

**STORMWATER MANAGEMENT REPORT**

**Alexander Island Resort**

**Prince Edward County**

**June 29, 2021**

**Prepared by**

**Bryon Keene, P.Eng.**

**Andrew Rosenthal, EIT**



**Belleville**

1 – 71 Millennium Pkwy  
Belleville, ON  
K8N 4Z5  
Tel: 613-969-1111  
[info@jewelleng.ca](mailto:info@jewelleng.ca)

**Kingston**

208 – 4 Cataraqui St  
Kingston, ON  
K7K 1Z7  
Tel: 613-389-7250  
[kingston@jewelleng.ca](mailto:kingston@jewelleng.ca)

**Mississauga**

200A – 2155 Leanne Blvd  
Mississauga, ON  
L5K 2K8  
Tel: 905-855-1592  
[mississauga@jewelleng.ca](mailto:mississauga@jewelleng.ca)

## **Revision Summary**

June 29, 2021 – Initial submission prepared to support Site Plan Approval.

## Table of Contents

<b>1</b>	<b>PURPOSE AND DESIGN CONSTRAINTS</b> .....	<b>1</b>
1.1	CONSTRAINTS .....	2
1.2	CONSULTATION .....	2
1.3	STORMWATER MANAGEMENT OBJECTIVES .....	3
<b>2</b>	<b>BACKGROUND</b> .....	<b>4</b>
2.1	RELEVANT STUDIES .....	4
<b>3</b>	<b>SOILS</b> .....	<b>5</b>
<b>4</b>	<b>QUANTITY CONTROL</b> .....	<b>6</b>
4.1	CULVERT DESIGN .....	6
<b>5</b>	<b>QUALITY CONTROL</b> .....	<b>8</b>
<b>6</b>	<b>LOW IMPACT DEVELOPMENT</b> .....	<b>10</b>
6.1	THEME 1 – PRESERVING IMPORTANT HYDROLOGIC FEATURES .....	10
6.2	THEME 2 – APPLICATION OF SITING AND LAYOUT TECHNIQUES .....	11
6.3	THEME 3 – REDUCING THE IMPERVIOUS AREA .....	11
6.4	THEME 4 – USING NATURAL DRAINAGE SYSTEMS .....	12
6.5	LID SUMMARY .....	13
<b>7</b>	<b>SEDIMENT AND EROSION CONTROLS</b> .....	<b>14</b>
<b>8</b>	<b>CONCLUSIONS</b> .....	<b>15</b>
<b>9</b>	<b>REFERENCES</b> .....	<b>16</b>

## Table of Tables

TABLE 3-1: SOIL TYPES BY CATCHMENT AREA .....	5
TABLE 4-1: RATIONAL METHOD 5-YEAR PEAK FLOWS .....	7
TABLE 4-2: ALEXANDER ISLAND PROPOSED CULVERTS .....	7

## Table of Figures

FIGURE 1-1: SITE LOCATION (MAP SOURCE – MNRF, 2021) .....	1
---	---

## List of Appendices

APPENDIX A	IDF CURVES
APPENDIX B	CULVERT SIZING
APPENDIX C	CATCHMENT AREA DRAWINGS

# 1 Purpose and Design Constraints

---

This stormwater management report is prepared to guide the design of drainage and management of stormwater in support of the proposed resort development on Alexander Island. The resort will include 60 single-room cottages and a main inn that will contain an additional 20 rooms. Spas and other recreational buildings complete the resort hotel complex. The island has a total area of 25.6 hectares, and overall post-development imperviousness will be 5.4%.

The lands under consideration are highlighted in red in Figure 1-1.

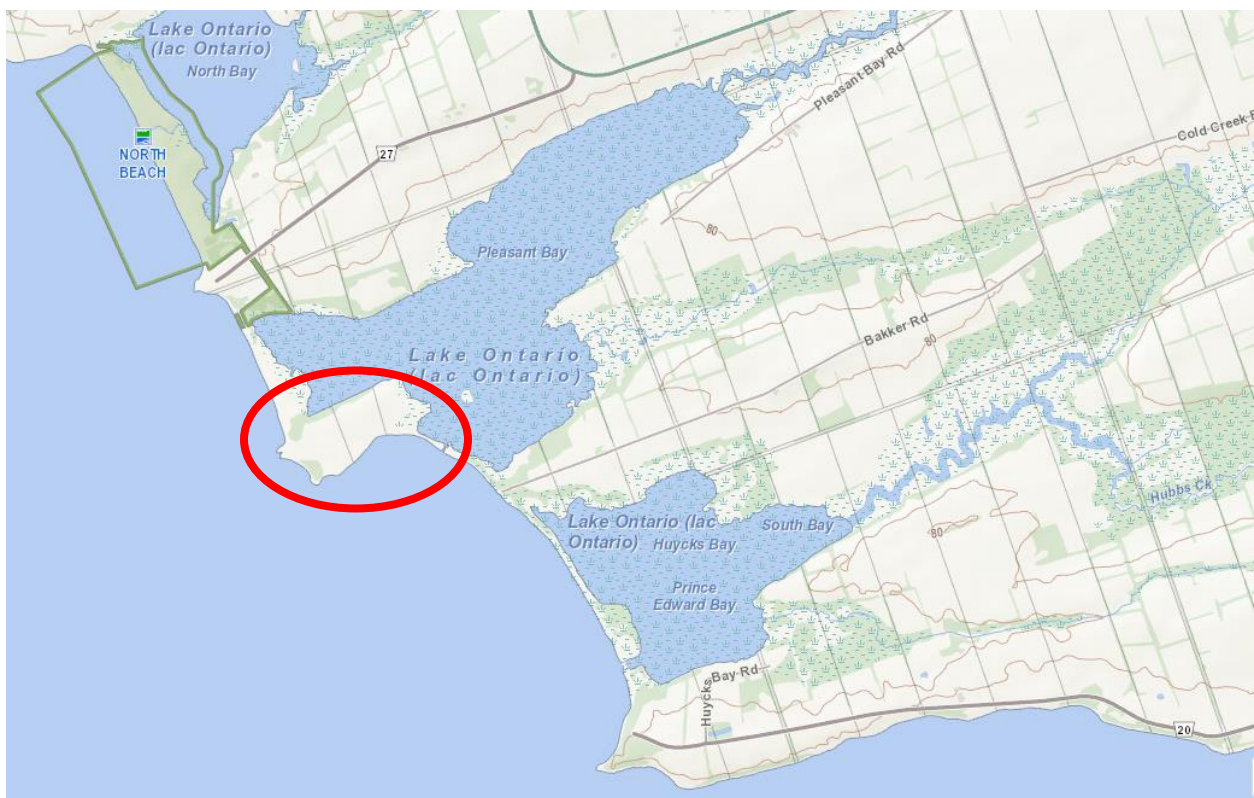


Figure 1-1: Site Location (map source – MNRF, 2021)

Alexander Island is situated on the perimeter of the west side of Prince Edward County separating Lake Ontario and Pleasant Bay. The site is within the Municipality of Prince Edward County and the jurisdiction of Quinte Conservation Authority.

The development was originally conceived in 2000 and formal applications for rezoning were filed and approved by PEC in 2001. The zoning permits up to 85 overnight guest accommodation rooms as well as various indoor and outdoor recreational uses related to the travelling public. A holding provision on the site will be released subject to approval of a site plan, a hydrogeological report and an archaeological report.

The stormwater management plan is prepared in support of the site plan approval.

---

## 1.1 Constraints

---

The island is associated with several environmental constraints as identified by Beacon Environmental. These included:

- 30m setback from the shoreline of Lake Ontario and Pleasant Bay
- 30m setback from the Pleasant Bay PSW and coastal wetlands
- 10m setback from woodlands (within the 30m setback)
- 50m setback from Least Bittern habitat

The EIS also identified constraints associated with the access road along the barrier beach. These included:

- The entire beach and dune system
- 30m buffer from Pleasant bay (overlapping the dunes)
- 30m buffer from Lake Ontario (overlapping the dunes)
- Various turtle species nesting habitat

Beacon made recommendation for extensive mitigation measures to offset negative impacts associated with the proposed improvements of the access road. These are addressed in the Beacon Preliminary Natural Hazard Constraint Analysis report.

---

## 1.2 Consultation

---

The applicant and project staff engaged PEC staff and elected officials as well as QCA staff on several occasions to review the project.

Aside from concerns regarding access, Quinte Conservation expressed no concerns with the proposed resort so long as the environmental setbacks were observed.

PEC support for the road access was also uncertain and the applicant has amended the plan to include access by watercraft from both Pleasant Bay and Lake Ontario.

As a result of the consultations, the applicant made several significant changes to the plan in order to align with the TC-22 zoning. In particular, the development concept was completely revised from a subdivision (considered in 2017) to a full destination resort with 80 overnight stay accommodations.

Additional changes include the minimization of imperviousness by using gravel surfaces instead of asphalt and a reduction in the road network to include a 3m wide one-way road to guest cottages.

There are no tributaries on the island and therefore no associated restrictions or setbacks are required.

The floodplain associated with Lake Ontario is 75.7m. An allowance for wave uprush of 1.1m was included by the Hall Coastal Engineering report making the flood risk elevation of 76.8m along the shoreline. All structures must be constructed outside of the 100-yr static flood elevation and have lowest elevations at least 77.1m to account for wave uprush.

---

### **1.3 Stormwater Management Objectives**

---

Stormwater management features will be positioned outside of the recommended setbacks from all environmental constraints.

Specific stormwater objectives are:

- 1) Enhanced water quality treatment is targeted.
- 2) Quantity control is not required.
- 3) Sediment and erosion control must be provided.

## 2 Background

---

The lands are currently not in any active use but have been recently used for agricultural purposes. An existing farm roadway is evident through the property traversing from west to east. The land cover is mostly grassed with some old field along central to northeast portion, but with a greater vegetated cover in the lands south of the road. The island is more densely vegetated on the perimeter.

Within the embayment of Pleasant Bay, the lands transition to coastal wetlands and along the north connection to the barrier beach and dune system the tree cover is the most significant.

---

### 2.1 Relevant Studies

---

Several background studies were available and helped to inform the proposed development.

1. Hall Coastal Engineering, 2000. Evaluation of an Access Road to Pleasant Bay Lodge Along Pleasant Bay Beach
2. Northeastern Archaeological Associates, 2001. Stage 1 and Stage 2 Archaeological Assessment
3. Beacon Environmental, 2017. Preliminary Natural Heritage Constraint Analysis

### 3 Soils

---

Alexander Island has a total area of 25.6 hectares and is comprised of 83.4% Ameliasburgh Loam, 7.3% Muck, and 9.4% Marsh according to the OMAFRA Agricultural Atlas (Table 3-1, Appendix C).

Table 3-1: Soil Types by Catchment Area

Catchment	100	101	102	103	TOTAL
Area	5.1 ha	10.6 ha	7.2 ha	2.7 ha	25.6 ha
Ameliasburgh Loam (% area)	98.8%	95.3%	73.6%	33.3%	83.36%
Muck (% area)	1.2%		25.0%		7.27%
Marsh (% area)		4.7%	1.4%	66.7%	9.38%

Ameliasburgh Loam is a sand-silt mixture with small particle size that has HSG rating B (moderate infiltration rate). As per Low Impact Development (LID) guidelines (2010), the depth to water table or bedrock is recommended to be 1m for infiltration technologies, such as soakaways, infiltration trenches, or chambers.

A report from Quinte-Eco Consultants (QEC) shows Grey Limestone bedrock as shallow as 2 feet below the surface at Well 3 that can limit deep infiltration, and depth to groundwater ranges from 1.2 to 2.2m. However, the predominant class-B soils are supportive of superficial infiltration technologies such as filter strips and enhanced swales.

## 4 Quantity Control

---

No quantity control measures are required for the development as runoff flows directly into Lake Ontario and Pleasant Bay. However, the Alexander Island design uses strategies to reduce percent imperviousness that will reduce peak flow impacts.

Roads will be constructed with gravel which has less imperviousness than asphalt surfaces. In addition, the one-way nature of the ring road halves the required width to 3.0m which reduces the total road area and materials required.

The development's impervious areas will be disconnected to the receiving waters (that is, there will be no direct pipe connection) to allow quality and quantity treatment to occur as the flows traverse over land. The total impervious areas are 1.03ha (flowing to Lake Ontario) and 0.35ha (flowing to Pleasant Bay), which results in an overall imperviousness of 5.4% (6.6% to Lake Ontario and 3.6% to Pleasant Bay). Impervious calculations assume 60% for gravel.

The guidelines (Ontario Ministry of the Environment, 2003, pp. pp1-8, 3-14) indicate the potential for erosion and steam instability occurs for catchment areas where impervious cover is typically 10% or greater. Maintaining a total impervious of 10% or less decreases erosion concerns and the potential for negative quality impacts.

Therefore, the site development is not expected to have any negative erosion impacts that would trigger quantity controls.

---

### 4.1 Culvert Design

---

Culverts are required to pass flows under the ring road. The only culvert size that can be used is 300mm due to shallow limestone bedrock in the area. Peak flows were calculated using the Rational Method. The catchment area peak flows are shown in Table 4-1.

A 300mm culvert has a maximum flowrate of 0.06 m<sup>3</sup>/s which was compared with the 5-Yr flowrate to determine the number of culverts required (Table 4-2). The MTO nomograph can be seen in Appendix B.

For most culvert a single 300mm CSP is required, with the exception of culvert numbers 3, 4 and 7 that will have two 300mm CSPs.

Table 4-1: Rational Method 5-Year Peak Flows

Catchment	Area (ha)	Runoff Coefficient	Time of Concentration (min)	Intensity (mm/hr)	Q <sub>5</sub> (m <sup>3</sup> /s)
200	0.55	0.30	18.4	55.3	0.03
201	0.64	0.40	11.1	77.1	0.05
202+201	1.51	0.38	23.8	46.5	0.07
205+203	1.59	0.35	19.8	52.7	0.08
204	0.24	0.25	6.2	113.4	0.02
205	0.69	0.30	9.9	83.1	0.05
206	2.10	0.25	15.5	61.8	0.09
207	0.55	0.25	17.1	57.9	0.02
208	0.36	0.25	11.0	77.6	0.02
209	0.73	0.25	8.1	95.6	0.05

Table 4-2: Alexander Island Proposed Culverts

Catchment	Culvert	Design Flow (m <sup>3</sup> /s)	Crossing Capacity (m <sup>3</sup> /s)	Crossing Configuration	Crossing Capacity Meets Req'ments
200	1	0.03	0.06	300mm CSP	✓
201	2	0.05	0.06	300mm CSP	✓
202+201	3	0.07	0.12	2 x 300mm CSP	✓
205+203	4	0.08	0.12	2 x 300mm CSP	✓
204	6	0.02	0.06	300mm CSP	✓
205	5	0.05	0.06	300mm CSP	✓
206	7	0.09	0.12	2 x 300mm CSP	✓
207	10	0.02	0.06	300mm CSP	✓
208	9	0.02	0.06	300mm CSP	✓
209	8	0.05	0.06	300mm CSP	✓

## 5 Quality Control

---

Quality control on Alexander Island will primarily occur through minimizing impervious cover, ensuring impervious areas are not directly connected to receiving waters, employing vegetative filter strips and enhanced grass swales.

The road system has no ditches and is minimally raised above the existing ground. Drainage from the road will be filtered by perimeter grassed areas. Quality treatment will occur in the grassy shoulders. These grassy areas will filter out entrained particles from the flow which will decrease the amount of sediment travelling to Lake Ontario and Pleasant Bay.

Enhanced grass swales slow flows and allow the filtration of particles and storage of portions of runoff. They remove 76% of total suspended solids, according to the MOE Stormwater Manual (2003).

The water quality treatment follows a treatment train approach where stormwater quality will be improved through three technologies:

- Shallow grassed swales.
- 5m grassed filter strips.
- Sheet flow through unmanicured, undeveloped lands.

The grassed swales will provide opportunity for filtration of runoff and will slow the velocity to less than 0.5m/s. In a study performed by Terry Lucke et al. (2014), researchers studied the effectiveness of TSS removal in grassed swales and concluded **grass swales were very effective in a treatment train approach at providing pre-treatment**. Swales investigated were triangular in shape and had slopes of 1% or less. They found:

*Results showed that between 50% and 80% of the TSS was generally removed within the first 10 m of the swales. A further 10% to 20% reduction in TSS concentrations can be expected in swales up to 30 m long.*

Factors that improve the removal rates include a reduced longitudinal slope and reduced velocity. The widened flat bottom will help to reduce the velocity well below 0.5m/s.

**A TSS removal in excess of 80% can be expected at the point of discharge to the lake.**

In addition to enhanced swales and vegetated filter strips, buffer zones will be used to provide additional quality treatment to runoff. The perimeter of the island is comprised of a 30m environmental setback, and protected species (Least Bittern) habitat increases the setback to 50m in some areas. This vegetated buffer ensures additional quality treatment will occur before the flows reach the Lake or Bay, decreasing the quality impairment of the receiving bodies.

**Extensive grassy contact and settlement in the grassy surfaces within the swales, filter strips, and sheet flow outlet will provide water quality mitigation to achieve *Enhanced* water quality objectives.**

## 6 Low Impact Development

---

Low Impact Development is a requirement of the 2014 Provincial Policy Statement (and continues to be supported in the May 1, 2020 version). This requires that all developments consider LID strategies to reduce the impact of development on the hydrologic regime.

The Low Impact Development Guidelines (Toronto and Region Conservation Authority, 2010) states that “increases in the quantity, rate, and frequency of runoff can be linked to two root causes:

- the conversion of undeveloped or agricultural land cover to urban uses, and
- the application of storm sewer systems.”

The goal of LID site design strategies is to minimize these two sources of hydrologic impacts (Toronto and Region Conservation Authority, 2010, p. 3.3). Large urban areas are negatively impacted by flash flooding associated with extensive hardening. The LID design techniques seek to mitigate flooding and erosion associated with urbanization. While water quality improvements are associated with the recommended techniques, quantity control remains the focus of LID.

The guidelines provide some site design strategies for reducing the hydrologic impact postulating 4 major groupings or “themes”:

- 1) Preserving important hydrologic features and functions;
- 2) siting and layout of development;
- 3) reducing impervious area; and
- 4) using natural drainage systems.

The site design incorporates all four of the themes. Some strategies are applied with greater care since municipal requirements limit such techniques as setbacks, road design, parking, and drainage design. The LID guidelines provide a hierarchy of applying the LID techniques by first invoking the use of natural hydrologic areas and then development of green infrastructure. As such, the site design makes extensive use of the natural features and adds limited green technologies that will encourage infiltration.

Discussion of the LID design used in the stormwater management design is provided below.

---

### 6.1 Theme 1 – Preserving Important Hydrologic Features

---

This theme focuses on preservation. Site design is adjusted to preserve natural features that benefit hydrology.

- Preserve stream buffers, including along intermittent and ephemeral channels.
- Preserve areas of undisturbed soil and vegetation cover.
- Avoid development on permeable soils.
- Preserve existing trees and, where possible, tree clusters.

Important hydrologic features include:

- highly permeable soils
- pocket wetlands
- significant small (headwater) drainage features
- riparian buffers
- floodplains
- undisturbed natural vegetation, and
- tree clusters.

The island's topography, wetlands, and vegetation are all preserved by the proposed plan. The areas were identified early in the planning process and were protected from development using the municipal zoning by-law. As such, important hydrologic features and their beneficial functions have been preserved.

---

## **6.2 Theme 2 – Application of Siting and Layout Techniques**

---

Siting and layout techniques aim to reduce the environmental impacts of the development by fitting the development within the framework of the natural heritage features.

- Fit the design to the terrain.
- Use open space or clustered development.
- Use innovative street network designs.
- Reduce roadway setbacks and lot frontages.

The proposed site layout uses best practices by disconnecting impervious areas. Open-space development separates impervious areas, such as roofs, roads, and parking lots. Rooftop areas are disconnected from the road which allows runoff to be discharged to green areas, and pervious grassed surfaces will encourage infiltration into the soils. Green spaces separating the impervious areas provide opportunity for infiltration and quality treatment of runoff, as discussed in further detail below.

---

## **6.3 Theme 3 – Reducing the Impervious Area**

---

Imperviousness can be reduced by minimizing unnecessary surface hardening. Some strategies include:

- Reduce street width.
- Reduce building footprints.
- Reduce parking footprints.
- Consider alternatives to cul-de-sacs.
- Eliminate unnecessary sidewalks and driveways.

Impervious cover increases post-development peak flows and increases the amount of suspended particles entrained in flow. If a development area has a high percentage of impervious cover, the peak flowrate for the runoff will be significantly higher than the pre-development peak. In contrast, a development with low percentage of impervious cover will have a flatter discharge curve due to the attenuation of flows and storage or infiltration of a significant portion of runoff. It is important to maintain lower flowrates to reduce the risk of flooding or erosion.

The main access road to the development will be constructed of gravel. Gravel roads allow precipitation to infiltrate into the ground unlike conventional hard-surfaced roads. This reduces the impervious cover which decreases the amount of runoff that occurs. Narrow roads, such as the 3m roads that connect the various buildings, also produce less impervious cover. These gravel roads will be one-way roads to halve the required width.

According to Schueler (2000), total runoff is almost 16 times higher for impervious areas, such as a parking lot, than an undeveloped area such as a meadow. Transport-related imperviousness typically has a greater hydrological impact, so reducing the impervious cover on roads can have a positive impact on overall runoff conditions (such as peak flows).

Quantity control of runoff is not a major concern for this development as runoff from Alexander Island flows directly into Pleasant Bay and Lake Ontario. However, the reduction of impervious area, in combination with separation of impervious areas, has a major impact on quality control.

---

#### **6.4 Theme 4 – Using Natural Drainage Systems**

---

These strategies focus on the use of existing natural drainage systems where available “to take advantage of undisturbed vegetated areas and natural drainage patterns”.

- “Disconnect” impervious areas.
- Preserve or create micro-topography.
- Extend drainage flow paths.

The runoff will be directed towards the shoreline as the island naturally slopes towards Pleasant Bay and Lake Ontario. To direct the runoff and improve quality control, vegetated filter strips and enhanced swales will be used.

Vegetated filter strips are wide, narrow areas of grass or vegetation that filter particles out of suspension. This is achieved by slowing runoff over the area to allow particles to fall out of suspension, and by allowing water to permeate into the soil. It is important to spread the flow over a large area to maximize quality treatment of flows. The north and east shores of the island consist of an environmentally protected wetland zone where land is not permitted to be developed. This setback will ensure that sufficient space is available to filter out sediment and provide quality treatment for surface runoff.

Enhanced swales are another way to provide quality control of surface runoff. Check dams, grass, and other vegetation in the swales slow flows to allow sediment to fall out of suspension, similar to vegetated filter strips. Enhanced swales can have benefits over curb and gutter systems as they achieve the same purpose (conveyance of stormwater runoff), however they provide additional quality treatment. The island is gently graded towards the shoreline, which is ideal for the creation of enhanced swales, as the longitudinal slope of these swales is generally between 0.5 and 6% (TRCA Low Impact Development Guide, 2010).

According to the Guide, pollutant removal can also occur in enhanced swales. Typical pollutant removal rates for swales are 76% for total suspended solids, 55% for total phosphorus, and 50% for total nitrogen. Factors that increase pollutant removal are longitudinal slope of 1% or less, measured soil infiltration rate of 15mm/h or greater, 4 hour, 25mm Chicago storm event flowrates of 0.5m/s, and side slopes of 3:1 or less. It is expected that these parameters will be achieved with the constructed swales.

---

## 6.5 LID Summary

---

The development site design follows the LID strategies provided in the Low Impact Development guide and makes extensive use of techniques to preserve natural drainage features, adjust the layout to the site, reduce impervious areas, and take advantage of natural drainage features.

## 7 Sediment and Erosion Controls

---

There is a high risk of sediment release surrounding construction activities. Typical sediment and erosion control measures include:

- Siltation fencing.
- Strawbale check dams.
- Rip-rap check dams.
- Filter sock inserts in catch basins.

Controls are to be placed downstream of all active work areas and upstream of protected receivers. Controls should also be placed around stockpiles of topsoil and fill materials.

Typical OPSDs provide good instruction on the correct placement and construction of the controls. The controls provide some protection if they are properly maintained, but they should be considered last-resort measures. The most effective means of control are those which prevent or reduce erosion at the source. This would include diligent stabilization of exposed areas immediately after grading is completed. Stabilization measures include sod, erosion blankets, or rip-rap and filter cloth on steep slopes, as well as topsoil and hydroseed on gently sloped areas (with slope 10% or less).

The site developer and contractor should actively maintain the new drainage works to remove accumulations of sediment within catch basin sumps.

A silt fence should be located along the upland perimeter of all sensitive features during the construction process, which should be maintained until the lands have stabilized or as directed by the municipality. There would be benefit in maintaining this silt fence for up to 2 growing seasons.

## 8 Conclusions

---

LOBP Inc. intends to construct a resort development on Alexander Island. The development lands drain directly into Lake Ontario and Pleasant Bay.

Water quality treatment will achieve *Enhanced* criteria as defined by the Stormwater Management Planning and Design Manual.

**Enhanced swales and vegetated filter strips, along with other best management practices, will achieve water quality objectives. Quantity controls are not required for this project as lands drain directly into Lake Ontario and Pleasant Bay.**

**Stormwater runoff can be effectively managed within the available lands for the proposed development.**

Prepared by:



Andrew Rosenthal, EIT  
Jewell Engineering Inc.

Reviewed by:



Bryon Keene, P.Eng.  
Jewell Engineering Inc.

## 9 References

---

Ministry of Environment (2003). *Stormwater Management Planning and Design Manual*.

Oak Ridges Moraine Land Trust (2020). *Oak Ridges Moraine Conservation Plan – Technical Paper Series*.

Schueler, T. (2000). *The Importance of Imperviousness: The Practice of Watershed Protection*. Center for Watershed Protection, Ellicott City, MD

Toronto and Region Conservation Authority, Credit Valley Conservation Authority (2010). *Low Impact Development Stormwater Management Planning and Design Guide*.

**APPENDIX A**

**IDF Curves**

**Trenton Ontario, 6158875**

**From Environment Canada**



\*\*\*\*\*

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

\*\*\*\*\*

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1965	7.4	10.9	14.7	17.3	18.3	19.0	26.9	29.5	43.9
1966	8.1	10.9	11.7	16.5	20.1	22.4	35.8	44.7	45.7
1967	9.1	10.9	11.7	14.2	15.5	16.3	29.7	47.2	69.6
1968	4.1	6.1	7.4	9.7	13.5	16.5	33.0	40.1	40.9
1969	5.8	9.7	13.5	18.8	21.6	24.6	34.0	39.1	54.9
1970	6.1	7.9	10.2	13.7	15.0	20.6	28.2	40.4	48.0
1971	7.1	10.9	11.2	12.2	12.7	17.5	22.1	29.0	35.1
1972	11.2	13.2	13.7	15.5	16.0	20.8	27.7	31.5	47.2
1973	6.6	10.4	10.4	15.0	15.5	22.4	43.2	52.1	53.6
1975	6.9	7.6	10.7	13.7	15.5	25.4	32.3	33.5	34.3
1976	6.9	11.2	11.7	12.7	14.0	14.5	27.9	29.2	30.2
1977	6.9	11.2	11.7	21.8	37.1	45.5	67.3	72.1	72.1
1978	7.1	9.9	11.2	15.0	15.9	19.9	31.7	34.1	36.6
1979	6.5	9.3	11.5	11.5	11.5	17.0	37.7	54.8	55.8
1980	9.3	14.0	16.3	22.9	31.1	37.6	46.6	46.6	60.0
1981	11.4	20.2	25.0	25.0	25.0	25.0	32.9	46.8	48.2
1982	14.2	18.4	22.2	22.4	23.2	30.7	39.0	39.0	39.0
1983	5.9	10.3	14.0	15.0	21.8	34.0	36.4	42.0	63.3
1984	4.4	7.2	7.8	10.1	11.8	13.0	27.7	41.7	42.2
1985	12.2	15.2	18.3	24.3	24.4	37.1	37.1	39.3	39.7
1986	24.3	24.8	26.0	27.1	27.1	32.8	63.2	65.0	65.6
1987	12.2	13.6	14.7	17.3	18.3	20.3	30.4	39.1	42.4
1988	4.7	8.1	8.8	9.9	15.1	15.2	20.2	28.0	28.0
1989	7.3	10.5	10.5	16.8	25.3	25.3	29.8	29.8	34.7
1990	6.6	7.5	9.0	11.0	12.7	16.7	32.9	46.1	50.0
1991	10.6	11.6	12.6	12.8	14.0	15.8	25.7	26.2	32.8
1992	4.7	8.1	9.6	12.1	14.9	20.2	30.1	38.0	42.8
1993	4.2	6.8	9.3	11.7	21.1	23.6	25.5	41.7	56.0
1994	5.6	8.8	10.5	14.6	17.8	19.6	31.3	32.5	34.8
1995	10.6	14.6	18.0	22.2	28.3	41.4	50.4	56.8	64.9
1996	3.4	6.2	7.3	9.5	14.2	19.8	30.0	33.8	42.8
1997	5.0	9.1	11.7	19.8	34.8	43.1	48.7	48.7	53.9
2000	11.4	17.6	22.3	33.5	59.6	68.2	69.8	69.8	71.6
2001	4.7	5.2	7.0	9.2	17.4	19.5	22.3	32.9	40.4
2002	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	78.8	78.8
2003	6.1	11.8	14.0	21.3	26.8	34.0	42.1	45.1	50.2
2004	7.1	10.0	14.9	18.9	31.7	48.9	88.9	109.6	123.7
2005	5.0	7.0	7.2	7.9	13.6	19.1	40.8	50.3	54.1
2006	5.0	8.1	9.6	15.6	20.4	25.0	42.9	55.1	69.9
2007	10.3	11.4	14.2	21.2	26.3	30.5	44.3	60.9	62.1
2008	6.1	12.1	14.0	21.2	23.1	32.5	32.7	40.4	47.6
2009	4.6	8.6	9.0	11.8	12.6	18.7	-99.9	58.0	75.8
2010	5.0	5.3	6.9	8.4	9.6	11.8	24.7	48.3	59.1

Stormwater Management Report  
Alexander Island Resort

2012	5.5	8.0	10.5	21.1	35.7	44.5	60.5	79.9	80.6
2013	5.4	9.5	13.8	20.5	20.8	25.0	30.7	33.5	42.8
2014	7.8	10.7	11.3	13.7	23.9	33.6	43.3	47.1	79.4
2016	7.1	10.9	16.1	23.7	24.8	27.2	34.9	46.2	46.2
2017	5.5	10.3	12.6	13.8	20.3	27.8	33.8	52.0	66.3
-----									
# Yrs.	47	47	47	47	47	47	46	48	48
Années									
Mean	7.5	10.7	12.7	16.5	21.1	26.4	37.5	46.4	53.3
Moyenne									
Std. Dev.	3.6	3.8	4.5	5.6	8.9	11.2	13.8	16.0	17.5
Écart-type									
Skew.	2.55	1.57	1.32	0.70	1.99	1.50	1.80	1.71	1.49
Dissymétrie									
Kurtosis	12.61	6.57	4.92	3.48	9.40	6.09	6.82	7.30	7.19

\*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount  
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1986	5 min	24.3	18.7
1986	10 min	24.8	22.7
2000	1 h	59.6	49.0
2000	2 h	68.2	61.4
2004	6 h	88.9	80.8
2004	12 h	109.6	96.5
2004	24 h	123.7	108.1

\*\*\*\*\*

Table 2a : Return Period Rainfall Amounts (mm)  
Quantité de pluie (mm) par période de retour

\*\*\*\*\*

Duration/Durée	2	5	10	25	50	100	#Years
	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans	Années
5 min	6.9	10.1	12.2	14.8	16.8	18.7	47
10 min	10.0	13.4	15.7	18.5	20.6	22.7	47
15 min	12.0	15.9	18.5	21.8	24.2	26.7	47
30 min	15.5	20.5	23.8	27.9	31.0	34.0	47
1 h	19.6	27.5	32.7	39.3	44.2	49.0	47
2 h	24.5	34.4	41.0	49.2	55.4	61.4	47
6 h	35.3	47.5	55.5	65.7	73.3	80.8	46
12 h	43.8	57.9	67.2	79.1	87.8	96.5	48
24 h	50.4	65.9	76.1	89.0	98.6	108.1	48

\*\*\*\*\*

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits  
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

\*\*\*\*\*

Duration/Durée	2	5	10	25	50	100	#Years
	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans	Années
5 min	83.1	120.9	146.0	177.7	201.2	224.5	47
	+/- 11.2	+/- 18.9	+/- 25.6	+/- 34.5	+/- 41.3	+/- 48.1	47
10 min	60.3	80.6	94.0	111.0	123.7	136.2	47
	+/- 6.0	+/- 10.2	+/- 13.7	+/- 18.5	+/- 22.1	+/- 25.8	47
15 min	47.8	63.6	74.0	87.1	96.9	106.6	47
	+/- 4.7	+/- 7.9	+/- 10.6	+/- 14.3	+/- 17.1	+/- 20.0	47
30 min	31.1	41.0	47.5	55.8	61.9	68.0	47
	+/- 2.9	+/- 4.9	+/- 6.7	+/- 9.0	+/- 10.8	+/- 12.5	47
1 h	19.6	27.5	32.7	39.3	44.2	49.0	47
	+/- 2.3	+/- 3.9	+/- 5.3	+/- 7.2	+/- 8.6	+/- 10.0	47
2 h	12.3	17.2	20.5	24.6	27.7	30.7	47
	+/- 1.5	+/- 2.5	+/- 3.3	+/- 4.5	+/- 5.4	+/- 6.3	47
6 h	5.9	7.9	9.3	11.0	12.2	13.5	46
	+/- 0.6	+/- 1.0	+/- 1.4	+/- 1.9	+/- 2.2	+/- 2.6	46
12 h	3.6	4.8	5.6	6.6	7.3	8.0	48
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.5	48
24 h	2.1	2.7	3.2	3.7	4.1	4.5	48
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.7	+/- 0.8	48

\*\*\*\*\*

Table 3 : Interpolation Equation / Équation d'interpolation:  $R = A \cdot T^B$

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)

RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)

T = Rainfall duration (h) / Durée de la pluie (h)

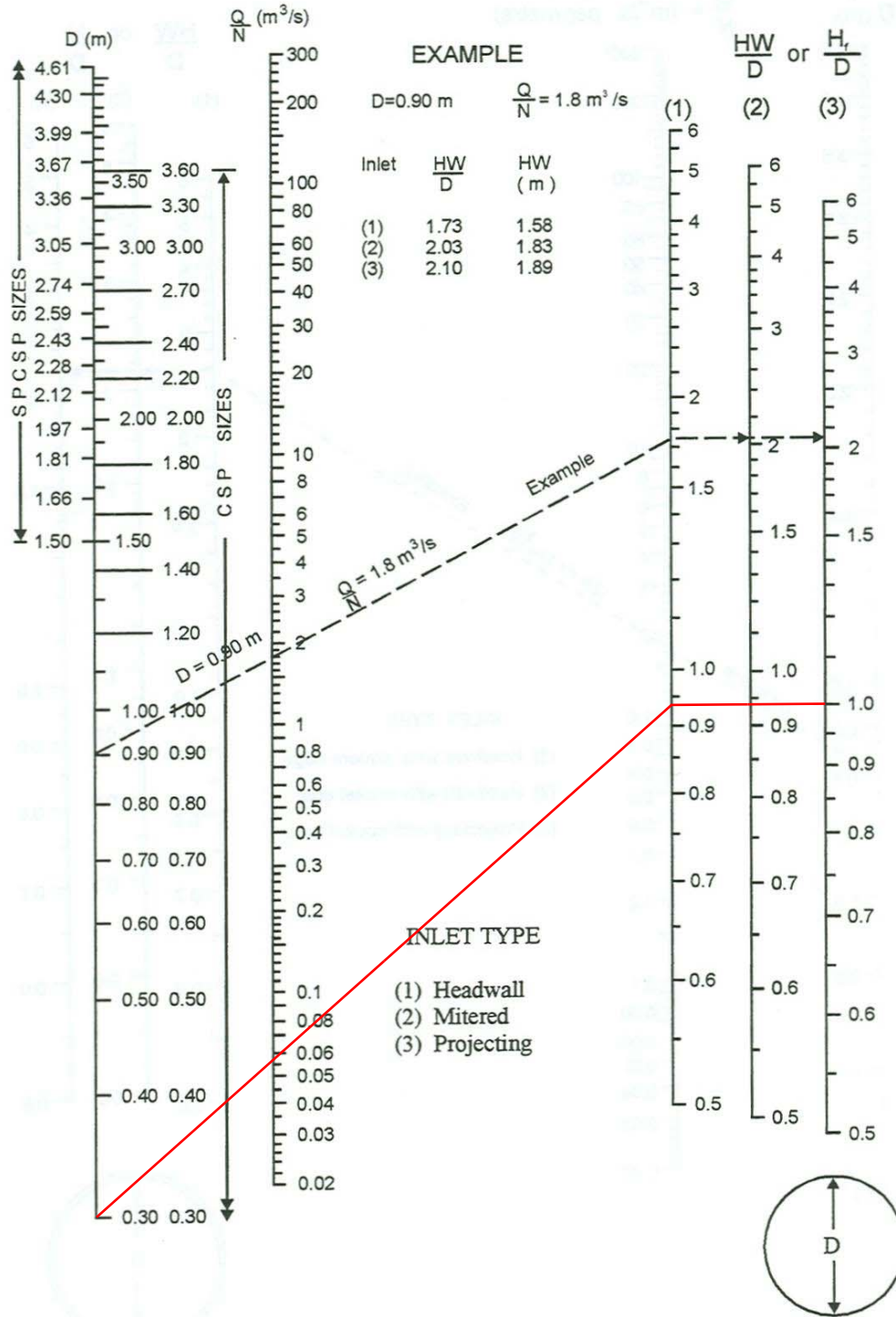
\*\*\*\*\*

Statistics/Statistiques	2	5	10	25	50	100
	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans	yr/ans
Mean of RR/Moyenne de RR	29.5	40.7	48.1	57.4	64.4	71.2
Std. Dev. /Écart-type (RR)	28.6	40.4	48.3	58.4	65.8	73.2
Std. Error/Erreur-type	4.5	4.2	4.2	4.5	4.9	5.3
Coefficient (A)	18.6	25.2	29.6	35.2	39.3	43.4
Exponent/Exposant (B)	-0.656	-0.664	-0.668	-0.671	-0.673	-0.674
Mean % Error/% erreur moyenne	5.1	5.0	5.2	5.6	6.0	6.2

**APPENDIX B**

**Culvert Sizing**

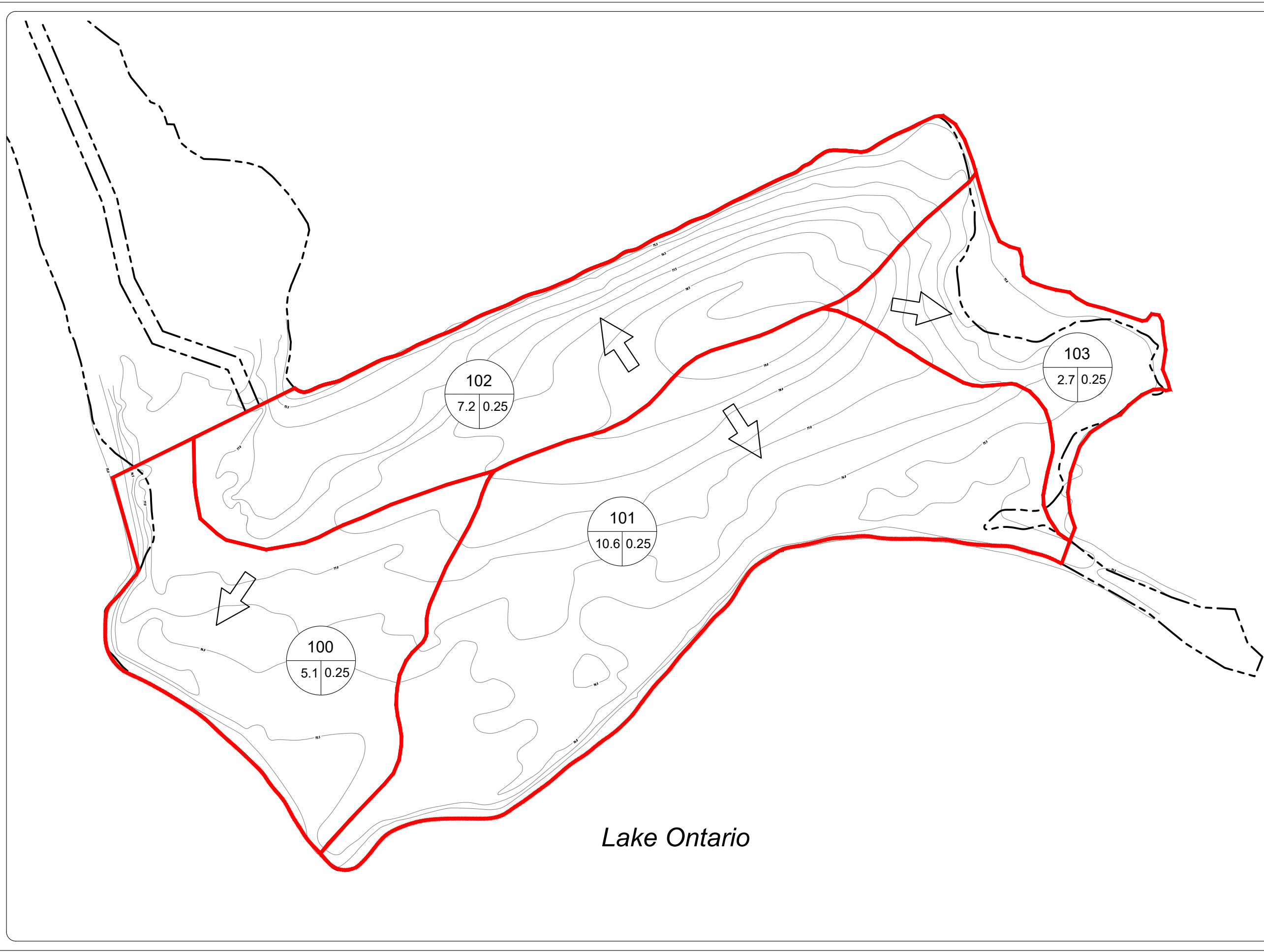
**Design Chart 2.32: Inlet Control: Circular CSP and SPCSP Culverts**



Source: Herr (1977)

**APPENDIX C**

**Catchment Area Drawings**



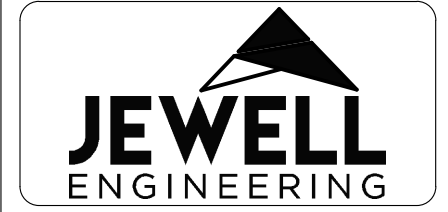
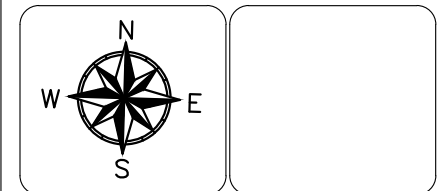
**GENERAL NOTES:**  
 ALL INFORMATION TO BE VERIFIED ON SITE PRIOR TO COMMENCING ANY WORK. ANY DISCREPANCIES ARE TO BE REPORTED TO THE CONSULTANT IMMEDIATELY.  
 ALL UTILITY LOCATIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE. THE CONTRACTOR SHALL CONFIRM THE LOCATION ON SITE AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES.  
 EXCLUDING THE BENCHMARK AND DESCRIPTION PROVIDED FOR THIS PROJECT, NO OTHER ELEVATIONS ARE TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.  
**METRIC NOTE:**  
 ALL DIMENSIONS SHOWN ARE IN METRES OR MILLIMETRES, UNLESS OTHERWISE NOTED.  
 \*\* DRAWINGS ARE NOT TO BE SCALED \*\*

**REVISIONS**

NO.	DATE	DESCRIPTION	BY

**LEGEND**

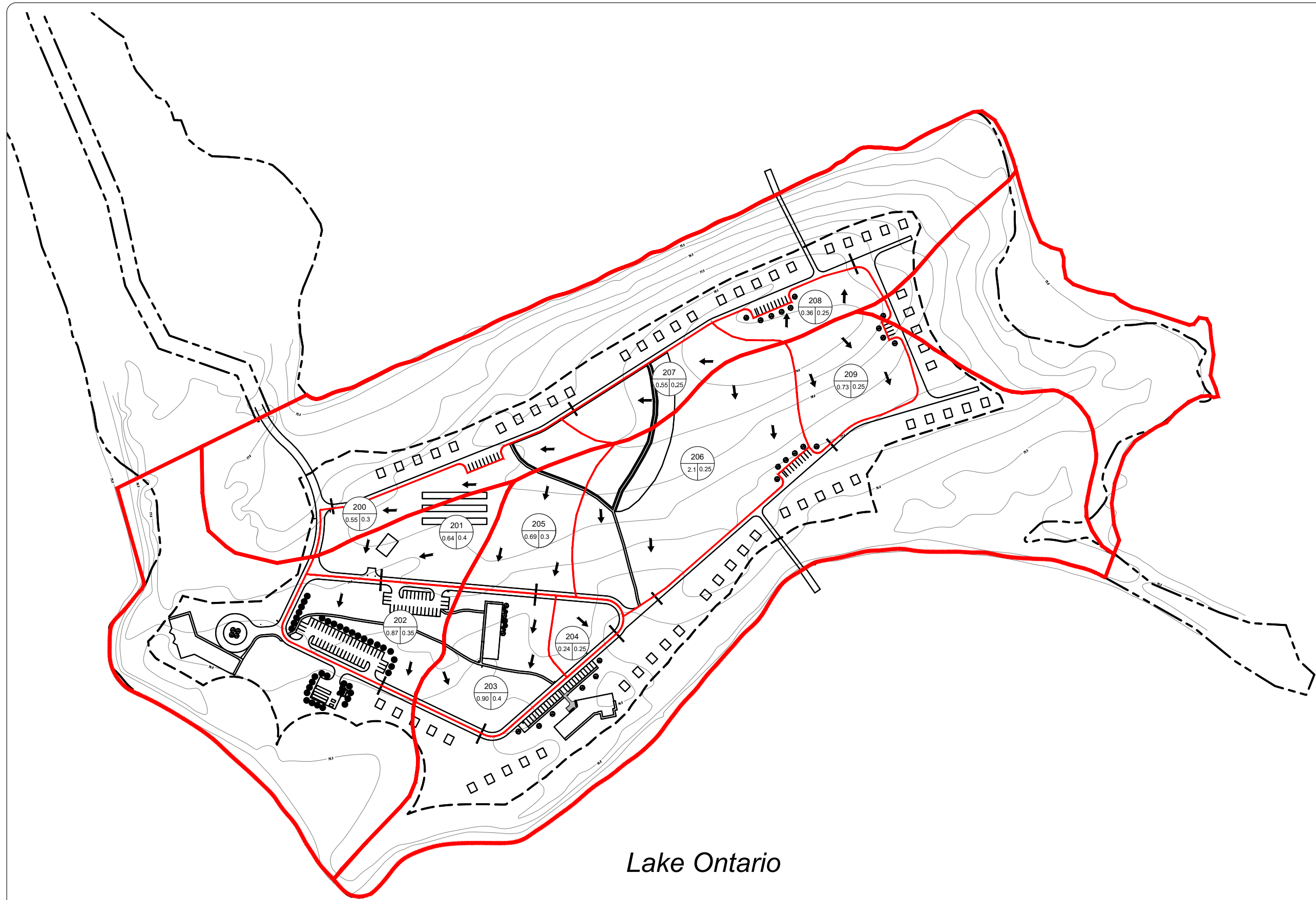
PROPERTY BOUNDARY	
CATCHMENT BOUNDARY	
DRAINAGE DIRECTION	
CATCHMENT AREA ID	
DRAINAGE AREA IN HECTARES (HA)	
RUNOFF COEFFICIENT	



**LOBP INC.**  
**ALEXANDER ISLAND**  
 PRINCE EDWARD COUNTY

**PRE-DEVELOPMENT**  
**CATCHMENT AREAS**

DRAWN BY:	PROJECT NO:	
MB	170-4137	
DESIGNED BY:	DATE:	
BK	June 2021	
CHECKED BY:	SCALE:	
BK	HORIZONTAL -1:3000	
	VERTICAL -N/A	
APPROVED BY:	CONTRACT NO:	DRAWING NO:
BK		C1



Lake Ontario

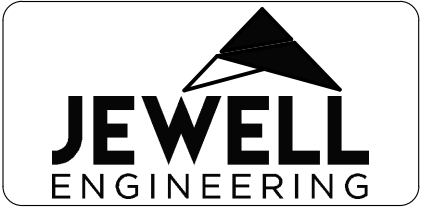
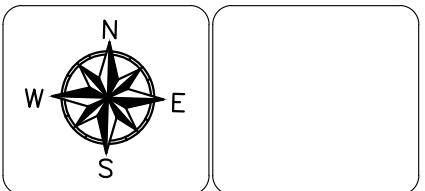
**GENERAL NOTES:**  
 ALL INFORMATION TO BE VERIFIED ON SITE PRIOR TO COMMENCING ANY WORK. ANY DISCREPANCIES ARE TO BE REPORTED TO THE CONSULTANT IMMEDIATELY.  
 ALL UTILITY LOCATIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE. THE CONTRACTOR SHALL CONFIRM THE LOCATION ON SITE AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES.  
 EXCLUDING THE BENCHMARK AND DESCRIPTION PROVIDED FOR THIS PROJECT, NO OTHER ELEVATIONS ARE TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.  
**METRIC NOTE:**  
 ALL DIMENSIONS SHOWN ARE IN METRES OR MILLIMETRES, UNLESS OTHERWISE NOTED.  
 \*\* DRAWINGS ARE NOT TO BE SCALED \*\*

**REVISIONS**

NO.	DATE	DESCRIPTION	BY

**LEGEND**

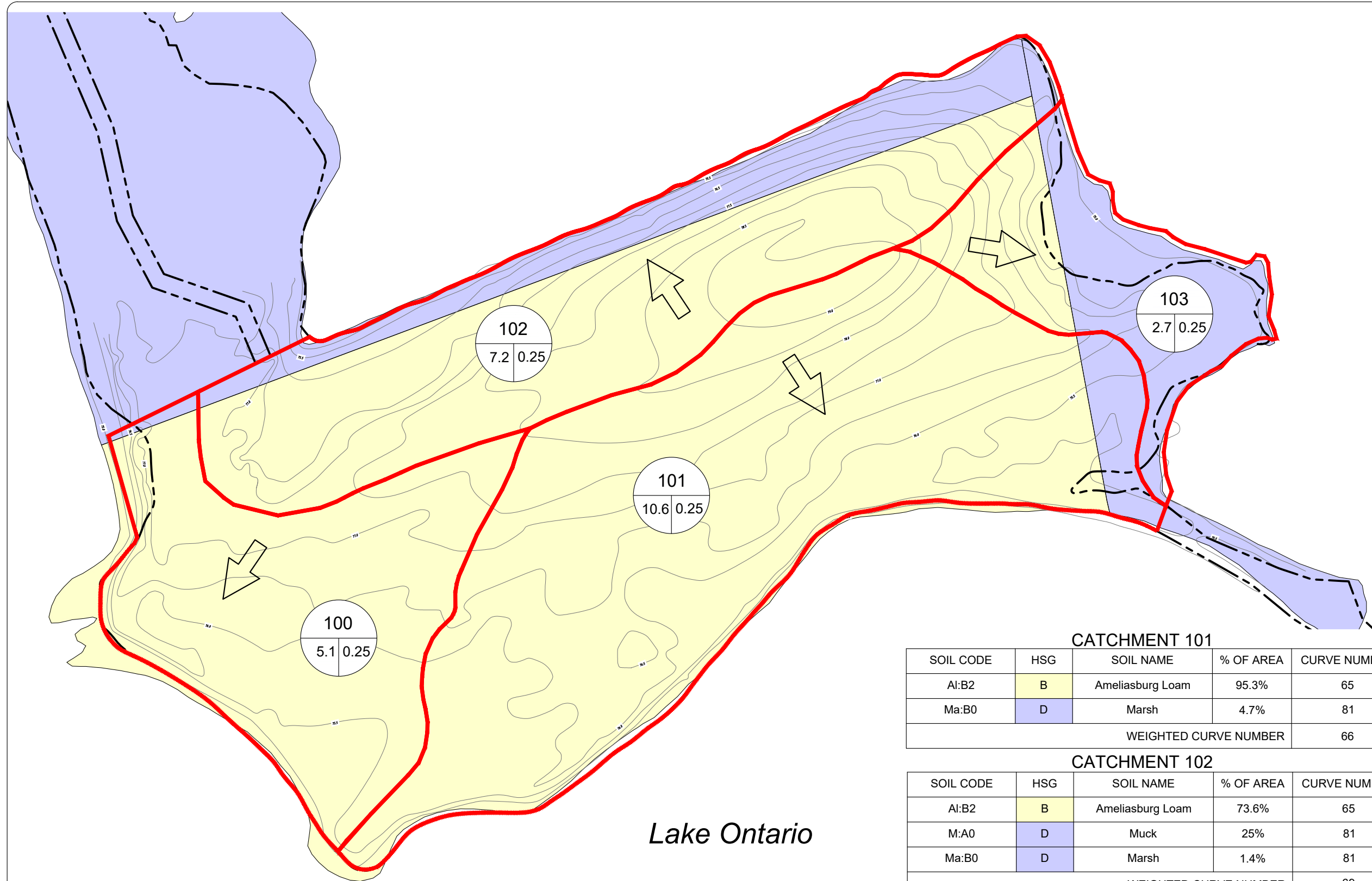
PROPERTY BOUNDARY	---
ENVIRONMENTAL SETBACK	- - - -
CATCHMENT BOUNDARY	---
DRAINAGE DIRECTION	←
CATCHMENT AREA ID	ID #
DRAINAGE AREA IN HECTARES (HA)	ha
RUNOFF COEFFICIENT	RC



**LOBP INC.**  
**ALEXANDER ISLAND**  
 PRINCE EDWARD COUNTY

POST-DEVELOPMENT  
 CATCHMENT AREAS

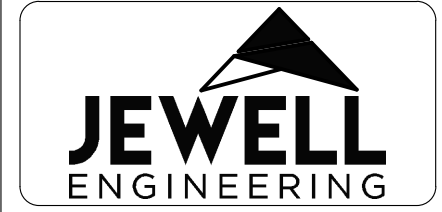
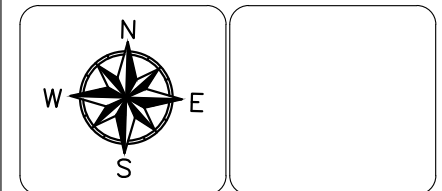
DRAWN BY:	PROJECT NO:	
MB	170-4137	
DESIGNED BY:	DATE:	
BK	June 2021	
CHECKED BY:	SCALE:	
BK	HORIZONTAL -1:3000	
	VERTICAL -N/A	
APPROVED BY:	CONTRACT NO:	DRAWING NO:
BK		C2



**GENERAL NOTES:**  
 ALL INFORMATION TO BE VERIFIED ON SITE PRIOR TO COMMENCING ANY WORK. ANY DISCREPANCIES ARE TO BE REPORTED TO THE CONSULTANT IMMEDIATELY.  
 ALL UTILITY LOCATIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE. THE CONTRACTOR SHALL CONFIRM THE LOCATION ON SITE AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES.  
 EXCLUDING THE BENCHMARK AND DESCRIPTION PROVIDED FOR THIS PROJECT, NO OTHER ELEVATIONS ARE TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.  
**METRIC NOTE:**  
 ALL DIMENSIONS SHOWN ARE IN METRES OR MILLIMETRES, UNLESS OTHERWISE NOTED.  
 \*\* DRAWINGS ARE NOT TO BE SCALED \*\*

REVISIONS			
NO.	DATE	DESCRIPTION	BY

LEGEND	
PROPERTY BOUNDARY	-----
CATCHMENT BOUNDARY	—————
DRAINAGE DIRECTION	↑
CATCHMENT AREA ID	ID #
DRAINAGE AREA IN HECTARES (HA)	ha
RUNOFF COEFFICIENT	RC



**LOBP INC.**  
**ALEXANDER ISLAND**  
 PRINCE EDWARD COUNTY

SOILS

**CATCHMENT 100**

SOIL CODE	HSG	SOIL NAME	% OF AREA	CURVE NUMBER
Al:B2	B	Ameliasburg Loam	98.8%	65
M:A0	D	Muck	1.2%	81
WEIGHTED CURVE NUMBER				65

**CATCHMENT 101**

SOIL CODE	HSG	SOIL NAME	% OF AREA	CURVE NUMBER
Al:B2	B	Ameliasburg Loam	95.3%	65
Ma:B0	D	Marsh	4.7%	81
WEIGHTED CURVE NUMBER				66

**CATCHMENT 102**

SOIL CODE	HSG	SOIL NAME	% OF AREA	CURVE NUMBER
Al:B2	B	Ameliasburg Loam	73.6%	65
M:A0	D	Muck	25%	81
Ma:B0	D	Marsh	1.4%	81
WEIGHTED CURVE NUMBER				69

**CATCHMENT 103**

SOIL CODE	HSG	SOIL NAME	% OF AREA	CURVE NUMBER
Al:B2	B	Ameliasburg Loam	33.3%	65
Ma:B0	D	Marsh	66.7%	81
WEIGHTED CURVE NUMBER				76

DRAWN BY: MB PROJECT NO: 170-4137  
 DESIGNED BY: BK DATE: June 2021  
 CHECKED BY: BK SCALE: HORIZONTAL -1:3000  
 VERTICAL -N/A  
 APPROVED BY: BK CONTRACT NO: DRAWING NO: C3