MacDonald Drive Lansdowne Stormwater Management Report

DRAFT

Prepared for:

GoBox Portable Storage Inc.

Prepared by:

FOREFRONT Engineering Inc. **613-634-9009**
1329 Gardiners Road, Suite 210
Kingston, ON, Canada K7P 0L8

Date: November 2024

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November 7, 2024

Rob Schur
GoBox Portable Storage Inc.
417 South Lake Road
Gananoque, ON K7G 2V3

Regarding: MacDonald Drive, Lansdowne
Stormwater Management Report

Dear Mr. Schur,

The enclosed report details the existing drainage conditions, provides a hydrologic and hydraulic analysis of the existing site and surroundings and provides recommendations for the proposed development.

It is understood that the site is to be developed for storage purposes. The majority of the site would be covered with gravel and used for storage. It is understood that shipping containers would be used to store items and that no permanent structures or buildings are proposed at this time.

Conveyance swales and a bioretention facility are proposed to provide quantity and quality control for stormwater outflow. Post-development flows are proposed to be attenuated to pre-development levels for all storm events up to the 100-year event.

A 6.0m setback from the floodplain limit of the regulated watercourses on and adjacent to the site is recommended.

If you have any enquiries or wish to discuss further, please contact this office.

Sincerely,
FOREFRONT Engineering Inc.

Jeff Homer

Jeff Homer, P.Eng.

FOREFRONT Signatures

Report Prepared By: Luke Prinsen

Luke Prinsen, EIT

DRAFT

Report Reviewed By:

Jeff Homer, P.Eng.

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1. Introduction

Forefront has completed this stormwater design report for the proposed development of the subject property. The legal description of the land is Block 44, Registered Plan No. 397 and it is located west of the existing cul-de-sac of MacDonald Drive, located off Prince Street (County Road 3) in Lansdowne. The site is accessed by an existing site entrance extending from the MacDonald Drive cul-de-sac.

The site is approximately 1.9 hectares in area and is bounded by the CN Rail line to the north, highway commercial and institutional (St. Lawrence District Medical Centre) uses to the east, the future extension of MacDonald Drive to the south, and future development lands to the west. Refer to Figure 1 for the site location.

Figure 1: Location Plan

It is understood that the site is to be developed for storage purposes. The majority of the site would be covered with gravel and used for storage. It is understood that shipping containers would be used to store items and that no permanent structures or buildings are proposed at this time.

The overall site topography involves a gentle slope from the east to the west. Site drainage is conveyed to an intermittent channel bordering the site to the south and to an intermittent channel on the west side of the site, which discharges to the south channel.

This Report recommends drainage requirements and stormwater management mitigation measures to accommodate an increase in the imperviousness onsite.

Please refer to the Site Plan and Grading Plan drawings in Appendix A for the proposed development plan.

2. Existing Conditions

The site is currently vacant and is not serviced by any storm sewer or formal stormwater management facilities. There are no storm sewers in the vicinity of the site.

The overall site topography involves a gentle slope from the east to the west. Site drainage is generally conveyed to an intermittent channel on the west side of the site (west channel), which discharges to a channel bordering the site to the south (south channel). The west channel generally provides some level of quantity and quality control for site runoff.

The west and south channels are regulated watercourses. Cataraqui Region Conservation Authority (CRCA) has requested that hydrologic and hydraulic analyses be carried out to identify the floodplain and justify a reduction in the 30 m setback to site works.

Figure 2 in Appendix A illustrates the drainage regime for the subject site.

Four external catchment areas drain to the west or south channels. Refer to Figure 2 in Appendix A.

External catchment area 1 (EX.1) is a large area north of the CN rail corridor that drains to the CN rail ditch and into the west channel. EX.1 consists of a large portion of the Village of Lansdowne as well as rural land. EX.1 includes the area immediately southeast of the intersection of Prince Street and the CN rail line.

External catchment areas 2, 3, and 4 include the lands east of Prince Street and drain to the south channel at the east side of the site.

The Soil Survey of Leeds County identifies the soil cover in this area as Napanee Clay. Napanee Clay is considered a poor-draining soil and is characterized by low organic content and high clay content.

Please refer to Appendix A, Figure 2: Pre-Development Catchment Areas, for the pre-development condition details.

<u>Source Water Protection</u>

The subject site is part of the Cataraqui Source Protection Area (SPA). The site is outside the Wellhead Protection Zone of the Lansdowne deep wells and is not within any Intake Protection Zone. A small portion of the site falls within an area considered a highly vulnerable aquifer with a vulnerability score 6. The outlet for the site is not considered a significant groundwater recharge area. Refer to Appendix A, Source Protection Map for further details.

The proposed development will not pose a risk to source water protection, but any future redevelopment of the site must adhere to all source water protection policies.

3. Proposed Development

The site is proposed to be developed for storage purposes. The majority of the site would be covered with gravel and used for storage. It is understood that shipping containers would be used to store items and that no permanent structures or buildings are proposed at this time.

Development will result in an increase in impervious surfaces and could potentially impact stormwater quantity and quality. Without stormwater management controls, this development could have potential impacts on the natural drainage and environment.

3.1 Drainage Plan

Consistent with general stormwater management practices, stormwater quality and quantity control are proposed for the development. Post-development flows will be maintained to pre-development levels for all storm events up to and including the 100-year design event.

A bioretention-type stormwater management facility is proposed at the west of the site to provide water quantity and quality control onsite prior to site runoff discharging to the existing west channel. Refer to Appendix A, Drawing C1 - Grading Plan for the site grading details.

It is proposed that the majority of the site would drain to the proposed bioretention facility. Swales are proposed around the perimeter of the gravel area to convey drainage to the bioretention facility. Ponding will be limited to the bioretention facility and the existing channel.

Major and minor flow paths will be directed to the proposed stormwater facilities and swales. Concentrated outlet locations will be enhanced with rip-rap and geotextile.

Refer to Figure 3: Post-Development Catchment Areas in Appendix A for the post-development catchment details.

3.2 Water Quantity

3.2.1 Rational Method

The rational method calculates the peak flow rate in a catchment due to the runoff contributed from the entire upstream catchment area at a specific location. The rational method is represented by the following equation:

$$Q = 0.0028\ C\ I\ A$$

Where:

C = Runoff coefficient
I = Rainfall intensity (mm/hr)
A = Drainage area (ha)

When developing the rational method, the runoff volume was not considered, and the rational method alone was not meant for detention basin design. For drainage areas smaller than 20 acres, the modified rational method can be used to size detention basins. The modified rational method uses the peak flow calculations and approximates the storage volume using the following equation:

$$S_d = Q_p t_d - Q_d((t_d + t_c)/2)$$

*Storage Formula (Aron and Kibler, 1990)

Where:

Q=Peak runoff rate (m3/s)	td = Duration of Storm (min)
C=Composite runoff coefficient	Qp = Peak Flow (m3/s)
I=Rainfall intensity (mm/hr)	Qd = Discharge Rate (m3/s)
A=Drainage area (ha)	Sd = Required Storage Volume (m3)
tc= Time of Concentration (min)	

The design storm duration is that duration that maximizes the detention storage volume, S_d, for a given return period. An allowable target outflow is set based on predevelopment conditions. The storm duration, td, is varied until the storage volume is maximized. Because the calculated times of concentration onsite are less than 15 minutes, a minimum time of concentration (t_c) of 15 minutes is proposed.

3.2.2 Runoff Coefficients

The runoff coefficient (C) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. The value of C is larger for areas with low infiltration and high runoff (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land). Coefficients were assigned based on surface cover and soil conditions as per Table 1.

Composite runoff coefficients were calculated for the site for pre-development and post-development conditions. The Soil Survey of Leeds County identifies the soil cover in this area as Napanee Clay. Napanee Clay is considered a poor-draining soil and is characterized by low organic content and high clay content. A runoff coefficient of 0.35 was used for the existing soil cover. Refer to the Composite Runoff Coefficients page in Appendix B for details on pre-development and post-development runoff coefficient calculations.

Table 1: Runoff Coefficient Guide

Land Use & Topography	**Runoff Coefficients**		
Urban			
Asphalt, concrete, roof areas	0.9		
Grassed area, parkland	0.25		
Gravel area	0.60		
Commercial	0.8		
Industrial	0.7		
Rural	**Soil Texture**		
	Open Sand Loam	**Loam or Silt Loam**	**Clay Loam or Clay**
Cultivated			
Flat 0-5% Slopes	0.22	0.35	0.55
Rolling 5-10% Slopes	0.3	0.45	0.6
Hilly 10-30% Slopes	0.4	0.65	0.7
Pasture			
Flat 0-5% Slopes	0.1	0.28	0.4
Rolling 5-10% Slopes	0.15	0.35	0.45
Hilly 10-30% Slopes	0.22	0.4	0.55
Woodlands and Cutover			
Flat 0-5% Slopes	0.08	0.25	0.35
Rolling 5-10% Slopes	0.12	0.3	0.42
Hilly 10-30% Slopes	0.18	0.35	0.52
Bare Rock	**Coverage**		
	30%	**50%**	**70%**
Flat 0-5% Slopes	0.4	0.55	0.75
Rolling 5-10% Slopes	0.5	0.65	0.8
Hilly 10-30% Slopes	0.55	0.7	0.85
Lakes and Wetlands	0.05		

3.2.3 Design Storm Events

The Ministry of the Environment Stormwater Management Manual suggests a 12.5mm to 25mm 4-hour Chicago Storm event for sizing quality treatment facilities in Ontario. The following formula has been developed for a 25mm, 4hr Chicago Design Storm for this area:

$$I_{25mm} = \frac{498}{(t_c+9.7)^{0.825}}$$

A minimum t_c (time of concentration) of 15 minutes is to be used.

The minor and major event of 5-year and 100-year design storm events were based on IDF rainfall statistics that describe the frequency of rainfall depths over a specified duration. Rainfall intensities with various durations and return periods for the site were obtained from the Environment Canada website. Refer to Appendix B for IDF Curve. The 100-year design storm event is the major event analyzed.

The modified rational method was used to analyse the pre-development and post-development flows from each catchment area.

Pre-Development Flows

Table 4-1 shows the pre-development peak rate of surface runoff, calculated using the rational method and assigned catchment characteristics.

Table 4-1 Existing Conditions

Hydrologic Units - Existing Conditions						
Hydrologic Unit	Est'd C	Area (ha)	T_c (min)	2 Year Storm Event (m^3/s)	5 Year Storm Event (m^3/s)	100 Year Storm Event (m^3/s)
E1	0.25	1.58	15	0.051	0.070	0.122

Post-Development Flows

Table 4-2 shows the post-development uncontrolled peak rate of surface runoff calculated using the rational method and assigned catchment characteristics.

Table 4-2 Post-Development Conditions – Peak Flows

Hydrologic Units - Proposed Conditions						
Hydrologic Unit	Est'd C	Area (ha)	T_c (min)	2 Year Storm Event Uncontrolled (m^3/s)	5 Year Storm Event Uncontrolled (m^3/s)	100 Year Storm Event Uncontrolled (m^3/s)
P1	0.55	1.58	15	0.114	0.155	0.270

Conveyance controls and storage are proposed to limit post-development flows to pre-development levels shown in Table 4-1.

Peak flows will be limited by storage in the enhanced swale, with an outlet pipe sized to restrict post-development flows to the required levels given the storage requirements.

Table 4-3 quantifies the storage required for the 2-year, 5-year and 100-year design storms. Refer to the Modified Rational Method Calculations & Storage Volume Calculations in Appendix B.

Table 4-3 Onsite Storage Requirements

Description	2-Year Storm Event	5-Year Storm Event	100-Year Storm Event
	Storage Required (m^3)	Storage Required (m^3)	Storage Required (m^3)
P1	63.4	87.5	148.0

Peak flows can be attenuated to pre-development levels by using onsite storage and controlling outflow. The storage provided by the bioretention facility is shown on the Modified Rational Method design sheets provided in Appendix B.

Major flow paths will be maintained to the pre-development drainage pattern. Ponding onsite during major storm events will be limited to the bioretention facility. Given the stormwater management design and proposed grading scheme there will be no impact to the surrounding infrastructure. Under blocked outlet conditions, flows will overtop the enhanced swale and be directed to the existing channels via the major flow path.

3.3 Water Quality

The Stormwater Management Planning and Design Manual by the MOE describes various levels of protection of water quality, based on a general relationship between the end-of-pipe stormwater management facilities long-term suspended solids removal and the lethal and chronic effects of suspended solids on aquatic life.

Based on the characteristics of the receiving watercourse, normal protection (corresponding to the end-of-pipe storage volumes required for the long-term removal of 70% of suspended solids) is proposed.

The bioretention filter has been sized for the 25mm event and is to provide in excess of 70% TSS removal.

3.3.1 *Bioretention Filter*

A bioretention type stormwater facility is to be utilized for the proposed development.

The following criteria was utilized in the design:

- 1.25 m deep (75mm mulch, 0.875 mm Engineered soil, 0.3m Gravel Storage Layer)
- 0.3 m gravel storage layer (50mm clean stone)
- 100 mm underdrain
- Overflow structure
- The interior side slopes are 3:1
- Native Plantings
- 200mm maximum ponding depth for the 2 year event

The gravel area shall be graded to discharge runoff to the bioretention facility.

According to the "*Low Impact Development Stormwater Management Planning and Design Guide*" (2010) by the Toronto and Credit Valley Conservation Authority, bioretention systems are one of the most effective BMP's for pollutant removal. bioretention facilities that incorporate an underdrain are found to have removal efficiencies for of Total Suspended solids (TSS), Total Nitrogen (TKN), Total Phosphorous (TP) are between 30 to 90%. The proposed bioretention facility will provide a minimum of 70% removal of suspended solids.

3.4 Maintenance

The pipe system will require routine periodic maintenance including hydro vacuuming, flushing and debris removal annually. Removal of accumulated sediment will be required.

<u>Bioretention Facility</u>

Periodic maintenance inspection of the facilities should be undertaken. The inspection should provide a summary of the following items:

- hydraulic operation of the facilities (detention time, evidence or occurrence of overflows);
- condition of vegetation in and around facility;

- occurrence of obstructions at the inlet and outlet;
- evidence of spills and oil/grease contamination;
- frequency of trash build-up;
- Measured sediment depths in the facilities;
- Maintenance and operational control undertaken during the year;
- Recommendations for inspection and maintenance program for the coming year;
- The pipe system and culverts will require routine periodic maintenance including hydro vacuuming, flushing and debris removal annually. Removal of accumulated sediment will be required.

The bioretention filter will require routine periodic maintenance including weed control and trash removal will be required several times per year. Removal of accumulated sediment, replacement of mulch and replacement of plantings should be evaluated annually with a recommended replacement period every 5 years.

The landowner is responsible for all maintenance of the stormwater infrastructure;

3.5 Quality Control (Short Term)

Silt fencing is to be provided at all side slopes and down gradient locations to ensure sediment and erosion control during construction. Other control devices such as straw bale check dams will also be provided where drainage is concentrated. Sediment and erosion management measures also serve to provide a limit to the grading operations.

The stormwater facility and components are to be constructed concurrently with initial phases of development. The timeframe for land to remain exposed before it is stabilized with sod, mulch, or hydroseeding is to be minimized. Topsoil is to be stockpiled away from watercourses and wetlands. Inspection of the sediment control works should be undertaken before and after all rainfall (and snowmelt) events.

4. Floodplain Analysis

A floodplain analysis was completed for the CRCA regulated watercourse adjacent to the subject site. Due to the proximity of the nearby watercourse along the west side and south side of the property, a setback is required by the CRCA. A floodplain analysis was completed to justify a reduction to the required setback to the proposed grading works from the watercourse floodplain. The floodplain analysis is intended to demonstrate that the proposed works lie outside and above the subject regulated watercourse.

The watercourse is a seasonal intermittent watercourse and includes two primary branches near the site: the west branch and the south branch. Drainage from north of the site (Catchment EX.1) flows to the west branch, which outlets at node **1B** and has a drainage area of approximately 33.98 ha. Drainage from the east of the site having a drainage area of approximately 16.58 ha (Catchment EX.2, EX.3, EX.4 and EX5), including lands east of Prince Street (County Road 3), flows to the south branch which outlets at node **1C**. The west branch ultimately connects and discharges into the south branch directly south of the site, with an outfall at **Outlet 1A**. Refer to Figure 4 in Appendix A for reference.

<u>Field Review and Background Information</u>

Forefront staff conducted data collection and a limited field investigation in October 2024. A topographic survey of the watercourse was completed.

LIDAR survey data and DRAPE imagery from 2014 was provided by the Cataraqui Region Conservation Authority. Forefront reviewed the LIDAR data and completed field verification with the topographic survey and field review. Where topographic field survey data is limited, the analysis substitutes the LIDAR data.

The Frontenac County Soil Survey identifies the soil in this area as Lansdowne Clay. Refer to the **Soil Survey Map** in **Appendix A** for reference.

Watercourse Hydrologic Analysis

The hydrologic analysis for the site was conducted using the recent version of the U.S. Environmental Protections Agency's StormWater Management Model (SWMM5). The model has been widely used in similar stormwater management analyses in Ontario and is recognized as a reliable modelling technique for estimating hydrologic and hydraulic responses for both rural and urban watersheds.

The 100-year storm event 24-hour SCS Type II distribution was used to assess the 100-year peak flow and floodplain. A 6-hour SCS Type II was also assessed and the 24-hour SCS II was the greater peak flow of the two scenarios. The latest Brockville Environment and Climate Change Canada (ECCC) Intensity-Duration-Frequency (IDF) curve (Station 6100971, 2022) for the area was used to develop the rainfall depth for the 24-hour 100-year event. Refer to the **Brockville ECCC IDF** in **Appendix B** for reference. The following summarizes the parameters of the hydrologic model. Refer to Table 3-1 in Appendix B for percent impervious calculations.

- A 100-year, 24-hour SCS Type II peak flow of 2.56 m^3/s was calculated for the west branch of the seasonal watercourse at node **1B**. For the south branch at node **1C**, the 100-year peak flow was calculated at 0.54 m^3/s. The combined 100-year peak flow at **Outlet 1A** was determined to be 3.04 m^3/s.
- A total catchment area of approximately 50.7 ha is considered draining to the two branches of the regulated watercourse. The catchment areas considered are the following:

    - **Catchment Area EX.1** consists of residential, industrial, commercial and institutional lands north of CN Rail having an area of approximately 33.98 ha at a percent impervious area of ±19.9% discharging to the west branch at node 1B.
    - **Catchment Area EX. 2** consists of residential lands east of Prince Street having an area of approximately 3.16 ha at a percent impervious of 25.5% draining to a 1200 mm box culvert below Prince Street draining to the south branch at node 1C.
    - **Catchmenet Area EX.3** consists of agricultural field having an area of approximately 5.41 ha draining to the Prince Street 1200 mm box culvert.
    - **Catchment Area EX.4** is runoff from Prince Street and roadside ditches having area of approximately 0.23 ha and percent imperviousness of 39.3%.
    - **Catchment Area EX.5** is agricultural fields having an area of approximately 7.78 ha at a percent impervious of 4.2% draining to node 1C.
    - **Total Catchment Area** draining to **Outlet 1A** is approximately 50.56 ha, having a combined peak flow of 3.02 m^2/s.

- Infiltration was considered utilizing the Green-Ampt model. A conservative clay soil type having a suction head of 315mm, conductivity of 0.6 mm/hr and initial soil moisture deficit of 0.205 was selected based off the Soil Survey and soil class for the area.
- A rainfall depth of 115 mm for the 24-hour 100-year storm event was taken from the latest Brockville *Environment and Climate Change Canada* intensity duration frequency IDF, Station 6100971, 2022.
- Modelling calculates the time to peak of the rainfall event at 11:50 hours from the onset of the rainfall event and the time to peak flow at 12:10 hours.

It is noted that the Ministry of Natural Resources and Forestry Ontario Watershed Information (OWIT) map calculates the upstream catchment area at approximately 30 ha which is in fair agreement with the west branch watercourse catchment area. However, the mapping does not include the lands to the east of Prince Street which is likely due to the limitations of OWIT mapping only considering contours and not considering the box culvert under

Prince Street conveying flows to the south watercourse. Also, the east lands are fairly flat and likely only contribute to runoff during major storm events and infiltrate the majority of rainfall during annual events.

Watercourse Hydraulic Analysis

Hydraulic analysis was completed using a recent version of the HEC-RAS River Analysis System software (Version 6.5, released March 2024). The software is widely used in similar open channel flow analyses and is recognized as a reliable technique for estimating one-dimensional steady state flow, unsteady state flow calculations, sediment transport, bed computations, water temperature modeling and their associated parameters.

- A steady state flow analysis with a combination of subcritical and supercritical flow (mixed flow regime) was conducted for the proposed channel re-alignment. The software utilizes the one-dimensional energy equation and/or momentum equations combined with Manning's equation to calculate the water surface profile, critical depth, velocity, Froude Number and maximum flow depth for the proposed scenario.
- The west branch seasonal watercourse cross-section through the subject site is approximately a ±2.8 wide bottom channel, having an average longitudinal slope of 0.6% and a Manning's n value of 0.035. A peak flow of 2.56 m^3/s was selected for the analysis of the west branch seasonal watercourse based on the hydrologic analysis.
- The south branch seasonal watercourse cross-section through the subject site is approximately a 2.5 wide bottom channel, having an average longitudinal slope of 0.65% and a Manning's n value of 0.035. A peak flow of 0.55 m^3/s was selected for the analysis of the south branch seasonal watercourse based on the hydrologic analysis.
- The bank height of the watercourses along the west and southeast of the property are typically less than 0.7 up to 1m in depth. The substrate for the watercourse is composed of silt and much with some vegetation along the southern watercourse.
- A combined 100-year peak flow of 3.02 m^3/s is calculated discharging to Outlet 1A.

From MTO Design Chart 2.01, a Manning's n value of 0.030 to 0.035 is appropriate for a natural watercourse having a regular section with light brush.

The existing seasonal watercourse alignment and reach data were input into HEC-RAS with the critical sections selected from the topographic survey. Refer to Figure 4-1 below for reference.

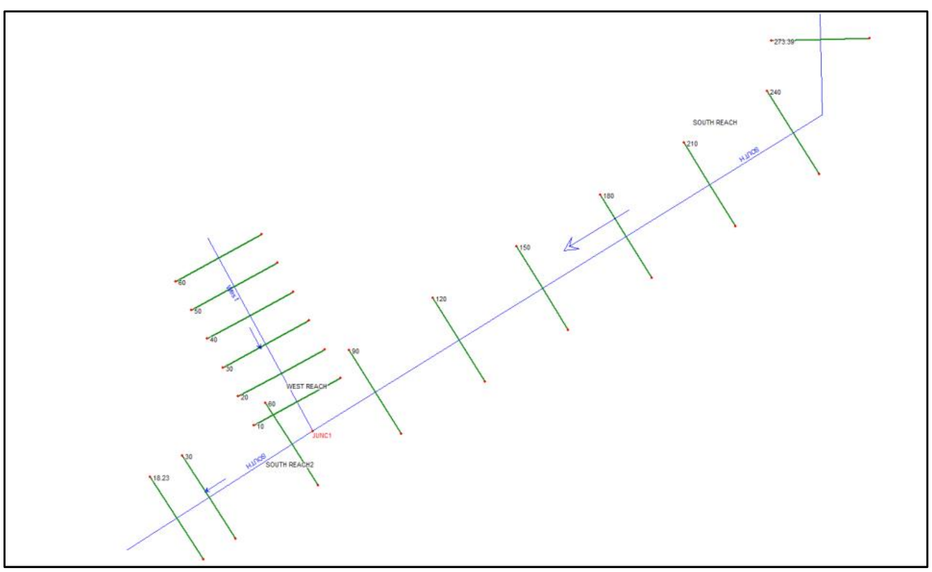


Figure 4-1 HEC-RAS Model

Refer to Table 4-1 below for the results of the HEC-RAS analysis.

Table 4-1 HEC-RAS Model Results

W.S. = Water Surface, E.G. = Energy Grade Line, Elev. = Elevation, Crit. = Critical Flow

Station	Q (m^3/s)	Min. Elev. (m)	W.S. Elev. (m)	W.S. Crit. (m)	W.S. Height (m)	E.G. Elev (m)	E.G. Slope (m/m)	Velocity (m/s)	Flow Area (m^2)	Froude Chl.
S 273	0.55	97.57	98.10		0.53	98.13	0.004	0.75	0.74	0.45
S 240	0.55	97.62	97.91		0.29	97.94	0.008	0.83	0.66	0.60
S 210	0.55	97.44	97.78		0.34	97.80	0.003	0.63	0.86	0.40
S 180	0.55	97.28	97.62		0.34	97.65	0.007	0.85	0.65	0.59
S 150	0.55	97.17	97.59		0.42	97.59	0.001	0.36	1.54	0.20
S 120	0.55	97.22	97.54		0.32	97.56	0.002	0.53	1.06	0.35
S 090	0.55	96.90	97.53		0.63	97.53	0.000	0.23	2.46	0.14
Node 1C										
W 060	2.56	97.10	97.62		0.52	97.66	0.010	0.92	2.78	0.68
W 050	2.56	97.04	97.62		0.58	97.63	0.001	0.40	6.45	0.25
W 040	2.56	96.96	97.60		0.64	97.61	0.001	0.42	6.13	0.27
W 030	2.56	96.89	97.56		0.67	97.59	0.004	0.72	3.58	0.47
W 020	2.56	96.80	97.50		0.70	97.54	0.005	0.91	2.8	0.53
W 010	2.56	96.46	97.49		1.03	97.50	0.002	0.50	5.16	0.31
Node 1B										
Junction	1B & 1C									
S 060	3.02	96.64	97.49		0.85	97.50	0.001	0.41	7.33	0.25
S 030	3.02	96.64	97.42		0.78	97.45	0.003	0.67	4.50	0.39
S 018	3.02	96.60	97.33		0.73	97.40	0.005	1.21	2.49	0.54

Where the flow is combined at the junction point the high-water elevation is approximately 97.49 m. The west branch flow discharging into the south branch creates a backwater effect on the southern branch as can be seen by the water elevation gradually increasing from approximately 0.35 m in depth to 0.63 m in depth approaching node 1C.

The south branch floodplain is contained within the channel. The west branch floodplain is largely approximate to the tops of bank of the channels.

The channel is fairly regular in shape with a straight alignment and a 6 m setback is in accordance with the Ontario Ministry of Natural Resources Technical Guide for River and Stream Systems Flooding Hazard Limit. A setback of 6.0 m is recommended from the floodplain limit to any site disturbance or grading works.

5. Conclusions

It is recommended that the development proceed with the mitigation measures detailed in this report to address storm water quality, storm water quantity and erosion concerns on the site.

Stormwater runoff within the development should be directed via swales to the proposed bioretention facility to be constructed along the west side of the site, which will provide further treatment and storage before outflowing to the wetland.

A hydrologic and hydraulic analysis has shown the floodplain limits on and adjacent to the site. A recommended 6.0 m setback from the floodplain limits is recommended for the site.

Appendix A

Site Plan

Grading Plan

Figure 2 – Pre-Development Catchment Areas

Figure 3 – Post-Development Catchment Areas

Figure 4 – Floodplain Analysis Catchment Areas

Soil Survey Map

PROJECT
MacDONALD DRIVE, LANSDOWNE
SITE INFORMATION
LOCATION: MacDONALD DRIVE, LANSDOWNE
ZONE: LIGHT INDUSTRIAL (ML)

BASIC SITE STATISTICS (PROPOSED)
SITE AREA: 19,178.5 m²
PROPOSED GRANULAR PAVED AREA: 1745.6 m²

SITE STATISTICS (ZONING COMPLIANCE)

Provision	Requirement	Proposed	Complies?
Light Industrial (ML) – Section 7.1			
Permitted Uses	• Various industrial uses	Transportation Depot	Yes
Lot Area (min)	465 m²	19,178.5 m²	Yes
Lot Frontage (min)	15 m	239.3	Yes
Front Yard (min)	7.5 m	n/a	Yes
Rear Yard (min)	7.5 m	n/a	Yes
Interior Yard (min)	3 m	n/a	Yes
Building Height (max)	12 m	n/a	Yes
Lot Coverage (max)	40%	0%	Yes
General Provisions – Section 3			
Landscaped Open Space (3.15.a)	In any zone, any portion of any minimum required yard which is not used for any other permitted purpose shall be devoted to landscaped open space.	To comply.	Yes
Setbacks (3.32.b)	Where any lot is adjacent to a waterbody or watercourse, any building, structure, campsite, agricultural use that includes the keeping of livestock, and septic disposal system shall be set back a minimum of 30 m from the high water mark.	10 m	No

KEY PLAN
NTS

LEGEND
SITE BOUNDARY
FLOODPLAIN
FLOODPLAIN 6m SETBACK
GRANULAR PAVEMENT
PROPOSED SWALE

Benchmark

No.	Revision/Issue	Date

LICENSED PROFESSIONAL ENGINEER
2024/10/31
K.M. NIELISSEN
100155232
PROVINCE OF ONTARIO

Forefront Engineering Inc

1329 Gardiners Road, Suite 210
Kingston, ON, Canada K7P 0L8
613.634.9009 tel.
1.888.884.9392 fax.

Client
GOBOX PORTABLE STORAGE INC.

Project
MacDONALD DRIVE LANSDOWNE

Drawing
SITE PLAN

Drawn by: LAP	Checked by: JH	Project No.
Designed by: KMN	Approved by: KMN	Drawing No. SP
Date: NOVEMBER 2024		
Scale: 1:500 ANSI D		

SITE WORKS

1. All works to be installed in accordance with current Township Site Plan Control Guidelines, Ontario Building Code, and Ontario Provincial Standard Specifications and Drawings unless specified otherwise.
2. Any existing unused wells found within the site are to be abandoned as per R.R.O. 1990 Regulation 903 Amended to O.Reg. 128/03.
3. Aggregates - Granular A and B as per OPSS.MUNI. 1010.
4. The Contractor shall acquire all permits as required for all works within the Municipal Right of Way. Cut permits are required for all offsite works.
5. Prior to construction, Contractor to verify all dimensions and utility locates and identify possible conflicts.
6. Granular pavement sections shall be:
   150mm Granular 'A'
   300mm Granular 'B' Type I or II

GRADING

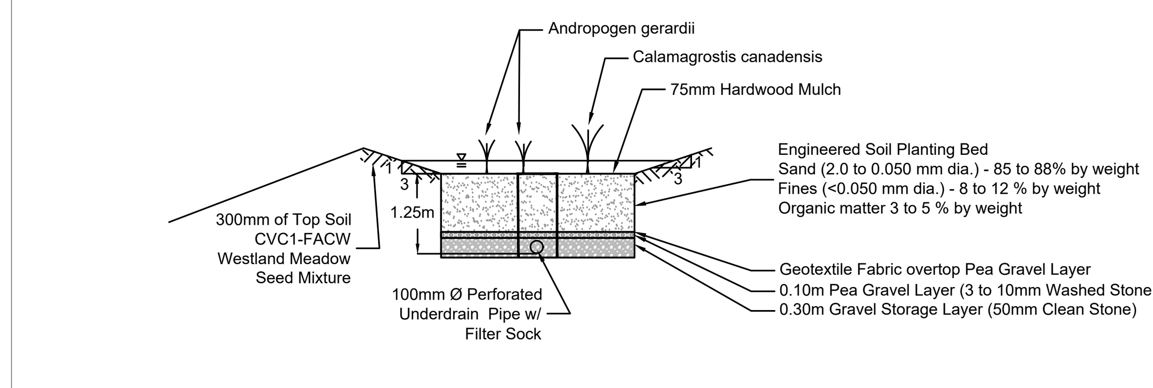
1. Existing elevations as per Forefront Engineering field survey and LIDAR data provided by CRCA.
2. Positive drainage away from structures shall be achieved. Finished surfaces shall be at a minimum grade of 2% unless otherwise noted.
3. Side slopes shall be a maximum slope of 3:1 unless otherwise noted.
4. All existing elevations and grades are to be verified by the contractor prior to grading.
5. Utilities are to be located prior to construction.
6. All ground surfaces shall be graded to prevent ponding except where approved swale or catchbasin outlets are provided.
7. Maximum hard surface grades are to be 8.0%.
8. Sub-drain and outlet elevations are to be confirmed prior to the construction of any structures.
9. Sub-grade shall be graded at a minimum of 2% until a lower ditch is encountered or the existing surface drains away from the sloped sub-grade.
10. Grades are to match the adjacent properties unless otherwise noted.

SEDIMENT AND EROSION CONTROL NOTES

1. All erosion and sediment controls shall be installed prior to construction and monitored and maintained by the Contractor throughout the construction process, until all disturbed areas have been re-vegetated, then the temporary sediment and erosion control measures must be removed once the site has been stabilized and or the site works are complete.
2. Staked straw bale filters and flow checks to be installed as per OPSD 219.100 and OPSD 219.180 around catchbasins and sewer inlets.
3. Any disturbed area not scheduled for further construction within forty-five (45) days will be provided with a suitable temporary mulch and seed cover within seven (7) days of completion of that particular phase of construction.
4. Regardless of site specific items detailed on the plans, the Contractor shall install erosion control measures to suit the proposed work methods controlling sediment runoff from discharging offsite prior to any disturbance.
5. Following construction, disturbed areas, as well as proposed grassed and vegetated surfaces, shall be reinstated as soon as practical.
6. Fill locations, side slopes, elevations as per the Approved Drawings. Restoration to be completed during the final phase of construction.
7. All roads used to access the site shall be kept clean to the satisfaction of the Township.

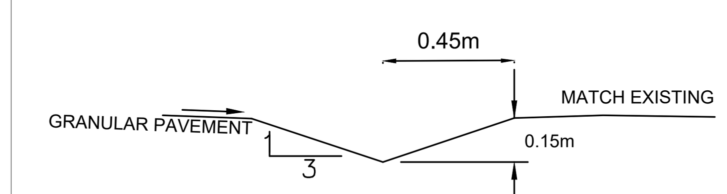
ENVIRONMENTAL

1. Any contaminated soils and/or groundwater, underground fuel tanks, buried wastes, designated substances or abandoned water wells encountered during construction will need to be managed in accordance with all applicable Provincial regulations.

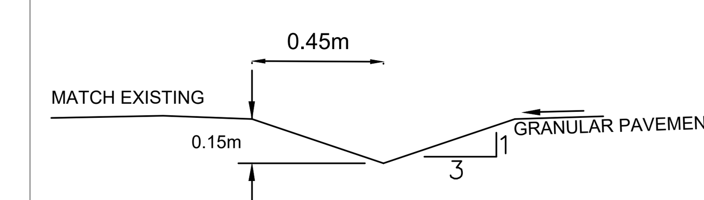


Notes:
1. Pea Gravel to be washed 3 to 10 mm diameter stone, minimum 300mm wide and 600mm deep
2. Species:
- Andropogen gerardii - 0.7m h x 0.4m w - surround perimeter at 0.5m spacing (15cm pots)
- Calamagrostis canadensis - 1.5m h x 1.5m w - in the middle staggered at 1m spacing (15cm pots)

B / C1 **BIORETENTION POND**
NTS



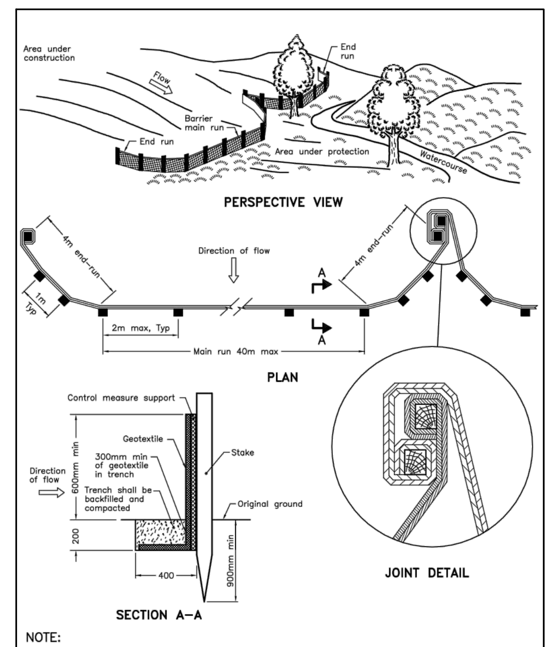
C / C1 **NORTH SIDE YARD SWALE**
NTS



D / C1 **SOUTH SIDE YARD SWALE**
NTS

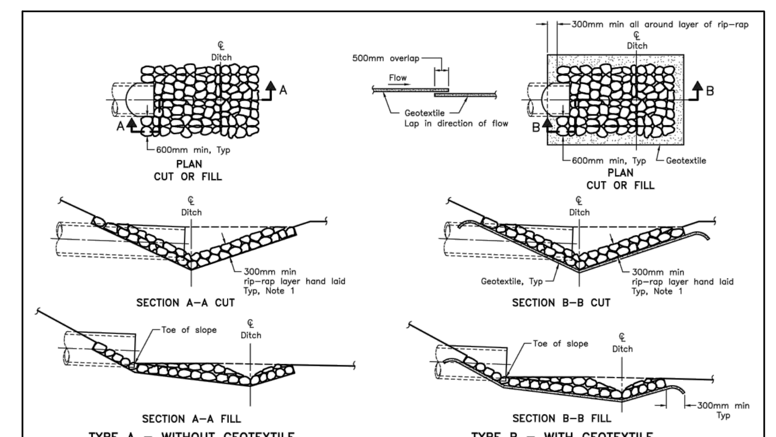
LEGEND

- SITE BOUNDARY
- FLOODPLAIN
- FLOODPLAIN 6m SETBACK
- GRANULAR PAVEMENT
- PROPOSED SWALE
- EXISTING GRADE
- PROPOSED GRADE
- SILT FENCE



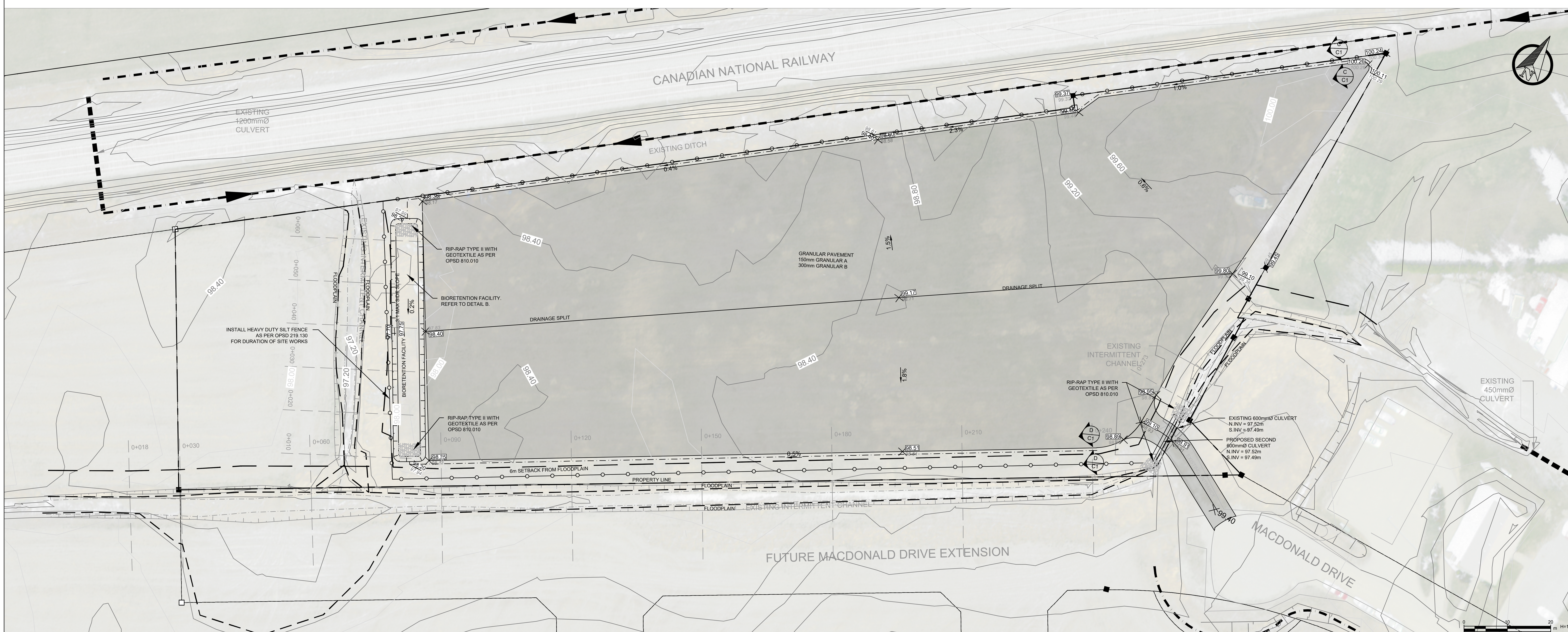
NOTE:
A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING — Nov 2015 — Rev 2
HEAVY-DUTY SILT FENCE BARRIER
OPSD 219.130



NOTES:
1 The thickness of the rip-rap layer shall be at least 1.5 times the rip-rap mean diameter.
A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING — Nov 2018 — Rev 2
GENERAL RIP-RAP LAYOUT FOR SEWER AND CULVERT OUTLETS
OPSD 810.010



Benchmark		
No.	Revision/Issue	Date

Forefront Engineering Inc

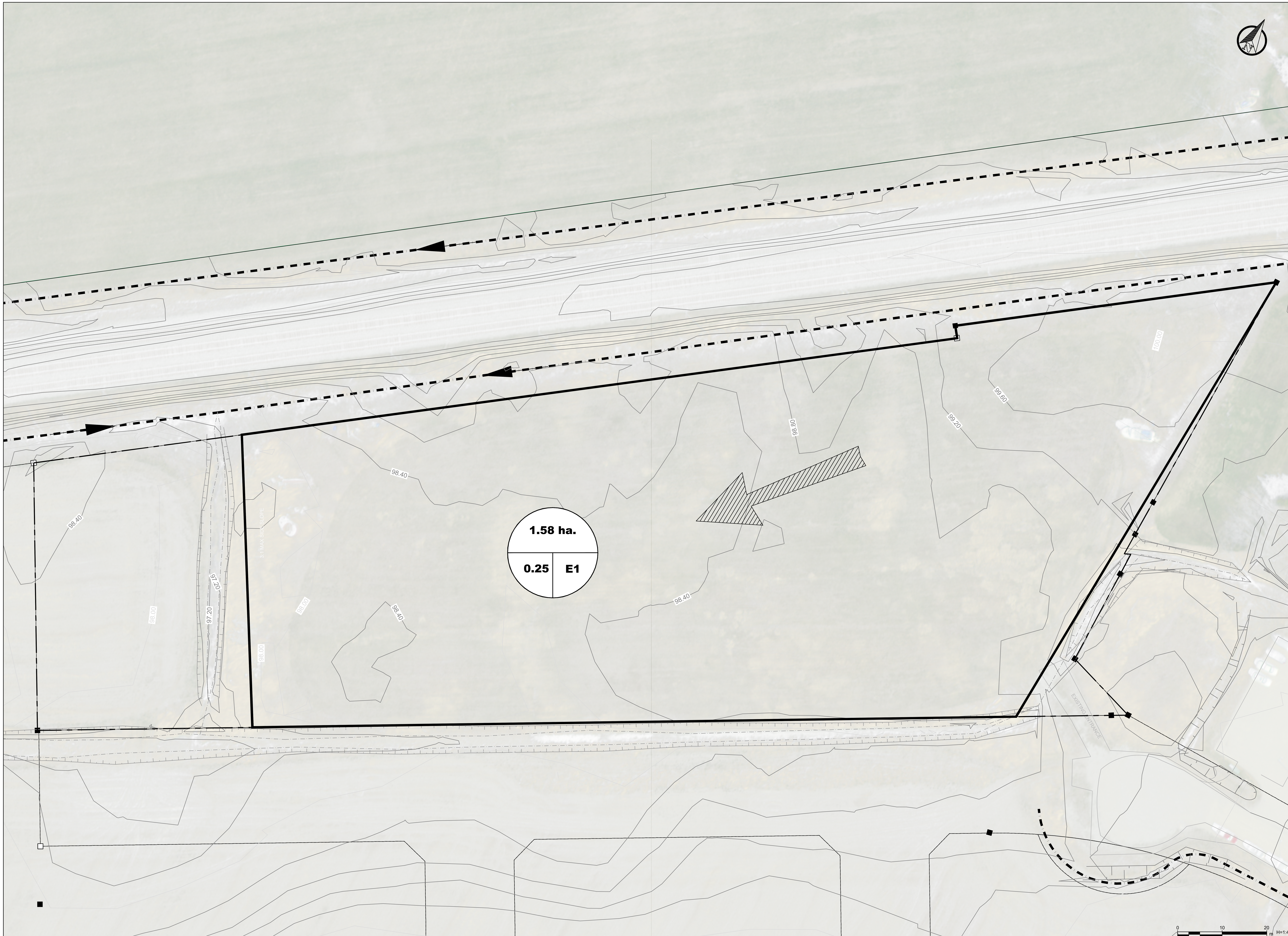
1329 Gardiners Road, Suite 210
Kingston, ON, Canada K7P 0L8
613.634.9009 tel.
1.888.884.9392 fax.

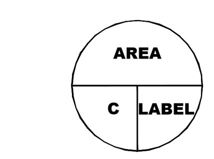
Client
GOBOX PORTABLE STORAGE INC.

Project
MacDONALD DRIVE LANSDOWNE

Drawing
GRADING PLAN

Drawn by: LAP	Checked by: JH	Project No.
Designed by: KMN	Approved by: KMN	Drawing No. C1
Date: NOVEMBER 2024		
Scale: 1:500 ANSI D		





Benchmark

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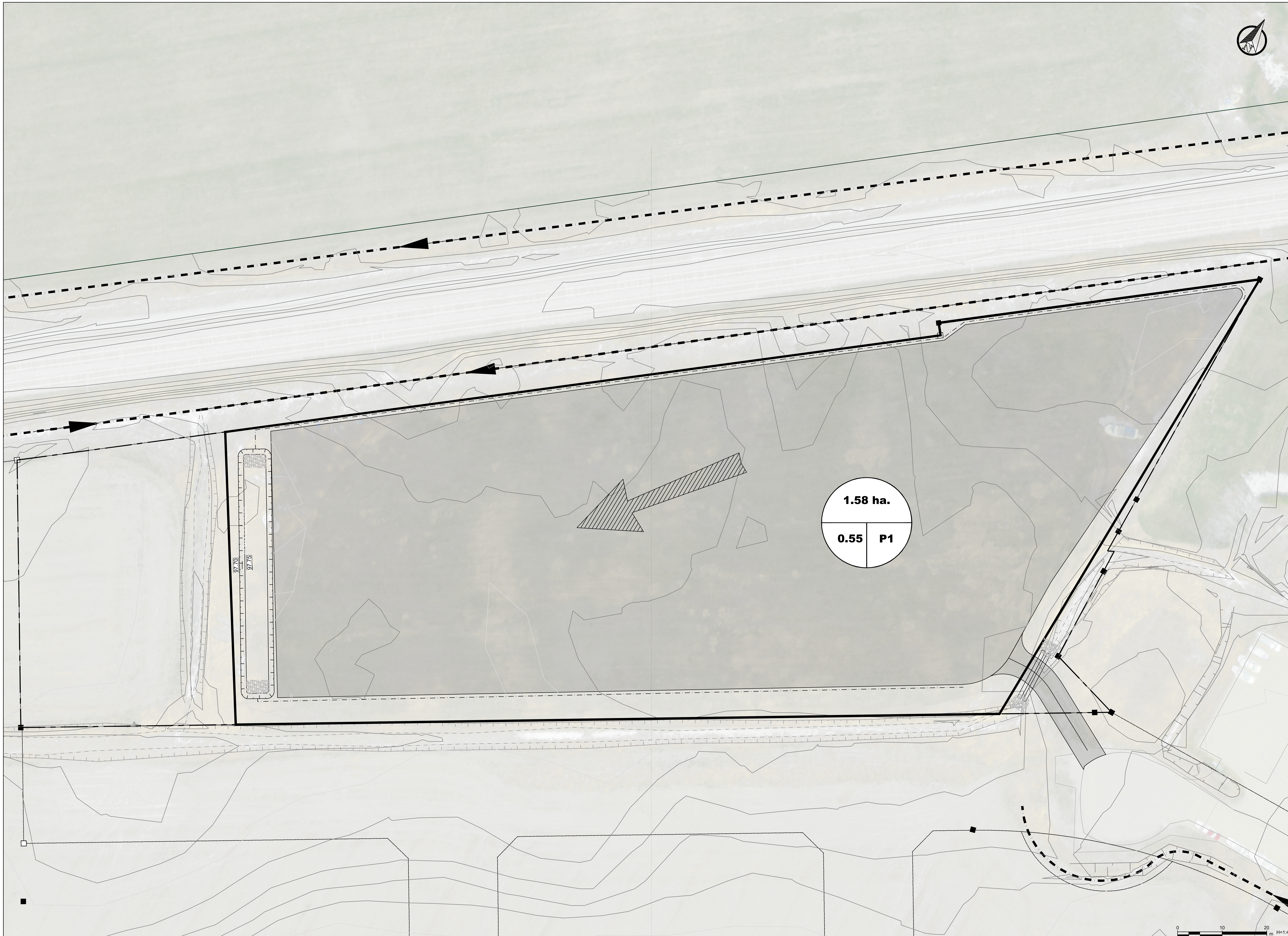
Kingston, ON, Canada K7P 0L8
613.634.9009 tel.
1.888.884.9392 fax.

Client
GOBOX PORTABLE STORAGE INC.

Project
MacDONALD DRIVE LANSDOWNE

Drawing
PRE-DEVELOPMENT CATCHMENT AREAS

Drawn by: LAP	Checked by: KMN	Project No.
Designed by: KMN	Approved by: KMN	Drawing No.
Date: NOVEMBER 2024		FIG.2
Scale: 1:400 ANSI D		



AREA
C LABEL

Benchmark

No.	Revision/Issue	Date

Forefront Engineering Inc

1329 Gardiners Road, Suite 210
Kingston, ON, Canada K7P 0L8
613.634.9009 tel.
1.888.884.9392 fax.

Client
GOBOX PORTABLE STORAGE INC.

Project
MacDONALD DRIVE LANSDOWNE

Drawing
POST-DEVELOPMENT CATCHMENT AREAS

Drawn by:	Checked by:	Project No.
LAP	KMN	
Designed by:	**Approved by:**	**Drawing No.**
KMN	KMN	FIG.3

Date: NOVEMBER 2024

Scale: 1:400 ANSI D

Benchmark

No.	Revision/Issue	Date

Forefront Engineering Inc

1329 Gardiners Road, Suite 210
Kingston, ON, Canada K7P 0L8
613.634.9009 tel.
1.888.884.9392 fax.

Client
GOBOX PORTABLE STORAGE INC.

Project
MacDONALD DRIVE LANSDOWNE

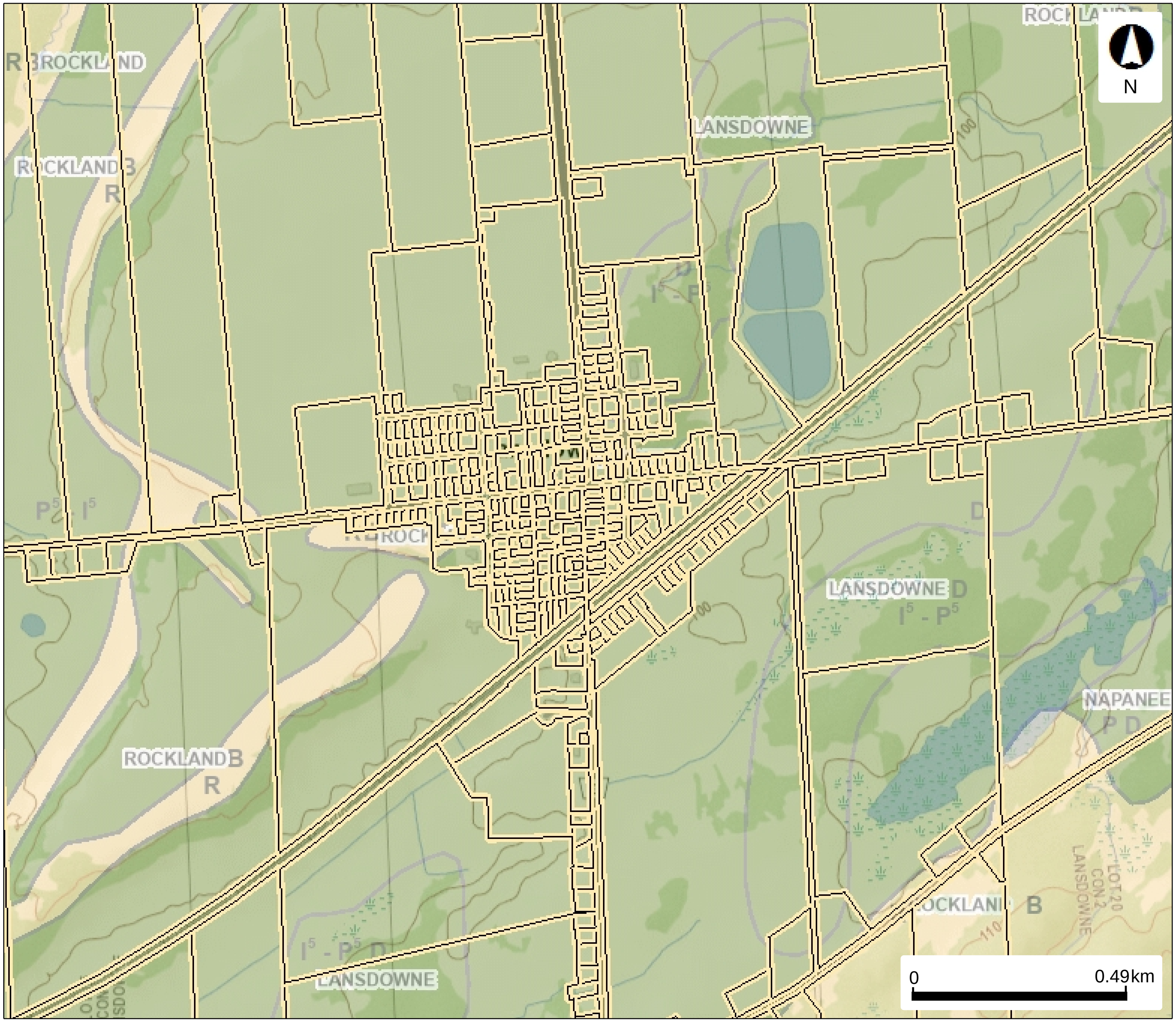
Drawing
FLOODPLAIN ANALYSIS
CATCHMENT AREAS

Drawn by:	Checked by:	Project No.
LAP	KMN	
Designed by:	**Approved by:**	**Drawing No.**
KMN	KMN	FIG.4

Date: NOVEMBER 2024

Scale: 1:2000 ANSI D

Soil Survey Map



Legend

- Assessment Parcel
- Soil Name Label

Hydrologic Soil Group

- A - High
- B - Moderate
- C - Slow
- D - Very Slow

Drainage

- Very Rapidly Drained
- Rapidly Drained
- Well Drained
- Moderately Well Drained
- Imperfectly Drained
- Poorly Drained
- Very Poorly Drained
- Water
- Variable
- Not Applicable

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Agriculture, Food and Agribusiness (OMAFA) shall not be liable in any way for the use or any information on this map. of, or reliance upon, this map.

Map Created: 11/5/2024
Map Center: 44.40526 N, -76.01804 W

Appendix B

Runoff Coefficient Calculations

Rational Method Calculations

Culvert Sizing

Brockville IDF Data

Table 3-1: Surface Cover Parameter Calculations

100-year event SWMM5 Modeling (24hr SCS II)

Composite Runoff Coefficients MacDonald Drive Lansdowne			
Pre-Development Conditions			
Catchment Area No.	**Area (m^2)**	**Runoff Coefficient -C**	**Description**
E1			
Hard	0.0	0.90	Rooftop, Concrete, Asphalt
Gravel	0.0	0.60	Gravel
Pervious	15,810.0	0.25	Grass Area
Total	15,810.0	0.25	
Post-Development Conditions			
Catchment Area No.	**Area (m^2)**	**Runoff Coefficient -C**	**Description**
P1			
Hard	0.0	0.90	Rooftop, Concrete, Asphalt
Gravel	13,680.0	0.60	Gravel
Pervious	2,130.0	0.25	Grass Area
Total	15,810.0	0.55	

$$C_{weighted} = \frac{C_1 * A_1 + C_2 * A_2 + C_3 * A_3 \ldots + C_n * A_n}{A_1 + A_2 + A_3 \ldots A_n}$$

Runoff coefficients are consistent with the City of Kingston Site Plan Control Guidelines .
Gravel coefficient is 0.7 pre-development and 0.9 post-development as per City requirements.

MODIFIED RATIONAL METHOD CALCULATIONS &
STORAGE VOLUMES FOR SMALL SITES

Project: MacDonald Drive Lansdowne
Date: November 2024

Formulas:

I= MTO District 8 West IDF Curve

Q = 0.0028 * C * I * A

$S_d = Q_p t_d - Q_d((t_d+t_c)/2)$

*Storage Formula (Aron and Kibler, 1990)

Where:

Q=Peak runoff rate (m^3/s)
C=Composite runoff coefficient
I=Rainfall intensity (mm/hr)
A=Drainage area (ha)
tc= Time of Concentration (min)
td = Duration of Storm (min)
Qp = Peak Flow (m^3/s)
Q_d = Discharge Rate (m^3/s)
Sd = Required Storage Volume (m^3)

Orifice Equation Q= 0.65A(2gH)^0.5 (MTO Guidelines)
A = orifice area; g=9.8; H=head above centre of orifice (m)

Weir Equation Q= 1.837(L-.06H)xH^1.5 (MTO Guidelines)
H= Upstream- Downstream elevation

2 Year Return Period

Pre-Development	E1
C	0.25
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	46.47
Q (m^3/s)	0.051

Post-Development	P1
C	0.55
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	46.47
Q_{Peak} (m^3/s)	0.114

Required Storage (P1)

Duration td (min)	Intensity (mm/hr)	CxA	Q_p Uncontrolled Runoff Rate (m^3/s)	Q_d Allowable Outflow (m^3/s)	Peak Storage Rate (m^3/s)	Storage Volume Total (m^3)	Comments
10	58.55	0.87	0.143	0.051	0.092	47.4	
15	46.47	0.87	0.114	0.051	0.062	56.1	
20	39.13	0.87	0.096	0.051	0.044	60.9	
25	33.96	0.87	0.083	0.051	0.032	62.9	
30	30.16	0.87	0.074	0.051	0.022	**63.4**	**storage required**
35	27.23	0.87	0.067	0.051	0.015	62.8	

Orifice Diameter (m)	Water Surface Elevation (m)	Invert of Orifice (m)	Invert of Orifice (m)	Head (m)	Release Rate (m^3/s)	Required Release (m^3/s)	Velocity m/s	Comments
0.30	97.92	97.75	97.90	0.17	0.083	0.051	1.66	

Provided Enhanced Swale Characteristics

Side Slopes	3:1	
Bottom Width	6.0	m
Length	58	m
Outlet Elevation	97.75	
Water Surface Elevation	97.92	m
Volume	**63.4**	**m^3**

MODIFIED RATIONAL METHOD CALCULATIONS &
STORAGE VOLUMES FOR SMALL SITES

Project: MacDonald Drive Lansdowne
Date: November 2024

5 Year Return Period

Pre-Development	E1
C	0.25
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	63.50
Q (m^3/s)	0.070

Post-Development	P1
C	0.55
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	63.50
Q_{Peak} (m^3/s)	0.155

Formulas:

I= MTO District 8 West IDF Curve

Q = 0.0028 * C * I * A

$S_d = Q_p t_d - Q_d((t_d+t_c)/2)$

*Storage Formula (Aron and Kibler, 1990)

Where:

Q=Peak runoff rate (m^3/s)
C=Composite runoff coefficient
I=Rainfall intensity (mm/hr)
A=Drainage area (ha)
tc= Time of Concentration (min)
td = Duration of Storm (min)
Qp = Peak Flow (m^3/s)
Q_d = Discharge Rate (m^3/s)
Sd = Required Storage Volume (m^3)

Orifice Equation Q= 0.65A(2gH)^0.5 (MTO Guidelines)
A = orifice area; g=9.8; H=head above centre of orifice (m)

Weir Equation Q= 1.837(L-.06H)xH^1.5 (MTO Guidelines)
H= Upstream- Downstream elevation

Required Storage (P1)

Duration td (min)	Intensity (mm/hr)	CxA	Q_p Uncontrolled Runoff Rate (m^3/s)	Q_d Allowable Outflow (m^3/s)	Peak Storage Rate (m^3/s)	Storage Volume Total (m^3)	Comments
10	79.21	0.87	0.194	0.070	0.124	63.6	
15	63.50	0.87	0.155	0.070	0.085	76.6	
20	53.66	0.87	0.131	0.070	0.061	83.8	
25	46.63	0.87	0.114	0.070	0.044	86.8	
30	41.41	0.87	0.101	0.070	0.031	**87.5**	**storage required**
35	37.36	0.87	0.091	0.070	0.021	86.6	

Orifice Diameter (m)	Water Surface Elevation (m)	Invert of Orifice (m)	Invert of Orifice (m)	Head (m)	Release Rate (m^3/s)	Required Release (m^3/s)	Velocity m/s	Comments
0.30	97.98	97.75	97.90	0.23	0.097	0.070	1.43	

Provided Enhanced Swale Characteristics

Side Slopes	3:1	
Bottom Width	6.0	m
Length	58	m
Outlet Elevation	97.75	
Water Surface Elevation	97.98	m
Volume	**87.5**	**m^3**

MODIFIED RATIONAL METHOD CALCULATIONS &
STORAGE VOLUMES FOR SMALL SITES

Project: MacDonald Drive Lansdowne
Date: November 2024

Formulas:

I= MTO District 8 West IDF Curve

Q = 0.0028 * C * I * A

S_d= $Q_p t_d - Q_d((t_d+t_c)/2)$

*Storage Formula (Aron and Kibler, 1990)

Where:

Q=Peak runoff rate (m^3/s)
C=Composite runoff coefficient
I=Rainfall intensity (mm/hr)
A=Drainage area (ha)
tc= Time of Concentration (min)
td = Duration of Storm (min)
Qp = Peak Flow (m^3/s)
Q_d = Discharge Rate (m^3/s)
Sd = Required Storage Volume (m^3)

Orifice Equation Q= 0.65A(2gH)^0.5 (MTO Guidelines)

A = orifice area; g=9.8; H=head above centre of orifice (m)

Weir Equation Q= 1.837(L-.06H)xH^1.5 (MTO Guidelines)

H= Upstream- Downstream elevation

100 Year Return Period

Pre-Development	E1
C	0.25
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	110.24
Q (m^3/s)	0.122

Post-Development	P1
C	0.55
Area (ha)	1.581
t_c (min)	15
Intensity (mm/hr)	110.24
Q_{Peak} (m^3/s)	0.270

Required Storage (P1)

Duration td (min)	Intensity (mm/hr)	CxA	Q_p Uncontrolled Runoff Rate (m^3/s)	Q_d Allowable Outflow (m^3/s)	Peak Storage Rate (m^3/s)	Storage Volume Total (m^3)	Comments
10	138.41	0.87	0.339	0.122	0.217	111.7	
15	110.24	0.87	0.270	0.122	0.148	133.0	
20	92.70	0.87	0.227	0.122	0.105	144.1	
25	80.21	0.87	0.196	0.122	0.074	148.0	
30	70.98	0.87	0.174	0.122	0.052	**148.0**	**storage required**
35	63.85	0.87	0.156	0.122	0.034	145.1	

Orifice Diameter (m)	Water Surface Elevation (m)	Invert of Orifice (m)	Invert of Orifice (m)	Head (m)	Release Rate (m^3/s)	Required Release (m^3/s)	Velocity m/s	Comments
0.30	98.11	97.75	97.90	0.36	0.122	0.122	1.13	

Provided Enhanced Swale Characteristics

Side Slopes	3:1	
Bottom Width	6.0	m
Length	58	m
Outlet Elevation	97.75	
Water Surface Elevation	98.11	m
Volume	**148.0**	**m^3**

Culvert Report

100 Year Peak Flow - 0.56 cms - (2) 600mm Culverts

Invert Elev Dn (m)	=	97.4900
Pipe Length (m)	=	12.0000
Slope (%)	=	0.2500
Invert Elev Up (m)	=	97.5200
Rise (mm)	=	600.0
Shape	=	Circular
Span (mm)	=	600.0
No. Barrels	=	2
n-Value	=	0.012
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

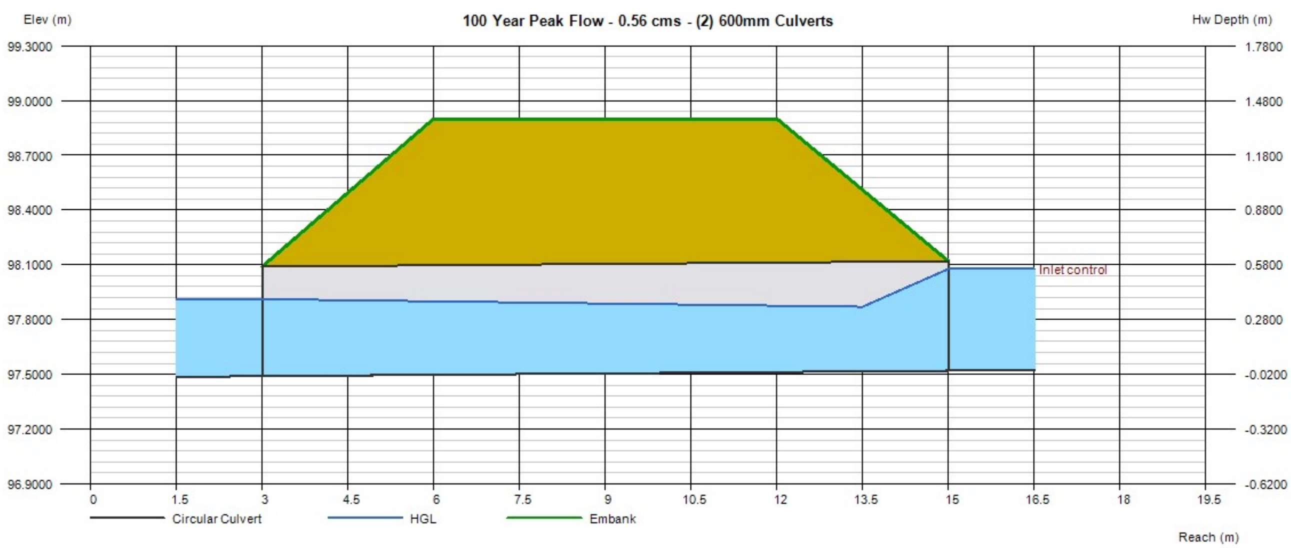
Top Elevation (m)	=	98.9000
Top Width (m)	=	6.0000
Crest Width (m)	=	10.0000

Calculations

Qmin (cms)	=	0.2000
Qmax (cms)	=	0.5600
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.5600
Qpipe (cms)	=	0.5600
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	1.3172
Veloc Up (m/s)	=	1.6682
HGL Dn (m)	=	97.9121
HGL Up (m)	=	97.8643
Hw Elev (m)	=	98.0774
Hw/D (m)	=	0.9289
Flow Regime	=	Inlet Control



Environment and Climate Change Canada
Environnement et Changement climatique Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2022/10/31

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BROCKVILLE PCC ON 6100971

Latitude: 44 36'N Longitude: 75 40'W Elevation/Altitude: 96 m

Years/Années : 1967 - 2017 # Years/Années : 43

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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
1967	6.9	11.9	14.5	26.4	35.6	36.6	39.9	43.7	51.3
1968	5.8	7.9	8.4	9.9	16.0	24.4	39.6	48.0	54.4
1969	6.3	11.7	11.7	13.2	18.3	25.4	34.5	50.8	59.7
1970	11.2	13.0	19.0	20.6	26.2	40.4	41.7	46.2	62.2
1971	8.4	8.9	9.1	9.7	18.0	24.1	29.0	31.0	31.0
1972	9.7	14.2	17.0	18.8	23.4	27.4	46.5	62.2	64.0
1973	8.6	14.7	20.8	25.4	29.0	29.2	29.5	29.5	29.5
1974	19.3	27.9	38.1	49.3	52.1	54.1	55.1	55.1	55.1
1975	10.7	17.5	21.1	26.9	34.5	55.9	55.9	69.8	82.5
1976	7.4	13.2	15.2	16.8	19.6	27.7	30.2	35.1	40.1
1977	9.4	12.2	15.2	29.7	40.9	47.8	47.8	50.8	52.6
1978	7.4	10.4	10.8	11.2	13.3	16.6	21.4	24.6	24.6
1980	8.4	15.3	16.6	18.9	19.0	21.9	32.0	32.0	56.6
1981	-99.9	-99.9	-99.9	25.1	27.6	28.4	30.3	42.6	50.0
1982	10.1	16.2	19.4	22.6	23.9	28.6	62.5	70.4	70.4
1983	9.7	12.4	12.6	12.8	15.9	21.1	35.5	37.8	37.8
1984	5.2	7.4	8.8	14.2	22.3	31.8	37.7	39.4	39.4
1985	7.9	9.4	9.4	15.2	19.7	24.7	38.0	49.6	52.8
1986	9.8	15.7	23.0	42.2	48.4	50.2	55.6	63.0	64.7
1987	7.6	10.2	10.8	15.4	21.4	31.4	42.4	50.7	61.2
1988	5.2	7.0	8.4	9.5	13.2	16.4	29.4	41.4	42.2

1989	11.2	20.4	29.4	47.9	49.0	52.6	89.0	89.5	89.7
1990	6.4	12.8	15.5	17.2	19.4	19.7	35.8	37.4	42.0
1991	7.6	8.8	11.0	14.4	21.8	25.8	28.4	42.3	52.4
1992	5.9	7.2	8.0	12.6	24.4	37.0	45.3	46.4	46.4
1995	9.7	12.0	14.1	16.9	19.0	20.0	40.6	61.7	68.8
1996	6.4	12.6	14.9	22.7	29.6	34.2	38.6	40.2	58.4
1997	10.6	12.7	12.9	13.6	21.5	29.5	37.2	42.8	44.6
1998	10.9	16.7	21.0	22.5	25.2	29.4	31.5	35.4	41.6
1999	9.1	10.7	11.7	13.7	14.6	16.8	33.5	36.6	54.4
2000	6.0	7.4	9.7	12.3	17.4	22.2	30.8	34.0	43.9
2001	10.5	12.6	15.6	19.3	20.4	21.4	38.9	65.4	79.5
2002	7.1	9.0	9.2	9.2	9.8	13.8	32.1	39.4	42.4
2003	8.5	11.2	14.7	16.0	17.3	17.7	29.3	44.1	54.7
2004	12.1	17.7	18.3	24.7	25.3	31.8	63.6	100.0	109.6
2005	8.1	11.5	12.7	14.2	21.3	33.1	66.9	81.7	83.3
2008	10.7	14.5	15.5	22.7	32.1	33.4	43.2	51.2	51.6
2009	6.0	11.7	14.7	15.4	16.5	18.1	23.0	26.1	30.8
2012	8.1	12.1	13.1	15.1	15.6	23.6	28.2	39.2	39.2
2013	8.3	16.0	21.4	30.9	31.1	38.4	42.1	43.9	46.0
2014	5.5	7.7	10.0	16.8	20.1	30.1	40.1	43.4	48.5
2015	8.4	13.6	17.4	20.7	20.9	23.8	39.2	39.2	44.2
2016	8.0	13.4	16.7	21.0	25.2	25.7	29.3	40.1	57.6
2017	4.4	6.9	9.4	13.5	18.9	31.0	67.9	108.7	116.7
# Yrs. Années	43	43	43	44	44	44	44	44	44
Mean Moyenne	8.5	12.5	15.0	19.7	24.0	29.4	40.7	49.1	55.2
Std. Dev. Écart-type	2.6	4.0	5.9	9.2	9.5	10.4	13.6	18.4	19.2
Skew. Dissymétrie	1.72	1.36	1.72	1.75	1.47	1.03	1.51	1.58	1.35
Kurtosis	9.37	7.01	7.71	6.45	5.15	3.85	5.84	5.64	5.46

*-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
1974	5 min	19.3	16.5
1974	10 min	27.9	25.1
1974	15 min	38.1	33.6
1974	30 min	49.3	48.5
1989	6 h	89.0	83.2
2017	12 h	108.7	106.9
2017	24 h	116.7	115.5

****

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

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	8.1	10.3	11.8	13.7	15.1	16.5	43
10 min	11.8	15.4	17.7	20.7	22.9	25.1	43
15 min	14.1	19.3	22.8	27.1	30.4	33.6	43
30 min	18.2	26.3	31.7	38.5	43.5	48.5	44
1 h	22.4	30.8	36.3	43.4	48.6	53.7	44
2 h	27.7	36.8	42.9	50.6	56.3	61.9	44
6 h	38.4	50.4	58.4	68.4	75.8	83.2	44
12 h	46.1	62.4	73.2	86.8	96.9	106.9	44
24 h	52.0	69.0	80.3	94.5	105.1	115.5	44

****

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 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	96.7	123.8	141.8	164.5	181.3	198.1	43
	+/- 8.4	+/- 14.2	+/- 19.2	+/- 25.8	+/- 30.9	+/- 36.0	43
10 min	70.9	92.2	106.3	124.2	137.4	150.6	43
	+/- 6.6	+/- 11.2	+/- 15.1	+/- 20.3	+/- 24.3	+/- 28.3	43
15 min	56.3	77.2	91.0	108.5	121.5	134.3	43
	+/- 6.5	+/- 10.9	+/- 14.8	+/- 19.9	+/- 23.8	+/- 27.7	43
30 min	36.4	52.6	63.4	77.0	87.0	97.0	44
	+/- 5.0	+/- 8.4	+/- 11.3	+/- 15.3	+/- 18.3	+/- 21.3	44
1 h	22.4	30.8	36.3	43.4	48.6	53.7	44
	+/- 2.6	+/- 4.3	+/- 5.9	+/- 7.9	+/- 9.4	+/- 11.0	44
2 h	13.8	18.4	21.5	25.3	28.1	31.0	44
	+/- 1.4	+/- 2.4	+/- 3.2	+/- 4.3	+/- 5.2	+/- 6.0	44
6 h	6.4	8.4	9.7	11.4	12.6	13.9	44
	+/- 0.6	+/- 1.0	+/- 1.4	+/- 1.9	+/- 2.3	+/- 2.6	44
12 h	3.8	5.2	6.1	7.2	8.1	8.9	44
	+/- 0.4	+/- 0.7	+/- 0.9	+/- 1.3	+/- 1.5	+/- 1.8	44
24 h	2.2	2.9	3.3	3.9	4.4	4.8	44
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.8	+/- 0.9	44

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Table 3 : Interpolation Equation / Équation d'interpolation: R = A*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 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	34.3	45.7	53.3	62.8	69.9	76.9
Std. Dev. /Écart-type (RR)	33.6	43.5	50.1	58.5	64.7	70.9
Std. Error/Erreur-type	6.5	11.3	14.5	18.5	21.5	24.4
Coefficient (A)	21.0	28.2	32.9	38.9	43.4	47.8
Exponent/Exposant (B)	-0.679	-0.679	-0.678	-0.678	-0.677	-0.677
Mean % Error/% erreur moyenne	6.3	8.2	9.1	10.1	10.6	11.1

Table 3-1: Surface Cover Parameter Calculations - MacDonald Drive Lansdowne

Surface Cover Type	Manning's "n"		Dep. Storage (mm)		% Impervious	Subarea Routing	% Routed	% Impervious without Storage
	Impervious	Pervious	Impervious	Pervious				
Forest	0.03	0.4	10	15	1		100	10
Grass	0.025	0.25	5	10	2.5		75	10
BioRet	0.025	0.3	25	30	2.5		75	10
Bare	0.02	0.15	5	7.5	5		50	10
GrnRoof	0.025	0.3	17.5	20	25		25	15
Ex Bed Rock	0.025	0.2	5	7.5	90		25	20
RegRoof	0.015	0.15	2.5	5	95		10	25
PrmPave	0.02	0.2	12.5	15	50		25	15
ImpPave	0.015	0.15	2.5	5	95		10	20
Gravel	0.025	0.2	5	7.5	90		25	20
Wetland	0.015	0.35	0	15	50		50	10
Water	0.015	0.015	0	0	100		0	0

Code	Description
Forest	Forest/meadow, heavy vegetation with high transpiration/deep root zone
Grass	Grass/turf, light vegetation/landscaped areas with shallow roots
BioRet	Bioretention/rain garden/planter, engineered with underdrain
Bare	Un-vegetated soil or loos granular materials
GrnRoof	Green roof
RegRoof	Regular roof
Ex Bed Rock	Exposed bedrock
PrmPave	Permeable paved surfaces (with underdrain)
ImpPave	Impermeable paved surfaces (i.e. roadways, parking, driveways)
Gravel	Gravel and compacted granular in traffic areas
Wetland	Roughly half open water and half heavily vegetated
Water	Open water surface

Hydrologic Unit Name	Percent by Surface Cover Type													% Impervious	Manning's "N"		Dep. Storage (mm)		% Impervious without Storage	% Routed	Subarea Routing
	Forest	Grass	BioRet	Bare	GrnRoof	Ex Bed Rock	RegRoof	PrmPave	ImpPave	Gravel	Wetland	Water	Total		Impervious	Pervious	Impervious	Pervious			
Lansdowne Development (Pre-Development)																					
EX.1	2.00%	79.00%					8.00%		9.00%	2.00%			100.00%	19.9	0.0234	0.235	4.675	9.2	12.3	63	Impervious to Pervious
EX.2		70.00%		5.00%			5.00%		15.00%	5.00%			100.00%	25.5	0.02275	0.2225	4.5	8.75	12.75	58	Impervious to Pervious
EX.3		60.00%							35.00%	5.00%			100.00%	39.3	0.0215	0.2125	4.125	8.125	14	50	Impervious to Pervious
EX.4	10.00%	90.00%											100.00%	2.4	0.0255	0.265	5.5	10.5	10	78	Impervious to Pervious
EX.5	10.00%	85.00%		3.00%					1.00%	1.00%			100.00%	4.2	0.02525	0.2605	5.475	10.35	10.20	76	Impervious to Pervious

100 Year Event SWMM5 Modeling (24hr SCS II)

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Autodesk® Storm and Sanitary Analysis 2016 - Version 13.4.304 (Build 0)
-----------------------------------------------------------------------------------------

*******************
Project Description
*******************
File Name ................ MacDonald Drive Lansdowne Pre.SPF


****************
Analysis Options
****************
Flow Units ............... cms
Subbasin Hydrograph Method. EPA SWMM
Infiltration Method ....... Green-Ampt
Link Routing Method ....... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date ............ OCT-05-2024 00:00:00
Ending Date .............. OCT-08-2024 00:00:00
Antecedent Dry Days ....... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ......... 30.00 sec


*************
Element Count
*************
Number of rain gages ...... 1
Number of subbasins ....... 5
Number of nodes ........... 10
Number of links ........... 9
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Subbasin Summary
****************
Subbasin                 Total    Equiv.   Imperv.   Average    Raingage
                          Area     Width      Area     Slope
ID                    hectares         m         %         %
-----------------------------------------------------------------------------
EX1                      33.98    440.00     19.90    2.4000    -
EX2                       3.16     65.00     25.50    0.5000    -
EX3                       0.23    100.00     39.30    1.0000    -
EX4                       5.41    250.00      2.40    0.2000    -
EX5                       7.78    140.00      4.20    0.3000    -


************
Node Summary
************
Node                Element             Invert   Maximum    Ponded    External
ID                  Type             Elevation     Elev.      Area      Inflow
                                             m         m        m²
--------------------------------------------------------------------------------
450_OUT             JUNCTION             97.52     99.70     0.000
BOX_CULV_IN         JUNCTION             98.75    100.75     0.000
BOX_CULV_OUT        JUNCTION             98.65    100.75     0.000
CN_1200_IN          JUNCTION             98.25     99.50     0.000
CN_1200_OUT         JUNCTION             97.25     99.50     0.000
EX2_CHANNEL_IN      JUNCTION             99.75    101.00     0.000
NODE_1B             JUNCTION             96.84     98.00     0.000
```

NODE_1B_&_1C	JUNCTION	96.62	98.00	0.000
NODE_1C	JUNCTION	97.07	98.50	0.000
OUTLET_1A	OUTFALL	96.30	97.00	0.000

****
Link Summary
****

Link ID	From Node	To Node	Element Type	Length m	Slope %	Manning's Roughness
450_PIPE	BOX_CULV_OUT	450_OUT	CONDUIT	45.0	2.5100	0.0150
BOX_CULV	BOX_CULV_IN	BOX_CULV_OUT	CONDUIT	16.5	0.6057	0.0150
CN_1200_CULV	CN_1200_IN	CN_1200_OUT	CONDUIT	30.0	3.3333	0.0150
EX2_CHANNEL	EX2_CHANNEL_IN	BOX_CULV_IN	CHANNEL	150.2	0.6659	0.0320
JUNCTION1	NODE_1B	NODE_1B_&_1C	CHANNEL	5.0	4.4000	0.0320
OUTLET_CHANNEL	NODE_1B_&_1C	OUTLET_1A	CHANNEL	60.0	0.5333	0.0320
SOUTH_CHANNEL_2	NODE_1C	NODE_1B_&_1C	CHANNEL	100.0	0.4500	0.0320
SOUTH_CHANNEL1	450_OUT	NODE_1C	CHANNEL	100.0	0.4500	0.0320
WEST_WATERCOURSE	CN_1200_OUT	NODE_1B	CHANNEL	60.0	0.6833	0.0320

****
Cross Section Summary
****

Link ID	Shape	Depth/ Diameter m	Width m	No. of Barrels	Cross Sectional Area m²	Full Flow Hydraulic Radius m	Design Flow Capacity cms
450_PIPE	CIRCULAR	0.45	0.45	1	0.16	0.11	0.39
BOX_CULV	RECT_CLOSED	1.20	1.20	1	1.44	0.30	3.35
CN_1200_CULV	CIRCULAR	1.20	1.20	1	1.13	0.30	6.17
EX2_CHANNEL	TRAPEZOIDAL	1.20	7.95	1	5.22	0.63	9.74
JUNCTION1	TRAPEZOIDAL	0.80	8.40	1	4.16	0.48	16.81
OUTLET_CHANNEL	TRAPEZOIDAL	0.70	6.70	1	3.22	0.46	4.41
SOUTH_CHANNEL_2	TRAPEZOIDAL	0.75	7.00	1	3.56	0.49	4.65
SOUTH_CHANNEL1	TRAPEZOIDAL	0.75	7.00	1	3.56	0.49	4.65
WEST_WATERCOURSE	TRAPEZOIDAL	0.80	10.70	1	5.36	0.49	8.65

************************** Runoff Quantity Continuity **************************	Volume hectare-m	Depth mm
Total Precipitation	5.840	115.500
Evaporation Loss	0.000	0.000
Infiltration Loss	2.643	52.282
Surface Runoff	3.168	62.650
Final Surface Storage	0.033	0.653
Continuity Error (%)	-0.074	

```
*************************         Volume         Volume
Flow Routing Continuity         hectare-m        Mliters
*************************       ---------      ---------
Dry Weather Inflow .......          0.000          0.000
Wet Weather Inflow .......          3.168         31.676
Groundwater Inflow .......          0.000          0.000
RDII Inflow ..............          0.000          0.000
External Inflow ..........          0.000          0.000
External Outflow .........          3.170         31.700
Surface Flooding .........          0.000          0.000
Evaporation Loss .........          0.000          0.000
Initial Stored Volume ....          0.002          0.021
Final Stored Volume ......          0.000          0.000
Continuity Error (%) .....         -0.009


**************************************************
EPA SWMM Time of Concentration Computations Report
**************************************************

        Tc = (0.94 * (L^0.6) * (n^0.6)) / ((i^0.4) * (S^0.3))

        Where:

        Tc = Time of Concentration (min)
        L  = Flow Length (ft)
        n  = Manning's Roughness
        i  = Rainfall Intensity (in/hr)
        S  = Slope (ft/ft)

---------------
Subbasin EX1
---------------

        Flow length (m):                            772.27
        Pervious Manning's Roughness:              0.23500
        Impervious Manning's Roughness:            0.02340
        Pervious Rainfall Intensity (mm/hr):       4.81250
        Impervious Rainfall Intensity (mm/hr):     4.81250
        Slope (%):                                 2.40000
        Computed TOC (minutes):                     234.57

---------------
Subbasin EX2
---------------

        Flow length (m):                            486.15
        Pervious Manning's Roughness:              0.22250
        Impervious Manning's Roughness:            0.02275
        Pervious Rainfall Intensity (mm/hr):       4.81250
        Impervious Rainfall Intensity (mm/hr):     4.81250
        Slope (%):                                 0.50000
        Computed TOC (minutes):                     260.10

---------------
Subbasin EX3
---------------

        Flow length (m):                             23.00
        Pervious Manning's Roughness:              0.21250
        Impervious Manning's Roughness:            0.02150
        Pervious Rainfall Intensity (mm/hr):       4.81250
        Impervious Rainfall Intensity (mm/hr):     4.81250
        Slope (%):                                 1.00000
```

Computed TOC (minutes): 28.52

Subbasin EX4

Flow length (m):	216.40
Pervious Manning's Roughness:	0.26500
Impervious Manning's Roughness:	0.02550
Pervious Rainfall Intensity (mm/hr):	4.81250
Impervious Rainfall Intensity (mm/hr):	4.81250
Slope (%):	0.20000
Computed TOC (minutes):	275.12

Subbasin EX5

Flow length (m):	555.71
Pervious Manning's Roughness:	0.26050
Impervious Manning's Roughness:	0.02525
Pervious Rainfall Intensity (mm/hr):	4.81250
Impervious Rainfall Intensity (mm/hr):	4.81250
Slope (%):	0.30000
Computed TOC (minutes):	422.48

****
Subbasin Runoff Summary
****

Subbasin ID	Total Rainfall mm	Total Runon mm	Total Evap. mm	Total Infil. mm	Total Runoff mm	Peak Runoff cms	Runoff Coefficient	Time of Concentration days hh:mm:ss
EX1	115.50	0.00	0.00	48.70	66.10	2.57	0.572	0 03:54:34
EX2	115.50	0.00	0.00	46.10	68.50	0.24	0.593	0 04:20:05
EX3	115.50	1285.57	0.00	36.24	1363.79	0.23	0.973	0 00:28:31
EX4	115.50	0.00	0.00	60.76	54.65	0.22	0.473	0 04:35:07
EX5	115.50	0.00	0.00	65.03	50.29	0.18	0.435	0 07:02:28

****
Node Depth Summary
****

Node ID	Average Depth Attained	Maximum Depth Attained	Maximum HGL Attained	Time of Max Occurrence	Total Flooded Volume	Total Time Flooded	Retention Time

	m	m	m	days	hh:mm	ha-mm	minutes	hh:mm:ss
450_OUT	0.08	0.19	97.71	0	12:41	0	0	0:00:00
BOX_CULV_IN	0.20	0.74	99.49	0	12:39	0	0	0:00:00
BOX_CULV_OUT	0.24	0.84	99.49	0	12:39	0	0	0:00:00
CN_1200_IN	0.23	0.75	99.00	0	12:05	0	0	0:00:00
CN_1200_OUT	0.16	0.47	97.72	0	12:05	0	0	0:00:00
EX2_CHANNEL_IN	0.08	0.25	100.00	0	00:00	0	0	0:00:00
NODE_1B	0.13	0.45	97.29	0	12:05	0	0	0:00:00
NODE_1B_&_1C	0.24	0.62	97.24	0	12:06	0	0	0:00:00
NODE_1C	0.11	0.24	97.31	0	12:39	0	0	0:00:00
OUTLET_1A	0.15	0.44	96.74	0	12:06	0	0	0:00:00

****
Node Flow Summary
****

Node ID	Element Type	Maximum Lateral Inflow cms	Peak Inflow cms	Time of Peak Inflow Occurrence days	hh:mm	Maximum Flooding Overflow cms	Time of Peak Flooding Occurrence days	hh:mm
450_OUT	JUNCTION	0.000	0.368	0	12:40	0.00		
BOX_CULV_IN	JUNCTION	0.225	0.451	0	12:06	0.00		
BOX_CULV_OUT	JUNCTION	0.000	0.368	0	12:37	0.00		
CN_1200_IN	JUNCTION	2.568	2.568	0	12:05	0.00		
CN_1200_OUT	JUNCTION	0.000	2.567	0	12:05	0.00		
EX2_CHANNEL_IN	JUNCTION	0.241	0.241	0	12:05	0.00		
NODE_1B	JUNCTION	0.000	2.560	0	12:05	0.00		
NODE_1B_&_1C	JUNCTION	0.000	3.021	0	12:05	0.00		
NODE_1C	JUNCTION	0.179	0.546	0	12:37	0.00		
OUTLET_1A	OUTFALL	0.000	3.001	0	12:06	0.00		

****
Outfall Loading Summary
****

Outfall Node ID	Flow Frequency (%)	Average Flow cms	Peak Inflow cms
OUTLET_1A	75.77	1.051	3.001
System	75.77	1.051	3.001

****
Link Flow Summary
****

Link ID	Element Type	Time of Peak Flow Occurrence days hh:mm	Maximum Velocity Attained m/sec	Length Factor	Peak Flow during Analysis cms	Design Flow Capacity cms	Ratio of Maximum /Design Flow	Ratio of Maximum Flow Depth	Total Time Surcharged minutes	Reported Condition

450_PIPE	CONDUIT	0	12:40	3.02	1.00	0.368	0.392	0.94	0.71	0	Calculated
BOX_CULV	CONDUIT	0	12:37	0.75	1.00	0.368	3.349	0.11	0.66	0	Calculated
CN_1200_CULV	CONDUIT	0	12:05	4.45	1.00	2.567	6.170	0.42	0.51	0	Calculated
EX2_CHANNEL	CHANNEL	0	12:05	0.79	1.00	0.236	9.742	0.02	0.39	0	Calculated
JUNCTION1	CHANNEL	0	12:05	1.18	1.00	2.544	16.810	0.15	0.67	0	Calculated
OUTLET_CHANNEL	CHANNEL	0	12:06	1.38	1.00	3.001	4.410	0.68	0.76	0	Calculated
SOUTH_CHANNEL_2	CHANNEL	0	12:39	0.40	1.00	0.546	4.654	0.12	0.57	0	Calculated
SOUTH_CHANNEL1	CHANNEL	0	12:41	0.54	1.00	0.368	4.654	0.08	0.29	0	Calculated
WEST_WATERCOURSE	CHANNEL	0	12:05	1.11	1.00	2.560	8.650	0.30	0.57	0	Calculated

****
Flow Classification Summary
****

Link	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
450_PIPE	0.00	0.00	0.00	0.21	0.79	0.00	0.00	1.73	0.0001
BOX_CULV	0.00	0.01	0.00	0.99	0.00	0.00	0.00	0.23	0.0000
CN_1200_CULV	0.00	0.00	0.00	0.27	0.73	0.00	0.00	1.76	0.0001
EX2_CHANNEL	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.25	0.0000
JUNCTION1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.39	0.0000
OUTLET_CHANNEL	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.48	0.0001
SOUTH_CHANNEL_2	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.16	0.0000
SOUTH_CHANNEL1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.27	0.0000
WEST_WATERCOURSE	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.48	0.0000

****
Time-Step Critical Elements
****

Link JUNCTION1 (33.82%)
Link CN_1200_CULV (12.16%)
Link 450_PIPE (11.28%)

****
Highest Flow Instability Indexes
****

Link CN_1200_CULV (4)

****
Routing Time Step Summary
****

```
Minimum Time Step           :     1.26 sec
Average Time Step           :    15.37 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01
```