PROJECT N°: P24-13
Client: Mid-Huron Landfill Site Board

EVAPLANT TECHNOLOGY FOR THE VOLUME REDUCTION OF LEACHATE AT MID-HURON LANDFILL

TECHNICAL AND REGULATORY FEASIBILITY STUDY (PHASE 1)

VERSION: Rev B

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ramo

Signatures

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Revision Table

Version	Publication date	State	Modifications since previous version
Rev A	2025-05-22	For comments	Initial publication
Rev B	2025-07-23	For comments	First revision

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List of Abbreviations and Acronyms

BOD	Biological Oxygen Demand
°C	Degree Celsius
CAPEX	Capital Expense
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
ECA	Environmental Compliance Approval
EPA	Environmental Protection Act
ha	Hectare
kg	Kilogram
km	Kilometre
L	Litre
LTF	Leachate Transfer Facility
cm	Centimetre
m	Metre
mg	Milligram
MECP	Ministry of the Environment, Conservation and Parks
MH	Manhole
MHLSB	Mid-Huron Landfill Site Board
mm	Millimetre
mS	milliSiemens
OPEX	Operating Expense
ppm	Parts per million
RCW	Ramial Chipped Wood
RDA	Relocated Disposal Area
SAR	Sodium Adsorption Ratio
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids

1. Introduction

1.1. Context

The Mid-Huron Landfill Site (the "Site"), located at 37506A Huron Road in Clinton, Ontario, is managed by the Mid-Huron Landfill Site Board (MHLSB), which is jointly governed by six municipalities: the Town of Goderich, Township of Huron-Kinloss, Municipality of Central Huron, Municipality of Bluewater, Municipality of Huron East, and Township of Ashfield-Colborne-Wawanosh. The Site is regulated under Environmental Compliance Approval (ECA) No. A161302, issued on December 24, 1990, as amended April 14, 2015. Under the terms of the current ECA, the Site is authorized to receive domestic, commercial, and non-hazardous solid waste, along with Municipal Hazardous and Special Waste, electronic waste, and select industrial byproducts such as food processing waste and sewage sludge. After reaching its full capacity, the landfill closed and stopped accepting waste in June 2018. Final cover was placed over the disposal area, and the Site was converted into a waste transfer station, now called the Mid-Huron Recycling Centre. The six municipalities are responsible for the long-term closure and post-closure care of the Site over a 50-year period, extending through to 2068.

The MHLSB is actively seeking long-term, cost-effective solutions to reduce leachate volumes and associated trucking fees at the Mid-Huron Landfill. Currently, all leachate is managed by pumping it into tanker trucks and transporting to the Parsons Court Leachate Transfer Facility (LTF) in Goderich. This report aims to assess the feasibility of implementing Evaplant technology (also referred to as the "Evaplant system") for onsite leachate management at the Mid-Huron Landfill.

The Evaplant technology consists of a dense plantation of fast-growing willows equipped with a precision irrigation system specifically designed for wastewater application (see Figure 1). Willows (genus *Salix*) are a diverse group of tree and shrub species known for their high biomass yield and ability to thrive in wet or disturbed environments. These characteristics make them especially well-suited for applications such as phytoremediation and engineered systems like Evaplant. The Evaplant technology achieves a combination of high-rate evapotranspiration, combined with constituent degradation/utilization in the soil-plant system and immobilization through soil adsorption and plant tissue absorption. The process results in a zero-discharge system which grows a biomass product while retaining all constituents of concern within the plantation's boundaries. This patented zero-discharge technology allows the willows to maximize evapotranspiration while maintaining conditions necessary for the degradation, transformation, and/or confinement of contaminants present in the irrigated water. Wastewater irrigation on the plantation uses a control loop that allows irrigation only in optimized soil conditions. This technology limits the risk of runoff outside the planted area or percolation below the willows' root system.

The Evaplant technology, provided as a turnkey solution, includes a pumping station, a control station composed of the patented irrigation control system as well as a specialized irrigation system, a telemetry system for remote management, a tracking and reporting software, and a fast-growing willow plantation.

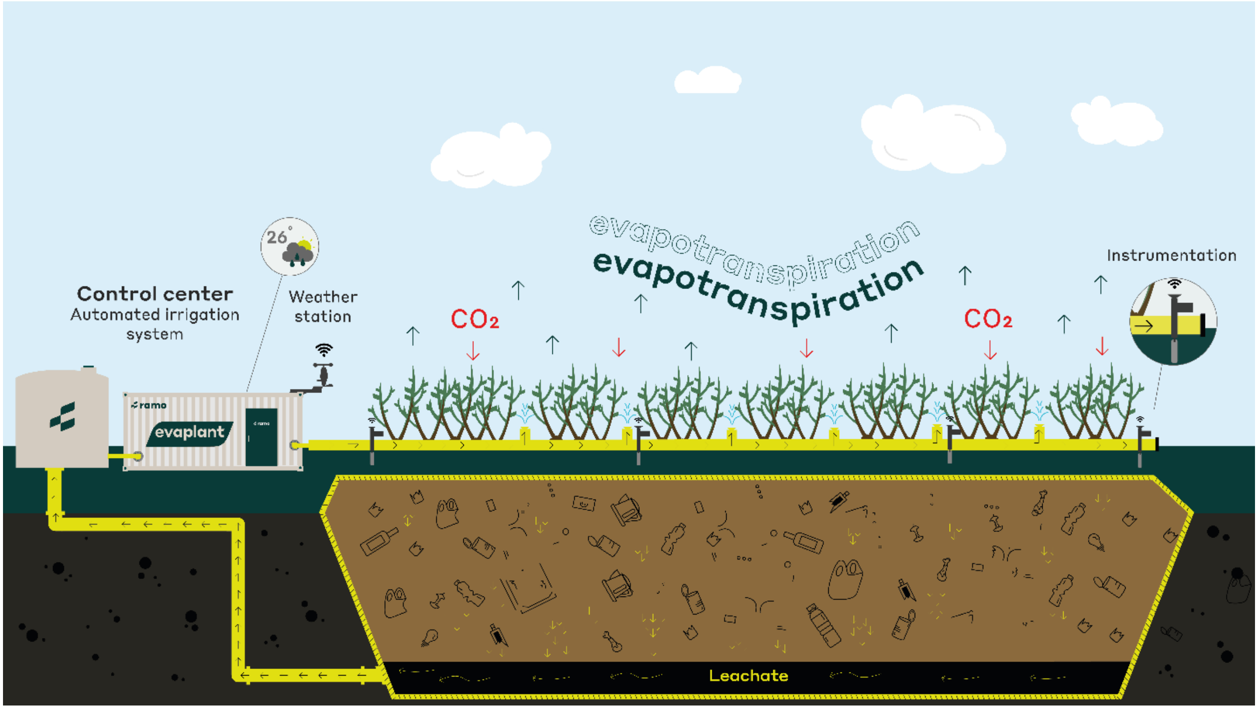

Figure 1. Illustration of Ramo's Evaplant technology

Ramo currently operates four Evaplant systems on landfill sites located in the province of Quebec, managing raw leachate mostly coming from first generation landfills and partially treated leachate coming from second generation landfills. Figure 2 shows an example of a 1.2-hectare Evaplant System built by Ramo in 2018 on a Quebec landfill site. This system was established directly on a first-generation closed landfill cell.

Figure 2. Example of 1.2-ha Evaplant system built by Ramo in 2018 on a Quebec landfill site (picture taken in 2023).

1.2.Objectives

This study aims to evaluate the technical and regulatory feasibility of implementing the Evaplant technology at the Mid-Huron Landfill to provide an onsite leachate management solution. The specific objectives are listed below:

- Technical assessment initialization:
    - Review of current approvals (ECA) regarding final vegetation cover.
    - Review of provincial legislation (final vegetation cover).
    - Review of site technical documentation (gap analysis).
- Analysis of technical documentation and technical feasibility:
    - Analysis of leachate characterization provided by the Client (one source).
    - Analysis of leachate seasonal variations provided by the Client (one source).
    - Potential plantation sites analysis (soil quality, composition, topography, obstacles, vegetation, access for machinery, etc.).
    - Research and selection of willow species to plant according to the site conditions.
    - Evapotranspiration estimation according to the Site conditions.
    - Preliminary process design and specifications (m^3/ha/season).

1.3. List of Consulted Documents

The analysis of available documentation conducted within the scope of this study aimed to gather the information needed to achieve its objectives. The documents consulted as part of this work, along with their sources, are presented in Table 1.

Table 1. Documents consulted for the study.

Document	Description	Source
2023 Annual Monitoring Report	GHD Limited, 2024	Provided by the MHLSB
2022 Annual Monitoring Report	GHD Limited, 2023	Provided by the MHLSB
2021 Annual Monitoring Report	GHD Limited, 2022	Provided by the MHLSB
2020 Annual Monitoring Report	GHD Limited, 2021	Provided by the MHLSB
2019 Annual Monitoring Report	GHD Limited, 2020	Provided by the MHLSB
2023 Annual Performance Report	GHD Limited, 2024	Provided by the MHLSB
2022 Annual Performance Report	GHD Limited, 2023	Provided by the MHLSB
2021 Annual Performance Report	GHD Limited, 2022	Provided by the MHLSB
2020 Annual Performance Report	GHD Limited, 2021	Provided by the MHLSB
2019 Annual Performance Report	GHD Limited, 2020	Provided by the MHLSB
Landfill Closure Plan Mid-Huron Landfill Site	Conestoga-Rovers & Associates, 2007	Provided by the MHLSB
Leachate Chemistry 2019-2024	XLSX	Provided by the MHLSB
Ontario Water Resources Act, R.S.O 1990, c. O.40	Government of Ontario, 1990	Online
R.R.O. 1990, Reg. 347: General - Waste Management	Government of Ontario, 1990	Online
Environmental Protection Act, R.S.O. 1990, c. E.19	Government of Ontario, 1990	Online

1.4. Site Description

The Mid-Huron Landfill Site encompasses a total area of 42.41 hectares, of which 11.39 hectares have been approved for waste disposal. The Site's development has occurred in phases over time. Initial disposal activities occurred in the Pre-1991 Disposal Area between 1970 and 1990. Subsequent development was carried out in the Relocated Disposal Area (RDA), also known as the Post-1991 Disposal Area, starting with Phase I Stage I in 1990. This was followed by Phase II Stage I in 1991, Phase I Stage II in 1993, Phase II Stage II in 1995, Stage III in 2000, and the Final Stage in 2009, which remained active until landfill operations ceased on June 30, 2018. The Site now functions as a waste transfer station and recycling facility. The Mid Huron Recycling Centre Board manages ongoing diversion programs for materials such as Municipal Hazardous and Special Waste, electronic waste, refrigerators, tires, and metal at the Site. Existing infrastructure includes an office building and a scale house, located beside the main entrance in the southernmost area of the property. There is a leachate collection system which consists of perimeter and lateral drains that direct flow to a holding tank for off-site treatment. Gas monitoring infrastructure is also in place to detect and manage potential landfill gas emissions.

2. Regulatory Review

2.1. Current Approval

The Mid-Huron Landfill Site operations are governed by ECA No. A161302, issued on December 24, 1990, as amended. It authorizes the establishment, operation, and closure of the landfill, including ongoing environmental monitoring and post-closure care. In addition, the associated LTF, which manages the temporary storage and discharge of leachate to the municipal sanitary sewer system, is regulated under ECA No. 6867-AK8L9F, issued on March 7, 2017. This approval outlines the design and operational requirements for the LTF, including features such as a 100 m^3 concrete holding tank, a dual-pump system, and flow control infrastructure. Together, these ECAs establish the framework for leachate management at the Site.

Leachate must be collected, stored in a designated tank, and discharged to the Goderich sanitary sewer system where it ultimately flows to the Goderich Wastewater Treatment Plant for treatment. Any deviation from this process, such as land application with an Evaplant system, would require formal Ministry of the Environment, Conservation and Parks (MECP) approval as a modification to the existing ECA. Section 3.6 and 4.3 of the Landfill Closure Plan for Mid-Huron Landfill Site explicitly mandates the continued use of off-site leachate transport and disposal, reinforcing the need for a formal amendment to allow any alternative system (Conestoga-Rovers & Associates, 2007). Section 4.1 of the Landfill Closure Plan also establishes seeding a grass mixture is required for final cover, which would need to be removed in order to establish a willow plantation.

2.2. Applicable Legislation

A review was undertaken to assess the regulatory framework applicable to the current project, specifically regarding landfill management in Ontario. This is governed by both provincial and municipal legislation, with the *Environmental Protection Act* (EPA) serving as the primary statute for environmental protection. Under the EPA, the MECP is authorized to develop regulations and guidelines for the operation of landfill sites, including leachate collection, treatment, and discharge. More specifically, the Revised Regulations of Ontario (R.R.O.) 1990, Regulation 347: General – Waste Management, and Ontario Regulation 232/98:

Landfilling Sites, both established under the EPA, are particularly relevant, as they govern the management and operation of landfill sites. The Ontario Water Resources Act (R.S.O. 1990, c. O.40) is also applicable, particularly in relation to water quality and sewage works.

Regulation 347: General – Waste Management sets out the requirements for the classification, handling, transportation, storage, and disposal of waste in Ontario. It includes sections relevant to leachate management, particularly:

- Schedule 4 – Leachate Quality Criteria: Sets out hazardous leachate concentration limits for various contaminants.

Regulation 232/98 outlines requirements for design, operation, closure, and post-closure care of municipal waste landfilling sites. While the regulation does not explicitly address the management of leachate through evapotranspiration within a landfill cell, several sections are pertinent to leachate management and final cover during closure and post-closure phases:

- Section 11 – Leachate Disposal: Mandates that leachate management plans have been prepared.
- Section 12 – Leachate Contingency Plans: Requires the development of contingency plans to address potential leachate management issues.
- Section 29 – Final Cover: Ensures that final cover includes a vegetative cover that is suited to local conditions.
- Section 31 – Closure Report: Stipulates that a detailed closure plan for all activities is required.

These sections collectively imply that any significant changes to leachate management, such as introducing an Evaplant system, would require a formal amendment to the site's ECA. Furthermore, under the description provided in Regulation 232/98, willows meet the requirements of a vegetative cover. They are well-suited to the Ontario climate and are expected to develop a closed canopy that needs minimal care by the second year of growth. Preliminary analysis indicates that the implementation of an Evaplant system is technically feasible and aligns with the environmental goals of the site.

An Evaplant system must abide by Ontario's regulations for leachate management. To further assess regulatory expectations and confirm the feasibility of implementing the Evaplant system at the Mid-Huron Landfill, early engagement with the MECP is strongly recommended. The objective of this step is to position the Evaplant technology as a viable and sustainable leachate management solution, and to obtain clear guidance on any additional requirements that may apply to secure the necessary ECA amendment. Ramo has proven experience in supporting this type of regulatory pathway for implementing an Evaplant system and can assist in preparing the necessary technical documentation and coordinating communications with the MECP throughout the process. For informational purposes, it is worth noting that phytoremediation of leachate through irrigation on poplar plantations has already been authorized by MECP through an ECA request for a landfilling site under the same applicable legislation.

3. Analysis of Documentation and Technical Feasibility

3.1. Potential Plantation Sites Analysis

Several factors must be evaluated to identify the most appropriate area for deploying Evaplant technology at Mid-Huron Landfill. The key criteria for site selection include:

- Infrastructure presence.
- Access to plantation areas.
- Full sunlight exposure.
- Soil type.
- Reasonable gradient slope to minimize the need for earthworks:
  - Slopes 0-5°: Optimal for an Evaplant system.
  - Slopes 5-10°: Mechanical management and harvesting is possible, but irrigation may be reduced to account for runoff potential.
  - Slopes >10°: Constraints for water retention and equipment access.

Preliminary analysis identifies the optimal location for an Evaplant willow plantation as the RDA, which is underlain by an active leachate collection system. This location is preferred in part because regulatory approval is more favourable when the plantation is sited over areas with existing leachate collection infrastructure. This area received final cover in August and September of 2018, consisting of a minimum 600 mm thick layer of low-permeability compacted soil, overlain by 150 mm of topsoil and a vegetative layer. According to the Landfill Closure Plan, final vegetation cover would have been hydroseeded as a mix of tall fescue, annual rye grass, creeping red fescue, timothy, birdsfoot trefoil, white Dutch clover, and alsike clover (Conestoga-Rovers & Associates, 2007).

Phase 2 of the project will need to include a soil sampling program to characterize agronomic properties, including organic matter content. This assessment is necessary to determine whether existing substrate conditions are adequate for willow establishment or if amendments are required to support long-term system performance.

A general overview of the Site layout is presented in Figure 3 below, highlighting the proposed location for an Evaplant willow plantation. The final layout will be refined during Phase 2, based on findings from an on-site assessment. It should be noted that all existing vegetation must be removed prior to the establishment of the willow plantation.

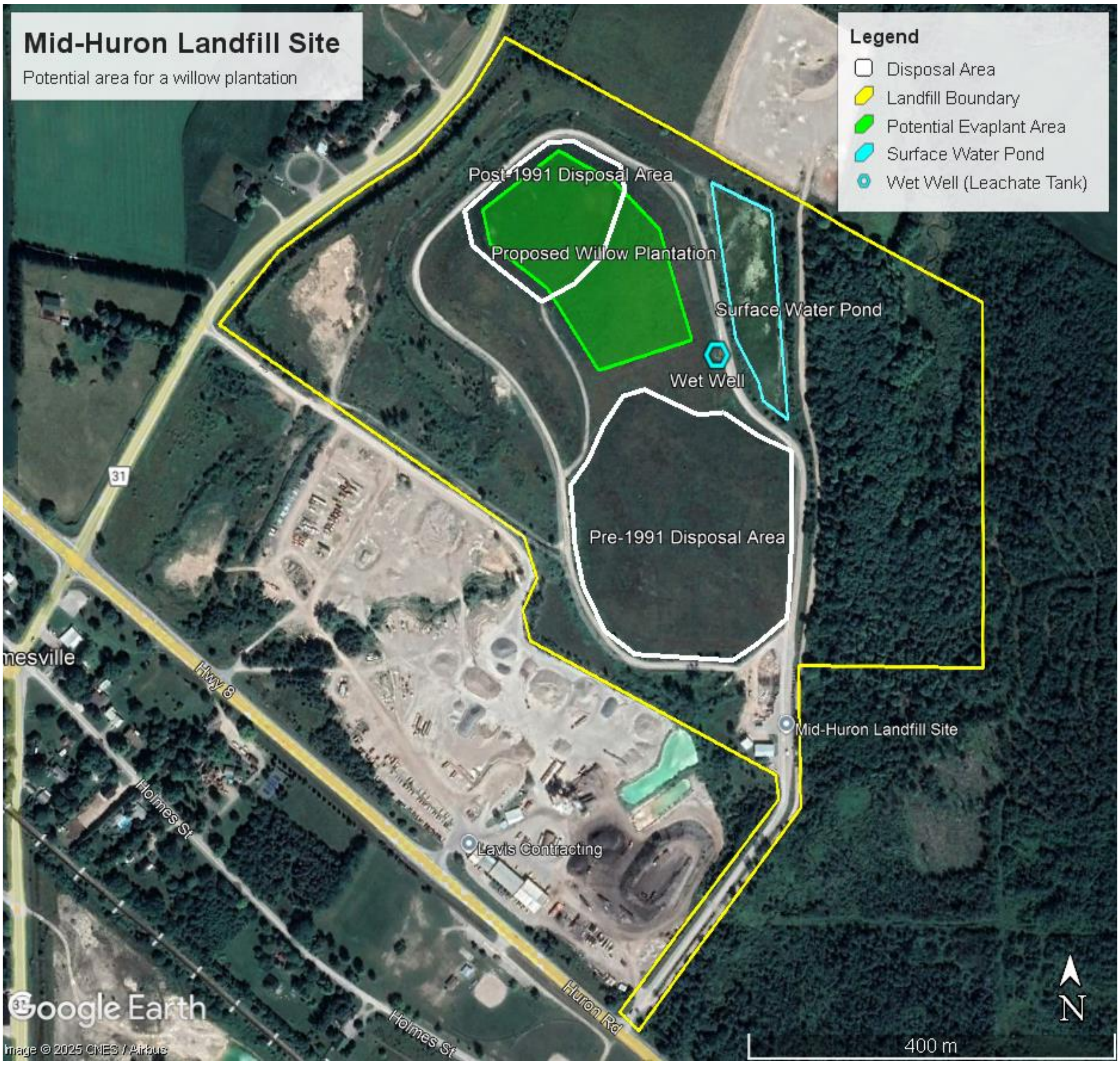

Figure 3. General layout of the Mid-Huron Landfill and the proposed plantation area (3-ha)

3.2. Selection of Willow Varieties

The region's climate can limit the efficacy of a vegetated technology. Hardiness, temperature, and precipitation conditions in the area directly impact the survival and biomass yield of plants, as well as the potential for evapotranspiration by the willows.

The selection of varieties to be planted is based on regional census data, exchanges with various experts, scientific literature, as well as a vast knowledge base and experience acquired by Ramo, which has been cultivating hundreds of hectares of willows since 2006. The parameters considered when selecting the varieties include:

- Productivity of harvestable woody above-ground biomass.
- Hardiness (cold resistance, tolerance to long winters, and sensitivity to photoperiod).
- Resilience to poor growth substrates.
- Resistance to local pests.
- Tolerance to relevant contaminants, including salts.

The suggested willow varieties for an Evaplant system at the Site are presented in Table 2 below.

Table 2. Suggested potential varieties for an Evaplant system at the Mid-Huron Landfill.

Variety	Origin
Salix 'Discolor'	Canada
Salix ‘Owasco’	USA
Salix 'Preble'	USA
Salix miyabeana ‘SX64’	Japan

It is recommended to plant multiple varieties in an Evaplant system to increase biodiversity and its overall resilience to contaminants and pests.

3.3. Analysis of Water Management Practices

Managing leachate and surface water is a key part of post-closure care at the Mid-Huron Landfill. Water monitoring is conducted twice annually and includes groundwater, surface water, leachate, and nearby private wells. The Pre-1991 Disposal Area lacks an engineered base and leachate collection system; furthermore, leachate in this area is managed through natural attenuation. In contrast, the RDA is equipped with a leachate collection system consisting of perimeter and lateral pipes beneath the waste. The RDA’s leachate infrastructure includes Manholes MH1 through MH12. Leachate flows by gravity to Manhole 11 (MH11) in the southeast corner of the RDA and into the adjacent Wet Well, a 25 m^3 underground holding tank. The Wet Well is the only leachate collection location at the Site. Leachate is pumped from the Wet Well into tanker trucks and transported to the Parsons Court LTF in Goderich, where it enters a 100 m^3 tank and is discharged into the municipal sewer system. The sewer conveys wastewater to the Goderich WWTP, which discharges treated water to Lake Huron.

Surface water is directed clockwise around the RDA and counterclockwise around the Pre-1991 Disposal Area using ditches. Surface water is directed to a pond in the northeast of the site, which allows sediment to settle before the water is discharged or infiltrates into groundwater, eventually ending up in Bridgewater Creek.

3.4. Analysis of Leachate Volume

The Mid-Huron Landfill generates an average of 9,710 m^3 of leachate per year, with daily flow rates ranging between 29 and 67 m^3/day. The annual volume of leachate collected from 2019 to 2023 is summarized in Table 3, ranging from 8,710 to 10,300 m^3 of leachate per year. This study will consider maximum yearly leachate generation to be 10,300 m^3 for Evaplant system sizing and processing capability estimations. The average annual leachate volume collected per month between 2019 and 2023 is shown in Table 4.

During the growing season (May to October), an average of 3,140 m^3 is produced annually. Leachate generation tends to be higher in winter and spring and lower in summer and fall. An average of 318 truckloads of leachate are hauled from the landfill to the LTF per year, averaging 17 loads per month.

To optimize irrigation capacity during the Evaplant operational period (the growing season), consideration of additional storage infrastructure, such as another leachate holding tank or small engineered pond, is recommended for accumulating winter leachate volumes. Additional storage may also be provided by the drainage layers within the landfill cells and the conveyance infrastructure, such as piping. The retention capacity of the leachate collection system, along with overall storage availability, will be further evaluated during detailed engineering for the Evaplant system (Phase 2).

Table 3. Total leachate trucked from Mid-Huron Landfill to the LTF (2019 to 2023).

Year	Annual leachate collection
	m^3
2019	10,000
2020	8,710
2021	10,300
2022	9,990
2023	9,570
Average	9,710

Table 4. Monthly average leachate volume hauled, number of leachate transfer days, and average daily leachate flow at the Mid-Huron Landfill (2019 to 2023).

Month	Average leachate volume	Leachate Transfer Days	Average Daily Flow
	m^3	# days/month	m^3/day
January	1,200	21	57
February	995	20	49
March	1,280	22	57
April	1,360	20	67
May	1,140	20	56
June	558	16	37
July	454	14	32
August	351	13	28
September	273	12	26
October	365	14	29
November	701	17	43
December	1,030	19	53

3.5. Evapotranspiration Estimation

The data from meteorological stations near the Site were analyzed to determine the climatic context in which the project will take place. Some seasonal climate standards of interest for estimating evapotranspiration and yield are presented in Table 5 below.

Table 5. 1991-2020 Canadian Climate Normals from Environment and Climate Change Canada for the Goderich Reference Station

Parameters	Values	Units
Canadian Climate Normals 1991-2020		
Season	May to October	--
Reference weather station	Goderich	--
Hardiness zone	6a	--
Average temperature	15.8	°C
Precipitation	495	mm
Degree Days above 5°C	1,977	Degree Days

Evapotranspiration rates and climatic data from projects carried out by Ramo in recent years were compared to the data above to estimate the potential evapotranspiration rate at the project Site. It was estimated that the net potential evapotranspiration, which is the total evapotranspiration minus the total normal precipitation during the irrigation period, is in the range of 460 to 690 mm per season (equivalent to 4,600 to 6,900 m^3/ha/season). Evapotranspiration rate calculations yield a hypothetical maximum evapotranspiration, which may be limited by leachate quality, soil characteristics, or seasonal climatic variations.

3.6. Analysis of Water Characteristics and Future Considerations

The historical data used to carry out the technical assessment of the project was provided by representatives of the Town of Goderich. The analytical values considered in this study were those collected between 2019 and 2023. Leachate from the Wet Well (leachate storage tank) was considered and evaluated in this study for irrigation purposes. Data from the LTF for 2020 to 2023 was used to estimate TSS of the Wet Well because it is not part of the normal sampling program. The values retained for feasibility assessment purposes are presented in Table 6.

Table 6. Values retained by Ramo for feasibility assessment purposes for each type of water considered

Parameter	Units	Retained values	Selection method
		Wet Well	
Number of samples analyzed	-	12	-
Alkalinity (as $CaCO_3$)	mg/L	2,580	Average
BOD_5	mg/L	42.6	Maximum
pH	-	6.96	Average
Chemical Oxygen Demand (COD)	mg/L	762	Maximum
Electrical Conductivity (EC)	mS/cm	7.02	Average
Nitrate(N) and Nitrite(N)	mg N/L	0.300	Average
Nitrogen ammonia (N-NH_4^+ and N-NH_3)	mg N/L	468	Maximum
Sulfate (SO_4^{2-})	mg/L	47.9	Average
Sodium Absorption Ratio (SAR)	-	17	Average
Total Dissolved Solids (TDS)	mg/L	3,700	Average
Total Kjeldahl Nitrogen (TKN)	mg N/L	394	Average
Total Suspended Solids (TSS)	mg/L	910*	Maximum
Nitrogen (N)	mg/L	394	Average
Arsenic (As)	mg/L	0.00540	Average
Barium (Ba)	mg/L	0.196	Average
Boron (B)	mg/L	5.33	Average
Cadmium (Cd)	mg/L	0.000166	Average
Calcium (Ca)	mg/L	192	Average
Chlorides (Cl^-)	mg/L	1,490	Average
Chromium (Cr)	mg/L	0.0337	Average
Cobalt (Co)	mg/L	0.00712	Average
Copper (Cu)	mg/L	0.0173	Average
Iron (Fe)	mg/L	6.95	Average
Lead (Pb)	mg/L	0.00334	Average
Magnesium (Mg)	mg/L	206	Average
Manganese (Mn)	mg/L	0.555	Average
Molybdenum (Mo)	mg/L	0.000800	Average
Nickel (Ni)	mg/L	0.0203	Average
Potassium (K)	mg/L	206	Average
Selenium (Se)	mg/L	0.000590	Average
Silver (Ag)	mg/L	0.0000500	Average
Sodium (Na)	mg/L	1,000	Average
Tin (Sn)	mg/L	0.00192	Average
Zinc (Zn)	mg/L	0.0330	Average

*Based on 2020-2023 data from the LTF. TSS data is not available for the Wet Well.

Maximum values from available data sets were used to assess the system's capacity to manage parameters that can have a short-term effect on the system's effectiveness (TSS, BOD_5, COD, and $N\text{-}NH_4$), while average values were used for parameters that can lead to long-term effects on the system's effectiveness (e.g. pH, electrical conductivity, SAR, and metals). The average value of alkalinity was compared to the average value of $N\text{-}NH_4$ to evaluate if its concentration is sufficient to support nitrification.

Parameter Analysis

Nitrogen, organic content, and total suspended solids

The sum of Total Kjeldahl Nitrogen (TKN) and nitrite-nitrate ($N\text{-}NO_x$) concentrations was regarded as being equal to the total nitrogen concentration. BOD_5 and $N\text{-}NH_4$ concentrations were used to assess the oxygen required for the oxidation of biodegradable organic matter and the nitrification of ammonium nitrogen. This oxygen balance indicates if the BOD_5 and $N\text{-}NH_4$ loads are limiting factors for the design of the Evaplant technology at the Site. The alkalinity present in each type of water was also used to assess if its concentration is sufficient to support nitrification of ammonium nitrogen. The capacity for nitrate absorption by willows is estimated to be between 200 and 300 kg N/ha/year. Excess nitrogen, if present, will be volatilized and denitrified by the soil's organisms when the soil is saturated (following heavy rainfall, during snowmelt or throughout the season in anoxic microsites). High concentration of suspended solids in the water can also lead to clogging of the soil at its surface if above typical vegetated filter thresholds. Suspended solids may be mitigated with filtration; however, this is unlikely to be necessary at the Mid-Huron Landfill Site.

Alkalinity

High alkalinity can lead to chemical obstruction of the hydraulic infrastructure in at-risk irrigation systems such as drip irrigation. The Evaplant system is designed to mitigate the impact of clogging on its operation.

High ionic strength leachates may result in reduced water uptake by plants. Landfills that have prolonged dry seasons often demonstrate increased concentration of ions in leachate, resulting in higher alkalinity, electrical conductivity, and salinity. Methods to improve leachate uptake by plants include salt partitioning pre-treatment systems or flushing with clean water. The alkalinity is not high enough at the Mid-Huron Landfill to require pre-treatment but operational measures, using methods such as flushing, could be necessary. This could potentially be achieved with local pond water (with regulatory authorization).

Salinity

High salt content in irrigation water can affect yield and the health of the soil-plant system. Electrical conductivity, sodium, and chloride concentrations, as well as total dissolved salts, are all indicators of the salt content found in irrigation waters and can be used to assess the potential impact of continuous irrigation on the Evaplant system's capacity. The concentration of specific ions such as sodium and chloride can also lead to toxicity for sensitive crops as well as contributing to the salt content. It has been demonstrated that most willows have moderate tolerance to salinity and ion toxicity while specific varieties have notably high tolerance (Hangs et al., 2011; Huang et al., 2020; Aronsson et al., 2010; Stephens et al., 2000). Specifically, *Salix miyabeana* 'SX64' has demonstrated high salt tolerance with maintained biomass productivity up to a soil EC of 9.1 dS m^{-1} (Sas, et al., 2025). The Sodium Adsorption Ratio (SAR) is a measure used in irrigation water quality assessment to evaluate the sodium hazard by comparing the concentrations of sodium, calcium, and magnesium ions, indicating the potential for soil structure deterioration due to sodium-induced dispersion. SAR greater than 9, as is the case for leachate in the Wet Well at the Mid-Huron Landfill, can potentially lead to soil deterioration (CRAAQ, 2018) if no operational considerations to manage contaminants are in place.

Management practices to negate the impacts of irrigating high-salinity waters, such as at Mid-Huron Landfill, include:

- Applying a source of magnesium or calcium, such as gypsum, lime, or calcium-nitrate, to the plantation to minimize the adsorption of sodium on the soil colloid and therefore limit the increase in soil salinity.
- Improving the soil quality through organic matter addition, which can improve soil structure, increase its water-holding capacity, and reduce the impact of chloride or sodium on plant health. The short-rotation willow coppice technique used by Ramo allows for a consistent and significant ligneous biomass production that could serve as the continuous organic matter addition that would mitigate the impact of salinity in the system. An initial investment of organic matter, such as the application of a layer of compost, is also recommended.
- Applying a balanced fertilizer can help counteract the negative effects of sodium on nutrient uptake by plants.

The natural leaching caused by rainfall and snowmelt can also be significant, but proper drainage and irrigation control are critical to allow the flushing of salts, including chloride. In the absence of these natural flushing systems, the use of clean water or local stormwater may also achieve the same outcome by flushing the soils through the irrigation system (with regulatory authorization). Ramo's experience suggests that willows can potentially withstand the levels of salinity in the Wet Well leachate with operational measures in place, but pot trials are recommended to evaluate impacts. Willow varieties known to be tolerant to salinity were considered in the variety selection (section 3.2).

pH

pH directly impacts the availability of plant nutrients. The optimal soil pH for willow growth is between 5.5 and 6.5, while pH between 5 to 8 is not a concern. pH is not anticipated to be problematic at the Mid-Huron Landfill.

Leachate Quality Assessment

Wet Well

- BOD_5 and $N\text{-}NH_4$ are not of concern since the oxygen balance and alkalinity content are adequate and allow for complete degradation and nitrification, respectively.
- Total Suspended Solids (TSS) is not expected to be high enough to cause clogging issues. However, TSS is not part of the annual sampling program for the Wet Well, and sampling is recommended prior to Evaplant implementation.
- Leachate pH is within an acceptable range.
- Alkalinity, salinity, sodium, TDS, EC, and SAR in the leachate are elevated, and should be considered in system design and operation. Considerations include:
    - Initial application of a layer of organic matter.
    - Periodical spreading of a magnesium or calcium amendment, such as gypsum, lime, or calcium-nitrate, to limit sodium adsorption.
    - In situ spreading of the harvested biomass or periodical spreading of compost or biosolids to continuously increase the organic matter content in the soil.
    - Co-irrigation of local water from the Surface Water Pond.
- Metals are present at acceptable levels and are not expected to pose toxicity risks to willows or lead to soil contamination.

3.7. Preliminary Plantation Plan

Plantation Design

To identify the limiting factor in designing the Evaplant technology at the Site, key parameters were evaluated: the system's hydraulic capacity in relation to the Site's climatic conditions, and its treatment capacity based on the leachate water quality. As identified in Section 3.5, the maximum evapotranspiration capacity of the Evaplant system in the region is 4,600 to 6,900 m^3/ha/season. Furthermore, the Wet Well leachate is expected to be able to be irrigated at 4,600 to 6,900 m^3/ha/season.

This estimation considers that operational measures are in place to negate the risks associated with specific parameters as highlighted in Section 3.6.

Ramo recommends that the project proceeds in two stages: a pot trial followed by full-scale deployment. The first step involves conducting irrigation pot trials at Ramo's facilities in Saint-Roch-de-l'Achigan to evaluate the impact of leachate from the Mid-Huron Landfill on willow growth and soil performance. Based on the results, a full-scale system will be installed. This system will incorporate the necessary operational measures to manage water quality risks. The following sections provide detailed descriptions of each recommended phase.

Pot Trial Stage

Ramo recommends conducting a laboratory-scale irrigation trial for assessing willow growth under irrigation with leachate collected from the Wet Well. These trials will evaluate the impact of leachate quality on short term willow health, helping identify the most effective combinations of operational modalities before moving to full-scale implementation. The specific objectives involve comparing the physiological and chemical differences in willows irrigated with these effluents versus those irrigated with potable water only.

The trials will take place at Ramo's facilities in Saint-Roch-de-l'Achigan, Québec, over a 12-week period. Three willow varieties will be tested using leachate from the Wet Well and clean water as a control. Each water source will be paired with three operational considerations to manage contaminants: one with organic matter amendment, one with gypsum or lime amendment, and one without any amendment as a control. This results in six total treatment combinations (2 effluents x 3 amendments).

The experimental monitoring of the trials will include:

- Two soil sampling campaigns; one at the beginning and one at the end of the experiment.
- Two effluent sampling campaigns; one at the beginning and one at the end of the experiment.
- Monthly characterization of the willows (height, number of stems, leaf appearance, and overall appearance).
- One destructive biomass sampling at the end of the experiment; measurement of dry yield and chemical characterisation of woody biomass and leaves.

A detailed proposal outlining costs can be prepared if the MHLSB wishes to proceed with the pot trials.

Figure 4. An example of a previous lab-scale irrigation trial executed by Ramo.

Full-Scale Plantation Stage

Given the evapotranspiration capacity of the Site, the estimated area required for Evaplant to manage the entirety of leachate at the Mid-Huron Landfill is 3 hectares, with approximately 2.2 hectares irrigated. The required area includes a planted buffer zone that is not irrigated, which mitigates the risks of runoff leaving the plantation area. This potential area is highlighted in Figure 3, shown in Section 3.1. Planting a 3-ha plantation and irrigating 2.2-ha would allow the evapotranspiration of between 10,100 and 15,200 m^3/year of leachate, which would accommodate maximum leachate flow volumes at the Site. The detailed design is planned as part of Phase 2 of the feasibility study.

3.8. Estimation of Willow Biomass Yield and Carbon Sequestration Potential

The short-rotation willow coppice technique used by Ramo allows for a consistent ligneous biomass production and carbon sequestration. As fast-growing trees, willows absorb atmospheric CO_2 through photosynthesis in their leaves, storing carbon in their woody biomass and root systems. While the CO_2 equivalent captured in the aboveground willow biomass will eventually be released if the biomass is harvested for Ramial Chipped Wood (RCW) and used as a soil amendment, a portion of the carbon will remain sequestered long-term through the belowground root system. At the Mid-Huron Landfill, a 3-hectare Evaplant willow plantation is estimated to generate 13 tonnes of above-ground dry woody biomass production per hectare per year. Assuming a biomass yield of 13 tonnes/ha/year, a 3-ha plantation is projected to yield 39 tonnes of biomass per season, capturing approximately 70 tonnes of CO_2 equivalent annually.

3.9. Preliminary Project Schedule

The following preliminary schedule outlines the recommended timeline for key phases and milestones for the implementation of the Evaplant system at the Mid-Huron Landfill, providing a high-level overview from design approval through to full operational readiness. This project schedule is considered preliminary and will be subject to revision based on components such as the duration of the regulatory approval process and the results of the pot trials.

Q3-Q4 2025

- Go/no-go decision to proceed with Feasibility Study Phase 2: Cost estimate, site visit, preliminary engineering work, designs and plans.
- Initiate discussions with the MECP.
- Conduct irrigation pot trials to evaluate willow response and viability.

Q1 2026

- Finalize detailed engineering and design for the Evaplant system.
- Obtain regulatory permissions (expected 3-6 months processing time).

Q2 2026

- Prepare the soil at the plantation location in the RDA.
- Plant 48,000 willows.
- Install the 3-ha Evaplant system.

Q3 2026

- Monitoring and management.
- Irrigate water from the onsite Surface Water Pond during the first growing season to ensure healthy establishment of the willows.

2027

- Activate the Evaplant system to manage leachate from the Mid-Huron Landfill.
- Monitoring, management, and reporting.

4. Feasibility Summary

The Evaplant system has the potential to effectively address the leachate management needs of the Mid-Huron Landfill through a sustainable, nature-based approach. In doing so, it could also help reduce nutrient loads reaching the Parsons Court LTF, and ultimately, Lake Huron. Key findings of the Evaplant feasibility assessment are listed below.

- **Evapotranspiration capacity:** The net potential evapotranspiration of the Evaplant technology at the Site fluctuates from 4,600 to 6,900 m^3/ha/year for leachate, during the potential operation period from May to October.
- **System sizing:** A 3-hectare plantation with 2.2 hectares irrigated with Evaplant would be required to manage 10,300 m^3 per year of leachate, which is the maximum yearly generation at the Mid-Huron Landfill.
- **Leachate quality:** Monitoring and preplanned operational measures may be required for the operation of the Evaplant system due to leachate quality, such as:
  - Initial application of a layer of organic matter.
  - Periodical spreading of a magnesium or calcium amendment, such as gypsum, lime, or calcium-nitrate, to limit sodium adsorption.
  - In situ spreading of the harvested biomass or periodical spreading of compost or biosolids to continuously increase the organic matter content in the soil.
  - Co-irrigation of local water from the Surface Water Pond.
- **Generation of woody biomass:** A 3-hectare Evaplant system would produce an estimated 39 tonnes of above-ground dry woody biomass production per year.
- **Carbon capture potential:** A 3-hectare Evaplant system would capture approximately 70 tonnes of CO_2 equivalent annually in woody biomass.
- **Regulatory approval**: The implementation of an Evaplant system appears technically feasible and aligned with the Site's long-term environmental objectives. The next step will be to engage with the MECP to initiate discussion on a clear regulatory pathway for leachate irrigation.

This report represents the first stage of project development. The next step is to make a go/no-go decision on whether to proceed with Phase 2 of the Evaplant Feasibility Study, which includes cost estimates, a site visit, project work breakdown structure, discussions with the regulator, and preliminary planting pattern and process engineering work. To further evaluate the feasibility of implementing an Evaplant system at the Site, Ramo also recommends undertaking bench-scale trials using representative leachate samples. These tests, to be conducted at Ramo's laboratory facilities, will help assess system compatibility and performance under controlled conditions, prior to on-site deployment. Should MHLSB wish to proceed, Ramo can provide a detailed cost estimate for these laboratory trials as a logical next step in advancing the project. If the project moves forward, subsequent steps will also include securing regulatory permissions, preparing the soil, planting willows on-site, and installing the 3-hectare Evaplant system in the RDA.

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Scope and Limitations

This study has been conducted for the exclusive benefit and use of the MHLSB. It contains proprietary information regarding Ramo intellectual property that may not be reproduced, published, or shared in whole or in part without written authorization from Ramo, for each specific circumstance.

This is a point-in-time assessment. The results and conclusions presented in this report have been obtained using information provided by the MHLSB, testimonies collected during the historical and factual Site investigation, documented assumptions, and the standards in place at the time of writing this report. Ramo is not responsible for any other interpretation made by a third party. Ramo is also not liable for consequences arising from atypical data points despite the diligence of its professionals. In considering design specifications, Ramo will consider the potential variation, and deterioration of leachate quality and other variables; however, Ramo is not responsible for unanticipated changes which occur with the passage of time. Limitations in the quantity and quality of client-provided data can also impact the accuracy of analysis. Insufficient data may lead to incomplete conclusions, resulting in suboptimal recommendations.

The results and conclusions presented in this document are valid only in the context of consideration for Ramo’s Evaplant technology. These results shall not be applied for any other vegetated technology for wastewater treatment or volume reduction technology and therefore should not be used to estimate the performance of any other technologies.