August 2019

Proposed Terms of Reference Environmental Assessment of the Township of North Dundas Waste Management Plan

Volume 2

Table of Contents

Volume 2 – Supporting Documents

SUPPORTING DOCUMENT #1

Waste Management Alternatives Evaluation

August 2019

November 2015

REPORT ON

Waste Management Alternatives Evaluation Township of North Dundas

Submitted to:
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636 St. Lawrence Street
P.O. Box 489
Winchester, Ontario
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REPORT

Report Number: 1416664/6000

Distribution:

8 copies - Township of North Dundas
1 copy - Golder Associates Ltd.

Golder Associates

Executive Summary

The Executive Summary highlights key points from the report only; for complete information and findings, as well as the limitations, the reader should examine the complete report.

The Boyne Road Landfill Site (the Site) is the only municipal waste disposal site available for residents and businesses located in the Township of North Dundas (the Township). As part of a previous application procedure intended to amend the Site Environmental Compliance Approval (ECA), the Ministry of the Environment and Climate Change (MOECC) determined in late 2014 that the Site has exceeded its approved capacity and is in an overfill situation. Due to the elements governing the approved site capacity, the Township is unexpectedly now required to evaluate waste management alternatives to deal with this overfill situation at the Site.

This report provides an evaluation of waste management alternatives using a combination of technical, approvability and financial factors to assist the Township in deciding on the preferred course of action to provide both short-term and long-term waste management services for the municipality.

The alternatives available to the Township consist of the following:

- Alternative 1 – Landfill Site Closure and Export of Waste for Disposal;
- Alternative 2 – Landfill Site Expansion;
- Alternative 3 – Establish New Landfill Site in the Township; and,
- Alternative 4 – Alternative Waste Management Technologies (thermal treatment, e.g., Energy-from-Waste).

In this assessment, only Alternatives 1 and 2 were considered. Alternatives 3 and 4 are not expected to be financially viable alternatives considering the relatively small volume of waste generated within the Township, a lengthier and likely more contentious approvals process and/or the need to collaborate with other municipalities.

Alternative 1 would involve the following steps: 1) preparation of a closure plan for the landfill site by January 1, 2016; 2) application to establish a waste transfer facility at the Site (if the Township decides to continue providing the same level of service to the self-hauled and non-residential waste stream, referred to herein as Alternative 1a; it is referred to as Alternative 1b if the Township decides to cease providing these services to the non-residential waste stream); 3) negotiation of a disposal contract at the Lafleche landfill facility and commencement of hauling for disposal; and 4) completion of the landfill closure works (likely later in 2016).

Alternative 2 would involve the following steps: 1) obtain approval to continue landfilling operations on the existing approved footprint at the Site during the expansion approvals process; 2) secure the property and easements required for the expansion (or options to acquire them); 3) commence Environmental Assessment (EA) process for a 25-year Site expansion; 4) after EA approval, apply for amended ECA for expanded Site operations (expected 5 to 6 year combined EA and ECA approvals process); and 5) construct initial phase and associated works for the expansion area and commence landfilling. Closure work would occur in phases over the operational life of the expansion.

For Alternative 2, preliminary studies were undertaken to assess potential impacts associated with a conceptual expanded landfill layout on groundwater, surface water, atmospheric (air, odour, noise) and natural environment (biology). Details on each of these studies and the key findings and implications on the landfill expansion are provided. Of the technical considerations associated with the expansion, in terms of both operating considerations and costs, it is expected that the only economically viable approach for the Township is to continue operating an expanded Boyne Road Landfill as a natural attenuation site (one without a bottom liner, a leachate collection system and a requirement for treatment of the collected leachate), recognizing that it may be necessary for the Township to acquire additional property and/or Contaminant Attenuation Zone (CAZ) easement agreements. As such, the groundwater and surface water technical feasibility studies only considered proceeding with a landfill expansion on the basis of a continued natural attenuation landfill design approach.

To compare Alternatives 1 and 2, the following evaluation factors were considered:

- Technical feasibility;
- Likelihood to obtain MOECC Approval; and,
- Opinion of Probable Costs (capital expenditures and long-term annual operating costs over 30 years).

Alternative 1 – Closure of Boyne Road Landfill and waste export for disposal – is considered to be technically feasible. The only uncertainty for the Township under Alternative 1 would be the Conditions imposed by the MOECC for approval of the landfill site closure and for the establishment of a waste transfer station at the Site (if the Township decides to continue providing the current level of service to the self-hauled and non-residential waste stream), but these requirements are common to many landfill sites and the Conditions are not expected to be onerous. Beyond the 30-year planning period considered in this report, the Township may face uncertainty related to the remaining capacity at the selected private waste disposal facility (the Lafleche site), although the continuing demand for waste disposal in eastern Ontario is expected to result in the availability of an alternative to this facility in the longer-term, in the event the Lafleche site is not able to provide continuing services to the Township.

Alternative 2 – Expand the Boyne Road Landfill Site – is considered to have a reasonable likelihood of obtaining EA approval as a natural attenuation landfill, with the understanding that the Township can secure the required additional lands for the expansion and negotiate the required CAZ easements with adjacent landowners. If these cannot be secured, then an expansion application is unlikely to be successful since there is insufficient land area available on the currently owned landfill property and the CAZ does not extend far enough beyond the property in the required directions. If EA approval is received, in our experience there is little risk that the ECA amendment will not be subsequently approved. The technical feasibility of Alternative 2 appears favourable, although in view of changing political positions that could affect EA requirements, Ministerial approvals, and waste management practices, as well as potential stakeholder concerns, there is always a degree of uncertainty inherent in the outcome of an EA process.

The comparison of the Financial Implications of each Alternative indicates that Alternative 2 would yield an overall probable cost over 30 years approximately three times lower than Alternative 1a, and a similar overall probable cost to Alternative 1b over 30 years. Although the capital costs involved for Alternative 2 are greater than those of Alternative 1, the difference in operating costs over the course of the expected expansion lifetime

favours Alternative 2 over Alternative 1a and results in Alternative 2 being similar to Alternative 1b in terms of overall financial implications. It is noted that the capital costs for Alternatives 1a and 1b are expected to all occur in 2016 whereas much of the capital costs for Alternative 2 are expected to occur over the course of the lengthy approval process and the initial phase of construction of the expansion (from 2016 to 2022). Moreover, the difference in operating costs between the three Alternatives is due to waste hauling costs and tipping fees associated with Alternatives 1a and 1b. Although the Township is able to tender the hauling contract regularly (often on a 3 to 5 year basis), the waste disposal service provider is currently the only viable option available for the Township. The Township is expected to have to consider negotiation of a long-term contract for the tipping fees to avoid unforeseen future cost increases.

The summary of the waste disposal alternatives evaluation is presented in the table below:

	Considerations			Main Advantages	Main Disadvantages
	Technical Feasibility	**MOECC Approvals**	**Capital and Operating Costs**		
<u>Alternative 1:</u> Closure of Boyne Road Landfill and Waste Export (1a and 1b)	High degree of certainty	High degree of certainty	Similar (1b) to less favourable (1a)	1) High certainty 2) Fast transition from current waste management service 3) Lower capital expenditures	1) Higher operating costs 2) Dependency on a single waste disposal service provider
<u>Alternative 2:</u> Boyne Road Landfill Expansion	Likely	Reasonable likelihood to obtain approvals for a natural attenuation landfill	Similar (1b) to more favourable (1a)	1) Lower operating costs 2) Similar (1b) to lower (1a) overall financial implications 3) Continued operations at the Site under Township control	1) Higher capital expenditures 2) Relative uncertainty of EA approval 3) Lengthy approval process

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the results of an evaluation of waste management alternatives completed by Golder Associates Ltd. (Golder Associates) for the Township of North Dundas (the Township).

The Township of North Dundas (the Township) is located in Eastern Ontario, in the United Counties of Stormont, Dundas and Glengarry, approximately 40 km south of Ottawa. It was established in 1998 with the amalgamation of the former Townships of Winchester and Mountain and the Villages of Chesterville and Winchester.

The only waste disposal service currently available within the Township for local residents and businesses is the Boyne Road Landfill (the Site), owned and operated by the Township. The Site is located along Boyne Road, approximately 1.5 kilometres east of the Village of Winchester on Lot 8, Concession VI in the former Township of Winchester. The location of the Site is indicated on the Study Plan presented in Figure 1. Note that for the purposes of the discussion contained herein, Boyne Road is considered to be oriented in an east-west direction.

An Environmental Compliance Approval (ECA) amendment application was prepared in 2013 to recognize the Site Design and Operations Plan (D&O plan), include all lands used for contamination attenuation purposes on the Site ECA, and allow the Site to receive, and subsequently transfer, waste electronic and electrical equipment (WEEE).

Further to the receipt of comments from the Ministry of the Environment and Climate Change (MOECC) reviewer on the D&O Plan, it was determined that the Site has exceeded its approved capacity and is in an overfill situation. Due to the elements governing the approved site capacity, the Township is unexpectedly now required to evaluate waste management alternatives to deal with this overfill situation at the Site. This report is intended to provide an evaluation of waste management alternatives using a combination of technical, approvability and financial factors to assist the Township in deciding on the preferred course of action to provide both short-term and long-term waste management services for the municipality.

1.1 Background

The Boyne Road Landfill Site has been operating as a licensed landfill facility since 1965. The landfill site currently operates under Environmental Compliance Approval (ECA) No. A482101 issued on December 4, 1989. The ECA was amended on September 5, 1995 to allow the landfill site to accept waste from the Village of Chesterville, in addition to waste from the Village of Winchester and the Township of Winchester. Subsequent to municipal amalgamation, the landfill site was licensed to accept waste from the newly established Township (which includes the Village of Chesterville, the Village of Winchester, the former Township of Winchester, and the former Township of Mountain). The ECA was amended on October 2, 1995 to allow the Township to operate a municipal waste recycling facility at the Site. The ECA was again amended on September 18, 1996 to allow the establishment and operation of a household hazardous waste transfer facility at the Site.

As indicated earlier, an ECA amendment application was prepared in 2013. Further to review of the D&O Plan by the MOECC in late 2014, it was determined that the Site has exceeded its approved capacity and is in an overfill situation. An Emergency ECA was issued by the MOECC (ECA Notice No. 6 issued on July 10, 2015) to grant a temporary approval for continued landfilling at the Site lasting until January 31, 2016.

In the Addendum to the Site D&O Plan dated January 2015, during the emergency period it was proposed to evaluate alternatives to identify the preferred alternative for the Township's long-term waste management plan. In a letter dated August 28, 2015, Golder Associates, on behalf of the Township, indicated that the Township would submit Council's decision to the MOECC by November 30, 2015.

2.0 WASTE DISPOSAL ALTERNATIVES

Prior to the determination that the disposal of waste at the Boyne Road Landfill is in excess of its maximum approved site capacity, the Township's waste management plan was to continue to carry out waste diversion operations at the Site and utilize the Site for disposal of waste for another 10 years or more.

However, during the Emergency ECA period, the Township is required to undertake an assessment of waste management alternatives available to them to decide on their preferred approach for short term to long term waste management in the Township.

The alternatives available to the Township consist of the following:

- Alternative 1 – Landfill Site Closure and Export of Waste for Disposal

  Under Alternative 1, the Boyne Road Landfill would be closed following the emergency operational period. The Township would likely continue to operate waste diversion activities at the landfill site or elsewhere, and the remaining waste would be exported to an appropriately licensed landfill for disposal. The Township may decide to operate a waste transfer station to continue accepting/collecting the self-hauled and non-residential waste stream and export it to a disposal facility. At the present time there are two landfill sites in eastern Ontario licensed to receive solid non-hazardous waste from the Township of North Dundas for disposal, both of which are owned and operated by the private sector. The two sites are the Eastern Ontario Waste Handling Facility located in North Stormont near Moose Creek (commonly referred to as the Lafleche site) and Waste Management's Ottawa (Carp Road) Landfill in the western portion of Ottawa. The Carp Road Site is currently inactive, and has applied for an ECA to re-open an expansion of the site that has already received approval under the Environmental Assessment Act (EAA).

- Alternative 2 – Landfill Site Expansion

  Under Alternative 2, the process to obtain approval for an increase in the disposal capacity of the Boyne Road Landfill would be undertaken so that waste disposal would continue at this location under the ownership of the municipality. To determine the technical and economic feasibility of this alternative, an initial technical evaluation of the expected design and operational requirements to successfully obtain approval of an expansion under the *Environmental Assessment Act* (EAA) as well as O.Reg. 232/98 Landfill Standards was undertaken and is reported in Section 4.2.

- Alternative 3 – Establish New Landfill Site in the Township

  Under Alternative 3, the Township would evaluate the potential to establish a disposal site at a new location within the municipality. The Boyne Road Landfill would therefore be closed following the emergency operational period. However, considering the long time period typically required to undertake waste management planning studies to obtain approval for the establishment of new waste disposal site, it is expected that a short term alternative would have to be selected from either obtaining an extension of the emergency operational period to continue landfilling at the Boyne Road Landfill in the interim period or export waste to an appropriately licensed landfill for disposal (likely the Eastern Ontario Waste Handling Facility as per Alternative 1).

  The Township could consider establishing a new regional waste disposal site to share the capital expenditures and financial liability with neighbouring municipalities that may also be in the process of evaluating their long-term options for waste management.

Because this alternative would involve a search for and identification of a new site for a new landfill, of the available alternatives it is anticipated that this one is likely to be the most controversial (followed by Alternative 4, see below) with the public and raise the greatest concerns. Based on recent discussions between representatives of the Township and neighbouring municipalities about their need for long-term waste management options, neighbouring municipalities did not express interest in partnering with the Township for the establishment of a new regional landfill site, mostly due to their relatively close proximity to the existing Eastern Ontario Waste Handling Facility, located near Moose Creek, Ontario (operated by Lafleche Environmental Inc.). It is assumed that further assessment of this alternative is not required at this time.

- Alternative 4 – Alternative Waste Management Technologies (thermal treatment, e.g., Energy-from-Waste facility)

Under Alternative 4, the Township would evaluate the potential to use an alternative waste management technology like an energy-from-waste facility (EFW, where waste is combusted at extremely high temperature, resulting in heat that can be used in a steam powered generator for instance) at a new location within the municipality. The Boyne Road Landfill would therefore be closed following the emergency operational period. However, considering the length of time to select a technology provider, obtain approval and build such a facility, it is expected that a short term alternative would have to be selected from either obtaining an extension of the emergency operational period to continue landfilling at the Boyne Road Landfill in the interim period or export waste to an appropriately licensed landfill for disposal (likely the Eastern Ontario Waste Handling Facility as per Alternative 1).

Similar to Alternative 3, the Township could share the capital expenditures and financial liability with neighbouring municipalities that may also be in the process of evaluating their long-term options for waste management.

It is noted that the few approved EFW in Ontario (Algonquin Power EFW Facility in Brampton, Durham York Energy Centre in Clarington, and the Peel Energy Recovery Centre) have a processing capacity of 140,000 to 182,500 tonnes of waste per year, more than 10 times the current waste disposal needs of the Township. Also, the capital and operating costs of such facilities are expected to be magnitudes higher than Alternatives 1 and 2 (e.g., $284.2 million gross capital costs and $8.5 million gross annual operating costs in 2010 dollars for the Durham York Energy Centre). EFW facilities usually operate at a steady processing rate for their lifetime, making them adapted for a large base load waste processing need. Also, these technologies still require a disposal or reuse solution for the remaining residual materials (bottom ash).

In view of the high capital and operating costs associated with a waste management alternative involving a technology such as incineration/EFW, it is considered that this would not be feasible for a small municipality such as the Township, and so assessment of this alternative is not included in this evaluation.

In this assessment it is proposed to only consider Alternatives 1 and 2. Alternatives 3 and 4 are not expected to be viable alternatives considering the relatively limited volume of waste produced within the Township and their controversial nature, which could result in a lengthier approval process compared to the two short listed Alternatives.

3.0 CURRENT WASTE MANAGEMENT PROGRAMS AND WASTE DISPOSAL PROJECTIONS

3.1 Waste Management Programs Provided by the Township

The Township, through its Waste Management department and its waste hauling contractors, provides curbside waste collection and disposal services to its ratepayers. It also provides several waste diversion services, including recyclable materials and leaf and yard waste curbside collection, as well as the collection of household hazardous waste (HHW) as well as Waste Electrical and Electronic Equipment (WEEE) for export to authorized processing facilities.

The Township's diversion rate, as reported in 2013 to Waste Diversion Ontario, is approximately 25 percent (%).

The recycling facility, the HHW and WEEE transfer station as well as the waste disposal facility are located at the Boyne Road Landfill Site. All recyclables collected within the Township are taken to the recycling transfer station at the Boyne Road Landfill Site, from where they are transferred out of the Township by a recycling contractor. In 2014, the following recyclable materials were collected: 29.70 tonnes of steel; 92.35 tonnes of plastic; 9.22 tonnes of aluminum; 259.76 tonnes of (news) paper; and 312.67 tonnes of cardboard.

The Site is licensed for the disposal of domestic, commercial, and industrial solid non-hazardous waste. Waste received by the facility consists of all domestic household waste and a large portion of the institutional, commercial and industrial (IC&I) non-hazardous solid waste generated within the Township. According to the most recent estimate (from November 2014), which consisted of volumetric calculations based on topographical survey data, the annual calculated fill rate at the Site is 18,900 m^3 per year.

The approved landfill disposal area is 8.1 hectares. A buffer zone that extended the property boundaries of the Site 30 metres east, west, and south of the fill area was purchased in 1992 (Part 2 of Plan 8R – 3142, Lot 8, Concession VI). A rectangular parcel of land (7.2 hectares in area, Part 1 of Plan 8R – 4441, Lot 8, Concession VI) that extends 150 metres south of the buffer zone was subsequently purchased by the Township to be used for contaminant attenuation purposes.

In 2011, a 10.59 acre parcel of land to the south of the landfill (4.29 hectares in area, Part 7 of Plan 8R – 5197) was purchased by the Township to be used for contaminant attenuation purposes, while a groundwater easement was obtained on a 54.45 acre parcel of land to the south and west of the site (22.04 hectares in area, Parts 1 to 6 of Plan 8R – 5197) to be used as a contaminant attenuation zone (CAZ). These lands were registered on title to the landfill on October 24, 2011.

A portion of the landfill leachate plume extends to the north of Boyne Road, onto property owned by the Ministry of Natural Resources and Forestry (MNRF). The Township has notified the MNRF of the potential leachate impacts to groundwater. As the MNRF did not at the time wish to transfer land or groundwater rights, an agreement was reached to allow the Township to use the MNRF property for contaminant attenuation purposes. A Land Use Permit (LUP) to reflect this agreement has been negotiated between the Township and the MNRF and was signed on October 14, 2015 for 49.21 hectares of the MNRF property (Parts 1 and 2 of Plan 8R – 225). It is noted that the LUP is only valid until September 28, 2016. However, it is understood that MNRF indicated to the Township that it was willing to negotiate in 2016 to establish a long term registered easement over the property.

It is noted that Boyne Road is owned by the Township and therefore no easement is required for this road allowance to be used for contamination attenuation purposes.

The landfill site boundaries (including the buffer zone) and the CAZ boundaries are indicated on Figure 2.

3.2 Volume of Waste in Place and Approved Site Capacity at Boyne Road Landfill

Further to the receipt of comments from the MOECC as described in the Introduction and subsequent consultation with the MOECC Cornwall Area Office on November 6, 2014, the Township requested Golder Associates to calculate the corresponding approved site capacity and have the Site surveyed to estimate the volume of waste currently in place.

According to the Ministry's Landfill Capacity Determination Guideline published in 1993, it was determined that the approved site capacity was approximately 395,000 m^3, based on the dimensions provided in the original application for registration as a landfill disposal site (an application form filled out by a Township clerk in 1971).

A site survey was subsequently carried out by Golder Associates on November 12, 2014 to estimate the amount of waste in place. The volume of waste in place at the Site as of November 2014 was estimated to be 462,000 m^3. It was determined that the Site had exceeded its approved capacity and was overfilled by approximately 67,000 m^3. This is referred to as an overfill situation in the MOECC Guidelines.

In the Addendum to the D&O Plan (January 2015), a disposal volume of approximately 22,000 m^3 was designed to accommodate the estimated amount of waste to be landfilled until the end of January 2016. Therefore, the amount of waste in place at the Site at the end of the emergency period on January 31, 2016 is estimated to be approximately 484,000 m^3.

3.3 Waste Disposal Requirements Projections

For the purpose of this evaluation, it is assumed that the waste diversion rate of the Township will remain constant at the current level for future years. However, it is understood that, in accordance with both municipal and provincial objectives, the Township will continue to provide waste diversion services to its ratepayers and continue looking for opportunities to increase its waste diversion rate, regardless of the waste management alternative selected by Council. Waste disposal projections for this assessment were based on the latest population growth statistics available for the Township, as shown in Table 1.

Table 1: Total Population – Township of North Dundas

	Census Year			
	1996	**2001**	**2006**	**2011**
Total Population	11,064	11,014	11,095	11,225

Source: Statistics Canada http://www.statcan.gc.ca

It is therefore assumed in this report that the waste disposal requirements of the Township will increase by 0.24% per year in the next 20 to 30 years based on a percentage change of 1.2% in the Township's population from 2006 to 2011 (see Table 2). In this evaluation, the projected waste disposal requirements for 25 years include approximately two years of waste disposal contingency to account for unexpected variations in waste disposal requirements over time.

Table 2: Assumed Waste Disposal Requirements, Township of North Dundas

Year	Assumed Annual Volume of Landfilled Waste (m^3)
2014	18,900
2015	19,000
2016	19,100
2017	19,200
2018	19,300
2019	19,400
2020	19,500
2021	19,600
2022	19,700
2023	19,800
2024	19,900
2025	20,000
2026	20,100
2027	20,200
2028	20,300
2029	20,400
2030	20,500
2031	20,600
2032	20,700
2033	20,800
2034	20,900
2035	21,000
2036	21,100
2037	21,200
2038	21,300
2039	21,400
2040	21,500
2041	21,600
TOTAL for 2016 to 2041 + 2 years disposal contingency	**553,500 m^3**

As noted in Section 3.1, in the absence of a weigh scale at the landfill site, the conversion from known volume to tonnage is only an approximation. The volumetric projections provided in Table 2 have been used in the assessment of Alternative 2.

The volumetric projections of the Township's waste disposal requirements presented above indicate that waste generated within the Township consumed approximately 19,000 m^3 of landfill space in 2015. As noted above, in the absence of a weigh scale at the landfill site, the conversion from known volume to tonnage is only an approximation. Assuming a typical waste to cover ratio of 4 to 1 and a density of compacted waste of 0.7 MT/m^3, the conversion to tonnage based on this annual landfill volume consumption would correspond to approximately 10,600 tonnes of waste disposed in 2015 (which includes both residential and non-residential waste streams).

However, it is understood that the actual tonnages of residential waste currently being exported to the Lafleche landfill site by neighbouring municipalities are in the order of 3,000 tonnes per year for a similar number of residents.

According to CANSIM Table 153 0041 from Statistics Canada, in Ontario the residential sources of waste for disposal represented 36.4% in 2012 and non-residential sources represented 63.6%. Based on the 2012 population estimate for Ontario (CANSIM Table 051 0001 from Statistics Canada), a total of 666 kg of waste was generated per capita in Ontario in 2012.

Considering the Township population (estimated to be 12,000 residents in 2015), this would represent a total of 8,000 tonnes of waste for disposal generated per year by both residential and non-residential sources. The discrepancy between this estimate and the higher previous estimate based on annual landfill volume consumption can be explained by variability in landfill operations (density obtained after compaction, use of cover material, etc.) and diversion rates.

Assuming the portion of residential waste generated for disposal within the Township does not differ greatly from the Ontario average, residential waste would represent approximately 2,900 tonnes per year. This estimate is similar to actual tonnages of residential waste exported yearly to Lafleche by neighbouring municipalities.

Current landfill operations at the Site include municipal collection and the self-hauled and IC&I waste stream from local Township residents and businesses. For this assessment, there are two options to be considered for Alternative 1. The first option (Alternative 1a) would be that the Township intends to continue providing the current level of service for both the residential and non-residential waste streams. However, the Township can decide whether or not to continue providing waste management services to the non-residential waste stream (Alternative 1b). If the Township decides not to continue to provide this service, then those that self-haul their waste (including local institutions and businesses) would have to look after their waste disposal requirements independent of the Township. The quantity of waste being exported by the Township for disposal would decrease by a corresponding amount, i.e., from approximately 8,000 tonnes per year to 2,900 tonnes per year.

Therefore, for Alternative 1 it was decided in conjunction with the Township to base tonnage estimates in this assessment on Ontario average waste generation statistics. It appears that a large portion of waste currently accepted at the Boyne Road Landfill for disposal may be generated by non-residential sources.

Based on these statistics, under Alternative 1a, the Township would export approximately 8,000 tonnes of waste per year for disposal at the Lafleche site. Under Alternative 1b, only 2,900 tonnes of waste would have to be exported for disposal.

It is noted that the introduction of new regulations mandating increased IC&I and Construction and Demolition (C&D) waste diversion by the Province of Ontario, which are anticipated, will further motivate/require IC&I and C&D generators and haulers within the Township to take actions to increase diversion, and should over time decrease the amount of waste being sent for disposal.

Although the assumptions of future population growth and diversion rates may diverge from the Township's own projections, the intention is to quantify the Township's waste disposal requirements to evaluate the corresponding annual operating costs and expected capital expenditures for each waste management alternative considered in this assessment.

4.0 WASTE DISPOSAL ALTERNATIVES CONSIDERED IN THIS EVALUATION

As discussed in Section 2.0, from the four alternatives available to the Township for its long-term management of waste, only two alternatives are being considered in this evaluation: Alternative 1 (Landfill Site Closure and Export of Waste for Disposal) and Alternative 2 (Boyne Road Landfill Site Expansion). This Section provides an analysis of the technical feasibility, approvability and financial implications for each of these two alternatives to assist the Township in its decision-making process.

4.1 Alternative 1: Landfill Closure and Waste Export

Condition 2.4 of the Site ECA dictates the immediate requirements should the Township decide to discontinue landfilling operations at the Site beyond January 31, 2016, which includes the following:

- preparation of a detailed Closure Plan for submission by January 1, 2016 to the Director of the MOECC for review and approval; and,
- placement of 300 mm of interim clayey cover upon the site ceasing landfilling operations until the Closure Plan has been approved.

While the Closure Plan submission is undergoing MOECC review, preparation of the closure cover design and tender package would proceed such that the work is ready to proceed on receipt of MOECC approval of the Plan.

The closure of the only active waste disposal site within the Township would not only require planning for site closure works, but also selection of an appropriate licensed landfill for disposal of the waste stream that cannot be diverted from disposal. Based on current operations at the Site, a Waste Transfer Station (WTS) would be established at the Site (if the Township decides to continue collecting the self-hauled and IC&I portion of the waste stream) for subsequent export to the preferred waste disposal service provider. The Township would have to obtain approval from the MOECC via the issuance of an ECA amendment to establish a Waste Transfer Facility at the Site.

According to Condition 2.1 of the Site ECA, continued landfilling operations have been permitted only until January 31, 2016. Considering that the Township is intending to communicate to the MOECC its preferred alternative for the long-term management of waste by November 30, 2015, there would be only two months available to prepare the transition to waste export, which could be difficult to achieve. Although it is believed that such a transition could be done for the curbside collection waste stream using the existing waste hauling contractor, the Township would require additional time to amend the D&O Plan and prepare an application package to obtain ECA amendment approval from the MOECC if it is decided to continue providing services to the self-hauled and IC&I waste stream via the establishment of a WTS.

Therefore, it would be reasonable to assume an interim solution should be negotiated with the MOECC to grant permission to continue landfilling operations at the Site at least until the end of April 2016 to allow sufficient time for Council to approve each decision leading to the closure of the Site and the establishment of a long-term waste disposal service contract with the preferred waste services provider. Depending on the complexity of the D&O Plan for the WTS, the MOECC may grant an interim approval to start operations of a WTS at the Site (if Council decides to continue this service) reasonably soon after receiving the application package.

4.1.1 Boyne Road Landfill Site Closure Approval Process

As indicated earlier, under Alternative 1 the Township would have to prepare a Closure Plan in accordance with Condition 2.4 of the Site ECA. The Closure Plan should include at least the following items listed in the ECA:

- A plan showing site appearance after closure;
- A description of the proposed end-use of the Site;
- Descriptions of the procedures for the closure of the Site, including:
  - Advance notification of the public of the landfill closure;
  - Posting of a sign at the Site entrance indicating the landfill is closed and identifying any alternative waste disposal arrangements;
  - Completion, inspection and maintenance of the final cover and landscaping;
  - Site security;
  - Removal of unnecessary landfill-related structures, buildings and facilities; and,
  - Final construction of any control, treatment, disposal and monitoring facilities for leachate, groundwater, surface water and landfill gas.
- Descriptions of the procedures for post-closure care of the Site, including:
  - Operation, inspection and maintenance of the control, treatment, disposal and monitoring facilities for leachate, groundwater, surface water and landfill gas (if any);
  - Record keeping and reporting; and,
  - Complaint contact and response procedures.
- An assessment of the adequacy of and need to implement the contingency plans for leachate and landfill gas; and,
- An updated estimate of the contaminating life span of the Site, based on the results of the monitoring programs to date.

A topographical survey of the entire waste footprint should be completed at the Site soon after the Township has made a decision on the preferred alternative. A test pit investigation would need to be conducted by the Township in order to evaluate the thickness of soil cover materials currently in place at the Site. The data from the survey and the test pit investigation would be used to design the final cover with the intent to limit the amount of closure works required. The final cover design should follow the recommendations presented in Section 8.22 of the approved 2013 D&O Plan that were based on the requirements of O. Reg. 232/98 Landfill Standards.

The Closure Plan must be submitted by January 1, 2016 to the Director of the MOECC for review and approval (Condition 2.4 (1) of the Site ECA). The estimated time to receive MOECC approval of the Closure Plan is 3 to 6 months from its submission for approval (i.e., spring or summer of 2016). The Township would then be able to proceed with the closure works, likely during the 2016 construction season.

4.1.2 Boyne Road Waste Transfer Station Approval Process

Current landfill operations at the Site include processing of the self-hauled and IC&I waste stream from local Township residents and businesses. In this analysis, two options (Alternatives 1a and 1b) are being considered for Alternative 1. The first option (Alternative 1a) is for the Township to continue providing the current level of service for both the residential and non-residential waste streams. However, the Township can decide whether or not to continue providing waste management services to the non-residential waste stream (Alternative 1b).

As indicated in Section 4.1, if the Township decides to continue providing these services to the self-hauled and IC&I waste stream, under Alternative 1a, the Township would have to establish a WTS to collect this waste stream and transfer it off-site to another appropriately licensed waste disposal site.

In accordance with Section 27 of the *Environmental Protection Act* (EPA), the Township would have to obtain approval from the MOECC via an amendment of the current Site ECA to establish such a facility.

The preparation of this application package would require an estimate of the current and future tonnages of the self-hauled and IC&I waste stream at the Site to determine the design capacity of the future WTS. A D&O Plan would then have to be developed based on these estimates and the Township would have to prepare the MOECC ECA Application Form for a Waste Transfer Facility.

The estimated length of time to receive MOECC approval for the establishment of a WTS at the Site is typically about 1 to 1.5 years from its submission for approval (i.e., spring or fall of 2017).

Based on the processing time generally experienced for similar projects, it is considered that an interim solution could be negotiated with the MOECC District Manager to grant permission to start operation of an interim WTS immediately after ceasing landfilling operations. Interim approval may be granted by the District Manager via the issuance of a Provincial Officer Order under Section 157.1 of the EPA.

4.1.3 Closure Works and Waste Export Technical Feasibility

Review of the landfill cross-sections shown on Figure 4 indicates that the western portion of the Boyne Road Landfill has been developed using 4H:1V side slopes from the approved waste footprint.

There is, however, by virtue of small deviations from the approved waste contours, a small amount of waste in place outside of the proposed final contours presented in the original 2013 D&O Plan along the western slope of the landfill, and along the eastern toe of the landfill. It is intended to complete shaping of the waste pile prior to application of final cover.

Closure works would therefore require re-shaping limited areas of the Site and then construction of the final cover.

Based on a preliminary evaluation of the design capacity required for the WTS, it may be possible to handle the self-hauled and IC&I waste stream with the use of a couple of self-contained waste roll-off compactors, which could be stationed outdoors near the existing recycling facility. The WTS operations would require a supervisor to ensure safe and appropriate use of the compactors by the Site visitors. Once they reach capacity, the compactors could be hauled by a contractor to the waste disposal facility selected by the Township for its curbside waste collection stream.

At the present time there are two landfill sites in eastern Ontario licensed to receive solid non-hazardous waste from the Township for disposal, both of which are owned and operated by the private sector, and which can be considered. The two sites are the Eastern Ontario Waste Handling Facility located in North Stormont near Moose Creek (commonly referred to as the Lafleche site) and Waste Management's Ottawa (Carp Road) Landfill in the western portion of Ottawa. The Carp Road Site is currently inactive, and has applied for an ECA to re-open an expansion of the site, which has already received approval under the *Environmental Assessment Act* (EAA). Therefore, in the short term, the Lafleche site is the only waste export option for the Township.

Lafleche Environmental Inc. (LEI) operates the Lafleche site, and also provides waste transfer services at the Russell/Vars WTS. Although the Russell/Vars WTS is located closer to the Township compared to the Lafleche site (see Figure 1), the price quoted by LEI to haul waste from its transfer station to its waste disposal site does not compensate the marginal difference in hauling costs for the Township to send its waste directly to the Lafleche site ($21 extra per metric tonne (MT) to handle waste from their WTS as compared to direct hauling waste to their disposal facility). The Russell/Vars WTS is located approximately 35 km north of Boyne Road Landfill, whereas the Lafleche disposal site is located approximately 45 km northeast of the Site.

Based on information provided by LEI, from a disposal capacity perspective it appears that the Lafleche site currently has a remaining site life of 8 years. However, LEI is in the process of obtaining an expansion approval for Stages 3B/4, which would enable an estimated additional 10 years of disposal capacity. In the long term, LEI assured the Township that they can provide a secure long term waste disposal alternative for the next 25 years.

It is understood that LEI would be able to handle waste from the Township for disposal as soon as Boyne Road Landfill Site ceases its landfilling operations.

Alternative 1, consisting of closure works at the Site, the establishment of a WTS at Boyne Road Landfill Site (for Alternative 1a only), and the export of waste to the Lafleche site for disposal is considered to be technically feasible.

4.1.4 Financial Implications for Alternative 1

The capital expenditures and annual operating costs have been estimated for each of the two waste management alternatives for waste disposal. It is noted that all costs provided herein are Opinions of Probable Cost (OPC) based on a number of assumptions and are likely to vary from actual costs. They should therefore not be considered for budgeting purposes at this time, but should only be considered as "ballpark" cost estimates to compare the financial implications of each waste management alternative presented in this report.

The following table presents the estimated expenditures that can be expected in 2016 if a decision is made by the Township to proceed with Alternative 1:

Table 3: Alternative 1 – Estimated Expenditures

Description	Est. Quantity	Unit	Unit Price	OPC (in 2015 dollars)
Closure Works				
Shape Waste[1]	1	L.S.	$20,000	$20,000
Placement of Interim Cover[2]	6,800	m^3	$15	$100,000
Placement of General Earth Material[3]	24,300	m^3	$15	$370,000
Placement of Soil Capable to Sustain Vegetation (topsoil)[4]	12,200	m^3	$30	$370,000
Hydroseeding	81,000	m^2	$0.50	$40,000
Signage	1	L.S.	$1,000	$1,000
Engineering and Approvals				
Engineering and Supervision of Work[5]	1	%	10	$100,000
Preparation of a Closure Plan	1	L.S.	$10,000	$10,000
Preparation of an ECA Amendment Application	1	L.S.	$2,000	$2,000
Submission to Ministry for Review and Approval (Site Closure)[6]	1	L.S.	$1,400	$1,400
Obtaining Approval from the Ministry to Establish a WTS at the Site (Alternative 1a only)[7]	1	L.S.	$14,300	$14,300
10% Contingency	1	%	10%	$103,000
OPC TOTAL (excluding HST):				**$1,130,000**

Notes:
L.S.: lump sum; m^3: cubic metre; %: percent
[1] Based on estimate from the Township.
[2] Includes hauling, placing, compacting and grading of material (quantities based on 300 mm of clayey material as per Condition 2.4 (2) of the Site ECA over the 2015 active area). It is assumed that the Township would source the material from its property north of Boyne Road.
[3] Includes hauling, placing, compacting and grading of material (quantities based on assumed 300 mm cover already in place and 300 mm of general earth material to be added over the entire waste footprint, in accordance with the approved 2013 D&O Plan). It is assumed that the Township would source the material from its property north of Boyne Road.
[4] Includes supplying, hauling, placing, compacting and grading of material (quantities based on 150 mm of soil capable of sustaining vegetation over the 8.1 hectare area of the Site, in accordance with the approved 2013 D&O Plan). It is assumed that the Township would source the material from a contractor.
[5] Includes topographical surveys before and after placement of cover materials, test pit evaluation of cover materials already in place, as well as supervision and documentation of closure works. It was assumed that the Township would prepare a tender package and locate sources for the materials required.
[6] Based on Minister's Requirement for Fees, October 31, 2011. Administrative fee: $200; Amendment & Revocations: $1,200 if no fundamental design review or hydrogeological assessment is required; $22,500, if the design capacity of the site is more than 40,000 m^3 and not more than 3 million m^3 and, in the opinion of the Director, the application requires a fundamental design review or hydrogeological assessment.
[7] Includes preparation of a D&O Plan for a WTS, submission to the Ministry for review and approval, as well as Ministry processing fees based on Minister's Requirement for Fees, October 31, 2011. Administrative fee: $200; Amendment & Revocations: $100, if, in the opinion of the Director, the application does not require a fundamental design review; $700 if the design capacity of the WTS is 100 tonnes or less per day and, in the opinion of the Director, the application requires a fundamental design review.

If the Township decides to cease providing services to the self-hauled and IC&I waste stream (Alternative 1b), the capital expenditures associated with the establishment of a WTS would not be incurred and the annual operating costs would decrease since they are proportional to the quantity of waste to be exported for disposal at the Lafleche Site.

The following tables present the expected annual operating costs (in 2015 dollars) for Alternatives 1a and 1b, as defined in Section 3.3:

Table 4a: Alternative 1a – Estimated Annual Operating Costs

Description	Est. Quantity	Unit	Unit Price	OPC (in 2015 dollars)
Elimination of Landfill Operating and Maintenance Costs[1]	1	L.S.	-$55,000	-$55,000
Incremental Operating Costs for WTS	--	--	--	--
Incremental Hauling Costs for Waste Export[2]	1	L.S.	$100,000	$100,000
Lafleche Site Tipping Fees	8,000	Tonnes	$56	$450,000
Engineering				
Incremental Annual Monitoring and Reporting Costs as Compared to Alternative 2	--	--	--	--
OPC TOTAL (excluding HST):				**$500,000**

Notes:
Costs savings are in red. L.S.: lump sum
[1] Based on estimate from the Township.
[2] Based on unit prices obtained by the Township (30 MT per load, $125/hour to haul waste and 3-hour round-trip between the Township and the Lafleche site, $56/MT tipping fee at Lafleche site in 2015).

Table 4b: Alternative 1b – Estimated Annual Operating Costs

Description	Est. Quantity	Unit	Unit Price	OPC (in 2015 dollars)
Elimination of Landfill Operating and Maintenance Costs[1]	1	L.S.	-$55,000	-$55,000
Incremental Operating Costs for WTS	--	--	--	--
Incremental Hauling Costs for Waste Export[2]	1	L.S.	$40,000	$40,000
Lafleche Site Tipping Fees	2,900	Tonnes	$56	$160,000
Engineering				
Incremental Annual Monitoring and Reporting Costs as Compared to Alternative 2	--	--	--	--
OPC TOTAL (excluding HST):				**$150,000**

Notes:
Costs savings are in red. L.S.: lump sum
[1] Based on estimate from the Township.
[2] Based on unit prices obtained by the Township (30 MT per load, $125/hour to haul waste and 3-hour round-trip between the Township and the Lafleche site, $56/MT tipping fee at Lafleche site in 2015).

It is noted that the annual operating costs are expected to increase by CPI rate as well as population growth, as indicated in Section 3.3.

4.2 Alternative 2: Boyne Road Landfill Expansion

The expansion of the Boyne Road Landfill to increase its disposal capacity by approximately 642,500 m^3, including the overfill volume at the end of the emergency period (since it is the volume of waste in excess of the currently approved capacity) and 553,500 m^3 to meet the Township's waste disposal requirements for a 25-year planning period (estimated additional volume includes approximately 2 years of disposal capacity as a contingency, refer to Section 3.3) will require completion of an environmental assessment (EA) for approval under the *Environmental Assessment Act* (EAA). Following EA approval, an application is required for amendment to the site's Environmental Compliance Approval (ECA) to satisfy both the technical and operational requirements of the *Environmental Protection Act* (EPA) and *Ontario Water Resources Act* (OWRA), and the requirements of O.Reg. 232/98 Landfill Standards.

Section 4 of O.Reg. 101/07 requires completion of an individual EA to obtain approval for this amount of landfill capacity increase. An EA is a planning study that assesses environmental effects and advantages and disadvantages of a proposed project, uses a decision-making framework to compare alternatives and identify the preferred alternative for the project, and provides opportunity for consultation with interested stakeholders and requires consideration of their input to the process. The environment has to be considered broadly to include the natural, social, cultural and economic aspects of environment. The EA process has two steps:

- Step 1 is the preparation and submission for approval by the MOECC of the EA Terms of Reference (TOR). The TOR provides the framework and methodology to be followed for the preparation of the EA. Consultation with government review team agencies, Aboriginal groups and the public is required during development of the TOR. It is permissible to scope the EA such that certain requirements of the EA process are satisfied and approved in the TOR; for this landfill expansion, it is expected that the rationale for the project (why the landfill expansion is needed) and the evaluation of 'alternatives to' (the different ways that the need could be addressed and identification of the preferred approach, which is essentially described in this report) would be completed in the approved TOR. Because the EA must be completed in accordance with the approved TOR, it is important to carefully and strategically plan the EA methodology, scope of the EA studies and consultation process and define them in the TOR; in this way, limits are established in the approved TOR on the extent of the studies and alternatives that have to be subsequently considered and assessed in the EA.
- Step 2 is preparation and submission of an EA Study Report for approval by the Minister of the MOECC. For the expansion of the Boyne Road Landfill Site, it is expected that the EA will involve: 1) completion of a number of technical studies to characterize the existing physical and natural environment on and in the area of the site (groundwater, surface water, biology, atmospheric, archaeological, socio-economic); 2) development of a limited number of alternatives for expansion of the landfill; 3) prediction of the potential effects of the expansion alternatives on the environment and, where applicable, assessment of the expected performance of the expanded landfill against regulatory standard and guidelines; 4) using evaluation criteria established in the approved TOR, comparison of the expansion alternatives and identification of the preferred alternative; 5) preparation of the EA Study Report; and 6) a consultation process throughout.

The time required for the work and the regulatory approvals process to prepare, consult on and obtain approval of the TOR and EA from the Minister of the MOECC depends to some degree on the complexity of the project, technical issues that arise and require resolution, and the amount of public participation and/or opposition to the project. For the Boyne Road Landfill expansion, the following time estimates are provided:

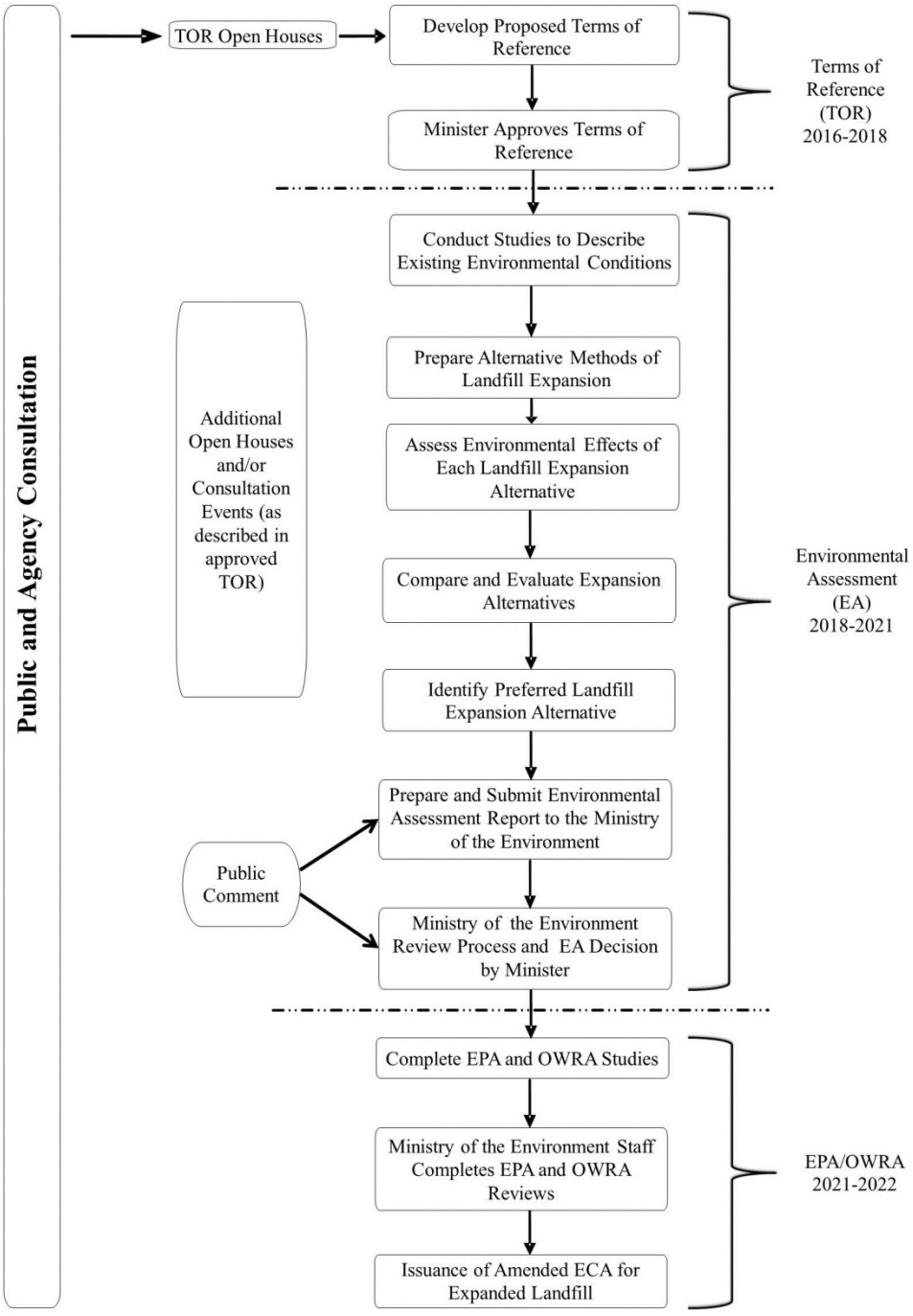
- TOR – 1.5 to 2 years
- EA – 2 to 3 years
- ECA Amendment – Expansion design, revised Development and Operations Report, ECA amendment application and negotiation of conditions of approval, allow 1 to 1.5 years. If municipal rezoning is required for any parcels of land that are required to accommodate the expansion, this process under the Planning Act would take place in parallel with the ECA amendment application.

As such, the process to obtain the approvals required to expand the Boyne Road landfill could take about 5 to 6.5 years. During this time period, it will be necessary to obtain an extension of the Emergency ECA to allow continued landfilling operations at the Site, which would be designed to take place by raising the landfill above the currently approved waste footprint. Therefore, for evaluation purposes, considering both the expansion approvals process and a 25-year expansion, the evaluation of alternatives will be considered over 30 years from 2016. An expansion operational period of 25 years would provide disposal capacity from about 2022 to 2046.

Similar to Alternative 1b, the Township could decide at some time to cease providing waste management services to the self-hauled and IC&I waste stream under Alternative 2 for the Site expansion. However, this decision would not affect the approval process the Township has to follow to obtain a Site expansion approval.

A flow chart illustrating the overall approvals process and the main steps in proceeding through EA approval and then the ECA amendment process under the EPA is provided on the following page.

EA/EPA Process Flow Chart
Boyne Road Landfill Expansion



4.2.1 Landfill Expansion Feasibility Assessment

In view of the above, a decision by the Township to commence the EA process for expansion of the landfill will commit the Township to a process and associated costs that are expected to extend over a 5 to 6.5 year period, while continuing landfill operations at the existing site, with the risk that the EA will not receive approval. If EA approval is received, in our experience there is little risk that the ECA amendment will not be subsequently approved. To better inform the Township's decision-making process on whether or not to proceed with the landfill expansion EA, a number of preliminary studies were undertaken to assess what are expected to be the key technical issues to be satisfied in the EA and satisfy regulatory requirements, and thereby gain a better understanding of the associated risks.

The studies undertaken were related to potential impacts from the expanded landfill of groundwater, surface water, atmospheric (air, odour, noise) and natural environment (biology). Details on each of these studies are provided in Appendices A to D, respectively, and the key findings and implications on the landfill expansion are summarized and discussed below.

The existing Boyne Road Landfill operates as a natural attenuation site, where leachate generated by the landfill is allowed to enter into the groundwater below the disposal area and the leachate-impacted groundwater then moves in the direction of groundwater flow. The MOECC Reasonable Use Guideline (RUG) B-7 and O.Reg. 232/98 Landfill Standards define the allowable effects of leachate on off-site groundwater quality. At the Boyne Road Landfill (and many other small to medium size landfills), RUG compliance is achieved by having a large enough landfill site property and CAZ groundwater easements on adjacent lands that the leachate effects on groundwater quality are reduced to the allowable concentrations before the impacted groundwater reaches the boundaries of these properties. An alternative design approach is to provide the landfill with a bottom liner and leachate collection system to contain the leachate, and then remove the collected leachate wastewater from the landfill for treatment prior to discharging it to the natural environment. In addition to the capital costs associated with constructing the engineered bottom liner and leachate collection system and associated operating costs with system maintenance, there is a need for a facility to treat the leachate. Although, where possible, leachate is often combined with municipal sewage for treatment in an existing sewage treatment facility, the only Township-owned sewage treatment facilities are the Winchester and Chesterville lagoons, and it is understood that their physical capacity and treatment capability would be challenged with accepting leachate (that would be trucked by tanker to one or both lagoons for treatment) for a period that will extend many tens of years after the landfill is closed and no longer accepting waste. Another alternative is to consider pre-treatment of the leachate at the landfill property and then truck it by tanker to one or both of the lagoons for final treatment prior to discharge. Construction of a pre-treatment facility, or a separate leachate treatment facility at the landfill site property for discharge to the Boyne Road roadside ditch is also not considered a practical or affordable approach to consider in view of the need for year-round treatment, high capital and operating costs and absence of a receiving watercourse for the treated effluent that has year round flow.

Of the technical considerations associated with the expansion, in terms of both operating considerations and costs, it is expected that the only economically viable approach for the Township is to continue operating an expanded Boyne Road Landfill as a natural attenuation site, recognizing that it may be necessary for the Township to acquire additional property and/or CAZ easement agreements. As such, the groundwater and surface water technical feasibility studies only considered proceeding with a landfill expansion on the basis of a continued natural attenuation landfill design approach.

4.2.1.1 Landfill Expansion Concept

Expansion Location

There were two options considered for the location of a landfill expansion. The first was on the existing landfill site property on the south side of Boyne Road; a landfill footprint expansion at this location would be adjacent to the south side of the existing disposal area, possibly requiring the Township to acquire additional property to the southeast to enlarge the landfill site property. The second was to establish a new landfill footprint within a portion of the large Township-owned property on the north side of Boyne Road that is used for snow disposal.

The subsurface conditions and groundwater flow system associated with the existing landfill have been investigated and are relatively well understood, whereas this work has not been done and would have to be initiated to understand the potential for developing a landfill on the property north of Boyne Road. The subsurface information available on the north side of Boyne Road suggests that this area may be underlain by compressible peat soils, which would present a challenge and add costs to construction of a landfill to satisfy the O.Reg. 232/98 Landfill Standards requirements. Lastly, the Raisin-South Nation Source Water Protection Plan identifies a portion of the Township-owned property north of Boyne Road as within an area of the predicted groundwater capture zone of the Chesterville municipal wells and subject to the source protection policies. For these reasons it is proposed that for this assessment of waste management alternatives the landfill expansion be considered only on the existing landfill property on the south side of Boyne Road.

It is noted that the current Site property is also located within an area of the Chesterville Well Head Protection Area (WHPA) currently identified as vulnerable. This portion of the WHPA has been assigned a vulnerability score of 4. Landfills licensed for municipal and IC&I waste are only considered a significant threat in the Chesterville WHPA for scores of 8 or higher. As such, the area south of the current waste footprint considered for the landfill expansion is not listed as a significant drinking water threat in the Raisin-South Nation Source Water Protection (SWP) Plan (Version 1.3.1, dated October 23, 2014), or considered as such under the application of the SWP policies. Golder Associates pre-consulted the South Nation Conservation authority (SNC) on this matter and they provided an opinion suggesting that expanding a landfill into any part of a predicted WHPA does not “meet the intent and spirit of Source Water Protection”, and cautioned that this is the position that they would put forward to the MOECC during the EA process. The MOECC are the regulatory agency responsible for decision-making on this matter as part of the EA and subsequent ECA approvals processes, noting that they would seek an opinion and guidance from SNC. This will have to be considered in the approval of a landfill expansion and is an important issue to be addressed with SNC and resolved early on in the approvals process if the Township decides to proceed with Alternative 2.

Expansion Alternative Preliminary Design

The EA process would require the development of alternative landfill expansion designs. For purposes of this waste management alternatives assessment, one preliminary landfill expansion natural attenuation design configuration is shown in plan view on Figure 3, with cross-sections provided on Figure 4. The expansion footprint would cover an additional area of approximately 5.7 ha (14.1 acres) adjoining the south side of the existing waste disposal area, and will require the Township to acquire an additional approximately 7.6 ha (18.8 acres) of property to the southeast to add onto the landfill site. A 100 m wide buffer has been provided between the east limit of the expansion footprint and the east property boundary, to respect the generic buffer requirements in O.Reg. 232/98 and to try to avoid potential leachate impacts on groundwater to the east and southeast. It is also anticipated that it will be necessary for the Township to acquire an additional strip of

approximately 1.6 ha land (4 acres) adjacent to the east side of the existing landfill for buffer purposes. These additional land areas to be acquired are shown on Figure 2; an alternative to outright purchase is for the Township to initially acquire an Option to Purchase agreement and proceed with the purchase only on receipt of approval of the expansion.

An additional waste disposal capacity of approximately 553,500 m^3 could be achieved by a combination of raising the elevation of the west and south portions of the disposal area and tying this into the capacity achievable above the expanded footprint to the south, with the geometry satisfying the slope angle requirements of O.Reg. 232/98. The height of this concept design is about 14 m above ground level. The total disposal capacity would be approximately 1,037,500 m^3. In view of the length of time required to obtain approval for an expansion as described in Section 4.2, the actual total disposal capacity is likely to be somewhat larger and the design geometry somewhat different than shown on Figure 3. The Landfill Standards also require a minimum separation of 1 m between the high groundwater table and the base of the waste; because the high groundwater table in the area south of the existing disposal area is essentially at ground surface, the design includes the construction of an approximately 1-metre thick pad of imported permeable fill material (for example, sandy material) above the ground surface to provide a base for waste disposal. The use of permeable fill will also allow the leachate to infiltrate into the groundwater system while minimizing the potential for both the development of a leachate mound within the waste and lateral leachate seeps at the perimeter of the expanded disposal area footprint.

As shown on Figure 3, the design provides continued operation of waste diversion operations in the north central part of the site. Also shown on Figure 3 are other features associated with the possible expansion, including additional lands to be acquired or groundwater CAZ easements to be negotiated by the Township and a stormwater management system. These are discussed below in Sections 4.2.1.2 and 4.2.1.3, respectively.

4.2.1.2 Groundwater Assessment

As described in Section 4.2.2, it is expected that the only economically viable approach for the Township is to continue operating an expanded Boyne Road Landfill as a natural attenuation site, recognizing that it may be necessary for the Township to acquire additional property and/or CAZ easement agreements. As such, the preliminary landfill expansion design was evaluated to estimate the potential effects of leachate on groundwater quality and assess the likelihood that the expanded site will satisfy the requirements of the MOECC Reasonable Use Guideline (RUG) in the long term. This is the primary technical factor in determining whether or not expansion of the Boyne Road Landfill as a natural attenuation site is feasible. The details of the assessment are provided in Appendix A and summarized below.

The assessment was carried out using a series of screening level contaminant transport calculations based on a conceptual model of the groundwater flow system and contaminant transport at the site, to determine current and future compliance with the RUG at the boundaries of the existing CAZ or, if required, the need for additional CAZ easements to increase the groundwater travel distance from the landfill disposal source area to the farthest boundary of the CAZ property.

The calculations were calibrated using the information available from the ongoing annual groundwater quality monitoring program and from the subsurface and hydrogeological setting from historical and recent borehole drilling and testing programs.

The subsurface conditions generally consist of surficial topsoil/peat overlying a silty sand/sandy silt glacial till and then limestone bedrock at depths ranging from about 1.5 to 9 metres below ground surface. The groundwater table is quite flat, and groundwater flow from the landfill area is to both the north/northwest and south/southwest at a slow rate estimated at about 4 metres per year. Based on these estimates, the effects of leachate in groundwater could be expected to have travelled about 200 m from the disposal area during the 50 years that the site has been in operation.

The calibration of the model calculations of the transport of chloride (a conservative parameter) from the landfill in groundwater north of the site required the addition of chloride to account for the effects of the Township snow disposal site on groundwater quality on the north side of Boyne Road.

Predictive calculations were used to determine the peak chloride concentrations at various distances downgradient from the expanded disposal area. Results were compared to the Reasonable Use Performance Objectives (RUPO) for the Site. Predictive results indicate that chloride concentrations are likely to meet the RUPO for both bedrock and overburden groundwater if the boundary of the groundwater easements on CAZ lands extends to 700 m downgradient (north and south) of the expanded disposal area. Based on this analysis, it is recommended that if the Township is to proceed with the proposed natural attenuation landfill expansion, easement agreements on CAZ land to the north and south of the fill area would need to extend at least 700 m beyond the fill area.

Because this is the primary technical factor in determining whether or not expansion of the Boyne Road Landfill as a natural attenuation site is feasible, Golder Associates project staff requested a meeting that was held on October 8, 2015 with MOECC hydrogeologists and surface water staff who are familiar with the Boyne Road Landfill. The purposes of this technical meeting were: 1) to present the results of recent additional site investigations, the predictive calculation approach, and the results of the assessment as summarized above and presented in Appendix A; and 2) to obtain MOECC feedback on the approach taken and whether or not they would likely be supportive of this approach and the findings if these were presented in the context of EA studies undertaken for a natural attenuation expansion design of the Boyne Road Landfill. The MOECC technical staff considered that the approach taken was appropriate and that the results indicated that an expanded natural attenuation site with the proposed CAZ easements could be expected to satisfy the Reasonable Use Guideline requirements with an acceptable level of confidence.

Figure 2 illustrates the anticipated CAZ easement requirements for an expansion of the Boyne Road Landfill site. The Township has already acquired sufficient groundwater easement requirements on the west side of the landfill property and to the northwest through a Land Use Permit on the MNRF lands. To have CAZ lands extending at least 700 m from the expanded disposal area in the directions of groundwater flow, it is expected to be necessary to negotiate a groundwater easement on an additional 32.4 ha (80 acres) of land further to the south, and add at least a portion (or perhaps all) of the Township-owned property on the north side of Boyne Road as a CAZ easement. As described above regarding additional land acquisition, the Township may also be able to initially negotiate an Option to Obtain an Easement and proceed with the completion of the transaction on receipt of approval of the expansion. From experience with landfill sites in general and the meeting with MOECC on the Boyne Road Landfill expansion, it is known the MOECC's level of confidence in the acceptable long term performance of natural attenuation landfills increases as the land area around the landfill site under the site owner's control increases.

4.2.1.3 Surface Water Assessment

As part of an EA for a landfill expansion, an evaluation of potential effects on surface water quality and quantity is typically required. This includes both the potential impacts of leachate on surface water quality and management of stormwater runoff from the landfill site such that post-expansion development runoff quantity is controlled and does not have an adverse effect on downstream receiving water courses. A preliminary design and assessment of a stormwater management system for the conceptual landfill design alternative was prepared to assess the feasibility of being able to satisfy the regulatory requirements if landfill expansion is decided as the preferred waste management approach for the Township. The details are provided in Appendix B and summarized below.

In terms of the existing landfill site, drainage off the north part of the site is directed towards Boyne Road while the remainder of the site drains to the constructed perimeter ditch around the west, south and east sides of the disposal area. The perimeter ditch outlets directly (without any quality or quantity control) via an existing culvert at the northeast corner of the landfill property to the roadside ditch on the north side of Boyne Road (refer to Figure B-2 in Appendix B). The ongoing annual surface water monitoring program indicates that there are periodic effects on surface water quality in the roadside ditch from landfill leachate, either due to site runoff or the seepage of leachate-impacted groundwater into the ditch.

During the continuing operations phase of the expanded landfill and post-closure, it is proposed that stormwater from the landfill will continue to be collected by existing and proposed grass-lined ditches, but it will be directed to a stormwater management wetland located at the northeast corner of the landfill. The stormwater wetland will be located within an existing partially filled, partially low area adjacent to the landfill. The depth of the wetland excavation will be limited to the existing grades in the area, in order to limit the possibility of interception of groundwater potentially impacted by leachate. The stormwater run-off from the wetland will discharge via an existing culvert into the roadside ditch on the north side of Boyne Road. The preliminary system design is shown on Figure B-1 in Appendix B.

Since the wetland is proposed to service the existing landfill along with the expansion of the landfill, the design will be a best efforts approach to provide additional water quality improvements for an area where runoff is currently draining. The wetland has been designed in general accordance with the MOECC SWM Planning and Design Manual (2003) and will provide an enhanced level of quality control (80% TSS removal). The proposed wetland will also provide quantity control of stormwater runoff by attenuating the post-closure peak flow rates to at or below pre-development levels. To be conservative, the pre-development peak flow rates were calculated based on the site before the landfill existed. Further details are provided in Appendix B.

One of the contingency measures in the ECA for the current landfill site is to install a culvert in the roadside ditch along the north side of Boyne Road opposite the landfill site frontage. If required, this measure would isolate and convey surface water past the landfill site from upstream (west) to downstream (east) and prevent leachate-impacted groundwater from seeping into the surface water in the ditch. With the culvert installed and provided with periodic seepage collars to prevent water movement along the granular bedding and backfill, the groundwater would continue northward as groundwater flow into the CAZ easement, and site compliance would be evaluated by the groundwater Reasonable Use Guideline rather than effects on ditch surface water quality. This culvert replacement of the existing open ditch is illustrated on Figure 3. It is anticipated that installation of this culvert may be required as a design feature to obtain approval of a landfill expansion.

Based on this preliminary analysis, it appears that a stormwater management system could be designed for the expansion concept using currently accepted approaches and that would satisfy the requirements of the O.Reg. 232/98 Landfill Standards.

4.2.1.4 Atmospheric Assessment

As part of the EA process required for expansion of the landfill site, an assessment of the impacts of the proposed landfill expansion in terms of emissions to the atmosphere would be required including air quality, odour, noise, and compliance with provincial atmospheric quality regulations. A preliminary desktop study was carried out to determine potential receptors in the vicinity of the Site and their corresponding distance from the expanded landfill site emission sources, and to identify potential concerns that could subsequently arise as part of the EA process during the assessment of project impacts to the atmospheric environment. The preliminary study is described in Appendix C and summarized below.

Sources of air quality emissions (any of chemicals, odour, dust, noise) for the proposed expansion are anticipated to be basically the same as the current site operations and consist of the landfill footprint and active disposal area, landfill compactor and loader, diversion operations compactor and conveyor, on-site unpaved roads and building exhaust fans.

The atmospheric assessment to be carried out during the EA would involve assessing potential air and noise impacts at the off-site sensitive receptors (residences). There are no residences immediately adjacent to the landfill site; in fact, there are no potentially sensitive receptors within 500 metres of the Site. Six receptors were identified as being within 1,000 metres from the landfill site emission sources and are considered to have the potential for being impacted by noise emissions associated with the landfill activities. During the expansion EA, the potential noise impacts would be evaluated using the Ontario Noise Guidelines for Landfill Sites. There would also need to be an assessment of noise from Site-related truck traffic along the haul route, as well as an assessment of potential noise at vacant lots in the area of the site where the current zoning allows development of a sensitive land use, i.e., a residence.

Based on this preliminary assessment and experience on other landfill Site expansion atmospheric assessments, it is expected that the combination of separation distances and standard emission controls as part of site operations, it is expected that this assessment would conclude that the expanded site could be expanded in accordance with provincial air quality, odour and noise requirements.

4.2.1.5 Natural Environment Assessment

A preliminary assessment of potential constraints at the Boyne Road Landfill property associated with the existing natural environment was prepared based on a desktop review of relevant background data sources and a single site reconnaissance visit by a biologist on July 19, 2015. The assessment focused on the area of the property south of the current landfill footprint, where the preliminary landfill expansion has been placed for this assessment, and the property to the southeast that is proposed to be acquired and added to the landfill property. The details of the assessment are provided in Appendix D and summarized below.

A background data review was used to identify significant natural features and the presence of suitable habitat for Species at Risk (SAR) that have been reported as occurring, or potentially occurring in the local landscape around the Site. The site reconnaissance involved a traverse of the expansion area on foot to characterize, at a high level, the natural features and verify the findings, where possible, of the background review.

Plant Communities: The area studied is primarily deciduous and thicket swamp, deciduous forest, deciduous hedgerows, small disturbed areas and edge habitats. Some portions of the swamp appear to undergo flooding and formation of vernal pools during spring. At the southeastern edge of the area is a portion of an upland deciduous forest that is contiguous off the area to the south and southeast. The southwestern portion of the area is an agricultural row crop field, contiguous with larger row crop fields to the west. No SAR plants or rare plant communities were observed during surveys.

Surface Water Features and Fish Habitat: The constructed watercourse (drainage ditch) that follows the perimeter of the current landfill connects to the naturalized roadside ditch on the north side of Boyne Road. There is also a feeder ditch that flows into this constructed watercourse from the south. Since it is connected to known fish habitat in the roadside ditch, this watercourse could be considered fish habitat, if water quality is sufficient to support fish. None of these features appear to have habitat that would support at risk or provincially rare fish species.

Species at Risk: No provincially or regionally rare plants or wildlife, plant communities, plant SAR, or wildlife SAR were identified during the surveys, although taxa specific surveys were not completed, and the Site visit was outside of the optimal survey period for most wildlife. In addition, the entire Site was not adequately surveyed to be considered a full botanical inventory. A SAR screening suggests that the habitat within the area studied has a moderate to high potential for 9 species on the current SAR list to be present.

An assessment of the implications of the observed natural environment features considering the natural heritage policies of the current Provincial Policy Statement and other relevant provincial guidance documents was carried out. The main natural environment features that are expected to require further study and evaluation during the EA are related to Significant Woodlands; fish habitat and headwater drainage; Significant Wildlife Habitat; and the presence or absence of the Threatened and Endangered species and, if present, the extent of their habitats on the Site.

Based on the initial evaluation, expansion of the landfill site may have design/approval constraints associated with endangered bat habitat, significant woodland, significant wildlife, and fish habitat. Development of the area outside of the current landfill footprint is expected to require additional investigation and design/mitigation. With the possible exception of significant woodlands, it is not expected that any of these potential constraints are likely to prevent development of the site for a landfill expansion, as long as appropriate design, permits, compensation/and or mitigation is implemented. Within forests designated as significant woodlands, development encroachments can sometimes occur but would be subject to the outcome of an Environmental Impact Statement or Environmental Assessment to show no negative impact to the overall function of the woodland.

4.2.2 Financial Implications for Alternative 2

The capital expenditures and annual operating costs have been estimated for each of the two waste management alternatives for waste disposal. It is noted that all costs provided herein are Opinions of Probable Cost (OPC) based on a number of assumptions and are likely to vary from actual costs. They should therefore not be considered for budgeting purposes but should only be considered as “ballpark” cost estimates to compare the financial implications of each waste management alternative presented in this report.

Different than Alternative 1 where the expenditures associated with site closure will largely take place in 2016, the expenditures presented herein for approval and implementation of Alternative 2 are expected to occur over the course of the next 30 years, based on the time period described in Section 4.2 to obtain approval for the Site expansion as well as the phased approach that is likely to be proposed for development of the expansion.

The following table presents the estimated expenditures between 2016 and 2047 for Alternative 2:

Table 5: Alternative 2 – Estimated Expenditures

Description	Period	Est. Quantity	Unit	Unit Price	OPC (in 2015 dollars)
Engineering and Approvals					
EA Process – TOR	2016 – 2018	1	L.S.	$200,000	$200,000
EA Process – EA Study Report	2018 – 2021	1	L.S.	$600,000	$600,000
ECA Amendment	2021 – 2022	1	L.S.	$100,000	$100,000
Submission to Ministry for Review and Approval[1]	2021	1	L.S.	$22,700	$22,700
Land Acquisitions and Easements for CAZ					
Land Acquisitions (or Option to Purchase)	2016 – 2017	22	acres	$5,000	$110,000
Groundwater Easements for CAZ (or Option to Obtain)	2016 – 2017	80	acres	$2,500	$200,000
Construction of Base Layer					
Clearing Expansion Footprint[2]	2021 – 2039	--	--	--	--
Placement of Permeable Fill Material for Base Layer for Expansion Phase 1[4]	2022	17,500	m^3	$20	$350,000
Placement of Permeable Fill Material for Base Layer for Expansion Phase 2[4]	2027	17,500	m^3	$20	$350,000
Placement of Permeable Fill Material for Base Layer for Expansion Phase 3[4]	2033	17,500	m^3	$20	$350,000
Placement of Permeable Fill Material for Base Layer for Expansion Phase 4[4]	2039	17,500	m^3	$20	$350,000
Surface Water Works					
Construction of the Wetland	2022	1	L.S.	$150,000	$150,000
Construction of Ditch near Recycling Facility	2022	100	m	$100	$10,000
Replacement of Perimeter Ditch	2022	560	m	$60	$35,000
Installation of Culvert to Replace the Open Ditch along north side of Boyne Road	2023 – 2024	500	m	$400	$200,000

Description	Period	Est. Quantity	Unit	Unit Price	OPC (in 2015 dollars)
Closure Works, Engineering and Approval					
Preparation of a Closure Plan[5]	2022	1	L.S.	$13,400	$13,400
Placement of Interim Cover over the Active Area[6]	2022	1	L.S.	$120,000	$120,000
Remaining Closure Works for the Historical Waste Footprint	2023	1	L.S.	$640,000	$640,000
Closure Works for Expansion Phase 1	2029	1	L.S.	$300,000	$300,000
Closure Works for Expansion Phase 2	2035	1	L.S.	$300,000	$300,000
Closure Works for Expansion Phase 3	2041	1	L.S.	$300,000	$300,000
Closure Works for Expansion Phase 4	2047	1	L.S.	$300,000	$300,000
10% Contingency	2016 – 2047	1	%	10%	$500,000
OPC TOTAL (excluding HST):					**$5,500,000**

Notes:
L.S.: lump sum; m^3: cubic metre; %: percent
[1] Based on Minister's Requirement for Fees, October 31, 2011. Administrative fee: $200; Amendment & Revocations: $22,500, if the design capacity of the site is more than 40,000 m^3 and not more than 3 million m^3 and, in the opinion of the Director, the application requires a fundamental design review or hydrogeological assessment.
[2] Assumes the Township would complete this task progressively at no cost approximately one year before construction of each expansion phase.
[3] It is noted that these total costs may be incurred only after obtaining EA approval (around 2021) if the Township is able to negotiate Options to Purchase and Options to Obtain.
[4] Assumes the work associated with construction of the expansion of the waste footprint to the south would be phased, with the corresponding base area for each phase constructed in 2022, 2027, 2033, and 2039.
[5] Includes preparation of a Closure Plan, preparation of an ECA Amendment Application, submission to the Ministry for review and approval, as well as Ministry processing fees based on Minister's Requirement for Fees, October 31, 2011. Administrative fee: $1,200 if no fundamental design review or hydrogeological assessment is required; $22,500, if the design capacity of the site is more than 40,000 m^3 and not more than 3 million m^3 and, in the opinion of the Director, the application requires a fundamental design review or hydrogeological assessment. It is assumed that 75% of the historical waste footprint (the north portion of the landfill) would have to be closed the year after obtaining expansion approval south of the existing disposal area.
[6] Includes shaping waste to eliminate Fill Beyond Approved Limits within the historical waste footprint of the Site, placement of 300 mm of interim cover material over the active area, and engineering activities (topographical surveys before placement of cover materials, test pit evaluation of cover materials already in place, as well as supervision and documentation of closure works).

The incremental operating costs of Alternatives 1a and 1b compared to Alternative 2 are provided in Section 4.1.4. Since Alternative 2 is basically a continuation of current disposal operations, it is anticipated that the annual operating costs of Alternative 2 should be similar to those of the current operations at the Site, perhaps marginally increased to allow for additional groundwater and surface water monitoring and periodic maintenance of the stormwater management system. It is noted that the annual operating costs are expected to increase by the CPI rate as well as population growth, as indicated in Section 3.3.

It is expected that closure activities listed in Table 5 would be undertaken progressively over the course of the expansion's life time as part of planned site operations, which is a good practice to limit the financial liability related to closure works. Based on our experience with operations at similar sized landfills, on-going closure costs to place final cover material over sections of the landfill can be accommodated under the annual operational landfill budget assuming: 1) clean fill acceptable for final cover is regularly received at the Site and 2) assuming Township equipment is made available on a regular basis to complete placement and grading of cover materials. However, for this analysis it was assumed that the cover construction works would be contracted out for each landfill expansion phase after completion to top of waste design elevations.

5.0 EVALUATION OF WASTE DISPOSAL ALTERNATIVES

To assist the Township in comparing and evaluating the two waste disposal Alternatives short listed in Section 2.0, the following factors were considered:

- Technical feasibility;
- Likelihood to obtain MOECC Approval; and,
- Opinion of Probable Costs (capital expenditures and long-term annual operating costs over 30 years).

As indicated in Section 4.1.3, Alternative 1 – Closure of Boyne Road Landfill and waste export for disposal – is considered to be technically feasible. The only uncertainty for the Township under Alternative 1 would be the Conditions imposed by the MOECC for approval of the landfill site closure and the establishment of a waste transfer station at the Site, but these requirements are common to many landfill sites and the Conditions are not expected to be onerous. Beyond the 30-year planning period considered in this report, the Township may face uncertainty related to the remaining capacity at the selected private waste disposal facility (the Lafleche site), although the continuing demand for waste disposal in eastern Ontario is expected to result in the availability of an alternative to this facility in the longer-term, in the event the Lafleche site is not able to provide continuing services to the Township.

As indicated in Section 4.2.1, based on the results of the preliminary studies completed by Golder Associates for this report, Alternative 2 – Expand the Boyne Road Landfill Site – is considered to have a reasonable likelihood of obtaining EA approval as a natural attenuation landfill, with the understanding that the Township is able to secure the required additional lands for the expansion and negotiate the required CAZ easements with adjacent landowners. If these cannot be secured, then an expansion application is unlikely to be successful since there is insufficient land area available on the currently owned landfill property and the CAZ does not extend far enough beyond the property in the required directions. If EA approval is received, in our experience there is little risk that the ECA amendment will not be subsequently approved. The technical feasibility of Alternative 2 appears favourable, although in view of changing political positions that could affect EA requirements, Ministerial approvals, and waste management practices, as well as potential stakeholder concerns regarding the expansion, there is always a degree of uncertainty inherent in the outcome of an EA process. Table 6 summarizes the Financial Implications of each Alternative.

Table 6: Comparison of Financial Implications of each Alternative

	Quantities Considered (in 2015)	Capital expenditures (in 2015 dollars)	Estimated Annual Operating Costs[1] (in 2015 dollars)	Estimated Overall Probable Costs over 30 years[2] (in 2015 dollars)
Alternative 1a: Closure of Boyne Road Landfill and Waste Export (Residential and Non-Residential Waste)	8,000 tonnes	$1,130,000	$550,000	$17,630,000
Alternative 1b: Closure of Boyne Road Landfill and Waste Export (Residential Waste Only)	2,900 tonnes	$1,115,000	$200,000	$7,115,000
Alternative 2: Boyne Road Landfill Expansion	18,900 m^3	$5,500,000	$55,000	$7,150,000

Note:
[1] Curbside collection costs are not taken into consideration in this evaluation and only the incremental costs to haul waste to the Lafleche site for disposal are included in Alternative 1.
[2] For this calculation, annual operating costs were not adjusted for inflation or for an increase in waste disposal requirements, as they are not meant to reflect future values. Instead, it is intended to evaluate the general financial implications of each Alternative.

As indicated in Section 4.1, if the Township decides to continue providing waste management services to the self-hauled and IC&I waste stream, under Alternative 1a the Township would have to establish a WTS at the Site to collect this waste stream and transfer it off-site for disposal. However, if the Township decides to cease providing services to the self-hauled and IC&I waste stream (Alternative 1b), the capital expenditures of Alternative 1 presented in Table 6 would decrease to reflect the cost savings associated with the WTS approval process. Annual operating costs would also decrease due to lower waste tonnages to be handled by the Township (savings in hauling costs and tipping fees at the Lafleche site). Such a decision would have minimal impact on the capital expenditures or annual operating costs under Alternative 2 (see Section 4.2).

It is noted that the capital expenditures for both Alternatives account for landfill closure works. However, as indicated in Section 4.2.2, based on our experience of operations at similar sized landfills, under Alternative 2 on-going closure costs to place cover material over sections of the landfill can be accommodated under the annual operational landfill budget assuming: 1) clean fill acceptable for final cover is regularly received at the Site and 2) assuming Township equipment is made available on a regular basis to complete placement and grading of cover materials. Undertaking progressively closure activities is good practice to limit the financial liability related to closure works and may help reduce capital expenditures over the course of the landfill life. However, for this analysis it was assumed that the cover construction works would be contracted out for each landfill expansion phase after completion to top of waste design elevations.

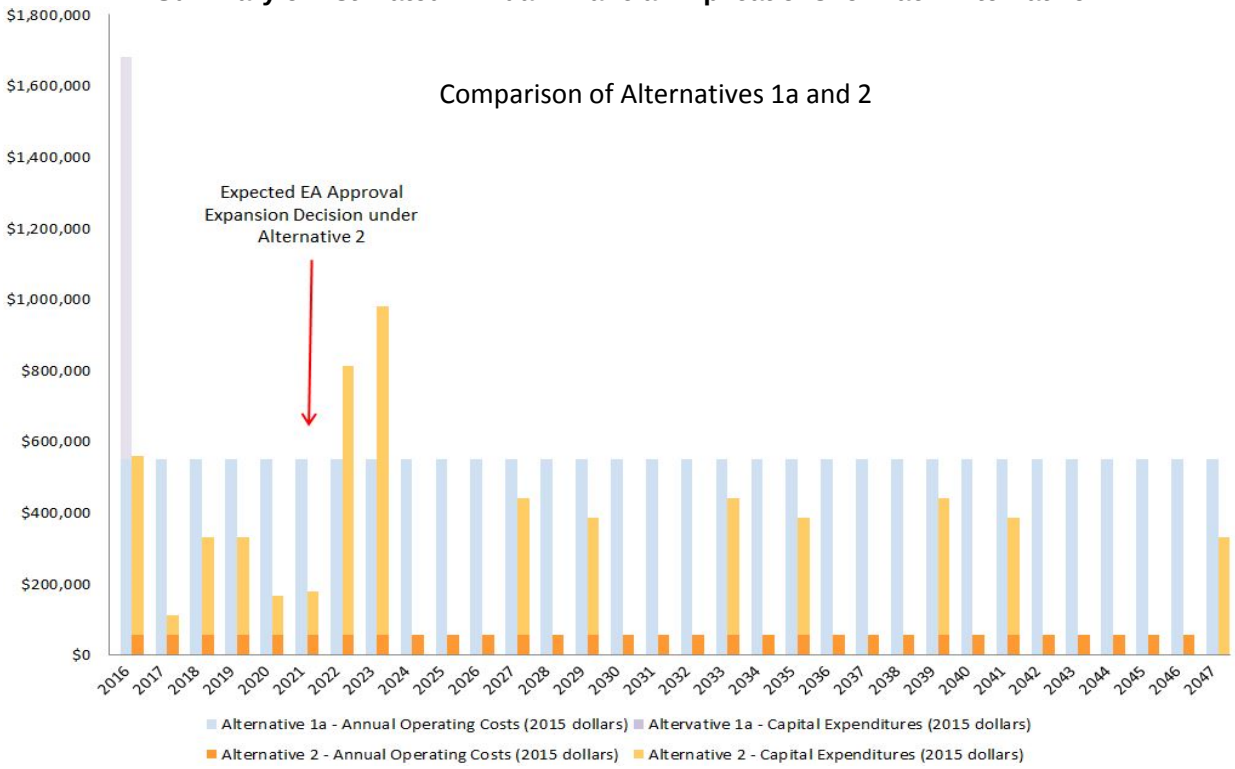
This comparison of the Financial Implications of each Alternative indicates that Alternative 2 would yield an overall probable cost over 30 years approximately three times lower than Alternative 1a, and similar overall probable costs to Alternative 1b over 30 years. The costs associated with operating a landfill site do not cease once the landfill has reached capacity and is closed. Post-Closure Care (PCC) costs are expected to be

required for many years after closure (over the remainder of the contaminating lifespan of the landfill site), mainly continued monitoring and reporting activities as well as site maintenance (e.g., cover inspections and repairs, maintenance of the monitoring well network, fence repairs, etc.). Based on current MOECC requirements, PCC costs for the landfill are expected to be generally similar between the two Alternatives.

Although the capital costs for Alternative 2 are greater than those of Alternative 1, the difference in operating costs over the course of the expected expansion life time favours Alternative 2 over Alternative 1a and results in Alternative 2 being similar to Alternative 1b in terms of overall financial implications. It is noted that the capital costs for Alternatives 1a and 1b are expected to all occur in 2016 whereas much of the capital costs for Alternative 2 are expected to occur over the course of the lengthy approval process and the initial phase of construction of the expansion (from 2016 to 2022). Moreover, the difference in operating costs between the three Alternatives is due to waste hauling costs and tipping fees associated with Alternatives 1a and 1b. Although the Township is able to tender the hauling contract regularly (often on a 3 to 5 year basis), the waste disposal service provider is currently the only viable option available for the Township. The Township is expected to have to consider negotiation of a long-term contract for the tipping fees to avoid unforeseen future cost increases.

A summary of the estimated annual costs associated with each of Alternatives 1a and 2 and Alternatives 1b and 2 is illustrated on the following graphs. These graphs illustrate that over the 30-year planning period the estimated annual costs associated with Alternative 2 are generally lower than Alternatives 1a and 1b, and in specific years are either similar to Alternative 1a or higher than Alternative 1b.

Summary of Estimated Annual Financial Implications for Each Alternative



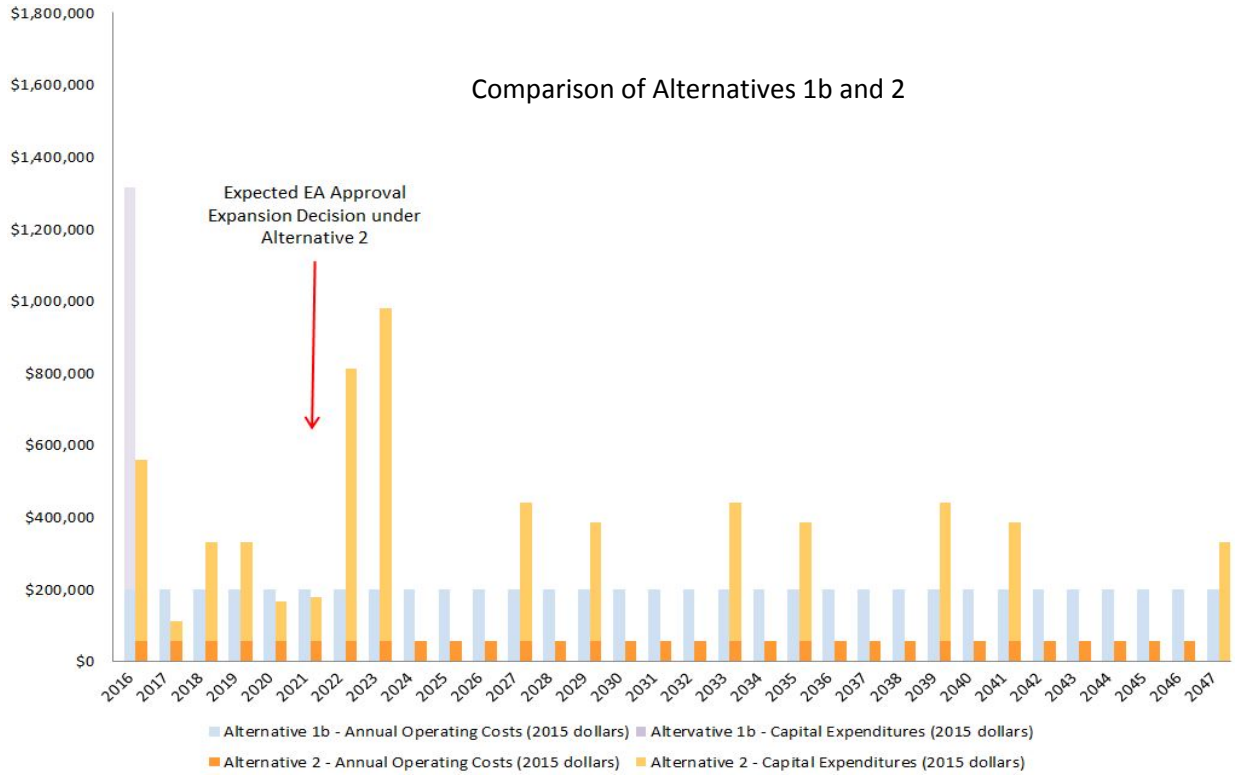


Table 7 summarizes the results of this evaluation for the factors considered.

Table 7: Evaluation of Waste Disposal Alternatives

	Considerations			Main Advantages	Main Disadvantages
	Technical Feasibility	**MOECC Approvals**	**Capital and Operating Costs**		
Alternative 1: Closure of Boyne Road Landfill and Waste Export (1a and 1b)	High degree of certainty	High degree of certainty	Similar (1b) to less favourable (1a)	1) High certainty 2) Fast transition from current waste management service 3) Lower capital expenditures	1) Higher operating costs 2) Dependency on a single waste disposal service provider
Alternative 2: Boyne Road Landfill Expansion	Likely	Reasonable likelihood to obtain approvals for a natural attenuation landfill	Similar (1b) to more favourable (1a)	1) Lower operating costs 2) Similar (1b) to lower (1a) overall financial implications 3) Continued operations at the Site under Township control	1) Higher capital expenditures 2) Relative uncertainty of EA approval 3) Lengthy approval process

6.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of the Township of North Dundas. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this report.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

7.0 CLOSURE

We appreciate the opportunity to complete this Waste Management Alternatives Evaluation for the Township of North Dundas. If you have any questions, please contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

Y.J. Marcerou, M.Eng.
Environmental Consultant

P.A. Smolkin, P.Eng.
Principal

YJM/PAS/md
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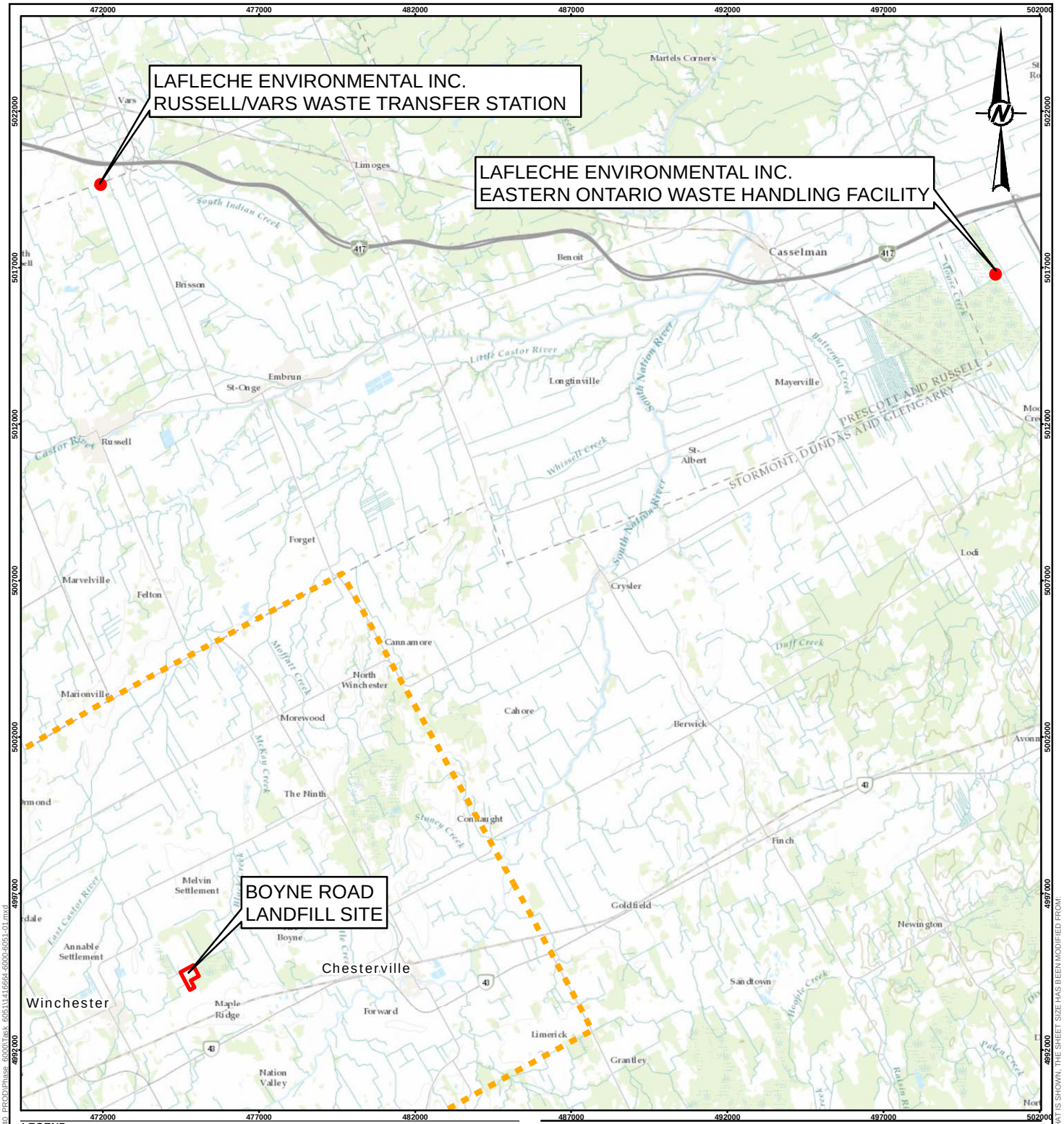

LEGEND

- BOYNE ROAD LANDFILL SITE
- TOWNSHIP OF NORTH DUNDAS

0 1.25 2.5 5 7.5

1:175,000 KILOMETRE

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 18 NAD 83 VERTICAL DATUM: CGVD28
2. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, DELORME, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
TOWNSHIP OF NORTH DUNDAS

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

TITLE
STUDY PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-07-14
DESIGNED	YJM
PREPARED	PJM
REVIEWED	YJM
APPROVED	PAS

PROJECT NO.	PHASE	REV.	FIGURE
1416664	6000	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: N:\Active\Spatial\MXD\Township of North Dundas\BoyneRoadLandfill\69 PROJ\1416664\40 PROD\Phase 6000\Task 6051\1416664-6000-6051-01.mxd

OPTIONAL ADDITIONAL CONTAMINANT ATTENUATION ZONE FOR ALTERNATIVE 2 (MNRF-OWNED PROPERTY, GROUNDWATER EASEMENT TO BE NEGOTIATED)
7.8 ha

ADDITIONAL CONTAMINANT ATTENUATION ZONE FOR ALTERNATIVE 2 (TOWNSHIP-OWNED PROPERTY, GROUNDWATER EASEMENT REQUIRED)
75.4 ha

ADDITIONAL PRIVATELY OWNED LAND TO BE PURCHASED FOR ALTERNATIVE 2
1.6 ha

ADDITIONAL PRIVATELY OWNED LAND TO BE PURCHASED FOR ALTERNATIVE 2
7.6 ha

ADDITIONAL CONTAMINANT ATTENUATION ZONE FOR ALTERNATIVE 2 (PRIVATELY OWNED PROPERTY - GROUNDWATER EASEMENT TO BE NEGOTIATED)
32.4 ha

COUNTY RD 3

BOYNE RD

BELANGER RD

GRAY RD

HELMER RD

LEGEND

- APPROXIMATE LANDFILL PROPERTY BOUNDARY
- APPROXIMATE LOCATION OF THE SNOW STORAGE FACILITY
- EXISTING CONTAMINANT ATTENUATION ZONE EASEMENT LANDS
- LOT FABRIC

REFERENCES

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. COORDINATE SYSTEM: MTM ZONE 9 NAD83.

NOTES

1.THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

0 100 200 300 400 500

1:10,000 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-21
PREPARED	PJM
DESIGN	YJM
REVIEW	YJM
APPROVED	PAS

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

TITLE
ALTERNATIVE 2: PROPOSED ADDITIONAL LANDFILL PROPERTY AND CONTAMINANT ATTENUATION ZONE EASEMENT REQUIREMENTS, BOYNE ROAD LANDFILL EXPANSION

PROJECT NO.	PHASE	REV.	FIGURE
1416664	6000	0	2

Path: N:\Active\Spatial_IM\Township of North Dundas\BoyneRoadLandfill\99_PRO\1416664\40_PROD\Phase_6000\Task_605\1416664-6000-6051-02.mxd

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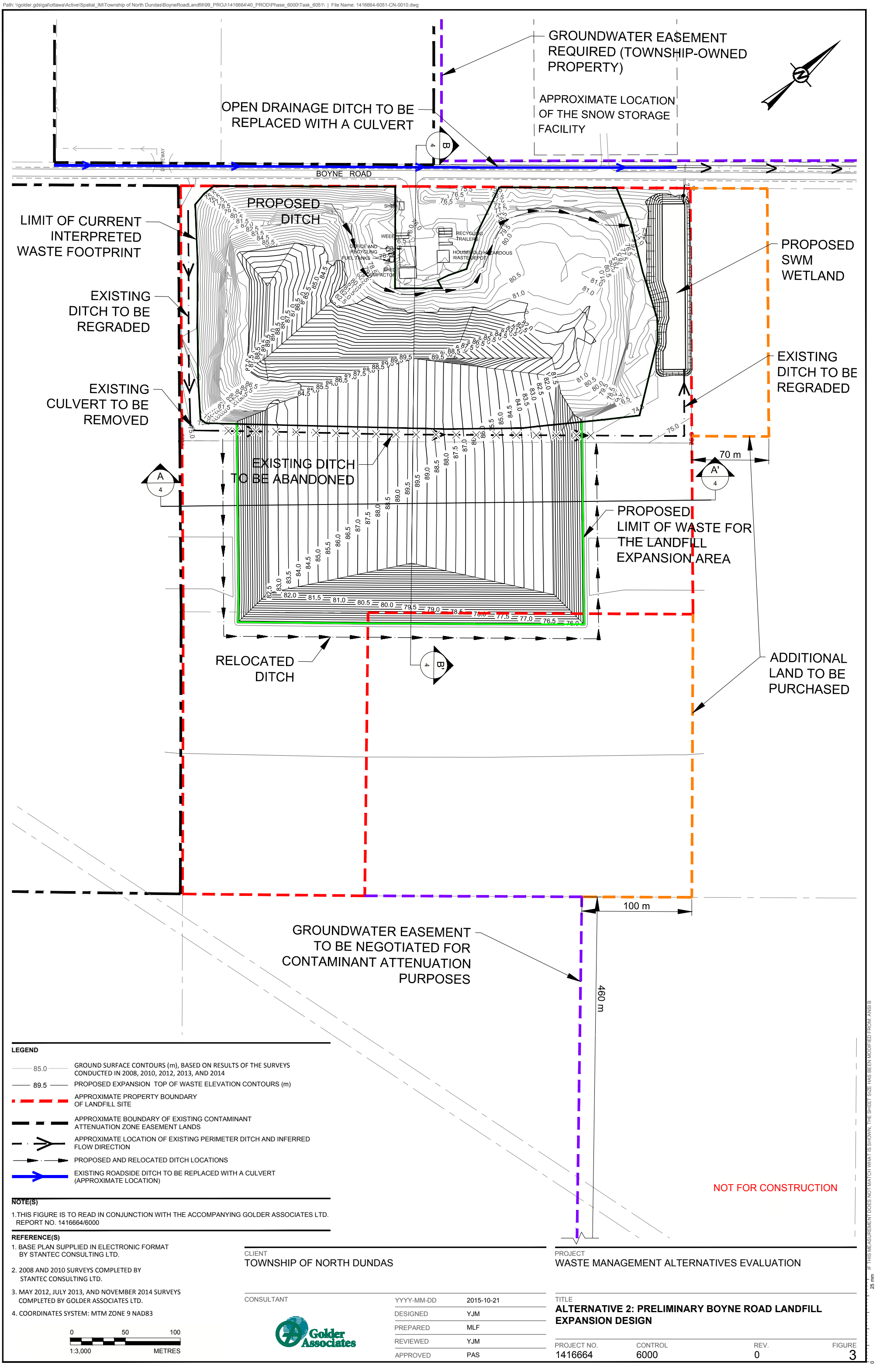


LEGEND

- 85.0 — GROUND SURFACE CONTOURS (m), BASED ON RESULTS OF THE SURVEYS CONDUCTED IN 2008, 2010, 2012, 2013, AND 2014
- 89.5 — PROPOSED EXPANSION TOP OF WASTE ELEVATION CONTOURS (m)
- APPROXIMATE PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE BOUNDARY OF EXISTING CONTAMINANT ATTENUATION ZONE EASEMENT LANDS
- APPROXIMATE LOCATION OF EXISTING PERIMETER DITCH AND INFERRED FLOW DIRECTION
- PROPOSED AND RELOCATED DITCH LOCATIONS
- EXISTING ROADSIDE DITCH TO BE REPLACED WITH A CULVERT (APPROXIMATE LOCATION)

NOTE(S)

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. 2008 AND 2010 SURVEYS COMPLETED BY STANTEC CONSULTING LTD.
3. MAY 2012, JULY 2013, AND NOVEMBER 2014 SURVEYS COMPLETED BY GOLDER ASSOCIATES LTD.
4. COORDINATES SYSTEM: MTM ZONE 9 NAD83

0 50 100
1:3,000 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

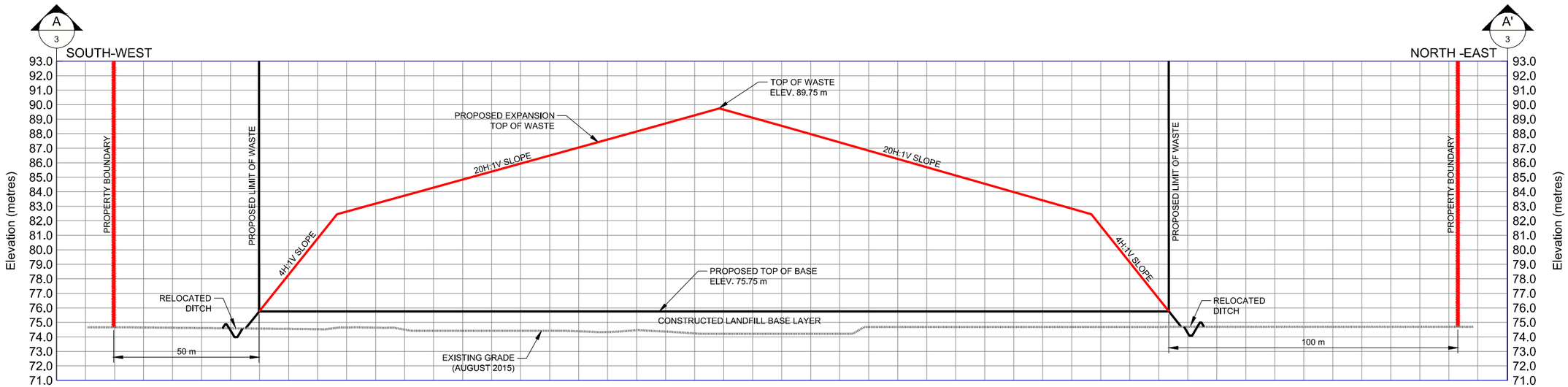
CONSULTANT
Golder Associates

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

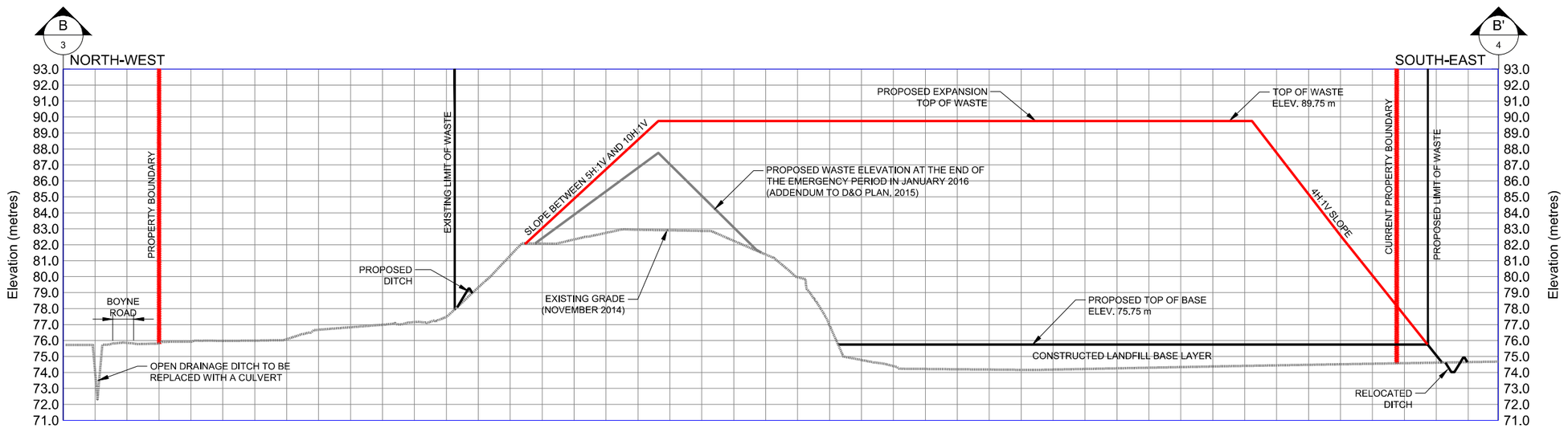
YYYY-MM-DD	2015-10-21
DESIGNED	YJM
PREPARED	MLF
REVIEWED	YJM
APPROVED	PAS

TITLE
ALTERNATIVE 2: PRELIMINARY BOYNE ROAD LANDFILL EXPANSION DESIGN

PROJECT NO.	CONTROL	REV.	FIGURE
1416664	6000	0	3



HORIZ. SCALE: 1:1,500 m
VERT. SCALE: 1:300 m
A-A' 3 SECTION



HORIZ. SCALE: 1:1,500 m
VERT. SCALE: 1:300 m
B-B' 3 SECTION

NOT FOR CONSTRUCTION

0 25 50
1:1,500 METRES

0 5 10
1:300 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-21
DESIGNED	YJM
PREPARED	MLF
REVIEWED	YJM
APPROVED	PAS

TITLE
ALTERNATIVE 2: PRELIMINARY BOYNE ROAD LANDFILL EXPANSION DESIGN - CROSS-SECTIONS

PROJECT NO.	CONTROL	REV.	FIGURE
1416664	6000	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25 mm

Path: \\golder.gds\gal\ottawa\Active\Spatial_IM\Township of North Dundas\BoyneRoadLandfill\99_PRO\1416664(40_PRO)\Phase_6000\Task_6051\ | File Name: 1416664-6051-CN-0012.dwg

APPENDIX A

Technical Memorandum – Predictive Assessment of Groundwater Compliance, Boyne Road Landfill, Natural Attenuation Landfill Expansion Alternative

November 2015
Report No. 1416664/6000

TECHNICAL MEMORANDUM

DATE October 27, 2015 **PROJECT No.** 1416664/6000/6023

PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

1.0 INTRODUCTION

The Boyne Road Landfill Site (the Site) has been operating as a licensed landfill facility for the Township of North Dundas (the Township) since 1965. The Site is licensed for the disposal of domestic, commercial, and industrial solid non-hazardous waste. It was recently determined that the Site has exceeded its approved capacity and is in an overfill situation. The Site is currently operating under an Emergency Environmental Compliance Approval (Emergency ECA) to allow disposal to continue at the site until January 31, 2016. A Site plan showing the current Site configuration as well as the existing Contaminant Attenuation Zones is included as Figure A-1.

The Township is currently assessing available waste management alternatives. One alternative under consideration is the expansion of the Site from approximately 484,000 cubic metres of airspace on an 8.1 hectare (ha) footprint to 1,037,500 m^3 of airspace on a 13.7 ha footprint. A possible expansion option is shown on Figure 2. This expansion would provide the capacity to allow the Site to continue to operate for an additional 25 years. It is expected that the only economically viable option for the Township is to continue operating the Site (including the proposed expansion option) as a natural attenuation landfill site (one in which the natural groundwater setting and land acquisition and/or groundwater easements enables the landfill to remain in compliance with provincial requirements for leachate effects on off-site groundwater quality, without the requirement for engineered liners, leachate collection systems and treatment of collected leachate).

Based on ongoing monitoring of the Site, it has been determined that groundwater compliance with the Ministry of the Environment and Climate Change (MOECC) Guideline B-7 (MOE, 1994) will be the main technical factor in determining whether or not expansion of the landfill as a natural attenuation landfill site is feasible. A series of screening level contaminant transport calculations were conducted based on a conceptual model of groundwater flow and contaminant transport at the Site to determine current and future compliance. The calculations were completed using GoldSim, a flexible, non-specific modelling code, designed to provide the user with an understanding of the factors that control the performance of an engineered or natural system (as defined by a user-specified mathematical model) and to predict the future behaviour of the defined system. With respect to addressing the Site groundwater quality, GoldSim was used to simulate the passage of contaminants in the landfill leachate from the source area (i.e., the active and expanded landfill area) through the downstream groundwater flow systems to the downgradient boundary of the CAZ. GoldSim is fully documented in the Main Users Guide (GTG, 2010a) and the Contaminant Transport Module Users Guide (GTG, 2010b). These screening level calculations were completed for both current conditions at the Site, and expected conditions under the possible expansion option.

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This technical memorandum describes the background information and conceptual model development in Section 2, and the screening calculation set-up, calibration to current conditions, adaptation for predictive simulations, and assumptions in Section 3. The calculation results are provided in Section 4 and a summary discussion is provided in Section 5.

2.0 BACKGROUND INFORMATION

Site conditions were determined based on subsurface conditions encountered during borehole drilling programs, groundwater level measurements, and groundwater sampling previously conducted at the Site. To supplement the existing data an additional groundwater investigation was conducted at the Site in the summer of 2015. This investigation included the drilling, installation and sampling of two overburden monitoring wells (15-1 and 15-2) and one bedrock monitoring well (15-3). In-situ hydraulic conductivity testing in the new wells and six existing wells was also conducted. A summary of data collected to date is provided in the following sections.

2.1 Geology

Published geological maps indicate that overburden in the area consists of: organic deposits comprised primarily of peat; underlain by offshore marine deposits comprised of clay, silty clay, and silt; underlain by silty sand and sandy silt till (Geological Survey of Canada, 1982). Published geological maps indicate that bedrock in the area consists of limestone, dolostone, shale, and sandstone of the Gull River Formation (Ontario Ministry of Natural Resources, 1985).

Based on subsurface conditions encountered during borehole drilling programs completed at the Site, overburden in the area consists of discontinuous topsoil/peat (between 0 and 2 metres in thickness), underlain by discontinuous silt/clay (between 0 and 2.9 metres in thickness), underlain by silty sand/sandy silt till (between 0.9 and 6.0 metres in thickness). Bedrock, consisting of limestone (interbedded with shale), has been encountered at between 1.4 and 9.0 metres below ground surface (mbgs).

2.2 Groundwater Elevations and Groundwater Flow Directions

Topography in the area of the landfill site is flat; as a result, hydraulic gradients, and groundwater flow directions may vary temporally/seasonally and can be influenced by very slight variations in groundwater elevations. Based on review of topographic maps of the area, the regional groundwater flow direction is expected to be north, toward the East Castor River (located approximately four kilometres to the north).

Locally, groundwater elevations may be influenced by leachate build up within the waste mound, resulting in a local groundwater divide in close proximity to the Site. Groundwater flow in the area to the north of the Site is generally to the north, and groundwater flow in the area to the south of the site is generally to the south. These flow directions can be variable with flow to the north occasionally being to the northeast and flow to the south occasionally being to the southwest or southeast. Contours generated from groundwater elevations measured at the Site in overburden in July 2015 are shown in Figure A-3.

Groundwater elevations in the bedrock show very minimal spatial variation. In July 2015 groundwater levels at BRW1 and BRW3 indicate that bedrock groundwater flow is to the south in the area immediately south of the Site. Further south of the Site, groundwater levels at BRW3 and 15-3 indicate that bedrock groundwater flow is to the north. Historically, groundwater flow directions in the bedrock have been observed to vary. Groundwater elevations measured in bedrock monitoring wells in July 2015 are shown in Figure A-4.

2.3 Hydraulic Conductivity, Hydraulic Gradients, and Groundwater Velocity

The hydrogeological investigation conducted at the Site in 2015 included in-situ hydraulic conductivity testing of five monitoring wells screened in the silty sand or sandy silt, one monitoring well screened in the silty till, and three monitoring wells screened in the bedrock. Results of these tests are included in Attachment A. Based on this investigation the horizontal hydraulic conductivity of the silty sand/sandy silt/silt was found to range from $7x10^{-7}$ m/s to $8x10^{-5}$ m/s, with a geometric mean of $1.3x10^{-5}$ m/s. Horizontal hydraulic conductivity of the bedrock ranged from $3x10^{-6}$ to $1x10^{-2}$ m/s. The high hydraulic conductivity measured at BRW2 (greater than 1×10^{-2} m/s) is likely indicative of the presence of a fracture.

Horizontal hydraulic gradients to the north and south of the Site are similar, and on the order of 0.001 m/m to 0.003 m/m. Horizontal hydraulic gradients to the east and west of the Site are much lower, on the order of 0.0005 m/m. These results are similar to those previously reported for the Site.

Horizontal gradients in the bedrock have historically been weak, and variable in direction. In July 2015 a slight (0.0006 m/m) horizontal hydraulic gradient to the immediate south of the Site was observed, but further to the south the gradient appears to be to the north. Elsewhere on the Site bedrock hydraulic gradients were flat. Based on this observation it is inferred that advection is negligible and contaminant transport in the bedrock is dominated by diffusion.

Vertical gradients from the overburden to the bedrock vary by location. A comparison of overburden/bedrock well pairs in 2015 indicates an upward vertical gradient between MW10 and BRW2, and negligible gradients between MW12 and BRW3 (south of the Site) and MW13 and BR07-26 (east of the Site). A downward vertical gradient of approximately 0.09 m/m was measured between MW1 and BRW1-C, but with depth the vertical gradients in bedrock reverse at this location. To the south of the Site a downward vertical gradient of 0.02 m/m was observed between MW06-20 and BRW15-3.

The average linear groundwater velocity in the overburden, to the north and south of the Site was calculated based on the geometric mean hydraulic conductivity (1.3×10^{-5} m/s), the observed hydraulic gradient at the Site in July 2015 (0.002 m/m), and an assumed average porosity of 35 percent. The average linear velocity to the north and south of the waste mound is estimated to be 4 metres per year. This estimate is consistent with estimates made in previous annual monitoring reports (which range from 0.1 to 5 metres per year). Historically, the leachate mound has resulted in groundwater velocities up to one order of magnitude higher in close proximity to the Site; however, recent monitoring has indicated a lower degree of mounding. Based on these estimates, the leachate plume could be expected to have travelled approximately 200 metres from the waste fill area during the 50 years of operation at the Site.

2.4 Groundwater Quality and Leachate Indicators

Monitoring wells MW13 and BR07-27 (to the east of the Site) have been established as representative of background water quality in the overburden and the bedrock, respectively. Monitoring well MW06-22 and the replacement well MW06-22R are screened in the silty sand unit immediately below the waste mound, and have been used as indicators of leachate strength at the Site. Based on a comparison of background groundwater quality and leachate water quality, leachate indicator parameters for the Site are: alkalinity, aluminum, ammonia, barium, BOD, boron, chloride, cobalt, conductivity, DOC, hardness, iron, manganese, phenols, potassium, sodium and TDS.

Conservative and mobile leachate indicators were considered for the transport calculations. Of those available, chloride and potassium were considered most appropriate as they are present in low concentrations in background groundwater in both the overburden and the bedrock, and generally show decreasing concentration trends in the downgradient direction. Average observed concentrations of potassium and chloride are shown on Figures A-5 and A-6, respectively.

3.0 SCREENING LEVEL CALCULATIONS

3.1 Assumptions

One-dimensional contaminant transport calculations were completed to provide a screening level assessment of contaminant transport with a reasonable degree of confidence given the available data for the Site. The calculation setup is illustrated on Figure A-7 for current conditions and Figure 8 for predictive calculations. The following assumptions were made for the calculations:

- One-dimensional contaminant transport was represented. This representation assumes that the flow path is linear between points.
- The leachate plume in the overburden is assumed to be more extensive than the plume in the bedrock. For the purposes of the calculations, leachate source concentrations were applied to overburden only. It is acknowledged that some portion of the plume may extend to bedrock. The vertical spreading of the plume to the bedrock would result in lower concentrations in the bedrock relative to what is represented in the one-dimensional calculations. The leachate plume is also assumed to travel at a lower velocity in the bedrock relative to the overburden due to the lower hydraulic gradients. As such, it is assumed that if regulatory compliance is met in the overburden, compliance would also be met in the bedrock at the same distance from the disposal area.
- The calibration is considered at steady-state (long term) conditions; data for calibration was limited to points within 200 m to the north and south of the fill area.
- Leachate source terms for chloride were applied based on the empirical waste volume versus chloride regression equation presented in Gehrels and Puumala (2000). For current conditions, a leachate chloride concentration of 970 mg/L was applied. For the expansion, a chloride concentration of 1500 mg/L was applied (as per O. Reg. 232/98 (Ministry of the Environment, 2012)). For the closure period, a chloride source depletion curve was generated using POLLUTEv7 (Rowe and Booker, 2005).
- The leachate source term for potassium under current conditions was set at 85 mg/L. This value represents the average observed in the leachate monitoring wells at the Site.
- No retardation or decay of chloride or potassium in the downgradient flow path was accounted for.
- To account for the potential impacts on groundwater quality due to the Township owned snow disposal facility to the north of the Site, additional loading of chloride (associated with snow melt) was applied to the flow path adjacent to the snow disposal facility.
- As the transport calculations are one-dimensional, any transverse dispersion or spreading of the plume is not explicitly accounted for. To account for these processes, along with potential recharge of unimpacted water downgradient, the calculations were calibrated by “mixing” additional volumes of groundwater, at background concentrations, between the landfill source area and the CAZ.
- The expansion of the landfill is not expected to affect existing groundwater flow directions or gradients.
- Additional lands will be acquired to the south for the expansion, and are available further south as CAZ. Considering that the groundwater flow systems are similar in the north and south directions, predictive calculations were carried out to the north only. Results for the northern flow path can be applied to the south of the Site.

4.0 RESULTS

4.1 Calibration to Current Conditions

As described above, screening calculations were calibrated to existing conditions by adding recharge volumes of water (at background groundwater concentrations) to the downgradient flow path until calculated steady-state concentrations were similar to the observed data. For the northern flow path, an additional chloride load was added between the landfill and MW10 and between MW10 and MW16 to account for the effects of the snow disposal facility on groundwater quality. As shown on Figure A-8, mixing volumes equivalent to 175 mm per year were added to each portion of the flow path. For the northern flow path, an additional chloride load of 2,500 grams per day was added between the landfill and MW10, and 5,000 grams per day was added between MW10 and MW16. Calibration results are shown on Figure A-9.

To the south of the Site, calculated chloride concentrations are higher than observed concentrations for the wells closest to the fill area, and are slightly lower than observed concentrations further downgradient. To the north of the site, the addition of a chloride load adjacent to the snow disposal area is required to increase the calculation results closer to observed concentrations. Observed concentrations at MW07-25 are likely to increase in time until the plume reaches steady state at this location (MW07-25 is 325 m from the fill area). To the south of the Site, calculations overestimate potassium at all but MW19. MW19 is situated in a corn field, and may be subject to an additional potassium source from fertilizer.

4.2 Predictive Calculations

Predictive calculations were used to determine the peak chloride concentrations at various distances downgradient from the fill area. Results were compared to the Reasonable Use Performance objectives (RUPO) for the Site (as described under Guideline B-7 (MOE, 1994)). Results of the predictive simulations are provided in Figure A-10. As shown, predictive results indicate that chloride concentrations are likely to meet the RUPO for both bedrock and overburden groundwater if the boundary of the CAZ lands extends to 700 m downgradient of the fill area. Doubling of the distance from the fill area to the CAZ boundary would provide an almost fifty percent reduction in chloride concentrations at the boundary.

5.0 DISCUSSION

The analysis presented above was completed to provide an estimate of landfill contaminant concentrations in groundwater at the downgradient boundaries of the CAZ for both current conditions and the landfill expansion option. Chloride concentrations were found to meet RUPO at 700 m downgradient from the fill area. Based on this analysis, it is recommended that if the Township is to proceed with the proposed natural attenuation landfill expansion, CAZ land to the north and south of the fill area would need to extend at least 700 m downgradient from the fill area.

6.0 LIMITATIONS

This memo was prepared for the exclusive use of the Township of North Dundas. The memo, which specifically includes all tables, figures and appendices, is based on subsurface data and information collected by Golder Associates Ltd. and is based solely on the conditions of the property at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. and others. The factual information, descriptions, interpretations, comments, conclusions and recommendations contained herein are specific to the project described in this memo and do not apply to any other project or site. Under no circumstances may this information be used for any other purposes than those specified in the scope of work unless explicitly stipulated in the text of this memo or formally authorized by Golder Associates Ltd.

The assessment of existing environmental conditions and possible hazards and subsurface conditions at this Site has been made using the results of physical measurements and chemical analyses of liquids from a number of locations. The Site conditions between sampling locations have been inferred based on conditions observed at borehole and monitoring well locations. Subsurface conditions may vary from these sampled locations.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the time limits and financial and physical constraints applicable to the services. The calculations provide a predictive scientific tool to evaluate the impacts on a real groundwater system. However, and despite the professional care taken during the calculation process, its accuracy is bound to the normal uncertainty associated to groundwater studies and no warranty, express or implied, is made.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Attachments: Figures A-1 to A-10
Attachment A – Slug Test Analysis

MIB/PLE/PAS/md
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7.0 REFERENCES

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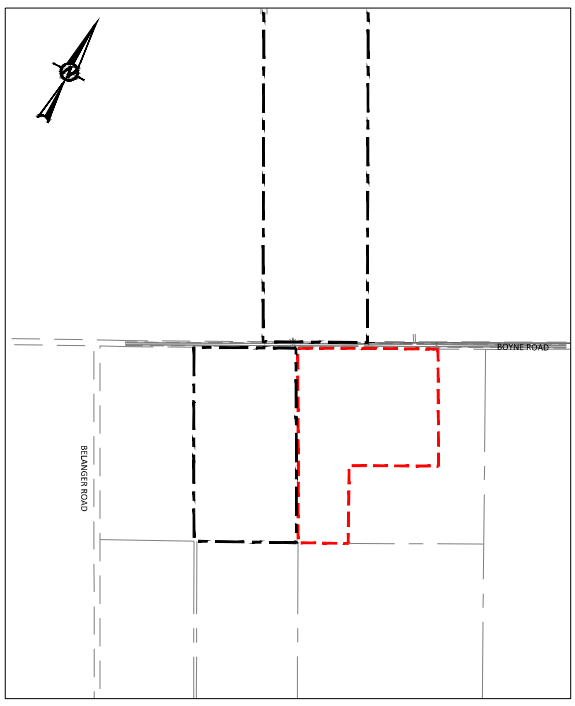


INSET MAP
SCALE 1:25,000

LEGEND

- APPROXIMATE LOCATION IN PLAN OF DESTROYED MONITORING WELL NO LONGER IN USE
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY OTHERS
- APPROXIMATE SURFACE WATER SAMPLING LOCATION IN PLAN
- GEO-REFERENCING POINTS
- APPROXIMATE WELL LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE LOCATION OF PERIMETER DITCH AND FLOW DIRECTION
- INFERRED FLOW DIRECTION IN THE DRAINAGE DITCH ALONG BOYNE ROAD
- EASEMENTS AND PROPERTY BOUNDARIES

NOTES

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. 2008 AND 2010 SURVEYS COMPLETED BY STANTEC CONSULTING LTD.
3. MAY 2012, JULY 2013, AND NOVEMBER 2014 SURVEYS COMPLETED BY GOLDER ASSOCIATES LTD.
4. COORDINATE SYSTEM: MTM ZONE 9 NAD83

0 100 200
1:5,000 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

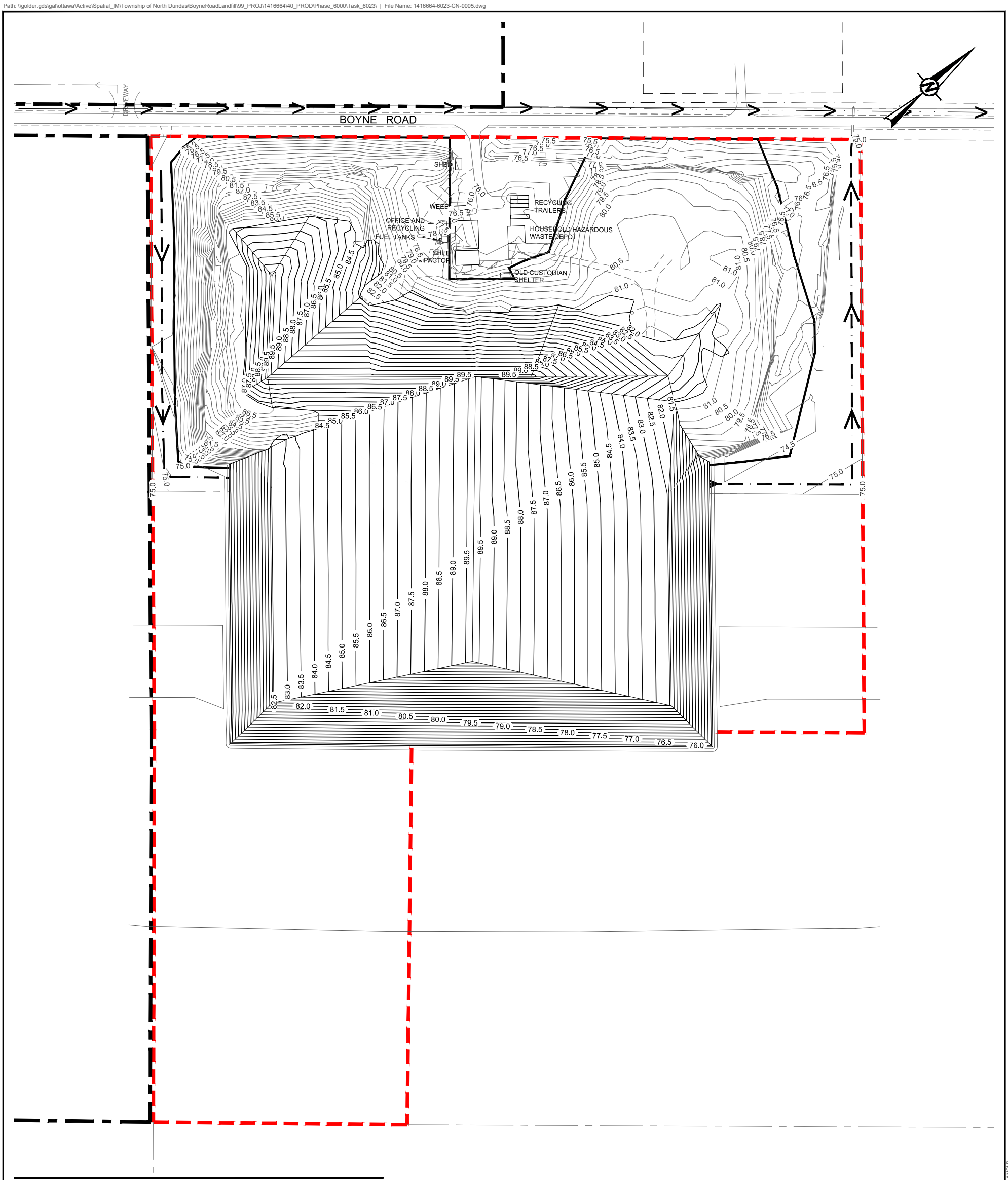
CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
DESIGNED	MB
PREPARED	MLF
REVIEWED	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

TITLE
SITE PLAN

PROJECT NO.	CONTROL/TASK	REV.	FIGURE
1416664	6000/6023	0	A-1



LEGEND

- 85.0 — GROUND SURFACE CONTOURS (m), BASED ON RESULTS OF THE SURVEYS CONDUCTED IN 2008, 2010, 2012, 2013, AND 2014
- APPROXIMATE PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE LOCATION OF PERIMETER DITCH AND FLOW DIRECTION
- EXISTING ROADSIDE DITCH (APPROXIMATE LOCATION)
- 89.50 — PROPOSED EXPANSION CONTOURS (INTERVAL 0.5 m)

NOTE(S)

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
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4. COORDINATE SYSTEM: MTM ZONE 9 NAD83

NOT FOR CONSTRUCTION

0 50 100
1:2,500 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

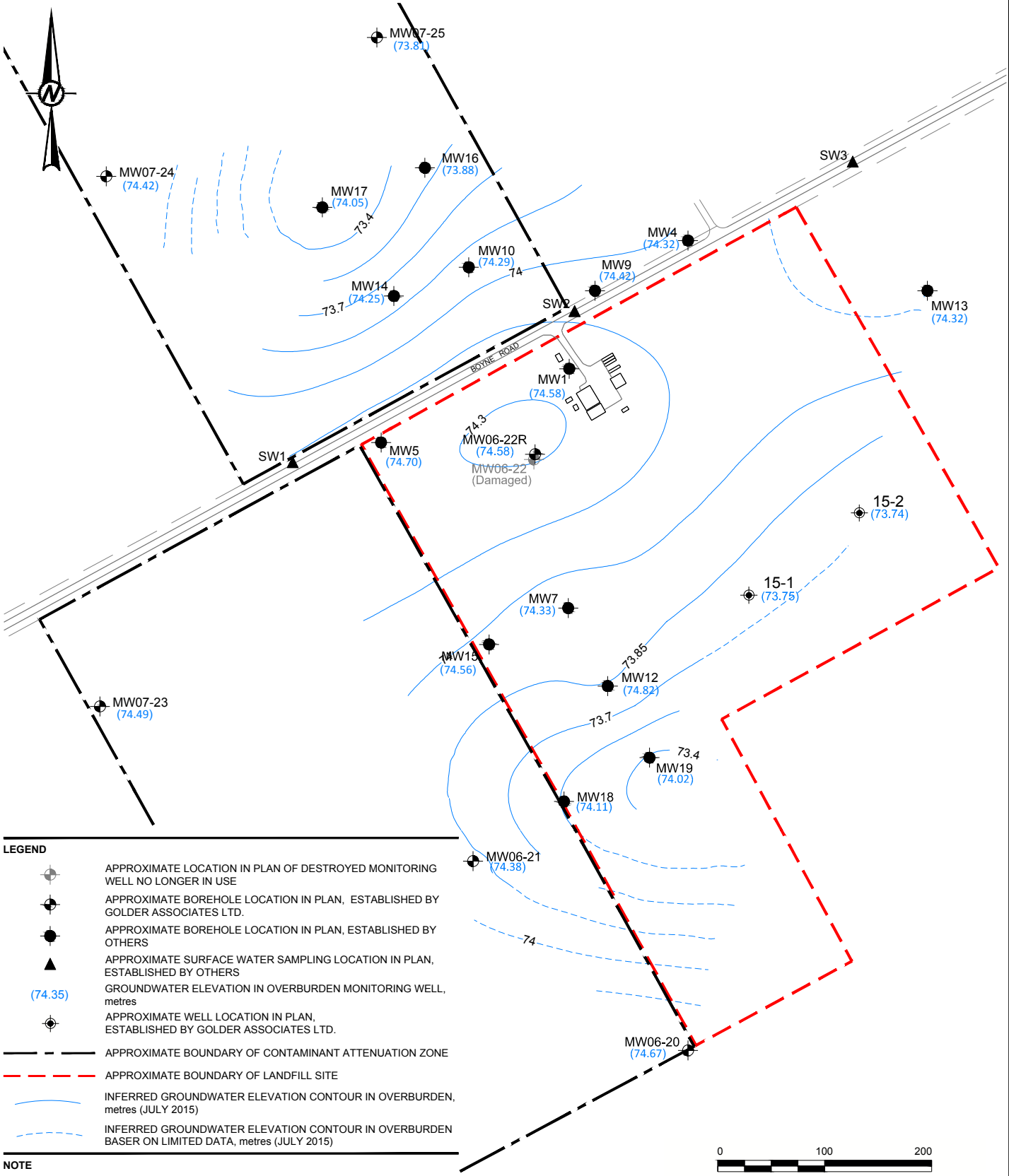
CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
DESIGNED	MB
PREPARED	MLF
REVIEWED	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

TITLE
PRELIMINARY BOYNE ROAD LANDFILL EXPANSION DESIGN

PROJECT NO.	CONTROL/TASK	REV.	FIGURE
1416664	6000/6023	0	A-2



LEGEND

- APPROXIMATE LOCATION IN PLAN OF DESTROYED MONITORING WELL NO LONGER IN USE
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY OTHERS
- APPROXIMATE SURFACE WATER SAMPLING LOCATION IN PLAN, ESTABLISHED BY OTHERS
- (74.35) GROUNDWATER ELEVATION IN OVERBURDEN MONITORING WELL, metres
- APPROXIMATE WELL LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE BOUNDARY OF LANDFILL SITE
- INFERRED GROUNDWATER ELEVATION CONTOUR IN OVERBURDEN, metres (JULY 2015)
- INFERRED GROUNDWATER ELEVATION CONTOUR IN OVERBURDEN BASER ON LIMITED DATA, metres (JULY 2015)

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT 1416664/6000.

CLIENT
TOWNSHIP OF NORTH DUNDAS

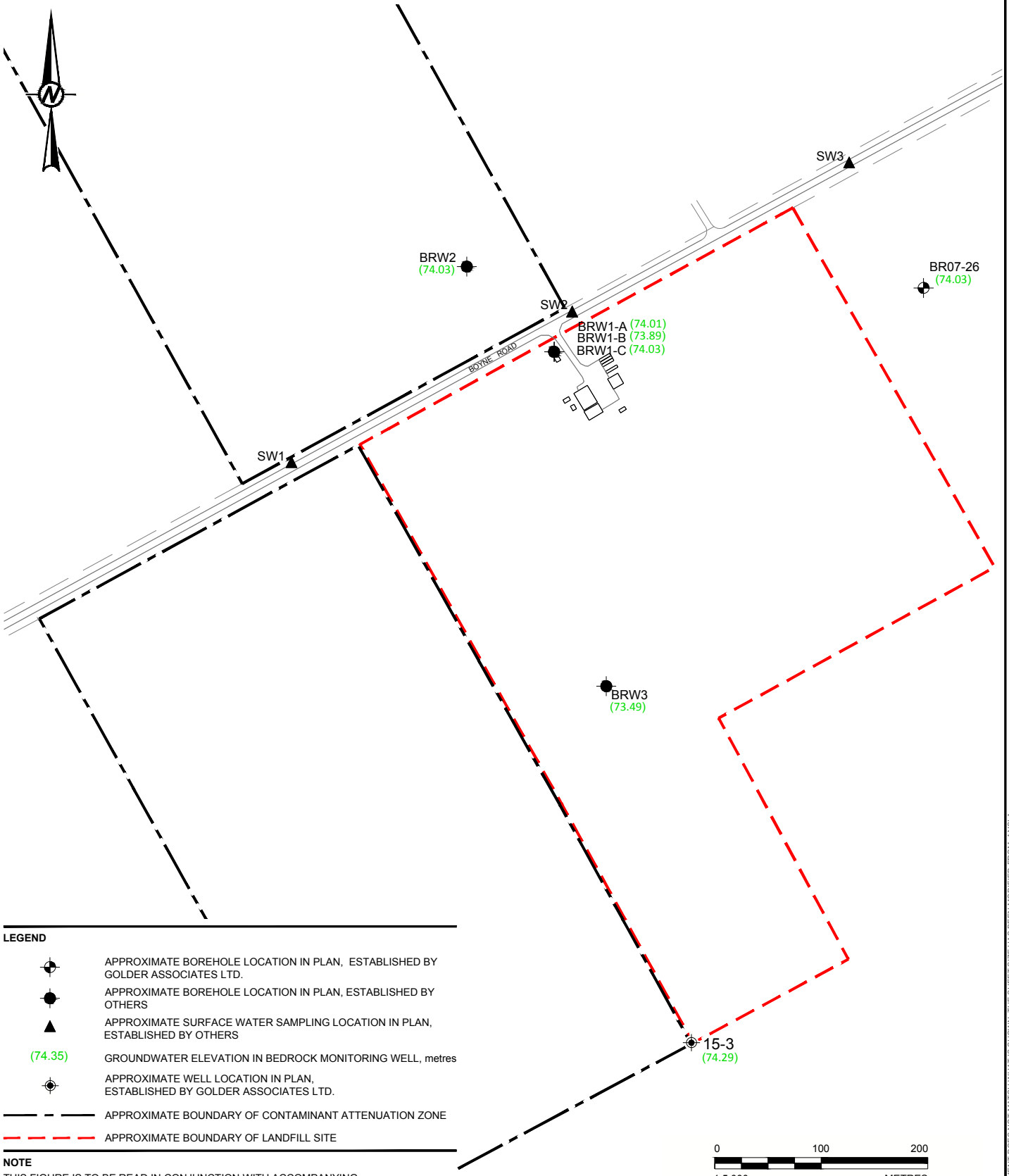
CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MLF
DESIGN	MB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

TITLE
OVERBURDEN GROUNDWATER ELEVATION (JULY 2015)

PROJECT No.	CONTROL/TASK	Rev.	FIGURE
1416664	6000/6023	0	A-3



LEGEND

- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY OTHERS
- APPROXIMATE SURFACE WATER SAMPLING LOCATION IN PLAN, ESTABLISHED BY OTHERS
- (74.35) GROUNDWATER ELEVATION IN BEDROCK MONITORING WELL, metres
- APPROXIMATE WELL LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE BOUNDARY OF LANDFILL SITE

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT 1416664/6000.

CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MLF
DESIGN	MB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

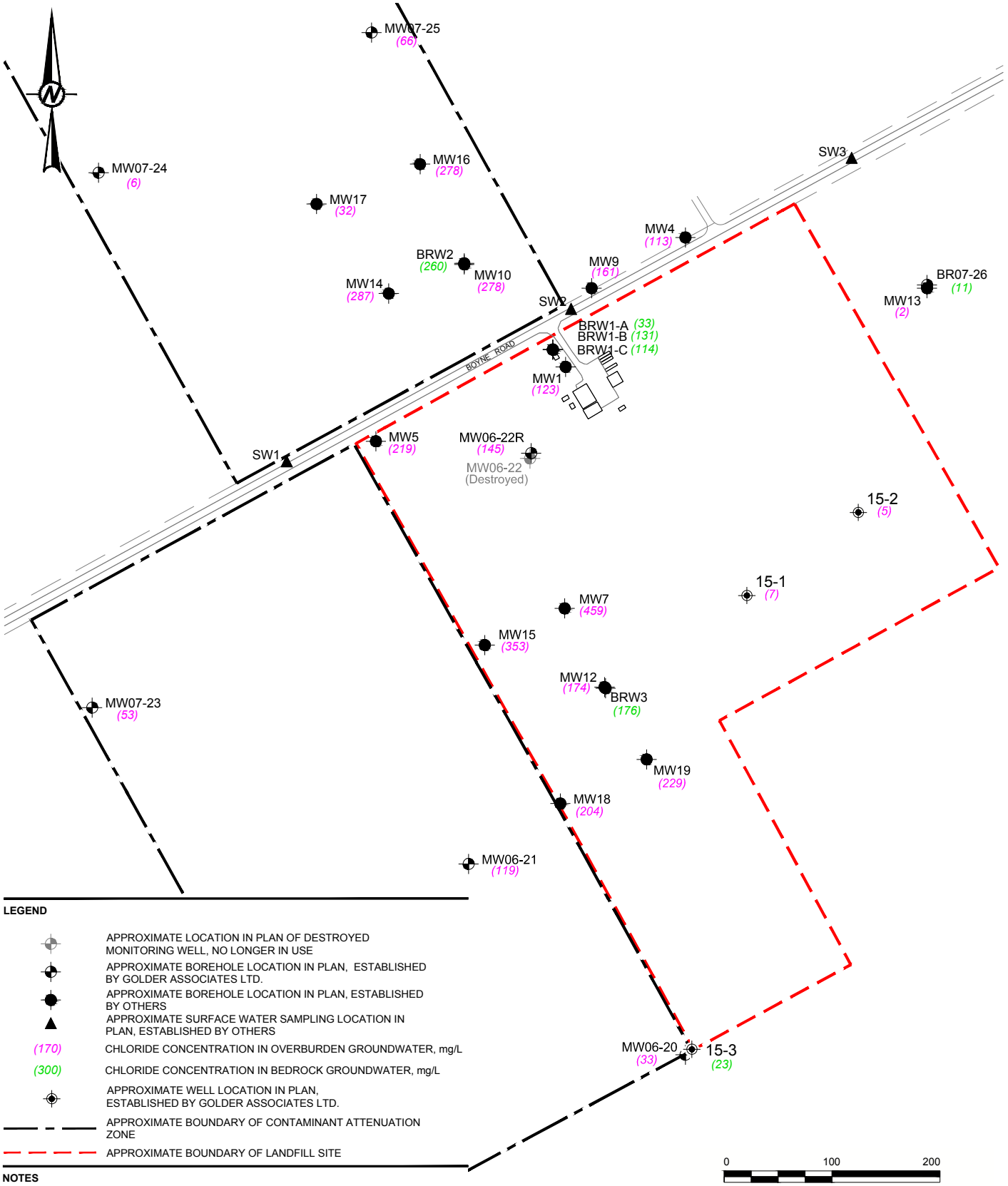
TITLE
BEDROCK GROUNDWATER ELEVATION (JULY 2015)

PROJECT No.	CONTROL/TASK	Rev.	FIGURE
1416664	6000/6023	0	A-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 25 mm

Path: \\golder.gds\gal\ottawa\active\Spatial_IM\Township of North Dundas\BoyneRoadLandfill\69_PRO\1416664\40_PROD\Phase_6000\Task_6023\ | File Name: 1416664-6023-CN-0007.dwg



LEGEND

- APPROXIMATE LOCATION IN PLAN OF DESTROYED MONITORING WELL, NO LONGER IN USE
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY OTHERS
- APPROXIMATE SURFACE WATER SAMPLING LOCATION IN PLAN, ESTABLISHED BY OTHERS
- *(170)* CHLORIDE CONCENTRATION IN OVERBURDEN GROUNDWATER, mg/L
- *(300)* CHLORIDE CONCENTRATION IN BEDROCK GROUNDWATER, mg/L
- APPROXIMATE WELL LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE BOUNDARY OF LANDFILL SITE

NOTES

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT 1416664/6000.

CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MLF
DESIGN	MB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

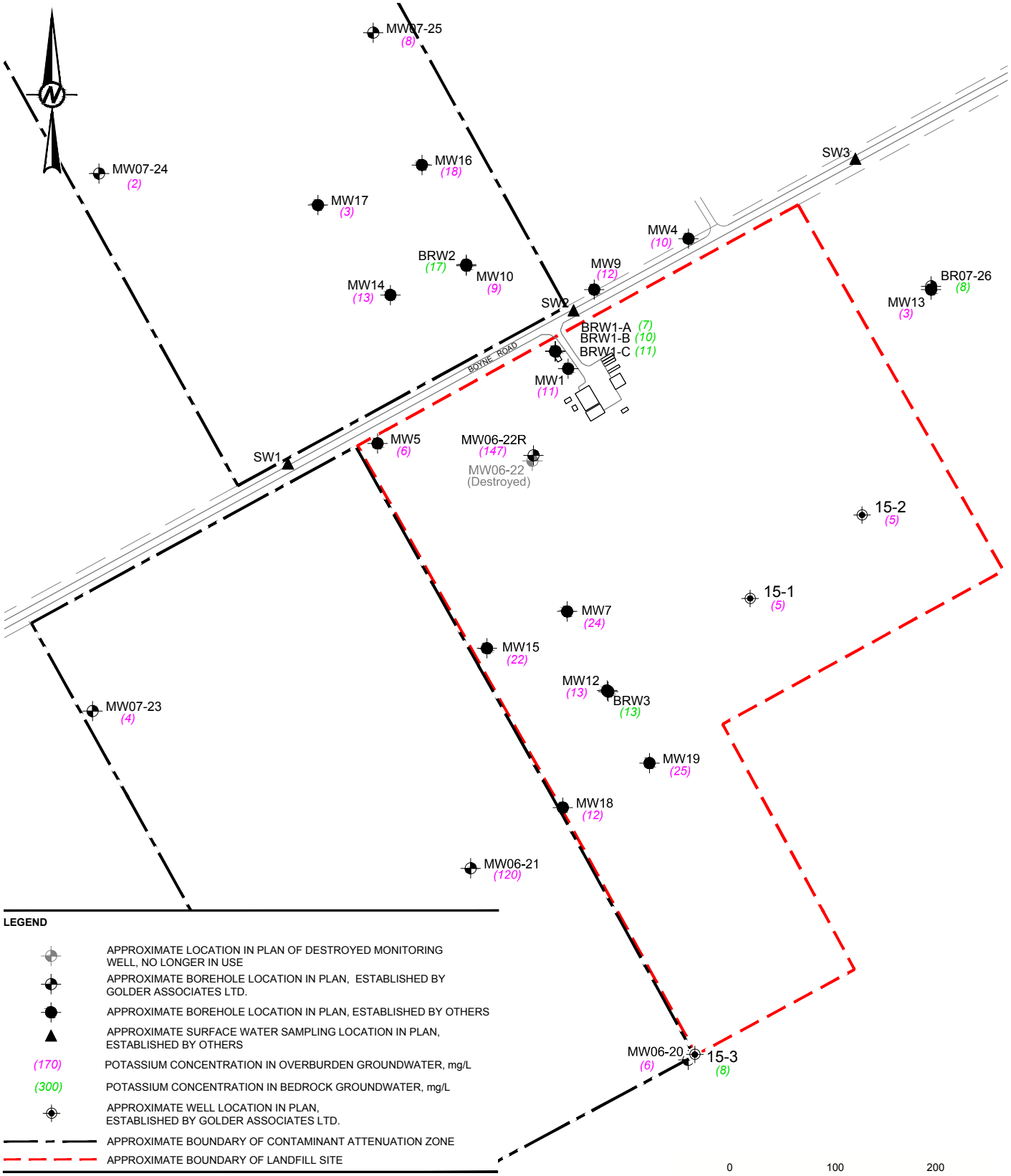
TITLE
AVERAGE OBSERVED CHLORIDE CONCENTRATIONS IN GROUNDWATER

PROJECT No.	CONTROL/TASK	Rev.	FIGURE
1416664	6000/6023	0	A-5

Path: \\golder.gds\gal\ottawa\active\Spatial_IM\Township of North Dundas\BoyneRoadLandfill\69_PRO\11416664\40_PROD\Phase_6000\Task_6023\ | File Name: 1416664-6023-CN-0008.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 25 mm



LEGEND

- APPROXIMATE LOCATION IN PLAN OF DESTROYED MONITORING WELL, NO LONGER IN USE
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, ESTABLISHED BY OTHERS
- APPROXIMATE SURFACE WATER SAMPLING LOCATION IN PLAN, ESTABLISHED BY OTHERS
- *(170)* POTASSIUM CONCENTRATION IN OVERBURDEN GROUNDWATER, mg/L
- *(300)* POTASSIUM CONCENTRATION IN BEDROCK GROUNDWATER, mg/L
- APPROXIMATE WELL LOCATION IN PLAN, ESTABLISHED BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE BOUNDARY OF LANDFILL SITE

NOTES

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CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MLF
DESIGN	MB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, NATURAL ATTENUATION LANDFILL EXPANSION ALTERNATIVE

TITLE
AVERAGE OBSERVED POTASSIUM CONCENTRATIONS IN GROUNDWATER

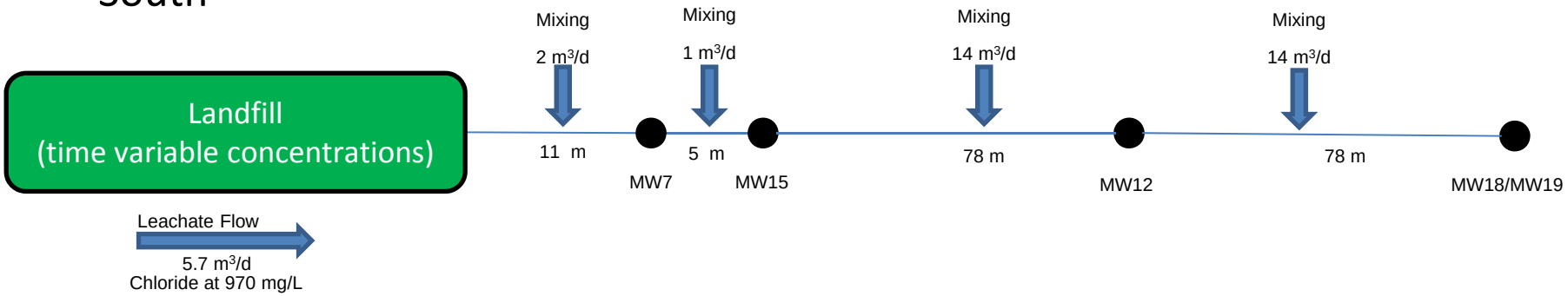
PROJECT No.	CONTROL/TASK	Rev.	FIGURE
1416664	6000/6023	0	A-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

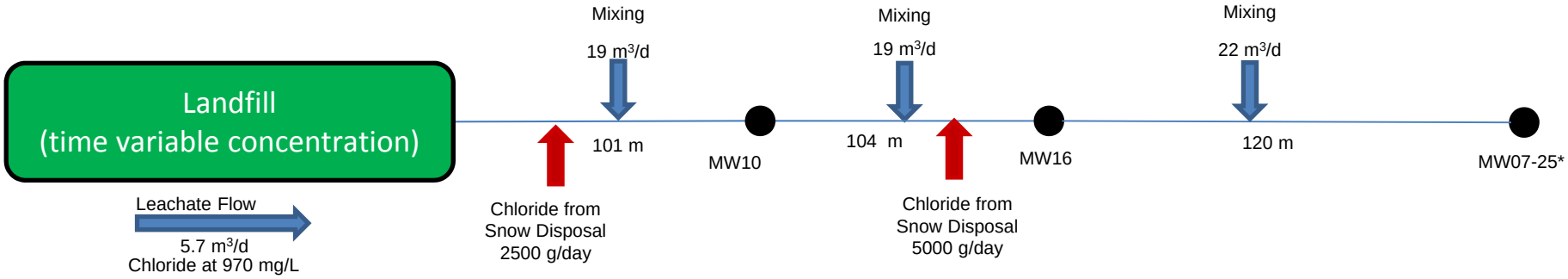
0 25 mm

Path: \\golder.gds\gal\ottawa\active\Spatial_IM\Township of North Dundas\BoyneRoadLandfill\69_PRO\1416664\40_PROD\Phase_6000\Task_6023\ | File Name: 1416664-6023-CN-0009.dwg

South



North



Notes

Not to Scale

Mixing equivalent to recharge of 175 mm/year

*Leachate plume not likely at steady-state at MW07-25

CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

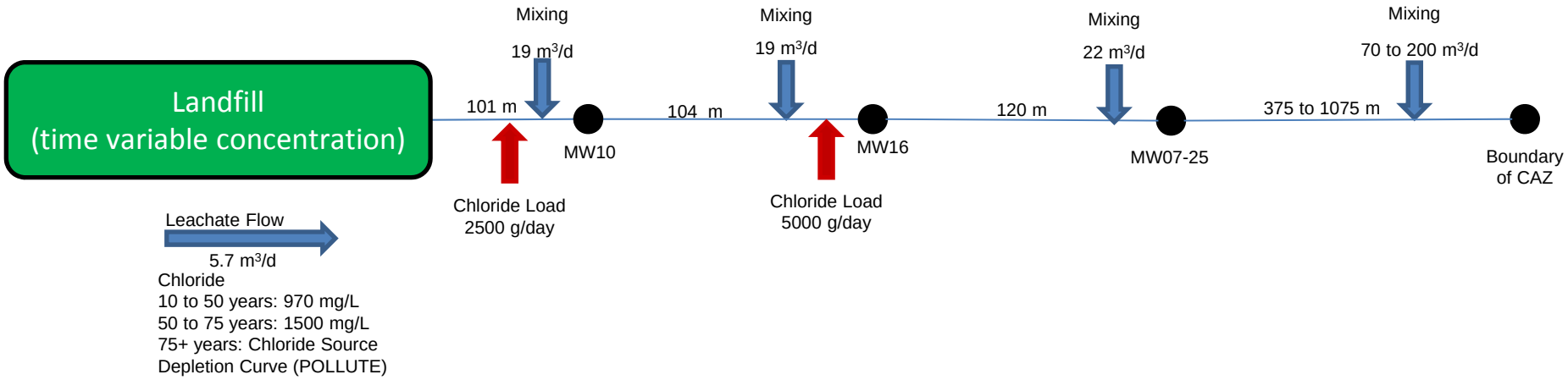
YYYY-MM-DD	2015-10-22
PREPARED	MIB
DESIGN	MIB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, PROPOSED EXPANSION ALTERNATIVE

TITLE
SCREENING CALCULATION – CALIBRATION SET-UP

PROJECT No.	Phase/Task	Rev.	Figure
1416664	**6000/6023**	**0**	**A-7**

North



Chloride
10 to 50 years: 970 mg/L
50 to 75 years: 1500 mg/L
75+ years: Chloride Source Depletion Curve (POLLUTE)

Notes
Not to Scale
Mixing equivalent to recharge of 175 mm/year
Range in distance to boundary reflective of potential to acquire additional MNRF land

CLIENT
TOWNSHIP OF NORTH DUNDAS

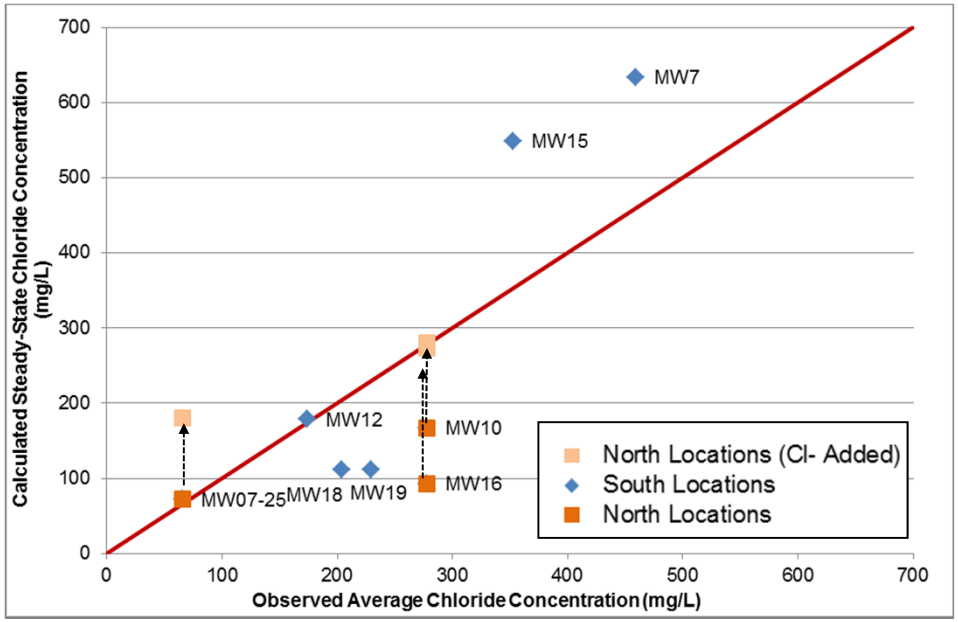
CONSULTANT
Golder Associates

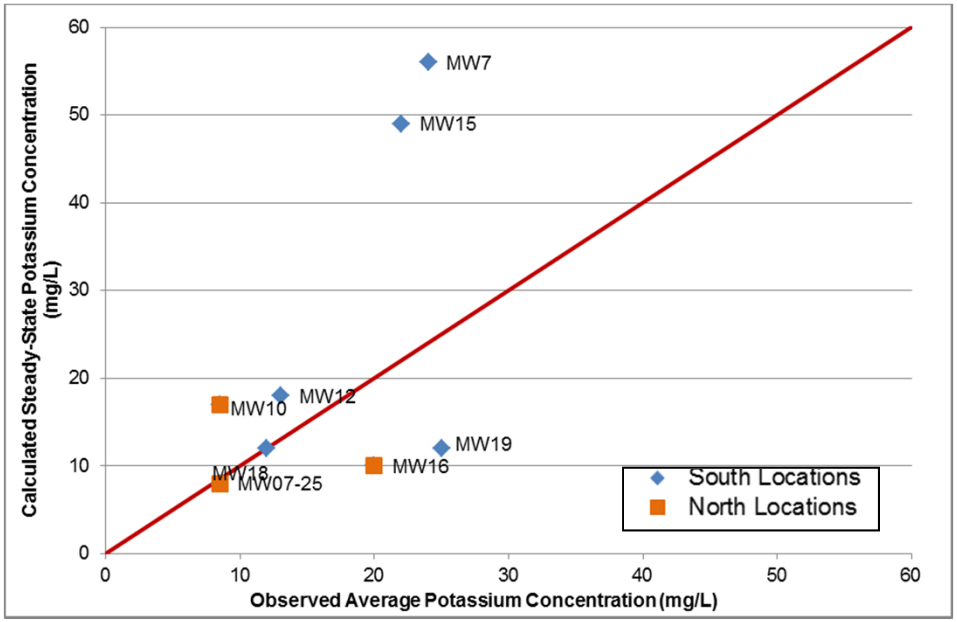
YYYY-MM-DD	2015-10-22
PREPARED	MIB
DESIGN	MIB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, PROPOSED EXPANSION ALTERNATIVE

TITLE
SCREENING CALCULATION – PREDICTIVE SET-UP

PROJECT No.	Phase/Task	Rev.	Figure
1416664	**6000/6023**	**0**	**A-8**





Location	Distance from site (m)	Chloride Concentrations (mg/L)				Potassium Concentration (mg/L)		
		Observed		Calculated		Observed		Calculated
		Max	Average	Steady State	Added Cl-	Max	Average	Steady State
North								
MW10	101	343	278	167	280	10	8.5	17
MW16	205	484	278	93	273	27	20	10
MW07-25	325	130	65.8	67	180	11	8.5	8
South								
MW7	11	670	459	634	--	40	24	56
MW15	16	510	353	549	--	40	22	49
MW12	94	390	174	179	--	22	13	18
MW18	165	430	204	112	--	28	12	12
MW19	172	460	229	112	--	73	25	12

CLIENT
TOWNSHIP OF NORTH DUNDAS

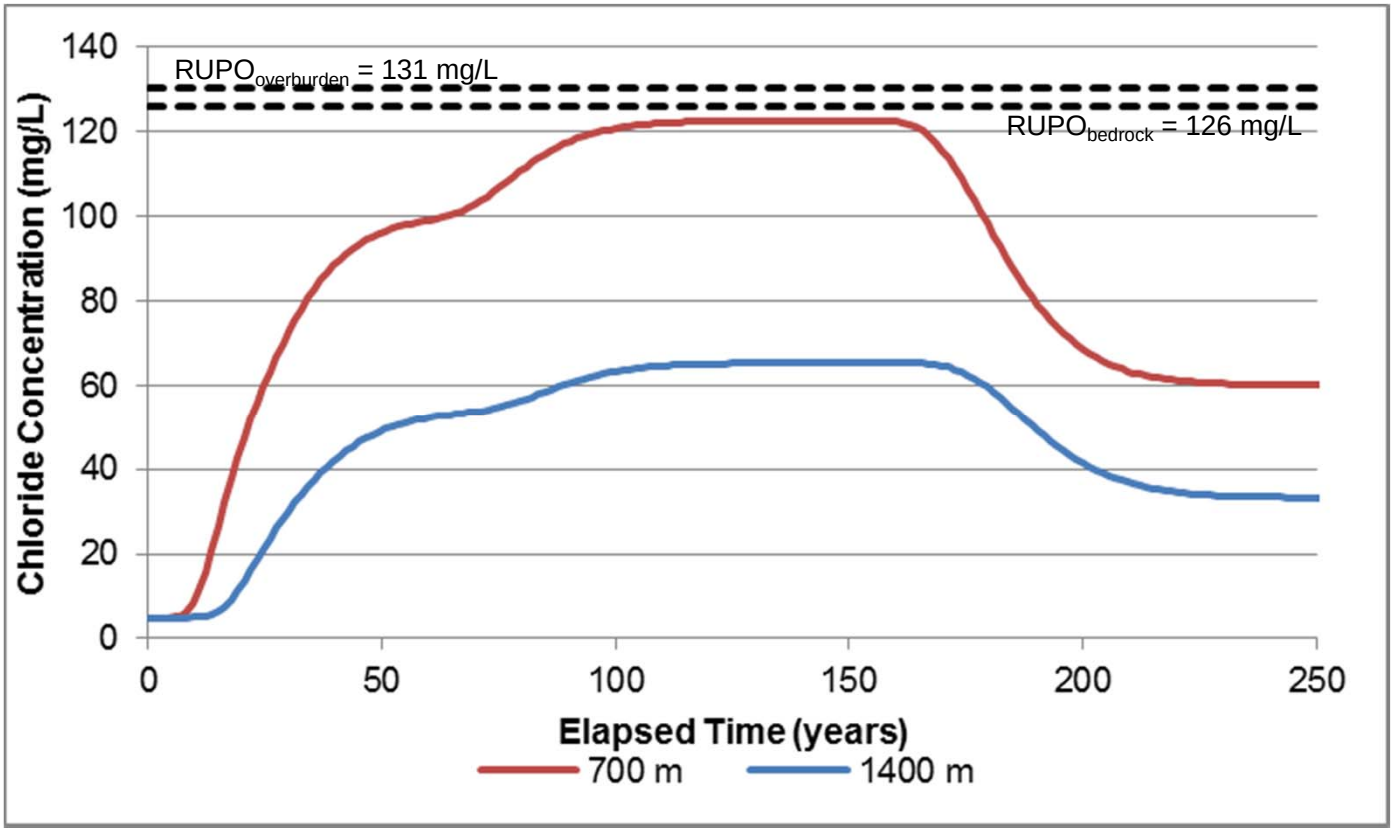
PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, PROPOSED EXPANSION ALTERNATIVE

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MIB
DESIGN	MIB
REVIEW	PLE
APPROVED	PAS

TITLE
CALIBRATION RESULTS

PROJECT No.	Phase/ Task	Rev.	Figure
1416664	**6000/6023**	**0**	**A-9**



RUPO - Reasonable Use Performance Objective

CLIENT
TOWNSHIP OF NORTH DUNDAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-22
PREPARED	MIB
DESIGN	MIB
REVIEW	PLE
APPROVED	PAS

PROJECT
PREDICTIVE ASSESSMENT OF GROUNDWATER COMPLIANCE, BOYNE ROAD LANDFILL, PROPOSED EXPANSION ALTERNATIVE

TITLE
PREDICTIVE RESULTS

PROJECT No.	Phase/ Task	Rev.	Figure
1416664	**6000/6023**	**0**	**A-10**

ATTACHMENT A

Slug Test Analysis

Table 1: Slug Test Analysis Results

Well ID	Geological Unit	Horizontal Hydraulic Conductivity (m/s)	Analysis Method
MW5	Till	2×10^{-5}	Hvorslev
MW16	Silty Sand	4×10^{-5}	Hvorslev
MW18	Silty Sand	2×10^{-5}	Hvorslev
BRW2	Limestone	1×10^{-2}	Springer and Gelhar
MW06-20	Sandy Silt	1×10^{-5}	Bouwer and Rice
MW06-21	Sandy Silt	8×10^{-6}	Bouwer and Rice
MW07-23	Till	7×10^{-5}	Hvorslev
BR07-26	Limestone	6×10^{-6}	Hvorslev
15-1	Sandy Silt	8×10^{-5}	Hvorslev
15-3	Limestone	3×10^{-6}	Hvorslev
Geometric Mean (Overburden)		1.3×10^{-5}	--
Geometric Mean (Rock)		6×10^{-5}	--

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST MW5

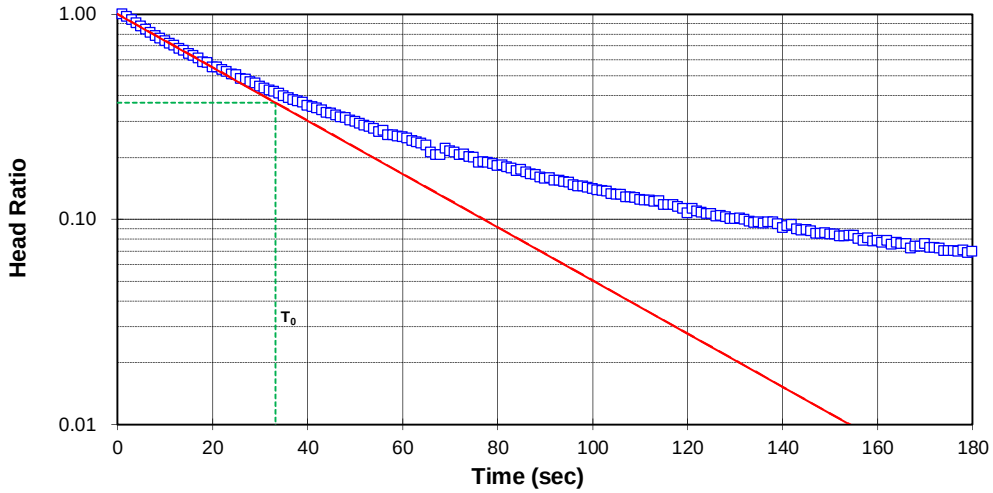
INTERVAL (metres below ground surface)

Top of Interval =	**3.43**
Bottom of Interval =	**4.93**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

INPUT PARAMETERS		**RESULTS**		
r_c =	2.5E-02	K=	2E-05	m/sec
R_e =	7.6E-02	K=	2E-03	cm/sec
L_e =	1.5			
T_0 =	33			



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 29/7/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST MW16

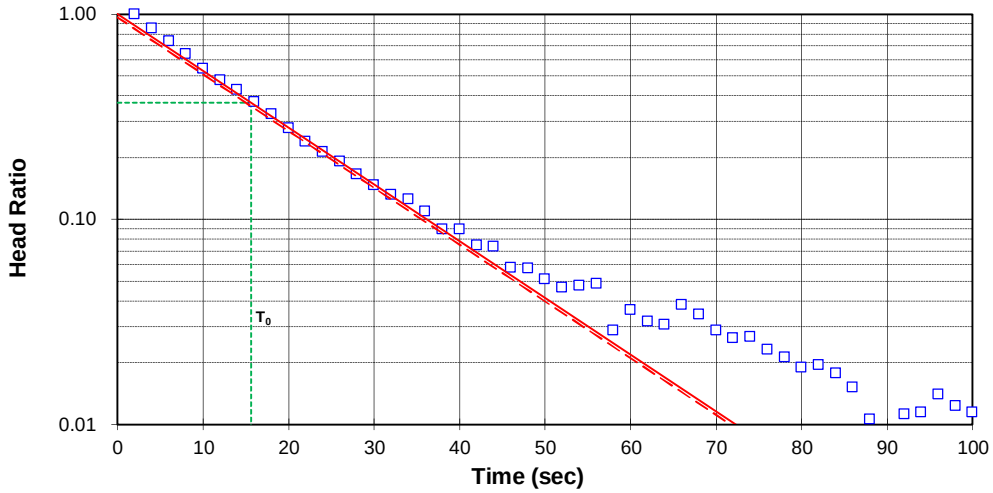
INTERVAL (metres below ground surface)

Top of Interval =	**3.10**
Bottom of Interval =	**4.60**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

INPUT PARAMETERS		**RESULTS**		
r_c =	2.5E-02	K=	4E-05	m/sec
R_e =	7.6E-02	K=	4E-03	cm/sec
L_e =	1.5			
T_0 =	16			



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 18/8/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST MW18

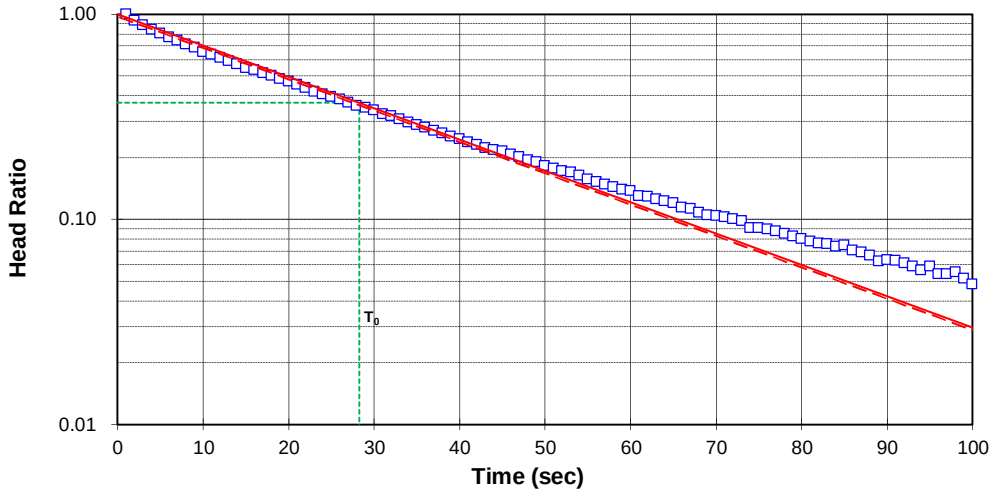
INTERVAL (metres below ground surface)

Top of Interval =	**1.80**
Bottom of Interval =	**3.40**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

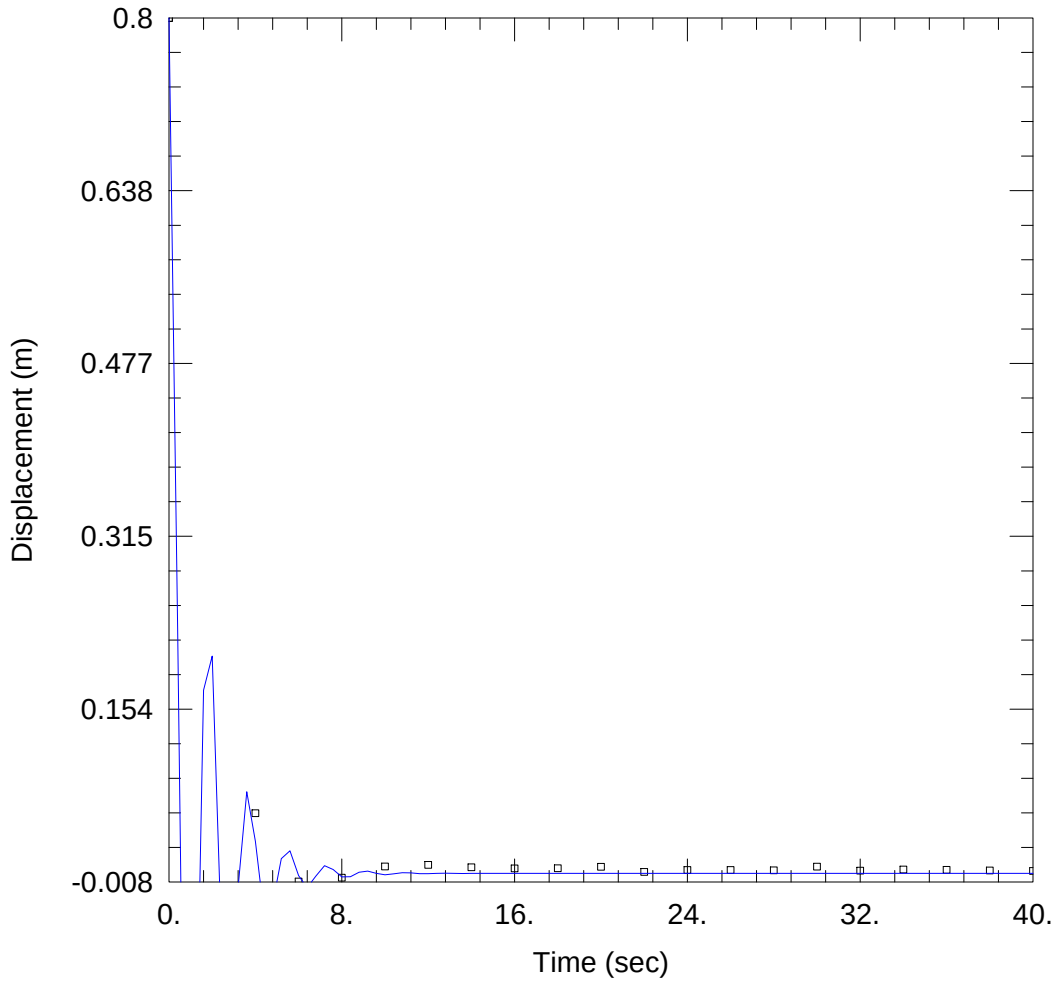
INPUT PARAMETERS		**RESULTS**		
r_c =	2.5E-02	K=	2E-05	m/sec
R_e =	7.6E-02	K=	2E-03	cm/sec
L_e =	1.6			
T_0 =	28			



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 29/7/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

Golder Associates Ltd.



WELL TEST ANALYSIS

Data Set: N:\...\BRW2.aqt
Date: 10/19/15 Time: 09:05:04

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Twp. North Dundas
Project: 1416664/6000/6023
Location: Boyne Road Landfill
Test Well: BRW2
Test Date: August 18, 2015

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BRW2)

Initial Displacement: 0.8 m Static Water Column Height: 6.6 m
Total Well Penetration Depth: 6.6 m Screen Length: 0.75 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Springer-Gelhar
K = 0.01124 m/sec Le = 0.7943 m

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST MW06-20

INTERVAL (metres below ground surface)

Top of Interval =	**1.17**
Bottom of Interval =	**4.27**

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

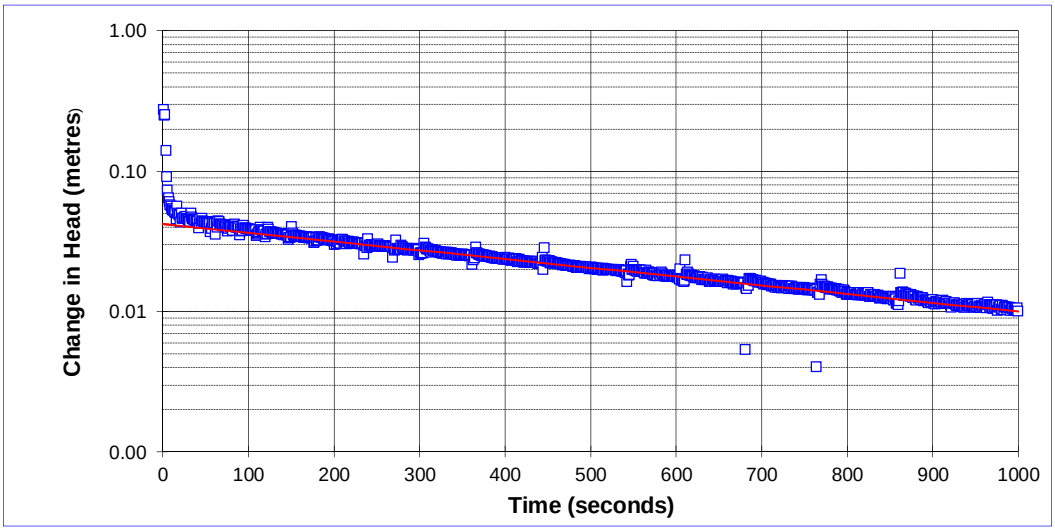
where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS	
r_c =	**0.06**
r_w =	**0.10**
L_e =	**2.37**
$\ln(R_e/r_w)$	**14.88**
y_0 =	**0.04**
y_t =	**0.01**
t =	**1000.0**

RESULTS

K=	**1E-05**	**m/sec**
K=	**1E-03**	**cm/sec**



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 18/8/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

BOUWER AND RICE SLUG TEST ANALYSIS
FALLING HEAD TEST 06-21

INTERVAL (metres below ground surface)

Top of Interval =	**0.90**
Bottom of Interval =	**4.05**

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

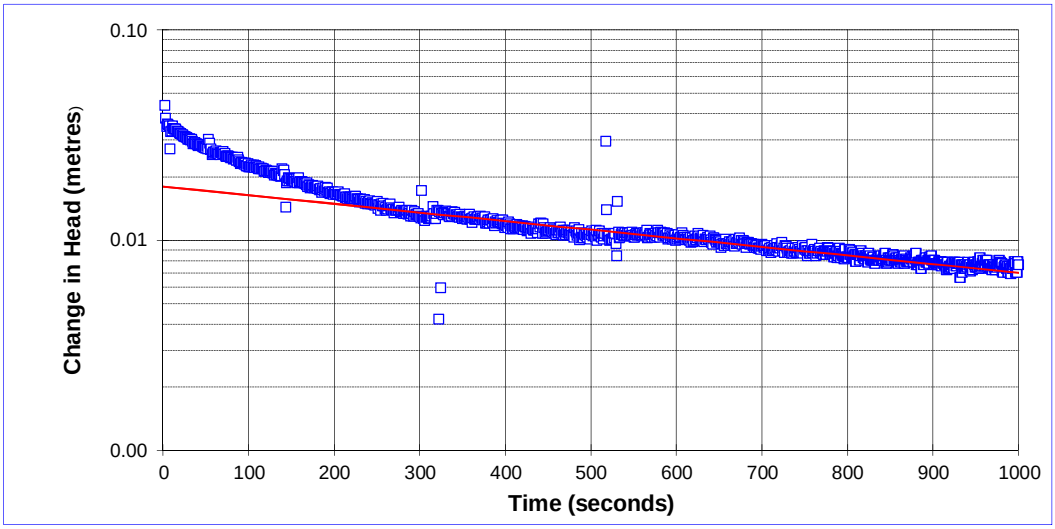
where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS	
r_c =	**0.06**
r_w =	**0.10**
L_e =	**3.01**
$\ln(R_e/r_w)$	**16.58**
y_0 =	**0.02**
y_t =	**0.01**
t =	**1000.0**

RESULTS

K=	**8E-06**	**m/sec**
K=	**8E-04**	**cm/sec**



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 29/7/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 07-23

INTERVAL (metres below ground surface)

Top of Interval =	**1.20**
Bottom of Interval =	**3.70**

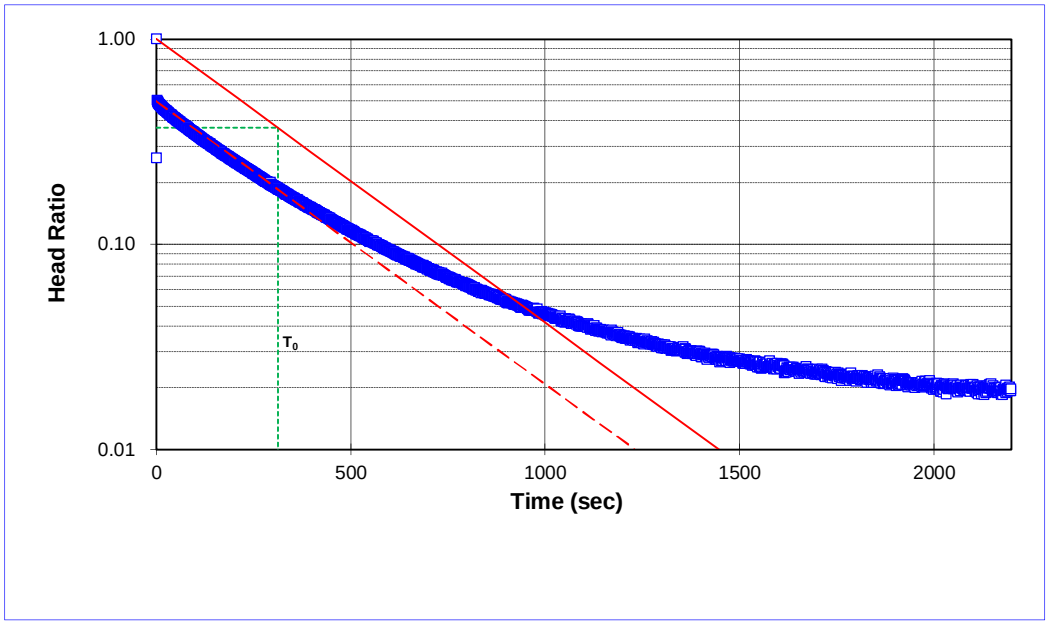
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

INPUT PARAMETERS	
r_c =	**1.9E-02**
R_e =	**1.0E-01**
L_e =	**2.5**
T_0 =	**312**

RESULTS

K=	**7E-07**	**m/sec**
K=	**7E-05**	**cm/sec**



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 29/7/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST BR07-26

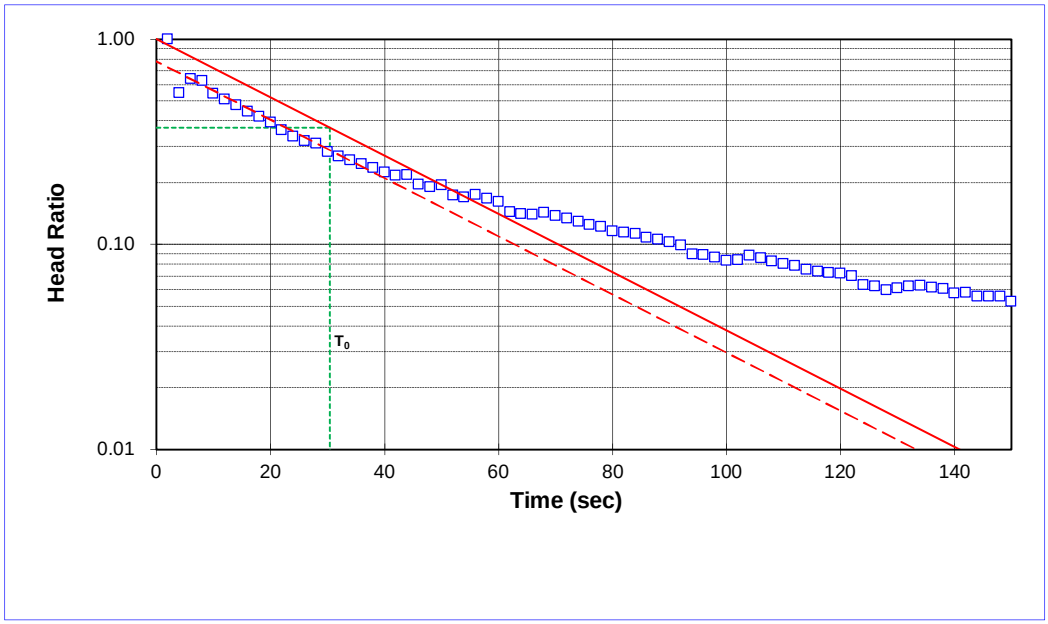
INTERVAL (metres below ground surface)

Top of Interval =	**6.10**
Bottom of Interval =	**9.10**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

INPUT PARAMETERS		**RESULTS**		
r_c =	1.6E-02	K=	6E-06	m/sec
R_e =	4.8E-02	K=	6E-04	cm/sec
L_e =	3.0			
T_0 =	30			



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 18/8/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST BH15-1

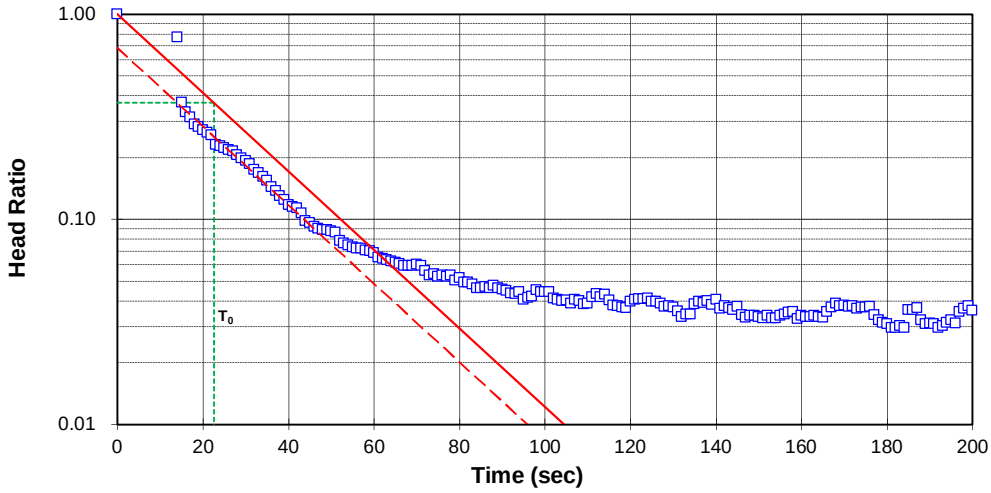
INTERVAL (metres below ground surface)

Top of Interval =	**1.41**
Bottom of Interval =	**2.18**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right)}{2L_e T_0}$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
T_0 = basic time lag (seconds; time where head ratio = 0.37)

INPUT PARAMETERS		**RESULTS**		
r_c =	2.5E-02	K=	8E-05	m/sec
R_e =	1.0E-02	K=	8E-03	cm/sec
L_e =	0.8			
T_0 =	23			



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 18/8/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST MW15-3

INTERVAL (metres below ground surface)

Top of Interval =	**5.03**
Bottom of Interval =	**8.08**

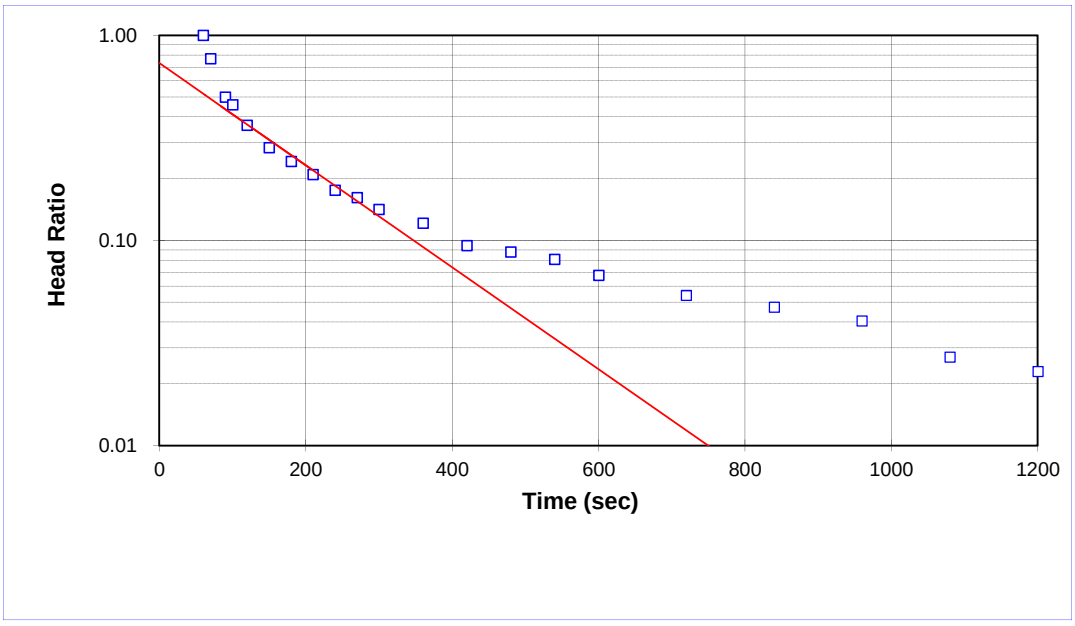
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	**2.5E-02**
R_e =	**3.8E-02**
L_e =	**3.1**
t_1 =	**210**
t_2 =	**85**
h_1/h_0 =	**0.22**
h_2/h_0 =	**0.45**

RESULTS

K=	**3E-06**	**m/sec**
K=	**3E-04**	**cm/sec**



Project Name: Boyne LF/Winchester/Ottawa
Project No.: 141664/6000
Test Date: 24/7/2015

Analysis By: MIB
Checked By: BH
Analysis Date: 8/4/2015

APPENDIX B

Technical Memorandum – Conceptual Stormwater Management Plan for Boyne Road Landfill Expansion Alternative

November 2015
Report No. 1416664/6000

TECHNICAL MEMORANDUM

DATE October 26, 2015 **PROJECT No.** 1416664/6000/6026

CONCEPTUAL STORMWATER MANAGEMENT ASSESSMENT
BOYNE ROAD LANDFILL EXPANSION ALTERNATIVE

1.0 INTRODUCTION

The Boyne Road Landfill Site (the Site) has been operating as a licensed landfill facility for the Township of North Dundas (the Township) since 1965. The Site is licensed for the disposal of domestic, commercial, and industrial solid non-hazardous waste. It was recently determined that the Site has exceeded its approved capacity and is in an overfill situation. The Site is currently operating under an Emergency Environmental Compliance Approval (Emergency ECA) to allow disposal to continue at the site until January 1, 2016.

The Township is currently assessing available waste management alternatives. One alternative under consideration is the expansion of the Site from approximately 484,000 cubic metres (m^3) of airspace on an 8.1 hectare (ha) footprint to 1,307,500 m^3 of airspace on a 13.7 ha footprint. A preliminary expansion design concept is shown on Figure B-1.

In accordance with Condition 5.7 of ECA No. A482101 Notice 6, issued on July 10, 2015, the Township shall ensure that approval is obtained under Section 53 (sewage works) of the *Ontario Water Resources Act*, 1993 (OWRA) for any future surface water management works prior to construction. As indicated earlier, to accommodate the volume of waste disposal required by the Township, the landfill footprint would have to be increased from 8.1 ha to 13.7 ha, with the most likely concept being that the expansion footprint will be located south of the existing footprint (see Figure B-1). Therefore, the existing perimeter ditch along the south side of the existing footprint would have to be abandoned and the perimeter ditch would have to be re-designed to accommodate the proposed expansion design. In any case, approval of a landfill expansion will require a stormwater management system to be designed to meet the requirements of O.Reg. 232/98 Landfill Standards, and approval of the stormwater management system under the *Ontario Water Resources Act* (OWRA).

This Technical Memorandum presents a conceptual stormwater management (SWM) plan for the Boyne Road Landfill expansion alternative being considered in this assessment.

2.0 QUALITY CONTROL FOR PROPOSED EXPANDED LANDFILL

During the continuing operations phase of the expanded landfill and post-closure, it is proposed that stormwater from the landfill will continue to be collected by existing or proposed grass-lined ditches along the west, south and east sides of the landfill, but it will be directed to a stormwater management wetland located at the northeast corner of the landfill. The stormwater wetland will be located within an existing partially filled, partially low area adjacent to the landfill. The depth of the excavation will be limited to match existing grades

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in the area, to limit the possibility of interception of groundwater potentially impacted by leachate. The stormwater run-off from the wetland will discharge via an existing culvert into the roadside ditch on the north side of Boyne Road. Refer to Figure B-1 for details. The total contributing drainage area is approximately 14.780 ha (Areas 2 and 3 on Figure B-3).

Since the wetland is proposed to service the existing landfill along with the expansion of the landfill, the design will be a best efforts approach to provide additional water quality improvements for an area where runoff is currently draining. Table 3.2 of the MOECC SWM Planning and Design Manual (2003) provides storage volume design requirements based on specific site imperviousness levels to achieve required Total Suspended Solids (TSS) removal objectives. Table 3.2 indicates that the minimum storage volume should be based on 80.0 m^3/ha, for 80% TSS removal and an impervious level of 35%. The 80% target has been selected since it is likely that South Nation Conservation will request that level of treatment. If they identify that only 70% removal is sufficient, then the design is conservative and the wetland footprint may be able to be reduced. For a drainage area of 14.78 ha, the 80% criteria results in a required storage volume of approximately 1,182 m^3. Section 3.3.2 of the MOECC SWM Planning and Design Manual (2003) indicates that 40.0 m^3/ha of the storage volume can be included in the extended detention. Therefore, a permanent pool of approximately 591 m^3 is required. The proposed pond provides a permanent pool storage volume of approximately 895 m^3 at the normal water level depth of 0.3 m, as per the following table:

Depth (m)	Area (m^2)	Volume (m^3)
0.0	2,780	0
0.1	2,910	285
0.2	3,047	583
0.3	3,185	895
0.4	3,324	1,221
0.5	3,465	1,561
0.6	3,607	1,916
0.7	3,750	2,285
0.8	3,894	2,670
0.9	4,040	3,069
1.0	4,187	3,484
1.1	4,335	3,913
1.2	4,485	4,359
1.3	4,636	4,820
1.4	4,788	5,297

As this is a best efforts approach, the proposed wetland does not meet all of the typical design standards. The following table provides the design values for the wetland and whether these values meet the minimum criteria as per Table 4.7 of the MOECC SWM Planning and Design Manual.

Design Element	Design Value	MOECC Criteria
Drainage Area	14.78 ha	Minimum Criteria
Treatment Volume	895 m^3	Minimum Criteria
Forebay	No Forebay is included	Not Met
Length-to-Width Ratio	7.5:1	Minimum Criteria
Permanent Pool Depth	300 mm	Minimum Criteria
Active Storage Depth	Maximum Depth – 1.0 m	Minimum Criteria
Side Slopes	4H:1V	Not Met
Inlet	Ditch	N/A
Outlet	450 mm dia. outlet pipe, 1.0% slope	Minimum Criteria

3.0 QUANTITY CONTROL FOR PROPOSED EXPANDED LANDFILL

3.1 Pre-Development Flow Rates

Area 1, as shown on the Pre-Development Drainage Area Plan (Figure B-2), drained to the existing roadside ditch along Boyne Road before the landfill existed. The following calculations provide the 1:5 and 1:100 year pre-development peak outlet flow rates for the drainage area. To be conservative, the pre-development peak flow rates were calculated based on the site before the landfill existed.

Time of Concentration

The airport formula was used to determine the time of concentration for the pre-development conditions.

Airport Formula

Runoff Coefficient = C = 0.30 (MTO Design Chart 1.07, 1997, Woodland, silt/clay, 0-5% slope)

Length of Flow Path = L = 560 m

Slope of Flow Path = S = 0.15%

Time of concentration = $Tc = (3.26\ (1.1 - C)\ (L)^{0.5}) / (S)^{0.33}$

$= (3.26\ (1.1 - 0.30)\ (560)^{0.5}) / (0.15)^{0.33}$

$= 115.4$ min

Therefore, a time of concentration for the pre-development conditions of 115.4 minutes will be used.

1:5 Year Pre-development Flow

A = 16.794 ha

Time of concentration = Tc = 115.4 min

Rainfall intensity = i = 20.1 mm/hr (City of Ottawa Sewer Design Guidelines, Meteorological Services of Canada Rainfall Data, MacDonald Cartier Airport, 1967 – 1997)

Runoff Coefficient = C = 0.30

Pre-development flow rate = Q

$= 2.78\ AiC$

$= 2.78\ (16.794)\ (20.1)\ (0.30)$

$= 281.5$ L/s

1:100 Year Pre-development Flow

A = 16.794 ha

Time of concentration = Tc = 115.4 min

Rainfall intensity = i = 33.9 mm/hr (City of Ottawa Sewer Design Guidelines, Meteorological Services of Canada Rainfall Data, MacDonald Cartier Airport, 1967 – 1997)

Runoff Coefficient = C = 0.38 (increased by 25%)

Pre-development flow rate = Q

= 2.78 AiC

= 2.78 (16.794) (33.9) (0.38)

= 601.4 L/s

Therefore, to meet allowable pre-development flow rates, the post-development peak flow rate from the drainage area should not exceed 281.5 and 601.4 L/s for the 1:5 and 1:100 year storm events, respectively.

3.2 Post-Closure Flow Rates

Area 1, as shown on the Post-Closure Drainage Area Plan (Figure B-3) is a limited area along the front of the site and is proposed to continue to drain without stormwater controls to the existing roadside ditch along Boyne Road, since it would be difficult to redirect runoff from this area to the proposed pond and to do so would require removal of significant screening along the road allowance. The following calculations provide the 1:5 and 1:100 year post-closure peak outlet flow rates.

Time of Concentration

The airport formula was used to determine the time of concentration for Area 1.

Airport Formula

Runoff Coefficient = C = 0.47 (weighted average)

Length of Flow Path = L = 98 m

Slope of Flow Path = S = 2.6%

Time of concentration = Tc $= (3.26 (1.1 – C) (L)^{0.5}) / (S)^{0.33}$

$= (3.26 (1.1 – 0.47) (98)^{0.5}) / (2.6)^{0.33}$

= 14.8 min

Ditch Flow

Length of Flow Path = L = 250 m

Velocity of Flow = V = 0.5 m/s (assumed)

Time of concentration = Tc = L / V * 60

= 250 / (0.5 * 60)

= 8.3 min

Therefore, a time of concentration for the pre-development conditions of 23.1 minutes will be used.

1:5 Year Pre-development Flow

A = 2.014 ha

Time of concentration = Tc = 23.1 min

Rainfall intensity = i = 64.1 mm/hr (City of Ottawa Sewer Design Guidelines, Meteorological Services of Canada Rainfall Data, MacDonald Cartier Airport, 1967 – 1997)

Runoff Coefficient = C = 0.47

Pre-development flow rate = Q

= 2.78 AiC

= 2.78 (2.014) (64.1) (0.47)

= 168.7 L/s

1:100 Year Pre-development Flow

A = 2.014 ha

Time of concentration = Tc = 23.1 min

Rainfall intensity = i = 109.4 mm/hr (City of Ottawa Sewer Design Guidelines, Meteorological Services of Canada Rainfall Data, MacDonald Cartier Airport, 1967 – 1997)

Runoff Coefficient = C = 0.59 (increased by 25%)

Pre-development flow rate = Q

= 2.78 AiC

= 2.78 (2.014) (109.4) (0.59)

= 361.4 L/s

Therefore, the post-closure flow rates from Area 1 are 168.7 and 361.4 L/s for the 1:5 and 1:100 year storm events, respectively.

Post-Closure runoff from Areas 2 and 3, as shown on the Post-Closure Drainage Area Plan (Figure B-3), is proposed to be controlled by the proposed wetland. An iterative approach was used along with the Modified Rational Method to attenuate the post-closure peak flow rates to the pre-development levels. The required storage volume has been calculated using the Modified Rational Method. This method is a conservative approach, as it provides the maximum storage volume for any storm duration.

The release rate from the wetland will be controlled by an orifice installed in the inlet end of the proposed outlet structure pipe (as shown on detail 4 on Figure B-1).

SWM Wetland: Areas 2 and 3 – 1:5 year

Time of Concentration (min)	Rainfall Intensity (mm/hr)	Uncontrolled Flow Rate (L/s)	Controlled Release Rate (L/s)	Release Rate Stored (L/s)	Storage Volume Required (m^3)
50	37.7	526.7	112.8	413.9	1,241.7
60	32.9	459.6	112.8	346.8	1,248.5
70	**29.4**	**410.7**	**112.8**	**297.9**	**1,251.2**
80	26.6	371.6	112.8	258.8	1,242.2
90	24.3	339.5	112.8	226.7	1,224.2

Total Release Rate

Therefore, the total maximum 1:5 year release rate from Areas 1, 2, and 3 is 281.5 L/s. This release rate is equal to the 1:5 year pre-development peak flow rate.

Orifice Sizing

The required storage volume of 1,251.2 m^3 from the 1:5 year storm event relates to a ponding depth of 0.36 m above the normal water level in the wetland. The following calculations provide the required orifice diameter:

Q = 0.1128 m^3/s (112.8 L/s)

H = 0.18 m (height above center of orifice)

Orifice Diameter = D

$= 2*\sqrt{(Q / (0.61*\pi*\sqrt{(2*9.81*H)}))}$

$= 2*\sqrt{(0.1128 / (0.61*\pi*\sqrt{(2*9.81*0.18)}))}$

= 0.354 m

Therefore, to control the release rate to 112.8 L/s, a 354 mm diameter orifice has been selected.

An iterative approach was used to assess the 1:100 year event discharge based on the orifice selected for the 1:5 year event.

SWM Wetland: Areas 2 and 3 – 1:100 year

Time of Concentration (min)	Rainfall Intensity (mm/hr)	Uncontrolled Flow Rate (L/s)	Controlled Release Rate (L/s)	Release Rate Stored (L/s)	Storage Volume Required (m^3)
50	64.0	1,104.5	199.0	905.5	2,716.5
60	55.9	964.7	199.0	765.7	2,756.5
70	**49.8**	**859.4**	**199.0**	**660.4**	**2,773.7**
80	45.0	776.6	199.0	577.6	2,772.5
90	41.1	709.3	199.0	510.3	2,755.6

Total Release Rate

Based on the selected orifice the total maximum 1:100 year release rate from Areas 1, 2, and 3 is 560.4 L/s. This release rate is less than the 1:100 year pre-development peak flow rate of 601.4 L/s.

Orifice Sizing

The required storage volume of 2,773.7 m^3 from the 1:100 year storm event relates to a ponding depth of 0.74 m in the wetland. The following calculations confirm the required orifice diameter:

Q = 0.1990 m^3/s (199.0 L/s)

H = 0.56 m (height above center of orifice)

Orifice Diameter = D

$= 2*\sqrt{(Q / (0.61*\pi*\sqrt{(2*9.81*H)}))}$

$= 2*\sqrt{(0.1990 / (0.61*\pi*\sqrt{(2*9.81*0.56)}))}$

= 0.354 m

This confirms that the 354 mm diameter orifice selected for the 1:5 year storm event will provide a release rate of 199.0 L/s for the 1:100 year storm event.

4.0 DITCH DESIGN

The onsite ditches have been designed to convey the peak runoff rate from the 1:100 year storm event. The drainage areas for each ditch are shown on Figure B-3. The detailed calculations for the ditch sizing are attached. Refer to Figure B-1 for details.

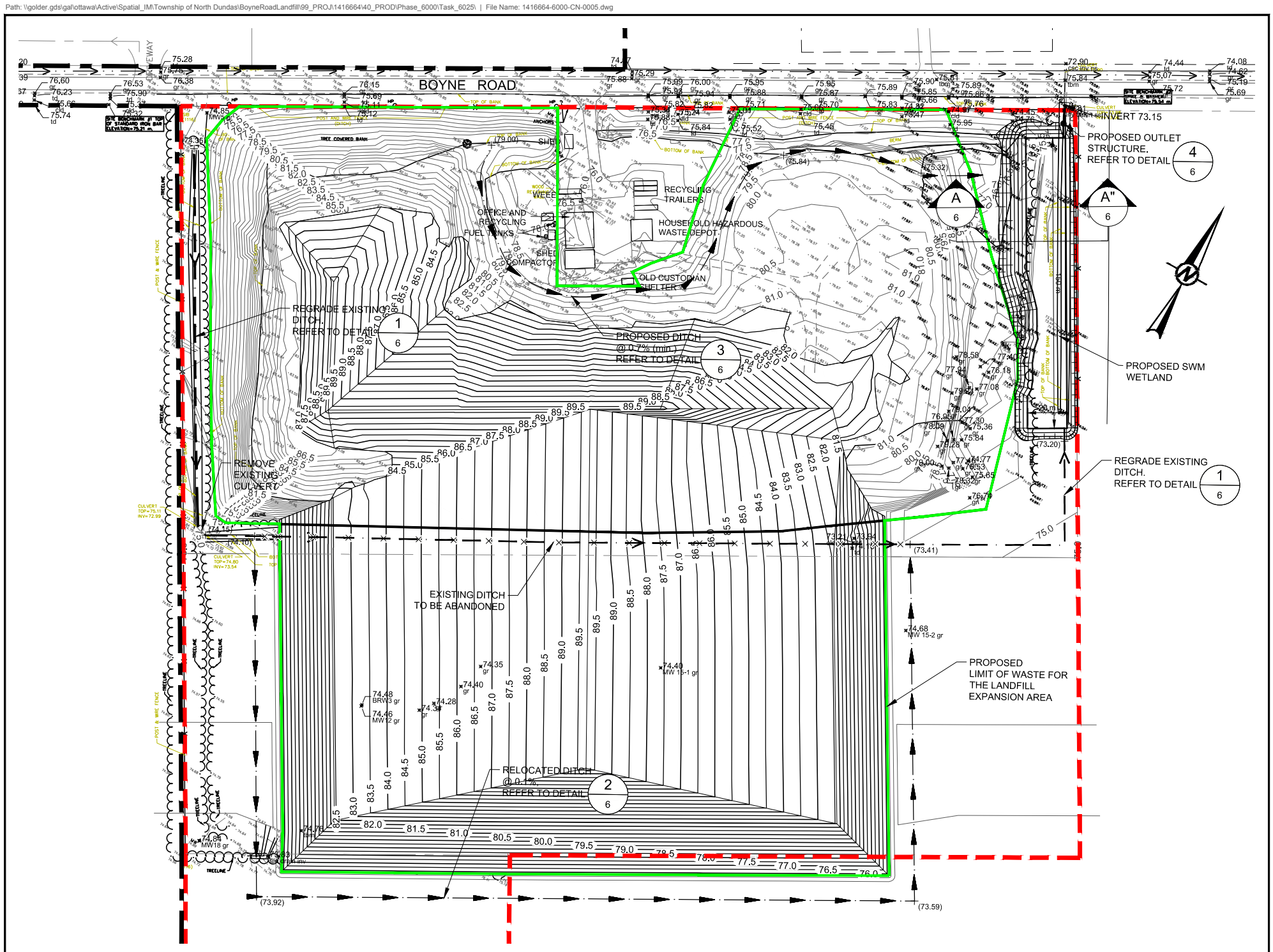
During the continuing operations phase of the expanded landfill and post-closure, it is proposed that stormwater from the landfill will be collected by existing and proposed grass-lined ditches and will be directed to a stormwater management wetland located at the northeast corner of the landfill. The stormwater wetland will be located within an existing partially filled, partially low area adjacent to the landfill. The depth of the excavation will be limited to the existing grades in the area, in order to limit the possibility of interception of groundwater potentially impacted by leachate. The stormwater run-off from the wetland will discharge via an existing culvert into the roadside ditch on the north side of Boyne Road.

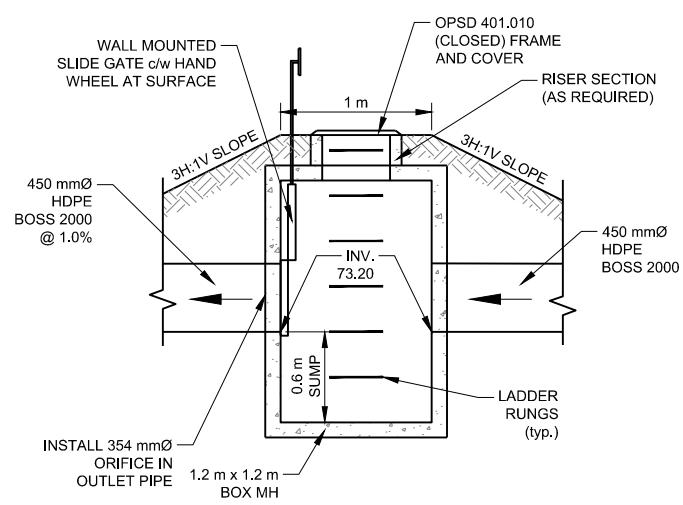
Since the wetland is proposed to service the existing landfill along with the expansion of the landfill, the design will be a best efforts approach to provide additional water quality improvements for an area where runoff is currently draining. The wetland has been designed in general accordance with the MOECC SWM Planning and Design Manual (2003) and will provide an enhanced level of quality control (80% TSS removal). The proposed wetland will also provide quantity control of stormwater runoff by attenuating the post-closure peak flow rates to at or below pre-development levels. To be conservative, the pre-development peak flow rates were calculated based on the site before the landfill existed. Further details are provided in the Technical Memorandum provided in Appendix B.

Based on this preliminary analysis, it appears that a stormwater management system could be designed for the expansion concept using currently accepted approaches and that satisfies the requirements of the O.Reg. 232/98 Landfill Standards.

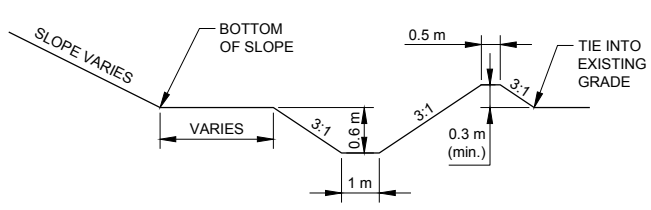
Attachments: Figures B-1 to B-3
Detailed Calculations for the Ditch Sizing

SWT/DVK/PAS/md
n:\active\2014\1125 - eceag\1416664 township of north dundas - 2015 lf activities\04_reporting\waste management alternatives evaluation\6026 sw mgt\swm report 2015.10.26.docx

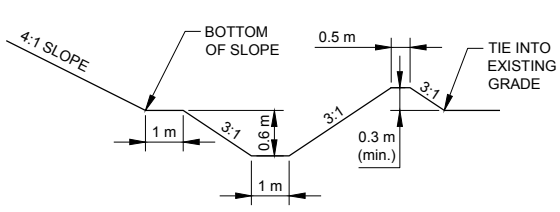




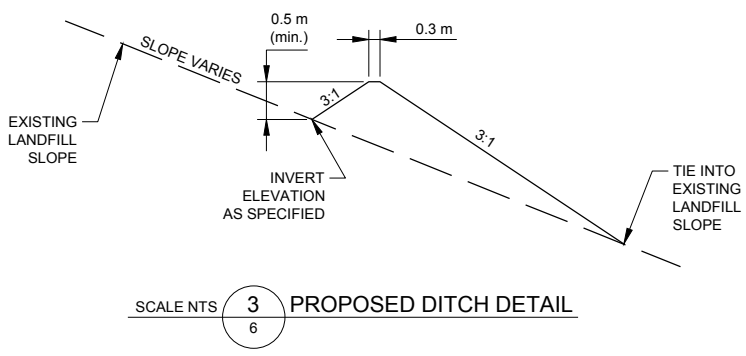
SCALE NTS 4/6 PROPOSED OUTLET STRUCTURE DETAILS



SCALE NTS 1/6 REGRADING OF EXISTING DITCH DETAIL



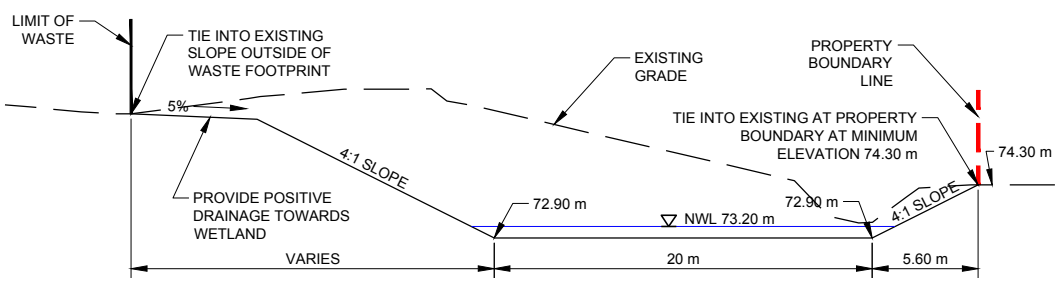
SCALE NTS 2/6 RELOCATED DITCH DETAIL



SCALE NTS 3/6 PROPOSED DITCH DETAIL

LEGEND

- 85.0 — GROUND SURFACE CONTOURS (m), BASED ON RESULTS OF THE SURVEYS CONDUCTED IN 2008, 2010, 2012, 2013, AND 2014
- APPROXIMATE EXISTING PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE EXISTING BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE LOCATION OF EXISTING PERIMETER DITCH AND INFERRED FLOW DIRECTION
- EXISTING ROADSIDE DITCH (APPROXIMATE LOCATION)
- EXISTING GRADE (FROM STANTEC)
- EXISTING GRADE (2015 GOLDER SURVEY)
- (73.20) + PROPOSED DITCH GRADE ELEVATION
- PROPOSED AND RELOCATED DITCH LOCATIONS



SCALE NTS A-A' 6 SECTION

NOTE(S)

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. 2008 AND 2010 SURVEYS COMPLETED BY STANTEC CONSULTING LTD.
3. MAY 2012, JULY 2013, AND NOVEMBER 2014 SURVEYS COMPLETED BY GOLDER ASSOCIATES LTD.
4. COORDINATES SYSTEM: MTM ZONE 9 NAD83

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
1	2015-10-21	ISSUED FOR REVIEW	SWT	MLF	SWT	DVK

NOT FOR CONSTRUCTION

0 50 100
1:2,500 METRES

CLIENT
TOWNSHIP OF NORTH DUNDAS

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

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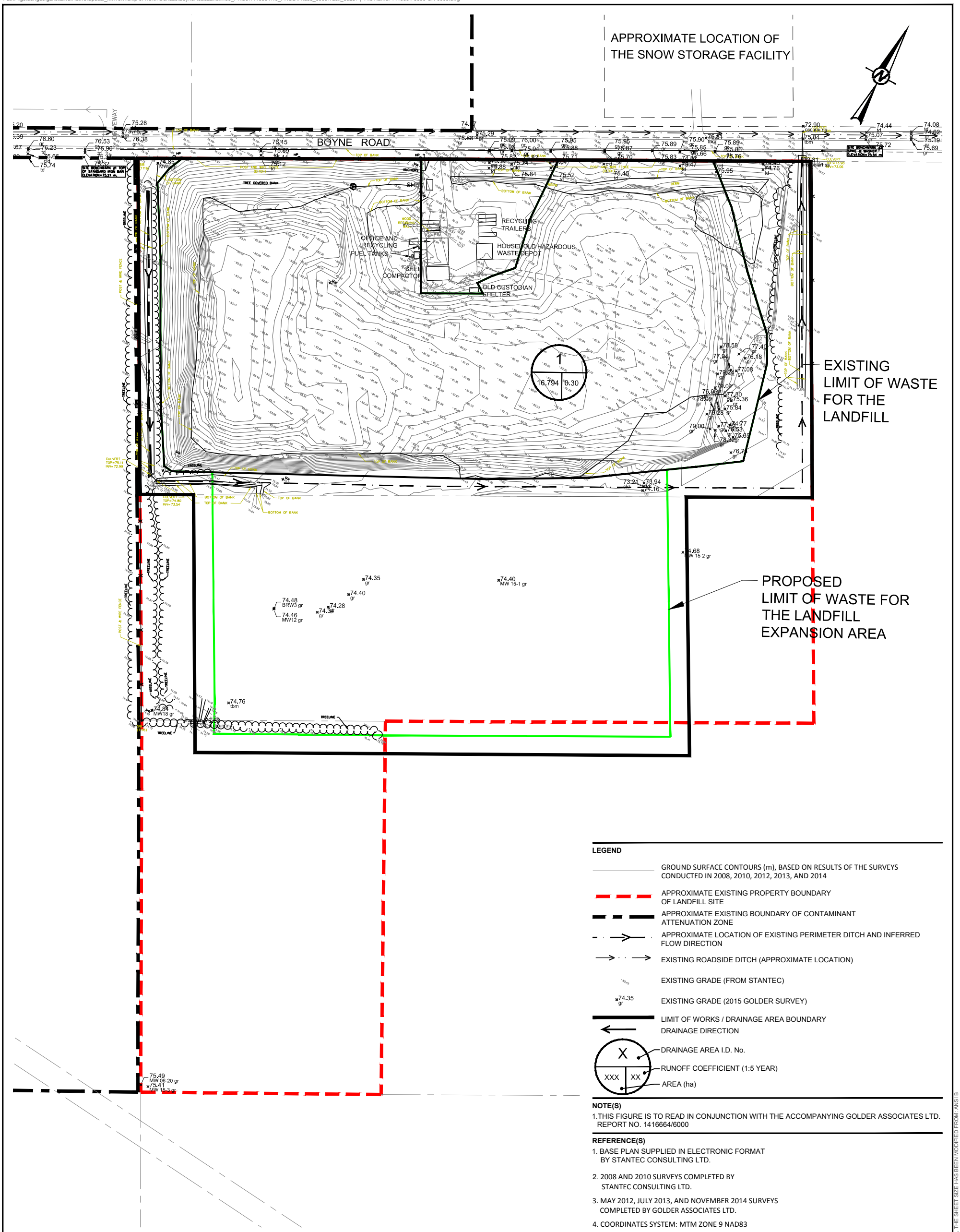
TITLE
ALTERNATIVE 2: PROPOSED SWM DESIGN CONCEPT, BOYNE ROAD LANDFILL EXPANSION

PROJECT NO.	CONTROL	REV.		FIGURE
1416664	6000	1	1 of 3	B-1



NOT FOR CONSTRUCTION

0 50 100
1:2,500 METRES

LEGEND

- GROUND SURFACE CONTOURS (m), BASED ON RESULTS OF THE SURVEYS CONDUCTED IN 2008, 2010, 2012, 2013, AND 2014
- APPROXIMATE EXISTING PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE EXISTING BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE LOCATION OF EXISTING PERIMETER DITCH AND INFERRED FLOW DIRECTION
- EXISTING ROADSIDE DITCH (APPROXIMATE LOCATION)
- EXISTING GRADE (FROM STANTEC)
- EXISTING GRADE (2015 GOLDER SURVEY)
- LIMIT OF WORKS / DRAINAGE AREA BOUNDARY
- DRAINAGE DIRECTION
- X — DRAINAGE AREA I.D. No.
- XXX / XX — RUNOFF COEFFICIENT (1:5 YEAR) / AREA (ha)

NOTE(S)

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. 2008 AND 2010 SURVEYS COMPLETED BY STANTEC CONSULTING LTD.
3. MAY 2012, JULY 2013, AND NOVEMBER 2014 SURVEYS COMPLETED BY GOLDER ASSOCIATES LTD.
4. COORDINATES SYSTEM: MTM ZONE 9 NAD83

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
1	2015-10-21	ISSUED FOR REVIEW	SWT	MLF	SWT	DVK

CLIENT
TOWNSHIP OF NORTH DUNDAS

PROJECT
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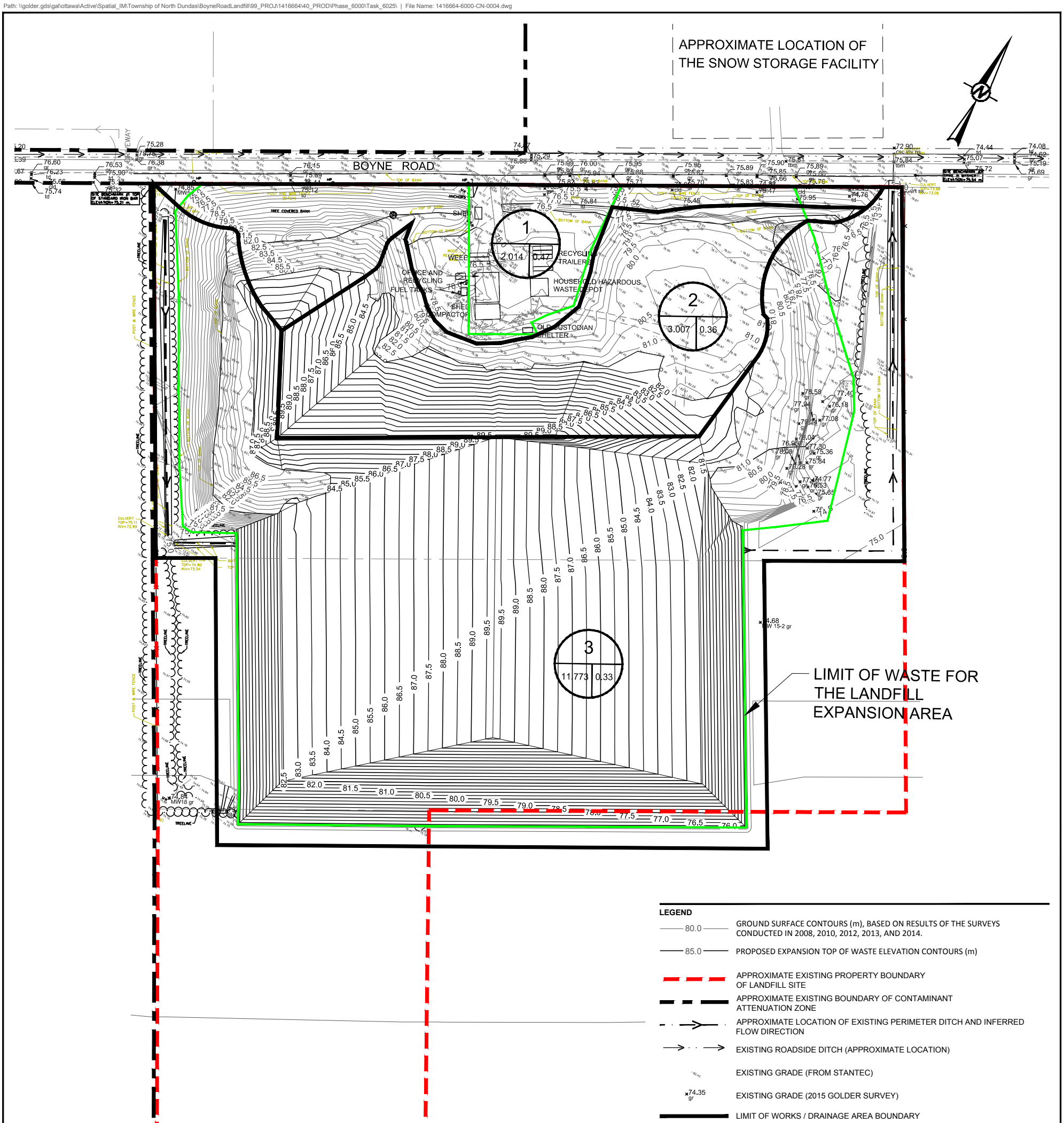
TITLE
ALTERNATIVE 2: PRE-DEVELOPMENT DRAINAGE AREA PLAN, BOYNE ROAD LANDFILL EXPANSION

PROJECT NO.	PHASE	REV.		FIGURE
1416664	6000	1	2 of 3	B-2



LEGEND

- 80.0 — GROUND SURFACE CONTOURS (m), BASED ON RESULTS OF THE SURVEYS CONDUCTED IN 2008, 2010, 2012, 2013, AND 2014.
- 85.0 — PROPOSED EXPANSION TOP OF WASTE ELEVATION CONTOURS (m)
- APPROXIMATE EXISTING PROPERTY BOUNDARY OF LANDFILL SITE
- APPROXIMATE EXISTING BOUNDARY OF CONTAMINANT ATTENUATION ZONE
- APPROXIMATE LOCATION OF EXISTING PERIMETER DITCH AND INFERRED FLOW DIRECTION
- EXISTING ROADSIDE DITCH (APPROXIMATE LOCATION)
- EXISTING GRADE (FROM STANTEC)
- 74.35 gr — EXISTING GRADE (2015 GOLDER SURVEY)
- LIMIT OF WORKS / DRAINAGE AREA BOUNDARY
- DRAINAGE DIRECTION
- X — DRAINAGE AREA I.D. No.
- XXX / XX — RUNOFF COEFFICIENT (1:5 YEAR) / AREA (ha)

NOTE(S)

1. THIS FIGURE IS TO READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1416664/6000

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY STANTEC CONSULTING LTD.
2. 2008 AND 2010 SURVEYS COMPLETED BY STANTEC CONSULTING LTD.
3. MAY 2012, JULY 2013, AND NOVEMBER 2014 SURVEYS COMPLETED BY GOLDER ASSOCIATES LTD.
4. COORDINATES SYSTEM: MTM ZONE 9 NAD83

NOT FOR CONSTRUCTION

0 50 100
1:2,500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
1	2015-10-06	ISSUED FOR REVIEW	SWT	MLF	SWT	DVK

CLIENT
TOWNSHIP OF NORTH DUNDAS

PROJECT
WASTE MANAGEMENT ALTERNATIVES EVALUATION

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TITLE
ALTERNATIVE 2: POST-CLOSURE DRAINAGE AREA PLAN, BOYNE ROAD LANDFILL EXPANSION

PROJECT NO.	CONTROL	REV.		FIGURE
1416664	6000	1	3 of 3	B-3

Ditch Design Sheet

File No.: 1416664/6000/6026
Project: Boyne Road Landfill Expansion Alternative
Date: 26-Oct-15

Location	Drainage Area					Ditch Characteristics						Check		
	A ha	C	Tc min.	i (Ottawa, 100 yr) mm/hr	Q m^3/s	Manning's Roughness Coefficient n	Slope S m/m	Bottom Width m	Side Slope X:1	From Manning's Equation (Q)n/(√ S)	Depth of Flow m	From Manning's Equation $A^{5/3}/P^{2/3}$	Cross-Sectional Area m^2	Actual Velocity m/s
Drainage Area 2	3.007	0.360	24.6	105.0	0.3160	**0.035**	**0.007**	0.00	3	0.132	0.380	0.138	0.433	0.73
Drainage Area 3	11.773	0.330	49.8	64.1	0.6923	**0.035**	**0.001**	1.00	3	0.766	0.580	0.775	1.589	0.44

Manipulation of Manning's Equation:

$Q=(AR^{2/3}\sqrt{S})/n$

R=A/P (Cross-Sectional Area/Wetted Perimeter)

Therefore:

$Qn/(\sqrt{S})=A^{5/3}/P^{2/3}$

APPENDIX C

Technical Memorandum – Preliminary Atmospheric Impact Assessment, Boyne Road Landfill Expansion Alternative

November 2015
Report No. 1416664/6000

Golder Associates

TECHNICAL MEMORANDUM

DATE October 26, 2015 **PROJECT No.** 1416664/6000/6027

PRELIMINARY ATMOSPHERIC IMPACT ASSESSMENT, BOYNE ROAD LANDFILL EXPANSION ALTERNATIVE

As part of the EA process required for expansion of the landfill site, an assessment of the impacts of the proposed landfill expansion in terms of emissions to the atmosphere would be required including air quality, odour, noise, and compliance with provincial atmospheric quality regulations. A preliminary desktop study was carried out to determine potential receptors in the vicinity of the Site and their corresponding distance from the expanded landfill site emission sources, and to identify potential concerns that could subsequently arise as part of the EA process during the assessment of project impacts to the atmospheric environment.

Table 1 presents the list of potential existing emission sources as well as whether they are expected to have substantial impact in terms of air quality, odour, and noise. It should be noted that no new sources (including equipment) would be expected as part of the proposed landfill expansion; sources identified below are already present and part of site operations at the Site.

Table 1: Landfill Site Potential Atmospheric Emission Sources

Emission Source	Source power	Substantial Emission Source		
		Air Quality	Odour	Noise
Landfill footprint and working face	n/a	Yes	Yes	No
Compactor	Diesel	No	No	Yes
Loader	Diesel	No	No	Yes
Metals recycling compactor	Electric	No	No	Yes
Metals recycling conveyor	Electric	No	No	Yes
Roads	n/a	Yes	No	Yes
Office and Recycling Building fans (2)	Electric	No	No	Yes
Fuel Tanks	n/a	No	No	No

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The atmospheric assessment to be carried out during the EA would involve assessing potential air and noise impacts at the identified sensitive receptors. The following table presents the locations and approximate distances from landfill emission sources for the fifteen (15) identified potential sensitive receptors:

Table 2: Potential Receptors in Site Vicinity

Receptor No.	Receptor Address	UTM Coordinates (m)	Approximate Distance From Landfill Emission Source[1] (m)
1	12505 Boyne Road	473912, 4994238	670
2	12495 Boyne Road	473861, 4994208	730
3	12491 Boyne Road	473828, 4994193	760
4	12485 Boyne Road	473788, 4994180	810
5	12464 Boyne Road	473664, 4994056	960
6	12455 Boyne Road	473556, 4994104	1,050
7	12421 Boyne Road	473196, 4994269	1,360
8	12764 Boyne Road	475665, 4995063	940
9	12418 Ottawa Street	473032, 4994581	1,480
10	12441 Ottawa Street	472922, 4995356	1,850
11	12700 Gray Road	475844, 4993840	970
12	12686 Gray Road	475949, 4993801	1,080
13	12721 Gray Road	476041, 4993951	1,100
14	12731 Gray Road	476106, 4993978	1,160
15	12741 Gray Road	476163, 4994018	1,200

[1]Distances were estimated from the nearest on-site emissions source, including the landfill footprint, to each receptor.

There are no potentially sensitive receptors within 500 metres of the Site. Six receptors were identified as being within 1,000 metres from the landfill site emission sources and are considered to have the potential for being impacted by noise emissions associated with the landfill activities. During the expansion EA, the potential noise impacts would be evaluated using the Ontario Noise Guidelines for Landfill Sites. There would also need to be an assessment of noise from Site-related truck traffic along the haul route, as well as an assessment of potential noise at vacant lots in the area of the site where the current zoning allows development of a sensitive land use, i.e., a residence.

Potential air and odour emissions would be evaluated as part of the expansion EA using the area of coverage in Section 14 of Ontario Regulation 419/05 and compared against the applicable Ontario air quality standards.

Based on this preliminary assessment and experience on other landfill Site expansion atmospheric assessments, it is expected that the combination of separation distances and standard emission controls as part of site operations, it is expected that this assessment would conclude that the expanded site could be expanded in accordance with provincial air quality, odour and noise requirements.

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APPENDIX D

Technical Memorandum – Natural Environment Constraints Analysis, Boyne Road Landfill Expansion Alternative

November 2015
Report No. 1416664/6000

TECHNICAL MEMORANDUM

DATE October 21, 2015 **PROJECT No.** 1416664/6000/6028

NATURAL ENVIRONMENT CONSTRAINTS ANALYSIS, BOYNE ROAD LANDFILL EXPANSION ALTERNATIVE

This constraints analysis was prepared based on a desktop review of relevant background data sources and a single site reconnaissance visit on July 19, 2015. This assessment focuses on the areas of the property that are outside of the current landfill footprint (the Site).

1.0 METHODS

1.1 Background Review

A background data review was used to identify significant natural features and Species at Risk (SAR) that have been reported as occurring, or potentially occurring in the local landscape around the Site. The background review was also used to complete a high-level assessment of whether or not there is suitable habitat for SAR on the Site. The information gathered from the following sources was used to inform the site reconnaissance visit:

- Provincial Policy Statement (PPS) (MMAH 2014);
- Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Information Centre (NHIC);
- Atlas of Breeding Birds of Ontario (Cadman et al. 2007);
- Atlas of the Mammals of Ontario (Dobbyn 1994);
- Species At Risk in Ontario List (MNRF 2015);
- Species At Risk Public Registry (EC 2015);
- Ontario's Reptile and Amphibian Atlas (Ontario Nature 2015);
- Bat Conservation International (BCI 2015);
- Royal Ontario Museum (ROM) range maps (ROM 2010);
- Ontario Butterfly Atlas (Jones et al. 2015);
- eBird (eBird 2012);
- Information and data contained in natural heritage related map layers from Ontario Base Map series, Natural Resource Values Information System (NRVIS) mapping and Land Information Ontario; and,
- Existing aerial imagery and mapping.

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1.2 Site Reconnaissance

A Site reconnaissance was completed on July 19, 2015 by a qualified biologist. The Site was traversed on foot to characterize, at a high level, the natural features and verify the findings, where possible, of the background review. Because of the timing, scope, and effort of the Site reconnaissance, minimal information on the Site could be gathered for wildlife species directly, but wildlife and SAR habitat suitability was assessed.

Habitats on the Site, particularly those that may be suitable for SAR, were observed and noted. A list of all wildlife encountered during the reconnaissance was compiled, based on direct visual or auditory observations, as well as through signs (e.g., tracks, nests, etc.). In addition, high level information was collected on the plant communities encountered, although this information is only preliminary and should not be considered final.

1.3 Species at Risk Screening

A desktop assessment was completed to determine which species listed under the *Species at Risk Act* (SARA) or the *Endangered Species Act* (ESA) have the potential to be located on the Site. The potential for SAR to occur was assessed based on species range information, known records, review of the habitat observations made during the site visit, historic land use practices, and the preferred habitat requirements of these species (Attachment A).

The potential for the species to occur was determined through a probability of occurrence. A ranking of low indicates no suitable habitat availability for that species on the Site and no specimens identified. Moderate probability indicates greater potential for the species to occur, as suitable habitat appeared to be present on the Site, but no occurrence of the species was recorded. High potential indicates a known species record on the Site (including observations during the Site reconnaissance or through the background data review) and the presence of good quality habitat. In instances where the aforementioned methods don't apply (e.g., borderline habitats), probability was assessed based on the expert opinion of the biology team through habitat assessment. Preliminary searches were conducted for suitable habitat for those species with moderate or high potential to be found on the Site during the Site reconnaissance.

2.0 RESULTS

2.1 Plant Communities

The Site is primarily deciduous and thicket swamp, deciduous forest, deciduous hedgerows, small disturbed areas and edge habitats. The deciduous swamp makes up a large portion of the Site, south and east of the existing landfill footprint, and is contiguous off the Site to the east. It is dominated by trees such as red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), and green ash (*Fraxinus pennsylvanica*). The age of the trees in the swamp appear to vary from immature to semi-mature, with some individual older trees throughout. Although no large areas of permanent water features were identified within this swamp, some portions appear to undergo flooding and formation of vernal pools during spring. At the southeastern edge of the Site is a portion of an upland deciduous forest that is contiguous off the Site to the south, and southeast. It appeared to be dominated by sugar maple (Acer saccharum) and was semi-mature with some individual older trees. The southwestern portion of the Site is an agricultural row crop field, contiguous with larger row crop fields to the west of the Site. Between this field and the active landfill is an open area within the larger deciduous swamp. This open area is a mix of meadow marsh and thicket swamp, dominated by a mix of shrubs, grasses, and forbs, such as willows (*Salix* spp.), reed canary grass (*Phalaris arundinacea*), and Joe-pye weed (*Eutrochium maculatum*). No SAR plants or rare plant communities were observed during surveys.

2.2 Surface Water Features and Fish Habitat

There is a constructed watercourse (drainage ditch) that follows the perimeter of the current landfill, flowing south along the western side of the Site, then east across the Site, then north along the eastern side of the Site before connecting through a culvert with a larger naturalized roadside ditch north of Boyne Road. There is also a feeder ditch that flows into this watercourse from the south. The reaches of this watercourse that are west and south of the current landfill appeared to be stagnant during the site visit, with no visible flow, and dense with algae and other vegetation. The portion of this water course at the eastern boundary had moderate flow, and connected with a larger naturalized roadside ditch north of Boyne Road, where fish were observed. Since it is connected to known fish habitat, this watercourse could be considered fish habitat, if water quality is sufficient to support fish. Within the swamp areas, there are signs of ephemeral pools and channels throughout, but would not likely be considered fish habitat. None of these features have habitat that would support at risk or provincially rare fish species.

2.2.1 General Wildlife Observations

Due to the time of year and scope of the study, taxa specific surveys were not completed. The majority of the birds observed on Site were post-breeders that likely breed either on in the immediate vicinity of the Site, including species such as song sparrow (*Melospiza melodia*) and American obin (*Turdus migratorious*). Birds that may not breed on the Site but were observed, included large numbers of scavenging birds such as ring-billed gull (*Larus delawarensis*), common crow (*Corvus brachyrhynchos*), and turkey vultures (*Cathartes aura*) that were likely utilizing the existing landfill for food. Signs and tracks of a few species of mammals were observed throughout the site, including white-tailed deer (*Odocoileus virginianus*), and Racoon (*Procyon lotor*). Mammals are likely attracted to the existing landfill. Northern leopard frogs (*Lithobates pipiens*), spring peepers (*Pseudacris crucifer*), and a single red-bellied snake (*Storeria occipitomaculata*), were observed in and around the swamp. No SAR wildlife was observed during surveys. The wildlife community observed is typical of the habitats on the Site.

2.2.2 Species at Risk

No provincially or regionally rare plants or wildlife, plant communities, plant SAR, or wildlife SAR were identified during the surveys, although taxa specific surveys were not completed, and the Site visit was outside of the optimal survey period for most wildlife. In addition, the entire Site was not adequately surveyed to be considered a full botanical inventory.

Suitable habitat for butternut (*Juglans cinerea*), monarch (*Danaus plexippus*), western chorus frog (*Pseudacris triseriata*) eastern milksnake (*Lampropeltis triangulum*), eastern wood-pewee (*Contopus virens*), wood thrush (*Hylocichla mustelina*), tri-colored Bat (*Perimyotis subflavus*), little brown myotis (*Myotis lucifugus*), and northern myotis (*Myotis septentrionalis*) was identified on the Site. No other potential SAR habitat was identified. The following is a discussion of those species identified in the desktop SAR screening as having a moderate or high potential to be present on the Site. Species identified as having a low potential are included in Attachment A, but are not discussed further in this memo.

Butternut

Butternut is listed as endangered under the ESA and the SARA. This tree can be found in most habitats if conditions are right. The upland areas and drier microsites within the swamps are potential habitat for this species. Although this species was searched for during the site reconnaissance and not found, the Site is large and heavily treed and not every single tree on the Site was observed. This species is found throughout eastern Ontario.

Monarch

Monarch is listed as special concern under the ESA and the SARA. This butterfly is found wherever there are milkweed (*Asclepius* spp.) plants for its caterpillars and wildflowers that supply a nectar source for adults. Milkweeds were found along the edges of the Site, and within the open areas of the swamp, and there are records in the vicinity of the Site in the Ontario Butterfly Atlas (Jones et al. 2015).

Western Chorus Frog

Western chorus frog is listed as threatened under the SARA, and is ranked as S3 (vulnerable) in Ontario by NHIC. The open areas within the swamps on the Site, in particular the thicket swamp, are suitable habitat for this species. In addition, there are records in the vicinity of the Site in the Ontario Reptile and Amphibian Atlas (Ontario Nature 2015).

Milksnake

Milksnake is listed as a species of special concern under the ESA and the SARA. Milksnake is found in a wide variety of habitat types. The mosaic of disturbed and open areas, agricultural fields and forest is suitable habitat for this species. In addition there have been records of the species in the vicinity of the Site in the Ontario Reptile and Amphibian Atlas (Ontario Nature 2015).

Eastern Wood-Pewee and Wood Thrush

Eastern wood-pewee and wood thrush are listed as special concern under the ESA. The forested portions of the Site, including the swamp, provide suitable habitat for these species. In addition, there are records of both species in the vicinity of the Site in the Atlas of Breeding Birds of Ontario (Cadman et al. 2007).

Tri-Colored Bat, Little Brown Myotis, and Northern Myotis

Little brown myotis, and northern myotis are listed as endangered under the ESA and the SARA. Tri-colored bat is listed as endangered under the SARA. Maternity roosts for Little Brown Myotis and Northern Myotis include large cavity trees and trees or snags with visibly loose bark. Tri-colored bats roost in clumps of old leaves, hanging moss or squirrel nests. Forested areas on the Site are suitable habitat for these species.

3.0 CONSTRAINTS ANALYSIS

3.1 Provincial Policy

The updated Provincial Policy Statement (PPS) was issued under Section 3 of the *Planning Act* and came into effect April 30, 2014 (MMAH 2014). It replaces the PPS issued March 1, 2005.

The natural heritage policies of the PPS indicate that:

2.1.4 Development and site alteration shall not be permitted in:

a) significant wetlands in Ecoregions 5E, 6E and 7E; and,

b) significant coastal wetlands.

2.1.5 Unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions, development and site alteration shall not be permitted in:

a) significant wetlands in the Canadian Shield north of Ecoregions 5E, 6E and 7E;

b) significant woodlands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Mary's River);

c) significant valleylands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Mary's River);

d) significant wildlife habitat;

e) significant areas of natural and scientific interest; and,

f) coastal wetlands in Ecoregions 5E, 6E and 7E that are not subject to policy 2.1.4(b).

2.1.6 Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements;

2.1.7 Development and site alteration shall not be permitted in habitat of endangered species and threatened species, except in accordance with provincial and federal requirements;

2.1.8 Development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in policies 2.1.4, 2.1.5 and 2.1.6 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions; and,

2.1.9 Nothing in policy 2.1 is intended to limit the ability of agricultural uses to continue.

Natural heritage features described in the PPS, and the potential constraints associated with each, are discussed below in the context of the Site.

Significant Wetlands

Based on the desktop assessment there are no Provincially Significant Wetlands (PSW) identified on or within the vicinity of the Site. The swamps on the Site include wetlands that were evaluated as not significant and those that are unevaluated.

Significant Woodlands

The responsibility for identifying significant woodlands is in transition from local municipalities to the Province since the release of the latest PPS, but both authorities may be used for guidance. If the local planning authority has not undertaken this exercise, then the Natural Heritage Reference Manual (NHRM) (MNR 2010) provides guidance on determining significance of woodlands.

Much of the site is forested and may meet the criteria to be considered significant. Additional studies, such as tree age surveys, may be required to determine significance.

Within forests designated as significant woodlands, development encroachments can sometimes occur but would be subject to the outcome of an Environmental Impact Statement or Environmental Assessment and some design modifications or mitigation may be required.

Significant Valleylands

No significant valleylands were identified during the desktop review or the Site reconnaissance, and the Site is not within or immediately adjacent to a valley.

Fish Habitat

The watercourse on the Site may be considered fish habitat, as it connects downstream with fish-bearing waters. Additional information on the habitat in this watercourse, and the water quality would be required. Further, given that a permit will likely be required from South Nation Conservation (SNC) for modifications or relocation of the watercourse in relation to the landfill expansion, an evaluation of these watercourses may be required following the *Evaluation, Classification and Management of Headwater Drainage Features Guideline* developed by the Toronto Regional Conservation Authority (TRCA).

Significant Wildlife Habitat

Significant wildlife habitat, as defined by the NHRM, includes:

- Habitats of seasonal concentrations of animals;
- Rare vegetation communities or specialized habitat for wildlife;
- Habitat of species of conservation concern; and,
- Animal movement corridors.

Guidance on determining the significance of these habitats is provided in the Significant Wildlife Habitat (SWH) Technical Guide (MNR 2000) and the SWH Ecoregion Criterion Schedules (MNR 2013). The Site potentially supports a variety of SWH based on preliminary observations, including but not limited to:

- Habitat for species of special concern (see discussion in Section 2.2.2);
- Habitat for Woodland Amphibians;
- Habitat for Area Sensitive Birds; and,
- Bat maternity colonies.

The constraints associated with these habitats, if confirmed on the Site, would be further defined as part of a more detailed environmental study such as an Environmental Impact Statement (EIS), or Environmental Assessment (EA). Any development within, or adjacent to, confirmed SWH must demonstrate no negative impacts to the form or function of the habitat as a whole (as per Policy 2.18 of the PPS).

Significant Areas of Natural and Scientific Interest

No significant ANSIs were identified during the desktop review.

Habitat of Endangered and Threatened Species under the ESA

As discussed in Section 2.2.2, there is potential suitable habitat for three endangered species listed under the ESA (Butternut, Northern Myotis, and Little Brown Myotis) on the Site. These species and their habitats are protected by the ESA. The other species identified in Section 2.2.2 are listed as Special Concern under the ESA, or only listed under the SARA. As such, individuals and their habitat are not protected, although they may be considered significant species through other policies, such as SWH. Additional studies are required to determine the presence or absence of the Threatened and Endangered species and, if present, the extent of their habitats on the Site. Any removal of the habitats of Threatened or Endangered species must be undertaken in accordance with the ESA and associated regulations. Specifically, the areas of the Site with relatively mature trees may provide maternity roost habitat for endangered bats.

4.0 SUMMARY

Based on the initial evaluation, expansion of the landfill Site may have design/approval constraints associated with endangered bat habitat, significant woodland, significant wildlife, and fish habitat. Development of the area outside of the current landfill footprint is expected to require additional investigation and design/mitigation. With the possible exception of significant woodlands, all of these potential constraints would not likely prevent development of the Site for a landfill expansion, as long as appropriate design, permits, compensation/and or mitigation is implemented. Within forests designated as significant woodlands, development encroachments can sometimes occur but would be subject to the outcome of an Environmental Impact Statement or Environmental

Assessment to show no negative impact to the overall function of the woodland. Although not certain until the studies and assessment are complete, pending the results of the EIS or EA, development within an area designated as significant woodland could be prohibited by regulatory agencies.

The information provided in this technical memorandum is based on the results of a high-level desktop assessment and a single Site reconnaissance. Multiple, targeted site visits, including species-specific surveys, and a more detailed analysis through an EIS or EA would be required to verify the findings of this memorandum.

Attachments: Attachment A – Species At Risk Screening

5.0 REFERENCES

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Attachment: Attachment A – Species at Risk Screening Table

FN/SM/PAS/md
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Common Name	Scientific Name	Species At Risk Act (Sch 1)[1]	Endangered Species Act[2]	COSEWIC[3]	Provincial (SRank)[4]	Habitat Requirements[5]	Potential to Occur on Site
Western chorus frog - Great Lakes St. Lawrence/Canadian Shield Population	*Pseudacris triseriata*	THR	—	THR	S3	In Ontario, this amphibian species habitat typically consists of marshes or wooded wetlands, particularly those with dense shrub layers and grasses, as this species is a poor climber. They will breed in almost any fishless pond including roadside ditches, gravel [pits and flooded swales in meadows. This species hibernates in terrestrial habitats under rocks, dead trees or leaves, in loose soil or in animal burrows. During hibernation, this species is tolerant of flooding.	Moderate to High
Monarch	*Danaus plexippus*	SC	SC	SC	S2N, S4B	In Ontario, monarch is found throughout the northern and southern regions. This butterfly is found wherever there are milkweed (Asclepius spp.) plants for its caterpillars and wildflowers that supply a nectar source for adults; often found on abandoned farmland, meadows, open wetlands, prairies and roadsides, but also in city gardens and parks. Important staging areas during migration occur along the north shores of the Great Lakes.	Moderate to High
West Virginia white	*Pieris virginiensis*	—	SC	—	S3	In Ontario, West Virginia white is found primarily in the southern region of the province. This butterfly lives in moist, mature, deciduous woodlands, and the caterpillars feed only on the leaves of toothwort (*Cardamine* spp), which are small, spring-blooming plants of the forest floor. These woodland habitats are typically maple-beech-birch dominated.	Low
Bank swallow	*Riparia riparia*	—	THR	THR	S4B	In Ontario, the bank swallow breeds in a variety of natural and anthropogenic habitats, including lake bluffs, stream and river banks, sand and gravel pits, and roadcuts. Nests are generally built in a vertical or near-vertical bank. Breeding sites are typically located near open foraging sites such as rivers, lakes, grasslands, agricultural fields, wetlands and riparian woods. Forested areas are generally avoided.	Low
Barn swallow	*Hirundo rustica*	—	THR	THR	S4B	In Ontario, barn swallow breeds in areas that contain a suitable nesting structure, open areas for foraging, and a body of water. This species nests in human made structures including barns, buildings, sheds, bridges, and culverts. Preferred foraging habitat includes grassy fields, pastures, agricultural cropland, lake and river shorelines, cleared rights-of-way, and wetlands. Mud nests are fastened to vertical walls or built on a ledge underneath an overhang. Suitable nests from previous years are reused.	High
Black tern	*Chlidonias niger*	—	SC	NAR	S3B	In Ontario, the black tern breeds in freshwater marshlands where it forms small colonies. It prefers marshes or marsh complexes greater than 20 ha in area and which are not surrounded by wooded area. Black terns are sensitive to the presence of agricultural activities. The black tern nests in wetlands with an even combination of open water and emergent vegetation, and still waters of 0.5-1.2 m deep. Preferred nest sites have short dense vegetation or tall sparse vegetation often consisting of cattails, bulrushes and occasionally burreed or other marshland plants. Black terns also require posts or snags for perching.	Low

Common Name	Scientific Name	Species At Risk Act (Sch 1)[1]	Endangered Species Act[2]	COSEWIC[3]	Provincial (SRank)[4]	Habitat Requirements[5]	Potential to Occur on Site
Bobolink	*Dolichonyx oryzivorus*	—	THR	THR	S4B	In Ontario, the bobolink breeds in grasslands or graminoid dominated hayfields with tall vegetation. Bobolinks prefer grassland habitat with a broad-leaf component and a substantial litter layer. They have low tolerance for presence of woody vegetation and are sensitive to extensive mowing. They are found in greater numbers in old fields where mowing and re-sowing are infrequent. Their nest is woven from grasses and forbs. It is built on the ground, in dense vegetation, usually under the cover of one or more broad-leaved forbs.	Low
Canada warbler	*Cardellina canadensis*	THR	SC	THR	S4B	In Ontario, breeding habitat for the Canada warbler consists of moist mixed forests with a well-developed shrubby understory. This includes low-lying areas such as cedar and alder swamps, and riparian thickets. It is also found in densely vegetated regenerating forest openings. Suitable habitat often contains a developed moss layer and an uneven forest floor. Nests are well concealed on or near the ground in dense shrub or fern cover, often in stumps, fallen logs, overhanging stream banks or mossy hummocks.	Moderate
Cerulean warbler	*Setophaga cerulea*	SC	THR	END	S3B	In Ontario, breeding habitat of the cerulean warbler consists of second-growth or mature deciduous forest with a tall canopy of uneven vertical structure and a sparse understory. This habitat occurs in both wet bottomland forests and upland areas, and often contains large hickory and oak trees. This species may be attracted to gaps or openings in the upper canopy. The cerulean warbler is associated with large forest tracks, but may occur in woodlots as small as 10 ha. Nests are usually built on a horizontal limb in the mid-story or canopy of a large deciduous tree.	Low
Chimney swift	*Chaetura pelagica*	THR	THR	THR	S4B, S4N	In Ontario, chimney swift breeding habitat is varied and includes urban, suburban, rural and wooded sites. They are most commonly associated with towns and cities with large concentrations of chimneys. Preferred nesting sites are dark, sheltered spots with a vertical surface to which the bird can grip. Unused chimneys are the primary nesting and roosting structure, but other anthropogenic structures and large diameter cavity trees are also used.	Low - Moderate
Common nighthawk	*Chordeiles minor*	THR	SC	THR	S4B	These aerial foragers require areas with large open habitat. This includes farmland, open woodlands, clearcuts, burns, rock outcrops, alvars, bog ferns, prairies, gravel pits and gravel rooftops in cities.	Low
Eastern meadowlark	*Sturnella magna*	—	THR	THR	S4B	In Ontario, the eastern meadowlark breeds in pastures, hayfields, meadows and old fields. Eastern meadowlarks prefer moderately tall grasslands with abundant litter cover, high grass proportion, and a forb component. They prefer well drained sites or slopes, and sites with different cover layers.	Low

Common Name	Scientific Name	Species At Risk Act (Sch 1)[1]	Endangered Species Act[2]	COSEWIC[3]	Provincial (SRank)[4]	Habitat Requirements[5]	Potential to Occur on Site
Eastern wood-pewee	*Contopus virens*	—	SC	SC	S4B	In Ontario, the eastern wood-pewee inhabits a wide variety of wooded upland and lowland habitats, including deciduous, coniferous, or mixed forests. It occurs most frequently in forests with some degree of openness. Intermediate-aged forests with a relatively sparse midstory are preferred. Tends to inhabit edges of younger forests having a relatively dense midstory. Also occurs in anthropogenic habitats providing an open forested aspect such as parks and suburban neighborhoods. Nest is constructed atop a horizontal branch, one to two meters above the ground, in a wide variety of deciduous and coniferous trees.	High
Least bittern	*Ixobrychus exilis*	THR	THR	THR	S4B	In Ontario, the least bittern breeds in marshes, usually greater than 5 ha, with emergent vegetation, relatively stable water levels and areas of open water. Preferred habitat has water less than 1 m deep (usually 10 – 50 cm). Nests are built in tall stands of dense emergent or woody vegetation. Clarity of water is important as siltation, turbidity, or excessive eutrophication hinders foraging efficiency.	Low
Loggerhead shrike	*Lanius ludovicianus (migrans subsp)*	END	END	END	S2B	In Ontario, the loggerhead shrike breeds in open country habitat characterized by short grasses with scattered shrubs or low trees. Unimproved pasture containing scattered hawthorns (*Crataegus* spp.) on shallow soils over limestone bedrock is the preferred habitat. Preferred nest sites include isolated hawthorns or red cedar. Males defend large territories of approximately 50 ha.	Low
Peregrine falcon (anatum subspecies)	*Falco peregrinus anatum*	SC	SC	SC	S3B	In Ontario, the peregrine falcon breeds in areas containing suitable nesting locations and sufficient prey resources. Such habitat includes both natural locations containing cliff faces (heights of 50 - 200 m preferred) and also anthropogenic landscapes including urban centres containing tall buildings, open pit mines and quarries, and road cuts. Peregrine falcons nest on cliff ledges and crevices and building ledges. Nests consist of a simple scrape in the substrate.	Low
Red-headed woodpecker	*Melanerpes erythrocephalus*	THR	SC	THR	S4B	In Ontario, the red-headed woodpecker breeds in open, deciduous woodlands or woodland edges and are often found in parks, cemeteries, golf courses, orchards and savannahs. They may also breed in forest clearings or open agricultural areas provided that large trees are available for nesting. They prefer forests with little or no understory vegetation. They are often associated with beech or oak forests, beaver ponds and swamp forests where snags are numerous. Nests are excavated in the trunks of large dead trees.	Moderate
Short-eared owl	*Asio flammeus*	SC	SC	SC	S2N,S4B	In Ontario, the short-eared owl breeds in a variety of open habitats including grasslands, tundra, bogs, marshes, clearcuts, burns, pastures and occasionally agricultural fields. The primary factor in determining breeding habitat is proximity to small mammal prey resources. Nests are built on the ground at a dry site and usually adjacent to a clump of tall vegetation used for cover and concealment.	Low

Common Name	Scientific Name	Species At Risk Act (Sch 1)[1]	Endangered Species Act[2]	COSEWIC[3]	Provincial (SRank)[4]	Habitat Requirements[5]	Potential to Occur on Site
Eastern whip-poor-will	*Antrostomus vociferus*	THR	THR	THR	S4B	In Ontario, the whip-poor-will breeds in semi-open forests with little ground cover. Breeding habitat is dependent on forest structure rather than species composition, and is found on rock and sand barrens, open conifer plantations and post-disturbance regenerating forest. Territory size ranges from 3 to 11 ha. No nest is constructed and eggs are laid directly on the leaf litter.	Low
Wood thrush	*Hylocichla mustelina*	—	SC	THR	S4B	During the breeding season, the wood thrush is found in moist, deciduous hardwood or mixed stands, often previously disturbed, with dense deciduous undergrowth and with tall trees for singing perches. Wood thrush chooses habitats based on the structure of the forest. Specifically, this species selects nesting sites with the following characteristics: lower elevations with trees >16 m in height, a closed canopy cover (>70 %), a high variety of deciduous tree species, moderate subcanopy and shrub density, shade, fairly open forest floor, moist soil, and decaying leaf litter.	High
American eel	*Anguilla rostrata*	—	END	THR	S1?	In Ontario, the American eel is native to Lake Ontario, St. Lawrence River and Ottawa River watersheds. Their current distribution includes lakes Huron, Erie, and Superior and their tributaries. The Ottawa River population is considered extirpated. The preferred habitat of the American Eel is cool water of lakes and streams with muddy or silty substrates in water temperatures between 16 and 19°C. The American eel is a catadromous fish that lives in fresh water until sexual maturity then migrates to the Sargasso Sea to spawn.	Low
Bridle shiner	*Notropis bifrenatus*	SC	SC	SC	S2	In Ontario, the bridle shiner is a species found only in the St. Lawrence River and its tributaries. Preferred habitat conditions include substrates of sand, silt or organic debris and relatively warm, clear water. Bridle shiner is a freshwater fish species that inhabit slow-moving areas of unpolluted streams with abundant aquatic vegetation. The bridle shiner is not acid tolerant and so distribution in Precambrian shield may be limited. Typical spawning habitat is in water of depth 45-120 cm over medium to high density of submerged aquatic vegetation, and fine substrates of clay, silt or sand.	Low
Lake sturgeon - Great Lakes / upper St. Lawrence Population	*Acipenser fulvescens*	—	THR	THR	S2	In Ontario, the lake sturgeon, a large prehistoric freshwater fish, is found in all the Great Lakes and in all drainages of the Great Lakes and of Hudson Bay. This species typically inhabits highly productive shoal areas of large lakes and rivers. They are bottom dwellers, and prefer depths between 5-10 m and mud or gravel substrates. Small sturgeons are often found on gravelly shoals near the mouths of rivers. They spawn in depths of 0.5 to 4.5 metres in areas of swift water or rapids. Where suitable spawning rivers are not available, such as in the lower Great Lakes, they are known to spawn in wave action over rocky ledges or around rocky islands.	Low
Grey fox	*Urocyon cinereoargenteus*	THR	THR	THR	S1	While the historic Ontario range of this species extends across much of southern and southeastern Ontario, the only known population in the province is on Pelee Island, with very rare sightings elsewhere in the province at points close to the border with the United States. This species inhabits deciduous forests and marshes, and will den in a variety of features including rock outcroppings, hollow trees, burrows or brush piles, usually where dense brush provides cover and in close proximity to water. This species is considered a habitat generalist.	Low

Common Name	Scientific Name	Species At Risk Act (Sch 1)[1]	Endangered Species Act[2]	COSEWIC[3]	Provincial (SRank)[4]	Habitat Requirements[5]	Potential to Occur on Site
Eastern small-footed myotis	*Myotis leibii*	—	END	—	S2S3	The species generally roosts on the ground under rocks and in rock crevices. It occasionally inhabits buildings. Areas near the entrances of caves or abandoned mines may be used for hibernaculum, where the conditions are drafty with low humidity, and may be subfreezing.	Low
Little brown myotis	*Myotis lucifugus*	END	END	END	S4	In Ontario, this species range is extensive and covers much of the province. It will roost in both natural and man-made structures. They require a number of large dead trees, in specific stages of decay and that project above the canopy in relatively open areas. May form nursery colonies in the attics of buildings within 1 km of water. Caves or abandoned mines may be used for hibernaculum, but high humidity and stable above freezing temperatures are required.	Moderate
Tri-colored bat	*Perimyotis subflavus*	END	—	END	S3?	The appearance of this species at tree-top levels indicates that they may roost in foliage or in high tree cavities and crevices. They are not often found in buildings or in deep woods, seeming to prefer edge habitats near areas of mixed agricultural use. Hibernation sites are found deep within caves or mines in areas of relatively warm temperatures. These bats have strong roost fidelity to their winter hibernation sites and may choose the exact same spot in a cave or mine from year to year.	Moderate
Northern myotis	*Myotis septentrionalis*	END	END	END	S3	In Ontario, this species range is extensive and covers much of the province. It will usually roost in hollows, crevices, and under loose bark of mature trees. Roosts may be established in the main trunk or a large branch of either living or dead trees. Caves or abandoned mines may be used for hibernaculum, but high humidity and stable above freezing temperatures are required.	Moderate
Blanding's turtle - Great Lakes/St.Lawrence population	*Emydoidea blandingii*	THR	THR	THR	S3	Blanding's turtle will utilize a range of aquatic habitats, but favor those with shallow, standing or slow-moving water, rich nutrient levels, organic substrates and abundant aquatic vegetation. They will use rivers, but prefer slow-moving currents and are likely only transients in this type of habitat. This species is known to travel great distances over land in the spring in to order reach nesting sites, which can include dry conifer or mixed forests, partially vegetated fields, and roadsides. Suitable nesting substrates include organic soils, sands, gravel and cobble. They hibernate underwater and infrequently under debris close to water bodies.	Low
Eastern ribbonsnake - (Great Lakes population)	*Thamnophis sauritius*	SC	SC	SC	S3	Eastern ribbonsnake is semi-aquatic, and is rarely found far from shallow ponds, marshes, bogs, streams or swamps bordered by dense vegetation. They prefer sunny locations and bask in low shrub branches. Hibernation occurs in mammal burrows, rock fissures or even ant mounds.	Low
Milksnake	*Lampropeltis triangulum*	SC	SC	SC	S3	Milksnake utilizes a wide range of habitats including prairies, pastures, hayfields, wetlands and various forest types, and is well-known in rural areas where it frequents older buildings. Proximity to water and cover enhances habitat suitability. Hibernation takes place in mammal burrows, hollow logs, gravel or soil banks, and old foundations.	Moderate

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Snapping turtle	*Chelydra serpentina*	SC	SC	SC	S3	Snapping turtle utilizes a wide range of waterbodies, but shows preference for areas with shallow, slow-moving water, soft substrates and dense aquatic vegetation. Hibernation takes place in soft substrates under water. Nesting sites consist of sand or gravel banks along waterways or roadways.	Low
American ginseng	*Panax quinquefolius*	END	END	END	S2	American ginseng is found in moist, undisturbed and relatively mature deciduous woods often dominated by sugar maple. It is commonly found on well-drained, south-facing slopes. American ginseng grows under closed canopies in neutral, loamy soils.	Low
Butternut	*Juglans cinerea*	END	END	END	S3?	Butternut is found along stream banks, on wooded valley slopes, and in deciduous and mixed forests. It is commonly associated with beech, maple, oak and hickory. Butternut prefers moist, fertile, well-drained soils, but can also be found in rocky limestone soils. This species is shade intolerant.	Moderate
Eastern prairie fringed-orchid	*Platanthera leucophaea*	END	END	END	S2	Eastern prairie fringed-orchid grows in wet prairies, fens, bogs, wet meadows, and wet successional fields. It grows in full sun in neutral to mildly calcareous substrates, and occasionally grows along roadsides or lake margins.	Low

[1] *Species at Risk Act* (SARA), 2002. Schedule 1 (Last amended 17 Dec 2014); Part 1 (Extirpated), Part 2 (Endangered), Part 3 (Threatened), Part 4 (Special Concern).
[2] *Endangered Species Act* (ESA), 2007 (O.Reg 242/08 last amended 26 Nov 2014 as O.Reg 232/14). Species at Risk in Ontario List, 2007 (O.Reg 230/08 last amended 31 Mar 2015 as O.Reg 66/15, s. 1.); Schedule 1 (Extirpated - EXP), Schedule 2 (Endangered - END), Schedule 3 (Threatened - THR), Schedule 4 (Special Concern - SC).
[3] Committee on the Status of Endangered Wildlife in Canada (COSEWIC) http://www.cosewic.gc.ca/.
[4]Provincial Ranks (SRANK) are Rarity Ranks assigned to a species or ecological communities, by the Natural Heritage Information Centre (NHIC). These ranks are not legal designations. SRANKS are evaluated by NHIC on a continual basis and updated lists produced annually. SX (Presumed Extirpated), SH (Possibly Extirpated - Historical), S1 (Critacally Imperiled), S2 (Imperiled), S3 (Vulnerable), S4 (Apparently Secure), S5 (Secure), SNA (Not Applicable), S#S# (Range Rank), S? (Not ranked yet), SAB (Breeding Accident), SAN (Non-breeding Accident), SX (Apparently Extirpated). Last assessed August 2011.
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