Appendix F

Other Supporting Documents

Waste Connections of Canada
Environmental Assessment Report - DRAFT
Appendix F - July 2019

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Appendix F

Content Guide

- **Appendix F1** - **Problem/Opportunity Assessment Supporting Document #1**
- **Appendix F2** - **Alternative Methods Figures**
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- **Appendix F4** - **Landfill Mining Report**

Appendix F1

Problem/Opportunity Assessment Supporting Document #1

MEMO

TO: Cathy Smith, Project Manager
FROM: Betsy Varghese, P.Eng.
DATE: July 9, 2019
SUBJECT: DRAFT Update to Problem/Opportunity Assessment Supporting Document #1
OUR FILE: 15-2456

The Ministry of Environment, Conservation and Parks approved the Amended Terms of Reference (ToR) in May 2018. As per the Ridge Landfill Expansion Environmental Assessment (EA) Commitments Table, this memo is intended to fulfill the following two commitments:

1. As outlined in the Code of Practice, Waste Connections will reconfirm the data used to develop the rationale for the undertaking that is outlined in the ToR. The rationale for the project and opportunity will be revisited during the EA.

2. Waste Connections will revisit the purpose and opportunity outlined in the Terms of Reference. Waste Connections will reconfirm the data and methods used to develop the rationale for the undertaking that considers the available disposal volume at existing landfill sites, anticipated capacity from proposed landfill facilities, and waste export to the United States. Waste Connections will prepare a comprehensive market analysis to quantify the industrial, commercial and institutional waste that the Ridge Landfill can reasonably expect to receive over the 20-year planning period to support the identified opportunity.

The ToR included Supporting Document #1: Purpose/Opportunity Assessment (SD #1). The purpose of SD#1 was to illustrate the opportunity for Waste Connections to continue operating the Ridge Landfill beyond 2021. This was done using waste generation data was taken from Statistics Canada's Waste Management Industry Survey. Waste projections were compiled to estimate the quantity of residual waste remaining after diversion during the future period of the Ridge Landfill operation. Estimated available capacity at central and southern Ontario landfills over the 20-year planning period was estimated based on waste disposal capacity data received from the Ministry of Environment, Conservation and Parks (MECP) in December 2017. It was assumed that private sector disposal facilities within the service area (existing and planned facilities) would reserve 100% of their capacity for IC&I waste (even though some of these sites receive residential waste). Since municipal disposal facilities typically reserve capacity to meet future residential waste disposal needs, it was assumed that 15% of the waste received at municipal disposal facilities would come from the IC&I sector, which was based on data received from municipalities within the service area. The projections assumed that Ontario will not be able to continue exporting waste to landfills throughout the planning period since there is no guarantee that export will still be permitted by the US and uncertainty about the annual quantity that could be sent to US landfills.

The conclusion in SD#1 was that there is a business opportunity for the Ridge Landfill to continue to provide an annual waste disposal rate of 1.3 million tonnes for the management of residual IC&I waste during the planning period of the EA.

In order to revisit the purpose and opportunity described in the ToR, the data that was previously used was reviewed to confirm if there were any changes (database updates), relevant regulations were researched to identify any changes since 2017 and observations about any changes in market conditions were made. The following provides our observations:

Data Sources

The data used to estimate the remaining waste disposal capacity of existing landfills in southern and central Ontario remains unchanged (as confirmed by MECP in March 2019). The estimated population growth from the Ministry of Finance of nearly 1% per year has not been changed.

It is noted that Statistics Canada waste generation estimates do not account for land clearing activities on areas not previously developed, as well as annual daily cover, concrete, asphalt, bricks, clean sand, gravel and likely not all of the waste exported to the US. This means that the waste generation estimates in SD#1 are lower than what the true generation rates are in the province therefore the remaining available disposal capacity is only further consumed than what was estimated in SD#1.

In addition, waste generation, particularly in the IC&I sector, can be linked to patterns in economic activity. There is a boom of economic activity with the Greater Toronto and Hamilton Area and with the province's Open for Business mandate, economic activity and the resulting waste generation is anticipated to increase.

SD#1 did not account for waste generated from natural disasters and climate change related events (e.g., ice storms, flooding) although there have been more occurrences of these incidents resulting in additional and unplanned disposal capacity being consumed.

SD#1 assumed that no municipal waste is landfilled at private sector landfills even though it is known this is not the case (e.g., Peel Region and City of Guelph send their residual waste to private sector landfills within the proposed service area). The assumption was made to be conservative (e.g., capacity could be consumed only by IC&I waste in the future) and because the proportions of residential to IC&I waste in these landfills was not known due to lack of available data. Accounting for municipal waste being landfilled in private sector disposal sites increases the opportunity for the Ridge Landfill expansion.

Similarly, we had previously assumed that all currently planned capacity via current EA projects for new or expanded landfill capacity (i.e., Southwestern Landfill, Terrapure, W12A) will be approved. It is not certain that they will in fact be approved. These projects were assumed to dispose of 1.7 million tonnes of IC&I waste (and we noted that a small portion of W12A's landfill was assumed to be for IC&I waste).

Regulations

The previous Provincial guidance document (Strategy for a Waste-Free Ontario) had provided a long term overall diversion goal of 80% by 2050 (for residential and non-residential, combined). The projections that were done in SD#1 assumed that the residual waste remaining for disposal would be after 80% diversion was achieved in 2050. Two sensitivity analyses were done that looked at the quantities of residual waste should only 75% and 50% of the target be achieved (i.e., 60% and 40% diversion by 2050). However, the available disposal capacity in the Province over the 20-year planning period was estimated assuming the 80% diversion goal. Even with using this aggressive diversion target, a strong need and opportunity was still demonstrated.

Currently, the two main Provincial regulations / guidelines related to this work are the Made-in-Ontario Environment Plan and the Food and Organic Waste Policy Statement. There are no specific overall diversion goals mentioned, but the Policy Statement has set recovery targets for food and organic waste by different sectors by 2025. It is acknowledged that the previous overall diversion goal of 80% by 2050 was very ambitious. As part of revisiting the need and opportunity, a more realistic overall diversion goal of 40% by 2050 has been carried forward. It is assumed that achieving these targets will be made possible by the efforts undertaken as the results of current Provincial regulations / guidelines.

The Federal government recently announced a proposal to ban single-use plastics (e.g., straws, stir sticks) as early as 2021. Consultation with provinces and territories will occur to determine the extent and timing of the ban. Once the ban is in full effect, it will impact the quantity of waste generated and could contribute to the future diversion achieved in the proposed service area (i.e., 40% diversion by 2050).

Review of Market Conditions

SD#1 included an assumption that the Ridge Landfill would receive 1.3 million tonnes in 2017 when the ToR was submitted in December 2017. The actual waste disposed at the Ridge Landfill in 2017 was just under that amount at 1.294 million tonnes. In 2018, the demand for capacity at the Ridge was high and as a result, the MECP approved an emergency ECA amendment to receive up to 50,000 tonnes more residual waste. At year-end, the Ridge received 1,302,199 tonnes of waste (i.e., approximately 2,200 tonnes more than originally permitted annual capacity). Waste Connections has already committed the remaining available capacity for 2019 and all of the capacity for 2020 and will have to turn additional capacity requests away.

There has recently been significant media attention related to the issues with the quality of materials being placed in Blue Boxes and finding markets for Blue Box recyclable materials. Current market conditions have resulted in an increased need for disposal capacity for Blue Box materials with the advent of overseas markets placing greater restrictions on imported waste. While the hope is that these restrictions will drive innovation towards a circular economy and redesign of products, at present, this has reduced viable markets for previously recycled materials thereby increasing the quantity of residual waste disposal needs.

Waste generated in Ontario continues to be exported for disposal to the United States. In 2018, Michigan landfills received over 2.95 million tonnes of Canadian waste which accounted for almost 19% of the total airspace consumed at Michigan landfills[1]. Waste Connections' Brent Run landfill in Michigan received almost 685,000 tonnes of waste generated in Ontario. The quantities of Ontario waste that were sent to New York landfills in 2018 is unknown.

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[1] Michigan Department of Environmental Quality, *Report of Solid Waste Landfilled in Michigan (Oct. 2017-Sept. 2018),* January 2019.

It is challenging to estimate or predict how long Ontario can rely on disposal capacity in the United States. Recent news articles suggest that the politicians in the State of Michigan are once again considering imposing disposal taxes on international wastes[2] which, depending on the level of tax, has the potential to make Ontario disposal facilities more competitive/more attractive to customers. However, given the projected shortfall in Ontario waste disposal capacity, this will only exacerbate the problem. In revisiting the need and opportunity for the Ridge Landfill to continue operations, the assumption that reliance on US landfills is uncertain remains valid and is therefore not considered in future available disposal capacity estimates.

The "Landfill Management and Planning in Ontario Study[3]", commissioned by the previous Government, measured the current and future landfill capacity needs of Ontario. It found that Ontario has just 12-15 years of disposal capacity remaining if the current rates of waste disposal, diversion and US exportation remain the same. It went on to state that even with new regulatory goals of increasing diversion rates, southeastern and southwestern Ontario will run out of currently approved landfill capacity by 2030 and 2035, which further illustrates how tenuous the Province's waste capacity situation is.

Based on the above, there remains a significant need for the Ridge Landfill to continue operations beyond 2021, as now more than ever; it is a key component in Ontario's waste management infrastructure.

This is further demonstrated by the attached flow chart prepared in response to our discussions with the MECP on May 24, 2019. **Figure 1** illustrates the opportunity for Waste Connections to continue to provide disposal capacity over the planning period and is based primarily on the same data used in SD#1 with the noted exception of the future waste diversion assumption changing from an overall rate of 80% to 40% by 2050. As previously mentioned, an opportunity was demonstrated with the 80% diversion goal and therefore, the opportunity is only greater with the less aggressive diversion assumption of 40% by 2050. Descriptions of the components of the flow chart are provided following **Figure 1**.

Summary

As previously identified in the ToR and reconfirmed in this memo, there remains a substantial, sustained need for additional landfill capacity in the Province. Even with the additional disposal capacity that will be added if the Ridge expansion and other planned facilities are approved, there remains a deficit of disposal capacity in the Province over the planning period. Given the significant overarching factor of population increases and now a new government whose mandate is economic growth, this situation means the Ridge Landfill has become a crucial component of the Province waste management landscape; therefore it requires an immediate expansion.

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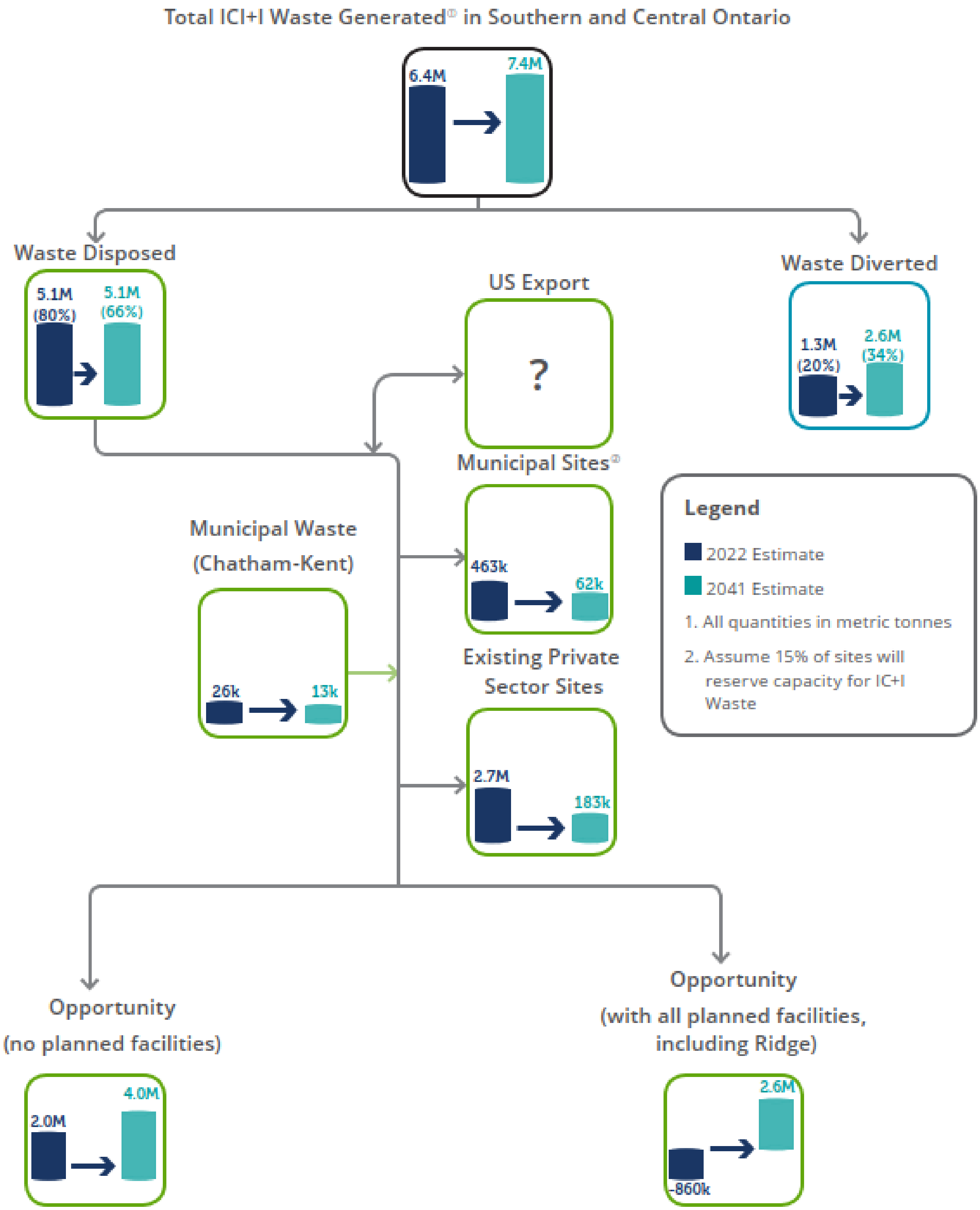
[2] https://www.mlive.com/news/2018/01/snyder_renew_michigan_trash_ta.html, Accessed June 2019.

[3] GHD, Policy Integrity and HDR for MOECC, *Landfill Management and Planning in Ontario Study*, September 2018.

FIGURE 1: OPPORTUNITY FOR THE RIDGE LANDFILL (2021 AND 2041)

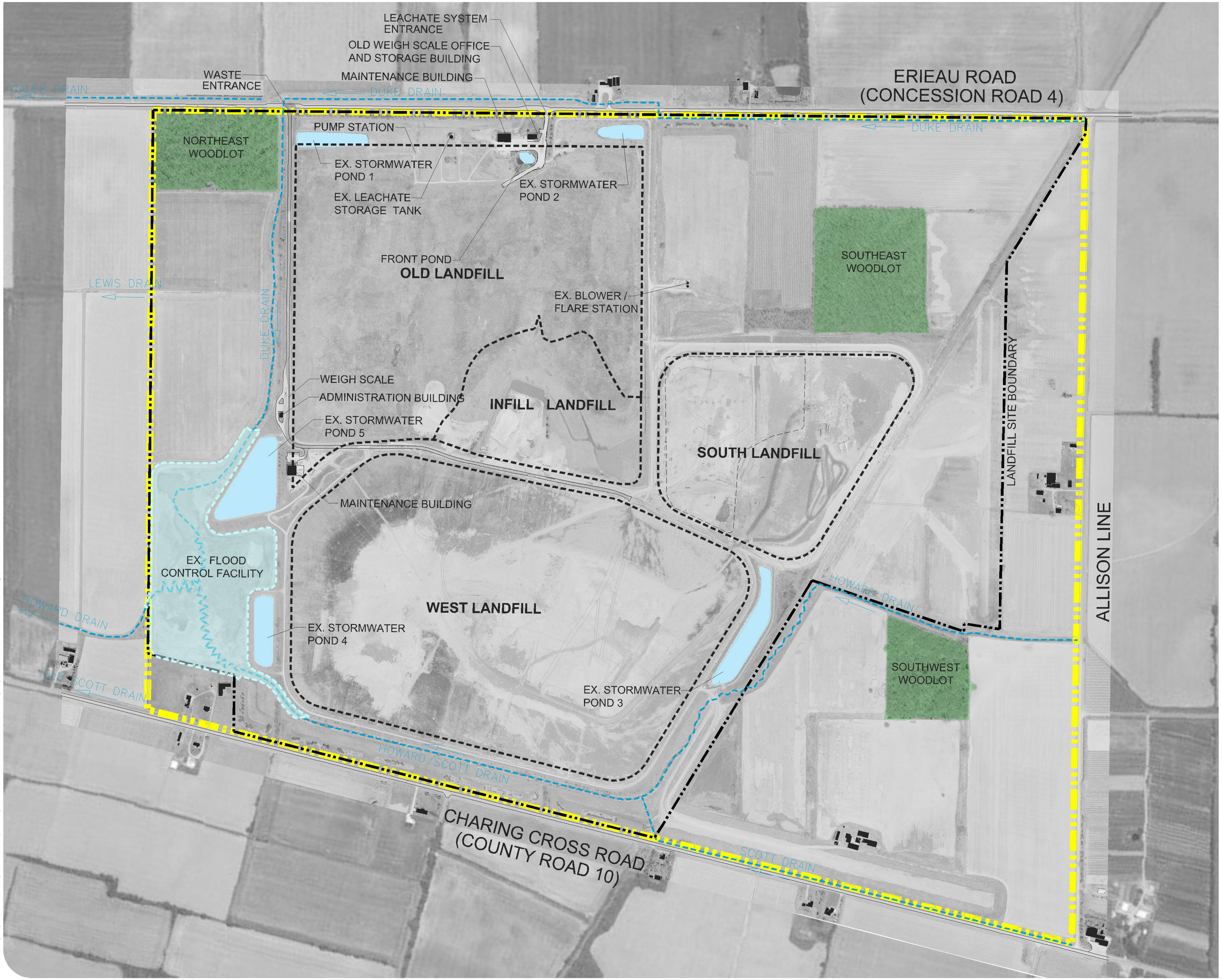


The following is an explanation of the flow chart contents:

- **Total IC&I Waste Generated in Southern and Central Ontario** – waste generation quantities over the planning period were estimated in SD#1 based on Statistics Canada waste management data and Provincial population projection for the proposed service areas.
- **Waste Diverted** – calculated by multiplying the estimated diversion rates by the total IC&I waste generated for IC&I. The assumption is that the overall diversion rate of 40% is achieved by 2050.
- **Waste Disposed** – calculated by subtracting Waste Diverted from Total IC&I Waste Generated for 2022 and for 2042.
- The next four boxes in the flow chart under **Waste Disposed** reflect estimates based on existing sites in the proposed service area and customers:
    - **Existing Municipal Sites** – the available permitted annual capacity among public sector disposal facilities. It was assumed that these facilities will reserve an average of 15% of their capacity for IC&I waste which was based on data received from municipal landfill operators. The quantities shown are subtracted from the Waste Disposed quantities.
    - **Existing Private Sector Sites** – the available permitted annual capacity among private sector disposal sites. It was assumed that these facilities would reserve 100% of the capacity for IC&I waste but it is known that some of these sites do take municipal waste. However, data was not available to estimate the proportion of municipal versus IC&I waste. The quantities shown are subtracted from the Waste Disposed quantities.
    - **Municipal Waste (Chatham-Kent)** – this is the estimated quantity of post-diversion waste requiring disposal generated from the Municipality of Chatham-Kent. This quantities shown are added to the Waste Disposed.
    - **US Export** – there is a box to highlight the fact that this may or may not continue into the future. The uncertainty is illustrated by the two arrows and the absence of an estimated quantity.
- **Opportunity Timeline** – this graph shows the estimated surplus and deficit in disposal capacity within Southern and Central Ontario over the planning period. This is based on the waste disposed quantities for the diversion scenario of achieving 40% by 2050 after subtracting existing disposal capacity and adding in municipal waste which equates to the capacity needed. The planned disposal capacity was estimated to account for those facilities that are currently in the EA process to expand or build new landfill capacity within the service area (including the Ridge Landfill). The surplus/deficit was estimated by subtracting the planned facility capacity from the capacity needed to determine the opportunity for Waste Connections to provide disposal capacity for Southern and Central Ontario.

Appendix F2

Alternative Methods Figures



WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL
ENVIRONMENTAL ASSESSMENT

EXISTING SITE CONDITIONS AND CURRENTLY APPROVED WASTE LIMITS
FIGURE 1

🟨	PROPERTY LIMITS
▬	EXISTING LANDFILL SITE BOUNDARY
▬	EXISTING WATER COURSE
☐	APPROVED WASTE LIMIT
▬	EXISTING POND
🟩	EXISTING WOODLOT

0 100 200 400m

TRUE NORTH

PLAN NORTH

MAP/DRAWING INFORMATION
MAPPING FROM THE BASE MAP CO. LTD.,
MAY 1, 2018

CREATED BY: SKB
CHECKED BY: CO
DESIGNED BY: FG

DILLON CONSULTING

PROJECT: 14 1382
STATUS: FINAL
DATE: 03/29/16

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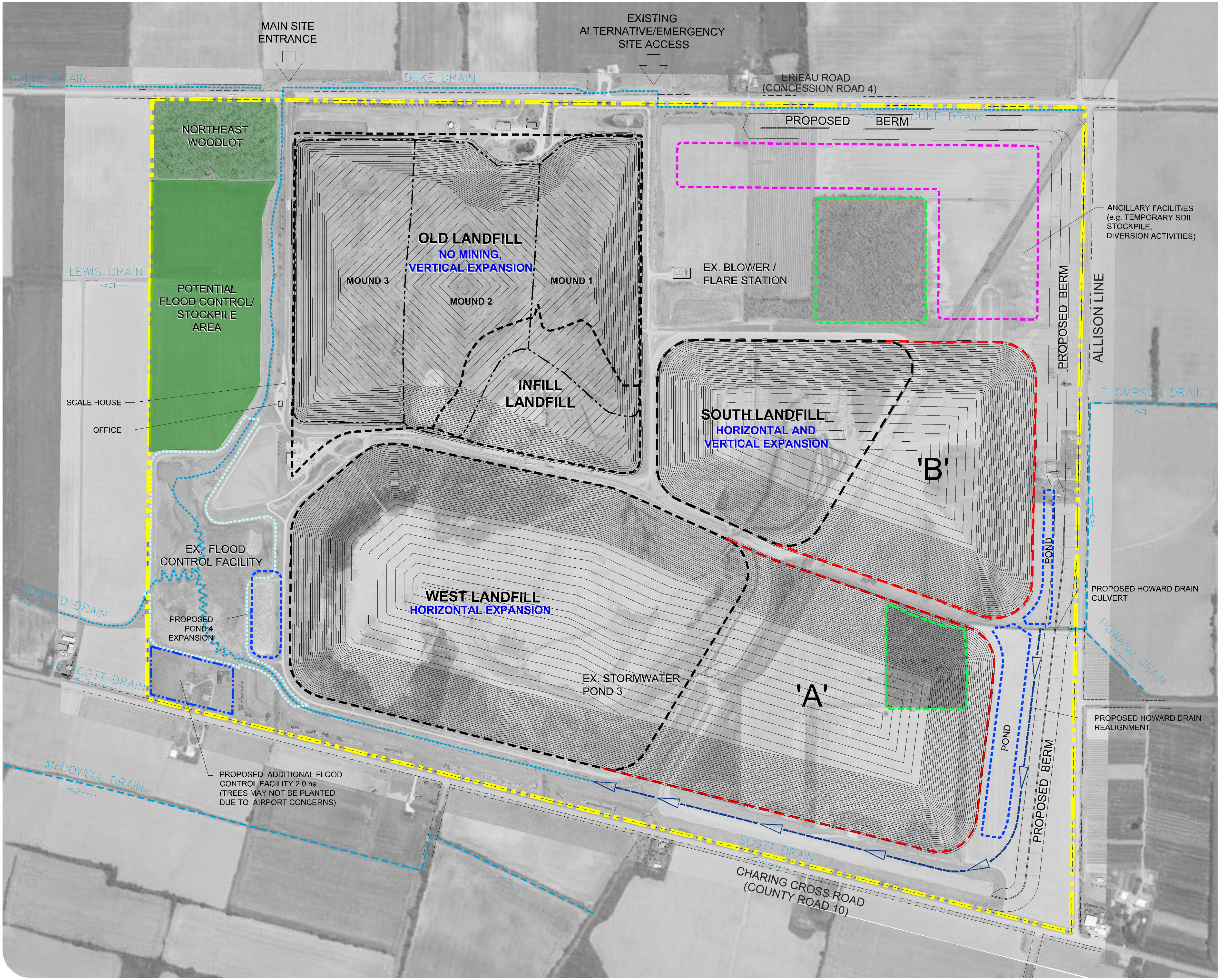

WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL
ENVIRONMENTAL ASSESSMENT

PROPOSED EXPANSION FILL AREAS
FIGURE 2
ALTERNATIVE 1
(HORIZONTAL AND VERTICAL EXPANSION)

🟨	PROPERTY LIMITS
⬚	APPROVED WASTE LIMIT
▢	OLD LANDFILL EXISTING WASTE LIMIT
⇠	EXISTING WATER COURSE
🟥	PROPOSED WASTE LIMIT FOR EXPANSION AREAS
⬚	PROPOSED STORMWATER POND
⇠	PROPOSED WATERCOURSE
▬	PROPOSED ROAD
🟩	EXISTING WOODLOT AREAS

0 100 200 400m

TRUE NORTH

PLAN NORTH

MAP/DRAWING INFORMATION
MAPPING FROM THE BASE MAP CO. LTD.,
MAY 1, 2018

CREATED BY: SKB
CHECKED BY: CO
DESIGNED BY: FG

DILLON CONSULTING

PROJECT: 15 2456
STATUS: DRAFT
DATE: 05/31/17

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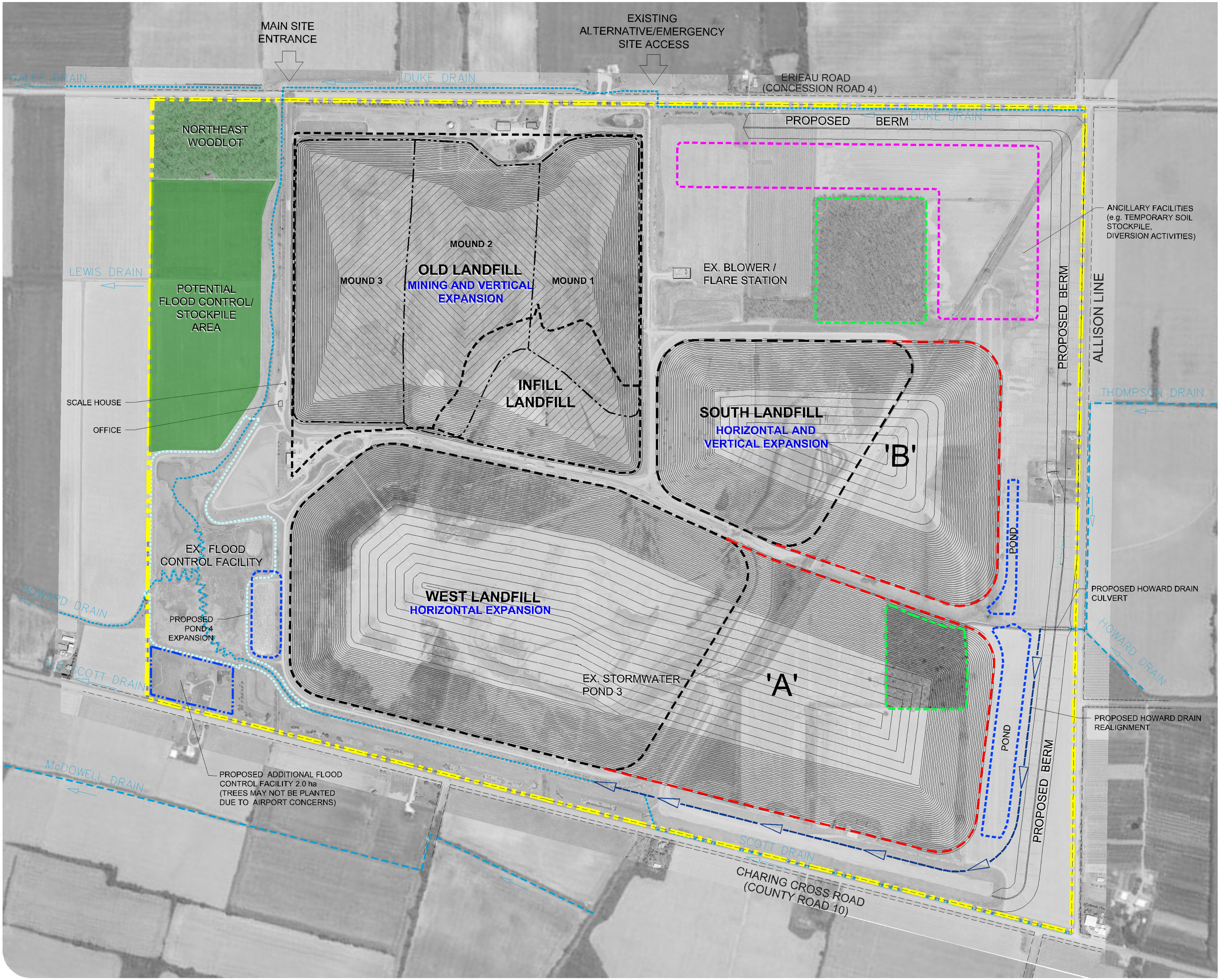

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WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL
ENVIRONMENTAL ASSESSMENT

PROPOSED EXPANSION FILL AREAS
FIGURE 3
ALTERNATIVE 2
(HORIZONTAL AND VERTICAL EXPANSION PLUS LANDFILL MINING)

▬	PROPERTY LIMITS
▭	APPROVED WASTE LIMIT
▭	OLD LANDFILL EXISTING WASTE LIMIT
←	EXISTING WATER COURSE
▭	PROPOSED WASTE LIMIT FOR EXPANSION AREAS
▭	PROPOSED STORMWATER POND
←	PROPOSED WATERCOURSE
▬	PROPOSED ROAD
▭	EXISTING WOODLOT AREAS

0 100 200 400m

TRUE NORTH

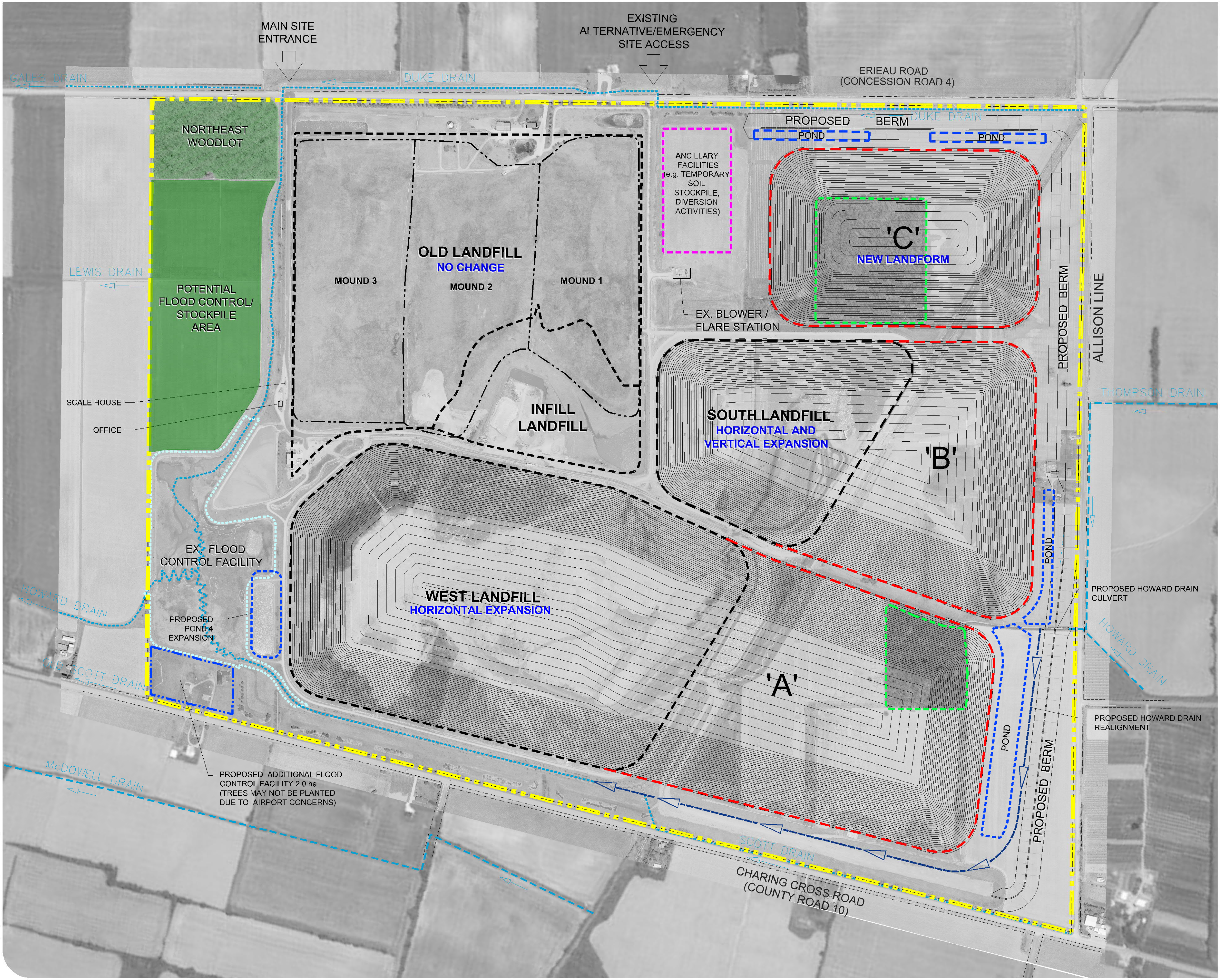
PLAN NORTH

MAP/DRAWING INFORMATION
MAPPING FROM THE BASE MAP CO. LTD.,
MAY 1, 2018

CREATED BY: SKB
CHECKED BY: CO
DESIGNED BY: FG

DILLON CONSULTING

PROJECT: 15 2456
STATUS: DRAFT
DATE: 05/31/17



WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL
ENVIRONMENTAL ASSESSMENT

PROPOSED EXPANSION FILL AREAS

FIGURE 4
ALTERNATIVE 3
(HORIZONTAL EXPANSION)

🟨	PROPERTY LIMITS
⬚	APPROVED WASTE LIMIT
⬚	OLD LANDFILL EXISTING WASTE LIMIT
←-	EXISTING WATER COURSE
🟥	PROPOSED WASTE LIMIT FOR EXPANSION AREAS
⬚	PROPOSED STORMWATER POND
←-	PROPOSED WATERCOURSE
—	PROPOSED ROAD
⬚	EXISTING WOODLOT AREAS

0 100 200 400m

TRUE NORTH

PLAN NORTH

MAP/DRAWING INFORMATION
MAPPING FROM THE BASE MAP CO. LTD.,
MAY 1, 2018

CREATED BY: SKB
CHECKED BY: CO
DESIGNED BY: FG

DILLON CONSULTING

PROJECT: 15 2456

STATUS: DRAFT

DATE: 05/31/17

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Appendix F3

Capacity Summary Table

Ridge Landfill Expansion
Capacity Summary
Table 1

Alternative ID	Figure No.	Composition	A (A1 + A2) (Mm3)	B (Mm3)	Reduced B (Mm3)	C (Mm3)	Mound 1 Mining (Mm3)	Mound 2 Mining (Mm3)	Mound 2 Excavation (Mm3)	Mound 3 Mining (Mm3)	Vertical Expansion of the Old Landfill (Mm3)	Disposal Capacity (Mm3)	Meets 28.9 Mm3 Needs? (Yes/No)
		Available Capacity (Mm3)	*13.2*	*8.6*	*6.5*	*7.1*	*0.4*	*0.5*	*0.8*	*0.5*	*7.2*		
1	1	Lateral expansions of West Landfill (Area A) and South Landfill (Area B), South Landfill (Area B) and Old Landfill vertical expansions	13.2	8.6							7.2	28.9	Yes
2	2	Lateral expansions of West Landfill (Area A) and South Landfill (Area "Reduced" B)*, South Landfill and Old Landfill vertical expansions. Landfill mining of Old Landfill	13.2		6.4		0.4	0.5	0.8	0.5	7.2	28.9	Yes
3	3	Lateral expansions of the West Landfill (Area A) and the South Landfill (Area B). Vertical expansion of the South Landfill and creation of new landform C	13.2	8.6		7.1						28.9	Yes

* For Alternative 2, the size of area B is reduced from Alternatives 1 and 3 because of the capacity gained through landfill mining activity.

All calculations rounded to the nearsest 0.1 Mm3

Volume of vertical expansion of West and South Landfills included in Area A and B calculations.

Appendix F4

Landfill Mining Report

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WASTE CONNECTIONS OF CANADA

Landfill Mining Assessment Report

Ridge Landfill Expansion EA

June 2018 – 15-2456

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Tables

Figures

Appendices

References

Executive Summary

Waste Connections of Canada Inc. (WCC) is proposing to expand the Ridge Landfill and one of the contemplated options is to mine the existing portion of the site known as the Old Landfill to gain additional landfill capacity. Landfill mining (or landfill reclamation) consists of excavating existing disposed waste and cover material, attempt to recover typically 1-2% by volume of recyclables, separate earthen material or “fines”, and return the waste to an engineered disposal area.

The purpose of this report is to assess the site-specific advantages and disadvantages associated with landfill mining. To support this mining assessment report, we reviewed available background documents, completed a literature review and interviews with landfill managers that have completed mining projects, conducted a site investigation at the Old Landfill (i.e. drilled boreholes, observed the type of waste materials and measured leachate levels).

Landfill mining has been completed in Ontario and elsewhere in North America under favourable conditions when combined with significant drivers such as remediating groundwater impacts, gaining landfill capacity or accessing soil for future needs.

As discussed in this report, the Old Landfill does not have favourable conditions for landfill mining and none of the typical main drivers apply. Therefore, the potential advantages associated with landfill mining are limited and are by far outweighed by the various challenges and concerns specific to the Old Landfill.

The Ridge Landfill future capacity needs can be achieved by expanding the waste footprint horizontally and vertically expanding the Old Landfill without the contemplated mining component.

1.0 Introduction

1.1 Purpose of Report

Waste Connections of Canada (WCC) is currently undertaking an Environmental Assessment (EA) to expand the Ridge Landfill to fulfill a need for additional waste disposal capacity in Ontario. The proposed expansion would maintain the annual fill rate and extend the operating life of the facility for an additional 20 years. The EA will consider site development alternatives to physically expand the waste disposal capacity of the site. The primary purpose of this report is to examine the technical and economic feasibility, benefits and challenges related to undertaking landfill mining activities at the Old Landfill as a way to gain landfill capacity. Landfill mining has been discussed with the Ministry of the Environment and Climate Change (MOECC) and was described as a potential component of a site development alternative in the Terms of Reference (ToR) for the EA.

This report documents a desktop assessment for the potential to mine a portion of the Ridge Landfill. In preparing this report, we reviewed background documents available in our files for the Ridge Landfill, conducted interviews with WCC personnel, reviewed notes of previous site visits at the City of Barrie Landfill in Ontario and Ocean County Landfill mining project in New Jersey, interviewed landfill operators that have completed or are completing other mining (reclamation) projects in Ontario, and completed a literature review for landfill mining projects in Ontario and the USA.

2.0 Background

The Ridge Landfill started operations at the area currently known as the Old Landfill. The Old Landfill started operations in 1963 (Garter Lee, 1981) and received a Certificate of Approval (now called Environmental Compliance Approval) No. A021601, which was dated July 25, 1983.

The Waste Certificate of Approval changed its name to Environmental Compliance Approval No. A021601 (Waste ECA) and was consolidated in May 1, 2013. The Old Landfill is referred to in the consolidated Waste ECA as the Existing Fill Area with a 48.2 hectare waste fill area.

The Old Landfill did not have a weigh scale until 1992. Prior to 1992, waste records were tracked using truck load counts or ground survey methods.

Maps, aerial photos and plans are available from 1981 (Dillon, 1981 and Garter Lee, 1981).

The Old Landfill has 3 Mounds as shown on *Figure 1*. The landfill operations first started in Mound 2 and subsequently Mounds 1 and 3 were developed. The Old Landfill operated until December 31, 1999 and has not received waste since then.

3.0 Old Landfill Design

The development of the Old Landfill started in Mound 2 in 1963 (Garter Lee, 1981). A dozer was the only equipment on-site to excavate trenches, spread the waste and fill (trench and fill method) at Mound 2. The majority of Mound 2 was developed using the trench and fill method. According to Tim Kozlof (former Landfill Manager), the Mound 2 trenches had depths between 3 and 4.5 m (10 and 15 ft.) below the original ground. The filling method changed at later stages of Mound 2 with the introduction of a cell filling method (i.e. excavation of a wide area with rectangular or square shape excavated below the ground surface and filled to a final grade above the ground level) with base excavations up to 8.2 m (27 ft.) below original ground (Dillon, 1981).

Mound 1 was developed using a cell landfilling method. Dillon prepared excavation plans for Mound 1 from 1981, which consisted of generally rectangular cells up to 120 m long and with variable widths. Each individual cell was designed with a sloped base, a low point/sump to allow temporary pumping as needed, cut-off ditches at the edges, separation berms and access roads (Dillon, 1981). *Figure 2* illustrates a general representation of the base of Mound 1 without identification of individual cells.

An excavation plan was prepared for Mound 3 in 1985 (Dillon, 1985a). The base excavation of Mound 3 was initiated in 1985 and its filling started in 1992 and continued until the end of 1999. The cross-sections shown on *Figure 2* provide a visualization of the Mound 3 base. Note that the base of Mound 2 is not shown on *Figure 2* because we could not find records to confirm its depth.

The Old Landfill had an original approved capacity of 4,483,000 m^3 (5,864,000 yd^3) for waste and daily/intermediate cover (Dillon, 1985a, pg. C-8). An additional 689,000 m^3 of landfill capacity was approved as part of the late 1990s EA to horizontally expand the Old Landfill footprint. The approved horizontal expansion is located west of Mounds 1 and 2 in the area identified as Infill (shown on *Figure 1*).

Six leachate wells were drilled at the Old Landfill in January 2017 (refer to *Appendix A* – Leachate Well Borehole Logs and *Appendix B* – Leachate Well Photographs). The key information found in the borehole logs was added to *Figures 1* and *2*. The base depths determined in the drilling program and shown on the borehole logs suggest a reasonable correlation with the base design for Mounds 1 and 3.

Figure 2 indicates that waste was buried at Mound 2 at 3.2 m below original ground (M2W1 - from elevation 194.8 to 198 m above sea level) and 9.8 m (M2W2 - from elevation 188.2 to 198 m above sea level). The shallow landfill base at M2W1 location confirms the trench and fill method used at the majority of Mound 2 of the Old Landfill. The deeper base at M2W2 location confirms the cell fill method applied at later stages of the Mound 2 development.

3.1 Leachate Management System at the Old Landfill

During the operational period of the Old Landfill, a series of leachate collection ditches at the edges of the active cells of Mounds 1 and 3 were drained by gravity to low points/sumps. Leachate was pumped from the low points/sumps to leachate recharge trenches in the landfill waste cells. This leachate recharge practice was used from 1988 until the closure of the Old Landfill in 1999, i.e. for approximately 11 years.

Mounds 1 to 3 have a perimeter leachate collection system (toe drain). The perimeter leachate collection system was approved by MOECC in 1994 (Dillon, 1995, pg. 15&16) and constructed in three phases:

- Phase 1 - Mounds 1 and 2 perimeter completed in 1995.
- Phase 2 – Mound 3 perimeter initial phase completed in 1997.
- Phase 3 – Mound 3 perimeter final phase completed in 2000.

Leachate is collected at the perimeter of the Old Landfill by perforated pipes with finger drains spaced 60 m apart and drained by gravity to manholes and pumping stations, which pump to an above ground storage tank with a capacity of 600 m^3 (160,000 U.S. gallons). Leachate is pumped from the above ground storage tank through an off-site forcemain to the Blenheim Sewage Treatment Plant for treatment.

There is a low permeability wall (recompacted clay cut-off wall) constructed with native clay soil at the perimeter of the Old Landfill and outside the perimeter toe drain to enhance horizontal containment.

4.0 Old Landfill Operations

4.1 Filling Sequence

The available reports were reviewed to define the filling sequence determined by the location of the active landfilling area.

Table 1 below provides the annual location of the active landfilling area for the Old Landfill relative to each Mound.

Table 1: Location of Active Landfilling Area

Year	Mound		
	1	2	3
Initial Operations of Mound 2		ü	
Later Operations of Mound 2/Initial Operations of Mound 1	ü	ü	
1981	ü	ü	
1982	ü	ü	
1983	ü	ü	
1984	ü	ü	
1985	ü	ü	
1986	ü	Not filled	
1987	ü	Not filled	
1988	ü	Not filled	
1989	ü	ü	
1990	ü	ü	
1991	Closed	ü	
1992	Closed	ü	ü
1993	Closed	Not filled	ü
1994	Closed	Not filled	ü
1995	Closed	Not filled	ü
1997	Closed	Not filled	ü
1998	Closed	Not filled	ü
1999	Closed	ü	ü

Notes:

- The 1981 Dillon and Gartner Lee reports show aerial photographs and maps with the majority of the waste footprint on Mound 2 and a small waste footprint area on Mound 1. Since there are no records prior to 1981, the exact year when operations started in Mound 1 is unknown.
- The 1996 annual report was not available at the time of this report preparation.

In general, the filling operations proceeded in the following fashion:

- Mound 2 operations first started in 1963;
- Mound 1 operations started before 1981 (historical maps show small areas filled in Mound 1 in 1980);
- Mound 1 closed in 1991;
- Mound 3 landfilling started in 1992;
- Mound 2 operations resumed in 1999 to fill localized settlement areas before closure in 1999; and
- Mound 3 closed in December 31, 1999.

The filling sequence is relevant to the mining assessment because it gives an indication of the age of the waste.

4.2 Filling Method

The majority of Mound 2 was developed using the trench and fill method with depths between 3 and 4.5 m (10 and 15 ft.) below original ground, while Mounds 1 and 3 were developed using a cell filling method with deep cell excavations. Mound 2 therefore has soils between the trenches that were completed at earlier stages of Mound 2 operation, which could increase airspace gain if waste is excavated or mined. Further excavation can potentially be completed at soils under the trenches of Mound 2 to gain additional airspace.

4.3 Types and Quantities of Waste

From November 1972 to September 1981, the Ridge Landfill received approximately 1,400,000 m³ of municipal waste from the City of Chatham, the Town of Blenheim and the Town of Tilbury, approximately 580,000 m³ of industrial, commercial and institutional (IC&I) solid waste, and approximately 74,000 m³ (20,000,000 gal) of liquid industrial waste (which included municipal and industrial sludge). The municipal and IC&I sector wastes included grit from wastewater treatment facilities, wastes from street cleaning and other municipal activities, sludge from municipal sewage works, sludge from industrial wastewater treatment facilities and demolition debris (Dillon, 1981).

Based on the 1981 Design and Operations Report, on average, about 4,500 tonnes (5,000 tons) of waste per month was received at the site and it was anticipated that this amount would increase to 18,100 tonnes (20,000 tons) per month by 1991 (Dillon, 1981). The Old Landfill operated until December 31, 1999. During the operational period, the maximum annual tonnage received was 261,800 tonnes in 1999 (Dillon, 2000).

The following wastes were prohibited from 1981 (Dillon, 1981):

- Pathological wastes from hospitals or laboratories;
- Industrial liquid wastes;
- Hazardous or toxic substances;
- Radioactive wastes; and
- Septic tank pumpings.

Sludges from municipal sewage works and industrial wastewater treatment facilities continued to be accepted at the Old Landfill (Dillon, 1981).

There used to be a liquid waste lagoon at the east corner of Mound 1 with an interceptor trench in between the lagoon and the adjacent property (Dillon As-Built Drawing, Drawing 9 - Interceptor Trench, December 9, 1983). The liquid waste lagoon was later excavated, had its contents removed and was filled with clean soil (Dillon, 1987, Drawings 1 and 9, August, 1985).

The Existing Site Conditions map (Dillon, 1983, Drawing 1) shows that at different locations in Mounds 1 and 2 there were areas where liquid wastes had been co-disposed with solid waste and in Mound 2 there were also locations of industrial sludge and municipal sewage sludge co-disposed with solid waste in 1983.

The available reports indicate that Mounds 1 and 2 received sludge and liquid wastes. The available borehole logs and photographs (Appendix A and B) indicate the presence of sludges with strong odours. Mining wet wastes or sludges is not practical and is usually avoided based on our literature review.

4.4 Daily Cover

Based on the background information reviewed, a 4:1 waste to daily/intermediate soil cover was estimated, which equates to 20% by volume. Since no alternative daily cover was used at the Old Landfill, approximately 20% of the Old Landfill volume is comprised of local soils that were used as daily/intermediate cover and buried with waste.

The local soils, used as daily cover, are cohesive due to high clay content. Since cohesive soils holds moisture and tends to attach to waste, the mining process in this case would be less efficient, would possibly require additional equipment and as a consequence it would be more time consuming, which in turn would increase the potential for odour concerns.

4.5 Landfill Densities

Landfill densities are reviewed in this report to assist with the assessment of potential air space gain if landfill mining was done in the Old Landfill. Landfill mining is often conducted on closed landfill sites that have low compaction rates because the airspace gained through the mining operations offsets some or all of the mining costs.

Waste records were kept at the Ridge Landfill until February 1992 by volume. A weigh scale was installed in February 1992, with waste tonnages being recorded since then. Since tonnage information prior to 1992 is not available, density calculations were not completed for that period of time. For 1983 and 1984, the uncompacted and compacted waste densities were assumed to be 267 kg/m^3 (450 lb/yd^3) and 593 kg/m^3 (1000 lb/yd^3), respectively (Dillon, 1984, pg. 4; Dillon, 1985b, pg. 5).

From 1992 to 1999, waste/soil volume, waste weight, and apparent density were reported every year in annual reports, which are summarized on *Table 2* below.

Table 2: Annual Waste Tonnage, Depleted Capacity and Density

Reporting Period	Waste Weight (Jan – Dec) (tonnes)	Depleted Capacity Between Two Mappings (m³)	Apparent Density (kg/m³)
1992	183,300	304,000	603
1993	216,500	244,800	743
1994	214,500	256,400	878
1995	201,700	239,300	882
1997	209,900	282,400	924
1998	215,500	285,100	623
1999	261,800	525,800	564

Notes:

- Values rounded to the next 100 for Waste Weight and Depleted Capacity.
- The 1996 annual report was not available at the time of writing.

The apparent density reported in *Table 2* is defined as the weight of waste divided by the volume of waste and daily/intermediate cover. The volume change due to landfilling between two subsequent surveys was calculated for each annual report and the waste weight for the exact same period of time was used to calculate the waste apparent density.

For additional context, we also reviewed the landfill compaction equipment for the Old Landfill. In 1990, a CAT 826C landfill compactor was purchased by the Ridge Landfill (Dillon, 1991, pg. 8). Prior to 1990, there was no “Equipment List” in the annual reports so it is unclear what compaction equipment was available on site. According to Tim Kozlof (former Landfill Manager), there was no landfill compactor during the earlier stages of Mound 2 operations. *Table 3* summarizes the type of compactors available on site from 1990.

Table 3: Site Compactors

Annual Report Date	CAT 826C Landfill Compactor	CAT 836 Landfill Compactor	Trashmaster Rex 3-70 Landfill Compactor
1990-1993	ü		
1994	ü		ü
1995	ü	ü	
1997- 1999		ü	

Note

- The 1996 annual report was not available at the time of writing.

The overall density for the Old Landfill was not calculated because waste tonnages are not available for the entire site history. The apparent density summarized on *Table 2* is considered high, with a maximum value of 924 kg/m^3 and an average of 745 kg/m^3 from 1992 to 1999. Also, large size compactors were used on site from 1990 to 1999. The 2016 annual mapping indicates that there have been some settlements, which contributes to a further increase to the apparent density.

Based on the data above, Mound 3 was filled with a high compaction rate, which limits the opportunity to gain landfill capacity through mining operations.

5.0 Leachate Levels Monitoring

Leachate levels were measured on February 24, 2017 at the six new leachate wells installed at the Old Landfill. Since an accurate base is not available for Mound 2, we will refer to leachate depth from the existing top of the landfill surveyed in March 2017.

The following leachate levels were measured from the existing ground on February 24, 2017 (refer to Figure 2):

- Mound 1: 5.3 m below top of landfill surface (mbgs) measured at both leachate wells M1W1 and M1W2;
- Mound 2: 7.1 to 9.2 mbgs measured at M2W1 and M2W2 respectively; and
- Mound 3: 14.2 to 15.2 mbgs measured at M3W1 and M3W2 respectively.

The leachate levels at Mound 1 and 2 are higher than the leachate levels at Mound 3. Higher leachate levels can indicate isolated perched leachate conditions or some leachate mounding, which add significant challenges to mining operations in Mounds 1 and 2 as described later in this report. The higher leachate levels at Mounds 1 and 2 could be attributed to liquids/sludge disposal and since these Mounds are older they had more opportunity for more infiltration and associated leachate generation.

6.0 Literature Review

A literature review was conducted of four Canadian and two American landfill sites that are pursuing or have completed landfill mining operations. The literature review is provided in *Appendix C* for each landfill followed by a discussion on problems and mitigation measures implemented during the mining operations.

Based on our literature review and site visits to the City of Barrie Landfill and Ocean County Landfill Corporation Site, landfill mining is only considered or completed when its benefits outweigh the associated high costs, and odour and health and safety concerns. *Table 4* below summarizes the reasons to consider landfill mining.

Table 4: Summary of Key Findings and Mining Reasons

Landfill Site	Key Findings	Reasons to Consider Landfill Mining
Trail Landfill, Ottawa	· Unlined existing site on sand setting. · Site with existing groundwater impacts. · No leachate mounding because the landfill base would not offer natural containment.	· Groundwater impacts mitigation. · Landfill capacity gain.
Sault Ste. Marie Municipal Landfill	· Unlined existing site on sand and gravel setting. · Site with existing groundwater impacts. · No leachate mounding because the landfill base would not offer natural containment.	· Groundwater impacts mitigation. · Landfill capacity gain.
City of Barrie Landfill	· Unlined existing site on sand setting. · Site with existing groundwater impacts. · No leachate mounding because the landfill base would not offer natural containment.	· Groundwater impacts mitigation. · Landfill capacity gain.
Blue Mountains Landfill	· Unlined existing site on sand and gravel setting. · Site with existing groundwater impacts. · Existing site was filled using trench and fill method, providing higher potential for landfill capacity gain. · No leachate mounding because the landfill base would not offer natural containment.	· Groundwater impacts mitigation. · Landfill capacity gain.
Perdido Landfill	· Unlined existing site on sand setting. · Site with existing groundwater impacts. · Existing site had leachate seeps. · Existing site had differential settlement. · Existing site was filled using trench and fill method, providing higher potential for landfill capacity gain.	· Groundwater impacts mitigation. · Landfill capacity gain.
Ocean County Landfill Corporation Site	· The site did not have enough soils for regular landfill operations. · There were limited vertical and horizontal options.	· Fines recovery supplemented soils deficit for landfill operations. · Landfill capacity gain.

Most of the mining drivers above do not apply to the Ridge Landfill as will be discussed in details as follows.

7.0 Site Specific Mining Assessment

This section provides discussions for the Old Landfill mining option at the Ridge Landfill.

7.1 Process Description

The typical mining process that would be followed at the Ridge Landfill should, in general, be completed according to the following sequence (for a process flow diagram, refer to *Figure 3*):

- *Planning* - Prepare and implement a health and safety plan, air quality monitoring plan, odour mitigation plan, dust and erosion and sedimentation control plans.
- *Mobilization* – Mobilize waste excavation, processing and transport equipment.
- *Site preparation* – Strip existing soil cover within the area to be mined for each day. Soil would be stockpiled for future cover use.
- *Waste excavation and pre-separation* – Excavate waste in lifts of approximately 3 m thick using an excavator and/or dozer. Materials that could be reused, recycled or cause damage to screening equipment (typically large size, bulky items) would be pre-separated. During waste excavations, large size materials (e.g. tires, long metal rebars, concrete rubble and boulders) could be pre-separated and stockpiled or stored for reuse or recycling, which may include mechanical processing such as shredding, grinding or crushing. However, it is expected that amount of waste that would be recyclable from the Old Landfill would be extremely low; the recovery rate at the Barrie Landfill mining operations was about 1-2% of the waste processed volume.
- *Waste screening* - Excavated waste materials that are not pre-separated would be loaded by an excavator into screening equipment (e.g. trommel screen). The screening process would mechanically separate fine parts (mainly soil), from the residual materials typically referred to as waste overs. In the case of the Ridge Landfill (unlike other reviewed landfills), additional efforts would be required to separate the fines fraction from the previously landfilled waste material because the soil applied as daily/intermediate cover at the Ridge Landfill would have been cohesive due to high clay content, and would require a shredder to break the material or as a minimum longer or more screening (e.g., two screens placed in series).
- *Fines* – Typically, the fines fraction would be hauled to the working face of the active cell for use as daily/intermediate cover, or temporarily stockpiled on the existing landfill footprint. The stockpiled fines would be used to offset the need for virgin soils in future daily/interim cover needs. However, the Ridge Landfill has a soil surplus and therefore additional soils for cover material is not expected to be needed. Because the natural soils are clayey, the successful recovery of fines in any significant amount is unlikely.

- *Waste overs* - The waste overs would be hauled to the working face of the active cell and immediately re-landfilled along with the regular incoming solid waste materials.
- *Compaction and cover* - Mined waste that is re-landfilled would be treated as regular waste, would be compacted and/or mixed with other waste and would be covered with daily cover at the end of each operating day.

7.2 Operational Requirements

The following are the minimum key operational requirements for mining of the Old Landfill:

- Prepare and implement an effective air quality and odour control plan.
- Prepare and implement an effective health and safety plan.
- Plan for an efficient layout and excavation sequence.
- Plan for the introduction of an additional shredder to break the cohesive soils prior to screening. Expect low recovery rate of recyclable materials (approximately 1-2% was achieved in Barrie).
- Have an active working face at the expansion area ready to receive wastes from the mining operations.
- Construct low points (sumps) to pump leachate out of the mining area.
- Construct stormwater separation berms as needed to minimize leachate volumes.

7.3 Potential Volume Recovery Rates in Air Space

The recovered air space (landfill capacity) rates ranged from 20% to 70% at the reviewed mining projects (*Appendix C*). Considering that Mound 3 was filled with a high waste density, and the presence of sludges and high moisture in Mounds 1 and 2, and the presence of cohesive soils in all Mounds, a realistic recovery rate of recyclables is expected to be extremely low.

A potential air space recovery volume for the Old Landfill is likely close to 20% of the mined volume. In addition, since the majority of the bottom of Mound 2 was filled with shallow trenches, its base could be excavated 6 m below the existing trenches following mining. The soil excavation volume below existing waste at Mound 2 is estimated at 0.8 million m^3.

It should be noted that the estimated 1 to 2% maximum volume of recycling materials potentially recoverable is included in the likely 20% airspace recovery volume.

7.4 Air Quality Assessment

An initial review of potential landfill mining impacts on air quality was completed. In 2010, the City of Barrie completed an air quality assessment to determine if mining and routine landfill operations could pose a human and environmental health concern. Air samples were collected and analyzed for target parameters of concern. The conclusions of the health assessment indicated that there were no unacceptable health risks to off-site residents resulting from the landfilling or mining activities at the City of Barrie Landfill.

A desktop screening assessment was completed for the Town of Blue Mountain's proposed landfill during the Environmental Assessment approvals process to assess potential air quality impacts associated with landfill mining operations. This screening assessment concluded that there would be no health risks related to landfill mining operations.

Based on the City of Barrie and the Town of Blue Mountain's mining experience, landfill mining operations are typically not expected to pose health risks at municipal landfills. However, health risks would be monitored during mining operations at the Old Landfill since its waste composition is different than a typical municipal landfill waste composition. Also, residents at the vicinity of the Ridge Landfill may raise concerns that could delay the Ridge Landfill Environmental Assessment approval.

Odours and dust generated during landfill mining operations may impact the air quality if not properly managed. Separate odour and dust assessments are presented as follows.

7.5 Odour Impact Assessment

7.5.1 Surface Monitoring of Emissions

Surface monitoring scans were completed at the Ridge Landfill in 2012 and 2013 by RWDI with the purpose to determine areas of elevated Total Hydrocarbon (THC) concentrations. Walkover surveys were conducted at the entire area of the Old Landfill using a handheld THC analyser.

Higher measurements of THC (as methane) were measured at the following locations in 2012 (RWDI, 2012):

- 7 spots at the final cover;
- 16 leachate manholes; and
- 1 red pipe.

Higher measurements of THC (as methane) were measured at the following locations in 2013 (RWDI, 2013):

- 48 spots at the final cover;
- 4 leachate manholes; and
- 1 red pipe, with leak near the cap.

The 2012 and 2013 findings indicate that landfill gas emissions, and therefore active decomposition of materials within the Mounds, are present.

The final cover design for the Old Landfill has a minimum of 1 metre of uncompacted soil including topsoil with no geomembrane. A review of the borehole logs (*Appendix A*) indicate that the final cover may be thinner than the minimum design at some locations, i.e. the final cover thickness ranges from 0.3 m to 0.7 m plus some mixed soil/waste.

7.5.2 Potential for Odour Emissions

Based on the records from site condition in 1983, at various locations in Mounds 1 and 2, liquid industrial waste and sewage sludge were co-disposed with solid waste. The borehole log records for Mounds 1 and 2 from January 2017 (two boreholes in each mound), show that below soil cover, there is a mixture of soil and domestic household waste (the depth varies between 4.6 m to 15.2 m) (*Appendix A*) and below that there is wet black sludge with no distinguishable waste and with "heavy waste" smell (with thickness between 3.7 m to 10 m) (*Appendix A*). In three out of four boreholes, the sludge begins at least 3.2 m below the leachate level and in the fourth borehole (M1W2), it is slightly above the leachate level (0.6m). In Mound 3, there is no record of sludge and it is just soil mixed with domestic, household waste (*Appendix A*).

Based on the recent boreholes in the 3 Mounds of the Old Landfill, Mounds 1 and 2 have odourous sludge beneath the mixture of soil and domestic waste. The household waste is at least 17 years old so it is expected to be mostly decomposed.

Old wastes generally have less odour potential; however, the type of waste also influences odour potential. Mound 3 is 17-25 years old and did not receive high quantities of sludges, while Mounds 1 and 2 are older and received higher quantities of liquid wastes and sludges. The borehole logs indicate that strong odours were observed at Mounds 1 and 2 when sludges were encountered (Appendix A).

Based on the experience of other sites, odour management measures would be required at mining in any of the Mounds with Mounds 1 and 2 having higher potentials for odour generation. Although Mound 3 waste is relatively younger, it is at least 17 years old in advanced stage of decomposition and based on the field observations recorded in the borehole logs, no strong odours were observed during Mound 3 drilling (*Appendix A*).

7.5.3 Odour Management

For odour management, different site-specific practices were employed in other landfill mining operations at other landfills. These practices include:

- Minimizing the active excavation area during the operation;
- Conducting the waste excavation during the cool and cold months and when there is little precipitation is often advantageous for drier sites. However, in the case of the Ridge Landfill, which is a wet and clayey site, waste excavation and mining operations during winter or colder months will likely not be feasible and can actually be problematic to screening equipment, causing poor recyclables recovery and mechanical issues;
- Increasing the slope of excavation to decrease the exposed area of waste;
- Monitoring meteorological conditions such as wind speed and direction and manage the operations based on the climatic conditions and location of sensitive receptors;
- Proactive and ongoing communication with neighbours and nearby residents;
- By-passing processing of highly odourous and/or young waste;

- Covering the waste with soil at the end of each work day; and
- Applying a foam control agent/masking agent/odour neutralizing agent to exposed waste surfaces and surfaces of coarse and fine-screened stockpiled materials to supress odour if problems arise. This may require an understanding of the types of compounds that are being emitted, so that appropriate odour control agents could be selected and made available at the site.

In most cases, odour management entailed on-going monitoring of operations and the application of a combination of measures at any given time.

7.6 Other Nuisances Effects

Dust, litter and noise are other typical nuisances that require mitigation during landfill mining operations. Although the Ridge Landfill is located in a remote and rural setting and dust, litter and noise are still important, and the general mitigation approaches for those nuisances are described in this section.

7.6.1 Dust and Airborne Contaminant Management

Mining operations have the potential to generate dust during dry periods (usually in the summer when the ground is dried up by higher temperatures). Dust can be generated by typical mining operations such as cover stripping, waste and soil excavation, screening and heavy equipment and truck traffic.

Dust is a concern because it may reduce visibility, generate airborne contaminants and potentially may become a nuisance to off-site receptors if not controlled at the source. Airborne contaminants should be controlled because they represent a safety hazard to site personnel and should be addressed in the health and safety plan.

A dust and airborne contaminant management plan should be prepared and implemented for mining operations. The dust and airborne contaminant management plan should include equipment used to control dust and describe the liquid and rate that will be applied as a minimum. Monitoring procedures should also be included in the dust and airborne contaminant management plan.

7.6.2 Litter Control

Several measures should be taken to minimize the amount of wind-blown debris leaving the landfill mining operations area.

Similar to regular landfilling operations, litter control measures to be applied during mining operations can be divided into two groups: preventative measures to limit the generation of litter and regular maintenance measures to collect and prevent litter from leaving the site. Those measures include covering loose waste, keeping the size of the exposed mining face to a minimum and using portable litter control fences.

7.6.3 Noise Control

Potential noise impacts may result from waste mining operations equipment. The operation of this equipment should be conducted in such a manner as to minimize noise impacts, whenever possible. All operation equipment used during waste mining activities should comply with the noise level limits outlined in the *"Noise Guidelines for Landfill Sites"* (MOECC, 1997) and the Municipal Noise By-Law.

7.7 Surface Water and Leachate Management

Clean surface water, originating from non-operating areas of the landfill (i.e., undeveloped areas or areas completed with final cover) will continue to be collected in a ditch inside the perimeter road and conveyed to one of the surface water management ponds that serves the existing Old Landfill. Berms or ditching will be used to divert any non-contaminated storm water away from landfill mining operations where it may cause operational problems and from operating areas where it may come in contact with waste.

Potentially contaminated surface water, such as that originating from mining operation areas where drainage may come in contact with waste or leachate, will not be discharged to the surface drainage system. This isolation of drainage from operating areas will be accomplished by grading of waste and daily/intermediate cover surfaces (i.e. interim separation berms, slopes and diversion ditches will be constructed as part of the landfill mining operations). All drainage from operating areas that may come in contact with waste or leachate will be collected and managed as leachate, i.e. allow infiltration within the open waste areas.

If perched leachate is encountered during waste excavations, low points (sumps) will be constructed to allow temporary pumping to drain the waste and to pump leachate out of the mining area. Surface water separation berms can also be constructed as needed to minimize leachate volumes.

7.8 Health and Safety Considerations

Prior to landfill mining operations, a site-specific health and safety plan should be prepared and implemented.

The health and safety plan should consider different potential hazards (physical, chemical and biological) associated with mining operations, such as gases (methane, hydrogen sulphide). Sharps, liquid waste and sludge, asbestos and equipment traffic will be identified and mitigated. The health and safety plan should include specific operating procedures to address air quality for on-site personnel, dust monitoring, airborne contaminant management, suspect wastes/liquids, personal protective equipment (PPE), decontamination procedures and emergency procedures.

The health and safety plan should include procedures to manage anticipated or confirmed hazardous materials. It should also address potential presence of any material of concern and include material-specific procedures such as asbestos handling or other materials or chemicals of concern.

The health and safety plan should include procedures to operate heavy equipment, processing equipment and tools. Heavy equipment and processing equipment should be provided with engineering controls.

7.9 Cost Estimate

Costing information for various landfill mining projects were collected as summarized below.

- City of Barrie Landfill mining: \$10 to \$15 per m^3 (information received from Chris Visser, Waste Connections).
- Blue Mountains Landfill mining: \$10 to \$20 per m^3 (information received from Chris Visser, Waste Connections).
- Ocean County Landfill Corporation Site: \$24 per m^3 (\$13.69 USD per yd^3) using union labour (Dillon Consulting, 2017b).

The mining cost for the Ridge Landfill is estimated at \$25 per m^3. The mining cost for the Ridge Landfill is expected to be higher due to the nature of the waste, soils and other site-specific conditions.

All costs per cubic meter above are for the mining component, i.e. it includes waste excavation, screening, loading, hauling and unloading at the working face and excludes liner and leachate collection system construction.

7.10 Evaluation Criteria

The following table provides a summary of our evaluation criteria prepared for each Mound of the Old Landfill.

Table 5: Criteria and Evaluation of Mining Potential

Criteria	Mound 1	Mound 2	Mound 3
Odour Potential (based on observations recorded on the leachate wells borehole logs and photographs)	· High	· High	· Medium
Leachate Levels	· High (5.3 m below top of landfill surface)	· High (7.3-9.1 m below top of landfill surface)	· Low (14.2-15.2 m below top of landfill surface)
H&S Concerns for On-Site Staff	· Lower than Mound 2, higher than Mound 3 · High leachate level · Types of waste · Odourous sludges	· Highest · High leachate level · Types of waste · Odourous sludges	· Lowest
Air Quality	· No health risks related to	· Same as Mound 1	· Same as Mound 1

Criteria	Mound 1	Mound 2	Mound 3
	landfill mining operations · No health related to airborne emissions are anticipated based on Barrie and Blue Mountains mining projects (to be confirmed by air quality monitoring during mining operations)		
Estimated Capacity Gain	· 0.4 million m^3	· 1.3 million m^3 (0.5 million m^3 mining and 0.8 million m^3 excavation under existing waste)	· 0.5 million m^3
Costs	· Relatively higher than Mound 3 due to intense liquid management · Probably equivalent to Mound 2	· Relatively higher than Mound 3 due to intense liquid management · Probably equivalent to Mound 1	· Lower than Mounds 1 and 2 · Comparable to the mining costs for the Ocean County Landfill Corporation Site

7.11 Opportunities and Risks with Mining the Old Landfill

Since landfill mining has high cost implications, mining projects usually have multiple benefits to offset the mining costs. As described in the literature review, the most common benefits are improvement of groundwater conditions, reduction of potential liabilities as a risk management strategy, gain landfill capacity, and supply soils for sites that have soil deficiency. We will discuss and test each opportunity and identify constraints applicable to the Old Landfill as follows.

7.11.1 Site-Specific Opportunities

The following are the typical opportunities associated with a landfill mining project and how they might apply to the Old Landfill:

- Remediation of groundwater impacts. This is the usually the main driver to complete landfill mining projects and typically occurs at sites with unfavourable hydrogeological conditions (i.e. high permeability soils such as sandy soil or gravel at the base of the landfill, or high groundwater levels). In the case of the Old Landfill, there are no groundwater impacts and the site meets regulatory requirements. The Ridge Landfill is located in a thick natural clay plain that serves as an in-situ clay liner, i.e. approximately 30 m thick till (clayey silt/silty clay).
- The trench and fill method used in the Old Landfill area represents an opportunity to gain airspace as the soils between existing trenches are excavated. This is applicable to most of Mound 2.

- Mining can typically address a shortage of soil for future landfill operations. The Ridge Landfill is in a soil surplus situation and therefore mining to access more soils or fines for future cover needs does not provide an opportunity in this instance.
- Mining can provide limited opportunity to extend landfill site life if there is no opportunity to complete a horizontal or vertical expansion. This does not apply to the Ridge Landfill since there are opportunities for horizontal and vertical expansions.

7.11.2 Site-Specific Risks

There are site-specific risks that on balance do not support mining operations at the Ridge Landfill as discussed below.

- The landfills that have been mined in Ontario (included in the literature review section) are located in sand/gravel deposits, which allow leachate to drain downwards while keeping the waste dry. The deep, low permeability in-situ clay base at the Old Landfill does not promote leachate subsurface infiltration, rendering mining of saturated (wet) wastes not practical below the leachate levels.
- The soils at the Ridge Landfill have a high clay content, which would make screening and separation of materials very challenging due to the soil cohesion nature and moisture holding capacity. A pre-screening process would likely be needed with the introduction of a shredder to break the cohesive materials or alternatively potentially increased processing time in the screener.
- Mounds 1 and 2 have a history of liquid co-disposal.
- The combination of the three site-specific factors above would require an intense level of moisture and liquid management, making mining more problematic. The mining operations may become even more difficult during winter or cold months as the moisture in the waste and soil cover freezes and attaches with the processing equipment. High leachate levels would delay mining operations and could cause more odours.

8.0 Summary and Conclusions

Based on the background and literature review, field investigations and assessment described in this report, there are limited advantages and strong reasons to not consider mining the Old Landfill as summarized below.

- Remediation is not a driver for mining the Old Landfill because there are no groundwater impacts and the site meets regulatory requirements.
- The thick in-situ clay liner (i.e. approximately 30 m thick clayey silt/silty clay till) that forms the base of the Old Landfill does not promote moisture drainage, creating leachate pockets within the waste that would make mining operations problematic.
- The cohesive nature of the local soil that was used as daily cover at the Old Landfill holds moisture and tends to attach with waste and processing equipment, making materials separation more challenging during mining operations.
- The amount of recyclables recovered is not anticipated to be significant (estimated between 1 and 2% based on the Barrie Landfill experience and the Old Landfill boreholes).
- Mining to gain airspace is not the only available option to expand the Ridge Landfill. Since the site has available land for horizontal expansion and there are opportunities to vertically expand the Old Landfill and the South Landfill, the limited volume achieved with landfill mining is actually not needed for the proposed landfill expansion.
- The amount of soils or fines that are generated through mining operations would not help the site soil management as the site has enough soil material for operations and closure needs.

In summary, unlike other landfills that are considering or have completed mining, the Ridge Landfill does not have the compelling benefits to mine versus the associated disadvantages of mining, i.e. cost, operational challenges, potential nuisances, site constraints, and health and safety concerns. The potential benefits associated with landfill mining are limited and are by far outweighed by the various concerns mentioned above.

As an option, the Old Landfill could be vertically expanded without mining considerations, since the existing ground contours are much lower than the maximum elevation allowed by the airport regulation.

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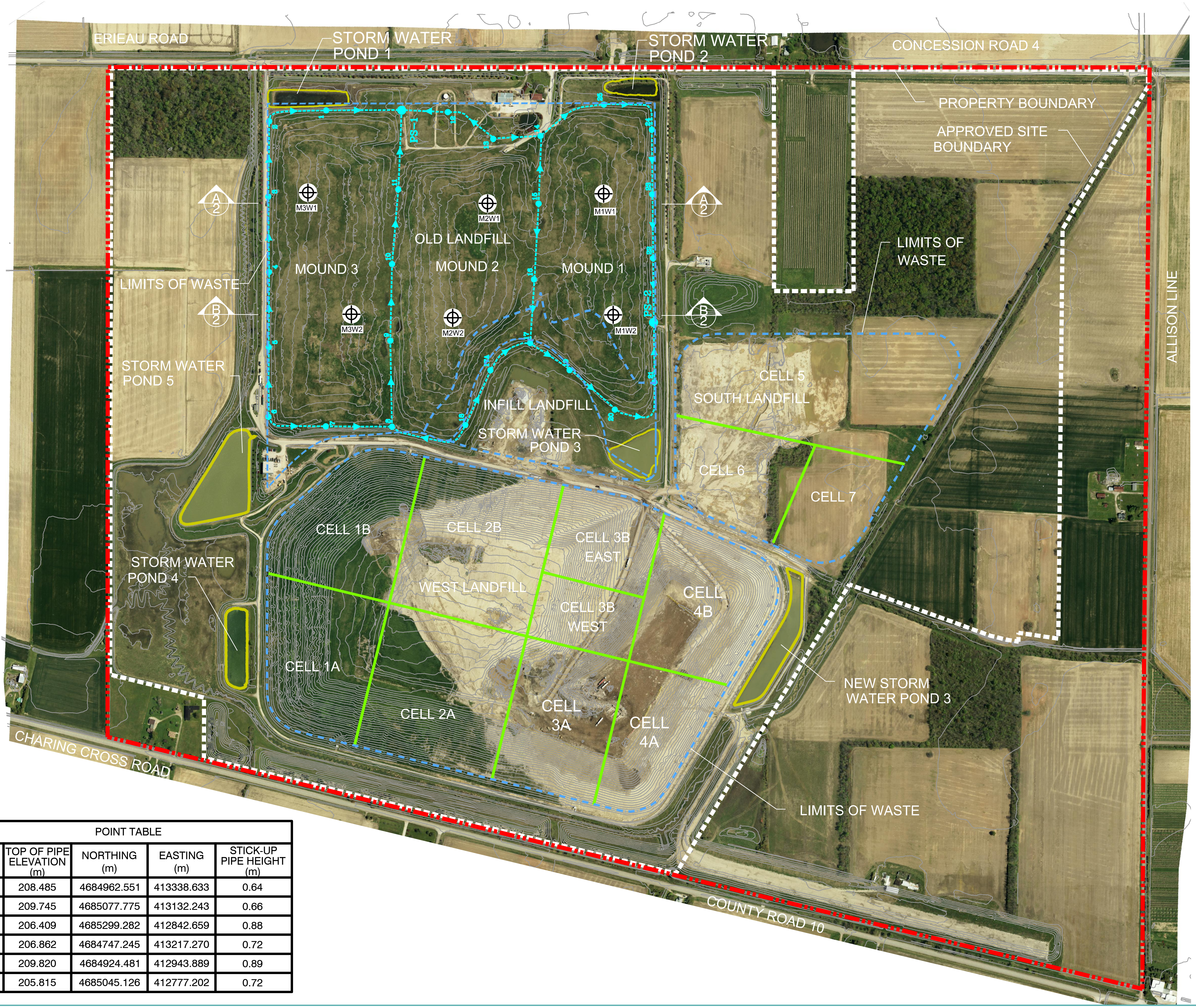

POINT TABLE				
No.	TOP OF PIPE ELEVATION (m)	NORTHING (m)	EASTING (m)	STICK-UP PIPE HEIGHT (m)
M1W1	208.485	4684962.551	413338.633	0.64
M2W1	209.745	4685077.775	413132.243	0.66
M3W1	206.409	4685299.282	412842.659	0.88
M1W2	206.862	4684747.245	413217.270	0.72
M2W2	209.820	4684924.481	412943.889	0.89
M3W2	205.815	4685045.126	412777.202	0.72

WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL

OLD LANDFILL MINING ASSESSMENT REPORT

Figure 1 - Site Plan

🟥	PROPERTY BOUNDARY
▭	APPROVED SITE BOUNDARY
🟩	CELL LIMITS
🟨	STORM WATER POND
⊕	MONITORING WELL
● 10	MANHOLE CLEANOUT AND IDENTIFICATION
◄	LEACHATE COLLECTION PIPE
- - -	APPROVED LIMIT OF FILL FOR EXISTING LANDFILL
— · —	APPROVED LIMIT OF FILL FOR EXPANSION

TRUE NORTH

PLAN NORTH

SCALE 1:8,000

0 75 150 300m

Base Mapping Data from The Base Mapping Co. Ltd, May 16, 2016.

Ground elevations/co-ordinates and pipe stick-up heights for leachate wells obtained by Lance Tavener, Dillon Consulting, on March 21, 2017, using Trimble R10 GNSS GPS system.

CREATED BY: AZ
CHECKED BY: FG

File Location:
c:\projectwise\working directory\active\34axz\d0469912\figure 1 – site plan.dwg June, 09, 2017 9:17 AM

DILLON CONSULTING

PROJECT: 152456
STATUS: DRAFT
DATE: 03/28/17

A–A

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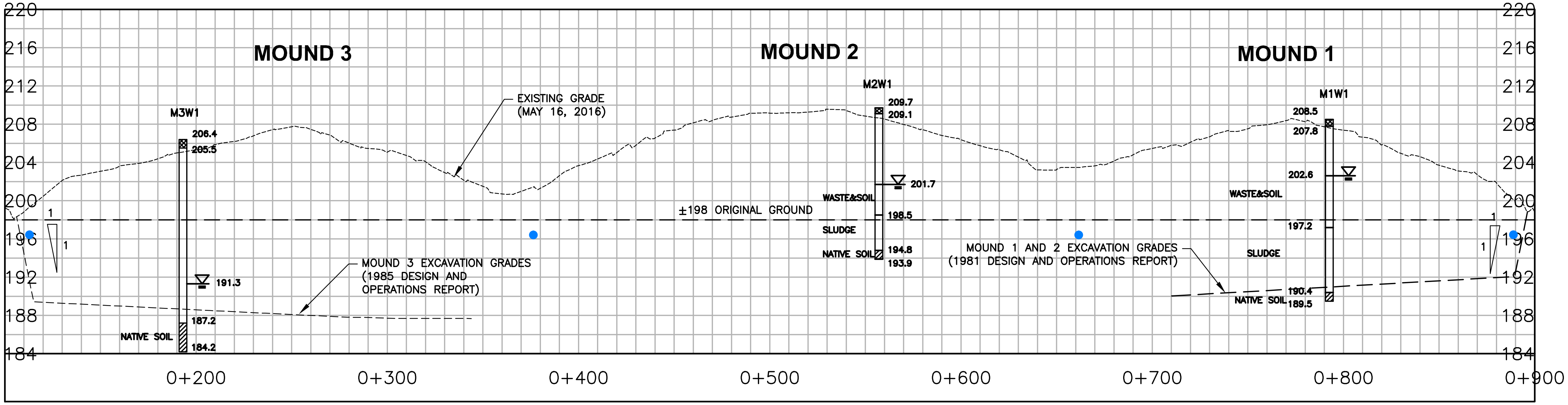
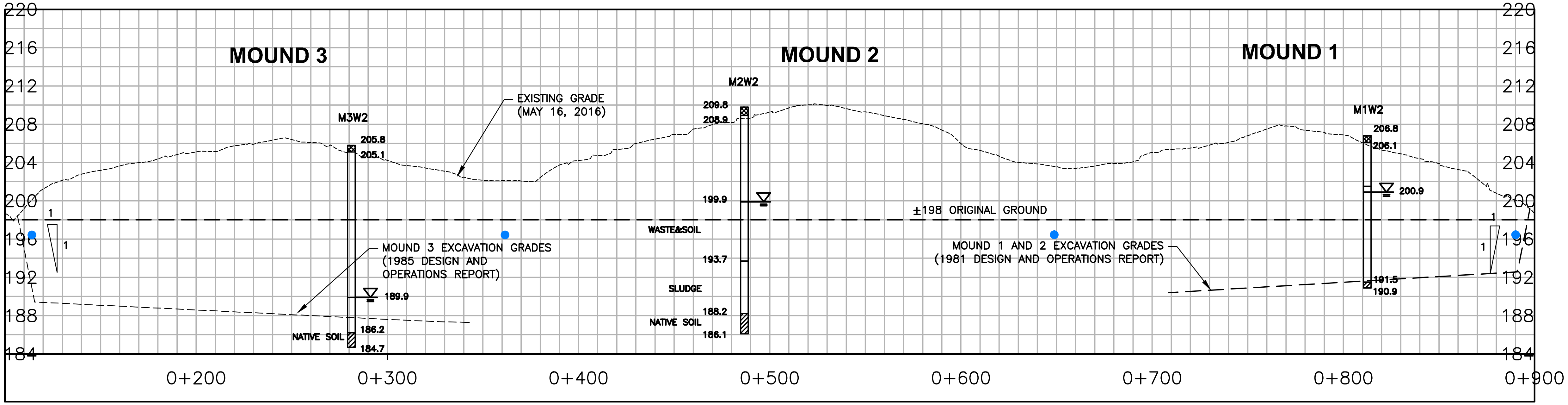
VERT: 1:500



B–B

HORIZ: 1:2500
VERT: 1:500



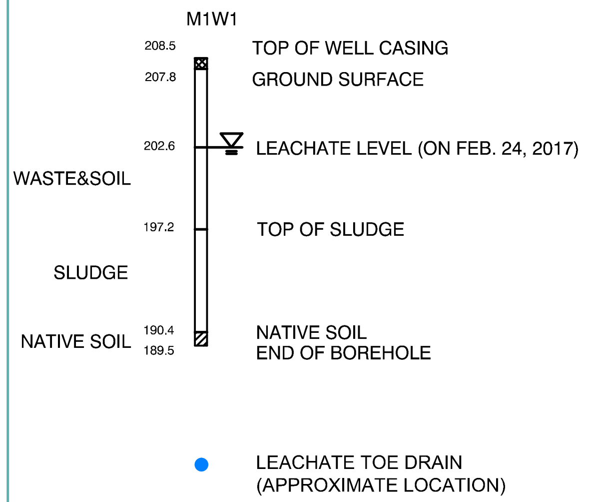
WASTE CONNECTIONS OF CANADA

RIDGE LANDFILL

OLD LANDFILL MINING ASSESSMENT REPORT

Figure 2 - Cross Sections

LEGEND



Base Mapping Data from The Base Mapping Co. Ltd, May 16, 2016.

Ground elevations/co-ordinates and pipe stick-up heights for leachate wells obtained by Lance Tavener, Dillon Consulting, on March 21, 2017, using Trimble R10 GNSS GPS system.

CREATED BY: AZ
DESIGN BY: PS
CHECKED BY: FG

File Location:
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DILLON CONSULTING

PROJECT: 152456
STATUS: DRAFT
DATE: 03/28/17

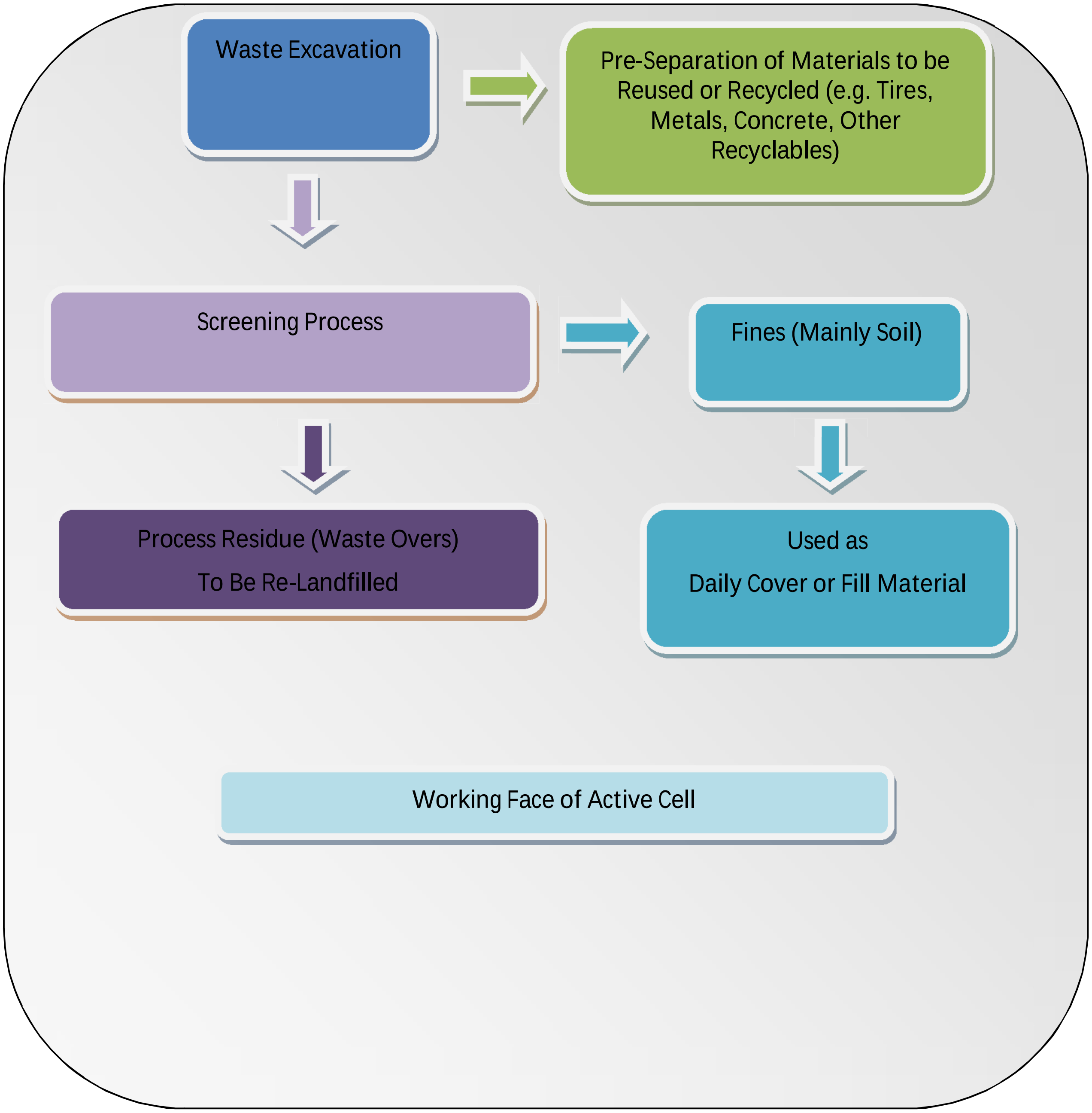


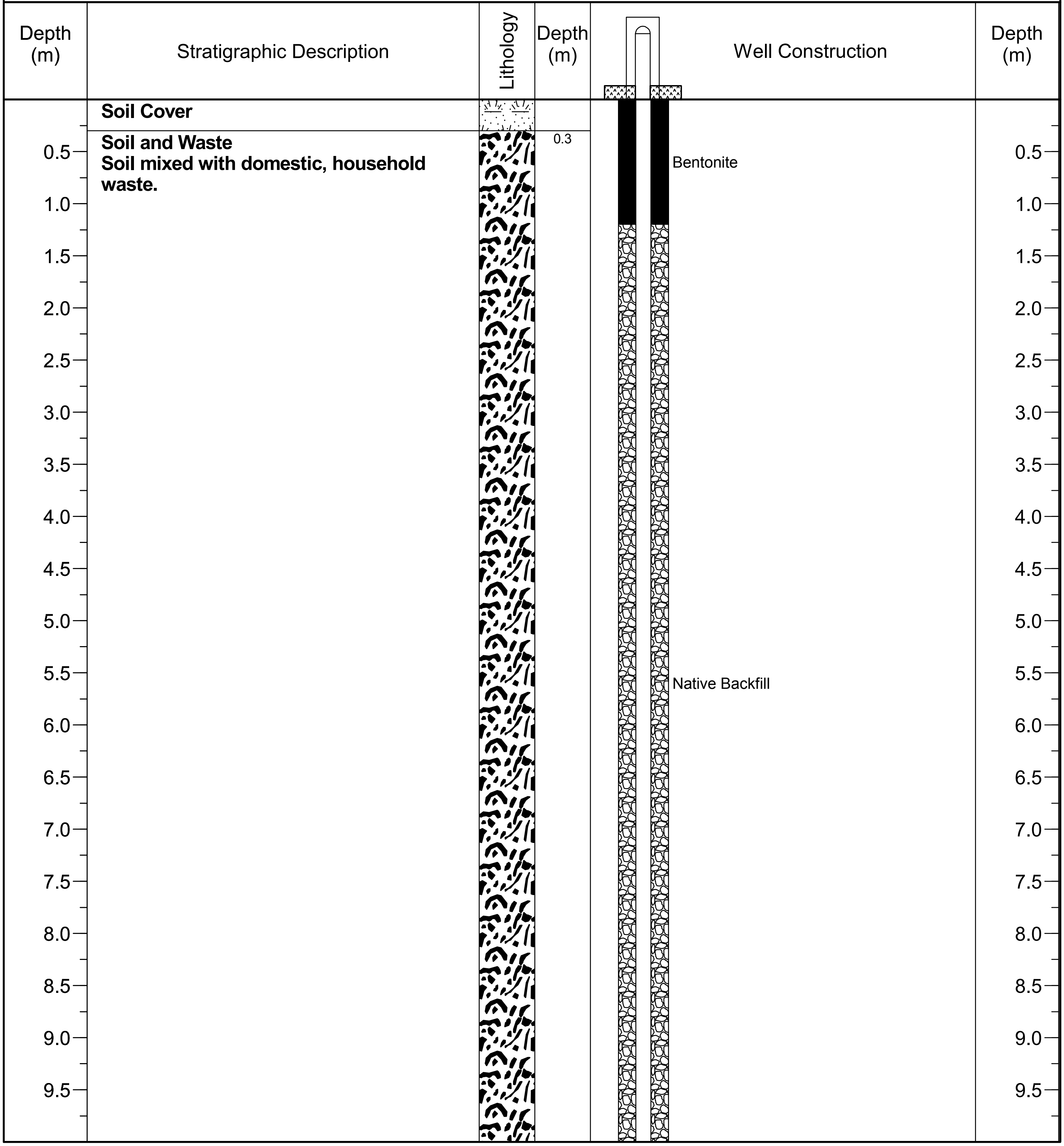
Figure 3 - Process Flow Diagram for Landfill Mining

Appendix A

Leachate Well Borehole Logs

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/23/17 Date Completed: 1/23/17



Soil Cover

Soil and Waste
Soil mixed with domestic, household waste.

LITHOLOGY SYMBOLS
- Organics
- Fill
- Misc. Debris
- Clayey Silt

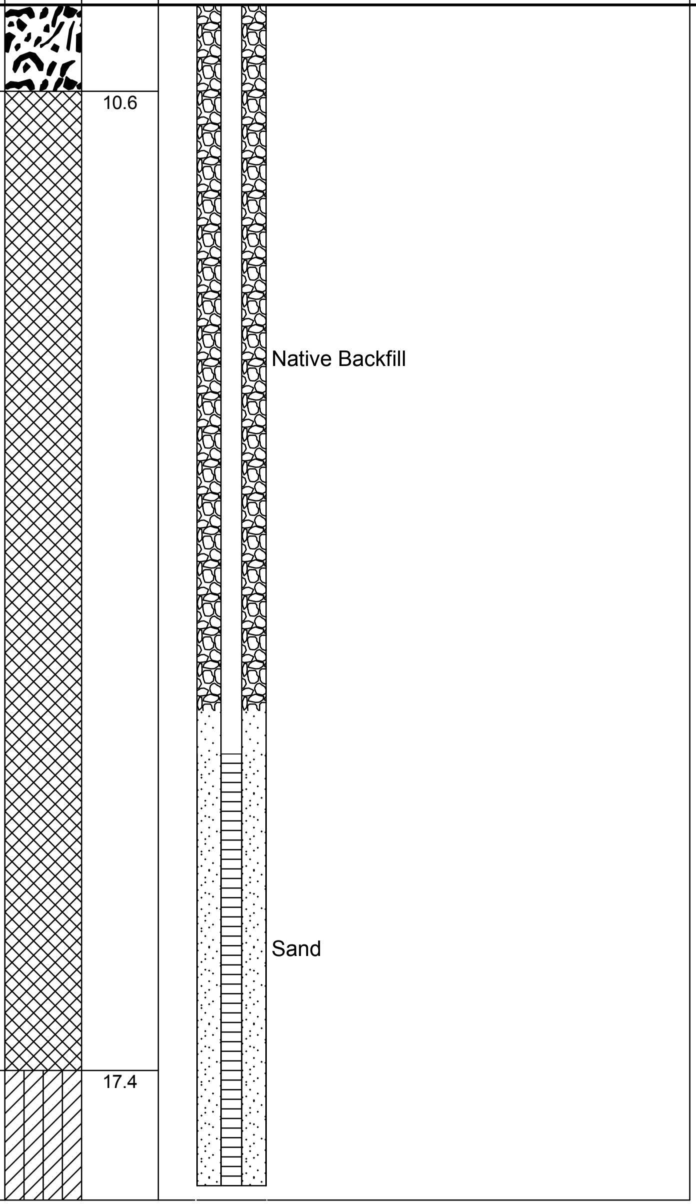
SAMPLE TYPE

M1W1

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/23/17 Date Completed: 1/23/17

Stratigraphic Description (continued)	Depth (m)
Waste Wet black "sludge", no distinguishing waste, heavy garabage smell	10.6
Native Till Grey clayey silt till.	17.4
	18.3



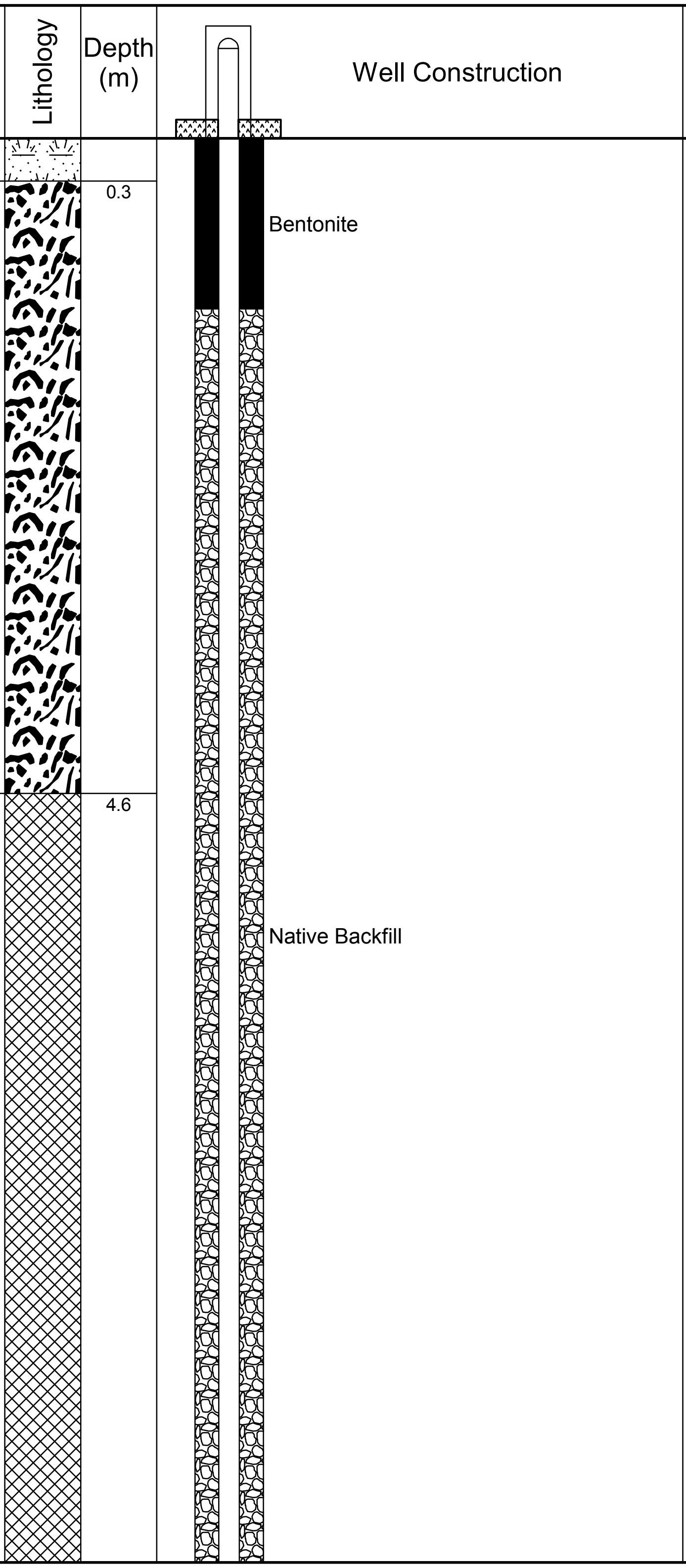
LITHOLOGY SYMBOLS
- Organics
- Fill
- Misc. Debris
- Clayey Silt

SAMPLE TYPE

M1W2

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski
Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/23/17
Date Completed: 1/24/17

Depth (m)	Stratigraphic Description
	Soil Cover
0.3	**Soil and Waste** Waste is domestic; clothes, food wrappers, household waste.
4.6	**Waste** Wet black "sludge", heavy garbage smell.



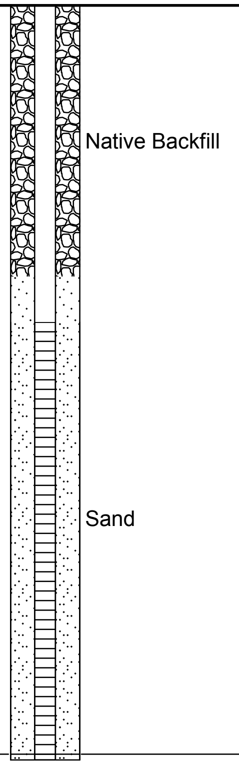
Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5

LITHOLOGY SYMBOLS
- Organics
- Fill
- Misc. Debris
- Clayey Silt

SAMPLE TYPE

Client: Progressive
Project: Ridge Landfill Expansion
Project No.: 152456
Location: Blenheim ON
Drilling Co.: Direct Environmental
Drilling Method: Auger
Supervised by: J.Sikorski
Date Started: 1/23/17
Date Completed: 1/24/17

Depth (m)	Stratigraphic Description (continued)	Lithology	Depth (m)	Well Construction	Depth (m)
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5	**Waste** Wet black "sludge", heavy garbage smell.*(Continued)*	▩			10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5
15.0	**Native Till** Grey clayey silt till.	▨	14.6 15.2		15.0



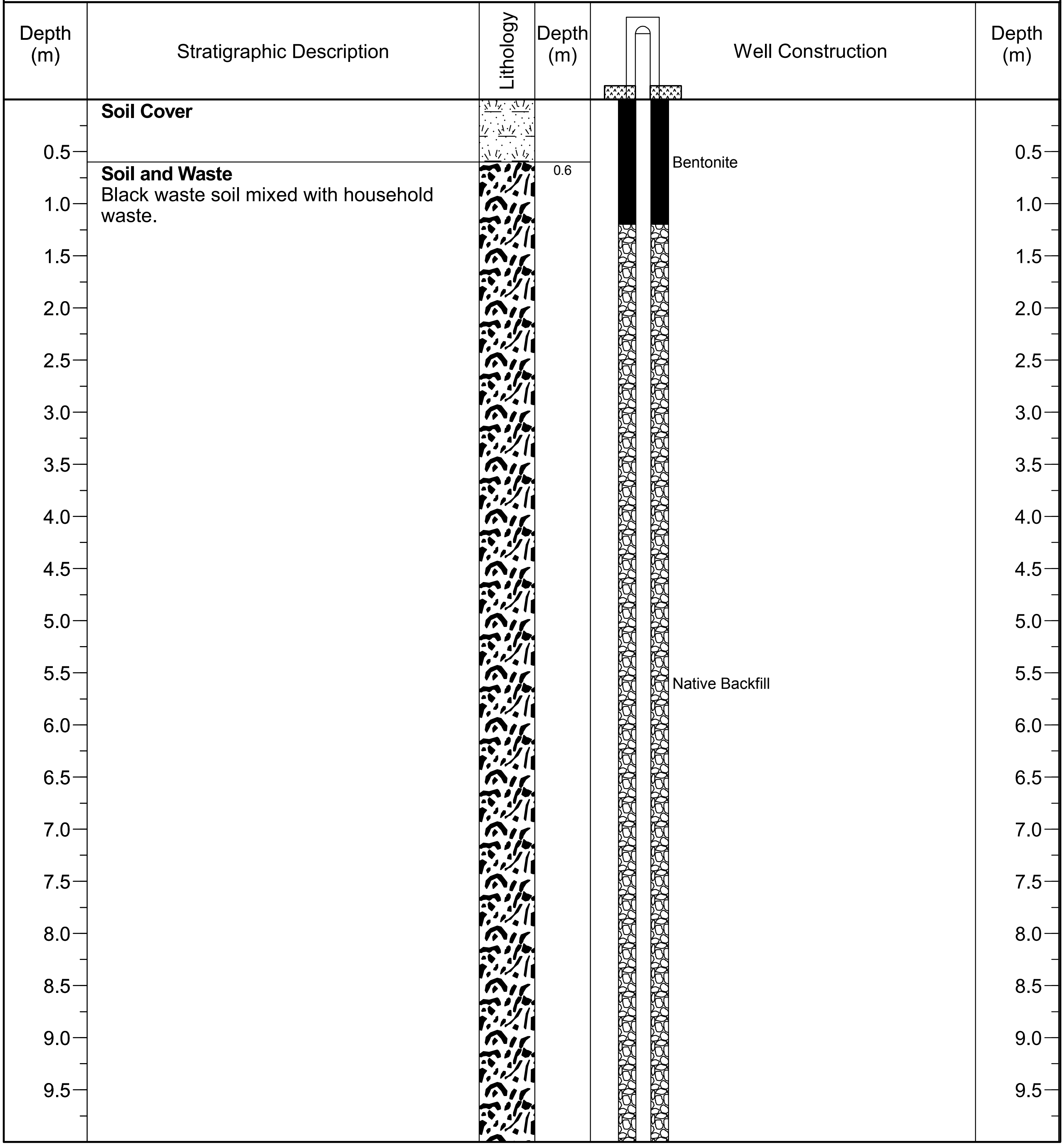
LITHOLOGY SYMBOLS
- Organics
- ▩ Fill
- Misc. Debris
- ▨ Clayey Silt

SAMPLE TYPE

M2W1

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/24/17 Date Completed: 1/24/17



Stratigraphic Description	Depth (m)
Soil Cover	
Soil and Waste Black waste soil mixed with household waste.	0.6

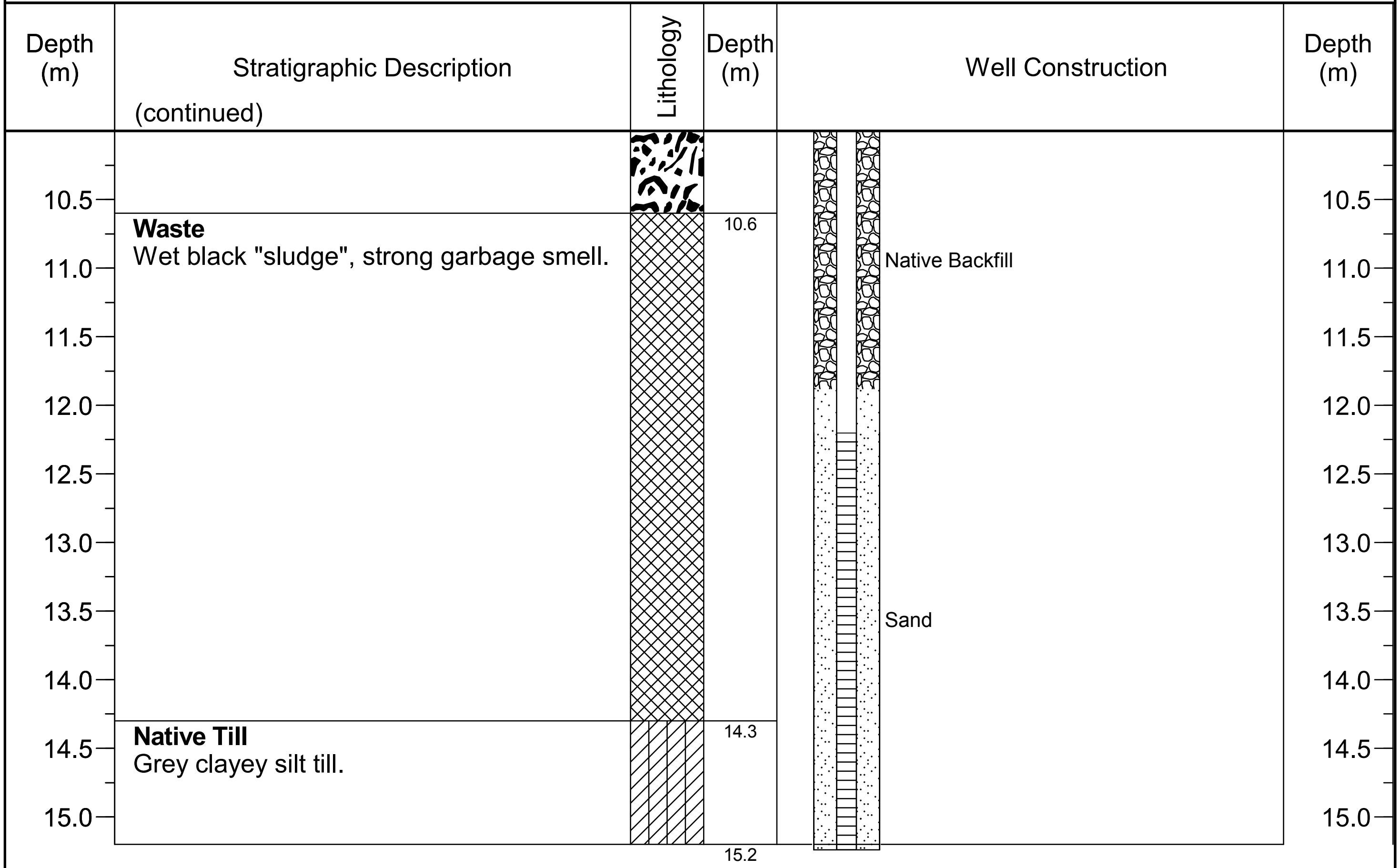
LITHOLOGY SYMBOLS

▨ Organics	▨ Misc. Debris
▨ Fill	▨ Clayey Silt

SAMPLE TYPE

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/24/17 Date Completed: 1/24/17



Waste
Wet black "sludge", strong garbage smell.

Native Till
Grey clayey silt till.

LITHOLOGY SYMBOLS		SAMPLE TYPE
Organics	Misc. Debris	
Fill	Clayey Silt	

DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

Client: Progressive

Project No.: 152456

Drilling Co.: Direct Environmental

Supervised by: J.Sikorski

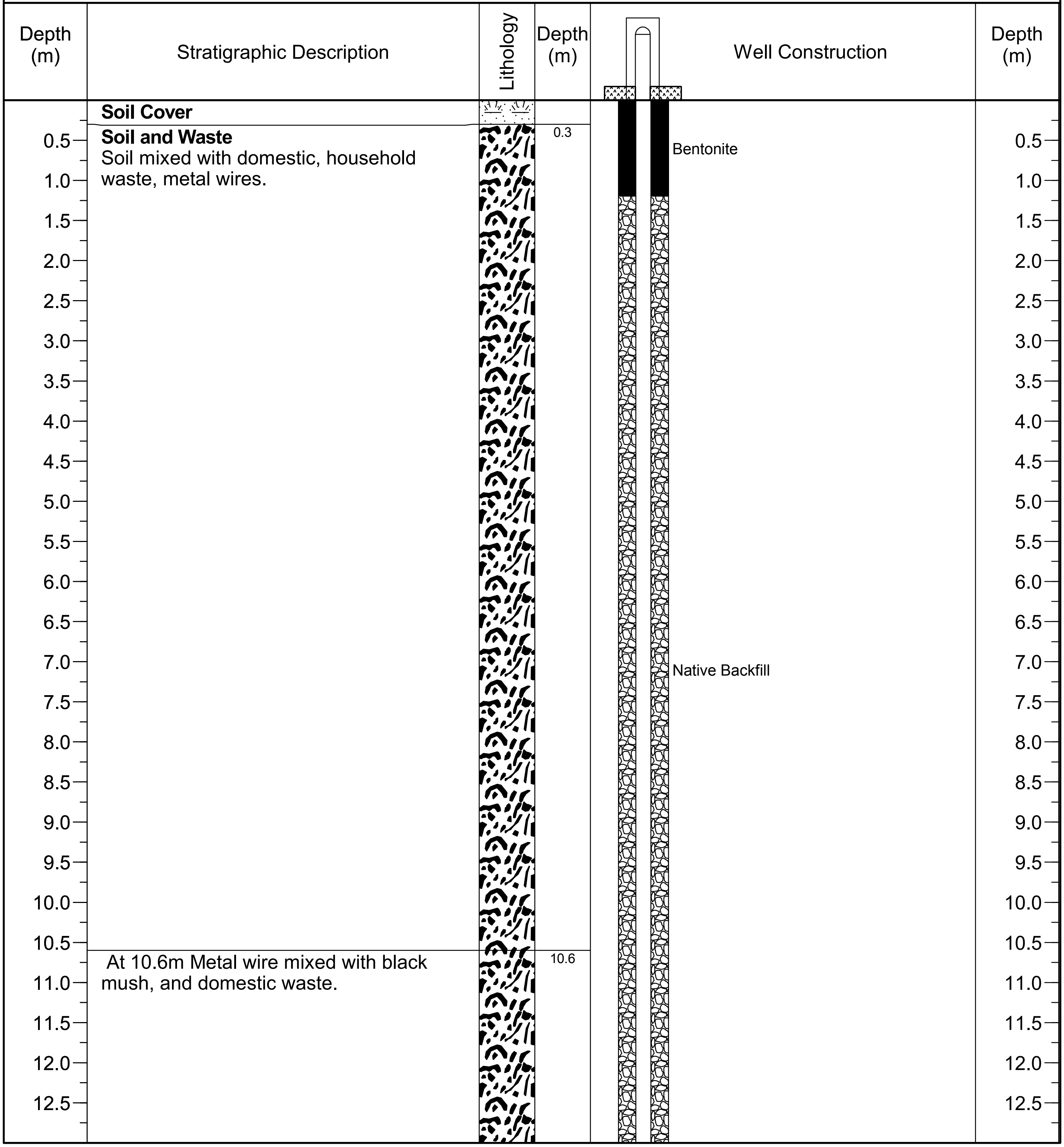
Project: Ridge Landfill Expansion

Location: Blenheim ON

Drilling Method: Auger

Date Started: 1/24/17

Date Completed: 1/25/17



Stratigraphic Description

Soil Cover

Soil and Waste
Soil mixed with domestic, household waste, metal wires.

At 10.6m Metal wire mixed with black mush, and domestic waste.

LITHOLOGY SYMBOLS

▨ Organics

☒ Fill

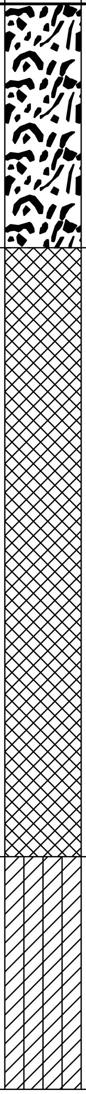
■ Misc. Debris

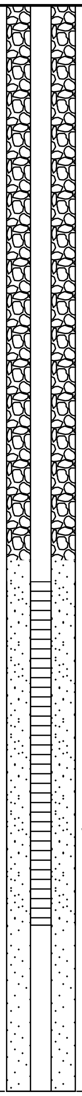
▨ Clayey Silt

SAMPLE TYPE

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski
Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/24/17
Date Completed: 1/25/17

Depth (m)	Stratigraphic Description (continued)	Lithology	Depth (m)	Well Construction	Depth (m)
13.5–15.0	**Soil and Waste** Soil mixed with domestic, household waste, metal wires.*(Continued)*	Misc. Debris		Native Backfill	13.5–15.0
15.5–20.5	**Waste** Wet black "sludge", strong garbage smell.	Fill	15.2	Native Backfill Sand	15.5–20.5
21.0–22.5	**Native Till** Grey clayey silt till.	Clayey Silt	20.7	Sand	21.0–22.5
			22.8		

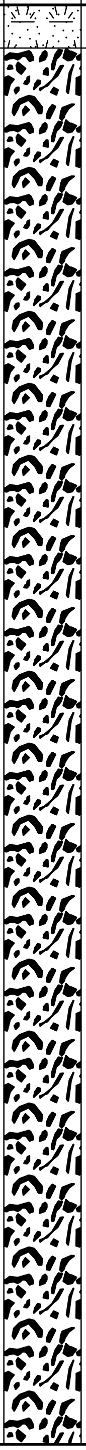


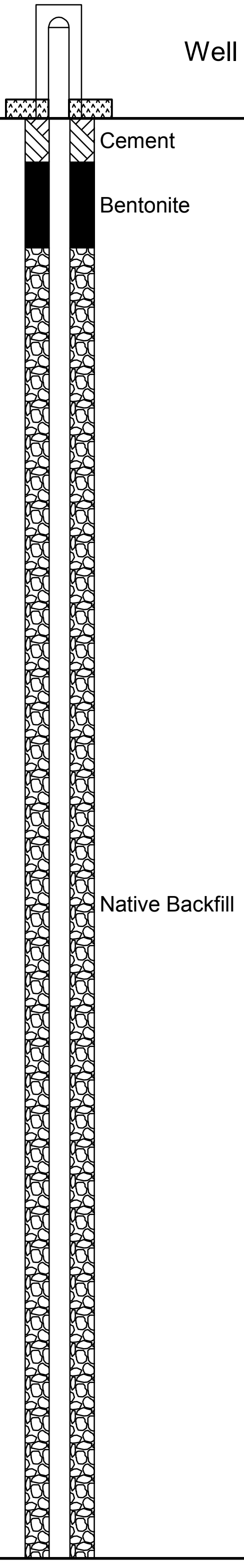


LITHOLOGY SYMBOLS
▨ Organics
▨ Fill
▨ Misc. Debris
▨ Clayey Silt

SAMPLE TYPE

Client: Progressive
Project: Ridge Landfill Expansion
Project No.: 152456
Location: Blenheim ON
Drilling Co.: Direct Environmental
Drilling Method: Auger
Supervised by: J.Sikorski
Date Started: 1/25/17
Date Completed: 1/26/17





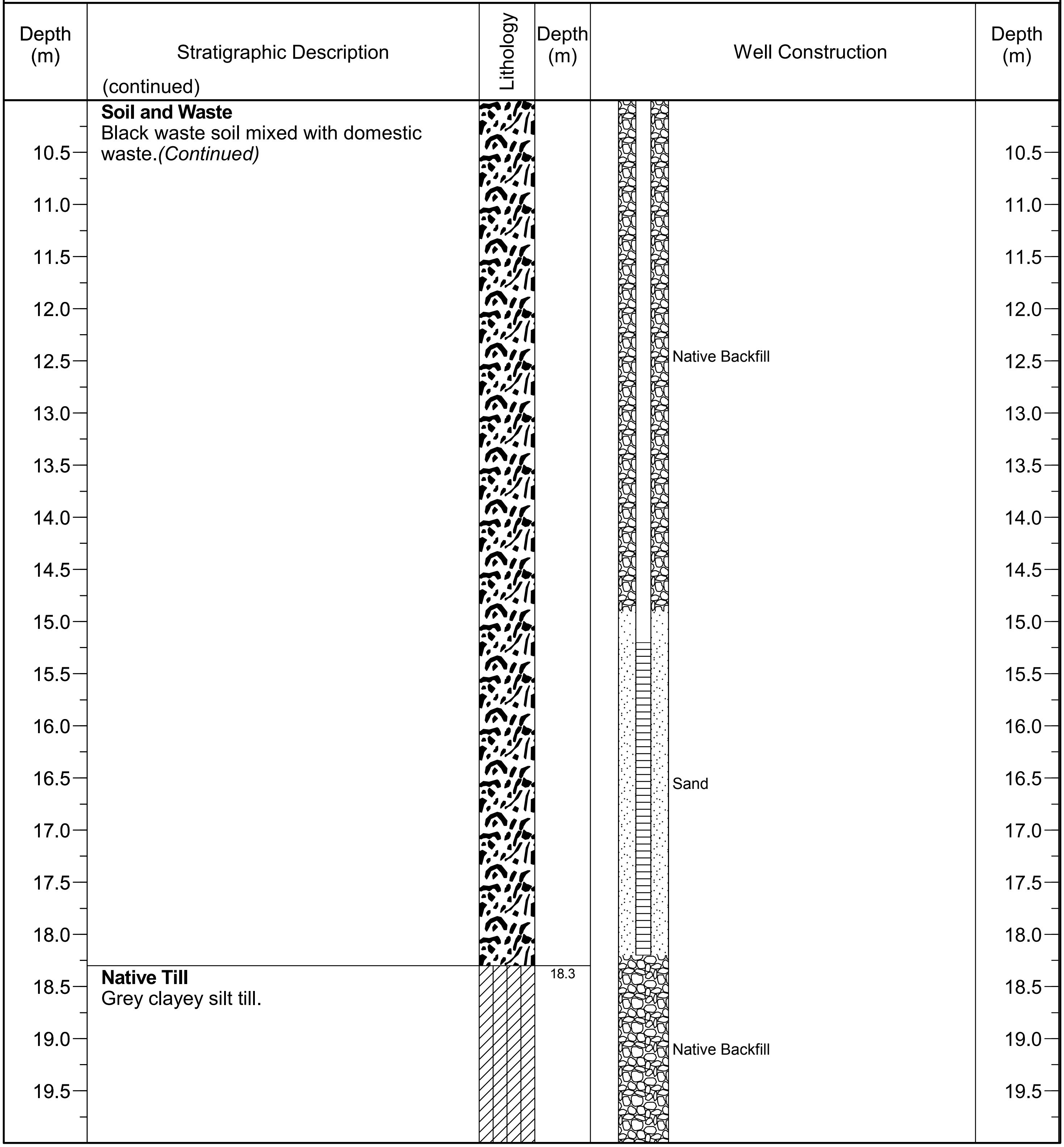
Depth (m)	Stratigraphic Description	Depth (m)	Well Construction	Depth (m)
	Soil Cover		Cement	
0.5	**Soil and Waste** Black waste soil mixed with domestic waste.	0.3	Bentonite	0.5
1.0				1.0
1.5				1.5
2.0				2.0
2.5				2.5
3.0				3.0
3.5				3.5
4.0				4.0
4.5				4.5
5.0				5.0
5.5			Native Backfill	5.5
6.0				6.0
6.5				6.5
7.0				7.0
7.5				7.5
8.0				8.0
8.5				8.5
9.0				9.0
9.5				9.5

LITHOLOGY SYMBOLS
▨ Organics
▨ Clayey Silt
▨ Misc. Debris

SAMPLE TYPE

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: J.Sikorski

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/25/17 Date Completed: 1/26/17



(continued)

Soil and Waste
Black waste soil mixed with domestic waste.*(Continued)*

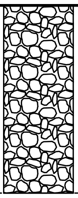
Native Till
Grey clayey silt till.

LITHOLOGY SYMBOLS
▨ Organics
▨ Clayey Silt
▨ Misc. Debris

SAMPLE TYPE

Client: Progressive
Project: Ridge Landfill Expansion
Project No.: 152456
Location: Blenheim ON
Drilling Co.: Direct Environmental
Drilling Method: Auger
Supervised by: J.Sikorski
Date Started: 1/25/17
Date Completed: 1/26/17

Depth (m)	Stratigraphic Description (continued)	Lithology	Depth (m)	Well Construction	Depth (m)
20.5 21.0	**Native Till** Grey clayey silt till.*(Continued)*	▨	21.3	Native Backfill	20.5 21.0



LITHOLOGY SYMBOLS
- Organics
- ▨ Clayey Silt
- Misc. Debris

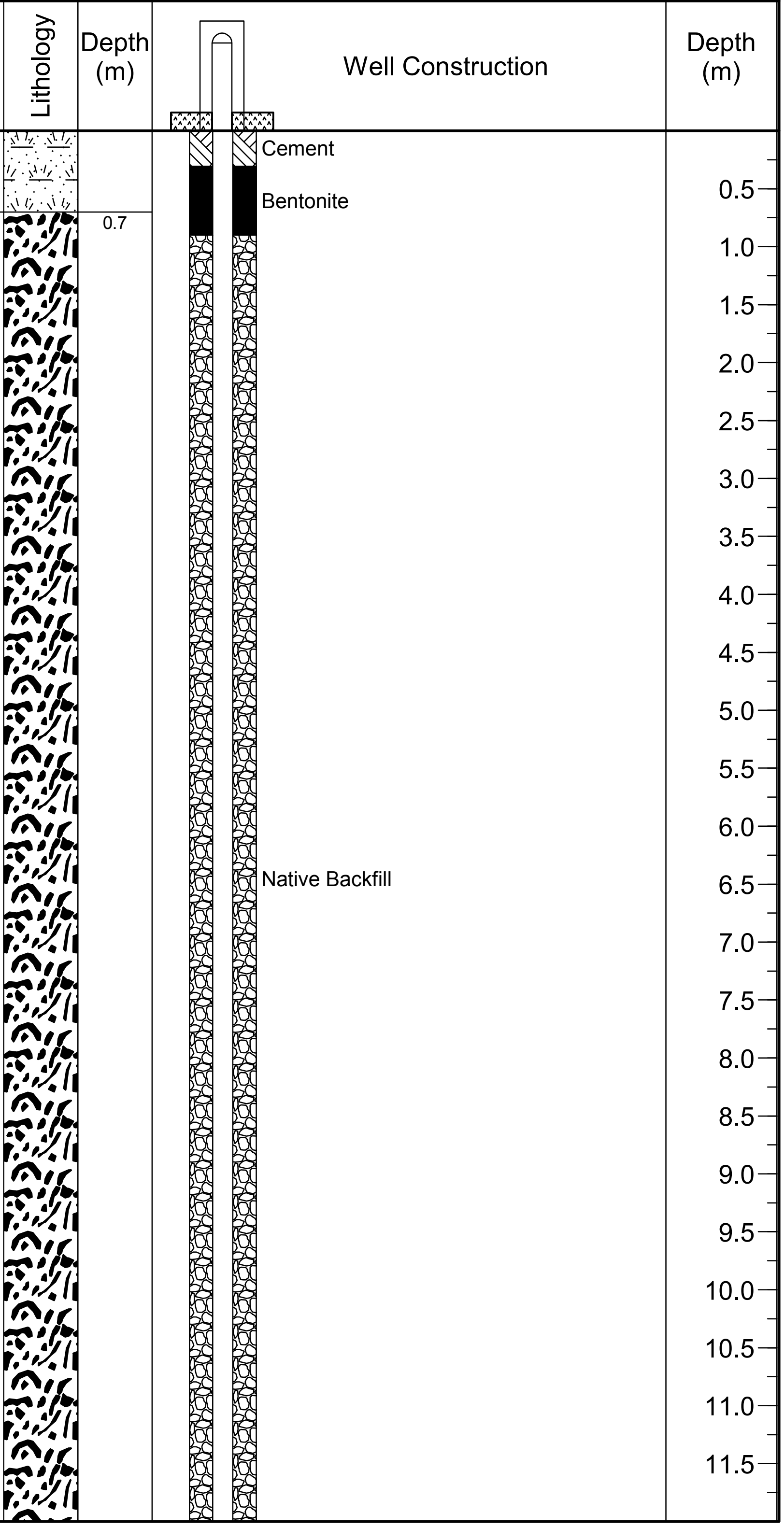
SAMPLE TYPE

M3W2

Client: Progressive
Project No.: 152456
Drilling Co.: Direct Environmental
Supervised by: M. Pardhan

Project: Ridge Landfill Expansion
Location: Blenheim ON
Drilling Method: Auger
Date Started: 1/26/17 Date Completed: 1/26/17

Depth (m)	Stratigraphic Description
0.0	**Soil Cover**
0.7	**Soil and Waste** Soil mixed with domestic, household waste.



LITHOLOGY SYMBOLS
- ▨ Organics
- ▨ Clayey Silt
- ▨ Misc. Debris

SAMPLE TYPE

Client: Progressive

Project: Ridge Landfill Expansion

Project No.: 152456

Location: Blenheim ON

Drilling Co.: Direct Environmental

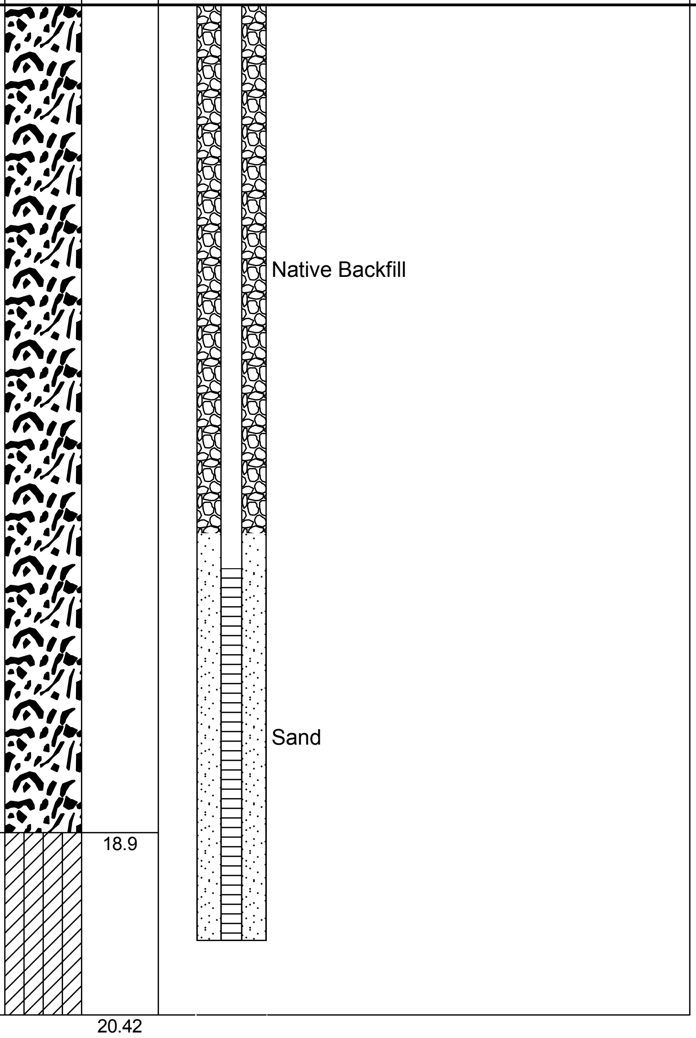
Drilling Method: Auger

Supervised by: M. Pardhan

Date Started: 1/26/17

Date Completed: 1/26/17

Depth (m)	Stratigraphic Description (continued)	Depth (m)
12.5–18.5	**Soil and Waste** Soil mixed with domestic, household waste.*(Continued)*	
19.0–20.0	**Native Till** Grey clayey silt till.	18.9
		20.42



LITHOLOGY SYMBOLS

▨ Organics

▨ Clayey Silt

▨ Misc. Debris

SAMPLE TYPE

Appendix B

Leachate Well Photographs

Photo #1: Mound 1 Hole 1 (M1W1) – 20 ft Depth - January 23, 2017

Photo #2: Mound 1 Hole 1 (M1W1) - 35 ft Depth - January 23, 2017

Photo #3: Mound 1 Hole 1 (M1W1) - 55 ft Depth - January 23, 2017

Photo #4: Mound 1 Hole 2 (M1W2) - 15ft Depth - January 23, 2017

Photo #5: Mound 1 Hole 2 (M1W2) - 45ft Depth - January 23, 2017

Photo #6: Mound 2 Hole 1 (M2W1) - 20 ft Depth - January 24, 2017

Photo #7: Mound 2 Hole 2 (M2W2) - 15ft Depth - January 24, 2017

Photo #8: Mound 2 Hole 2 (M2W2) - 35ft Depth - January 24, 2017

Photo #9: Mound 2 Hole 2 (M2W2) - 50ft Depth - January 24, 2017

Photo #10: Mound 3 Hole 1 (M3W1) - 30ft Depth - January 25, 2017

Photo #11: Mound 3 Hole 1 (M3W1) - 45 ft Depth - January 25, 2017

Appendix C

Literature Review

DILLON
CONSULTING

C.1.0 Introduction

We conducted a literature review of four Canadian and two American landfill sites that are pursuing or have completed landfill mining operations. A summary is provided for each landfill followed by a discussion on problems and mitigation measures implemented during the mining operations.

Tables C-1 and *C-2* in *Section C.8* provide a summary of key details for landfill mining operations obtained for Canadian and USA sites, respectively.

C.2.0 Trail Waste Facility Landfill (Reclamation Pilot Program)

The Trail Waste Facility Landfill (Trail Landfill) is located in Ottawa and its reclamation (mining), as a possible landfill expansion alternative, was proposed in October 1998. Landfill mining was considered because it could mitigate existing groundwater impacts (by mining the existing landfill and constructing a new lined disposal area) and provide additional landfill capacity. A pilot-scale mining project was approved and completed in 2001 to assess mining feasibility for further consideration. Specifically, the following was reviewed during the pilot test:

- State of decomposition of the waste;
- Landfill net volume gain;
- Recovered materials type, quantities and quality;
- Odour effects and management;
- Health and safety issues;
- Interaction between reclamation activities and operation of the gas extraction system;
- Leachate management required in conjunction with landfill cap removal;
- Review of the most effective methods of excavation, processing and re-landfilling; and
- Achievable rates of production and costs for landfill reclamation operations.

The landfill received domestic/residential and commercial wastes and had two capped stages and two operational stages at the time of the pilot program.

An area of 825 m² of Stage 1 of the Trail Landfill, which was in operation from May 1980 to July 1986, was chosen for the pilot program and six gas probes were installed to monitor the gas component concentration in February 2001. After removing soil cover, drainage layer, high density polyethylene geomembrane, sand bedding and subgrade material, 4440 m³ of waste (5.5 m thick) was excavated during an eight-day period in March 2001. The waste was processed using an Erin 165 finger screener during a 9-day period and the fines were used as daily cover and the rest of the waste was recompacted and relandfilled in the active working face of the landfill. The air space recovery for the pilot gained by processing and recompacting the waste was 18%.

The average existing apparent density was 580 kg/m³ (pre-mining) which increased to 650 kg/m³ after re-compaction (post-mining).

Waste characterization was performed on three 1.7 m³ representative samples from three locations and the result was as follows:

- Wood (7-13%);
- Plastics (17-22%);
- Paper (34-41%);
- Metals (6-7%);
- Glass (1%);
- Textiles (3-5%); and
- Fines (17-25%).

C.2.1 Concerns and Mitigation Measures

For this pilot work, management of leachate was not an issue due to low moisture content in the waste. Also, the weather conditions were favourable (i.e., no precipitation and low winds) during the pilot but for a full-scale operation over a long period of time, conditions would vary with the possibility of encountering saturated waste, perched leachate and unfavourable weather conditions that could result in the requirement to manage the leachate.

The decomposition of the biodegradable wastes produces landfill gas that would have associated odours and health and safety concerns during the excavation, processing, and re-landfilling of waste. Six gas probes were installed around the excavation perimeter to monitor and collect samples of landfill gas for characterization.

During the pilot project, temporary foam control agents were applied to the exposed waste surface in the excavation face and to the surfaces of the coarse and fine-screened stockpiled materials to control odours. Odour complaints associated with the mining pilot program were received from area residents from a distance up to 2.8 km from the pilot activities. Under full scale mining operations, odour emissions would vary by season and would require a more comprehensive and robust odour control plan.

In terms of health and safety, a minor fire developed under the screening unit's muffler which was extinguished using on-site hand held extinguishers. During the excavated waste characterization, five used hypodermic needles were encountered in one of the samples. The sorter was wearing hand protection, which prevented any injury.

The mining full-scale option was not chosen during the Trail Landfill expansion EA process as the selected preferred alternative did not include a mining component.

For additional details refer to *Table C-1* on *Section C.8*.

C.3.0 Sault Ste. Marie Municipal Landfill

The Sault Ste. Marie Municipal Landfill has an approved waste footprint of 44.6 ha and a disposal capacity of 2,260,000 m³ for waste and daily/intermediate cover.

The City is undergoing an EA where the preferred alternative is to expand the existing landfill to increase the site capacity to 6,460,000 m³ for disposal of solid residential, IC&I, construction and demolition (C&D) wastes and biosolids, assuming an apparent density of 0.56 t/m³. The proposed expansion alternative includes landfill mining as a component (i.e., excavate the existing waste and cover material, recover large size recyclable materials like tires, long metal rebars, concrete and boulders, earthen material or “fines” and return the residual waste to a lined cell).

The existing landfill has no liner and only a perimeter leachate control system and is located in gravel and sandy soils (i.e. highly permeable base). The site also has a soil deficit. The main driver behind landfill mining for the proposed expansion is to improve the groundwater conditions of the existing waste footprint with the installation of a liner. The secondary driver for mining is to recover fines to be used as daily/intermediate cover to offset the site soil deficit.

An area of approximately 3.4 ha is proposed to be mined and assuming an excavation of 320,000 m³ of waste and cover materials and 50% recovery, this will generate a disposal capacity of 160,000 m³ for waste and daily/intermediate cover.

C.3.1 Concerns and Mitigation Measures

As proposed in the Design and Operations Report, a site-specific health and safety plan should be prepared before mining operation and it should address:

- Physical, chemical and biological hazards such as gases (methane, hydrogen sulphide), sharps, wastewater biosolids, asbestos;
- Equipment traffic, and procedures to operate heavy equipment, processing equipment and tools; and
- Air quality, dust monitoring, airborne contaminant management, personal protective equipment (PPE), decontamination procedures and emergency procedures as well as procedures to manage anticipated or confirmed hazardous materials (e.g., asbestos).

A site specific preliminary odour management plan (OMP) was prepared as part of the EA. The OMP includes operational and administrative controls to mitigate odour emissions.

The proposed operational odour control measures for waste mining include:

- Minimize the area of active excavation to one day production whenever possible and cover with soil as soon as possible;

- Increase the slope of excavation considering the slope stability since a steeper slope will expose less waste and minimize odours (the slopes of exposed waste are expected to be between 4V:1H and 2H:1V);
- By-pass screening of waste where highly odourous waste (e.g., new waste) may be excavated;
- Avoid mining in known or suspected areas that may have perched leachate since perched leachate could cause odour emissions. Leachate or leachate impacted water should be drained or pumped as soon as possible to allow mining;
- Manage operations based on meteorological conditions to mitigate odour impacts. For example, avoidance of mining on hot days or when winds are blowing in the direction of residences and if possible conduct waste mining during wet days and/or colder months; and
- Use chemical and/or biological treatment to mitigate odour emissions.

The proposed administrative odour control measures for waste mining include:

- Training employees in the operational controls and related Standard Operating Procedures (SOPs);
- Selecting a contractor with adequate experience in waste mining projects and odour management;
- Incorporating requirements to strictly comply with the SOPs monitoring program; and
- Completing daily inspections of the active waste mining area(s) to document Site conditions, adherence to the control measures and SOPs, and potential odour impacts.

Another issue that needs to be addressed is dust and airborne contaminant management. Mining operations have the potential to generate dust during dry periods. Dust can be generated by typical mining operations such as cover stripping, waste and soil excavation, screening and heavy equipment and truck traffic. Dust is a concern because it may reduce visibility, generate airborne contaminants and potentially may become a nuisance to off-site receptors if not controlled at the source. A dust and airborne contaminant management plan should be prepared and implemented by the mining contractor and approved by the City and the contract administrator retained by the City.

For additional details refer to *Table C-1* on *Section C.8*.

C.4.0 City of Barrie Landfill

In 2008, the City of Barrie started a landfill mining program as part of the remedial plan to address groundwater impacts in a high permeable (i.e. sandy) soils base. The re-engineering plan consisted of three phases during which about 60% of the landfill was reclaimed and lined. The reclamation project extended the landfill life by 18 years from 2017 to 2035.

A pilot reclamation program was performed in 2008 to test the approach and the full scale reclamation started in the winter of 2009 and was completed in December, 2015. About 1.6 million m^3 of waste was excavated at the rate of 1,000 m³/day. Prior to reclamation, the remaining airspace was approximately 850,000 m^3 and it increased to 1,144,550 m^3 at the end of reclamation in 2015 (Dewaele and Brunet, 2017). Excavated materials were about 47% overs and 53% fines and approximately 50% of volume was recovered with the landfill mining operations. The fines composition on a weight basis consisted of 74% of fine-grained sand, 15% of dry combustible consisting largely of paper, fibre and plastic (Dewaele and Brunet, 2017)

The cost to mine the landfill was $10 to $15 per m^3 excluding liner and leachate collection system.

C.4.1 Concerns and Mitigation Measures

Odour was the major concern at the Barrie Landfill. The odour generation potential was grouped in different categories by the age of waste. Generally, younger wastes (within 7 years of being landfilled) are more odourous and so this waste was typically not processed but directly relocated to the new lined cell and landfilled immediately. Wastes between 7-14 years old were identified as having potential for odour but likely to be more manageable. Waste that was over 14 years old was assumed to be more stabilized and would generate less odours. Approximately 20% of the waste was re-landfilled without screening including newer waste with high odours during the excavation and asbestos (Dewaele and Brunet, 2017).

During the summer of 2010, an average of 10 complaints per day was received from local residents. The weather was checked regularly along with wind speed and direction to determine potential impacts to neighbouring residents and to plan mining operations accordingly. When possible, the operation was performed during wet conditions or the site was wetted to minimize odours. In addition, there was no screening of waste during the summer months (i.e., waste was excavated and then landfilled in the new cell immediately). Odour assessments were completed by taking readings regularly during the active mining periods.

For odour control, masking agents (200 Gallon reservoir attached to a fan), aerosols, foam canons and misters were used. The size of the open face of the operations was kept at a minimum and was covered with recaptured fines at the end of the day. Waste screening equipment was kept clean and operable to avoid downtime and delays to support odour control efforts.

Steeper working face reduced the exposed surface area and therefore reduced odour emissions. Interim waste slopes were as steep as 2:1 and sometimes the contractor excavated the waste at 1:1 slopes.

Only large items are typically recovered during mining operations. Recovered tires were shredded and used as internal road construction materials. Large concrete rubble was crushed and the aggregate used on site. Excavated wires from the landfill were contaminated with sand and debris to the point that the wires were not marketable to third party metal processors. The presence of wires and industrial fabrics slowed down the reclamation process (Dewaele and Brunet, 2017).

The landfill received asbestos during its operational life. There were Health & Safety protocols to handle asbestos, which included using respirators and other required PPE. When asbestos had been received at the landfill, it was bagged and tagged and their locations were marked at the landfill. During mining excavations, the asbestos containing materials was segregated and landfilled in the new lined cells. Asbestos was handled only during favourable weather conditions or alternatively the asbestos area was sprayed with water to minimize the potential for airborne releases of asbestos. Asbestos handling was avoided during windy conditions.

For additional details refer to *Table C-1* on *Section C.8*.

C.5.0 Blue Mountains Landfill

The Blue Mountains Landfill is owned and operated by the Town of The Blue Mountains and is located in Blue Mountains, Ontario. The total landfill property is about 23.1 ha and the landfill footprint is about 10.1 ha. The landfill includes the former Thornbury Landfill and the active Blue Mountains Landfill (collectively referred to as Blue Mountains Landfill) and it has been used for the disposal of waste since 1976. Both landfills are located in sandy deposits, rely on natural attenuation and do not have leachate collection systems. Both landfills received solid non-hazardous domestic waste and IC&I waste from within the municipal boundaries.

The Thornbury Landfill was capped with 1 m thick clayey soil cover material in 1996. The depth of the waste at the Thornbury Landfill is about 4 to 5 meters based on field investigations and with an area of approximately 2 ha, its volume is estimated to be 100,000 m^3. The completed and partially filled portions of the Blue Mountains Landfill covers an area of about 8 ha and the thickness of the waste in the completed areas is estimated to be 6 m.

A vertical expansion combined with mining was approved in 2012 by MOECC. The main drivers for the landfill mining operations were to reduce groundwater impacts and to increase landfill capacity. The total landfill capacity of the proposed expansion was 470,000 m^3 which increases the original capacity by 100,000 m^3. The approval included the reclamation (mining) of the former Thornbury Landfill and the eastern one third of the Blue Mountains Landfill. The proposed reclamation project included 162,500 m^3 of waste excavation in two stages of equal areas (Stage 1 in 2014 and Stage 2 in 2024). Based on previous field investigations, the overs to fines ratio was anticipated to be 40% to 60%.

The first phase of the landfill mining program was completed in 2014. Approximately 49,000 m^3 of material was mined over one construction season at the Thornbury Landfill. The mining operations were relatively straightforward in this case because the waste was shallow and dry since it was buried through a trench and fill method with large amounts of native sandy soil and gravel between the waste trenches. Approximately $2.6 million was spent to mine 49,000 m^3 ($53/$m^3$) of material and to build a new cell with geomembrane/geosynthetic clay liner and leachate collection system. The cost for the landfill mining component ranged from $10 to $20 per m^3.

C.5.1 Concerns and Mitigation Measures

The Thornbury Landfill was closed in the 1970s and the eastern part of the Blue Mountains Landfill was capped in 1996 therefore the waste in the reclamation area was 20-40 years old and therefore significant odour would not be expected during the reclamation operations. However, proper operational procedures were followed to manage odour concerns. These procedures included: keeping the excavation face small and cover it as soon as possible, having an odour neutralizing foam sprayer on site for use as needed, monitoring the wind and weather conditions (temperature, precipitation, humidity, etc.) and adjusting the reclamation operation accordingly to manage potential odour impacts.

During landfill mining, oversized waste and overs were hauled, landfilled, and covered and in the case of equipment failure or emergency situations, waste was covered with a minimum of 150 mm thick layer of fines until it was properly landfilled. Temporary waste stockpiles that could not be landfilled on the same day were covered with 300 mm of fines. Exposed waste that would not be excavated immediately and be inactive for a period of time was covered with 300 mm fines. At the end of each day, active excavation face was covered with a minimum of 150 mm fines.

It was critical to control the placement of materials in the hopper of the screening plant because some materials such as metal bars, large metal items or concrete blocks can cause damage to the feeding belt or screen of the screening plant. Large sized materials were pulled out of the screening process using an excavator or backhoe to avoid damages to the screener.

During the reclamation process, appropriate temporary erosion and sediment control measures were necessary until the final grading was completed and the vegetation was established. Erosion and sedimentation controls were inspected regularly.

Although the reclamation operations were not expected to have significant noise impacts on the neighbouring residents (located 1 km minimum from the mining operations), the Town considered mitigation measures such as lowering the backup beeper sound level and installing additional temporary acoustical barriers.

A project specific health and safety plan was developed for the project addressing hazard identification, mitigative measures, safe operating procedures, air and dust monitoring, personal protective equipment, personal and equipment decontamination, and emergency procedures.

For additional details refer to Table C-1 on Section C.8.

C.6.0 Perdido Landfill

The Perdido Landfill is located in Florida, US, and is owned and operated by Escambia County Department of Solid Waste Management. The unlined area of the landfill covers approximately 18.2 ha

(45 acres) and received municipal solid waste from residential and commercial sources and non-hazardous waste from industrial waste from 1981 to 1990.

The trench and fill method was used for waste disposal and in early 1990 the unlined cells were capped with soil. A number of factors made the reclamation of the unlined cells a favourable option. Firstly, the unlined cells caused groundwater impacts at the site and benzene and vinyl chloride were encountered at elevated levels outside the property boundary. Secondly, due to leachate outbreaks (seeps) and differential settlement, the maintenance of the unlined cells had been a challenge. Thirdly, the landfill expansion into adjacent areas was limited due to site specific constraints. Lastly, the final grade of the unlined cells was at least 30 m below the permitted final grades for the adjacent lined cells and this elevation difference could be used for landfilling more wastes.

In 2006, a preliminary technical and economic feasibility assessment was performed by excavating eight test pits and screening the excavated waste as well as analysing data from 39 boreholes to estimate the depth of the waste and the final cover. It was estimated that 30% of the material in the unlined areas was final cover. The fine material, produced by screening the waste, was estimated to be 24% of the volume. The feasibility assessment results suggested that the reclamation cost was lower than the value of the recovered airspace, screening the excavated soil and using the fines as daily covers. The landfill capacity gain was mainly due to the fact that the new cells in the mining area could be developed with a much higher elevation.

A pilot program was performed in 2008 to evaluate the nature and volume of the waste as well the cost and technical feasibility of the reclamation before considering a full scale project. About 42,000 m³ of material was excavated from a 1 hectare (2.5 acre) section during the pilot period. The pilot program provided information and data that were used in the full scale program.

The full scale project was planned in two phases. Phase I was conducted from 2009 to 2011 and about 371,000 m³ of waste was excavated from a 6.8 ha (17 acre) area. The volume of the final cover soil was estimated to be 126,350 m³ (34%). The combination volume of final cover soil, reclaimed soil, and bermed soil was approximately 62% of the mined airspace.

C.6.1 Concerns and Mitigation Measures

The waste screening process slowed down the project because of frequent equipment breakdowns. In 2010, a second screener was set up to increase the screening rate; however, typically only one screen was operating at a time.

A major issue during the mining was the transport of sediments from the mined area before stabilization with vegetation. Clayey-silt sediment was transported with stormwater runoff from the reclamation area to the stormwater pond and covered the entire sand drainage layer. Silt barrier fences were used to control further impacts.

Odour was not a concern during the reclamation project as it dissipated with distance (over 2 km from the mining operations to the closest receptors) and waste was more than 20 years old.

Litter was controlled by installing litter control fences.

The reclamation cost for this project was \$11/m^3 (\$8.33 USD per m^3) of airspace. This relative low unit cost is due to the fact that the new lined cell was filled at the mining site with a much higher elevation, i.e. the unit cost was spread across all capacity. Therefore, this cost is not representative of a typical landfill mining project.

For additional details refer to Table C-2 on Section C.8.

7.0 Ocean County Landfill Corporation (OCLC) Site

The Ocean County Landfill Corporation (OCLC) Site is a privately owned and operated sanitary landfill in Manchester Township, New Jersey. The landfill is constructed above sandy soil and the water table is just below the landfill base. The OCLC property has approximately 280 hectares (700 acres) and it serves 33 municipalities including the Ocean County. It receives 453,000 tonnes (500,000 tons) of waste per year and its remaining capacity is expected to last for 25 years (from December 2015).

Landfill mining was proposed for this landfill as an expansion option since vertical expansion of the landfill was challenging due to height restrictions imposed by the New Jersey Department of Environmental Protection (NJDEP). Lateral expansion would not be a feasible option due to surrounding neighbourhoods and wetlands. Also, the site had a soil deficit and there was history of high amounts of recyclables being landfilled. Soils and fines were recovered and used for daily/intermediate cover.

An extensive test pit program was conducted in July 2007 to assess waste characterization, delineation of limits and also to measure Biochemical Methane Potential (BMP) and hydrogen sulfide exposure. The test pit was also used to conduct visual observation regarding waste decomposition, odour, moisture, and perched conditions. BMP testing showed that the waste was largely decomposed. No perched leachate was encountered during the test pit program and it was observed that a large amount of soil had been used as daily cover during the waste placement. The cover soils above and below the liner were also thicker than expected, which made the mining operations more attractive because the landfill needed soils for future operations.

The landfill received approval to mine 3.06 million m^3 (4 million yd^3) of waste over an area of 27.5 ha (68 acres), including a pilot test. Excavating this amount of waste, screening, re-compacting the covers, and using the fines as daily cover would add an additional 0.96 million m3 (1.25 million yd3) of landfill capacity, which equals 31% of additional capacity and expand the operating life of the landfill by 1.5 years.

Landfill mining was planned in 3 phases over a 15-year period. For Phase 1, it was planned to excavate and screen 1.15 million m^3 (1.5 million yd^3) of waste. The mining started in September 2014 and 150,000 m^3 (200,000 yd^3) waste was mined in the first year.

The mining cost was estimated at $24 per m^3 ($13.69 USD per yd^3) excluding liner and leachate collection system.

C.7.1 Concerns and Mitigation Measures

The concerns for this particular site were relatively moderate. To mitigate various concerns and adjust the operations, a pilot test and various test pits were completed.

To mitigate odours, a stationary odour misting system was installed on poles and the mining operations was planned to take place downstream of the landfill gas collection system when possible.

To mitigate health and safety concerns, hydrogen sulphide masks were used when needed and a general rule was adopted to never allow anyone to approach the trommel while in operation; if the trommel needed to be checked or maintained, it should first be shut down.

For additional details refer to *Table C-2* on *Section C.8*.

C.8.0 Summary of Additional Landfill Mining Information

Tables C-1 and *C-2* below provide a summary of key details for landfill mining operations for Canadian and USA sites.

Table C-1: Landfill Mining Summary for Canadian Sites

Name of the Landfill	Trail Landfill	Sault Ste. Marie Municipal Landfill	City of Barrie Landfill	Blue Mountains Landfill
Location	· Ottawa, ON	· Sault Ste. Marie, ON	· Barrie, ON	· Blue Mountains, ON
Filling History	· Stage 1 (before expansion approval): filling from May 1980 until July 1986	· Opened in the 1960s	· Opened in the 1960s	· Opened in 1976. The Thornbury site closed in 1994.
Current Phase of the Project	· Below information is from pilot phase in 2001. · Current status: EA approved June 1, 2005. Mining was not a component of the preferred alternative	· EA under approval. The Terms of Reference were approved. · The environmental impact assessment reports have been submitted to MOECC	· Completed (60% of the existing landfill was reclaimed and lined)	· Stage 1 completed, Stage 2 planned for the future
Mining Timeline	· Pilot: Feb 2001 (gas probe well installation). Excavation: March 6 to 15, 2001. Refuse processing: March 6 - 16, 2001 · Pilot: 8 days for excavation and hauling; 16 days for screening and processing of material · Full Scale (all Stage 1, 2 and east side of 3): Excavation and processing wouldl take approximately 10 years	· Mining will start after the EA is approved by MOECC · 3 years estimated	· 6 years for pilot and 3 phases · 2008 pilot program · Phase 1 completed in 2009 · Phase 2 completed in 2013 · Phase 3 from March 2013 to December 2015	· Stage 1: mining in 2014 and construction of lined cell in 2015 · Stage 2: planned to start in 2024 · Taking in account downtime, equipment breakdown, and weather condition etc., each stage should take between 9 months to a year to finish. Timeline assumes using screening equipment to handle approximately 500 m3/day over a 5 day working week with 8 hours per day
General Site Information	· Total site area: 200 ha with 85.2 ha footprint · Total approval capacity of 16,998,442 m^3 · Fill rate: 563,300 tonnes/year	· Existing fill Area: 25.8 ha · Proposed expansion fill area addition: 17.8 ha · Max fill rate: 78,500 tonnes/year	· Total site area of 121.3 ha with 18.6 ha footprint Approved capacity of 3,924,750 m^3 · Existing fill area: 18.6 ha Max fill rate: 81,000 tonnes/year	· Total site area of 23.1 ha with 10.1 ha waste footprint · 370,000 m^3 disposal capacity with approximately 52,000 m^3 remaining (as of 2012) · Site receives on average 4,330 tonnes of waste/year
Waste Type	· Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids	· Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids	· Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids	· Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids
Mining Area and Volumes	· Pilot: 825 m^2 surface area (4440 m^3 of refuse excavated)	· Proposed Mining Area: 3.4 ha · 320,000 m^3 to be excavated, of which 160,000 m3 will likely be recovered	· Excavated 1,620,000 m^3 (44% of the total licensed landfill volume) between 2009 and 2015 · Production rate: approximately 1000 m^3/day of material screening	· Total of 162,500 m^3 waste planned to be mined over 2 stages (81,250 m^3 each stage) · The volume of waste mined was actually 49,000 m^3 and the rest was relocated or not mined · Assumed production rate: approximately 500 m^3/day of material screening over 5 days a week,

Name of the Landfill	Trail Landfill	Sault Ste. Marie Municipal Landfill	City of Barrie Landfill	Blue Mountains Landfill
				8 hours/day
Recovery Rate (%)	Pilot:18.2% airspace recovery Overall: Approx. 13% estimated	50% (estimated)	50%	
Mining Depth (m)	8.5 m	10 m	20 m	Up to 2.5 m
Types of Waste Recovered	79% of the overall recovered volume was recyclable content: Wood (7-13%) Plastics (17-22%) Paper (34-41%) Metals (6-7%) Glass (1%) Textiles (3-5%) Fines (17-25%)	Recovery of large size recyclable materials such as tires, long metal rebars, concrete rubble and boulders. Fines material to be used as daily cover	Recovery of large size recyclable materials such as tires, long metal rebars, concrete and boulders Fines (approx. 875,000 m^3), tires (approx. 3 million tires recovered which were then ground up and used internally for internal road base)	Recovery of large size recyclable materials (white goods, tires, long metal rebars, concrete rubble and boulders) represented 40% recovery of fine materials represented 60% of overall recovered materials
Waste Apparent Density	Existing (pre-mining): 582.9 kg/m^3 Re-compacted (post-mining): 646 kg/m^3	0.56 t/m^3	650-750 kg/m^3 The apparent density of the re-compacted oversize fraction was 1,280 kg/m^3	Historical range from 275 to 432 kg/m^3
Equipment Used/Proposed	CAT 330 tracked Hydraulic shovel Volvo articulated trucks Erin 165 finger screener CAT 826C (35 tonne) landfill compactor CAT 330 excavator CAT 320 c/w Grapple CAT 980C rubber Tire Loader Application odour suppressant	1 Dozer Cat D7 2 Excavators fitted with hydraulic "thumbs" 2 Trommel screen(s) Loader 2 Articulated trucks Cat 735 Top loading trucks to haul waste 1 Hydraulic stacker (stacking conveyor) Water truck for dust control Odour misting system 1 Grinder	2 Dozer D6 2 Excavators 2 McClosky MCB 733 2 Trommel screens 1 50-ft stacker for the fines 4 articulated haul trucks 1 Cat 826 compactor Odour misting system	Dozers Excavators with thumb Trommel screens Rubber tire loader Articulated trucks Top loading waste hauling vehicles Conveyors/stackers Water truck/tank for dust control/suppression Odour suppressant foam sprayer Odour neutralizing misting systems
Cost	$35/$m^3$ estimated for the full-scale mining project excluding liner and leachate collection system	Not available (proposed mining is under approval)	$10 to $15 per m^3 excluding the liner and leachate collection system	$10 to $20 per m^3 excluding the liner and leachate collection system
References	J.L. Richards & Associates Ltd. (2001) https://www.ontario.ca/environment-and-energy/large-landfill-site-details?site=A461303 https://www.ontario.ca/page/trail-waste-facility-landfill-optimization-project	Dillon (2017a) Feb 2016 Open Public House Displays: http://saultstemarie.ca/Cityweb/media/PWT/Public%20Works/SolidWasteEAFeb9Displays.pdf	Dillon (2011) Dillon (2013a) Dillon (2013b) Dillon (2014) Dillon (2017c) https://www.ontario.ca/environment-and-energy/large-landfill-site-details?site=A250101 http://www.barrie.ca/Living/GarbageAndRecycling/Pages/LandfillProject.aspx	Golder (2014) Dillon (2017d)

Table C-2: Landfill Mining Summary for American Landfills

Name of the Landfill	Perdido Landfill	Ocean County Landfill Corporation Site
Location	· Cantonment, Florida	· Manchester, New Jersey
Site History	· Operational from 1981 to 1990 · In early 1990 the unlined cells were capped with soil	
Mining Timeline	· In 2006, a preliminary technical and economic feasibility assessment was performed · A pilot program was performed in 2008 · Phase 1 of the full scale project was conducted from 2009 to 2011	· Started in Sept 2014 · 3 phases over a 15 year period
General Site Information	· The unlined area of the landfill covers approximately 18.2 ha (45 acres)	· Site area: 280 Ha (700 acres) · Waste footprint: 120 Ha (300 acres) · Sandy soil with water table below the landfill base. · Approx. 500,000 tonnes of solid waste disposed on annual basis at $80 USD per ton
Waste Type	· Received municipal solid waste from residential and commercial sources and non-hazardous waste from industrial sources	· Serves 33 municipalities comprising the Ocean County
Mining Area and Volumes	· For the pilot project about 42,000 m^3 material was excavated from a 1-ha section · For the Phase 1, 371,000 m^3 waste was excavated from 6.8 ha area	· Received approval to mine 3.06 million m^3 (4 million yd^3) · Excavated 150,000 m^3 (200,000 yd^3) of material in the first year · Mining started in September 2014 and still ongoing
Recovery Rate (%)	· 62%	· Varied on a daily basis from 30% to 70%
Type(s) of Waste Recovered	· Mostly fines, including soils	· Recovery of large size recyclable materials such as tires, long metal rebars, concrete and boulders · Fines used as daily cover · Drums with chemicals or any concerning materials were not found · Asbestos outside the dedicated area were not found
Equipment Used	· Four Excavators · One dozer · Two Trommel screens · Six articulated dump trucks	· Excavator · Trommel screen(s) · 1 front end loader · Truck(s) to haul waste · 4 John Deere rock trucks
Cost	· $11 per m^3 ($8.33 USD per m^3) · Note that this cost is not representative of a typical mining project as explained above	· $24 per m^3 ($13.69 USD per yd^3) excluding liner and leachate collection system
Source	· Jain et al. (2013)	· Cornestone Environmental (2014) · Dillon (2015) · Ocean County Landfill Corporation (2015) · Dillon (2017b)