February 8, 2021

Attention: Kelly M. Walsh, P. Eng.
Director, Infrastructure Services
The Corporation of the Town of Fort Erie
1 Municipal Centre Drive, Fort Erie, ON
L2A 2S6
KWalsh@forterie.ca

Dear Mr. Walsh:

Please find enclosed with this letter our report titled, Shirley Rd Drainage Study. We're pleased to have been of service to the Town of Fort Erie and appreciate the opportunity to work on this assignment.

The report identifies the problem for Shirley Road area as seiche influenced flooding, that is flooding from Lake Erie water surface being pushed up by meteorological conditions so that the existing Six Mile Creek effectively runs backwards. Our report identifies two such occasions within the past two years when this occurred, and the Town's surveyor determined the flood elevations. This type of flooding is different from the flooding that occurs during a riverine runoff event, which was modelled by the NPCA report in 2008.

The report includes a long list of possible options for solving the identified drainage but we selected a short-list of four preferred options that were analyzed for each option's suitability along three basic attributes:

- Effective; the degree to which the option solves the flooding problem.
- Approved; the degree of challenge or difficulty with each option's jurisdictional approval requirements.
- Construction; the option's constructability or degree of difficulty for construction.

In addition to these option attributes, we considered the capital cost of construction (CAPEX) along with the forecasted operational costs (OPEX) and a simplified Total Cost of Ownership (TCO).

From this analysis, two of the options are suitable for implementation; however, there are a number of factors that are excluded from our report. A cost vs benefit analysis could be considered, and we did not discuss any funding options. If this project were to be implemented under various programs, the costs would be assessed to the upstream landowners and that would require that a majority of the landowners be in favour of the project.

There are actions that the Town of Fort Erie could implement to reduce but not eliminate the impact or risk of flooding in the Shirley Road area, but the two most recent severe events, (2019 & 2020) present a significant challenge to prevent completely.

Yours truly,

Paul C. Marsh, P.Eng.
Principal Engineer, EWA Engineering Inc.

Town of Fort Erie

Shirley Road Drainage Study



February 5, 2021

Project No: 209997

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Revision and Version Tracking

Title: Shirley Rd Drainage Study
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Paul C. Marsh, P.Eng.
EWA Engineering Inc.
Principal Engineer

Notice:
This report is based on information and data that was available for review as provided. The analysis undertaken is for the purpose stated in the report and is not for use elsewhere.

Table of Contents

Executive Summary

1 Introduction 1

2 Background 2

2.1 Study Area 2
2.2 Previous Reports and Studies 3
2.2.1 Niagara Soils 5
2.3 Historical Storms and Seiche Events 6
2.3.1 October 31, 2019 Storm 7
2.3.2 November 15, 2020 Storm 7
2.4 Reference Literature 9

3 Study Approach 11

3.1 Project Objective 11
3.2 Methodology 11

4 Analysis 13

4.1 Topographic Catchment Analysis 13
4.2 Hydrologic Analysis 15
4.2.1 Port Colborne IDF curve data 15
4.3 Hydraulic Analysis 17
4.4 Existing Infrastructure Plan & Profile 19
4.4.1 Outlet #1: Storm Sewer 20
4.4.2 Outlet #2: Open Swale outlet 21

5 Drainage Options 22

5.1 Long List of Opportunities 22
5.2 Selection Criteria 25
5.3 Preferred Options 25
5.3.1 Option 1: Construct a levee and install flap gates. 26
5.3.2 Option 2: Berm, flap gate and a stormwater pump system 28
5.3.3 Option 3: Slide gates on SMC downstream side of Thunder Bay Road. 30
5.3.4 Option 4: Retreat from flooding using property purchase. 32
5.4 Option Comparison 33
5.5 Agency Consultation 35
5.5.1 Niagara Peninsula Conservation Authority (NPCA) 35
5.5.2 Ministry of the Environment, Conservation and Parks 35
5.5.3 Department of Fisheries and Oceans (DFO) 36
5.5.4 OMAFRA Drainage Act 37
5.6 Preferred Option Evaluation 38

6 Observations: 40

Appendix A: Maps and Drawings

Appendix B: Hydrologic and Hydraulic Model Data

Appendix C: NPCA info

Appendix D: Calculations

Figures

Figure 1 2002 Orthophoto site view 1
Figure 2 Project Extents 2
Figure 3: Shirley Rd. Drainage Area 3
Figure 4 Niagara Soils 5
Figure 5: Historical Flood Record Oct 31, 2019 7
Figure 6 Nov 15, 2020 Storm Highwater Mark 8
Figure 7 DFO Great Lakes Water Level at Port Colborne 8
Figure 8 Existing Stormwater Infrastructure 13
Figure 9 Surface Drainage Catchment Areas 14
Figure 10 Pipe Drainage Catchment Areas (pink shading) 14
Figure 11 MTO Port Colborne IDF chart 15
Figure 12 SCS Curve Number Reference Table 16
Figure 13 Open Channel Flow Profile 1:5 year storm 69.6mm 17
Figure 14 Pipe Flows Profile 1:5 year storm 69.6mm 17
Figure 15 HY-8 Analysis of North Culvert 18
Figure 16 Hydraulic Profile Illustration 19
Figure 17 Storm sewer As Built Drawing 1997 21
Figure 18 Plan and Profile Views of Option #1 - Berm 26
Figure 19 Option 2: Pumping System with Flap gate and berm 28
Figure 20 Option 3 Backflow structure on SMC at Thunder Bay Rd. 30
Figure 21 Retreat Potential Impact Zone 32
Figure 22 DFO Drain Classification for works affecting fish or habitat 37

Tables

Table 1 Hydrologic 1:5 year predicted flows, cms 16
Table 2 HY-8 Culvert Analysis - Surface Flows 19
Table 3 Option #1: Berm Qualitative Analysis 27
Table 4 Option #2: Pump Station and Berm Qualitative Analysis 28
Table 5 Option #3: SMC Backflow at Thunder Bay Rd Qualitative Analysis 31
Table 6 Option #4: Retreat by removing flood impacted homes Qualitative Analysis 32
Table 7 Option Analysis Summary Table 33
Table 8 Option Solution Effectiveness Score 38
Table 9 Option Evaluation 39

Introduction

The study will identify drainage solutions to prevent flooding from high lake levels and seiche driven inundation of the lands around 127 Shirley Rd. The intent is to identify four possible options to address the current site flooding that is occurring.

Analysis

The site features two stormwater conveyance systems; a local surface water open channel system and a piped stormwater system that brings upland runoff for discharge through a submerged outlet.

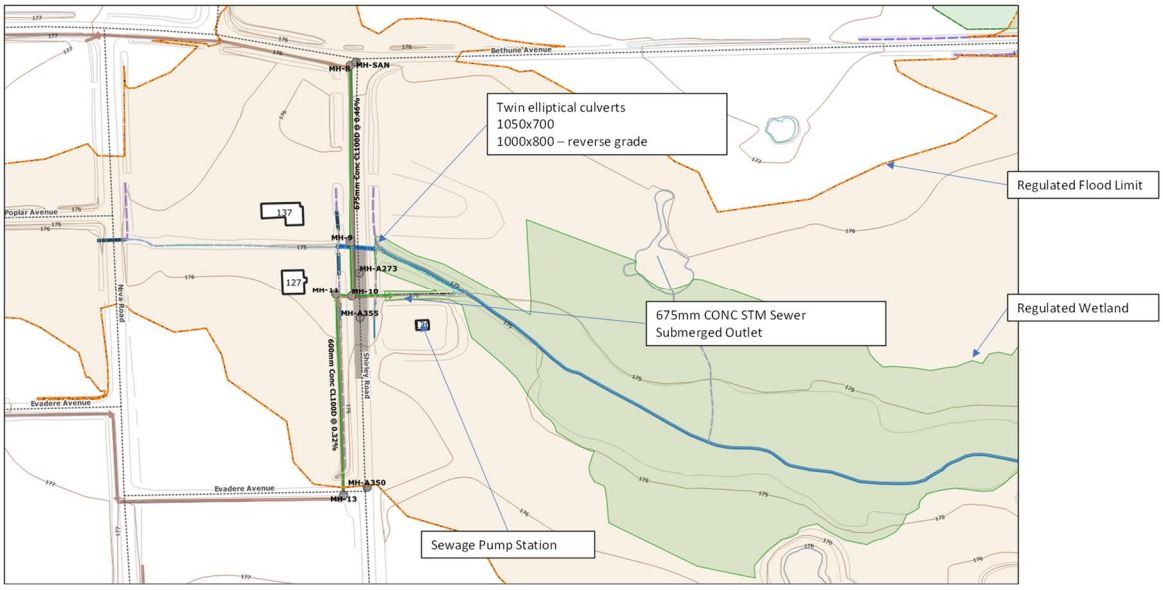


Figure 1 Existing Stormwater Infrastructure

Hydrologic Analysis

Hydrologic analysis was completed using PC-SWMM to establish a SWMM 5.1 model for runoff rates and flows for a 1:5 year design storm to represent the existing system performance for the minor system design.

Table 1 Hydrologic 1:5 year predicted flows, cms

Outlet conveyance	Runoff m3/s	Full Flow m3/s	% capacity
Surface water conveyance	0.46	0.31	148%
Pipe conveyance (submerged outlet)	1.116	2.49	45%

The table shows that the open channel approaching Shirley Rd. is compromised for the available grade to accommodate predicted runoff rates. The piped flow conveying upload runoff to outlet, is calculated as half capacity; however, this is assuming a free flowing outlet which is not the actual pipe install. The submerged outlet compromises the available capacity and accurate modelling is more complex.

Drainage Options

The following opportunities are composed based on experience and from contributors. There may be other options that were not identified but based on available information these are the opportunities considered in the report. Some opportunities are combinations of technologies that have larger or lessor control of seiche impacts. The following options were evaluated to be the three preferred for more detailed analysis.

Option 1: Construct a Levee and install flap gates.
Option 2: Culvert Flap gate integrated with a stormwater pump system.
Option 3: Slide Gates on SMC downstream side of Thunder Bay Road.
Option 4: Retreat from Flooding using property purchase.

Agency Consultation

As part of the evaluation of the preferred alternatives a preliminary discussion as conducted with agencies to solicit views on proposed works and approval requirements.
A consultation meeting was held with NPCA on November 23, 2020 and a review meeting was held January 28, 2021. Based on this being proposed and existing municipal works, there is some basis for review and approval by NPCA within the wetland and within the wetland buffer. For any option considered the following are required:

- Environmental Impact Study (EIS)
- Review and update of the flood lines based on any proposed changes with the flood zone. Update of the US Army Corps of Engineers Hydraulic Engineer Centre data file (HEC). Latest version is Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) version 5.0.7
- Permit for work within the cut/fill control zone.
- Application for consideration and potential approval for work in fish habitat zone by Department of Fisheries and Oceans (DFO). Mostly pertaining to Option 3, a flow control structure on Six Mile Creek

Preferred Option Evaluation

This evaluation is performed based on the data available at the time of the study. The options considered have not been designed and there are many details outstanding that could or would affect and impact the evaluation. A cost verses benefit analysis has not been performed and only a cost estimate of the identified short-listed options is made. The identification of funding sources has not been completed at this time.
A points system is used to evaluate each of the identified options:

- A high score reflects the ease of accomplishment or the quality of the solution.
- A low score reflects the difficulty to achieve and the lower value of resulting benefit.
- CAPEX – Capital Expenditure is an estimate prepared for each option. (see Appendix)
- OPEX – Operational Expenditure are each an estimate based on available data.
- TCO – Total Cost of Ownership: CAPEX + OPEX * Design life (25 years)

Table 2 Option Solution Effectiveness Score

Options	Effective	Approve	Construct	Effectiveness Score (30)
#1 Levee with two backwater controls.	8	4	7	**19**
#2 Culvert Flap Gate & Pump	9	4	5	**18**
#3a: Knife Gates with motorized control on SMC downstream side of Thunder Bay Road.	8	3	6	**16**
#3b: Flap Gates at Thunder Bay Road, downstream side	8	3	8	**18**
#4 Retreat from Flooding; Purchase affected properties.	7	10	9	**26**

It was identified by NPCA that the approval under flood regulations and Environmental Impact for all three proposed options was similar but that additional effort could be expected for DFO approval on SMC.

Table 3 Option Evaluation

Options	CAPEX	OPEX	TCO	Pts/$ (per $100,000)
#1 Levee with two backwater controls.	$775,000	$3,000	$850,000	**2.24**
#2 Culvert Flap Gate & Pump	$1,375,000	$10,000	$1,625,000	**1.11**
#3a: Knife Gates with motorized control on SMC downstream side of Thunder Bay Road.	$950,000	$3,000	$1,025,000	**1.66**
#3b: Flap Gates at Thunder Bay Road, downstream side	$750,000	$3,000	$825,000	**2.30**
#4 Retreat from Flooding; Purchase affected properties. [1]	$850,000 to $4.5M	$0	$850,000	**3.06**

1 – using purchase of 2 properties only. Additional properties to purchase as a contingency.

A clear preferred option is not identified from the comparative analysis undertaken. A conclusion with regards to the sensitivity of the gate control structure on the Six Mile Creek to total cost relative to other options, meaning that where the capital cost of the gate structure can be reduced, this option provides a same or better outcome when compared to the berm along Shirley Rd.

1 Introduction

The following figure shows the approximate study area.

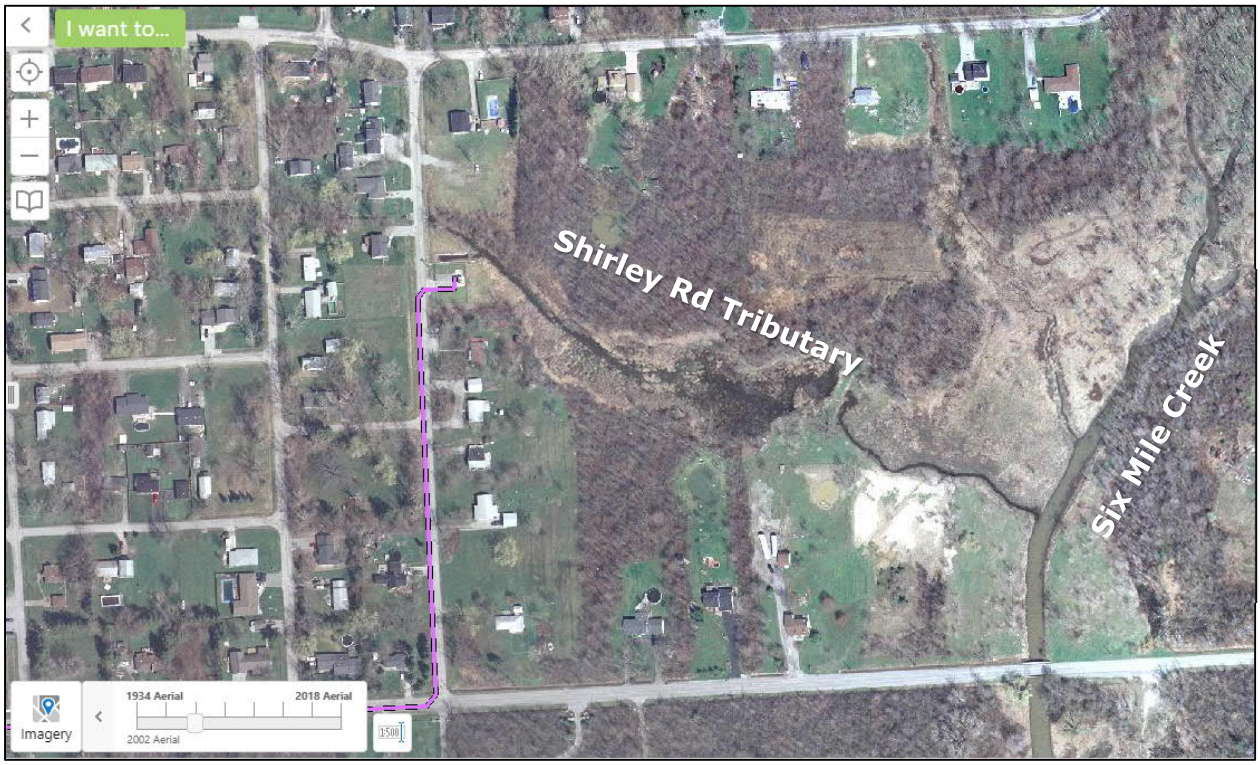


Figure 1 2002 Orthophoto site view

The purple line shown above is a forcemain from the Shirley Road Sewage Pumping Station, (SPS) located at 120 Shirley Rd.

The two houses located on the West side of Shirley Rd., 127 Shirley Rd. and 137 Shirley Rd., are the two properties most impacted by the Lake Erie Seiche for the Shirley Rd area. The seiche causes water to rise in Six Mile Creek and up the tributary, causing water to back across Shirley Rd. and negatively affect properties.

The riverine flooding impacts are shown in Figure 3: Shirley Rd. Drainage Area and Figure 8 Existing Stormwater Infrastructure. These two figures show the modelled flood impacts for a Regulated Flood limit, which are riverine flood lines as shown in the respective figures.

2 Background

This study identifies solutions to the seiche flooding from Lake Erie storms. The study does not determine a cost vs benefit of the identified option. This study does not examine funding of the identified solutions. The study is limited to the available information at the time of composition and focused on identification of options without a recommendation of a particular option.

2.1 Study Area

The bounds for the study area are limited to the specific area bounding Shirley Rd., however, the overall area is identified as the water flow path starting at the outlet of Six Mile Creek and then proceeding upstream along the Shirly Rd. tributary to Dominion Rd. as shown in the following figure.

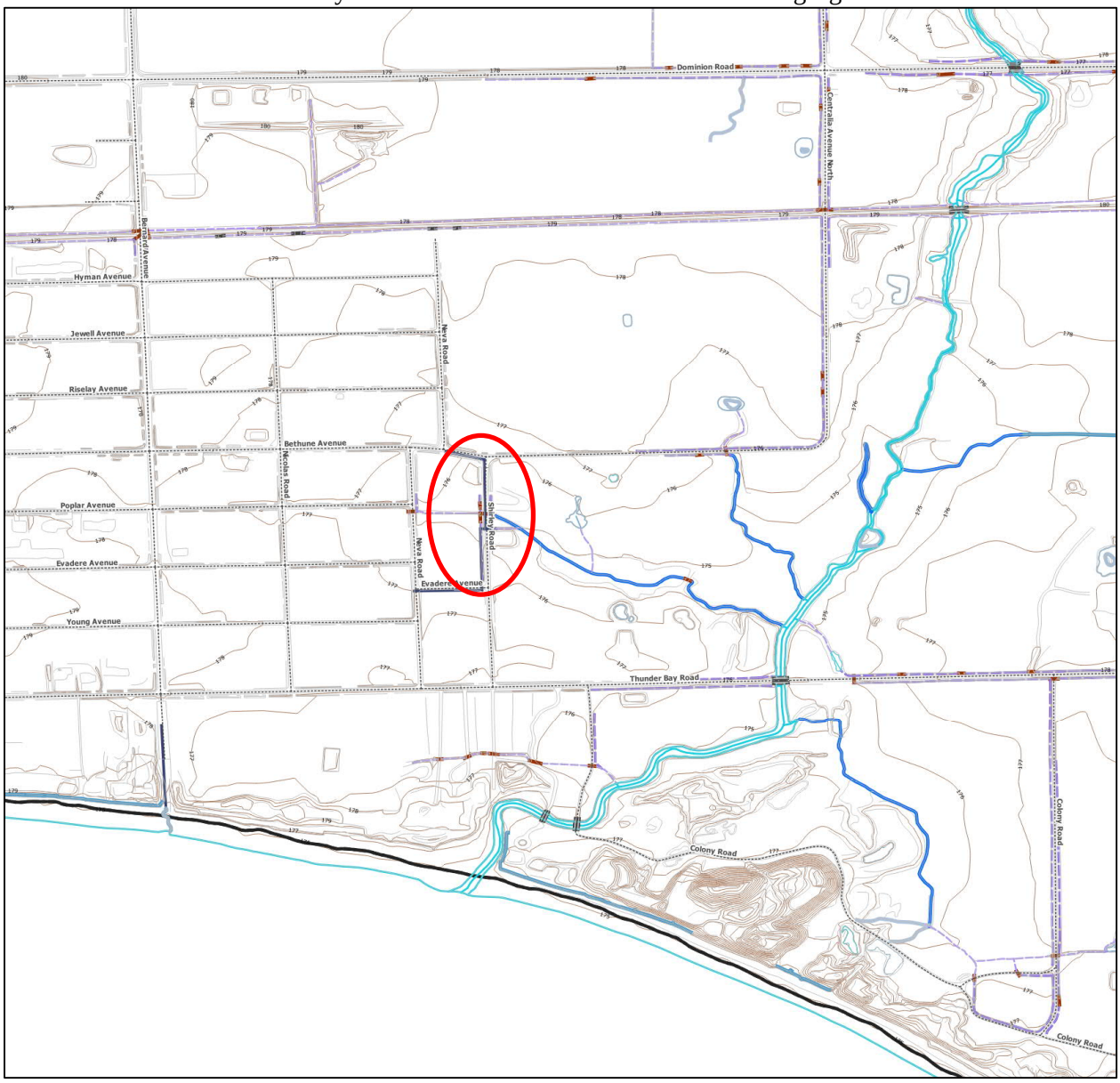


Figure 2 Project Extents

A larger format site plan is included in Appendix A.

2.2 Previous Reports and Studies

The following data was accessed online and used for the purpose of preparation of plans and diagrams.

- NPCA publicly available data including Wetlands, Flood lines and other environmental data
- NPCA 2012 Orthographic data, DEM 20m with contour lines.
- NPCA Contemporary Watercourses, 2018 – public data download
- A survey of the Shirley Rd. area was prepared by Town of Fort Erie staff on or about September 24, 2020 and was and supplied to EWA. The survey was updated on November 17, 2020 to include data from the storm and again on November 25, 2030 with survey data of the Thunder Bay Rd Bridge.

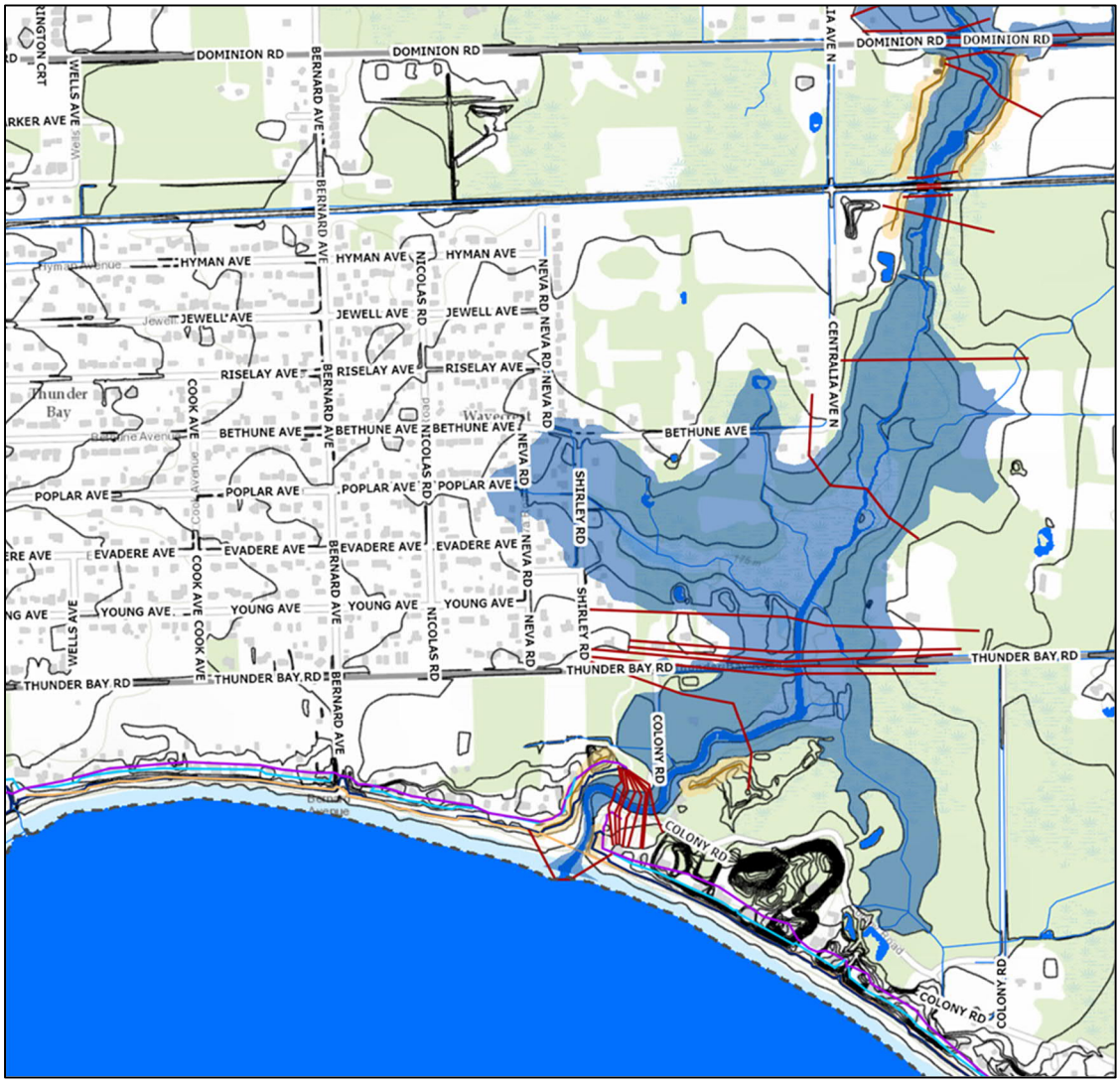


Figure 3: Shirley Rd. Drainage Area

Figure 3: Shirley Rd. Drainage Area shows the flood mapping for NPCA, 2012 analysis including Six Mile Creek cross-sections, (lines in red perpendicular to the flow). Shirley Rd. site is located between two NPCA flood sections with a listed flood elevation of:

- STA 100750 – 176.32
- STA 101000 – 176.37

The Shirley Rd. area is clearly identified as being within the Regulated Flood limit for the Six Mile Creek.

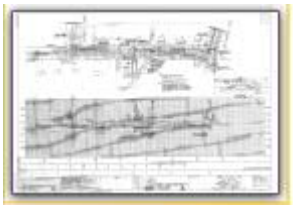
Reference Documents:



Fort Erie Creeks – Watershed Plan

Philips Engineering, NPCA
March 2008
Highlights:
Model study forecasts flood levels using SWMHYMO for the 1:100 year storm event.

- "In general, the land uses surrounding Six Mile Creek have not been altered since 1955. The majority of the lands remain enveloped in agricultural and scrubland designations, with minor residential parcels present around the main road intersections and the shoreline of Lake Erie."
- "In the downstream section, closest to Lake Erie, channel bankfull widths increased and resembled areas close to the Niagara River. Reach SMC-2 and SMC-1 have been straightened at Thunder Bay Road and few residential properties were observed in this area."
- "Strategically alter the development standard (from urban curb and gutter to roadside swales); protect existing swales where possible through appropriate land use designations."
- Table 6.1.11 Summary of Prioritized Local Actions Six Mile Creek Remediate 5 potential flood damage centres, through conveyance improvements, and potentially local flood-proofing:
  - up to 25 flood-prone structures near the mouth, Bethune and Shirley
- "In order to determine the 100 year floodlines on the Fort Erie Creeks watersheds, two different downstream boundary conditions have been modeled:
  - The 100 year hydrologic rainfall-runoff event peak flows run with the mean annual water surface elevation at the outlet (i.e. Niagara River or Lake Erie)
  - The 100 year downstream boundary condition superimposed on the surrounding lands at the creek mouths
- The greater of the two water surface elevations has been selected by the NPCA as the regulatory elevation."



Town of Fort Erie As-Builts Thunder Bay Trunk Storm Sewer and Outlet Shirley Road Evadere Ave. To Bethune Ave.

Kerry T. Howe Engineering Ltd.
Sept. 02, 1997

- Submerged Outlet with Spill over Area Gabion Mat
- Extend existing twin 800x1000 CSP Culverts 4.3m West

2.2.1 Niagara Soils

The predominate soils series for the area is NM for Not Mapped shown in the following figure as grey. The other dominate soil identified is Alluvium (shown in light blue), which identifies soils that are modified by a riverine, lake or other process and characterized as medium-textured loamy floodplain deposits. These soils are likely to be sorted gravels, or silts based on changes in geomorphology over time. The area around the ALU series is Niagara soil series (light green colour), identified as a mainly reddish-hued lacustrine heavy clay soil with imperfect drainage characteristics.

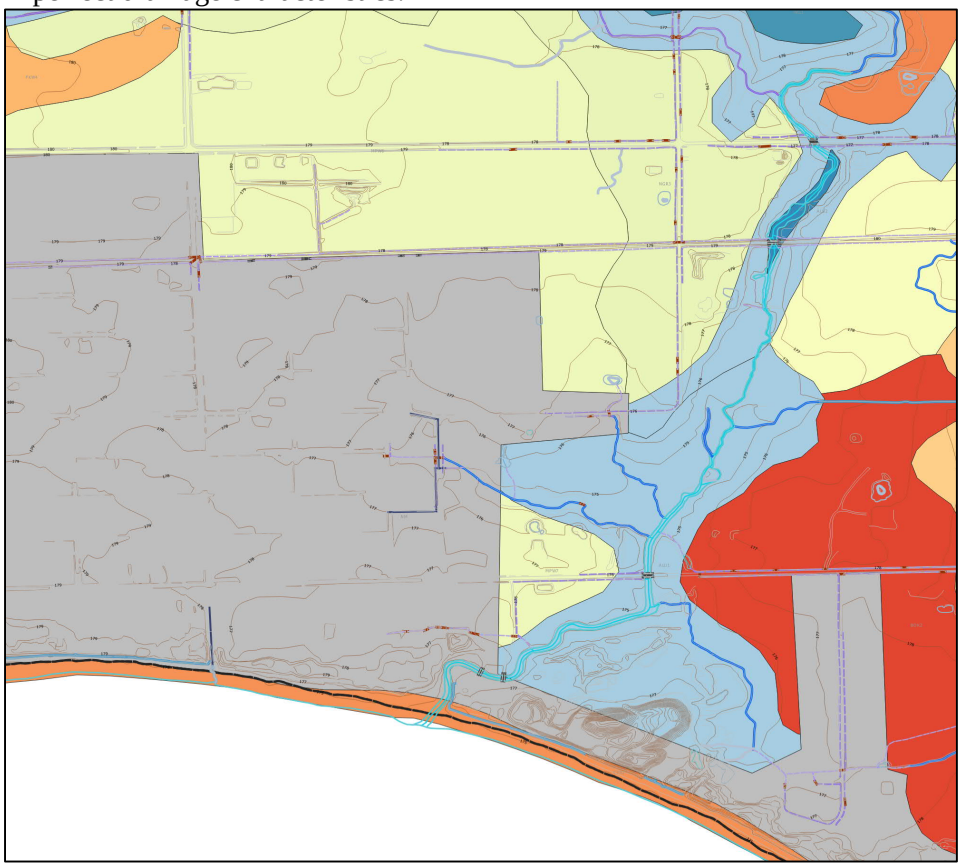


Figure 4 Niagara Soils

The other interesting feature of the soils series is the shoreline thin series identified as CPX1, beach-marsh complex; beaches, exposed sand bars, variable widths.

2.3 Historical Storms and Seiche Events

This area is influenced by both upstream runoff that exceeds the available channel capacity, but also backwater effects from Lake Erie that inundate the near shore area.

Seiche

A seiche (/ˈseɪʃ/ SAYSH) is a standing wave in an enclosed or partially enclosed body of water.



Differences in water level caused by a seiche on Lake Erie, recorded between Buffalo, New York (red) and Toledo, Ohio (blue) on November 14, 2003:
Source: https://en.wikipedia.org/wiki/Seiche

Surge

A storm surge, storm flood, tidal surge or storm tide is a coastal flood or tsunami-like phenomenon of rising water commonly associated with low-pressure weather systems, such as tropical cyclones. It is measured as the rise in water level above the normal tidal level, and does not include waves.

For our purposes in this report we will use the terms seiche and surge interchangeably and reference the same phenomena, which is a rise in Lake water surface level that causes water to back up from the lake into the local streams and drainage systems.

2.3.1 October 31, 2019 Storm

This sudden storm caused widespread flooding along the Lake Erie North Shore and was both an intense precipitation event and a high wind lake surge or seiche event. In additional to very high winds driving up lake levels, there was a recorded 29.4mm of precipitation, which is not a significant amount (5 days prior there was 36.6mm without flooding). Using Environment Canada reporting for Port Colborne station.



Figure 5: Historical Flood Record Oct 31, 2019

Susan's hand indicates the level that the water had risen to and this was subsequently surveyed and reported to be 176.45m based on the survey using UTM NAD 83 datum.

2.3.2 November 15, 2020 Storm

This storm surge caused a similar flood as the previous year's storm. Post-storm, the Town of Fort Erie surveyed the debris highwater mark left on the fence for #137 Shirley Rd.

Precipitation report from Environment Canada for the Port Colborne station showed that a total day recorded rainfall was 6.6mm of precipitation. This was confirmed by precipitation reports for two stations in Fort Erie operated by RMON.

- 500 Ridgeway Road, Crystal Beach precipitation station: 6.75mm
- 660 Industrial Drive, Industrial Park precipitation station: 7.75mm

(Data provided by email from Mr. Glenn Fulton dated January 8th, 2021.)

This confirms that the local flooding experienced is from Lake effect flooding and not from precipitation induced stormwater runoff.



Figure 6 Nov 15, 2020 Storm Highwater Mark

This storm flood elevation was recorded as 176.46m, the same as the previous year.

This sudden storm caused widespread flooding along the Lake Erie North Shore and was predominately a high wind lake surge or seiche event. The following chart shows the average hourly results for lake levels as recorded at Port Colborne, (note that these values are recorded as height above the International Great Lakes Datum (IGLD which is not the same datum as used by the survey).

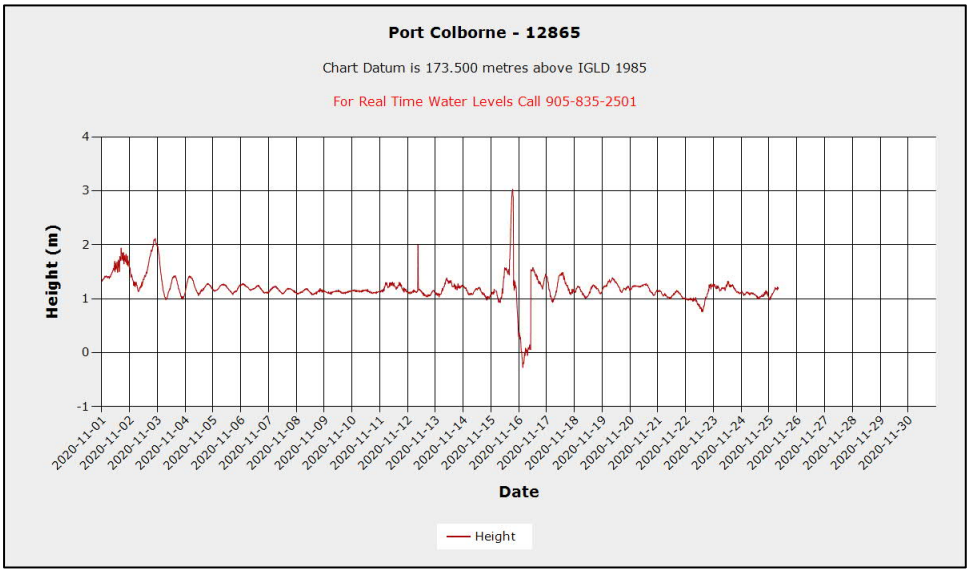


Figure 7 DFO Great Lakes Water Level at Port Colborne

A recent presentation titled, “Vulnerability Assessment and Climate Change Adaptation Options for the Great Lakes Coastline – The Chatham-Kent Lake Erie Example” by Pete Zuzek and Linda Mortsch hosted by Climate Risk Institute identified that as winter temperatures change with climate change, we

expect to have more winter storms with open water in Lake Erie. The prediction is for fewer winters with lake ice acting to dampen the effects of storm surge and seiche impacts.

The conclusion is that the risk of wintertime events on the lakes will be greater in the future than the past.

Risk of these events is a combination of high lake levels and storm surge/seiche. A storm event when the lake levels are low poses less risk.

2.4 Reference Literature

There are a variety of online flooding documents providing information on flood reduction techniques. Here are some selected sources.

INTACT CENTRE
ON CLIMATE ADAPTATION

Faculty of Environment, EV3 4334, University of Waterloo,
200 University Avenue West,
Waterloo, ON, N2L 3G1



"3 steps to reduce your risk of flooding and lower the cost of cleanup"

- Install window wells that sit 10-15cm above ground and upgrade to water resistant windows
- Install backwater valve
- Install backup sump pump and battery



WATER ON THE RISE: PROTECTING CANADIAN HOMES FROM THE GROWING THREAT OF FLOODING

Pg. 14 3.2 Summary of Top Flood Risks

> Eighty-two percent of homes with window wells had wells that were not 10-15 cm above grade and sealed at the foundation. Seventy-eight percent of homes with downspouts and 68% of homes with sump pump discharge pipes discharged water less than 2m from the home's foundation.

Pg. 18 Top Ten Actions to reduce basement flood risk. Intact Centre, 2018

CSA GROUP

Z800-18
Published by CSA Group in 2018, 64 pages
SKU: 2426266

Guideline on basement flood protection and risk reduction
CSA Z800 outlines measures that can be taken in existing, new, rebuilt and renovated houses in rural and urban settings under the National Building Code of Canada (NBCC) Part 9. The guideline also serves as the basis for the curriculum of a new training course for Canada's 40,000 home inspectors


CREDIT VALLEY CONSERVATION
TECHNICAL GUIDELINES FOR FLOODPROOFING

1) INTRODUCTION

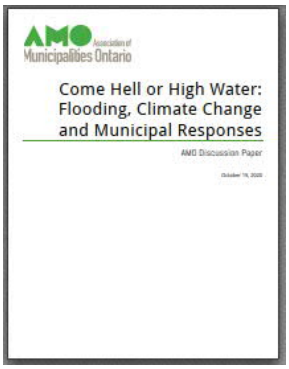
Floodproofing incorporates the use of designed structural treatments to render structures flood free, impervious and/or immovable. Dry, passive floodproofing to the level of the Regulatory Flood is the preferred approach and shall be given primary consideration for all new construction (CVCA 1990). Ancillary structures such as garages and sheds (usually without basements) are wet-floodproofed to allow free flow and equalized pressure of water through the structure, while also being rendered immovable. Designing floodproofing for a given structure must consider the hydrotechnical effects of the flood. The *Flood Plain Planning Policy Statement Implementation Guidelines*, July 1986 and the *Credit Valley Conservation Authority Policies for Floodproofing of Buildings and Structures*, June 1990, have established threshold criteria for velocity and depth of flooding. Dry-floodproofing is acceptable up to a maximum velocity of 1.7m/sec. and a flood depth from existing grade of 0.8m plus a 0.3m contingency freeboard. These criteria are implemented as upper limits to which flood damages can be acceptably reduced within feasible economic limits. Above and beyond these limits it is argued that uncertainty replaces effectiveness in the design of floodproofing. There are no explicit policy criteria for wet-floodproofing but the above noted figures are reasonable benchmarks.

2) HYDROTECHNICAL DESIGN CONSIDERATIONS

The following phenomena occur during flooding:

- Hydrostatic pressure
- Velocity - Hydrodynamic load
- Velocity - Shear stress
- Frequency of flooding
- Duration of flooding
- Ice jamming effects

TECHNICAL GUIDELINES FOR FLOODPROOFING
Floodproofing berms can be made impervious by compaction of non-swelling, non-plastic cohesive clayfills. It is usually appropriate to use cohesive and relatively impervious till in the berm core which can be keyed into a deeper excavation to improve the cut-off effect.



Association of Municipalities of Ontario, **Come Hell or High Water Flooding, Climate Change and Municipal Responses**

Ultimately, all cases of flooding boil down to the fact that nature is throwing more water at municipalities than can be managed. This paper explores what options exist for municipalities to address this reality.

3 Study Approach

3.1 Project Objective

The study will identify drainage solutions to prevent flooding from high lake levels and seiche driven inundation of the lands around 127 Shirley Rd. The study will consider riverine systems but the focus is solely on the protection of properties from the seiche flood impacts.

The intent is to identify three possible options to address the current site flooding that is occurring.

3.2 Methodology

The following data was accessed online and used for the purpose of preparation of plans and diagrams.

- GIS data from NPCA for hydrology and mapping
- Region data for roads
- Town of Fort Erie data for stormwater pipes, MHs and CBs

A survey of the Shirley Rd. area was prepared by Town of Fort Erie on or about September 24, 2020 and was supplied to EWA.

Topographic Map

Using available data and the survey results, a Plan of the area was prepared and is included in Appendix A.

Digitize Catchment Areas

Catchments are composed to characterize the local hydrologic properties, but a model implementation is not planned for the option assessment preliminary assessment. Rational Method peak flows will be calculated using a Rational Method spreadsheet.

Note: This was changed from the Rational Method spreadsheet to an implementation of SWMM model using PC-SWMM as being faster and better to achieve results.

Analyze Culvert Capacity

EWA used the USA DOT HY-8 software to confirm existing culvert capacity.

A long list of options will be identified, but only a short-list of 3 options will be analyzed for potential implementation and discussion. Those 3 will be identified based on an agreed upon criteria for selection validated with Town of Fort Erie Engineering staff.

Plans and diagrams of the proposed options will be presented to a pre-feasibility design composition, limited to illustrative examples only.

A preferred option will be identified based on discussions with review agencies having jurisdiction within the area.

Identify a preferred Option

Use a Municipal Class EA approach of methodology to assess and develop a preferred option.

- Prepare long – list of options
- Assess and select a short – list of options (3)
- Analyze options
- Discuss with relevant agencies
- Recommend a preferred option

4 Analysis

The site features two stormwater conveyance systems; a local surface water open channel system and a piped stormwater system that brings upland runoff for discharge through a submerged outlet.

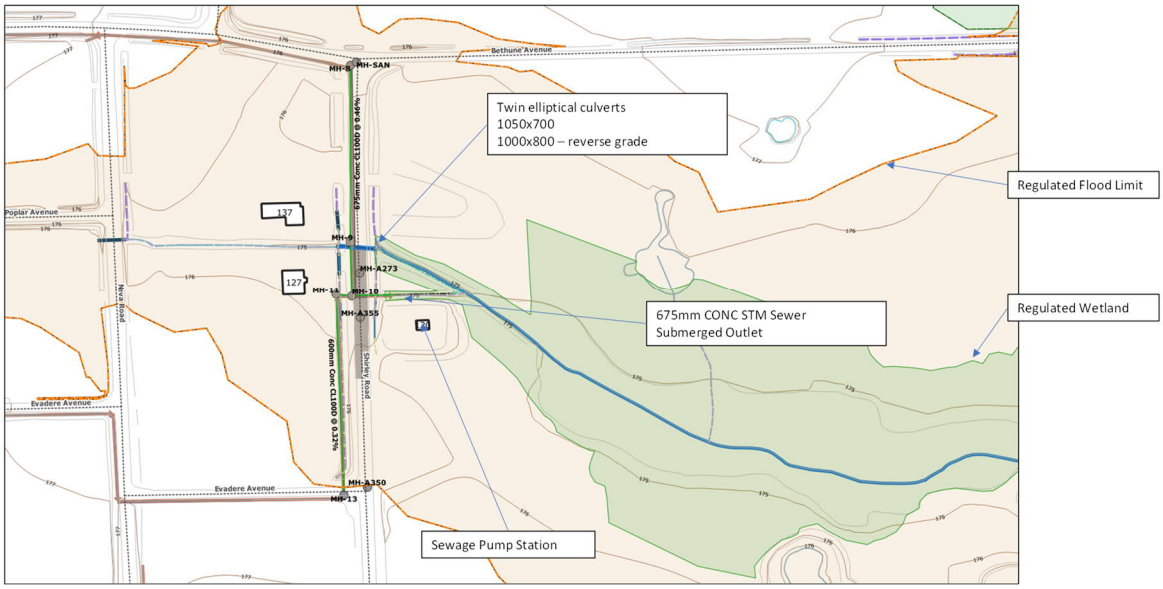


Figure 8 Existing Stormwater Infrastructure

House 127 and 137 both have their basement window sill elevations above the calculated 1:100 year flood line.

- #127 Shirley Rd. has a basement window sill elevation of 176.759m
- #137 Shirley Rd. has a basement window sill elevation of 176.371m

The Flood Forecasted 1:100 year flood line is 176.37m (NPCA data).

4.1 Topographic Catchment Analysis

Catchments contributing flows to the subject area are delineated using the NPCA contour lines from 2012 Orthophoto information.

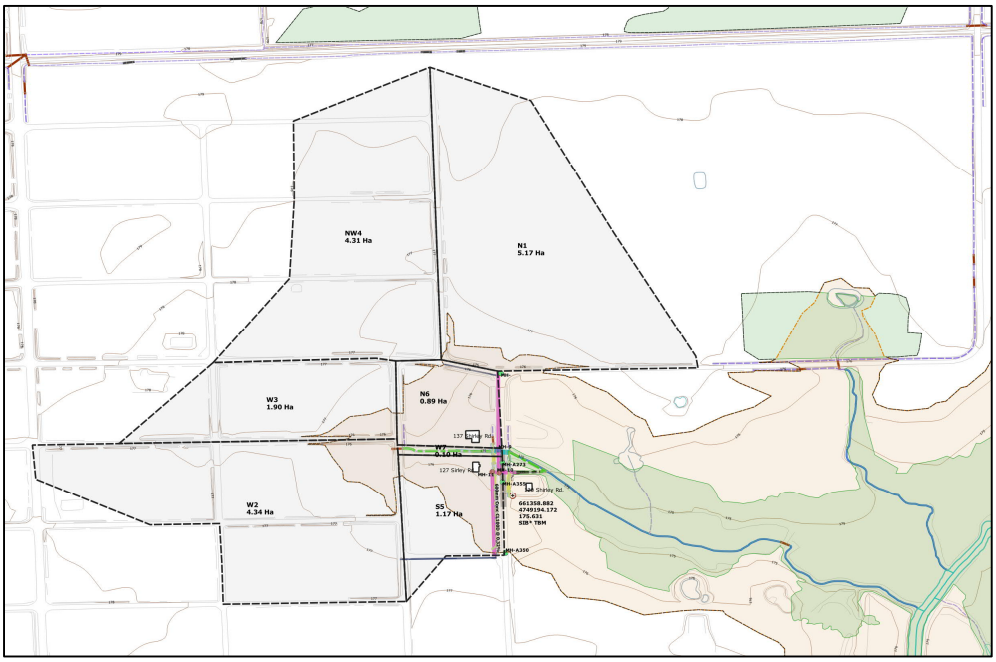


Figure 9 Surface Drainage Catchment Areas

Storm sewer catchment area is shown in the following figure based on information provided by the Town of Fort Erie.

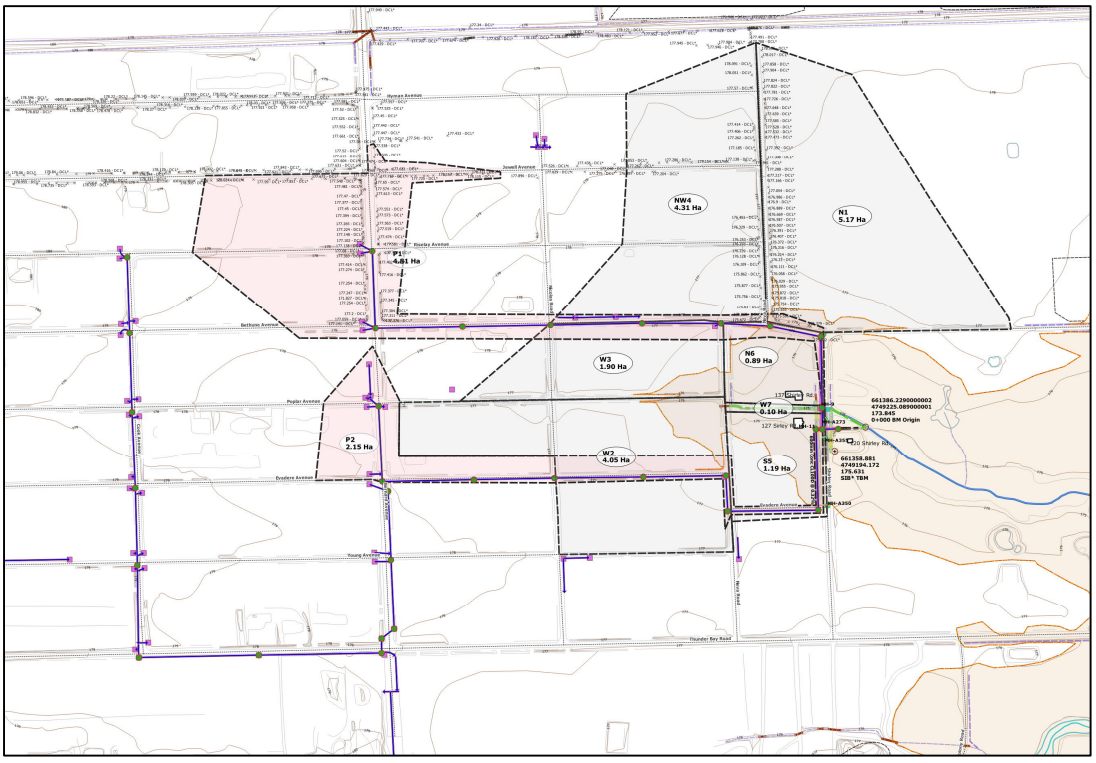


Figure 10 Pipe Drainage Catchment Areas (pink shading)

4.2 Hydrologic Analysis

Hydrologic analysis was completed using PC-SWMM to establish a SWMM 5.1 model for runoff rates and flows for a 1:5 year design storm to represent the existing system performance for the minor system design.

4.2.1 Port Colborne IDF curve data

The following chart provides the 1:5 year return period Intensity-Duration-Frequency (IDF) chart data for use in composing a design storm. The design storm used for predicting runoff was a 24-hour SCS type II storm with a total volume of 69.6mm using the Environment Canada Gumble probability distribution results.

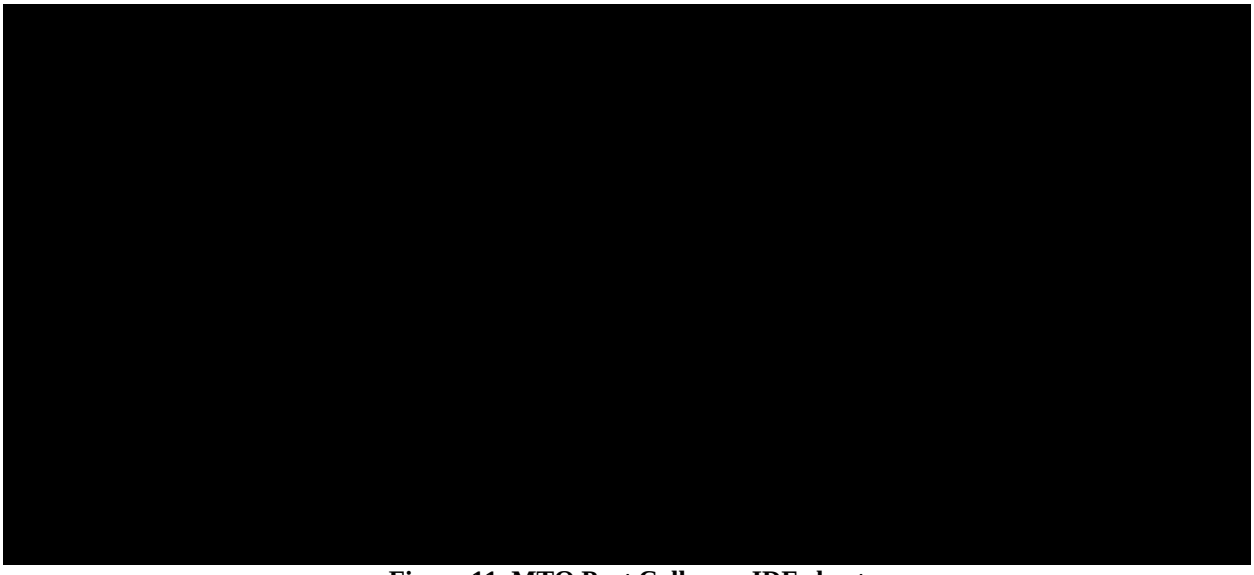


Figure 11 MTO Port Colborne IDF chart

The storm volume used in the model is 69.6mm over 24 hours using a SCS Type II distribution.

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) 4/		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

Figure 12 SCS Curve Number Reference Table

An SCS CN value of 83 was used with a 40% impervious area value.

Using common and standard variables for all catchments results in a model prediction event for the 1:5 year SCS Type II 24 hour storm with a total volume of 69.6mm results in a runoff event for both outlets as follows:

Table 1 Hydrologic 1:5 year predicted flows, cms

Outlet conveyance	Runoff m3/s	Full Flow m3/s
Surface water conveyance	0.46	0.31
Pipe conveyance (submerged outlet)	1.116	2.49

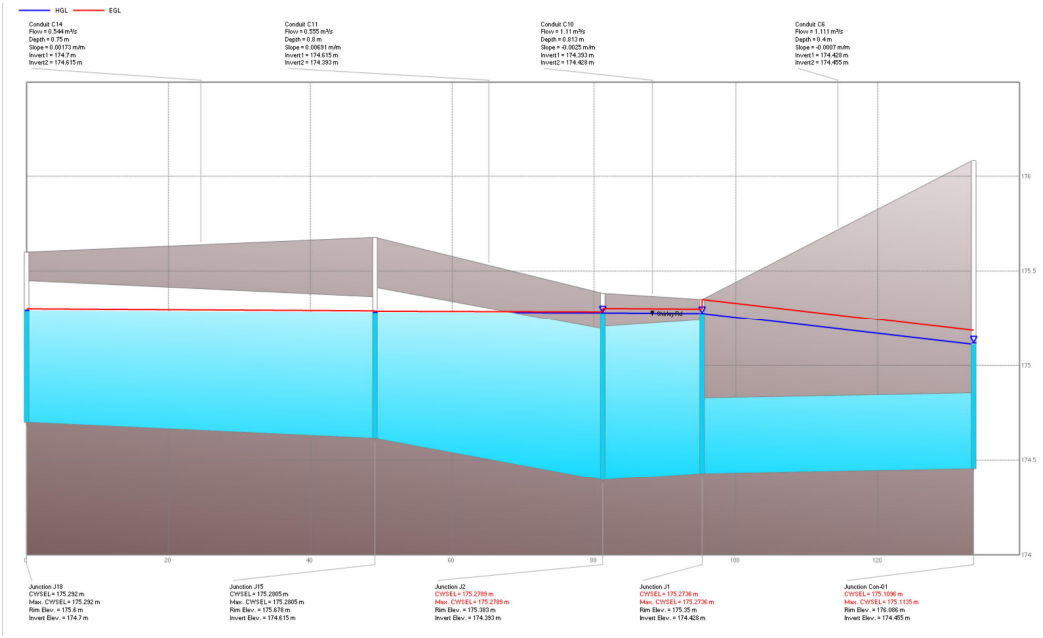


Figure 13 Open Channel Flow Profile 1:5 year storm 69.6mm

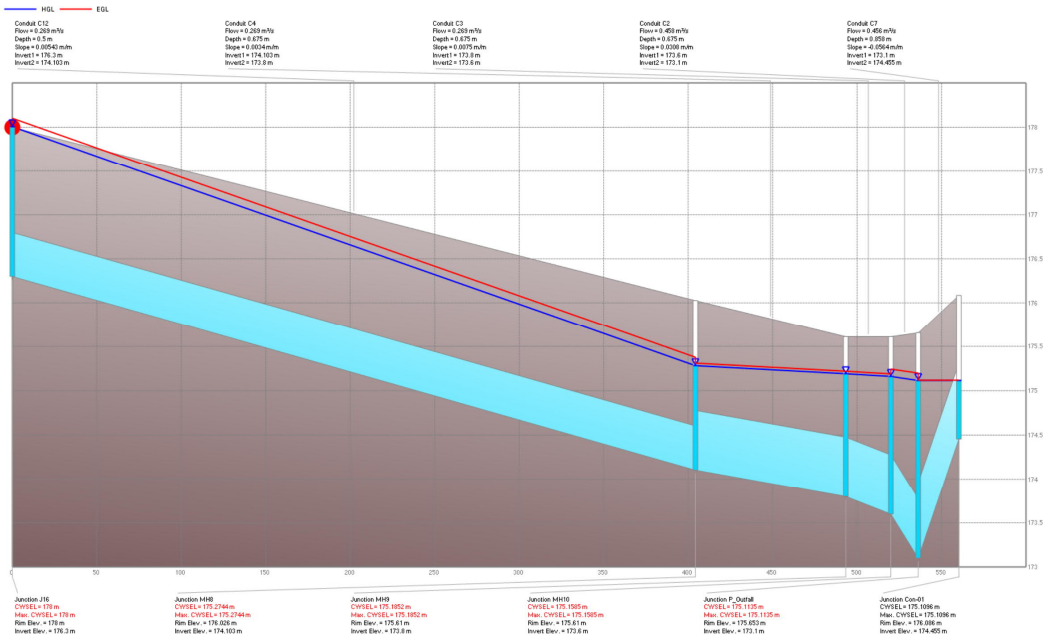


Figure 14 Pipe Flows Profile 1:5 year storm 69.6mm

Model Output is included in Appendix B

4.3 Hydraulic Analysis

Analysis is performed to show the existing capacities for culverts and design information is based on previously conducted studies. The collected survey inverts and based culvert size data provided input for the following analysis using HY-8 software.

The twin elliptical culverts were measured as:

- 1000x800mm for the South, and
- 1050x750mm for the North Culvert.

The HY-8 software does not have a profile configured for these direct measurements and instead the nearest closest elliptical culvert was selected; Barrel Span: 1066.80 mm x Barrel Rise: 736.60 mm

The survey indicates that the culverts have a reverse grade, both culverts and this data was used directly in the analysis.

The culvert crossing was analysed for outlet control and this is very influenced by downstream conditions. The survey of channel bottom indicates that a channel slope is present of 1.2%. However, the standing water is this area indicates that the effective slope is actually the water surface elevation. As a compensation for the standing water being present, a downstream grade of 0.008 m/m was selected. The following figure shows the profile result for the North Culvert.

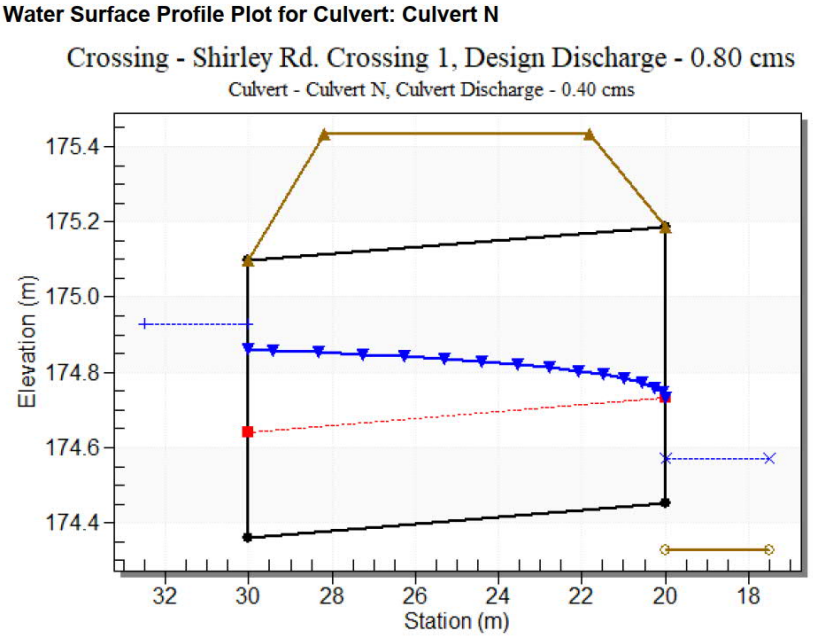


Figure 15 HY-8 Analysis of North Culvert

The flows through both culverts is reported in the following table.

Table 2 HY-8 Culvert Analysis - Surface Flows

Table 1 - Summary of Culvert Flows at Crossing: Shirley Rd. Crossing 1

Headwater Elevation (m)	Total Discharge (cms)	Culvert N Discharge (cms)	Culvert S Discharge (cms)	Roadway Discharge (cms)	Iterations
174.66	0.20	0.10	0.10	0.00	6
174.73	0.33	0.16	0.17	0.00	4
174.79	0.46	0.23	0.23	0.00	4
174.84	0.59	0.29	0.30	0.00	4
174.90	0.72	0.36	0.36	0.00	3
174.93	0.80	0.40	0.40	0.00	3
175.00	0.98	0.49	0.49	0.00	3
175.04	1.11	0.55	0.56	0.00	2
175.09	1.24	0.62	0.62	0.00	3
175.14	1.37	0.68	0.69	0.00	3
175.19	1.50	0.74	0.76	0.00	4
175.43	2.29	1.17	1.12	0.00	Overtopping

The full report of both culverts is included in Appendix B.

4.4 Existing Infrastructure Plan & Profile

The site survey was used to compose a profile for the storm sewer pipes that outlet from Shirley Rd., the surface water open channel and the culvert profile. Each of these profiles has an overlay of the Lake Erie water surface elevations dated Oct. 7th, 2020. The profile drawing is included in Appendix A.

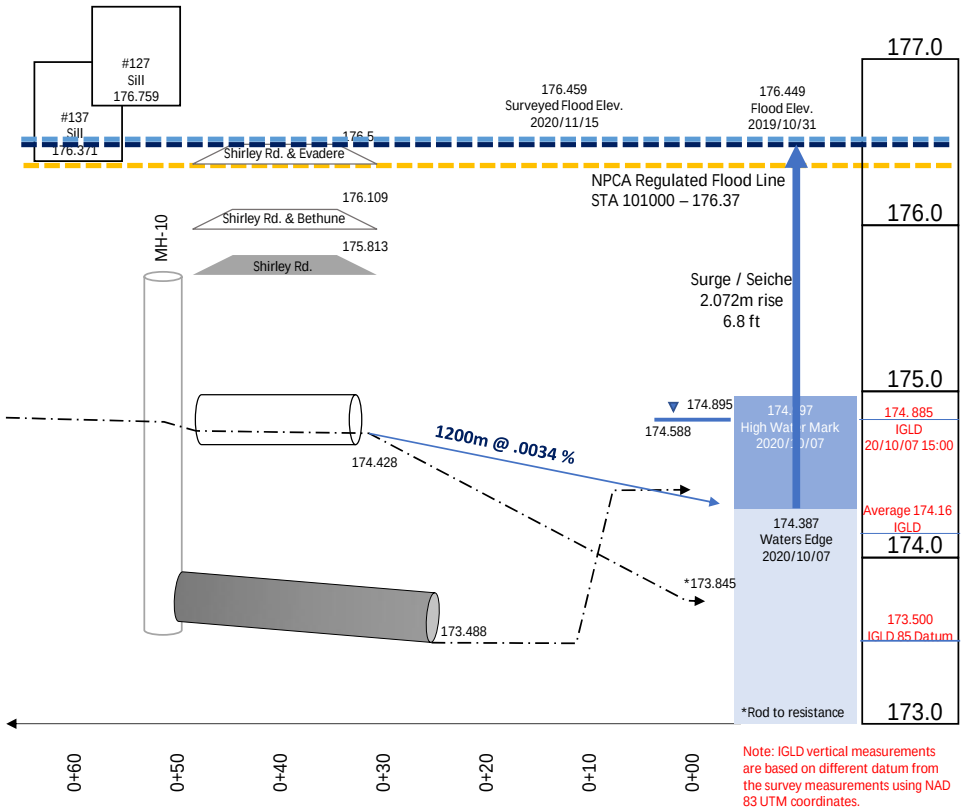


Figure 16 Hydraulic Profile Illustration

The invert of the elliptical culverts and the average IGLD Lake Erie level of 174.16 creates a flow path of 1,200m length at an average grade of 0.0225% (0.000225 m/m). This is a very low, almost zero gradient to the current lake level but is improved once lake levels return to their average reported levels.

This analysis of the flow path grade line from Shirley Rd. to a confluence of Six Mile Creek (SMC) and then to outlet to Lake Erie mixes two coordinate systems into a comparison.

Aside

The survey data was collected using a GPS survey instrument that reports the Northing, Eastings and Elevations using a reference to NAD83 and a UTM coordinate system. The lake levels are reported as a reference to the International Great Lakes Datum (IGLD). We can accept that for all of these comparisons that the horizontal positions are consistent with each other. However, the vertical elevations are not considered to be comparable and in fact the relative comparisons between reference datums will result in different offsets at different locations. For comparison, a survey of the same point was made on the same day as follows:

- GPS Survey of the waters edge (2020/10/07) 174.387m
- IGLD of the waters height (2020/10/07 15:00) 174.885m
- A difference of 0.498m, a considerable difference.

There is an initiative underway to harmonize and make the two systems consistent.

For most analysis purposes, we only use the comparable values obtained from the survey so that elevation and grade calculations are consistent. Care must be taken when making comparisons between survey elevations and the reported elevations of lake levels from the Canadian Hydrographic Service (CHS) using the IGLD 85 system.

4.4.1 Outlet #1: Storm Sewer

The storm sewer outlet is submerged as stated on the original As-Built drawings.

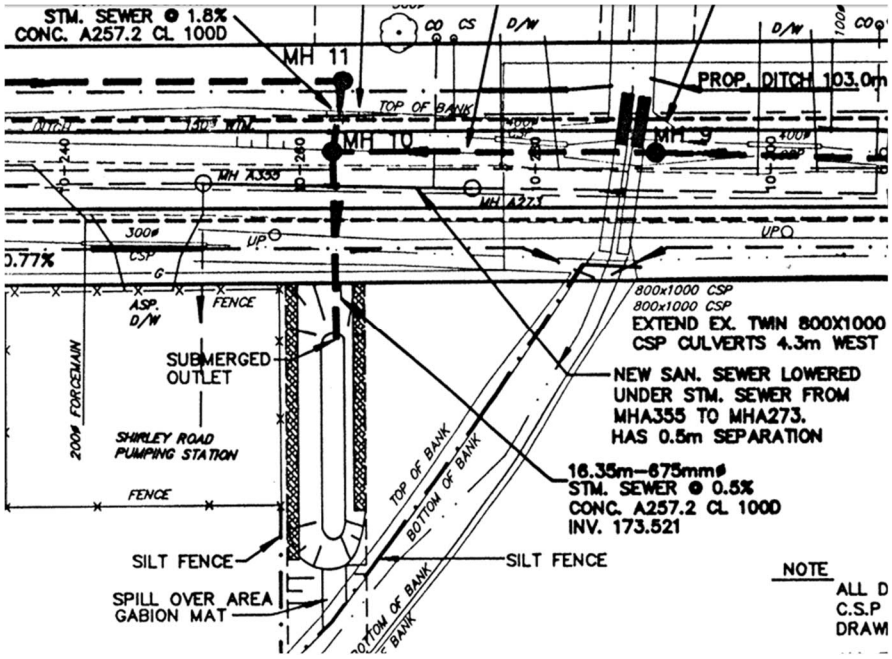


Figure 17 Storm sewer As Built Drawing 1997

The submergence is deeper, the top of the pipe is under water as measured at the Lake 1.2km away.

4.4.2 Outlet #2: Open Swale outlet

The swale has the appearance of having a significant gradient from the outlet of the elliptical culverts. However, this was obtained by pushing the survey rod as deep as possible given that the bottom of the channel is not firm and is composed of organic material without a clear bottom. The hydraulic effective grade is given by the water surface elevation rather than the actual measured bottom.

5 Drainage Options

The following opportunities are composed based on experience and from contributors. There may be other options that were not identified but based on available information these are the opportunities considered in the report. Some opportunities are combinations of technologies that have larger or lessor control of seiche impacts.

5.1 Long List of Opportunities

The long list of options to address backwater flooding from Lake Erie seiche.

a. Flap gates on both outlets A flap gate can be installed on the outlet of the existing concrete storm sewer pipe located in the rectangular channel. The twin elliptical outlets are a bit more of a challenge but can be addressed using a precast box with flap gate on a single common outlet. Flap gates could be constructed from HDPE or steel.

HDPE flap gate for submerged outlet	Aluminium version
	
http://www.flapvalvehdpe.com/pages2/flap-valve-hdpe-always-submerged-design.php	https://armtec.com/products/specialty-products/water-control-gates/

This works to a specific level coincident with the road centreline elevation. A flap gate invert has to have positive grade to outlet.

b. Constructed Knife gates on both outlets This is similar to the flap gate except that the knife gate is operated to close securely. This requires either operation or a control reaction system with an actuator to close the gates upon a sensed condition being met or associated signal given. Manual operation is also possible but would be prone to risk based on a timely response, unless operation is delegated to local residents, which then has other risks and issues.



c. Constructed Levee and backflow control Constructed parallel to Shirley road on the Eastern ROW, it could become a barrier to flows.

d. Tide flex type valves on both outlets Same or similar to flap gates



e. Tideflex in line checkmate valve Same or similar to flap gates but requires replacement of existing outlets / culverts.



f. A pump, positive displacement of water A screw or centrifugal pump to move water across the road. Requires a motive force to work, electric motor, or other motor, wind turbine or some other form of drive of a size to meet requirements.

g. Raise the road giving a greater control to hold back flood waters, still requires back flow control on the outlets.

h. Levee and control gates through the channel North of the SPS



i. Replace twin culverts with single conveyance structure incorporating backflow control

This is quite similar to other options but instead of maintaining the existing twin culverts with the need to treat two ends,

j. Retreat – property purchase

In this option, the problem is solved using capital to purchase the properties and to remove the risk of damage and allow a flood hazard land designation to be approved.

k. Install slide gates on the downstream side of the Thunder Bay Road bridge crossing of Six Mile Creek.

This would block the 9m by 1.5m opening under the bridge and thus restrict flow from backing up the SMC and into the Shirley Rd. area.

z. Do Nothing.

This option is included for reference as an option for consideration. However, this option does not address the recent flooding events by continuing with the status quo. Under specific circumstances, taking no action is an acceptable solution.

5.2 Selection Criteria

The following are the evaluation criteria for the assessment of the long list of options to the short-list for further evaluation.

- Effective; the option must work for all seiche conditions or the limitations must fall within an acceptable range.

- Approvable; the option should be acceptable as a method to control stormwater to review agencies.

- Constructable; the option should be able to be constructed without extensive requirements.

- Cost; the option must be affordable
  Assessment is made by estimating the Capital Cost (CAPEX) to construct complete the proposed option or solution. The result will be a single numeric value representing CAPEX.

- Operational Impacts; such as manual operation, higher than normal periodic cleaning etc.
  This will include two aspects of evaluation:
  - a qualitative discussion of additional effort and response that may be required to ensure that the proposed option continues to meet design service expectations.
  - a quantitative evaluation of an estimate of the OPEX, or annual estimated operational cost to perform inspection, maintenance and otherwise ensure that the proposed option continues to be in a State of Good Repair (SOGR).

5.3 Preferred Options

The following options were evaluated to be the preferred for more detailed analysis. Each option was detailed in a Plan and/or diagrams of the proposed options such that an estimate of the cost of construction can be completed.

5.3.1 Option 1: Construct a levee and install flap gates.

Option 1 includes the construction of a berm to a proposed elevation of 176.5m. To match this berm height to existing ground elevation, it will be 360m long. This is an average height of 0.82m above existing ground elevations and require a berm width of 4m on average, (some areas require more height and wider base.)

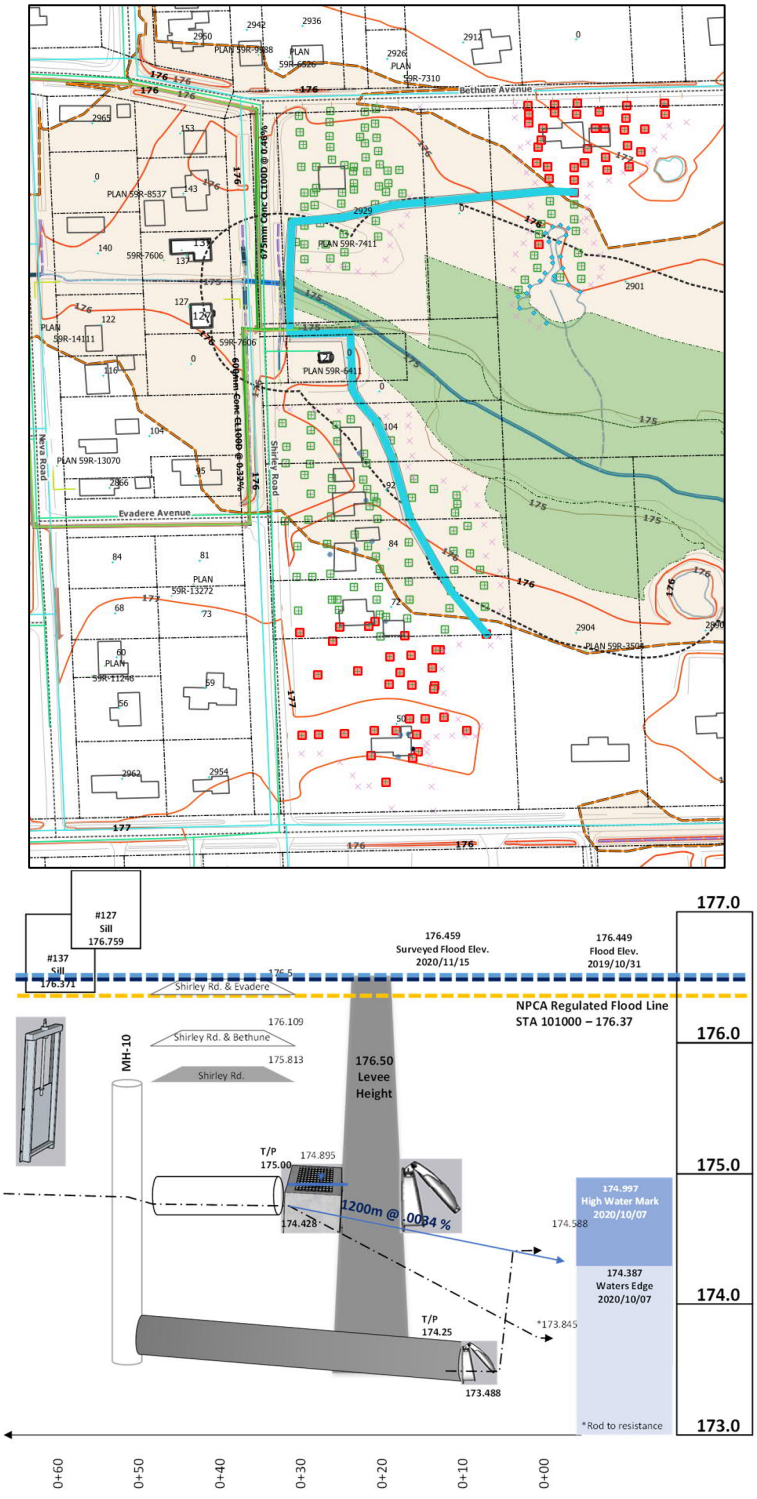


Figure 18 Plan and Profile Views of Option #1 - Berm

This option requires the installation of back flow prevention flap gates on the two existing outlets, which may be required to extend through the berm.

Table 3 Option #1: Berm Qualitative Analysis

Criteria	Description
Effective	Protects to elevation 176.5m Flap gates cause increase in discharge head on surface flows and submerged outlet flows.
Approvable	Requires: - Work Permit required within 30m of PSW. - Environmental Impact Study (EIS) - HEC model updates to show re-vised flood impacts. - No DFO impacts
Constructable	Some works are shown on private property.
Capital Cost	Berm Construction: - 360m - Double CB with grate - Pipe - Flap gate on surface outlet - Flap gate on existing submerged outlet - Design & Approvals require updates to the Flood forecasted models. - 7 properties are affected by the berm.
Operating Cost & Practices	Maintenance is predicted for the flap gates to ensure they can seal. The submerged outlet is a concern for maintenance and effective discharge.

5.3.2 Option 2: Berm, flap gate and a stormwater pump system

Option #2 adds a pumping station capability to the berm to move water from the protected side of the berm to the discharge or highwater side of the berm. This ensures that regardless of the elevation of water on the other side of the berm, stormwater runoff is still conveyed to sufficient outlet.

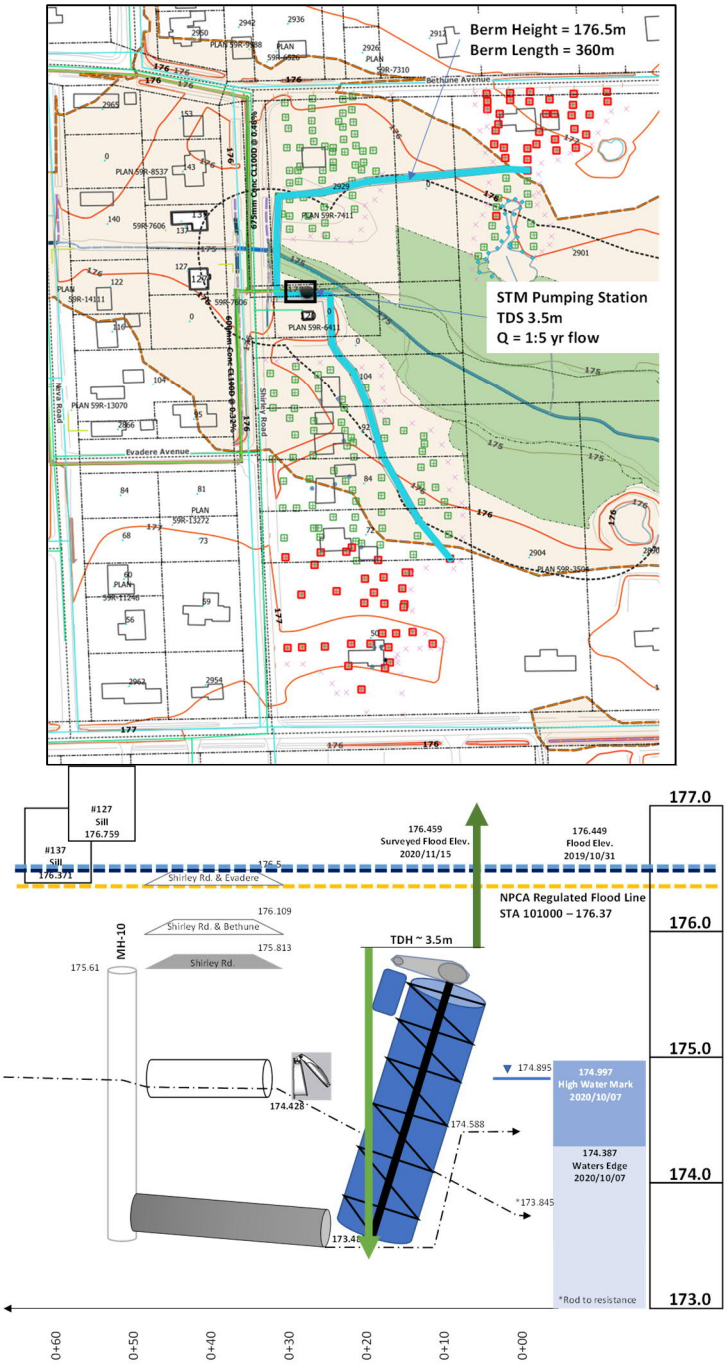


Figure 19 Option 2: Pumping System with Flap gate and berm

Table 4 Option #2: Pump Station and Berm Qualitative Analysis

Criteria	Description

Effective	Protects to elevation 176.5m Flap gates cause increase in discharge head on surface flows. 300mm pump is selected using a electric motor with no back up power nor standby pump. Pump works or doesn't work and is to be repaired on emergency basis if required. Temp pump can be deployed at Double CB with grate. Hydraulic pumping draws down standing water in pipe and surface flows, if piping is adjusted to 'pull' surface water into the piping system. Right now the two are mostly separated but possibly hydraulically connected by through a slow groundwater movement connection.
Approvable	Requires: Work Permit required within 30m of PSW. Environmental Impact Study (EIS) HEC model updates to show re-vised flood impacts. No DFO impacts
Constructable	Some works are shown on private property.
Capital Cost	Berm Construction: 360m Double CB with grate Pipe Flap gate on surface outlet Pump on submerged outlet Hydraulic changes on piping system to include surface water. Single Pump, no backup power. Suction pipe & pump size 300mm (subject to review). Design & Approvals more significant effort required for a pumping station including MOECP ECA. 7 properties are affected by the berm.
Operating Cost & Practices	Mechanical pumping systems require regular scheduled maintenance and additional unscheduled maintenance is expected as necessary. Maintenance is predicted for the flap gates, grates or any equipment that can be clogged from normal operation. Electricity costs to run the pump will be an ongoing expenditure. Pump service life is roughly 25 years and pump replacement will be on a service life schedule. Regular maintenance and site inspections are anticipated along with requirements to ensure site security.

5.3.3 Option 3: Slide gates on SMC downstream side of Thunder Bay Road.

This option moves the structure to protect from lake effect seiches to Thunder Bay Road at the crossing of Six Mile Creek (SMC). This will require construction of an independent backflow prevention structure along additional berms to raise the elevation downstream of the road to 176.5m, which is consistent with 0.4m higher than the existing deck of the bridge. The existing bridge opening is 9m (span) with an estimated height of 2m.

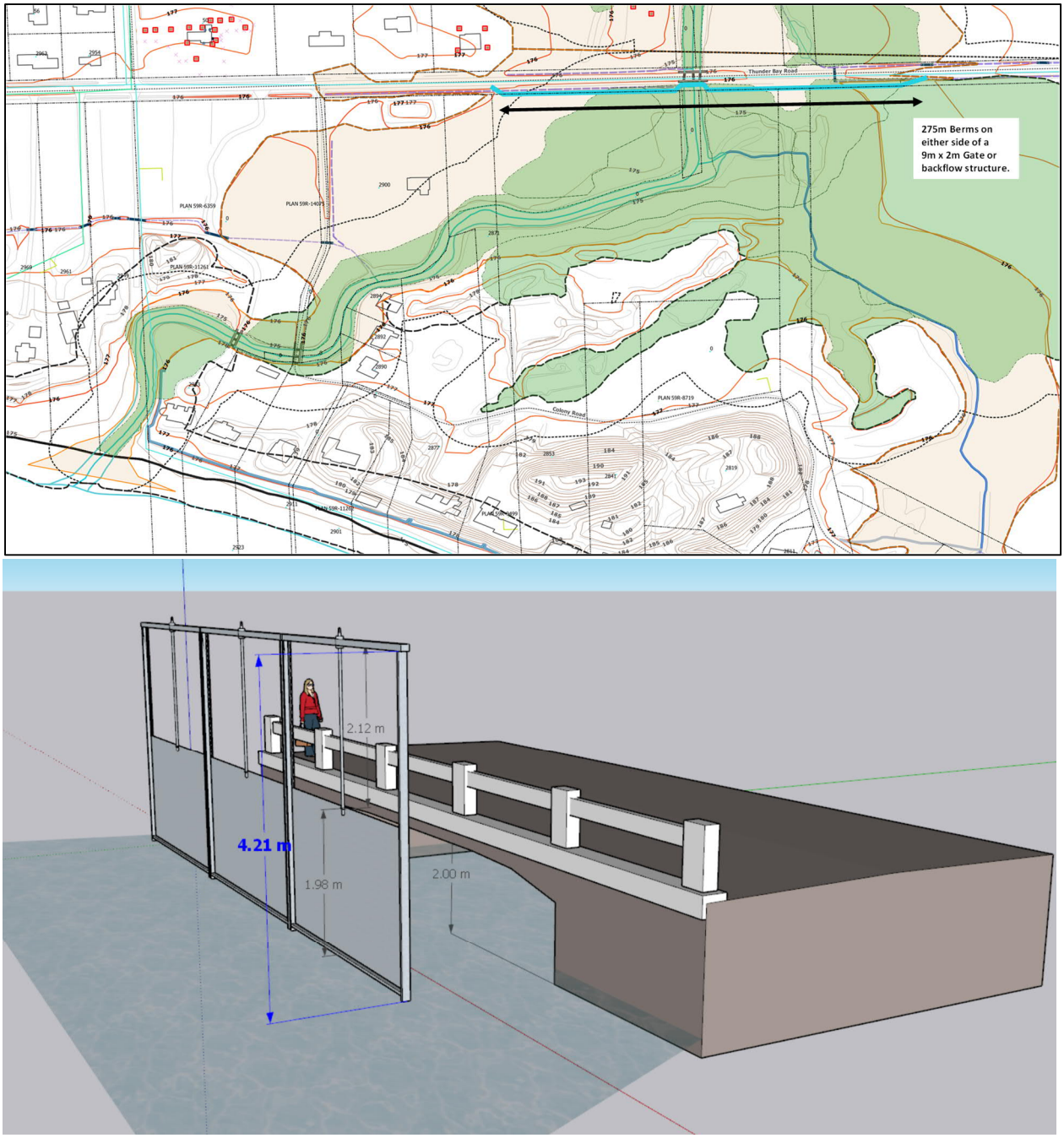


Figure 20 Option 3 Backflow structure on SMC at Thunder Bay Rd.

The solution to backflow shown above is a standard vertical gate structure that is operated, raised and lowered, through the use of threaded rods and motorized actuators that can be remotely operated. This structure will be required as a self-standing installation that does not impact the upstream bridge in any way and is independent of the existing bridge structure.



Flexible Flap Gates are manufactured with a stainless steel frame and a reinforced neoprene cover. To aid in the sealing of the gate, a flexible neoprene seal is mounted to a steel frame. This type of gate may be a suitable option for using on the downstream side of the existing bridge with supporting steel work that may include screw piles.

Table 5 Option #3: SMC Backflow at Thunder Bay Rd Qualitative Analysis

Criteria	Description
Effective	Protects to elevation 176.5m Slide gates block both ways. Can involve automation to close on detection of rising inlet water level. Use or consider flap gates to reduce costs and maintenance.
Approvable	Requires: Work Permit required within 30m of PSW. Environmental Impact Study (EIS) HEC model updates to show re-vised flood impacts. DFO impacts and approval likely required. In-stream work required. Will require significant analysis for automated gate closure.
Constructable	Challenging site for construction. Presumed to need footings to support gates adjacent to existing bridge. Works to connect to bridge but have no structural load transferred to existing bridge.
Capital Cost	Berm Construction: 275m total length Includes three 3mx2m gates, total of 9m span. Automation, including level monitoring with Internet connection. Automatic closure requires more design and technology effort (warning lights and siren). Design & Approvals will be significant for two aspects; larger upstream are impacted along with the potential risk of stream flow impacts during low flow events.
Operating Cost & Practices	Maintenance is predicted for the gates to ensure they can seal. Consideration to heat the slide mechanics to allow closure in winter. Ice may be present on the gate but open water on the lake. Actuators will require scheduled maintenance as will any security adopted at site.

5.3.4 Option 4: Retreat from flooding using property purchase.

Two (or 3) properties to purchase;

- 137 Shirley Rd. (MVA is $ 230,000)
- 127 Shirley Rd. (MVA is $ 235,000)
- 0-5829 Shirley Road. Empty lot south of #127. (MVA is $5,800)

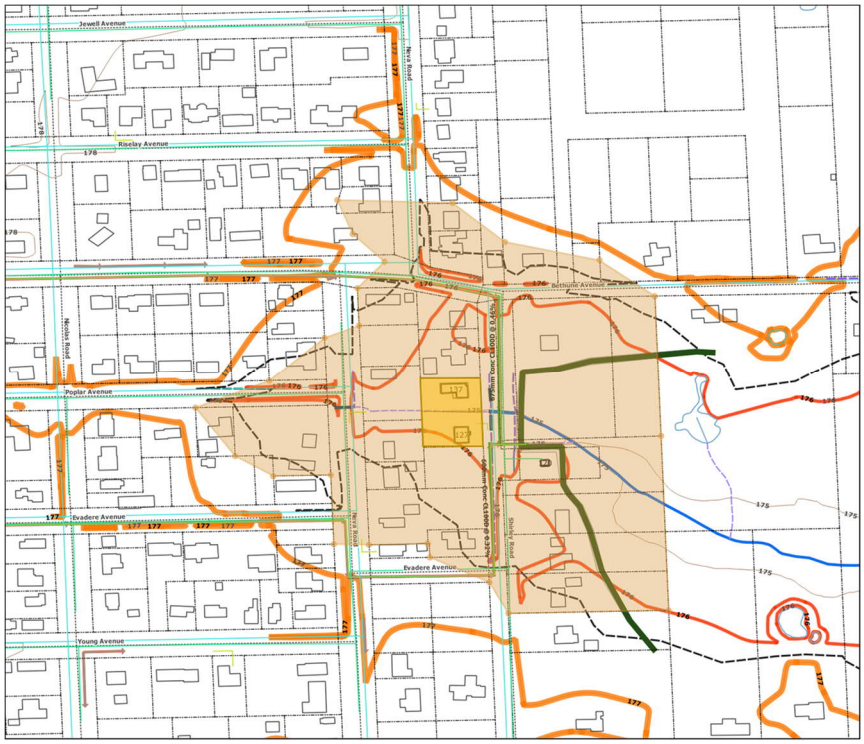


Figure 21 Retreat Potential Impact Zone

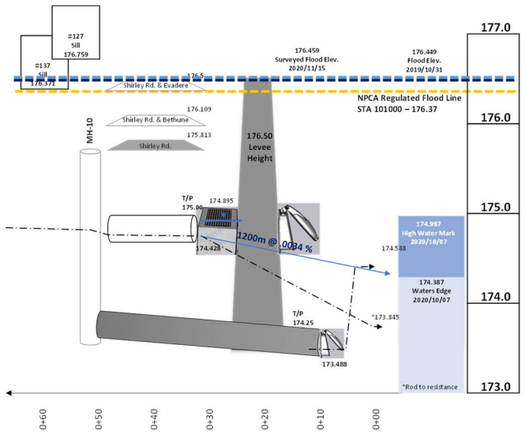
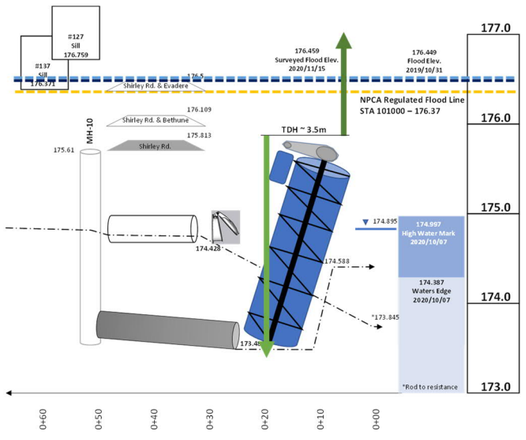
The orange line is contour line at elevation 177m and the red line is for elevation 176m. The shaded area is the estimated extent of the 176.5m flood zone which is different from the riverine flood zone of 176.37m. Not all properties within the seiche zone are affected or impacted.

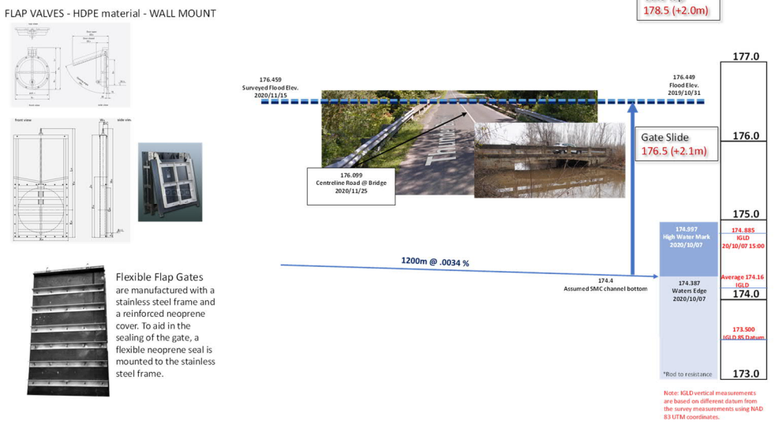
Table 6 Option #4: Retreat by removing flood impacted homes Qualitative Analysis

Criteria	Description
Effective	No protection for any other houses on Shirley Rd. The seiche impact is greater than just these 2 houses but the degree of impact is not assessed.
Approvable	Meets regulatory conditions
Constructable	No construction but demolition of two houses is required.
Capital Cost Number of properties affected:	Two houses (3 properties) * potentially precedent setting.
Operating Cost & Practices	None

5.4 Option Comparison

Table 7 Option Analysis Summary Table

Option	Profile	Effective	Approvable	Constructable	Capital Cost	Operating Cost & Practices
#1 Levee with two backwater controls.		Controls to elevation 176.5m consistent with built Levee or raised road as a barrier.	Challenge to approved works within the Provincially Significant Wetland	Flap gates on elliptical culvert requires design attention. (basin with new outlet) Flap gates on submerged outlet risk sediment blocking seal. Flap gates increase the outlet head for stormwater runoff flows. Levee has several possible locations, but the location shown is both within the regulated fill limit and the wetland designation. Flap gates increase the outlet head for stormwater runoff flows.	**Project Budget $775,000** Significant cost to raise the road. Significant asset sunk cost since Shirley Rd. not on rehab list, for 20+ years. Local clay sourced core for the berm in to achieve a avg. height of 0.82m. Addition of new CSP with flap gates or other backflow prevention is required. Berm Construction: 325m @ $115/m = $37,500 Double CB with grate Pipe Flap gate on surface outlet Flap gate on existing submerged outlet Design & Approvals $185,000 7 properties are affected by the berm.	Requires maintenance to ensure the flag gates close properly. Slide gates requires operation unless operated by actuators which increases the capital costs.
#2 Culvert Flap Gate & Pump		Controls to existing road height or to new berm height. Pump rate of flow has significant impact on flood levels. 300mm pump is selected using a electric motor with no back up power nor standby pump. Pump works or doesn't work and is to be repaired on emergency basis if required. Temp pump can be deployed at Double CB with grate. Hydraulic pumping draws down standing water in pipe and surface flows, if piping is adjusted to 'pull' surface water into the piping system.	Requires: Work Permit required within 30m of PSW. Environmental Impact Study (EIS) HEC model updates to show re-vised flood impacts. No DFO impacts	Some works are shown on private property. Existing submerged outlet offers a possible pumping system platform. Significant design and construction effort to build. Additional approvals. Backup generator? To ensure operation during a storm. Available local hydro supplied from the LDC was not evaluated as meeting the needs of a pump station.	**Project Budget $1,375,000** Berm Construction: 325m @ $115/m = $37,500 Double CB with grate Pipe Flap gate on surface outlet Pump on submerged outlet Hydraulic changes on piping system to include surface water. Single Pump, no backup power. Suction pipe & pump size 300mm (subject to review). Design & Approvals $220,000 7 properties are affected by the berm.	Mechanical device will require regular maintenance and a life – cycle replacement schedule. Pump consumes electricity, which is an increased operating cost. It would be recommended to put any pump through the Drainage Act and distribute the costs locally and within the watershed.

Option	Profile	Effective	Approvable	Constructable	Capital Cost	Operating Cost & Practices
#3: Backflow control on SMC downstream side of Thunder Bay Road. 		Controls to a constructed height of 176.5m. Preferred option may be the flexible backwater flap gates using HDPE	Solution was suggested by the NPCA as viable. Requires significant analysis including: EIS, HEC analysis and downstream impact study.	installation independent of existing concrete 9m bridge structure. Requires in water construction work with significant bypass with environmental controls.	**Project Budget $650,000 to $850,000 depending on type of back flow gate.** Berm Construction: 205m @ $115/m = $31,000 3 Knife Gates, 2. x 3m with threaded rods and actuators. Automation, including level monitoring with Internet connection. Automatic closure requires more design and technology effort (warning lights and siren). Design & Approvals $220,000 7 properties are affected by the berm directly but upstream properties are protected by the gate.	Maintenance is predicted for the gates to ensure they can seal. Consideration to heat the slide mechanics to allow closure in winter. Ice may be present on the lake.
#4 Retreat from Flooding; Purchase affected properties. 		Does not address flooding for other properties which have yet come forward.	Requires no environmental approvals.		Estimate $850,000	$0

5.5 Agency Consultation

As part of the evaluation of the preferred alternatives a preliminary discussion was conducted with agencies to solicit views on proposed works and approval requirements.

5.5.1 Niagara Peninsula Conservation Authority (NPCA)

A consultation meeting was held with NPCA on November 23, 2020 using MS Teams. A short presentation to NPCA to provide the background of the flooding issues was made and a discussion of options followed.

Based on this being proposed and existing municipal works, there is some basis for review and approval by NPCA within the wetland and within the wetland buffer.

For any option considered the following are required:

- Environmental Impact Study (EIS)
- Review and update of the flood lines based on any proposed changes with the flood zone. Update of the US Army Corps of Engineers Hydraulic Engineer Centre data file (HEC). Latest version is Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) version 5.0.7
- Permit for work within the cut/fill control zone.

Note 1: Current legislation being considered by the Province may impact or affect the role and regulation by conservation authorities with regards to Provincially Significant Wetlands.

A follow up discussion to clarify requirements was held January 28, 2021. Meeting notes are included in Appendix C.

5.5.2 Ministry of the Environment, Conservation and Parks

Stormwater works, such as those being proposed for implementation, would require an Environmental Compliance Approval (ECA) by providing Technical Information for a Part C – Sewage Works review.

On October 31, 2011, an environmental approvals system came into effect in Ontario. The system allows businesses to register certain activities with the ministry, rather than apply for an approval (known as the Environmental Activity and Sector Registry - EASR).

In the Technical Information section (i.e. Parts A to G) ministry staff verifies if the submitted documentation and its content are complete for the application type. To do so, at Stage 1 of the ministry’s application screening process, staff

employs a "Pass/Fail" test to verify if, on the face of the application, the appropriate documents are included in the submission. The requirements for the test are spelled out in provincial environmental legislation and ministry policies and guidelines.

At Stage 2, ministry staff engages in a preliminary engineering review of the application and supporting documents and makes a determination if the submission is complete. If the submission is deemed incomplete, the applicant will be notified of the deficiencies or the file may be closed. If the submission is deemed complete, the file moves to the full technical review stage.

Some of the information requirements are as follows:

Engineering Drawings, stamped and signed by P.Eng.:

- pre-development catchment areas
- post-development catchment areas
- site plan of existing and proposed SWM works, including outlet location(s)
- design details of each treatment train components of the SWM system
- detailed cross-section of any outlet structure(s), including elevations for the control run-off event
- proposed erosion and sedimentation control plan

Additional Information: (may apply)

- Conservation Authority (CA) or Ministry of Natural Resources (MNR) or MECP clearance
- CA, MNR or MECP comments
- Geotechnical/ Hydrogeological Investigation Report
- EAASIB staff to note if the application includes any correspondences with MECP offices (District Office or Technical Support Section)
- Map of sampling location (existing works)
- Analytical results of any sampling taken at the site
- Receiving Water Body information
- Pre-Development Flow and Post-Development Flow Quantities Table
- Major Flow Routing
- Proposed operation and maintenance procedures for the works
- Schedule of ICD
- Proposed monitoring
- Water Balance
- Lake Simcoe Protection Plan (SWM Report requirements: Enhanced level of protection)
- Phosphorus Budget
- Proposed Erosion and Sediment Control Plan

5.5.3 Department of Fisheries and Oceans (DFO)

DFO consultation review is considered for any work that would impact fish or fish habitat. Options proposed on Shirley Rd. would not meet that condition as

the portion of the channels are dry for considerable times during the year depending on lake elevation.

DFO would be consulted on any proposed works within the SMC watercourse.

The following figure from OMAF AgAtlas shows the DFO drain classification for streams.

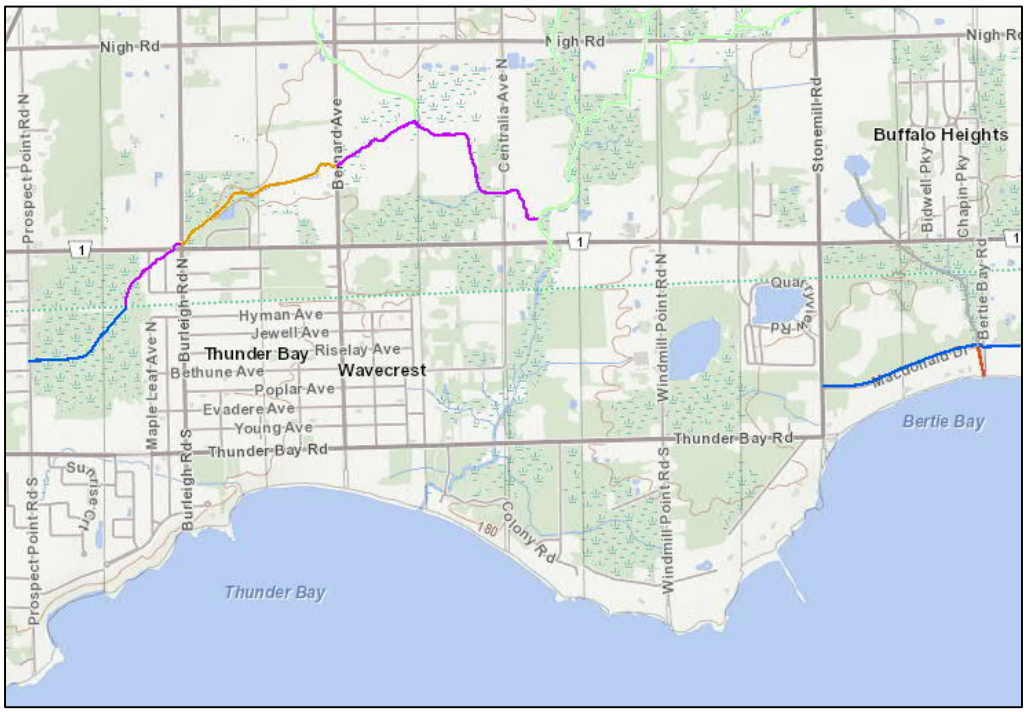


Figure 22 DFO Drain Classification for works affecting fish or habitat

5.5.4 OMAFRA Drainage Act

Landowner(s) could make a petition under Section 4 for sufficient outlet and create a new municipal drain under the Drainage Act for any works proposed. This would assess the costs for the works to upstream contributing landowners. A petition under Section 4 requires: a) the majority of landowners in the watershed, b) the owners representing 60% of the watershed area, or c) a road superintendent or someone having jurisdiction over the roads, if drainage is required for a road.

The Drainage Act has a very prescriptive process to achieve a drainage works through an appointed Engineer's Report, and the opportunities for appeals require a significant schedule and time commitment. The benefit is the equitable assessment of costs to upstream owners, including future maintenance costs in perpetuity.

5.6 Preferred Option Evaluation

This evaluation is performed based on the data available at the time of the study. The options considered have not been designed and there are many details outstanding that could or would affect and impact the evaluation.

A points system is used to evaluate each of the identified options:

- A high score reflects the ease of accomplishment or the quality of the solution.
- A low score reflects the difficulty to achieve and the lower value of resulting benefit.
- CAPEX – Capital Expenditure is an estimate prepared for each option. (see Appendix)
- OPEX – Operational Expenditure are each an estimate based on available data.
- TCO – Total Cost of Ownership: CAPEX + OPEX * Design life (25 years)

Table 8 Option Solution Effectiveness Score

Options	Effective	Approve	Construct	Effectiveness Score (30)
#1 Levee with two backwater controls.	8	4	7	**19**
#2 Culvert Flap Gate & Pump	9	4	5	**18**
#3a: Knife Gates with motorized control on SMC downstream side of Thunder Bay Road.	8	3	6	**17**
#3b: Flap Gates at Thunder Bay Road	8	3	8	**19**
#4 Retreat from Flooding; Purchase affected properties.	7	10	9	**26**

The most effective solution for lowering surface water on the upstream side of Shirley Rd. is the berm and pump. This option prevents backflow while the pump lowers the potential runoff flows. However, as the pump is to be sized for a 1:5 year storm, there are circumstances where flooding could still occur.

The retreat doesn't remove the flooding but it does mitigate the perceived negative impacts of the flooding event itself. We have assumed that demolition would be a requirement for the retreat option.

Environmental approvals are not required for the retreat option as there is no infrastructure proposed that would require approvals. The environmental approvals for the berm to the East of Shirley Road would be considerable as some of the works would occur within the regulated wetland and definitely within the 30m buffer. The construction of the berm and the backflow prevention would impact the existing flood lines and an update to the flood mapping models would be required. The berm would require permission for construction on private property. A cost to proceed with this is not included as it is assumed that property owners will 'opt in' to the proposed option.

The most difficult to approve option would be the flood gates located on the SMC downstream of the Thunder Bay Rd. This would involve a larger update to the flood mapping study and models, plus additional consideration of environmental impacts of preventing backflows into the lower reaches of the Six Mile Creek Watershed.

The pumpstation is the most difficult to construct option, requiring work on a wetwell and other infrastructure works within a wetland setting.

Table 9 Option Evaluation

Options	CAPEX	OPEX	TCO	Pts/$ (per $100,000)
#1 Levee with two backwater controls.	$775,000	$3,000	$850,000	**2.24**
#2 Culvert Flap Gate & Pump	$1,375,000	$10,000	$1,625,000	**1.11**
#3a: Knife Gates with motorized control on SMC downstream side of Thunder Bay Road..	$950,000	$3,000	$1,025,000	**1.66**
#3b: Flap Gates at Thunder Bay Road	$750,000	$3,000	$825,000	**2.30**
#4 Retreat from Flooding; Purchase affected properties. [1]	$850,000 to $4.5M	$0	$850,000	**3.06 to 0.58**

1 – using purchase of 2 properties only. Additional properties to purchase as a contingency.

The highest scoring option, assuming that only two properties are purchased, is the retreat option. However, this sets a precedent that can't be ignored and if other properties are also required to be purchased, then this score can be as low as 0.58, making it also the lowest scoring option. This recognizes the inherent unknown aspects of the potential extent of cost implications for the retreat option.

The next highest scoring option is the use of a flap gate structure at the Thunder Bay Road Six Mile Creek bridge. This option is only slightly better than the berm with backwater controls at Shirley Rd. because of the lower total cost of construction that is represented by the flap gates instead of the proposed sliding sluice gates which are the most costly to construct and operate. A major feature of the flap gates is the passive operation of the close or open function, which does not require an operator or an active control operation to function. The sluice gate option does require either an operator or some form of automation to open and close the gates. The additional infrastructure works to operate the sluice gate option at Thunder Bay Road is considerable.

The lowest scoring option is the pumping station with berm option, which is largely a result of the considerable capital and operating expense required for this option.

Recognizing that there are only two properties at the centre of the report identified in the general discussion, there are other properties that would benefit from these proposed works. The concept of a benefit is not assessed by this study of options for improving the stormwater management and reducing the risk of flooding in the Shirley Rd. area. A cost benefit analysis of a preferred solution based on the potential benefitting properties would be of value in the consideration of a project for funding.

6 Observations:

The following observations are provided for consideration.

1. As a preliminary design option analysis, the final design is not detailed for any one particular solution. The preferred solution is thus a class of elements that could be changed or adjusted by the final design process into a final design to solve the stated problem.

2. There are two solutions that are simpler that the others to implement from a constructability view.

    a. Option 1: A berm with backflow prevention gates on the two outfalls, and

    b. Option 3: A flap gate on the downstream side of the Thunder Bay Rd. bridge over Six Mile Creek.

3. Option 1: Berm with backflow flap gates is the most local solution to implement for protecting addresses #127 and #137 of Shirley Rd. However, the berm would have to be 360m long to be effective and requires construction on several parcels of private property.

4. Option 3: A storm gate on SMC has environmental implications that are considerable. The implementation of a control structure on SMC to prevent Lake Erie storm induced flooding of the wetland may be evaluated as a significant negative environmental impact. It is effective at preventing upstream flooding of the subject area on Shirley Rd., but also of other areas impacted by surge/seiche flooding. Thus, the impacts of the proposed option have wider impact than just the Shirley Rd. area.

    The proposed 9m span may require a gate structure that will introduce drag or friction factors that impact existing storm runoff events. This outfall impact will require significant effort to analyze during the design stage as it will require two cases for consideration:

    a. Case 1: show the impact of preventing storm surge/seiche events for scenarios including partial closure of the proposed control structure.

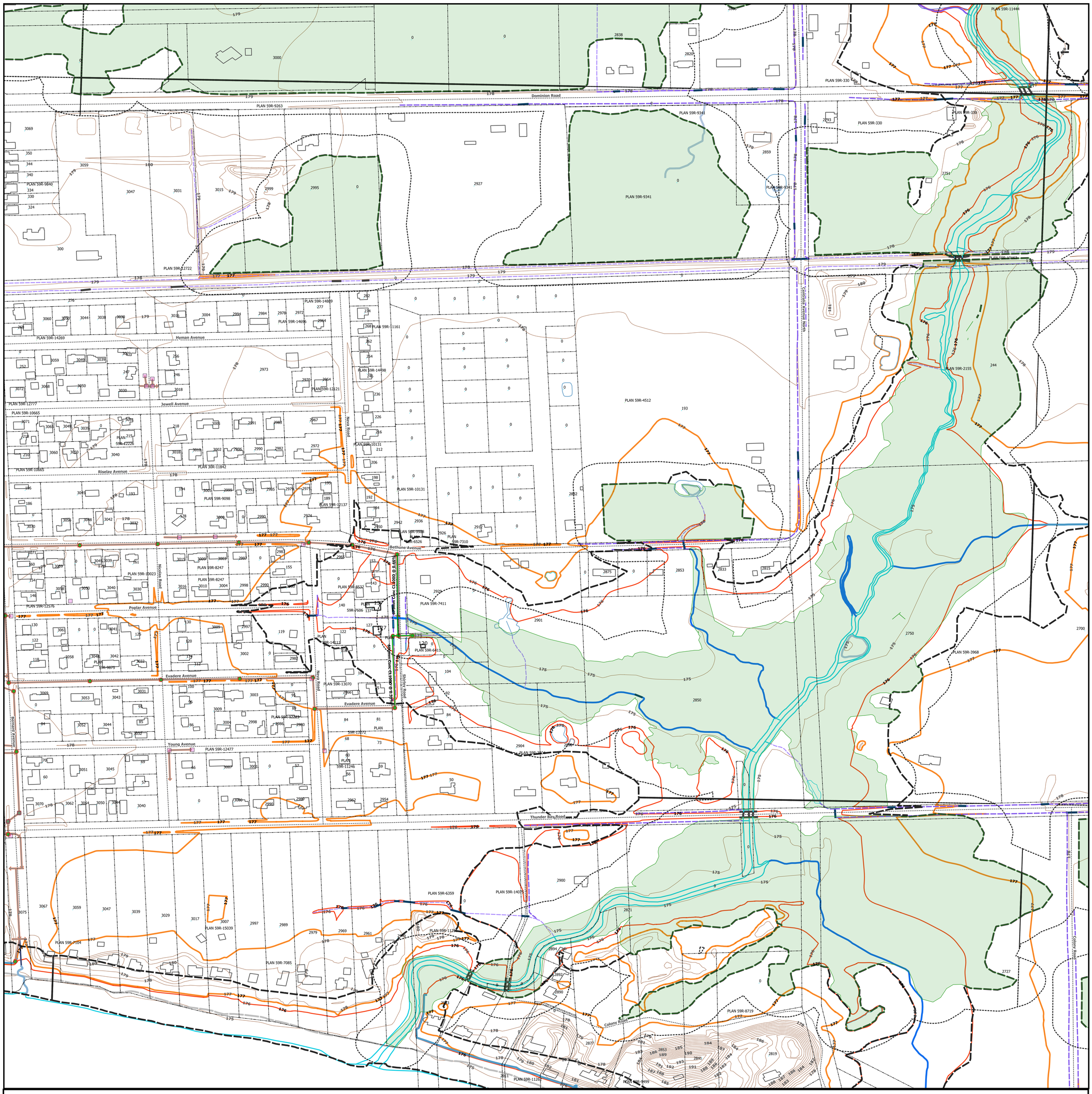
    b. Case 2: Runoff flood events where the existing bridge and the new flood control structure are identified as an existing constraint on flows to the Lake. New flood lines are expected and these could increase flooding on some properties from precipitation runoff events.

5. These costs, roughly $850,000, are significant for the benefit of two properties, although other properties will benefit.

6. Using the Drainage Act to assess costs to benefitting properties would require a significant acceptance for the proposed works. Opposition to the proposed works may be considerable and delay implementation until all appeals have been heard.

7. Both options, #1 and #3b succeed and for similar estimated Capital costs. The selection of a preferred option between these two would be based on other factors.

Appendix A: Maps and Drawings



25 0 25 50 75 100 m

Map Scale: 1:1000

Shirley Rd. Drainage Option Assessment

From survey data collected by TofFE 20201203
Teranet Parcel data dated 202006 - Troy's

Teranet parcel fab June 2016-2020 - Troy's
Teranet parcel fab June 2016-2020 - Troy's entities
- 8-ref plan number
- House Numbers updated July 2016

Teranet parcel fab June 2016-2020 - Troy's entities
- 1-parcel fab

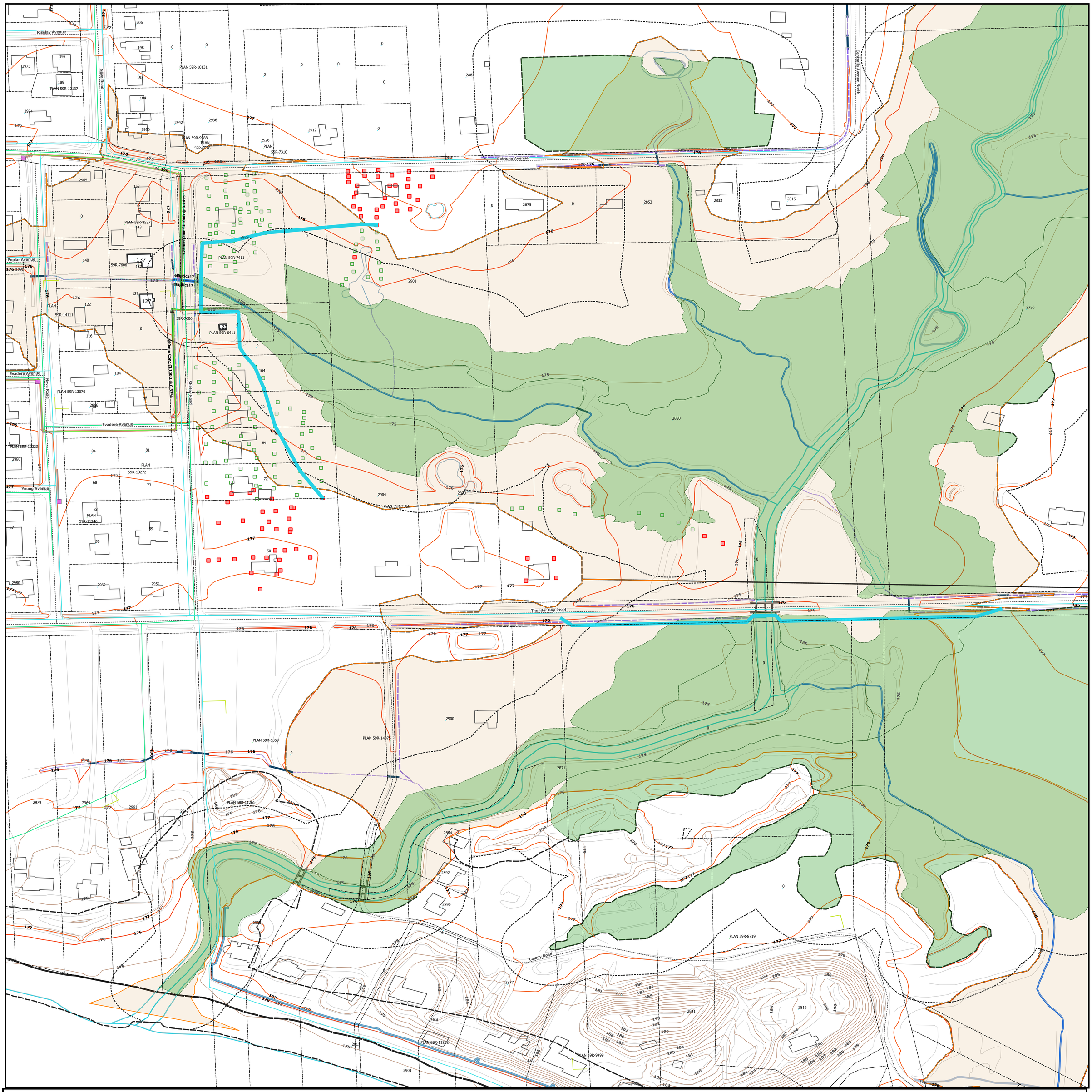
- buildings 2010
- NPCA_MUNICIPAL DRAINS-LINE
- GR_WetlandAllowance_NPCA
- Roads
- build
- GR_RegulatedWetlands_NPCA
- GR_RegulationAreaLimit_NPCA

Pipe
- Access_cul
- STMPipe
- STMCulvert
- Tbay_Catchbasins
- Tbay_Stm_MH
- Tbay_Stm_Swr

ContemporaryMappingofWatercourses
- Bridge/Overpass
- Conduit
- Culvert
- Ditch - Agricultural
- Ditch - Other
- Ditch - Roadside
- Headwater
- Island
- Pipe/Inlet/Outlet/Outfall
- Pond - Other
- Retaining Wall
- Rural Drainage
- Slough
- Stream/Creek
- Waterbody - Great Lakes
- Waterbody - River
- Waterbody - Seasonal
- MUNICIPAL_BOUNDARY_LOWER_AND_SINGLE_TIER
- Contours - 177.0
- Contours - 176.0
- Contours

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25 0 25 50 75 100 m

Map Scale: 1:600

Shirley Rd. Proposed Berm Alignment

From survey data collected by TofFE 20201203
Teranet Parcel data dated 202006 - Troy's

Teranet parcel fab June 2016-2020 - Troy's
Teranet parcel fab June 2016-2020 - Troy's entities
- 8-ref plan number
- House Numbers updated July 2016

Teranet parcel fab June 2016-2020 - Troy's entities
- 1-parcel fab
- 8-ref plan number

- buildings 2010
- TOFE-SANITARY_SEWER-LINE
- TOFE-STORM_SEWER-LINE
- TOFE-WATER_MAIN-LINE
- berm

SHIRLEY RD - PUMP STATION AREA 4000 SERIES copy
- 175.36 - 176.5
- 176.5 - 177.33

- GR_WetlandAllowance_NPCA
- EPA_Provincial_Sig_Wetlands
- Roads
- build
- GR_RegulatedFloodplains_NPCA
- GR_RegulationAreaLimit_NPCA
- Breaklines

swale
- Channel
- Open
- Roadside

Pipe
- Access_cul
- STMPipe
- STMCulvert

- Tbay_Catchbasins
- Tbay_Stm_Swr

ContemporaryMappingofWatercourses
- Bridge/Overpass
- Conduit
- Culvert
- Ditch - Other
- Ditch - Roadside

- Headwater
- Island
- Pond - Other
- Retaining Wall
- Slough
- Stream/Creek
- Waterbody - Great Lakes
- Waterbody - River
- Waterbody - Seasonal

- MUNICIPAL_BOUNDARY_LOWER_AND_SINGLE_TIER
- Contours - 177.0
- Contours - 176.0
- Contours

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Appendix B: Hydrologic and Hydraulic Model Data

```
[TITLE]
;;Project Title/Notes

[OPTIONS]
;;Option             Value
FLOW_UNITS           CMS
INFILTRATION         CURVE_NUMBER
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO

START_DATE           11/01/2020
START_TIME           00:00:00
REPORT_START_DATE    11/01/2020
REPORT_START_TIME    00:00:00
END_DATE             11/02/2020
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:01:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         5
RULE_STEP            00:00:00

INERTIAL_DAMPING     PARTIAL
NORMAL_FLOW_LIMITED  BOTH
FORCE_MAIN_EQUATION  H-W
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              4

[EVAPORATION]
;;Data Source    Parameters
;;-------------- ----------------
CONSTANT         0.0
DRY_ONLY         NO

[RAINGAGES]
;;Name           Format    Interval SCF      Source
;;-------------- --------- -------- -------- ----------
SCS_Type_II_69.6mm_5yr VOLUME    0:06     1.0      TIMESERIES SCS_Type_II_69.6mm_5yr

[SUBCATCHMENTS]
;;Name           Rain Gage        Outlet           Area     %Imperv  Width    %Slope   CurbLen  S
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- -
P1               SCS_Type_II_69.6mm_5yr J16        3.8814   40       150      0.2      0
P2               SCS_Type_II_69.6mm_5yr J17        1.9494   40       75       0.2      0
W1               SCS_Type_II_69.6mm_5yr J2         2.1136   40       80       0.2      0
W2               SCS_Type_II_69.6mm_5yr J19        9.3895   40       300      0.2      0
W3               SCS_Type_II_69.6mm_5yr J18        5.873    40       225      0.2      0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
```

```
P1               0.01       0.1        0.05       0.1        10         OUTLET
P2               0.01       0.1        0.05       0.1        10         OUTLET
W1               0.01       0.1        0.05       0.1        10         OUTLET
W2               0.01       0.1        0.05       0.1        10         OUTLET
W3               0.01       0.1        0.05       0.1        10         OUTLET

[INFILTRATION]
;;Subcatchment   Param1     Param2     Param3     Param4     Param5
;;-------------- ---------- ---------- ---------- ---------- ----------
P1               83         0          7          7          0
P2               83         0          7          7          0
W1               83         0          7          7          0
W2               83         0          7          7          0
W3               83         0          7          7          0

[JUNCTIONS]
;;Name           Elevation  MaxDepth   InitDepth  SurDepth   Aponded
;;-------------- ---------- ---------- ---------- ---------- ----------
Con-01           174.455    1.631      0          0          0
J1               174.428    0.922      0          0          0
J10              0          0          0          0          0
J11              0          0          0          0          0
J12              0          0          0          0          0
J13              174.25     1.25       0          0          0
J14              174.35     1.15       0          0          0
J15              174.615    1.063      0          0          0
J16              176.3      1.7        0          0          0
J17              176.2      1.85       0          0          0
J18              174.7      0.9        0          0          0
J19              175.5      0.4        0          0          0
J2               174.393    0.99       0          0          0
J3               0          0          0          0          0
J4               0          0          0          0          0
J5               0          0          0          0          0
J6               0          0          0          0          0
J7               0          0          0          0          0
J8               0          0          0          0          0
J9               0          0          0          0          0
MH10             173.6      2.01       0          0          0
MH11             173.713    1.831      0          0          0
MH12             174.08     2.342      0          0          0
MH8              174.103    1.923      0          0          0
MH9              173.8      1.81       0          0          0
P_Outfall        173.1      2.553      0          0          0

[OUTFALLS]
;;Name           Elevation  Type       Stage Data       Gated    Route To
;;-------------- ---------- ---------- ---------------- -------- ----------------
OF1              174.2      FIXED      174.599          NO

[CONDUITS]
;;Name           From Node        To Node          Length     Roughness  InOffset   OutOffset  In
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- --
C1               MH11             MH10             5.985      0.013      0          0          0
;Shirley Rd Twin Ellipitical Culverts
C10              J2               J1               14.007     0.01       0          0          0
C11              J15              J2               32.116     0.024      0          0          0
C12              J16              MH8              404.29     0.015      0          0          0
C13              J17              MH12             401.713    0.015      0          0          0
C14              J18              J15              49.109     0.024      0          0          0
C15              J19              J2               84.97      0.024      0          0          0
C2               MH10             P_Outfall        16.232     0.013      0          0          0
C3               MH9              MH10             26.662     0.013      0          0          0
C4               MH8              MH9              89.017     0.013      0          0          0
```

```
C5               MH12             MH11             99.657     0.013      0          0          0
C6               J1               Con-01           38.301     0.024      0          0          0
C7               P_Outfall        Con-01           24.072     0.01       0          0          0
C8               Con-01           J14              403.626    0.024      0          0          0
;Six Mile Creek
C9               J14              J13              686.835    0.01       0          0          0

[OUTLETS]
;;Name           From Node        To Node          Offset     Type              QTable/Qcoeff    Q
;;-------------- ---------------- ---------------- ---------- ----------------- ---------------- -
OL1              J13              OF1              0          FUNCTIONAL/DEPTH 10                0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels    Culver
;;-------------- ------------ ---------------- ---------- ---------- ---------- ---------- ------
C1               CIRCULAR     0.6              0          0          0          1
C10              HORIZ_ELLIPSE 7               0          0          0          2
C11              TRAPEZOIDAL  0.8              1.5        1          1          1
C12              CIRCULAR     0.5              0          0          0          1
C13              CIRCULAR     0.5              0          0          0          1
C14              TRAPEZOIDAL  0.75             1.2        1.5        1.5        1
C15              TRAPEZOIDAL  0.35             0.5        1          1          1
C2               CIRCULAR     0.675            0          0          0          1
C3               CIRCULAR     0.675            0          0          0          1
C4               CIRCULAR     0.675            0          0          0          1
C5               CIRCULAR     0.6              0          0          0          1
C6               TRAPEZOIDAL  0.4              1.7        1.5        1.5        1
C7               RECT_OPEN    0.858            2.4        0          0          1
C8               TRAPEZOIDAL  0.75             3.6        1          1          1
C9               TRAPEZOIDAL  0.85             4.5        1          1          1

[LOSSES]
;;Link           Kentry     Kexit      Kavg       Flap Gate  Seepage
;;-------------- ---------- ---------- ---------- ---------- ----------

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
;SCS_Type_II_69.6mm design storm, total rainfall = 69.6 mm, rain interval = 6 minutes, rain units
SCS_Type_II_69.6mm_5yr            0:00       0.0703
SCS_Type_II_69.6mm_5yr            0:06       0.0703
SCS_Type_II_69.6mm_5yr            0:12       0.07169
SCS_Type_II_69.6mm_5yr            0:18       0.07169
SCS_Type_II_69.6mm_5yr            0:24       0.07308
SCS_Type_II_69.6mm_5yr            0:30       0.07308
SCS_Type_II_69.6mm_5yr            0:36       0.07447
SCS_Type_II_69.6mm_5yr            0:42       0.07447
SCS_Type_II_69.6mm_5yr            0:48       0.07586
SCS_Type_II_69.6mm_5yr            0:54       0.07586
SCS_Type_II_69.6mm_5yr            1:00       0.07726
SCS_Type_II_69.6mm_5yr            1:06       0.07726
SCS_Type_II_69.6mm_5yr            1:12       0.07865
SCS_Type_II_69.6mm_5yr            1:18       0.07865
SCS_Type_II_69.6mm_5yr            1:24       0.08004
SCS_Type_II_69.6mm_5yr            1:30       0.08004
SCS_Type_II_69.6mm_5yr            1:36       0.08143
SCS_Type_II_69.6mm_5yr            1:42       0.08143
SCS_Type_II_69.6mm_5yr            1:48       0.08282
SCS_Type_II_69.6mm_5yr            1:54       0.08282
SCS_Type_II_69.6mm_5yr            2:00       0.08422
SCS_Type_II_69.6mm_5yr            2:06       0.08422
SCS_Type_II_69.6mm_5yr            2:12       0.08561
SCS_Type_II_69.6mm_5yr            2:18       0.08561
SCS_Type_II_69.6mm_5yr            2:24       0.087
```

SCS_Type_II_69.6mm_5yr	2:30	0.087
SCS_Type_II_69.6mm_5yr	2:36	0.08839
SCS_Type_II_69.6mm_5yr	2:42	0.08839
SCS_Type_II_69.6mm_5yr	2:48	0.08978
SCS_Type_II_69.6mm_5yr	2:54	0.08978
SCS_Type_II_69.6mm_5yr	3:00	0.09118
SCS_Type_II_69.6mm_5yr	3:06	0.09118
SCS_Type_II_69.6mm_5yr	3:12	0.09257
SCS_Type_II_69.6mm_5yr	3:18	0.09257
SCS_Type_II_69.6mm_5yr	3:24	0.09396
SCS_Type_II_69.6mm_5yr	3:30	0.09396
SCS_Type_II_69.6mm_5yr	3:36	0.09535
SCS_Type_II_69.6mm_5yr	3:42	0.09535
SCS_Type_II_69.6mm_5yr	3:48	0.09674
SCS_Type_II_69.6mm_5yr	3:54	0.09674
SCS_Type_II_69.6mm_5yr	4:00	0.09814
SCS_Type_II_69.6mm_5yr	4:06	0.09953
SCS_Type_II_69.6mm_5yr	4:12	0.10092
SCS_Type_II_69.6mm_5yr	4:18	0.10231
SCS_Type_II_69.6mm_5yr	4:24	0.1037
SCS_Type_II_69.6mm_5yr	4:30	0.1051
SCS_Type_II_69.6mm_5yr	4:36	0.10649
SCS_Type_II_69.6mm_5yr	4:42	0.10788
SCS_Type_II_69.6mm_5yr	4:48	0.10927
SCS_Type_II_69.6mm_5yr	4:54	0.11066
SCS_Type_II_69.6mm_5yr	5:00	0.11206
SCS_Type_II_69.6mm_5yr	5:06	0.11345
SCS_Type_II_69.6mm_5yr	5:12	0.11484
SCS_Type_II_69.6mm_5yr	5:18	0.11623
SCS_Type_II_69.6mm_5yr	5:24	0.11762
SCS_Type_II_69.6mm_5yr	5:30	0.11902
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[REPORT]
;;Reporting Options
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CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]
Link       C10             ShirleyRd
Link       C8              ShirleyRd.Tributary
Link       C9              SixMileCreek

[MAP]
DIMENSIONS       660713.956244667 4748576.58987481 661769.318929647 4749754.36784934
UNITS            Meters

[COORDINATES]
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J13              661366.8           4748664
J14              661721.348         4749063.267
J15              661308.3           4749247
J16              660933.592         4749337.008
J17              660944.119         4749144.973
J18              661259.216         4749248.433
J19              661336.725         4749332.168
J2               661340.412         4749247.285
J3               661340.842         4749242.73
J4               661341.273         4749233.87
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J7               661354.682         4749211.592
J8               661355.022         4749200.766
J9               661355.813         4749192.789
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OF1               661341.344        4748630.125

[VERTICES]
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C8                661627.511        4749095.749
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C9                661720.145        4748900.857
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C9                661582.998        4748856.344
C9                661550.516        4748805.816
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C9                661383.293        4748762.507

[POLYGONS]
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P1                660770.524        4749521.551
P1                660922.398        4749530.148
P1                660926.696        4749564.534
P1                660938.158        4749545.908
P1                661044.183        4749534.446
P1                661044.928        4749526.799
P1                660964.279        4749518.848
P1                660951.217        4749347.896
P1                661123.872        4749351.872
P1                661253.364        4749355.847
P1                661253.931        4749345.056
P2                661268.704        4749121.596
P2                661271.676        4749111.832
P2                661260.213        4749108.435
P2                661257.242        4749155.558
P2                660945.64         4749143.671
P2                660936.725        4749148.341
P2                660884.509        4749146.006
P2                660887.693        4749243.434
P2                660932.474        4749312.116
P2                660957.464        4749246.802
P2                660959.65         4749177.208
P2                661263.397        4749185.487
P2                661268.704        4749121.596
W1                661353.955        4749112.174
W1                661273.894        4749104.525
W1                661271.676        4749111.832
W1                661268.704        4749121.596
W1                661263.397        4749185.487
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W1                661253.364        4749355.847
W1                661293.697        4749352.053
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W1                661353.955          4749112.174
W2                661517.951          4749349.897
W2                661343.292          4749342.35
W2                661293.697          4749352.053
W2                661253.364          4749355.847
W2                661123.872          4749351.872
W2                661095.877          4749351.227
W2                661156.773          4749446.93
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W2                661274.83           4749700.832
W2                661361.081          4749664.715
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W3                660957.464          4749246.802
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W3                661077.868          4749325.746
W3                661085.788          4749337.854
W3                661253.931          4749345.056
W3                661267.562          4749065.627

[SYMBOLS]
;;Gage           X-Coord             Y-Coord
;;-------------- ------------------ ------------------
```

Appendix C: NPCA info

Meeting Record

Meeting
November 23, 2020 @ 14:30 to 15:45
Attendees:

Kelly Walsh <KWalsh@forterie.ca>,
Tim Marotta <TMarotta@forterie.ca>,
George Stojanovic <GStojanovic@forterie.ca>,
David Deluce <ddeluce@npca.ca>,
Steve Miller <smiller@npca.ca>
Paul Marsh, pcmarsh@ewaend.com, EWA Engineering Inc. - MS Teams

Items:

1. Meeting Open:

1.1. Project History and background – K.Walsh

1.2. Project Scope Presentation – P.Marsh

Paul presented the following subjects using Powerpoint.

- Meeting Objectives – Paul Marsh
- Site Background Review – Paul Marsh
- Project Process & Criteria – Paul Marsh
- Options – Paul Marsh

Steve mentioned the high lake levels that cycle from high (current) to low on a 40 year cycle. The levels could stay high for 3 to 5 years but that climate change makes these predictions difficult to rely on. Kelly / Steve pointed out the profile illustration identified that the surge / seiche event rose above the lake level about 1.5m (5 ft).

Steve asked if we had included purchasing property at 127/137 as one of the long list of options. (Paul to make sure it's clearly described in the list of possible options.) The other option being the retrofit of these two properties to flood proof the buildings individually from surge/seiche storm events.

Steve also asked about a Storm surge gate structure similar to Wignell/Eaglemarsh Drains in Port Colborne could be constructed on the lake side of Thunder Bay Rd. The bridge is currently a flow restriction which in part causes some of runoff flooding above.

Paul mentioned a protected height using a berm of 176.0 with the remainder of flood impact being the responsibility of the impacted homeowners. This was not seen as a viable option given the past 2 year history and the likelihood of another similar event over the next 3 to 5 years before the Lake elevation retreats to average levels.

Kelly stated a preference for a berm to meet the identified flood level of 176.50m

David identified that an Environment Impact Study (EIS) would be required for work within the PSW or the 30m buffer lands. NPCA has a biologist that could perform a site review to assess the size /scale of EIS that may be required to be preformed during design. He also mentioned that the Berm would potentially shift the flooding during a runoff event and Steve identified that the HEC model would be available to demonstrate what those impacts may be.

Action: David to discuss the Shirley Rd. site with the NPCA Ecologist/Biologist for a consideration of PSW potential impacts for Public Infrastructure.

Action: Kelly to ask Troy (Surveyor) to collect elevation for the Thunder Bay Rd. Bridge deck.

Action: Paul to revise and update the report preferred options to include Retreat as an option, Berm along Shirley Rd. ROW, Stormwater Pumping and Thunder Bay Rd. Flood wall.

2. Meeting Close (15:45)

Gmail Paul Marsh <pcmarsh@ewaeng.com>

Re: 127/137 Shirley Rd. Drainage improvements Meeting summary

1 message

Paul Marsh <pcmarsh@ewaeng.com> Thu, Jan 28, 2021 at 3:49 PM
To: Darren MacKenzie <DMacKenzie@npca.ca>
Cc: Steve Miller <smiller@npca.ca>, David Deluce <ddeluce@npca.ca>, Adam Aldworth <aaldworth@npca.ca>, Kelly Walsh <KWalsh@forterie.ca>, Tim Marotta <TMarotta@forterie.ca>, George Stojanovic <GStojanovic@forterie.ca>

HI Darren:
Thanks for setting up the meeting today.

The following is a point form record of the discussion.

1. An NPCA permit would be required for all three of the options. Not required for the retreat option.
2. Property access consent required for conducting the EIS.
3. EIS is expected to be a three (3) season study.
4. DFO will be responsible for their own assessment but the expectation is that SMC Option 3 would get far more scrutiny than Option 1 or 2. SMC is identified as a sensitive habitat.
5. The Berm south of the wetland on properties East of Shirley Rd. would appear to cut off the natural drainage into the wetland.
6. The expected effort of study for EIS is similar for all three Options 1, 2 or 3. This effort is estimated at roughly $50,000 but will vary depending on scope and specific investigation involved.
7. An update of the hydraulic analysis will be required. It is not acceptable to solve one problem in one area and cause a problem somewhere else, shifting the problem as a result of the conservation of volume of runoff.
8. Confirmed that the original flood modelling was done in 2008/2010.
9. The options and the potential impact to the existing wetland would be the focus and that no negative impacts to surrounding properties occurs.
10. An easement for the berm to provide access has been anticipated as part of the option.
11. A rough estimate of the total study cost per option was discussed as being $250,000 for EIS and hydraulic study updates.

In addition to these specific points, a recognition of other impacts beyond these specific issues was discussed.

If there is an omission or a clarification in these notes, please reply all with your comment.

Regards,
Paul

--
Paul C. Marsh, P.Eng.
EWA Engineering Inc.
647.400.2824

Appendix D: Calculations

Shirley Rd. Stormwater Investigation
Town of Fort Erie

Option Summary

CapEx	Construction	Construction Mgmt	Contingency	Total	Report
Option #1: Berm with Flap Gates	$548,013	$101,000	$129,803	$778,815	$775,000
Option #2: Berm with Pump Station	$970,513	$177,500	$229,603	$1,377,615	$1,375,000
Option #3: Tbay Road Control Gate Structure	$677,800	$126,500	$160,860	$965,160	$950,000
Option #4: Retreat	$692,750	$5,500	$4,189,500	$837,900	$850,000 to $4.5M

Shirley Rd. Stormwater Investigation
Town of Fort Erie
Option #1: Berm with Flap Gates

Report

Shirley Rd. Drainage — Linear, Each or Lump Sum — 700000

Cost ID:	Stage	From STA	To STA	Work	Description	Cost Type	Units m	1300000	Qnty	/each	$	Notes
	Construction			Clear and Grub work site		lump sum		850000			$3,000.00	
	Construction			Grade to base - width of berm		qty	350	50			$ 17,500.00	
	Construction			Clay key @ berm centre	is 1.5m wide base by Berm Height(m) tall with 0.6m top width. Need to import clean clear clay to site.	qty	350	$ 100.00	250	$ 10.00	$ 37,500.00	
	Construction			Gravel compacted at front and back face of berm.	filter fabric wrapped gravel, depth of 400mm by width of 400mm to 600mm and includes outlets	qty	350	$ 75.00	125	$ 50.00	$ 32,500.00	
	Construction			Berm to design height, compacted in lifts		qty	350	$ 50.00			$ 17,500.00	
	Construction				Imported soil	qty	200	$ 75.00			$ 15,000.00	
	Construction			Steel Flap gate on submerged outlet - installed	675mm				1	$ 45,000.00	$ 45,000.00	
	Construction			Double CB on twin elliptical culverts	includes AL grating as per OPSD				1	$ 8,000.00	$ 8,000.00	
	Construction			triple wall HDPE Width, m +1.5m with HDPE flap gate, installed at grade.			7.5	$ 135.00			$ 1,012.50	
	Construction				diameter HDPE flap gate	each			1	$ 38,500.00	$ 38,500.00	
	Construction			Final Grading					1	$ 20,000.00	$ 20,000.00	
	Construction			Seeding					1	$ 5,000.00	$ 5,000.00	
											$ -	
	Engineering			Design Engineering	50%, 75%, 90% and IFT	lump sum			1	$ 100,000.00	$ 100,000.00	
											$ -	
	Approvals			Base Approval Documentation		lump sum			1	$ 125,000.00	$ 125,000.00	* adjusted from NPCA meeting 2021/01/28
				NPCA		each			1	$ 22,500.00	$ 22,500.00	
				DFO		each			1	$ 5,500.00	$ 5,500.00	
				MOECP		each			1	$ 12,500.00	$ 12,500.00	
				Property - Easements	Easement in Gross - registration of land easement on title - PTEs	lump sum			7	$ 6,000.00	$ 42,000.00	

SubTotal for: Cost ID: $548,012.50

Construction Mgmt — Linear, Each or Lump Sum

Cost ID:	Drain	From STA	To STA	Work	Description	Cost Type	Length	$/m	Qnty	/each	$	Notes
				Bonding							$ 12,000.00	
				Environmental Management - Compliance with legislative requirements	Preparation of Environmental Management Plan - Exclusions for SAR incidents that require on site expertise.	Lump Sum					$ 5,500.00	Program budget - actual cost will vary
				Erosion Control During construction - including setup, maintenance and final configuration on site	Site review and maintenance during construction	Lump Sum					$ 6,500.00	Program budget - actual cost will vary
				Construction Management	Traffic Control, Layout, and all compliance items for submission on construction startup.						$ 12,500.00	Budget
				Construction Management	Site supervision, 90 days				90	850	$ 76,500.00	

SubTotal for: Construction Mgmt $ 101,000.00

SubTotal for: Shirley Rd. Drainage $ 649,012.50
Contigency Allowance, (20%) $ 129,802.50
Cost of Construction: $ 778,815.00

Shirley Rd. Stormwater Investigation
Town of Fort Erie
Option #2: Berm with Pump Station

Report

Shirley Rd. Drainage

Linear, Each or Lump Sum

700000

Cost ID:	Stage	From STA	To STA	Work	Description	Cost Type	Units m	1300000	Qnty	/each	$	Notes
	Construction			Clear and Grub work site		lump sum		850000			$3,000.00	
	Construction			Grade to base - width of berm		qty	350	50			$ 17,500.00	
	Construction			Clay key @ berm centre	is 1.5m wide base by Berm Height(m) tall with 0.6m top width. Need to import clean clear clay to site.	qty	350	$ 100.00	250	$ 10.00	$ 37,500.00	
	Construction			Gravel compacted at front and back face of berm.	filter fabric wrapped gravel, depth of 400mm by width of 400mm to 600mm and includes outlets	qty	350	$ 75.00	125	$ 50.00	$ 32,500.00	
	Construction			Berm to design height, compacted in lifts		qty	350	$ 50.00			$ 17,500.00	
	Construction				Imported soil	qty	200	$ 75.00			$ 15,000.00	
	Construction										$ -	
	Construction			Double CB on twin elliptical culverts	includes AL grating as per OPSD				1	$ 8,000.00	$ 8,000.00	
	Construction			triple wall HDPE Width, m +1.5m with HDPE flap gate, installed at grade.	diameter HDPE flap gate		7.5	$ 135.00	1	$ 38,500.00	$ 39,512.50	
	Construction			Wetwell	Assumed to be same size as submerged discharge	each			1	$ 50,000.00	$ 50,000.00	
	Construction			Pump Purchase		each			1	$ 10,000.00	$ 10,000.00	
	Construction			Pump Install		lump sum			1	$ 250,000.00	$ 250,000.00	
	Construction			Pump housing, controls, electrical connections		lump sum			1	$ 120,000.00	$ 120,000.00	
	Construction			Changes to Street Grading		lump sum			1	$ 35,000.00	$ 35,000.00	
	Construction			Seeding					1	$ 5,000.00	$ 5,000.00	
											$ -	
	Engineering			Design Engineering	50%, 75%, 90% and IFT	lump sum			1	$ 100,000.00	$ 100,000.00	
											$ -	
	Approvals			Base Approval Documentation		lump sum			1	$ 125,000.00	$ 125,000.00	* adjusted from NPCA meeting 2021/01/28
				NPCA		each			1	$ 32,500.00	$ 32,500.00	
				DFO		each			1	$ 5,500.00	$ 5,500.00	
				MOECP		each			1	$ 25,000.00	$ 25,000.00	
				Property - Easements	Easement in Gross - registration of land easement on title - PTEs	lump sum			7	$ 6,000.00	$ 42,000.00	

SubTotal for: Cost ID: $970,512.50

Construction Mgmt

Linear, Each or Lump Sum

Cost ID:	Drain	From STA	To STA	Work	Description	Cost Type	Length	$/m	Qnty	/each	$	Notes
				Bonding							$ 12,000.00	
				Environmental Management - Compliance with legislative requirements	Preparation of Environmental Management Plan - Exclusions for SAR incidents that require on site expertise.	Lump Sum					$ 5,500.00	Program budget - actual cost will vary
				Erosion Control During construction - including setup, maintenance and final configuration on site	Site review and maintenance during construction	Lump Sum					$ 6,500.00	Program budget - actual cost will vary
				Construction Management	Traffic Control, Layout, and all compliance items for submission on construction startup.						$ 12,500.00	Budget
				Construction Management	Site supervision, 90 days				180	850	$ 153,000.00	

SubTotal for: Construction Mgmt $ 177,500.00

SubTotal for: Shirley Rd. Drainage $ 1,148,012.50
Contigency Allowance, (20%) $ 229,602.50
Cost of Construction: $ 1,377,615.00

Shirley Rd. Stormwater Investigation
Town of Fort Erie
Option #3: Tbay Road Control Gate Structure

Report

Shirley Rd. Drainage

Linear, Each or Lump Sum

700000

Cost ID:	Stage	From STA	To STA	Work	Description	Cost Type	Units m	1300000	Qnty	/each	$	Notes
	Construction			Clear and Grub work site		lump sum		850000			$10,000.00	
	Construction			West side Berm		qty	122	100			$ 12,200.00	
	Construction			East side Berm		qty	145	$ 100.00			$ 14,500.00	
	Construction			Screw piles	Depth to rock may make this convert to actual piles to bedrock.	qty			4	$ 15,000.00	$ 60,000.00	
	Construction			concrete sill	includes base prep but excludes bypass pumping	qty	12	$ 550.00	1	$ 1,000.00	$ 7,600.00	
	Construction			Steel Framework		qty			1	$ 35,000.00	$ 35,000.00	
	Construction			Steel or HDPE Gates or Flaps		qty			3	$ 40,000.00	$ 120,000.00	
	Construction										$ -	
	Construction										$ -	
	Construction					each					$ -	
	Construction			Final Grading						$ 20,000.00	$ -	
	Construction			Seeding						$ 5,000.00	$ -	
											$ -	
	Engineering			Design Engineering	50%, 75%, 90% and IFT	lump sum			1	$ 150,000.00	$ 150,000.00	
											$ -	
	Approvals			Base Approval Documentation		lump sum			1	$ 125,000.00	$ 125,000.00	* adjusted from NPCA meeting 2021/01/28
				NPCA		each			1	$ 40,500.00	$ 40,500.00	
				DFO		each			1	$ 12,500.00	$ 12,500.00	
				MOECP		each			1	$ 18,500.00	$ 18,500.00	
				Property - Easements	Easement in Gross - registration of land easement on title - PTEs	lump sum			2	$ 6,000.00	$ 12,000.00	
											$ -	
				By-pass pumping druing specific construction stages	* required Environmental monitoring during bypass	days	24	$ 2,000.00	24	$ 500.00	$ 60,000.00	

SubTotal for: Cost ID: $677,800.00

Construction Mgmt

Linear, Each or Lump Sum

Cost ID:	Drain	From STA	To STA	Work	Description	Cost Type	Length	$/m	Qnty	/each	$	Notes
				Bonding							$ 12,000.00	
				Environmental Management - Compliance with legislative requirements	Preparation of Environmental Management Plan - Exclusions for SAR incidents that require on site expertise.	Lump Sum					$ 5,500.00	Program budget - actual cost will vary
				Erosion Control During construction - including setup, maintenance and final configuration on site	Site review and maintenance during construction	Lump Sum					$ 6,500.00	Program budget - actual cost will vary
				Construction Management	Traffic Control, Layout, and all compliance items for submission on construction startup.						$ 12,500.00	Budget
				Construction Management	Site supervision, 120 days				120	850	$ 102,000.00	

SubTotal for: Construction Mgmt $ 126,500.00

SubTotal for: Shirley Rd. Drainage $ 804,300.00
Contigency Allowance, (20%) $ 160,860.00
Cost of Construction: $ 965,160.00

Shirley Rd. Stormwater Investigation
Town of Fort Erie
Option #4: Retreat

Shirley Rd. Drainage

Linear, Each or Lump Sum

Report

Cost ID:	Stage	From STA	To STA	Work	Description	Cost Type	Units m	700000	Qnty	/each	$	Notes
	Construction					lump sum		1300000			$0.00	
	Construction					qty		850000			$ -	
	Construction					qty					$ -	
	Construction					qty					$ -	
	Construction					qty					$ -	
	Construction					qty					$ -	
	Construction										$ -	
	Construction										$ -	
	Construction										$ -	
	Construction					each					$ -	
	Construction										$ -	
	Construction			Demolition		each			2	$ 10,000.00	$ 20,000.00	
											$ -	
	Engineering					lump sum					$ -	
											$ -	
	Purchase			127 Shirley	MVA 235,000	lump sum			1.35	$ 235,000.00	$ 317,250.00	
				137 Shirley	MVA 230,000	lump sum			1.35	$ 230,000.00	$ 310,500.00	
	Closing Costs					each			2	$ 12,500.00	$ 25,000.00	
	Re-zoning			Hazard land designation		each			2	$ 10,000.00	$ 20,000.00	
						lump sum					$ -	

SubTotal for: Cost ID: $692,750.00

Construction Mgmt

Linear, Each or Lump Sum

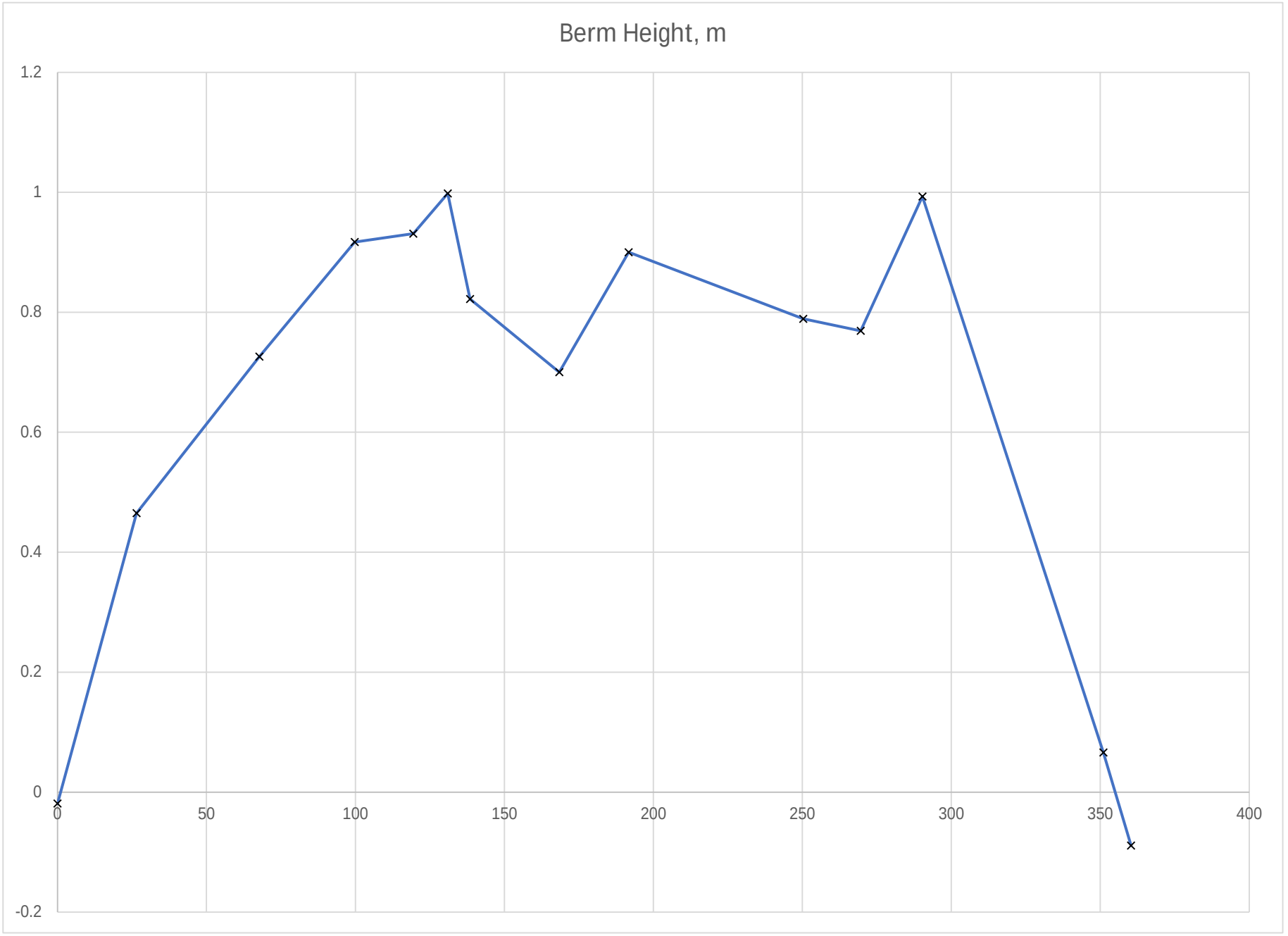
Cost ID:	Drain	From STA	To STA	Work	Description	Cost Type	Length	$/m	Qnty	/each	$	Notes
				Bonding							$ 1,000.00	
				Environmental Management - Compliance with legislative requirements	Preparation of Environmental Management Plan - Exclusions for SAR incidents that require on site expertise.	Lump Sum					$ 2,500.00	Program budget - actual cost will vary
				Erosion Control During construction - including setup, maintenance and final configuration on site	Site review and maintenance during construction	Lump Sum					$ 500.00	Program budget - actual cost will vary
				Construction Management	Traffic Control, Layout, and all compliance items for submission on construction startup.						$ 2,500.00	Budget
				Construction Management	Site supervision, 90 days				0	850	$ -	

SubTotal for: Construction Mgmt $ 5,500.00

SubTotal for: Shirley Rd. Drainage $ 698,250.00
Contigency Allowance, (20%) $ 139,650.00
Contigency Allowance, (6 other properties) $ 4,189,500.00
Cost of Construction: $ 837,900.00

Berm Quantity Size Estimate

														0.6	0.4	
							176.5	0.6	2				0.3	1.5	0.4	
Linear distance, m	field_1	field_2	field_3	field_4	field_5	Length, m	Berm Height, m	TW	SS	BW	X-sect, m2	Berm Volume, m3	Removal, m3	Clay	Gravel	Soil Import
0	4086	4749065	661437.9	176.519	GSHOT*	0	-0.019			0	0		0	0	0	0
26.55	4052	4749087	661423.5	176.035	GSHOT*	26.55	0.465			2.46	0.711	9.4	19.6	13.0	8.5	7.6
41.232	4044	4749125	661406.9	175.774	GSHOT*	67.782	0.726			3.504	1.490	45.4	43.3	31.4	13.2	44.1
31.987	4017	4749156	661399.4	175.583	GSHOT*	99.769	0.917			4.268	2.232	59.5	41.0	30.8	10.2	59.4
19.682	4014	4749175	661393.1	175.569	GSHOT*	119.451	0.931			4.324	2.292	44.5	25.5	19.2	6.3	44.5
11.542				175.502		130.993	0.998			4.592	2.591	28.2	15.9	12.1	3.7	28.3
7.495				175.678		138.488	0.822			3.888	1.845	16.6	8.7	6.5	2.4	16.5
29.944				175.8		168.432	0.7			3.4	1.400	48.6	30.5	22.0	9.6	47.5
23.29				175.6		191.722	0.9			4.2	2.160	41.5	29.3	22.0	7.5	
58.604	4173	4749278	661358	175.711	GSHOT*	250.326	0.789			3.756	1.718	113.6	66.0	48.6	18.8	112.4
19.265	4208	4749281	661377.1	175.731	GSHOT*	269.591	0.769			3.676	1.644	32.4	21.2	15.6	6.2	31.9
20.723	4201	4749288	661396.6	175.507	GSHOT*	290.314	0.993			4.572	2.568	43.6	28.4	21.6	6.6	43.8
60.743	4316	4749297	661456.7	176.434	GSHOT*	351.057	0.066			0.864	0.048	79.5	15.7	4.2	19.4	71.6
9.28	4333	4749296	661466	176.589	GSHOT*	360.337	-0.089			0	0.000	0.2	0.0	0.0	3.0	0.0
360.337							0.82			3.9		563.1	345.4	246.9	115.3	507.6


Berm Height, m
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
300
350
400