# Appendix K Hydrogeology

# Technical Memorandum

| | | | |
|---|---|---|---|
| **Subject:** | ARL Transition Project - Hydrogeological Assessment | **Reference No:** | 1092369.6000-HYD-v0.3 |
| **Author:** | Leon Pemberton | **Date:** | 14 November 2025 |

## 1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by WM New Zealand (WMNZ) to provide technical assessments to understand the effects from a proposal to reconsent Redvale Landfill, north of Auckland.

Redvale Landfill is currently scheduled to cease accepting waste in December 2028 and due to a delay in the authorisation and establishment of the replacement Auckland Regional Landfill (ARL) a transition plan is required. The proposal is to continue sending the current residual waste (around 600,000 tonnes per year) to Redvale Landfill, beyond the existing consent limit of December 2028. This would require new resource consents at Redvale Landfill.

To accommodate the on-going placement of waste at Redvale Landfill beyond 2028, the proposed works will involve the following:

- **Revised final surface profile of the existing landfill:** The current final design landfill ground profile varies but is less than 1V:3H across the footprint. That ground profile will be steepened up to a maximum grade of 1V:3H, to allow placement of additional waste within the existing landfill footprint. Bunds, varying in height between 2 and 6 m, will be constructed along the eastern and southern boundaries to accommodate the required additional waste volumes.
- **Class 2 extension:** The landfill is proposed to be extended to the south-west of the current landfill boundary, within the area currently occupied by the of the now decommissioned Managed Fill and Pond 6. The extension will comprise the excavation and lining of a new landfill cell, allowing the acceptance of waste that meets the Class 2 waste acceptance criteria, which will be constructed in a manner similar to the already constructed cells within the current landfill.
- **Relocation of ancillary activities:** the relocation of ancillary activities to allow for the placement of waste.
- **Sediment Retention Ponds:** The removal and filling in of Sediment Retention Pond 6 and the Office Pond while enlarging Pond 1 to capture and treat the stormwater from these catchments.

This technical memorandum provides an outline of the initial findings of the Hydrogeological Assessment and has been prepared for inclusion in an application for Ministerial referral of the project under the Fast-track Approvals Act 2024. Specifically, this technical memorandum responds to the requirements under section 3.4 of the Fast-track Approvals Referral Application Form. A full description of the draft proposal is included in the accompanying information attached to the application form for the referral.

## 2 Summary of findings

The Hydrogeological Assessment has drawn on over two decades of groundwater and leachate monitoring data, historical hydrogeological reports and recent field investigations. It also incorporates analytical modelling to evaluate the potential effects of the proposed extension of landfill operations, specifically the revised final surface profile and the Class 2 footprint extension, on groundwater systems and nearby surface water bodies.

The findings confirm that the potential effects on groundwater quantity, quality, and regional groundwater users as a result of the proposed works are likely to be negligible. Groundwater take during construction of the Class 2 extension is expected to be minor and temporary, with inflow rates ranging from 11 to 35 $m^3$/day and a maximum radius of influence of up to 100 m, confined within WMNZ landholdings. Post-construction, groundwater levels are expected to recover, and any long-term diversion through the liner is considered negligible.

A leachate flux assessment undertaken to assess effects of high leachate levels in the southeast corner of the existing landfill (Phase 1) indicates the potential for discharge of leachate to ground soakage is well below the daily discharge limit of 0.3 $m^3$/day. Contaminant fate and transport modelling[1] for the existing landfill indicates that, even under conservative assumptions and worst-case scenarios, contaminant concentrations from potential leachate seepage remain well below ecological and irrigation guideline values. The modelling confirms that the Rangitopuni Stream, the nearest downgradient receptor, is unlikely to be affected.

For the Class 2 extension, the application of WAC largely adopted from national technical guidelines are considered protective of both ecological and irrigation receptors, thereby negating the need for further modelling.

This assessment shows that the proposed works will not measurably impact stream baseflow or cause saline intrusion, given the site's inland location and elevated groundwater levels. Proposed mitigation measures, including engineered lining systems, leachate collection systems, and a targeted groundwater monitoring programme, are appropriate to ensure continued protection of groundwater and surface water resources. Overall, the Hydrogeological Assessment supports the conclusion that the proposed landfill extension can be implemented with negligible adverse effects on groundwater systems.

## 3 Assessment methodology

The methodology to inform the assessment to date has been desktop-based, utilising the long-term groundwater quality and level data along with the leachate quality and level data.

The following desktop-based tasks have been undertaken to inform the assessment:

- Review of historical reporting relevant to the groundwater system and fate and transport of contaminants.
- Review of recent field investigations completed by T+T, with specific reference to vibrating wire piezometers (VWPs) and the ongoing groundwater level monitoring.
- Processing and analysing groundwater level data to develop representative groundwater level contours.
- Processing and analysing groundwater and leachate quality data.
- Developing the conceptual hydrogeological model, including aquifer parameters for fate and transport modelling and assessing effects on groundwater.

[1] Fate and transport modelling is a way to predict how contaminants (i.e., leachate derived contaminants) move through soil and water over time, helping to understand where they go and how long they might stay in the environment.

Modelling that has been undertaken to inform this assessment has been analytical and has included:

- Leachate flux modelling to calculate the discharge of leachate from the existing landfill to ground soakage.
- Analytical contaminant fate and transport modelling using proprietary software to predict potential impacts on sensitive receptors downgradient of the landfill.
- Analytical element modelling using Anaqsim software[2] to predict groundwater inflows during the construction of the Class 2 extension in relation to the temporary take and diversion of groundwater.

## 4 Site and project context

A general description of the site and surrounding locality is included in the accompanying information as part of the referral application. The following elements of the site and project are key to the Hydrogeological Assessment:

- The extensive groundwater monitoring network around the perimeter of the landfill and Class 2 extension consisting of standpipe piezometers and vibrating wire piezometers. The network is illustrated on Figure 4.1.
- The long-term water quality monitoring data that has been collected from a range of monitoring locations over 20+ years.
- The long-term leachate quality monitoring data also collected over 20+ years.
- The leachate level monitoring locations in the south eastern corner and the leachate collection system.
- The location of the surrounding surface water bodies, in particular the nearest receiving environment, the Rangitopuni Stream.
- The low hydraulic conductivity values associated with the underlying mudstone of the Northland Allochthon.
- The design of the Class 2 extension, including the lining system, leachate collection system, the footprint and depth, as described in the Landfill Engineering Memo.

[2] Anaqsim - Meshless Groundwater Simulator for Engineers

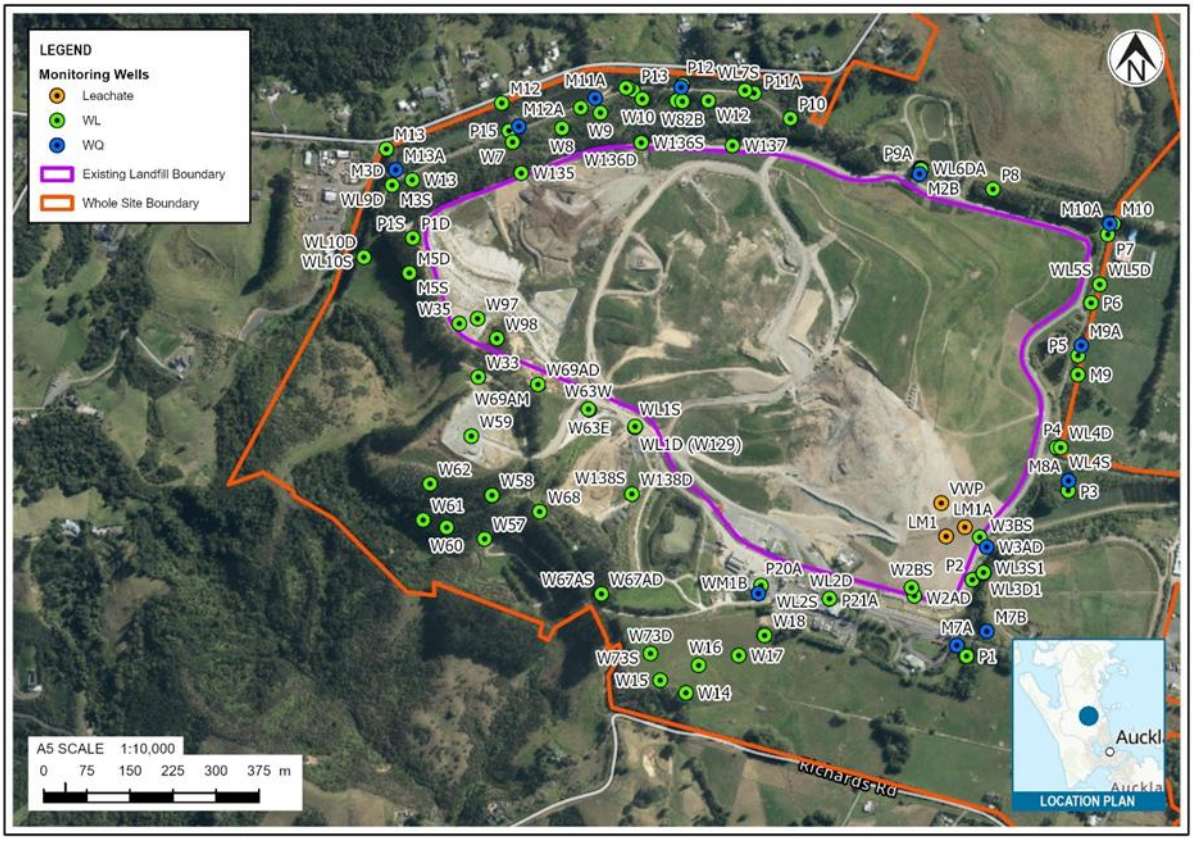


*Figure 4.1: Groundwater monitoring well network around Redvale Landfill.*

# 5 Assessment of potential effects on groundwater

Based on the proposal and the information available, an assessment of potential effects on groundwater has been undertaken and is summarised below.

## 5.1 Groundwater take and diversion for the Class 2 extension

The excavation of the Class 2 extension is expected to reach up to 16 m below the groundwater table,[3] requiring temporary subsoil drains to manage groundwater inflow and reduce uplift pressures on the liner. These drains will divert groundwater to the landfill's stormwater system and will be sealed once sufficient waste has been placed on the liner to resist uplift.

Groundwater modelling using Anaqsim[2], estimates inflow rates ranging from 11 to 35 m³/day over a six-month period, with a maximum radius of influence of approximately 80 to 100 m. The drawdown effects are predicted to be confined within WMNZ landholdings, with no adverse impacts on neighbouring properties. Post-construction, groundwater levels are expected to recover to pre-construction static levels after the subsoil drains are decommissioned, and any long-term diversion through the liner is likely to be minimal and localised to the Class 2 extension footprint, within WMNZ's landholdings.

## 5.2 Effects on regional groundwater resources and users

The effects on the regional groundwater resources and users relate specifically to the Class 2 extension because the construction of a new low permeability lining system will affect rainfall

[3] The groundwater table is the depth below the surface where pore spaces in soil and rock are completely filled with water, i.e., fully saturated. It marks the boundary between the unsaturated zone above and the saturated zone below.

recharge to groundwater. The Class 1 footprint has not been considered because its lateral extents remain unchanged.

The effects on the regional and local groundwater quantity and neighbouring groundwater users are described in the following sub-sections.

### 5.2.1 Effects on regional groundwater quantity

The groundwater inflow analysis estimates that, during the first year of dewatering activities, the maximum groundwater take could be approximately 11,900 m³. This is expected to reduce to around 6,935 m³ per year under steady-state conditions. This take is considered temporary and conservative, as they are based on modelling scenarios that reflect seasonal high groundwater levels and the range of hydraulic conductivity values in the Rangitopuni Waitemata sub-aquifer zone. Importantly, there is sufficient groundwater allocation available in the sub-aquifer zone, and the proposed take would have a negligible impact on the regional groundwater resource.

### 5.2.2 Effects on local groundwater catchment quantity

Our Hydrogeological Assessment distinguishes between temporary dewatering impacts on the local groundwater catchment during construction and the longer-term post-construction effects.

During temporary dewatering, groundwater will be diverted via subsoil drains installed beneath the excavation to control uplift pressures and manage groundwater inflow. The estimated groundwater take during this phase is approximately 11,900 m³ in the first year, reducing to around 6,935 m³/year under steady-state conditions. Given that the estimated groundwater resource in the local catchment is approximately 3,724,000 m³/year, this temporary take represents a very small fraction of the available resource. Consequently, the effect on the local groundwater catchment quantity during dewatering has been assessed as negligible.

Post-dewatering, once the subsoil drains are sealed and the Class 2 landfill cell is operational, rainfall recharge over the footprint extension area will be reduced. Additionally, there is a conservative assumption that some groundwater may migrate through the liner and be diverted to the leachate collection system. This could result in a long-term reduction of up to approximately 6,935 m³/year in groundwater availability. However, this equates to only a 0.4% reduction in the total local groundwater resource, which is also considered negligible. Thus, both temporary and long-term effects on the local groundwater catchment are minimal and unlikely to impact groundwater availability.

## 5.3 Surface water and stream depletion effects

Surface water and stream depletion effects have been assessed specifically in relation to the Class 2 extension. The Hydrogeological Assessment concludes that the proposed Class 2 extension is unlikely to cause any measurable effects on surface water or stream depletion. Although shallow groundwater in the area naturally discharges to the Rangitopuni Stream, modelling indicates that the influence of dewatering activities during excavation will be limited to a radius of approximately 100 m from the edge of the excavation, well short of the stream itself.

Additionally, while the Class 2 extension will slightly reduce the area available for rainfall recharge and may divert a small volume of groundwater, this reduction is estimated to be only 0.4% of the local groundwater catchment. This minimal change is considered negligible and unlikely to impact the existing groundwater baseflow to the Rangitopuni Stream.

## 5.4 Potential for saline intrusion

The site is located approximately 7 km inland from the coast, with groundwater levels measured at around 49 m relative to sea level. Applying the Ghyben-Herzberg relation,[4] the depth of the saline interface is estimated to be approximately 1,900 m below sea level. Based on this assessment, saline intrusion is not considered to pose a risk to groundwater quality at the site.

## 5.5 Discharge of contaminants to ground and groundwater

### 5.5.1 Extension of existing landfill operations

The Hydrogeological Assessment presents the findings of a leachate flux assessment and a comprehensive fate and transport modelling assessment for the existing Redvale Landfill, focusing on the potential environmental effects of leachate seepage through the landfill lining system.

#### 5.5.1.1 Leachate flux assessment

A leachate flux assessment to evaluate high leachate levels in the southeast corner of the existing landfill (Phase 1) has been undertaken to calculate the potential for the discharge of leachate from the landfill to ground soakage. The total outward leachate flux was calculated to be approximately 1.5 $m^3$/year (or 0.004 $m^3$/day). This is well below the consented limit of 0.3 $m^3$/day (refer condition 80).

#### 5.5.1.2 Contaminant fate and transport modelling

The contaminant fate and transport modelling builds on previous assessments from 2013 and 2017 and incorporates updated site-specific data, including hydrogeological parameters, leachate quality, and receptor characteristics. The modelling approach is analytical, using the RBCA (Risk-Based Corrective Action) software[5], which applies the Domenico solution for multi-dimensional contaminant transport. This method accounts for advection, dispersion, adsorption, and degradation processes, and includes mixing with surface water at the point of exposure.

The modelling considers the proposed changes to the existing landfill, including an increased waste mass and steepened slopes, which may influence leachate generation and hydraulic load on the liner. Conservative assumptions were adopted throughout, such as continuous outward hydraulic gradients, non-depleting source concentrations, and no attenuation through the liner. Leachate source concentrations were derived from the 95% upper confidence limit of historical data, with additional conservative values adopted for contaminants not included in the dataset.

The primary exposure pathway assessed is the potential migration of leachate from the southeastern corner of the landfill (Phase 1) to the Rangitopuni Stream. Two receptors were considered: ecological life in the stream and irrigation use for tomato plants. The modelling results indicate that predicted contaminant concentrations in both groundwater and surface water are well below relevant guideline values, including ANZG (2018) ecological protection thresholds and ANZG (2023) irrigation standards. A sensitivity analysis confirmed that even under varied hydraulic conductivity and reduced stream flow conditions, contaminant concentrations remained below guideline values, reinforcing the robustness of the modelling.

The modelling confirms that even under steady-state conditions, which represent worst-case scenarios over long timeframes, the adverse effects posed by leachate seepage is negligible. It

---

[4] The Ghyben-Herzberg relation is a simplified approach used to assess the depth to the saltwater interface in aquifers close to the coast. It assumes that for every metre of freshwater above sea level, there's about 40 m of freshwater below sea level. Hiscock, K.M., 2005. Hydrogeology – Principles and Practice. Blackwell Publishing, Malden, Oxford. 389 pp.

[5] GSI Environmental Inc., 2011. Risk-Based Corrective Action Tool Kit for Chemical Releases (Version 2.6). https://www.gsi-net.com/en/software/rbca-software-tool-kit-for-chemical-releases-version-2-6.html

supports the conclusion that the landfill, with proposed changes, is unlikely to adversely affect groundwater or surface water quality, provided that current management practices and monitoring continue as proposed in these conditions.

### 5.5.2 Class 2 extension: Waste Acceptance Criteria

The proposed Class 2 extension at Redvale Landfill will adopt the WAC outlined in the Landfill Engineering Memo, which broadly follow the Technical Guidelines for Disposal to Land (Rev 3.1) (Technical Guidelines)[6]. These criteria are designed to protect both human health and the environment by limiting the concentration of contaminants in waste that could leach into soil, groundwater, or surface water. The Class 2 extension will be constructed with a 900 mm thick compacted clay liner, engineered to achieve a hydraulic conductivity of $1 \times 10^{-8}$ m/s, and will include a leachate collection system to minimise leachate head and reduce the potential for seepage.

The primary exposure pathway considered is the potential for leachate to seep through the liner and migrate into the underlying formation, eventually discharging via groundwater to surface water features. The Rangitopuni Stream has been identified as the nearest downgradient receptor. A review of the WAC derivation confirms that the conceptual model and exposure assumptions used in the Technical Guidelines, such as contaminant source, transport through groundwater, exposure via surface water, and ecological receptors, are consistent with the site-specific conditions at Redvale Landfill.

The WAC were developed using a structured risk-based approach, incorporating dilution and attenuation factors (DAF) of 20 for inorganic and 10 for organic contaminants. These criteria are considered protective of aquatic life in the Rangitopuni Stream and of irrigation water takes. Although the irrigation guidelines for boron, fluoride, and molybdenum are slightly more stringent than the aquatic criteria, the distance to the receptor and low hydraulic conductivity of the formation provide sufficient attenuation. Therefore, fate and transport modelling was not undertaken for the Class 2 extension, as the WAC are deemed appropriately conservative and protective.

## 6 Mitigation and monitoring

The following mitigation and monitoring measures are proposed to manage potential effects on groundwater and surface water resulting from the time extension of the existing landfill operations and the Class 2 extension. These measures will be secured by way of conditions:

- For the Class 2 extension, the construction of a 900 mm thick compacted clay liner and a leachate collection system, both designed to minimise leachate seepage and maintain an inward hydraulic gradient. The WAC will be applied to limit contaminant concentrations in the waste, ensuring protection of groundwater and surface water receptors.
- A targeted groundwater monitoring programme is proposed for the Class 2 extension. This includes 8 to 12 rounds of groundwater level and quality monitoring prior to waste placement, using existing wells (W69, WL2S/WL2D, M7A, and W67AS (or its replacement)). Ongoing monitoring will follow the same analyte suite and frequency as the current resource consent conditions for the existing landfill, which are still considered appropriate.
- For the time extension of the existing landfill operations, ongoing groundwater level and quality monitoring is proposed in accordance with current consent conditions. This includes monitoring in well W3A, which has recently been incorporated into the site wide monitoring programme by WMNZ.

[6] WasteMINZ, September 2023. Technical Guidelines for Disposal to Land, Revision 3.1.

- Overall, these mitigation and monitoring measures are designed to ensure continued protection of groundwater resources and the Rangitopuni Stream throughout the life of the landfill extension.

# 7 Conclusions

The Hydrogeological Assessment confirms that the potential effects on groundwater quantity, quality, and regional groundwater users as a result of the proposed extension of the existing landfill operations and proposed Class 2 extension at Redvale are likely to be negligible.

Groundwater take during construction of the Class 2 extension is temporary and modest, with effects confined to WMNZ landholdings and recovery expected post-construction. Long-term diversion of groundwater through the Class 2 extension liner (should this occur) is minimal and is unlikely to impact regional or local groundwater resources. In terms of contaminant transport from the Class 2 extension, the application of the WAC is considered protective of downgradient receptors, including the Rangitopuni Stream.

A leachate flux assessment associated with high leachate levels in the southeast corner of the existing landfill (Phase 1) indicates the potential for discharge of leachate to ground soakage is well below the daily discharge limit of 0.3 $m^3$/day. Further to the flux assessment, contaminant transport modelling to evaluate potential changes associated with the time extension of the existing landfill operations indicates that leachate seepage, if it occurs, should remain well below ecological and irrigation guideline values.

Proposed mitigation measures, including continued monitoring are appropriate to ensure the ongoing protection of hydrogeological systems throughout the life of the Class 2 extension and time extension of the existing landfill operations.

## 8 Applicability

This report has been prepared for the exclusive use of our client WMNZ, with respect to the particular brief given to us, and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that WMNZ will submit this report to the Environmental Protection Authority in support of a referral application under the Fast-track Approvals Act 2024 for the works described herein, and that the Environmental Protection Authority will rely on this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

| Technical memorandum prepared by: | Authorised for Tonkin & Taylor Ltd by: |
|---|---|
| ..... | ..... |
| Leon Pemberton | Simonne Eldridge |
| Senior Hydrogeologist | Technical Director – Environmental Engineering |