water Quality Milestones

1900's	1931	1940's	1945	1950's	1955- 66	1963	> <sup>19</sup>	66- 59	1970	197	73	1976	1978	
<ul> <li>Direct</li> <li>sewage</li> <li>discharges</li> <li>into river and</li> <li>bay</li> </ul>	Centralized sewage treatment plant WWTP and trunk sewers	Combined sewer overflows into river and bay	Plan to separate sanitary sewer and stormwater systems Acquired industrial and commercial properties on West Bay	West Bay water pollution creates need to move water intake	• Relocate City Water Supply from West to East Grand Traverse Bay	• Excess nutrients and phosphorus into river from WWTP	<ul> <li>Upgrad WWTF reduce nutrien phosph into rive</li> </ul>	le • to norus er •	Combined sewer overflows into river and bay Expanded sanitary sewer service into areas surrounding City	<ul> <li>Complete sanitary sewer and stormwa systems separatio</li> <li>Purchase Morgan McCool property (Open Sparation)</li> </ul>	ed Deve Boar I Rive ter Rive n d	elop rdman r Natural r Plan	• Infiltration/ Inflow Analysis	
1991	2001	2002	2003	200	4 20	05 2	.006	20	07	2008	> 201	0	2011	
<ul> <li>City of Traverse City Code of Ordinances Chapter 1068 Ground-Water Protection and Storm- Water Runoff Control</li> <li>City became Municipal Enforcing Agency for stormwater and soil erosion</li> </ul>	Stormwater Source Identification study	• Public Act 507- beach monitoring for water quality enacted	<ul> <li>The Grand Traverse Bay Watershed Protection Plan (Updated 2005)</li> <li>The Boardman Lake Watershed Study</li> <li>Regional WWTP Improvement including integrated membrane bioreactor technology</li> </ul>	<ul> <li>Groundwar protection stormwater control</li> <li>ordinance guidelines updated</li> <li>City of Traverse Ci Garfield</li> <li>City of Traverse Ci Garfield</li> <li>Porship Recreation Authority established and Smith- Barney property or West Bay acquired</li> </ul>	ter • Demolisi bayfront fueled-st generato power pl ity/	hed coal rravers ream ant New D for Gro Develo Guideb	se water gement t besigns owth opment oook	<ul> <li>"Your Bay Your Say Waterfrod Plan</li> <li>City of Traverse Stormwa Manager Report</li> <li>Implement stormwa BMP pro- in 7 locat city-wide</li> </ul>	y, Gr ont W M (re City atter ment ented atter ojects tions e	and averse Area ater Systems aster Plan evised 2010)	• Bayfront P adopted	lan • Bi sto pr	yant Park ormwater oject	•





- Determined that street sweeping and catch basin cleaning is highly effective for improving water quality
- Eastern Avenue Drainage **Basin Study**

1987

- 1988
- · Kid's Creek Stormwater Management Plan
- Acquired waterfront property from Oak Street to Division Street



- Brown Bridge Dam removal East Bay Park stormwater project
- 2013

Boardman

Watershed

Prosperity

Boardman

River Plan (not adopted)

River

Plan

- 2014
- SAW Grant Spruce Street and West End Beach trail stormwater project

### 1.3 Stormwater Management Plan Meetings

The City of Traverse City held more than 7 public meetings and several SAW grant update meetings. These meetings occurred in conjunction with a Flooding Survey, which received more than 1000 responses, with 23% of responders noting flooding concerns. City staff then followed up with the reported flooding based on the survey responses, but found that few related to public infrastructure or were already addressed or included in the Stormwater Management Plan (SMP). The survey responses were matched to the XP-SWMM modeling and confirmed the Kid's Creek and Cedar Street area as the primary location for folding concerns in the City. The survey can be found in **Appendix H** and the results of the Flooding Survey are shown in the following chart and graph:



#### How often do you experience flooding problems?



## SECTION 2: ASSET EVALUATION—OPEN CHANNELS AND SHORELINE

ey drainage courses that have a significant impact on the City's stormwater assets were identified through streambank inventories and channel cross section surveying along Kids

Creek and its immediate tributaries, along with a shoreline survey of Boardman Lake (within the City Limits). This information was gathered to identify the areas of concern, for hydraulic modeling purposes, and to be transferred to the City's GIS database for future reference.

### 2.1 Kid's Creek and Immediate Tributaries Survey

The water quality impairment of Kids Creek has been a focus area for the City for years. Groundwork has been laid by the City, the County, the State, the Watershed Center Grand Traverse Bay and others, that the Kids Creek impairment can be addressed directly with a series of management activities and channel projects.

For this study the impaired reach (see figure to right) of Kids Creek was divided into two sub-reaches based on the City's relative impact and capacity to manage the channel, and given the fact that the reaches are very different. The upper, impaired reach from Silver Lake Road to 7<sup>th</sup> Street has a relatively wide, and intact stream corridor. Below 7<sup>th</sup> Street, down to the Kids Creek mouth with the Boardman below Front Street, there is little stream corridor as the creek flows through downtown Traverse City.

The City Engineering Department performed the streambank inventories along Kids Creek and its immediate tributaries from the Boardman River to Silver Lake Road in 223 locations. Examples of the filled out field worksheets can be found in **Appendix H.** 

The evidence suggests that the persisting habitat impairments upstream of Seventh Street are due both to the impacts of runoff as well diminished transport capacity. While there has been a great deal of focus on both stormwater and sediment as sources of stream impairment, the stream's poor in-stream habitat, particularly from Silver Lake Road to 7<sup>th</sup> Street seems Watershed Map and Impaired reach of Kids Creek within City Limits (Source: The Watershed Center, 2013. Kids Creek Action Plan)



to be largely a function of poor channel gradient and over-widening. In its sandiest reaches, the stream lacks the power to move anything bigger than sand.

The lower Kids Creek reach, from 7<sup>th</sup> Street to the Boardman Lake is also plagued with grade issues, sedimentation, misplaced or undersized culverts and a severely under-sized private crossing. There is a narrow corridor and near the Front Street culvert some very poor quality, crushed concrete and stone that also appears to be inhibiting macroinvertebrate diversity as well. Also, the culvert that ties into the Boardman River is wide, promoting very thin normal flow depths, likely inhibiting fish passage. This area also shows some water quality impact from runoff and definitely still requires more attention to water quality, particularly street runoff.

### 2.1a Lower Kids Creek (7<sup>th</sup> Street to Boardman River Confluence)

By far and away, the most impacted reach of lower Kids Creek is between 6<sup>th</sup> Street and the lower crossing on Cedar Street. There are two culvert crossings on Cedar Street and a private crossing between them that together are severely restricting flow and lowering the energy grade line. The upper and lower Cedar Street crossings are shown in Figures 1 and 2, and the private crossing in Figure 3 below. These crossings are full of sediment and have stone and/or wood grade controls, which are impeding flow. This artificially high culvert offset "robs" the channel of fall. The more that the fall down the length of the stream is interrupted, the lower the flow energy and capacity of the channel to move sediment. The impact of the high sediment levels and grade controls in this set of culverts is shown in the profile of Kids Creek during a two-year rain event as run in the USEPA SWMM model of Kids Creek (Figure 4). As shown in the figure, the impact of these crossings for the two-year event as demonstrated by a nearly horizontal water surface profile extends more than 1,500-feet up the channel. For larger events, the impact would extend even further upstream. A solution to this problem would be to reset the upper Front Street culvert to a higher elevation and remove the grade controls in the Cedar Street culverts. The additional fall would increase the flow through the culverts and help clear the sediment.



Figure 1. Looking upstream from the Upper Cedar Street crossing (note heavy sand deposition)



**Figure 2.** Upstream of the lower Cedar Street Crossing (note sand deposition and culvert filling)



**Figure 3.** Private crossing between Cedar Street crossings (note that the bridge is at and also below top of bank)

### 2.1b Upper Kids Creek (7th Street to Silver Lake Road)

Looking at the upper Kids Creek stream profile, one can already identify that the reach downstream of Silver Lake Road (US 31) is where the upper, steeper stream profile flattens out (Figure 5). This is naturally a depositional reach where material that is actively transported above may not be transported below.

Much of the Kids Creek watershed soils are composed of sand so that the majority of sediment the stream has to carry will also be sand. In fact, we would contend that local soil erosion control programs do a decent job keeping large sediment, both particle sizes and volume, releases from getting to the creek. What is now 'delivered' to the creek via most sediment losses, particularly those generated by construction and development tend to have a size classification that is mostly composed of sand and smaller particles such as silts and clays. There is plenty of sand getting back into the channel but probably not much larger sediment, such as gravels.



Figure 4. Kids Creek Streambed Profile during 2-year rain event (approximate elevations for Upper Kids Creek)



**Figure 5.** Kids Creek approximate stream bed profile (From: Fongers, D., 2010. Kids Creek Watershed Hydrologic Study, MDEQ)

### 2.2 Boardman Lake Shoreline Survey

As part of the SAW grant tasks, The Watershed Center (TWC) staff inspected 1.5 miles of shoreline along the north half of Boardman Lake within the City Limits for evidence of erosion, illicit discharges, unstable banks along the shoreline, and other physical characteristics that could impact water quality. This inventory was conducted in Summer 2015 and consisted of a visual inspection of the shoreline by kayak looking for signs of current or potential sources of water quality pollution. Locations of potential pollution sources or spots of concern were noted at 21 sites where GPS points, pictures, and descriptive notes were taken about the site (Table 1). Results were summarized in an Excel spreadsheet and divided into four categories: Erosion Spots, Lack of Riparian Buffer, Stormwater Outfalls, and Boat Launch Runoff with each category having a different type of pollution. Additionally, a map was produced showing noted locations from Excel spreadsheet grouped by the type of pollutant: minor/moderate sediment erosion, nutrients, nutrients/E.coli, stormwater outfall, and stormwater runoff (Figure 6).



Figure 6. Boardman Lake Shoreline Survey Results grouped by Pollutant Type

Latitude	Longitude	Location ID	Type of Pollutant	Description/Notes		
Erosion Spots						
44.75166508	-85.60879125	3	Sediment	MINOR Erosion Foot traffic, Path down to lake from TART trail, erosion		
44.74917457	-85.61847361	10	Sediment	MINOR Erosion Foot traffic, Path down to lake, erosion		
44.74947497	-85.61794957	11	Sediment	MINOR Erosion Foot traffic, Path down to lake, erosion		
44.74978594	-85.61768814	12	Sediment	MODERATE Erosion Foot traffic, Path down to lake, erosion		
44.7567456	-85.61558805	19	Sediment	MODERATE Erosion Foot traffic, Path down to lake, erosion		
44.74513767	-85.61788671	7	Sediment	MINOR Erosion; Steep bank		
44.74620083	-85.6182157	8	Sediment	MODERATE Erosion; Steep bank end point 1		
44.74799146	-85.61852323	9	Sediment	MODERATE Erosion; Steep bank end point 2		
44.75705154	-85.61528438	20	Sediment	MINOR Erosion		
Lack of Ripari	an Buffer					
44.75455709	-85.60915645	2	Nutrients, Ecoli	Lack of Buffer, Grass down to water's edge, excess plant growth in water, waterfowl congregating		
44.75039799	-85.61637746	14	Nutrients	Lack of Buffer, Grass down to water's edge		
44.75182199	-85.61539711	16	Nutrients, Ecoli	Lack of Buffer, Grass down to water's edge, excess plant growth in water, waterfowl congregating		
Stormwater Ou	utfall Pipes					
44.75010839	-85.61756258	13	Stormwater Outfall	Outlet end broken off of pipe		
44.75214427	-85.61576223	17	Stormwater Outfall	Stormwater outfall, black plastic up near hill		
44.75694844	-85.61368159	21	Stormwater Outfall	Drain pipe outlet, cladophora present		
44.75699471	-85.61257057	22	Stormwater Outfall	Outlet pipe, plastic		
44.75708557	-85.61126165	24	Stormwater Outfall	Between launches		
44.75173524	-85.60863577	25	Stormwater Outfall	Storm drain outlet under water, long way out		
44.75538195	-85.60865614	26	Stormwater Outfall	2 storm drain outlets, both under water, Southern one larger than Northern one		
Boat Launch F	Runoff					
44.75684426	-85.61068045	1	Stormwater Runoff	Boat Launch on North End of Lake		
44.75681769	-85.61150548	23	Stormwater Runoff	Boat Launch		

 Table 1. Shoreline Survey Locations of Concern

No major areas of concern were found in the survey, however there are several areas of minor and moderate erosion along the lake, mostly from foot traffic to access the lake and from steep banks. These are localized areas and aren't contributing large amounts of sediment to the lake (see accompanying photos below).





Examples of minor (right, location 3) and moderate (left, location 12) noted erosion spots on Boardman Lake. Both of these pictured sites are caused by foot traffic, with the picture on the right coming from the TART trail.

Additionally, a few places were noted where there is no riparian buffer along the lake and grass extends all the way to the water's edge (see accompanying photos below). This could lead to excess nutrients and bacteria entering the water, as evidenced by the noted excessive plant/algae growth see in the inventory in this area and waterfowl congregating along the shore (Table 1).



Grassed lawns up to the edge of the lake, such as these condo developments along the west side of the lake (location 14), can add excessive nutrients and bacteria pollution to Boardman Lake.

Seven locations were noted where pipes (ranging from small plastic to larger concrete) outlet to the water. These were noted on the map as well.



Location 13



Location 22



Location 21



Location 17

### **SECTION 3: CAPACITY ANALYSIS**

### 3.1 Capacity Level of Service

In order to determine where the capacity of a system truly is, an acceptable level of service for different street types had to be outlined. Upon meeting with local stakeholders, the City determined that the following flooding durations and levels, with no damage to property, were tolerable:

Location	Acceptable Level of Service
All City Streets	6 inches or less of water, any duration
Primary Emergency Routes (>5000 ADT)	More than 6 inches, 30 minutes or less
Medium Volume Streets (2000 to 5000 ADT)	More than 6 inches, 1 hour or less
Low Volume Streets (<2000 ADT)	More than 6 inches, 6 hours or less

Increasing the size of pipes in order to meet these criteria is acceptable, but only if the larger pipes allow improvements with water quality. Efforts should first be made to reduce the amount of stormwater runoff entering the system before pipe size is increased.

### 3.2 Discharge Locations and Drainage Area Boundaries

The City of Traverse City is home to 95 drainage area boundaries and associated points of entry into area bodies of water. Below is a table briefly describing the different boundary areas. Maps of these areas can be found in **Appendices A-D**.

Boundary Zone	Description
A-AZ	Primarily drainage areas in the northwest portion of the City such as the Munson Medical Campus, Slabtown neighborhood, the north portion of Pine St, the warehouse district, and the northeast corner of State St and Washington St
B-BZ	Primarily drainage areas on the central west side of the City such as the neighborhoods south of Fourteenth St, the entire length of Wadsworth St, Front St from Division St to Park St, Locust St north of Eleventh St, and Lake Ave
C-CZ	Primarily drainage areas on the east side of the City such as Airport Industrial Park, Orchard Heights neighborhood, Central High School, the Civic Center, Traverse Heights neighborhood, Oak Park neighborhood, Boardman Ave, State St from Union St to Boardman Ave, and Eighth St from Boardman Ave to Fair St
D-Z	Includes drainage areas throughout the City, including Union south of Thirteenth St, Cass St between Fourteenth St and Lake Ave, Boardman neighborhood, Front St between Munson Ave and East Bay Blvd, Eighth St and the surrounding neighborhoods between Cochlin St and Cromwell St, and the neighborhoods immediately south of the NMC campus

Each drainage boundary also has an expected runoff volume and runoff depth calculated for the 2 year, 5 year, 10 year, and 25 year storm, as well as the area in acres of pavement, residential, forested ground cover, and the total area in acres and for each boundary. Each boundary area also has the percent of the boundary that is considered impervious calculated, along with the average runoff curve number, and average pipe and watershed slope. Using this information, the approximate run-off volumes and peak discharge rate was calculated for the 2 year, 5 year, 10 year, and 25 year storm based on both the watershed and the average pipe slope for each boundary, along with the treatment flow range (1/3 of the unit peak discharge), following the methodology in Chapter 7 of the *MDEQ Soil Erosion and Sedimentation Control Training Manual (Revised 2005)* (see **Appendix H**). Tables for these values can be found in **Appendix E**.



### 3.3 Stormwater System Modeling

### 3.3a Modeling

Given the reliability on community wide data sets, as well as the lack of actual hydraulic flow data in the collection system, the computer modeling should be considered a planning level tool suitable for generating wide recommendations related to general stormwater quantities and areas of water quality management. Stormwater modeling was used to identify undersized pipes and to aide in the development of a management strategy for undersized pipes and flooding.

The City Engineering Department completed Geographic Information Systems inventory and mapping of the City's existing storm sewer system for the 2007 Stormwater Management Report. This included more than 1900 drainage structures and manholes, 54 miles of storm sewers open channels and culverts and more than 90 points of entry into area streams, rivers, lakes and the Grand Traverse Bay.

The 2007 report used the Soil Conservation Service (SCS) Curve Number method adapted by the MDEQ in their publications Computing Flood Discharges for Small Ungauged Watersheds and Certified Storm Water Operator and Soil Erosion and Sedimentation Control Inspector/Comprehensive Training Manual to approximate runoff volumes and peak discharge rates. The Runoff Curve Number method is well established in hydrologic engineering and environmental impact analysis. Its simplistic

approach does not include the ability to evaluate pollutant loading and incremental effects of adding green infrastructure to urban drainage areas.

Therefore the XP-SWMM software model was used by OHM for preparing the 2017 Stormwater Asset Management Plan. The SWMM Runoff method is ideal for modeling the impacts of Green Infrastructure retrofits, such as bioretention, on peak flows and total runoff volumes. This provides an ideal foundation on which to calculate pollutant reduction and other water quality benefits. The model included 32 of the 95 (33%) drainage areas of the City. As a part of the stormwater system model for the City, OHM also incorporated the open channel flow of Kids Creek into the model.

Since modeling stormwater quality requires the consideration of more frequent (lower magnitude) storm events, such as the 90% event storm and 2-year storm, the SWMM Runoff method is recommended. Fortunately, the SWMM Runoff method can be scaled up to model larger storm events, including but not limited to the 10-year, 50-year, and 100-year recurrence interval storms. It should be noted that the XP-SWMM modeling of less frequent (i.e. 5-year /10-year) events yielded, in several cases, higher peak discharge rates as compared to the 2007 results. This is likely due to the inclusion of directly-connected impervious surfaces, such as roadways, parking lots, and driveways, which immediately contribute stormwater runoff to the collection system.

With the varied results between the 2007 method and the XP-SWMM model results, Prince and Lund was hired by the City of Traverse City to complete an Independent Technical Review (ITR) of the XP-SWMM model. Prince-Lund created their own "Modified City Model" using EPA SWMM and the information provided by OHM for four of the City's stormwater systems. Prince-Lund found that using EPA SWMM (free version) as opposed to XP SWMM led to a number of difficulties, such as not being able to export data, not being able to interface with GIS, and not having the ability to quickly and easily adjust and add/subtract variables. Despite these difficulties, Prince-Lund found similar peak flow values to those found by OHM for four drainage areas:

- Pine Street
- Hannah Avenue
- Bryant Park/Garfield Avenue
- 14th Street

The ITR is further detailed in **Appendix H**. The ITR created a cursory link between the XP-SWMM model and the 2007 calculations for the peak discharge rate. This link is intended to be used until such time as the City can purchase the XP-SWMM software and complete input of the data for all of the drainage areas. The comparisons are shown in Figures 7, 8, and 9.







Figure 8. Flow Calculations Comparison for Outfall #33, Pine St



Figure 9. Flow Calculations Comparison for Outfall #147, Bryant Park



Figure 10. Flow Calculations Comparison for Outfall #33, Pine St

AECOM created an EPA-SWMM stormwater system model for Fourteenth Street drainage area. Unlike Prince-Lund's model, AECOM found the peak flow rates to be more similar to those found by the 2007 City Model than those found by OHM. A comparison of these three models and the 2007 City Model can be found in Figure 10.

OHM's stormwater system model found that there are areas of the City that experience flooding that is not within the City's acceptable Level of Service parameters. These areas are shown in Figure 11 and Figure 12, outlined in light blue. However, it should be noted that OHM's model does not account for the existing and future private on-site stormwater systems, which currently effect 554 parcels/properties within the City Limits (see **Appendix G** for a map showing the private stormwater on-site stormwater systems), and needs further calibration using actual storm events in order to confirm the model results are within 15% of actual stormwater runoff volumes and 20% of actual peak flow rates. Also, the predicted flooding areas were not identified by respondents of the Flooding Survey.

Until the City is able to create their own model for all of the stormwater sewer systems in the City, the 2007 City Model treatment values had to be converted to equivalent XP SWMM treatment values in order to determine what treatment types are appropriate for each stormwater sewer system. The conversion factors were determined by Prince-Lund as being a range between 1 and 2, with 1 being for very complex, globular stormwater sewer systems and 2 being for very simple, linear systems. Each system that was not included in the XP SWMM model was then reviewed and assigned a conversion factor so that an equivalent water quality flow number could be calculated. The equivalent water quality flow numbers are the average of the 2 year, 5 year, 10 year, and 25 year high treatment flow range times the designated conversion factor. Table 7-3a and Table 7-3b showing the calculated XP SWMM or equivalent water quality flow value can be found in **Appendix E**.

It should also be noted that the standard practice of using the 90-Percent Annual Non-Exceedance Storm method for statistically evaluating water quality storm events results in Traverse City having a 90 percent storm value of 0.78 inches. OHM used a value of 1" in their modeling. However, this method of determining the water quality storm value does not take into account any storm event that results in an accumulation of 0.1 inches or less, which account for 44% of the storms in the Traverse City area.








#### 3.3b 90-Percent Annual Non-Exceedance Storms for Water Quality Treatment

### 3.3b.1 History and Methodology

Upon further review, it was found that the standard practice within the industry for statistically evaluating storm events has become the 90-Percent Annual Non-Exceedance Storm method. The standard was originally developed by Schueler (1987) <sup>a</sup>. This method eliminates all rainfall data recorded less than 0.1 inches and analyzes the remaining data. This technical publication is out of print however, a simple explanation is found in an EPA (2015) <sup>b</sup> publication. "The rainfall from minor storms may be entirely stored in surface depressions and eventually lost to evaporation or infiltration. As a result, no runoff is produced. Schueler further elaborated on the 90-Percent storm in the document Design of Stormwater Filtering Systems (1996)<sup>d</sup> for the Chesapeake Research Consortium. The 90-Percent Storm method was now applied to the east coast and the State of New Mexico for Water Quality Treatment.

#### 3.3b.2 Qualifying the Practice

The original intent of the 90-Percent storm was to help better define the method of determining a storm and treating a majority of the storm events within a given area. Per Schueler's (1996)<sup>d</sup> publication, "Additional rainfall frequency analysis is required for more complete reliance on this value. If a particular jurisdiction has the resources and long term data, a complete RFS should be conducted and the 90% rule applied to establish a local water quality precipitation value." It is also recognized that as the storm event increases over the maximum treated storm the treatment condition largely decreases. This is due to the amount of volume passing through the system as well as treatment system efficiencies decreasing as flow rates increase.

### 3.3b.3 State Practices

The Michigan Department of Environmental Quality (MDEQ) BMP Manual<sup>e</sup> provides rainfall data from 1948 to 1999 calculating the 90-Percent Non-Exceedance Storm for ten areas of Michigan. It was found in a technical memorandum (2006)<sup>e</sup> that, area #3 (Kalkaska), has a 90-Percent storm value of 0.77 inches. The state allows the use of these regional numbers or a conservative alternative of 1.0 inches of runoff over the entire site.

#### 3.3b.4 Findings

To affirm the findings through the MDEQ, The City of Traverse City added to the MDEQ 2006 data of 2001 through 2016. The City then plotted the rainfall events on a graph and locating the 90% storm value of 0.45, shown below in Figure 13. This was followed up with additional analysis utilizing the 90-percent storm. The storm events less than 0.1 inches were eliminated from the data series and plotted, yielding 0.78 as shown in Figure 14. Remembering the 90-Percent Non-Exceedance Storm value is 0.77 inches with data collected from May of 1948 to Dec. of 1999. In adding data from Jan of 2001 to Jan of 2017 (attached), no noticeable change has been noted. An additional item of interest includes the percentage of storms in the Traverse City area less than 0.1 inches. The Traverse City area storms less than 0.1 inches are approximately 44% of the areas storm events.

Therefore, based on these findings, it is recommended that the stormwater guideline of 0.78 inches for the 90% design storm be incorporated into the City stormwater ordinance for water quality considerations.



Figure 13. Rainfall events in Traverse City including all rainfall events.





## 3.4 Kids Creek Surveying and Modeling

Detailed survey and hydrologic and hydraulic modeling were conducted on the downstream sub-reach of Kids Creek from 7<sup>th</sup> Street down to the Boardman Lake. Preliminary survey and modeling were conducted on the reach from Silver Lake Road to 7<sup>th</sup> Street. The upper watershed of Kids Creek above Silver Lake Road is shown in Figure 15 below. Note that almost all the contributing area to the impaired reach above 7<sup>th</sup> Street comes from outside the City limits.



Figure 15. Kids Creek subwatersheds above Silver Lake Road (and outside of City limits)

The goal of this survey was aimed at establishing more heterogeneous stream bed habitat with a larger variety of bed sediment sizes. Part of this larger bed sediment will come from increasing transport capacity and part will likely need to be either imported or by uncovering coarse sediment underneath sand. More transport capacity comes from increasing stream power. Total stream power and unit stream power can both be increased

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independently. Total power is the product of the weight of the water and the slope it slides down. Total unit power is total power divided by the width of flow. Total power is increased either with a higher flow and/or higher bed slope. An increase in unit width stream power can be achieved with narrowing the channel; that is, the same amount of power is forced through a smaller area.

The bed profile from the survey is shown in Figure 16. Note that the bed elevations upstream of 7<sup>th</sup> Avenue are approximate and are primarily based on 2-ft contour maps and some limited survey in the creek. What is quickly apparent from the hydraulic profile shown along the channel is the extent to which the culverts at Cedar Street alter the hydraulic profile. Showing the profile from 7<sup>th</sup> to the Boardman River shows this more clearly (Figure 17).



Figure 16. Profile from Seventh Street Crossing (between model nodes 206-207) to Boardman River. Note undersized and high crossing at lower Cedar Creek culvert (between model nodes 219-220).



**Figure 17.** Incipient motion analysis results, showing maximum sized particle mobility along Kids Creek from Silver Lake Road to 7<sup>th</sup> Street, assuming an average bed slope along the entire reach of 0.17%

This kind of change to the hydraulic profile is crucial to sediment transport. The average slope of Kids Creek from Silver Lake Road to 7<sup>th</sup> Street is approximately 0.17%. This slope can be sufficient to move sand, as long as the channel dimensions are small enough to maintain a reasonable unit stream power. Looking at cross-section data and applying that average stream gradient (refer to Figure 18) one can see that at bankfull flow – the flow theoretically doing the most work to shape the channel, on average most cross-sections can potentially move up to fine gravel (4-8 mm), but few can move even medium-sized gravel (8-16 mm). It is these larger particle sizes from fine gravel on up, that help create the kind of bed heterogeneity that are also going to retain a wider variety of macroinvertebrates.



However, Kids Creek has a distinct pool-riffle pattern, like most natural channels in lower Michigan. This poolriffle pattern means that the channel bed rises up to the riffles and falls again into the pools. Looking at flow at the very local scale, water moving through a pool bottom actually rises up against a local adverse slope to reach the top of a riffle. The overall slope of the channel is maintained by the riffles and the riffles are typically where the coarser bed material is found. However, when a downstream riffle or obstruction such as woody debris or culvert increases head loss or raises the bed, even by inches, the impact of that obstruction can reach hundreds of feet upstream. When a downstream riffle elevation is above the upstream riffle, it will tend to diminish the stream power over that upstream riffle.

The hypothesis is that Kids Creek, particularly in the Silver Lake to 7<sup>th</sup> Street, on average has sufficient power to move sand and fine gravel but due to over-widening in some places, wood and culvert obstructions acting as grade controls, bed slopes and flow area have reduced transport capacity in multiple locations. For instance, some recently-taken bed profile shots upstream and downstream of the 11<sup>th</sup> Street culvert, show how the culvert raises the bed profile. In this case, it is not more than a foot, however, a foot rise can impact almost 600-ft back upstream. The culvert is also too narrow, adding to head losses that will affect flow and sediment transport capacity within and upstream of the culvert.

# SECTION 4: WATER QUALITY CONSIDERATIONS



One of the primary goals of the City is to "protect and improve the quality of water resources within the City that effect water quality in Grand Traverse Bay and its watershed", which was first declared in the Grand Traverse Bay Watershed Plan. There are a number of ways that the City can reach this goal. First is to strengthen City regulations by ensuring that the regulations address water quality. The City's existing Ground-Water Protection and Stormwater Control Ordinance Guidelines, see **Appendix F**, should be regularly updated to meet current best management practices (BMPs) and should be incorporated into the City's stormwater ordinance. An ordinance which regulates the use of open loop geothermal systems within the City should also be created as a way to reach this goal.

### 4.1 Stormwater Management

Stormwater management is a key component to ensuring the longevity of storm water treatment systems and maintaining healthy natural water sources such as rivers, lakes, streams, and the Grand Traverse Bay. Stormwater management is a combination of stormwater treatment and stormwater system maintenance, as well as policies to help encourage the infiltration of stormwater before it reaches catchbasins, stormwater treatment systems, or surface waters.

"To protect and improve the quality of water resources within the City that effect water quality in Grand Traverse Bay and its watershed"

> ~ Grand Traverse Bay Watershed Plan



The City currently uses a number of BMPs as a way to protect and improve water quality, such as street sweeping and the use of catch basin sumps. A table of currently installed and implemented stormwater BMPs within the City can be found on the following page (Table 2). Although the use of BMPs is an important part of any proposed City project, maintenance of the BMPs is crucial. In many cases, if a BMP is not properly maintained, it may lead to the BMP no longer improving water quality or a clog in the stormwater sewer system. Therefore, consideration of how the BMP will be maintained and ensuring that a regular maintenance schedule is adhered to is pivotal when looking at different BMP options for any given project. Along with BMPs, river bank stability and green infrastructure (Low Impact Development) should be considered for all applicable projects, public and private, within the City Limits.

#### Table 2. Currently Installed/Implemented Stormwater BMP

		Stormwater Quantity Functions			Stormwater Quality Functions							
			GW									Winter
	Stormwater BMP	Volume	Recharge	Peak Rate	TSS	TP	Nitrogen*	Hydrocarbons	Temp	Cost	Maintenance	Performance
	Drywell	MEDIUM	HIGH	MEDIUM	HIGH**	MED/HIGH	LOW/MED	MED/HIGH	HIGH	MEDIUM	LOW/MED	HIGH
	Infiltration Trench	MEDIUM	HIGH	LOW/MED	HIGH**	MED/HIGH	LOW/MED	MED/HIGH	HIGH	MEDIUM	LOW/MED	HIGH
	Pervious Pavement	HIGH	HIGH	MED/HIGH	HIGH**	MED/HIGH	LOW	LOW/MED	HIGH	MEDIUM	HIGH	MEDIUM
Runoff	Rain Garden	MED/HIGH	MED/HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM	MED/HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM
Volume/	Vegetated Swale	LOW/MED	LOW/MED	LOW/MED	MED/HIGH	LOW/HIGH	MEDIUM	MED/HIGH	MEDIUM	LOW/MED	LOW/MED	MEDIUM
Infiltration	Infiltration Basin	HIGH	HIGH	HIGH	HIGH**	MED/HIGH	MED (NO3)	MED/HIGH	HIGH	LOW/MED	LOW/MED	MED/HIGH
	Tree Box	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW/MED	LOW/MED	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
	Nutrient Separating Baffle Box	HIGH	HIGH	HIGH	HIGH**	MED/HIGH	LOW	MED/HIGH	HIGH	HIGH	MEDIUM	HIGH
	Subsurface Infiltration Bed	HIGH	HIGH	HIGH	HIGH**	MED/HIGH	LOW	MED/HIGH	HIGH	HIGH	MEDIUM	HIGH
	Hydrodynamic Device	N/A	N/A	N/A	VARIES	VARIES	VARIES	VARIES	NONE	MED/HIGH	VARIES	HIGH
	Constructed Wetland	LOW	LOW	HIGH	HIGH	MEDIUM	MEDIUM	MED/HIGH	LOW/MED	HIGH	LOW/MED	MED/HIGH
	Traverse City Outlet Cover w/ Microbial Skirt	N/A	N/A	N/A	HIGH	LOW	LOW	MED/HIGH	NONE	LOW	LOW	HIGH
Runoff	Helical Filter	N/A	N/A	N/A	HIGH	MEDIUM	MEDIUM	LOW/MED	LOW	MED/HIGH	HIGH	MEDIUM
Quality/	Detention Pond/Basin	LOW	LOW	HIGH	MEDIUM	MEDIUM	LOW	MEDIUM	LOW	HIGH	LOW/HIGH	MED/HIGH
Non-	Sediment Trap	LOW	LOW	HIGH	MEDIUM	LOW	LOW	LOW	NONE	MEDIUM	MEDIUM	MED/HIGH
infiltration	Traverse City Screen	N/A	N/A	N/A	HIGH	MEDIUM	MEDIUM	MEDIUM	NONE	MEDIUM	HIGH	MEDIUM
	Fall/Spring Leaf Pickup*	N/A	N/A	N/A	HIGH	MED/HIGH	MED/HIGH	LOW	N/A	MEDIUM	MEDIUM	N/A
	Street Sweeping*	N/A	N/A	N/A	HIGH	MED/HIGH	MED/HIGH	MED/HIGH	N/A	MED/HIGH	HIGH	LOW
	Catchbasin Sump	LOW	LOW	HIGH	MEDIUM	LOW	LOW	LOW	NONE	MEDIUM	MEDIUM	HIGH
Postoration	Riparian Buffer Restoration	LOW/MED	LOW/MED	LOW/MED	MED/HIGH	MED/HIGH	MED/HIGH (NO3)	MED/HIGH	MED/HIGH	LOW/MED	LOW	HIGH
Restoration	Native Revegitation	VARIES	VARIES	LOW/MED	HIGH	HIGH	MED/HIGH	HIGH	MEDIUM	LOW/MED	LOW	MEDIUM

\*Reported at TN except as noted as (NO<sub>3</sub>)

\*\*This assumes TSS loads and their debris have been managed properly before entering the BMP to prevent clogging

\*\*\*Stormwater Quality Preventative Maintenance Measure

### 4.1a Stormwater Best Management Practice (BMP)

There are currently dozens of stormwater management BMP's to choose from to meet stormwater management goals. The list grows as technologies and testing of installed BMP's continues to develop. No single BMP can address all stormwater quality issues. Each type has unique effectiveness and limitations depending on the site specific characteristics, the intensity of stormwater events, and the ease of maintaining the system.

There are a number of low impact development (LID) options, options that mimic the natural environment, that



have been proven to be effective stormwater management tools. These options include: green roofs, rain gardens, drainage swales, leaching basins, and permeable pavement. One benefit of most LID methods is that they allow stormwater to infiltrate back into the water table, which uses the soil and plants as natural filters, instead of entering a municipal stormwater system. The most prevalent limitation of most LID options is that the area required for LID methods to treat the desired volume of stormwater is often too great to be used as the only stormwater treatment option in highly developed areas. Some LID options are also weather dependent and may not be effective in the spring, when runoff can be at its peak, in areas that experience harsher winters due to the ground being frozen.

BMP's for municipal stormwater sewer systems also exist. These options include stormwater treatment units that can be installed in

manholes to filter out debris and/or oils from stormwater before reaching an outlet to surface water. The benefit of these systems is that many municipalities already have an extensive stormwater sewer network, and these systems allow for treatment of existing systems with little to no change to the existing stormwater sewer network.

Often, it is most practical and sometimes most effective to use a combination of LID methods and stormwater sewer BMP's for stormwater management. These options include retention basins with stormwater sewer overflows, stormwater sewers connected to leaching basins, or raingardens surrounding raised catchbasins with outlets protected by filtration systems installed in manholes.

# 4.2 Storm Drain Monitoring

It is important to note when looking at water quality results from stormdrains whether or not discharge or flow measurements were taken during sampling. Most stormwater samples are taken using the 'grab sample' method, which are only taken once during a rain event and represent a snapshot in time of the water quality at that particular storm drain. However, during rain events there are typically fluctuating volumes of water and concentrations of different types of pollutants coming out of a drain, which in turn will affect the pollutant load coming out of each drain (pollutant load calculated by multiplying volume by concentration). The higher the concentration of pollutant or the volume of water coming out of the drain, the higher the pollutant load.

Only thorough sampling during multiple rain events will lead to a clear picture of pollutant loadings to a watershed. Care should be taken not to make broad assumptions on stormwater quality in an urban area based solely on grab samples taken at a particular time during a rain event. In lieu of a potentially time consuming and expensive stormwater monitoring program, the use of models can be an effective way to approximate the amount of pollution to a watershed from stormdrains. Additionally, results from similar urban areas that have done stormwater monitoring can also be used to approximate pollutant loads.



A wide variety of water quality parameters have been tested in stormdrains throughout the City of Traverse City, with some testing dating back to 1980. However, a thorough stormwater analysis, including discharge and flow volumes, has not been conducted on a city-wide basis to date. Water quality results from a select number stormdrains in the City from 2009-2015 were averaged from 10 locations for Nitrate, Total Phosphorus (TP), and Total Suspended Solids (TSS). Results were as follows:

- TP average = 0.10 mg/l (100 ug/L)
- Nitrate average 0.47 mg/L
- TSS average = 96 mg/L

Data sources are from TWC-led studies including stormdrain testing program with City of Traverse City funds (2009), GLRI Project at Bryant Park (2011/2012), and BMP effectiveness testing at GLRI East Bay Park project (2013-2015).

Comparisons of stormwater results were also made on select storm drains with data from the 1990s to more recent results from 2009 and after - 8th Street, Bryant Park, East Bay Park (north and south drains), and Hannah Park. At these select sites Nitrates appear to have increased since the 1990s, TP has decreased, TSS was inconclusive (see Table below). Again, caution should be taken when comparing stormwater results where only grab samples were taken.

Location	Timeframe	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)
8th Street	Historic	0.01	0.27	30
	Recent	0.56	0.1	49
Bryant Park	Historic	0.10	0.20	43
	Recent	0.66	0.08	68
East Bay Par (north)	Historic	0.29	0.56	76
	Recent	0.29	0.12	47
East Bay Park (south)	Historic	4.5	0.20	n/a
	Recent	n/a	0.09	145
Hannah Park	Historic	0.01	0.46	91
	Recent	0.42	0.095	59

\*Historic - 1991, 1992, 2000

\*Recent - 2009-2015

Water quality results from surrounding waters in the Boardman River and Grand Traverse Bay reveal much lower levels of TP and Nitrogen than those found in stormwater samples. In general we are most concerned with Total Phosphorus (TP) levels in local waters because it's the growth limiting nutrient for the bay. This is because nitrogen/phosphorus ratios exceed 10:1 in Grand Traverse Bay and therefore Phosphorus input will drive plant growth. In general, TP values greater than 0.01 mg/L (10 ug/L) in water bodies such as lakes and rivers are indicative of impaired water quality and contribute to increased plant growth. Phosphorus levels in Grand Traverse Bay (as stated in 2005 GTBWPP) are 0.005 mg/L (5 ug/L), which are well below that threshold and indicate excellent water quality and oligotrophic conditions. In contrast, TP values in storm drains range between 0.03 - 0.2 mg/L, with an average of about 0.1 mg/L (see table above). This is an average of twenty times higher than water in Grand Traverse Bay.

Additional water quality information summarized in Section 2.4 of The Boardman River Watershed Prosperity Plan (BRWPP) show that nutrient levels are relatively low in the river and have been on a continual decline since the 1960s. A historical trend station was placed in the Boardman River at Beitner Road by the MDEQ in the 1960s, which gathered a wide variety of data over the years. A summary of TP and total nitrate/nitrite results show the gradual decline of nutrients at this station since it was installed. Specifically, TP has fallen from 0.029 mg/L from the historical record to more recent levels of 0.007 mg/L. Higher readings were also observed at the mouth of the Boardman River and range from 0.021-0.054 mg/L (average of 0.035 mg/L). Total phosphorus levels along Kids Creek, the largest tributary to the Boardman River, averaged 0.027 mg/L. The mouth of the Boardman River and Kids Creek both receive large amounts of stormwater input from the City of Traverse City and on the average have TP levels 3-4 times lower (respectively) than the levels measured in storm drain outputs. Additionally, to control eutrophication, the USEPA recommends that total phosphorus not exceed 0.05mg/L in a stream at a point where it enters a lake or reservoir. Kids Creek and the Boardman River are both below this threshold, but stormdrain samples are not. (http://pubs.usgs.gov/circ/circ1136/circ1136.html#CONCERNS)

Location	TP Level (mg/L)
GT Bay	0.005
<b>Boardman River</b>	0.035
Kids Creek	0.027
Storm Drains	0.100

The GTBWPP also states that TP levels are higher at nearshore areas than offshore. This is most likely due to runoff from urban areas and nutrient inputs along the shoreline from streams and stormdrain outlets. The effect of the nutrient inputs on the nearshore zone of west Grand Traverse Bay can be seen in a 2009 study TWC conducted on macrophyte bed growth in the bay (TWC 2010. *Grand Traverse Bay Macrophyte Bed and Sediment Survey Final Report.* Available from the Watershed Center Grand Traverse Bay at: (231) 935-1514). TWC conducted aquatic plant surveys in Grand Traverse Bay in 1991, 1998, and 2009, and completed a variety of water and sediment testing for nitrogen and phosphorus at locations with and without macrophyte beds and the mouths of several tributaries to the bay. These surveys showed a six-fold increase in the number of plant beds identified between 1991 and 2009 (1991: 64 beds; 1998: 124 beds; 2009: 402 beds). Most of the macrophyte beds were concentrated in embayments, such as Northport and Omena bays, as well as the southern end of west



Grand Traverse Bay, where the Boardman River drains. This growth is attributed to rapid development and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay.

The overall message is that our water quality in the Grand Traverse Region of a very high quality and levels of TP in stormwater are three to 10 times higher than the receiving water body it goes into. Therefore we must do better to protect the Bay and streams/lakes in the watershed from degradation.

## 4.2b Bacteria (E.coli) Levels in Storm Drains

Bacteria levels of *E. coli* in stormdrains are high throughout the City of Traverse City during rain events. A summary of results from 11 outfalls confirm this (8th Street, Bryant Park - 2 locations, East Bay Park - 2 locations, Hannah Park, Holiday Inn, Hope Street, Maple Street, Sunset Park, and West End Beach). The highest results were noted at 8th Street, Bryant Park, East Bay Park, Sunset Park.

EPA recommends measuring recreational water quality by the abundance of *Escherichia coli* (*E. coli*), which is a common intestinal organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other disease causing pathogens. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal pollutions. The presence of *E. coli* in water does indicate what kinds of pathogens may be present, if any. If more than 300 *E. coli*/100mL of water are present in a single sample, or if more than 130 *E. coli*/100mL of water in 5 samples over 30 days, the water is considered unsafe for swimming.

The Watershed Center monitored both the Boardman River and Kids Creek from 2002-2004 (TWC 2004). *E. coli* levels at the mouth of the Boardman were relatively low; out of 44 samples over three years, only one registered above state Water Quality Standards for full body contact (300 col/100mL), and the average reading was 88 col/100mL. However, Kids Creek did have elevated *E. coli* levels; out of 41 samples collected over three years, 17 samples were above 300 col/100mL, and the average of all results was 327 col/100mL

*E. coli* is a major problem in stormdrains in the City of Traverse City as discussed in the GTBWPP. Many stormdrains outlet adjacent to public lands as well, with many of the public lands being designated beach areas, which have the potential to negatively impact public health. The source of much of this pollution is from pet waste runoff and wildlife

and waterfowl droppings. Stormdrains, especially on east side of Traverse City, have large numbers of raccoons living in them. In fact, the City has done camera work in drains and found multiple piles of raccoon droppings; and city workers cleaning out fire hydrants routinely see raccoon families coming in and out of catch basins.

## 4.3 Kids Creek Water Quality Recommendations

The recommendations fall into three categories:

- Programmatic Traverse City stormwater program recommendations
- Infrastructure improvements primarily culvert replacements
- Stream improvements stream restoration projects

### 4.3a Programmatic Recommendations

The City shall strengthen its groundwater/storm water ordinance by incorporating design into ordinance form. Another programmatic recommendation would be to develop a Kids Creek monitoring program. For instance, currently wood in and around the channel is only attended to when it becomes a problem, for instance, clogging up a culvert. All natural channels in wooded areas have downed trees. These downed trees create their own microhabitats and should not just be pulled from the channel without consideration of the wood's function and impact on stream health. Some of the stream restoration recommendations following include strategic placement of wood in the channel for narrowing overwide reaches. In order to pre-emptively manage wood in the City's stormwater system, City staff should perform at least an annual inspection of the channel including wood either in the channel, or wood that is about to be "recruited" into the channel. The inspection would be about both sustaining habitat as well as pre-emptively managing wood that could become a problem for the City's stormwater system downstream. Kids Creek should be thought of both as an element of the City's stormwater system as well as a natural system and managed to benefit both. They do not have to be mutually exclusive goals.

### 4.3b Infrastructure Improvements

These infrastructure improvements center on culverts and culvert replacements. The recommended culvert replacements in the upstream Kids Creek reach include:

- 1. Elmwood crossing, just below Silver Lake Road
- 2. The two-track road crossing on the continuation of 14th Street
- 3. The 11<sup>th</sup> Street culvert
- 4. The pedestrian pathway crossing, just north of 11th Street
- 5. The Upper Front Street culvert

The upstream crossing replacements (items 1-4 above) are necessary both to improve the stream channel slope and improve sediment transport capacity to help address the creek's impairment. The upper Front Street culvert replacement would address sediment transport capacity at the Cedar Street and private crossing as well as flow capacity and would help make the Cedar Street culverts significantly less prone to filling. These culvert replacements are further described in the 2017 Stormwater Asset Management Plan recently prepared for the City.

#### 4.3c Kids Creek Stream Improvements

The recommended improvements for Kids Creek are based on improving stream function and ecology; however, they are also predicated on either improving flood frequencies or at least not degrading them. Because the recommended improvements also have the potential to improve or even lift the impairment on Kids Creek, they would be good candidates for securing outside funding. Every outside funding source we are familiar with also requires or recommends match funds. The recommended improvements to Kids Creek have the potential to deliver several different kinds of benefits. For instance, while the projects could improve sediment transport and natural habitat, they have the potential to also increase flood frequencies as well. With this range of benefits, the City can build an appeal to the community for public funding. This public funding can then act as match to go after grant funds to complete the stream habitat improvements.

#### 4.3c.1 Lower Kids Creek Stream Improvements

There are a set of projects in the lower portion of Kids Creek that would help with lifting the impairment in the creek. The highest priority project is to replace both Cedar Street crossings and the private driveway crossing between them. These crossings need to be lowered an enlarged to increase both water and sediment transport downstream. This reach is severely degraded both completely filled in with sand as well as over-widened. This area also floods frequently. Final design of this set of improvements would have to also manage the increased flow capacity and might potentially require some grade improvements downstream as well as increasing floodplain storage in the reach between the Cedar Street culverts. With care during planning, design and construction, this reach could become significantly improved, both from stream and flood protection perspective as well as from an aesthetic perspective.

Additionally, the outlet culvert of Kids Creek at its confluence of the Boardman River is wide and relatively steep (See Figure 20), resulting in shallow flow. We recommend that some "roughening" of the culvert be undertaken to enhance fish passage back up Kids Creek (Figure 21). This roughening could be the installation of stones that would function both to raise low flow elevations and provide resting spots for fish as they begin their trip back upstream in Kids Creek. This has become a standard practice to improve passage through culverts with reliable guidance documents.



**Figure 20.** Downstream end of Kids Creek (Wadsworth Street culvert) at the Boardman River. Flow depth is less than 6-inches deep



**Figure 21.** Example of Culvert bottom roughening (USFS photo)

Upper Kids Creek improvements would include both culvert replacements as well as a series of in-stream improvements that would help introduce habitat variability as well as create a series of "self-cleaning" riffles that would have a gravel bed (refer to Figures 22 and 23). The culvert replacement projects would provide more flow capacity for flow up to bankfull flow. New culvert design and additional floodplain storage would be created to limit peak flows for large events (>10-year return period) to current peak flows to limit impacts downstream impacts downtown.



Figure 22. Recommended riffle improvements (in brown), culvert replacements (in purple) and floodplain storage improvements (in green) on Kids Creek from Silver Lake Street to above 11th Street



Figure 23. Recommended riffle improvements (in brown), culvert replacements (in purple) and floodplain storage improvements (in green) on Kids Creek from 11th Street to 7th Street

As part of this planning process for upper Kids Creek, both the Tributary A daylighting project as well as some numerical experiments on potential improvements in Kids Creek were reviewed. The goal of these tasks is to develop a set of design criteria for "self-cleaning" riffles. For instance, Figure 24 on the next page shows two installed riffles on Tributary A. Based on the design both of these riffles were created with imported cobble. After more than four years from installation, the cobble is completely covered by sand, while the other riffle is

still relatively clean. The second riffle can, at least up to this point considered "self-cleaning", that is, the coarse material is not being buried by finer material.



**Figure 24.** Conditions of installed riffle cobble on two designed riffles on Tributary A daylighting project. On the left, visible cobble; on the right no cobble visible due to sand deposition.

With the numerical experiment, a set of model runs where the total flow area of Kids Creek cross-sections were systematically changed and also either two or four inches of additional height for existing riffles was added were run. This experiment demonstrates that as the slope over the riffle increases or the channel cross-sectional area is decreased, stream power goes up and the size of a particle that would theoretically be mobile over the riffle goes up (Figure 25). With sufficient power over the riffle, sand cannot accumulate.





Final design of the stream improvements would require more detailed information, including a detailed, integrated geomorphic assessment that includes a longitudinal profile with thalweg shots at each stream feature such as each riffles and pools, along with representative cross-sections at each stream feature; a particle size assessment at selected stream features, and a linked hydrologic, hydraulic and sediment transport model that incorporates all the data from the assessment. It is also recommended that collection of some of the same data at representative riffles on Tributary A be completed, since the starting condition of that stream is so well-defined. The index derived from these parallel analyses is a shear stress/particle size mobilization metric that can be used to define channel characteristics, at riffles in particular.

# SECTION 5: CAPITAL IMPROVEMENT PLAN (CIP)

Based on the findings of the stormwater sampling outlined in the previous section, the City's main focus with regard to stormwater quality should be with reducing total phosphorus (TP) and E. Coli while increasing the quantity and quality of stormwater sampling. With this in mind, all applicable future projects, public and private, should consider the use of BMPs and green infrastructure to improve water quality within the City. All projects need to consider operational and maintenance requirements and cost. Projects need to consider available maintenance equipment and trained staff.

Along with the general maintenance and upkeep of stormwater quality utilities, municipalities should have a number of environmental stewardship programs in place. Environmental stewardship programs are programs aimed to increase the quality of the environment and prevent higher cost maintenance and environmental concerns down the road. These programs are sometimes a collaborative effort between the City and property owners, such as leaf pickup, or are the sole responsibility of the City, such as catchbasin cleanout. The City of Traverse City currently has a number of environmental stewardship programs in place. These programs include:



- Fall Leaf Pickup
  - To reduce the amount of leaves entering the storm system and to prevent the clogging of catchbasin inlets and storm sewers
- Spring Cleanup
  - To reduce the amount of organic matter entering the storm system, which clogs existing treatment systems and can lead to algae plumes
- Annual Clean Up and Green Up Recycling Event
  - Residents may bring a number of items to be recycled, repurposed, or reused to a designated location in the City for collection, free of charge
- Street Sweeping
  - To reduce the amount of road sediment and debris from entering the storm system during rain events. A map showing street sweeping routes and frequencies can be found in **Appendix G**.
- Catch Basin Cleanout
  - To remove suspended solids including nutrients, pathogens and toxins which was demonstrated to be effective in reducing mass emissions of pollutants associated with solids via stormwater
  - The City invests \$270,000 to \$350,000 annually towards street sweeping, catch basin cleaning, and cleaning water quality treatment systems

# 5.1 Determining BMPs for Future Investment Projects

The City currently has a number of stormwater BMPs installed, with an investment of \$1,805,000 in BMPs (not including maintenance and prevention items such as street sweeping, brush pick up, and catchbasin cleaning) since 2003. A map showing the locations of these improvements can be found in **Appendix G**. Using the installation cost of these devices and the XP SWMM model or equivalent water quality flow values, the City Engineering Department evaluated each of the stormwater sewer systems and determined a treatment type and

associated cost for each stormwater sewer system. Using this information, an estimated \$4,314,000 is needed to ensure that each stormwater sewer system has an appropriate stormwater BMP installed. A breakdown of the proposed BMPs and installation costs for each of the stormwater sewer systems can be found in the following table (Table 3).

Boundary	XP SWMM/	Existing Treatment Type/ Proposed Improvement	Area	Proposed	
	Equivalent		(acres)	Improvement	
	Water			Cost	
	Quality				
	Flow				
Α	13.53	Aqua Swirl (AS - 8)	45.69		
AA	7.10	Drywell, Traverse City Outlet Cover	5.37	\$	50,000.00
AB	1.25	Munson Campus	1.73		
AC	0.84	Munson Campus	1.64		
AD	5.87	Munson Campus	3.66		
AE	7.70	Munson Campus	16.38		
AF	1.43	Munson Campus	2.78		
AG	17.96	Aqua Swirl AS-5	100.52		
AH	0.76	Traverse City Outlet Cover	0.85	\$	8,500.00
AI	9.52	Suntree Nutrient Separating Baffle Box	71.59		
AI	16.88	(see above)	71.59		
AJ	6.36	Drywell, Traverse City Outlet Cover	9.36	\$	20,000.00
AK	6.27	Traverse City Outlet Cover w/Aluminum Hatch/3'	22.74	\$	50,000.00
		sump (In Parking Lot Only), Oil Grit Separator			
AL	0.69	Traverse City Outlet Cover	0.49	\$	8,500.00
AM	1.02	Traverse City Outlet Cover	0.73	\$	8,500.00
AN	8.39	Underground Infiltration (In Parking Lot Only), Oil	20.07	\$	50,000.00
		Grit Separator			
A0	11.31	Drywell, Traverse City Outlet Cover	38.41	\$	60,000.00
АР	1.15	Traverse City Outlet Cover	2.26	\$	8,500.00
AQ	7.57	Munson Campus	19.11		
AR	2.90	Traverse City Outlet Cover	2.77	\$	8,500.00
AS	3.17	Drywell, Traverse City Outlet Cover	5.39	\$	20,000.00
AT	5.48	Drywell, Traverse City Outlet Cover	10.09	\$	20,000.00
AU	14.52	Oil Grit Separator, Drywell, Traverse City Outlet Cover (MDOT)	65.94	\$	70,000.00
AV	2.17	Traverse City Outlet Cover	2.10	\$	8,500.00
AW	6.95	Drywell, Traverse City Outlet Cover	8.66	\$	20,000.00
AX	6.89	Traverse City Outlet Cover	7.32	\$	8,500.00
AX	7.66	Traverse City Outlet Cover	7.32	\$	8,500.00
AY	5.16	Oil Grit Separator, Drywell, Traverse City Outlet Cover	23.57	\$	70,000.00
AZ	1.75	Drywell, Traverse City Outlet Cover	2.32	\$	20,000.00
В	9.26	Settling - STC 2400 - Stormceptor, Leaching Basins	14.38		
		w/2' and 3' Sumps			
BA	3.28	Traverse City Outlet Cover in Catchbasin into Oil Grit Separator	3.51		

Table 3. Stormwater Quality Treatments Based on Water Quality Flow

Boundary	XP SWMM	Existing Treatment Type/ Proposed Improvement	Area	a Proposed	
	or		(acres)	Improvement	
	Equivalent			Cost	
	Water				
	Quality				
	Flow				
BB	6.45	Drywells, Traverse City Outlet Cover in Manhole	5.35		
DE	2 51	Drinuall Travarsa City Outlat Covar	5 25	\$ 20,000,00	
BE	7.40	Drywell, Traverse City Outlet Cover	6.72	\$ 20,000.00	
BG	19.10	Oil Grit Senarator Traverse City Outlet Cover	4.60	\$ 180,000,00	
BH	19.10	(see above)	88 79	φ 100,000.00	
BI	9.86	Rain Gardens Traverse City Outlet Cover	22 71	\$ 50,000,00	
BI	0.85	Traverse City Outlet Cover	1 58	\$ 8500.00	
BK	7 69	Vegetated Swales Drywell Traverse City Outlet Cover	58.35	\$ 50,000,00	
BM	50.19	Tree Boxes Drywells Oil Grit Senarator Traverse City	177 53	\$ 430,000,00	
DII	50.17	Outlet Cover (Grant Applied For)	177.55	φ 150,000.00	
BN	0.17	Traverse City Outlet Cover	0.14	\$ 8,500.00	
BO	0.15	Traverse City Outlet Cover	0.09	\$ 8,500.00	
BP	0.32	Traverse City Outlet Cover	0.18	\$ 8,500.00	
BQ	7.35	Traverse City Outlet Cover in Manhole w/2ft Sump,	7.86		
		Contech - Model CDS3030			
BR	2.23	Traverse City Outlet Cover w/2ft Sump, AquaSwirl	1.22		
		AS-3, Rain Gardens			
BS	0.67	40' x 15' Stone Drainbed	0.35		
ВТ	1.56	Permeable Pavement, Traverse City Outlet Cover (Farmer's Market)	0.98	\$ 300,000.00	
BU	0.66	Drywell, Traverse City Outlet Cover	1.41	\$ 20,000.00	
BV	3.48	Tree Boxes, Traverse City Outlet Cover	3.12	\$ 58,000.00	
BW	2.61	Tree Boxes, Traverse City Outlet Cover	4.54	\$ 107,500.00	
BX	2.75	Tree Boxes, Traverse City Outlet Cover	3.50	\$ 41,500.00	
ВҮ	1.74	Drywell, Traverse City Outlet Cover (Lot K Permeable Pavement)	1.52	\$ 20,000.00	
BZ	1.62	Tree Box, Traverse City Outlet Cover	4.93	\$ 25,000.00	
BZ	1.62	Tree Box, Traverse City Outlet Cover	4.93	\$ 25,000.00	
C	5.52	Swirl (CDS Technologies PSWC 30 - 20) Left handed, Aqua-Swirl Separator Unit	14.14		
СА	1.31	Aqua-Swirl Separator Unit	2.38		
СВ	10.37	Drywells, Traverse City Outlet Cover	13.85	\$ 70,000.00	
CE	13.68	Oil Grit Separator, Drywell, Traverse City Outlet Cover	25.70	\$ 250,000.00	
CF	4.54	Drywell, Traverse City Outlet Cover	8.23	\$ 20,000.00	
CG	2.47	Drywell, Traverse City Outlet Cover	2.27	\$ 20,000.00	
СН	4.08	Drywell, Traverse City Outlet Cover	5.54	\$ 20,000.00	
CI	19.90	Drywells, Rain Gardens, Oil Grit Separator, Traverse City Outlet Cover	36.21	\$ 100,000.00	
CI	7.60	Drywells. Traverse City Outlet Cover. Oil Grit Separator	23.75	\$ 85.000.00	

Boundary	XP SWMM	Existing Treatment Type/ Proposed Improvement		Proposed
	or		(acres)	Improvement
	Equivalent			Cost
	Water			
	Quality			
	Flow			
СК	12.74	Drywells, Oil Grit Separator, Traverse City Outlet Cover	64.39	\$ 74,500.00
CL	24.50	6ft Downstream Defender, Settling Tanks/Screen	149.55	
		Filter Treatment System, Chambered Filtration		
CM	36.80	System Vagatated Swales, Druguells, Traverse City Outlet Cover	125 10	\$ 245,000,00
	8 90	Rain Cardens, Traverse City Outlet Cover	9.27	\$ 13500.00
	52 70	Inderground Detention TC Screen Hydo-senarator	147 32	φ 13,300.00
	56.13	Vagetated Swales Rain Cardens Traverse City Outlet Cover	262.83	\$ 210,000,00
CI	50.15	vegetated Swales, Kull bardens, Traverse City batter Cover	202.03	φ 210,000.00
CQ	58.30	Vegetated Swales, Rain Gardens, Traverse City Outlet Cover	930.86	\$ 29,500.00
CS	18.00	Vegetated Swales, Drywell, Traverse City Outlet Cover	113.85	\$ 38,000.00
СТ	49.40	Vegetated Swales, Drywells, Oil Grit Separator, Traverse	151.49	\$ 250,000.00
CU	84 50	Vegetated Swales Drywells Oil Grit Separator Traverse	399.04	\$ 256 500 00
00	01.50	City Outlet Cover	577.01	\$ 250,500.00
CV	2.69	Vegetated Swales, Rain Gardens, Traverse City Outlet Cover	8.79	\$ 20,500.00
CW	1.81	Rain Gardens, Traverse City Outlet Cover	7.37	\$ 13,500.00
СХ	5.69	Vegetated Swales, Rain Gardens, Traverse City Outlet Cover	18.31	\$ 14,500.00
CY	12.53	Oil Grit Separator System Traverse City Outlet Cover	79.66	\$ 58 500 00
CZ	3.33	Drywell Traverse City Outlet Cover	4 76	\$ 20,000,00
D	24 39	Swirl (Contech VS - 70), 4ft Downstream Defender	108 53	¢ 10,000100
 	35.40	6ft & 8 ft Downstream Defenders, Settling Tank/	60.23	
2	00110	Screen Filter Treatment System, Helix Filtration	00120	
		Treatment System		
F	31.40	Swirl (8ft Downstream Defender), Filtration	134.13	
G	11.60	Swirl (6ft Downstream Defender), Filtration	31.43	
Н	4.32	Vegetated Swales, Rain Gardens, Traverse City Outlet Cover	26.88	\$ 26,500.00
<u> </u>	1.32	Traverse City Outlet Cover	7.73	\$ 8,500.00
J	6.31	Drywells	13.50	\$ 48,500.00
K	7.39	Traverse City Outlet Cover	11.69	\$ 8,500.00
	2.10	Drywell	1.35	
M	0.52	Traverse City Outlet Cover	0.43	\$ 8,500.00
N	3.14	Aqua Swirl (AS-2 w/H-20 Lid)	1.65	
P	1.19	Traverse City Outlet Cover	0.57	\$ 8,500.00
Q	2.07	Traverse City Outlet Cover	1.29	\$ 8,500.00
R	1.76	Traverse City Outlet Cover	1.01	\$ 8,500.00

Boundary	XP SWMM or Equivalent	Existing Treatment Type/ Proposed Improvement	Area (acres)	Proposed Improvement Cost
	Water Quality Flow			
S	0.83	Traverse City Outlet Cover	0.72	\$ 8,500.00
Т	1.07	Traverse City Outlet Cover	0.57	\$ 8,500.00
V	2.05	Drywell, Traverse City Outlet Cover	2.45	\$ 20,000.00
V	2.05	Drywell, Traverse City Outlet Cover	2.45	\$ 20,000.00
W	12.50	Tree Boxes, Drywells, Oil Grit Separator, Traverse City Outlet Cover	25.39	\$ 214,500.00
X	1.52	Drywell, Traverse City Outlet Cover	1.21	\$ 20,000.00
Z	6.06	Drywells, Traverse City Outlet Cover	18.22	\$ 56,500.00
			TOTAL=	\$4,314,000.00

Considerations for prioritization of sites to receive stormwater quality improvements should include attention to areas that are:

- Near public beaches and parks
- Adjacent to surface waters
- Known for water quality issues
- In Central Business Districts
- Easily funded by grants



## 5.2 Grand Traverse Watershed Center Grants

Currently, a 4-mile portion of Kids Creek, located in an urban area on the west side of Traverse City, is on the State's 303(d) Impaired Waters List due to the 'Other Indigenous Aquatic Life' Designated Use not being met (i.e. poor macroinvertebrate community). This is mainly due to sedimentation, flow regime alteration, and other human-caused sources. Although a Total Maximum Daily Load (TMDL) plan for Kids Creek is not currently scheduled to be drafted as part of the MDEQ's 2016-2022 "Prioritization Framework for the Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program," it remains on the 303(d) non-attainment list as needing a TMDL. Kids Creek is an important spawning stream, nursery stream, and coldwater contributor to Grand Traverse Bay and has self-sustaining populations of Brook Trout and Brown Trout, as well as migratory populations of Chinook Salmon, Coho Salmon, and steelhead.

In 2013, The Watershed Center Grand Traverse Bay (TWC) began a large-scale Kids Creek Restoration Project with the goal of reducing the impact of stormwater and sedimentation on Kids Creek and its tributaries so it could be removed from the State's 303(d) Impaired Waters List. Working in partnership with the MDEQ, TWC completed a draft Kids Creek Action Plan in 2013 to address stormwater and sediment inputs and their effects on Kids Creek. The action plan provided a prioritized list of BMPs that would decrease both the input and effects of stormwater and sediment to the creek as well as improve in-stream habitat for macroinvertebrates and fish communities. Restoration methods outlined in the plan follow general guidelines and recommendations from the Grand Traverse Bay Watershed Protection Plan. Over the past several years, TWC has been working with MDEQ, EPA, and other local partners to implement this action plan as part of our Kids Creek Restoration Project.



To date, TWC has received more than \$4.2 million in MDEQ, EPA-Great Lakes Restoration Initiative (GLRI), and private funding to implement key portions of the Kids Creek Action Plan as part of the Kids Creek Restoration Project. Thus far, much of the project work has focused on reducing stormwater inputs to Kids Creek from urban areas using green infrastructure and low impact development techniques. However, the next phase of the restoration project includes work within the channel to restore in-stream habitat and provide floodplain storage during periods of high flow. This work is critical to restore and protect the habitat necessary for thriving fish and macroinvertebrate communities in the creek, which will be a key factor in getting the impairment lifted. Several projects with these components are already planned or completed along Kids Creek

including daylighting 900 feet of Kids Creek Tributary A to a new 1,275 foot channel and establishment of 27,000 square feet of vegetated floodplain (completed September 2013); restoring natural stream function, connecting the floodplain, and installing a riparian buffer on Kids Creek Tributary AA (planned 2017) and Kids Creek Tributary A (downstream from daylighting site, planned for 2018); and creating a wetland floodplain area adjacent to a ditch conveying runoff to Kids Creek from a major storm drain outfall in the City of Traverse City (GLRI proposal submitted January 2017, planned for 2019 construction).

In an effort to make improvements to known Kids Creek problem areas in the City, TWC has secured two grants. One grant is from the EPA Great Lakes Restoration Initiative for making improvements to Kids Creek as it follows 14<sup>th</sup> St in stormdrains. The other is from the National Fish and Wildlife Foundation for the improvement of the natural stream function and habitat of Kids Creek between 7<sup>th</sup> St and Silver Lake Rd. These projects will continue the important stream restoration activities to improve natural stream function and instream habitat described above, which are key components to the impairment to the creek being lifted.

### 5.2a Kids Creek 14th Street Stormdrain Project

This project will improve water quality and reduce stormwater and sediment inputs to Kids Creek, an impaired stream reach in the Grand Traverse Bay watershed. A wetland floodplain area will be created adjacent to a ditch conveying runoff to Kids Creek from a major storm drain outfall in the City of Traverse City. This wetland area will receive stormwater as it flows down the conveyance ditch and help reduce peak flows and sediment input to Kids Creek. This project will continue work on the large-scale Kids Creek Restoration Project by implementing BMPs to improve water quality and reduce stormwater and sediment inputs to Kids Creek, with the goal of removing the creek from the State's 303(d) Impaired Waters List.



### 5.2b Kids Creek between 7th Street and Silver Lake Road Restoration Project

This project will continue work on the large-scale Kids Creek Restoration Project in the Grand Traverse Bay watershed by implementing BMPs to improve water quality and reduce stormwater and sediment inputs to Kids Creek, with the goal of removing the creek from the State's 303(d) Impaired Waters List. Specifically, to improve natural stream function and improve in-stream habitat on a 5,400-foot (1 mile) section of Kids Creek by installing riffle-pool enhancements, placing large wood in the stream, connecting the stream to its floodplain, removing an unnecessary culvert, and narrowing the stream channel using natural, bioengineering techniques.

On a broader scale, this project will not only help reduce the impairment on a 303(d) listed stream section, it will also help meet the goals of the Great Lakes Restoration Initiative (GLRI), specifically working towards three Measures of Progress under the Habitats and Species section in the GLRI Action Plan II that state:

- Number of acres of other habitats in the Great Lakes basin protected, restored, and enhanced by GLRI-funded projects (2019 target - 207,000 acres)
- Number of miles of Great Lakes shoreline and riparian corridors protected, restored and enhanced by GLRI-funded projects (2019 target - 300 miles)
- Number of GLRI-funded projects that promote populations of native non-threatened and nonendangered species self-sustaining in the wild.

# 5.3 Grand Traverse Bay Watershed Protection Plan and Boardman Lake Watershed Study

Both the Grand Traverse Bay Watershed Protection Plan and Boardman Lake Watershed Study were reviewed and recommendations for updating the two documents were referred to the Grand Traverse Bay Watershed Center.

Some of the tasks recommended for the Grand Traverse Bay Watershed Protection Plan include: additional shoreline protection and restoration efforts, best management practices for road stream crossings, zoning and land use plan and ordinance development, utilization of low impact development (LID) standards, and shoreline and nutrient monitoring. Likewise, many of the same tasks recommended for the Grand Traverse Bay Watershed Protection Plan were recommended for the Boardman Lake Watershed Study, but with a focus on the Boardman Lake Watershed. The recommended updates to the plan are to meet current needs and implement the latest trends in stormwater management for water quality purposes.

# APPENDIX A

Stormwater Boundary Areas A to AZ



# APPENDIX B

Stormwater Boundary Areas B to BZ



# APPENDIX C

Stormwater Boundary Areas C to CZ


# APPENDIX D

Stormwater Boundary Areas D to Z



**Runoff Calculations** 

2 Year	5 Year	10 Year	25 Year
2.09	2.70	3.21	3.89

### Table 7-1: Average Runoff Curve Number (Acres)

Boundary	ary Hydrologic Soil Group B								
	Pavement 98	Residential 75	Forested 55	Total	Average Curve Number				
Α	1115.54	756.08	1332.44	3204.06	70.13				
AA	296.16	66.58	80.28	443.02	82.51				
AB	24.43	73.44	27.85	125.72	72.47				
AC	38.85	1.84	66.86	107.56	65.72				
AD	260.40	8.15	49.28	317.83	86.80				
AE	474.96	503.42	265.13	1243.52	75.92				
AF	65.88	110.62	34.53	211.04	76.05				
AG	1603.92	814.82	4030.89	6449.63	64.16				
АН	33.52	6.12	23.61	63.24	74.16				
AI	1253.02	734.65	2695.57	4683.24	65.42				
AJ	273.00	119.99	273.82	666.81	71.21				
AK	919.91	281.08	528.10	1729.09	76.05				
AL	31.80	0.00	9.26	41.06	83.32				
AM	48.34	0.00	13.14	61.48	83.97				
AN	930.41	279.66	376.77	1586.84	79.05				
A0	1031.14	517.84	1154.35	2703.34	70.37				
AP	53.67	4.65	90.58	148.90	65.99				
AQ	782.22	255.05	425.16	1462.43	76.52				

Boundary	Hydrologic Soi				
	Pavement 98	Residential 75	Forested 55	Total	Average Curve Number
AR	117.71	40.57	56.67	214.95	77.53
AS	103.81	83.97	176.55	364.32	67.61
AT	227.12	164.86	306.81	698.79	69.23
AU	1504.25	1003.15	2046.62	4554.03	69.07
AV	101.06	25.74	39.70	166.51	79.43
AW	269.45	121.87	235.83	627.15	72.40
AX	315.14	107.40	146.86	569.40	77.81
ΑΥ	531.93	441.08	674.54	1647.55	69.89
AZ	67.73 30		67.27	165.21	71.30
В	540.05 262.64		295.08	1097.77	76.35
BA	123.77	65.93	75.01	264.72	75.51
BB	249.42	100.97	80.05	430.44	80.50
BE	111.61	93.39	157.75	362.74	69.07
BF	375.91	110.25	77.61	563.77	83.93
BG	95.57	86.44	135.88	317.90	69.13
BH	1871.89	1503.56	2730.54	6106.00	68.77
BI	621.24	381.24	620.59	1623.07	71.48
BJ	62.31	16.85	39.84	119.00	75.09
BK	1085.93	433.37	2282.04	3801.35	65.15
BM	4109.19	3661.99	4772.43	12543.60	70.66
BN	6.76	1.85	2.75	11.36	79.09
BP	12.13	3.04	1.11	16.27	88.25
BQ	310.83	174.17	129.93	614.93	78.27
BR	90.63	6.81	11.29	108.73	89.06
BS	27.12	1.82	2.80	31.74	90.19
BT	71.88	2.46	11.61	85.94	87.94

Boundary Hydrologic Soil Group B

-					
	Pavement 98	Residential 75	Forested 55	Total	Average Curve Number
BU	96.35	2.57	21.39	120.31	85.55
BV	118.34	140.17	2.23	260.73	83.65
BW	109.82	241.35	11.29	362.46	79.77
BX	85.20	156.14	30.22	271.56	77.57
BY	70.98	32.76	19.78	123.52	81.22
BZ	39.04	18.11	235.73	292.88	59.46
С	532.13	241.91	301.54	1075.58	76.08
СА	105.77	34.96	46.11	186.84	78.38
СВ	521.77	258.70	278.93	1059.41	76.52
СЕ	1190.89	761.41	186.72	2139.03	83.23
CF	356.35	154.26	139.39	650.01	79.00
CG	110.06	37.92	35.36	183.34	80.71
СН	243.92	90.45	101.54	435.91	78.67
CI	1431.75	467.89	845.12	2744.76	75.79
CJ	725.34	316.45	666.99	1708.79	71.96
СК	1817.94	943.75	1828.91	4590.60	71.30
CL	6118.12	1686.48	3554.64	11359.23	75.96
СМ	3625.98	1690.55	4160.97	9477.50	70.10
СО	4043.57	2299.05	4147.03	10489.65	71.21
СР	3438.73	1512.81	11416.35	16367.89	62.28
CQ	19558.46	3071.04	37968.44	60597.94	65.10
CS	2818.81	1152.40	3834.68	7805.89	68.56
СТ	4796.80	1889.01	4254.66	10940.47	72.22
CU	9876.47	3613.33	13754.27	27244.07	68.27
CV	57.60	33.72	426.16	517.48	58.90
CW	0.56	0.02	405.05	405.64	55.03

Boundary	Hydrologic Soil Group B								
	Pavement 98	Residential 75	Forested 55	Total	Average Curve Number				
СХ	199.33	124.81	803.42	1127.56	61.60				
СҮ	1408.37	337.71	3343.50	5089.57	63.89				
CZ	114.84	79.87	138.54	333.25	70.07				
D	3142.04	1600.33	3032.01	7774.38	71.64				
Е	1032.36	734.96	2194.05	3961.37	65.78				
F	38.77	1.84	7353.94	7394.56	55.13				
G	851.13	457.61	915.17	2223.90	70.77				
Н	494.56 275.48		998.59	1768.63	65.81				
I	19.76 138.16		312.63	470.54	60.89				
J	359.99	92.17	473.09	925.25	68.52				
К	253.51 155.82		386.32	795.65	68.07				
L	109.37	7.96	6.77	124.10	92.25				
Μ	27.04	6.59	3.72	37.35	86.57				
N	125.70	16.42	8.38	150.49	90.99				
Р	47.44	2.08	3.15	52.67	92.55				
R	76.75	1.79	10.91	89.46	88.97				
S	38.80	3.54	15.17	57.51	79.99				
Т	43.86	2.80	4.48	51.14	90.31				
V	98.09	43.06	48.12	189.26	77.25				
W	665.65	497.77	658.02	1821.43	71.73				
X	64.28	22.51	13.84	100.63	83.32				
Z	661.11	222.06	468.38	1351.56	74.17				

Table 7-2:	Expected	<b>Runoff Volume</b>	(Cubic Fee	et)
	1		<b>`</b>	

Boundary	2 Year	5 Year	10 Year	25 Year	
Α	42791	92879	140314	201681	
AA	14092	22610	30386	40112	
AB	2173	4093	6027	8483	
AC	992	2258	3660	5555	
AD	12388	18875	24697	31622	
AE	25269	45782	65819	91386	
AF	4775	8361	11766	16188	
AG	53638	127710	209810	322925	
АН	1223	2260	3272	4542	
AI	43400	98754	160085	242986	
AJ	10707	20735	30797	43407	
AK	39121	68502	96399	132631	
AL	1365	2183	2912	3809	
АМ	2028	3242	4327	5658	
AN	41825	71408	98878	132469	
A0	35977	78089	117971	169565	
АР	1368	3113	5046	7659	
AQ	32886	57584	81035	111492	
AR	5072	8856	12449	16887	
AS	4225	8803	13810	20441	
AT	9380	19420	29533	42358	
AU	61273	126855	192915	276687	
AV	4368	7458	10326	13835	
AW	10848	20439	30092	42355	
AX	13388	23376	32860	44574	
AY	21906	45353	68970	98920	

Boundary	2 Year	5 Year	10 Year	25 Year	
AZ	2649	5130	7620	10740	
В	24739	43319	60959	83871	
BA	5409	9799	14088	19561	
BB	12092	19991	27522	36644	
BE	4881	10105	15367	22039	
BF	18604	29747	39695	51911	
BG	4273	8847	13454	19296	
ВН	76069	161162	243677	356169	
BI	25963	50277	74674	105253	
BJ	2445	4430	6369	8843	
ВК	35373	80489	130477	198046	
BM	166262	360880	545186	783624	
BN	299	511	707	948	
во	322	482	621	794	
ВР	698	1044	1346	1720	
BQ	15799	26522	36732	49822	
BR	4924	7268	9302	11744	
BS	1496	2185	2784	3500	
ВТ	3519	5286	6878	8758	
BU	4452	6841	9031	11731	
BV	8633	13804	18420	24088	
BW	9468	16164	22383	29987	
BX	6405	11183	15719	21323	
ВҮ	3715	6072	8214	10864	
BZ	1284	4064	7257	11609	
С	24326	42596	59943	82473	
СА	4794	8048	11145	15117	
СВ	23822	41714	58701	80764	

Boundary	2 Year	5 Year	10 Year	25 Year
СЕ	71178	113811	151872	198609
CF	17143	29269	40528	54296
CG	5137	8493	11692	15568
СН	11143	18706	25907	35139
CI	55869	101222	145523	202050
CJ	27155	52585	78102	110084
СК	73623	142572	211754	298465
CL	230712	417996	600937	834363
СМ	126615	274823	415180	596759
CN	6290	14127	22368	33166
СО	168448	326201	484488	682883
СР	111626	276681	472266	747993
CQ	564296	1284026	2081474	3159381
CS	97533	206638	312437	456670
СТ	189720	357443	526267	740733
CU	341846	724250	1095066	1600592
CV	2017	6553	12061	19509
CW	1156	4018	8187	13691
СХ	6512	17941	30833	48176
СҮ	39618	86755	157316	238576
CZ	4454	9667	14605	20992
D	124095	240311	356921	503077
Е	36509	83075	134669	204409
F	21039	73123	148982	249148
G	29432	63882	96508	138716
Н	16292	37072	60096	91218
I	2188	6452	11894	18935
J	11569	24510	37059	54167

Boundary	2 Year	5 Year	10 Year	25 Year
К	10013	21215	32076	46884
L	6533	9247	11647	14429
М	1459	2224	2909	3725
N	7030	10266	13082	16450
Р	2764	3911	4927	6103
Q	4363	6648	8698	11138
R	3804	5694	7337	9377
S	1498	2558	3541	4745
Т	2407	3515	4479	5632
V	4482	7826	11000	14922
W	29036	56228	83512	117710
X	3345	5349	7137	9334
Ζ	26129	48289	69920	97041

#### Unit Peak Discharge (cfs) **Pipe Slope Curve Method** Conver XP-SWMM Model (or Pipe Pipe -sion Equivalent) Size Capacity (CFS) Factor (in) 5 Yr 2 Yr 5 Yr 10 Yr 25 Yr 2 Yr 10 Yr Bound- Outfall ary 33 7.43 16.12 24.35 35.00 27.01 27.30 28.08 30.00 15.50 Α N/A AA 8.98 12.07 15.93 2.00 11.20 17.96 24.14 12.00 3.50 29 5.60 AB 91 0.87 1.65 2.42 3.41 1.80 1.57 2.96 4.36 15.00 ---AC 0.40 0.91 1.47 2.23 2.00 0.80 1.82 2.94 24.00 --83 AD 87 4.98 7.59 9.93 12.72 2.00 9.97 15.18 19.87 --93 10.16 34.81 40.25 36.00 AE 18.41 26.47 36.76 N/A 25.85 20.00 AF 92 1.77 3.11 4.37 6.02 6.25 7.10 8.89 30.00 --N/A 44.29 AG 2 13.21 79.53 47.58 50.57 36.00 31.45 51.67 N/A 35.00 AH 3 0.49 0.91 1.32 1.83 2.00 0.98 1.82 2.63 --AI 4 8.35 19.00 30.79 46.74 N/A 22.11 29.80 36.06 36.00 55.00 AI 8.35 19.00 30.79 46.74 27.12 27.57 27.97 36.00 55.00 4.1 N/A AJ 4.30 8.33 12.37 17.43 7.74 14.99 22.26 15.00 --149 1.80 AK 5 7.95 13.92 19.59 26.96 1.10 8.75 15.32 21.55 24.00 10.00 AL 0.55 0.88 1.53 2.00 1.76 2.34 12.00 3.90 6 1.17 1.10 3.48 10.00 --AM 7 0.82 1.30 1.74 2.28 2.00 1.63 2.61 AN 61 10.29 17.57 24.32 32.59 N/A 24.98 26.65 28.56 30.00 20.00 52.71 24.00 AO 9.40 20.41 30.83 44.32 31.94 42.41 20.00 70 N/A AP 87 0.55 1.25 2.03 3.08 2.00 1.10 2.50 4.06 ---AQ 90 12.43 21.76 30.63 42.14 N/A 25.08 34.96 45.62 42.00 100.00 AR 2.04 6.79 7.12 89 3.56 5.01 2.00 4.08 10.01 15.00 2.92 AS 88 1.70 3.54 5.55 8.22 2.00 3.40 7.08 11.11 6.00 ---AT 75 3.40 7.04 10.71 15.36 1.80 6.12 12.67 19.27 12.00 3.00 AU 76 11.01 22.79 34.65 49.70 N/A 36.72 45.08 55.15 36.00 45.00 5.56 7.48 AV 1.76 3.00 4.15 1.80 3.16 5.40 6.00 ---84 AW 71 4.36 8.22 12.10 17.04 2.00 8.73 16.44 24.21 10.00 --5.38 9.40 13.22 17.93 1.80 9.69 16.92 23.79 12.00 AX 136 3.19 AX 138 5.38 9.40 13.22 17.93 2.00 10.77 18.80 26.43 12.00 3.84 AY 4.80 9.95 15.12 21.69 1.20 11.93 18.15 24.00 10.00 69 5.76 AΖ 72 1.07 2.06 3.06 4.32 2.00 2.13 4.13 6.13 12.00 2.09 В 32 6.46 11.30 15.91 21.89 2.00 12.91 22.61 31.81 21.00 20.00 BA 68 2.18 3.94 5.67 7.87 2.00 4.35 7.88 11.33 8.00 2.20 9.73 BB 4.86 11.07 16.08 22.14 12.00 --135 8.04 14.74 2.00 BE 66 1.96 4.06 6.18 8.86 2.00 3.93 8.13 12.36 12.00 1.50 BF 65 6.56 10.49 14.00 18.30 1.80 11.81 18.88 25.19 8.00 ---BG 35 1.72 3.56 5.41 7.76 47.09 55.18 67.72 36.00 40.00 N/A 35 11.94 40.00 BH 25.31 38.26 55.93 N/A 47.09 55.18 67.72 36.00 BI 6.66 12.90 19.16 27.00 11.99 23.22 34.48 21.00 22.00 25 1.80 2.94 21.00 22.00 BJ 25 0.63 1.14 1.63 2.27 1.80 1.13 2.05 32.17 BK 117 8.72 19.84 48.83 N/A 24.05 29.45 30.19 24.00 15.00

#### Table 7-3a: Unit Peak Discharge (cfs) Using Pipe Slope

			Curve	Method	I	Conver	XP-SW	MM Mo	del ( <i>or</i>	Pipe	Pipe
						-sion	Eq	uivalen	t)	Size	Capacity
Bound-	Outfall	2 Yr	5 Yr	10 Yr	25 Yr	Factor	2 Yr	5 Yr	10 Yr	(in)	(CFS)
ary	=										
BM	115	30.55	66.30	100.16	143.96	N/A	106.47	124.11	166.55	48.00	50.00
BN	63	0.12	0.21	0.28	0.38	2.00	0.24	0.41	0.57		
BO	64	0.13	0.19	0.25	0.32	2.00	0.26	0.39	0.50		
BP	62	0.28	0.42	0.54	0.69	2.00	0.56	0.84	1.08	12.00	
BŐ	60	6.01	10.08	13.96	18.94	1.80	10.81	18.15	25.14	21.00	13.00
BR	34	1.98	2.92	3.74	4.72	2.00	3.96	5.85	7.48	10.00	
BS	52	0.60	0.88	1.12	1.41	2.00	1.20	1.76	2.24	8.00	1.91
BI	54	1.42	2.13	2.//	3.52	1.90	2.69	4.04	5.26	10.00	4.24
BU	51	1.78	2.73	3.61	4.69	N/A	2.17	2.88	3.19	36.00	
BV	53	3.47	5.55	7.41	9.69	1.60	5.56	8.88	11.85	15.00	11.50
BW	49	3.81	6.50	9.00	12.06	1.00	3.81	6.50	9.00	15.00	
ВХ	45	2.58	4.50	0.32	8.58	1.50	3.86	0.75	9.48	15.00	8.00
BT D7	122	1.49	2.44	3.30	4.37	1.80	2.69	4.40	5.95	12.00	
DZ DZ	132	0.52	1.03	2.92	4.67	2.00	1.03	3.27	5.84	12.00	
BZ	133	0.52	15.43	2.92	4.67	2.00	1.03	3.27	5.84	6.00	
	31	8.80	15.42	21.69	29.85	N/A	10.78	21.76	27.12	30.00	35.00
	Z/	1.92	3.23	4.47	0.00	1.00	14.46	3.23	4.47	18.00	8.00
	41	9.04	10.00	22.27	30.04	1.00	14.40	25.32	35.03	18.00	10.50
	42	11.00	19.00	25.35	33.10	IN/A	43.71	22.41	15.51	24.00	90.00
	23	2.52	9.42	13.04	17.47	1.20	0.02	6 1 5	15.05	24.00	10.00
	24	2.07	7 10	4.70	12 51	1.00	5.72	10.13	12.05	15.00	0.33
СП	20	4.29	20.64	9.90	41 20	1.40 N/A	22 70	24 30	12.92	30.00	20.00
	22 8	0/3	18 27	29.07	38.25		22.70	24.30	2.90	30.00	12.00
	0	15 50	30.01	44 57	62.82	1 00	15 50	29.40	44 57	21.00	12.00
	11	17.80	32.24	46.35	64.36	N/A	30.20	31.00	31 70	36.00	35.00
	10	28.08	60.95	92.08	132 35		58.40	59 10	59.80	30.00	40.00
	17	2 52	5 66	8.96	13 28	N/A	8 90	8 90	8 90	15 00	4 00
	147	28 77	55 71	82 75	116 64	N/A	71 10	73 30	75 20	48.00	80.00
CP	122	23.37	57.93	98.88	156.60	2.00	46.74	115.86	197.75	12.00	
CO	19	50.30	114.45	185.53	281.60	N/A	141.80	169.00	180.30	54.00	80.00
CS	145	9.25	19.60	29.63	43.31	N/A	18.40	18.60	18.80	30.00	15.00
СТ	21	24.63	46.41	68.32	96.17	N/A	95.70	98.30	100.10	36.00	37.00
CU	20	40.49	85.79	129.72	189.60	, N/A	197.30	229.10	259.10	66.00	250.00
CV	113	0.81	2.64	4.85	7.85	2.00	1.62	5.27	9.70	21.00	26.00
CW	114	0.47	1.62	3.29	5.51	2.00	0.93	3.23	6.59	18.00	30.00
СХ	148	2.39	6.58	11.31	17.67	1.80	4.30	11.85	20.36	12.00	5.90
CY	1	15.93	34.89	63.27	95.96	N/A	36.93	38.49	39.87	24.00	29.00
CZ	77	1.79	3.89	5.87	8.44	2.00	3.58	7.78	11.75	10.00	2.60
D	28	19.83	38.40	57.03	80.38	N/A	80.61	106.52	108.25	24.00	15.00
E	16	7.60	17.30	28.05	42.57	N/A	91.50	105.00	146.20	36.00	45.00
F	18	3.46	12.01	24.48	40.93	N/A	37.40	39.50	40.10	30.00	26.00
G	36	7.75	16.82	25.41	36.52	N/A	26.90	34.70	59.60	24.00	10.00
Н	152	4.13	9.39	15.22	23.10	1.00	4.13	9.39	15.22	30.00	18.00
I	94	0.88	2.60	4.78	7.62	1.00	0.88	2.60	4.78	12.00	

		Curve Method				Conver	XP-SW	MM Mo	del ( <i>or</i>	Pipe	Pipe
Bound-	Outfall	2 Vr	E Vr	10 Vr	25 Vr	Factor		E Vr	() 10 Vr	(in)	(CFS)
ary	Outian	2 11	5 11	10 11	25 11		2 11	5 11	10 11		
J	79	3.44	7.29	11.02	16.11	2.00	6.88	14.58	22.04	12.00	
К	119	4.03	8.53	12.90	18.86	2.00	8.05	17.07	25.80	24.00	10.00
L	126	2.63	3.72	4.68	5.80	1.50	3.94	5.58	7.03		
М	-	0.59	0.89	1.17	1.50	1.50	0.88	1.34	1.76		
Ν	47	2.83	4.13	5.26	6.62	2.00	5.66	8.26	10.52	12.00	
Ρ	46	1.11	1.57	1.98	2.45	2.00	2.22	3.15	3.96	12.00	
Q	43	1.75	2.67	3.50	4.48	2.00	3.51	5.35	7.00		
R	44	1.53	2.29	2.95	3.77	2.00	3.06	4.58	5.90		
S	40	0.60	1.03	1.42	1.91	2.00	1.21	2.06	2.85		
Т	39	0.97	1.41	1.80	2.27	2.00	1.94	2.83	3.60		
V	67	1.80	3.15	4.42	6.00	1.60	2.88	5.04	7.08	10.00	1.40
V	68	1.80	3.15	4.42	6.00	1.60	2.88	5.04	7.08	8.00	2.00
W	38	7.60	14.72	21.86	30.81	2.00	15.20	29.43	43.71	30.00	
X	55	1.35	2.15	2.87	3.75	1.80	2.42	3.87	5.17	10.00	2.50
Z	5.1	10.14	18.74	27.13	37.66	N/A	17.09	21.01	27.09	30.00	40.00

Key

**XX.XX** Pipe Capacity is less than 2 yr Curve Method Unit Peak Discharge

**XX.XX** Pipe Capacity is less than 2 yr XP SWMM Unit Peak Discharge

Unit Peak Discharge (cfs)											
Watershed Slope											
		Curve Method			Conver XP-SWMM Model (or			Pipe	Pipe		
Bound-	Outfall	2 Vr	5 Vr	10 Vr	25 Vr	Factor	Ly 2 Vr	5 Vr	10 Vr	(in)	(CFS)
arv	outian	2 11	5 11	10 11	25 11		2 11	5 11	10 11	. ,	. ,
A	33	4.10	8.90	13.45	19.33	N/A	27.01	27.30	28.08	30.00	15.50
AA	29	4.13	6.63	8.91	11.76	2.00	8.26	13.25	17.81	12.00	3.50
AB	91	0.82	1.55	2.28	3.21	1.80	1.48	2.79	4.11	15.00	
AC	83	0.40	0.91	1.47	2.23	2.00	0.80	1.82	2.94	24.00	
AD	87	4.98	7.59	9.93	12.72	2.00	9.97	15.18	19.87		
AE	93	7.64	13.85	19.91	27.64	N/A	25.85	34.81	40.25	36.00	20.00
AF	92	1.92	3.36	4.73	6.51	N/A	6.25	7.10	8.89	30.00	
AG	2	7.83	18.65	30.63	47.15	N/A	44.29	47.58	50.57	36.00	35.00
AH	3	0.49	0.91	1.32	1.83	2.00	0.98	1.82	2.63		
AI	4	8.43	19.18	31.09	47.19	N/A	22.11	29.80	36.06	36.00	55.00
AI	4.1	8.43	19.18	31.09	47.19	N/A	27.12	27.57	27.97	36.00	55.00
AJ	149	3.65	7.08	10.51	14.81	1.80	6.58	12.74	18.92	15.00	
AK	5	8.70	15.23	21.44	29.49	1.10	9.57	16.76	23.58	24.00	10.00
AL	6	0.55	0.88	1.17	1.53	2.00	1.10	1.76	2.34	12.00	3.90
AM	7	0.81	1.30	1.73	2.26	2.00	1.62	2.59	3.46	10.00	
AN	61	8.53	14.57	20.18	27.03	N/A	24.98	26.65	28.56	30.00	20.00
AO	70	7.22	15.68	23.69	34.05	N/A	31.94	42.41	52.71	24.00	20.00
AP	87	0.55	1.25	2.03	3.08	2.00	1.10	2.50	4.06		
AQ	90	11.64	20.38	28.68	39.46	N/A	25.08	34.96	45.62	42.00	100.00
AR	89	1.46	2.54	3.57	4.85	2.00	2.91	5.09	7.15	15.00	2.92
AS	88	1.44	3.00	4.70	6.96	2.00	2.88	5.99	9.40	6.00	
AT	75	2.17	4.48	6.82	9.78	1.80	3.90	8.07	12.27	12.00	3.00
AU	76	4.73	9.78	14.88	21.34	N/A	36.72	45.08	55.15	36.00	45.00
AV	84	1.76	3.00	4.15	5.56	1.80	3.16	5.40	7.48	6.00	
AW	71	4.36	8.22	12.10	17.04	2.00	8.73	16.44	24.21	10.00	
AX	136	5.38	9.40	13.22	17.93	1.80	9.69	16.92	23.79	12.00	3.19
AX	138	5.38	9.40	13.22	17.93	2.00	10.77	18.80	26.43	12.00	3.84
AY	69	3.26	6.76	10.28	14.74	1.20	3.92	8.11	12.33	24.00	10.00
AZ	72	1.07	2.06	3.06	4.32	2.00	2.13	4.13	6.13	12.00	2.09
В	32	4.13	7.23	10.18	14.00	2.00	8.26	14.46	20.35	21.00	20.00
BA	68	2.12	3.83	5.51	7.65	2.00	4.23	7.67	11.02	8.00	2.20
BB	135	3.54	5.86	8.07	10.74	2.00	7.09	11.72	16.13	12.00	
BE	66	1.96	4.06	6.18	8.86	2.00	3.93	8.13	12.36	12.00	1.50
BF	65	6.33	10.12	13.51	17.67	1.80	11.40	18.22	24.32	8.00	
BG	35	1.72	3.56	5.41	7.76	N/A	47.09	55.18	67.72	36.00	40.00
BH	35	5.87	12.43	18.80	27.47	N/A	47.09	55.18	67.72	36.00	40.00
BI	25	4.59	8.89	13.20	18.60	1.80	8.26	16.00	23.76	21.00	22.00

# Table 7-3b: Unit Peak Discharge (cfs) Using Watershed Slope

		Curve Method			d Conver XP-SWMM Model (or					Pipe	Pipe
						-sion	Equivalent)			Size	Capacity
Bound-	Outfall	2 Yr	5 Yr	10 Yr	25 Yr	Factor	2 Yr	5 Yr	10 Yr	(in)	(CFS)
ary B1	25	0 43	0.78	1 1 3	1 56	1 80	0.78	1 /1	2 03	21.00	22.00
BK	117	7 70	17 52	28.40	43 10	1.00 N/A	24.05	29.45	30.19	21.00	15.00
BM	115	33 58	72.88	110 10	158 26	N/A	106 47	174 11	166 55	48.00	50.00
BN	63	0 12	0.21	0.28	0.38	2 00	0.24	0 41	0.57		
BO	64	0.13	0.19	0.25	0.32	2.00	0.26	0.39	0.50		
BP	62	0.28	0.42	0.54	0.69	2.00	0.56	0.84	1.08	12.00	
BO	60	5.76	9.66	13.38	18.15	1.80	10.36	17.40	24.09	21.00	13.00
BR	34	1.96	2.89	3.70	4.67	2.00	3.92	5.78	7.40	10.00	
BS	52	0.60	0.88	1.12	1.41	2.00	1.20	1.76	2.24	8.00	1.91
вт	54	1.42	2.13	2.77	3.52	1.90	2.69	4.04	5.26	10.00	4.24
BU	51	1.49	2.29	3.03	3.94	N/A	2.17	2.88	3.19	36.00	
BV	53	3.04	4.87	6.50	8.49	1.60	4.87	7.79	10.39	18.00	11.50
BW	49	3.81	6.50	9.00	12.06	1.00	3.81	6.50	9.00	15.00	
BX	45	2.51	4.38	6.16	8.36	1.50	3.76	6.57	9.24	15.00	8.00
BY	30	1.49	2.44	3.30	4.37	1.80	2.69	4.40	5.95	15.00	
BZ	132	0.52	1.63	2.92	4.67	2.00	1.03	3.27	5.84	12.00	
BZ	133	0.52	1.63	2.92	4.67	2.00	1.03	3.27	5.84	6.00	
С	31	5.72	10.01	14.09	19.38	N/A	16.78	21.76	27.12	30.00	35.00
CA	27	1.93	3.24	4.48	6.08	1.00	1.93	3.24	4.48	18.00	8.00
СВ	41	7.06	12.37	17.41	23.95	1.60	11.30	19.79	27.85	18.00	10.50
CE	42	14.56	23.28	31.06	40.62	N/A	43.71	55.41	65.31	54.00	90.00
CF	23	5.28	9.02	12.49	16.74	1.20	6.34	10.83	14.99	24.00	10.00
CG	24	1.87	3.10	4.26	5.68	1.80	3.37	5.57	7.67	12.00	6.33
СН	26	4.30	7.21	9.99	13.55	1.40	6.02	10.10	13.98	15.00	4.40
CI	22	15.33	27.77	39.93	55.44	N/A	22.70	24.30	2.90	30.00	20.00
CJ	8	4.88	9.45	14.03	19.77	N/A	23.10	29.40	36.30	30.00	12.00
СК	9	9.94	19.25	28.58	40.29	1.00	9.94	19.25	28.58	21.00	18.00
CL	11	20.97	38.00	54.63	75.85	N/A	30.20	31.00	31.70	36.00	35.00
CM	10	27.30	59.26	89.52	128.67	N/A	58.40	59.10	59.80	30.00	40.00
	147	1.63	3.66	5.80	8.59	N/A	8.90	8.90	8.90	15.00	4.00
	147	28.77	55./1	82.75	116.64	N/A	/1.10	/3.30	/5.20	48.00	80.00
	122	21.72	53.85	91.91	145.57	2.00	43.45	160.00	183.82	12.00	
	145	23.32	33.00	80.01 70 59	102 16	IN/A	141.80	109.00	10.30	20.00	15.00
	21	22.03	40.00	70.30	01 02		05.70	10.00	100.10	26.00	27.00
	21	20.90	50.86	00 50	01.02	IN/A	95.70	90.30	250 10	56.00	250.00
	20	0.23	2 64	4 85	7 85	1N/A	1 62	5 27	239.10 Q 70	21.00	250.00
<u>cw</u>	11/	0.01	1.62	2 20	5 51	2.00	0.02	3.27	6 50	18.00	30.00
CX	14	2.62	7.22	12 40	19.32	1.80	4 71	12 99	22 22	12.00	5 90
	1	8 77	19.22	34.84	52.84	N/A	36.93	38 40	39.87	24 00	29.00
C7	77	1.63	3 54	5 34	7.68	2 00	3 26	7 07	10.68	10.00	2 60
D	28	15.21	29.46	43.75	61.67	N/A	80.61	106.52	108.25	24.00	15.00
E	16	6.35	14.45	23.43	35.56	N/A	91.50	105.00	146.20	36.00	45.00

		Curve Method			Conver -sion	Conver XP-SWMM Model ( <i>or</i> -sion Equivalent)				Pipe Capacity	
Bound- ary	Outfall	2 Yr	5 Yr	10 Yr	25 Yr	Factor	2 Yr	5 Yr	10 Yr	(in)	(CFS)
F	18	3.31	11.51	23.45	39.22	N/A	37.40	39.50	40.10	30.00	26.00
G	36	5.73	12.43	18.78	26.99	N/A	26.90	34.70	59.60	24.00	10.00
Н	152	5.01	11.40	18.48	28.04	1.00	5.01	11.40	18.48	30.00	18.00
I	94	0.88	2.60	4.78	7.62	1.00	0.88	2.60	4.78	12.00	
J	79	3.44	7.29	11.02	16.11	2.00	6.88	14.58	22.04	12.00	
К	119	4.03	8.53	12.90	18.86	2.00	8.05	17.07	25.80	24.00	10.00
L	126	2.63	3.72	4.68	5.80	1.50	3.94	5.58	7.03		
Μ	-	0.59	0.89	1.17	1.50	1.50	0.88	1.34	1.76		
Ν	47	2.83	4.13	5.26	6.62	2.00	5.66	8.26	10.52	12.00	
Р	46	1.11	1.57	1.98	2.45	2.00	2.22	3.15	3.96	12.00	
Q	43	1.75	2.67	3.50	4.48	2.00	3.51	5.35	7.00		
R	44	1.53	2.29	2.95	3.77	2.00	3.06	4.58	5.90		
S	40	0.60	1.03	1.42	1.91	2.00	1.21	2.06	2.85		
Т	39	0.97	1.41	1.80	2.27	2.00	1.94	2.83	3.60		
V	67	1.80	3.15	4.42	6.00	1.60	2.88	5.04	7.08	10.00	1.40
V	68	1.80	3.15	4.42	6.00	1.60	2.88	5.04	7.08	8.00	2.00
W	38	7.60	14.72	21.86	30.81	2.00	15.20	29.43	43.71	30.00	
X	55	1.35	2.15	2.87	3.75	1.80	2.42	3.87	5.17	10.00	2.50
Z	5.1	10.14	18.74	27.13	37.66	N/A	17.09	21.01	27.09	30.00	40.00

Key

**XX.XX** Pipe Capacity is less than 2 yr Curve Method Unit Peak

XXXXX Pipe Capacity is less than 2 yr XP SWMM Unit Peak
 Discharge

#### High Treatment Flow Range (1/3 Unit Peak XP SWMM (or **Boundary** Outfall # Conversion **Discharge**) Factor Equivalent\*) Water Quality 2 Year 5 Year 10 Year 25 Year Flow **XP SWMM** А 33 2.48 5.37 8.12 11.67 13.53 AA 29 1.87 2.99 4.02 5.31 2.00 7.10 AB 91 0.29 0.55 0.81 1.14 1.80 1.25 AC 83 0.13 0.49 0.74 2.00 0.30 0.84 AD 87 1.66 2.53 3.31 4.24 2.00 5.87 AE 93 3.39 6.14 8.82 12.25 **XP SWMM** 7.70 AF 92 0.59 2.01 **XP SWMM** 1.04 1.46 1.43 AG 2 17.22 26.51 4.40 10.48 **XP SWMM** 17.96 AH 3 0.16 0.30 0.44 0.61 2.00 0.76 4 2.78 10.26 15.58 **XP SWMM** 9.52 AI 6.33 AI 4.1 2.78 6.33 10.26 15.58 **XP SWMM** 16.88 AJ 149 1.43 2.78 4.12 5.81 1.80 6.36 AK 5 2.65 6.53 8.99 1.10 4.64 6.27 AL 6 0.18 0.29 0.39 0.51 2.00 0.69 AM 7 0.27 0.43 0.58 0.76 2.00 1.02 AN 61 3.43 8.11 10.86 **XP SWMM** 8.39 5.86 **AO** 70 3.13 6.80 10.28 14.77 **XP SWMM** 11.31 AP 87 0.18 0.42 0.68 1.03 2.00 1.15 AQ 90 4.14 7.25 10.21 14.05 **XP SWMM** 7.57 AR 89 0.68 1.19 1.67 2.26 2.00 2.90 AS 88 0.57 1.85 2.74 2.00 1.18 3.17 AT 75 1.13 2.35 3.57 5.12 1.80 5.48 AU 76 3.67 7.60 16.57 **XP SWMM** 11.55 14.52 AV 0.59 1.38 84 1.00 1.85 1.80 2.17 AW 71 2.74 4.03 5.68 2.00 1.45 6.95 AX 136 1.79 3.13 4.41 5.98 1.80 6.89 AX 138 1.79 3.13 4.41 5.98 2.00 7.66 AY 69 1.60 3.32 5.04 7.23 1.20 5.16 AZ 72 0.36 0.69 1.02 1.44 2.00 1.75 B 32 2.15 3.77 5.30 7.30 2.00 9.26 68 0.73 1.89 2.62 2.00 BA 1.31 3.28 BB 135 1.62 2.68 3.69 4.91 2.00 6.45 BE 2.95 2.00 66 0.65 1.35 2.06 3.51 BF 65 2.19 3.50 4.67 6.10 1.80 7.40 BG 35 0.57 1.19 2.59 **XP SWMM** 19.10 1.80 BH 35 3.98 8.44 12.75 18.64 **XP SWMM** 19.10 BJ 25 0.21 0.38 0.54 0.76 1.80 0.85 BK 117 2.91 6.61 10.72 16.28 **XP SWMM** 7.69

#### Table 7-4:Water Quality Flow

Boundary	Outfall #	High T	reatment Flow	Range (1/3 U	Conversion	XP SWMM (or	
			Disch	large)		Factor	Equivalent*)
		2 Year	5 Year	10 Year	25 Year		Water Quality Flow
BM	115	10.18	22.10	33.39	47.99	XP SWMM	50.19
BN	63	0.04	0.07	0.09	0.13	2.00	0.17
BO	64	0.04	0.06	0.08	0.11	2.00	0.15
BP	62	0.09	0.14	0.18	0.23	2.00	0.32
BQ	60	2.00	3.36	4.65	6.31	1.80	7.35
BR	34	0.66	0.97	1.25	1.57	2.00	2.23
BS	52	0.20	0.29	0.37	0.47	2.00	0.67
BT	54	0.47	0.71	0.92	1.17	1.90	1.56
BU	51	0.59	0.91	1.20	1.56	XP SWMM	0.66
BV	53	1.16	1.85	2.47	3.23	1.60	3.48
BW	49	1.27	2.17	3.00	4.02	1.00	2.61
BX	45	0.86	1.50	2.11	2.86	1.50	2.75
BY	30	0.50	0.81	1.10	1.46	1.80	1.74
BZ	132	0.17	0.54	0.97	1.56	2.00	1.62
BZ	133	0.17	0.54	0.97	1.56	2.00	1.62
С	31	2.93	5.14	7.23	9.95	XP SWMM	5.52
СА	27	0.64	1.08	1.49	2.02	1.00	1.31
СВ	41	3.01	5.27	7.42	10.21	1.60	10.37
СЕ	42	3.96	6.33	8.45	11.05	XP SWMM	13.68
CF	23	1.84	3.14	4.35	5.82	1.20	4.54
CG	24	0.69	1.14	1.57	2.09	1.80	2.47
СН	26	1.43	2.40	3.32	4.50	1.40	4.08
CI	22	3.80	6.88	9.89	13.73	XP SWMM	19.90
CJ	8	3.14	6.09	9.05	12.75	XP SWMM	7.60
СК	9	5.17	10.00	14.86	20.94	1.00	12.74
CL	11	5.93	10.75	15.45	21.45	XP SWMM	24.50
СМ	10	9.36	20.32	30.69	44.12	XP SWMM	36.80
CN	17	0.84	1.89	2.99	4.43	XP SWMM	8.90
CO	147	9.59	18.57	27.58	38.88	XP SWMM	52.70
СР	122	7.79	19.31	32.96	52.20	2.00	56.13
CQ	19	16.77	38.15	61.84	93.87	XP SWMM	58.30
CS	145	3.08	6.53	9.88	14.44	XP SWMM	18.00
CT	21	8.21	15.47	22.77	32.06	XP SWMM	49.40
CU	20	13.50	28.60	43.24	63.20	XP SWMM	84.50
CV	113	0.27	0.88	1.62	2.62	2.00	2.69
CW	114	0.16	0.54	1.10	1.84	2.00	1.81
CY	1	5.31	11.63	21.09	31.99	XP SWMM	12.53
	77	0.60	1.30	1.96	2.81	2.00	3.33
D	28	6.61	12.80	19.01	26.79	XP SWMM	24.39
Ł	16	2.53	5.77	9.35	14.19	XP SWMM	35.40

Boundary	Outfall #	High Ti	reatment Flow Disch	Range (1/3 U arge)	Conversion Factor	<b>XP SWMM (or</b> Equivalent* <b>)</b>	
		2 Year	5 Year	10 Year	25 Year	•	Water Quality Flow
F	18	1.15	4.00	8.16	13.64	XP SWMM	31.40
G	36	2.58	5.61	8.47	12.17	XP SWMM	11.60
Н	152	1.38	3.13	5.07	7.70	1.00	4.32
I	94	0.29	0.87	1.59	2.54	1.00	1.32
J	79	1.15	2.43	3.67	5.37	2.00	6.31
К	119	1.34	2.84	4.30	6.29	2.00	7.39
L	126	0.88	1.24	1.56	1.93	1.50	2.10
М	-	0.20	0.30	0.39	0.50	1.50	0.52
N	47	0.94	1.38	1.75	2.21	2.00	3.14
Р	46	0.37	0.52	0.66	0.82	2.00	1.19
Q	43	0.58	0.89	1.17	1.49	2.00	2.07
R	44	0.51	0.76	0.98	1.26	2.00	1.76
S	40	0.20	0.34	0.47	0.64	2.00	0.83
Т	39	0.32	0.47	0.60	0.76	2.00	1.07
V	67	0.60	1.05	1.47	2.00	1.60	2.05
V	68	0.60	1.05	1.47	2.00	1.60	2.05
W	38	2.53	4.91	7.29	10.27	2.00	12.50
X	55	0.45	0.72	0.96	1.25	1.80	1.52
Z	5.1	3.38	6.25	9.04	12.55	XP SWMM	6.06

Boundary	Low Treatment Flow Range						
	2 Year	5 Year	10 Year	25 Year			
Α	1.37	2.97	4.48	6.44			
AA	1.38	2.21	2.97	3.92			
AB	0.27	0.52	0.76	1.07			
AC	0.13	0.30	0.49	0.74			
AD	1.66	2.53	3.31	4.24			
AE	2.55	4.62	6.64	9.21			
AF	0.64	1.12	1.58	2.17			
AG	2.61	6.22	10.21	15.72			
AH	0.16	0.30	0.44	0.61			
AI	2.81	6.39	10.36	15.73			
AJ	1.22	2.36	3.50	4.94			
AK	2.90	5.08	7.15	9.83			
AL	0.18	0.29	0.39	0.51			
AM	0.27	0.43	0.58	0.75			
AN	2.84	4.86	6.73	9.01			
AO	2.41	5.23	7.90	11.35			
AP	0.18	0.42	0.68	1.03			
AQ	3.88	6.79	9.56	13.15			
AR	0.49	0.85	1.19	1.62			
AS	0.48	1.00	1.57	2.32			
AT	0.72	1.49	2.27	3.26			
AU	1.58	3.26	4.96	7.11			
AW	1.45	2.74	4.03	5.68			
AX	1.79	3.13	4.41	5.98			
AY	1.09	2.25	3.43	4.91			
AZ	0.36	0.69	1.02	1.44			
В	1.38	2.41	3.39	4.67			
BA	0.71	1.28	1.84	2.55			
BB	1.18	1.95	2.69	3.58			
BE	0.65	1.35	2.06	2.95			
BF	2.11	3.37	4.50	5.89			
BG	0.57	1.19	1.80	2.59			
BH	1.96	4.14	6.27	9.16			
BI	1.53	2.96	4.40	6.20			
BJ	0.14	0.26	0.38	0.52			
BK	2.57	5.84	9.47	14.37			
BM	11.19	24.29	36.70	52.75			

Boundary	ary Low Treatment Flow Range						
	2 Year	5 Year	10 Year	25 Year			
BN	0.04	0.07	0.09	0.13			
BO	0.04	0.06	0.08	0.11			
BP	0.09	0.14	0.18	0.23			
BQ	1.92	3.22	4.46	6.05			
BR	0.65	0.96	1.23	1.56			
BS	0.20	0.29	0.37	0.47			
BT	0.47	0.71	0.92	1.17			
BU	0.50	0.76	1.01	1.31			
BV	1.01	1.62	2.17	2.83			
BX	0.84	1.46	2.05	2.79			
BY	0.50	0.81	1.10	1.46			
BZ	0.17	0.54	0.97	1.56			
С	1.91	3.34	4.70	6.46			
CA	0.64	1.08	1.49	2.03			
СВ	2.35	4.12	5.80	7.98			
CE	4.85	7.76	10.35	13.54			
CF	1.76	3.01	4.16	5.58			
CG	0.62	1.03	1.42	1.89			
СН	1.43	2.40	3.33	4.52			
CI	5.11	9.26	13.31	18.48			
CJ	1.63	3.15	4.68	6.59			
СК	3.31	6.42	9.53	13.43			
CL	6.99	12.67	18.21	25.28			
СМ	9.10	19.75	29.84	42.89			
CN	0.54	1.22	1.93	2.86			
СО	9.59	18.57	27.58	38.88			
СР	7.24	17.95	30.64	48.52			
CQ	7.77	17.69	28.67	43.52			
CS	7.34	15.56	23.53	34.39			
СТ	6.99	13.16	19.38	27.27			
CU	9.42	19.95	30.17	44.09			
CV	0.27	0.88	1.62	2.62			
CW	0.16	0.54	1.10	1.84			
CY	2.92	6.41	11.61	17.61			
CZ	0.54	1.18	1.78	2.56			
D	5.07	9.82	14.58	20.56			
E	2.12	4.82	7.81	11.85			
F	1.10	3.84	7.82	13.07			
G	1.91	4.14	6.26	9.00			
Н	1.67	3.80	6.16	9.35			

Boundary	Low Treatment Flow Kange							
	2 Year	5 Year	10 Year	25 Year				
Ι	0.29	0.87	1.59	2.54				
J	0.66	1.40	2.11	3.08				
K	1.08	2.29	3.46	5.06				
L	0.88	1.24	1.56	1.93				
Μ	0.20	0.30	0.39	0.50				
Ν	0.91	1.32	1.69	2.12				
Р	0.37	0.52	0.66	0.82				
Q	0.58	0.89	1.17	1.49				
R	0.51	0.76	0.98	1.26				
S	0.20	0.34	0.47	0.64				
Т	0.32	0.47	0.60	0.76				
V	0.58	1.02	1.43	1.95				
W	2.30	4.45	6.60	9.31				
X	0.45	0.72	0.96	1.25				
Ζ	2.14	3.95	5.71	7.93				

# Steps in Chapter 7 of the MDEQ Soil Erosion and Sedimentation Control Training Manual

### 1. Identify Soil Type

• All soils within the City Limits are assumed to be Hydrologic Soil Group B

#### 2. Evaluate Surface Conditions

• Use **Table 7-1 in Appendix E**: each boundary has the areas broken up into the number of acres considered pavement, residential, and forested, along with the calculated Average Runoff Curve Number

### 3. Determine Runoff Volume

• Use **Table 7-2 in Appendix E** for the expected runoff volume for the 2 year, 5 year, 10 year, and 25 year storm

### 4. Determine Unit Peak Discharge

- Use **Table 7-3a in Appendix E** for the estimated unit peak discharge rate using the average pipe slope for the 2 year, 5 year, 10 year, and 25 year storm
- Use **Table 7-3b in Appendix E** for the estimated unit peak discharge rate using the average watershed slope for the 2 year, 5 year, 10 year, and 25 year storm

#### 5. Determine the Treatment Flow Range

- Use **Table 7-6 in Appendix E** for the high end of the treatment flow range (1/3 of the higher unit peak discharge, using pipe slope versus watershed slope) for the 2 year, 5 year, 10 year, and 25 year storm
- Use **Table 7-5 in Appendix E** for the low end of the treatment flow range (1/3 of the lower unit peak discharge, using pipe slope versus watershed slope) for the 2 year, 5 year, 10 year, and 25 year storm

#### 6. Design Stormwater Treatment System

- Design the stormwater treatment system based on the determined treatment flow range
- Examine low impact development options as well as conventional BMP treatment options

# APPENDIX F

Environmental Regulations

## Traverse City Ground-Water Protection and Stormwater Control Ordinance Guidelines

#### PREAMBLE

The guidelines were developed to be used in conjunction with the Traverse City Ground-Water Protection and Storm-Water Runoff Control Ordinance. These guidelines will be updated as needed to reflect the new technology and best management practices available to deal with ground-water protection and storm-water runoff on sites within the City of Traverse City.

#### A. <u>GROUND-WATER PROTECTION</u>

- 1. General-purpose floor drains shall be allowed only if they are connected to: an on-site holding tank; to the public sanitary sewer system with approved oil separator system or; a system authorized through a State ground-water discharge permit.
- 2. Secondary containment for above-ground areas where hazardous substances and polluting materials are stored or used shall be provided. Secondary containment shall be sufficient to store the substance for the maximum anticipated period of time necessary for the recovery of any released substance.
- 3. Outside storage of hazardous substances and polluting materials shall be prohibited except in product-tight containers which are protected from weather, leakage, accidental damage and vandalism and are stored within a secondary containment system.
- 4. Out-of-service abandoned tanks shall be emptied and removed in accordance with the State of Michigan Underground Storage Tank Rules.

#### B. <u>STORM-WATER RUNOFF CONTROL FACILITIES</u>

- 1. Earth changes and related improvements shall be designed, constructed and maintained to minimize the extent and duration of earth disruption and to protect the natural environment.
- 2. On-site storm-water runoff control facilities which protect water quality and prevent unwanted flooding shall be required for all sites. Storm-water runoff control facilities may include but are not limited to detention basins, retention ponds, infiltration trenches, infiltration basins, drainage wells, grass swales, grass swales with check dams, filter strips and other facilities.
- 3. Storm-water control facilities shall be planned and designed to reproduce the pre-development hydrology of the site to the maximum possible extent.
- 4. Infiltration trenches, perforated pipe and infiltration basins shall be encouraged provided that (a) sediment is removed from storm-water runoff before runoff reaches the infiltration facility and (b) adequate provisions for facility maintenance have been made.
- 5. Infiltration basins shall be lined with a vegetative cover designed to slow the flow of runoff and to trap pollutants. Sediment traps, catch basins and/or sediment basins shall be provided for the purpose of collecting sediment before storm water reaches the infiltration basin or trench. Infiltration facilities shall be designed to distribute storm-water runoff volume evenly over the floor of the basin or trench and to prevent ponding or standing water.

- 6. Drainage wells, commonly known as dry wells, may be used as a storm-water control method if the use of storm-water retention or detention basins, either on- or off-site, is not feasible. All drainage wells must provide the following: (1) catch basins, sediment basins, silt traps or vegetative filter strips to remove sediment from storm water flowing to the drainage well, (2) an approved overflow system and (3) adequate provisions for maintenance.
- Detention basins shall be designed as extended detention basins to detain runoff on the site for 24 hours or more to allow for maximum settling and removal of suspended solids and other pollutants. Vegetation shall be installed and maintained in the basin to help absorb pollutants.
- 8. When a downstream outlet (open channel or storm sewer) is unacceptable, minimum detention, retention and infiltration basins on the site shall have the storage capacity to hold the increase in runoff volume generated by the earth change. The required volume shall be calculated by comparing the undeveloped condition to the developed condition for a 25-year 24-hour frequency storm event. Provisions for overflow shall be made. In general, this paragraph shall apply to larger open areas where storm sewers do not exist.
- 9. If a quantity or capacity problem exists with an outlet as may be determined by the City Engineer, the peak rate of discharge from a site shall be as determined by the City Engineer. It should be assumed for design purposes, that such problems exist with almost all storm sewers within the City. However, in general, such runoff rate will normally not be less than the pre-developed rate, and required on-site storage shall not be greater than that required for a 10-year frequency storm event with 24 hour minimum detention. In general, a short hand design method of a 2<sup>1</sup>/<sub>2</sub>" rain over all impervious surfaces may be used. Drainage facilities for quantity purposes shall be designed to pass a 10-year frequency storm event.
- 10. As a minimum, all drainage control on all multi-family, commercial and industrial sites when developed shall be designed to allow infiltration or to retain in some acceptable manner all small storms or first-flush runoff which shall be the first one-half (1/2") inch of runoff. The City Engineer, at the written request of the Michigan Department of Environmental Quality, may reduce the minimum infiltration retention requirements if it is determined that the introduction of surface storm-water infiltration into the groundwater would increase and/or exacerbate the existing known pollution at a site.
- 11. A two-stage design for detention and retention basins shall be used on sites where parking lots and other impervious surfaces exceed five (5) acres in size as well as for other sites identified by the City Engineer or the Michigan Department of Environmental Quality as requiring special protection for water quality purposes. In such cases, a meeting will be set up between the property owner/developer and City Engineer to discuss details of design and requirements.
- 12. The use of Swirl Concentrator technology or other "new technology" systems in which the removal of a minimum of 80% of pollutants, including grit, oil, hydrocarbons and floating contaminants for on-site storm-water runoff control facilities, is encouraged. Where these "new technology" systems are designed within projects for areas where off-site receiving and conveyance facilities have adequate capacity, the City Engineer may reduce or eliminate on-site retention/detention requirements.
## C. <u>STORM-WATER CONVEYANCE FACILITIES AND RECEIVING WATERS</u>

- 1. Unless otherwise approved, storm-water runoff shall be conveyed through swales, vegetated buffer strips or other approved facilities so as to decrease runoff velocity, to remove pollutants, to allow suspended sediments to settle and to encourage infiltration.
- 2. When storm sewers are determined to be necessary by the City Engineer, the applicant shall design the drainage system to mitigate any harmful impact on water quality by using appropriate structural devices or other best management methods.
- 3. Drain spouts from roofs and sump pumps from basements shall be directed to on-site swales, detention basins or other measures designed to slow the flow of storm-water runoff to non-erosive velocities whenever possible.

### D. <u>SITE CONSTRUCTION CONTROL</u>

- 1. All earth changes shall be designed, constructed and maintained in such a manner as to minimize the extent and duration of earth disruption.
- 2. Soil erosion control facilities shall be designed to remove sediment from storm water before the storm water leaves the site of the earth-change activity.
- 3. Vegetative stabilization or other soil erosion control measures shall be installed and maintained throughout the development process. Critical areas exposed during construction shall be protected with temporary vegetation, mulching, filter fences or other methods of stabilization.
- 4. Storm-water runoff control and soil erosion control measures shall be installed before grading, filling or removal of vegetative cover is initiated.
- 5. Filter fences and other soil erosion control facilities installed at the perimeter of a development site shall be installed at least five (5') feet from the property boundary to allow for on-site maintenance.
- 6. Fill slope grades on the perimeter of the graded area adjacent to lakes, streams, wetlands and storm-water ponds, or adjoining properties shall not have a slope steeper than a 33 percent rise (3 feet horizontal to 1 foot vertical) unless approved by the City Engineer.
- 7. Retention and detention basins shall have an emergency overflow system. The overflow system shall be designed to accommodate flow from the 100-year storm event, or as otherwise required by the Michigan Department of Environmental Quality.
- 8. Side slopes of any storm-water retention or detention basin shall be no greater than 3:1 (horizontal to vertical) so as to prevent soil erosion and allow for basin maintenance.
- 9. Storm-water basins with depths greater than three feet shall have one or more of the following safety features: (a) Safety ledges at the basin perimeter which are at least eight feet wide for every three feet of vertical height; (b) aquatic vegetation surrounding the basin which discourages wading; or (c) fencing to prevent unauthorized access to the basin.
- 10. Soil erosion control measures shall be maintained throughout the duration of the earth change including the later stages of development. Maintenance activities include but are not limited to

removal of accumulated sediment, structural repairs, reseeding or replacement of vegetative cover and lawn mowing.

- 11. Removal of natural vegetation and tree roots within twenty five (25) feet of the ordinary high water mark of any wetland, lake or stream shall be prohibited unless approved for recreational uses. A lake or stream buffer area greater than twenty five (25) feet may be required by the City Engineer if necessary for soil erosion control purposes.
- 12. Grading of land or other earth changes shall not be permitted in any flood plain unless approved by the Michigan Department of Environmental Quality as well as the City Engineer. Further, all approved grading of land or other earth changes within a flood plain or within the required buffer area of a lake or stream shall not reduce the storage capacity of the flood plain and shall meet the requirements of the City Zoning Ordinance.

## E. DESIGN PARAMETERS FOR FACILITY CONSTRUCTION

- 1. Design parameters for ground-water protection, storm-water management and soil erosion facilities shall follow best management practices as identified by the City Engineer, the Grand Traverse County Soil Conservation Service and/or the Michigan Department of Environmental Quality.
- 2. The Michigan Department of Environmental Quality "Urban Storm-water Best Management Practices Manual" will be used as a reference along with other manuals such as "Controlling Urban Runoff" by the Metropolitan Washington Council of Governments and the Small Business Guide to Secondary Containment by the Clinton River Watershed Council.

## Public Health Code (Excerpt : Act 368 of 1978) Public Act 507 of 2002

# 333.12541 Testing and evaluating quality of water at bathing beaches; purpose; posting sign; injunction; definitions.

Sec. 12541.

(1) The local health officer or an authorized representative of the local health department having jurisdiction may test and otherwise evaluate the quality of water at bathing beaches to determine whether the water is safe for bathing purposes. However, the local health officer or authorized representative shall notify the city, village, or township in which the bathing beach is located prior to conducting the test or evaluation.

(2) If a local health officer or an authorized representative of a local health department conducts a test or evaluation of a bathing beach under subsection (1), within 36 hours of conducting the test or evaluation, he or she shall notify the department, the city, village, or township in which the bathing beach is located, and the owner of the bathing beach of the results of the test or evaluation.

(3) The owner of the bathing beach shall post at the main entrance to the bathing beach or other visible location a sign that states whether or not the bathing beach has been tested or evaluated under subsection (1) and, if the bathing beach has been tested, the location of where test results may be reviewed. Open stretches of beach or beaches at road ends that are not advertised or posted as public bathing beaches do not need to have signs posted.

(4) If a local health officer or authorized representative of the local health department conducts a test or evaluation under subsection (1) and, based upon the standards promulgated under section 12544, the health officer or the authorized representative determines that the water is unsafe for bathing, he or she may petition the circuit court of the county in which the bathing beach is located for an injunction ordering the person owning or operating the bathing beach to close the bathing beach for use by bathers or ordering other measures to keep persons from entering on the bathing beach. Upon receipt of a petition under this subsection, the court may grant an injunction if circumstances warrant it.

(5) As used in this section:

(a) "Bathing beach" means a beach or bathing area offered to the public for recreational bathing or swimming. It does not include a public swimming pool as defined in section 12521.

(b) "Department" means the department of environmental quality.

History: 1978, Act 368, Eff. Sept. 30, 1978 ;-- Am. 2002, Act 507, Eff. Mar. 31, 2003 Popular Name: Act 368

# APPENDIX G

Stormwater Treatment Maps







# APPENDIX H

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Barris Correction and Andreas									
EVVASIVE PLANIN:		ie 🗋 Rare	• L	Partial	coverage	L Ext	ensive coverage	:una	1980
S ERKAM SHADE PROVE	ED? Not	ne 🔛 Parti	ា [	- Fuil	WHIL	ANDS PRESI	NT? No	Ves.	Unknown
POTENTIAL RESTORATI	ON CANDIDA	IIK 🗍 Activ	e reforestar	tion: 🕅 Gi	recurvay d	kaign 🗌 N	aturul regenera	tion 🗋 Lor	/asives removal
RESTORABLE AREA LT nogo Length (fl):	5 RT	REFORESTA POTENTIAL (Circle #)	TION :	Impacied where the not appear specific pu area avait	area on pub ripertan are r to be used urpose; plen able for plan	nic fand inter ta does out i for any pre thy α' pur ting pla	nacted area or eith bild or private tand t samty used for a s pose; available ere nding adequete	er Imp hot is Iani pecific enc a for Feat ava	acted area on private I where react Building coachment or other area significantly limits lable area for planting
Width (ft): :=					5	4	3	2	1
POTENTIAL CONFLICTS V Poeo'unsafe access to sit	w <b>⊺TH REFO</b> B ≌ 📋 Existin	SESTATION g impervious co	. 🗌 Wi wur 🗌 Se	idespread vero anim	invasive j al împace	plants 🔲 s (deer, beav	Pelentral contac er} 🗌 Other:	nination [	Lack of sun
NOTES:									

					Storr	n Wate	r Outfails	0	Γ
WATERSHED/SUBS	HED:		D	MTE: <u>10</u>	128 16	Assi	SSED BY:	20 89	
SURVEY REACH I	D:	TIME:AMP	PM P	ното D:	(Camera-Pic	9 109	1. 1# 1	094	
SID. ID (Consistion of	6 OT	LAT_	_ HLONG	•	"	LMK		GPS: (Unit II.	044
BANK: LT MRT Hea FLOW: None Tric Substantial	id Closed pipe	MATERIAL: Concrete PVC/Plastic Other: Concrete ::	Motal 5	HAPK Circular Elliptical Other: Trapezoie Parabolic	Single	Diamete Diamete th:	SIONS : #: <u>\$ (in</u> <u>\$ (in)</u> (in)	SUBMERGE	ED:
CONDITION: Nune Chip/Cineked Peeling Paint Corresion Orier: 8LD	Core Core Core Core Core Core Core Core	Other:		] Other: RCGIE DE [ None ] Nonnal ] Inhibited ] Excessive [ Other:	NSITY:	Bottom):_ Bottom):_ Brow; Other: Good Suds Other:	UALITY: 1 Oddars 1 Algee 1	WTII: Non ge   Green	nia je Oila
POR COL PLOWPAG OVLY PLO OTHER IF CONCERNS: N POTENTIAL RESTO 00	RATION CANDED	Aone Slight Cloud; Aone Slight Cloud; fono Sewage (taile riplastic bags) I niomatice I ATE Dischotge inv Storm water re	Grey ness ( trapper, cte.) Dumping (bu Sauk Ervsiun Sauk Ervsiun trofit	Yellow L Doudy L dk) L Stream do Other:	Green C C Opaque Potroleum (o. Excessive Se Ocher: A C	range L Laheen) dimentat DS Z REMO Lecal sir	Red C C	nher; Ther; The <i>N (</i> )[7- outfall stabilizat	tion
If yes for daylighting Longth of vegetative of lastonuwater current Yes No No No OUTFALL SEVERITY; (chock 2)	g: over from outfall: y controlled? far investigated heavy decharge with a throng artis . The anou compared to the smou strong risk inte smou strong risk internet form	fi Type Land Atea defined color antion a ntof discharge is agriftent f. of normal flaw in receiving as to be having a dissum. S	of existing v Use descript available: Smithatoria discharge is flow and any	regetation: ion: go, flow mos s e color and rery small con impact appea	chy clean and oderh or open, the amoun opened to the stream is to be minor if the	tes. If the t of mis base alized.	Slope; Cuthi dose discharge; st of causing a	c rot have dry weather la ring; or appenance ny erosion problems	21 108 %
SKETCH/MADN;	ja ja	- Co	24	F	энытая: РАСКОО	13 —	16	1	
					Rep	DRTED TO	AUTHORIZI	ES: YES 1	NG

Normality       WiresumSustants:       Date:       Link:       Aussense         SNAFT       TINNE:		
SURVEY REACH ID:       Wreven/Sussep:       Date:       1/2/2/1/L       Asseption by the second		Reach Lavel Assessment RCH
82/47       TMME:	SURVEY REACH ID: WIRSHD/SUBSED:	DATE: 10 / 26 // ASSESSED BY:
LAT	START TIME:	EAD THRE: AMPM LMR: GPS ID:
DBSCLIPTION:     DESCRIPTION:     DESCRIPTION:     DESCRIPTION:     THE CLASS       None     All Instruction     Gettody alla     PRESTRY CONNETTON:     Description     Description       SERBORRINGGI AND LASS:     Individual Commercial UCIONETRONS (Index option)     Description	LATU LosgU	LAT_0_1_BLONG_0_1_B
RAIN IN LAST 24 HOURS [ Henry rain ] Stordy allo       PRESTRY CONNECTIONS ] Heavy rain ] Lotanzitient         None       A incremented [ Frace       Prace         SERBAGINONCGI AND LASK [ Confightial ]       Commental Life [ Prace       Prace         SERBAGINONCGI AND LASK [ Confightial ]       Commental Life [ Prace       Prace         A VERAGE CONFIGNON (check supplemental Life (spectro in the new prace) in the new prace of ADI (D, B). (B). (D, Confightial B) and the new prace of ADI (D, B). (B). (D, Config and the new prace) and (D) (D, B). (D, Config and the new prace) and (D) (D, B). (D, Config and the new prace) and (D) (D, Config and the new prace) and (D) (D	DESCRIPTION :	DESCRIPTION: 10/20 - 10/68
Disone       A intermitted       Trace       I Trace       Overant       Partly cloudy         Stitubulummarki AND Jask       I intermitted       I Clear       Overant       Partly cloudy         Stitubulummarki AND Jask       I intermitted       I Clear       Overant       Partly cloudy         AVTERAGE CONDITIONS (does applicable)       Chonsell       I Chon Residential       Other:       Orbit:         AVTERAGE CONDITIONS (does applicable)       Stitubulummarkit       I Coope       Pastare       Orbit:         AVTERAGE CONDITIONS (does applicable)       Stitubulummarkit       Stitubulummarkit       I Coope       Pastare       Orbit:         Canaves (intermarket)       I Coope       Stitubulummarkit       I Coope       I Stitubulummarkit       I Coope       I Stitubulummarkit       Stitubuluummarkit       Stitubuluuuuuuuuuuuuuuuuuuuuuu	RAIN IN LAST 24 HOURS   Heavy rain   Stordy rain	PRESENT CONDITIONS
Senteolinenaci A ND 3.581 <pre>             Get course [] Partur</pre> Cop             [] Porture	O None - A Intermittent D Trace	!! Clear □ Trace □ Overvast □ Partly cloudy
AVERIAGE CONDITIONS (elses applicable)     REACH SETTCH AND STRE INPACT TRACKING       Base ROW AS*/s     0.025%     0.95%-75%       CALNEL WITTELSO %     0.95%-75%       DOULDANT KURSTRATE     0.025%       Fillediay (files or calua)     0.065ke (2.5 10°)       Caravel (0.1-2.5°)     0.065ke (2.5 10°)       Caravel (0.1-2.5°)     0.065ke (2.5 10°)       Caravel (0.1-2.5°)     0.065ke (2.5 10°)       Stained (elses autority or clored)     0.09e quo (autority)       Other (obscinit), dos;     0.09e quo (autority)       Aquartu: PLANTX     Attached:       Fibi Basits condition:     0.09e quo (autority)       Other (obscinit), dos;     0.09e quo (autority)       Monthy Thous and (2.50%)     0.000       Transmin     Downeuting       Basit Scott     Basit Scott       Oraven:     Downeuting       Distribution (autority)     0.09e quo (autority)       Other (obscinit), dos;     0.000       Craven:     Downeuting       Distribution (autority)     0.000       Craven:     Basit Scott       Other (obscinit)     0.000       Craven:     Basi	SURROHNINKGLAND LSN: Diedustriki D'Commercial D'Golf course Depark	Urbon/Residential      Suburban/Res      Forested      Institutional     Crop      Pasture      Other:
BASE DOW AS%   0-25%   54%-75%   75-108%   75-	AVERAGE CONDITIONS (check applicable)	REACH SKETCH AND STIE IMPACT TRACKING
Downwart Sunstrate PSilidaly (fao or sluk) Stand (gitty)       Cobble (2.5 10") End (gitty)         Chavel (0.1-2.5")       Bed rock         Water Charty       Clear Clear Turbid (supendarestor) Stand (gitty)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Other (device), dogs, namewith, robored)       Dog (u c /mlhy)         Acutaru: PLANIX       Attached: Clear (Dube)         Mottvo STREAM       Stande (Dilen, Br R) Bolico         Mottvo STREAM       Stande (Dilen, Br R) Bolico         Drankets:       Stande (Dilen, Br R) Bolico         Drankets:       Breadenting Brank Solure Blank Solure Blank Solure Blank Solure Blank Solure Blank Solure Blank Solure Blank Solure Blank Solure Blank Accressibilitor Canamica       Phot TOS: Phot TOS: Phot TOS: Phot TOS: Phot Solure Solure Blank Solure Brank Solure Brank Solure Blank Accressibilitor Brank Accressibilit	BASE FLOW AS% □ 0-25% □ 50%-75% CHANNEL WIDTH 1725-50 % □ 75-100%	Simple planar (Swith of enrory reach, Drack locations and His for all site impacts within the survey reach (OI, SR, IB,SC, (OT, TP, MI) or well as any additional features (download memory download context) or action.
28 State(gritty)       □ Cooble (25 - 10°)         □ Gravel (0.1-2.57)       □ Bed rock         WATER CLARITY       Que number of (0.1-2.57)         □ State (gritty)       □ Ope que (nully)         ○ Oher (dewise)       Que number of (0.1-2.57)         □ State (gritty)       □ Ope que (nully)         ○ Oher (dewise)       □ Ope que (nully)         ○ Oher (dewise)       ○ Ope que (nully)         ○ Ope que (nully)       ○ Ope que (nully)      <	DOMINANT SUBSTRATE	Sector as a contract of the sector of the se
□ Ciraver (0.1-2.57)       □ Bid rock         WATER CLARITY       □ Clear         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Other (dec., subword): redown)       □ Ope quo (subby)         □ Ope quo (subby)       □ Ope quo (subby)         □ Ope quo (s	ar Subctay (the or slick)     □ Cobble (2.5 - 10 <sup>n</sup> )     U: Boulder (>10 <sup>n</sup> )	
WATER CLARITY       Clear       Thurbid (supercludencetor)         Staimed (steep, superclutencetor)       Ope que (suffy)         Other (steep, superclutencetor)       Ope que (suffy)         Aquartic Plantix       Attached:       mone (some ) lots         STREAM       Floating:       mone (some ) lots         Withing Construction       Stream (some ) lots         Withing Construction       Stream (some ) lots         Withing Construction       Monty shuded (>75% coverage)         Stream (some )       Device utiling         Device utiling       Beak Sulfure         Bank Sour       Book Sulfure         Dividening       Bank Sour         Dividening       Book Sulfure         Difforton Took       Retacentric scens	□ Gravei (0.1-2.5") □ Bed rock	
Stained (clear, namonity refered)       Opeque (nullhy)         Other (clear, namonity refered)       Opeque (nullhy)         Oduarit: Planting       none () some () lots         NSTREAM       Floating: mone () some () lots         Windows Rive, No.       () Addity shedde (>25% coverage)         STREAMS BADING       () Addity shedde (>25%)         Oraving       () Downeuting         Driving       () Bad sour         Driving       () Driving         Bad sour       () Driving         Drivi	WATER CLARITY BClear Durbid (sugardial metter)	
CHORE (Generating, open)         Aquartic PLANTS         Aquartic PLANTS         Fisialing:         INSTREAM         Fisialing:         INSTREAM         State (Addition of)         Matter State (Construction)         INSTREAM         State (Construction)         INSTREAM         State (Construction)         INSTREAM         State (Construction)         INSTREAM         Matter states         INSTREAM         Instruction         Instruction      <	□ Stained (clear, naturally rolored) □ Opeque (milly)	
Aquartic PLANTS Attached: in none (g some 1) ots INSTREAM Exating: in none (g some 1) ots Multiple rook (Fish Bosver (Down Another Stream) (Fish Bosver (Down Another Stream) (Fish Bosver (Down Another Stream) (Fish Bosver (Down (Construction) (Fish Bosver (Down (Construction) (Fish Bosver (Down (Construction) (Fish Bosver (Down (Construction) (Fish Bosver (Fish B	U Of Def fatomacinia, rojes,	
WILDWARE CONSTREAM       Frain Bis Source (10)s         WILDWARE CONSTREAM       Fish Bis Ver Dour         Notive Streams Badrixe       Monity shudde (25%)         STREAMS BADRYC       Monity shudde (25%)         Breams Badrixe       Downeutling         Databade (22%)       Bed sour         Drivense       District Streams         Drivense       Bed sour         Drivense       Bed sour         District Streams       Stope führe         District Streams       Rivense Streams         Bank sour       (ft)         District Streams       Reactifier Forestad Tore         Reactifier Streams       Streams         Bank sour       (ft)         Bank sour       (ft)         Bank sour       (ft)         Bank sour       (ft)         Bared is matedis, sour       (ft)	AQUATIC PLANTS Attached: LI none & some Li lots	XX
WILDLASE & OR       Anothe Break       Figh       Besker       Dour         Anothe StreEAst       Notify shuded (≥75%)       Dour         STREAMS BADING       Distrated (≥25%)         STREAMS BADING       Distrated (≥25%)         Charwier,       Downeutling         Drivanics       Bed secur         Bank soour       Bed secur         Bank soour       Bonk Skince         Drivanics       Height, Lf bank         Charwier,       Bonk Skince         Drivanics       Height, Lf bank         Charwier,       Beight, Lf bank         Charwier,       Boltom         Charwier,       Beight, Matters         Boltom       (ft)         Boltom       (ft)         Boltom       Withell, Matters         Boltom       Streams banks         Boltom       Streams bankstak         Boltom       Stre	(Evidence of)	
Image: Stream Stability () Collect: ST(S) (S)         STREAMS BADING: STabled (>25%)         Image: Stream Stability () Devinculting         Devinculting         Downeutling         Dramming:         Dramming:         Dramming:         Dramming:         Dramming:         Dramming:         Dramming:         Dramming:         Balk Scour         Stream Stability:         Unknown         Augrenting         Balk Scour         Stream Stability:         Unknown         Mage: Stability:         Unknown         Mage: Stability:         Crannel:         Height:       L / Dank         Z: S         (f)         Downensions         RT bank       Z: S         (f)         diacerk band         diacerk band         diacerk band	AROUND STREAM	
STREAMS BADING       Entitivery (\$50%)         Partially shaded (\$25%)         Partially shaded (\$25%)         Binsbaded (\$25%)         Cravern.       Downeuting         Balk Surre         Fiesdeuting       Balk Surre         Cravern.       Downeuting         Driven uning       Balk Surre         Cravern.       Downeuting         Driven uning       Balk Surre         Respective respectiv	Martin childed (>75% converse)	
Senior sumace)       D'artially shaded (< 25%)	STREAMS BADING KILLIF (250%)	\ <i>A</i> ₩ <sub>14</sub>
Criassing, Downetting Bed scaur DYNAMICS Diversing Bank Stillure Bank Solure Bank Solure Bank Solure Bank Solure Bank Solure Bank Solure Channel, Height L / bank Z 5 (f) Diversions RT bank Z 5 (f) Photos: Reach Accessibility Reach Accessibility Reach Accessibility Diversions British, Solure Reach Accessibility Diversions British, Solure Reach Accessibility Reach Accessibility Reach Solure Britishe anithis Solution Interest big to Strate for stand Strate for stand big stand Strate for strate for stand big stand Strate for strate for stand big stand Strate for	(weater sums(x) □ Partially shaded (≥25%) □ Unshaded (< 25%)	
Charlow Construction       Wideming       Bank Stiture         DYNAMICS       Headcutting       Bank Stiture         Unknown       Apgrading       Slope fülture         Unknown       Sed. deposition       Commutizeri         Channelle       Height: L / bank       Z · 5 (ft)         Developmentations       RT bank       Z · 5 (ft)         Reach Accressibility       (ft)       Top       (ft)         Developmentations       Reach Accressibility       webood measing the stoche accessibility       PHOTOS:         Reach Accressibility       webood measing the stoche access to gits       webood measing the stoche access to gits       PHOTOS:         Development using state of maximum encasts to gits and the stoche access to gits of maximum encasts to gits active acces to gits of each back beautify active access to gits of maximum encasts to gits active access to gits of maximum encasts to gits active access to gits of maximum encasts active access to gits active access to gits of maximum encasts active access to gits active accest acces to gits active access to gits active access t	Courses Downcutting Bed scour	
Image: Sect deposition       Bank soour         Image: Sect deposition       Commutization         Image: Sect deposition       Co	DYNAMICS Widening Bank failure	/ /
□ Unknown       □ Accelerating         □ Unknown       □ Accelerating         □ Crannelizeri       □ Crannelizeri         Demensions       RT bank       2.5         Recent Accession       (ft)       Top         Development demension       Accession       Mtalk Astross         adgrant to stream, favores to go to       mtant/ware sto go to       PH 2600 42 - Ph 72.00 444         Mteen com to       Access requires to sto go to       stactple aniable       stactple aniable         Seed stand to stream, favores to       stactple aniable       stactple aniable       stactple aniable         Seed stand from tream       Spediate leave       stactple aniable       stactple aniable         statt base       and otsast tom       statt base       statt base         statt bastatt bastanista       statabatt bastatt base	Headcutting Bank scour	
Conversions Response of the series of the s	Unknown	1 1
CHANNEL LINE CHANNEL LINE CAR TO CAR	Height ) ( bank 7 15 (ff)	
Visite     Width:     Boltom     (ft)       Top     13     (J)       REACH ACCESSIBLUTY     PhotoS:       Dodd: Open size In sublic convership, aufficient room is exclusion strickle, services workway     Fell: Fonested or developed areas aufficient room is aufficient room is aufficient room is aufficient room is services workway     Difficult, Mustamuss working ange bype or excersive means to get strickle analobic and/or form tream.     PHOTOS:       Developed areas working works of traits.     Smithple aveas strickle analobic and/or form stream.     PHOTOS:       Strickle analobic and/or form tream.     Smithple aveas strait form analobic and/or form stream.     PHOTOS:       Yoursees for base working works of traits.     Smithple aveas strait form stream.     PHOTOS:       Yoursee (friggent problem you gree in sourvey reack)     Photosic (friggent problem you gree in sourvey reack)	Dimensions RT bank 2.5 (ft)	
Top     13     (II)       Reach Accessibility     Reach Accessibility     PHoTOS:       Dood: Open area in tuble connecting, adfietent room to developed armas adfietent room to developed armas difficult. Must const adfietent room to developed armas difficult. Must const adfietent room to developed armas difficult. Must const association adfietent to affieting. Access requires time and/or located a great statuble available and/or located a great distance from stream. Specification lice way dignered problem joing area in sources reackit     PHOTOS:       PA 2600 42 - Pre 7600 444     Pre 7600 444       Photos:     Photos:       Present construct storphe available and/or located a great distance from stream. Specification lice way for stant toom etheam       3     4     3       4     3       4     3       4     3       4     3       4     3       7     4       3     4       3     4       3     4       3     2       4     3       4     3       4     3       5       4     3       7	(Factoric Width: Boltom(ft)	
REACTE ACCESSIBILITY       Dood: Open area In tuble: conversity, authern conversity, and therm conversity, and therm conversity, and therm conversity acciption materials, says sharm clarinel consets to particular term solution conversity and acciption materials, says sharm clarinel consets of particular term solution conversity and acciption materials, says sharm clarinel consets of particular term solution consets of particular and troaped arease. Sindlight and terms solution consets of particular and troaped arease. Sindlight and terms of the mean flow areas in the share flow areas in the share flow areas in the share flow areas in the share flow areas. Specification from sharm. Specification from sharm. Speci	Top(1)	Pulstos)
Book: Operates In     Instruction of the construction       Stable converting, Builden materials, says bream clamped arread stable primate light says bream clamped arread stable and coged arread.     Instruction arread bits and coged arread.       Says bream clamped arread. stable primate light solution construction of table primate light solution of t	REACH ACCESSIBILITY	20101
auflicient rosm ib drochylie materials, swy straam cisioned introbylie materials, swy straam cisioned introbylie analyzie analyzie cross for heavy supprent using sisting roads or thats, sisting roads or that and sisting roads sisting roads sisting roads sisting roads sisting roads sisting roads sisti	Good: Open area in drawing of area wedged area wedged, streep stope, or turneau, streep stope, st	PA 260042 - PA 000047
sery stheam clamet totes to heavy support using sing roads or heavy sing roads or heavy Sing roads or heavy 3 4 3 2 Vortice: (biggent problem you sere in convey mack) Become to automorphic to a	aufficient room to adjacent. Eo stream, sensitive areas to get to stretinite materials. Access requires tree stream. Few areas to	
Lusse un inservy	easy stream channel ternovel or impact to stockpile available tantscaped areas. and/or located a over	
Signed of that is, and the second of the	equipment using small or dispatchers distance from stream.	
NOTEs: (htgp://problem.jou.sys.in.survey.reach)	sosting reads or trails. elisaria term equipment required.	
	a 4 3 2 1 NOTEs: (biggest problem jung see in survey reach)	
REPORTED YOU ALL PRODUCTION IN MARKED AND A		
		REPORTED TO ADVOORTITIES YES NO

						Stre	am Cro	ssing	SC
WATERSHED	SUBSH RD :			DAT	E: /0	186 116	Ass	SSED BY:	TL RG
SURVEY REA	CHID:	Пімк: 🕉 : 🔿	O AMP V	РПО	TO H	): (Camera-Pl	c #}	/#	
SITE ID: (Can	ulition-#) SC LAT		<sup>H</sup> LONG	٠		L	MK_	GPS	(Unit ID) 7.1
				_					0.1
TYPE: 🗌 Ros	ed Crossing 🔲 Railroad Cross	sing 🔲 Manmada	Dam 🗌 Beav	et Da	m 🗆	Geological For	mation [	Other:	
FOR ROAD/ RATEROAD CROSSINGS ONLY	SHAPE:       March       Box       Circolar       Other:       CONDITION: (6)sidence of)       Cracking/chipping/corrosi       Sediment depusition       Other (describe):	# BARRELS: Single Double Triple Other: Dowastreal Failing emb	MATERIAL 2 Metal Other: Metal Other: m scour hole conktnent		AUG Flo Do COLV	NMENT: rwsligned t flowaligned not know ERT SLOPE2 it ght (2° – 5°) visus (>5°)	Diðfens Barrel di Culvert 1 Roadway	rons : (y'v amotor: Height: ength: Width:	uriable, skaarly (fi (fi) (fi)
					-				
POTENTIAL F	G AS GRADE CONTROL	Fish barrier o Local stream	emoval Culv repair Otho es Duk	ert rej at: nown	pain're;	placement 🔲	Upstream a	torage retro	pfit
	EXTENT OF PHYSICAL BL	DEKAGE			BLO	CKAGE SEVER	arry : (circ	le \$j	
lf yes for fish barrier	Totel Partial     Temporary Unkno     CAUSE     Drop too high Water D     Flow too shallow Warer J     Other:	wn rup: (in) Depth: (in)	A structure such a road culvert on a greater stream bit upstream möverin anedramovis fish, passage device p	s a dan Sird ondi oking if ant of no fish resent.	n or Ieror NB	A total fish blocks tributary that woul significant reach o or partial blocks interfere with the anadromous fish.	ge on a ki isolale a ri stream, e theil may migretion of	A temporary beaver dam the very nea very ittle via above it; nat as waterfal :	i banlet such as a i or obtockage at al of a stream with the fish hab tat tyraf banlers such s.
			5		4			2	
192600 6	05: 1 ~ 10A2600 67	#Z	ð		~	5			
		1				/ (			-
		(W)							
						REPORT	ED TO AUT	HORITIES	YES NO

				Trash ar	nd Debris
WATERSHED/SU	BSHED:		DATE: // /	2-116 AS	SESSED BY: 20 TV
SURVEY REACH	ID:	TIME:	PHOTO ID: (Ca	unera-Ptc #)	14
SITE ID: (Conditio	u.+) TR LAT_	• '''LONG	G'	LMK	GPS: {Unit 1D} 2.07
TYPE: Industrial Construction Residential	MATERIAL: Plastic P Tires C Appliances Y Automotive 0	aper 🗌 Meial construction 🗍 Medical ard Waste ther:	SOURCE: Unknown Flooding Illegal dump Local cutfail	LOCATION: Stream Ripsrian Arca Lt bank Rtbank	LAND OWNERSHIP :   Public   Uaknown   Private AMOUNT( ? Pickup puck foads):
POFENTIAL RES	TORATION CANDIDATE	🛛 Siream oleanap 🗌 Strea	m adoption argmen	t 🕅 Removal/prevez	doon of dumping
lf yes for trash or dehris removal	BQUIPMENT NEEDED : Who can do it:	KVolunteers Local G	ash hags 🛄 Unkne lov 🔲 Hazmat Te	wn Du sm Other	Yes Na Unknown
CLEAN-GP POTENTIAL: (Circle #)	A small amount of trash (i.e., i than two pickup truck (bada) loca inside a park with easy access	A large amount of tresh, or with easy access. Tresh mi a long period of true but it iew days, possibly with a an	buik terna, in a small an ay have been dumped ov sould be cleaned up in reli backhoe.	A large amount of the area, where accession of hard area, where accession of hard area of hard area.	rash or debris scattered over a large a very difficult. Or presence of drame ardious motortals
NOTES: Dates	5	4	3	2	
PBoz	0165-167				
				REPORTED TO A	UTRORITIES - YES NO





														Land	l Use Designa	tions	т	c Input/IDF Data			
Pine Stree	et 5-Yea	ar Returi	n Inter	val											Curve Number	5	Townsid =	41 min			Har
														Pavement	Residential	Forested	Vpipe, ave =	2.5 fps		Ross	miller
														98	75	55	(8) RI -	5 yr		Rationa	Method
Declarations		64	orm Deale De	e erintien			Challes	Area Proportions (6) ID = 1.34 in/hr No k											No la comp	ponent(12) Turna Alacil	
Designations	Identification	SWMM	orm Drain De	senption			51410		310	Je .	Subo	atchmen		0.25	0.22	0.55	Тс	Batia	nalC	2007 CN	(B)
	Numbers	Junction	МНЕ	vations	Diameter	Cum Dist			Pipe	Land	Area		"Width"	Proportional	Land Use per §	Subcatchment	(min)	(Boss	niller)	[c.]	
	Manhole	Conduit	Bim	Invert	(inches)	Length			(ft/1	t)	(sq feet)	(acres)	(feet)		(acres)		,,	2007 CN	(Type A soil)		
	Pipe		Estimate			(feet)				1)	(2)		(3)		(4)		(6)	(10)	(11)	1	
14th Street	33002	J14 Cure	613.4	610.40		3881.77	38 + 8	81.77	0.0004	0.0011	10110	0.00	100	0.07	0.00	0.45	10.10	0.05	0.00		
Griffin	33003		6127	609.80	- °	3703 18	37 + 0	03.18	0.0034	0.0011	12413	0.20	400	0.07	0.08	0.15	42.10	0.25	0.22	0.1	0.1
Grinn	2409	CG-13	012.1	000.00	10	208.99	57 4 6	00.10	0.0033								1.38				
13.3 Alley	33004	J13.3	613.0	609.10		3494.19	34 + 9	94.19													
A13.3	2406	C13.3-13			10	219.35			0.0037	0.0011	159023	3.65	500	0.91	0.81	1.94	1.44	0.25	0.22	1.3	1.1
13th Street	33005	J13 Castor	613.1	608.29	10	3274.84	32 + 7	74.84	0.0004	0.0011	100000	0.05	010	0.71	0.00	4.54	1.50	0.05	0.00		2.0
12.5 Alley	33006	J125	612.9	607.50	12	3042.61	30 + 4	42.61	0.0034	0.0011	123982	2.85	310	0.71	0.63	1.51	1.53	0.25	0.22	2.2	2.0
,	2402	C12.5-12			12	203.20			0.0032								1.34				
12th Street	33007	J12 Output	613.29	606.84	10	2839.41	28 + 3	39.41	0.0010	0.0044	0700.05	0.70	070	0.47	100	4.00	1.50	0.05	0.00		4.5
A12 11.5 Alley	33008	J115	612.68	606.43	18	2612.19	26 +	12.19	0.0018	0.0011	379085	8.70	870	2.17	1.92	4.62	1.50	0.25	0.22	5.1	4.5
,	694	C11.5-11S			18	157.25			0.0021								1.04				
11th Street S side	33009	J11s	612.13	606.10		2454.94	24 + 5	54.94	0.0000	a aadd	domod		700			a. 10		0.05			
A11 11th Street Niside	593 33010	U11S-11N	61188	605.92	24	2375 18	23 + 7	75.18	0.0023	0.0011	198901	4.57	/30	1.14	1.01	2.42	0.53	0.25	0.22	6.6	5.8
THI Sheet if She	692	C11N-10.5		000.82	24	185.62	20 + 1		0.0017								1.22				
10.5 Alley	33011	J10.5	612.18	605.60		2189.56	21 + 8	89.56													
iout Stand	691	C10.5-10		005.00	24	198.91	to	00.05	0.0014								1.31				
A10	683	J10 C10-9.5	611.6	605.33	30	226.98	19 + 5	90.65	0.0015	0.0011	277511	6.37	730	1.59	141	3 38	1.50	0.25	0.22	87	76
9.5 Alley	33013	J9.5	611.23	605.00		1763.67	17 + 6	63.67	0.0015	0.0011	Enstr	0.07	100	1.00	1.41	0.00	1.00	0.2.5	0.22	0.7	7.0
,	682	C9.5-9			30	185.77			0.0017								1.22				
9th Street	33014	Ja	611.0	604.68		1577.90	15 + 7	77.90													
A9	1412	C9-8.5	010.05	coi 20	30	243.05	io	24.95	0.0015	0.0011	154307	3.54	570	0.88	0.78	1.88	1.60	0.25	0.22	9.9	8.7
8.5 Alley Ass	1971	J8.5 Casa	610.85	604.32	30	1334.85	13 + 3	34.85	0.0018	0.0011	02574	2 12	2/5	0.53	0.47	1 12	194	0.25	0.22	10.6	0.3
8th Street	33016	J8	610.76	603.96	30	1132.17	11 + 3	32.17	0.0010	0.0011	32374	2.10	343	0.55	0.47	1.15	1.04	0.23	0.22	10.0	3.3
A8	1370	Ca-7			21	430.53			0.0026	0.0011	131717	3.02	450	0.75	0.67	1.60	2.84	0.25	0.22	11.6	10.2
7th Street	33017	J7	610.2	602.83		701.64	07 + 0	01.64									1				
A7	1303	C7-6.5	600.40	e02 12	21	213.89	04	07.75	0.0033	0.0011	222177	5.10	640	1.27	1.13	2.70	1.41	0.25	0.22	13.3	11.6
A6.5	1298	06.5 Ca 5-65	609.40	002.12	21	212.97	04 + 6	87.75	0.0061	0.0011	208426	4.78	680	1,19	1.06	2.54	1.40	0.25	0.22	14.9	13.0
6th Street Side	33019	J6S	609.48	600.83		274.78	02 + 7	74.78	0.0001	0.0011	200120	1.70	000	1.10	1.00	2.01		0.20	0.22	11.0	10.0
A6	1297	C6S-6N			18	61.26			0.0504	0.0011	29937	0.69	120	0.17	0.15	0.36	0.40	0.25	0.22	15.1	13.2
6th Street N side	33020	J6N	613.62	597.75		213.52	02 + 1	13.52	0.000								0.05				
Instream Swirt MH	32024	.IA1	600.00	592.45	24	160.00	01 - 6	60.00	0.0989								0.35				
Bypass pipe	1295	CA1-A2	000.00	002.40	24	15.00	01+ 0	00.00	0,5033						-						
Downstream Swirl MH	33025	JA2	598.50	584.90		145.00	01 + 4	45.00													
Outfall pipe	4726	Countert			24	145.00			0.0269												
Boardman Outfall	-99999	Out1		581.00		0.00	00 + 0	00.00													
		Error Outlall 4	22) Elevation	691.0	Total Longth	0000		Ave Slope	0.0046	Total Area	1000052 -1	45.00	20	11.00	10.08	04.00	To CC min				
		Free Outan (	ss) Elevation:	361.0	l'otar cengin-	3662	"   i	(W/Odroofrom	m 6th St)	2007 Area -	1990053 SI	45.69	ac	11.38	10.08	24.23	10 86 min			15.1	13.2
												i ar i afai			1.010.00	an Tile M					

										SCS Method	ł	1	MDEQ	
	5-Yea	r Inf	iltratio	n/Ra	infall/Runoff I	Data		Su	urface Runoff (S	SRO)	Unit SI	RO (qu)		
								Calcula	Calculated* (15) Tabular Unit Peak Hy					
Description	2007		Rossmill	er	24	4-hr Rainfall		la Con	stant	Table 7.2	Table 7-3**	ulated (17)		
Soil type:	В		A					0.05	0.2					
					2 yr	P2 =	2.09 in			0.26 in	0.64 cfs/(in-ac)	0.39	cfs/(in-ac)	
Curve No.	70.1	(5)	66.7	(5)	5 yr	P₅ =	2.7 in	0.917	0.559	0.56 in	0.64 cfs/(in-ac)			
Storage	4.26	in	4.99	in	10 yr	P10 =	3.21 in			0.85 in	0.64 cfs/(in-ac)			
*Per 2007 Cl	N						la =	0.213 in	0.852 in	(16) **	2007 average slopes: pipe 0.	78%; watershe	ed 0.11%	
										-	Table 7-3 value for 0.11% slo	pe: 0.35	cfs/(in-ac)	





PINE STREET HYDROLOGY AND HYDRAULICS 5-YR RETURN PERIOD HAND CALCS AND MODELING RESULTS



<u>EX STORM DRAIN AND SUBCATCHMENTS-PINE STREET</u> 1"=100





E VISIONS	PINE STREET DRAINAGE AREA HYDROLOGY AND HYDRAULICS EX STORM DRAIN AND SUBCATCHMENTS, 5-YEAR ANALYSIS, TIME OF CONCENTRATION, AND STORM DRAIN PERFORMANCE TRAVERSE CITY, MICHIGAN	DATE BY	and the second secon
DF SC DF SF	BINE STF BINE STF BIGINGELING BIGING BIG	AL D T7 M	Converte Drive Drive Drive Drive Drive Drive the second high the terms of an End Hear Line Line of the End Hear Line of the End Hear Line Drive these alone the second and the End Hear Line of the En

<u>EPA SWMM INPUT</u>
ROUTING DYNAMIC WAVE INFILTRATION CURVE NUMBER DURATION 66 MIN TIME STEPS
REPORTING – 1 MIN DRY WEATHER – 1 MIN WET WEATHER – 1 SEC ROUTING MODEL DYNAMIC WAVE TIME SERIES
TIME       –       1.5 HR; 66 MIN; 24 HR         INTERVAL       –       1 MIN; 0.1 HR; 0.25 HR         TYPE       –       2–, 5–, 10– YEAR; TYPE II         RAIN GAUGE       100 YEAR; TYPE II
FORMAT – VOLUME; CUMULATIVE/INCHES SOURCE TYPE – TIME SERIES SUBCATCHMENT
AREA-VARIES, 45.7 AC TOTALWIDTH-0.11%GROUND SLOPE0.11%IMPERVIOUSNESS0%, 47%N impervious-Opervious0, 0.014N pervious0, 0.05D impervious0, 0.05D pervious0, 10%Z impervious-PARTIAL ROUTING41% IMPERV OVER PERV100% PERV TO OUTLET
BASELINE DATA OBSERVATION POINT - 6TH ST/C6S-6N Tc - 66 MIN
CURVE NUMBER NUMBER – 55.0, 70.1 DRY TIME – 1.4
MODIFIED GREEN-AMPT K saturated - 5 SUCTION HEAD - 1.909* DEF initial 0.34
*MATHEMATICALLY RELATED=3.237*Ks (-0.328)
I maximum – 20** I minimum – 5** T drying – 1.40*** K decay – 6
**National Resources Conservation Service (±) ***BY DEFINITION; T drying=3.125*(I min)^0.5

													Lar	nd Use Designat	tions	т	c Input/IDF Data							Pea	ak Flow Ra	ite (cfs) (7)					
Pine Stree	et 2-Yea	ar Retur	n Inter	rval										Curve Numbers	5	Toverland =	41 min			Ha	nd Calculatio	ns (14)				E	PA SWMM Softwa	110			XP SWMM
													Pavement	Residential	Forested	V <sub>pipe, we</sub> -	2.5 fps		Ross	miller		MDEQ/S0	S	C	urve Number	,	Horton		Green-A	mpt	
													98	75	55	(8) RI -	2 yr		Rational	Method	Calc	ulated	Tabular (13)		2007			L <u></u>	/	N N	/lodel
Designations	1		Storm Drain De	escription			Station	SI	ope	Sub	catchmen	t Info	0.25	Area Proportion 0.22	s 0.53	(8) 12 -	1.07 in/hr		2007 CN	oonent (12) Type A soil	la const-0.05	(9)	ns1-0.2	Single Sub Area	Durati	on/Frequency Ir	Modified City Mo	xdei	Type		
	Identification	SWIMM														Te	Ration	nalC		.,,,		<u>(-)</u>		(18)		(20)			;	(a)	(b)
	Numbers	Junction	MHE	evations	Diameter	Cuml Dist		Pipe	Land	Area	1	"Width"	Proportiona	al Land Use per S	Subcatchment	(min)	(Rossn	niller)	4										/		
	Pipe	Conduit	Bum Estimate	Invert	(inches)	Length (feet)		(†	(1)	(sq teet) (2)	(acres)	(feet) (3)		(acres)		(6)	2007 CN (10)	(Type A soil) (11)	-					55.0 4.7% IMP	55.0 47%/IMP	70.1 0%IMP	loss-bypasis (ofe)		/	1	
	1.150		Lotinate			lieety			(1)	(2)	-	(3)				(6)		()	-					47.56 101	477610	0.561011	(cis)		/	1	
14th Street	33002	J14	613.4	610.40		3881.77	38 + 81.77					1																		1	
A14 Griffin	2410	C14-G	612.7	ຂກວ ຄາ	8	178.59	27 . 02 18	0.0034	0.0011	12413	0.28	400	0.07	0.06	0.15	42.19	0.23	0.20	0.1	0.1	0.1	0.0	0.0		0.6	0.0	9.0	0.1	0.6	1	
	2409	CG-13	012.7	009.00	10	208.99	37 + U3.10	0.0033								1.39													(23) 11:58-12:17	1	
13.3 Alley	33004	J 13.3	613.0	609.10		3494.19	34 + 94.19																						0.4101.3 (22)	1	
A13.3	2406	C13.3-13	cic i	600 m	10	219.35	00. <b>7</b> /0/	0.0037	0.0011	159023	3.65	500	0.91	0.81	1.94	1.46	0.23	0.20	1.0	0.9	0.9	0.4	0.7		1.6	0.1	1.2	1.2	1.6	4	
A13	2403	G13-12.5	613.1	608.29	12	232 23	32 + 74.84	0.0034	0.0011	123982	2.85	310	0.71	0.63	151	1.55	0.23	0.20	17	15	15	0.7	11	-	26	0.1	20	20	0.3101.6 (22)	1	
12.5 Alley	33006	J 12.5	612.9	607.50		3042.61	30 + 42.61	0.0004	0.00011		2.55	0.0		0.00	1.01	1.55	0.20	<sup>2</sup>	1	1.0	1.5				2.0		2.0	2.0	11:58-12:17	1	
	2402	C12.5-12			12	203.20		0.0032								1.35													/	1	
12th Street	33007	J 12 C 12 11 5	613.29	606.84	10	2839.41	28 + 39.41	0.0018	0.0011	2700.05	0.70	870	2.17	102	4.62	1.51	0.22	0.30	2.0	24	2.5	17	26		5.4	0.2	4.0	4.6		1	
11.5 Alley	33008	J11.5	612.68	606.43	10	2612.19	26 + 12.19	0.0018	0.0011	3/9085	0.70	870	2.17	1.92	4.62	1.31	0.23	0.20	3.0	2.4	3.5	1.7	2.6		5.4	0.2	4.0	4.6		12:00-12:07	11:50-12:04
	694	C11.5-11S			18	157.25		0.0021								1.05													/	0.7103.7	1.5 to 15.5
11th Street Side	33009	Jiis	612.13	606.10		2454.94	24 + 54.94																						/	9.5	9.2
A11 11th Street Nicide	693	G11S-11N	611.88	605.02	24	79.76	22 . 75 1.9	0.0023	0.0011	198901	4.57	730	1.14	1.01	2.42	0.53	0.23	0.20	5.0	4.3	4.5	2.2	3.3		7.1	0.3	6.0	6.0	11.6	1	
This offeet is side	692	C11N-10.5	611.00	600.92	24	185.62	23 + 73.10	0.0017								1.24													/	1	
10.5 Alley	33011	J 10.5	612.18	605.60		2189.56	21 + 89.56																						/	1	
	691	C10.5-10			24	198.91	10 00 05	0.0014								1.33													(21)	1	
A10	683	J 10 C 10-9.5	611.6	605.33	30	1990.65	19 + 90.65	0.0015	0.0011	277511	6.37	730	1.59	141	3 38	1.51	0.23	0.20	6.5	57	6.0	29	4.4		89	0.3	7.8	7.8	11:57-12:03	1	
9.5 Alley	33013	J95	611.23	605.00		1763.67	17 + 63.67	0.0015	0.0011	2.7.511	0.07	,	1.55		0.00	1.51	0.20	0.20	0.5	5.7	0.0	2.0			0.5	0.0	7.0	7.0	0.110 10.4	12:00-12:09	11:52-12:03
	682	C9.5-9			30	185.77		0.0017								1.24													12:01-12:07	1.5 to 5.8	0.3 to 11.9
9th Street	33014	J9 J9	611.0	604.68	20	1577.90	15 + 77.90	0.0015	0.0011	154907	2.54	570	0.00	0.78	1 00	1 60	0.00	0.90	74	0.5			5.0		10.4	0.2	0.0		1.3103.5	11.0	14.6
8.5 Allev	33015	Ja5	610.85	604.32		1334.85	13 + 34.85	0.0015	0.0011	154307	3.54	570	0.00	0.76	1.00	1.62	0.23	0.20	1.4	6.0	0.0	3.3	5.0		10.4	0.3	0.0	0.0	10.7	1	
A8.5	1371	C8.5-8			30	202.68		0.0018	0.0011	92574	2.13	345	0.53	0.47	1.13	1.35	0.23	0.20	7.9	7.0	7.2	3.5	5.3	-	11.1	0.3	9.5	9.5	13.7		
8th Street	33016	J8	610.76	603.96		1132.17	11 + 32.17		e esti	destation		1			4.00		0.00	0.05		7.0	7.0				ن م		10.0	in c		1	
A8 7th Street	1370	J7	e ota	602 83	21	430.53	07 + 0164	0.0026	0.0011	131717	3.02	450	0.75	0.67	1.60	2.87	0.23	0.20	8.7	7.6	7.9	3.8	5.8		12.1	0.3	10.2	10.2	14.5	1	11-65-15-01
A7	1303	C7-6.5	010.2	001.00	21	213.89	0.1 01.04	0.0033	0.0011	222177	5.10	640	1.27	1.13	2.70	1.43	0.23	0.20	10.0	8.7	9.1	4.4	6.7	-	13.8	0.3	11.6	11.6	16.2	1	0.6 to 4.7
6.5 Alley	33018	J6.5	609.40	602.12		487.75	04 + 87.75																						,	19.6	27.2
A6.5	1298	C6.5-65		600.00	21	212.97	02 . 74 70	0.0061	0.0011	208426	4.78	680	1.19	1.06	2.54	1.42	0.23	0.20	11.1	9.7	10.1	4.9	7.5		15.0	0.3	13.0	13.0	19.1	4	
As Street S Side	33019	L 162-6N	609.48	600.83	18	274.78	02 + 74.78	0.0504	0.0011	29937	0.69	120	0.17	0.15	0.36	0.41	0.23	0.20	113	99	10.3	50	76	16.0	15.3	0.3	13.3	13.3	19.5	1	
6th Street N side	33020	J6N	613.62	597.75		213.52	02 + 13.52	0.0001	0.0011	2000,	0.00	120		0.10	0.00	0.41	0.20	0.20	11.5	0.0	10.0	0.0	7.0	10.0	10.0	0.0	10.0	10.0		1	
		C6N-A1		_	24	53.52		0.0989								0.36													1		
Upstream Swirl MH	33024	JA1 CALL	600.00	592.45		160.00	01 + 60.00	0.5000																					1		
Downstream Swirl MH	33025	JA2	598.50	584.90	24	145.00	01 + 45.00	0.5033																					1		
Outfall pipe	4726	Coulet			24	145.00		0.0269							-														1		
Boardman Outfall	-99999	Out1		581.00		0.00	00 + 00.00																						1		
		Free Outfall	(33) Elevation:	5810	Total Length-	3882 ft	Ave Slope	= 0.0046	Total Area -	1990053 et	f 45.69	ac	11.38	10.08	24.23	To 66 min													69	84	27.9
		, ice outdi	poy crostation.			300E II	(W/O drop	from 6th St)	2007 Area -	10000000	45.69	ac	11.38	10.08	24.23				11.3	9.9	10.3	5.0	7.6	16.0	15.3	0.3	13.3	13.3	19.5	19.6	27.2
								2																					26.5	27.9	55.1

<u>NOTES</u>

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													Lan	nd Use Designa	tions		Tc input/IDF Data	i.					Peak F	low Rate (cfs)	(7)			
Pine Stree	t 10-Ye	ar Retu	n Inter	val										Curve Numbe	s	Touriand =	41 min			Ha	and Calculation	ns (14)				EPA SWMM Softwa	are	
													Pavement	Residential	Forested	Vpipe, ave =	2.5 fps		Ross	miller		MDEQ/SC	cs		Curve Numb	oer	Green-Ampt	Horton
													98	Area Proportio	55 15	(8) RI = (8) 110 =	10 yr 1.59 in/hr		No la como	onent (12)	Calci la const=0.05	ulated la cor	labular (13) nst=0.2	Single Sub Area	2007	Modified	City Model	
Designations			torm Drain Des	cription			Station	Sl	ope	Subo	catchment	Info	0.25	0.22	0.53	1-7			2007 CN	Type A soil		(9)						
	Identification	SWMM	MHEby	rations	Diameter	Cuml Dist		Pina	Land	Area		'W/idth'	Broastional	Lland llaa oor	Subaatabmaat	Tc (min)	Ratio	onal C millor\						(10)		(20)		
	Manhole	Conduit	Rim	Invert	(inches)	Length		(ft	/ft)	(sq feet)	(acres)	(feet)	Fioportional	(acres)	subcatchment	(mm)	2007 CN	(Type A soil)	1					55.0	55.0	70.1		loss-bypass
	Pipe		Estimate			(feet)			(1)	(2)		(3)		(4)		(6)	(10)	(11)						47% IMP	47%IMP	0%IMP		(cfs)
14th Street	33002	J14	613.4	610.40		3881.77	38 + 81.77			10.110		10.0			0.45	10.10									(21)		(21)	(21)
A14 Griffin	2410	C14-G JG	612.7	609.80	8	178.59	37 + 03.18	0.0034	0.0011	12413	0.28	400	0.07	0.06	0.15	42.18	0.26	0.23	0.1	0.1	0.1	0.1	0.2		0.3	0.2	0.6	0.6
	2409	CG-13	0.21	000.00	10	208.99	0, 1 00.10	0.0033								1.38									00:21-01:25	() (,	00:21-01:17	00:21-01:17
13.3 Alley	33004	J13.3	613.0	609.10		3494.19	34 + 94.19			150000		500													0.1 to 1.0		0.9	0.9
A13.3 13th Street	2406	G13.3-13 J13	613.1	608.29	10	219.35	32 + 74.84	0.0037	0.0011	159023	3.65	500	0.91	0.81	1.94	1.44	0.26	0.23	1.6	1.4	1.9	1.3	2.1		2.4	0.6	1.8	0.1 to 02
A13	2403	C13-12.5			12	232.23		0.0034	0.0011	123982	2.85	310	0.71	0.63	1.51	1.53	0.26	0.23	2.8	2.4	3.3	2.2	3.7		4.0	0.8	2.3	2.3
12.5 Alley	33006	J12.5	612.9	607.50	10	3042.61	30 + 42.61	0.0000								1.94									00:45-01:09		01:00-01:07	01:00-01:07
12th Street	33007	J12	613.29	606.84	12	2839.41	28 + 39.41	0.0032								1.34									ы		(b)	(b)
A12	700	C12-11.5			18	227.22		0.0018	0.0011	379085	8.70	870	2.17	1.92	4.62	1.50	0.26	0.23	6.4	5.6	7.6	5.1	8.4		6.3	2.0	6.3	6.3
11.5 Alley	33008	J11.5	612.68	606.43	10	2612.19	26 + 12.19	0.0001								1.04												
11th Street S side	33009	J115	612.13	606.10	18	2454.94	24 + 54.94	0.0021								1.04												
A11	693	C11S-11N	012.10	000.70	24	79.76	211 01.01	0.0023	0.0011	198901	4.57	730	1.14	1.01	2.42	0.53	0.26	0.23	8.2	7.2	9.8	6.6	10.9		6.8	2.4	8.2	8.2
1 1 th Street N side	33010	J11N	611.88	605.92		2375.18	23 + 75.18									4.00												
105 Allev	692	C11N-10.5	612.18	605 60	24	185.62	21 89.56	0.0017								1.22												
10.071109	691	C10.5-10	012.10	000.00	24	198.91	21 + 00.00	0.0014								1.31												
10th Street	33012	J10	611.6	605.33		1990.65	19 + 90.65																					
A10 9.5 Alley	683	C10-9.5	611.23	605.00	30	226.98	17 + 63 67	0.0015	0.0011	277511	6.37	730	1.59	1.41	3.38	1.50	0.26	0.23	10.8	9.5	12.9	8.7	14.4		10.3	2.9	9.8	9.8
3.3 1169	682	C9.5-9	011.20	000.00	30	185.77	17 + 00.07	0.0017								1.22									00:56-01:07			
9th Street	33014	Ja	611.0	604.68		1577.90	15 + 77.90																		0.2 to 0.9			
A9 8.5 Allow	1412	C9-8.5	c1 0.95	604 22	30	243.05	10 . 04.05	0.0015	0.0011	154307	3.54	570	0.88	0.78	1.88	1.60	0.26	0.23	12.3	10.8	14.6	9.9	16.3		10.4	3.1	10.4	10.4
A8.5	1371	C8.5-8	610.85	004.32	30	202.68	13 + 34.83	0.0018	0.0011	92574	2.13	345	0.53	0.47	1.13	1.34	0.26	0.23	13.2	11.6	15.7	10.6	17.5		11.3	3.3	11.3	11.3
8th Street	33016	J8	610.76	603.96		1132.17	11 + 32.17																		0.3 to 0.8			
A8 7th Street	1370	C8-7	eto a	602.02	21	430.53	07, 01.64	0.0026	0.0011	131717	3.02	450	0.75	0.67	1.60	2.84	0.26	0.23	14.4	12.7	17.1	11.6	19.1		12.6	3.5	12.6	12.6
A7	1303	C7-6.5	010.2	002.03	21	213.89	07 + 01.04	0.0033	0.0011	222177	5.10	640	1.27	1.13	2.70	1.41	0.26	0.23	16.5	14.5	19.6	13.3	21.9		15.1	3.8	14.9	14.9
6.5 Alley	33018	J6.5	609.40	602.12	01	487.75	04 + 87.75	0.0001	0.0011	008400	4.70	680	1.10	1.00	0.54	1.40	0.00	0.00	10.5	10.0	00.0	14.0	04.5		17.0	4.4	100	10.0
6th Street Sside	33019	J6S	609.48	600.83	21	274.78	02 + 74.78	0.0061	0.0011	208426	4./0	680	1.19	1.06	2.54	1.40	0.26	0.23	6.01	16.2	22.0	14.9	24.5		17.9	4.1	16.9	16.9
<b>A</b> 6	1297	C6.S-6N			18	61.26		0.0504	0.0011	29937	0.69	120	0.17	0.15	0.36	0.40	0.26	0.23	18.8	16.5	22.3	15.1	24.9	28.1	18.3	4.1	17.2	17.2
6th Street Niside	33020	J6N	613.62	597.75		213.52	02 + 13.52	0.0000								0.05												
Upstream Swirl MH	33024	JA1	600.00	592.45	24	53.52	01 + 60.00	0.0989								0.35												
Bypa.ss pipe	1296	CA1-A2			24	15.00		0.5033				-	-	-	-	-												
Downstream Swirl MH	33025	JA2	598.50	584.90		145.00	01 + 45.00																					
Outfall pipe Boardman Outfall	4726	Coutlet Qut1		581.00	24	145.00	00 + 00.00	0.0269				-	-	-	-	-												
o dar en la rico de la ll	00000			001.00		0.00	007 00100	1					L				1											
		Free Outfall	(33) Elevation:	581.0	Total Length=	3882 ft	Ave Slope	= 0.0046	Total Area. =	1990.053 sf	45.69	ac	11.38	10.08	24.23	Tc 66 min	1		100	105	00.0	454	04.0	0.01	7.6		3.1	3.1
							(W/O drop 1	irom 6th St)	2007 Area -		45.69 8	3G	11.38	10.08	24.23				18.8	16.5	22.3	15.1	24.9	28.1	18.3	4.1	17.2	17.2

e drainage area is extremely flat, with high and low points along the alignment. The 2007 average slope of 0.0011 (L=3700 ft/dE=4.07 ft) was used as part of the input for calculations herein. ty storm drain maps were reviewed and the overall drainage boundary estimated based on inlet locations; area was narrowed slightly 30 ft (+/-) to nearly match 2007 total area Vidth" calculated or estimated based on EPA Storm Water Management Model (SWMM) Reference Manual Volume 1, Chapter 3

rtions of the subarea, in acres; classified impervious, residential, and forested per the 2007 Stormwater Management Report rerage curve number per 2007 model | curve number based on impervious area per Rossmiller CN equation using TYPE A soil constant (39); Note: using Type B constant (61), resulting CN is 70.2 or approx equal to 2007 CN nce the drainage areas and storm drain piping were finalized, first ran a simulation with only the upper subcatchment (A13.3) draining plus a somewhat arbitrary input of 3 cfs at the node, providing a "slug" of water traveling along e pipe in order to determine a time of equalibrium of 41 minutes; then took a general look assuming 600 ft@1 fps in A13.3 and 2.6 fps in the pipe for a total of 35 minutes, which does not account for the time to fill Initial Abasractions, Tc something greater; finally, analyzed A13.3 subcatchment using the 0.97Qp to determing an equilazation time of 37 minutes, to which the 25 minute travel time was addded to establish a Tc of 60 minutes. ak Flow Rate(cfs) = Unit SRO (qu) <see (16) belows mult by SRO < (P-la+S) in inchess mult by Area in square miles See (15) below for S and la Note: USDA T55 Appendix f has refined qu= based on Tc (not used) nosen return period and corresponding average intensity for a duration equal to the Tc calculated in (7); average intensity is calculated using equation (Boucher, Costa County, CA, 2010) fit to NOAA DDF curves developed for rainfall ta at Cherry Capital Airport (see IDF equations tab)

e SCS/MDEQ methods typically underestimate peak runoff rates for total surface runoff (SRO) less than 1/2 in tional method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (2007 Study, Type B soil), return interval, average land surface slope, rainfall intensity, and percent impervious ational method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (Rossmiller Type A soil), return interval, average land surface slope, rainfall intensity, and percent impervious th C coefficients were calculated Rossmiller's equation to convert from CN, however the 2007 is based on a Type B soil while the other is based on a Type A soil per NRCS Web Soil Survey, maps and descriptions ese replicate the 2007 Stormwater Management Report calculations using the tabular SCS curve method based on areas and land uses assumed/measured therein; the 5-year return interval (only) includes the land slope Qpeak for mparison purposes; see MDEQ Soil Erosion and Sedimentation Control Training Manual, Chapter 7 s worth noting how rational method numbers and SCS/MDEQ numbers are close to one another; although both are based on the same return period, one is entirely derived from projected local/historical intensities of the calculated

nfall duration (Tc), while the other is based on a peak runoff relationships derived from a 24-hour duration rainfall based on certain statistical correlations al SRO in inches; based on 24-hour rainfall, curve number, and initial abstraction; TR-55 runoff equation, Appendix F; see Chapter 7 "Computing Flood Discharges for Small Ungauged Watersheds", Mich DNR, June 2010 for following equ: RO= ((P-la)^2)/(S+P-la) where: S=storage in inches=((1000/CN)-10); CN=curve number; P= 24-hr rainfall in inches for a given return period; la=initial abstraction=(constant)\*S; constant=0.2 normally, but 0.05 is proposed in certain instances able 7-2 equivalent; MDEQ Soil Erosion and Sedimentation Control Training Manual, Chapter 7; see SCS Curve Method tab}

r definition, however for tabular calcs do not account for this, only the equation approach and numbers are very sensative to changes; 0.05 has been proposed to replace the current 0.2 constant; see (6) and SCS Curve No. Method tab DEQ Stormwater Management Guidebook, Chapter 7, Unit Hydrograph Peak, Equation 21: qu (unit surface runoff)= 270.9\*((Tc)^-0.81) in cfs/(sq mi-in) {Table 7-3 equivalent; MDEQ Soil Erosion and Sedimentation Control Training Manual, napter 7} mult by area in square miles where=> S= (1000/CN) - 10 Note: USDA T55 Appendix f has refined qu= based on Tc (not used) initial estimate of peak flow modeling the entire drainage area as one, using a "width" of 7760 ft (2xpipe length) and the average slope of 0.0011 odel was run with all existing pipes oversized to 42 inches so system flows entirely as an open channel with no losses occuring upstream; runoff quantities are identical for both ex piping and oversized piping simulations

WMM infiltration methodology does not support curve numbers weighted with impervious areas as these results illustrate; instead, use the percent impervious and appropriate routing in conjunction with a representative pervious CN (55) hough flooding noted within the model output, a review of reported "flooding" is actually oscillations of the HGL and does not appear to reflect actual ponded conditions cumented "flooding" includes reverse flow conditions during simulation

s simulation reflects the 3-subcatchment model configuration with inputs (slopes, routing, etc.) reflecting those developed for the City model with a standard Type II rainfall distribution with 0.1 hr time-step increments (P2=2.09; P5=2.70 in); aximum subcatchment runoff as developed on MODEL EQUIVALENCE CONFIRMATION AND STEPPED INPUT CHANGE ANALYSIS, bottom left, Column (7) s simulation reflects the 3-subcatchment model configuration with inputs (slopes, routing, etc.) reflecting those developed for the OHM model including their 15-minute, Type II rainfall distribution (OHM P2=2.27; P5=2.76 in); maximum subchment runoff as developed on MODEL EQUIVALENCE CONFIRMATION AND STEPPED INPUT CHANGE ANALYSIS, bottom left, Column (1)

ak subcatchment surface runoff generated by EPA SWMM cust Street lateral capacity limits inflows from Subcatchment A12b; creates following losses: Type II-0.1 to 3.6 cfs from 11:57 to 12:21 (24 min) w/revese flow in pipe (up to 1.9 cfs from 11:58 to 12:19 (21 min); Green-Ampt I5 - 0.12(+/-) cfs from 2:38 to 01:07 (29 min); Horton - 0.12(+/-) cfs from 00:38 to 01:07 (29 min); CN 55.0 - 0.2 to 2.0 cfs from 00:37 to 01:08 (41 min) w/reverse flow in pipe from 00:50 to 01:08 cust Street lateral capacity limits inflows from Subcatchment A12b; creates following losses: Green-Ampt 110 - 0.5 to 1.7 cfs from 00:28 to 01:08 (40 min) w/revese flow in pipe from 00:29 to 01:07; Horton - 0.5 to 1.7 cfs from 00:28 to 01:08 ) min) w/revese flow in pipe from 00:29 to 01:07; CN 55.0 - 0.1 to 2.8 cfs from 00:28 to 01:18 (50 min) w/revese flow in pipe from 00:29 to 01:16

										SCS Method			MDEQ			
	2-Yea	r Inf	iltratio	n/Ra	infall/Runoff	Data		S	Surface Runoff (	SRO)	Unit SF	RO (qu)				
								Calcu	lated* (15)		Tabular Unit Peak Hydrograph					
Description	2007		Rossmill	er	2	24-hr Rainfall		la Cor	nstant	Table 7.2	Table 7-3**	ulated (17)				
Soil type:	В		A					0.05	0.2							
					2 yr	P2 =	2.09 in	0.574	0.279	0.26 in	0.64 cfs/(in-ac)	0.39	cfs/(in-ac)			
Curve No.	70.1	(5)	66.7	(5)	5 yr	P5 =	2.7 in			0.56 in	0.64 cfs/(in-ac)					
Storage	4.26	in	4.99	in	10 yr	P10 =	3.21 in			0.85 in	5 in 0.64 cfs/(in-ac)					
*Per 2007 CM	N					l	la =	0.213 in	0.852 in	(16) **2007 average slopes: pipe 0.78%; watershed 0.1%						

										SCS Method			MDEQ
1	0-Yea	r In	filtratio	n/Rai	nfall/Runoff	Data		S	urface Runoff (	SRO)	Unit S	RO (qu)	
							2	Calcul	ated* (15)		Tabular	Unit Pea	ak Hydrograph
Description	2007		Rossmill	er	24	-hr Rainfall		la Cor	Istant	Table 7.2	Table 7-3**	Calc	ulated (17)
Soil type:	В		A					0.05	0.2				
					2 yr	P2 =	2.09 in			0.26 in	0.64 cfs/(in-ac)	0.39	cfs/(in-ac)
Curve No.	70.1	(5)	66.7	(5)	5 yr	P5 =	2.7 in			0.56 in	0.64 cfs/(in-ac)		
Storage	4.26	in	4.99	in	10 yr	P10 =	3.21 in	1.238	0.840	0.85 in	0.64 cfs/(in-ac)		
'Per 2007 CN							la =	0.213 in	0.852 in	(16) **20	007 average slopes: pipe 0.7	8%: watershed	0.1%

PINE STREET HYDROLOGY AND HYDRAULICS 2-YR RETURN PERIOD HAND CALCS AND MODELING RESULTS 10-YR RETURN PERIOD

REVISIONS		DESCRIPTION DESCRIPTION DATE BY	
	PINE STREET DRAINAGE AREA HYDROLOGY AND HYDRAULICS 2-YEAR AND 10-YEAR ANALYSES, NOTES, AND GENERAL INFORMATION TRAVERSE CITY, MICHIGAN		Agreement (EULA) that accompanies these plans, it we user continues acceptance of the EULA is not attached by contacting Kichard E. Prince at fickp@bulid-on-prince.com
DR SC DA PR	AMING: 1014-OH AMING: AMING		Ince-Lund Engineering, PLC 2016. All rights reserved. Use of these Plans is governed by the terms of an End User Licu



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												Lan	d Use Designatio	ons	Тс	Input/IDF Dat	a						Pe	ak Flow R	late (
Hanna Avenue	5-Year	Return	Interv	al									Curve Numbers		Toverland =	30 min				Hand Calcula	ations (14)				
												Pavement	Residential	Forested	Vpipe, ave =	2.6 fps		Ross	miller		MDEQ/S	CS (8)	(	Curve Numbe	er
												98	75	55	(7) RI =	5 yr		Rational	I Method	Calc	ulated	Tabular (13)		2007	
Designations		s	torm Drain De	escription			Slo	pe	Sub	catchmen	t Info	0.3231	Area Proportions	0.51	(/) 15 =	1.38 in/nr		2007 CN	Type A soil	la const=0.05	(9)	const=0.2	Single Sub Area	Durati	on/Free
	Identification	SWMM						<b>-</b>							Тс	Rat	ional C	[A]	[B]	[C]	[D]	[E1] [E2]	[F]	[G]	
	Numbers	Junction	MH Ele	evations	Diameter	Cuml Dist	Pipe	Land	Area	(00100)	"Width"	Proportional	Land Use per Sul	ocatchment	(min)	(Ros	smiller)	-					(18)	(21)	1
	Pipe	Conduit	Estimate	nven	(inches)	(feet)	(10	(1)	(2)	(acres)	(1001)		(acres) (4)		(6)	(10)	(11)	1					55.0	55.0	1
								( )										1						)	1
S Hastings Street at Contro Street	21001	lonur	616 00	610 50		5140.09										72.2	67.9							)	1
Southerly SD reach on Hastings St	2683	CHstgS	010.82	010.55	12	290.01	0.0025								31.86									)	1
S End Consumers Power Bldg	21002	JCnsmrS	616.27	609.87	662500	4859.97																		)	1
AHstg S End Consumers Power Bldg	2680	CConsumer	615.69	609 17	15	297.56 4562.41	0.0024	0.001	588945	13.52	1010	4.37	2.25	6.90	1.91	0.27	0.23	5.0	4.2	5.4	3.5	4.1 3.5	_		1
S End Consumers Power blog	3144	CHstgN	015.05	003.17	18	238.75	0.0024								1.53									7.1	1
N Hastings Street	21004	JHstg N	615.07	608.59		4323.66																			
Hastings S/O Bailroad	3143 21005	CHstgRR	615 71	608 21	18	162.48 4161.18	0.0023								1.04										1
Hastings of o Hamoud	2012.1	CRRE	010.71	000.27	24	374.51	0.0023								2.40									)	1
Railroad Easement	21006	JRR	610.0	607.33		3786.67					1000													)	1
AGtide Hannah at Garfield-East	2012.2	JGfidE	614.0	606.49	24	3520.30	0.0032	0.001	508653	11.68	1060	3.77	1.94	5.96	- 1.71	0.27	0.23	9.3	7.9	10.1	6.6	/./ 0.0		)	1
	2012.3	CGfld		-0.000	24	82	0.0028								0.53										1
S Carfield S/of Hanna	21027	ICHAO	614.0	609 90				0.0018	723803	16.62	1430	5.27	2.76	8 40	-	0.27	0.23	15.5	13.0	16.9	11.0	12.8 10.9	-	13.3	<u> </u>
AGfldS	21027	CGfidS	014.0	000.00	18	400	0.0028	0.0018	723093	10.02	1450	5.57	2.70	0.45		0.27	0.23	15.5	13.2	10.0	11.0	12.0 10.9	(28	s) 10.8	
	01000	les au	011 70	607.66		0.400.00									]									00:44-01:04	
Aanah at Garlield-West Aalaulo	21008	CA1	614.73	606.26	30	3438.30 311	0.0023	0.0034	142358	3.27	300	1.06	0.54	1.67	1.99	0.28	0.24	16.8	14.3	18.1	11.8	13.8 11.7		20.9	1
Hannah at A1 Auto	21009	JA1Auto	613.94	605.53	citera II	3127.30									1								-		
AFern Hannah at Fern	2012.5	CFemE	614.67	605 17	30	311 2816 30	0.0012	0.0024	164430	3.77	960	1.22	0.63	1.93	1.99	0.27	0.23	18.2	15.5	19.7	12.8	14.9 12.7	_	22.6	<b> </b>
	2013.1	CFemW	014.07	003.17	30	333	0.0017								2.13									)	1
955 Hanna/Tan House	21011	J955	612.9	604.59		2483.30					1540								10.0						1
ARoseE Rose St @ Kelley St S/of Hanna	2013.2		615.0	610.40	30	333	0.0019	0.0038	377226	8.66	1540	2.80	1.44	4.42	2.13	0.28	0.24	21.5	18.3	23.2	15.1	17.6 15.0	-	24.9 0.4 to 2.9	
AKelley		CRoseS		A CONTRACTOR	12	366	0.0071	0.002	409396	9.40	1680	3.04	1.56	4.80		0.27	0.23	3.5	3.0	3.8	2.5	2.9 2.4		00:12-01:07	
Rose St @ Wood St S/of Hanna	21033	JWood	614.1	607.79	12	320	0.0071	0.002	244335	5.61	1160	1.91	0.93	2.86		0.27	0.23	5.6	1.8	60	15	17 15	(28	0.4 to 1.1	
Avvoda		Chose		605.51	16	520	0.0071	0.002	244555	5.01	1100	1.01	0.95	2,00	1 1	0.27	0.23	5.0	1.0	0.0	1.5	1.7 1.5	(20	00:44-01:05	<u> </u>
Hannah at Rose	21012	JRose	612.70	603.97		2150.30																			1
879 Hanna/Lavender House	1886.1	CRoseW J879	612.0	602.26	30	233 1917.30	0.0073								1.49									34.9	<del> </del>
ABatesE	1886.2	CBatesE		1990 Metalow -	30	233	0.0064	0.0026	245861	5.64	950	1.82	0.94	2.88	1.49	0.28	0.24	32.9	23.1	35.3	20.5	23.9 20.3			1
Hannah at Bates	21014	JBates	613.64	600.77	26	1684.30	0.0022	0.0080	197204	4 20	760	1 20	0.71	2.20	0.75	0.20	0.25	24.6	24.6	27.0	21.6	25.2 21.4		20 1	1
Hannah at Grant	21015	JGrant	608.8	599.41	30	1255.30	0.0032	0.0089	187304	4.30	760	1.39	0.71	2.20	2.75	0.29	0.25	34.0	24.0	37.0	21.0	25.2 21.4		30.1	<u> </u>
ABarlowE	1887.2	CGrantW	500.4	500.00	30	429	0.0218	0.018	336972	7.74	1670	2.50	1.29	3.95	2.75	0.30	0.26	37.7	27.3	40.1	23.7	27.6 23.5	_	43.6	<b> </b>
AwdmrNE	1887.3	CVallevE	599.1	590.06	36	826.30 207.60	0.0053	0.0028	299946	6.89	1520	2.22	1.14	3.52	1.33	0.28	0.24	40.3	29.6	42.9	25.5	29.7 25.2		48.0	1
Hannah at Valley	21017	JValley	597.11	588.97		618.70									1								-		
AWdmrSE Hannah at Wdmr Alley	1670	CValleyW	599.40	588 76	36	122.03 496.67	0.0017	0.0104	79080	1.82	400	0.59	0.30	0.93	0.78	0.29	0.25	41.1	30.2	43.6	26.0	30.2 25.7		55.0	<u> </u>
. annar ac roini riicy	1475.1	CAlleyW	000.40	300.70	36	149.79	0.0020								0.96									53.5	
Hanna/Woodmere SE Corner	210??	JWdmrSE	594.5	588.46		346.88	0.0100	0.0060	060710	E OF	040	1.05	1.01	0.00	0.14	0.00	0.04	40.4	20.0	46.0	07.5	201 070			
East of E'ly twin Manholes	21019	JWdmrE	594.65	588.24	30	324.88	0.0100	0.0063	203/10	6.05	840	1.90	1.01	3.09	0.14	0.28	0.24	43.4	32.2	40.0	27.5	32.1 27.3			1
AWdmrNW	1317	CShorty			36	7.38	0.0054	0.0045	242450	5.57	800	1.80	0.93	2.84	0.05	0.28	0.24	45.6	34.1	48.3	29.0	33.8 28.7		57.2	$\square$
West of E'ly twin Manholes	3336	JWdmrW CWdmrE	594.63	588.20	36	317.50 22.88	0.0035								0.15								68.72	60.6	1
Woodmere Eside C/L	21021	JECL	594.86	588.12		294.62	0.0000																00.72		<u> </u>
	3337	CWdmrW			36	149.66	0.0023								0.96										1
Hanna Eside RR Tracks	21022	JRRE	596.00	587.78	36	144.96 94.96	0 0023								0.61										1
Beachfront Manhole	21023	JBeach	596.00	587.56		50.00	0.0020								0.01										1
Boardman Lake Outlets (2)	1480	C21		507.00	30	50.00									0.32										1
	1481	C21.1		587.00	18	Each																			1
	Out-21.1	Out21.1		587.60	(೧೯೭																				1
		Submerged Outfall	(21) Elevation:	500.0				1																	1
	8	Ave Slope =	0.0045					Total Area	4814565 sf	110.53	ac	35.71	18.38	56.44	Tc 63 min									4.9	1
		2 201002 - <sup>20</sup> -102010 -						2007 Area		151.80	ac	49.05	25.24	77.52			4.070	45.6	34.1	48.3	29.0	33.8 28.7	68.7	60.6	
															Area Convers	sion:	1.373	62.6	46.8	66.3	39.8 M Multiplier	46.4 39.5 ( 0.538 (tabular	27) ave/XP neak fla	65.4	т
																					in manupiler:	ulabula	aventi peak nu	•••)	

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Second Control



	<u>EPA SWN</u>	<u>im input</u>
ROUTING INFILTRAT DURATION TIME STEI	10N I PS	DYNAMIC WAVE CURVE NUMBER 63 MIN
REPORT DRY WE WET WE ROUTING TIME SER	TING – EATHER – EATHER – MODEL IES	1 MIN 1 MIN 1 SEC DYNAMIC WAVE
TIME INTERV. TYPE RAIN GAL	4L — 2—,5—, IGE	3.0 HRS; 24 HRS 1 MIN; 0.1 HR; 0.25 HR 10–YEAR; IDF AND TYPE II
FORMA SOURCE SUBCATCI	T – VO E TYPE – HMENT	LUME; CUMULATIVE/INCHES TIME SERIES
AREA WIDTH GROUNI IMPERV N impe N pervi D impe D pervi Z impe PARTIA	– D SLOPE – IOUSNESS – rvious – rvious – rvious – rvious – L ROUTING –	VARIES, 110.5 AC TOTAL VARIES, FEET VARIES 0.1 TO 1.8% 49% 0, 0.014 0.16, 0.30 0, 0.05 0.127, 0.2 3% 26% IMPERV OVER PERV 100% PERV TO OUTLET
BASELINE OBSERV Tc	DATA /ATION POINT _ _	CGrantW/1887.2 63 MIN
CURVE NU NUMBEN DRY TII	'JMBER r – me –	55.0, 72.2 2.2/1.4
MODIFIED K satur SUCTIO DEF ini	GREEN—AMP rated – N HEAD – tial	T 2.579 /1.909* 0.34
*MA THE	EMATICALLY RELA	TED=3.237*Ks^(-0.328)
HORTON I maxin I minim T dryin K deca	num – num – g – y –	6 / 20** 2 / 5** 2.2/1.4*** 6
**Natio ***BY [	nal Resources Co DEFINITION; T dry	nservation Service (±) ing=3.125*(1 min)^—0.5

HANNA AV	E STATISTICS-20	07 STORMWA	ATER MANAGEM	ENT REPORT
PAVEMENT RESIDENTIAL	2,136,536 SF 1,099,404 SF	32.31% 16.63%	CN=98 CN=75	IMPER VIOUS IMPER VIOUS
FORESTED	3,376,651 SF	51.06%	CN=55	PERVIOUS
TOTAL	6,612,591 SF <sup>[1]</sup>	100%	CNave=70.1	
SIDEWALK STRUCTURE STREET	92,258 SF 1,004,146 SF 2,136,536 SF	2.85% <sup>[2]</sup> 31.06% 66.09%	<=100% TO PERV <=75% TO PERV	10US [3] 10US [3]
TOTAL	3,232,940 SF	100%		
[1] MULTIPL [2] ASSUMEL [3] ASSUMEL	LY BY 0.6107 TO OB D % IMPERVIOUS WITH D% ROUTED ACROSS	TAIN MODIFIED ( 1 NO DEPRESSIO PERVIOUS AREA	CITY MODEL AREA ON STORAGE; ROU 1: (92+(0.75*1004)	NDED TO 3% ))/3233 ~ 26%

# <u>NOTES</u>

(1)	The drainage area varies significantly in elevation, with notable drops west of Grant on Hanna and north on Woodmere Alley to its intersection with Hanna. Surface slope was calculated for each subcatchm
	low point and dividing their difference by their separation. The 2007 average slope of 0.0035 (L=5560 ft/dE=19.5 ft) did not appear reflective of underlying topography of the drainage area as a whole.
(2)	City storm drain maps were reviewed and the overall drainage boundary estimated based on inlet locations   The Modified City Model area was widened into the area north of Hanna identified as having no ri
( )	drainage area of 110.53 acres, which appears overstated. The determination of 110.53 acres was erroneously understated when additional subcatchments were found out of sequence in the OHM input file :
	to about 163 ac. or 7% greater than the 2007 area estimate (151 80). Neither the 2007 nor the OHM areas could be substantiated based on both the storm drain maps and field visits. The City Model remains
	argument can be made to reduce this back to the original drainage area of argund 100 acres. 1 2007 peak runoff determinations are proportional by area to those produced by the City Model
(3)	"Width" calculated or estimated based on EPA Storm Water Management Model (SWMM) Beference Manual Volume 1. Chapter 3 Lithis number is noted in documentation as a calibration value.
(4)	Portions of the subarea, in acres I classified pavement, residential, and forested per the 2007 Stormwater Management Report. Note that residential area is counted in its entirety as part of the 49 percent im
(.)	the weighted curve number calculation (probably should have been counted as 98 accordingly)
(5)	Average curve number of 72.2 per 2007 model which appears to have underestimated CN by weighting residential as 75, when in fact it is counted as 100 percent impervious in the overall calculations I The
(0)	impervious area per Bossmiller CN equation using percent impervious and the TYPE A soil constant (39)
(6)	Once the drainage areas and storm drain piping were finalized, a simulation was run with only the upper subcatchment (AHsto) discharging to the storm drain plus an input of 2 cfs (pipe capacity) at the upstr
(0)	"slug" of water traveling along the pipe in order to determine the time of equalibrium of 27 minutes (40% Opeak: hydrograph inflection point) at Grant Street plus an estimated travel time of 6 minutes to the o
	Street is the location where the storm drain begins to slope downward to an elevation where backwater occurs from the outlet, which affects the output to some degree. I Overland travel time was defined at
	equal to 0.9 in/br (upper limit of open channel flow in the storm drain) which resulted in a 30 minute estimate: To estimate equals the total (27+6+30) or 63 minutes.
(7)	Chosen return period and corresponding average intensity for a duration equal to the To calculated in (6) Laverage intensity is calculated using equation (Boucher, Costa County, CA, 2010) fit to NOAA DDE
(1)	data at Cherry Capital Airport (see IDE equations tab)
(8)	Peak Elow Bate(ofs) – Unit SBO (qu) <see (15)="" (17)="" (p-la)="" (p-la+s)="" 2="" <="" and="" appendix="" area="" below="" belows="" by="" f="" for="" has="" in="" inchess="" la="" lnote:="" lsee="" miles="" mult="" qu-<="" refined="" s="" sbo="" square="" t55="" td="" usda=""></see>
(9)	The SCS/MDEQ methods typically underestimate peak runoff rates for total surface runoff (SBQ) in the neighborhood of 1/2-inch or less
(10)	Bational method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (2007 Study Type B soil), return interval, average land surface slope, rainf
(11)	Bational method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (Rossmiller Type A soil), return interval, average land surface slope, rainfa
(12)	Both C coefficients were calculated Bossmiller's equation to convert from CN, however the 2007 is based on a Type B soil while the other is based on a Type A soil per NBCS Web Soil Survey, maps and de
(13)	These replicate the 2007 Stormwater Management Report calculations using the tabular SCS curve method based on and land uses assumed/measured therein 1 the 5-year return interval (only) includes the
()	purposes, see MDEQ Soil Erosion and Sedimentation Control Training Manual, Chot 7   actual peak flow is proportionally larger based on drainage area [(151.80/110.53)*28.7=39.4 cfs].
(14)	It is worth noting how rational method numbers and SCS/MDEQ numbers are somewhat close to one another; although both are based on the same return period, one is entirely derived from projected local
(,	calculated rainfall duration (Tc), while the other is based on a peak runoff relationships derived from a 24-hour duration rainfall based on certain statistical correlations
(15)	Total SRO in inches; based on 24-hour rainfall, curve number, and initial abstraction; TR-55 runoff equation, Appendix F; see Chapter 7 "Computing Flood Discharges for Small Ungauged Watersheds", Micl
· · ·	SRO= ((P-la)^2)/(S+P-la) where: S=storage in inches=((1000/CN)-10); CN=curve number; P= 24-hr rainfall in inches for a given return period; la=initial abstraction=(constant)*S; constant=0.2 normally, but (
	{Table 7-2 equivalent: MDEQ Soil Erosion and Sedimentation Control Training Manual, Chapter 7; see SCS Curve Method tab}
(16)	Per definition, tabular calcs reflect the 0.2 "constant", which was actually developed from a relatively diverse data set gathered througout the country; the equation approach allows varying this "constant" whi
	0.05 has been proposed to replace the current 0.2 constant; see SCS Curve No. Method tab
(17)	MDEQ Stormwater Management Guidebook, Chapter 7, Unit Hydrograph Peak, Equation 21: qu (unit surface runoff)= 270.9*((Tc)^-0.81) in cfs/(sq mi-in) {Table 7-3 equivalent; MDEQ Soil Erosion and Sedir
	Chapter 7} mult by area in square miles and SRO as described in (15) to determine peak runoff flow rate.
(18)	An initial estimate of peak flow modeling the entire drainage area as one, using a "width" of 10,000 ft and the 2007 Stormwater Management Report average slope of 0.0035.
(19)	Model run with all existing pipes oversized to 72 inches so no losses occur upstream; the purpose is to determine a maximum resultant or total peak flow rate without any system losses occurring; subcatching
	for both existing piping and oversized piping simulations
(20)	Not used
(21)	Modified City Model simulations incorporating 15 subcatchments discharging to 15 inputs on the storm drain system; rainfall intensity for columns [G] through [J] correspond to the time of concentration and r
	and (7), respectively. Column [G] reflects the Modified City Model with impervious area (pavement and residential) defined as such with the remaining pervious area (forested) defined by a 55 curve number
	[G] but instead uses the 72.2 weighted curve number as well as area weighted OHM values for Nperv (0.16) and Dperv (0.127)   Column [K] reflects the Modified City Model performance with Green-Ampt in
	distribution imposed on the system.
(22)	This simulation reflects the OHM model configuration as described in (23) with additional changes to slopes, routing, etc. which reflect those developed for the City model; a standard Type II rainfall distribution
	(P2=2.09; P5=2.70 in) was also incorporated.
(23)	This simulation reflects the OHM model configuration as described in (24) except areas of Subcatchments 21005, 21014, and 21021 proportioned downward to reflect areas within the City Model (totalling 1)
(24)	This simulation reflects the OHM model configuration with inputs (slopes, routing, etc.) reflecting those developed for the OHM model including the 15-minute, Type II rainfall distribution (OHM P2=2.27; P5=2
	generated OHM's EPA SWMM (as converted from XP-SWMM and provided to the City for review) for all subcatchments; the OHM model has 5 input points along storm drain, each having 3 subcatchments
	system was modeled this way).
(25)	Totals of peak subcatchment surface runoff except XP where Area 3s are routed across Area 1s; nearly the same as generated in OHM's XP-SWMM output as provided February 3, 2017
(26)	Flow rate of this magnitude is "forced" into storm drain with a certain amount of the subcatchment runoff traveling to the next upstream node and reported as "flooding" at this rate
(27)	Peak flows proportioned upward based soley on the ratio (110.53/151.8) of 2007 drainage areas to Modified City Model area; identical to flows calc'd in 2007 Stormwater Management Report
(28)	The period of "flooding" is approximately 25 minutes for each of the simulations and is either a result of erroneous data and/or flows approaching system capacity. The results of these analyses indicate it may
	performance within this vicinity as time permits to either verify or dispute the validity of this ouput.
(29)	Intermediate junction losses (at 12:00) between subcatchment outlet/connections to the storm drain in the model; note the water balance between upstream and downstream junction maintanins continuity.
(30)	Discontinuity in water balance due to oscillations of incoming flow

												Land	d Use Designat	ions	Te	Input/IDF Data							Pe	ak Flow Ra	te (cfs)							1	
Hanna Avenue	2-Year	Return	Interval										Curve Numbers		To verticed =	30 min				Hand Calculati	ions (14)					EPA SWI	MM Software					XP SW MM	
Construction (EEC) Construction of the cons												Pavement	Residential	Fo rested	Vpipe, eve -	2.6 fps		Rossr	miller		MDEQ/SC	CS (8)		Curve Number		Horton				Green-Ampt			Pipe/Junction
												98	Area Proportions	55	(7) HI -	2 yr 1 10 in/hr		No la comp	Method onent (12)	Calcu la const-0.05	lated	Tabular (13)	Single Sub Area	2007		Modified City Mod	del		Ci	v Model	ОНМ		Identification
Designations		St	orm Drain Descrip	ption			SI	оре	Su	bcatch ment l	Info	0.32	0.17	0.51	07 -			2007 CN	Type A soil	RECOVER TO CO	(9)		Chighe Coloritor	Duration	/Frequency Inte	insities		Туре	1	y model	OHM Typell		1
	Identification Numbers	SWMM	MH Elevatio	ons D	)iameter	Cuml Dist	Pi pe	Land	A rea	B (2000)	'Width'	Proportional	Land Use per Si	ubcatch ment	Te (min)	Ratio (Ross	nal C miller) (Turo Angil)	[A]	[B]	[C]	[a]	[E2] [E1]	[F] (18)	[G] (21)	[H] (21)	[1] (21)	[J] (21)	[K] (21)	[L] (22)	[M] (23)	[N] (24)		
	Pipe	Collouit	Estimate	inven (	(incries)	(feet)	<u> </u>	(1)	(2)	(acres)	(1001)		(4)		(6)	(10)	(11)	1				12.2 12.2	55.0	55.0	122	(chi)							
	25152223	20	2010-00 CT	-		1999 100 1000										72.2	67.9																
S Hastings Street at Centre Street Southerly SD reach on Hastings St	21001 2683	JCenter CHstgS	616.82 6	10.59	12	5149.98 290.01	0.0025								31.86																		
S End Consumers Power Bldg Altsta	21002 2680	JC rism (S CConsumer	616.27 6	09.87	15	4859.97 297.56	0.0024	0.001	588945	13.52	1010	4.37	2.25	6.90	1.91	0.25	0.21	3.8	3.2	3.4	1.9	2.2 1.9						12:00-12:09					JCmmS
S End Consumers Power Bldg	21003	JC rism N CHerterN	615.69 6	09.17	18	4562.41	0.0024								1.52								1	5.4	0.2	54	54	1.0 to 5.1					JCrismiN
N Hastings Street	21004	JHstg N	615.07 6	08.59	10	4323.66	0.0000								1.00									267		S7-T	20	10.0	11 56-12:09	11:47-12:02	11:46-12:03	11:48-12:03	JHatg N
Hastings S/O Rai Iroad	21005	JHstgRR	615.71 6	08.21	18	4161.18	0.0023								1.04														0.2 to 9.5 23.6	3.1 to 23.80 42.8	3.5 to 33.8 56.2	43.13 (25)	JHstgRR21005
Rai Iroad Easement	2012.1 21006	CHRE Jan	610.0 6	07.33	24	374,51 3786.67	0.0023								2.40													12:02-12:06 1.2 to 1.9	14.2	20.2	23.5 13.3	20.09 9.23	CRRE/2021.1
Agkite Han nah at Garfield-East	2012.2	CRRW JGIdE	614.0 6	06.49	24	266.37 3520.30	0.0032	0.001	5086.53	11.68	1060	3.77	1.94	5.96	1.71	0.25	0.21	7.0	5.9	6.4	3.5	4.1 3.5	-						18	9.5	10.4	6.55	JGHE
	2012.3	OGild	liter and liter	F1 F1 F1 F1 F1	24	82	0.0028								0.53									303	0.2	10.1	10.1	18.4	416654		6.8		JGIdW
S Gartield S/of Hanna	21027	JEtas	6(4.0 6	08.80	10	400	0.0009	0.0018	723893	16.62	1430	5.37	2.76	8,49		0,26	0,22	11.7	9.9	10.7	5.7	6.9 5.9			0.2	67	67	0.000	000				Joids
Adido		Catab	6	07.66	10	400	0.0020														-		(20	0.0	0.5	0.7	0.7	11:58-12:09	4.8	-6.7 (26)	-6.9 (26)	4.30 (26)	0.000
Aaiauto	21008	GA1	614.73 6	06.26	30	3435.30	0.0023	0.0034	142358	3.27	300	1.05	0.54	1.67	1.99	0.26	0.22	12.6	10.7	11.5	6.2	7.4 6.3		16.7	0.4	16.6	16.6	25.7	12:02-12:06 0.2 to 1.8	1157-12103 3.1 to 10 A	11:47-12:00 3.4 to 11.6	0.4 to 8 D	CA1
Hannahat A1 Auto AFem	21009 2012.5	JA 1Auto GFernE	613.94 6	05.53	30	3127.30 311	0.0012	0.0024	164430	3.77	960	1.22	0.63	1.93	1.99	0.26	0.22	13.7	11.6	12.5	6.7	8.0 6.8		18.0	0.4	17.7	17.7	26.7	24.1	34.0 19.5	34.0 18.6	24.1.4 (25) 20,35	JA 1Auto21009 GFernE/2012.5
Hannah at Fern	21010 2013.1	JForn CFornW	e         0.002         0.002         0.0002        0.0002         0.0002																														
955 Hanna/Tan House ABreat	21011	Jess CBoseF	10.1       20.4       20.33       20028       10.0       2.0       10.0																														
Rose St @ Kelley St S/of Hanna	21032	Jicoloy	1         24         22         0.023         0.0024         0.0015         72959         162         1.40         5.37         2.76         6.49         0.25         0.22         1.17         99         107         5.7         6.9         6.7																														
Rose St @ Wood St S/of Hanna	21033	JWood	net         i																														
AWOOD		Uniose	6	05.51	12		0.0071	V.W/C	244330	10.6	1100	(1.0)	0.86	2.00		0.20	U.ee	40	1.4	0.0	0.0	0.9 0.6	(20	0 0.1	0.0	0.0	0.0	0, <del>1</del> 1156-12:08	(20)	1.3 to 11.9	0.7 to 14.9	7.41	CRoseE
Hannah at Hose	1 896.1	CRoseW	612.70 6	03.97	30	2150.30 233	0.0073								1.49									28.5	1.1	27.8	27.8	39.9	33.4	28.8	28.3	22.06 (25)	CRoseW
879 Hanna/Lavender House ABatese	21013 1886.2	J879 QBatesE	612.0 6	102.26	30	1917.30 233	0.0064	0.0026	245861	5,64	950	1.82	0.94	2.88	1.49	0.26	0.22	24.7	17.4	22.3	10.7	12.9 10.9							33.4	0.0 28.8	63 22.0		JBarlow
Han nah at Bates AGant E	21014 1887.1	JB atos OB atesW	613.64 6	00.77	36	1684.30 429	0.0032	0.0089	187304	4.30	760	1.39	0.71	2.20	2.75	0.27	0.23	26.0	18.5	23.4	11.3	13.6 11.5	1	30.9 (2	ao) 1.2	30.1	30.1	41.1	47.4	24.0 52.7	54.1	21.55 (25) 50.93	JBatos/21014 CBatesW
Hannah at Grant ABatowe	21015 1887.2	JGrant OGrantW	608.8 5	99.41	30	1255.30	0.021.8	0.018	336972	7.74	1670	2.50	1.29	3.95	2.75	0.28	0.24	28.4	20.5	25.4	12.4	14.8 12.6	1	34.2	1.4	33.2	33.2	52.1	0.0 47.4	3.1 49.5	6.0 48.1	(27)	J879 CGantW
Han nah at Barlow Awdm NE	21016 1887 3	Jeatow	599.1 5	90.06	36	826.30 207.60	0.0053	0.0028	2999.46	6.89	1520	2.22	1.14	3.52	1 33	0.26	0.22	30.4	22.2	27.2	133	160 126	1	38.2	19	36.3	963	59.0	11 58-12:00	11:40-12:00	11:49-12:00	1152-1201	()/alacE
Hannah at Valley	21017	JValey	597.11 5	88.97	36	618.70	0.0017	0.0104	79080	1.82	400	0.50	0.30	0.02	0.78	0.27	0.23	30.0	22.7	276	126	16.3 12.0		41.3	24	30.0	39.0	50.5	10.9	14.8	14.8	11.40 (25)	JValley/21042
Hannah at Wdmr Alley	21018	JwdmrAllay	599.40 5	88.76	00	495,67	0.0000		//////	1.02	Tere	0.00	0.50		0.00		Willow		All line of	27.0		10.0 12.0	1	40.0	0.7	20.0	20.0	61.0				2227	CALL M
Han na/Woodmere SEComer	210??	JWdmrSE	594.5 5	88.46	30	346.88	0.0020								0.90				-					42.2	2.1	39.0	38.0	1.0 to 7.2	6.1	3,4	7.6	5.07 (29)	JWdmrSE
East of Ely twin Manholes	21019	JWdmrE	594.65 5	88.24	36	22 324.88	0.0100	0.0063	263716	6.05	840	1.96	1.01	3,09	0.14	0.27	0.23	32.7	24.2	29.2	14.4	17.3 13.7	-					11:57-12:09	4.0	33	75 74	4.93 (29) 4.91 (29)	Jwdmie Jwdmiw
AWdmiNW West of Elly twin Manholes	1317 21020	UShoty Jwamrw	594.63 5	88.20	36	7.38	0.0054	0.0045	242450	5.57	800	1.80	0.93	2.84	0.05	0.26	0.23	34.3	25.6	30.6	15.2	18.2 14.5	4	44.9	2.8	42.2	42.2	63.4	-		33.8 11:51-12:00	40.95 1153-1201	OShoty
Woodmere Eside C/L	3338 21021	OWdmrE JECL	594.86 5	88.12	36	22.88 294.62	0.0035								0.15								51.2	47.4	3.3	44.4	44.4	67.8	47.3	51.0	7.2 to 9.0 55.6	2.2 to 5.0 40.83 (25)	GWdmrE JECL/21021
Hanna Feida BB Tradva	3337 21022	OWd mrW looc	505.00 5	87.78	36	149.66	0.0023								0.96														72.0	75.0	82.0	77.00	CWdmiW
Dana Martin II.	1479	QBeach	500.00	07 50	36	94,96	0.0023								0.61																		In
Beachfront Mannole Boardman Lake Outlets (2)	1480	C21	50000000	07.00	30	50.00									0.32																		Joseach
	Out-21 1 481	Out21 021.1	5	87.00	18	Each																											
	Out-21.1	Out21.1	5	87.60																													
	1	Submerged Outfall () Ave Slope -	21) Elevation: { 0.0045	590.0				Total Area	481 4565 =	1 110.53 =	C	35.7 f	18.38	55.44	To 63 min									17.9		2.5	25	14.7	10.0	70.9	95.1	79.32	
	Out-21.1       Out-21.1       587.00       Image: Conversion for the leval on the level on																																
																par 1940 ()						ಪಾರಾಷಕ್ರೆ ನಿರ್ದೇಶಗೊಂಡಿ		1000000	Total Subca	tchment Peak R	unoff:	101.6	116.1	169.1	222.2	163.11	

										SCS Method		M
	2-Ye	ar In	filtratio	n/Ra	ainfall/Runoff D	)ata			Surface Runoff (	SRO)	Unit SRO (qu)	
								Calcula	ated* (15)		Tabular	Unit Peak
otion	2007		Rossmille	ər	24-hr	Rainfall		la Cons	stant	Table 7.2	Table 7-3**	Calcula
type:	В		A					0.05	0.2			
Γ					2 yr	P2 =	2.09 in	0.627	0.338	0.35 in	0.47 cfs/(in-ac)	
No.	72.2	(5)	67.9	(5)	5 yr	P5 =	2.7 in	0.990	0.645	0.65 in	0.47 cfs/(in-ac)	0.41 cfs/
rage	3.85	in	4.73	in	10 yr	P10 =	3.21 in			0.96 in	0.47 cfs/(in-ac)	
CN						(16)	la =	0.192 in	0.769 in	**	2007 average slopes: pipe 0.52%; v	watershed 0.35
						_				-	Table 7-3 value for 0.35% slope:	0.40 cfs/

													Land	i Use Designa	tions	Τα	Input/IDF Dat	8					Peak	Flow Rate (c1	<b>(</b> \$)				
	Hanna Avenue	10-Yea	r Return	n Inter	val									Curve Numbe	18	Towned	30 min				Hand Calcula	tions (14)			FPA	SWMM Software			
	i lainia / ii onao		i i iotai i		· ai								Pavement	Residential	Forested	Vpps, ave =	2.6 fps		Ross	miller		MDEQ/S	GCS (8)		Gurve Number	SW min Software	Horton	Green-Ampt	Pipe/Junction
Import         Protect         Protoct         Protoct <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>98</td><td>75 Area Proportion</td><td>55</td><td>(7) RI - (7) I10 -</td><td>10 yr 1,63 in/hr</td><td></td><td>Rational No la comp</td><td>I Method ponent (12)</td><td>Calc la const -0.05</td><td>ulated la</td><td>Tabular (13)</td><td>Single Sub Area</td><td>2007</td><td>Modified</td><td>City Model</td><td></td><td>Identification</td></th<>													98	75 Area Proportion	55	(7) RI - (7) I10 -	10 yr 1,63 in/hr		Rational No la comp	I Method ponent (12)	Calc la const -0.05	ulated la	Tabular (13)	Single Sub Area	2007	Modified	City Model		Identification
	Designations		Sto	orm Drain D	escription	1		SI	оре	Sub	catchment Inf	fo	0.3231	0.17	0.51	-			2007 CN	Type A sol	101	(9)	1503 1543		Duration	/Frequency Inten	sities		1
Image: state         Image: state<		Numbers	Junction	мне	evations	Diameter	Cuml Dist	Pipe	Land	Area		"Width"	Proportional	Land Use per 8	Subcatchment	(min)	(Ros	smiller)	IAI			[1]	[E2] [E1]	(18)	(21)	[H] (21)	[1] (21)	(21)	
Nor         Nor <td></td> <td>Manhole Pine</td> <td>Conduit</td> <td>Rim Estimate</td> <td>Invert</td> <td>(inches)</td> <td>Length (feet)</td> <td>(f</td> <td>(1)</td> <td>(sq feet)</td> <td>(acres)</td> <td>(feet) (3)</td> <td></td> <td>(acres)</td> <td></td> <td>(6)</td> <td>2007 CN (10)</td> <td>(Type A soil) (11)</td> <td>-</td> <td></td> <td></td> <td></td> <td></td> <td>55.0</td> <td>55.0</td> <td>72.2</td> <td>(cis-bypass (cis)</td> <td></td> <td></td>		Manhole Pine	Conduit	Rim Estimate	Invert	(inches)	Length (feet)	(f	(1)	(sq feet)	(acres)	(feet) (3)		(acres)		(6)	2007 CN (10)	(Type A soil) (11)	-					55.0	55.0	72.2	(cis-bypass (cis)		
shore with the state         state </td <td></td> <td>1190</td> <td></td> <td>Lauria</td> <td></td> <td></td> <td>(1001)</td> <td></td> <td></td> <td>(-/</td> <td></td> <td>(0)</td> <td></td> <td>(4/</td> <td></td> <td>(0)</td> <td>(10)</td> <td></td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>(cm)</td> <td></td> <td>   </td>		1190		Lauria			(1001)			(-/		(0)		(4/		(0)	(10)		1								(cm)		
Norm         Norm <th< td=""><td>S Hastings Street at Centre Street</td><td>21001</td><td>JCenter</td><td>616.82</td><td>610.59</td><td></td><td>5149.98</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>72.2</td><td>67.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>   </td></th<>	S Hastings Street at Centre Street	21001	JCenter	616.82	610.59		5149.98										72.2	67.9											
non-       no-	Southerly SD reach on Hastings St	2683	CHstgS	818.97	800.87	12	290.01	0.0025								31.86													100
bit       b	A Hatg	2680	Consumer	010.27	009.07	15	297.56	0.0024	0.001	588945	13.52	1010	4.37	2.25	6.90	1.91	0.28	0.24	6.2	5.3	7.3	5.2	6.1 5.2		00:33-01:06		00:33-01:04	00:33-01:04	JUNISTIS
network         network <t< td=""><td>S End Consumers Power Bldg</td><td>21003 3144</td><td>JC rismiN CHistoN</td><td>615.69</td><td>609.17</td><td>18</td><td>4562.41 238.75</td><td>0.0024</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1.53</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0.1 to 2.1 1:17 9.5</td><td>0.9</td><td>0.1 to 1.0 9.2</td><td>0.1 to 1.0 9.2</td><td>JCnsmrN CHstaN</td></t<>	S End Consumers Power Bldg	21003 3144	JC rismiN CHistoN	615.69	609.17	18	4562.41 238.75	0.0024								1.53									0.1 to 2.1 1:17 9.5	0.9	0.1 to 1.0 9.2	0.1 to 1.0 9.2	JCnsmrN CHstaN
Alt of the transmission         Alt of transmission </td <td>N Hastings Street</td> <td>21004</td> <td>JHstg N</td> <td>615.07</td> <td>608.59</td> <td></td> <td>4323.66</td> <td></td> <td>02 10 0 6</td> <td></td> <td></td> <td></td> <td>JHstg N</td>	N Hastings Street	21004	JHstg N	615.07	608.59		4323.66																		02 10 0 6				JHstg N
new         new <td>Hastings S/O Rai Iroad</td> <td>3143 21005</td> <td colspan="3">man         man         man</td>	Hastings S/O Rai Iroad	3143 21005	man         man																										
matrix         matrix<	Bailroad Exement	2012.1																											
norm         norm <th< td=""><td>AGidE</td><td>2012.2</td><td>CREW</td><td colspan="2"></td><td></td></th<>	AGidE	2012.2	CREW																										
new         new <td>Hannah at Garfield-East</td> <td>21007 2012.3</td> <td>Jorde Ogra</td> <td>614.0</td> <td>606.49</td> <td>24</td> <td>3520.30 82</td> <td>0.0028</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.53</td> <td></td> <td>JG1dE</td>	Hannah at Garfield-East	21007 2012.3	Jorde Ogra	614.0	606.49	24	3520.30 82	0.0028								0.53													JG1dE
<ul> <li>and series</li> <li>and series</li></ul>		04007			000.00				0.001.0	700000	40.00	1.100		0.75	0.40			0.01	10.0	10.5		10.1	100 101		1.08 15.5	1.6	14.3	14.3	CGId
matrix	AGlidS	21027	Ostas	614.0	608.80			11.4	11.4	Catds																			
Answer in the second s	Hannah at Garlield-West	210.08	. Icataw	614 73	607.66 606.26		3438.30																	1	00:27-01:05		00:25-01:05	00:26-01:05	
nome       no	AA1Auto	2012.4	CA1	014.75	000.20	30	311	0.0023	0.0034	142358	327	300	1.06	0.54	1.67	1.99	0.29	0.25	20.9	17.8	24.3	17.4	20.3 17.3		1:08 23.5	3.2	22.7	22.7	GA1
Hord State       And State	Han nahat A1 Auto A Fern	21009 2012.5	JA 1Auto CFernE	613.94	605.53	30	3127.30 311	0.0012	0.0024	164430	3.77	960	1.22	0.63	1.93	1.99	0.29	0.25	22.6	19.3	26.4	18.8	22.0 18.8		1:08 24.8	3.6	23.8	23.8	JA 1Auto21009 CFernE/2012.5
norm	Hannah at Fern	21010	JFern Cfourth	614.67	605.17		2816.30	0.001.7								0.10								1					JFern
Alter         Alter <th< td=""><td>955 Hanna/Tan House</td><td>21011</td><td>Jass</td><td>612.9</td><td>604.59</td><td></td><td>2483.30</td><td>0.0017</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2.13</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>J955</td></th<>	955 Hanna/Tan House	21011	Jass	612.9	604.59		2483.30	0.0017								2.13													J955
All         All <td>ARoseE Bose St @ Kelley St S/of Hanna</td> <td>2013.2</td> <td>CRoseE</td> <td>615.0</td> <td>610.40</td> <td>30</td> <td>333</td> <td>0.0019</td> <td>0.0038</td> <td>377226</td> <td>8.66</td> <td>1 540</td> <td>2.80</td> <td>1.44</td> <td>4.42</td> <td>2.13</td> <td>0.29</td> <td>0.25</td> <td>26.8</td> <td>22.8</td> <td>31.0</td> <td>22.2</td> <td>26.0 22.1</td> <td>-</td> <td>1:09 26,1 05 to 4 2</td> <td>4.3</td> <td>26.1 0.2to35</td> <td>26.1 02 to 3.5</td> <td>CRoseE</td>	ARoseE Bose St @ Kelley St S/of Hanna	2013.2	CRoseE	615.0	610.40	30	333	0.0019	0.0038	377226	8.66	1 540	2.80	1.44	4.42	2.13	0.29	0.25	26.8	22.8	31.0	22.2	26.0 22.1	-	1:09 26,1 05 to 4 2	4.3	26.1 0.2to35	26.1 02 to 3.5	CRoseE
nome       no       no <th< td=""><td>Akoloy</td><td></td><td>CRoses</td><td></td><td></td><td>12</td><td>356</td><td>0.0071</td><td>0.002</td><td>409396</td><td>9.40</td><td>1680</td><td>3.04</td><td>1.56</td><td>4.80</td><td></td><td>0.29</td><td>0.25</td><td>4.4</td><td>3.8</td><td>5.1</td><td>3.6</td><td>4.2 3.6</td><td></td><td>00:10:01:09</td><td></td><td>00:10-01:07</td><td>00:10-01:07</td><td></td></th<>	Akoloy		CRoses			12	356	0.0071	0.002	409396	9.40	1680	3.04	1.56	4.80		0.29	0.25	4.4	3.8	5.1	3.6	4.2 3.6		00:10:01:09		00:10-01:07	00:10-01:07	
non-finite       non-finit       non-finite       non-finite <td>AWood St Good St Syot Hanna</td> <td>21033</td> <td>JWood CRose</td> <td>614.1</td> <td>607.79</td> <td>12</td> <td>320</td> <td>0.0071</td> <td>0.002</td> <td>244335</td> <td>5.61</td> <td>1 160</td> <td>1.81</td> <td>0.93</td> <td>2.86</td> <td></td> <td>0.29</td> <td>0.25</td> <td>7.0</td> <td>2.2</td> <td>8.1</td> <td>2.2</td> <td>2.5 2.2</td> <td></td> <td>(28) 0.1 to 2.7 1:19 5.6</td> <td>3.2</td> <td>0.1to12 5.4</td> <td>0.1 to 1.2 5.4</td> <td>JWood CRose</td>	AWood St Good St Syot Hanna	21033	JWood CRose	614.1	607.79	12	320	0.0071	0.002	244335	5.61	1 160	1.81	0.93	2.86		0.29	0.25	7.0	2.2	8.1	2.2	2.5 2.2		(28) 0.1 to 2.7 1:19 5.6	3.2	0.1to12 5.4	0.1 to 1.2 5.4	JWood CRose
norm	Hannah at Rose	21012	Boso	612.70	605.51 603.97		2150.30																	1	1.35 00.26-01.96		00/25-01:05	00:25-01:05	IRono 21012
All Mandembersaria       7170       Ann       610       1070       1070       000       -000       -000       1000		1 896.1	CRoseW	012.70	000.57	30	233	0.0073								1.49									0.45 35.7	9.0	35.8	35.8	CRoseW
International basis       1010       Lane       Lane <thl< td=""><td>879 Hanna/Lavender House ABatesE</td><td>21013 1886.2</td><td>J879 OBatesE</td><td>612.0</td><td>602.26</td><td>30</td><td>1917.30 233</td><td>0.0064</td><td>0.0026</td><td>245861</td><td>5.64</td><td>950</td><td>1.82</td><td>0.94</td><td>2.88</td><td>1.49</td><td>0.29</td><td>0.25</td><td>40.8</td><td>28.8</td><td>47.3</td><td>30.1</td><td>35.3 30.0</td><td></td><td>1:05</td><td></td><td></td><td></td><td>J879</td></thl<>	879 Hanna/Lavender House ABatesE	21013 1886.2	J879 OBatesE	612.0	602.26	30	1917.30 233	0.0064	0.0026	245861	5.64	950	1.82	0.94	2.88	1.49	0.29	0.25	40.8	28.8	47.3	30.1	35.3 30.0		1:05				J879
$     \begin{array}{  c c c c c c c c c c c c c c c c c c $	Hannah at Bates	21014	JBatos	613.64	600.77	~	1684.30	0.0020	0.0000	187204	4.90	760	1.50	0.71	2.20	0.75	0.30	0.06	42.0	20.7	40.6		97.5 91.7	1	out - 50.1	100	20.1	20.1	JBatos/21014
Advance       18072       Circuit       Circuit       18072       Circuit	Han nah at Grant	21015	JGrant	608.8	599.41	30	1255.30	0.0032	6800.0	18/304	4.30	/60	1.39	0.71	220	2.75	0.30	0.20	43.0	30.7	49.0	31.0	31.2 31.1	1	0347 339.1	10.0	39.1	39.1	CBatestiv
	ABalowE Hannah at Barlow	1887.2 21016	OGrantW JBatow	599.1	590.06	30	429 826,30	0.0218	0.018	336972	7.74	1670	2.50	1.29	3.95	2.75	0.31	0.27	46.9	34.0	53.8	34.8	40.7 34.6	-	1.08 45.9	11.4	45.1	45.1	GGrantW
1010       0.43 / 2       0.01 / 2.01/2       0.01 / 2.01/2       0.00 / 2.01/2       0.00 / 2.0 </td <td>AwdmiNE</td> <td>1887.3</td> <td>CvaloyE</td> <td>507.11</td> <td>500.07</td> <td>36</td> <td>207.50</td> <td>0.0053</td> <td>0.0028</td> <td>299946</td> <td>6.89</td> <td>1520</td> <td>2.22</td> <td>1.14</td> <td>3.52</td> <td>1.33</td> <td>0.29</td> <td>0.25</td> <td>50.1</td> <td>36.8</td> <td>57.5</td> <td>37.4</td> <td>43.8 37.3</td> <td>-</td> <td>1:04 51.6</td> <td>14,3</td> <td>48.3</td> <td>48.3</td> <td>CvalloyE</td>	AwdmiNE	1887.3	CvaloyE	507.11	500.07	36	207.50	0.0053	0.0028	299946	6.89	1520	2.22	1.14	3.52	1.33	0.29	0.25	50.1	36.8	57.5	37.4	43.8 37.3	-	1:04 51.6	14,3	48.3	48.3	CvalloyE
Image: Proper term         Properterm	AWdmise	1670	JValley OValleyW	597.11	588.97	36	122.03	0.0017	0.0104	79080	1.82	400	0.59	0.30	0.93	0.78	0.30	0.26	51.0	37.6	58.4	38.1	44.6 38.0		1:04 57.0	16.1	52.4	52.4	JValley/21042 GValleyW
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Hannah at Wdmr Alley	21018 1.475.1	JWdmrAlley	599.40	588.76	36	496.67	0.0020								0.95								1	10/ 58.6	16.9	53.5	53.5	Callcont
AWade       14752       CAvic       6       2       2       0.0000       0.0003       280716       6.05       6.05       1.01       3.09       0.11       0.02       0.28       6.0       0.10       6.17       4.05       47.4       40.3       47.4      <	Hanna/WoodmereSEComer	210??	JWdmrSE	594.5	588.46		346.88	0.002.0								0.50									104 00.0	10.3	00.0	03.0	JWdmrSE
Award       Mode       Set of ty win Marchine       Set of ty win Marchine <t< td=""><td>AWdm/SW East of Elly twin Manholes</td><td>1 475.2 210 19</td><td>GAngle JNVdmrE</td><td>594.65</td><td>588.24</td><td>36</td><td>22 324.88</td><td>0.0100</td><td>0.0063</td><td>263716</td><td>6.05</td><td>840</td><td>1.96</td><td>1.01</td><td>3.09</td><td>0.14</td><td>0.30</td><td>0.26</td><td>54.0</td><td>40.1</td><td>61.7</td><td>40.5</td><td>47.4 40.3</td><td>-</td><td></td><td></td><td></td><td></td><td>JWdmrE JWdmrW</td></t<>	AWdm/SW East of Elly twin Manholes	1 475.2 210 19	GAngle JNVdmrE	594.65	588.24	36	22 324.88	0.0100	0.0063	263716	6.05	840	1.96	1.01	3.09	0.14	0.30	0.26	54.0	40.1	61.7	40.5	47.4 40.3	-					JWdmrE JWdmrW
View of begin mannance       3100       94.83       94.03       94.04       94.0	AWdmNW	1317	OShoty	50.4.00	500.00	36	7.38	0.0054	0.0045	242450	5.57	800	1.80	0.93	2.84	0.05	0.29	0.25	56.6	42.4	64.7	42.6	49.9 42.4	4	1:04 63.3	19.3	57.1	57.1	CShoty
Wood mee Eide Cl       2f0 cf       Mic.       94.86       586.12       V       294.26       S86.12       V       S86.12       S86.12 </td <td>West of Ely finn Manholes</td> <td>3336</td> <td>OwdmrE</td> <td>594.63</td> <td>568.20</td> <td>36</td> <td>22.88</td> <td>0.0035</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.15</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>86.8</td> <td>1:04 67.6</td> <td>20.0</td> <td>60.4</td> <td>60.4</td> <td>CWdmirE</td>	West of Ely finn Manholes	3336	OwdmrE	594.63	568.20	36	22.88	0.0035								0.15								86.8	1:04 67.6	20.0	60.4	60.4	CWdmirE
Hanse Each RR Track:       0.00       0.000       0.0003       0	Woodmere Eside C/L	21021	JECL	594.86	588.12	26	294.62	0.0022								0.06													JECL/21021
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Hanna Eside RR Tracks	21022	JRRE	596.00	587.78		144.96	0.002.0								0.00													Givening
Boardman Lake Outlets (2)       1480       Q21       30       50.00       Each       30       50.00       Each       557.00       30       557.00       18       30       50.00       Each       18       0.021       0.021       557.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       18       567.00       10.53 ac       357.1       18.38       56.44       7c       63.71       64.7       42.4	Beachfront Manhole	1479 21023	OBeach JBeach	596.00	587.56	36	94.96 50.00	0.0023								0.61													JBeach
$ \frac{1}{12} = \frac{1}{12} + \frac{1}{12}$	Boardman Lake Outlets (2)	1480	C21		507.00	30	50.00									0.32													
Out-21.1       Out21.1       587.60       Image: Second		1481	C21.1		567.00	18	Cach																						
Submerged Outfall (21) Elevation: 590.0 Ave Slope = 0.0045       Total Area 2007 Area       4814565 sf 110.53 ac 151.80 ac       35.71 49.05       18.38 25.24       56.44 77.52       Tc 63 min 56.6       42.4       64.7       42.6       49.9       42.4       86.8       139 67.6       20.0       60.4       60.4         V       Area Conversion:       1.373       77.8       58.2       88.9       58.5       68.5       58.3       67.9		Out-21.1	Out21.1		587.60																								
Ave Slope = 0.0045       Total Area       4814565 sf 110.53 ac 2007 Area       35.71       18.38       56.44 ft       Total Area       4819 ft       7.5       75         2007 Area       151.80 ac       49.05       25.24       77.52       56.6       42.4       64.7       42.6       49.9       42.4       86.8       67.6       20.0       60.4<		s	ubmerged Outfall (2	21) Elevation	: 590.0												1												
Submerged Outfail [2] Elevation: 590.0 Ave Slope = 0.0045       Total Area (1) 10,53 ac (2) 007 Area       Assa (35,71) (51,50) ac       18.38 (35,74)       56,4 (7,52)       Tc       63 min       Tc       63 min       64.7       42.6       49.9       42.4       86.8       139 (67.6)       7.5																													
																Area Conver	sion:	1.373	77.8	58.2	88.9	58.5	68.5 58.3		81.5	Tatal Culture	67.9 tobacat Deck C	67.9	

subcatchment by identifying a high point and a having no runoff to nearly match the OHM M input file and when added, this total increased odel remains at 110.53 acres, however an

epercent impervious calculation, but as a 75 in ations | The 67.9 curve number is based on at the upstream (CConsumer) node, providing a ites to the outlet at Boardman Lake. Grant s defined at 97% Qpeak at steady state intensity NOAA DDF curves developed for rainfall refined qu= based on Tc (not used)

slope, rainfall intensity, and percent impervious slope, rainfall intensity, and percent impervious maps and descriptions includes the land slope Qpeak for comparson jected local/historical intensities of the

sheds", Mich DNR, June 2010 for following equ: rmally, but 0.05 is proposed in certain instances

onstant" which is very sensative to changes; on and Sedimentation Control Training Manual,

; subcatchment runoff quantities are identical

tration and return interval as described in (6) rve number | Column [H] is the same model as reen-Ampt infiltration and a 24-hour, Type II rainfall

all distribution with 0.1 hr time-step increments

el (totalling 110.53 acres). 2=2.27; P5=2.76 in); maximum runoff equals that

catchments connected (it is not clear why the

ndicate it may be prudent to observe system

/DEQ ak Hydrograph culated (17) -fs/(in-ac) .35% cfs/(in-ac)

<u>HANNA AVENUE HYDROLOGY AND HYDRAULICS</u> 2-YR RETURN PERIOD HAND CALCS AND MODELING RESULTS 10-YR RETURN PERIOD

										CCC Mathed		MDEO
										SCS Method		MDEQ
	10-Ye	ear li	nfiltratio	n/R	ainfall/Runoff I	Data			Surface Runoff (S	RO)	Unit SRO (q <sub>u</sub> )	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	r	24-hr	Rainfall		la Cons	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		Α					0.05	0.2			
[					2 yr	P2 =	2.09 in			0.35 in	0.47 cfs/(in-ac)	
Curve No.	72.2	(5)	67.9	(5)	5 yr	Ps =	2.7 in	0.990	0.645	0.65 in	0.47 cfs/(in-ac)	0.41 cfs/(in-ac)
Storage	3.85	in	4.73	in	10 yr	P10 =	3.21 in	1.327	0.947	0.96 in	0.47 cfs/(in-ac)	
*Per 2007 CN						(16)	la =	0.192 in	0.769 in	** 2	2007 average slopes: pipe 0.52%; v	watershed 0.35%
						_					Table 7-3 value for 0.35% slope:	0.40 cfs/(in-ac)







[												Lan	d Use Designa	tions		c input/IDF Da	ata							Peak Flow	Rate (cfs)									
Bryant Park 2-	Year Re	eturn Inte	erval										Curve Number	~~~~	Tovationat				ŀ	land Calculatio	ons (14)					EPA SWN	MM Software					XP.SWMM		
Biyanti ant	rour ric		Jivai									Pavement	Residential	Porested		1.57 fps		Rossn	niller Mathad	Calau	MDEQ/S	SCS (7)		Curve Numb	ber	Horton				Green-Ampt		AI SWAM	Pipe/Junction	Sub-
Decignations	- 1	64	arm Drain D	escention			6	an a	Eub	antah manti	Info	0.42	Area Proportion	5 0.42	(8) 12 -	0.86 in/h	r	No la compo	onent (12) Turce A soil	la corst=0.05		const=0.2	Single Sub Area	a Dura	i en/Erecuencia la	Modified City Model	(20)	Tues		City Model	OHM Typedu	OHMRouted	- Kentrication	Catorment
Designations	Identification	SWMM	MH F	levations	Diamotor	Cum L Di et	Pine	land	Area	catonment	"Wieth"	Proportional		U.43	Te (min)	Ra	ntional C	[A]	[B]	[C]	[0]	[E1] [E2]	[F] (18) (30)	[G]	[H] (31)	[1]	[h]	[K]		XP Converted to	EPA INI	101	-	
	Manhole	Conduit	Fim	Invert	(inches)	Length	(1	t/ft)	(sq feet)	(acres)	(feet)	Tioponiona	(acres) (4)	Jubitantiment	(8)	2007 CN	(Type A soil)	-					55.0	55.0	76.0	Duration (min)			(21)	(22)	(23)	(24)		
			Contracto			(1001)		()	(=)		(0)					(10)	(,	1					IMP	IMP	IMP	Cas (ange (on)								
East Hanna Atlanna	11001 2003	Jhan na-E Ghan na-F	613.35	611.23	15	7873.80 268.43	0.0031	0.0006	60700	1.39	420	0.58	0.21	0.60	31.85	0.29	0.26	0.4	0.3	0.3	0.2	03 02		0.62	0130 0.15	0.5	0.53	1.52 1200					Jhanna-E Channa-E	AHanna
Mid Hanna	11002 1381	JHanna Channa-W	613.39	810.41 610.31	15	7605.37	0.0036								1.95								1					1.48 12:01					J Hanna Channa-W	
W Hanna	11003 1318	Jhanna-W CHstaXing	614.31	609.75 609.70	15	7421.45 23.24	0.0073								0.25																		Jhan na-W CHstoXing	
S Hastings	11004 2002	JHstg-S CHstg-s	614.47	809.58 609.34	15	7398.21 432.77	0.0034								4.59																-0.57	-0.25	JHstg-S CHstg-S	
Hastings AHSTG	11005 1996	JHstg CHatgtoOk	613.43	608.11 608.11	1.8	6965.44 441.47	0.0022	0.0006	263200	6.04	1880	2.52	0.91	2.61	4.69	0.29	0.26	1.9	1.6	1.7	1.0	1.4 1.2	01:	31 2.69	01:31 0.67	2.8	2.82	1.47 12:05 6.66	-0.39	-0.31	11x46bo12x07 1.9 to 61.2	11:49 to12:11 1.0 to 38.5	JHstg CHstg to Ok	AHSTG
Hastings/Oakland	11006 1693	JHstg-Ok CHstg-N	613.09	807.13	24	6523.97 371.24	0.0020								3.94								01:	31 3.27	0132 0.72			(5.62) 12:06	6 7.59 7.20	10.85 12:05 10.54 12:0	72.83 0 11.34	50.16 11.36	JHstg-Ok CHstg-N	
N Hastings	<i>11007</i> 1692	JHstg-N C8th36 ng	612.69	606.40	24	61 52.73 77.41	0.0018								0.82																11:52 to 12:02	11:58 to12:02	JHstg-N C8thXing	
W'ly 8th/Hastings	<i>11008</i> 1694	Jath-W Cath to WHth	612.13	606.26	24	6075.32 113.29	0.0019								1.20													attenuated	7.06	12:05 10.08 12:0	1 0.7 to 1.5 11:53 to 12:02	0.2 to 1.6 11:58 to 12:02	Jath-W Cath to W Hith	
8th/Whole Health Aath2	11009 1695	Jath-Whole Hith Cath to Cvc	611.95	606.05	24	5962.03 123.09	0.0019	0.0006	167200	3.84	600	1.60	0.58	1.66	1.31	0.29	0.26	2.8	2.5	2.5	1.6	2.1 1.9	01:	31 1.59	01:31 0.24	4.3	4.28	6.95 12:05 3.59	5 7.04	12:05 10.10 12:0	1 0.3 to 0.9	0.2 to 0.7	Jath-Whole Hith Cath to Ovc	A&h2
8th/Civic	2112	Usth-Cvc Osth to WDDS	611.87	605.81	24	5838.94 255.01	0.0022								2.71								01:	31 4.81	0135 0.88			(3,46) 12:06	6				Jath-Ove Cath to WDDS	
8th/West DDS lot	21 13	C8th to DDS	611.85	605.26	24	122.62	0.0022								1.30													0.07					Cath to DDS	
Aahi	2114	Cath to FireSta	612.02	804.99	24	192.92	0.0024	0.0006	190200	4.37	670	1.82	0.66	1.89	2.05	0.29	0.26	3.9	3.5	3.5	2.2	2.9 2.6	01:	31 1.80	0131 0.27	5.9	5.94	9.27 1208 4.06					Cath to FireSta	Asthi
Cemetary		Non Contributing							3194900	73.34														31 6.04	02:10 0.14			(3.93) 12:00					Non Contributing	
8th/Fire Station	11013 2115	Jath-Rresta Cathle Fair	611.63	604.53	30	5268.39 211.02	0.0017		170000	3.52					2.24								1						attenuated	attenuated	-		Jath-FineSta Cath to Fair	
8th/S Fair	11014	Jath-FairS CFairto abS	610.95	B04.17	30	5057.37 226.40	0.0023								2.40														0.70	12.05 5.42 12.0	8.92 0.0	9.29	J8th-Fairs CFairtoalyS	
Fair/S'ly alley	11015 1951	JFairatyS CFairtoCBsS	610.40	603.66	30	4830.97 125.00	0.0024								1.33															attenuated	1152bo1202	11:58 to 12:01	JRainaly8 CFairto0BeS	
Fair/S'ly catch basins	11064 4296	JFair-CBsS CFairto TTS	610.00	603.36	36	4705.97 98.52	0.0019								1.05														attenuated 1.18	6.64 12:05 16.66 12:0	1.0 to 22.6 -5.55 12.0	5.0 to 14.5 (26) o -1.79	JFair0BsS CFairtoTTS	
Fair/Titus	11016 2094	JFair-Titus CFairto BDL	611.01	603.17	36	4607.45 358.63	0.0016								3.81													attenuated 10.77 12:15	8.61 5 9.79	(10.73) 12:0 12:05 17.37 12:0	3 21.25 3 15.70	15.88 (25) 14.09	J Rain-Titus C Fain to BDL	
Fair/Beadle AFB2	11017 1716	JFairBeadle CFairto atyN	610.43	602.59	36	4248.82 375.21	0.0017	0.0006	130200	2.99	35	1.25	0.45	1.29	3.98	0.29	0.26	4.7	4.1	4.2	2.6	3.4 3.1	01:	31 0.80	01:35 0.01 01:31 0.02	6.7	6.74	0.98 12:08 (0.89) 12:15	5				JFairBeadle CFairtoalyN	AFR2
Fair/N'ly alley AFRi	11018 3159	JFair-AlyN CFairtoHyd t	610.35	601.97	36	3873.61 395.26	0.0016	0.0006	99000	2.27	400	0.95	0.34	0.98	4.20	0.29	0.26	5.3	4.6	4.7	2.9	3.9 3.5	01: 01:	37 7.05 31 0.95	oz:to 0.54 o1:st 0.16	7.6	7.60	11.67 12:15 2.20 12:00	5		15.70 12x	o 14.09	JFair-AlyN CFairtoHydat	AFRI
FRE Fair/fire hydrant	11019	JFair Hydrt	610.67	601.33		3478.35			375200	8.61					-								01:	32 7.90	02:12 0.53			(0.85) 12:15	5				Non Contributing J Fair-Hydt	
Fair/Parkway Xgutter	3158 11020	C Fairto PW J Fair-PWXgttr	609.29	600.38	36	378.58 3099.77	0.0025								4.02														attenuated 7.48	12:05 17.44 12:0	11:52to12:01 4 2.3 to 18.1	11:58 to12:00 1.0to 3.0 (26)	GFairtoPW JFairPWXgttr	
Parkway/College	1713 11021	CPW Xing JPW-College	610.41	599.73	36	60.18 3039.59	0.0108								0.64													attenuated 12.33 12:18	6.49 a (5.00)	9.07 12:0 (4.59) 12:0	0 -2.43 4 47.19	11.06 33.66 (25)	CPW Xing JPW-College	1.
APW3 PWN 182	1708	CPW to Milkon Non Contributing			36	342.49	0.0022	0.0006	156800 65600	3.60	380	1.50	0.54	1.56	3.64	0.29	0.26	6.2	5.4	5.5	3.4	4.5 4.1	01:	31 1.78 31 9.61	0.68	9.0	8.97	4.35 (0.71) 12:18	12.48	12:06 22:03 12:0	4 44.76	44.72	C PW to Milliken Non Contributing	APW3
Parkway/Multicen	1700	CPW to HitigthE	610.47	599.99	36	112.97 2584.13	0.0016								1.20										02:16 0.55				12.40	22.03 12:0	4 44.70	44.72	CPW to HrtgtnE	
Parkway/Huntington West	1699 11024	CPW to HntgtnW	610.48	598.67	36	89.87 2494.26	0.0020								0.95																		CPW to HntgtnW	
Parkway/Plaza East	1698 11025	CPW to Plaza E JPW-PlazaE	611.06	598.18	36	210.02 2284.24	0.0021								2.23													13.00 12:19					CPW to Plaza E JPW-PlazaE	
APW2 Parkway/Plaza West	1697 11026	CPW to Plaza W JPW-PlazaW	611.32	596.08	30	134.69 21 49.55	0.0156	0.0006	93000	2.13	390	0.89	0.32	0.92	1.43	0.29	0.26	6.7	5.9	6.0	3.7	4.9 4.4	01:	at 1.13 33 10.69	1.24 01:32 1.23	9.8	9.78	2.66 (0.35) 12:19	attenuated 9 11.90	12:06 22:03 12:0	6		CPW to Plaza W JPW-PlazaW	APW2
Parkway/Church East	1696 11027	CPW to ChurchE JPW-GhurchE	609.43	595.21	30	152.45 1997.10	0.0057								1.62										0222 0.53			13.35 12:20		(28)			CPW to ChurchE JPW-ChurchE	
APW1 Parkway/Beltone East	1795 11028	GPW to Chuich W JPW-Chuich W	602.33	592.40	30	288.53 1708.57	0.0097	0.022	106900	2.45	310	1.02	0.37	1.06	3.06	0.32	0.29	7.4	6.5	6.5	4.1	5.4 4.8	01:	31 1.24 31 11.89	1.76 01:32 1.70	10.7	10.71	3.00 (0.41)	7.47	12:05 22.03 12:0	s 44.76	44.72	GPW to ChurchW JPW-ChurchW	APW1
Fairgrounds Drainage along Garfield	1797	CPW to GrildE			30	287.33	0.0108		1845200	42.36					3.05								÷		0222 0.52			12.73 12.06 13.75 12.20	6 7. <b>4</b> 7	(28) 22.03 12:0	6		CPW to GridE	<u> </u>
RIRNE RIRNW		Non Contributing							241 600 73800	5.55 1.69																								
AGF7 Railroad to N side of 8th Street		JGrideth	611.95	603.95		740.00	0.0000	0.0006	659900	15.15	1870	6.32	2.28	6.55		0.29	0.26							6.14		5.8	5.75	13.25 1.4 to 8.6					JGrid-8th	AGF7
AGF8		GGF7		-	18	710.00	0.0009	0.0006	348700	8.01	1120	3.34	1.20	3.46		0.29	0.26							3.28		3.0	3.04	11:57-12:10 7.23					CGF7	AGF6
TTSW		Non Contributing	611.33	60333	21	775.00	0.00.99		183,100	4.20														3.56									Core	
AGF5 Webster to State Street		Joint State	607.20	600.29	21	110.00	0.0035	0.0006	396200	9.10	660	3.80	1.37	3.93		0.29	0.26	8.1	7.2	7.2	4.5	7.3 6.6		ationatori	0.28 at licra valient	3.4	3.44	7.08					JantaStata	AGF5
		CGF5			18	500.00	0.0220																01:	31 12.90	0222 0.04	12.2	12,23	18.88 12.06 11.89 12.20	6	80.14			CGF5	
AGF4 Parkway/Garfield E side	11029	JPW-GanladE	597.64	589.29		1421.24		0.0006	316700	7.27	870	3.04	1.09	3.14	7	0.29	0.26	17.4	15.3	15.3	9.6	14.0 12.6	01	31 2.94	01:31 0.35	2.8	2.76	6.32 12.08 (2.30) 12.20	6 43.75 0	(39.53) 12:0 1.7 to 40.5	7 83.83 1.3 to 68.8	50.68 (25) 1.4 to 35.6	JPW-GanleidE	AGF4
Parkway/Coffee Shop	1789 11030	CPW to CottBhp JPW-ICShop	596.44	558.32	30	66.34 1354.90	0.0146								0.70													attenuated	51.21	59.76 12:0 3.0to7.3	7 59.76 0.1 to 5.9	59.76 0.4 to 5.9	CPW to CottShp JPW-CottShp	
	1788	CPW to PWNth			30	83.06	0.0043								0.88								01:	32 <b>28.22</b>	01.34 3.20 02.23 0.55	25.7	25.70	37.05 12:02 37.94 12:08	2	11:52-12:09	11:49-12:13	11:53-12:14	CPW to PWNth	
																											(29	9) 38.14 12:08 27.94 12:20	8				Non Contributing	
																																	AGF7	
Garfield/N Side Parkway	1 1031	JGrid-PWNth	596.35	587.96		1271.84																						5.28 12:00	51.21	52.49			Non Contributing JGrid-PWNth	
Garfield/Anderson	2946 1 1032	GG1d to Andrsn JGn1d-Anderson	592.46	584.61	30	360.42 911.42	0.0093								3.83													(4.63) 12:02 8.00 12:00	2				GGild to Andrean JGrild-Anderson	
AGF3 AGF2 AGF1	4/12	GGridto ParkS			30	210.27	0.0146	0.022	275700	4.49 6.33	360 1850 440	2.64	0.95	2.74	2.28	0.32	0.29	21.1	187	18.4	11.5	185 148	40.5	3.52	0131 0.71	2.4	2.40	(6.14) 1202 2.56 12:00 (2.08) 12:02	2	1000 52.40 10:0	53.02	53.02	GGridto Parks	AGF3 AGF2 AGF1
Garlield/Park Sside	1 1068	JGrid-PakS	592.00	581.55	37	701.15	0.01.42	0.022	117300	2.09	440	1.12	0.41	1.16	0.00	0.32	0.23	21.1	10./	10.4	11.5	10.0 14.8	40.5	1.4/	oran <u>0.00</u>	0.0	0.70	(2,00) 1202	01.21	12.00 02.49 12:0	, 03.92	03.92	JGrld-ParkS	a waf 1
Park/Beach	11033	JPark Createrater	589.96	580.17	30	608.15 175.94	0.0146		471100	10.81					1.85																		JPark CRastreeter	1
Beach S	1 1065	JBeachS	587.59	579.50	<u>~</u>	432.81	0.0855			1.0001					0.68								01	31 35 34	0132 659	30.6	30.58	49,90 1979					JBeachS CBasch	1
Beach N	1 1063	JBoachN CBohtsOutlail11	585.25	575.32	24	369.02	0.0000								3.92										0226 0.55	30,0	0.00	ione trade					JBeachN CBchtoOuttalli 1	1
Outlet*	Outfall 11	Outfall 11	577.00	573.00	.===100	0.00		Total Area:	10997300	252.46						-																	Outfall 11	1
		Water Surface Elev:	577.0					Cont'b Area: Non Cont'b:	3577100 7420200	82.12 170.34	Prop Area Totals	: 34.28	12.35	35.49	To 90 mi	n																		1
								2007 Cont'b Are	88:	149.55								21.1	18.7	18.4	11.5	16.5 14.8	40.5	35.34	6.6	0.0 30.6	0.00 30.58	7.16 49.90	3.8 51.2	45.94 52.49	112.31 53.92	52.61 53.92		
															Area Conve	ISION:	1.821	38.5	34.0	33.5	21.0	30.1 27.0 (2)	ŋ		Total Subca	30.6 tchment Peek Bun	30.55   xoff:	57.06 78.74	65.0 66.44	98.43	166.23	106.53 (19) 151.01		

										SCS Method		MDEQ
	2-Ye	ar Ir	nfiltratio	n/Ra	ainfall/Runoff D	Data			Surface Runoff (S	SRO)	Unit SRO (qu)	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	r	24-h	r Rainfall		la Cons	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		A					0.05	0.2			
Γ					2 yr	P2 =	2.09 in	0.732	0.460	0.474 in	0.39 cfs/(in-ac)	
Curve No.	76.0	(5)	72.5	(5)	5 yr	P5 =	2.7 in	1.132	0.817	0.83 in	0.39 cfs/(in-ac)	0.31 cfs/(in-ac)
Storage	3.16	in	3.79	in	10 yr	P10 =	3.21 in			1.168 in	0.39 cfs/(in-ac)	
*Per 2007 CN						(16)	la =	0.158 in	0.633 in	** 2007 average sk	opes: pipe 0.47%; watershed 0.30%	6 (0.30% appears in error)
						_				Table 7-3 value f	for 0.30% slope: 0.35 cfs/	(in-ac)

_												Lan	d Use Designat	ions	T	Tc Input/IDF Dat	ta							Peak Flow	Rate (cfs)									
Bryant Park 5-1	/ear Re	eturn Inte	erval									Bayamant	Curve Numbers	3 For upstand	Townerd _	29 min		Beege	millar	Hand Calculati	ions (14)	0.00		Cuso Nue	lane e	EPA SWM	MM Software			Green Amet		XP SWMM	Beelly estim	0.1
												98	Area Proportions	Forested 55	(8) RI =	: 1.57 tps : 5 yt 1.07 in/br		Rational	Method	Gaicu	Ilated	Tabular(13)	Single Sub Are	2007	Der		(20)			Green-Ampt	OHM	OHMBouted	Identification	Catchment
Designations	Identification	St	orm Drain D	escription	Ĩ		Sic	ope	Sut	catchment I	nfo	0.42	0.15	0.43	Тс	Rat	tional C	2007 CN	Type A soil [B]		(9) [D]	[E1] [E2]	[F]	Dun [G]	ation/Frequency Inte [H]	nsites [1]		Type   [K]		XP Converted to E	OHM Typell PA	1	1	+
	Numbers Manhole	Junction Conduit	MH El Rim	evations Invert	Diameter (inches)	Cuml Dist Length	Pipe (ft	Land /ft)	Area (sq feet)	(acres)	"Width" (feet)	Proportional	Land Use per Si (acres)	ubcatchment	(min)	(Ros 2007 CN	ssmiller) (Type A soil)						(18) (30) 55.0	(30) 55.0	(31) 76.0	Duation (min)			[L] (21)	[M] (22)	[N] (23)	[O] (24)	1	
	Pipe		Estimate			(feet)		(1)	(2)		(3)		(4)		(6)	(10)	(11)	-					57% IMP	57% IMP	0% IMP	loss range (cts)								
East Hanna	11001	Jhanna-E	613.35	011.23		7873.80					100																						Jhan na-E	
Mid Hanna	11002	JHanna Channa	613.39	610.41	15	7605.37	0.0031	0.0006	60/00	1.39	420	0.58	0.21	08.0	1.05	0.31	0.27	0.5	0.4	0.5	0.3	0.5 0.4	_	0.83	0130 0.31	0.7	0.7	2.02 1200					JHanna Channa	Allan na
W Hanna	11003	Jhenne-W	614.31	609.75 609.70	15	7421.45	0.0073								0.25													1.97 1201					Jhanna-W CHetaXing	
S Hastings	11004	JHetg-S CHeto-s	614.47	609.58 609.34	15	7398.21	0.0034								4.59																0.1	0.5	J Hstg-S CHsto-s	
Hastings Alistig	11005 1996	J Hstg CHstg to Ok	613.43	608.11 608.11	18	6965.44 441.47	0.0022	0.0006	263200	6.04	1 880	2.52	0.91	2.61	4.69	0.31	0.27	2.5	2.2	2.6	1.9	2.4 2.1	01	:31 3.60	0131 1.38	3.5	3.5	1.28 1201 8.83 1200	-0.8	-1.10	11:40 to 12:09	11:47 to12:14 0.6to 51.7	JHstg CHstgtoOk	AHSTG
Hastings/Oakland	11006 1693	J Histg-Ok C Histg-N	613.09	007. İS	24	6523.97 371.24	0.0020								3.94									4.43	0132 1.55			(8.34) 12:01	9.3	13.55 12:04 12.45 12:0	89.0 0 11.3	62.5 11.3	JHstg-Ok CHstg-N	
N Hastings	<i>11007</i> 1692	J Hstg-N Castrixing	612.69	606.40	24	6152.73 77.41	0.0018								0.82																11:50to12:03	11:55 to12:04	J Hstg-N Cathxing	
W'ly 8th/Hastings	11008 1694	Jath-W Cath to W Hith	612.13	606.26	24	6075.32 113.29	0.0019								1.20													attenuated	9.3	12:05 12:22	0.5 to 1.6 1151 to 12:03	0.3 to 1.5 11:56 to 12:03	Jath-W Cath to W Hith	
8th/Whole Health Asth2	11009	Jath-Whole Hith Cath to Give	611.95	606.05	24	5962.03 123.09	0.0019	0.0006	167200	3.84	600	1.60	0.58	1.66	1.31	0.31	0.27	3.7	3.3	3.9	2.8	3.6 3.2	01	:31 2.08	0131 0.51	5.3	5.3	7.60 12:09 4.86 12:00	9.3	12.22 12:0	1 02 to 0.9	0.2160.9	Cath to Ove	Astn2
8th/Givig	2112	Jath-Gva Cath to W D DS	611.87	605.81	24	255.01	0.0022								2.71									6.37	0134 1.97			(3.50) 12:08					Cath to WDDS	4
8th/Destist	2113	Cath to DDS	611.85	BI25.270	24	122.62	0.0022								1.30													11.12 19:09		(20)			Cath to DDS	
A8h1	2114	Gath to FireSta	612.02	EC4. 50	24	192.92	0.0024	0.0006	190200	4.37	670	1.82	0.66	1.89	2.05	0.31	0.27	5.2	4.6	5.4	3.9	5.1 4.5	01	31 2.36	01.31 0.57	7.4	7.4	5.51		(20)			C8th to FireSta	4 A8th1
Cemetary TTSE		Non Contributing							3194900 170600	73.34 3.92																		()					Non Contributing	4
8th/Fire Station	11013 2115	Jäth-FireSta Osth to Fair	611.63	604.53	30	5268.39 211.02	0.0017								2.24														8.6	11.19 12:0	3		J8th-FireSta C8th to Fair	
8th/S Fair	11014 2116	Jath-Fairs CFairtoalyS	610.95	604.17	30	5057.37 226.40	0.0023								2.40															Andrewsky (1997)	8.9	8.9	Jath-Fairs CFairtoalyS	
Fair/S'ly alley	11015 1951	JFai⊦alyS C Fairto CBsS	610.40	603.66	30	4830.97 125.00	0.0024								1.33																11:50 to12:02	11:55 to12:02	JFairalyS CRaintoCBsS	
Fair/Sily eatch basins	11064 4296	JFairGBsS CFairte TTS	610.00	603.36	36	4705.97 98.52	0.0019								1.05													attenuated	2.2	10.39 12:0 20.62 12:0	6 43 to 31.1 0 -10.1	4.2to23.7 (26 -4.3	) JFair-GBsS CFairtoTTS	
Fair/Titus	11016 2094	JFai⊁Titus GFairtoBDL	611.01	603.17	36	4607.45 358.63	0.0016								3.81													14.45 12:10	(11.53) 13.3	( <mark>8.91) 12.0</mark> 19.30 12:0	8 26.0 6 15.9	19.7 (25 15.4	) JFairTitus GFairtoBDL	
Fair/Beadle AFR2	11017	JFairBeadle CFairtoalyN	610.43	602.59	36	4248.82 375.21	0.0017	0.0006	130200	2.99	35	1.25	0.45	1.29	3.98	0.31	0.27	6.2	5.5	6.4	4.6	6.0 5.3	01	:31 1.07	0124 0.03	8.5	8.5	1.40 12:06 (1.33) 12:10					JFairBeadle CFairtoalyN	AFR2
A FB 1	3159	JFair-AlyN CRaintoHydat	610.35	601.97	36	38/3.61 395.26	0.0016	0.0006	99000	2.27	400	0.95	0.34	0.98	4.20	0.31	0.27	7.0	6.1	7.2	5.2	6.8 6.0	01	:37 9.29 :31 1.25	01.59 1.69 01.31 0.33	9.5	9.5	15.59 12:12 2.97 12:00			15.9	15.4	JFair-AlyN CFeirtoHydit	AFRI
Fair/ire hydrant	11019	JFair-Hydit	010.07	001.33	26	3478.35	0.0025		375200	8,61					402								01	:32 10.38	02:00 1.74			(1.34) 12:12			11.401-1202	11.55 1-12.02	J Rain-Hydit	1
Fair/Parkway Xgutter	11020	JFair-PWXgttr Crew xxm	609.20	600.39	30	3099.77	0.0108								0.64														10.2	12:05 21.69 12:0	6 1.6 to 288	1.0to 13.5 (26	) JFair-PWXgttr Cevy xing	(
Parkway/College Apwa	11021	JPW-College CPW to Miliken	610.41	589.73	36	3039.59 342.49	0.0022	0.0006	156800	3.60	380	1.50	0.54	1.56	3.64	0.31	0.27	8.1	7.2	8.5	6.1	7.9 7.0	01	31 2.39	1.28	11.2	11.2	16.92 12:13 5.68 12:00	(7.15)	(4.13) 12:0 25.82 12:0	57.7 6 44.8	42.8 (25	) JPW-College CPW to Miliker	n APW3
PWN 182 Parkway/Milliken	11022	Non Contributing JPW-Milkon	610.47	598.99		2697.10			65600	1.51					-								01	:31 12.66	01:32 1.53 02:02 1.73			(1.20) 12:19	17.2	12:06 25.82 12:0	6 44.8	44.8	Non Contributing J PW-Milikan	3
Parkway/Huntington East	1 700 1 1023	CPW to HntgtnE JPW-HntgtnE	610.28	598.81	36	112.97 2584.13	0.0016								1.20																		CPW to HritgtnE JPW-HritgtnE	<i>E</i>
Parkway/Huntington West	1 699 1 1024	CPW to HntgtnW JPW-HntgtnW	610.48	2983, 67	36	89.87 2494.26	0.0020								0.95															(28)			CPW to Hintgt nV JPW-HintgtnW	7
Parkway/Plaza East	1 698 1 1025	CPW to Plaza E JPW-PlazaE	611.06	598.18	36	210.02 2284.24	0.0021	0.0000						0.00	2.23											100		18.12 12:14					CPW to Plaza E JPW-PlazaE	é
Parkway/Plaza West	11026	JPW-PlazaW	611.32	596.08	30	2149.55	0.0156	0.0006	93000	2.13	390	0.89	0.32	0.92	1.43	0.31	0.27	8.9	7.8	9.2	6.6	8.6 7.6	01	:31 1.50 :33 14.09	01331 2.38	12.2	12.2	(0.54) 12:14	16.3	25.82 12:1	a		JPW-PlazaW	/ APW2
Parkway/Church East	11027	JPW-ChurchE CPW to ChurchW	609.43	595.21	30	1997.10	0.0097	0.022	106900	2.45	310	1.02	0.37	1.06	3.05	0.34	0.31	9.8	8.6	10.0	7.2	9.4 8.3	01	31 166	0.95	13.4	13.4	3.91 12:00	16.3	25.82 12.1	0 44.8	44.8	JPW-ChurchE	APW 1
Parkway/Beltone East Fai rarounds	11028 1797	JPW-ChurchW CPW to GridE	602.33	502.40	30	1 708.57 287.33	0.0108		1845200	42.36					3.05				0.0				01	31 15.69	0132 3.27	12.1		19.51 12:10	16.3	12:05 25.82 12:1	0		JPW-Chuich W CPW to GridE	1
Drainage along Garfield RRNE									241600	5.55																		19.27 12:15						
RRM AGF7		Non Contributing						0.0006	73800 659900	1.69 15.15	1 870	6.32	2.28	6.55		0.31	0.27							7.99	1.64	7.2	7.2	17.91						AGF7
Railroad to N side of 8th Street		JGitd-8h CGF7	611.95	603.95	18	710.00	0.0009																					0.3to 14.5 11:54-12:14					JGnld-8th CGF7	
AGR6 N side 8th Street to Webster		JGrld-Webster	611.33	603.33				0.0006	348700	8.01	1120	3.34	1.20	3.46		0.31	0.27							4.28	0.97	3.8	3.8	9.83 0.3 to 0.8					JGrld-Webster	r AGF6
TTSW		Non Contributing Care			21	775.00	0.0039		183,100	4.20														4.56	0.61			11 <i>:5</i> 9-12:06 9.56					CGF6	
AGES Webster to State Street		JGrid-State	607.29	000.29	10	500.00	0.0000	0.0006	396200	9.10	660	3.80	1.37	3.93		0.31	0.27	10.7	9.4	11.1	8.0	10.4 9.2		atternated	attenvated	4.3	4.3	0.8 to 5.5 11:58-12:09					JGrid-State	AGES
AGRI		GGFS			18	300.00	0.0220	0.0005	316700	7.27	870	3.04	1.09	314		0.31	0.27	22.9	20.2	23.7	17.1	22.2 19.6	01	31 16.77	0134 2.93	15.2	15.2	16.99 12:15 8.51 12:0	49.0	100.51	103.5	65.2 (25	UGF5	AGE4
Parkway/Garfield E side	11029	JPW-GarieldE CPW to Catisho	597.54	589.29	30	1 421.24	0.0146	0.0000	010/00	1	0.0	0.04	1.00	2.14	070	0.01	0.27		20.2	20.7						0.4	0.4	(5.54) 12:10 (3.77) 12:15	1.8to 15.7 59.8	0.4 to 64.0 59.76	12 to 99.5	0.5to 50.4 59.8	JPW-GarieldE CPW to CatiShr	
Parkway/Coffee Shop	11030	JPW-ICShop CPW to PWNth	596,44	588.32	30	1 354.90 83.06	0.0043								0.88								01	32 36.43	0133 6.83	32.1	32.1	(0.0.7)	0.2 to 7.3	1 2to 73	1.0 to 5.9	0.4 to 5.9 11:51-12:18	JPW-CottShp CPW to PWNth	
																												36.83 12:00						
																												44.69 12:08 43.38 12:10					Non Contributing	1
2002 Modelwayerstationer en unor	C. 10 (2010) - +10		100 000 / Aug																									40.03 12:15					Non Contributing	a
Garfield/N Side Parkway	11031 2946	JGrid-PWNth CGild to Andrean	596.35	587.98	30	1271.84 360.42	Se00.0								3.83														52.5	52.49			JGrtd-PWNth CGtd to Andrsr	л
Gartield/Anderson AGF3	4712	JGrid-Anderson CGrid to ParkS	592.45	284.67	30	210.27	0.0146	0.022	195400	4.49	360	1.87	0.67	1.94	2.23	0.34	0.31							2.87	01.31 1.37	2.1	2.1	6.93 12:00					CGrild to ParkS	AGF3
AGFI Gartield/Dark S alde	1106.9	Joan pero	502.02	CD1 C7	-	701.15		0.022	117300	2.69	440	1.12	0.41	≥./4 1.16		0.34	0.31	27.9	24.6	28.3	20.4	26.6 23.5	50.8	1.93	o131 3.24 o131 1.16	1.0	1.0	3.32 12:00	52.5	12:05 52.49 12:1	o 53.9	53.9	Јона р-не	AGF1
Park/Beach	537	Grid to Pak	589.95	380 17	30	93.00 608.15	0.0148								0.99											38.2	38.2						CGrid to Paik	
Beach S	538 11065	CPaktoBchS JBaachS	587.50	579.50	30	175.34 432.81	0.0038		471100	10.81					1.98																		CParktoBchS JBeachS	
Beach N	4440 11063	CBaach JBeachN	585.25	575.32		63.79 369.02	0.0655								0.68								01	:31 45.16	0132 12.11			57.41 12:00 48.65 12:10					CBeach JBeachN	
Outlet*	4260/539 Outfall 11	Outfall 11	577.00	573.00	24	369.02 0.00	0.0000								3.92																		Outfall 11 Outfall 11	1
		Water Surface Elev:	577.0			i		Total Area: Confb Area:	10997300 3577100	252.46 82.12						]																		
								Non Confb:	7420200	170.34	Prop Area Totals:	34.28	12.35	35.49	Te 90 mi	n								altenuated	attenualed	0.0	0.0	18.97	21.69	70.84	163.7	81.4		
								2007 Cont'b Are	ea:	149.55					Area Conve	ersion:	1.821	27.9 50.7	24.6 44.9	28.3 51.6	20.4 37.2	26.6 23.5 48.4 42.8 (	27)	45.2	12.1	38.2	38.2	57.41 76.38 12.05	52.49 74.18	52.49 123.33	53.9 21.7.6	53.9 135.31 (19)	) )	1
																				OHN	Multiplier:	0.846 (tabular	ave/XM peaK flo	OW)	Total Subcate	chment Peak Rund	off:	105.02	89.61	130.58	276.2	190.26		

										SCS Method		MDEQ
	5-Ye	ar In	filtratio	n/Ra	ainfall/Runoff [	Data			Surface Runoff (	SRO)	Unit SRO (q <sub>u</sub> )	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	er	24-h	nr Rainfall		la Con	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		А					0.05	0.2			
Γ					2 yr	P2 =	2.09 in			0.474 in	0.39 cfs/(in-ac)	
Curve No.	76.0	(5)	72.5	(5)	5 yr	P5 =	2.7 in	1.132	0.817	0.83 in	0.39 cfs/(in-ac)	0.31 cfs/(in-ac)
Storage	3.16	in	3.79	in	10 yr	P10 =	3.21 in			1.168 in	0.39 cfs/(in-ac)	
*Per 2007 CN						(16)	la =	0.158 in	0.633 in	** 2007 average slop	es: pipe 0.47%; watershed 0.30%	(0.30% appears in error)
										Table 7-3 value for	0.30% slope: 0.35 cfs	/(in-ac)

Subcatchment			Converted	EPA SWMM				F	nal OHM XP	SWMM	
Outlet Junction Reference	Area (acres)	"Width" (feet)	Surface Slope (%)	% Impervious	Routing to:	5-Year Subcatchment Peak Runoff (cfs)	"Width" (feet)	Surface Slope (%)	% Impervious	Routing to:	5-Year Subcatchment Peak Runoff (cfs)
STM-011006 JHstg-Ok	95.73 19.55 6.52	2471.4 2471 2471	3.7 3.7 3.7	0 100 100	Outlet Outlet Outlet	89.00	2471.4 2471 2471	0.3 0.3 0.3	0 100 100	Outlet Outlet 0% Imp	62.283 62.50
STM-011016 JFair-Titus	30.32 5.69 1.90	1193.5 1193.5 1193.5	3.7 3.7 3.7	0 100 100	Outlet Outlet Outlet	26.02	1193.5 1193.5 1193.5	1.4 1.4 1.4	0 100 100	Outlet Outlet 0% Imp	19.599 19.72
STM-011021 JPW-College	17.63 12.71 4.24	1100 1100 1100	4.8 4.8 4.8	0 100 100	Outlet Outlet Outlet	57.67	1100 1100 1100	1.0 1.0 1.0	0 100 100	Outlet Outlet 0% Imp	<b>42.513</b> 42.81
STM-011030 JPW-GarfieldE	26.50 24.00 8.00	735 735 735	5.1 5.1 5.1	0 100 100	Outlet Outlet Outlet	103.53	735 735 735	1.0 1.0 1.0	0 100 100	Outlet Outlet 0% Imp	64.826 65.22



										SCS Method		MDEQ
	10-Ye	ear Ir	nfiltratio	n/R	ainfall/Runo	ff Data			Surface Runoff (S	SRO)	Unit SRO (qu)	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	er 🛛	2	4-hr Rainfall		la Con	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		А					0.05	0.2			
					2 yr	P2 =	2.09 in			0.474 in	0.39 cfs/(in-ac)	
Curve No.	76.0	(5)	72.5	(5)	5 yr	Po =	2.7 in	1.132	0.817	0.83 in	0.39 cfs/(in-ac)	0.31 cfs/(in-ac)
Storage	3.16	in	3.79	in	10 yr	Pi: =	3.21 in	1.498	1.157	1.168 in	0.39 cfs/(in-ac)	
'Per 2007 CN						(16)	a =	0.158 in	0.633 in	** 2007 average slo	ppes: pipe 0.47%; watershed 0.30%	% (0.30% appears in error)
						_				Table 7-3 value I	for 0.30% slope: 0.35 cfs/	(in-ac)

	nt Park 10-Year Return Interval												nd Use Designat	ions	Те	Input/IDF Dat	ta					Pea	k Flow Rate	e (cfs)					
Bryant Park 10	-Year F	Return In	terva	I									Curve Numbers	S	Townset =	29 min				Hand Calcula	tions (14)	00.47		0	EPA SWA	IM Software	Ourse Ameri		
												98	Area Promotions	Forested 55	Vpipe.ave = (8) RI = (9) 110 -	1.57 tps 10 yr 1.27 in/hr		Rational	Method	Calc	ulated	CS (7) Tabular (13)	Single Sub A	2007 2007	Number Mr	Horton	Green-Ampt	Pipe'Junction Identification	Sub- Catchment
Designations	Identification	SWMM	orm Drain D	Description	1		SI	ope	Su	ubcatchmen	t Info	0.42	0.15	0.43	<u>(8) 110 =</u>	Bat	ional C	2007 CN	Type A soil	IC1	(9)	[E1] [E2]	IF1		Duration/Freq	uency Intensities	[.1]	-	
	Numbers Manhole Pipe	Junction Conduit	MH E Rim Estimate	levations Invert	Diameter (inches)	Cuml Dist Length (feet)	Pipe (f	Land t/ft) (1)	Are (sq feet) (2)	a (acres)	"Width" (feet) (3)	Proportion	al Land Use per S (acres) (4)	ubcatchment	(min) (6)	(Ros 2007 CN (10)	ssmiller) (Type A soil) (11)		[-]	[0]			(18) (30) 55.0 57% IMP	(30) 55.0 57%	(31) 76.0 0 76.0 1 0%	Duration (min) loss range (ofs)	[0]		
East Hanna Alianna	11001	Jhanna-E Channa-F	613.35	61 1.23	15	7873.80	0.0031	0.0006	60700	139	420	0.58	0.21	0.60	31.85	0.32	0.29	0.6	0.5	0.6	0.5	06 06		1.0	01:31 0.50	0.78	0.78	Jhanna-E Channa-F	Анапла
Mid Hanna	11002 1381	JHanna Qhan na-W	613.39	610.41 610.31	15	7605.37 183.92	0.0036								1.95													JHanna Channa-W	
W Hanna	11003 1318 11004	Jhan na-W C Histg Xing JHenry S	614.31	609.75 609.70 609.58	15	7421.45 23.24 7398.21	0.0073								0.25													CHstgXing	
Hastings	2002	CHstg-s JHstg	613.43	609.34 608.11	15	432.77	0.0034								4.59													CHstg-s JHstg	
Austa Hastings/Oakland	1996 11006	C Histg to Ok J Histg-Ok	613.09	608.11 607.13	18	441.47 6523.97	0.0022	0.0006	263200	6.04	1880	2.52	0.91	2.61	4.69	0.32	0.29	3.1	2.7	3.4	2.6	3.4 3.0		01.31 4.5 5.5	01:31 2.22 0 01:32 2.57	4.18	4.18	CHstg to Ok J Hstg-Ok	Анста
N Hastings	1693 11007 1692	Unisig-N JHistg-N Catrixing	612.69	606.40	24	6152.73 77.41	0.0020								0.82													JHstg-N Catholing	
W'ly 8th/Hastings	11008 1694	Jan-w Cant to Whith	612.13	606.26	24	6075.32 113.29	0.0019								1.20													Jatr-w Cath to w Hith	
8th/Whole Health Asin2 8th/Civic	11009 1695	J8th-Whole Hith C8th to Cvc	611.95	806.05	24	5962.03 123.09 5838.94	0.0019	0.0006	167200	3.84	600	1.60	0.58	1.66	1.31	0.32	0.29	4.6	4.1	5.2	4.0	5.1 4.6		01 31 2.6	01:31 0.86	6.34	6.34	Jan-Whole Hith Can to Cvc	Astn2
8th/West DDS lot	2112	C8th to W DDS J8th-WDDS	611.85	805.28	24	255.01 5583.93	0.0022								2.71									1.8	01:34 01:32			Cath to WDDS Jath-WDDS	
8th/Dentist	2113 11012	Canh to DDS Janh-DDS	612.02	604.99	24	122.62 5461.31	0.0022								1.30													C8th to DDS J8th-DDS	
STLW Cemetary	2114	Non Contributing			24	192.92	0.0024	0.0006	190200 799100 3194900	4.37 18.34 73.34	670	1.82	0.66	1.89	2.05	0.32	0.29	5.4	5.7	7.2	5.5	7.1 6.4		01.91 2.90 01.91 10.7	0 01:31 0.97 4 01:35 4.00	8.80	8.80	Cath to FireSta Non Contribution	Aan1
TTSE 8th/Fire Station	11013	Jath-FireSta	611.63	604.53		5268.39			170600	3.92													-					Jan-FireSta	
8th/S Fair	2115 11014	Cath to Fair Jath-Fairs	610.95	804.17	30	211.02 5057.37	0.0017								2.24													Cath to Fair Jath-Fairs	
Fair/S'ly alley	2116 11015 1951	CFaintoalyS JFainalyS CFainto CReS	610.40	803.66	30	226.40 4830.97 125.00	0.0023								2.40													CFair to alyS JFair-alyS CFair to CBase	
Fair/S'ly catch basins	11064 4296	JFair-CBsS CFairtoTTS	610.00	603.36	36	4705.97 98.52	0.0019								1.05													JFair-CBsS CFairto TTS	
Fair/Titus	11018 2094	JFai⊩Titus CFairtoBDL	611.01	803.17	36	4607.45	0.00 <b>1</b> 6								3.81													JFair-Titus CFair to BDL	
AFR2 Fair/N'ly alley	1716	JFair-Beade CFaintoalyN JFair-AlvN	610.43	802.59	36	4248.82 375.21 3873.61	0.00 <b>1</b> 7	0.0006	130200	2.99	35	1.25	0.45	1.29	3.98	0.32	0.29	7.7	6.8	8.5	6.6	8.5 7.6		01.31 1.34 01.37 11.6	01:28 0.06	10.13	10.13	JFain-Beadle CFaintoalyN JFain-AMN	AFR2
AFR1 FRE	3159	CFair to Hydri Non Contributing			36	395.26	0.0016	0.0006	99000 375200	2.27 8.61	400	0.95	0.34	0.98	4.20	0.32	0.29	8.6	7.6	9.6	7.4	9.5 8.5		01.31 1.50 01.32 12.9	01:31 0.56 7 01:54 3.52	11.41	11.41	CFair to Hydri Non Contributing	AFR1
Fair/fire hydrant	11019 3158 11020	JFair-Hydni CFair to PW	610.67	801.33	36	3478.35 378.58 3099.77	0.0025								4.02													JFair-Hydri CFair to PW	
Parkway/College	1713	C PW Xing JPW-College	610.41	599.73	36	60.18 3039.59	0.0108								0.64													CPW Xing JPW-Cotege	
Apws PWN 182	1708	CPW to Milliken Non Contributing			36	342.49	0.0022	0.0006	156800 65600	3.60 1.51	380	1.50	0.54	1.56	3.64	0.32	0.29	10.1	8.9	11.2	8.7	11.2 10.0		01.31 <u>3.0(</u> 01.31 <b>15.</b> 8	) <u>1.93</u> 3 01:32 2.52	13.44	13.44	CPW to Million Non Contributing	Apwa
Parkway/Multiken	11022 1700 11023	JPW-Milliken CPW to HintgthE JPW-HintothE	610.47	588.99	36	2697.10 112.97 2584 13	0.0016								1.20										01:532 3.72			GPW to HintgtinE	
Parkway/Huntington West	1699 11024	CPW to Hintgtriv JPW-Hintgtriv	610.48	598.63	36	89.87 2494.26	0.0020								0.95													CPW to HintgtinW JPW-HintgtinW	
Parkway/Plaza East	1698 11025 1697	CPW to Plaza E JPW-PlazaE CBW to Plaza W	611.06	598.18	36	210.02 2284.24	0.0021	0.0006	82000	2 12	200	0.89	0.22	0.02	2.23	0.22	0.29	110	9.7	12.2		121 100		01.01 1.0	1.27	1464	14.64	GPW to Plaza E JPW-PlazaE	Apura
Parkway/Plaza West	11026	JPW-PlazaW GPW to ChurchE	611.32	596.08	30	2149.55 152.45	0.0057	0.0000	33000	2.15	390	0.89	0.32	0.82	1.62	0.52	0.29	11.0	9.1	12.2	3.4	12.1 10.9		01.33 17.6	0 01:31 3.70 01:54 3.74	14.04	14.04	JPW-PlazaW CPW to ChurchE	Pr W2
Parkway/Church East Arw 1	11027 1795	J PW-Church E CPW to Church W	609.43	595.21	30	1997.10 288.53	0.0097	0.022	106900	2.45	310	1.02	0.37	1.06	3.06	0.36	0.32	12.1	10.7	13.3	10.3	13.3 11.9		01 31 2.00	1.41	16.02	16.02	JPW-ChuichE GPW to ChuichW	APW1
Parkway/Beltone East Fairgrounds Drainage along Garfield	17028	JPW-ChurchW CPW to Grite	602.33	592.40	30	1708.57 287.33	0.0108		1845200	42.36					3.05									01.34 (22.8 00.58 (15.8	7) 01:32 5.03 5) 01:53 3.85			GPW to Gifted	
RRNE RRNW		Non Contributing							241600 73800	5.55 1.69																			
AGF7 Railroad to Niside of 8th Street		JGrid-sin	611.95	603.95	10	710.00	0.0000	0.0006	659900	15.15	1870	6.32	2.28	6.55		0.32	0.29							9.9 0.5 to :	2.82	8.53 0.1 to 0.2	8.53 0.1 to 0.2	JGrt4-8th	AGF7
Ages N side 8th Street to Webster		JGiftid-Webster	611.33	80333	10	710.00	0.0009	0.0006	348700	8.01	1120	3.34	1.20	3.46		0.32	0.29							5.3	1.65	4.51	4.51	J Gritd-Webster	Ag F6
TTSW		Non Contributing			21	775.00	0.0039		183,100	4.20			1.07			0.05		10.5				11.7		5.6	1.07			CGF6	0.077
Webster to State Street		JGritd-State CGF5	607.29	600.29	18	500.00	0.0220	0.0006	396200	9.10	660	3.80	1.37	3.93		0.32	0.29	13.3	11.7	14.8	11.4	14.7 13.2		attenua 00.58 1.8.0	ted attenuated	5.11 atten ated	5.11 attenuated	J Gritd-State CGF5	AGF5
AGF4								0.0006	316700	7.27	870	3.04	1.09	3.14		0.32	0.29	28.3	25.0	31.4	24.2	31.3 28.0		01 34 15.8 01 31 4.74	0 01:34 5.17 01:31 1.32	18.01 4.09	18.01 4.09		Agf4
Parkway/Garfield E side	11029 1789	J PW-GarteldE C PW to CottShp	597.64	589.29	30	1421.24 66.34 1354.00	0.0146								0.70								0	00.58 (4.19 01.34 (3.5)	)) )			JPW-GarlieldE CPW to CottShp	
Parkway/Conse Shop	1788	CPW to PWNth	596.44	308.32	30	83.06	0.0043								0.88								0	01.01 38. <b>1</b> 01.34 42.3	5 01:33 <b>11.34</b>	38.00	38.00	CPW to PWNth	
																												Non Contributing	
																												AGF7	
Garfield/N Side Parkway	11031 2946	Jointo-PWINth Control to Andrisin	596.35	587.96	30	1271.84 360.42	0.0093								3.83													Jorto-PWNth Cotto Andren	
Garfield/Anderson Agra	11032 4712	JG rtid-Anderson CGrtid to ParkS	592.46	584.61	30	911.42 210.27	0.0146	0.022	195400	4.49	360	1.87	0.67	1.94	2.23	0.36	0.32							3.6	01:31 2.13	2.03	2.03	J Girlid-Anderson CGirlid to ParkS	Agra
AGF1 Garfield/Park S side	11068	J Grid-ParkS	59.2 00	58155		701 15		0.022	117300	0.33	440	1.12	0.95	2.74 1.16		0.36	0.32	34.5	30.5	37.6	29.0	37.4 33.6	62.1	2.3	01:31 4.44 01:31 1.68	1.20	1.38	JGrfid-ParkS	AGF1
Park/Beach	537 11033	OG rild to Park J Park	589.96	580.17	30	93.00 608.15	0.0148								0.99													CGrild to Park JPark	
Beach S	538 11065 4440	GParktoBchS JBeachS CBrach	587.59	579.50	30	175.34 432.81 63.79	0.0038		471100	10.81					1.86										10.1-22 10.02	المحافد بحجرائين	استخدر ورون الاور	GParktoBethS JBeachS CBeech	
Beach N	11063 4260/539	J BeachN CBichtoOutfall11	585.25	575.32	24	369.02 369.02	0.0000								3.92									30.1	- or.az 13.02	45.20	45.20	JBoachN CBehtoOutfall11	
Outlet*	Outfall 11	Outfall 11	577.00	573.00		0.00		Total Area:	10997300	252.46																		Outfall 11	
		Water Surface Elev:	577.0					Cont 6 Area: Non Cont'b	3577100 7420200	82.12 170.34	Prop Area Totale	s: 34.28 41.75%	12.35 15.04%	35.49 43.22%	Te 90 min									9.40		0.20	0.29		
								2007 Conf b A	rea:	149.55					Area Convers	lon:	1.821	34.5 62.8	30.5 55.6	37.6 68.4	29.0 52.8	37.4 33.6 68.1 61.1(2	62.1	<b>53.1</b> 56.2	0 19.02	45.20 45.49	45.20 45.49 (19	 }	



\*Average slope is the weighted average of the area specific averages listed in the table below.

## Weighted Averages % Impervious/%Routed/Slope

STM-011006/JHsta-O	k						
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area
Hanna	1.39 ac	57.0 %	79.43	23.0 %	32.05	0.0006	0.001
HSTG	6.04	57.0	344.41	23.0	138.97	0.0006	0.004
<b>T</b>			100.01		171.00		0.004
I otal Averace	7.44 ac	57.0 %	423.84	23.0 %	171.02	0.0006	0.004
Avelage		57.0 %		20.0 /8		0.0000	
STM-011016/JFair-Tit	us						
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area
8th2	3.84 ac	57.0 %	218.79	23.0 %	88.28	0.0006	0.002
8th1	4.37	57.0	248.88	23.0	100.43	0.0006	0.003
rn2	2.99	57.0	170.37	23.0	00.75	0.0006	0.002
Total	11.19 ac		638.04		257.46		0.007
Average		57.0 %		23.0 %		0.0006	
STM-011021/JPW-Co	llege	Impensious	0/*****	Douted to Domious	0/*****	Clana	0*4***
A-Reference	Area	Impervious	%"Area	Routed to Pervious	%"Area	Slope	5"Area
FR1	2.27 ac	57.0 %	129.55	23.0 %	52.27	0.0006	0.001
PW3	3.60	57.0	205.18	23.0	82.79	0.0220	0.079
Total	5 97 00		224 70		125.06		0.091
Average	5.07 ac	57.0 %	334.72	23.0 %	135.00	0.0137	0.001
1101490		0/10 /0		20.0 /0		0.0107	
STM-011030/JPW-Ga	rfieldE						
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area
DWO	0.12.00	EZ 0 %	101 60	22.0.9/	40.10	0.0000	0.047
PW1	2.13 ac 2.45	57.0 %	139.88	23.0 %	49.10 56.44	0.0220	0.047
GF7	15.15	57.0	863.51	23.0	348.43	0.0006	0.009
GF6	8.01	57.0	456.29	23.0	184.12	0.0006	0.005
GF5	9.10	57.0	518.44	23.0	209.20	0.0006	0.005
GF4	7.27	57.0	414.41	23.0	167.22	0.0006	0.004
GF3	4.49	57.0	255.69	23.0	103.17	0.0220	0.099
GF2	6.33	57.0	360.76	23.0	145.57	0.0220	0.139
GF1	2.69	57.0	153.49	41.0	110.41	0.0220	0.059
Total	57.62 ac		3284.17		1373.66		0.42
Average		57.0 %		23.8 %		0.0073	

AND HYDRAULICS NERAL INFORMATION		DESCRIPTION
BRYANT PARK DRAINAGE AREA HYDROLOGY 2-YEAR, 5-YEAR, AND 10-YEAR ANALYSES, NOTES, AND GI	I KAVEKSE CI I Y, MICHIGAN	
Prince-Lund Engineering, PLC P.O. Box 1268, Traverse City, Michigan 49685	(888) 418-2695 www.build-on-prince.com	

1614-OHM

RAWN BY:

PROJECT ID:

RAWING:

SCALE: AS NOTED

Hydrology and Hydraulics Bryant Park Drainage Area SHEET No:

03/23/1

2 of 2



												Lanc	i Use Designa	itions	Τα	nput/IDF Det	a						Pea	k Flow Rat	e (cfs)								
14th Street 2-Ye	ear Ret	turn Inte	rval										Curve Numbe	rs	Toverland _	19 min				Hand Calculat	ions (14)	20 (=)				EPA SWMM	Software					XP SWMM	
												98	Residental 75 Area Proportion	Forested 55	Vpips, svs = (7) RI - (7) l2 -	2.08 tps 2 yr 1.11 in/hr		Ratio nal No la comp	miller IMethod ponent (12)	Calcu la const-0.05	MDEQ/So ulated la:	US (8) Tabular (13) const-0.2	200 Single Sub Area	Jurve Numbe 7 3	r Rossmiller Mo	Horton dified City Model (2	20)		Q1	Green-Ampt	ОНМ	OHMRauted	ID Catchment
Designations	Identification	SW MM	orm Drain De	escription				Slope	Sub	ocatchment	Info	0.2316	0.2750	0.4888	Тс	Rat	ional C	2007 CN [A]	Type A soll [B]	[0]	(9) [D]	[E1] [E2]	[F]	Durati [G]	on/Frequency Int [H]	ensities [1]	[J]	Тур [К]	ell	XP Converted to	OHM Typell EPA	XP	SWMM
	Manhole Pioe	Gonduit	Rim	evations Invert	(inches)	Length (feet)	Pipe	(ft/ft) (1)	(sq feet)	(acres)	(feet)	Proportional	Land Use per 8 (acres) (4)	Subcatchment	(min) (6)	(Hos 2007 CN (10)	(Type A soil)	-					(18) 55.0 51%	55.0 51%	70.7	Loss Range (cts)			(21)	[M] (22)	[N] (23)	[O] (24)	Conduit
											,							1					IMP	IMP	IMP								
Atstw		ile in il	807.02	624.04		4705		0.0058	208629	4.79	1100	1.11	1.32	2.34		0.25	0.25	1.3	1.3	1.1	ao	0.8 0.9	_	1.86	0.41	1.26	1.26	3.18					Ansthw
19th Street at Center Lane	2462	Contor	698.23	693.54	12	4785 290 4495	0.0016								21.32													0.2to 13 1158-12:06					JGulDe CCentor JCantor
19th Street at West Lane Street	2465 1 1503 1	CW 19th E JLaneW	697.45	691.93	12	325 41 70	0.0050								2.60									1.84	0.96	1.26	1.26	1.87	-				CW1sthE JLaneW
Ashigh South High Stat W 19th Street	2472 1 15032 2383	CW 1981W JHighs Clustes	694.95	688.97	12	290 3880 295	0.0102	0.0102	177482	4.07	450	0.94	1.12	1.99	2.32	0.26	0.25	2.5	2.5	2.1	1.1	1.5 1.7	-	1.99	0.28	1.16	2.42	0.12	1				Civites
South High Street AWLane	1 1503 3	JHigh CHighN	690.0	687.21	12	3585 135	0.1064	0.013	167582	3.85	400	0.89	1.06	1.88	1.08	0.26	0.26	3.6	3.6	3.0	1.5	2.2 2.4		1.81	0.23	1.10	1.10	2.66					JHigh CHighN AWLene
Boughey at N end of South High St	1 1503 4 2376	J HighN CBgyHigh	680.0	672.84	15	3450 175	0.1229								1.40								1	5.34	0.66	3.52	3.52	7.25	5 6				Jingnis Qagyiligh
Boughey Street	1 15035 2373 1 15036	JBgyE CBgyE	656.0	651.33	15	3600 135 3465	0.1154								1.08																		JBgyE CBgyE
boughey ander	2303	CBgyW JBgyW	640.0	635.23	21	190 3275	0.0027								1.52										attenuation			allervation					CBgyW JBgyW
	2300	Свдуми	And Colorador D		21	105	0.0029	0.0014	007007	7.51	0.400			0.07	0.84					1.0			1	5.34	0.65	3.52	3.52	6.96	1 1				Cegyww
Al-a tane Fairlane Drive, 1/3rd into cul-de-sac	115002	UFairlane C Fairlano	696,0	690.0	18	1275	0.0432	0.0014	327037	7.51	2400	1.74	2.06	3.67		0.24	0.24	3.0	5.9	1.6	12	1.3 1.4		3.55	0.40	3.55	3.55	8.75 alienuation 8.57					dFaitane CFaitane
AVec FairBgy						1.000		0.045	113100	2.60	2480	1.17	1.17	0.26		0.33	0.32	0.9	0.9	0.6	0.3	0.5 0.5		2.62	0.95	2.62	2.62	6.77	-				AVetFairBgy
ABHQuad Monte in percentantia property		low	604.00					0.002	200146	4.59	1200	1.06	1.26	2.25		0.24	0.24	1.2	1.2	1.1	0.6	0.8 0.9		2.33	0,35	1.31	1.31	3.25					AB HQuad
Авни		CQuad	Ret Inlet Inv	: 688.0	12	165	0.0018	0.002	64015	1.47	300	0.34	0.40	0.72		0.24	0.24	0.4	0.4	0.4	0.2	0.3 0.3		0.65	0.07	0.43	0.43	1.00					CQued ABHIII
Manhole near retention pond ABHIIS	1 1505 3	JBHII CBHupr	696.23	687.5	8	265	0.0219	0.002	214407	4.92	600	1.14	1.35	2.41		0.24	0.24	1.3	No Retention A 1.3	ttenuation 1.2	0.6	0.9 0.9	-	1.85	0.15	etention Attenual o 1.40	1.40	3.01					JBHII CBHupr ABHIIS
Manhole on access easement Lower portion of lateral from Veterans	1 1505 4	GBHwr	690.0	681.7	8	445	0.1051																	3.70	0.47	3.14	3.14	3.66					JAccess C BHIWF
Boughey Street at Veterans	CB503	JBgyWW	639.27	634.93		31 70																	1	attentiation	allenuation			allenuation	1				JBgyWW
Αναιν	2259	CVas			21	360	0.0377	0.0034	177256	4.07	500	0.94	1.12	1.99	2.88	0.25	0.24	11.5	11.4	9.1	4.8	6.6 7.2		15.07	2.02 0.16	12.83	12.83	24.48	-				OVetS Jvan Aven
ABHIINW	2256	CVetN	625.57	621.37	21	290	0.0261	0.0085	96683	222	300	0.51	0.61	1.08	2.32	0.26	0.25	0.6	0.6	0.5	0.3	04 04		16.72	2.12	13.99	13.99	27.11	-				CV-etN ABHIINW
ABHIN Entrance to Bay Hill	CB202	Jehiin	616.66	613.80		2520		0.016	327748	7.52	800	1.74	2.07	3.68		0.26	0.25	14.5	14.1	11.4	5.9	8.3 9.0	-	01:01-01:04 0:2t o 0.7				1154-1209 0.9 to 123					JEHIIN
AGTownHts	2253	CGTownHts	014.00	8111.17	21	125	-43.9814	0.013	104401	2.40	500	0.56	0.66	1.17	1.00	0.26	0.26	15.1	14.8	12.0	6.2	8.7 9.5	_	20.58	2.54 0.27	16.30 0.69	16.30	20.47				11.15.15.57	CGTownHts AGTownHts
Short reach adjacent to George Twn Entrance to George Twn Entrance to George Town Subdivision	2252 1 15014	CGTshorty JGTown	613.34	607.79	21	40 2695	137.5920								0.32									21.98 0.1 to 8.3	2.75	0022-01:05	0022-01:05	22.20 03 to 118	11:55-12:11 1.3 to 19.8 34.4	0.1 to 37.2 49.62	1138-12 07 0.5 to 74.0 83.71	0.4 to 50.8 62.82 (25	CGTshoty JGTown
AGTown	3071	CGTown	0.000		24	300	0.0014	0.012	205295	4.71	650	1.09	1.30	2.30	2.40									00:22-01:08 15:78	2.72	0.2 to 1.9 15.80	0.2 to 1.9 15.80	11:52-12:12 10:37	15.6	12.97	10.36	12.18	CGTown AGTown
Atenw Veterans at 16th Street Reach through visidential area	1 1501 5	J16th	612.61	607.36	54	2395	0.0032	0.015	228227	5.24	450	1.21	1.44	2.56	245	0.26	0.26	18.1	17.7	14.4	7.3	10.4 11.4	-	4.76	0.65	2.84 0.10	2.84 0.10 1.9.52	6.91 0.2 to 20	15.6	12.07	11:52-12:50 0:3 to 0.5	1218	J18h
Manhole adjacent to Menio building	115016	J15th CMonioE	611.99	605.94	30	1965	0.0020								2.00									18.52	3.03	attin 18.12	attn 18.12	15.26	6.9 22.5	14.86	19.66	14.89 (25) 27.07	Jish CMonioE
Manhole adjacent to car wash ACwash	1 1501 7 2221	JCwash COwashW	610.97	605.45	30	1715 125	0.0018	0.0026	226657	5.20	4100	1.21	1.43	2.54	1.00	0.25	0.24	19.5	19.1	15.6	7.9	11.4 12.4		5.24	0.87	5.24	5.24	13.28			1012562314		JCwash CCwashW AOwash
45-d angle point in 14th at Veterans	115018 2218	JVetSE CishoityVet	610.8	605.22	30	1590 70	0.0020								0.56									23.76	3.22	23.36	23.36	28.54	22.5	27.83	29.49	27.1	JVetSE CshotyVet
ANewc Newcomb Street at 16th Street	1 15040	JNewc16th	616.87	611.58				0.014	126765	2.91	1000	1.09	1.09	0.73		0.29	0.29	0.9	0.9	0.7	0.3	0.5 0.6		2.44	0.49	2.44	2.44	6.24					ANewc 16th
APIne1617 Newcomb Street at 15th Street	1 1504 1	Chiswo JNewo15th	614.9	610.57	18	420	0.0024	0.028	200151	4.59	1000	1.06	1.26	2.25		0.27	0.27	1.4	1.4	1.1	0.6	0.8 0.9		2.62	0.71	2.62	2.62	6.73					CNewc APIne1617 JNewc19th
Pine Street at 15th Street APine	115042	JPinetSth	613.11	609.57	21	++0	0.0025	0.0034	62805	1.44	1230	0.65	0.65	0.14		0.29	0.29	0.5	0.5	0.3	0.2	0.3 0.3		_				1.0to 6.5			-0.28	-0.2	JPinetSh APine
A14thN APolice		CPine			21	425	0.0036	0.0058 0.0019	43822 60810	1.01 1.40	350 250	0.23 0.32	0.28 0.38	0.49 0.68		0.25 0.24	0.25 0.24	0.3 0.4	0.3 0.4	0.2 0.3	0.1 0.2	0.2 0.2 0.2 0.3		Attenuated 5.06	Attenuated 0.84	5.06	5.06	6.43	-5.6	-0.82 (27)	1 1 46-12 33 2.4 to 39.5	11:47-12:03 1.5 to 25 9	CRine APolice
Pine Street at 14th Street AFOE Ersternal Order of Eagles 383	1 15044	C14th	612.9	608.02	24	720	0.0031	0.0026	74385	1.71	150	0.40	0.47	0.83		0.25	0.24	0.5	0.5	0.4	0.2	0.3 0.3		2.61 7.67 0.61	1.01	2.42 7.48 0.49	2.42 7.48 0.49	12.51	14.0	10.46	14.72	41.48 (25 15.34	C14th AFOE
That that to be the Lagree and		COwmHN	Ser 12	000.01	30	265	0.0028																	8.28	0.94	7.97	7.97	13.51					QCwashN.
45-d angle point in 14th at Veterans Beach in front of auto body abor	115019	JVetNW CAste	611.46	605.08	38	1520 130	0.0058								1.0.4									32.04	4.07	31.33	31.33	42.05	Attenuated 35.6	38.20	44.21	42.41	JVetNW CArto
Intersection of 14th and Oak Reach in front of vacuum shop	1 15020 794	JOak	611.06	604.72	42	1390	0.0017								2.20									OL OT	7.07	01.00	01.00	12.00	33.0	00.25	ThE	12.11	JOwk
14th near Subway	1 1502 1 798	JSubway C711	610.41	604.25	42	1115 350	0.0014	0.001	050014		1000			1.00	2.80									32.04	Attenuated 3.96	31.33	31.33	42.05	Attenuated 35.1	38.29	44.21	Attenuated 42.19	JSubway C711
Ashar Ashard								0.0003	358214 193987	4.45	900	1.90	1.22	2.18		0.24	0.24	2.2 26.7	2.1 26.2	2.0	11.0	1.4 1.5 15.8 17.3		6.21	0.26	5.96	5.96	11.67	12:00	1146-12:01	1146-12-09	11:47-12:05	Asthaird
AMenio Meniow Office Center/Michael's Pl	115062	JMento	609.0	604.30				0.0044	355520	8.16	1400	1.89	2.24	3.99		0.25	0.25	2.3	2.2	2.0	1.0	1.4 1.5		3.79	0.48	2.33	2.33	5.62 0.2to 1.5	0.2	12 to 7.2	1.3 to 15.1 19.66	0.3 to 10.2 1 5.01 (25	AMenio JMenio
14th at Manle: Kan Ken(7th	115022	Chapte	600.01	603 77	15	320 765	0.0017																4	3.79	0.44	2,33	2.33	4.57	4.9	5.09	4.74	4.86	CMaple
Adjacent to Northwest Bank	2162 115023	CToms JNWB	609.46	603.46	42	190 575	0.0016								1.52									42.04	3.96	39.62	39.62	58.29	40.0	43.22	48.95	47.05	CToms JNWB
S side 14th adjacent to 5th3rd Bank	2159 1 15024	CNWB J1455W	609.84	603.13	42	210 365	0.0016								1.68																		CNWB J14thW
N side 14th adjacent to 5th3rd Bank	2158 1 15025 2155	Joinaid Cathaid	609.98	603.05	42	290 75	0.0029								08.0																		Uxing Jainaa Caihaid
2 of 2 manholes on NE corner@ Div	1 15026 2154	JDivNE2 CShortyDiv	610.44	602.83	48	215 35	0.0366								0.28																		J DivNE2 OshotyDiv
1 of 2 manholes on NE corner@ Div	1 15027	JOWNET	610.22	601.55		180																											J DIVINE 1
Aries Division Street in residential area	115067	JRes	607.79	604.17				0.0016	193220	4.44	1000	1.03	1.22	2.17		0.24	0.24	1.2	1.2	1.1	0.5	0.8 0.8		1.92	0.21	1.27	1.27	2.97					A Ros
AChurch Division Street NW corner of church	1 1506 9	CRes JChurch	608.0	603.67	18	215	0.0023	0.002	95035	2.18	320	0.51	0.60	1.07		0.24	0.24	0.6	0.6	0.5	0.3	0.4 0.4		0.86	0.08	0.62	0.62	1.39					CRes Achuich Johurch
ANWBark	2151	CDivision			48	125	0.0076	0.0096	128.40.4	2.96	40.0	0.68	0.81	1.45	1.00	0.21	0.21	31.5	30.8	26.1	13.1	18.9 20.6	-	2.78 Alternated 44.82	0.25	39.62	39.62	4.36	40.0	Aftienavalied 43.03	48.95	0.09 Attenuated 46.98	Gdivision
Manhole at angle pt to outlet; Division Kids Creek Outlet	1 15028 2741	Utivision C115	610.22	601.32	48	55 55	0.0022				।स्वर्थ			2.10	0.44							aure 62	50.2	1.24	0.13	0,84	0.84	1.95	21.4 61.5	40.41 83.44	20.88 69.83	14.22 (25) 61.29	Division ANWEark C115
	Out-115	Outl 15		601.20	arch57																												
		Free Outfall 0	15) Elevation	601.2																													
	Ave Sub Ave	catchment Slope - e Overland Slope -	0.0079 N/A, Variabl	8				Total Area 2007/OHM Area	4732187 st	1 08.64 1 77.90	ac	26.46 42.02	30.87 48.93	50.84 86.95	To 63 min			31.5	30.8	26.1	13.1	18.9 20.6	50.2	7.00	10000	1.594	1.94	21.88	16.1	41.20	124.53	77.2	88
															Area Conver	sion:	1.638	51.5	50.5	42.7	21.4	31.0 33.8		46.06 53.06	3.95	42.35 44.19	42.35	64.60 86.48	61.5 77.8	83.44 1 24.64	69.83 194.36	61.3 138.5 (19)	Outris
																									Total Subcat	chment Peak Rur	noff:	106.84	87.5	1 28 33	197.26	148.4	

										SCS Method		MDEQ
	2-Ye	ar Ir	nfiltratio	n/Ra	ainfall/Runoff D	)ata			Surface Runoff (S	SRO)	Unit SRO (q <sub>u</sub> )	
								Calcul	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	er	24-hr	<sup>r</sup> Rainfall		la Con	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		A					0.05	0.2			
I					2 yr	P2 =	2.09 in	0.587	0.293	0.26 in	0.67 cfs/(in-ac)	
Curve No.	70.7	(5)	70.1	(5)	5 yr	P5 =	2.7 in	0.935	0.580	0.56 in	0.67 cfs/(in-ac)	0.41 cfs/(in-ac)
Storage	4.15	in	4.26	in	10 yr	P-0 =	3.21 in			0.85 in	0.67 cfs/(in-ac)	
*Per 2007 CN						(16)	la =	0.208 in	0.831 in	· 2	007 average slopes: pipe 1.76%; v	vatershed 1.48%
						_				-	Table 7-3 value for 1.48% slope:	0.73 cfs/(in-ac)

												Lan	d Use Designa	tions	T	: Input/IDF Dat	a						Peal	k Flow Rat	e (cfs)									
14th Street 5-Ye	ear Retu	irn Inter	val									Pavement	Curve Numbe Residential	rs Forested	Toverland – Vpips, ave –	19 min 2.08 fps		Ross	smiller	Hand Calcula	tions (14) M DEQ/S	3CS (8)	C	Curve Numbe	ſ	EPA SWMM Horton	Software			Green-Ampt		XP SWMM	Pipe/Junct	Sub-
Designations			Storm Drain De	escription				Slope	Sul	bcatchment ir	nfo	98	75 Area Proportion 0.2750	55 13 0.4888	(7) RI – (7) IS –	5 yr 1.38 in/hr		Rationa Nolacomp 2007 C N	il Method ponent (12) Type A soil	Calc la const=0.05	ulated la (9)	Tabular (13) a const=0.2	2007 Single Sub Area	7 Durat	Rossmiller M on/Frequency In	odified City Model ( tensities	20)	Туря	Cit	ty Model	OHM OHM Typell	OHM Routed		Catchment
	Identification Numbers	SWMM	MH Ele	evations	Diameter	Cuml Dist	Pipe	Land	Area	ı (	"Wieth"	Proportional	Land Use per S	Subcatchment	Te (min)	Rati (Ros	ional C Ismiller)	[A]	[B]	[C]	P	[E1] [E2]	[F] (18)	[G]	[H]	[1]	61	[K]	[L]	XP Converted to [M]	EPA [N]	XP [0]	SW MM Junction	
	Pipe	Conduit	Rim	Invert	(inches)	Length (feet)		(1)	(3q teet) (2)	(acres)	(1eet) (3)		(acres) (4)		(6)	(10)	(Type A soil) (11)	-					55.0 51% IMP	55.0 51% IMP	70.7 0% IMP	Loss Hango (cts) Du ation			(21)	(22)	(23)	(24)	Conduit	
(a. 1)(1)(1)								0.005.0	~~~~		11.00		1.00	0.01								10.00			1.0		1.5							
End of Center Lane cul-de-sac	115029 2462	JCul De CConter	697.83	694.01	12	4785 290	0.0016	0.0058	200629	4.79	1100	1.11	1.32	2.34	21,32	0.2/	0.27	1.0	1.0	1.0	6.1	1.8 2.0	-	0.1 to 0.9 00 \$1-01:04	1.0	1.0	1.6	4.1 1.1 to 2.3 11 56-12:06					JCurbs CCenter	Alstiny
19th Street at Center Lane	11 <i>5030</i> 2465	JContor Cw 19thE	698.23	693.54	12	4495 325	0.0050								2,60									2.0	1.0	1.6	1.6	1.9					JContor Cw19thE	1
19th Street at West Lane Street Ashigh South High St at W 19th Street	115031 2472 115032	JLanow Cwisthw JHigh5	697.45	691.93	12	4170 290 3880	0.0102	0.0102	177482	4.07	450	0.94	1.12	1.99	2.32	0.28	0.27	3.3	3.3	3.4	2.1	3.3 3.6	_	2.8	0.7	1.4	1.4	3.7 01 to 1.0					JLanow Cwisthw JHights	Astigh
South High Street	2383 11 <i>503</i> 3	Chighs Jhigh	690.0	687.21	12	295 3585	0.0060								2.36									4.6	1.5	3.0	3.0	4.6 11 56-12:06	_				CHighs J High	
AwLans Boughey at N end of South High St	2382 115034 2375	Chights Jhights Ceaselion	680.0	672.84	12	135 3450 175	0.1064	0.013	167582	3.85	400	0.89	1.06	1.88	1.08	0.28	0.27	4.8	4.7	4.9	3.0	4.8 5.2	-	2.5	0.6	1.4 d d	1.4	3.3					ChighN JhighN Ceavhan	AwLane
	11 <i>5035</i> 2373	ук. Јвду∈ Свду∈	656.0	651.33	15	3600 135	0.1154								1.08																		JBgyE CBgyE	
Boughey Street	115036 2303 115037	JBgy CBgyW JBoyW	641.0	635.75	21	3465 190 3275	0.0027								1.52																		JBgy CBgyW JBgyW	
	2300	Cegyww	040.0	00010	21	105	0.0029								0.84									7.1	2.0	4.4	4,4	8.1					Cegyww	
Afaitane Fairlane Drive, 1/3rd into cul-de-sac	115002	J Fastano	696.0	690.0	18	1275	0.0432	0.0014	327037	7.51	2400	1.74	2.06	3.67		0.26	0.25	3.9	3.9	2.9	2.4	2.8 3.1		4.4	1.2	4.4	4,4	11.9					JFaitano CEartano	AFaitano
A VetFai Bgy		Graten			10	12/5	0.0432	0.045	113100	2.60	2480	1.17	1.17	0.26		0.35	0.34	1.3	1.2	1.0	0.6	1.0 1.1		3.3	1.5	3.3	3.3	8.7					Cranad	AVatFai Bgy
ABHQued		loanet	594.00	666.7				0.002	200146	4.59	1200	1.06	1.26	2.25		0.26	0.26	1.7	1.6	1.8	1.1	1.7 1.9		3.2	0.9	1.6	1.6	4.2					lower	
Авни		Cqued	Retinlet Inv:	688.0	12	165	0.001 8	0.002	64015	1.47	300	0.34	0.40	0.72		0.26	0.26	0.5	0.5	0.6	0.3	0.6 0.6		0.9	0.2	0.5	0.5	1.3					Cipued	Авни
Manhole near retention pond Askurs	115053	Јени Свнорг	696.23	687.5	а	265	0.0219	0.002	21 44 07	4.92	600	1.14	1.35	2.41		0.26	0.26	1.8	No Retention A	Attenuation 1.9	1.2	1.8 2.0	-	2.6	0.1	Retention Attenuation 1.8	1.8	4.0					Јени Свнирг	ABHIIS
Lower portion of lateral from Veterans	115054	CBHbar	09010	001.7	8	445	0.1051																	3.6	1.3	3.6	3.6	02 100.6 3.8					C BHMr	
Boughey Street at Veterans	CB503	Jegyww	639.27	634.93	~ .	3170																		dar		1		11 59-12:02 0.5 to 4.6	]				JBgyww	
Avan Residential area on Veterans Way	115013	Jvan	626.57	621.37	21	2810	0.0377	0.0034	177256	4.07	500	0.94	1.12	1.99	2.88	0.27	0.26	15.4	15.2	14.5	9.6	14.2 15.5	_	2.3	0.4	15.7	15.7	27.7 3.5 26 to 5.4					Jvan	Aviativ
ABHINW	2256	CVOLIN			21	290	0.0251	0.0085	96683	2.22	300	0.51	0.61	1.08	2.32	0.27	0.27	0.8	0.8	0.8	0.5	0.8 0.9		20.8 6.3	5.8 1.4	17.1 2.9	17.1 2.9	25.8 7.3	-				Cvotv	AB HINW
ABHIIN Entrance to Bay Hill	CB202 2253	JBHIIN CGTownHts	616.66	613.80	21	2520 125	-43.9814	0.016	327748	7.52	800	1.74	2.07	3.68	1.00	0.28	0.27	19.2	18.8	18.2	11.8	17.9 19.5	-	00 33-01:06 0 2to 6.7 20.6	7.1	20.0	20.0	11 54 12:09 4.0 to 9.1 24.0					JBHIIN CGTown Hts	ABHIIN
AGTownHts Entrance to George Town Heights	CB2130	JGTownHts	614.33	6111.47		2735		0.013	104401	2.40	500	0.56	0.66	1.17		0.28	0.27	20.1	19.7	19.1	12.4	18.8 20.4	_	1.9	2.1	0.9	0.9	2.3 0.6 to 3.1	11:49-12:09	11:46-12:03	11:35-12:09	11/43-12:09	JGTown Hts	AGTownHts
Short reach adjacent to George Twn Entrance to George Town Subdivision	2252 115014 3071	CGTshoty JGTown CGTown	61 3.34	607.79	21	40 2695 300	137.5920								0.32									22.3 0.4 to 10.7	7.6	00:15-01:06 1.3to 6.7	00:15-01:06 1.3 to 6.7	23.2 0.5to 12.8	0.8 to 35.3 49.8	1.3to 50.9 62.4	0.2 to 93.7 104.05	79.76 (25	CGTshorty JGTown	
AGTown A t6th W	5077	Carolin					0.0014	0.01 2 0.01 5	205295 228227	4.71 5.24	650 450	1.09	1.30 1.44	2.30 2.56		0.28	0.28	24.0	23.5	22.9	14.7	22.5 24.5		15.7	7.6	14.1 3.5	14.1 3.5	10.4 9.0	14.5	11.1	10.36	10.37	CGTown	AGTOWN Atethw
Veterans at 16th Street Reach through residential area Manhole artiscent to Manlo building	115015 2244 115016	J 16th C Vot Res	612.61	607.36	24	2395 430 1985	0.0033								3.45									19.0	8.9	17.6	17.6	11 56-12:06	14.5	11.1	05 to 3.0 7.40	0.08 10.28	J16th CVetRes	
Manhole adjacent to car wash	2224 115017	CMonioE Jowesh	610.97	605.45	30	250 1715	0.0020								2.00									19.0	8.9	17.6	17.6	13.3	23.1	29.6	32.01	29.33	CMonioE JCwash	
Acwash 45-d angle point in 14th at Veterans	2221 115018 2218	Cowashiv Jvorse Oshob//ct	610.8	605.22	30	125 1590 70	0.0018	0.0026	226657	5.20	41 00	1.21	1.43	2.54	1.00	0.26	0.25	25.9	25.3	24.9	15.9	24.5 26.6	-	6.5 25.4	1.9	6,5 24.1	6.5 24.1	17.2	23.1	29.6	32.01	20.33	Cowashw Jvarse Oshot-Vat	Acvash
Allanc	AL.10						0.0020	0.01 4	126765	2.91	1000	1.09	1.09	0.73		0.31	0.31	1.2	1.2	1.1	0.7	1.1 1.2		3.1	1.1	3.0	3.0	8.1	2017		02.01			Allenc
Newcomb Street at 16th Street ABrateit7 Newcomb Street at 15th Street	115040	UNewc16th CNewc	616.87	611.58	18	420	0.0024	0.028	200151	4.59	1000	1.06	1.26	2.25		0.29	0.28	1.8	1.8	1.8	1.1	1.7 1.9		3.3	1.6	3.3	3.3	0.4 to 0.9 8.7					Unawet6th CNawe	APino1617
Pine Street at 15th Street	115042	Cristri Jeinoristri	613.11	609.57	21	440	0.0023																					11 56 12 06 5 .110 11 .1	10000				Cran Jenotan	
A Fino A 14bN A Balico		CBm			21	425	0.0036	0.0034 0.0058	62805 43822 60810	1.44	1230 350 250	0.65	0.65 0.28 0.38	0.14 0.49 0.68		0.31 0.27 0.26	0.31 0.27 0.26	0.6	0.6	0.6 0.4 0.5	0.3 0.2 0.3	0.5 0.6 0.4 0.4 0.5 0.6		Attenuated 6.3	Attenanted 2.3	6.3	63	54	0.5	-28 m	0.37	-0.44 11.45-12:04	CPing	APIno A 14thN APriles
Pine Street at 14th Street Aroe	115044	JFine14th C14th	612.9	608.02	24	720	0.0031	0.0026	74385	1.71	1 50	0.40	0.47	0.83		0.26	0.26	0.6	0.6	0.7	0.4	0.6 0.7		3.3	1.0 3.0	3.0 9.3	3.0 9.3	7.9 12.2	24.0 16.0	12.0	66.62 14.40	14.79	JProv14th C14th	AFOE
Fraternal Order of Eagles 383	115046	JFOE COMERTY	611.3	605.82	30	265	0.0028																	0.8 11.4	0.1 3.0	0.6 9.9	0.6 9.9	1.3 13.5					JFOE Cowastini	
45-d angle point in 14th at Veterans	115019	JVarnov	611.46	605.08		1 520																	1										Jvarwy	
Reach in front of auto body shop Intersection of 14th and Oak Depahsio front of wayway aboa	799 11 <i>5020</i> 704	CAuto JOak Circos	611.06	604.72	36	130 1390	0.0028								1.04									34.9	12.6	34.1	34.1	44.0	39.1	41.6	45.41	44.12	CAuto JOak	
14th near Subway	11 <i>5021</i> 798	Jsubway C711	610.41	604.25	42	1115 350	0.0014								2.80									34.9	12.5	34.1	34.1	44.0	Attenuated 39.0	41.6	45.41	44.12	Jsubwww C711	
Ashan Ashan								0.001	358214 193987	8.22 4.45	900	1.90	2.26 1.22	4.02 2.18		0.26	0.25	2.9 35.5	2.8 34.8	3.1 34.7	1.9 22.0	3.1 3.4 34.1 37.2	_	7.9	0.7	7.4	7.4	15.9	1150.1200	11 46 19:01	11-32-12:04	11/06/19/07		Asmail Asinisid
AMarto Meniow Office Center/Michael's Pl	115062	Jidento	609.0	604.30				0.0044	355520	8.16	1400	1.89	2.24	3.99		0.27	0.25	3.0	3.0	3.1	1.9	3.1 3.3		5.3 0.1to04	1.3	2.9	2.9	7.4 02 to 4.0	0.1 to 7.1	3 Oto 10.4 1 5.2	0.1 to 19.9 24.61	02 to 14.6 19.31 (2	JManto	AMenio
14th at Maple: Kap Keg/711	115022	CMaple	609.91	603.77	15	320 765	0.0017																	4.9	1.1	2.9	2.9	3.4	5.1	5.1	4.69	4.79	Смарія Јжал	
Adjacent to Northwest Bank	2162 115023	CToms JNWB	609.46	603.46	42	190 575	0.0016								1.52									47.7	13.3	44.4	44.4	63.2	44.1	46.7	50.10	48.91	CToms JNWB	
S side 14th adjacent to 5th3rd Bank	2159 115024 2158	CNWB J1480W Cxipo	609.84	603.13	42	210 365 75	0.0016								1.68																		Criwe Ji 40w Cxiwi	
N side 14th adjacent to 5th3rd Bank	115025 2155	Jathard Cathard	609.98	603.05	42	290 75	0.0029								0.60																		Jathard Cathard	
2 of 2 menholes on NE corner@ Div	115026 2154 115027	JDMNE2 CShotyDM	610.44	602.83	48	215 35 180	0.0366								0.28																		JOWNE2 CShotyDiv	
		Tarres e	510.22			100																	-										S LIVER 1	
Anos Division Street in residential area	115067	JRes	607.79	604.17		015	0.0000	0.0016	193220	4.44	1000	1.03	1.22	2.17		0.26	0.25	1.6	1.6	1.7	1.1	1.7 1.8		2.7	0.6	1.6	1.6	3.9					JRes	Arios
Division Street NW corner of church	115069	Joharsh Cohursh	608.0	603.67	18	310	0.0076	0.002	55035	2.10	520	0.51	0.00	1.07		0.20	0.25	0.0	0.0	0.0	0.0	0.0 0.9		3.8	0.7	2.4	2.4	5.8			0.13	-0.05	Johush Column	- A RATERON
ANWBank Mappale at angle at to outlet: Duteters	2151	Conision	610.95	601 23	48	125	0.0018	0.0036	128608	2.96	400	0.68	0.81	1.45	1.00	0.22	0.22	41.6	41.0	41.5	26.2	40.6 44.4	71.2	47.7	13.3	44.4	44.4	63.2	Апоплаво 44.1	46.7	Attenuated 49.01	48.91	Covelor	ANWDerk
Kids Creek Outlet	2741 Out-115	C115 Out115	510.22	601.32	48	55	0.0022								0.44								11.3	1.7	0.3	Eat	and s	2.0	76.6	96.6	74.92	66.88	C115	-convestite.
	Ave Sub	Free Outfall catchment Slope	(115) Elevation: 0.0079	601.2	1	1	1	Total Area	4732187 sf	108.64 ac	0	26.46	30.87	50.84	Tc 63 min	1																		
	Ave	Overland Slope	= N/A, Variable	8				2007/OHM Area		177.90 ac	5	42.02	48.93	86.95	Area Conver	sion:	1.638	41.8 68.5	41.0 67.1	41.5 67.95	26.2 42.95	40.8 44.4 66.7 72.7	71.3	17.5 53.25	13.8	7.0 47.77	7.0 47.8	41.6 71.6	32.1 76.6	67.2 96.6	155.11 74.92	108.47 66.88	Outiis	
																			OHM	multiplier:	1.043	traonar ave/XP be	ean now)	70.7	Total Suban	54.5 tohmont Book Pum	54.8	196.9	108.7	153.8	230.03	175.35 (19)		

										SCS Method		MDEQ
	5-Ye	ar Ir	ofiltratio	n/Ra	ainfall/Runoff D	ata			Surface Runoff (S	SRO)	Unit SRO (q <sub>u</sub> )	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	er	24-hr	Rainfall		la Con	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		A					0.05	0.2			
Γ					2 yr	P2 =	2.09 in			0.26 in	0.67 cfs/(in-ac)	
Curve No.	70.7	(5)	70.1	(5)	5 yr	Pā =	2.7 in	0.935	0.580	0.56 in	0.67 cfs/(in-ac)	0.41 cfs/(in-ac)
Storage	4.15	in	4.26	in	10 yr	P-0 =	3.21 in			0.85 in	0.67 cfs/(in-ac)	
*Per 2007 CN						(16)	la =	0.208 in	0.831 in	· 2	007 average slopes: pipe 1.76%; w	atershed 1.48%
						_				-	Table 7-3 value for 1.48% slope:	0.73 cfs/(in-ac)

### (1) The drainage area varies significantly in elevation, with notable drops from south to north and from either side of Veterans Drive to its right-of-way. The 2007 average slope of 0.0148 (L=4110 ft/dE=61 ft) was not representative of most subcatchments within the model so surface slope was estimated for each subcatchment by identifying a high point and a low point and dividing their difference by their separation as noted on the drawing. (2) City storm drain maps were reviewed and the overall drainage boundary estimated based on inlet locations. Although the Modified City model area was extended to include the State Police Post on Pine Street, the overall 2007 drainage area was reduced significantly within its boundary by excluding wooded areas (including slopes), neighborhoods without curb and gutter, and other developed tracts where runoff contribution potential appeared negligible. The revised area totals 109 acres as compared to the 2007 178-acre drainage area used in both City calculations and the OHM model. For purposes of this exercise, hand calculations provided herein are proportional to those developed in 2007 and included below each (Columns [A] through [E2]). (3) "Width" calculated or estimated based on EPA Storm Water Management Model (SWMM) Reference Manual Volume 1, Chapter 3; this number is noted in documentation as a calibration value.

 Portions of the subarea, in acres; classified pavement, residential, and forested per the 2007 Stormwater Management Report; *adjusted per site conditions where warranted*.
 Average curve number of 70.7 per 2007 model | The 70.1 curve number is based on impervious area per Rossmiller CN equation using TYPE A soil constant (39). (6) Once the drainage areas and storm drain piping were finalized, a simulation was run with only the upper subcatchment (A19thW) discharging to the storm drain plus an input of 1 cfs (near pipe capacity) at the upstream (JCuIDe) node, providing a "slug" of water traveling along the pipe in order to determine the pipe travel time of 44 minutes (97% Qpeak; steep curve, no inflection) at the outlet. | Overland travel time was defined at 97% Qpeak at steady state intensity equal to 0.75 in/hr (upper limit of open channel flow in the storm drain) which resulted in a 19 minute estimate; Tc estimate equals the total (19+44) or 63 minutes. Overland was entered into the spreadsheet and pipe velocity adjusted until total Tc equaled 63 minutes, thereby providing a check to see if resulting pipe flow velocities are realistic. (7) Chosen return period and corresponding average intensity for a duration equal to the Tc calculated in (6); average intensity is calculated using equation (Boucher, Costa County, CA, 2010) fit to NOAA DDF curves developed for rainfall data at Cherry Capital Airport (see IDF equations tab) (8) Peak Flow Rate(cfs) = Unit SRO (qu) <see (17) below> mult by SRO < (P-la)^2 / (P-la+S) in inches> mult by Area in square miles See (16) below for S and la Note: USDA T55 Appendix f has refined qu= based on Tc (not used) (9) The SCS/MDEQ methods typically underestimate peak runoff rates for total surface runoff (SRO) in the neighborhood of 1/2-inch or less (10) Rational method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (2007 Study, Type B soil), return interval, average land surface slope, rainfall intensity, and percent impervious (11) Rational method C constant calculated using Rossmiller's equation which is dependent on several variables such as curve number (Rossmiller Type A soil), return interval, average land surface slope, rainfall intensity, and percent impervious (12) Both C coefficients were calculated from Rossmiller's equation to convert from CN, however the 2007 is based on a Type B soil while the other is based on a Type A soil per NRCS Web Soil Survey, maps and descriptions (13) These replicate the 2007 Stormwater Management Report calculations using the tabular SCS curve method based on and land uses assumed/measured therein; the 5-year return interval (only) includes the land slope Opeak for comparison purposes; see MDEQ Soil Erosion and Sedimentation Control Training Manual, Chpt 7; actual peak flow is proportionally larger based on drainage area per Area Conversion, bottom row (14) It is worth noting how rational method numbers and SCS/MDEQ numbers are somewhat close to one another; although both are based on the same return period, one is entirely derived from projected local/historical intensities of the calculated rainfall duration (Tc), while the other is based on a peak runoff relationships derived from a 24-hour duration rainfall based on certain statistical correlations (15) Total SRO in inches; based on 24-hour rainfall, curve number, and initial abstraction; TR-55 runoff equation, Appendix F; see Chapter 7 "Computing Flood Discharges for Small Ungauged Watersheds", Mich DNR, June 2010 for following equ: SRO= ((P-la)^2)/(S+P-la) where: S=storage in inches=((1000/CN)-10); CN=curve number; P= 24-hr rainfall in inches for a given return period; la=initial abstraction=(constant)\*S; constant=0.2 normally, but 0.05 is proposed in certain instances {Table 7-2 equivalent; MDEQ Soil Erosion and Sedimentation Control Training Manual, Chapter 7; see SCS Curve Method tab} (16) Per definition, tabular calcs reflect the 0.2 "constant", which was actually developed from a relatively diverse data set gathered througout the country; the equation approach allows varying this "constant" which is very sensative to changes; 0.05 has been proposed to replace the current 0.2 constant; see (6) and SCS Curve No. Method tab (17) MDEQ Stormwater Management Guidebook, Chapter 7, Unit Hydrograph Peak, Equation 21: qu (unit surface runoff)= 270.9\*((Tc)^-0.81) in cfs/(sq mi-in) {Table 7-3 equivalent; MDEQ Soil Erosion and Sedimentation Control Training Manual, Chapter 7} mult by area in square miles and SRO as described in (15) to determine peak runoff flow rate. (18) An initial estimate of peak flow modeling the entire drainage area as one, using a "width" of 9,570 ft and a calculated average surface slope of 0.0185. (19) Model run with all existing pipes oversized to 72 inches so no losses occur upstream; the purpose is to determine a maximum resultant or total peak flow rate without any system losses occurring; runoff quantities are identical for both existing piping and oversized piping simulations (20) City Model simulations incorporating 27 subcatchments discharging to 22 inputs on the storm drain system; rainfall intensity for columns [G] through [J] correspond to the time of concentration and return interval as described in (6) and (7), respectively. Column [K] reflects the City Model performance with a 24-hour, Type II rainfall distribution imposed on the system. (21) This simulation reflects the OHM model configuration as described in (22) with additional changes to slopes, routing, etc. which reflect those developed for the City model; a standard Type II rainfall distribution with 0.1 hr time-step increments (P2=2.09; P5=2.70 in) was also incorporated based on the 2007 calculations (22) This simulation reflects the OHM model configuration as described in (23) except areas of subcatchments proportioned mostly downward to reflect subcatchment area discharging to OHM model junctions based on the Modified City Model configuration (108.6 acres). (23) This simulation reflects the OHM model configuration with inputs (slopes, routing, etc.) reflecting those developed for the OHM model including the 15-minute, Type II rainfall distribution (OHM P2=2.27; P5=2.76 in); maximum runoff equals that generated OHM's EPA SWMM (as converted from XP-SWMM and provided to the City for review) for all subcatchments; the OHM model has 5 input points along storm drain, each having 3 subcatchments connected (24) This is the final configuration of the OHM model provided for analysis. It is the same as described in (23), but revised to reflect the final values for perviousness and slope as well as inter-routing of subcatchments at certain nodes. (25) Peak subcatchment surface runoff; indentical in most cases as generated in converted OHM EPA SWMM output as provided (26) Unidentifiable discontinuity in the SWMM output; negative flow is water filling the upstream reaches while downstream is flowing full. (27) Negative flow is water filling the upstream reaches while downstream is flowing full.

(29) These peak flows appear discontiuous until the timing of peak offset is incorporated; flows are as follows at J16th: @00:13 CGTown15.39 +A16thW1.93+CGTown1.86 = CVetRes19.17 cfs(peak); @01:04 CGTown 10.36+A16thW4.24(peak)+ CGTown4.19(peak) -J16th1.27(loss)= CVetRes17.54 cfs; @01:13 CGTown 15.48(peak)+A16thW1.46+CGTown1.24 = CVetRes18.18 cfs

			Varia	able Input F	aramete	rs Provided By	ОНМ				
Subastahmant			Converted I	EPA SWMM				Fir	al OHM XP-8	SWMM	
Outlet Junction Reference	Area (acres)	"Width" (feet)	Surface Slope (%)	% Impervious	Routing to:	5-Year Subcatchment Peak Runoff (cfs)	"Width" (feet)	Surface Slope (%)	% Impervious	Routing to:	5-Year Subcatchment Peak Runoff (cfs)
STM-115044	33.68 14.92 4.31	2173.5 2173.5 2173.5	6.8 6.8 6.8	0 100 100	Outlet Outlet Outlet	66.62	2173.5 2173.5 2173.5	2.8 2.8 2.8	0 100 100	Outlet Outlet 0% Imp	City Model 52.355 52.82
STM-115014	54.08 22.62 7.54	2054.95 2054.95 2054.95	11.2 11.2 11.2	0 100 100	Outlet Outlet Outlet	104.1	2054.95 2054.95 2054.95	5.5 5.5 5.5	0 100 100	Outlet Outlet 0% Imp	<b>79.18</b> 79.76
STM-115016	6.06 5.32 1.77	1176.5 1176.5 1176.5	4.06 4.06 4.06	0 100 100	Outlet Outlet Outlet	24.62	1176.5 1176.5 1176.5	0.5 0.5 0.5	0 100 100	Outlet Outlet 0% Imp	1 <mark>9.154</mark> 19.05
STM-115062	6.06 5.32 1.77	1156.56 1156.56 1156.56	4.06 4.06 4.06	0 100 100	Outlet Outlet Outlet	24.61	1156.56 1156.56 1156.56	0.7 0.7 0.7	0 100 100	Outlet Outlet 0% Imp	<b>19.429</b> 19.31
STM-115028	6.84 5.68 1.90	474.07 474.07 474.07	3.33 3.33 3.33	0 100 100	Outlet Outlet Outlet	25.78	474.07 474.07 474.07	0.5 0.5 0.5	0 100 100	Outlet Outlet 0% Imp	1 <b>8.019</b> 18.02

14	th STREET	STATISTICS	2007 ST	ORMWA T	ER MAN	AGEME	NT REPORT
	PAVEMENT	1,830,265	SF	23.61%	CA	V=98	IMPERVIOUS
	FORESTED	2,131,277 3,787,571	SF SF	27.50% 48.89%	CA CA	v=75 √=55	PERVIOUS
	TOTAL	7,749,113	SF /177.9	AC 100%	CN	'ave=70.1	1
	SIDEWALK	1,108,611	SF **	27.98%	<=100%	TO PERV	10US*
	STREET	1,830,265	SF SF	25.81% 46.21%	<=00%	IU PERI	///////////////////////////////////////
	TOTAL	3,961,542	SF /90.4	AC 100%			
*	ASSUMED% R	OUTED ACROSS	PFRVIOUS	ARFA: (11	109+(0.85	*1023))/	3962 ~ 50%

\*\* ASSUMED % IMPERVIOUS WITH NO DEPRESSION STORAGE; ROUNDED TO 28%

										SCS Method		MDEQ
	10-Y	ear l	nfiltrati	on/R	ainfall/Runoff D	)ata			Surface Runoff (S	SRO)	Unit SRO (qu)	
								Calcula	ated* (15)		Tabular	Unit Peak Hydrograph
Description	2007		Rossmille	ər	24-hr	Rainfall		la Con	stant	Table 7.2	Table 7-3**	Calculated (17)
Soil type:	В		A					0.05	0.2			
					2 yr	P2 =	2.09 in			0.26 in	0.67 cfs/(in-ac)	
Curve No.	70.7	(5)	70.1	(5)	5 yr	Ps =	2.7 in	0.935	0.580	0.56 in	0.67 cfs/(in-ac)	0.41 cfs/(in-ac)
Storage	4.15	in	4.26	in	10 yr	P10 =	3.21 in	1.260	0.867	0.85 in	0.67 cfs/(in-ac)	
*Per 2007 CN						(16)	a =	0.208 in	0.831 in	** 2	007 average slopes: pipe 1.76%; v	watershed 1.48%
						_					Table 7-3 value for 1.48% slope:	0.73 cfs/(in-ac)

												Lan	d Use Designa	tions	т	'e Input/IDF Dat	8					Peak F	low Rate (cfs)						
14th Street 10-	Year Re	eturn Inte	erval									Pavament	Curve Number Residential	rs Forested	Towned _	19 min 208 fos		Boss	miller	Hand Calcula	tions (14)	/CS /a)		Cuore Numb	EPA SWMM So	ftware Horton	Green-Amot	Boellund	Sib-
Parimetions		8	torm Drain	Description				2baa		o atab mont	Info	98	Area Proportion	55	(7) RI - (7) IIO -	10 yr 1.63 in/hr		Rationa No la com	I Method ponent (12)	Calc la const -0.05	ulated Ia	Tabular (13) const-0.2	200 Single Sub Are		Reasmiller Modified	City Model (20)		ID	Catchment
Designations	Identification Numbers	SWMM Junction	мн	Elevations	Diameter	Cuml Dist	Pipe	Land	Area	(norma)	"Width"	Proportional	Land Use per S	Subcatchment	Tc (min)	Rati (Ros	onal C smiller)	[A]	[B]	[C]	[D]	[E1] [E2]	[F] (18)	[G]	[H]	[1]	[1]	SWMM Junction	
	Pipe	Conduit	Ham	invert	(inches)	(feet)		(1)	(2)	(acres)	(3)		(4)		(6)	(10)	(1) (11)	-					51% IMP	51% IMP	0% IMP	Duration		Conduit	
Atethw								0.0058	208629	4.79	1 100	1.11	1.32	2.34		0.28	0.28	2.2	2.2	2.5	1.7	2.7 3.0		3.5	1,8	1.85	1.85		AtethW
End of Genter Lane cul-de-sac 19th Street at Center Lane	115029 2462 115030	JCul De OContor JContor	697.83	694.01 693.54	12	4785 290 4495	0.0016								21.32									0.1 to 1.6 00:37-01:0	6			JGulBe CCenter JCenter	
19th Street at West Lane Street	2465 11 <i>5031</i> 2472	CW1sthE JLandW CW19thW	697.45	691.93	12	325 4170 290	0.0050	0.0102	177482	4.07	450	0.94	1.12	1.99	2.60	0.29	0.29	4.2	4.1	4.6	3.1	5.0 5.5		1.9	1.7	1.85	1.85	CW 19thE JLaneW CW 19thW	Ashion
South High Stat W 19th Street	115032 2383	JHIghs CHighs	694.95	688.97	12	3880 295	0.0060								2.36									0.1 to 0.81 4.6	2.7	3.56	3.56	Jrighs Crights	
AWLane Boughey at N end of South High St	2382 115034	Unign CHighN JHighN	680.0	672.84	12	135 3450	0.1064	0.013	167582	3.85	400	0.89	1.06	1.88	1.08	0.29	0.29	6.0	5.9	6.5	4.5	7.2 7.9	-	3.2	1.1	1.62	1.62	Снум Снум Јнум	AWLene
	2376 115035 2373	CBgyHigh JBgyE CBgyE	656.0	651.33	15	175 3600 135	0.1229								1.40									7.8	3./	5.18	5.18	GBgyHigh JBgy£ GBgy€	
Boughey Street	11 <i>5036</i> 2303 11 <i>5037</i>	JBgy CBgyW JBgyW	641.0	635.75 635.23	21	3465 190 3275	0.0027								1.52													JBgy CBgyW JBgyW	
AFailanc	2300	Obgyww		200.00249	21	105	0.0029	0.0014	327037	7.51	2400	1.74	2.06	3.67	0.84	0.27	0.27	4.9	4.8	3.9	3.6	4.3 4.7	í i	7.8	3.7	5.18	5.18	Cegyww	AFaitane
Fairlane Drive, 1/3rd Into cul-de-sac	115002	dFaitana CFaitana	696.0	690.0	18	1275	0.0432																	5.4	2,1	5.22	5.22	JFairlane C Fairlane	
AVetFaiBgy ABHCand	N							0.045	2001.46	2.60	2480	1.17	1.17	0.26		0.37	0.36	1.6	1.5	1.3	0.9	1.5 1.6	1	4.0	2.0	3.85	3.85		AVetFailBgr ABHOuad
Manhole near retention pond		Jouan OQuad	694.00 Ret Inlet I	688.3 nv: 688.0	12	165	0.0018	0.000	04045	1.17		0.04		0.70		0.07	0.67	0.7		0.0	0.5	0.0 0.0		2161		0.00	0.52	JQuad CQuad	
Abrillion Manhole near referition pond Abrillion Abrillion	115053	Јани Овнирт	696.23	687.5	8	265	0.0219	0.002	214407	4.92	600	1.14	1.35	2.41		0.27	0.27	22	0.6 No Retention A 2.2	0.8 ttenuation 2.5	1.7	2.8 3.1		3.3	0.3 Retent	on Attenuation 2.06	2.06	JBHill OBH.pr	ABHIIS
Manhole on access easement Lower portion of lateral from Veterans	115054	JAcces Q8 Hwr	690.0	681.7	8	445	0.1051																	4.0	2.4	3.75	3.75	J Access C Bitling	
Boughey Street at Veterans	CB503 2259	JBgyWW CVatS	639.27	634.93	21	3170 360	0.0377								2.88									21.1	9.6	18.00	18.00	JBgyWW CVatS	
Avan Residential area on Veterans Way	115013 2256	Jvan Oven	626.57	621.37	21	2810 290	0.0261	0.0034	177256	4.07	500	0.94	1.12	1.99	2.32	0.28	0.27	19.2	18.9	19.5	14.3	20.8 23.5	202025945	2.9 24.0	0.8 10.3	1.71	1.71	Jiveni CVetN	Avoru
ABHIINW ABHIIN Entrance to Bay Hill	CB202	Jenin	616.66	613.80		2520		0.0085 0.016	96683 327748	2.22 7.52	300 800	0.51 1.74	0.61 2.07	1.08 3.68		0.29 0.30	0.28 0.28	1.0 23.9	1.0 23.4	1.1 24.5	0.8 17.8	1.3 1.4 22.0 29.5	21.01	8.1 00:16-01:0 0.4 to 11.8	2.5	0.93	0.93	Јеним	ABHIINW ABHIIN (25)
AGTown Hts Entrance to George Town Heights	2253 CB2130	CGTownHts /C3TownHts	614 33	611.47	21	2735	0.0186	0.013	104401	2.40	500	0.56	0.66	1.17	1.00	0.29	0.29	25.0	24.5	25.7	18.6	23.4 31.0	4	20.6 2.3	12.7	20.64	20.64	GTownHts	AGTownHts
Short reach adjacent to George Twn Entrance to George Town Subdivision	2252 115014	OGTshorty JGTown	613.34	607.79	21	40 2695	0.0920								0.32									22.6 1.2 to 12.5	13.6	00:12-01:07 1.1 to 8.7	00:12-01.07 1.1 to 8.7	CGTshorty JGTown	
AGTown Al6thw	30/1	OGIOWN			24		0.0014	0.012 0.015	2052.95 2282.27	4.71 5.24	650 450	1.09 1.21	1.30 1.44	2.30 2.56	2.40	0.30	0.29	29.8	29.2	30.9	22.2	29.1 37.2	0:	13 15.4 13 8.5	13.6 3.0	13.02 4.18	13.02 4.18	CGTown	AGTown A16thW
Veterans at 16th Street Reach through residential area Manhole adjacent to Menio building	2244 115016	J16th CVetRes J15th	612.61	607.36	24	2395 430 1965	0.0033								3.45								0: (29	0.1to13 13 19.2	16.3	17.19	17.19	J16th CVetRes J1stn	
Manhole adjacent to car wash AGwash	2224 115017 2221	OMontoE JGwaah OGwaahW	610.97	605.45	30	250 1715 125	0.0020	0.0026	226657	5.20	4100	1.21	1.43	2.54	2.00	0.28	0.27	32.2	31.5	33.5	24.0	32.0 40.4	t:	13 <u>18.7</u> 03 7.9	16.1 3.0	7.70	17.19	Ctwantoe JCwash GOwashW	AGwesh
45-d angle point in 14th at Veterans	115018 2218	JVatSE OshotyVat	610.8	605.22	30	1590 70	0.0020								0.56								1:	03 25.4	18.3	24.69	24.69	JV atSE CshortyVat	
ANewc Newcomb Street at 16th Street APinats 17	115040	JNewc18h Onlawc	616.87	611.55	18	420	0.0024	0.014	126765 200151	2.91	1000	1.09	1.09	1.42 2.25		0.33	0.32	1.6	1.5	1.5 2.4	1.0 1.6	1.7 1.8 2.6 2.9		3.7	1.7	3.59	3.59	JNewc16th CNewc	ANewc API na1617
Newcomb Street at 15th Street	115041	JNewc15th C15th	614.9	610.57	21	440	0.0023																					JNewe15th C15th	
APine Alithi	1150ac	Contraction	010.11	003.04		105	0.0008	0.0034 0.0058	62805 43822	1.44	1 230 350	0.65	0.65	0.14 0.49		0.33	0.32	0.8 0.5	0.8 0.5	0.7	0.5 0.4	0.8 0.9 0.6 0.6		Attenvates	Attenuated			One	APine A14thN
Prine Street at 14th Street AFOE	115044	Jeinotath Ctath	612.9	606.02	21	720	0.0035	0.0026	74385	1.71	150	0.32	0.38	0.83		0.27	0.27	0.5	0.8	0.9	0.6	1.0 1.1		4.1 12.5	5.6 1.7 5.1	3.56 11.00	3.56 11.00	UPinet 4th C14th	AFOE
Fraternal Order of Eagles 383	115046	dFOE QGwaahN	611.3	605.82	30	265	0.0028																	12.5	0.2 5.5	0.72 11.72	0.72	JFOE COwasHN	
45-d angle point in 14th at Veterans Reach in front of auto body shop	11 <i>5019</i> 799	JV etNW GAuto	611.46	605.08	36	1520 130	0.0028								1.04								t:	04 37.9	22.6	36.61	36.61	JVetNW CAuto	
Intersection of 14th and Oak Reach in front of vacuum shop 14th near Subway	115020 794 115021	JOek Ovec JSubway	611.06	604.72 604.25	42	1390 275 1115	0.0017								2.20													JCak Cvac JSubway	
ASMail Ann an	798	C711			42	350	0.0014	0.001	358214	8.22	1000	1.90	2.26	4.02	2.80	0.27	0.26	3.6 44.2	3.5 43.3	4.2	2.9	4.7 3.4 45.7 53.7	1:	9.5	22.3	36.61 8.77	36.61	C711	Ashal
AMerico	115000		600.0	คณ จภ				0.0044	355520	8.16	1 400	1.89	2.24	3.99		0.28	0.28	3.7	3.7	4.2	2.9	4.6 3.3	1	00:42-01:0	6 2.3	3.42	3.42	(Barrata)	Allenio
14th at Manley Kan Kon 711	115002	Oldaște	600.01	602.77	15	320	0.0017																t	04 4.6	2,3	3,42	3.42	CMaple	
Adjacent to Northwest Bank	2162 115023	CToms JNWB	609.46	603.46	42	190 575	0.0016								1.52								t:	04 51.7	24.7	48.60	48.80	CToms JNAVB	
S side 14th adjacent to 5th3rd Bank	2159 115024 2158	J1485W Cxing	609.84	603.13	42	210 385 75	0.0016								0.60													GNWB J14tHW Cxing	
N side 14th adjacent to 5th3rd Bank 2 of 2 m anholes on NE corner@ Div	115025 2155 115026	Jostnard Cathard JDivN E2	609.98	603.05	42	290 75 215	0.0029								0.60													Jotnard Cothard JDivNE2	
1 of 2 m anholes on NE corner@ Div	2154 115027	OShotyDiv JDIVNE1	610.22	601.55	48	35 180	0.0366								0.28													CShortyDiv JDIVNE1	
Aftes Division Street in resident al area	115057	JRes	607.79	504,17				0.0016	193220	4,44	1000	1.03	1.22	2.17		0.27	0.27	2.0	1.9	2.3	1.6	2.5 1.8		3.4	1.0	1,86	1.86	JRes	Afles
Achuich Division Street NW corner of church	115069	CRes JChurch	608.0	603.67	18	215	0.0023	0.002	95035	2.18	320	0.51	0.60	1.07		0.27	0.27	1.0	1.0	1.1	0.8	1.2 0.9		1.5	0.4	0.91	0.91	CRes Johuch	AChurch
ANWBark Manholo at pools at to evaluate Prints	2151	CDivision	610.00	201 00	48	125	0.0018	0.0036	128808	2.96	400	0.68	0.81	1.45	1.00	0.24	0.23	52.0	51.0	55.9	39.4	56.8 61.0	0101	51.7	24.7	48.80	48.80	CDivision	Anone
Mannore at angle puto outlet; Division Kids Creek Outlet	2741 Out-115	CI 15 Out115	610.22	601.32	48	55	0.0022								0.44								<u>814</u> 1:	2.2	0/5	124	1.24	C115	
	Ave Sub Ave	Free Outfall (1 catchment Slope - e Overland Slope -	115) Elevatio 0.0079 N/A, Varia	on: 601.2 able				Total Area 2007/OHM Area	4732187 sf	108.64 177.90	ac 80	26.46 42.02	30.87 48.93	51.53 86.95	To 63 min	n		52.0	51.0	55.9	39.4	56.8 61.0	91.4	30.0		11.94	11.94		
															Area Conve	rsion:	1.638	85.2	83.5	91.6	64.5	93.0 99.8	1:	04 58.78 88.7	26.6	52.81 64.75	52.81 64.75	Outi 15	

Weighted Averages % Impervious/%Routed/Slope									
115044/JPine14th									
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area		
Police	1.40 ac	51.0 %	71.40	51.0 %	71.40	0.0019	0.00266		
14thN	1.01	51.0	51.51	100.0	101.00	0.0058	0.00586		
Pine	1.44	90.0	129.60	100.0	144.00	0.0034	0.00490		
Newc	2.91	75.0	218.25	100.0	291.00	0.014	0.04074		
Pine1617	4.59	51.0	234.09	100.0	459.00	0.026	0.11934		
Total	11.35 ac		704.85		1066.40		0.17349		
Average		62.1 %		94.0 %		0.0153			
115014/JGTown									
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area		
19thW	4.79 ac	42.2 %	202.14	44.3 %	212.20	0.0058	0.02778		
WLane	3.85	51.0	196.35	50.0	192.50	0.0130	0.05005		
SHigh	4.07	51.0	207.57	50.0	203.50	0.0102	0.04151		
VetFairBgy	2.60	90.0	234.00	0.0	0.00	0.0450	0.11700		
Fairlane	7.51	42.2	316.92	0.0	0.00	0.0014	0.01051		
BHIIIS	4.92	51.0	250.92	50.0	246.00	0.0020	0.00984		
BHIII	1.50	51.0	76.50	50.0	75.00	0.0020	0.00300		
Quad	4.60	51.0	234.60	50.0	230.00	0.0020	0.00920		
DUIIN	4.07	51.0	207.57	50.0	203.50	0.0034	0.01304		
BHIINW	7.52	51.0	113 22	50.0	376.00	0.0160	0.12032		
GTownHts	2.40	51.0	122 40	50.0	120.00	0.0130	0.03120		
Growning	2.10	01.0	122.10	00.0	120.00	0.0100	0.00120		
Total	50.05 ac		2545.71		1969.70		0.45313		
Average		50.9 %		39.4 %		0.0091			
115016/1100									
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area		
16th	5.24 ac	51.0 %	N/A	50.0 %	N/A	0.0130	N/A		
GTown	4.71	51.0	N/A	50.0	N/A	0.0130	N/A		
	9.95 ac	51.0 %		50.0 %		0.0130			
115062/JMenlo									
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area		
Menio	8.16 ac	51.0 %	N/A	50.0 %	N/A	0.0044	N/A		
115028/ IDivision									
A-Reference	Area	Impervious	%*Area	Routed to Pervious	%*Area	Slope	S*Area		
FOE	1.71 ac	51.0 %	87.21	50.0 %	85.50	0.0026	0.00445		
Cwash	5.20	90.0	468.00	0.0	0.00	0.0026	0.01352		
SMall	8.22	51.0	419.22	0.0	0.00	0.0010	0.00822		
5th3rd	4.45	51.0	226.95	50.0	222.50	0.0003	0.00134		
NWB	2.96	51.0	150.96	50.0	148.00	0.0036	0.01066		
Church	2.18	51.0	111.18	50.0	109.00	0.0020	0.00436		
Res	4.44	51.0	226.44	50.0	222.00	0.0160	0.07104		
Total	29.16 ac		1689.96		787.00		0.11358		
Average		58.0 %		27.0 %		0.0039			

![](_page_138_Figure_15.jpeg)

![](_page_138_Figure_16.jpeg)

## 2017

# APPENDIX J

TWC updates to GTBWPP specific to the City's SAW grant

# TWC updates to GTBWPP specific to the City's SAW grant

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• Update as ne	eeded w/ SAW info will do with entire WPP update
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5.2	PRIORITY POLLUTANT RANKING
5.3	PRIORITY AREAS
• Need to brea	ak out priority and critical areas separately will do with larger WPP update
• Specific area	as and sites in TC? TC is already a critical area in the Boardman Prosperity Plan
and will be i	In GIBWPP as well.
5.4	POLLUTANTS OF CONCERN
5.5	SPECIAL SOURCES OF CONCERN: STORMWATER, LACK OF RIPARIAN BUFFER, AND MASTER PLANS AND ZONING ORDINANCES
• Break curren	nt three things in Chapter 5.5 out into separate sections:
o Mas	ter Plan and Zoning to be its own chapter - Chapter 5.5
l l l l l l l l l l l l l l l l l l l	<ul> <li>Include general info and format used in Boardman Prosperity Plan as it</li> </ul>
•	Add City of TC subsection
	Include specific info from BPP on City of TC
	• SAW grant info and accomplishments related to utility, stormwater
	ordinance, geothermal polity
<mark>○ Stor</mark>	mwater and Lack of Buffer are together as subsections in next chapter - Chapter
<mark>5.6</mark> .2	Special Sources of Concern: Stormwater
	Subsection for City of TC: discuss issues and summarize SAW Grant
	work, summarize BMP efforts, street and catch basin cleaning efforts,
	critter problems causing high EColi
	• Subsection for other WS areas: discuss issues and BMP efforts to date
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# 3.11 Existing Water Quality Information and Results for GTBWatershed

# Add stormwater data - NOTE: Not sure of final format for the section, write up below for TC SAW Stormwater Plan. Same info in bullet points below. Excel tables are included here.

Storm Drain Monitoring Results:

It is important to note when looking at water quality results from stormdrains whether or not discharge or flow measurements were taken during sampling. Most stormwater samples are taken using the 'grab sample' method, which are only taken once during a rain event and represent a snapshot in time of the water quality at that particular storm drain. However, during rain events there are typically fluctuating volumes of water and concentrations of different types of pollutants coming out of a drain, which in turn will affect the pollutant load coming out of each drain (pollutant load calculated by multiplying volume by concentration). The higher the concentration of pollutant or the volume of water coming out of the drain, the higher the pollutant load.

Only thorough sampling during multiple rain events will lead to a clear picture of pollutant loadings to a watershed. Care should be taken not to make broad assumptions on stormwater quality in an urban area based solely on grab samples taken at a particular time during a rain event. In lieu of a potentially time consuming and expensive stormwater monitoring program, the use of models can be an effective way to approximate the amount of pollution to a watershed from stormdrains. Additionally, results from similar urban areas that have done stormwater monitoring can also be used to approximate pollutant loads.

A wide variety of water quality parameters have been tested in stormdrains throughout the City of Traverse City, with some testing dating back to 1980. However, a thorough stormwater analysis, including discharge and flow volumes, has not been conducted on a city-wide basis to date. Water quality results from a select number stormdrains in the City from 2009-2015 were averaged from 10 locations for Nitrate, Total Phosphorus (TP), and Total Suspended Solids (TSS). Results were as follows:

- Nitrate average 0.47 mg/L
- TSS average = 96 mg/L
- TP average = 0.10 mg/l (100 ug/L).

Data sources are from TWC-led studies including stormdrain testing program with City of Traverse City funds (2009), GLRI Project at Bryant Park (2011/2012), and BMP effectiveness testing at GLRI East Bay Park project (2013-2015).

Comparisons of stormwater results were also made on select storm drains with data from the 1990s to more recent results from 2009 and after - 8th Street, Bryant Park, East Bay Park (north and south drains), and Hannah Park. At these select sites Nitrates appear to have increased since the 1990s, TP has decreased, TSS was inconclusive (see Table below). Again, caution should be taken when comparing stormwater results where only grab samples were taken.

Location	timeframe	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)
8th Street	Historic	0.01	0.27	30
	Recent	0.56	0.1	49
Brvant Park	Historic	0.10	0.20	43
	Recent	0.66	0.08	68
East Bay Par (north)	Historic	0.29	0.56	76
	Recent	0.29	0.12	47
East Bay Park (south)	Historic	4.5	0.20	n/a
	Recent	n/a	0.09	145
Hannah Park	Historic	0.01	0.46	91
	Recent	0.42	0.095	59

\*Historic - 1991, 1992, 2000

\*Recent - 2009-2015

Bacteria levels of *E. coli* in stormdrains are high throughout the City of TC during rain events. Summarized results from 11 outfalls confirm this (8th Street, Bryant Park (2 locations), East Bay Park (2 locations), Hannah Park, Holiday Inn, Hope Street, Maple Street, Sunset Park, and West End Beach). The highest results were noted at 8th Street, Bryan Park, East Bay Park, Sunset Park. *E. coli* is discussed at length in the Grand Traverse Bay Watershed Protection Plan.

- General disclaimers:
  - Only summarizing Nitrate, TP, TSS, and EColi
  - Nothing has been calculated to show pollutant loads from the stormdrains no discharge measurements were taken during sampling. When interpreting stormwater sampling results you need to be careful. Most samples are taken using the 'grab sample' method, which are only taken once during a rain event and represent a snapshot in time of the water quality at the storm drain. However, during rain events there are typically fluctuating volumes of water and concentrations of different types of pollutants coming out of a drain. Only thorough sampling during multiple rain events will lead to a clear picture of pollutant loadings to a watershed. This is why the use of models is a widely used practice among watershed managers, where acres of different types of land use are input and an estimate of different types of pollutant loads can be obtained (discussed later in pollutant load section, which is next).

- City of TC
  - Current data from various sources
    - Compiled from 10 locations
    - Range from 2009 2015
    - TSS average = 96 mg/L; TP average = 0.10 mg/l (100ug/L); Nitrate average 0.47 mg/L; Ecoli average = 13,314 col/100mL
    - Data sources are from TWC led studies including stormdrain testing program with City of Traverse City funds (2009), GLRI Project at Bryant Park (2011/2012), and BMP effectiveness testing at GLRI East Bay Park project (2013-2015)
  - Historical data comparison
    - Compiled numerous stormwater results from a variety of historic reports and found 5 common sites that have both historic (1990s) and current (after 2000) data - 8th Street, Bryant Park, East Bay Park (north and south drains), and Hannah Park
    - Nitrates appear to have increased, TP has decreased, TSS was inconclusive
    - Data sources:
      - Shuey, J.A., C.A. Harris, and G.M. DeGraeve. 1992. Final Report for the Grand Traverse Bay Watershed Initiative: Part II, Water Quality of the Bay and Tributaries. Great Lakes Environmental Center, Traverse City, MI. (Note: The Grand Traverse Bay Watershed Initiative is now known as The Watershed Center Grand Traverse Bay.)
      - City of Traverse City Waste Water Treatment Plant and Operations Management International. 1992. Stormwater Sewer Study
      - Great Lakes Environmental Center (GLEC). 2001. Stormwater Source Identification, Sampling, and Analysis at Select Storm Drains and Tributaries to Grand Traverse Bay (Lake Michigan). Prepared for The Watershed Center Grand Traverse Bay as part of an DEQ, Coastal Zone Management Study. (Principal Contact at GLEC: Dennis McCauley)
      - TWC GLRI Project at Bryant Park (2011/2012)
      - *TWC BMP* effectiveness testing at GLRI East Bay Park project (2013-2015)
      - TWC Project with City of Traverse City funds (2009)
    - Much more data available on TWC's interactive Online Water Quality Database: <u>http://www.gtbay.org/resources/water-quality-database/</u>
  - o EColi
    - Results for 11 stormwdrain outfalls: 8th Street, Bryant Park (2 locations), East Bay Park (2 locations), Hannah Park, Holiday Inn, Hope Street, Maple Street, Sunset Park, and West End Beach
    - Most drains tested high for Ecoli bacteria during rain events
    - Highest were: 8th Street, Bryan Park, East Bay Park, Sunset Park
    - State water quality standards indicate no body contact above 1,000 col/100mL
    - Data sources:
      - TWC Stormwater Project with City of Traverse City funds (2009)
      - TWC Beach testing with City of Traverse City funds (2015)

- TWC GLRI Project at Bryant Park (2011/2012)
- TWC GLRI Project at East Bay Park (2011/2012)
- USGS funded stormdrain study 2010-2012
- Boardman Lake Shoreline Survey
  - Inspect 1-1.5 mile of shoreline along north half of Boardman Lake (within City Limits) for evidence of erosion, illicit discharges, unstable banks along the shoreline, and other physical characteristics that could impact water quality. Establish a shoreline rating system and assign rating through the studied reach.
  - TWC staff conducted the shoreline erosion survey in Summer 2015. The inventory consisted of a visual inspection of the shoreline by kayak with staff looking for signs of current or potential sources of water quality pollution. Locations of potential pollution sources or spots of concern were noted by GPS, pictures were taken, and notes were taken about the site. Results were summarized in an Excel spreadsheet and divided into four categories: Erosion Spots, Lack of Riparian Buffer, Stormwater Outfalls, and Boat Launch Runoff.
  - A map was produced showing noted locations where pictures and notes were taken.
  - No major sources of concern were found, however there are several areas of minor erosion along the lake, mostly from foot traffic to access the lake and from steep banks. These are localized areas and aren't contributing large amounts of sediment to the lake. Additionally, a few places were noted where there is no riparian buffer along the lake and grass extends all the way to the water's edge. This could lead to excess nutrients entering the water (as evidenced by the excessive plant/algae growth) and waterfowl congregating (see accompanying pictures).
  - Seven locations were noted where pipes (ranging from small plastic to larger concrete) outet to the water. These were noted on the map as well.

# Stormwater Results for Total Suspended Solids, Total Phosphorus, Nitrate, and E.coli for Various Locations in the City of Traverse City

Location	date	TSS (mg/L)	TP (mg/L)	Nitrate (mg/L)	Ecoli (col/100mL)
	July 2009	51	0.14	0.56	>2419
8th Street #1 u/s OG separator	August 2009	17	0.09	ND	>2419
	Sept 2013	8	0.06		2,950
	October 2013	120	0.11		72,700
	July 2009	37	0.08	0.54	>2419
Bryant Park (drain #1)	August 2009	3	0.03	1.82	1,203
	December 2011	92	0.08	0.36	>2419
	March 2012	186	0.03	0.22	4,654
Bryant Park (drain #2)	December 2011	20	0.18	0.35	>2419
East Bay Park - #1 u/s OG separator	July 2009	23	0.07	0.29	>2419
	August 2009	7	0.05	0.29	>2419
	Summer 2013 (av.)	36.2	0.17		
East Bay Park - Front St. Influent	Summer 2014 (av.)	115.2	0.09		15,329
	Summer 2015 (av.)	52.2	0.214		46,413
	Summer 2013 (av.)	107.8	0.11		
East Bay Park - Shawnee Influent	Summer 2014 (av.)	41.1	0.08		40,729
	Summer 2015 (av.)	286.6	0.09		2,072

# Stormwater Management Plan

	Summer 2013 (av.)	243	0.14		
East Bay Park - Iroquois Influent	Summer 2014 (av.)	91.4	0.21		6,551
	Summer 2015 (av.)	646.2	0.08		1,073
Holiday Inn - #1 u/s OG separator	August 2009	5	ND	0.24	5
Hannah Park - #1 u/s OG separator	July 2009	65	0.07	0.55	1,986
	August 2009	53	0.12	0.29	1,733
West Fnd	July 2009	70	0.07	0.36	1,986
west Life	August 2009	22	ND	0.3	326
Average		96	0.10	0.47	13,314

# Historical (1990s) vs. Current (after 2009) Stormwater Test Results for Various Locations in Traverse City

# Location ID from Study

8th Street	Report*	Date	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	Ecoli col/100mL
Site #122	1	7/1/1991		0.596		
Site #122	1	7/22/1991		0.218		
Site #122	1	7/29/1991		0.0848		
Storm Sewer #9	2	4/16/1992	0.011	0.075	47	
Storm Sewer #9	2	6/5/1992	bdl	0.58	27	
Storm Sewer #9	2	7/10/1992	0.028	0.17	23	
Storm Sewer #9	2	8/18/1992	0.001	0.2	37	
Storm Sewer #9	2	9/18/1992	0.02	0.078	22	
Storm Sewer #9	2	11/2/1992	0.001	0.16	23	
E8S	3			0.56533		51,300
		AVERAGE:	0.01	0.27	30	51,300
8th Street - #1 u/s OG separator	6	July 2009	0.56	0.14	51	>2419
8th Street - #1 u/s OG separator	6	August 2009	ND	0.09	17	>2419
8th Street - #1 u/s OG separator	4	Sept 2013	0.06		8	2,950
8th Street - #1 u/s OG separator	4	October 2013		0.11	120	72,700
		AVERAGE:	0.56	0.1	49	37,825

Bryant Park	Report*	Date	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	Ecoli col/100mL
Storm Sewer #7	2	4/16/1992	0.012	0.085	74	
Storm Sewer #7	2	6/5/1992	0.48	0.27	34	
Storm Sewer #7	2	7/10/1992	0.024	0.19	60	
Storm Sewer #7	2	8/18/1992	0.037	0.27	21	
Storm Sewer #7	2	9/18/1992	0.014	0.061	15	
Storm Sewer #7	2	11/2/1992	0.003	0.16	53	
ВР	3	11/9/2000		0.372		15,300
		AVERAGE:	0.10	0.20	43	15,300
Bryant Park (drain #1)	6	July 2009	0.54	0.08	37	>2419
Bryant Park (drain #1)	6	August 2009	1.82	0.03	3	1,203
Bryant Park (drain #1)	4	December 2011	0.36	0.08	92	>2419
Bryant Park (drain #1)	4	March 2012	0.22	0.03	186	4,654
Bryant Park (drain #2)	4	December 2011	0.35	0.18	20	>2419
		AVERAGE:	0.66	0.08	68	2,929

2017 Stormwater Management Plan East Bay Park - north drain **Report\*** Date Nitrate (mg/L) TP (mg/L) TSS (mg/L) Ecoli col/100mL Storm Sewer #8 4/16/1992 0.046 26 2 0.005 Storm Sewer #8 6/5/1992 bdl 0.33 31 2 Storm Sewer #8 0.019 21 7/10/1992 0.14 2 Storm Sewer #8 8/18/1992 bdl 0.35 2 96 Storm Sewer #8 2 9/18/1992 0.014 0.067 14 Storm Sewer #8 0.011 2 11/2/1992 4 269 EBP 0.44 80,000 3 11/9/2000 Site #100 1.4 0.0323 1 2/5/1991 Site #100 7/1/1991 0.488 1 Site #100 7/22/1991 0.228 1 Site #100 0.0814 7/29/1991 1 **AVERAGE:** 0.29 0.56 76 80,000 East Bay Park - #1 u/s OG separator 6 July 2009 0.07 23 >2419 0.29 0.05 East Bay Park - #1 u/s OG separator August 2009 0.29 7 >2419 6 Summer 2013 East Bay Park - Front St. Influent 0.17 36.2 5 East Bay Park - Front St. Influent Summer 2014 0.09 115.2 15,329 5 46,413 East Bay Park - Front St. Influent 5 Summer 2015 0.214 52.2 30,871 **AVERAGE:** 0.29 0.12 47

Stormwater Management Plan

East Bay Park - south drain	Report*	Date	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	Ecoli col/100mL
Site #104	1	2/5/1991	4.5	0.0486		
Site #104	1	7/1/1991		0.456		
Site #104	1	7/22/1991		0.2016		
Site #104	1	7/29/1991		0.0848		
		AVERAGE:	4.5	0.20		
East Bay Park - Shawnee Influent	5	Summer 2013		0.11	107.8	
East Bay Park - Shawnee Influent	5	Summer 2014		0.08	41.1	40,729
East Bay Park - Shawnee Influent	5	Summer 2015		0.09	286.6	2,072
		AVERAGE:		0.09	145	21,400

Stormwater Management Plan

Hannah Park	Report*	Date	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	Ecoli col/100mL
Storm Sewer #3	2	4/16/1992	0.011	0.069	66	
Storm Sewer #3	2	6/5/1992	bdl	0.61	14	
Storm Sewer #3	2	7/10/1992	0.025	0.12	34	
Storm Sewer #3	2	8/18/1992	0.001	0.34	229	
Storm Sewer #3	2	9/18/1992	0.011	0.11	40	
Storm Sewer #3	2	11/2/1992	0.004	1.5	163	
		AVERAGE:	0.01	0.46	91	
Hannah Park - #1 u/s OG separator	6	July 2009	0.55	0.07	65	1,986
Hannah Park - #1 u/s OG separator	6	August 2009	0.29	0.12	53	1,733
		AVERAGE:	0.42	0.095	59	1,860

\*Data sources:

1. Shuey, J.A., C.A. Harris, and G.M. DeGraeve. 1992. Final Report for the Grand Traverse Bay Watershed Initiative: Part II, Water Quality of the Bay and Tributaries. Great Lakes Environmental Center, Traverse City, MI. (Note: The Grand Traverse Bay Watershed Initiative is now known as The Watershed Center Grand Traverse Bay.)

2. City of Traverse City Waste Water Treatment Plant and Operations Management International. 1992. Stormwater Sewer Study

3. Great Lakes Environmental Center (GLEC). 2001. Stormwater Source Identification, Sampling, and Analysis at Select Storm Drains and Tributaries to Grand Traverse Bay (Lake Michigan). Prepared for The Watershed Center Grand Traverse Bay as part of an DEQ, Coastal Zone Management Study. (Principal Contact at GLEC: Dennis McCauley)

4. TWC - GLRI Project at Bryant Park (2011/2012)

5. TWC - BMP effectiveness testing at GLRI East Bay Park project (2013-2015)

6. TWC Project with City of Traverse City funds (2009)

Site	Date	Ecoli (col/100mL)
8th Street		
8th Street	11/9/2000	51,330
8th Street - u/s separator	7/22/2009	>2419
8th Street - d/s separator	7/22/2009	>2419
8th Street - u/s separator	8/3/2009	>2419
8th Street - d/s separator	8/3/2009	>2419
8th Street Drain u/s separator	9/19/2013	2,950
8th Street Drain d/s separator	9/19/2013	15,530
8th Street Drain u/s separator	10/3/2013	72,700
8th Street Drain d/s separator	10/3/2013	38,700
8th Street Drain	7/3/2012	61,300
8th Street Drain	7/25/2012	21,430
8th Street Drain	8/16/2012	241,920
8th Street Drain	9/7/2012	198,630
Bryant Park		
Bryant Park	11/9/2000	15,300
Bryant Park	7/22/2009	>2419
Bryant Park	8/3/2009	1,203
Bryant Park (drain #1)	8/10/2010	35
Bryant Park (drain #1)	8/12/2010	210
Bryant Park (drain #1)	8/19/2010	>2419
Bryant Park (drain #1)	9/1/2010	>2419
Bryant Park (drain #1)	9/2/2010	>2419
Bryant Park (drain #1)	9/20/2010	387
Bryant Park (drain #1)	9/23/2010	899
Bryant Park (drain #1)	10/26/2010	>4838
Bryant Park (drain #1)	8/2/2011	9,208
Bryant Park (drain #1)	9/19/2011	3,448
Bryant Park (drain #1)	9/21/2011	10,460
Bryant Park (drain #1)	12/14/2011	>2419
Bryant Park (drain #1)	3/12/2012	4,654
Bryant Park (drain #2)	8/19/2010	>2419
Bryant Park (drain #2)	9/1/2010	>2419
Bryant Park (drain #2)	9/2/2010	1,046
Bryant Park (drain #2)	9/23/2010	3,921
Bryant Park (drain #2)	10/26/2010	>4838
Bryant Park (drain #2)	8/2/2011	19,863
Bryant Park (drain #2)	9/19/2011	17,329
Bryant Park (drain #2)	9/21/2011	5,040
Bryant Park (drain #2)	12/14/2011	>2419

# E.Coli Results for Various Stormdrains 2000-2015

		Ecoli, MPN
Site	Date	col/100mL
East Bay Park		
East Bay Drain North	8/2/2011	6,867
East Bay Drain North	9/19/2011	>24,192
East Bay Drain North	9/21/2011	32,550
East Bay Drain North	12/14/11	>2419
East Bay Drain North	3/12/12	445
East Bay Drain North	5/2/12	3,090
East Bay Drain North	7/3/2012	14,700
East Bay Drain North	7/25/2012	19,180
East Bay Drain North	8/16/2012	19,350
East Bay Drain North	9/7/2012	241,920
East Bay Park - #1 u/s	7/22/2009	>2419
East Bay Park - #1 u/s	8/3/2009	>2419
East Bay Park North	11/9/2000	80,000
East Bay Drain South	8/2/2011	17,329
East Bay Drain South	9/19/2011	24,192
East Bay Drain South	9/21/2011	6,500
East Bay Drain South	12/14/11	>2419
East Bay Drain South	3/12/12	160
East Bay Drain South	5/2/12	4,570
East Bay Drain South	7/3/2012	13,100
East Bay Park - #2 d/s	7/22/2009	>2419
East Bay Park - #2 d/s	8/3/2009	1,986
Hannah Park		
Hannah Park - #1 u/s separator	7/22/2009	1,986
Hannah Park - #2 d/s separator	7/22/2009	>2419
Hannah Park - #1 u/s separator	8/3/2009	1,733
Hannah Park - #2 d/s separator	8/3/2009	921
Holiday Inn		
Holiday Inn - #1 u/s separator	8/3/2009	5
Holiday Inn - #2 d/s separator	8/3/2009	26
Hope Street		
Hope Street	11/9/2000	487
Maple Street		
Maple Street	11/9/2000	2,700

		Ecoli, MPN
Site	Date	col/100mL
Sunset Drain	8/18/2015	3
Sunset Drain	8/19/2015	517
Sunset Drain	8/24/2015	100
Sunset Drain	9/3/2015	620
Sunset Park Drain	7/3/2012	130,000
Sunset Park Drain	7/25/2012	5,760
Sunset Park Drain	8/16/2012	111,990
Sunset Park Drain	9/7/2012	7,890
West End Beach/Park		
West End	7/22/2009	1,986
West End	8/3/2009	326
West End Drain	7/3/2012	1,200
West End Drain	7/25/2012	1,850
West End Drain	9/7/2012	19,180
West End Drain #2 (West)	9/7/2012	9,600
West End West Drain	7/3/2012	4,400
West End West Drain	7/25/2012	1,850
West End West Drain	8/16/2012	5,460
West End West Drain	9/7/2012	12,740

# 4.2 Impacted Designated uses in the Grand Traverse Bay Watershed

Add section on Kids Creek, bulk of info is in Boardman Prosperity Plan, update with most current work

#### **5.3 Priority Protection and Critical Areas**

NOTE: Not sure of final format for this section, will most likely be changed extensively with overall GTBWPP revision

- Critical Areas these will most likely be grouped into 'General' and 'Acute' areas
- In Boardman Prosperity Plan, the City of TC is Acute Critical Area #4 and Kids Creek Subwatershed was #5
  - Can drill down further and create more acute critical areas in TC, like downtown corridor, GTBay shoreline, ? Or, just leave it as is and put specific projects in the Implementation Task section...
  - #4: Traverse City and surrounding urban area, roughly defined by the land area encompassed by South Airport Road, Garfield Avenue, US31 North to Grand Traverse Bay (includes Traverse City and Garfield Township). This highly urbanized portion of the watershed in Traverse City contributes pollutants to the river and Grand Traverse Bay via stormwater runoff. While a number of stormwater reduction and filtration projects have been implemented, there is still a significant need to reduce the amount of oils, greases, litter, and other pollutants to the river in this portion of the watershed.
  - #5: Kids Creek subwatershed. As discussed in Chapter 4.3, Kids Creek is the only impaired waterbody on MDEQ's 303(d) list. Water quality in the creek is severely impacted by stormwater and sedimentation. TWC launched a large-scale Kids Creek Restoration Project a number of years ago that included stormwater reduction BMPs on tributaries A and AA of the creek, streambank stabilizations, and "daylighting" a portion of Tributary A (See Chapter 4.3 and Figure 14 for more detail). Restoration efforts must continue on Kids Creek to further aid in efforts for its removal from the impaired waters list



## 5.5 Master Planning and Zoning Ordinances

- Include general info and format used in Boardman Prosperity Plan as it pertains to focus areas of GTBWPP
- Add City of TC subsection

# **City of TC Subsection**

- Keep/utilize info in existing GTBWPP
- Add in additional from BPP
- Stormwater utility update (if any)
- Updated geothermal policy (if any)
- Updated stormwater ordinance (if any)
- TWC working with City on riparian vegetation ordinances to protect water quality (will start in 2017, update with larger GTBWPP)

## 5.6 Special Sources of Concern: Stormwater

# Keep general discussion

- include typical pollutant concentrations from SE Michigan study, Table 31 from original GTBWPP
- add pollutant loads from 1mi2 (640 acres) of different land uses using Region 5 spreadsheet tool (see table below)

Pollutant (lbs/yr)	Commercial	Industrial	Institutional	Transportation	Multi- Family	Residential	Agriculture	Vacant	Open Space
TSS (tons/yr)	337	354	377	646	377	88	44	29	17
TN	13,440	8,960	7,040	8,320	7,040	3,840	1,536	640	640
ТР	832	960	896	1,152	896	518	115	141	250
Lead	659	1,011	235	1,709	235	150	1	17	10
Copper	128	134	64	358	64	31	3	6	6
Zinc	1,024	832	365	2,048	365	576	44	64	51
Cadmium	5	16	2	13	2	1	0	0	0
BOD	54,400	32,000	33,280	32,000	33,280	14,080	1,920	1,280	640
COD	376,960	166,400	204,800	563,840	204,800	89,600	17,920	40,960	29,440

# Add section for City of TC

# Stormdrains in city

- incorporate any language in existing GTBWPP 1900 drainage structures and manholes, 54 miles of storm sewers open channels and culverts and more than 90 points of entry into area streams, rivers, lakes and the Grand Traverse Bay. (this is from 2003 Prezo copy and GTBWPP says 51 outfalls... which one is it?)
- Reference Stormwater Mngt Plan from SAW grant (discussed later)

#### **Compare monitoring results from Water Quality Section to stream, lake, and Bay values**

- Saginaw/GTBay Monitoring Report (1993-2004)
  - TP values greater than 10 ug/L (0.01 mg/L) indicative of impaired water quality and contributes to increased plant growth
  - Chlorophyll a values greater than 4ug/L indicate mesotrophic conditions, greater than 10 ug/L indicate eutrophic conditions
  - Saginaw Bay all stations at or above 0.01 mg/L TP; Nitrate higher than most inland lakes and Bays in MI; Chlorophyll a values all above 4ug/L, with some around 12ug/L

- GT Bay TP all below 0.01 mg/L which indicate oligotrophic and excellent water quality; same for nitrate and Chlorophyll a
- Saginaw Bay showing signs of water quality impairments and mesotrophic status GT Bay watershed doesn't want to get to that point Protection is KEY
- From Section 3.11 in original GTBWPP GTBay TP is 5ug/L (.005mg/L) TP values in storm drains range between 0.03 0.2 mg/L (average of 0.1 mg/L) which is an average of twenty times higher than water in GTBay
- DEQ communication with G.Goudy: TP Lake values should be around 10ug/L (.01 mg/L), stormdrains are ten times higher
- DEQ communication with G.Goudy: TP Stream values should be 10-20 ug/L (.01 .02 mg/L); Boardman River averages 0.012 mg/L (from Boardman Prosperity Plan); TP values are ten times higher than Boardman River
- **TAKE AWAY** While our concentration values of nutrients and sediments in stormwater runoff may be less than is seen in areas downstate, our water quality in the Grand Traverse Region is also of a much higher quality. Therefore we must do better to protect the Bay and streams/lakes in the watershed from degradation.

## **EColi and critters in stormdrains**

- EColi is a major problem in stormdrains in the City of TC as is seen by values from Table above. Many stormdrains outlet adjacent to public lands as well, with many of the public lands being designated beach areas.
- Reference later discussion on BMP projects with the City to reduce beach pathogens at East Bay and Bryant Parks
- Drains, especially on east side of TC, have large numbers of raccoons living in them. City has done camera work in drains and found multiple piles of raccoon droppings; and city workers cleaning out fire hydrants routinely see raccoon families coming in and out of catch basins.
- Other sources of EColi in stormdrains are from pet waste runoff, wildlife and waterfowl, and urban runoff

#### Summarize stormwater BMP efforts to date

TWC projects - will be summarized in larger table with all TWC completed BMP projects and pollutant savings elsewhere in plan, so we can reference that table as a whole. Notable projects include:

#### Kids Creek Restoration Project (to be discussed in-depth in a separate section in Chapter 4) -

Work on TWC's large-scale Kids Creek Restoration Project started in 2013 with the goal of reducing the impact of stormwater and sedimentation on Kids Creek and its tributaries so it could be removed from the State's 303(d) Impaired Waters List. Thus far, project work has focused on reducing stormwater inputs to Kids Creek from urban areas using green infrastructure and low impact development techniques. However, the next phase of the restoration project will also include work within the channel to restore habitat and provide floodplain storage during periods of high flow. To date, TWC has received more than \$4.2 million in MDEQ, EPA-GLRI, and private funding to implement key portions of the Kids Creek Action Plan as part of the Kids Creek Restoration Project. Much of this work has focused on installing green infrastructure and low impact development techniques in the vicinity of Tributaries A and AA of Kids Creek which includes a large hospital campus (Munson Medical Center), senior assisted living center (Grand Traverse Pavilions), and an historic preservation and adaptive reuse redevelopment called the Village at Grand Traverse Commons. The amount of stormwater generated in these urban areas are a

concern, as well as the amount of water being conveyed down both tributaries and the main branch of Kids Creek during rain events from upstream sources. A large amount of stormwater is generated by the vast areas of impervious surfaces (rooftops, parking lots, and roads), carrying high sediment loads as well as a variety of other pollutants normally found in stormwater (nutrients, oil/grease, litter). In addition, in-stream habitat has been negatively impacted due to excessive sand, silt, and impaired water flow. A summary of BMPs either completed or to be completed as part of the Kids Creek Restoration Project through previous grant funding follows:

#### Munson Medical Center

- Relocated 900 feet of underground culverts and channelized ditches of Kids Creek Tributary A to a natural meandering channel 1,275 feet in length and eliminated 72,000 ft<sup>2</sup> of impervious surfaces. Also restored natural sinuosity, meanders, riffles, and pools as well as established a native riparian buffer of 15-30 feet along the entire new section of creek and more than 27,000 ft<sup>2</sup> of vegetated floodplain. *(completed)*
- Installed green roof, underground infiltration trenches, and rain garden at the Cowell Family Cancer Center (*completed*)
- Installed 4 downspout planter boxes, converted parking lot to pervious pavers, and retrofitted existing detention basin to a rain garden at Building 29 on west side of parking garage (completed)
- Retrofitted ~3,100 ft<sup>2</sup> of roof on Munson Hospital Tower A to a green roof (completed)
- Installing bioretention basins and pervious pavement around the Munson Medical Center helipad parking lots (*to be completed 2017*)
- Installing tree box planters or rain gardens to reduce stormwater runoff from Medical Campus Drive (*to be completed 2017*).
- Excavating and enlarging the wetlands on the corner of Elmwood Avenue and Medical Campus Drive so more water can enter during storm events and be slowly released into Kids Creek (*to be completed 2017*)
- Installing LID techniques with new parking garage at main Munson parking lot (to be completed 2018)
- Restoring natural stream function and connecting Kids Creek Tributary A to floodplain along 6th/Elmwood Streets (*to be completed 2018*)

#### Grand Traverse Pavilions

- Restoring the natural floodplain and installing a buffer on Tributary AA between the Grand Traverse Pavilions and Grand Traverse Commons *(to be completed 2017)*
- Installing rain gardens to collect and filter rooftop, parking lot, and road runoff around Grand Traverse Pavilions (*to be completed 2017*)

#### Grand Traverse Commons

- Converting lined and rock-filled detention areas off of Cottageview Drive into functioning rain gardens (*to be completed 2017*)
- Reducing erosion and runoff issues by paving Yellow Drive and directing stormwater into a series of rain gardens (*to be completed 2017*)

#### <u>Other</u>

- Completed sediment basin reconstruction work at West Front Primary Care to prevent direct sediment input from parking lot runoff into Kids Creek Tributary A (*completed*)
- Installing a rain garden and bioswale to collect and infiltrate water from Elmwood Avenue and the parking area of the Traverse City State Office Building *(to be completed 2017)*
- Reducing sediment and stormwater runoff from industrial business near headwaters of Tributary A (to be completed 2017)

#### GLRI Bryant Park-

The goal of this project was to implement a stormwater infiltration system at one of two large storm drain outlets at Bryant Park to reduce bacterial contamination at the beach, with the ultimate goal of delisting the beach from the

State's Impaired Water's list. This project was paid for through a 2010 EPA Great Lakes Restoration Initiative (GLRI) grant awarded to the MDEQ and subawarded to TWC and was completed in June 2012. The chosen treatment system consists of the following components and was designed to treat the first flush of stormwater volume for 75% of the annual storm events:

- 1. <u>Diversion Weir</u> This component will divert up to the first 12 inches of flow in the 30 inch diameter pipe to the treatment system
- 2. <u>Oil Grit Separator</u> This component will separate soils and remove grit up to 125 microns
- 3. <u>Traverse City Treatment Box</u> This component will remove neutrally buoyant material (i.e. cigarettes) and fine sediment.
- <u>Chamber Infiltration System</u> This component will remove any fine sediment in the isolator row and provide for sand infiltration of the stormwater flow entering and draining to the ground via the chamber system.

#### GLRI East Bay Park -

This project implemented a three-step stormwater filtration system at East Bay Park to reduce bacterial contamination at the beach and was installed Spring 2013. It was paid for through a 2011 EPA-GLRI grant awarded to TWC, who worked collaboratively to achieve project goals with the City of Traverse City, who served as a subrecipient of grant funds for project implementation. As part of this project the City investigated and number of differenty types of stormwater treatment option to see which would work best with given conditions at the site. The plans consisted of utilizing an end of the pipe treatment cartridge filter system for stormwater coming from three stormdrains that outlet at the Park (two on north side, and another small one on south edge). The three drain lines have the following components and were designed to treat the first flush of stormwater volume for 75% of the annual storm events:

- 1. <u>Diversion weir</u> to allow for stormwater entry to filter system, and provide for overflow during heavy rain events
- 2. Oil/grit separator This component will separate soils and remove grit up to 125 microns
- 3. <u>Sediment Settling Tanks ('Traverse City Treatment Box')</u> This component will remove neutrally buoyant material (i.e. cigarettes) and fine sediment. It will also have a 1/4" x 1/4" stainless steel screen and chambers acting as sediment traps.
- 4. <u>Helix Cartridge Filtration System</u> These are manufactured, replaceable high flow cartridges effective at treating pathogens using treated foam filter media and increased contact time (through helix design). The cartridges also help remove sediment, hydrocarbons, and nutrients. We chose to use the Fabco Industries' Helix Filter (http://www.fabco-industries.com).
- 5. The drain lines were then combined to one outlet after treatment, which was located at the southern edge of the park, south of the bathing beach to prevent the outflow from stagnating in the beach's swimming area.

#### **Oil/Grit Separators -**

TWC has installed 7 oil/grit separators in the City of Traverse City using funding from numerous DEQ Nonpoint Source Unit grants. They were all installed in 2007. (Additional info from city re maintenance or how much 'stuff' removed?)

- Cass Street Outfall
- Union Street Outfall
- 8th Street
- East Bay Park
- Holiday Inn
- Hannah Park (2)

#### Pervious Pavement Demonstration - Parking Lot K -

TWC in conjunction with the City of TC installed 4 different types of pervious pavement systems in a heavily used parking lot near the Post Office downtown in 2007. Types of pervious pavement used were: porous asphalt, porous

concrete, paver stones, and Gravel Pave. This project was not as successful as initially hoped due to issues with incorrect installation of some of the types of pavement. Additionally, this project was done when the use of pervious pavement was not yet widely used and we believe technology has come a long way as it pertains to installation and maintenance with pervious pavement systems.

## Stormdrain BMPs city has done w/o TWC

City GIS Dept has list and map

#### **BMP effectiveness results -**

• **Oil-grit separators:** In Summer 2009 TWC, in conjunction with the City of TC tested four storm drains during two rain events where oil/grit separators had been installed in 2007 to see how well the BMPs were performing. While two grab samples at random times during the duration of a rain event is not a robust sampling program, the spot checks did indicate that the oil/grit separators were reducing Total Suspended Solids by some amount. Total Phosphorus amounts also seemed to be reduced comparing samples taken before and after the BMP system.

Location	Date	E.Coli col/100mL	TSS (mg/L)	TP (mg/L)	Nitrate (mg/L)
East Bay Park - #1 u/s	7/22/2009	>2419	23	0.07	0.29
East Bay Park - #2 d/s	7/22/2009	>2419	22	0.1	ND
East Bay Park - #1 u/s	8/3/2009	>2419	7	0.05	0.29
East Bay Park - #2 d/s	8/3/2009	1986	8	0.04	0.38
8th Street - #1 u/s	7/22/2009	>2419	51	0.14	0.56
8th Street - #2 d/s	7/22/2009	>2419	26	0.1	0.48
8th Street - #1 u/s	8/3/2009	>2419	17	0.09	ND
8th Street - #2 d/s	8/3/2009	>2419	14	0.06	ND
Holiday Inn - #1 u/s	8/3/2009	5	5	ND	0.24
Holiday Inn - #2 d/s	8/3/2009	26	4	ND	0.24
Hannah Park - #1 u/s	7/22/2009	1986	65	0.07	0.55
Hannah Park - #2 d/s	7/22/2009	>2419	59	ND	0.55
Hannah Park - #1 u/s	8/3/2009	1733	53	0.12	0.29
Hannah Park - #2 d/s	8/3/2009	921	27	0.08	0.32
ND = Non Detect	Limit of Dete	 ction: TP - 0.05 mg/L,	; Nitrate - 0.1 m	ng/L	

# 2009 BMP Effectiveness Tests for Oil/Grit Separators at 4 Locations in Traverse City

- **GLRI East Bay park:** In 2013, 2014, and 2015 TWC conducted testing stormdrains at East Bay Park to see how well the recently installed BMP system was working.
  - Three drains tested (Front Street, Shawnee, and Iroquois) for TSS, TP, and EColi
  - Testing program was not robust and shouldn't be considered statistically significant. Autosamplers were installed to get first flush at beginning of rain event, even if it was during the night. Even with autosamplers it was difficult to capture rain events that were within the right timeframe for holding sample time and when the water quality analysis lab was open (i.e. many rain events happened early evening and on weekends and could not be used b/c holding times would have been exceeded).
  - Overall the system did reduce all parameters tested, although not consistently all the time. It appeared that, during heavy rain events, the system was overwhelmed and

pollutant reductions were not observed. It was most effective on reducing TSS, but reduction in TP and EColi were observed as well.

- Managerial BMPs instituted
  - Street sweeping and catch basin cleaning:
    - Current catch basins cleaned once per year 1,200 basins 126 tons a year (wet weight)
    - Storm filters cleaned twice a year 15 to 20 cubic yards of debris each year (includes filters, oil/grit separator chambers, and sediment settling boxes)
    - Street sweeping
    - Schedule varies: all curb and gutter streets once/week; all city streets, alleys, and parking lots once/year in spring; non curb and gutter streets once /year in spring for winter sand cleanup; additional sweepings may occur on as-needed basis
    - 870 tons of sand/debris swept up each year
  - 1980 Historical Report compared \_\_\_\_\_ and targeted outreach to streets with no BMPs or education
    - 1974 GTBay study by MiSeaGrant, 3 drains: Spruce, Bryant North, East Bay... study developed pollution baseline
    - 1980 Study used those same sites for baseline to compare two stormwater BMP approaches: Spruce = control; Bryant North = aggressive education; East Bay = increased street sweeping and catch basin cleaning (sweep every 3-5 days)
    - in general there was a 67% less unit load for suspended solids where streets were swept ad catchbasins cleaned, and a 40% reduction of unit load where citizen education was implemented compared to the control basin
    - Shows importance of the impact of the simple practice of catch basin cleaning and street sweeping, in addition to public education.
    - Northwest Michigan Regional Planning and Development Commission. 1980. Stormwater Management: An Experiment & Demonstration in Traverse City, Michigan. December 1980. Prepared by: Environmental Research Group, Inc., Ann Arbor, MI.

# Summary of SAW grant

- The City of Traverse City received an MDEQ Stormwater, Asset Management, and Wastewater (SAW) grant to identify stormwater issues within the city limits, including hydrologic analyses for specific areas, including the impaired portion of Kids Creek that runs through the west side of Traverse City. The SAW grant also outlined BMPs to reduce stormwater impacts from the city's drains to surrounding waters.
  - o what did it do
  - recommendations
  - o timeline
  - o stormwater utility??

#### **Rural Stormwater**

- Issues
- Monitoring results? Suttons Bay, Northport, Elk Rapids?
- Stormwater Action Plans
- BMP efforts and projects

## 7.2 Best Management Practices

- Add section on Low Impact Development.... take wording from Boardman Prosperity Plan
- Somewhere in this chapter discuss all BMP efforts to date for entire watershed, maybe after the general BMP section
- Break out section for just City of TC BMPs, include any BMP effectiveness monitoring... City's SMP plan will have summary of all City BMPs and map

## 7.3 List of Implementation Tasks By Category

- Revise/add city of TC tasks as relevant
- Revise milestones for city as relevant
- •

NOTE: Not sure of final format for this section so looks may change, will most likely look like BPP format

# \*Tasks from Prosperity Plan are on following pages.... TC stormwater ones highlighted

Categories (from BPP):

- 1. Shoreline Stabilization and Protection
- 2. Stormwater
- 3. Transportation/Stream Crossings (i.e. roads, railroads, etc.)
- 4. Planning, Zoning, and Land Use
- 5. Land Protection and Management
- 6. Habitat, Fish, and Wildlife
- 7. Human Health Strategies
- 8. Hydrology and Groundwater
- 9. Water Quality Monitoring
- 10. Wetland
- 11. Invasive Species
- 12. Agriculture
- 13. Wastewater and Septics

# **Stormwater Category ADD:**

- Whenever a road is rebuilt and soil types allow, install drywell with TC Stormdrain cover and microbial skirt or other water quality treatment system
  - \$1,200/ea;
  - 1 street/year; West Front by 2018
- More frequent street sweeping
- Increased catch basin cleaning
  - fall and spring cleanup
- Monitor more frequently and maintain existing BMPs already installed
- Hire regional stormwater outreach coordinator

# Human Health Category ADD:

• Reduce pathogen input from stormdrains at area beaches by installing appropriate BMPs, including LID-based and end-of-pipe treatment filters.

# **Monitoring Category ADD:**

- More thorough stormwater monitoring including composite sampling to determine pollutant loads during rain events
- Monitor chloride levels in stormwater outfalls and streams from winter road salt practices

# TABLE 36. Watershed-wide Actions and Related Goals/Objectives

	Watershed Wide Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023	Y8: 2024	Y9: 2025	
Shoreline St	abilization and Protection Strategies															
WW.SS.1	Update GTCD's streambank erosion and road stream crossing inventory every five years to reflect newly identified road stream crossings and streambank erosion sites and restoration progress. Update the online River Restoration in Northern Michigan database accordingly ( <u>http://www.northernmichiganstreams.org/boardmansbe.asp</u> ). (CRA, N.d.)	1.1; 1.3	High	By 2018	\$25,000	GTCD TWC GTB CRA										
WW.SS.2	Work with public and private landowners to stabilize and restore eroding streambank sites at priority sites with biotechnical and soft engineering techniques.	1.1; 1.3	High	Complete 200 linear feet (LF) of restoration/ stabilization by 2020; 500 LF by year 2025	\$100/LF; Total \$50,000	GTCD TWC CRA										
WW.SS.3	Post dam removal - Monitor and restore resulting eroding streambanks.	1.1; 1.3	High	Restore a minimum of 100 LF per year	\$10,000/yr	GTCD GTB CRA										
WW.SS.4	Inventory riparian corridors on private property to identify a list of priority riparian buffer installation or restoration sites.	1.1; 1.3; 5.2	Low		Total = \$30,600	TWC GTCD										
WW.SS.5	Post dam removal - re-establish riparian zone vegetation along new stream channel to provide bank stability, shading, and other riparian zone benefits as soon as possible.	1.1; 1.3	High	Plant a minimum of 5,000 native trees and shrubs per year	\$16,000/yr	GTCD GTB TWC										
WW.SS.6	Install vegetated riparian buffers on private property in identified priority areas, with particular emphasis on tree preservation (where trees exist) or tree planting (where no or insufficient tree canopy exists).	1.1; 1.3; 5.2	Low	Install at least 1 riparian buffer on private land each year	Total costs TBD depending on sites. Average cost/acre ranges from \$220 to \$730	TWC GTCD										
WW.SS.7	Work with public landowners to install vegetated riparian buffers in priority areas, with particular emphasis on tree preservation (where trees exist) or tree planting ( where no or insufficient tree canopy exists ).	<mark>1.1; 1.3;</mark> 5.2	Medium	Install at least 1 riparian buffer each year	Total costs TBD depending on sites. Average cost/acre ranges from \$220 to \$730	TWC GTCD										
WW.SS.8	Install barriers, signage, or stairs where needed to manage human access to stream and lakeside banks at risk of erosion (steep slopes, sandy soils) from recreational foot traffic	1.3; 4.1; 4.2	Low		<\$10,00 year; S/V = \$1,400 year Total = \$4,200	GTCD GTB MDNR										

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Y10

Stormwater	Strategies															
WW.St.1	Work with local governments, area businesses, and property owners to install the following stormwater BMPs in urban areas where appropriate. Vegetative Filter Strips: Filter Strips/Aquatic Buffers, Wet Swales, Dry Swales, Grass Channels Stormwater Filtering Systems: Bioretention and Surface, Perimeter, Organic, Underground, Pocket Sand Filters Infiltration Practices: Infiltration Trench or Basin, Porous Pavement Retention and Detention Ponds Other Low Impact Design Elements: Rain/Roof Gardens, Native Plantings, Riparian Buffers	<mark>1.1; 1.3</mark>	High	Complete one LID project each year	Implementation costs vary Estimate ~\$200K/yr Total - \$2million	TWC										
WW.St.2	Upgrade or update applicable ordinances for local governments to accommodate and encourage more innovative forms of stormwater management See Planning, Zoning, and Land Use	-														
	Watershed Wide Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023	Y8: 2024	Y9: 2025	
Transportat	tion/Stream Crossings Strategies															
WW.TSX.1	Update Grand Traverse Conservation District's (GTCD) Boardman River Watershed Report every five years to reflect newly identified road stream crossings and streambank erosion sites and restoration progress. Update the online River Restoration in Northern Michigan database accordingly (http://www.northernmichiganstreams.org/boardmansbe.asp). See Shoreline Stabilization and Protection															
WW.TSX.2	Where priority transportation stream crossings have been identified, improve, repair, or replace outdated, failing, or eroding crossings by implementing the appropriate BMPs from the following; Crossings: Remove obstructions that restrict flow through the culvert; Replace undersized (too small or too short) culverts; Remove and replace perched or misaligned culverts to avoid erosion and provide for fish passage; Install bottomless culverts and bridges where possible; Replace culverts with a culvert that is $2x$ the bankfull width and a length that allows for $\geq$ 3:1 slope on embankments; Revegetate all disturbed or bare soils on embankments Approaches: Create diversion outlets and spillways to direct road runoff and stormwater away streams; Pave steep, sandy approaches where feasible; Dig or maintain ditches where needed and construct check dams if required Maintenance: Encourage Road Commissions and railroad officials to look at the long-term savings of crossing improvements over cumulative maintenance costs Construction and Closure: Minimize the number of access roads needed for oil, timber and gas exploration; When constructing new roads, avoid streams if possible and maintain natural channels to greatest extent possible; Close	1.1, 1.3	High	Complete upgrade of at least one priority transportation crossings per year.	Depends on size of crossing. \$75,000– \$100,000 per crossing; Total over 10 years = \$750,000 to \$11M	GTCD TWC CRA										

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	private roads and trails that are no longer needed. Remove culvert and restore stream channel.	o longer needed. Remove el.														
Planning, Zo	oning, and Land Use Strategies															
WW.PZL.1	Assist townships with drafting and updating zoning and master plans to protect water quality and natural resources. Examples of topics include: sufficient building setbacks from bodies of water, minimizing development clearings by landowners, minimizing vegetation removal and mowing to the water's edge, stormwater management, reducing impervious surfaces near water bodies, establishing riparian buffers along waterways, eliminating the dumping of grass clippings and other yard/solid wastes into the water, prohibiting the feeding of waterfowl near water bodies, and protecting wetlands.	1.1, 1.2, 1.5	High	Ongoing	<mark>S = \$5,000/yr</mark>	TWC LGOV										
WW.PZL.2	Encourage local governments to establish policies and undertake projects that prioritize the protection of water quality on public land, including streets, roads, parking lots, and park land. This includes implementing green infrastructure into the planning and design phases of capital projects related to publically-owned infrastructure, such as street maintenance, building renovations, parking lot surfacing, and landscaping.		High	Ongoing	<mark>S = \$5,000/yr</mark>	TWC LGOV										
WW.PZL.3	Upgrade or update applicable ordinances for local governments in the watershed to accommodate and encourage more innovative forms of stormwater management, including LID.	<mark>1.1</mark>	High	TC - by 2019 Garf Twp - by 2021	<mark>S = \$10,000/yr</mark>	TWC LGOV										
WW.PZL.4	Integrate LID standards and other innovative techniques into sedimentation control ordinances throughout the watershed.	<mark>1.1</mark>	<mark>High</mark>	Ongoing	<mark>S = \$5,000/yr</mark>	TWC LGOV										
WW.PZL.5	Ensure that zoning ordinances in all watershed communities include provisions to identify and protect scenic vistas, agricultural lands, and historic or cultural sites.	2.3; 3.4; 5.1	Low	Ongoing	S = \$2,800	LGOV GTCD GTRLC										
WW.PZL.6	Any future road capacity or upgrade analyses associated with new housing or economic development projects should be consistent with the approach in the Grand Vision, include an analysis of the Boardman River water quality and habitat implications, and support the Prosperity Plan's emphasis on clustering housing and jobs to limit the need for larger roads.	1.1; 1.2; 1.3; 3.2	Low		No cost	TWC GTCD LGOV										
WW.PZL.7	Develop a Boardman River Recreation Plan that addresses and guides all current and future recreational uses of the river, including points of access and establishes a "carrying capacity" for each use as to protect and enhance the important resource values.	1.1; 1.2	High	Complete Plan by 2017	\$50,000	GTCD MDNR GTB										
	Watershed Wide Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023	Y8: 2024	Y9: 2025	
Land Protec	tion and Management Strategies															
WW.LPM.1	WW.LPM.1   Work with local units of government to develop and promote local initiatives that preserve open space and sensitive/important natural areas.   1.2; 4.2; 5.1; 5.2   Medium		5.1; Medium				s	= 2,5	00/yr	C T L	GTRLC WC GOV					

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					S/V time = \$1,750- \$2,450/year;											
WW.LPM.2	Identify priority private lands for conservation and work to acquire conservation easements or other permanent protection of these priority parcels.	1.2; 4.2; 5.1; 5.2	High	Acquire five priority easements by 2023	Total = \$17,500 to \$24,500.	GTRLC										
					Acquisition costs TBD											
Habitat, Fish, a	nd Wildlife Strategies															
WW.HFW.1	Collect information that exists, and conduct stream inventories where needed, to evaluate appropriate sites for in-stream habitat improvement projects. Criteria to be assessed includes: woody debris, bank stability, floodplain connectivity, riparian vegetation, in-stream cover, flow dynamics, and fish population structure	1.1, 1.2	High	Complete by 2021	\$35,000	GTCD TWC CRA MDNR GTB										
WW.HFW.2	Install in-stream habitat improvements where appropriate, according to the inventory above.	1.1, 1.2	Medium	After inventory, one site/year	\$50,000/year (after inventory) Total= \$200K	GTCD TWC CRA MDNR										
WW.HFW.3	Continue to implement the Conservation Resource Alliance's Wild-Link program to protect and enhance fish and wildlife habitat on private property within ecological corridors throughout the watershed.	1.2; 1.4; 1.5; 5,1; 5.2	Low	Work with at least four or five landowners each year	~\$20,000 per year, plus S/V = \$1,400/year, Total = \$214,000	CRA										
Human Health	Strategies															
					\$10,000-\$15,000											
WW.HH.1	Conduct post-rain-event <i>E. coli</i> monitoring on inland lakes and Boardman River every two years in areas identified as potentially threatened by storm–water inputs of pathogens.	<mark>1.1</mark>	Low	Sample sites/ 2 yrs	Total = \$50,000 \$75,000	TWC										
Hydrology and	Groundwater Strategies															
WW.HG.1	Work with owners and operators of dams and lake-control structures to ensure these structures are operated so that they mimic natural flow conditions of the river. Where possible, seek permission for removal.	1.1, 1.2, 1.3	Medium	Contact two property owners annually	S=\$2,500/yr	GTCD TWC LGOV										
WW.HG.2	Remove inoperative, failing, or economically unfeasible dams as well as priority dams that are blocking fish passage. Utilize 2015 small dam inventory as resource.	1.1, 1.2, 1.3,	High	(See above) Contact two property owners annually	Cost vary depending on size of dam	GTCD TWC CRA GTB LGOV MDNR MDEQ BDIT										
WW.HG.3	Eliminate improperly or uncapped abandoned wells to prevent contaminants from moving into and among groundwater aquifers via this route. Tasks will be to 1) inventory existing abandoned wells through surveys, well logs, and landowner interviews and 2) properly plug the abandoned wells.	1.1	Low	Contact all property owners that have known improperly or uncapped abandoned wells	\$25,000 (well inventory only) \$250K/county/yr (plugging wells)	MSUE HDept, MDEQ										
	Watershed Wide Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023	Y8: 2024	Y9: 2025	Y10: 2026

Water Quality N	Ionitoring Strategies					
WW.WQ.1	Develop and implement a Comprehensive Water Quality Monitoring (CWQM) program to regularly monitor standard water quality parameters every three years (e.g., phosphorus, nitrogen, temperature, suspended solids, fecal bacteria), as well as fish and benthic communities. At a minimum, monitoring must include sites in identified Priority and Critical Areas to ensure pollutant concentrations remain the same or decrease <i>Details in Chapter 11.2 Water Quality Monitoring Plan</i>	1.1	High	Ongoing	\$50,000/year	MDEQ TWC BDIT GTCD
WW.WQ.2	Continue TWC's Adopt A Stream program that monitors macroinvertebrates and covers the Boardman River Watershed and expand to include additional streams.	1.1, 1.2	High	Yearly	\$10,000/year	TWC LA Schools
WW.WQ.3	Continue MDEQ collection and identification of macroinvertebrates from randomly selected stations on a 5-year rotating schedule, consistent with present sampling program.	1.1, 1.2	High	2018 2023	No Cost	MDEQ
WW.WQ.4	Support the MDNR and the GT Band in their efforts to determine fish population estimates and trends throughout the watershed	1.1, 1.2	Medium	Ongoing/Yearly	\$5,000/year	MDNR GTB
WW.WQ.5	Synthesize raw temperature data collected by GTCD since 2013	1.1	High	By 2018	Intern or College Grad: \$5,000	GTCD
WW.WQ.6	Update appropriate online databases as new water quality information becomes available (eg: TWC, MiCorps, northernmistreams.org, BeachGuard)	1.1	Low	Update as needed	S=\$1,000/yr	TWC GTCD   GTCD GTCD   CRA GTB
WW.WQ.7	Undertake further evaluation and monitoring of nutrient, bacterial and toxic pollution sites identified in the Boardman Lake Watershed Management Plan.	1.1	Medium	Study complete by 2025	\$50,000	TWC   TC   GarfTwp   GTB
WW.WQ.8	Conduct clean-up event(s) on Boardman Lake and downstream in Boardman River to remove tires, drums, various scrap metal, wooden pallets, bricks, ceramics and other debris.	1.1, 1.2	Low	ongoing	\$2,000/clean-up	GTCD TWC,
WW.WQ.9	Seek grant funding for research on (1) the impacts of climate change on Boardman River water quality; (2) ecosystem recovery following Boardman Dams removal; and (3) the impact of oil and gas extraction on Boardman River watershed natural resources.	1.1; 1.2	Low		S/V = \$2,100/year; Total = \$21,000	TWC GTCD
WW.WQ.10	**Invasive Species monitoring tasks are located in the Invasive Species Category	1.4				
Wetland Strate	gies					
WW.W.1	Protect and restore existing wetlands through the use of setback buffers, enforcement of wetlands regulations, and removal/management of invasive species.	1.2; 1.4	Low	ongoing	S=\$5,250 year; Total = \$52,500	GTCD TWC LGOV
# **TABLE 41.** Zone 5 Actions and Related Goals/Objectives (Encompassing Critical Areas #4, #5, and #6)

	Zone 5 Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023 Y8: 2024	Y9: 2025	Y10: 2026
Shoreline Stabi	lization and Protection Strategies									·			·		
Z5.SS.1	Stabilize severe and moderate streambanks along Kids Creek noted in the Kids Creek Action Plan. See Zone 4 Tasks	<mark>1.1, 1.2</mark>	High	30 sites by 2018	Included in Zone 4 Task										
<mark>Z5.SS.2</mark>	Work with residents and municipalities in the Kids Creek subwatershed to install riparian buffers where possible.	<mark>1.1</mark>	Medium		\$75/LF										
<mark>Z5.88.3</mark>	Work with the DEQ to develop and implement plans to stabilize sections of Kids Creek stream channel where needed to restore natural function, eliminate erosion, and transport storm events effectively. This will most likely entail the creation of sections of two-stage ditches along the creek to match the pattern dimension and profile to that of other sections of the creek so it can reduce flow velocities on the banks and store more water during times of high flow.	1.1, 1.2	High	Site 1 - by 2019 Site 2 - by 2023	Site 1 - \$250,000 Site 2 - \$500,000										
	Site #1: Tributary A along 6th street and Elmwood Ave Site #2: Kids Creek main branch u/s of Silver Lake Road														
Z5.SS.4	Monitor streambanks upstream of Union Street Dam to determine if they are slumping and how severe the problem may be. If necessary, work with the City of Traverse City and other stakeholders to determine a solution.	1.1, 1.2	Medium	Set up monitoring benchmarks by 2017	TBD (depends on BMP chosen)										
Z5.SS.5	Work with the City of Traverse City and the Downtown Development Authority to stabilize river access sites from Boardman Lake to the Mouth.	1.1, 1.2	Medium		TBD (depends on BMP chosen by City)										
Stormwater Stra	Stormwater Strategies														
Z5.St.1	Complete monitoring and assessments in the Kids Creek subwatershed to determine potential priority locations for LID BMP installations to reduce stormwater inputs to creek.	<mark>1.1</mark>	High	Complete by 2020	<mark>\$40,000</mark>	TWC MDEQ									
Z5.St.2	Implement stormwater BMPs in Kid's Creek including low impact design elements, riparian buffers and filter strips, and stormwater filtering and retention systems.	1.1; 1.2	High	One large-scale BMP/yr	~\$200,000/project \$2,000,000 total	TWC MDEQ EPA LGOV									
Z5.St.3	Implement stormwater BMPs in the urban areas of Traverse City and Garfield Township to reduce runoff impacts to Boardman River and Lake.	<mark>1.1</mark>	Medium	1st project by 2019 2nd project by 2022 3rd project by 2025	\$200,000/project \$600,000 total	TWC LGOV DEQ									
Transportation/	Stream Crossings Strategies														
Z5.TSX.1	Install road crossing BMPs at priority locations in the Kids Creek subwatershed. See general road crossing task for details	1.1, 1.4	Medium	1st crossing by 2019 2nd crossing by 2022 3rd crossing by 2025	~\$200,000/crossing (Depends on site & Selected BMP) ~ \$600,000 total	TWC GTCD TC LGOV NRCS RC									
Z5.TSX.2	Replace the South Airport Road crossing if deemed necessary by monitoring accumulated sediments See Monitoring task in Zone 4 related to Sabin Dam removal	1.1, 1.4	Medium	Depends on monitoring results	~\$4 million	GTCD RC									
Planning, Zoning, and Lane Use Strategies															

Z5.PZL.1	Continue discussions and work with the City of Traverse City to determine whether storm water may be addressed through alternative funding structures, such as a fee system or public utility, to improve water quality in priority areas and incentivize LID projects.	<mark>1.1</mark>	High		High		<mark>S = \$5,600</mark>	TWC TC										
	Zone 5 Actions	Goals/ Objectives Addressed	Priority	Milestones	Estimated Costs	Potential Partners	Y1: 2017	Y2: 2018	Y3: 2019	Y4: 2020	Y5: 2021	Y6: 2022	Y7: 2023	Y8: 2024	Y9: 2025	Y10: 2020		
Z5.PZL.2	Upgrade or update applicable ordinances for Traverse City and Garfield Township to accommodate and encourage more innovative forms of stormwater management, including LID.	<mark>1.1, 1.2, 1.4</mark>	High	Ongoing	S = \$3,000/yr \$30,000 total	TWC TC Garf.Twp												
Z5.PZL.3	Work with Traverse City on recommendations to update ordinances to improve preservation of urban vegetation resources to manage stormwater, particularly along shorelines, and ensure adequate water setbacks for all districts	<mark>1.1, 1.2, 1.4</mark>	<mark>High</mark>	Recommendations made by 2019	<mark>S = \$30,000</mark>	TWC TC												
Habitat, Fish, and Wildlife Strategies																		
Z5.HFW.1	Hire a professional consultant or firm to lead stakeholders through a neutral process that results in a recommendation to the MDNR and GTB regarding the passage of non-native Great Lakes fish in the Boardman River above Union Street Dam.	1.2, 1.4	High	By 2017	\$25,000	BDIT												
Human Health S	Strategies																	
Z5.HH.1	Conduct E.Coli monitoring on Kids Creek in Traverse City urban areas.	<mark>1.1</mark>	Low	Monitoring every 5 years	\$2,000	TWC GTHDept TC												
Hydrology and	Groundwater Strategies																	
Z5.HG.1	Implement cleanup or remediation efforts in the Boardman Lake area to improve water quality following recommendations made in WQ Monitoring task below.	1.1	Low	Funding secured and project initiated by 2024	TBD	TWC TC GarfTwp MDEQ EPA												
Water Quality Monitoring Strategies																		
Z5.WQ.1	Conduct monitoring to evaluate current status of areas in southern Boardman Lake and downstream of Boardman Lake outlet previously identified in the Boardman Lake WS Plan as contaminated.	<mark>1.1</mark>	Low	Monitoring by 2021 Remediation started by 2023	Monitoring: \$25,000 Remediation: TBD	TWC TC MDEQ EPA												
Z5.WQ.2	Seek long-term funding for the installation and support of a USGS gauging station below Union Street Dam	1.1	High	Installed by 2017	\$25,000	TC GTB USGS												
Invasive Specie	s Strategies																	
Z5.IS.1	Design and implement Union Street Dam modifications to limit passage of sea lamprey upstream.	1.4	Low	By 2025	>\$2million	BDIT												

#### **Chapter in GTBWPP**

# 7.4 Information and Education Strategy

- Already a lot of general tasks in GTBWPP re stormwater
- Any specific for TC (i.e. general education, stormwater utility)

### **Chapter in GTBWPP**

#### 7.5 Evaluation Procedures

- Add Monitoring Section related to evaluation... think about monitoring needs for TC stormwater and Kids creek
- Discuss Monitoring category tasks from Chapter 7