BEFORE A HEARINGS PANEL APPOINTED BY THE OTAGO REGIONAL COUNCIL

IN THE MATTER OF	the Resource Management Act 1991 ("the Act" or "the RMA")
AND	
IN THE MATTER OF	An application RM23.185 by Dunedin City Council for the continued operation and closure of the Green Island Landfill, Dunedin

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STATEMENT OF EVIDENCE OF TIMOTHY MICHAEL BAKER ON BEHALF OF OTAGO REGIONAL COUNCIL

21 February 2025

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1. INTRODUCTION

1.1 My full name is Timothy Michael Baker.

1.2 I am employed by SLR Consulting New Zealand Limited (SLR Consulting) as a Principal Consultant – Hydrogeology, based in Wellington.

1.3 I have read the Code of Conduct for Expert Witnesses in giving evidence to the Environment Court. I agree to comply with that code when giving evidence to the Hearing Panel in this matter. All my evidence is within my expertise, and I have considered and stated all material facts known to me which might alter or qualify the opinions I express

2. QUALIFICATIONS

2.1 I hold a Bachelor of Science (BSc) in Geography and Environmental Science (2000) and a Master of Science Degree with Honours in Physical Geography (2004) from Victoria University of Wellington.

2.2 I have over 20 years' experience in the field of hydrogeology, water resources and discharges to land. I have been in consultancy for 15 years both in NZ and UK, and prior to that held the role of Groundwater Scientist at Greater Wellington Regional Council from 2003-2007.

2.3 I am a member of the Hydrological Society of New Zealand and am certified as RMA decision maker through the Making Good Decisions Programme (2023).

2.4 I have acted as an Expert Witness in groundwater and environmental discharge related consent hearings in New Zealand for the past ten years. I have provided expertise in the fields of hydrogeology, groundwater quality and environmental monitoring plan design to a range of local and central Government clients including the Department of Conservation and regional councils across New Zealand.

2.5 Of relevance to this hearing is my involvement and/or experience in:

(a) The Application RM24.143 by Dunedin City Council to establish and operate a resource recovery park. I provided a review of groundwater aspects and provided evidence for the hearing.

(b) The ORC review of the application by Waste Management New Zealand to reconsent the Fairfield closed landfill (adjacent to Green Island).

(c) The provision of expert evidence on groundwater on behalf of Waikato Regional Council for the Waste Management New Zealand application to construct a second landfill cell at the Tirohia Landfill, Waikato.

(d) My role as technical lead for the KCDC closed landfill programme, which involved compliance monitoring, investigation and management of off-site migration of leachate and reconsenting of three closed landfills.

(e) My role in preparing the Groundwater Assessment and Hearing evidence for the expansion of the AB Lime Landfill in Winton, Southland.

3. ENGAGEMENT AND SCOPE OF EVIDIENCE

3.1 In December 2022 I was engaged by Otago Regional Council (ORC) to undertake a technical review of groundwater quantity and flood risk aspects of the submitted application documents provided by Dunedin City Council (DCC) for the Green Island Landfill (GIL). Subsequently, I have also been asked to consider groundwater quality, which was originally reviewed by my colleague Anna Lukey.

3.2 I have visited the site on two occasions, most recently on 4th February 2025. I am familiar with the site layout, and surrounding environment.

3.3 In preparing this evidence I have reviewed the following documents

(a) Boffa Miskell Limited, Green Island Landfill Closure, Assessment of Environmental Effects, March 2023 (Updated October 2024). Referred to herein as the 2024 AEE.

(b) GHD Limited, Green Island Landfill Interim Human Health and Environmental Risk Assessment, Dated 20 June 2024. Referred to herein as the HHERA.

(c) GHD Limited, Waste Futures – Green Island Landfill Closure Groundwater Technical Assessment – October 2024 Update, Dated 18 July 2024. Referred to herein as the 2024 GW Report.

(d) GHD Limited, Waste Futures – Green Island Landfill Closure Surface Water Report – October 2024 Update, Dated 18 July 2024. Referred to herein as the 2024 SW Report.

(e) Dateless excel file without letter head with eleven worksheets with filename “MASTER_RM23.185 GILF RFI Jan 2024-Tranche5-6.xlsx” provided to

SLR by Shay McDonald of ORC on 10 October 2024. Referred to herein as DCC Comments Response Spreadsheet.

(f) Dateless PDF document without letter head titled “Green Island Landfill Closure – Draft ORC Conditions of Consent” provided to SLR by Shay McDonald of ORC on 10 October 2024. Referred to herein as Existing Consent Conditions.

4. PROPOSED ACTIVITIES AS THEY RELATE TO GROUNDWATER & FLOODING

4.1 DCC is seeking consent to extend the operational lifetime of the GIL through until 2029/2030 at which time the newly consented Smooth Hill Landfill should be operational and is seeking consent for the GIL closure.

4.2 The following activities associated with the resource consent have the potential to affect groundwater and/or flooding:

(a) Discharge of waste, hazardous waste, and leachate onto land that may result in contaminants entering groundwater

(b) Take of groundwater from the Kaikorai Stream through a leachate collection trench and take of groundwater and leachate from groundwater bores

(c) Diversion of surface water in the Kaikorai Stream and Brighton Road Stream related to the construction of new flood defences

(d) Placement of a defence against water along the Kaikorai Stream for the purpose of diverting of floodwaters

5. SITE CONCEPTUALISATION

5.1 A comprehensive description of the site history, geology and hydrogeology is presented in the 2024 GW Report. I generally agree with the way in which the site has been conceptualised. For completeness, the main conceptualisation is summarised below:

(a) The landfill is an unlined landfill, in use since the mid-1950s.

(b) The pre-landfill landform was tidal estuary, part of the present-day Kaikorai Estuary. Historical imagery of the landfill footprint shows a series of channels flowing east to west beneath where the landfill is now present on

the estuary. Waste was placed directly on these estuarine deposits, and historical channel features.

(c) The estuarine deposits have been characterised as the Kaikorai Estuary Formation (KEF) which are further characterised into the Upper (4.5m thick) and Lower (6.5m thick) Kaikorai Estuary Members (UKEM & LKEM).

(d) Beneath the KEF and present as a ridge to the southeast of the site, is the Abbotsford Formation sequence. This is a grey to dark grey sandstone, siltstone and claystone (mudstone), overlain by colluvium and loess. Because of the low permeability of this formation, the mudstone is considered to act a groundwater boundary both beneath the Estuary and to the southeast of the site.

(e) Leachate generated within the landfill flows radially from the apex of the landfill, toward the Kaikorai Stream & estuary. Because the landfill is unlined, it mixes with and becomes indistinguishable from groundwater.

(f) To control leachate and groundwater flowing from the landfill, a leachate trench, which extends for most (though not all) of the perimeter, was installed in 1994 and commissioned in 1995. The leachate collection system comprises the gravel interception trench with an HDPE liner on the outside. The trench is typically 2 m deep and terminated in the UKEM. Leachate drains under gravity to pump stations, from where leachate is pumped into a rising main and ultimately to the wastewater treatment plant.

(g) Conceptually, the Applicant considers that the trench creates a hydraulic barrier to groundwater and leachate migration offsite. The HDPE liner is stated to reduce the volume of water entering the trench from the Kaikorai Stream, but it is acknowledged in the 2024 GW Report that it does not completely prevent inflows. Continuous dewatering of the trench is required to maintain this barrier. The purpose of the continuous dewatering is to create hydraulic gradient toward the base of the trench and prevent flow beyond the trench.

(h) The 2024 GW Report also states that an additional control of the migration of leachate is the presence of upward hydraulic gradients from the lower to upper KEM formations. Upward hydraulic gradients mean that groundwater is typically flowing upwards through the estuarine sediments toward shallower strata or the surface, rather than downward.

(i) The landfill is progressively being capped with low permeability material. Capping reduces the volumes of leachate being generated and this appears to be evident in the long-term record of leachate trench pumping volumes, that are reducing over time (Figure 2.6 of the 2024 GW Report).

6. CURRENT GROUNDWATER MONITORING

6.1 A network of monitoring wells around the perimeter of the landfill is used to monitor the quality of groundwater on both sides of the leachate trench. Figure 1 (**Attachment A)** is a plan of these wells and is also referred to later in my evidence.

6.2 There are 8 lines of monitoring wells across the leachate trench, with the wells labelled ‘A’ and ‘B’ being between the landfill and the trench, and wells ‘C’ and where present, ‘D’, being outside of the trench.

6.3 Figure 2 (**Attachment A**) is from the 2024 GW Report and shows the typical cross section and is replicated below. Noting the ‘D’ wells, which are the deep wells, are only present on lines 2, 4 and 7.

6.4 The intent of the C and D wells is to monitor groundwater moving beyond the landfill boundary and toward Kaikorai Stream/Estuary. However, as discussed in the next section, I have some concerns over the spatial coverage of these wells, and the fact that the deeper D wells are only present at some locations.

6.5 Groundwater quality is monitored on a quarterly basis in accordance with the consenting conditions, and results are reported in an annual monitoring report. The Applicant concludes that:

(a) The monitoring wells inside the leachate trench (A and B series) are likely to be impacted by leachate

(b) There are areas of the site where waste is likely present outside of the trench and leachate indicators are detected in the C series monitoring wells. The impacted wells are 8C, 7C, 6C, 4C, and 3C.

(c) Typical leachate indicators are present in some deep wells, namely Ammoniacal-nitrogen (2D, 4D), Boron (7D, 4D and 2D), arsenic (7D) and iron (2D). Furthermore, PFAS compounds have been detected in C and D wells (i.e. outside of the leachate trench) including deep wells 2D, 4D and 7D.

7. ASSESSMENT OF EFFECTS – GROUNDWATER

EFFECTS ON THE ESTUARY (QUALITY)

7.1 Fundamental to managing the effects of the landfill is the minimisation and control of leachate. This is discussed in the evidence of my colleague Mr James Elliot.

7.2 Ground is the primary pathway for leachate to migrate into the Estuary. I have not assessed the effects of any leachate on the estuary, that is addressed in the evidence of my colleague Dr Peter Wilson.

7.3 The groundwater level data measured by DCC shows that groundwater flows from the landfill toward the estuary, and therefore there is the potential for leachate contaminated groundwater to migrate under the estuary, and potentially surface and impact surface water.

7.4 While the leachate trench appears to function and likely intercepts a reasonable proportion of the shallow groundwater flow, I believe that there is still potential for groundwater to migrate deeper and flow below the trench, but above the underlying Abbotsford Mudstone formation.

7.5 Ideally, there would be monitoring of the base of the LKEM formation where it contacts the Abbotsford formation. This would give confidence that and groundwater moving deeper is being monitored. Unfortunately, there are no borelogs available for the deep wells, so it is not known whether they are sufficiently deep enough (and what the depth of the Abbotsford formation is at each location).

7.6 Furthermore, the absence of deep wells along key downgradient transects (there are only Deep wells on lines 2, 4 and 7) means there are large gaps in the spatial coverage of deep groundwater monitoring.

7.7 As discussed in my earlier technical memorandums, it is my recommendation that additional monitoring locations, particularly of deeper groundwater should be added to the network. The 2024 revision of the Groundwater Report included the addition of BH103 to the network. This well is screened in the LKEM with the bottom of the filter pack at 11 m below ground level. The mudstone was tagged at 12 m bgl. I support the addition of BH103 to the network.

7.8 In my 2024 technical memorandum, I recommended further deep wells added, at a minimum, to monitoring lines 1 and 3, and a new clustered well closer to the

estuary. This would provide a continuous network of deeper wells around the 'down-gradient' side of the landfill.

7.9 Following discussion onsite with Stephen Douglass of GHD (acting for the Applicant) we agreed that a good location for the new clustered bore would be at the end of the causeway between the two southern stormwater ponds. I have marked this location with a star on the Figure 1 (**Attachment A)**. Thise site would ideally include wells screened in the UKEM, LKEM and the Abbotsford mudstone.

7.10 In my opinion, the need for the additional monitoring wells is also justified by the groundwater chemistry observed in some of the deeper wells (discussed above in **paragraph 6.5**). The presence of leachate indicators warrants continued monitoring, and adding new wells to the gaps in spatial coverage will provide a more robust monitoring network through the closure period.

7.11 It is suggested in the 2024 GW Report that the naturally low oxygen and reduced conditions in the estuarine sediments could be the reason for the elevated ammoniacal nitrogen and iron, and that the presence of boron and elevated chloride reflect the marine influence. I agree that these are potential explanations, however the presence of arsenic and PFAS compounds does suggest an anthropogenic influence on groundwater at these locations. Furthermore, I also note that the chemistry observed in wells downgradient of the adjacent Fairfield landfill (across the estuary) is very similar and has been attributed to landfill leachate.

7.12 Given this uncertainty in the origin of leachate indicators in groundwater, ongoing and routine monitoring is required, including in the new wells discussed above.

7.13 One change I would recommend to the proposed sampling and analysis plan (Table 5.1 of the 2024 GW Report) would be to include dissolved metals into the quarterly suite, rather than annual. I consider the inclusion of metals, particularly of zinc and arsenic, would be helpful in providing more confidence over the source of the leachate indicators in groundwater.

EFFECTS ON NEIGHBOURING GROUNDWATER USERS (QUALITY & GROUNDWATER TAKE)

7.14 The site is not within a Groundwater Protection Zone so there are no effects on public water supplies.

7.15 A total of 49 bores were identified within the area of interest. The updated 2024 GW Report assessed the effects of the landfill on these neighbouring groundwater users and I am satisfied that the effects are now adequately addressed (it will have negligible, and potentially no, effects on neighbouring groundwater users).

EFFECTS OF THE GROUNDWATER TAKE ON THE HYDROLOGICAL FUNCTIONING OF THE WETLAND/STREAM

7.16 The 2024 GW Report includes an assessment of the stream depletion effects resulting from the taking of groundwater from leachate trench based on the results of SEEP/W model which predicts inflow into the leachate drain.

7.17 The modelling results (presented in Appendix G of the GW 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).

7.18 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.

7.19 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.

CUMULATIVE EFFECTS

7.20 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.

8. ASSESSMENT OF EFFECTS - FLOODING.

8.1 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.

8.2 The 2023 Design Report indicates that estimates that flood flows will increase by approximately 9% by 2050 due to climatic changes. 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.

8.3 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 1.0 m to minimise the risk of inundation by surface waters.

8.4 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 sits 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.

8.5 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 3.0 to 4.0 cm. I consider this negligible.

9. SUBMISSIONS

9.1 I have reviewed the four submissions received on the application. My comments on points relevant to groundwater and or flooding are below.

9.2 The submission from **Te Rūnanga o Ōtakou** raises the following concerns:

(a) That all possible measures are taken to preventing leachate from entering groundwater

(b) Whether the monitoring network is adequate, and

(c) Whether elevated levels of ammoniacal-nitrogen, boron, and zinc (all leachate indicators) are attributable to natural estuarine conditions, or another source.

9.3 I have the same concerns and have addressed all of these issues in my evidence above so will not repeat them here.

9.4 The submission from **Otago Fish & Game** raises the following concerns in relation to groundwater:

(a) They seek clarification on the effectiveness of the leachate trench in preventing the off-site migration of leachate

(b) They request the leachate head within the landfill is lowered

(c) They request that monitoring protocols are enhanced to assess off-site leachate migration in groundwater

(d) And they support the inclusion of additional monitoring wells to improve monitoring coverage

9.5 Again, I believe all of Fish and Games concerns have been addressed in my evidence above so I will not add any further discussion.

10. CONDITIONS

10.1 The key consent conditions relating to groundwater are those regarding ongoing monitoring. These are detailed in the section titled 'Groundwater and Surface Water Monitoring' [from condition 38].

10.2 In general, I agree with the groundwater monitoring conditions with the following exceptions.

10.3 Condition 38 refers to the monitoring well location map. I would like the new wells discussed in my paragraphs 7.6-7.8 added to the map (that is the new clustered well, 1D and 3D). These wells should be installed as soon as practicable following granting of consent and be incorporated into the monitoring programme immediately upon completion of installation.

10.4 Condition 40 requires annual monitoring of dissolved metals and boron. I consider these should be quarterly to assist with providing more confidence over the source of the leachate indicators in groundwater. This also aligns with the recommendations made by my colleague Dr Wilson in his surface water evidence.

10.5 Condition 43 states that the results of the monitoring of C& D wells will be compared to historical data obtained from previous annual monitoring. In my opinion this condition should be more explicit about how the monitoring data will be compared to historical data, with a focus on identifying changes in groundwater quality following each round of sampling. I recommend:

(a) That new triggers are established using monitoring results from the most recent five years. This could be, for example, the mean of the past five years, plus or minus two standard deviations

(b) That the comparison to historical data includes a trend analysis and assessment of statistical significance.

(c) For wells with less than 3 years of historical data, the derivation of triggers can be delayed until completion of the HHRA revision in 3 years' time.

10.6 I am supportive of conditions 49 – 51 which now provide clear guidance on the actions to be taken if groundwater parameters change or are attributable to effects on surface water quality.

10.7 I am also supportive of the inclusion of Condition 52 which requires the update of the HHRA after 3 years of monitoring. This will ensure that results from any of the new monitoring wells will be assessed and effects considered.

11. CONCLUSIONS

11.1 The application proposes to continue the landfill operations at the GIL until the Smooth Hill Landing landfill is in operation. At this point closure of the landfill will commence. Leachate will continue to be generated within the landfill post closure, and given the unlined nature of the landfill will continue to pose a risk to groundwater, and the Kaikiorai Estuary for many decades to come.

11.2 With regards to groundwater, my primary concerns are related to ensuring that the main groundwater pathways are monitored, this requires additional monitoring of deeper groundwater (the LKEM and Abbotsford mudstone), and of areas where historical imagery indicates the presence of former stream channels beneath the landfill. I have made recommendations for new wells to address these concerns.

11.3 There also remains some uncertainty over the source of some chemical constituents measured around the landfill. Some of these are typical leachate indicators, but the anoxic conditions present beneath the estuary may contribute to their presence. Increasing the frequency of monitoring of these metals and boron should help with identification of the source and will be beneficial for the required revision of the HHRA in 3 years' time.

11.4 Minor changes to flood level across the estuary have been predicted because of the proposed raising of the perimeter road, however the effects of the flood height

changes are considered negligible as they are in the order of centimetres. Furthermore, the benefits of raising the road with respect to improving the resilience of the leachate drain network are significant and required for long term landfill management.

Timothy Baker

21 February 2025

Appendices Appendix A: Figures

Appendix A

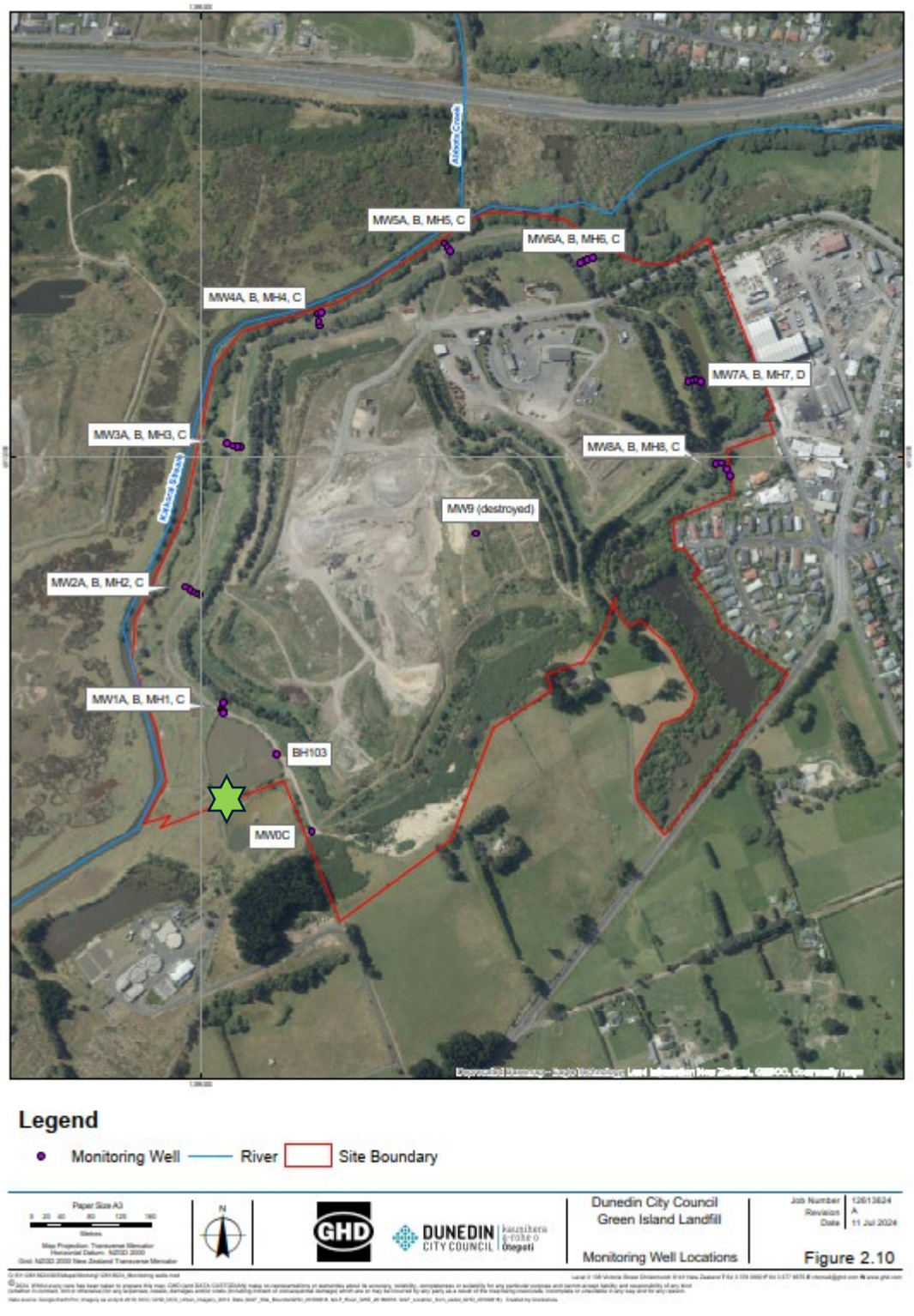
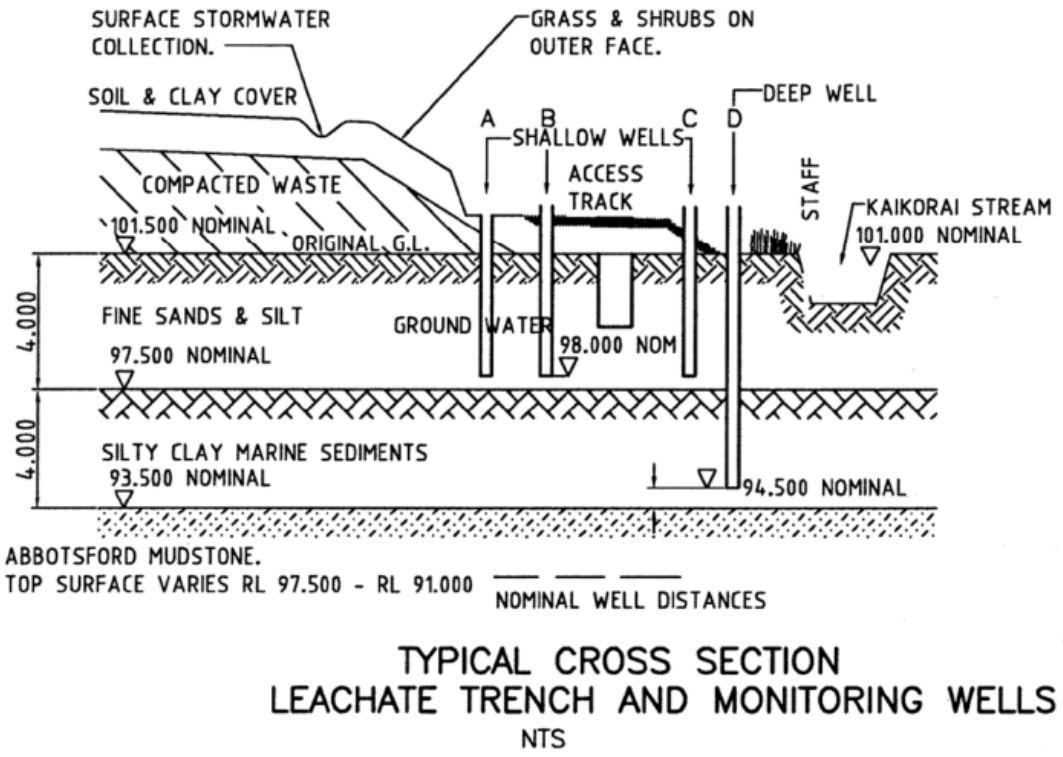


Figure 1: Monitoring Well Location including proposed new multi-depth well location.



TYPICAL CROSS SECTION
LEACHATE TRENCH AND MONITORING WELLS
NTS

Figure 2: Typical Leachate Trench Cross Section