Appendix D:

Supplementary Information & Documents

Technical Memorandum

Project:	Wignell Municipal Drain	Date:	February 4, 2018 updated July 14, 2021
Project #:	18-9999	Prepared by:	P.Marsh, P.Eng.
		PM:	P.Marsh, P.Eng.

	Wignell Bog Restoration
Purpose:	The original lands forming the Wignell Bog that were impacted by the construction of the Wignell Drain have been left fallow by the current owners. It is suggested that the lands formerly used for market gardens can be returned to a semi-natural state as a Bog. There is no way to have a purely natural water cycle be returned since the drain still passes through the centre of these lands and the both the upstream land owners and downstream land owners desire the continued benefits of drainage. It is presented in this Techncial Memo that a managed water level through the Wignell Bog lands can lead to a restoration in natural function and return some natural habitat to the area.
Requirements	Present the general view of where and what would be stored as a “Bog”. Provide details on what a bog is, how it would function in the context of a municipal drain.

Contents

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Bog is a nutrient-poor peatland characterized by acidic, saturated peat and the prevalence of sphagnum mosses and ericaceous shrubs.

Soils

The organic soils are composed of saturated fibric peat that contains partially decomposed sphagnum mosses and frequently, fragments of sedges and wood. Like the surface water, peat soils are extremely acidic, cool, and characterized by low nutrient availability and oxygen levels. The water-retaining capacity of sphagnum peat is tremendous and as a result bogs are saturated, anoxic systems with water tables near the surface. Peat composition changes with depth and is influenced by the successional history of a given site. Fiber content and hydraulic conductivity of peat soils usually decrease with depth.

Natural Processes

Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. Under cool, anaerobic, and acidic conditions, the rate of organic matter accumulation exceeds organic decay. Once sphagnum mosses become established on the peat mat, they maintain and enhance saturated and acidic conditions, which in turn promote continued peat development. Development and expansion of peatlands occur via two distinct processes: lake-filling and paludification. Lake-filling occurs in small lakes with minimal wave action, where gradual peat accumulation results in the development of a bog mat that can fill the basin or occur as a floating mat or grounded mat. Paludification is the blanketing of terrestrial systems (often forests) by the overgrowth of peatland vegetation. Paludified peatlands develop on flat areas (typically lakeplains) where peat develops vertically and spreads horizontally. For both lake-filling and paludification, peat accumulates above the water table and the bog becomes isolated from the influence of groundwater. Bogs are ombrotrophic to weakly minerotrophic peatlands, receiving inputs of water and nutrients primarily from ion-poor precipitation.

Text from Michigan State U: https://mnfi.anr.msu.edu/communities/description/10666

1. Introduction

A technical memo is produced as a subset technical document to complement the primary document through detailed analysis of a single individual problem or component of a larger system.

1.1. Problem Statement

What is the benefit of the re-introduction of a bog on the former market garden lands now owned by Vale?

What is required technically to restore the bog and manage the water into and out of the bog?

2. Background

The former bog lands were identified in early historical maps of the region that show the Wignell Bog was a significant land form for the early settlers. The following figure is an aerial photographic view of the area.

Figure 1 Aerial photographic view

Figure 2 Wignell Drain and Bog Lands looking South from Friendship Trail

It is important to distinguish between the two adjacent drains; the Wignell Drain and Michener Drain as shown in the following figure. The Wignell Drain behaves very differently from the Michener and the following profile view of the two drains south of the Friendship Trail to their common outlet shows.

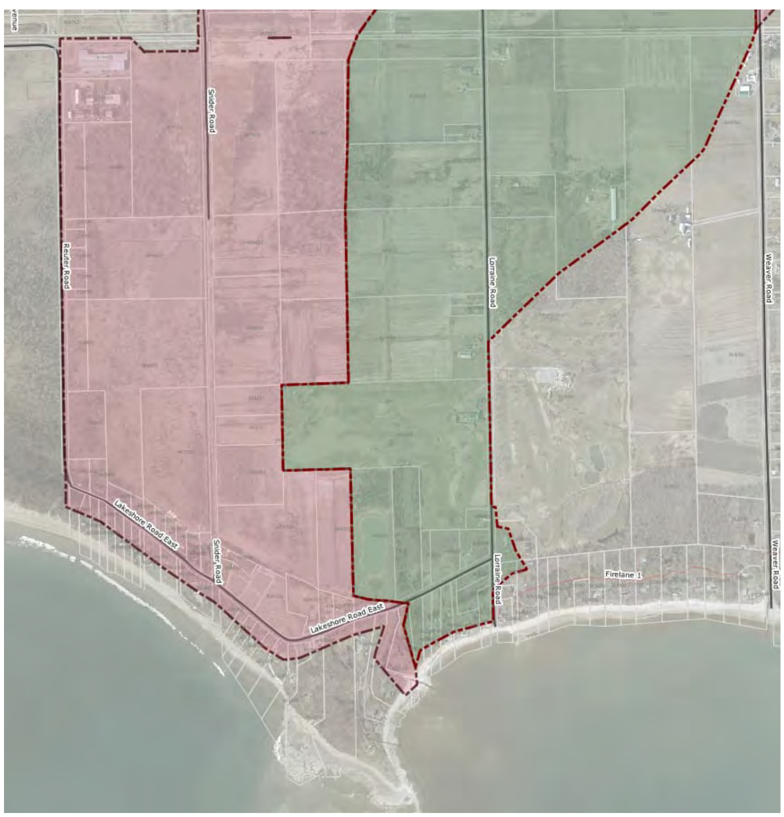

Figure 3 Wignell and Michener Drain Watersheds below Friendship Trail

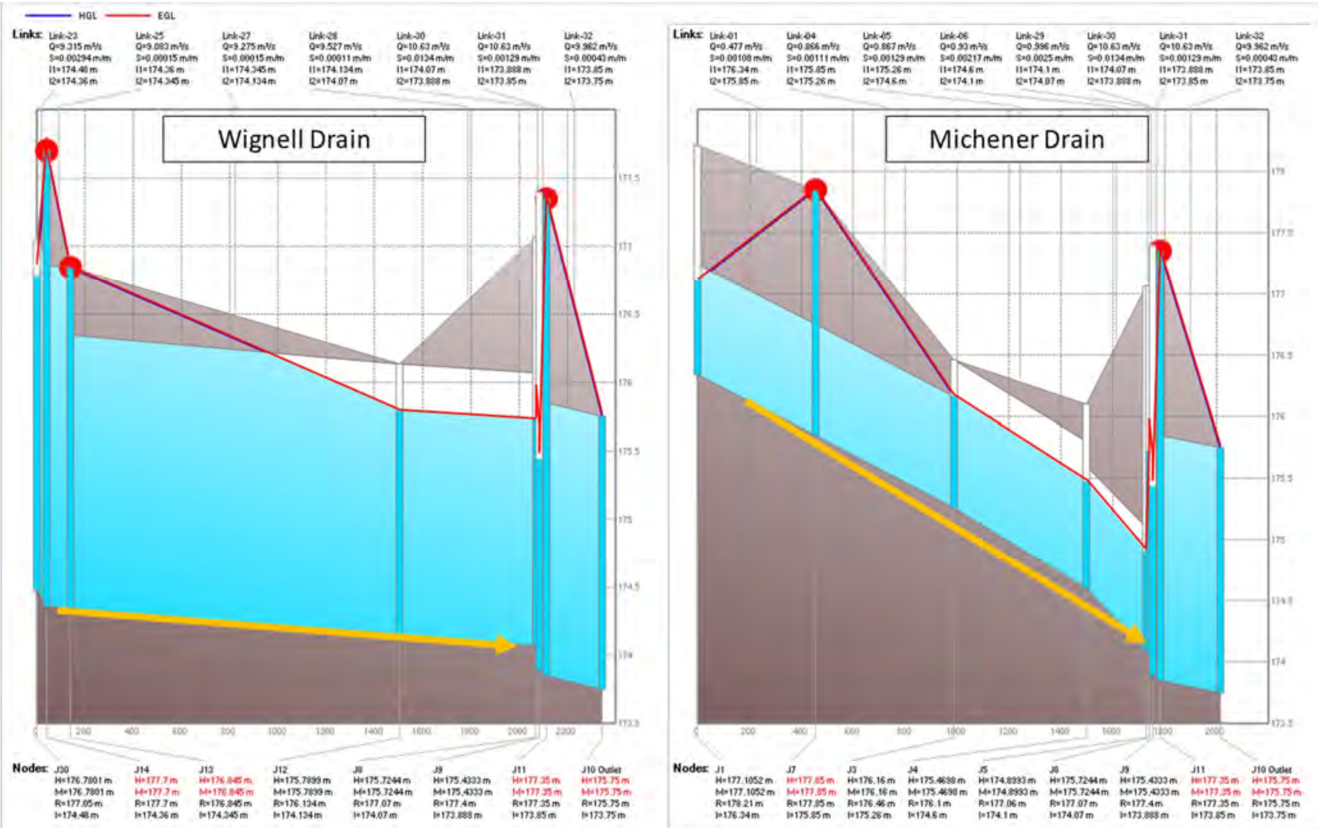

Figure 4 Wignell Michener Drain Profile Comparison

The Michener Drain has a drain slope, while small ~ 0.11% in upper reach, is positive to the outlet. The Wignell Drain has little to no positive drain slope to the outlet and is largely flat as per the 1969 CJ Clarke Design, shown above with yellow arrows.

Vale Canada

The role of Vale Canada in the Wignell Bog can't be understated as one of the major property owners within the Wignell, Port Colborne and Michener Drain Watershed.

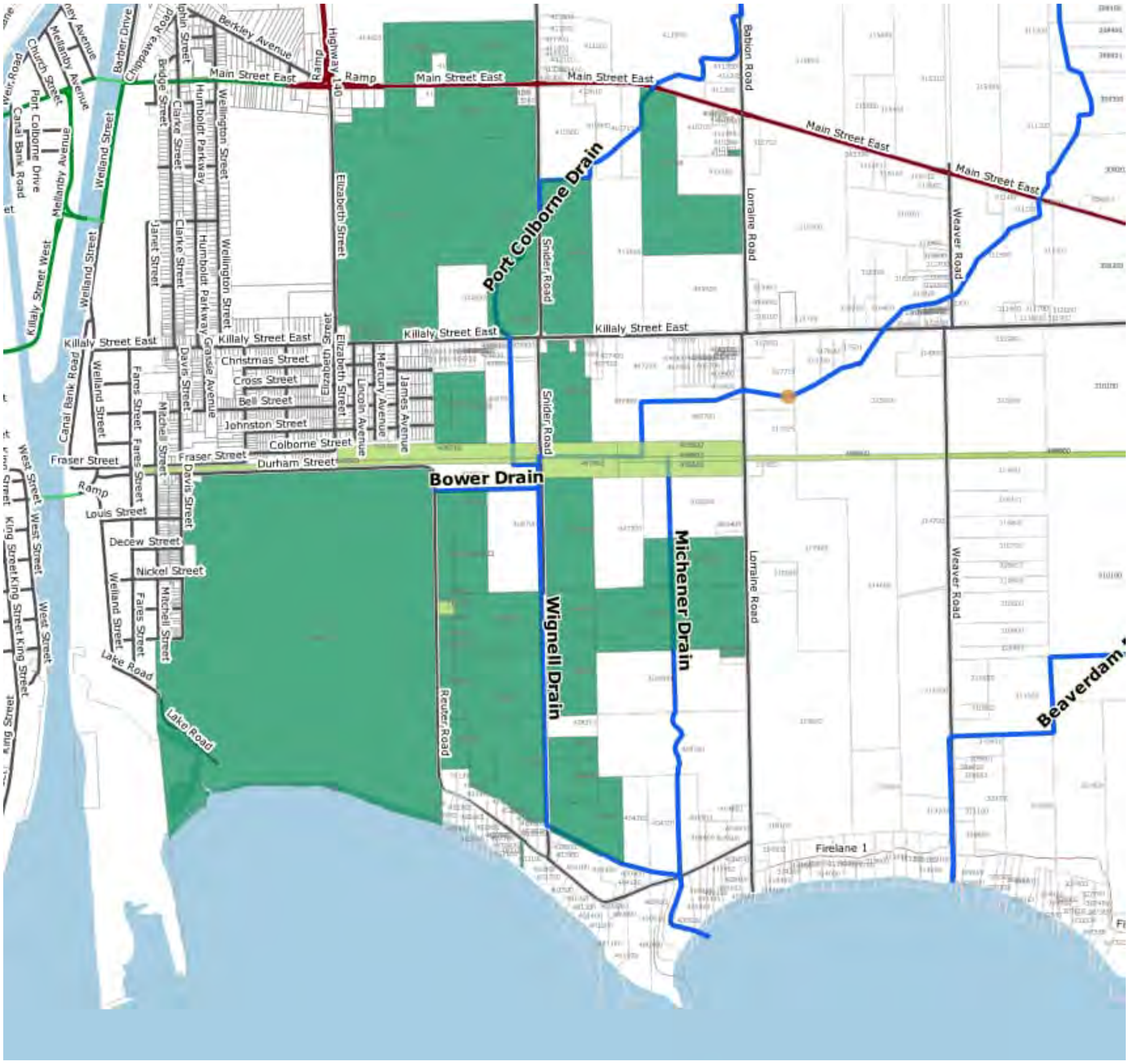

Figure 5 Vale Owner Property

Dark green in the above figure is Vale Property and the light green is City of Port Colborne property.

2.1. Available Information

Fire active in Wainfleet Bog, Port Colborne Leader, Jul 06, 2016

The bog was acquired by the NPCA in 1995 and is Niagara's only bog wetland and is characterized by peat deposits and sphagnum moss. Michael Reles, communications specialist for the NPCA, explained the nature of the peat and surface moss prompted the restriction on access that has yet to be imposed at other conservation areas.

Normally the bog's water level keeps surface moss and the underlying peat damp, however the ongoing dry spell has lowered the water table to sufficiently dry out the surface layer and underlying peat.

"It's highly flammable at the top," said Reles, adding, "when it does catch fire it just smolders."

He explained with a minimum of 40 cm of peat the fire can move underground, smoldering for weeks and hampering efforts to combat its spread.

https://www.niagarathisweek.com/news-story/6754455-fire-active-in-wainfleet-bog/

Mac prof warns bog fires to become more common, Wainfleet keeps burning, by Joel OpHardt, The Hamilton Spectator, Jul 08, 2016

"The good news of our research is that we demonstrate that rewetting peatland reduces the fire risk," said Waddington

Restoration of bogs comes essentially in two parts: blocking drainage ditches and building berms to hold more water, and adding sphagnum moss to the surface to kickstart moss growth.

The Wainfleet bog still suffers from the effects of decades of mining, but partial restoration of the bog has revealed positive results.

"When we studied the 2012 fire we found the areas where moss had started to grow on the surface again had minimal fire severity."

https://www.thespec.com/news-story/6758308-mac-prof-warns-bog-fires-to-become-more-common-wainfleet-keeps-burning/

2.2. References

NPCA studies

- Shoreline study
- Flood Study

Summarize both

2.3. Available Data

There are free reference data sets available through NPCA and Land Information Ontario.

Niagara Peninsula Conservation Authority, (NCPA)

At present the primary data set for assessing the bog lands is the NCPA DTM acquired by digital aerial imagery. The NPCA 2010 1 Meter Contour Supporting Digital Terrain Model provides elevation data capable of being '*used for pre-engineering survey and design, the production of municipal planimetric mapping and detailed topographic mapping at a minimum scale of 1:2000 with a contour interval of no less than one meter (1.0 m).*'

The NPCA 2010 DTM is quoted as having a minimum 0.5m horizontal and vertical accuracy.

> "General Specifications
>
> Horizontal Reference System: UTM NAD83-CSRS Zone 17N (Canadian Spatial Reference System)
>
> Vertical Datum: CGVD28 – 1978 (Canadian Geodetic Vertical Datum)
>
> Accuracy: ± 0.5 meter CMAS and LMAS, absolute horizontal and vertical positional accuracies of 0.5m"

SWOOP 215 DEM

"The SWOOP 2015 DEM is a 2m raster product that has been generated by an imagery contractor from the Raw LAS vector elevation dataset. The primary purpose for generating the DEM was to allow for the imagery to be ortho-rectified by the imagery contractor. … It is important to note that the DEM does not represent a full 'bare-earth' elevation surface. While the 'steam-rolling' algorithm has allowed for some raised features to be reduced closer to 'bare-earth' elevations (e.g. small buildings, small blocks of forest cover), many features are still raised above ground surface, such as larger buildings, larger forest stands and other raised features. The product is being distributed in the original state delivered by the imagery contractor without modification."

The following figure shows the 1m contour lines provided by NPCA 2010 DTM.

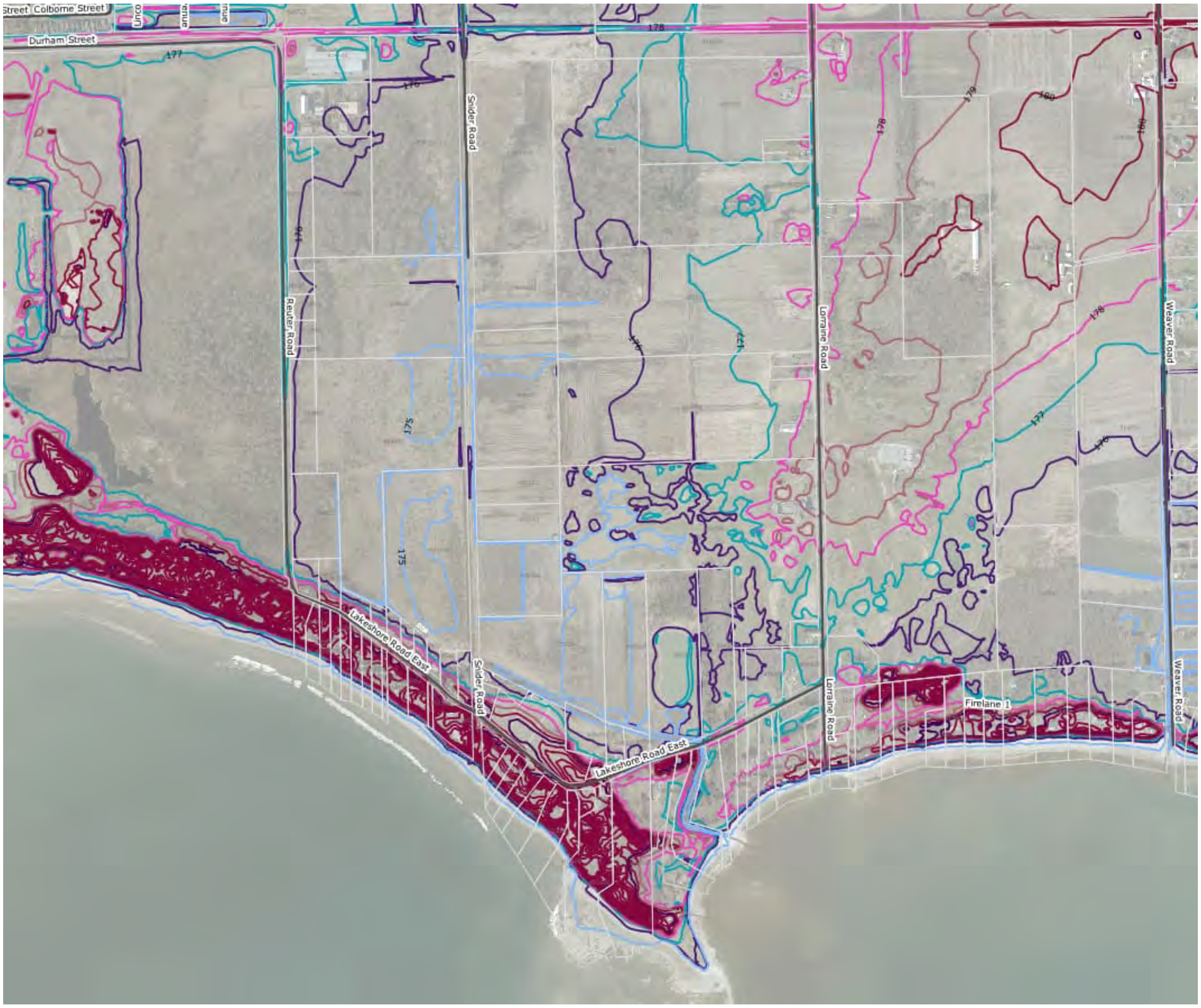

Figure 6 NPCA 1m Contour lines

The purple contour line is the 176.0m elevation and corresponds to the lands impacted by Seiche conditions in Lake Erie if not protected by the control structure. The light blue lines are the contours indicating the area prone to flooding from average runoff events.

3. Methodology

Using the available data, data from the NPCA mass point file and perform a colour coding operation on it. Points in the Wignell drain south of the Friendship Trail were selected and colour coded darker blue for lower points and lighter blue for higher points. Only selected points that were less than (or equal to) 175.5m which is the equivalent top of bank values through the 0+200 to 0+100 reach area were used.

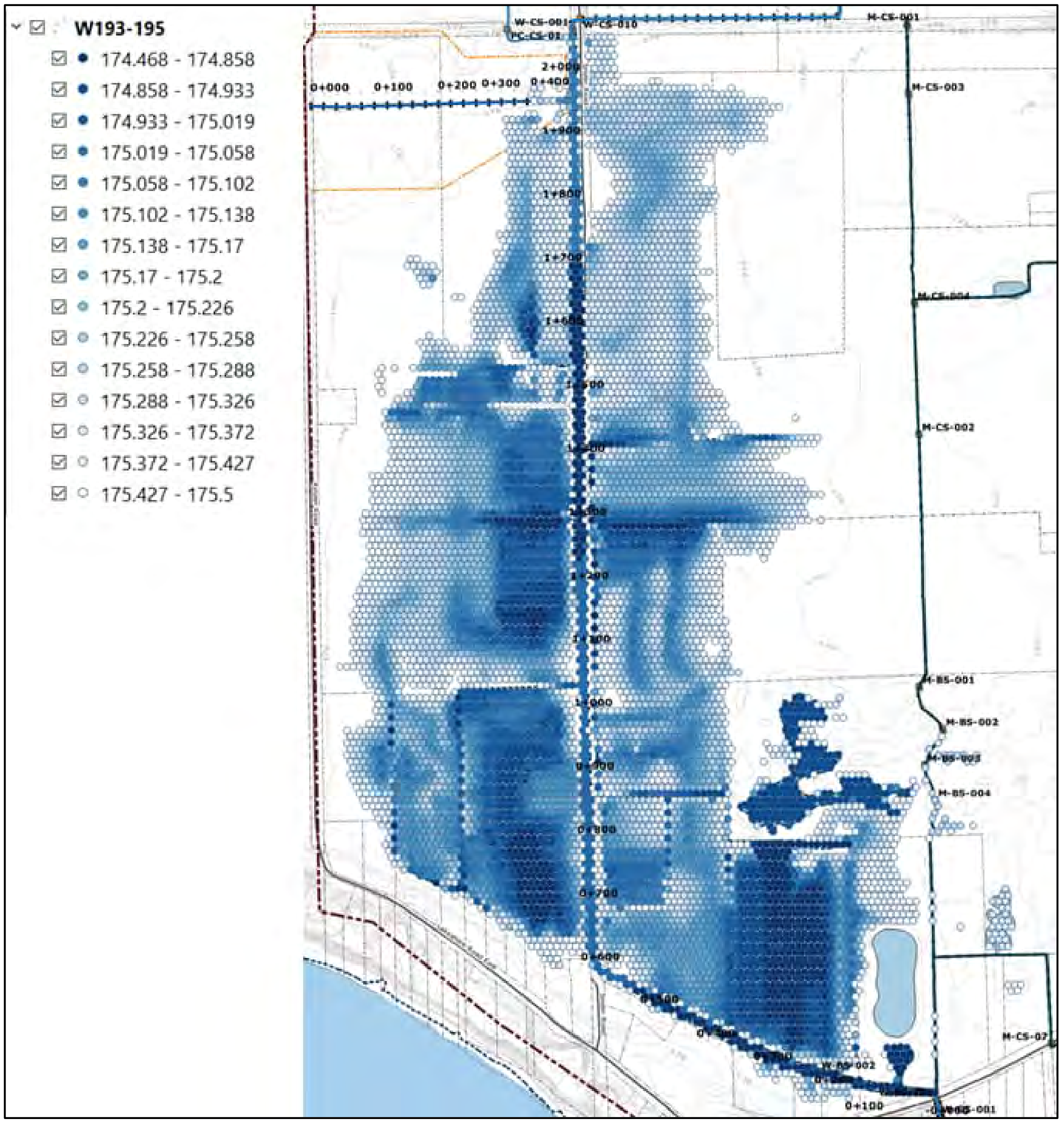

Figure 7 Colour coded points at 0.1m less than or equal to 175.5m

The area shown identifies the spread of lands impacted by a flow elevation of 175.5m, which ranges from the outlet all the way to the Friendship Trail crossing. There are clearly private drain connections with east / west pathways shown as well as extensive areas that are below 175.0m.

From the Drain Hydrology Model implemented for designing the channel parameters within the upper drain area, the model predicts a flood elevation for the 1:25 year storm of 175.72 at the Wignell Gate, same as that shown in Figure 4 Wignell Michener Drain Profile Comparison.

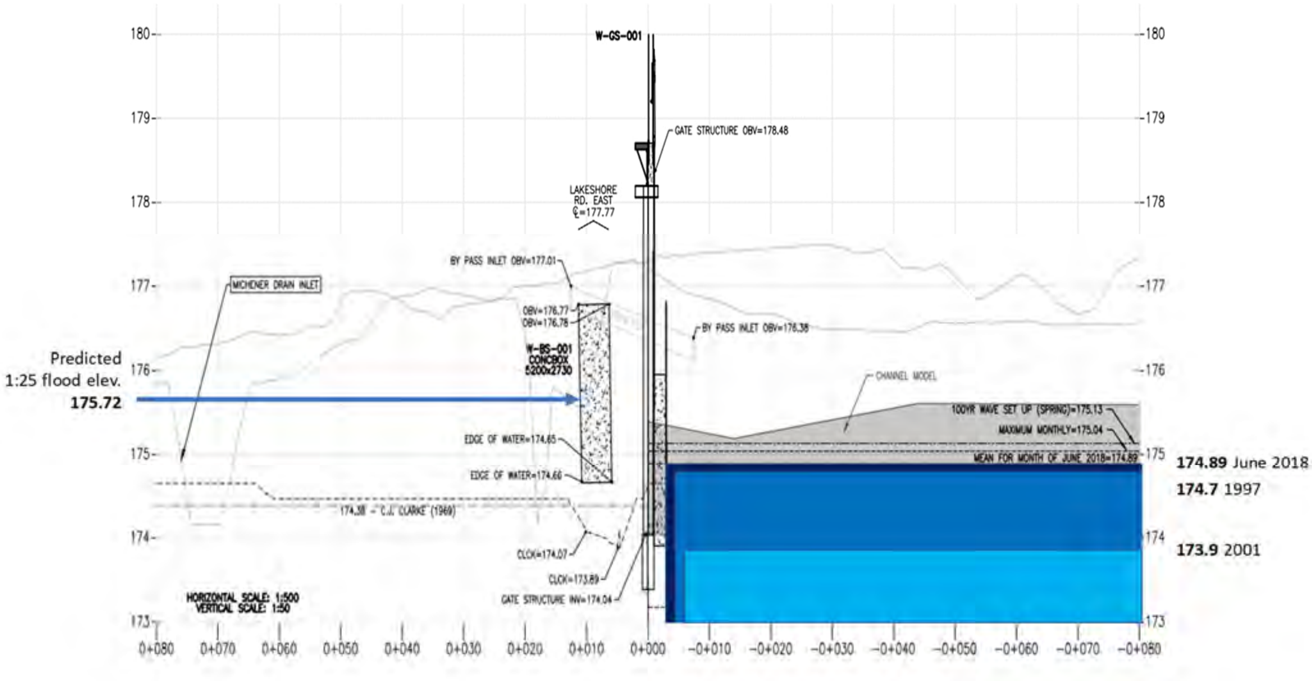

Figure 8 Wignell Gate Control Structure Elevation Profile

Also shown are the influence that the Lake has on the water surface elevation.

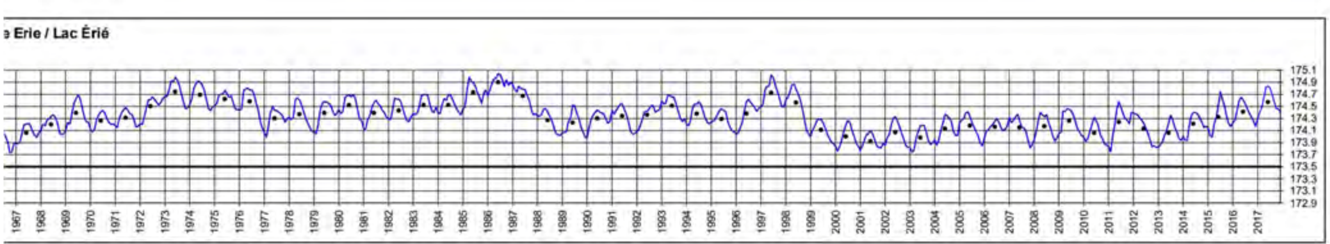

Figure 9 Lake Erie Water Level Annual Variation

The water level chart shows that a low water level occurred in or about 2001 after a period of high water levels in 1997 and 1998. These average levels are shown in Figure 8 Wignell Gate Control Structure Elevation Profile and compared to the level recorded for this past year, June 2018. These water levels for the Lake directly influence and impact the water levels in the Wignell Drain and consequently water levels for the proposed bog lands.

3.1. Additional Data Required

At present, actual flow monitoring data for the Wignell Drain is not available; however, putting a water level instrument on the Drain is proposed.

With regards to consider the bog extent, the existing available data is not suitable for assessing the flood impacts. For that to be relevant, a DTM (DEM) would be required to a minimum accuracy of +- 10 cm for Horizontal and Vertical accuracy.

4. Analysis

While the available data is not adequate to fully assess the topological influences related to restoring the Wignell Bog, a delineation of a bog area is possible and should aid in the discussion relating to bog management.

A bog park limit is shown in the following figure.

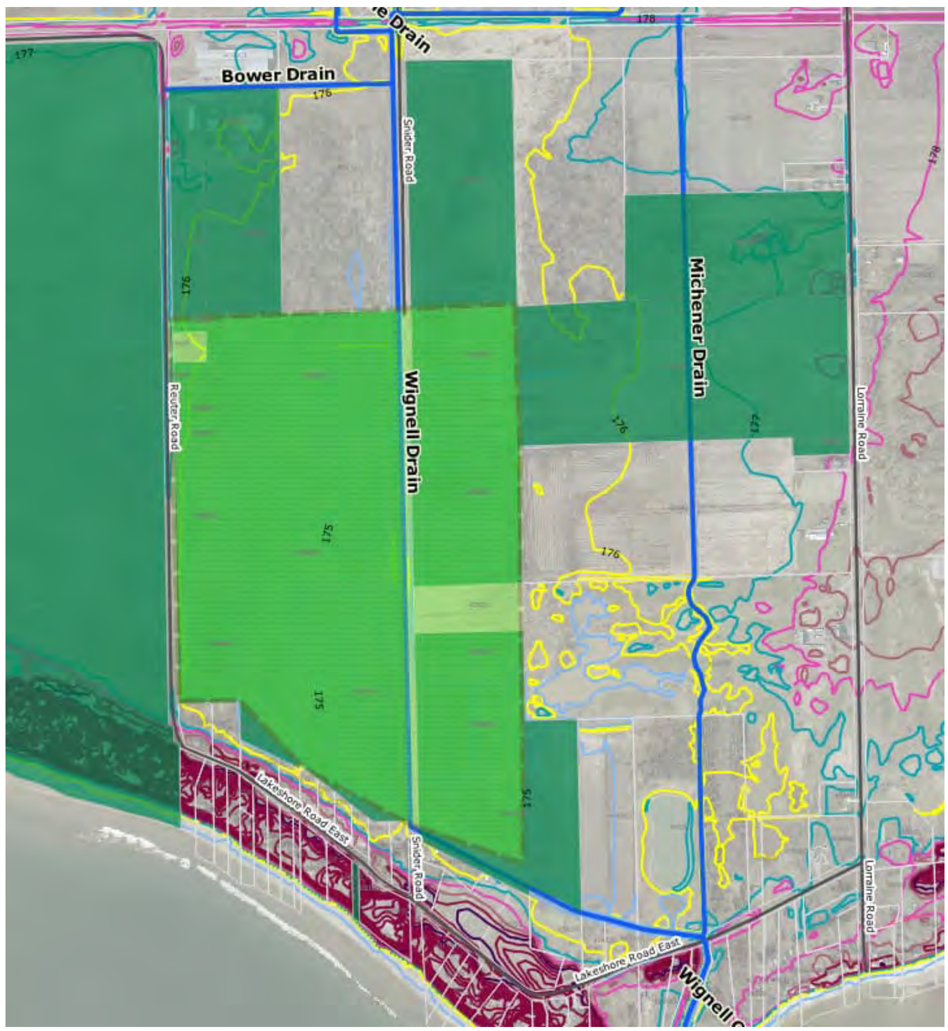

Figure 10 Proposed Bog Land area

The following properties would be directly impacted by the bog land limits.

Table 1 Proposed Bog Park Limit Affected Properties

ARN	Prime_Sub	Owner	Legal_Txt	PropCode	CATEGORY	Frontage	Depth	MPAC_Area	DESCRIPTIO	Location
271102000718300	0	VALE CANADA LIMITED	CON 1 PT TWP LOT 23	100	LAND	100	0	0.46	Vacant residential land not on water	REUTER ES RD
271102000718400	0	PORT COLBORNE CITY	CON 1 PT TWP LOT 23	100	LAND	180	200	0.83	Vacant residential land not on water	REUTER RD
271102000718500	0	VALE CANADA LIMITED	CON 1 PT TWP LOT 23	100	LAND	200	200	0.92	Vacant residential land not on water	REUTER ES RD
271102000718600	0	VALE CANADA LIMITED	CON 1 PT TWP LOT 23	100	LAND	200	200	0.92	Vacant residential land not on water	REUTER ES RD
271102000718700	0	VALE CANADA LIMITED	CON 1 PT TWP LOT 23	100	LAND	100	200	0.46	Vacant residential land not on water	REUTER ES RD
271102000718800	0	VALE CANADA LIMITED	HUMBERSTONE CON 1 PT LOT 23	200	FARM	0	0	4.07	Farm property without any buildings/structures	REUTER RD
271102000718900	0	VALE CANADA LIMITED	CON 1 PT TWP LOT 23 RP;59R10985 PART 1	100	LAND	660	366.86	5.65	Vacant residential land not on water	REUTER RD
271104000403700	0	VALE CANADA LIMITED	HUMBERSTONE CON 1 PT LOT 23	260	FARM	0	0	19.18	Vacant residential/commercial/ industrial land owned by a non-farmer with a portion being farmed	SNIDER RD
271104000403710	0	VALE CANADA LIMITED	HUMBERSTONE CON 1 PT LOT 22	260	FARM	0	0	25743.96	Vacant residential/commercial/ industrial land owned by a non-farmer with a portion being farmed	SNIDER RD
271104000403720	0	VALE CANADA LIMITED	HUMBERSTONE CON 1 PT LOT 22	260	FARM	0	0	19.48	Vacant residential/commercial/ industrial land owned by a non-farmer with a portion being farmed	SNIDER RD
271104000407900	0	VALE CANADA LIMITED	CON 1 PT LOT 22 RP 59R3414;PART 8	200	FARM	1501.3	0	21.86	Farm property without any buildings/structures	KILLALY ST E
271104000408100	0	VALE CANADA LIMITED	CON 1 PT LOT 22 RP 59R3414;PART 9	200	FARM	595.3	0	8.71	Farm property without any buildings/structures	741 SNIDER RD
271104000408200	0	VALE CANADA LIMITED	CON 1 PT LOT 22	100	LAND	1065.16	0	16	Vacant residential land not on water	SNIDER RD
271104000408201	0	570466 ONTARIO LIMITED	CON 1 PT LOT 22	100	LAND	282.22	0	4.5	Vacant residential land not on water	SNIDER RD
271104000408300	0	VALE CANADA LIMITED	CON 1 PT LOT 22	100	LAND	583.28	665.32	9	Vacant residential land not on water	SNIDER RD
271104000408400	0	VALE CANADA LIMITED	CON 1 PT LOT 23 RP59R3848;PART 1 PART 2	210	FARM	858.14	0	30.93	Farm without residence - with secondary structures; with farm outbuildings	SNIDER RD
271104000408600	0	VALE CANADA LIMITED	CON 1 PT LOT 23 RP 59R3414;PART 5 TO 7	210	FARM	0	0	21	Farm without residence - with secondary structures; with farm outbuildings	745 SNIDER RD

The following figure shows land use as reported in the MPAC property database.

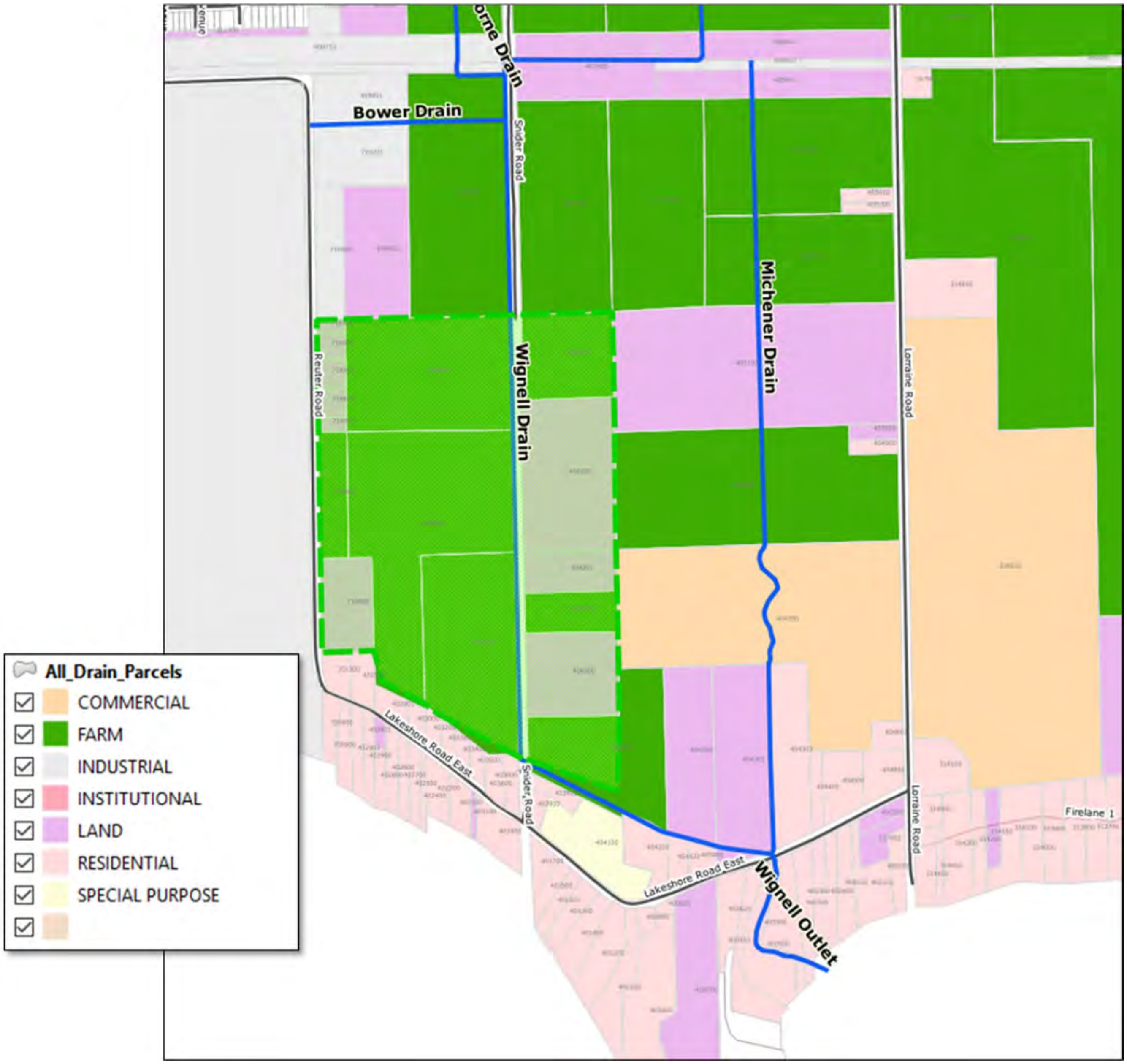

Figure 11 MPAC Land Use Designations

Clearly the bog would have industrial (grey), residential neighbours (light pink) to the West and South. The East is the Whiskey Run Golf Course (peach), vacant land (pink) and farm land (green).

4.1. Analysis Limitations

The currently available digital elevation data is not adequate in vertical resolution to properly characterize the bog lands; the extent and the potential impacts to dry down from Water Taking Permits or from flooding impacts.

5. Recommendations

More detailed investigation is needed to develop a technical basis for the rehabilitation of the existing lands restored to bog lands although technically the most likely requirement to accomplish restoration is to not continue pumping at the Wignell Drain Control Gate Structure and to limit water taking permits in the area to minimize the drying effects on the existing peat that forms the bog land.

1. Install level monitoring at the Wignell Control Structure to begin data logging Wignell Drain Water levels. Install a weather (precipitation) station in the upper Wignell Watershed. This will report on precipitation as input that can be correlated to observed runoff at flow levels at the Wignell outlet.
   An additional temporary level logging station located at the Friendship Trail or Lorraine Road crossing would provide beneficial data as well.
   Permanent level logging station at W-GS-001: $7,500
   Precipitation Station; $1,000
   Temporary level monitor for 10 months; $ 1,500
2. Purchase drone based Lidar to characterize the existing land area to the south of the Friendship Trail.
   $20,000
3. Conduct three (3) boreholes to characterize the existing peat lands including hydraulic conductivity. (4m depth assumed to bedrock)
   $18,000
4. Using more detailed information about the bog, an update to the existing Drainage Hydrologic Model would be implemented and used to have a better forecast of runoff events for water management within the Wignell Watershed basin.

Prepared by:	Paul C. Marsh, P.Eng. Principal Engineer; EWA Engineering Inc.	
Signature:	[signature]	Date: 2021-07-14

Technical Memorandum

Project:	Wignell Drain Report	Date:	January 25, 2019 Updated June 2, 2021
Project #:	18-9999	Prepared by:	P.Marsh, P.Eng.
		PM:	P.Marsh, P.Eng.

	Wignell Pump and Gate Structure Analysis
Purpose:	The pumping arrangement at the Wignell Control Gate Structure was removed from service. What size of pump would be required to provide a service that meet the resident needs and how does that compare with the original pump deployment.
Requirements	What is the most cost effective way to improve the Wignell Drain?

Contents

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1. Introduction

A technical memo is produced as a subset technical document to complement the primary document through detailed analysis of a single individual problem or component of a larger system.

1.1. Problem Statement

Determine the best methods for improving flow out of the Wignell Gate Structure and to prevent backwater from Lake Erie.

2. Background

For a full description of the Wignell Drain, refer to the EWA Wignell Drain Baseline Report.

There are three pumping platforms in the existing Wignell Gate Structure. They are described herein as;

- Single Centrifugal pump mount, added to Gate Structure approximately 1973.
- In stream submersible pump and piping, set of two with 100mm piping.
- By-Pass pumping NorthEast ramp to 450mm CSP piping.

and identified in the following figure.

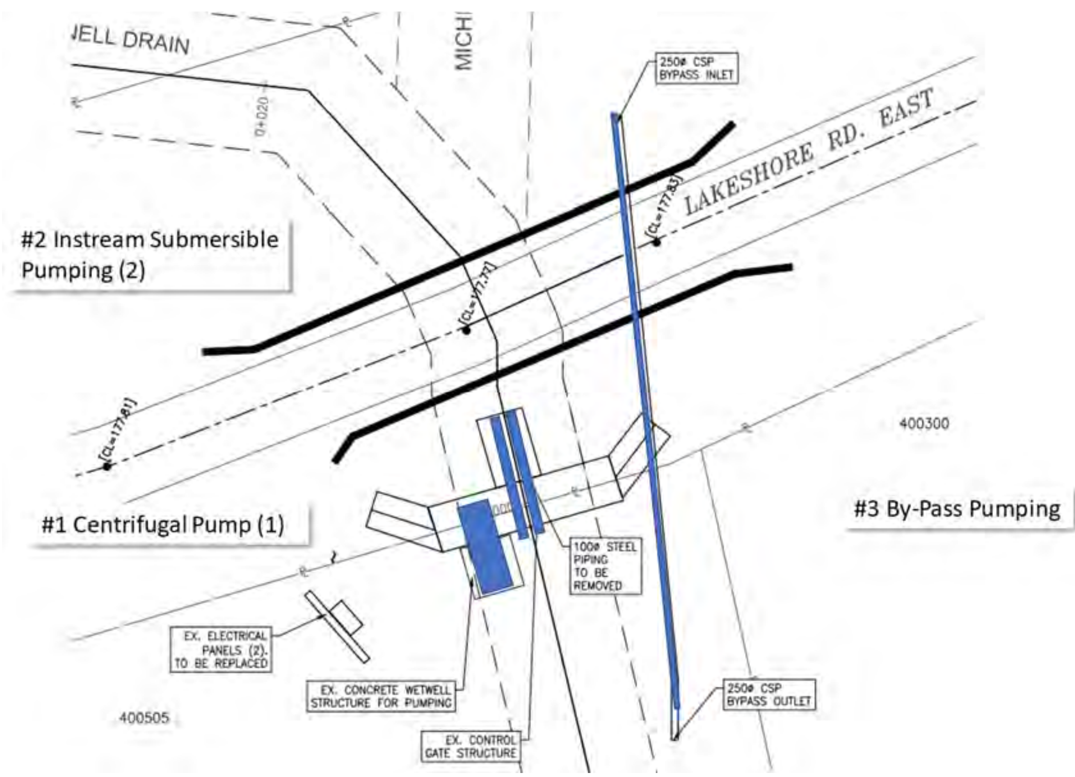


Figure 1 Wignell Gate Pumping Platforms

The general arrangement of the Wignell Drain outlet and the Wignell Control Gate Structure is shown in the following two figures. The first figure is a map showing the location of the control gate structure and the Wignell and Michener Drains and the general location of the Wignell Bog. The second figure is a profile view of the major components that comprise the analysis of pumping requirements.

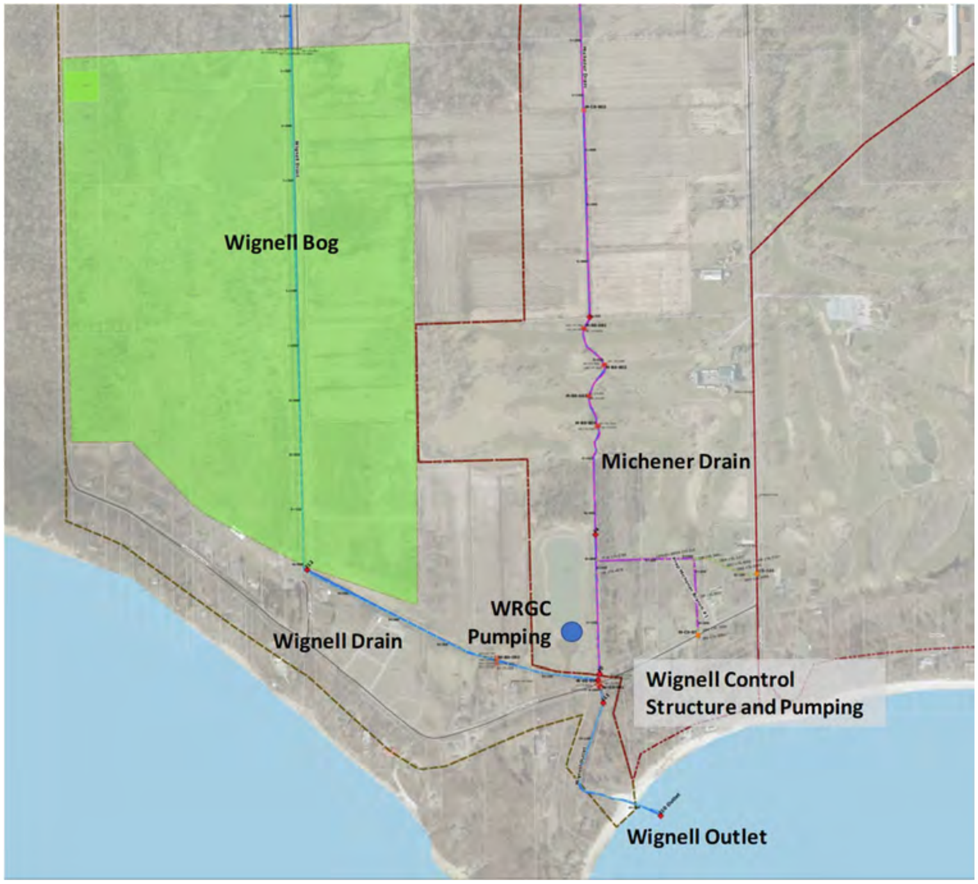


Figure 2 Wignell Drain Control Structure Location

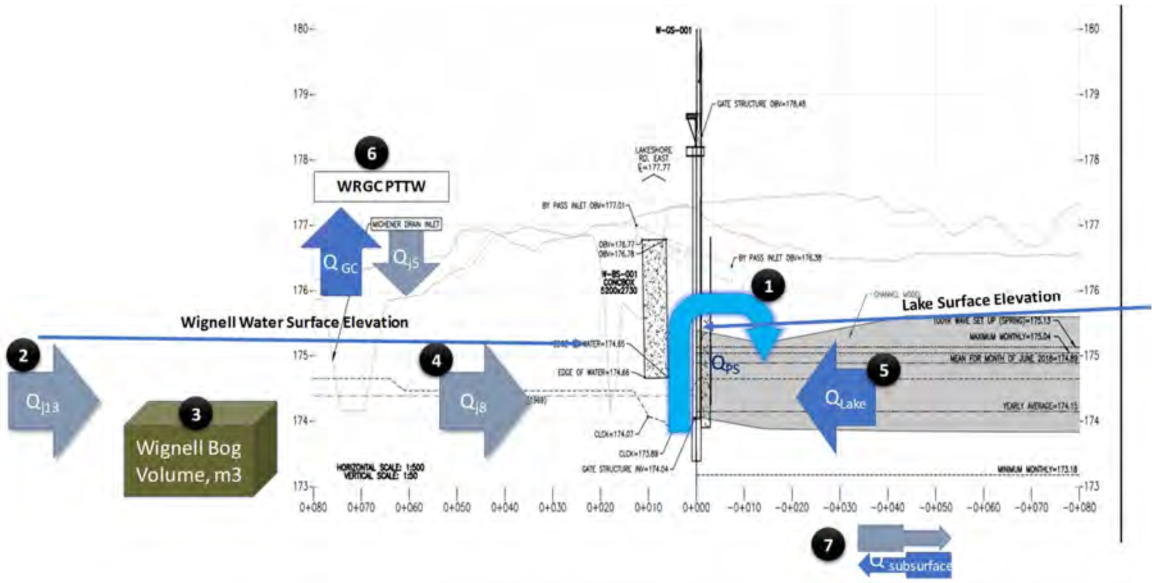


Figure 3 Wignell Outlet Profile & Flow Components

The flow components shown in the figure are directly tied to Flow, Pumping with a consequent impact on elevation control in the Wignell Drain.

Those components are:

1. There are three pumping areas at the Wignell Drain as presented currently. They are represented as Q_{PS1} for centrifugal pump, Q_{PS2} for instream pumping and Q_{PS3} for the bypass pump arrangement.
2. Q_{J13} is the runoff flow predicted for the Wignell Drain just south of the Friendship Trail. This flow is not a monitored flow location but a predicted flow based on hydrologic modelling. A model was implemented by NPCA in 2010 and a model was implemented for drainage design by EWA in 2018. The J13 refers to the Model Junction identifier used in the EWA Drainage Model.
3. The Wignell Bog is a historical bog land that existed and was identified on maps dating back to the formation of the Welland Canal in the 1800s. The bog exists where a former geologic landform created a crest from a former lake in the Onondaga limestone series that underlies the area. Behind this crest a bog formed and is composed of a peat bed that was the basis for black soil desirable for market gardening that took place prior to the identification of soil contamination.
   Where the bog dries out from the lowering of the Wignell Drain, the peat dries out and is lost causing the local land to slump and erode.
4. Q_{J8} is the runoff flow after the confluence of the Michener Drain with the Wignell Drain immediately upstream of the Wignell Control Structure. This runoff is influenced by three other upstream components:
   a. Q_{J13}, the Wignell and Port Colborne Watershed runoff.
   b. WRGC pumping, and

c. Michener Runoff.

5. Q $_{Lake}$ is a component to recognize the potential impact and backwater flow that will occur with a high lake level. Historically, the lake level can be higher than the Wignell Bog land level and this was the original driver for implementing the gate structure and pumping. (see lake level discussion)
6. The Whiskey Run Golf Course, WRGC is a public golf course granted a Water Taking Permit to remove water from the Wignell Drain by pumping to a temporary pond from which the water is fed by gravity to an irrigation / golf feature pond. This water is pumped from the Wignell Drain but some portion of it may flow back through the Michener Drain depending on golf course operations. Other water is lost to evaporation and evapotranspiration. So the water returned in the Michener is a small fraction of the water removed by pumping.
   There are two elements to this component; Q GC is the pumping flow and QJ5 is the Michener Runoff flow upstream from the Wignell confluence as represented in the Hydrologic Model implemented by EWA.
7. The other component influencing the Wignell Drain and Wignell Bog water levels is the subsurface flow that occurs through the dunes along Lake Erie shoreline. This is a slow flow driven by the Lake Water level and the bog water level but is a slow contributor relative to the runoff flows.

2.1. Lake Erie Levels

Lake Erie water level can vary and significantly impact the flow out of the Wignell Drain. It is possible for the lake level to be higher than the drain static water level and have lake water flow backwards into the drain. Lake Erie levels are influenced by several factors which are then temporal depending on the factor.

- Wind and wave setup from storms can influence the drain outlet by nearly a meter above the existing lake level.
- The existing lake level varies from year to year and month to month influenced by flows into and out of the Great Lakes basin.
- There is a Lake level seasonality influenced by annual variations in lake levels.

The following historic Lake levels are provided by the Government of Canada Fisheries & Oceans Hydrographic Service based on 100+ years of monitoring data and statistics. The values are quoted in monthly mean water levels reference to IGLD 1985.

Yearly Average	Minimum Monthly	Maximum Monthly
174.15	173.18	175.04

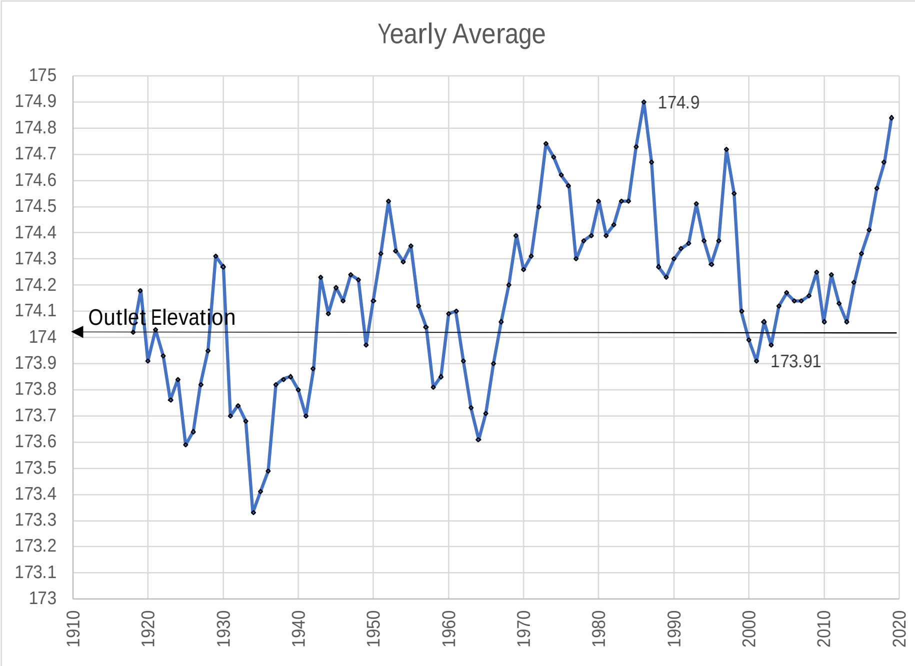


Figure 4 Lake Erie monthly mean water levels, m to IGLD 1985

The chart shows that for the past several years, water levels are above average conditions.

2.2. Wignell Gate Structure

The original Wignell Gate structure was constructed according to Drain Report prepared by CJ Clarke in 1969. The following figure illustrates the design as prepared by the Drainage Engineer in 1969.

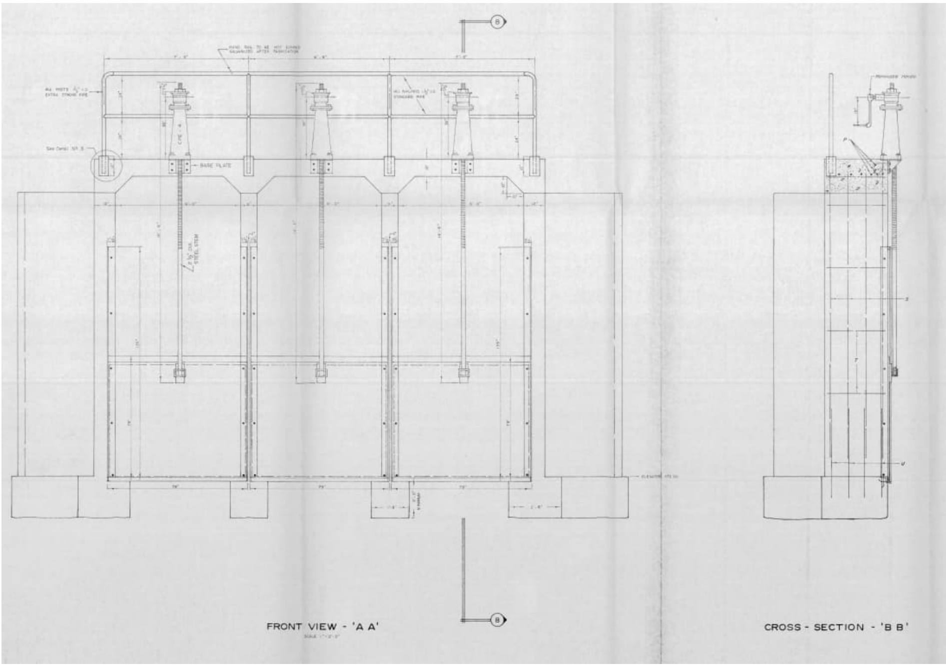


Figure 5 1969 Wignell Control Structure

The original design did not include pumping and used a hand crank to raise and lower the gate structure. Modifications were made to the structure on or about 1973 by the City of Port Colborne and CJ Clarke in response to high lake levels influencing the Wignell Bog lands which had market gardens at the time.

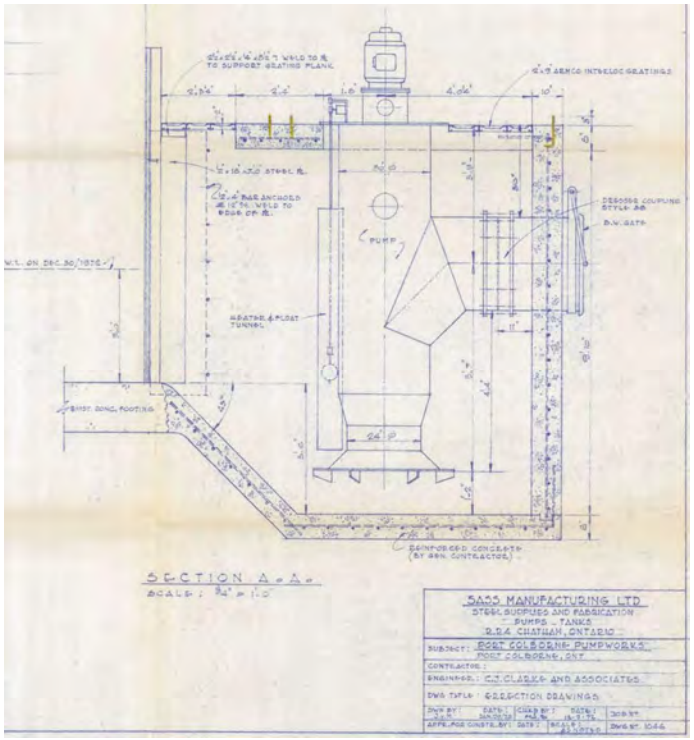
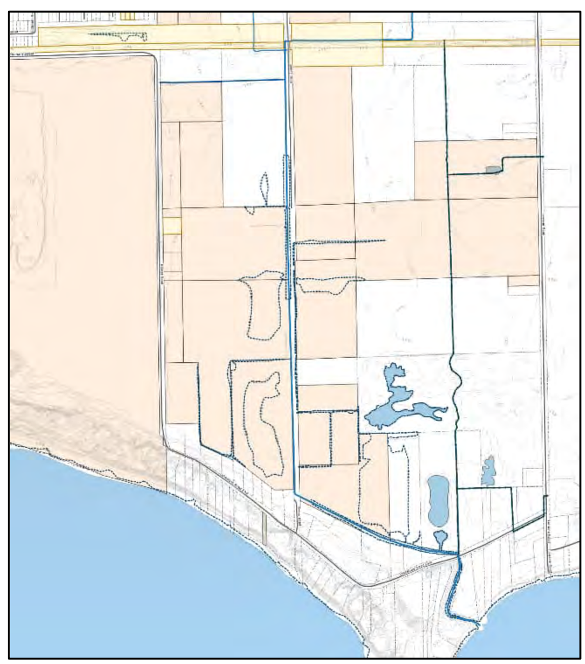


Figure 6 Wignell Centifugal Pump mount

Additional modifications are shown in the following photo.

Figure 7 Wignell Gate Structure Modifications - 1970s

The Drainage Superintendent removed the pump for service in 2015 and the pump has not been returned to service since that time, which is after the market garden operations ceased in the Wignell Bog lands.



The figure, at right, shows the lands now owned by Vale (salmon) and the lands owned by CofPC (yellow).

The dotted blue lines are the elevation contours from the NPCA topographic data for 175m elevation. It depicts the extent of the lands that flood regularly and would be considered part of the original Wignell Bog lands.

The linear 175m elevation features are canals created by the former market garden farmers to irrigate their crops.

A measurement performed by survey investigation indicates that the limit to raise the gates is effectively 175.13m and thus will limit flows to the lake for flows that are higher than the existing opening and grade permits.

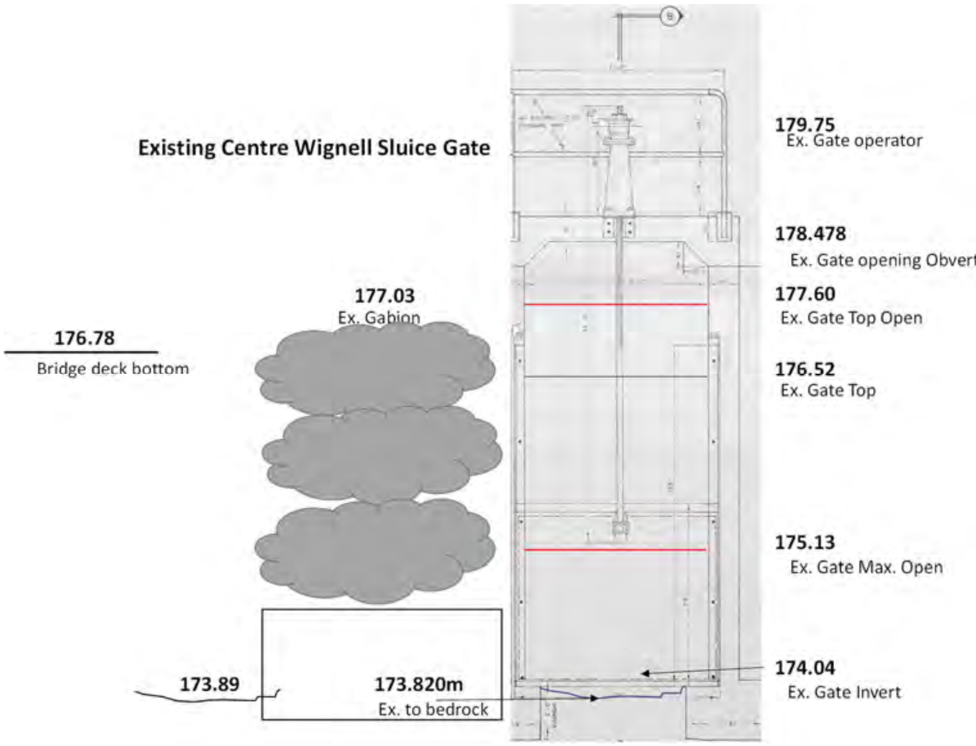


Figure 8 Wignell Gate Structure Key Elevations

This figure shows that the existing gates are not able to seal to the bottom of the existing channel, which is defined by the presence of bedrock.

2.3. References

Chatham Kent Drainage Superintendent was quoted in a published news item about accepted pumping rates. He said, ¼" to ½" of runoff for a given pump watershed should be pumped within 24 hours. This is a simple equation to assign an accepted pumping rate based on watershed served, (m2), 7 to 15mm depth over 24 hours.

From discussions with the former Drainage Superintendent, Mr. Henri Bennemeer CET, we understand that the instream pumping using submersible pumps was not an effective pump arrangement that consistently suffered from sediment clogging the pump.

The pumping platform was constructed with an intake screen and a flap gate to use a centrifugal pump that was removed and sent for service but not re-installed.

"The effect of Moisture on Decomposition Processes in the Disturbed Peatlands of the Wainfleet Bog", Joshua C. Diamond, B.Sc. Brock University, Nov 2006.

"… the Wainfleet Bog is a highly disturbed peatland and that the greatest reductions in decomposition can be obtained by restoring the soil moisture levels near those of undisturbed conditions."

2.4. Available Data

1. Great Lakes historical data is available for the Port Colborne lake level monitoring station. It provides hourly measurements to a reference datum of 173.5m IGLD.
2. Survey data from Amec Foster Wheeler, 2013.
3. Survey data from City of Port Colborne (RTK-GPS), 2021
4. Topographic survey from City of Port Colborne and EWA, *(level instrument with laser range measurement, pending June 8, 2021)*
5. GIS data, Drawings and past drain information provided by the City of Port Colborne.
6. MOE Water Taking Permit data.
7. AMEC file folders of documents received including As Constructed records for the Wignell Gate Structure.

3. Methodology

The Wignell Watershed Report provided analysis and results from a hydrology and hydraulic analysis of the Wignell Watershed. The hydrology analysis using PC-SWMM and for an SCS design storm and runoff model provides hydrograph flow predictions for 1:2 year storm events to 1:100 year events.

There are two primary data elements;

#1 is the Federal Government's Lake elevation data, which is available from the CHS online and provides statistical and historical data levels but does not make long term prediction levels.

#2 is the predicted runoff from the Wignell Watershed, which includes three drains; Wignell Drain, Port Colborne Drain and the Michener Drain.

There are secondary influences which are not considered in the overall evaluation of the Wignell Drain pumping analysis. They are:

- WRGC pumping rates and pumping durations / time of use.
- Subsurface groundwater flows to and from the Sand dunes along the Lake Erie shoreline and adjacent to the Wignell Drain / Bog.
- Wignell Bog water; the continued function of a bog relies not just on a single consistent water level but on fluctuating water levels that are within a specified range and duration. Extensive drying out for the bog can lead to degradation. Flood events into the bog represent a water storage, transpiration and slow release; all benefits for a healthy watershed.

At issue is the resulting water level between the Wignell Flood Gates. Lakeshore Road East and the Friendship Trail which effectively marks the end of drainage grade line and transitions to CJ Clarke's 1969 zero grade line of 174.38m for the Wignell drain bottom.

Hydraulic analysis is based on past work using HEC-RAS and on additional complementary assessment using HY-8.

The pumping rate analysis is similar to the analysis used for sizing of storage (pond volume) in an urbanizing watershed. The urbanized hydrograph is more 'peaky' and the use of a pond storage volume to store the peak flow reduces the resulting runoff peak flow while extending the average runoff flow duration. The following figure illustrates the analysis.

The key is to establish a limit or target rate of flow above which excess flooding occurs that negatively impacts the upstream area. This is to limit flooding to an amount that is acceptable but not to necessarily eliminate flooding completely although if the target is set low enough that can be achieved. This reflects that the volume of water removed from the hydrograph represents a benefit in reducing the impact of flooding.

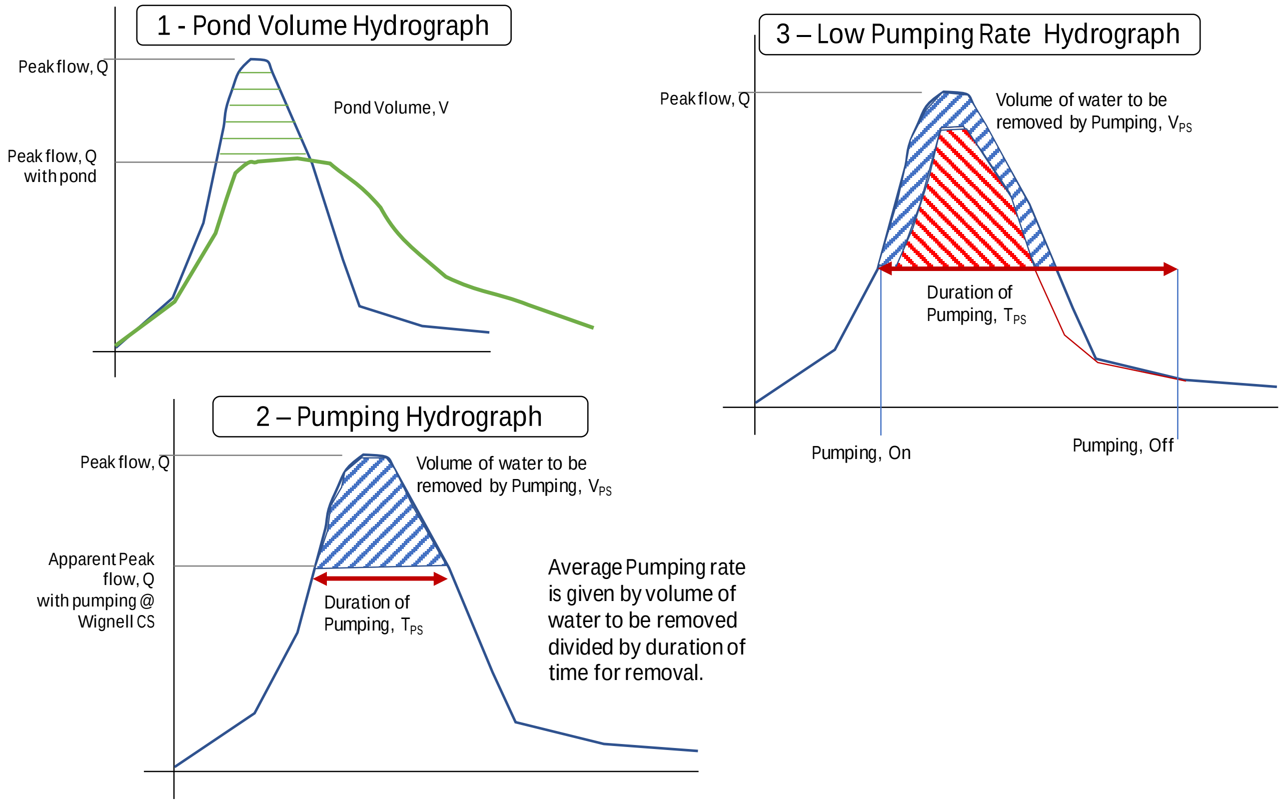


Figure 9 Pump Analysis Hydrographs

Hydrograph #2 illustrates the ideal pumping capacity for the hydrograph, which displaces the excess or flow above a specific design rate through pumping. The pumping occurs for a specified duration, which is the predicted duration that the runoff hydrograph is above a specified level. The result is a volume of water moved over a specified duration which provides an average pumping rate predicted.

Hydrograph #3 uses a hydrograph to illustrate the effect of a pump capacity that is too low. The pump is turned on at a specific point in the rising limb of the hydrograph but since the capacity is lower than the incoming rate of flow, the result is a short duration limit to flow that is then exceeded and the hydrograph continues to rise to a lower peak flow than previous being realized by the amount of the lower rate of fixed pumping. The shaded blue area is the volume of pumped water moved while the shaded red area is the volume and rate of flow of water that still exceeds the target flow limit to minimize flooding.

For this scenario, we have shown a late stage for the pump to be shut off and the consequence of this is additional pumping that may lower the elevation on the upstream side but it is of no consequence in the analysis related to the meeting the target flow limit for flow.

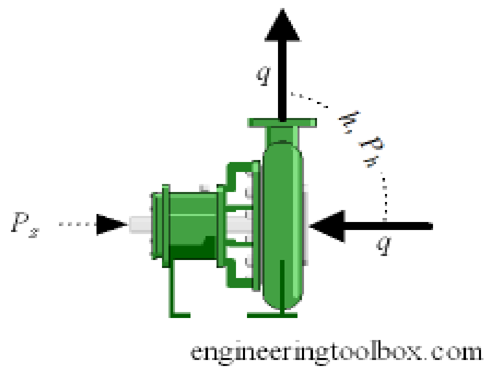
It should be emphasized that pumping and specific pump mechanics is more varied than this discussion. The analysis is presented to help define the correct capacity of pump to have an effect on lowering flood elevations behind the Wignell Control Gate Structure.

The size of the pump is determined from the average pumping rate using the conversion to pump power and shaft power provided by the formula detailed on the web site EngineeringToolbox .com

Hydraulic Pump Power

The ideal hydraulic power to drive a pump depends on

- the mass flow rate the
- liquid density
- the differential height



- either it is the static lift from one height to an other or the total head loss component of the system - and can be calculated like

$P_{h(kW)} = q\ \rho\ g\ h\ /\ (3.6\ 10^6)$ *(1)*

where

$P_{h(kW)}$ = *hydraulic power (kW)*
q = *flow capacity* (m^3/h)
ρ = *density of fluid* (kg/m^3)
g = *gravity* ($9.81\ m/s^2$)
h = *differential head (m)*

The hydraulic Horse Power can be calculated as:

$P_{h(hp)} = P_{h(kW)}\ /\ 0.746$ *(2)*

where

$P_{h(hp)}$ = *hydraulic horsepower (hp)*

4. Analysis

The objective is to identify the size of pump that would ensure that flooding through the Wignell Gates does not occur. For this to occur, the following assumptions are made.

1. The model assumes that the outlet is free flowing when in fact the lake level has a direct impact on the outlet flow.
2. The outlet capacity, that is the flow that can occur downstream of the Wignell Gate Structure based on a free flowing outlet is predicted to be based on the Manning equation for a full flowing channel with a bottom width of 2m and a depth of 2m

and a side slope for a trapezoidal channel of 1.5. This is calculated to be 7.3 cms for a channel with a bed slope of 0.00043 m/m.

3. The model is implemented with idealized channels based on actual slopes to reveal the target design flows. Actual channel dimensions are not modelled. Nor is the role of storage within the system modelled using the Wignell Watershed version 104 model to predict the design requirements for drain channel sizing.
4. For more details on the PC-SWMM version of the Wignell Watershed Model refer to the Wignell Watershed Hydrologic and Hydraulic Analysis Report.

4.1. Hydrologic Runoff Model

The drainage model shows flooding occurs at the Friendship Trail, meaning that the predicted flow exceeds the bank full capacity of the defined channel, and flooding occurs at the Wignell Gate Structure. The bridge opening for the Lakeshore Road East in the model does not show flooding. The following figure shows the profile result for the predicted 1:100 year Design Storm Event.

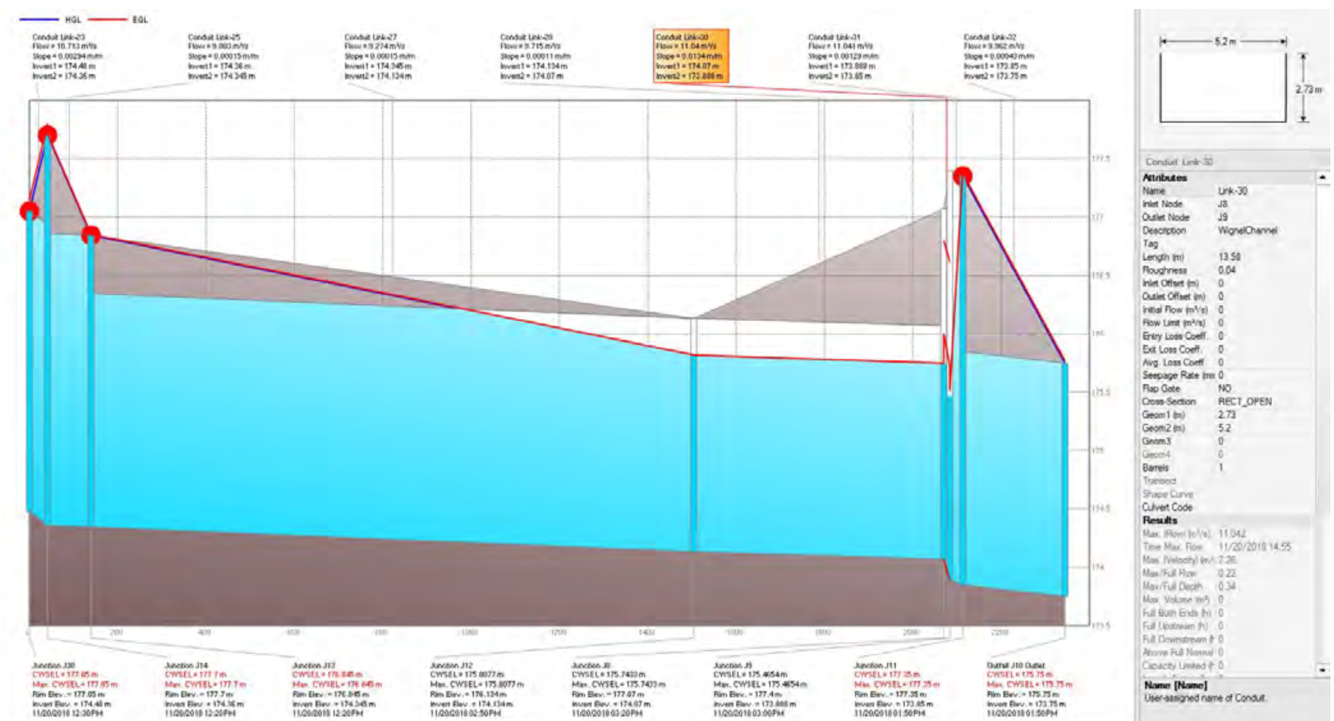


Figure 10 PC-SWMM Profile View of Wignell Drain 1:100 year Design Storm

The resulting hydrograph is shown in the following figure.

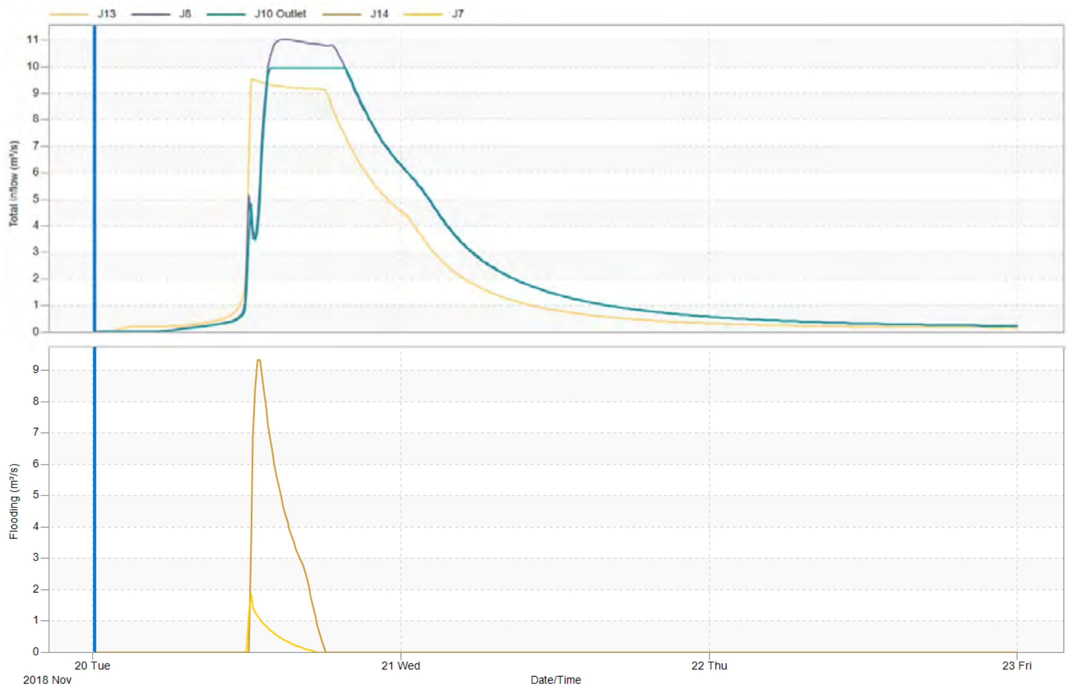


Figure 11 1:100 year Design Storm Runoff Hydrograph

For the 1:25 year design storm event, the runoff hydrograph is as follows. Additional hydrographs are shown for the Wignell outlet channels.

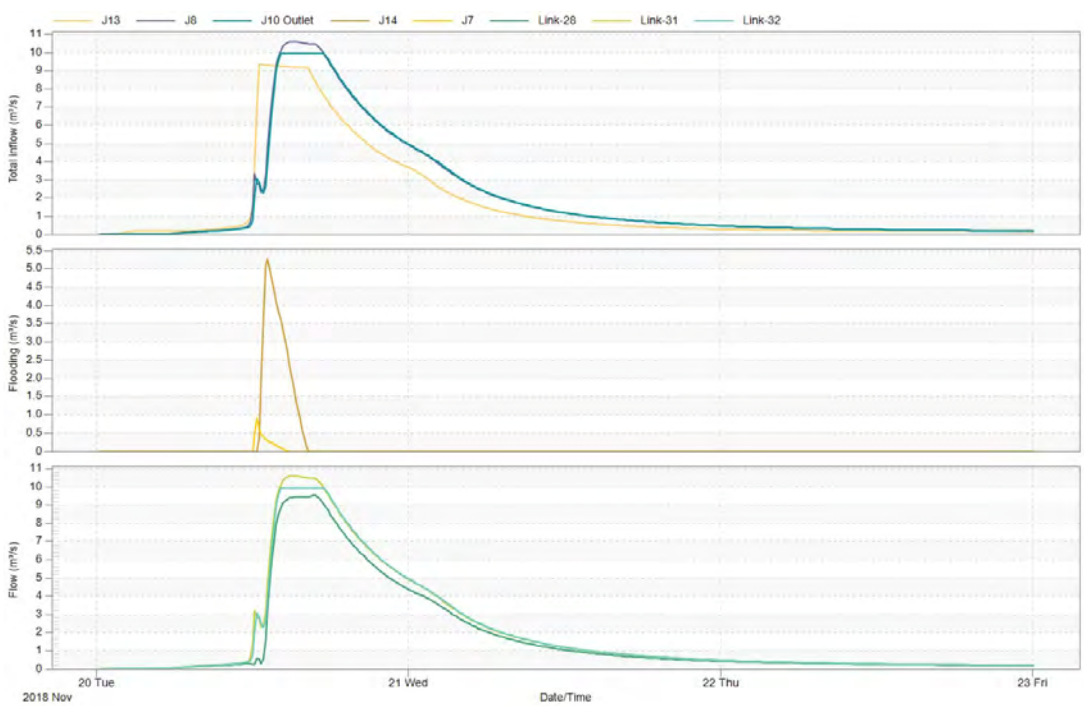


Figure 12 1:25 year Design Storm Runoff Hydrograph

The 1:25 year event shows a similar hydrograph as was shown for the 1:100 year Design Storm. This reflects the moderating influence that the Wignell Bog lands have on the runoff hydrograph. The wide channel with low to zero slope does not run a high flow to the Wignell Gate Structure. There is an effective limit to the rate of runoff that can pass from the Friendship Trail, through the bog (former market garden area) and pass the Lakeshore Road East Bridge structure and Wignell Control Structure.

Table 1 Junction Runoff Results

Wignell Watershed - Junction Runoff Rates									
		Model	Max. Total Inflow (m³/s)						
Drain	Crossing	Junction	100 YR	50 YR	25 YR	10 YR	5 YR	2 YR	1 YR
Port Colborne	PC-CS-007 2nd Conc. East	J21	2.928	2.425	1.966	1.417	1.049	0.606	
Port Colborne		J88	3.392	2.841	2.335	1.727	1.316	0.812	
PC Quarry P1		J19	0.118	0.118	0.118	0.118	0.118	0.118	
Port Colborne	PC-CS-005 Babion Rd.	J18	3.554	2.986	2.47	1.848	1.425	0.903	
PC Quarry P2		J20	0.057	0.057	0.057	0.057	0.057	0.057	
Port Colborne	PC-CS-004 Main Street East MTO Hwy #3 Rural Arterial	J17	4.893	4.041	3.26	2.328	1.708	0.977	
Port Colborne	PC-CS-003 Snider Road	J16	6.26	5.12	4.077	2.835	2.015	1.066	
Port Colborne	PC-CS-002 Killaly St East	J15	6.952	5.986	4.735	3.251	2.274	1.154	
		.. J14							
Michener		J1	0.37	0.31	0.255	0.19	0.146	0.092	
M- Branch	CS-101 Lorraine Rd.	J2	2.7	2.202	1.746	1.203	0.846	0.436	
Michener		J7	3.225	2.632	2.093	1.458	1.042	0.566	
Michener		J3	0.88	0.88	0.88	0.88	0.831	0.452	
Michener		J4	0.991	0.967	0.946	0.924	0.815	0.421	
Michener		J5	1.11	1.058	1.014	0.967	0.844	0.435	
		..J8							
Wignell		J22	3.217	2.632	2.098	1.463	1.045	0.559	
Wignell	W-CS-005 2nd Conc. East	J23	6.414	5.283	4.252	3.025	2.209	1.241	
Wignell		J24	6.717	5.519	4.324	2.884	1.988	1.015	
Wignell	W-CS-008 Main Street East	J25	8.667	7.004	5.419	3.537	2.325	1.021	
Wignell		J26	8.492	7.581	5.868	3.834	2.52	1.091	
Wignell	W-CS-003 Killaly St. East	J27	9.678	8.574	6.646	4.352	2.865	1.228	
W. Branch	CS-119 Killaly St. East	J87	1.497	1.226	0.978	0.684	0.49	0.264	
Wignell	W-CS-007 Lorraine Rd.	J28	8.793	8.354	7.776	5.098	3.356	1.417	
W. Branch	CS-120 Killaly St. East	J86	2.623	2.139	1.697	1.17	0.823	0.425	
Wignell		J29	10.06	9.321	8.681	6.095	4.036	1.71	
Wignell	W-CS-010 Snider Road	J30	11.311	10.211	9.317	6.55	4.357	1.857	
Wignell - Port Colborne Confluence	Friendship Trail	J14	18.449	16.801	14.5	9.942	6.698	2.996	
Bower/ W. Branch		J6	0.618	0.505	0.4	0.274	0.191	0.096	
Wignell		J13	6.528	6.385	6.24	6.102	6.026	3.04	
Wignell		J12	6.55	6.42	6.303	6.201	6.07	2.781	
Wignell - Michener Confluence	W-BS-001 Lakeshore Rd. East	J8	7.886	7.671	7.478	7.069	6.71	3.081	
Wignell		J9	7.886	7.671	7.478	7.069	6.71	3.081	
Wignell		J11	7.886	7.671	7.478	7.069	6.71	3.081	
Wignell		J10 Outlet						3.081	

The model uses colours for culvert design flow requirements. Yellow for local and MTO requirements.

Junction 11 corresponds to the Gate structure position within the node – link model. The gate structure itself is not modelled but the trapezoidal channel upstream and downstream is modelled for an idealized flow. The model shows a low 1:2 year flow value of 3.1 cms rising to a peak flow of 7.9 cms. This is very different from the NPCA hydrologic model which predicts a flow upstream, downstream and through the gates of 14.79 cms for the 1:2 year storm.

4.2. HEC-RAS Analysis

The following are presented as key views of the HEC-RAS model presented by file, “Wignell-Michener_up.prj” referred to as Plan 03 updated, with a runtime date stamp of Jan 2010.

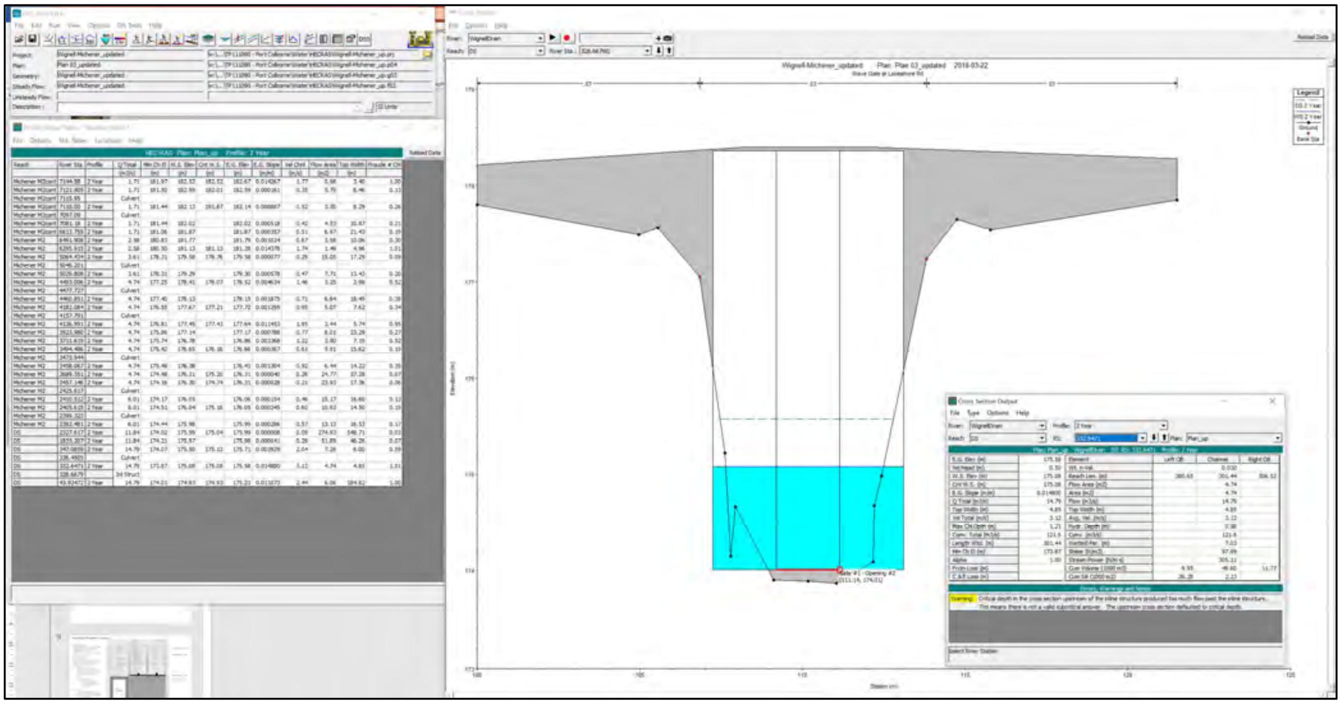


Figure 13 HEC-RAS X-section view of Wignell Gate Structure

There are a few observations to be made of this analysis.

1. There are three gates shown as being open for flow, when only 2 are functional. The gate in position 1 is blocked by the wet well for the pump is not available for flow as an open gate. Flow will occur through gate #1 once the level is higher than the inlet but it will not flow in the manner shown here.

2. The gates are shown as 2m wide when they are 1.8m with a 0.2m column between each gate. The sides are 0.3m and have wing walls. Thus the basic gate geometry and dimensions are not shown correctly.

3. The existence of a flow space under the centre gate is shown correctly and the gate inverts as compared to the channel bottom are as were shown by the surveyed of the CofPC in 2021.

4. The flow through the gate is reported as 14.79 cms based on a flow area of 4.74 m2 with an average velocity of 3.12 m/s resulting in a Froude number of 1.01 indicating super-critical flow just barely above critical. The water

surface elevation is reported as 175.08 m, which would be lower than the highest level of the gate position of 175.13 but just barely.

5. The energy grade line is shown in Figure 14 Outlet DS profile: Plan 02_updated. The portion through the gate structure is very steep consistent with high velocity flows through a constricted channel. It's also steep to the to the lake indicating a flow velocity of 2.44 m/s.

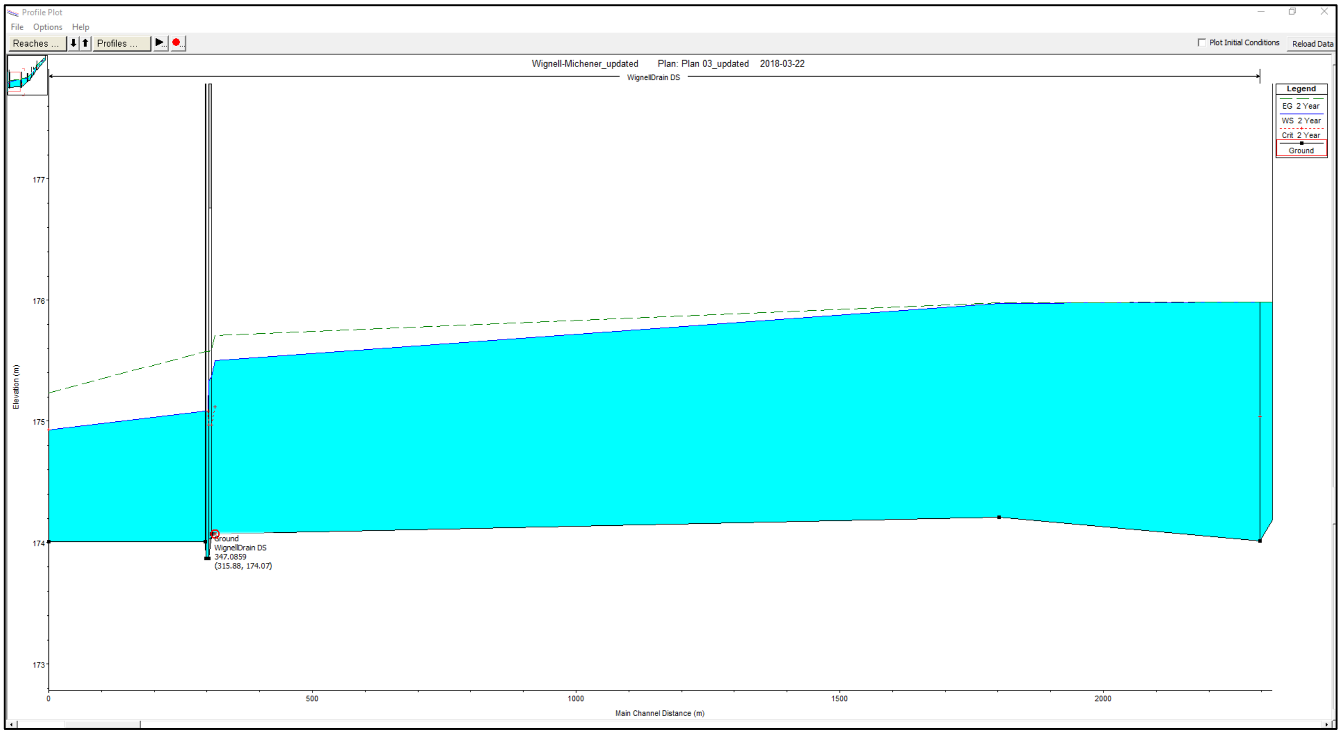


Figure 14 Outlet DS profile: Plan 02_updated

Conclusions from HEC-RAS

The smaller actual gate opening means that for the same flow to pass, the velocity would have to increase and this would be a larger Froude number and this doesn't seem representative of the observed flows through this area in the past. The forecast for a 2 year runoff peak flow through this gate of 14.79 cms would seem wildly inaccurate.

4.3. HY-08 Analysis

The Wignell Gate Control Structure was hydraulically modelled using HY-8 culvert analysis software. The gate structure was modelled using a concrete box with the same dimensions as the individual gate opening with a 100mm thick wall.

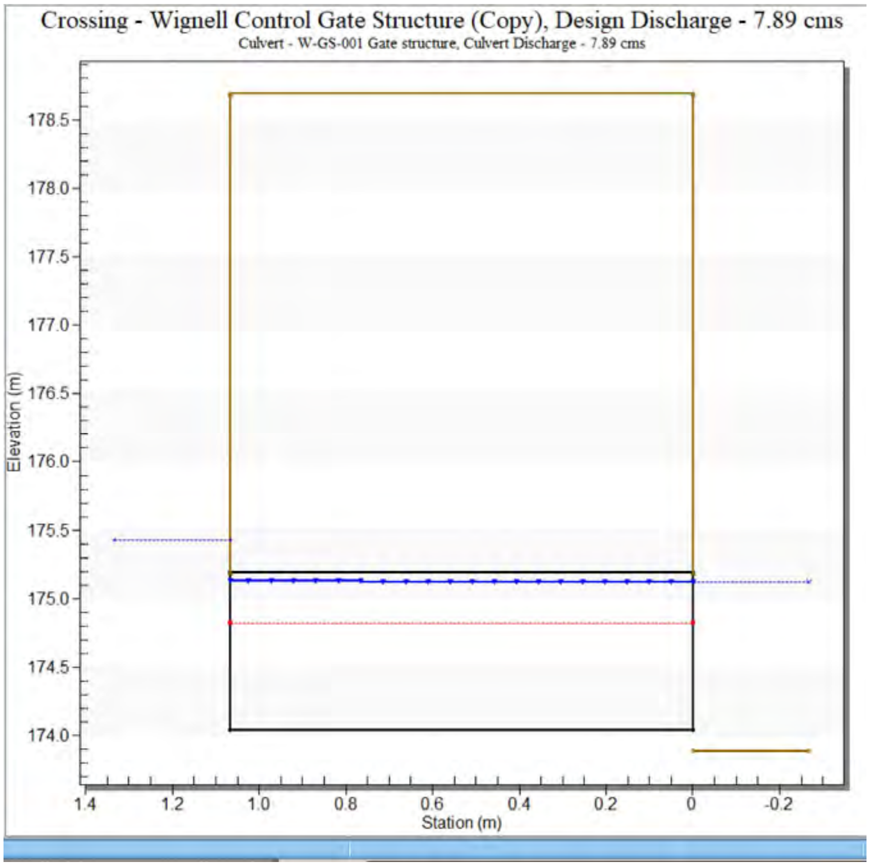


Figure 15 Wignell Gate Structure Hydraulic Analysis

The analysis shows that the two gate structures when open completely are able to pass a 7.89 cms design flow that also nearly matches the predicted outfall channel flow capacity of 7.3 cms. The capacity of the gate structure openings (2 are analyzed as the third is obstructed by the constructed pump wet well from 1993) under outlet control conditions. The outlet control reflects that the downstream slope, the channel to the lake is a very low slope trapezoidal channel. After that depth the opening is not available for flow as a result of the limit to which the sluice gate can be raised.

A target flow limit of 7 cms is proposed for the upset limit and the onset of pumping to reduce the overall impact of flows. Using the flow hydrograph presented in Figure 9 a volume to be shifted out using a pumping system is calculated to be 100675.8 cubic metre of runoff over a 9.5 hour period. This is a resulting flow rate of 2.94 cms or 10,600 m3 per hour, or 46,600 GPM.

Using the Engineering Toolbox calculator for Hydraulic Power, (as detailed above) the result for that flow rate and a hydraulic head of 3m is 116.17 Hp (86.6 kw) and a shaft power of 193.62 Hp (144.4 kw). Actual power requirements depend on TDH (total developed head), which is very low in this application.

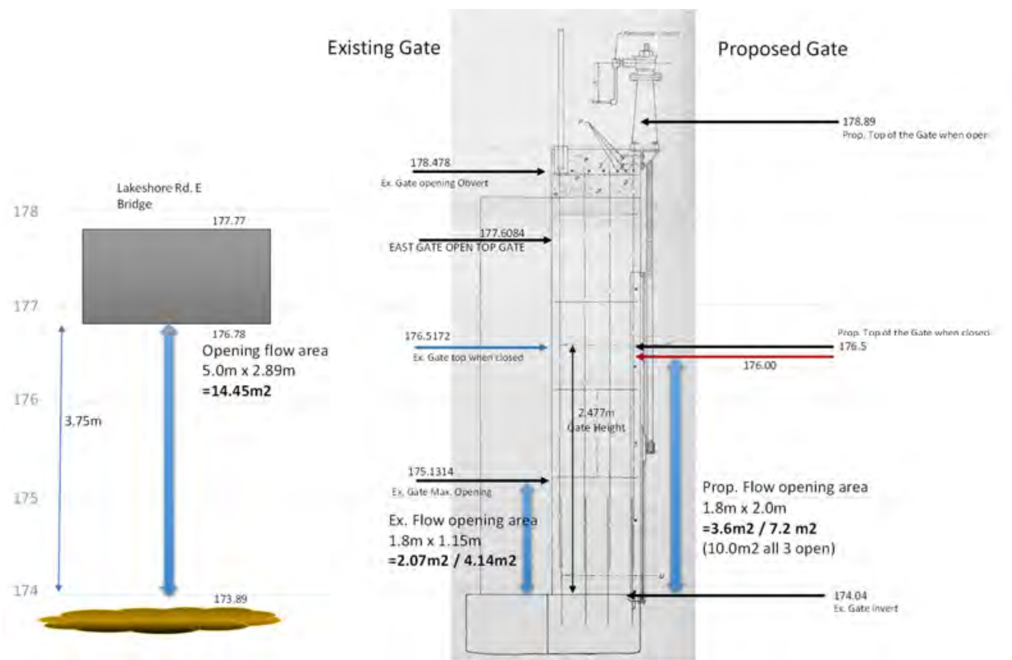
As indicated, for a 10,000 cubic metres per hour output, with a 480 rpm input, the pump would have a 900mm suction and discharge nozzle diameter.

This compares to the original design basis for a 30in suction pipe with an unknown impeller size but a 30 hp motor with an output estimated at 0.4cms as compared to the target.

4.4. Gate Improvement Options

The existing gate movement has restrictions resulting from the addition of instream pumping pipes. The existing motorized gate lifting mechanism is on/off without limit switches or controls. It's proposed that this 50 year old structure be modernized and upgraded using actuators and other mechanical improvements. This is referred as a refurbishment of the existing gate structure, changes to make modest improvements for a small amount of capital invested so that the gate functions well for another 50 years.

Alternatively, a complete replacement of the existing bridge and/or gate structure is an option for improving the function of the gate structure. The bridge for Lakeshore Road East will require replacement at some point in the future and an integrated design with the gate structure would present options to save money overall. Instead of gate structures, a PE flap gate could be used which doesn't require electric power to operate and achieves the same function as the knife gates.



From analysis using the HY-8 software there is a limitation in the height of the gates. This shows that the capacity is only moderately improved with the gates raised above a specific height depending on the target design capacity.

From these two replace or refurbish positions, we identified 7 possible options for consideration. For each option, we calculated the x-sectional flow area possible to be improved and the resulting increase in max. flow through the structure that is likely to achieve. From this we estimated the cost for each option and determined a benefit (max flow) that is compared against the cost charged to the watershed. For the bridge replacement, that cost would remain with the City for the Road portion of the project.

Table 2 Gate Structure Improvement Options

Options:	X-section Area (improved)	Q max, cms	Total Capital	$ assigned Road	$ assigned Watershed	Cost/Benefit $/cms
1.Improve movement for 2 of 3 existing gates = 7m2	7m2	7.5	$78,000	$0	$78,000	$10,400
2.Improve height and remove PS wet well	11m2	10	$100,000	$0	$100,000	$10,000
3.Complete replacement, 2 openings with PE flap gates 3x2m	12m2	12	$175,000	$0	$175,000	$14,583
4.Complete replacement, 2 3x2 openings with actuator lift gates	12m2	12	$250,000	$0	$250,000	$20,833
5.Put a new pump back in existing spot	7m2	0.4	$378,000	$0	$378,000	$945,000
6.Complete replacement with pump station	12m2	1	$850,000	$0	$850,000	$850,000
7.Integrated bridge and gate replacement.	16 m2	16	$1,200,000	$1,000,000	$200,000	$12,500

From this, the greatest benefit for improving flow through the gate structure is the refurbishment of the existing gate structure with new gates and removing the existing wet well to allow flow to pass through Gate position 1 again. If the bridge is to be replaced, then the integrated bridge / gate structure is a close second option.

This does not include operational costs in the assessment of a preferred option.

4.5. Tech Memo Limitations

This analysis is based on the information available at the time of preparation.

The PC-SWMM model is implemented as design aid for sizing drainage channels predominately in the areas of the upper watershed, north of the Friendship Trail, where there are drainage channel grades. As such, the role of storage within the runoff system is much greater than just the in channel storage that is assessed using the PC-SWMM model. The design drainage model can be said to be one dimensional model, (1D) and that the inclusion of storage for those portions of the drain that would have a culvert with a inlet condition controlling flow could be implemented as a two dimensional model (2D) such as has been performed in urban drainage modelling to assess the role and function of minor and major system flows. Implementing such a 2D model would require a more accurate Digital Elevation Model than is currently available using the NPCA DEM of 2010. The recent Provincial LIDAR for the Lake Erie North Shore would have been the ideal data set for implementing the 2D model; however, this data set does not extend as far East as Port Colborne and the Wignell Drain Watershed.

5. Conclusions:

The existing gate structure is built to control the backwater effects of seiche/surge storm conditions on Lake Erie. Recent storms have demonstrated a seiche/surge elevation impact of 176.5m, which the gate is able to control with the gates closed.

1. The existing gate structure is effective at controlling the impact of seiche/surge events from Lake Erie when the gates are closed before the storms impact occurs and opened immediately after the storm subsides.
2. The existing gate does not seal at the bottom and backwater flow does occur. This backwater flow should be prevented but not by causing an increase in outlet elevation. The gate bottom should be lowered instead of a sill raised.

This analysis shows that the former pump deployment was too small without the required capacity to meet the predicted peak flow requirements. The existing pump wet well and pump does not appear to have the required capacity to meet requirements during a design storm. Nor does it meet the expressed accepted standard rates described by Chatham-Kent. The peak flow pumping shows the need for a significantly larger pump that may not be deployable using the existing pump wet well.

3. A pump system sized for a 1 cms flow rate (16,000 USGPM) would be the minimum target design rate for a pump station.

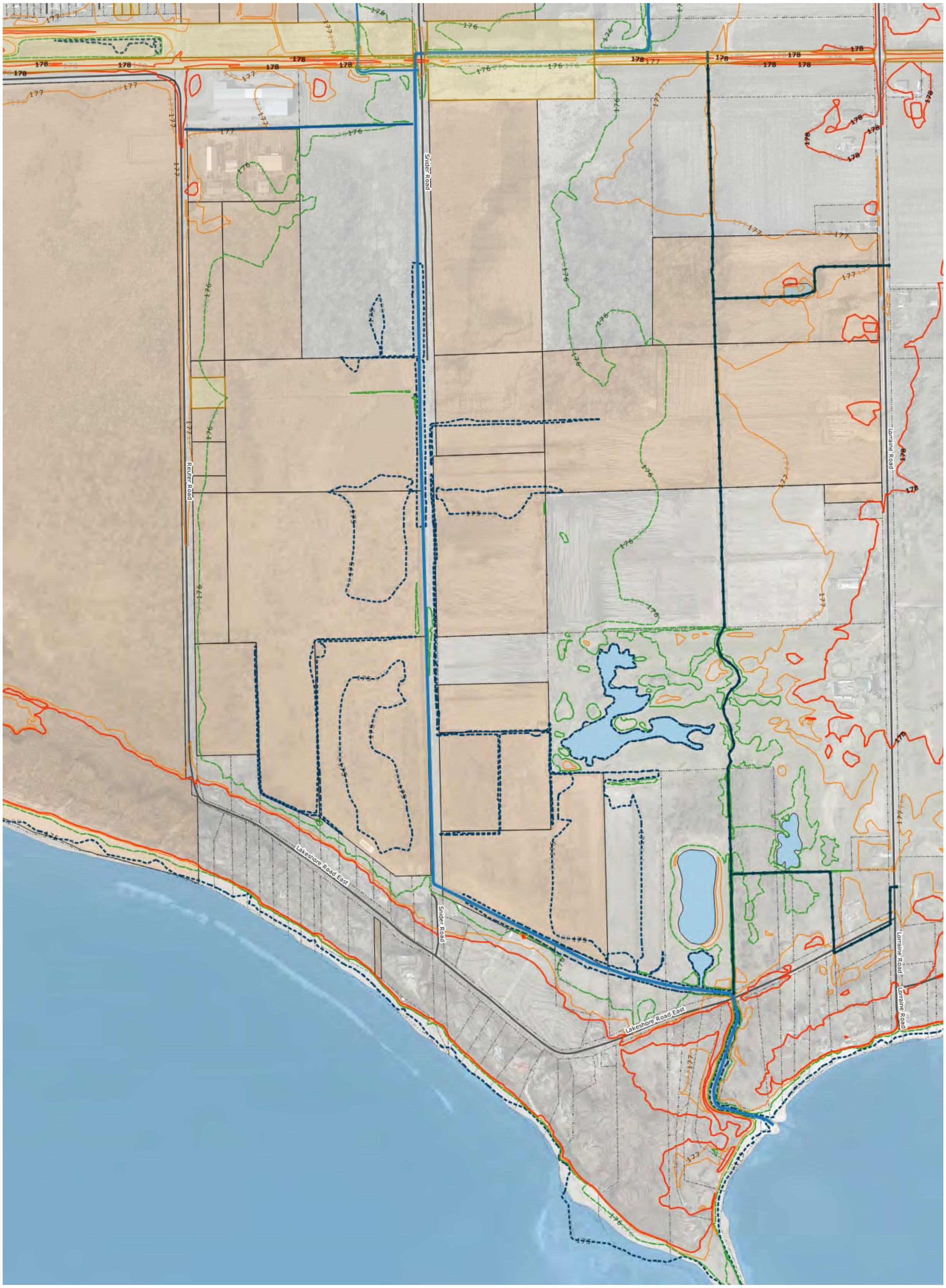
The existing gate structure with one opening blocked and two open with a high level gate elevation of 175.15m (maximum opening), provides 7.5 cms of flow capacity analyzed using HY-8 software with a downstream tailwater condition controlling the rate of flow through the gate structure. The downstream outlet capacity is controlled by the channel capacity and the slope to the lake. The lake elevation directly impacts the energy grade line controlling flow through the gate.

4. The refurbishment of the existing gates to optimize flow through the gate is the preferred option for improving the performance for the watershed.
5. If the bridge crossing Lakeshore Rd. E is planned for replacement then an integrated design including a new gate structure should be considered.

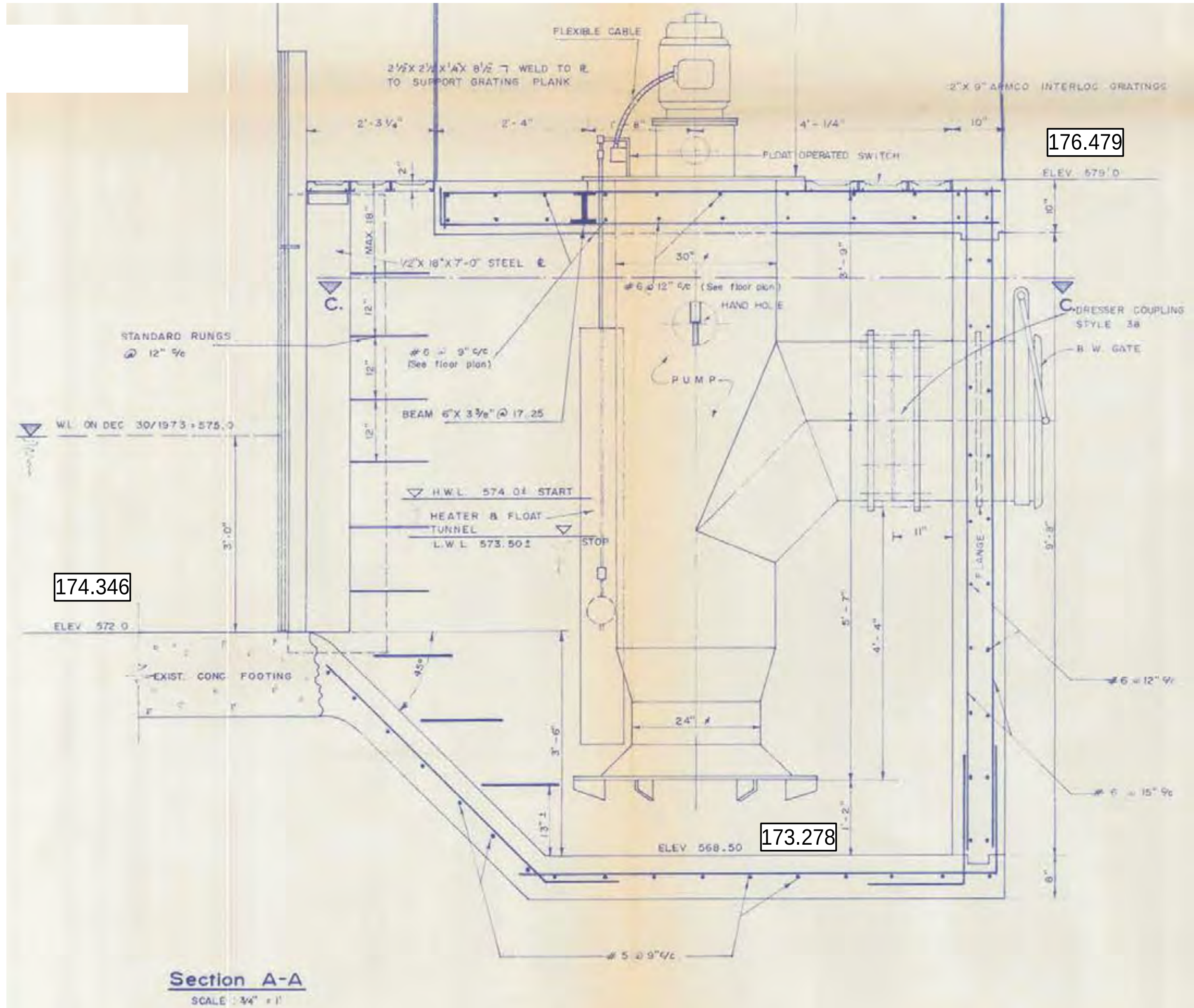
The existing lands north of the Lakeshore Rd E, west of Loraine and East of Snider could be implemented as a bog or stormwater detention facility. The use or the implementation of a bog/wetland to absorb and transpire flood water during significant runoff events would be a significant benefit to the watershed as a whole and for controlling flows to the gates specifically.

Prepared by:	Paul C. Marsh, P.Eng. Principal Engineer, EWA Engineering Inc.	
Signature:		Date: 2021-07-14

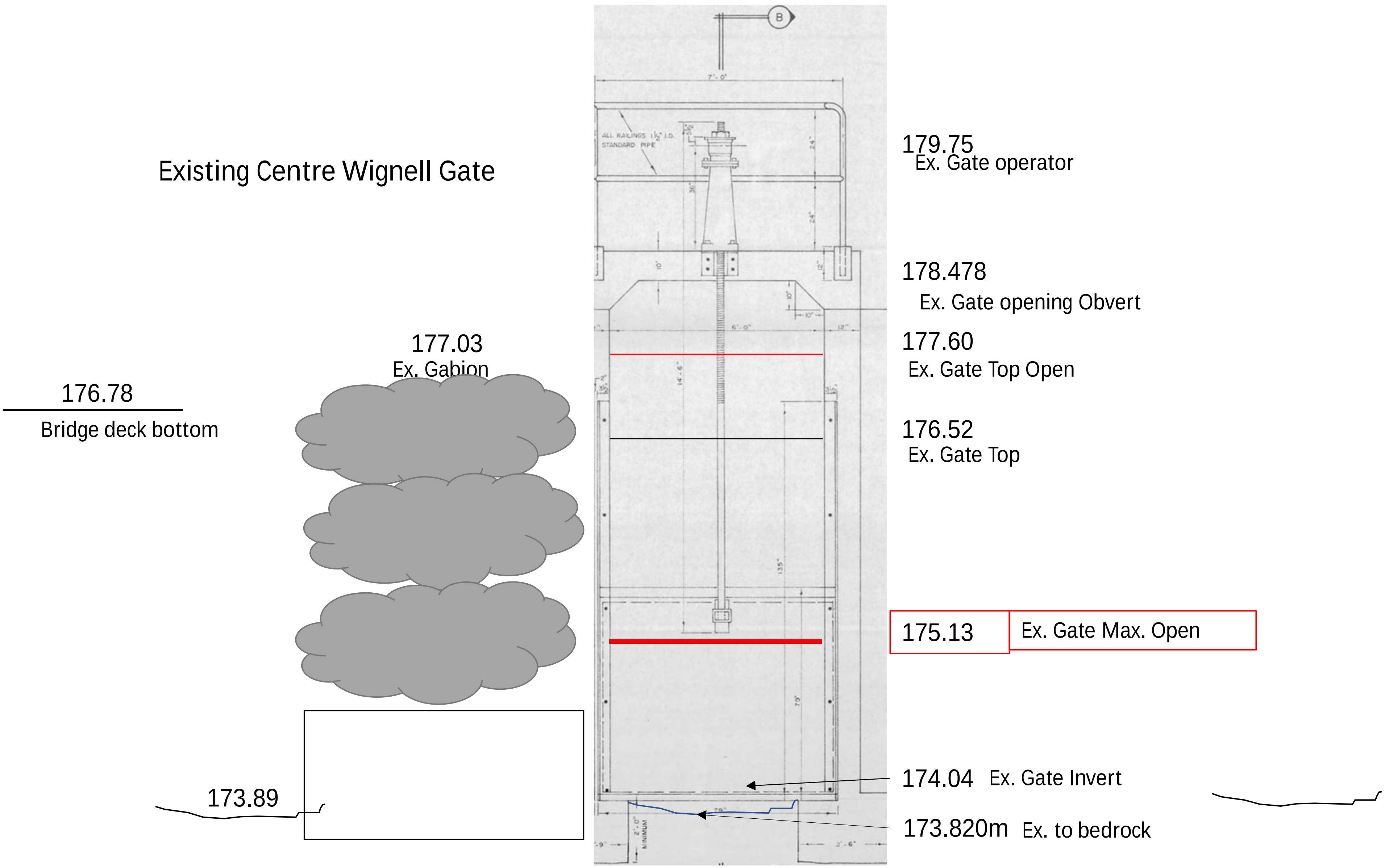
Topography of the Wignell Outlet Lands



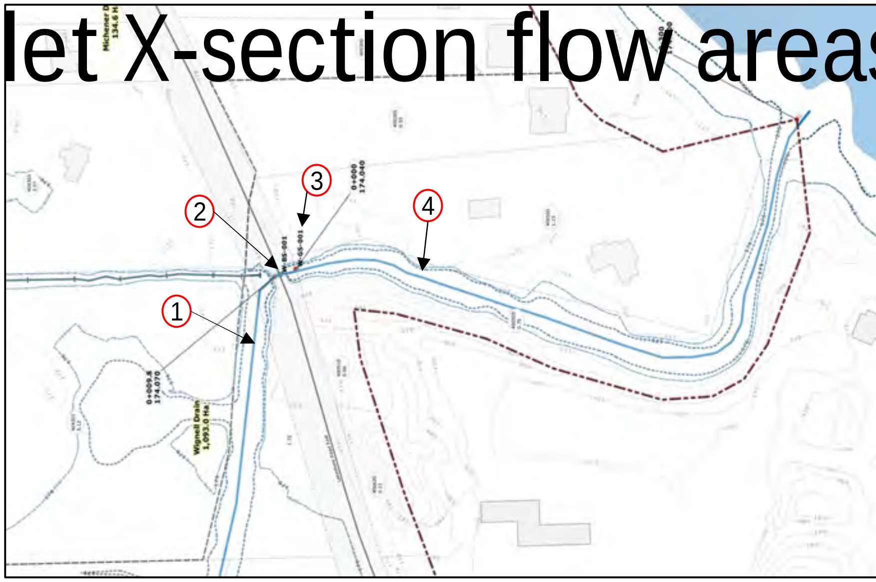
Pumping added around 1973



Existing Centre Wignell Gate



Wignell Outlet X-section flow areas

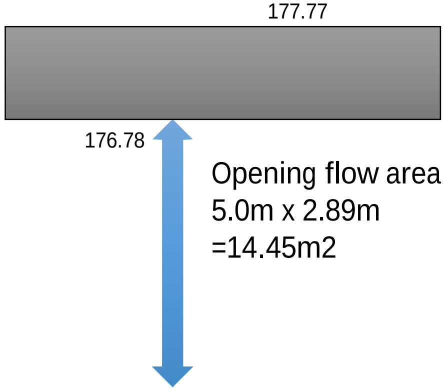


Section #1
Open Channel

BW = 7
SS = 1.0
D = 1.5m
S = 0.0001
N= 0.035

Q full = 3.962 cms
Area = 12.75 m2
V = 0.311 m/s

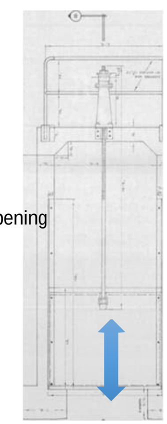
Section #2
Bridge Opening



Opening flow area
5.0m x 2.89m
=14.45m2

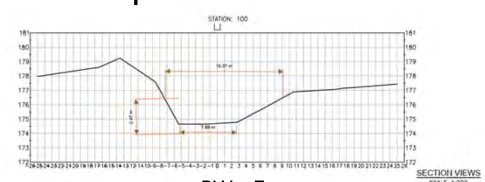
Section #3
Ex. Control Gate Opening

175.1314
Ex. Gate Max. Opening



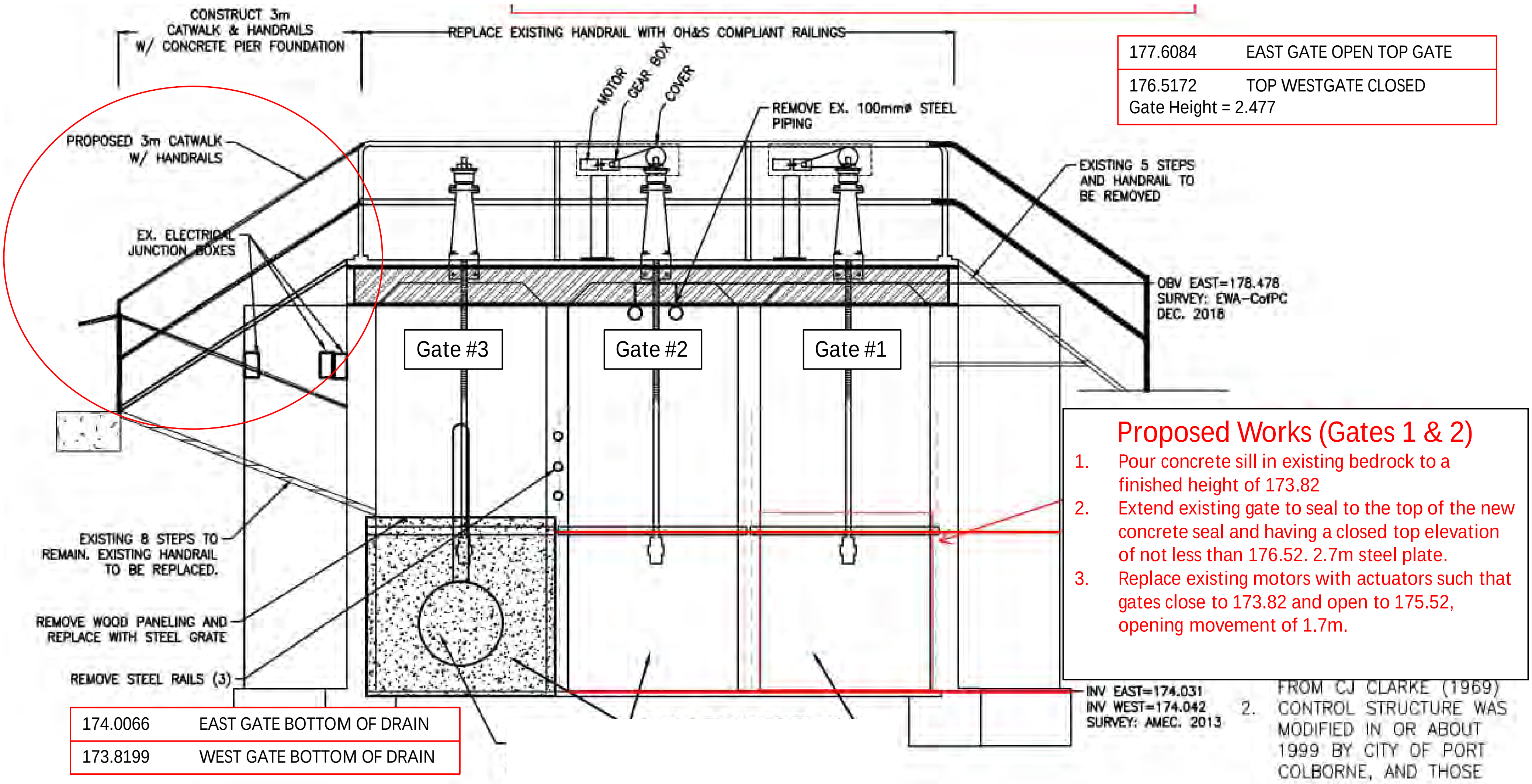
Ex. Flow opening area
1.8m x 1.15m =2.07m2
2 gates = 4.14 m2

Section #4
Open Channel



BW = 7
SS = 1.5
D = 1.5m
S = 0.0001
N= 0.035

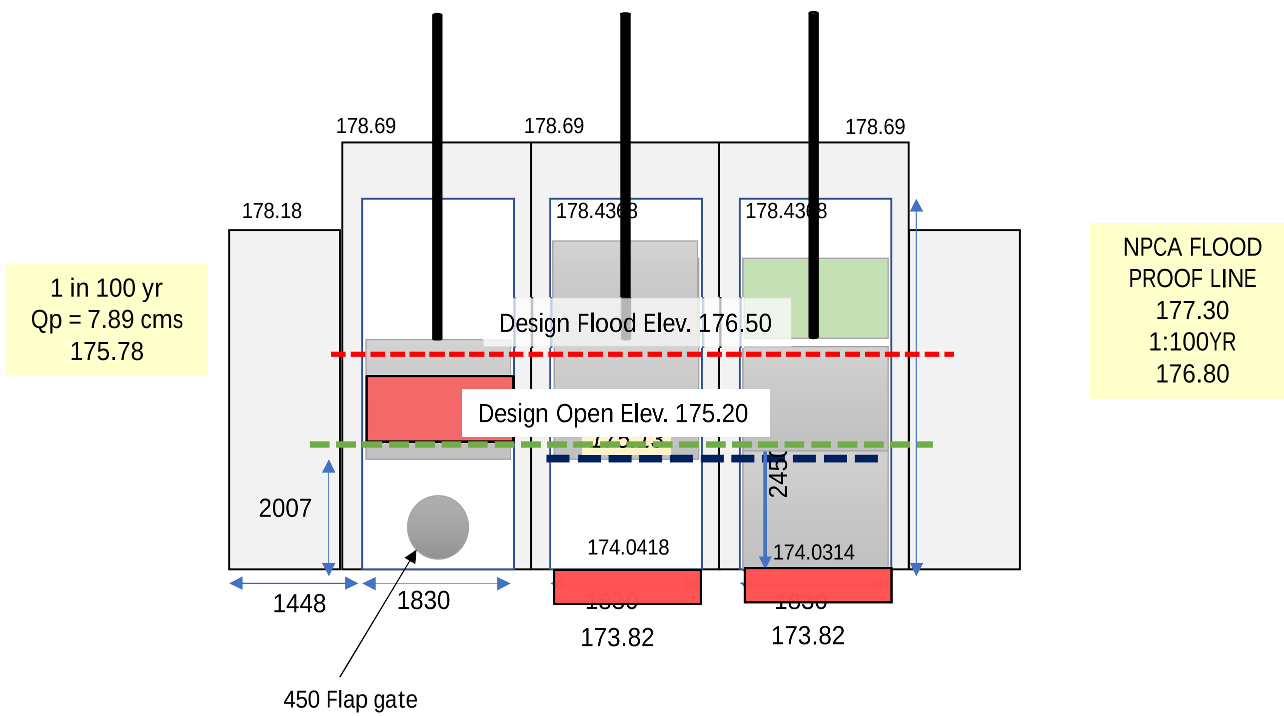
Q full = 4.271 cms
Area = 13.88 m2
V = 0.308 m/s



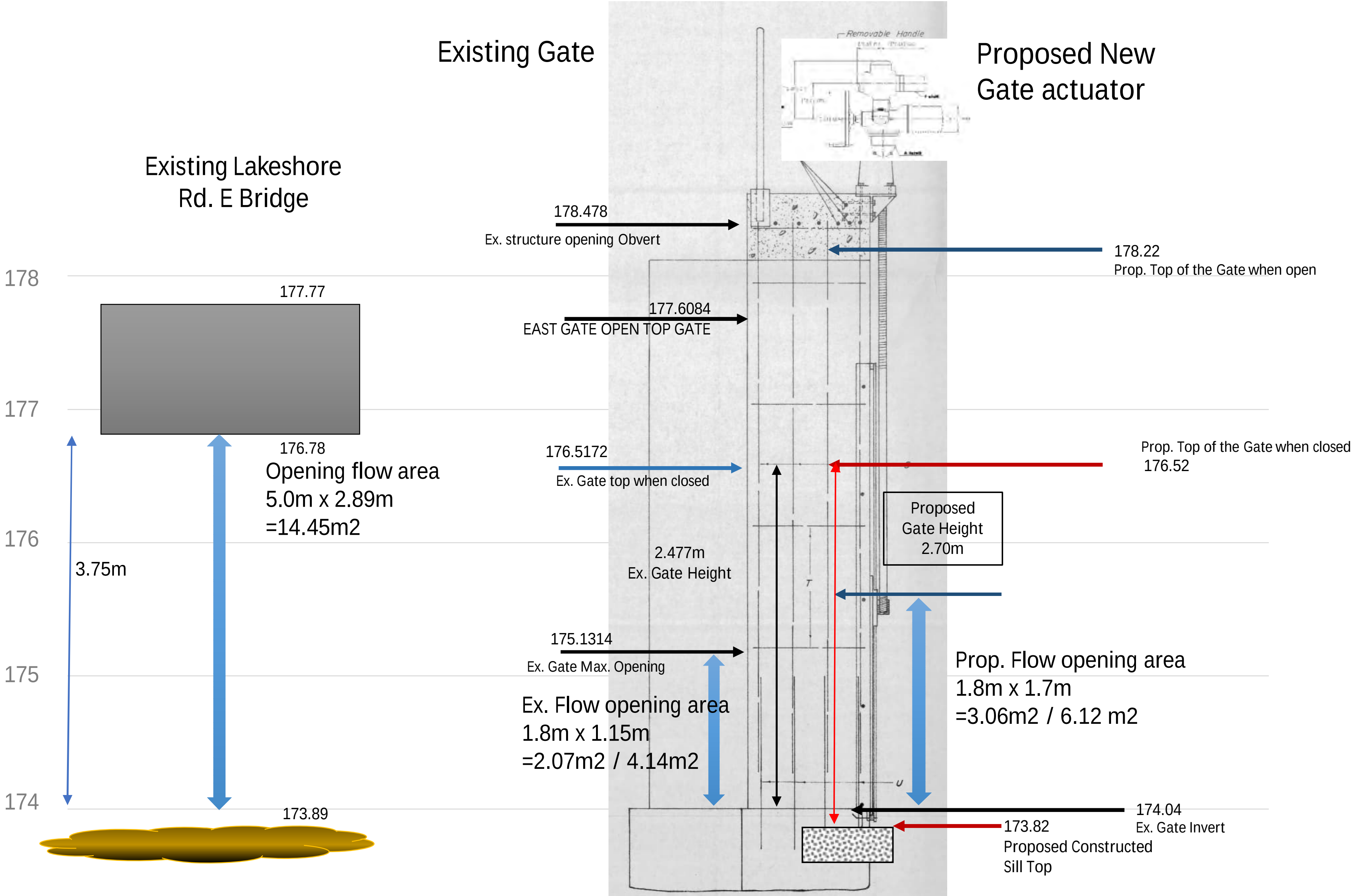
U/S BACK FACE VIEW

Wignell Gate Deficiencies & Resolutions

1. Gate close and seal to bottom of drain.
2. Gate close top at proposed flood elevation.
3. Gate open to max. height



Gate Upstream view


Existing Gate
Proposed New Gate actuator
Removable Handle
Existing Lakeshore Rd. E Bridge
178.478
Ex. structure opening Obvert
178.22
Prop. Top of the Gate when open
178
177.77
177.6084
EAST GATE OPEN TOP GATE
177
176.78
Opening flow area
5.0m x 2.89m
=14.45m2
176.5172
Ex. Gate top when closed
Prop. Top of the Gate when closed
176.52
Proposed
Gate Height
2.70m
176
3.75m
2.477m
Ex. Gate Height
175.1314
Ex. Gate Max. Opening
Prop. Flow opening area
1.8m x 1.7m
=3.06m2 / 6.12 m2
175
Ex. Flow opening area
1.8m x 1.15m
=2.07m2 / 4.14m2
174
173.89
174.04
Ex. Gate Invert
173.82
Proposed Constructed
Sill Top

Wignell Watershed Channel Capacities

Wignell, Port Colborne and Michener Drains (organized by SWMM model junctions, see Appendix B)

	Contributing Catchments	From (Up)	To (Dn)	Model Channel ID	Crossing ID	Data Source	Description	model length	5 Yr model Design Q, cms	Design Q cms	Proposed Design Grade line u/s STN	u/s INV	d/s STN	d/s INV	Length, m	BTM	Proposed Design Channel Side Slope	Avg. Depth	Manning n	Slope m/m	Slope (%)	TW	R_h	Prop. Capacity Q, cms	Velocity, V m/s	Design Ratio	Fr	Settling Length	Disp. Length	r	Area, a	Perim., p
							ROW North Side Swale		*0.5*			*182.86*	*3364.5*	*182.4*	*388*	*0.4*	*1.5*	*0.75*	*0.030*	*0.001186*		*2.65*	*0.368456757*	0.675	0.590	1.35	0.287				1.144	3.104
Port Colborne Drain	PC1				PC-CS-007	Amec OG Survey, 2013	culvert crossing Babion		0.65		3364.5	182.4	3350	182.35	14.5	0.4	1.5	0.75	0.030	0.0034		2.65	0.368456757	1.151	1.006	1.77	0.489				1.144	3.104
	PC2				PC-CS-006	Amec OG Survey, 2013	culvert crossing 2nd Concession		0.947		3350	182.35	3346	182.32	4	0.6	1.5	0.75	0.030	0.0075		2.85	0.391551452	1.999	1.545	2.11	0.732				1.294	3.304
						Proposed East Side relocated culvert			0.947		3346	182.32	3331	182.28	15	0.6	1.5	0.75	0.030	0.0027		2.85	0.391551452	1.192	0.921	1.26	0.437				1.294	3.304
	PC1, PC2	J21	J88	Link-07		2018	Proposed East side channel	302	0.947		3331	182.22	3077	181.5956	254	0.6	1.5	0.75	0.030	0.0025		2.85	0.391551452	1.144	0.885	1.21	0.419				1.294	3.304
							Prop. Sediment Basin @ 3+300								10	4	1.5	1.25	0.030	0.0025		7.75	0.409286891		0.911			97.7	6.67	2.50	2.375	5.803
	PC4-QE1	J19	J88			no info	Pump & discharge piping																									
	PC11	J88	J18	Link-08		No survey - NPCA 1m only	x-sect @ 3+200	500	1.23		3047	181.2468	2571.82	179.98	475.18	0.6	1.5	1.2	0.030	0.0027		4.2	0.584574358	3.465	1.203	2.82	0.464				2.880	4.927
	PC3-QW1	J20	J18			no info	Pump & discharge piping																									
	PC10	J18	J17	Link-11	PC-CS-005	NPCA 1m only	x-sect 2+200	640	1.301		2557.44	179.98	1952.07	178.17	605.37	0.6	1.5	1.2	0.030	0.0030		4.2	0.584574358	3.670	1.274	2.82	0.491				2.880	4.927
							Prop. Sediment Basin @ 2+400								18	6	1.5	1.7	0.030	0.0030		11.1	0.432538388		1.042			191.6	18.00	3.00	3.375	7.803
	PC9, PC5	J17	J16	Link-12	PC-CS-004	CofPC as Constructed Survey, 2017	x-sect ~1+450, from CofPC survey	860	1.578		1927.93	178.17	1072.54	176.1	855.4	0.6	1.5	1.2	0.030	0.0024		4.2	0.584574358	3.302	1.146	2.09	0.442				2.880	4.927
					PC-CS-003	Amec OG Survey, 2013	Prop. Sediment Basin @ 1+050								15	8	1.5	1.7	0.030	0.0024		13.1	0.446302166		0.958			143.6	14.88	1.88	4.375	9.803
	PC8	J16	J15	Link-13	PC-CS-002	CofPC as Constructed Survey, 2017	x-sect 0+900 from CofPC survey	580	1.956		1064.16	176.1	507.22	175.44	556.9	0.6	1.5	1.2	0.030	0.0012		4.2	0.584574358	2.310	0.802	1.18	0.309				2.880	4.927
	PC7, PC6	J15	J14	Link-14	PC-CS-001	CofPC as Constructed Survey, 2017	x-sect 0+300 from CofPC survey	600	2.243		489.33	175.44	6.61	174.63	482.7	1.2	1.5	1.2	0.030	0.0017		4.8	0.651387819	3.694	1.026	1.65	0.378				3.600	5.527
											0	174.63	-113	174.38	113	1.2	1.5	1.2	0.030	0.0022		4.8	0.651387819	4.241	1.178		0.434				3.600	5.527
PC Branch #1						CofPC survey Dec 18, 2016	200m for clearing and re-grading				683	180.25	483	179.86	200.0	0.4	2	0.7	0.030	0.0019		3.2	0.356890447	0.933	0.741		0.377				1.260	3.530
						CofPC survey Dec 18, 2017	existing channel to remain as is.				483	179.86	141	178.5	342.0	0.2	2	1.2	0.030	0.0040		5	0.560489465	4.458	1.429		0.578				3.120	5.567
	PC9					CofPC survey Dec 18, 2018	new outlet to PC Drain with berm and abandoned old channel to remain for floodway.		0.490		141	178.5	0	178.25	141.0	0.5	1.5	1.2	0.03	0.0018		4.1	0.571823813	2.669	0.967	5.45	0.376				2.760	4.827
Wignell	W1	J22	J23	Link-15	W-CS-004	EWA+CofPC RTK GPS, 2018		21.42	1.036	1.1	6691.2	181.5	6682	181.44	9.2	0.6	1.5	0.75	0.03	0.0065	0.652%	2.85	0.391551452	1.864	1.441	1.80	0.683				1.294	3.304
	W2	J23	J24	Link-16	W-CS-005	Amec OG Survey, 2013	x-sections very different just 50m apart.	840	1.358	1.5	6682	181.44	5744	180.42	938.0	0.8	1.5	1	0.03	0.0011	0.109%	3.8	0.522068603	1.639	0.713	1.21	0.293				2.300	4.406
							Prop. Sediment Basin @ 6+670								10	4	1.5	1.5	0.030	0.0011	0.109%	8.5	2.132600116	1.639	0.132			116.9	6.23	2.50	12.375	5.803
	WB2			C15		EWA+CofPC RTK GPS, 2018			0.22	0.3	407	181.35	0	180.7138	407.0	0.6	1.5	0.35	0.03	0.00156314	0.156%	1.65	0.211472645	0.184	0.468	0.61	0.306				0.394	1.862
	W7	J24	J25	Link-17		No survey - NPCA 1m only	x-sect from 4+800 to 5+800	1250	1.78	1.75	5744	180.4241	5100	179.3	644.0	1.6	2	1.15	0.03	0.001745	0.175%	6.2	0.665138519	4.759	1.061	2.72	0.398				4.485	6.743
											5100	179.3	4726.3	178.31	373.7	1.6	2	1.15	0.03	0.002649	0.265%	6.2	0.665138519	5.863	1.307		0.491				4.485	6.743
			J25				Prop. Sediment Basin @ 4+740								30	12	1.5	2	0.030	0.0026	0.265%	18	1.991407927	5.863	0.195			221.0	30.66	2.50	30.000	15.065
	W6	J25	J26	Link-18	W-CS-008	EWA+CofPC RTK GPS, 2018	x-sect from 4+200 to 4+600	522.47	2.321	2.5	4700	178.3	4148	177.25	552.0	1.8	1.5	1	0.03	0.001902	0.190%	4.8	0.610483526	3.452	1.046	1.38	0.403				3.300	5.406
	W5	J26	J27	Link-19	W-CS-006	EWA+CofPC RTK GPS, 2019	x-sect from 3+900 to 4+100	313.77	2.519	2.5	4138	177.22	3834	176.58	304.0	2.25	1.5	1	0.03	0.002105	0.211%	5.25	0.640417925	4.261	1.136	1.70	0.429				3.750	5.856
	W4	J27	J28	Link-20	W-CS-003	EWA+CofPC RTK GPS, 2020	x-sect from 3+200 to 3+800	618.63	2.857	2.8	3834	176.58	3200	175.52	634.0	2.5	1.5	1	0.03	0.001672	0.167%	5.5	0.655141497	4.112	1.028	1.47	0.385				4.000	6.106
	W3		J28																												0.000	0.000
	Wbranch #3	J87	J28	Link-33	CS-119	EWA+CofPC RTK GPS, 2020	Killaly St Crossing - 450mm	254.29	0.437	0.5	226	177.56	0	176.35	226.0	0.8	1.5	0.35	0.03	0.005354	0.535%	1.85	0.22490923	0.418	0.902	0.84	0.575				0.464	2.062
	W3	J28	J29	Link-21	W-CS-007	EWA+CofPC RTK GPS, 2020	from 2+900 to 3+100	289.09	3.354	3.3	3200	175.52	2851	175.11	349.0	2.5	1.5	1	0.03	0.001175	0.117%	5.5	0.655141497	3.447	0.862	1.04	0.323				4.000	6.106
							Prop. Sediment Basin @ 3+100								20	12	1.5	2	0.030	0.0012	0.117%	18	1.922392838	3.447	0.115			138.4	11.88	1.67	30.000	15.606
	Wbranch #2	J86	J29	Link-34	CS-120	EWA+CofPC RTK GPS, 2020	Killaly St Crossing - 900mm	278.16	0.752	0.75	200	175.65	0	175.43	200.0	0.6	1.5	0.75	0.03	0.0011	0.110%	2.85	0.391551452	0.765	0.592	1.02	0.280				1.294	3.304
	W8	J29	J30	Link-22		Amec OG Survey, 2013	x-sect ~ 2+400	567	4.025	4	2851	175.11	2444	174.36	407.0	2.5	1.5	1	0.03	0.001843	0.184%	5.5	0.655141497	4.317	1.079	1.08	0.404				4.000	6.106
										4	2444	174.5	2115	174.36	329.0	4.5	1.5	1.25	0.03	0.000426	0.043%	8.25	0.884734527	5.050	0.634	1.26	0.206				7.969	9.007
	W9	J30	J14	Link-23	W-CS-010	Amec OG Survey, 2013		40.77	4.357	4.3	2115	174.36	2055	174.351	60.0	6.5	1.5	1.25	0.03	0.0001500	0.015%	10.25	0.951104563	4.133	0.395	0.96	0.125				10.469	11.007
					W-CS-001	Amec OG Survey, 2013																										
		j14	J13	Link-25		Amec OG Survey, 2013		98.5	6.697	6.5	2055	174.351	1956	174.336	99.0	8.5	2	1.25	0.03	0.0001515	0.015%	13.5	0.975857641	5.551	0.404	0.85	0.128				13.750	14.090
Bower	B1	J6	J13	Link-26				25	0.19	0.2																						
Wignell		J13	J12	Link-27		Amec OG Survey, 2013		1364.61	6.286	6.5	1956	174.12																				
Wignell	W10	J12	J8	Link-28	W-BS-002	Amec OG Survey, 2013		566.25	6.359	6.5	2113	174.36	0	173.82	2113.0	8.5	2	1.25	0.03	0.000256	0.026%	13.5	0.975857641	7.209	0.524	1.11	0.166				13.750	14.090
	M1	J1	J7	Link-01	M-CS-001	NPCA 1m only	1+600, long grass swale / row crops	455	0.101		1715.65	176.360	1286	175.640	429.65	0.4	1.5	1.00	0.03	0.0017		3.4	0.4743417	1.577	0.830		0.355				1.900	4.006
	M2	J2	J7	Link-02	CS-101	NPCA 1m only	Michener Branch #2	352	0.719		345	176.3767	0	176.0461	345	0.4	1.5	0.85	0.03	0.0010		2.95	0.410928035	0.812	0.570		0.262				1.424	3.465
		J7	J3	Link-04		NPCA 1m only	1+100, row crop channel	533	0.831		1280	175.640	700	175.150	580	1	1.5	1.00	0.03	0.0008		4	0.542823182	1.612	0.645		0.260				2.500	4.606

	Contributing Catchments	From (Up)	To (Dn)	Model Channel ID	Crossing ID	Data Source	Description	model length	5 Yr model Design Q, cms	Design Q cms	Proposed Design Grade line u/s STN	u/s INV	d/s STN	d/s INV	Length, m	Proposed Design Channel BTM	Side Slope	Avg. Depth	Manning n	Slope m/m	Slope (%)	TW	R_h	Prop. Capacity Q, cms	Velocity, V m/s	Design Ratio	Fr	Settling Length	Disp. Length	r	Area, a	Perim., p
Michener					M-BS-001	Amec OG Survey, 2013																										
					M-BS-002	Amec OG Survey, 2013																										
	M3	J3	J4	Link-05	M-BS-003	Amec OG Survey, 2013	through golf course - 0+500	510	0.773		700	175.15	400	174.75	300	0.6	1.5	1.00	0.03	0.0013		3.6	0.499340006	1.609	0.766		0.320				2.100	4.206
					M-BS-004	Amec OG Survey, 2013					400	174.75	215	174.59	185	0.8	1.5	1.00	0.03	0.0009		3.8	0.522068603	1.462	0.636		0.261				2.300	4.406
	M4	J4	J5	Link-06		NPCA 1m only	Grass channel south of course; 0+300	230	0.811		215	174.59	15	174.47	200	1	1.5	1.00	0.03	0.0006		4	0.542823182	1.358	0.543		0.219				2.500	4.606
					SEDIMENT	NPCA 1m only									8	2	1.5	1.4	0.030	0.0006		6.2	0.302130557		0.368			134.6	2.85	4	1.040	3.442
	M5	J5	J8	Link-29		NPCA 1m only	many trees overgrowth, 0+050	12	0.844		15	174.47	0	174.46	15	1	1.5	1	0.03	0.0007		4	0.542823182	1.432	0.573		0.231				2.500	4.606
Michener Branch #1	1				CS-121	EWA/CofPC Nov/Dec 2018 Survey - equivalent Tile Diameter= 300mm	Tile Pipe run from Lakeshore Rd. East to M-Branch #1 confluence CB		0.070		130	175.75	20	175.45	110	0	1.5	0.35	0.03	0.0027		1.05	0.145608802	0.089	0.482		0.368				0.184	1.262
	1b					EWA/CofPC Nov/Dec 2018 Survey - equivalent Tile Diameter= 250mm	Tile pipe run from Lorraine Rd. a to M-Branch #1 confluence CB		0.031		292	175.75	178	175.45	114	0	1.5	0.25	0.03	0.0026		0.75	0.104006287	0.035	0.378		0.342				0.094	0.901
	1					EWA/CofPC Nov/Dec 2018 Survey	open channel - outlet to Michener		0.180		178	175.27	0	174.833	178	0.4	1.5	0.35	0.03	0.0025		1.45	0.194802114	0.180	0.555		0.375				0.324	1.662
Wignell to outlet	W11	J8	J9	Link-30	W-BS-001			13.58	7.067																							
				C27						7.1	13	174.05	0	173.82	13	5.7	0	2.70	0.03	0.0177	1.769%	5.7	0.916071429	64.362	4.182	9.07	0.813				15.390	16.800
					W-GS-001		1 gate open; square channel																									
		J9	J11	Link-31				29.342	7.067																						0.000	0.000
		J11	J10	Outlet						7.1	0	173.82	-297	173.45	297.0	8	1.25	2	0.03	0.001246	0.125%	13	1.458017001	31.769	1.513	4.47	0.380				21.000	14.403

Ontario Ministry of Agriculture, Food and Rural Affairs

Petition for Drainage Works by Road Authority – Form 2

Drainage Act, R.S.O. 1990, c. D.17, subs. 4(1)(c)

To: The Council of the Corporation of the City of Port Colborne

Re: Road name and road location (provide description of road or section of road that requires drainage)
Killaly Street East in the City of Port Colborne between Snider Road and Lorraine Road requires drainage to the south

I, Lee, Christopher (Last, first name), as an individual having jurisdiction over the above road system for the City **of** Port Colborne declare that the road described above requires drainage and hereby petition under subsection 4(1)(c) of the *Drainage Act* that this area be drained by means of a drainage works.

Organization
Corporation of the City of Port Colborne

Position Title	Signature	Date (yyyy/mm/dd)
Director of Engineering and Operations	Chris Lee	2019/02/01

Petitioners become financially responsible as soon as they sign a petition:

- Once the petition is accepted by council, an engineer is appointed to respond to the petition. *Drainage Act*, R.S.O. 1990, c. D. 17 subs. 8(1).
- After the meeting to consider the preliminary report, if the petition does not comply with section 4, the project is terminated and the road authority is responsible for the costs. *Drainage Act*, R.S.O. 1990, c. D. 17 subs. 10(4).
- After the meeting to consider the final report, if the petition does not comply with section 4, the project is terminated and the road authority is responsible for the costs. *Drainage Act*, R.S.O. 1990, c. D. 17 s. 43.
- If the project proceeds to completion, a share of the cost of the project will be assessed to the involved properties in relation to the assessment schedule in the engineer's report, as amended on appeal. *Drainage Act*, R.S.O. 1990, c. D. 17 s. 61.

Ontario Ministry of Agriculture, Food and Rural Affairs

Petition for Drainage Works by Road Authority – Form 2

Drainage Act, R.S.O. 1990, c. D.17, subs. 4(1)(c)

To: The Council of the Corporation of the City of Port Colborne

Re: Road name and road location (provide description of road or section of road that requires drainage)
Killaly Street East in the City of Port Colborne between Lorraine Road and Weaver Road requires drainage to the south

I, Lee, Christopher (Last, first name), as an individual having jurisdiction over the above road system for the City **of** Port Colborne declare that the road described above requires drainage and hereby petition under subsection 4(1)(c) of the *Drainage Act* that this area be drained by means of a drainage works.

Organization
Corporation of the City of Port Colborne

Position Title	Signature	Date (yyyy/mm/dd)
Director of Engineering and Operations	Chris Lee	2019/02/01

Petitioners become financially responsible as soon as they sign a petition:

- Once the petition is accepted by council, an engineer is appointed to respond to the petition. *Drainage Act,* R.S.O. 1990, c. D. 17 subs. 8(1).
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- After the meeting to consider the final report, if the petition does not comply with section 4, the project is terminated and the road authority is responsible for the costs. *Drainage Act,* R.S.O. 1990, c. D. 17 s. 43.
- If the project proceeds to completion, a share of the cost of the project will be assessed to the involved properties in relation to the assessment schedule in the engineer's report, as amended on appeal. *Drainage Act,* R.S.O. 1990, c. D. 17 s. 61.

