SUB-APPENDIX D6-L

Peer Review Memorandum #2

To: Fabiano Gondim, M.Eng., P.Eng.

From: Kerry Rowe, OC, Ph.D., D.Eng., DSc(hc), FRS, NAE, FREng, FCAE, FRSC, P.Eng.

Date: 2020 4 5

Re: Memorandum #2: Project No. 18111331 Ridge Landfill Expansion EA Phase 2000
Leachate collection for the proposed expansion of the old landfill, EA REF No. 16019

This memo (Memorandum 2) is a follow-up to a previous memo (Memorandum 1: **MECP submission of 9 January 2020**; Attachment 1) in response to my review and comments with respect to MECP comments regarding "Appendix D6 – Design and Operations Report, S.7.7 leachate control system design for the expansion of the old landfill area", which includes the statement from MECP that a "Vertical expansion is proposed for the Old Landfill Area, and the leachate collection system will consist of finger drains along the perimeter. For a major expansion with over 30 m of waste mound, the proposed finger drain system will be inadequate for leachate collection and will result in leachate mounding and seepage through side slope."

Sequence of Events Following the Peer Review Memorandum #1 Submission to MECP on January 9, 2020

As set out by Golder, the sequence of events leading to my review is as follows.

- The MECP Senior Waste Engineer (Rick Li) reviewed the Peer Review Memorandum #1 issued by Kerry Rowe (see Attachment 1) and sent an email to Carolyn Lee on January 14, 2020. In his email, the MECP Senior Waste Engineer stated his agreement with the peer review and requested that "a trigger criteria and contingency plan for the Old Landfill leachate management should also be included in the EA report."
- Golder revised the January 2020 Design and Operations Report (January 2020 D & O Report) to include an outline of the trigger criteria and contingency plan for seep remediation in the Old Landfill (see Attachment 2). The January 2020 D & O Report was submitted to MECP in support of the EA.
- MECP (Rick Li) provided two comments related to the January 2020 D & O Report on March 13, 2020, requesting that leachate levels be monitored at the Old Landfill and that leachate levels be included in the trigger criteria as part of the contingency plan (see Attachment 3).
- Golder prepared a Technical Memorandum dated 20 March 2020, regarding the effects of leachate mounding in the Old Landfill. The Memorandum provided an explanation as to why there was not a need to set a trigger elevation for the leachate mound level. Golder recommended leachate level monitoring to allow comparison against predicted levels and for assessing the performance of the final cover (see Attachment 4). This Technical Memorandum was submitted to MECP by Waste Connections on March 23, 2020.
- Waste Connections committed to addressing the other MECP comments during the ECA amendment application. The MECP Senior Waste Engineer agreed with the approach presented in the 20 March 2020 memo. However, follow-up comments from the MECP Senior Waste

Engineer were received on 27 March 2020, raising additional concerns about potential impacts related to leachate mounding in the Old Landfill (see Attachment 5).

- Golder prepared a Technical Memorandum dated April 2, 2020. Section 3 of the memo provides additional information and discussion and a cross-section through the Old Landfill showing the existing and proposed site geometry and features and predicted leachate mounding (see Attachment 6). It is understood that this Technical Memorandum is to be submitted to MECP at the same time as this follow-up peer review Memorandum #2 is submitted to MECP. In their note to Kerry Rowe, Golder advised: please disregard the C & D waste and landfill gas Sections 1 and 2 of the Memo as they are not relevant to the peer review.

Scope of this Review

The scope of this review is strictly limited to "two comments related to the January 2020 D & O Report on 13 March 2020, requesting that leachate levels are monitored at the Old Landfill and that leachate levels be included in the trigger criteria as part of the contingency plan (see Attachment 3)" and the subsequent comment (Attachment 5) and Golder's responses as contained in the Technical Memoranda dated March 20, 2020 (Attachment 4) and April 2, 2020 (Attachment 6).

Comments with Respect to MECP Comments and Golder's Response

The MECP comments regarding leachate mounding and monitoring, and the need for trigger levels and contingencies are understandable given the unusual circumstance that the "old" landfill already contains a substantial amount of waste and, with the expansion, soon-to-be substantially more waste without an underdrain system typical of most modern landfills. This "old" landfill had been approved and extensive waste already disposed at the site in that cell before current requirements and, in particular, before O.Reg. 232/98, were in place. What also makes the site unusual, in a very positive sense, is a substantial thickness (~32-35 m) of low permeability clay beneath the "old" landfill waste.

The questions/issues posed by MECP revolve around potential impact pathways. The first pathway, and by far the most immediate, is the potential for side seeps and, if not controlled, the potential for contamination of surface water by the side seeps. The second pathway is the potential for contaminant migration through the 32-35 m thick low permeability (k~10^{-10} m/s; Attachment 9, §3.1, Table 2) to the underlying aquifer (k ~ 10^{-6} m/s; Attachment 9, §3.1, Table 2). Golder's response addresses these two pathways and each is discussed separately below.

Surface seeps

If waste was homogeneous and isotropic, no leachate seeps would be expected until the mound reached the level that it intersected the surface of the landfill. Based on the calculations performed by Dillon/Golder this would seem unlikely (see Figure A below which is Figure 2 in Attachment 6). However, since the possibility cannot be excluded, I consider the request for monitoring wells by MECP to be quite reasonable and indeed Golder has indicated a willingness to address this issue by adding two additional leachate monitoring wells as described in their March 20, 2020 Technical Memorandum (Attachment 4).

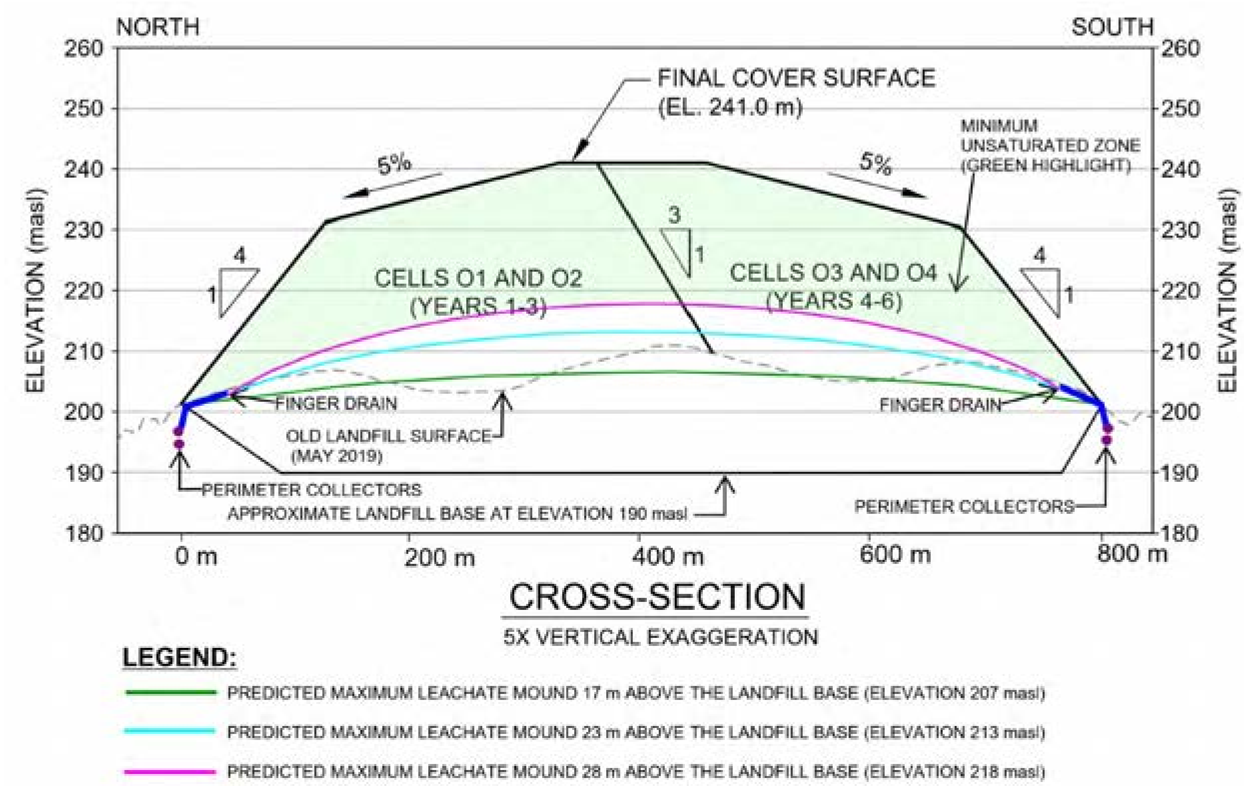

Figure A: Showing the proposed top contours and lower (17m), median (23 m) and upper (28 m) bound predicted leachate mound (directly from Attachment 6)

The fact that waste is highly non-homogeneous and anisotropic implies that there is potential for surface seeps even when leachate mound is well away from the surface contours of the landfill (as in Figure A above). This is because there can be preferential lateral flow (often on a low permeability layer such as daily cover that had not been adequately broken up) from the leachate mound to the surface of the landfill causing a seep. This can also occur above the leachate mound due to the perching of leachate and a low permeability layer can result in preferential migration laterally to the surface of the landfill to form a leachate seep. The finger drains that form part of the proposed Old Landfill expansion design is intended to provide a preferential path for this leachate and to prevent it from reaching the surface. Although discrete finger drains are an effective design approach to manage seeps, they cannot be expected to capture all possible such pathways. The surface seeps, while likely to be significantly reduced compared to what would be expected in the absence of finger drains, can still be expected to occur at some time in the future. In recognition of this, and in response to MECP comments, Golder has proposed a three-stage trigger and corrective action plan (Attachment 7, §17.3) that, in my opinion, is quite appropriate and realistic and should address anything from minor local seeps through to more significant and frequent seeps over a larger area. Provided these actions are taken in a timely manner after the detection of a seep, and the perimeter drain is kept clean and effective, I expect that these measures should be sufficient to prevent contamination of surface water or shallow groundwater (deep groundwater is addressed below).

Impact on the underlying aquifer

The second pathway that is, justifiably, of concern to the Ministry is impacting the aquifer beneath the site. As previously noted in the Dillon report (Attachment 9), there is between about 32 to 35 m of low permeability clay above the aquifer. In their July 2019 POLLUTE modeling report, Dillon indicates that a 17 m high predicted leachate mound would give rise to a predicted maximum concentration in the aquifer, after about 3,000 years, that would meet the requirements of the Reasonable Use Policy. In my review as part of my preparation of Memorandum #1, I raised a concern that the hydraulic conductivity of the waste that was used to get the 17 m mound may not have been conservative enough and that lower values might reasonably be anticipated, which would result in a higher leachate mound. In my opinion, the 17 m that had been calculated represents a reasonable lower bound estimate of the leachate mound but was not in itself sufficient. In response, Dillon examined what I consider to be a more likely expected and reasonable worst-case hydraulic conductivity of the waste and based on this calculated a median leachate mound of 22.9 m, and an upper bound leachate mound of 28.5 m (Attachment 10). Dillon's POLLUTE analyses conducted based on these leachate mounds gave predicted maximum chloride concentrations in the aquifer of 129 mg/L for the 17.2 m mound, 152 mg/L with a 22.9 m mound, and 186 mg/L with a 28.5 m mound. The latter value just meets the Reasonable Use Policy limit of 188 mg/L. Based on these calculations, the maximum mound that could be tolerated without impacting the aquifer and initiating the need for remedial action would be 28.5 m. The proposed installation of two new leachate monitoring wells as proposed by Golder (Attachment 4) is, in my opinion, sufficient to assess the general magnitude of the leachate mound and how it changes over time. In the event that the leachate mound exceeds 27 m, I would recommend the installation of additional wells to monitor the leachate mound as related to the preparation of an action plan in the event that the mound reaches 28.5 m. Based on currently available information, it is not expected that the mound should ever exceed 28.5 m; however, the purpose of monitoring is to indicate if the unexpected occurs. If used in this appropriate way, I do not anticipate any significant impact (i.e., none exceeding that allowable by the Reasonable Use Policy).

Conclusion

Based on my review, the measures now proposed by Golder to address the comments from MECP represent a reasonable and appropriate approach to leachate level monitoring, addressing side seeps as they occur, and indicate that for the expected leachate mound in a reasonable range of uncertainty the requirements of the Reasonable Use Guideline will be met in both shallow and deep groundwater. As described in the Design and Operations Report, post-closure activities include replacement of the perimeter drain, ongoing monitoring for seeps, and general maintenance of the cover.

APPENDIX A: Relevant Documents Reviewed

To: Fabiano Gondim, M.Eng., P.Eng.

From: Kerry Rowe, OC. Ph.D., D.Eng., DSc(hc), FRS, NAE, FREng, FCAE, FRSC, P.Eng.

Date: 2020 1 9

Re: Project No. 18111331 Ridge Landfill Expansion EA Phase 2000
Leachate control for the proposed expansion of the old landfill, EA REF No. 16019

This memo is in response to your request that I review and comment with respect to MECP comment No. 1 and the information provided by Golder and Dillon including supporting calculations, modelling, and drawings related to mounding and seepage control to the side slopes and base of the Old Landfill (Appendix A).

In particular, I am responding to the MECP comment regarding "Appendix D6 – Design and Operations Report, S.7.7 leachate control system design the expansion of the old landfill area" which provides a statement: "*Vertical expansion is proposed for the Old Landfill Area, and the leachate collection system will consist of finger drains along the perimeter. For a major expansion with over 30 m of waste mound, the proposed finger drain system will be inadequate for leachate collection and will result in leachate mounding and seepage through side slope*."

A memorandum from Mr. Rick Li to Ms. Carolyn Lee (MEPC; dated 2019 11 29) augmented this comment in item (b) which states:

"*In Attachment 4 - Calculation of Mounding between Finger Drains, the lateral flux collected by the finger drains was recalculated based on peak monthly average percolation rate through waste. The calculation underestimated the flux to the finger drains in several ways.*

First, according to the HELP model, the peak daily percolation through the waste is 3 mm, which should have been used for the calculation.

Second, the HELP model was only run for the closed site scenario. Simulation for the operation period without a final cover should also been completed because in the active landfill area, 100% of precipitation that comes into contact with waste will become leachate.

Last, the calculation of Q_{INF} in Attachment 4 only accounts for the infiltration over the unit width of the area at each finger drain. However, as the finger drains are spaced at 25 m, each drain will also collect leachate from its surrounding area (the space between two finger drains). Therefore, the lateral flux as calculated is significantly underestimated. (It would be correct if there were a continuous drainage layer.)

Proposed action: recalculate the finger drain fluxes and revise the design."

I have reviewed the documents provided to me, including reviewing of Dillon's hydrogeological model and POLLUTE (1995, 2005) modelling for an assessment of impact on groundwater of leachate mounding over the base of the Old Landfill as well as Golder's revised version of Attachment 4 (dated 20 December 2019) addressing the comments by Mr. Rick Li (MEPC; dated 2019 11 29) (as noted in the quotation above). With the MECP comments in mind, I provide my review comments in the following paragraphs.

I understand the MECP's caution in approving the proposed leachate collection system for the expansion over the existing Old Landfill since the Old Landfill has no underdrain system and currently relies on a series of finger drains around the perimeter and a perimeter drain for controlling leachate migration from beneath the landfill and surface seeps. Similarly, the leachate collection system for the proposed expansion also relies solely on a series of (albeit more frequent and longer) finger drains connected to a new perimeter drain. In most practical situations, I would consider this unacceptable. However, as is evident from the documents I reviewed, this is an exceptional case in that: (a) the existing waste, upon which the expansion is proposed, overlies a very thick layer of very low permeability ($1x10^{-10}$ m/s) clay and, (b) the Old Landfill has been in operation since 1963 and there is leachate data since February 1995. It is understood that the existing system for the Old Landfill is generally working well in terms of controlling lateral migration of leachate and surface seeps, with a maximum leachate mound reported to be about 12 m above the landfill base and hence approximately 5 m below the maximum mounding height predicted by Dillon. Thus, the proposed leachate control system design for the expansion of the Old Landfill must be looked at in this special context.

I emphasize that my comments below are very specific to this particular landfill and the special circumstances relevant to this exceptional case. Thus, these comments <u>should not be used to justify a similar design under different circumstances</u>.

My comments are based solely on the site-specific information provided to me, including calculations and drawings (Appendix A). I have not performed any independent check of the data or the POLLUTE or HELP modelling. However, I did perform checks of the leachate mounding calculations and independently evaluated the assumptions used in those calculations. I have not reviewed or commented upon anything beyond the issue of leachate collection/control and the leachate mound and its potential consequences with respect to groundwater or surface water for the proposed expansion of the Old Landfill.

The focus of this review has been on Golder's revised, in response to Mr. Li's comments, Attachment 4 (dated 20 December 2019) relating to the leachate mounding between finger drains and to Mr. Li's specific comments cited earlier.

- When a landfill has an under-drainage system and minimal waste, leachate generation responds very quickly and in relatively direct proportion to heavy (e.g., peak) rainfall events. However, in my experience, as the waste thickness increases there is an increase in the lag between the rainfall event and the corresponding peak leachate generation and a reduction in the level of peak response due to the different paths through the waste causing dispersion (damping) of the peak event and giving a lower leachate generation rate than the peak rainfall event but extending over a longer time. In a typical landfill, the peak generation rate is important in terms of the short-term management of leachate. The situation as proposed for the Ridge landfill expansion is, however, different from a typical landfill.

Given the large area of the expansion over the Old Landfill (my sole focus in this review) and with good operations, at any particular time, only a small proportion of the landfill should be the working face without cover, and so the area exposed to the peak infiltration rate should represent only a relatively small proportion of the landfill at any time. Based on the HELP modelling, in their revised calculations (Attachment 4, dated 20 December 2019) Golder used a maximum (peak) monthly percolation rate of 57 mm/month for an open working face area (i.e., no cover) and 34 mm/month for areas with intermediate cover. If the operator keeps the open working face to about 0.5 ha (as assumed in the Golder calculations), the contribution of the working face on the overall average leachate generated from Cell O1 was calculated to only marginally increase to 35 mm/month. Hence, the overall infiltration reaching the proposed finger drains, and subsequently new perimeter drain, would only be slightly increased by the effect of peak infiltration in the uncovered working area. In their revised Attachment 4 (dated 20 December 2019), Golder has, in my opinion, given reasonable consideration to this overall effect.

- In their revised calculation (Attachment 4, dated 20 December 2019), Golder has revised and more clearly explained their calculation of leachate mounding between the finger drains. They have considered the percolation from the centre of the mound to the edge being collected by the finger drains. Given the relatively low height of waste above the finger drains, in my opinion, they have made reasonable assumptions regarding the permeability (hydraulic conductivity, $k = 10^{-5}$ m/s) of waste and adopted a conservative[1] method of calculating, q_{LAT}, which is then used to calculate the maximum height leachate mound of 3.7 m for a spacing of 25 m between drains. It appears from the revised Attachment 4 (dated 20 December 2019) that they have increased the height of the finger drains to 3.7 m such that the maximum leachate mound does not enter into the cover. Given the conservative nature of the assumptions adopted in calculating the maximum height between drains, I consider the 25 m spacing and the 3.7 m drain height to be conservative in the absence of any significant clogging of the collection system.
- Based on the available leachate data for the existing landfill (between 1995 – 2018), the leachate has a chloride concentration averaging about 2500 mg/L over the past decade (consistent with what might be expected for a large landfill as anticipated in O/Reg. 232).

[1] i.e., likely to err in leading to an overestimate of the actual leachate mound between the finger drains.

In contrast, the concentration of the primary contributors to the clogging of leachate collection systems (reflected by COD, BOD, and calcium) are quite low. COD averaged ~ 1100 mg/L over the first decade and 700 mg/L over the last decade, with an overall average ~1000 mg/L over 23 years of monitoring. BOD averaged ~ 340 mg/L over the first decade and 210 mg/L over the last decade, with an overall average ~310 mg/L over 23 years. The calcium concentration averaged ~370 mg/L for years 2000-2004, ~330 mg/L between 2000 – 2009, and ~220 mg/L between 2010 – 2018. The calcium concentration is particularly critical with respect to biologically induced clogging and the average over the last 23 years is only 18% of that assumed when I performed the service-life calculations for the 100-year leachate collection system defined in O.Reg 232/98. However, notwithstanding the relatively low concentrations, if the flow is all to be collected by the finger drains, then the mass loading per m^3 of drainage gravel is around four times higher than it would be for a drainage blanket meeting the requirements of O.Reg. 232/98 for a service life of 100 years. Thus, clogging of the finger drains and perimeter drain is to be expected over the contaminating lifespan (which the report suggests is of the order of 380 years). Thus, it can be expected that additional finger drains will need to be installed and most likely the perimeter drain replaced several times over the contaminating lifespan. It should be noted for the contaminating lifespan on the order of 400 years that similar measures would likely be required even if there were an underdrain with a 100-year service-life since its service-life would be reached almost 300 years before the contaminating lifespan had been reached and a similar leachate mound would develop to that predicted in the absence of an underdrain system between the old and the new (vertical expansion) waste. Thus, the key difference between a drainage blanket and the finger drains is that it is not practical to rehabilitate or replace the drainage blanket whereas it is practical to install additional finger drains and to repair or replace the perimeter drainage system to control side slope leakage. It should be anticipated that the cover, finger drains, and perimeter drain will require monitoring and maintenance for several centuries based on the projected contaminating lifespan of 380 years.

- After landfill closure, the long-term mounding of the leachate will be largely governed by the annual percolation over the contaminating lifespan of this landfill, and this can be anticipated to change due to climate change. The exact effects of these changes are unknown at this time; however, as noted above, additional measures can be taken, if needed, in terms of installation of additional finger drains or perimeter drains.

- The predictions of leachate mounding between the finger drains are also predicated on assumptions regarding waste permeability (hydraulic conductivity). In my opinion, reasonable assumptions have been made. However, waste is heterogeneous and the possibility of local areas of lower permeability waste cannot be excluded. In the event that lower permeability waste is located in an area directly influenced by the drains, this could lead to higher mounding than predicted and potentially side slope seepage. In that unlikely event (unlikely, because of the conservative assumptions made in Golder's calculations), it would be relatively easy to provide local additional drainage to ensure that leachate seeps are controlled and the leachate directed to the finger drains and perimeter drain.

Based on the revised calculations (dated 20 December 2019), in my opinion, the issues raised by Mr. Li, as cited above, regarding the finger drains have been appropriately addressed by Golder.

There remains the question of the magnitude of the leachate mound between the perimeter drain in the expanded Old Landfill that may arise as a result of adding 30 m of waste to raise the top contour from 210 masl to 240 masl. One such effect will be increasing the effective stress in the existing waste due to the added weight. This can also be expected to decrease the hydraulic conductivity of the waste (due to primary and secondary compression as well as degradation of the waste) and such a decrease would lead to an increase in the height of leachate mound above the existing observed 12 m. Based on a hydraulic conductivity, k_w=2x10^{-6} m/s (attributed to the HELP model), Dillon predicted that the maximum leachate mound will increase to about 17 m above the landfill base. The hydraulic conductivity of k_w=2x10^{-6} m/s used in this calculation is slightly lower than the hydraulic conductivity of about 3x10^{-6} m/s needed to explain the existing 12 m of leachate mound after 20 years consolidation/degradation of the waste and precipitation with a maximum waste thickness of about 19 m. These values seem quite reasonable for the existing waste in the Old Landfill. There is invariably considerable scatter and heterogeneity in the hydraulic conductivity of waste. However, there is also a clear trend of decreasing waste hydraulic conductivity, k_w, with increasing overlying waste (Rowe and Nadarajah, 1996). In my opinion, the hydraulic conductivity of the waste after the addition of the proposed 30 m of new waste can be expected to be lower than that assumed in Dillon's calculation by a factor of two (k_w ~ 1x10^{-6} m/s) to three (k_w ~ 6x10^{-7} m/s).

In response to my comment in the previous paragraph, and following my recommendation, Dillon recalculated the maximum mound height based on k_w ~ 1x10^{-6} m/s and k_w ~ 6x10^{-7} m/s and used the resulting increased Darcy flux as input to additional POLLUTE modelling. The results of the new modelling were reported to me in a memo "Ridge Landfill Contaminant Transport Modelling Sensitivity of Waste Hydraulic Conductivity, Old Landfill Mounding Calculations and POLLUTE Modelling" (dated 7 January 2020).

Dillon has used a consistent methodology throughout the process in terms of calculating the maximum leachate mound [using the Hooghoudt (1940) equation] and in calculating the consequent Darcy flux and corresponding contaminant impact. In my opinion, this approach is reasonable but conservative. In my experience, the Hooghoudt Equation gives a higher calculated leachate mound than the more commonly used Harr (1962) equation. Also, the maximum leachate mound, h_{max}, and consequent Darcy flux, only corresponds to that at the center of the landfill, whereas POLLUTE calculates the impact of the entire landfill. Thus, using the maximum flux at the center for the entire landfill will overestimate the overall flux into the underlying aquifer beneath the landfill. For this reason, it is more common in impact calculations with POLLUTE to use the average head (h_{ave} ~ $0.785h_{max}$; Rowe et al. 2004). For h_{max} = 28.5 m (k_w = $6x10^{-7}$ m/s) calculated by Dillon, the average head below the mound would be h_{ave}= 22.4 m and based on Table 1 of the recent Dillon memo, one can infer that the corresponding predicted maximum chloride impact for this average head would about 150 mg/L; this is well below the allowable concentration based on the Reasonable Use Guideline. These results also indicate that for the lowest suggested k_w = $6x10^{-7}$ m/s, the impact on the aquifer due to the consequent maximum 28.5 m mound on the base still meets the allowable concentration based on the Reasonable Use Guideline.

Based on the foregoing comments and the recent Dillon memo (dated 9 January 2020), in my opinion, the expected impact on the aquifer due to leachate mounding between the perimeter drain, calculated based on a reasonable estimate of the hydraulic conductivity of the waste under the additional applied load due to the additional vertical expansion waste, can be expected to have an impact below the allowable concentration based on the Reasonable Use Guideline.

In summary, although I would generally not support an approach to controlling the leachate mound only using finger drains and a perimeter drain for a large expansion over an old landfill, based on the evidence I have reviewed, in my opinion, in this case, the proposed design approach is acceptable, would meet the objectives of the Reasonable Use Guideline and O.Reg 232/98 and can be expected to provide reasonable control of potential leachate seeps. Given the contaminant loading on the finger and perimeter drains, it must be anticipated that ongoing maintenance of the finger drains, control of occasional side seeps[2], and periodic replacement of the perimeter drain will be required over Dillon's estimated contaminating lifespan of 380 years.

References:

Harr, M.E. (1962) *Groundwater and seepage,* New York: McGraw-Hill, pp. 43-44.

Hooghoudt, S.B.(1940) (in Dutch). Algemene beschouwing van het probleem van de detailontwatering en de infiltratie door middel van parallel loopende drains, greppels, slooten en kanalen. No. 7 in de serie: Bijdragen tot de kennis van eenige natuurkundige grootheden van den grond. Bodemkundig Instituut te Groningen. Rijksuitgeverij Dienst van de Nderlandse Staatscourant. 's-Gravenhage, Algemeene Landsdrukkerij.

[2] In areas of local low hydraulic conductivity overlain by higher hydraulic conductivity material (not uncommon in landfills, due to their heterogeneity and inherent anisotropy of waste), which tends to locally direct leachate to landfill side slopes rather than further down into the leachate mound.

Rowe, R.K. and Booker, J.R. (1995). “A finite layer technique for modelling complex landfill history”, *Canadian Geotechnical Journal*, 32(4):660-676.

Rowe, R.K. and Nadarajah, P. (1996). “Estimating leachate drawdown due to pumping wells in landfills”, *Canadian Geotechnical Journal*, **33**(1):1-10.

Rowe, R.K., R.M. Quigley, R.W.I Brachman and J.R. Booker, 2004, *Barrier Systems for Waste Disposal Facilities*, 2nd Edition, SPON Press.

Rowe, R.K. and Booker, J.R. (2005). “POLLUTE v.7.0 1D Pollutant Migration through a Composite Liner Systems © 1983, 1990, 1994, 1997, 2005. Distributed by GAEA Technologies Ltd.

17.3.3 Archaeology and Heritage Resources

If significant archaeological resources are identified, archaeological testing and possibly excavations will be conducted.

If significant architectural elements are uncovered during unmonitored demolition of heritage features, contact should be made with applicable government agencies.

17.3.4 Transportation

If the haul route is closed temporarily due to an emergency, the existing network of county roads is designed to accommodate truck traffic and should be used. Unpaved local roads should only be used as a last resort and only for temporary emergencies.

17.3.5 Old Landfill Seep Remediation Trigger Criteria and Contingency Plan

As part of the initial review of the proposed expansion by the MECP, a request was made for Waste Connections to develop trigger criteria and a contingency plan in the event of failure of the finger drain system (leachate seeps). The following is an outline of the contingency plan that will be further developed as part of the ECA process. Any seep encountered during daily inspections will be remediated as soon as practical. The following two-tier approach will be implemented to remediate seeps. The first Tier would be to install additional finger drains with connection to the existing finger drains, manholes or perimeter collection system. If leachate seeps reoccur within the same general area after the installation of additional finger drains, the Tier 2 contingency will be to install a continuous drainage layer underneath the final cover on the side slope at the location of the seeps with a perforated pipe installed at the toe of the drainage layer. The perforated pipe will be sloped to discharge to the nearest manhole. The Tier 1 and 2 approach will be localized and implemented as needed.

Leachate subsurface migration beyond the perimeter collection system is covered under Section 17.1.

Table 1. Government Review Team Comment Summary Table

Proposal: Ridge Landfill Expansion Environmental Assessment (EA)
Proponent: Waste Connections of Canada
Date: March 13, 2020

Submitter	Summary of Comments	Proponent's Response	Status
Ministry of the Environment Conservation and Parks			
Senior Waste Engineer, Environmental Permissions Branch	To ensure that the leachate finger drains perform as designed (Appendix 6 – Design and Operations Report, Section 15.2.3) and to prevent excess leachate mounding at the Old Landfill, the leachate level at the Old Landfill should be monitored. However, there are currently no leachate wells within the Old Landfill. Leachate monitoring wells will need to be installed within the Old Landfill. (Appendix 6 – Design and Operations Report, Section 15.2.3)		
Senior Waste Engineer, Environmental Permissions Branch	To control leachate mounding and to prevent seeps at the Old Landfill, it is important to maintain the leachate level lower than a certain threshold level. Therefore, leachate level at the Old Landfill should be one of the trigger criteria. Please develop trigger criteria for the leachate level at the Old Landfill as part of the contingency plan. This may be completed at the ECA stage. (Appendix D6 – Design and Operations Report, Section 17.3.5)		

TECHNICAL MEMORANDUM

DATE March 20, 2020 **Project No.** 18111331

TO Cathy Smith
Waste Connections of Canada

CC

FROM Fabiano Gondim / Frank Barone **EMAIL fabiano_gondim@golder.com**

CONSIDERATION OF MECP COMMENTS ON REGARDING LEACHATE MOUNDING AND CONTROL IN THE OLD LANDFILL AREA, RIDGE LANDFILL EXPANSION ENVRIONMENTAL ASSESSMENT

In the comments provided March 13, 2020 by the Ministry of Environment, Conservation and Parks (MECP) on the final Environmental Assessment (EA) for the expansion of the Ridge Landfill, the following were provided by the Senior Waste Engineer, Environmental Permissions Branch:

> *To ensure that the leachate finger drains perform as designed (Appendix 6 – Design and Operations Report, Section 15.2.3) and to prevent excess leachate mounding at the Old Landfill, the leachate level at the Old Landfill should be monitored. However, there are currently no leachate wells within the Old Landfill. Leachate monitoring wells will need to be installed within the Old Landfill. (Appendix 6 – Design and Operations Report, Section 15.2.3)*
>
> *To control leachate mounding and to prevent seeps at the Old Landfill, it is important to maintain the leachate level lower than a certain threshold level. Therefore, leachate level at the Old Landfill should be one of the trigger criteria. Please develop trigger criteria for the leachate level at the Old Landfill as part of the contingency plan. This may be completed at the ECA stage. (Appendix D6 – Design and Operations Report, Section 17.3.5)*

In response to these comments on the EA, Waste Connections indicated that these two comments related to leachate mounding, monitoring, triggers and contingency for the Old Landfill expansion would be addressed as part of the Waste ECA amendment application process. These two comments have been considered and a response to each is provided in this memorandum.

During the review of the EA, the Senior Waste Engineer provided comments regarding the approach to design of the finger drains around the perimeter of the Old Landfill. In the responses to these comments prepared by Golder and provided to the MECP, the topic of leachate mounding in the Old Landfill was discussed and additional analyses were completed to address questions provided from the peer review by Prof. Kerry Rowe. The following key points that relate to the above comments are as follows:

- The Old Landfill is underlain by an approximately 30 m thick deposit of low permeability clay till that provides a natural liner and protection of the groundwater in the aquifer below the till. In the absence of an underdrain leachate collection system (as is the case for the Old Landfill), infiltrating precipitation builds up within the waste and forms a leachate mound.

- The height of the leachate mound and the rate at which it rises depends primarily on the hydraulic conductivity of the waste, the annual infiltration and the dimensions of the landfill. The dimensions of the landfill determine the length of the leachate path to travel laterally towards the perimeter of the landfill where it can emerge as seepage at the base or perimeter sideslopes.
- Control of this perimeter seepage for the existing Old Landfill is provided by a perimeter leachate collector and finger drains. The perimeter collector captures lateral leachate seepage through the upper fractured clay zone at the base of the landfill and prevents it from migrating away from the landfill; it also receives and conveys leachate seepage intercepted by the finger drains from perimeter sideslope areas. Control of potential seepage from the Old Landfill expansion will be provided by the existing and new perimeter leachate collector and an enhanced finger drain system, the design of which is based on the approach proposed by Golder and supported by the peer review by Dr. Kerry Rowe. This proposed design is provided in the Design & Operations report submitted in support of the Waste ECA amendment application for the Ridge Landfill expansion, and in the detailed design report and drawings for Cell O1 of the expansion.
- Neither the perimeter collector nor finger drain system control the height of the leachate mound. As noted above, the height of the leachate mound and the rate at which it rises depends primarily on the hydraulic conductivity of the waste, the annual infiltration and the dimensions of the landfill.
- The potential effect of the leachate mound is related to the downward migration of leachate contaminants into the subsurface groundwater and site compliance with the Reasonable Use Guideline (RUG). The assessment of RUG compliance was completed as part of the EA impact assessment, as documented by Dillon Consulting in their July 9, 2019 memorandum titled Ridge Landfill Contaminant Transport Modelling. This modelling estimated a maximum leachate mounding of approximately 17 metres above the Old Landfill base at the centre of the Old Landfill expansion and concluded that under this mounding height the landfill would meet the requirements of the RUG. It is noted that the leachate mounding at the Old Landfill was measured on February 24, 2017 at a maximum height of approximately 12 metres above base grades, which is approximately 5 metres below the maximum mounding height predicted for the proposed expansion.
- In the peer review by Dr. Kerry Rowe, it was requested that a sensitivity analysis be completed to investigate the possible effects of the hydraulic conductivity of the waste on the leachate mound height, and on RUG compliance. This analysis was completed by Dillon Consulting and reported in their memorandum dated January 7, 2020 that was submitted to the MECP as an attachment to Dr. Kerry Rowe's peer review memorandum as part of the EA approval process. In summary, the analysis found that decreasing the hydraulic conductivity of the waste from the 2×10^{-6} m/s used in the previous analysis to as low as 6×10^{-7} m/s increased the maximum leachate mound height from 17 m to 28 m. Under this range of maximum mound heights, compliance with the RUG was achieved with the time to maximum chloride concentration in the underlying aquifer ranging from 3400 to 2600 years.

The Senior Waste Engineer's comment requests that the leachate mound level should be monitored to ensure that that the finger drains perform as designed, and that a threshold leachate mound level should be established to control leachate mounding and prevent perimeter seepage, together with trigger criteria as part of the contingency plan for the Old Landfill.

As described above, the performance of the finger drains is not affected by the height of the leachate mound within the Old Landfill; the finger drain system has been designed and has sufficient capacity to capture and convey whatever resultant seepage travels to the landfill perimeter. Similarly, the height of the leachate mound is not affected by the performance of the finger drains. In addition, as demonstrated by the contaminant transport modelling, it is not necessary to control the height of the leachate mound to achieve long-term site compliance with the RUG. In the absence of these constraints on site operations and/or performance, in our opinion there is neither a technical basis for nor a need for establishing a threshold leachate mound level that would trigger some form of contingency mitigation measures. However, installation of leachate monitoring wells within the Old Landfill would allow measurement of leachate levels for comparison against predicted levels and for assessing performance of the final cover. For this reason, installation of two leachate level monitoring wells within the Old Landfill will be included in the March 2020 Design & Operations Report (monitoring program section and Drawing 29) submission in support of the Waste ECA amendment application.

As requested by the Senior Waste Reviewer in his response to the Kerry Rowe peer review, a trigger mechanism and contingency plan for the finger drain system has been further elaborated and expanded in Section 17.3 of the March 2020 Design & Operations Report submission in support of the Waste ECA amendment application to include additional details on a proposed trigger and a phased approach to address potential leachate seeps on the sideslopes of the Old Landfill.

We trust that this provides sufficient information on this matter for purposes of responding to the MECP. We would be pleased to provide additional input as required.

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https://golderassociates.sharepoint.com/sites/34627g/technical work/eca applications/2 waste/final submission response to mecp comments/18111331 tm resp to leachate mounding draft 1 2020mar20.docx

Table 4 - MECP Final EA Comments (Waste Comments)

Proposal: Ridge Landfill Expansion Environmental Assessment (EA)
Proponent: Waste Connections of Canada
Date: March 23, 2020

Submitter	Summary of Comments	Proponent's Response	Status **(Rick Li Comments Dated March 23, 2020)**
Senior Waste Engineer, Environmental Permissions Branch	To ensure that the leachate finger drains perform as designed (Appendix 6 – Design and Operations Report, Section 15.2.3) and to prevent excess leachate mounding at the Old Landfill, the leachate level at the Old Landfill should be monitored. However, there are currently no leachate wells within the Old Landfill. Leachate monitoring wells will need to be installed within the Old Landfill. (Appendix 6 – Design and Operations Report, Section 15.2.3).	Waste Connections will address these two comments related to leachate mounding, monitoring, triggers and contingency for the Old Landfill expansion as part of the Waste ECA amendment application process.	OK
Senior Waste Engineer, Environmental Permissions Branch	To control leachate mounding and to prevent seeps at the Old Landfill, it is important to maintain the leachate level lower than a certain threshold level. Therefore, leachate level at the Old Landfill should be one of the trigger criteria. Please develop trigger criteria for the leachate level at the Old Landfill as part of the contingency plan. This may be completed at the ECA stage. (Appendix D6 – Design and Operations	See above response	Leachate mounding at the Old Landfill will need to be controlled. We understand that the underlying thick clay till will provide protection to the groundwater and compliance with RUG, and the perimeter collector and clay cut off wall will control subsurface leachate migration in the weathered clay layer. However, excess leachate mounding will result in leachate break out through the final cover which will impact the surface water, the integrity of final cover, and cause odour problems. In addition, excessive leachate level will flood the gas extraction wells and significantly affect the gas control system. This issue will have to be addressed during ECA application.

TECHNICAL MEMORANDUM

DATE April 2, 2020 **Project No.** 18111331

TO Cathy Smith
Waste Connections of Canada

CC

FROM Fabiano Gondim / Frank Barone **EMAIL fabiano_gondim@golder.com**

RESPONSE TO ADDITIONAL MECP SENIOR WASTE ENGINEER COMMENTS REGARDING LANDFILL GAS AND LEACHATE MOUNDING AND CONTROL, OLD LANDFILL AREA, RIDGE LANDFILL EXPANSION ENVIRONMENTAL ASSESSMENT

Responses to the Ministry of Environment, Conservation and Parks (MECP) March 13, 2020 comments on the final Environmental Assessment (EA) for the expansion of the Ridge Landfill were provided by Waste Connections on March 23, 2020. Also provided was a March 20, 2020 memorandum prepared by Golder to address specific comments provided by the Senior Waste Engineer, Environmental Permissions Branch related to leachate mounding and control for the expansion of the Old Landfill area.

On March 27, 2020 the MECP advised that the Senior Waste Engineer had reviewed the responses to his comments and the Golder memorandum, and additional comments from the Senior Waste Engineer were received. The purpose of this memorandum is to address these additional comments.

1.0 C&D WASTE PROCESSING AT THE RIDGE LANDFILL

The reviewer's additional comment is:

> *Please note if wood chipping and concrete crushing are the main C&D waste stream, it will be reflected in the ECA.*

Response

To address this comment, the following sentence will be provided in Section 5.13.3 of the Updated Design & Operations report: "It is intended that wood and concrete will be the main construction and demolition (C&D) waste stream materials received and processed at the Ridge Landfill. Also, secondary materials to be received and separated for subsequent re-use may be shingles and glass."

2.0 LANDFILL GAS CONTROL IN INTERIM COVERED AREAS OF THE OLD LANDFILL

In the March 23, 2020 response to comments, a rationale was provided to support Waste Connections position that installation of a temporary landfill gas (LFG) control system in the interim covered cells O2, O3 and O4 (over the short period of time until they are sequentially covered with the vertical expansion waste and the proposed LFG well extraction system is installed) will provide very limited environmental benefit and is not warranted. The reviewer's additional comment provided is:

> *Please include the landfill gas generation model to estimate LFG generation rate for the Old Landfill. If it is feasible to collect the gas based on the generation rate, a collection system should be in place. Other than vertical extraction wells, horizontal collectors may be considered for shallow waste.*

Response

In the Design & Operations Report, LFG predictions using LandGEM were provided for both the completed existing approved landfill site (the three disposal areas combined) and for the whole of the proposed expansion (Sub-appendices D6-I and D6-J, respectively) and discussed in Section 8.0. The Old Landfill received waste between 1965 and 1999; as such, the waste in the Old Landfill was placed between 54 and 20 years ago. To prepare this response, the disposal tonnage data from 1965 through 1999 was taken from the Sub-appendices and the LandGEM Model used to predict the LFG generation from only the Old Landfill. The tonnage information and LandGEM LFG predictions are provided on the attached Table 1 and illustrated on the attached Figure 1.

The LFG predictions show that the peak LFG generation at 1,500 cfm happened in 2000, the year after disposal in the Old Landfill was completed. The LFG generation has declined since that time and in the proposed 2021-2027 period for completion of the Old Landfill expansion is predicted to be approximately 650 to 500 cfm (average 575 cfm), or about one-third of the peak generation, and well along on the declining LFG generation curve. Since the expansion will proceed with filling in cell O1, and assuming uniform gas generation over the area of the Old Landfill, there would only be temporary gas collection from cells O2, O3 and O4 or three-quarters of the landfill area, so 375 – 450 cfm (average 430 cfm) of the ongoing generation.

Acknowledging that a landfill gas collection system is not 100 percent effective, the following factors need to be considered in estimating a landfill gas collection efficiency for the existing Old Landfill:

- With reference to the attached Figure 2, the existing leachate mound level in some areas of the Old Landfill is high (about 5 m lower than what is shown on Figure 2 corresponding to about elevation 202 masl), leaving only about 4 to 5 m of unsaturated zone below the existing top surface in some areas from which to temporarily collect LFG. It is also noted that any temporary LFG collection approach would have to be isolated for some distance below the surface to minimize air intrusion, thereby further reducing the thickness of the potential gas capture zone.
- Old Landfill mounds 1 and 2 (i.e., approximately 2/3 of the Old Landfill area) were filled using the trench and fill method, which included vertical soil barriers between trenches. Vertical soil barriers limit the LFG collection efficiency using either horizontal collectors or vertical wells.
- The Old Landfill used a large amount of clay soil as daily cover and some clay stockpiles were buried within the waste according to the landfill operations staff. The presence of this clay, which has a lower hydraulic conductivity than the waste, will further compartmentalize the waste and further reduce LFG collection efficiency.
- The geometric configuration of the Old Landfill (i.e., a large footprint area of approximately 50 ha combined with a shallow unsaturated zone as little as 4 metres below landfill surface) will minimize LFG collection efficiency.

In view of these unfavourable conditions, it is considered that a low temporary LFG collection efficiency in the 20 to 30% range is likely realistic. For temporary LFG collection from all of cells O2, O3 and O4, this would correspond on average to approximately 85 to 130 cfm over the 2021 to 2023 period; then reduce to two-thirds of this when filling commences in cell O2; and reduce again by half when filling commences in cell O3.

This quantitative analysis of LFG generation and potential temporary LFG collection from cells O2, O3 and O4 of the Old Landfill supports Waste Connections' previously stated position that such temporary LFG will provide very limited environmental benefit and is not warranted. However, if gas emissions are observed from the existing surface of areas of the Old Landfill prior to their receiving waste that could result in off-Site odour issues, temporary horizontal LFG collectors will be installed to provide odour control as needed.

3.0 LEACHATE MOUNDING

The March 20, 2020 Golder memo in response to the Senior Waste Engineer's comments regarding the effects of leachate mounding in the Old Landfill provided an explanation as to why there was not a need to set a trigger elevation for the leachate mound level; a proposed trigger mechanism and associated contingency plan to manage potential leachate seepage was provided in the updated January 2020 Design & Operations Report submitted in support of the EA, and more detail has been added in the Design & Operations report to be submitted in support of the Waste ECA amendment application. Waste Connections proposed to install two leachate mounding monitoring wells in the Old Landfill. The Senior Waste Engineer has indicated agreement with this response. The additional comment provided is:

> *Leachate mounding at the Old Landfill will need to be controlled. We understand that the underlying thick clay till will provide protection to the groundwater and compliance with RUG, and the perimeter collector and clay cut off wall will control subsurface leachate migration in the weathered clay layer. However, excess leachate mounding will result in leachate break out through the final cover which will impact the surface water, the integrity of final cover, and cause odour problems. In addition, excessive leachate level will flood the gas extraction wells and significantly affect the gas control system. This issue will have to be addressed during ECA application.*

Response

In response to the comment regarding the need to control the leachate mound in the Old Landfill, the attached Figure 2 has been prepared using Cross-section K-K' on Drawing 5 from the Design & Operations Report to illustrate the position of the maximum predicted leachate mound in relation to the base of the landfill and the proposed final contours of the proposed vertical expansion of the Old Landfill.

The vertical expansion will result in raising the entire landfill by about 28 m on the perimeter 4H:1V sideslopes and to a peak at about 31 m above the highest elevation of the existing central mound. This will result in a total waste thickness of approximately 50 m above the base elevation. Depending on the hydraulic conductivity of the waste, and as previously documented in the January 7, 2020 memorandum from Dillon Consulting, the maximum predicted leachate mound elevation that may eventually occur ranges from 207 to 218 masl as illustrated on Figure 2; this is some 22 to 33 m lower than the finished landfill waste surface elevation of 240 masl. Also shown on Figure 2 is the position/elevation of the proposed finger drains at 25 m spacing around the entire perimeter of the Old Landfill. These finger drains are designed to control the elevation of the leachate mound around the perimeter. Even if the leachate mound in the central portion of the landfill approaches the maximum predicted mound height, the elevation control at the perimeter will be in place and there will still be a substantial thickness (i.e., between 22 m and 33 m) of waste between the mound and the finished landfill waste surface that will remain unsaturated.

As described in Section 13.4.2 of the Design & Operations Report, the landfilling operations will be carried out to minimize the interruption of the downward percolation of infiltrating precipitation, which could otherwise perch leachate above lower permeability clay soil daily cover layers within the fill; in turn, this will reduce the potential for leachate seeps. In this regard, horizontal surfaces of daily and intermediate soil cover will be stripped (or scarified as a minimum) before subsequent landfilling occurs to remove or disturb the cover soils, which will promote hydraulic connection through the entire waste mass.

Considering the conditions depicted on Figure 2 and the above discussion, the basis for the reviewer's comment "*leachate mounding will result in leachate break out through the final cover which will impact the surface water, the integrity of final cover, and cause odour problems. In addition, excessive leachate level will flood the gas extraction wells and significantly affect the gas control system"* is not apparent. It is not considered necessary to control the height of the leachate mound beyond the control provided by the proposed design, neither as part of design nor as a planned contingency. Instead, it is important to provide measures to control the potential effects from leachate mounding, i.e., leachate seeps at the perimeter, in design (finger drains and perimeter leachate collector); to include checking for seeps as part of the regular site inspection program; and to provide a trigger that would result in implementation of appropriate mitigation measures. As an additional measure against potential leachate seeps along the contact between the existing and proposed expansion waste fill emerging on the sideslopes, it is proposed to construct a seepage diversion berm using clay soil along the perimeter of the Old Landfill expansion. The purpose of this berm is to block potential leachate seepage that may be migrating laterally along the existing/new waste interface before it emerges on the surface and cause it to infiltrate and/or direct it to the finger drains. This berm will be constructed as part of the final cover. All of these measures are provided in the Design & Operations Report to be submitted in support of the Waste ECA amendment application for the expansion.

Lastly, in response to the portion of the reviewer's comment regarding effects of the leachate mound on the gas control system, there will be a substantial thickness (i.e., between 22 and 33 m) of unsaturated new waste into which the proposed LFG extraction wells can be installed and from which they can effectively collect LFG generated by the new waste. The maximum depth of LFG extraction wells installed at the Ridge Landfill have been limited to 26.6 m below the top of finished waste because the vacuum will not influence beyond this depth. This maximum LFG extraction well depth is within the expected range of unsaturated depth of between 22 and 33 m. As such, it is not expected that the predicted maximum leachate mound elevation will adversely affect the performance of the proposed vertical well LFG collection system for the Old Landfill.

We trust that this provides sufficient information on this matter for purposes of responding to the MECP. We would be pleased to provide additional input as required.

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https://golderassociates.sharepoint.com/sites/34627g/technical work/mecp comments on final ea/leachate mounding memo/18111331 tm response to addl rick li comments rev 3 final 2020apr2.docx

Attachments Table 1 - Old Landfill LFG Generation
Figure 1 – Old Landfill LFG Generation
Figure 2 – Cross-section through Expanded Old Landfill