Technical Memorandum

To:	Rebecca Jackson	**From:**	Tim Baker
Company:	Otago Regional Council	**SLR Consulting NZ**	
cc:	Samantha Iles	**Date:**	10 November 2023
		Project No.	13556

RE: RM23.185 - Green Island Landfill Groundwater Quantity & Flood Hazard Technical Review

1.0 Introduction

SLR Consulting NZ (SLR) has been engaged by Otago Regional Council (ORC) to conduct a technical review of the resource consent application (including multiple attachments and request for information (RFI) responses submitted by Dunedin City Council (the applicant) for the operation, expansion, and closure of the Green Island Landfill.

Dunedin City Council is proposing to continue to extend the life of the Green Island Landfill to allow acceptance of waste until between December 2029 and March 2031, following which closure operations and landfill aftercare will commence.

2.0 Scope of Review

This review covers Groundwater Quantity and some Flood Risk aspects of the application. A separate memo addresses Groundwater Quality (Lukey, 2023), although as they are interrelated, there is some cross over.

The Groundwater Quantity aspects of the application considered as part of this review this review include:

- Review of the hydrogeological conceptual model to check that it has been developed and is understood adequately and that subsequent effects assessments appropriately address all groundwater related effects.
- Review of the assessment of effects arising from any diversion or take of groundwater resulting from the landfill.
- Review of groundwater / surface water interaction and effects of the any groundwater diversion/take on surface water quantity and wetlands.

Following a review of the Application, a Section 92 Request for Further Information was submitted to the Applicant. This review considers the information presented in the RFI response.

The key documents reviewed were:

- AEE Appendix 3: Waste Futures - Green Island Landfill Closure Design Report
- AEE Appendix 5: Waste Futures - Green Island Landfill Closure Groundwater Technical Assessment
- AEE Appendix 10: Waste Futures - Green Island Landfill Closure Geotechnical Investigation Factual Report

3.0 Response

ORC posed the following questions (in bold) which we respond to in turn below.

Is the technical information provided in support of the application robust, including being clear about uncertainties and any assumptions? Yes, or no. If not, what are the flaws?

In reviewing the geological and hydrogeological conceptual model prepared by the Applicant, I found several areas where there are limitations in the information provided regarding groundwater flow direction and groundwater levels – this propagates to uncertainty in the adequacy of existing monitoring locations. These issues have been discussed with Anna Lukey, author of the Groundwater Quality assessment, and are presented in her report, however for completeness, I summarise them below:

- A fundamental assumption of the hydrogeological model is that the leachate collection trench intercepts <u>all</u> groundwater and prevents offsite migration. While the trench intercepts the more permeable estuarine silts and sands, I disagree that it would prevent offsite migration because trench does not extend to the depth of the Abbotsford Mudstone (basement) and therefore there remains potential for groundwater flow beneath the trench, above the low permeability mudstone.

  The applicant states that upward hydraulic gradients are a form of control on downward and offsite migration (Both Appendix 3 and 5 refer to artesian conditions preventing downward migration of contaminants). However, as I discuss below, there is very limited evidence of upward hydraulic gradients.

- The historical stream diversion, and historical evidence of channels on the estuarine mudflats (beneath the footprint of the landfill) increases the potential for preferential flow paths beneath the landfill (noting it is unlined). It is my view that the monitoring network around the boundary is currently insufficient to adequately represent off-site groundwater discharges.
  - Recommendation: Additional monitoring locations, particularly of deeper groundwater should be added to the network. Locations should include consideration of former estuarine and stream channels. Please refer to Technical Memo of Anna Lukey for more information on the proposed locations of these.

- There is very limited information on groundwater levels and flows beyond the landfill footprint, and because of this no piezometric contour maps of flow direction outside of the landfill has been able to be generated. The Applicant notes that this is due to the lack of private wells around the landfill, which is understandable, but not a reason to limit further investigation or information gathering.
  - Recommendation: All historical monitoring wells on the site should be surveyed in, allowing accurate representation of groundwater flow direction/elevation at the site.
  - Recommendation: the applicant should consider adding to the network of monitoring wells with additional wells at the property boundary around the landfill.

- While the ‘typical monitoring cross-section’ shown on Figure 2.4 (Appendix 5) shows a deep well (labelled D), the D wells actually only exist on Lines 2, 4 and 7 and there a no borelogs available for these wells. This means monitoring of the groundwater in the Lower Kaikorai Estuary Member (LKEM) is limited to those three transects. It is my opinion, that a Deep well should exist on every transect and that they be screen immediately above (they need to tag) the Abbotsford Mudstone layer.

- Recommendation: Addition of a D well to each transect

- There is limited information on hydraulic gradients between the different geological units at the site, or demonstration of the 'artesian' gradient referred to in Appendix 3 and 5.

  The Applicant, in the s92 Response (Question 69) states that the levels recorded in monitoring wells C & D at Transect 2 & 4 indicate an upward hydraulic gradient between from the lower to upper Kaikorai Estuary Member. I remain uncertain whether this is an upward hydraulic gradient, or just a reflection of the drawdown caused by the leachate interception trench. Furthermore, without wells in the Abbotsford Mudstone, there is no knowledge of what, if any, gradient exists between the mudstone and the estuarine deposit.

  - Recommendation: further demonstration of hydraulic gradient between all geological units is required. This assessment needs to ensure that the effects of groundwater drawdown from the trench are considered when making any conclusions. I would be comfortable seeing this work done as part of an adaptive groundwater monitoring plan, should ORC decide to issue consent.
  - Recommendation: Include one or two new wells in the Abbotsford Mudstone to prove hydraulic gradients

Are there any other matters that appear relevant to you that have not been included? Or is additional information needed? Please specify what additional info you require and why [please explain]

Addressed above.

If granted, are there any specific conditions that you recommend should be included in the consent?

With regards to groundwater levels and flow direction, I would request that a Groundwater Monitoring and Contingency Plan is developed and is subject to ORC approval. The plan should include:

- Details of all monitoring well construction (depth, elevation, material, logs)
- A sampling and analysis plan, including the sampling methodology to be followed.
- A plan for the installation of additional boundary wells, and new deep transect wells, including the proposed depths, construction, and timing of installation.
- Other items as addressed in the Groundwater Quality memo.

Has the applicant appropriately assessed the effects of the groundwater take on the hydrological functioning of the nearby Regionally Significant/Natural Wetland?

The assessment of the stream depletion effects resulting from the groundwater take have been assessed using the results of SEEP/W model which predicts inflow into the leachate drain.

The modelling results (presented in Appendix G of the Groundwater report) align relatively well with the observed leachate pumping record and indicate that inflows into the leachate trench are in the order of 1 to 2 L/s (inflow rates are very low).

The relative proportion of flow from each side of the trench was estimated using the model with 70% sourced from the landfill, 30% from the stream. Along the 1674 m trench length, this equates to ~0.5 L/s sourced from the stream side.

As a proportion of the Kaikorai mean flow (368 L/s) and mean annual low flow (81 L/s) the applicant considers this is insignificant and I agree with that conclusion.

Is the SEEP/W 2D groundwater model appropriate for use in this context? Has it been applied appropriately*?*

Two models were used for the assessment:

- The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate rainfall infiltration through the landfill cap
- SEEP/W was then used to estimate groundwater seepage from the landfill into the leachate collection drain. The SEEP/W model used the HELP outputs as the recharge input.

Overall, I consider the application of both models to be appropriate. I have some minor reservations about the consideration of climate change effects in the HELP model rainfall data series, and whether the assumptions around hydraulic gradients across the main geological units are valid. However, overall, the models appear to be a fair representation of long-term leachate/seepage process. The validation of the model outputs to measured abstraction rates supports the validity of the models, although the ability of the model to represent storm conditions is poor (leachate pumping rates following rainfall are 7-9 L/s, compared to 1-2 L/s under normal conditions).

I questioned whether the predicted 10% increase in rainfall for the Otago region had been considered in the HELP modelling. The Applicants response (Q70) suggests that it was, however, it is still not clear to me that the stochastic modelling input does consider this. I believe the stochastic rainfall model considered current variability (which would include >10% variability from the mean), but it does not account for a 10% increase in overall average rainfall.

The SEEP/W modelling did consider the effects of sea level rise on the inflow into the leachate trench (Scenario 2C). Across all scenarios, there was negligible change in inflows between scenarios. I have no reason to disagree with the results presented, however recommend that the modelling outputs, and inherent uncertainty, are validated though a robust long-term monitoring programme of groundwater levels and leachate trench outflow rates.

Have the cumulative effects of the activity been appropriately assessed?

With regards to groundwater abstraction from the leachate trench, I do not consider there to be any cumulative effects because the long-term abstraction volumes are very small compared to surface water flows, the tidal influence on estuary levels, and likely regional groundwater flows.

Have the effects of the defence against water been adequately assessed including:

- ***effects on existing defences?***
- ***Correctly identified any diversion or secondary flow paths because of the defence/ alteration to the defence?***

The land adjacent to the landfill is low lying between 1.5 and 2.0 m msl. It is situated within a flood plain and is subject to a moderate risk of flooding from storm surge and fluvial flooding in the Kakorai Stream.

The Design Report (Appendix 3) indicates that estimates that flood flows will increase by approximately 9% by 2050. The report concludes that '*this would be expected to increase flood levels by between 60 -100 mm and will not significantly impact the flooding extent in the area of the landfill or day-to-day operations*'. I agree with this.

Sea level rise is assessed to increase estuary water levels by 0.25 to 0.5 m. The planned response to this risk is to raise the level of the perimeter road berm that runs around the landfill between the adjacent Kaikorai Stream and leachate trench by approximately 1.0m to minimise the risk of inundation by surface waters.

Raising the perimeter road (stop bank) may reduce the cross-sectional area of the floodplain, and result in higher flood levels as the same (or greater with climate change) amount of water must flow through a smaller area. However, it is important to note that in this case, that only a very small part of the flood plain area sites on the landward side of the existing stop bank. Furthermore, it is my understanding that the proposed increase is of an existing stop bank (road) and therefore does not change any existing stormwater flow paths.

A part of the s92 request (q76), an assessment on the change in flood levels because of the increase stop bank height was carried out. This assessment was done using a simple analytical approach (not a model) and indicated the change in flood level height to be in the order of 3 to 4 cm. I consider this negligible.

4.0 Closure

In summary, the application with regards to groundwater quantity and flood risk covers the broad considerations but there remain some gaps in knowledge that need to be addressed, potentially via the use of detailed and adaptive management plans.

Regards,

SLR Consulting NZ

Tim Baker
Principal Hydrogeologist

Anna Lukey (Reviewer), CEnvP SC
Principal Environmental Consultant

cc Samantha Iles