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Appendix F

Surface Water Impact Assessment and Mitigation

City of Sault Ste. Marie

Sault Ste. Marie Solid Waste Environmental Assessment
Surface Water Impact Assessment
FINAL

Prepared by:

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Project Number:

60117627

Date:

February 2020

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February 3, 2020

Ms. Catherine Taddo, P. Eng.
Engineering Department
City of Sault Ste. Marie
99 Foster Drive, 5th Floor
Sault Ste. Marie, ON P6A 5N1

Dear Ms. Taddo:

Project No: **60117627**

Regarding: **Sault Ste. Marie Solid Waste Environmental Assessment**
Surface Water Impact Assessment

We are pleased to submit our FINAL Surface Water Impact Assessment Report which has been prepared to support a proposed expansion of the existing municipal landfill located on Fifth Line.

The surface water impact assessment examines and evaluates the potential for impacts on surface water resources from the proposed landfill development. This is achieved through the analysis of the potential effects of landfill development on surface water quality and water quantity (flood hazard).

This report has been updated to address comments included in a memo dated June 30, 2017 from Eva Maciaszek of the Ministry.

Sincerely,
AECOM Canada Ltd.

Rick Talvitie, P. Eng.
Manager, Northern Ontario
RT:nm
Encl.

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	R. Talvitie	January 29, 2015	DRAFT for City staff review
1	R. Talvitie	October 5, 2015	Revised DRAFT
2	R. Talvitie	February, 2020	FINAL – includes revisions to address Ministry June 2017 comments

AECOM Signatures

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1. Introduction and Background

1.1 Background

This document presents the findings of the surface water assessment impact assessment as part of the Environmental Assessment (EA) of the proposed expansion of the City of Sault Ste. Marie's landfill located on Fifth Line. The proposed project includes an expansion of the disposal boundaries to the north and west. Landfill mining is also proposed within the western portion of the existing disposal footprint to facilitate the construction of a liner to enhance environmental management at the site. The mining process involves excavation of waste within the existing disposal footprint, removing fines and recyclables, transferring the residual waste to a new lined cell and lining the mined area to accommodate future waste disposal. The City has owned and successfully operated this site for 30+ years and the proposed expansion incorporates operational and site development enhancements to further build on the historical success. The planned expansion will be accommodated within existing City-owned lands.

The role of the surface water impact assessment is to examine the potential for impacts on surface water resources from the proposed landfill development. This is achieved through the analysis of the potential effects of landfill development on surface water quality and water quantity (flood hazard). The preparation of a surface water management strategy will include stormwater management (SWM) measures that mitigate these impacts. The SWM measures reflect the guidelines and recommendations in the City of Sault Ste. Marie's recent document *Stormwater Management Guidelines – City of Sault Ste. Marie (R.V. Anderson 2014).*

Following this introductory section, the report takes on the following format:

- Description of the preferred expanded disposal footprint;
- Outline of the study approach and methodology;
- Information sources considered;
- Comparison of existing and proposed storm water management conditions;
- Surface water net effects;
- Overview of proposed storm water management plan; and
- Required approvals.

1.2 Objectives of Surface Water Impact Assessment

. The specific objectives guiding the investigations and analyses undertaken are as follows:

- Determine the existing conditions at the proposed site (recharge areas, floodplains, drainage) and along the receiving watercourses in terms of hydrologic characteristics (peak flows and runoff volumes) and surface water quality characteristics.
- Establish specific surface water goals and objectives for the new landfill expansion.
- Develop an appropriate surface water management plan comprising Best Management Practices (BMPs), conveyance and containment systems and operational practices to achieve the established objectives.
- Define any residual or net effects on surface water quality and quantity which may persist during the landfill facility operations and post-closure.
- Review and modify the existing surface water monitoring plan as required to account for the new landfill expansion.

2. Description of the Preferred Alternative Landfill Footprint

There is currently one operating landfill site in Sault Ste. Marie, located on **Figure 1,** at 402 Fifth Line East, owned and operated by the City of Sault Ste. Marie.

In the preceding Alternative Methods phase of the EA, a comparative evaluation of the four alternative landfill footprint options was carried out in order to identify a Preferred Alternative Landfill Footprint.

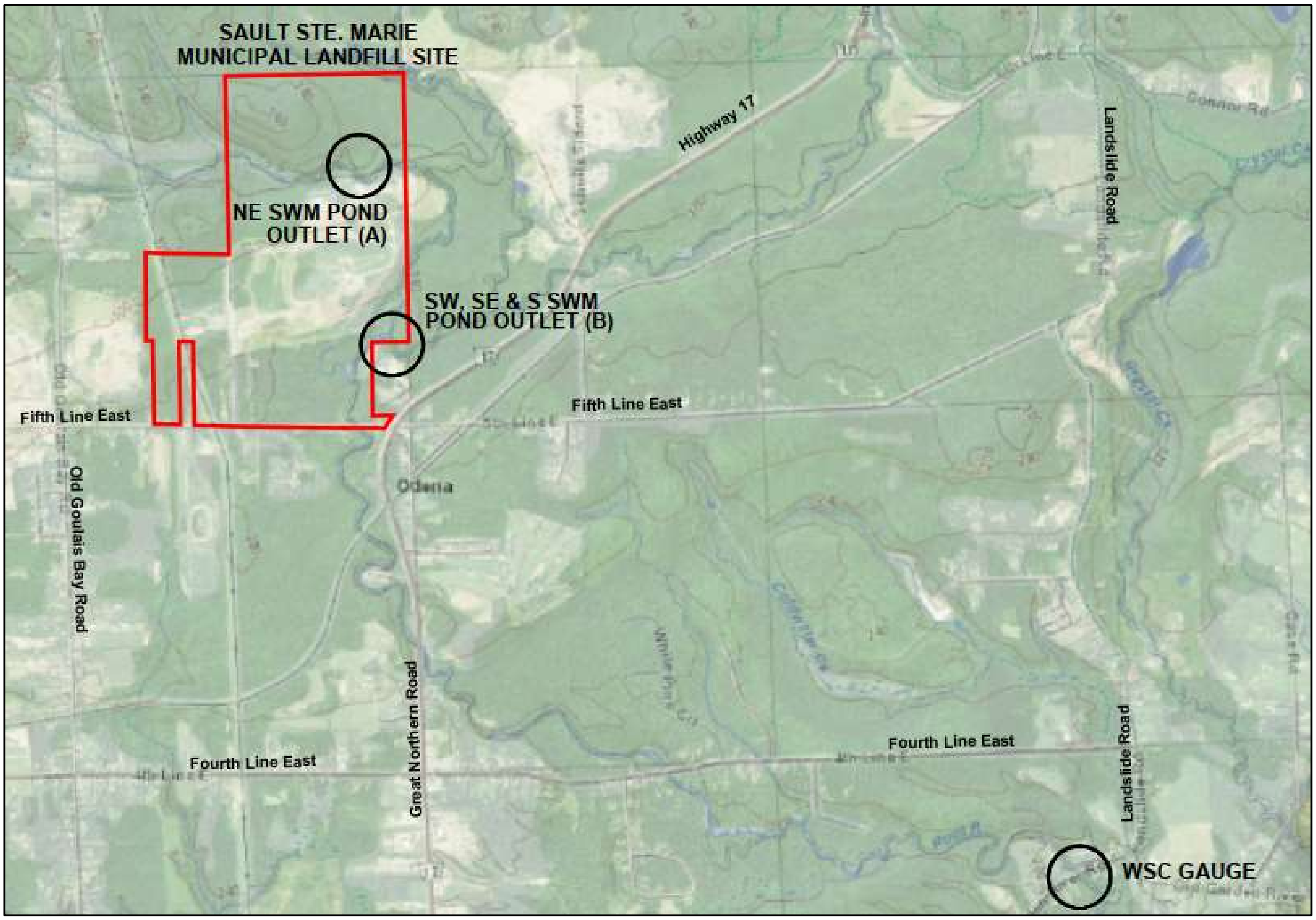
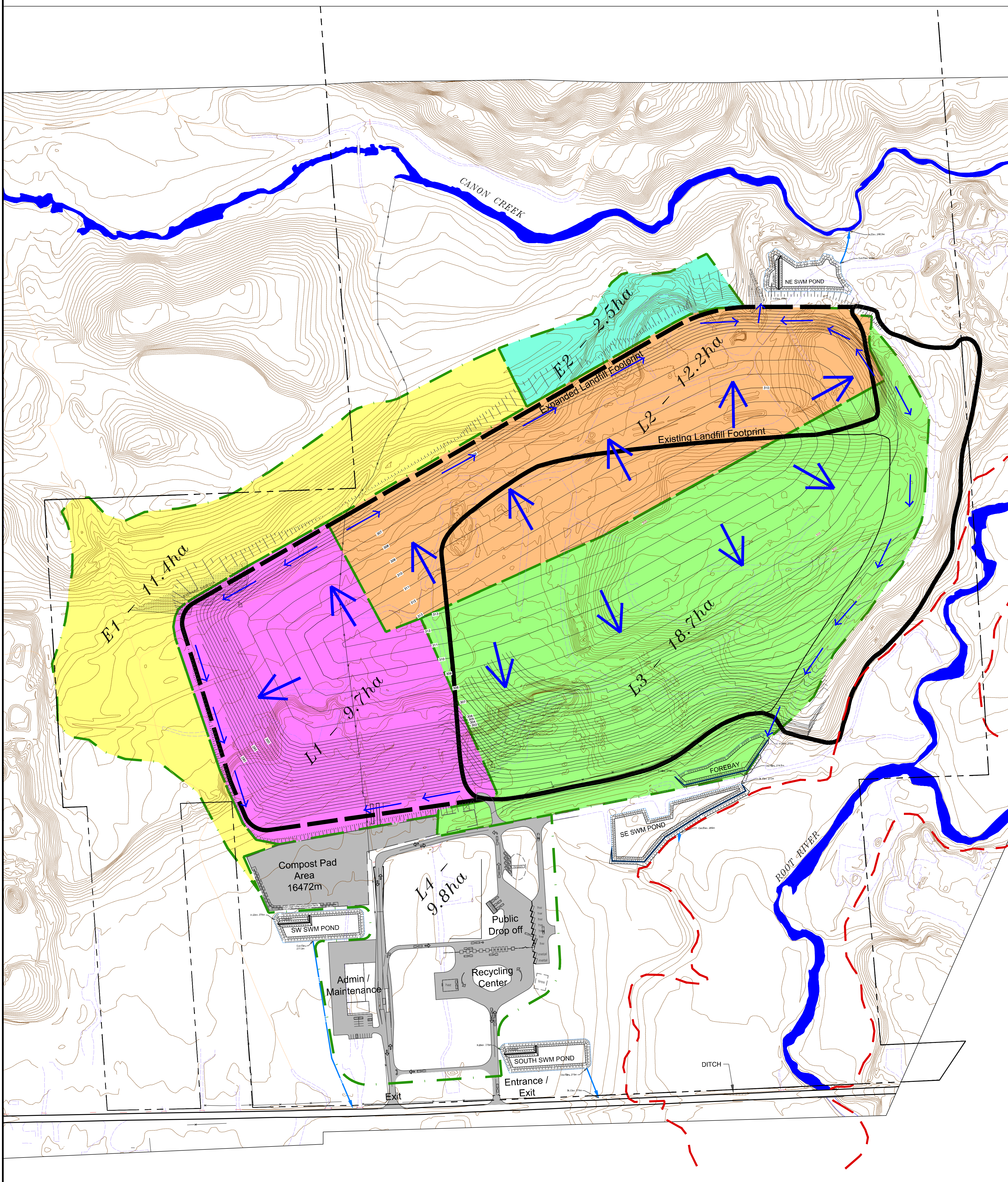


Figure 1 – Location

The preferred alternative landfill footprint was determined to be Option #3 – West and North Expansion B with landfill mining, as illustrated in **Figure 2**. This option includes the expansion of the landfill from the western edge of the existing site towards the hydro corridor and a northern expansion from the northern limit of the existing landfill. It also includes landfill mining within the western portion of the existing disposal footprint to facilitate the construction of a liner to enhance environmental management at the site.

The final contours of the landfill expansion are also shown in **Figure 2**. The contours reflect a maximum elevation (top of final cover) of 309.0 m with a maximum side slope of 4H to 1V. The total footprint area of the landfill expansion is approximately 18 ha.



LEGEND

- CATCHMENT AREAS
- FLOODPLAIN (100 YEAR)
- PAVEMENT
- OUTLET SWALE
- EXISTING LANDFILL FOOTPRINT
- EXPANDED LANDFILL FOOTPRINT

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City of Sault Ste. Marie

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ENGINEERING DEPARTMENT

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Sault Ste. Marie Municipal Landfill Site

ON-SITE DRAINAGE

Figure 2

3. Study Approach and Methodology

3.1 General

This section summarizes the approach and methodologies adopted to establish the existing conditions, to predict potential impacts, to identify alternative mitigation measures and evaluate their effectiveness, and to recommend the most suitable measures for implementation.

To assess the potential impacts of the proposed landfill expansion on surface drainage, hydrologic analysis was undertaken:

- To establish the peak flow rates and runoff volumes generated from the proposed site;
- To define the hydrologic regime in the receiving streams adjacent to the site;
- To identify any potential surface water quality impacts from site drainage associated with the expansion;
- To identify any potential surface water quantity impacts from site drainage associated with the expansion;
- To identify any internal drainage requirements including roadway ditch capacities.

Suitable mitigation measures were developed, at a conceptual level, that will mitigate any identified impacts. These are identified in Section 6 and are conservative estimates of volumes and areas required for impact mitigation.

3.2 Methodology

In order to quantitatively estimate runoff flows and volumes and to assess the effects of changes within a drainage area (land use and drainage patterns) a hydrologic model is required. For the evaluation of hydrologic impacts associated with the proposed landfill expansion, a Visual OTTHYMO (VO2) hydrology model was developed to determine the peak flow estimations at key locations within the Study Area. This is in keeping with City's SWM Guidelines (Anderson 2014).

The estimation of flows in larger watersheds is typically achieved by the statistical analysis of long term flow records. For Canon Creek and the Root River, the *WSC gauge 02CA002–Root River at Sault Ste. Marie* on the Root River provides a convenient source of long term flow record with forty-eight (48) years of observed flow data (1971-2018).

3.2.1 Hydrologic Modelling

The VO2 software is a single event model which can simulate the rainfall-runoff process from both rural and urban basins. The software responds to the input of a design storm rainfall hyetograph and produces an estimate of the time-history of runoff hydrograph as output. Hydrographs can be generated at selected locations in the watershed.

The VO2 software computes the excess runoff according to the Soil Conservation Service (SCS) method. The runoff hydrograph is determined by the software as a function of physical characteristics of the basin such as drainage area, surface soil type, land use, and channel hydraulics. The hydrographs can then be routed along the watercourses using the variable storage coefficient method, which accounts for the effect of the channel storage. The software can also account for the effect of storage in detention ponds.

The VO2 software requires several watershed parameters as input in order to generate runoff estimates. These parameters are described below:

1. **Drainage Area** – VO2 modelling requires the delineation of the drainage area upstream of the selected locations where the flow calculations are required. These contributing areas are referred to as subareas in this report.

2. **Runoff Curve Number (CN)** – This parameter is used to determine the percentage of rainfall which becomes runoff for a given event. It is based on the land use and soils found within the subarea. For areas less than 20% impervious, VO2 uses the NASHYD routine to determine runoff. This routine was used for the physical landfill and existing drainage areas.
3. **Initial Abstraction (Ia)** – This parameter consists mainly of the interception, infiltration and surface storage of rainfall during the beginning of storm events, before runoff is produced.
4. **Imperviousness (%)** – for areas with significant imperviousness (rooftops, roads, parking lots), VO2 uses the STANDHYD routine to determine runoff. This routine was used for the Administrative, Recycling and Compost areas.
5. **Time to Peak (Tp)** – This parameter represents the time from the beginning of rainfall to the peak of the hydrograph and is indicative of the basin response to storm events. This parameter is based on physical watershed characteristics such as length, slope and area.

3.2.2 Water Quality Consideration

Any proposed stormwater management (SWM) system to service the uncontaminated areas of the existing landfill site and proposed landfill expansion will require surface water quality control, assuming the uncontaminated areas, including the final cover, will be serviced by an internal paved road system, including roadside ditches that could produce impacts related to suspended solids and oil/grease contaminants. Water quality protection as described in the Ministry's Stormwater Management Planning and Design Manual (March, 2003), (Note: within this document Ministry refers to the current Ministry that has responsibility for review and approval of the Environmental Assessment) will be implemented as it relates to Total Suspended Solids (TSS) management and oil/grease traps will be considered at the outlets should site monitoring indicate ongoing and persistent oil/grease contamination. Given the potential for leachate breaches at the site and the possibility of oil/gas spills from landfill operations, the development of an emergency capability for holding and addressing contaminated runoff will also be considered.

3.2.3 Water Quantity Consideration

The Root River and its tributary Canon Creek fall under the jurisdiction of the Sault Ste. Marie Region Conservation Authority (SSMRCA).

In accordance with the Conservation Authorities Act, the Conservation Authority is empowered to prohibit or regulate any proposed works within areas susceptible to flooding during a Regulatory Storm. The Regulatory Storm in the areas under the jurisdiction of the SSMRCA is assigned to the higher of the Timmins Storm or the 100-year event.

For the purpose of this report, water surface elevations and regulatory floodplain were extracted from the most recent Root River Study (Dillon 1987), as shown in **Figure 2**. As concluded in the Dillon report, the landfill has a 7 meter freeboard above the Regulatory Flood level and it is evident that the landfill site is not impacted by the Root River or Canon River floodplain.

In terms of surface water quantity control, the analysis provided in Section 5.4 suggests that none is required since the peak flows from the proposed landfill site will have no or negligible impact on peak flows in the receiving watercourse due to both their magnitude and timing.

3.3 Study Assumptions

The surface water analyses were based on two key assumptions:

1. The general layout and drainage characteristics of the existing landfill facilities conform to the design concept presented in the Design and Operations Report;
2. The surface water drainage system collects runoff generated from uncontaminated areas; runoff which has come into contact with refuse, such as the working face or other possible sources of contamination, are collected by the leachate collection system and are disposed of via the City's sanitary sewer system for treatment.

4. Information Sources

The primary source of background information pertaining to site characteristics and the watersheds under considerations are:

- Topographic mapping and aerial photos of site and site vicinity;
- Sault Ste. Marie Flood Plain Mapping Report (M.M. Dillon, 1977);
- Root River Flood Plain Mapping Report (Walker Engineering, 1987);
- Design and Operations Report (M.M. Dillon Limited, 1990);
- Surface Water Drainage Assessment, Sault Ste. Marie Landfill (M.M. Dillon Limited, 1994);
- EA Terms of Reference (TSH, 2005);
- Relevant Sections of the Draft EA Report (AECOM/Dillon);
- Sault Ste. Marie Municipal Landfill Site Monitoring Report (Dillon, 2011 through 2018);
- Site Development and Operation Report, Sault Ste. Marie Municipal Landfill (AECOM, 2011 through 2018);
- Environment Canada Rainfall Intensity-Duration-Frequency (IDF) statistics (2013);
- Stormwater Management Guidelines – City of Sault Ste. Marie (R.V. Anderson 2014); and
- Water Survey of Canada Streamflow Data - WSC gauge 02CA002–Root River at Sault Ste. Marie (2014).

5. Existing - Proposed Conditions

5.1 General Features

The existing landfill site and proposed landfill expansion area are adjacent to Canon Creek to the North and East and the Root River to the South-East as illustrated in **Figure 2**.

The entire Root River basin is oriented in a northwest to southeast direction and drains approximately 210 km^2. It is the largest watershed within the jurisdiction of the Sault Ste. Marie Region Conservation Authority (SSMRCA). The Root River flows in a south to southeast direction from the Goulais River through the City of Sault Ste. Marie and the Rankin Indian Reserve to its outlet into the St. Mary's River near Little Lake George. There are four main tributaries within the basin, the Root River, the West Root River, Crystal Creek and Canon Creek.

Canon Creek is a major tributary of the Root River. It is oriented in a west to east direction and drains an area of approximately 23.3 km^2. In 2006, a small stretch of Canon Creek was realigned by moving the most southern section of the creek east away from the landfill to facilitate the extension of the existing landfill leachate collection system within the old creek bed. Canon Creek joins the Root River approximately 400 m north of the southern property boundary of the existing landfill site. Downstream of the confluence of Canon Creek and Root River is an old meander area that is to the south of the landfill and is frequently inundated with water during high flow periods.

a) Physiography and Surficial Deposits

The physiography and soils of the watershed are a result of the most recent glaciation of Ontario, the Wisconsin.

The northern portion of the Root River basin (including a majority of the Canon Creek basin) is located within the Pre-Cambrian Shield. This area is characterized by hard, igneous intrusive bedrock with little or no overlying soils.

The southern portion of the basin consists of a series of ancient lake beaches and terraces left after the last period of glaciation. The soils in this portion of the basin consist of medium textured sands and gravels. These sands are underlain by glacial till, silts and clays.

In the area immediately upstream of the outlet of the Root River the soil types change to lacustrine clays and silts, and glacial till. These soils characterize the area south of the shoreline of a glacial melt water lake.

The soils in the area of the proposed landfill expansion consist of a deep layer of medium to coarse sands and gravels over silt or clay.

b) Land Use

The lands in the upstream reaches of the Root River basin are primarily forested areas. The area in close proximity to the landfill site is generally sparsely developed with aggregate extraction, low density residential, and some commercial uses. Downstream of the landfill site the sparsely developed land use pattern persists in proximity to the Root River extending to the Rankin Indian Reserve. For further information to the land uses in proximity to the landfill site please refer to the Land Use Impact Assessment Report.

c) Flow Characteristics

Water Survey of Canada (WSC) has maintained a gauging station (02CA002 – shown on **Figure 1**) on the Root River located near the western boundary of the Rankin Indian Reserve since 1971. Flow recorded at the gauge from this unregulated watershed can be regarded as representative of the entire study area.

Historical flows show that annual flood peaks typically occur in month of April but can also occur in the September – November period. The highest flow officially observed for the 1971 – 2013 period was 66.8m^3/s on April 22, 1992. However, the peak flow in 2013 has been estimated at 76.4m^3/s based on a recorded maximum daily flow of 59.7m^3/s on September 10, 2013 and a peaking factor of 1.28 (see **Appendix A**). Low flows can be expected in the July and August but can occur as late as September.

The September 10, 2013 event caused significant creek bank erosion along Canon Creek adjacent to the landfill site but did not impact the landfill site itself. Following the event the City completed significant creek bank erosion protection measures along the south and west banks of Canon Creek immediately adjacent to the landfill site to mitigate potential future erosion impacts.

d) Climate

Sault Ste. Marie is located in the western part of the Sudbury climatic region. The growing season is longer and the winters are warmer than most of northern Ontario.

Local climatic variations occur due to topography, altitude, and proximity to water. Typical characteristics of the region are summarized in **Table 1.**

Table 1: Climatic Normals – Sault Ste. Marie

Mean Annual Temperature (^{0}C)	**4.3**
Mean Daily Maximum Temperature (^{0}C) • **January** • **July**	 -5.5 24
Mean Daily Minimum Temperature (^{0}C) • **January** • **July**	 -15.5 11.3
Extreme Low Temperature (^{0}C)	-38.9
Extreme High Temperature (^{0}C)	36.8
Mean Annual Precipitation (mm)	889
Mean Annual Snowfall (cm)	303

5.2 Proposed Landfill Site Conditions

A base map of the proposed landfill site, showing the drainage network, outlets and contributing subareas is provided in **Figure 2**. The proposed active landfill site (L1, L2, L3, L4) covers a total area of 50.4 ha (out of 145 ha owned by the City) and straddles the drainage divide between Canon Creek and the Root River watersheds. Surface drainage is provided by drainage ditches adjacent to the existing landfill: 12.2 ha of the northern half of the landfill site drains to Canon Creek while 38.2 ha drains to the Root River via both the meander loop south of the existing landfill footprint and the drainage ditch along the Fifth Line. Of the remaining drainage adjacent to the site that is not active landfill (E1, E2), 2.5 ha in the northeast will outlet to Canon Creek by a swale, to be constructed adjacent to the north perimeter of the SWM Pond, that conveys flow to the outfall swale at the SWM Pond.

There is currently no formal facility that provides SWM servicing for the existing landfill site, aside from the previously noted pit that collects water from the northeast portion of the site. Drainage ditches along the landfill perimeter intercept surface runoff and route stormwater from surrounding lands around the fill areas to one of the three outlets or the existing pit.

5.3 Hydrologic Modelling

Hydrologic modelling, using VO2, was undertaken to establish the peak flow rates at each drainage outlet from the site under proposed conditions. This is a HYMO based model and it use is consistent with the requirements of the City's SWM Guidelines. It is anticipated that the flows from the proposed conditions will not be significant enough to impact water levels or velocities in the receiving watercourses. The downstream reference points A and B (shown on **Figure 1**) were established to determine the potential influence on streamflow associated with the proposed landfill expansion.

In order to characterize the variation in flow rates, the analyses were carried out for two different design events, the 2-year and 100-year design storm. The former is representative of the more frequent rainfall events and appropriate for water quality considerations, while the latter is indicative of the more extreme events for which the flooding potential is evaluated.

The initial task in the hydrologic simulations involves the discretization of the site into units referred to as catchments. The discretization is normally governed by the specific locations where peak flow rates are required, the drainage network, site topography and uniformity of catchment characteristics.

The catchment delineation for the landfill site is shown on **Figure 2**. A total of six (6) catchments were used to define the proposed site conditions.

The input parameters employed in the hydrologic simulations, together with the methods used to derive the values, are consistent with the City's SWM Guidelines (Anderson 2014) and are presented as follows:

a) Design Storms

The design storm hyetographs for the 2 and 100-year return periods were developed using the intensity-duration-frequency (IDF) curves derived from rainfall recorded at the Sault Ste. Marie Airport meteorologic station. This station has been monitoring rainfall data in the area since 1962 and provides the most reliable data base for the analysis.

The temporal pattern of the rainfall for both design storms was arranged in accordance with the Keifer and Chu (Chicago) distribution with a storm duration of 12 hours. It is most appropriate for the examination of the attenuation effects of the storage elements. A computation time interval of 5 minutes was selected due to the short response time (time to peak) of the smaller subareas. The total rainfall depths are 40mm and 100mm for the 2-year and 100-year events respectively.

b) Runoff Curve Number (CN)

The runoff curve number (CN) is selected on the basis of soil type, land use and the antecedent moisture condition (AMC) of the soil. The antecedent moisture condition is an indicator of soil moisture based on the rainfall amount that occurred in the 5-day period prior to a storm event.

An average antecedent moisture condition (AMCII) is normally applied for the 2-year and 100-year design storms and the Timmins Storm. The land use for both basins was determined from available aerial photography and mappings of the existing landfill site. The soils were identified using the Blind River/Sault Ste. Marie soil map prepared by the Canada Department of Agriculture. The hydrologic classification was based on information contained in the United States Department of Agriculture Technical Release 55. The soil type throughout the site was determined to be Wendigo sand (hydrologic soil group A). Hence the runoff curve numbers within each subarea were weighted based on the percent of the subarea exhibiting a particular land use. The weighted CN values ranged from 51 to 70 for the existing site. The values assigned to each subarea are shown in **Table 2**.

c) Initial Abstraction (Ia)

The initial abstraction (Ia) is the interception, infiltration and surface storage of rainfall during the beginning of the storm before any runoff is produced. The primary factors which influence initial abstraction rates are the native soils, vegetative cover, and the extent of surface depressional storage. The initial abstraction was determined using guidelines provided in the VO2 reference manual:

$CN \leq 70$	$Ia = 0.075S$
$70 < CN \leq 80$	$Ia = 0.10S$
$80 < CN \leq 90$	$Ia = 0.15S$
$CN > 90$	$Ia = 0.2S$

Where S = soil storage (mm) and is given by the equation:

$$S = \frac{25400}{CN} - 254$$

The initial abstraction is used as a parameter in the Nash Unit Hydrograph model within VO2. The values assigned to each catchment are shown in **Table 2.**

d) Time to Peak (T_p)

The time of concentration of a watershed is the most difficult parameter to calculate when applying the Unit Hydrograph method, especially in areas with highly permeable soils. The time of concentration of a watershed comprises the initial overland and ditch flow times. The Soil Conservation Services (SCS) upland method was used to estimate the overland travel time component for each subarea. Ditch velocities were extracted from the OTTHYMO model contained in the Surface Water Assessment (Dillon 1994) and used to estimate channel travel times where applicable. Combining the overland and ditch travel times produced a time of concentration (T_c) for each subarea. The Time to Peak was determined to be the greater of 0.67Tc or the computational time step (5 min). The time to peak value for each catchment is shown in **Table 2**.

Table 2: VO2 Model Parameters

Catchment ID	Area (ha)	CN	Ia (mm)	%Impervious	T_p (hr)
L1	9.7	69	8.6	n/a	0.192
L2	12.2	69	8.6	n/a	0.258
L3	18.7	69	8.6	n/a	0.235
L4	9.8	54	16.2	45	n/a
E1	11.4	54	16.2	n/a	0.083
E2	2.5	54	16.2	n/a	0.112

5.4 Proposed Condition - Peak Flows and Runoff Volumes

The results of the hydrologic analysis for the proposed conditions are summarized in **Table 3**. Predicted peak runoff flow rates and volumes are presented for each of the four drainage outlets shown on **Figure 2**. For the purposes of estimating the potential leachate generation an infiltration flow has also been estimated and included in the Table based on an assumed infiltration rate of 20.3 mm/hr for Hydrologic Soil Group A (sandy loam). For further reference, the VO2 output for proposed conditions has been included in **Appendix B**.

Table 3: VO2 Modelling Results –Proposed Conditions

Flow Location	Landuse	Contributing Area (ha)	2-Year		100-Year		Infiltration Rate (mm/hr)	Infiltration Flow (l/s)
			Q (m^3/s)	R.V. (m^3)	Q (m^3/s)	R.V. (m^3)		
L1 – SW Pond - to Root River (B)	Proposed	9.7	0.101	679	0.513	3831	20.3	0.19
L2 – NE Pond - to Canon Creek (A)	Proposed	12.2	0..106	854	0.787	4819	20.3	0.24
L3 – SE Pond - to Root River (B)	Proposed	18.7	0.173	1309	1.270	7368	20.3	2.37
L4 – S Pond - to Root River (B)	Proposed	9.8	0.980	2058	2.570	5880	N/A	N/A

In addition, a flood frequency analysis was conducted for the Root River and Canon Creek to establish 2-year and 100 year peak flow estimates for comparative purposes. Forty-eight (48) years of observed flow data (1971-2018) obtained from WSC gauge 02CA002 – Root River at Sault Ste. Marie (shown on **Figure 1**) was used for the frequency analysis. Two missing peak flows were developed using daily flows and a peaking factor of 1.28 derived from available daily flow data for the entire period of record. Details are provided in **Appendix A**.

As recommended in the Flood Plain Management in Ontario, Technical Guidelines, as well as the Root River Study prepared by M.M. Dillon in 1987, the 3 Parameter Lognormal (3PLN) distribution (Maximum Likelihood) was selected as the preferred probability distribution. Results of the frequency analysis are presented in Table 4 and in **Appendix A**.

Table 4: WSC Gauge 02CA002 Peak Flow Estimates 3 Parameter Lognormal Distribution (3PLN)

Return Period (Years)	Peak Flow Estimates (m^3/s)
2	30
5	45
10	56
20	69
50	86
100	101

A Regional storm peak flow value of 159 m^3/s for the Root River at the WSC streamflow gauge was extracted from the Root River Study prepared by M.M. Dillon in 1987.

As shown in **Figure 1**, the WSC gauge station is located approximately 6 km downstream of the subject site. In order to establish a comparison of 2-year and 100-year peak flow estimates at the landfill site, an area versus flow reduction equation was applied to the gauge values.

The flow transposition equation is as follows:

$$Q_2 = Q_1 (\frac{A2}{A1})^{0.75}$$ (MTO Drainage Manual Volume 3)

Where Q_2 = Desired peak flow estimate (m^3/s)

Q_1 = Flow estimate at gauge station (m^3/s)

A_2 = Area upstream of desired flow point (km^2)

A_1 = Area upstream of gauge station (km^2)

Table 5 summarizes the transposed 2-year and 100-year peak flow estimates.

Table 5: Peak Flow Estimates: Canon Creek - Root River

Flow Location	Contributing Drainage Area (km^2)	Peak Flow Estimates (m^3/s)	
		2-Year	100-Year
WSC Gauge 02CA002	108	30	101
at Landfill Outlet to Canon Creek (Flow Location A)	22	9	26
at Landfill Outlet to Root River (Flow Location B)	90	31	88

From the frequency analysis, a 2-year and 100-year peak flow comparison was conducted between the VO2 peak flows generated from the proposed landfill site and the receiving watercourses. The purpose of the comparison was to establish the relationship between the magnitude of the peak flow from the site and the magnitude of the peak flow in the receiving watercourse. Results are summarized in **Table 6**.

Table 6: Peak Flow Comparison: Landfill vs Receiving Watercourse - Proposed Conditions

Design Storm	Peak Flow Rates (m^3/s)					
	Flow Location A (Outlet to Canon Creek)			Flow Location B (Outlet to Root River)		
	Proposed Landfill Site	Canon Creek	% of Flow from Landfill Site	Proposed Landfill Site	Root River	% of Flow from Landfill Site
2-Year	0.106	9	1%	1.3	31	4%
100-Year	0.787	26	3%	4.6	88	5%

The total drainage area upstream of existing landfill outlets to Canon Creek and Root River are 22 km^2 and 90 km^2 respectively. The total surface drainage area associated with the proposed landfill site is approximately 50.4 ha that includes both the proposed landfill footprint and adjacent drainage areas. This represents approximately 0.5% of the entire drainage area.

As shown in **Table 6**, the contribution of proposed site runoff to Canon Creek and the Root River is minimal in terms of peak flows: at flow location A, the landfill site (L2) generates a 2-year and 100-year storm flow of 0.106 and 0.787 m^3/s, representing only 1% and 3%, respectively, of the total flow in Canon Creek. Similarly, at flow location B (L1, L3, L4), the runoff from the landfill site generates a 2-year and 100-year storm flow of 1.3 and 4.6 m^3/s. These peak flows represent only 4% and 5%, respectively, of the Root River flow at this location.

More importantly, if you consider the timing of the peak flows (Tp) between the larger watercourse drainage areas of the receiving watercourses and the smaller landfill site drainage area, the impact of landfill site runoff on peak watercourse flows is negligible. Times of concentration (Tc=>travel time) on Canon Creek and the Root River have been estimated at 5 hours and 7 hours, respectively, based on channel lengths (18km; 35km) and channel slopes (0.8%; 0.6%) derived from Ontario Flow Assessment Tool III (MNR 2014) and estimated velocities of 1m/s. This is adjusted to Tp by a factor of 0.67 so that the Tp of Canon Creek and the Root River are 3.5 hours and 4.7 hours, respectively. Tp for the landfill site is 0.2 hours. Since the timing of the peak flows from the site and the receiving watercourse do not coincide by a significant margin, the unregulated peak flows from the landfill site will not impact peak flows on the receiving watercourses.

5.5 Water Quality

A monitoring program has been in place for the existing landfill site as directed by the Ministry. The surface water monitoring component includes the collection of water samples at sampling points along Canon Creek and the Root River. Five surface water sampling locations (stations S-1B, S-2, S-3, S-4 and S-5, shown on **Figure 3**) are being sampled five times annually, when sufficient flow exists. A statistical summary of the 2018 monitoring results that were presented in the *Sault Ste. Marie Municipal Landfill Site Monitoring Report 2018 - Final Report (Dillon, 2019)* are provided in **Table 7.** In 2018, surface water monitoring was conducted on January 12, May 13, June 15, August 17 and October 12. The surface water quality data provide an indication of baseline conditions before expansion and will be used as a long term indicator of change in water quality in relation to the landfill site.

Table 7: Surface Water Quality Summary – 2018 Monitoring Results

Parameter	Units	Criteria (PWQO, CWQG, Other)	S-1B (Upstream Canon Creek)		S-2 (Upstream Root River)		S-3 (Downstream Canon Creek)		S-4 (Meandering tributary between landfill and Root		S-5 (Downstream Root River)	
			Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
Temperature	(°C)	-	0.2 - 20.3	13.6	0 - 16.3	10.7	0.4 - 19.7	10.05	0.1 - 18.2	12.4	0.1 - 19.7	13.9
DO - Measured	(mg/L)	Temp dependent	8.23 - 16.52	11.04	8.37 - 17.4	12.91	10.5 - 15.11	13.62	**4.53** - 15.6	9.45	7.96 - 16.3	11.9
pH	-	6.5-8.5	7.91 - **8.80**	8.28	8.09 - **8.61**	8.35	6.56 - **8.75**	8.29	7.98 - **8.35**	8.10	8.18 - **8.71**	8.27
Phenolics	mg/L	0.001 above background	<0.001 - 0.0011	<0.001	<0.001 - <0.001	<0.001	<0.001 - 0.0002	<0.001	0.001 - **0.007**	0.0021	<0.001 - 0.002	<0.001
Total Phosphorus	mg/L	0.03	0.010 - **0.054**	0.022	<0.006 - 0.024	0.0145	0.012 - **0.039**	0.023	0.021 - **0.135**	**0.115**	0.012 - **0.048**	0.016
Copper	mg/L	0.005	<0.003 - <0.003	<0.003	<0.003 - <0.003	<0.003	<0.003 - 0.005	0.0035	<0.003 - **0.009**	<0.003	<0.003 - <0.003	<0.003
Zinc	mg/L	0.03	0.006 - 0.012	0.010	0.007 - 0.01	0.0085	0.010 - 0.017	0.0125	<0.005 - 0.024	0.013	<0.005 - 0.013	0.006
Lead	mg/L	0.02	<0.001 - <0.001	<0.001	<0.001 - <0.001	<0.001	<0.001 - 0.002	<0.001	<0.001 - 0.002	<0.001	<0.001 - <0.001	<0.001
Total Ammonia N	mg/L	-	<0.02 - 0.06	<0.02	<0.02 - 0.1	0.03	<0.02 - 0.2	0.15	0.02 - 1.48	0.89	<0.02 - 0.14	0.03
Un-ionized Ammonia N	mg/L	0.0164	<0.0012 - 0.00049	<0.0017	<0.0011 - 0.0045	0.0012	<0.0018 - 0.0135	0.0030	0.00096 - **0.2081**	**0.0239**	<0.0012 - 0.0042	0.0021
Chloride	mg/L	120	0.43 - 1.72	0.55	8.9 - 27.3	23.95	0.46 - 13.1	0.86	6.61 - 15.3	12.0	2.02 - 13.4	12.0

Notes: PWQO – Provincial Water Quality Objective
CWQG – Canadian Water Quality Guideline
Other – From the C of A, criterion for phenolics is 0.001 mg/L above background concentrations, as determined by S-1B phenolics concentrations.
Bolded values represent an exceedance of a criterion.

Surface water quality was assessed by Dillon (2019) and is briefly summarized here as it relates to establishing background water quality data for the purpose of setting trigger levels for the SWMP monitoring program, as described in Section 7.

Dissolved oxygen (DO) concentrations were above the minimum objective for coldwater biota on all monitoring occasions and locations except two monitoring events at S-4. (Canon Creek is considered a warmwater receiver while Root River is a coldwater receiver (Sault Ste. Marie Region Conservation Authority website, accessed 2019); however, given the proximity of the sampling stations on Canon Creek to Root River, the more conservative coldwater objective was used for comparison of the Canon Creek stations as well.

pH readings were typically alkaline at all stations throughout the monitoring year. The elevated pH favors speciation of ammonia to its un-ionized form.

Total phosphorus concentrations were largely below the PWQO of 0.03 mg/L; however, upstream and downstream Canon Creek total phosphorus concentrations collected in late spring/early summer were above the PWQO at a maximum concentration of 0.054 mg/L. The impact of the elevated total phosphorus in Canon Creek during these sampling events was noted at the downstream Root River station, in which total phosphorus concentrations were elevated in corresponding months. These results suggest a phosphorus input to Canon Creek upstream of the landfill. Total phosphorus concentrations at S-4 were above PWQO during three occasions in 2018.

Concentrations of total ammonia nitrogen (TAN) and un-ionized ammonia-N were low and below the PWQO for un-ionized ammonia-N at all surface water monitoring stations except S-4. There were three occasions in 2018 at S-4 where un-ionized ammonia-N concentrations were greater than PWQO.

Phenolics, copper, zinc, lead and chloride concentrations were all generally low and met PWQO.

A Provincial Water Quality Monitoring Network (PWQMN) Station (Station 13001100202) is located on Root River at its crossing with Highway 17. Data collected at this station between 2009 (i.e., since Canon Creek was re-aligned) and 2016 were assessed for the purpose of potentially adding this data to the receiving water data set. Although the PWQMN Station is located downstream of the landfill, the calculations in Table 6, Section 5.4 indicate that the surface water runoff contribution from the landfill area is a very small percentage of the total volume of water in the receiver. Given this, the PWQMN Station data were summarized for selected parameters to determine if water quality at the station was similar to that measured at S-5 and if the PWQMN Station data could complement the surface water quality monitoring data set in order to set background water quality.

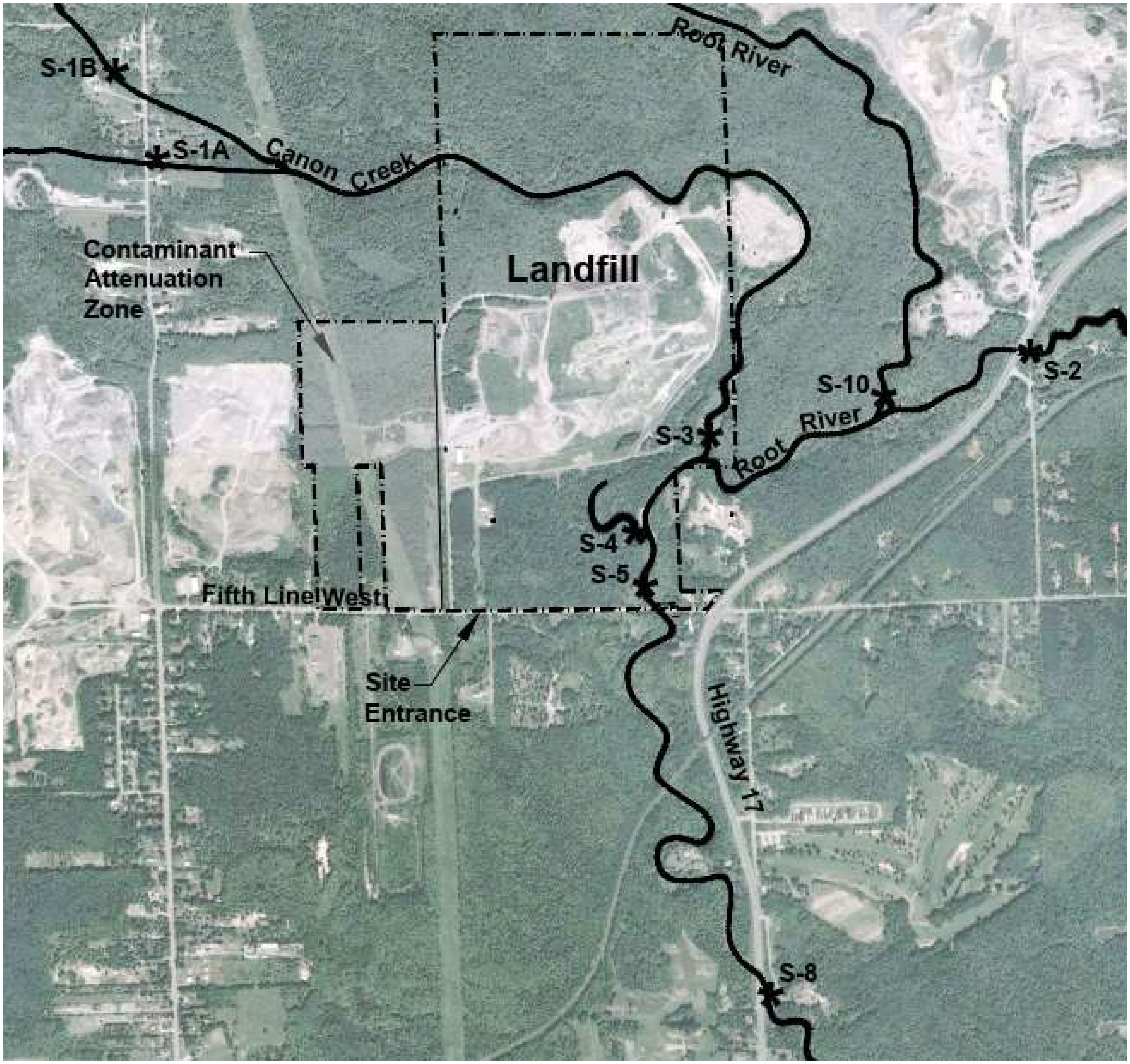
Table 8: PWQMN Station 13001100202 (Root River at Hwy 17) Surface Water Quality Statistics (2009-2016)

Parameter	Units	Criteria (PWQO, CWQG, Other)	PWQMN Station 13001100202 (2009 - 2016)		
			Minimum	Median	Maximum
Temperature	(°C)	-	2.4	13.95	23.2
DO - Measured	(mg/L)	Temp dependent	**4.7**	9.31	14.93
pH	-	6.5-8.5	6.74	**8.86**	**10.03**
Total Phosphorus	mg/L	0.03	0.002	0.009	0.022
Copper	mg/L	0.005	<0.0017	0.00099	0.0045
Zinc	mg/L	0.03	<0.0002	0.0029	0.0165
Lead	mg/L	0.02	<0.0053	<0.0099	0.0086
Total Ammonia N	mg/L	-	0.002	0.05	0.134
Chloride	mg/L	120	6.7	16.4	55.2

Notes:
PWQO – Provincial Water Quality Objective
CWQG – Canadian Water Quality Guideline
Other – From the C of A, criterion for phenolics is 0.001 mg/L above background concentrations, as determined by S-1B phenolics concentrations.
Bolded values represent an exceedance of a criterion.

In comparing between the PWQMN Station water quality statistics and the S-5 results of Dillon (2019), the following parameters were all similar in range and magnitude: temperature, DO, copper, lead and zinc. The pH readings that occurred at the PWQOMN station were larger in range from minimum to maximum over the S-5 readings. Further, the maximum chloride value of 55.2 mg/L at the PWQMN station was notably higher than the S-5 max reading of 13.4 mg/L. Regardless, the PWQMN Station data were deemed to be appropriate for use as needed in establishing background concentrations in the receiving waters for the purposes of setting trigger values at the landfill. The need for water quality impact mitigation due to the effect of the internal roadway system, the administrative building, public drop-off, recycling centre and composting area will be addressed by the design of SWM Ponds, with forebays. These SWMP will reduce Total Suspended Solids (TSS) loadings, by 80%, to the receiving watercourses. Preliminary conceptual designs have been developed and are reported in more detail below. These single stage SWMPs will not only reduce TSS loadings but also provide for emergency leachate/spill containment with the provision of an emergency shutoff valve at the outlet and a clay liner to prevent infiltration to groundwater.

Figure 3: Surface Water Quality Monitoring Stations



6. Surface Water Net Effects

The existing landfill site and proposed landfill expansion are situated adjacent to the Canon Creek to the North and East and the Root River to the South-East as illustrated in **Figure 1** and **Figure 2**. The soils in the area of the proposed landfill expansion consist of a deep layer of relatively permeable medium to coarse sands and gravels over silt or clay.

Potable water supply in adjacent built-up areas to the south and southwest is from the Municipal supply and distribution system while potable water for the rural areas to the north, east and southeast is from private wells.

The potential surface water effects, mitigation/compensation measures, and net effects are summarized in **Table 9** and described in further detail in the sections below.

Table 9: Net Effects

Potential Effect	Mitigation	Net Effect
Water quality impact from leachate or spills	Storage in lined SWM facility	none
Water quality impact from TSS	TSS Removal in SWM Facility	minimal
Water quality thermal impact	Bottom draw; Shading	reduced
Water quantity impact	Free Flow from site	none

6.1 Potential Effects on Surface Water

Potential surface water impacts from the landfill are as follows.

From a water quality perspective, there are potential impacts due to accidental spills or leachate seeps to the surface and/or increases in Total Suspended Solids (TSS) concentration due to runoff from the internal operations on the paved access roadways or site erosion. As well, there is a potential for thermal impact from the permanent pool feature of the SWMPs and the coldwater fisheries status of the Root River.

From a water quantity perspective, there are negligible impacts since peak flows from the site are significantly smaller than those of the receiving watercourse and the peaks do not coincide.

6.2 Mitigation, Compensation and/or Contingency Measures

Surface water impact mitigation will be as follows:

Water quality impacts would be mitigated by a single stage SWMP to reduce TSS loading and provide for emergency leachate/spill containment. SWMP outflow would be through open channel to the nearest receiving watercourse. The outflow structure design would have bottom draw characteristics and landscaping to provide shading of the SWMPs. Conceptual Plans are provided in **Appendix C.**

There is no mitigation proposed for water quantity as the impact is insignificant.

On site stormwater management (SWM) will be achieved through the existing/proposed system of ditches, culverts, and SWM ponds that have been designed to mitigate the impacts of stormwater runoff on water quality before discharge to Canon Creek or the Root River. The SWM criteria, as identified by the Ministry in Ontario Regulation 232/98 and related Landfill Standards Guidelines (1998), include ditches with a 1:25 year capacity and runoff treatment for 80% TSS removal.

The four new SWM ponds described in Section 7 will also be designed with emergency flow control systems at their outlet, as a contingency. The SWM Pond can act as an emergency response cell where runoff can be stored in case of surface water contamination by leachate or onsite spills. Emergency response would be assisted by: regular visual monitoring for leachate seeps; annual SWM Pond outflow compliance monitoring during a minimum of three significant rainfall events (i.e., one per season in spring, summer and fall, with a minimum of at 10 mm of rainfall in 12 hours); and an operational program that incorporates immediate reporting of on-site spills. Manual shutdown response would use either a control valve or gate at the SWM pond outlet. The ponds will be lined and designed to retain the complete runoff from the 1:100 year rainfall until appropriate treatment can be applied. The contaminated runoff will either be treated and discharged to the receiving watercourse or pumped and hauled for treatment elsewhere.

7. Proposed Surface Water Management Plan

7.1 Drainage

The proposed site will be drained by ditches adjacent to the internal roadway system. The ditches shall be V-shaped with a maximum 2:1 side-slope and a minimum depth of 0.3m (includes 0.1 m freeboard) to convey the 1:25 Year flow.

7.2 Stormwater Management Ponds

Four (4) SWM Ponds are proposed, to mitigate runoff impacts, as shown in **Figure 2**. One in the southwest for landfill catchment L1; one in the northeast for landfill catchment L2; one in the southeast for landfill catchment L3 and a final one in the south for catchment L4 which represents the public drop-off, administration building, recycling centre, compost pad and adjacent paved areas.

SWM Ponds for catchments L1, L2 and L3 will all have sufficient storage capacity to accommodate runoff from the 1:100 Year storm event for operation under emergency leachate spill conditions. Such emergency control is not required for drainage from catchment L4.

As well, all four (4) SWM Ponds will be designed to operate as water quality control facilities as identified in the City's SWM Guidelines (RV Anderson 2014) and will achieve Ministry Level 1 criteria (80%TSS removal). The SWMPs will be lined to eliminate infiltration since the landfill site is in an area of high groundwater recharge and runoff has the potential to be contaminated.

There will be no quantity control function. The proposed SWM Pond characteristics at the four locations are identified in more detail in **Appendix C**.

Influent/effluent monitoring requirements would be confirmed at the time of Ministry ECA approval and a proposed monitoring program is provided in **Table 10**. Sampling is to be implemented three times per year. Influent and effluent grab samples should be taken during storm events with a minimum 10 mm of precipitation within a 12 hr period.

Table 10: **SWM Pond – Recommended Surface Water Monitoring Program**

Sampling Location	Sampling Frequency	Parameters
Inlet (SW, NE, SE and S SWMPs)	3x/yr (once during each of spring, summer and fall) during a precipitation event with at least 10 mm of rainfall in 12 hours	• TSS • *In-situ parameters*: temperature, pH, conductivity, dissolved oxygen
Outlet (SW, NE, SE and S SWMPs)		• TSS, 5-day biochemical oxygen demand (BOD), alkalinity, total ammonia nitrogen (TAN), nitrate, nitrite, phenols, chloride, total phosphorus, total metals (barium, boron, cadmium, total chromium, copper, lead and zinc) • *In-situ parameters*: temperature, pH, conductivity, dissolved oxygen (DO) • *Calculated parameters*: un-ionized ammonia

Analysis of TSS at both inlet and outlet allows for comparison of inflow and outflow results during rainfall events to confirm TSS removal efficiency. The other parameters listed in **Table 10** are included in the current surface water monitoring program (Stations S-1B, S-2, S-3, S-4 and S-5), with selected additional parameters added based on the Ministry’s groundwater (leachate) trigger value list for the Site.

Table 11 presents trigger values for the SWMP proposed Surface Water Monitoring Program at which further action/investigation is required. The parameters with assigned trigger values were selected because they are contained within the group of leachate indicator parameters for the site.

Table 11: **SWM Pond – Surface Water Monitoring Program Trigger Values**

Location	Parameter	Trigger Value	Rationale
Outlet (SW, NE, SE and S SWMPs)	Alkalinity	50 mg/L	• Alkalinity is one of the leachate indicator parameters for this site. Prior to the re-alignment of Canon Creek near the south-eastern portion of the landfill, elevated alkalinity concentrations were measured in surface water. • Alkalinity measured in background wells ranged from 10 - 31 mg/L (Dillon, 2019). Maximum alkalinity measured at PWQMN Station 13001100202 (Root River at Hwy 17, North of SSM) between 2009-2016 was 39.6 mg/L. Trigger value was set at 1.25 times the maximum measured alkalinity in Root River (at the PWQMN station).
	Boron	0.2 mg/L	• Boron is one of the leachate indicator parameters for this site. Prior to the re-alignment of Canon Creek near the south-eastern portion of the landfill, elevated boron concentrations were measured in surface water. • Trigger was set at the PWQO of 0.2 mg/L. For comparison, the Ministry's leachate trigger value for this site is 3.55 mg/L.
	Chloride	120 mg/L	• Chloride is one of the leachate indicator parameters for this site. • Trigger was set at the Canadian Water Quality Guideline (CWQG) value. For comparison, the Ministry's leachate trigger value for this site is 180 mg/L.
	Un-ionized Ammonia-Nitrogen (calculated using temperature and pH spot measurements)	0.19 mg/L	• Prior to the re-alignment of Canon Creek near the south-eastern portion of the landfill, elevated un-ionized ammonia concentrations were measured in surface water. • The PWQO for un-ionized ammonia-nitrogen is 0.0164 mg/L. • Within the mixing zone (i.e., mixing between the SWMP discharge and the receivers [Canon Creek and Root River[), the Ministry's *Procedure B-1-5 Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters* (Ministry 1994) states that discharges must not be acutely toxic; however, the Ministry does not provide formal documented guidance on what levels of un-ionized ammonia are considered acutely toxic. • The U.S. EPA (2009) recommends 5 mg/L ammonia nitrogen as a criterion for acute toxicity at pH 8 and 25°C, or, that the average not exceed 4.5 mg/L over any 4 day period. TAN concentrations of 5 mg/L and 4.5 mg/L correspond to un-ionized ammonia-N concentrations of 0.27 mg/L and 0.24 mg/L, respectively, at pH 8 and 25°C (USEPA, 2009). Environment Canada (2001) provide a median LC50 of 0.481 mg/L unionized ammonia-N for rainbow trout and 1.16 mg/L for the most sensitive daphnid species tested. Therefore, the trigger was set at 0.19 mg/L to ensure no acute toxicity to test organisms and using the most recently published surface water quality guideline for unionized ammonia from the CWQG.

Monitoring data obtained through the SWMP monitoring program should be immediately reviewed upon receipt and compared against the trigger values. On an annual basis, monitoring data should be reported. The report should include comparison of data against PWQOs and historical monitoring results, and provide conclusions and recommendations for the monitoring program.

On any occasion that a trigger value is exceeded at a particular SWMP a visual inspection of the landfill shall be conducted for possible leachate seeps or other contributors and appropriate action is to be taken to address any adverse observations. The action taken may include item 3 noted below if warranted by the parameter and magnitude of the exceedance.

Should a trigger value be exceeded on two consecutive sampling events a contingency plan would be executed. The recommended contingency plan is as follows:

1. Conduct a visual inspection of the landfill for leachate seeps or other contributors.
2. Collect a duplicate inlet and outlet sample at the SWMP as soon as possible. If the SWMP is no longer flowing, the sample should be collected as soon as outlet flows resume (i.e., during the next significant storm event). These samples should be analyzed for the parameter whose trigger value was exceeded. Additional parameters may be added as appropriate based on scientific judgement.

If the duplicate outlet sample result exceeds the trigger value:

3. Depending on the parameter and magnitude, manually shut down the SWMP outlet using the control valve or gate. Determine options for treating water contained in the SWMP (i.e., pump and transport for treatment, pump and temporary treatment on-site, in-situ treatment)
4. Conduct an assessment into the cause of the trigger value exceedance and execute the recommended solution.

If the duplicate outlet sample result does not exceed the trigger value:

5. Continue with the regular SWMP monitoring program.

8. Surface Water Approvals Required for the Undertaking

As part of the implementation plan for surface water impact mitigation, the following permits and approvals would be required:

- Development, Interference with Wetlands and Alternations to Shorelines and Watercourses permit from the local Conservation Authority; and
- A Ministry Environmental Compliance Approval (ECA) for the four SWM Ponds and related conveyance systems.

APPENDIX A

Single Station Frequency Analysis (SSFA)

		PEAK			DAILY		DAILY			
ID	Year	HH:MM	MM--DD	PEAK	DAILY	Daily MM--DD	DAILY	Daily MM--DD	Peaking Factor	Peak Estimate
02CA002	1971	6:43	12--11	24.2	23.6	04--20	17.9	12--11	1.35	
02CA002	1972	1:20	05--03	28	24.8	05--03			1.13	
02CA002	1973	2:06	11--22	19.9	16.2	03--12	15.5	11--22	1.28	
02CA002	1974	5:50	04--22	20.3	19.3	04--22			1.05	
02CA002	1975	12:07	05--01	42.2	35.7	05--01			1.18	
02CA002	1976			26.6	20.8	04--17				26.6
02CA002	1977	22:15	04--18	29.4	23.4	04--19			1.26	
02CA002	1978	19:34	10--03	33.7	16.9	10--04			1.99	
02CA002	1979	20:30	04--25	55.7	42.2	04--26			1.32	
02CA002	1980	6:53	04--09	33.8	31	04--09			1.09	
02CA002	1981	22:14	04--04	40.6	31.8	04--04			1.28	
02CA002	1982	7:00	04--26	31.7	29.8	04--26			1.06	
02CA002	1983	18:02	04--14	56.7	27.7	04--14			2.05	
02CA002	1984	7:20	09--13	31.3	20.3	09--13			1.54	
02CA002	1985	22:19	04--22	53.9	43.2	04--23			1.25	
02CA002	1986	6:20	04--08	19.5	18.2	04--08			1.07	
02CA002	1987	4:11	10--18	14.7	12	10--18			1.23	
02CA002	1988	17:04	04--06	39.9	32.9	04--06			1.21	
02CA002	1989	0:59	04--27	20.2	17.8	04--27			1.13	
02CA002	1990	23:37	04--25	25	24.5	03--16	20.7	04--25	1.21	
02CA002	1991	1:07	04--08	31	26.1	04--08			1.19	
02CA002	1992	4:36	04--22	66.8	47.4	04--22			1.41	
02CA002	1993	17:43	04--09	26.4	20.6	04--09			1.28	
02CA002	1994	1:01	04--25	23.9	19.2	04--27			1.24	
02CA002	1995	11:17	08--31	27	16.7	08--31			1.62	
02CA002	1996	0:19	04--22	22.9	21.4	04--22			1.07	
02CA002	1997	22:00	04--06	27.2	22.2	04--07			1.23	
02CA002	1998	6:30	03--30	29.8	25.8	03--30			1.16	
02CA002	1999	18:15	04--06	35.5	25.2	04--08			1.41	
02CA002	2000	0:40	03--26	14.9	13	03--25			1.15	
02CA002	2001	12:10	10--14	42.6	32.9	04--12	28.3	10--14	1.51	
02CA002	2002	21:45	04--16	51.9	42.1	04--17			1.23	
02CA002	2003	17:40	04--20	45.1	34.4	04--20			1.31	
02CA002	2004	16:25	04--19	20.8	18.7	04--19			1.11	
02CA002	2005	5:20	04--07	23	21.2	04--07			1.08	
02CA002	2006	21:45	04--12	20.1	15.9	04--12			1.26	
02CA002	2007	5:35	11--06	17	14	11--06			1.21	
02CA002	2008	21:50	04--17	26.4	22.6	04--20			1.17	
02CA002	2009	2:00	04--25	17	15.3	04--25			1.11	
02CA002	2010	10:15	09--24	53	34	09--24			1.56	
02CA002	2011	3:30	04--28	28.3	20.9	04--28			1.35	
02CA002	2012	1:00	03--19	21.6	19.3	03--18			1.12	
02CA002	2013			76.4	59.7	09--10				76.4
								PEAKING FACTOR	1.28	

SSM - Landfill - WSC - Root River

3-parameter lognormal (Maximum Likelihood)

Results of the fitting

Number of observations : 43

Parameters

m	10.207561
mu	2.905805
sigma	0.635895

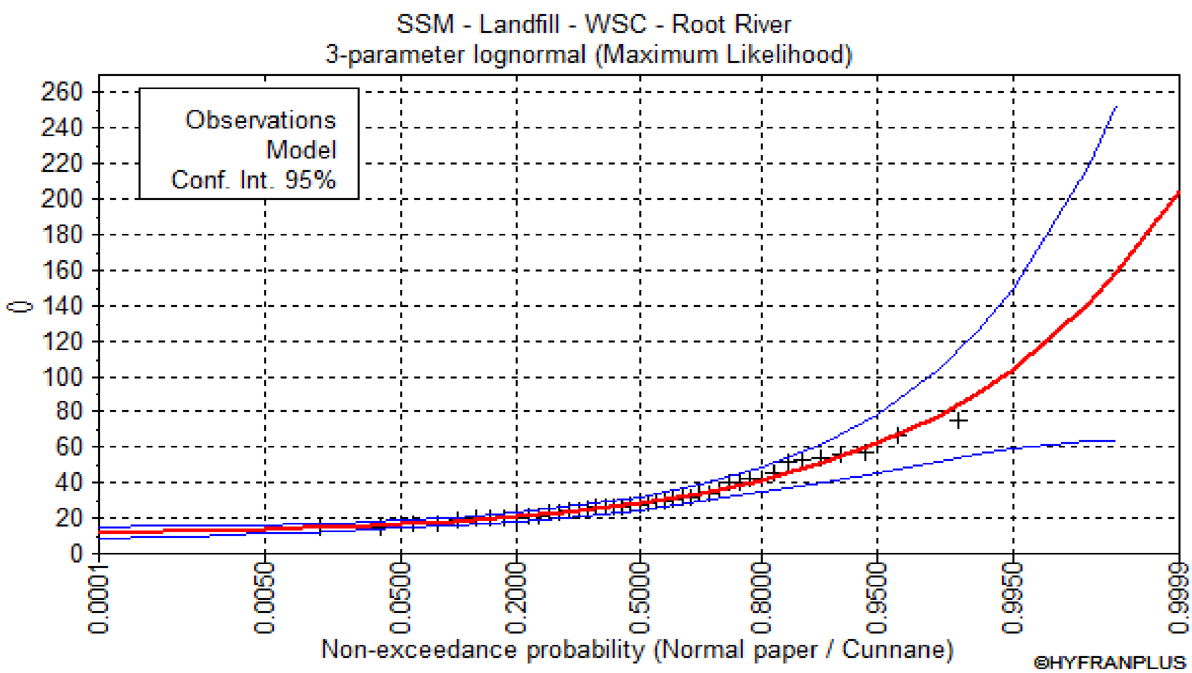
Quantiles

q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)
10000.0	0.9999	205	73.0	N/D
2000.0	0.9995	158	48.2	64.0 - 253
1000.0	0.9990	141	39.4	63.3 - 218
200.0	0.9950	104	23.2	58.8 - 150
100.0	0.9900	90.5	17.8	55.7 - 125
50.0	0.9800	77.7	13.2	51.9 - 104
20.0	0.9500	62.2	8.34	45.9 - 78.6
10.0	0.9000	51.5	5.56	40.6 - 62.4
5.0	0.8000	41.4	3.52	34.5 - 48.3
3.0	0.6667	34.2	2.48	29.4 - 39.1
2.0	0.5000	28.5	1.87	24.8 - 32.2
1.4286	0.3000	23.3	1.43	20.5 - 26.1
1.2500	0.2000	20.9	1.24	18.5 - 23.3
1.1111	0.1000	18.3	1.06	16.2 - 20.4
1.0526	0.0500	16.6	1.01	14.7 - 18.6
1.0204	0.0200	15.2	1.05	13.1 - 17.2
1.0101	0.0100	14.4	1.13	12.2 - 16.6
1.0050	0.0050	13.8	1.22	11.4 - 16.2
1.0010	0.0010	12.8	1.44	9.95 - 15.6
1.0005	0.0005	12.5	1.52	9.47 - 15.5
1.0001	0.0001	11.9	1.70	8.59 - 15.3

HYFRANPLUS

SSM - Landfill - WSC - Root River



APPENDIX B

Hydrologic Model Input/Output – Proposed Conditions

STANDHYD Used to simulate design hydrographs from urban watersheds. With this command, the model uses two parallel standard instantaneous unit hydrographs to convolute the effective rainfall intensity over the pervious and impervious surfaces. The losses over the pervious area can be calculated by one of the three methods: i) Horton's soil infiltration equation; ii) SCS modified CN procedure; or iii) Proportional Loss Coefficient. A baseflow can be added to the total simulated hydrograph. To obtain adequate results, the command should be applied to areas with impervious ratios larger than 20% (for smaller impervious ratios the watershed can be broken down into urban and rural basins).

NASHYD Used to simulate design hydrographs with the Nash instantaneous unit hydrograph. This hydrograph is made of a cascade of 'N' linear reservoirs. The command is mainly used for rural areas but can also be used for very large urban watersheds and to simulate the effects of infiltration /inflow in sanitary sewers. Rainfall losses can be computed by a SCS modified CN procedure or Proportional Loss Coefficient.

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	109.4	67.5	50.9	31.4	19.4	12.0	5.6	3.4	2.1
5-yr	148.5	91.7	69.2	42.7	26.4	16.3	7.6	4.7	2.9
10-yr	174.9	108.0	81.5	50.3	31.1	19.2	9.0	5.5	3.4
25-yr	208.1	128.5	97.0	59.9	37.0	22.9	10.7	6.6	4.1
50-yr	232.3	143.5	108.2	66.9	41.3	25.5	11.9	7.3	4.5
100-yr	255.9	158.1	119.2	73.7	45.5	28.1	13.1	8.1	5.0

```
------------------------------------------------------------------------------------------------
----------
  ***************************
  ** SIMULATION NUMBER:   1 **
  ***************************
```

2 YEAR EVENT – SSM Landfill – Proposed Conditions

```
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 320.010
| Ptotal= 40.73 mm |                           B=   0.001
--------------------                           C=   0.691
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 12.00 hrs
                         Storm time step    =  5.00 min
                         Time to peak ratio =  0.33
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.08	1.07	3.08	2.93	6.08	2.65	9.08	1.43
0.17	1.08	3.17	3.14	6.17	2.58	9.17	1.42
0.25	1.10	3.25	3.38	6.25	2.51	9.25	1.40
0.33	1.12	3.33	3.67	6.33	2.45	9.33	1.39
0.42	1.13	3.42	4.04	6.42	2.39	9.42	1.37
0.50	1.15	3.50	4.50	6.50	2.33	9.50	1.36
0.58	1.17	3.58	5.13	6.58	2.28	9.58	1.34
0.67	1.19	3.67	6.03	6.67	2.23	9.67	1.33
0.75	1.21	3.75	7.45	6.75	2.19	9.75	1.32
0.83	1.24	3.83	10.16	6.83	2.14	9.83	1.30
0.92	1.26	3.92	18.76	6.92	2.10	9.92	1.29
1.00	1.28	4.00	105.22	7.00	2.06	10.00	1.28
1.08	1.31	4.08	22.97	7.08	2.02	10.08	1.27
1.17	1.33	4.17	14.56	7.17	1.98	10.17	1.25
1.25	1.36	4.25	11.14	7.25	1.95	10.25	1.24
1.33	1.39	4.33	9.20	7.33	1.92	10.33	1.23
1.42	1.42	4.42	7.92	7.42	1.88	10.42	1.22
1.50	1.46	4.50	7.00	7.50	1.85	10.50	1.21
1.58	1.49	4.58	6.31	7.58	1.82	10.58	1.20
1.67	1.53	4.67	5.76	7.67	1.79	10.67	1.19
1.75	1.57	4.75	5.32	7.75	1.77	10.75	1.18
1.83	1.61	4.83	4.95	7.83	1.74	10.83	1.17
1.92	1.65	4.92	4.64	7.92	1.71	10.92	1.16
2.00	1.70	5.00	4.37	8.00	1.69	11.00	1.15
2.08	1.75	5.08	4.14	8.08	1.67	11.08	1.14
2.17	1.81	5.17	3.94	8.17	1.64	11.17	1.13
2.25	1.87	5.25	3.76	8.25	1.62	11.25	1.12
2.33	1.93	5.33	3.59	8.33	1.60	11.33	1.11
2.42	2.00	5.42	3.45	8.42	1.58	11.42	1.10
2.50	2.08	5.50	3.32	8.50	1.56	11.50	1.10
2.58	2.16	5.58	3.19	8.58	1.54	11.58	1.09
2.67	2.26	5.67	3.08	8.67	1.52	11.67	1.08

```
          2.75    2.36 |  5.75    2.98 |  8.75    1.50 | 11.75    1.07
          2.83    2.48 |  5.83    2.89 |  8.83    1.48 | 11.83    1.06
          2.92    2.61 |  5.92    2.80 |  8.92    1.47 | 11.92    1.06
          3.00    2.76 |  6.00    2.72 |  9.00    1.45 | 12.00    1.05


------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0005) |   Area    (ha)=  18.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.23

     Unit Hyd Qpeak  (cms)=   3.039

     PEAK FLOW       (cms)=   0.173 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=   7.052
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0001) |   Area    (ha)=  11.40   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.08

     Unit Hyd Qpeak  (cms)=   5.246

     PEAK FLOW       (cms)=   0.022 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=   2.373
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.058

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)=   9.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.19

     Unit Hyd Qpeak  (cms)=   1.930

     PEAK FLOW       (cms)=   0.101 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=   7.043
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173
```

```
     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):    11.40   0.022     4.17     2.37
        + ID2= 2 (0003):     9.70   0.101     4.17     7.04
          ==================================================
          ID = 3 (0006):    21.10   0.123     4.17     4.52

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0002) |   Area    (ha)=   2.50   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------  U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   0.853

     PEAK FLOW       (cms)=   0.005 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=   2.455
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.060

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0004) |   Area    (ha)=  12.20   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------  U.H. Tp(hrs)=   0.26

     Unit Hyd Qpeak  (cms)=   1.806

     PEAK FLOW       (cms)=   0.106 (i)
     TIME TO PEAK    (hrs)=   4.333
     RUNOFF VOLUME    (mm)=   7.054
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0007) |
```

```
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     2.50   0.005     4.25     2.45
        + ID2= 2 (0004):    12.20   0.106     4.33     7.05
          ==================================================
          ID = 3 (0007):    14.70   0.110     4.33     6.27

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0008) |   Area    (ha)=   9.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  47.00   Dir. Conn.(%)=  47.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       4.61         5.19
     Dep. Storage     (mm)=       1.00        10.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     255.60        40.00
     Mannings n           =      0.013        0.250

     Max.Eff.Inten.(mm/hr)=     105.22         1.70
                over (min)        5.00        45.00
     Storage Coeff.  (min)=       4.40 (ii)   40.39 (ii)
     Unit Hyd. Tpeak (min)=       5.00        45.00
     Unit Hyd. peak  (cms)=       0.23         0.03
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.98         0.01           0.980 (iii)
     TIME TO PEAK    (hrs)=       4.00         4.92            4.00
     RUNOFF VOLUME    (mm)=      39.73         3.96           20.77
     TOTAL RAINFALL   (mm)=      40.73        40.73           40.73
     RUNOFF COEFFICIENT   =       0.98         0.10            0.51

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  55.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
```

```
 ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************
```

100 YEAR EVENT – SSM Landfill – Proposed Conditions

```
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 705.090
| Ptotal= 98.40 mm |                           B=   0.001
--------------------                           C=   0.677
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 12.00 hrs
                         Storm time step    =  5.00 min
                         Time to peak ratio =  0.33
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.08	2.69	3.08	7.25	6.08	6.56	9.08	3.60
0.17	2.73	3.17	7.75	6.17	6.39	9.17	3.56
0.25	2.77	3.25	8.33	6.25	6.23	9.25	3.52
0.33	2.81	3.33	9.04	6.33	6.08	9.33	3.48
0.42	2.86	3.42	9.92	6.42	5.94	9.42	3.44
0.50	2.91	3.50	11.04	6.50	5.80	9.50	3.41
0.58	2.95	3.58	12.55	6.58	5.68	9.58	3.37
0.67	3.00	3.67	14.70	6.67	5.55	9.67	3.34
0.75	3.06	3.75	18.09	6.75	5.44	9.75	3.31
0.83	3.11	3.83	24.50	6.83	5.33	9.83	3.28
0.92	3.17	3.92	44.64	6.92	5.23	9.92	3.24
1.00	3.23	4.00	237.13	7.00	5.13	10.00	3.21
1.08	3.29	4.08	54.47	7.08	5.04	10.08	3.18
1.17	3.35	4.17	34.86	7.17	4.95	10.17	3.16
1.25	3.42	4.25	26.81	7.25	4.86	10.25	3.13
1.33	3.50	4.33	22.22	7.33	4.78	10.33	3.10
1.42	3.57	4.42	19.19	7.42	4.70	10.42	3.07
1.50	3.65	4.50	17.02	7.50	4.62	10.50	3.05
1.58	3.74	4.58	15.36	7.58	4.55	10.58	3.02
1.67	3.83	4.67	14.06	7.67	4.48	10.67	2.99
1.75	3.92	4.75	13.00	7.75	4.41	10.75	2.97
1.83	4.03	4.83	12.12	7.83	4.35	10.83	2.94
1.92	4.14	4.92	11.37	7.92	4.29	10.92	2.92
2.00	4.25	5.00	10.73	8.00	4.23	11.00	2.90
2.08	4.38	5.08	10.17	8.08	4.17	11.08	2.87
2.17	4.51	5.17	9.68	8.17	4.11	11.17	2.85
2.25	4.66	5.25	9.24	8.25	4.06	11.25	2.83
2.33	4.82	5.33	8.85	8.33	4.00	11.33	2.81
2.42	4.99	5.42	8.50	8.42	3.95	11.42	2.79
2.50	5.18	5.50	8.18	8.50	3.90	11.50	2.76
2.58	5.38	5.58	7.89	8.58	3.86	11.58	2.74
2.67	5.61	5.67	7.62	8.67	3.81	11.67	2.72
2.75	5.86	5.75	7.37	8.75	3.76	11.75	2.70
2.83	6.15	5.83	7.15	8.83	3.72	11.83	2.68

```
                 2.92    6.47 |  5.92    6.94 |  8.92    3.68 | 11.92    2.67
                 3.00    6.83 |  6.00    6.74 |  9.00    3.64 | 12.00    2.65


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0005) |   Area    (ha)=  18.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.23

     Unit Hyd Qpeak  (cms)=   3.039

     PEAK FLOW       (cms)=   1.271 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=  39.508
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.401

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0001) |   Area    (ha)=  11.40   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.08

     Unit Hyd Qpeak  (cms)=   5.246

     PEAK FLOW       (cms)=   0.680 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  21.501
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.219

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)=   9.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.19

     Unit Hyd Qpeak  (cms)=   1.930

     PEAK FLOW       (cms)=   0.760 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=  39.460
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.401

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):    11.40   0.680     4.00    21.50
        + ID2= 2 (0003):     9.70   0.760     4.17    39.46
          =================================================
          ID = 3 (0006):    21.10   1.277     4.08    29.76

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0002) |   Area    (ha)=   2.50   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   0.853

     PEAK FLOW       (cms)=   0.126 (i)
     TIME TO PEAK    (hrs)=   4.083
     RUNOFF VOLUME    (mm)=  22.242
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.226

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0004) |   Area    (ha)=  12.20   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.26

     Unit Hyd Qpeak  (cms)=   1.806

     PEAK FLOW       (cms)=   0.787 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=  39.520
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.402

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0007) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
```

```
          ID1= 1 (0002):     2.50   0.126     4.08    22.24
        + ID2= 2 (0004):    12.20   0.787     4.25    39.52
          ==================================================
          ID = 3 (0007):    14.70   0.862     4.25    36.58

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0008) |   Area    (ha)=   9.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  47.00   Dir. Conn.(%)=  47.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       4.61         5.19
     Dep. Storage     (mm)=       1.00        10.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     255.60        40.00
     Mannings n          =      0.013        0.250

     Max.Eff.Inten.(mm/hr)=     237.13        25.21
                over (min)        5.00        20.00
     Storage Coeff.  (min)=       3.18 (ii)   15.42 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=       0.27         0.07
                                                                *TOTALS*
     PEAK FLOW       (cms)=       2.51         0.21          2.569 (iii)
     TIME TO PEAK    (hrs)=       4.00         4.25           4.00
     RUNOFF VOLUME    (mm)=      97.40        26.38          59.76
     TOTAL RAINFALL   (mm)=      98.40        98.40          98.40
     RUNOFF COEFFICIENT   =       0.99         0.27           0.61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  55.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
```

Appendix C

Preliminary SWM Pond Design

SWM Ponds were conceptually and conservatively designed using MOE methods as identified in their 2003 Planning and Design Manual.

The **Table B-1**, below, identifies the Pond dimensions and the resulting volumes required for water quality impact mitigation including Permanent Pool , Extended Detention and Emergency 100 year retention requirements.

The drawing, below, identifies conceptual pond layouts and standard inlet and outlet configurations whose dimensions and elevations will be revised and optimised during detailed design. Typically all SWM Ponds will have a Permanent Pool that is a minimum 1.0m deep and will have an additional 0.5m for extended detention and 100 year emergency storage as well as another 0.5m to 1.25m to complete emergency storage requirements.

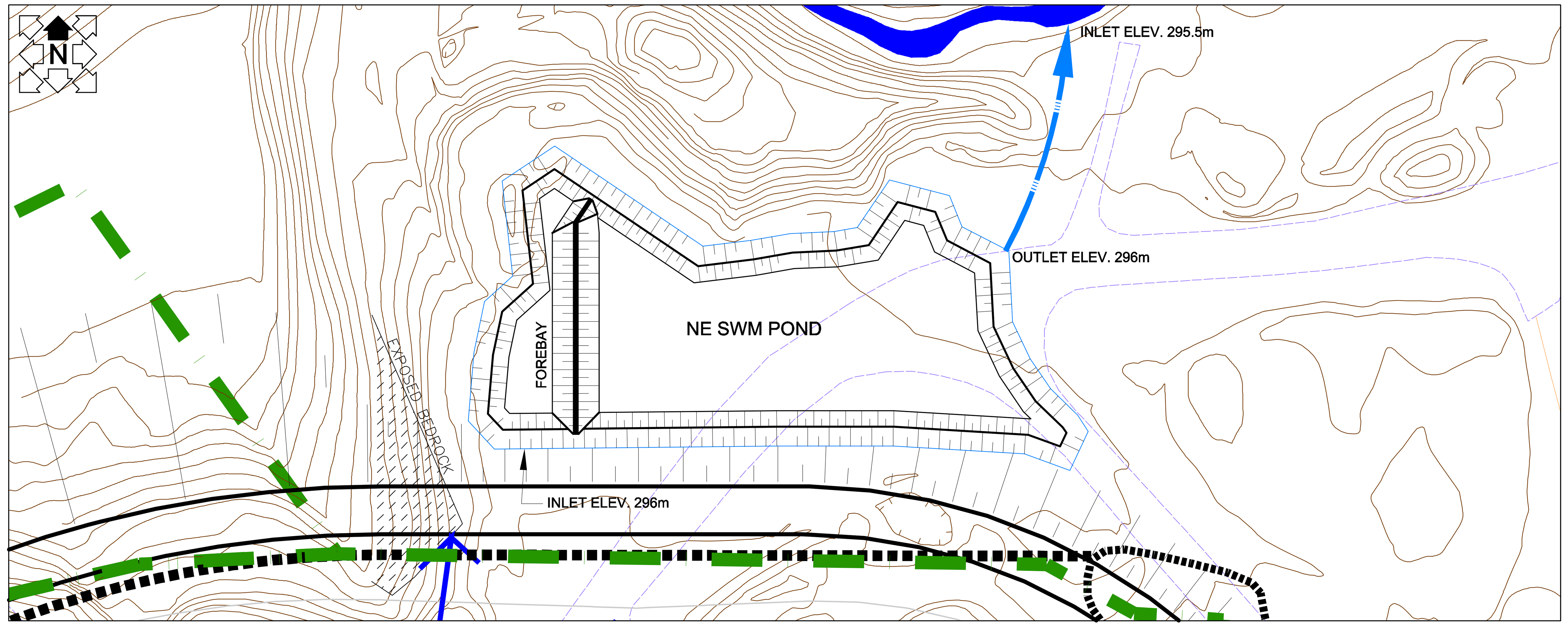
A bottom draw configuration is illustrated for thermal impact mitigation

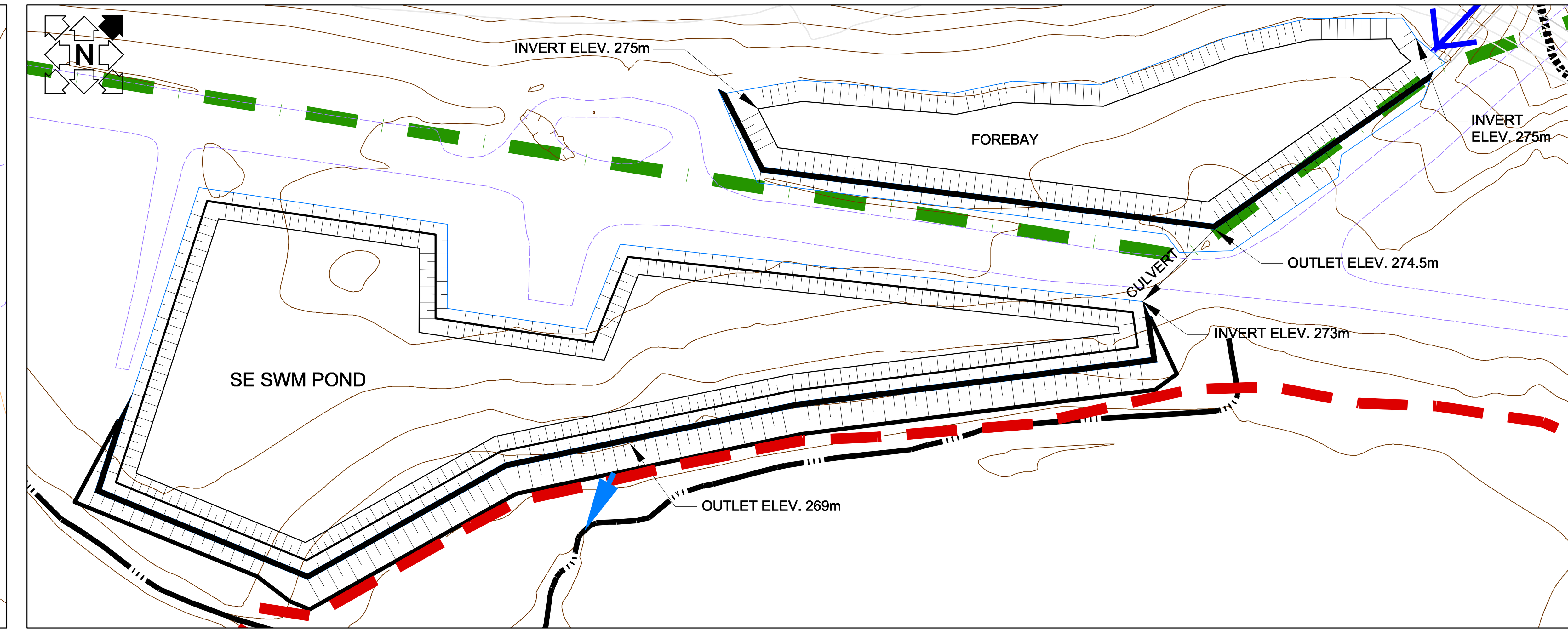
Table B-1 SWM Pond Design - Summary

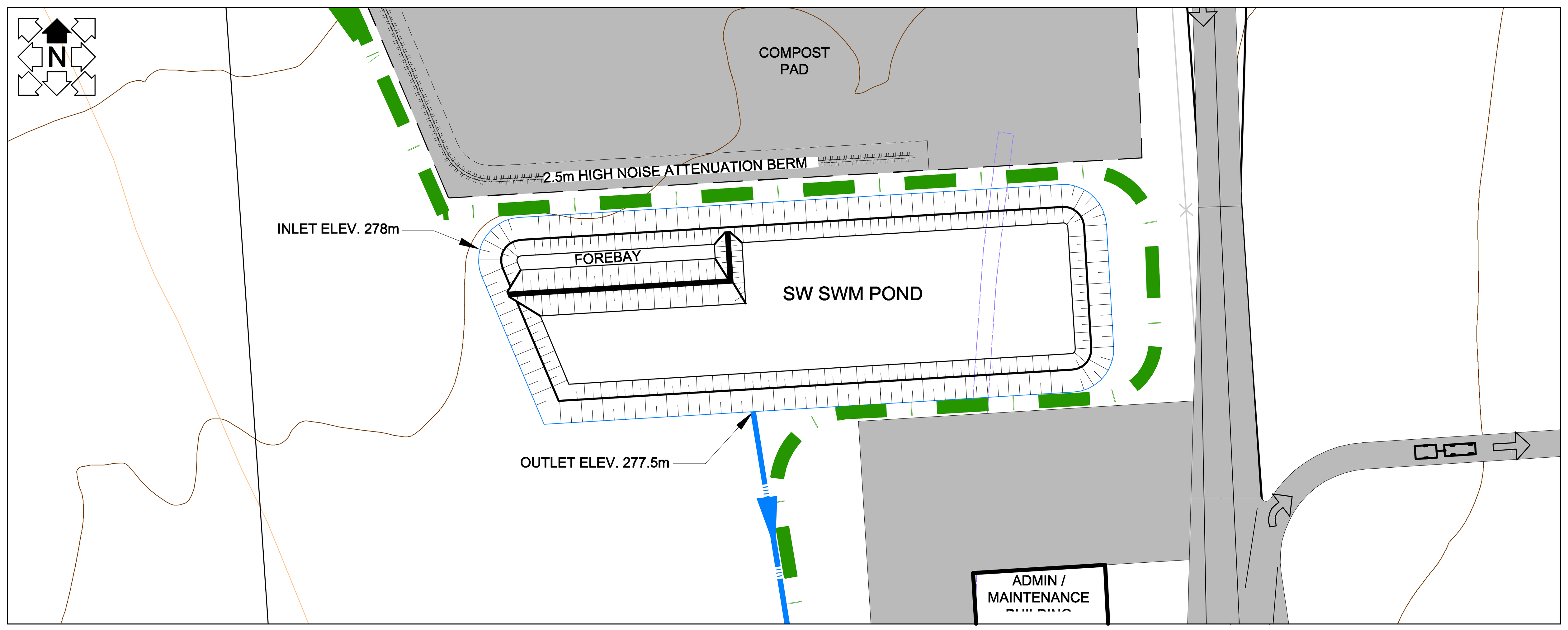
Drainage Area (DA) ID	DA (ha)	% IMP	Design Volume Criteria (m^3/ha - MOE 2003)			Associated SWM Pond	Volume Required (m^3)			Pond Dimensions	Volume Provided (m^3)		
			TOTAL	Permanent Pool (PP)	Extended Detention (ED)		PP	ED	100 Year Emergency[1.0]	LxWxD	PP	ED	100 Year Emergency (including ED)
L1	9.7	35	140	100	40	SW	970	388	3831	115x40x2.0	4145	1750	4635
L2	12.2	35	140	100	40	NE	1220	488	4819	100x45x2.75	4080	1735	5255
L3	18.7	35	140	100	40	SE	1870	748	7368	180x40x2.5	6550	2805	7510
L4	9.8	45	165	125	40	S	1225	392	NA	100x40x1.5	4560	1970	NA

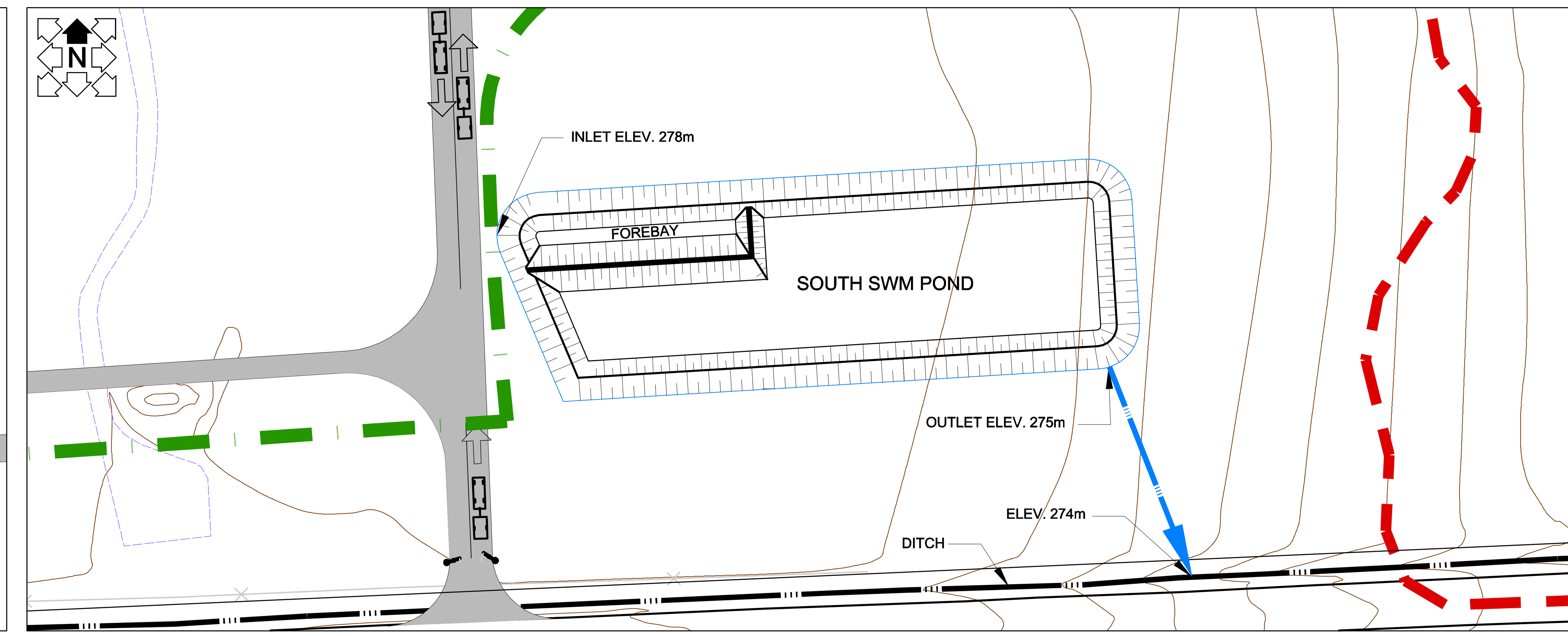
1.0 from hydrologic model

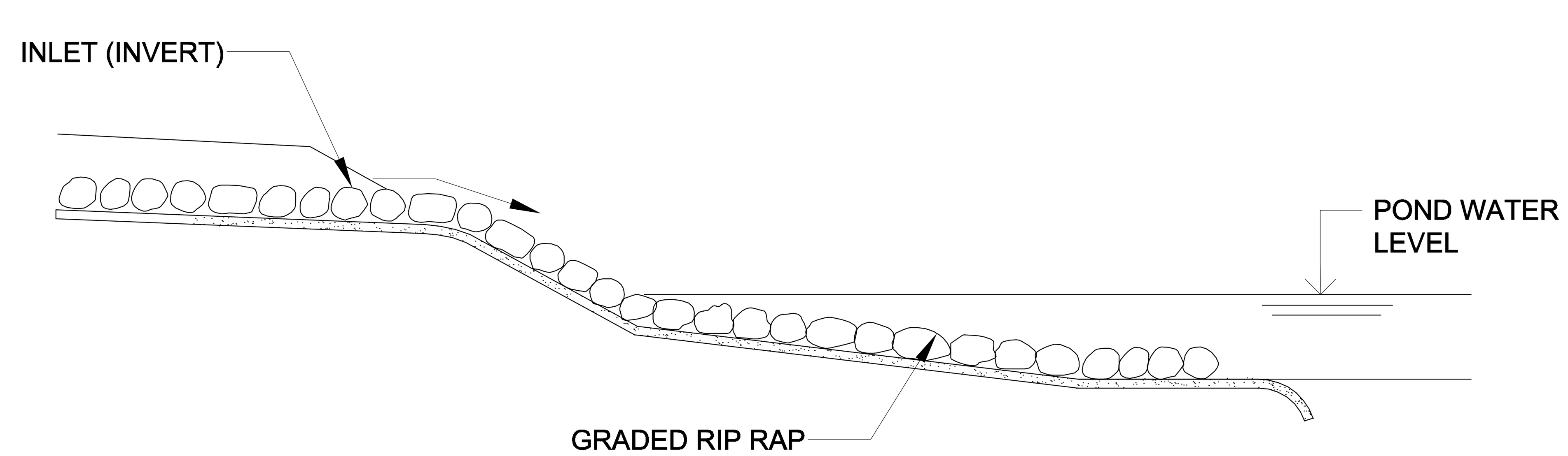
NA not applicable





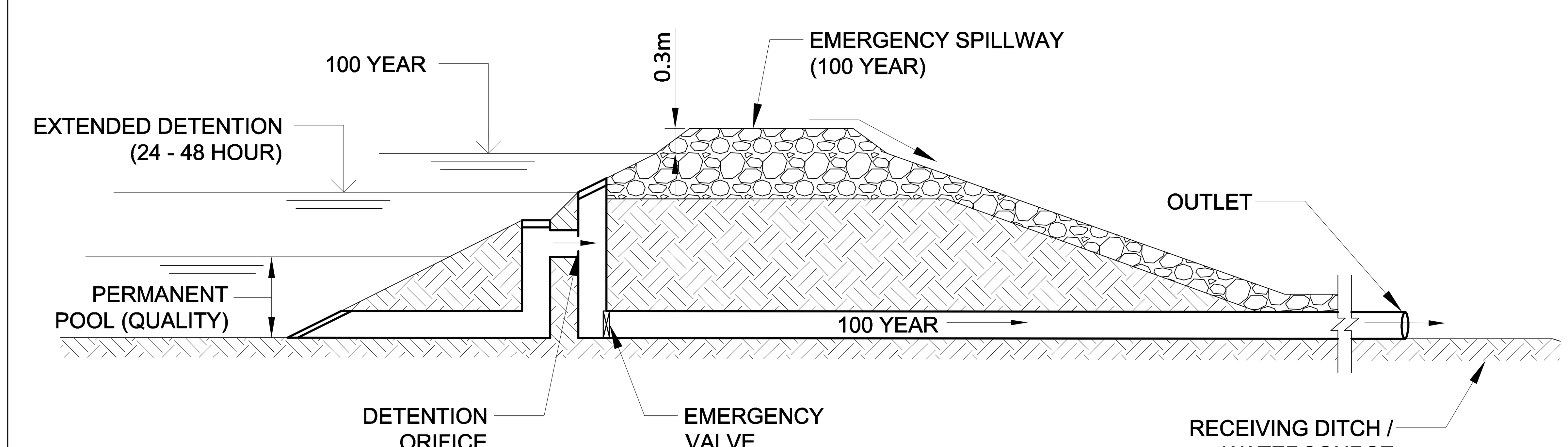






TYPICAL INLET WITH GEOTEXTILE

N.T.S.



TYPICAL OUTLET

N.T.S.

AECOM

AECOM Canada Ltd.
523 Wellington Street East, Sault Ste. Marie Ontario, Canada
P6A2M4 T705.942.2612 F705.942.3642

THE CORPORATION OF THE CITY OF SAULT STE. MARIE CANADA

STORMWATER MANAGEMENT PONDS

Sault Ste. Marie Municipal Landfill Site

THE CORPORATION OF THE CITY OF SAULT STE. MARIE, ONTARIO
ENGINEERING DEPARTMENT

COMMISSIONER OF ENGINEERING & PLANNING
JERRY DOLCETTI

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Consultant Drawing Number

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