
Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

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LEGEND

- Registered bores (WRC Well ID) - excluding OGL bores

**Authorised Takes - excluding OGL takes**

- Groundwater take (AUTH = WRC consent ID)
- Surface water take (AUTH = WRC consent ID)
- Shed Spring
- Farm pond
- Rivers (LINZ)

Oceana Gold Limited
Waihi North

Job Number 12590241
Revision 1
Date 13 Feb 2025

TSF3 Surface Water and Groundwater Takes

Figure 5.10

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Level 3, 138 Victoria Street, PO Box 13 468, Christchurch 8141, New Zealand T 64 3 378 0900 F 64 3 378 8001 E chcmail@ghd.com W www.ghd.com



Data source: LINZ (cc-by): Aerial imagery (NZ - Imagery: Classic Basemap Server - Deprecated Basemap - Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors), Rivers - https://services7.arcgis.com/jl87xPT7G1AGV8Uo/arcgis/rest/services/, Roads - 20200216; GHD: Bores_TSF3, Consents_TSF3. Created by:nrama

## 5.4 TSF3 assessment

### 5.4.1 Design iteration

Various iterations of the design of the TSF3 have been prepared; with engineering design always an iterative process dependent on evolving construction logistics and feedback from the wider project team. The design iteration available at the time of undertaking the assessment of potential impact of the TSF3 on groundwater and surface water is presented in Figure 5.11 and Figure 5.12 (referred to within this report as 'Iteration 1'). A new design iteration has since been prepared, which is presented in Figure 5.13 and Figure 5.14 (referred to within this report as 'Iteration 2').

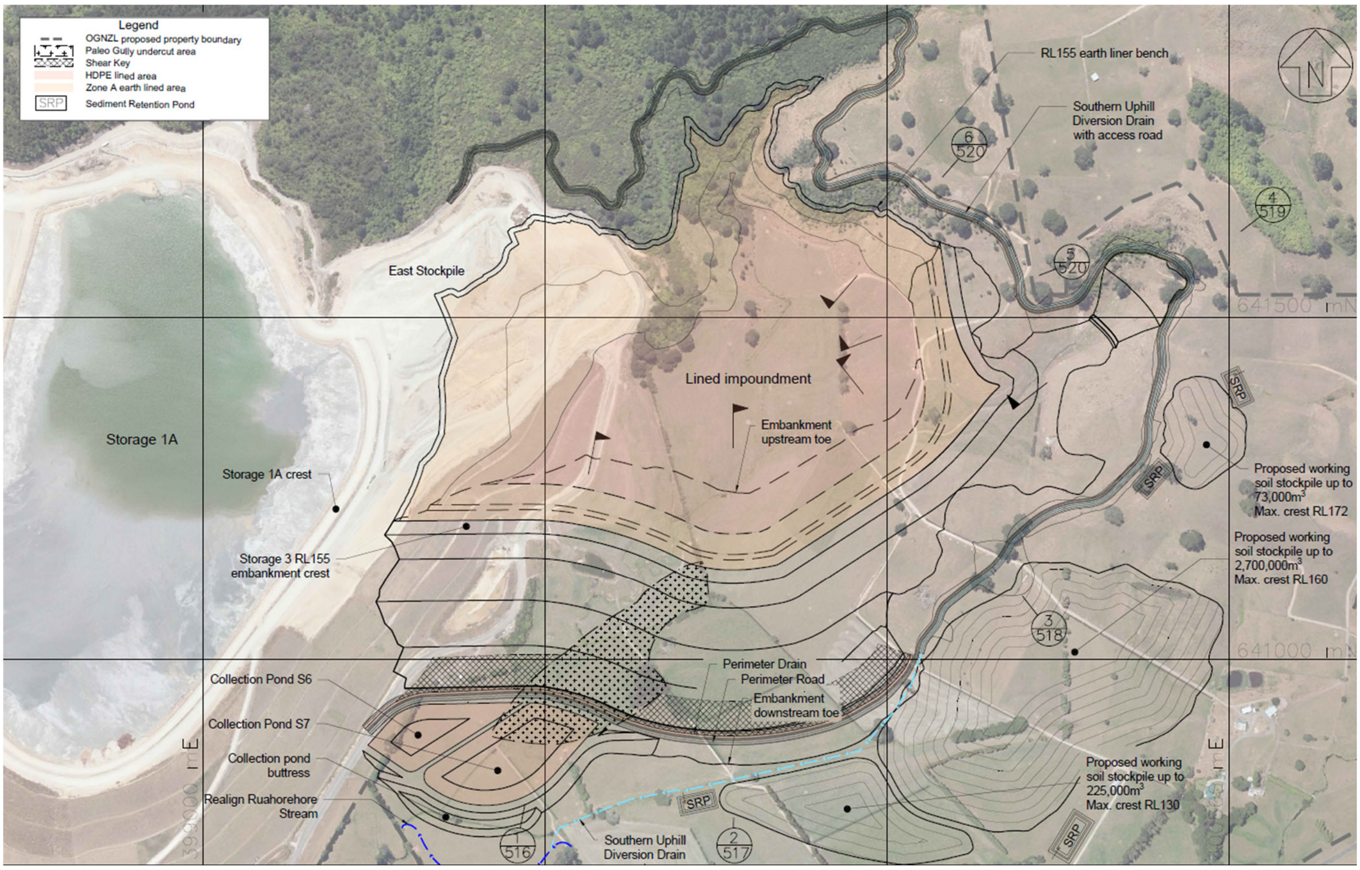


*Figure 5.11 Iteration 1 TSF3 layout plan (EGL, 2021)*

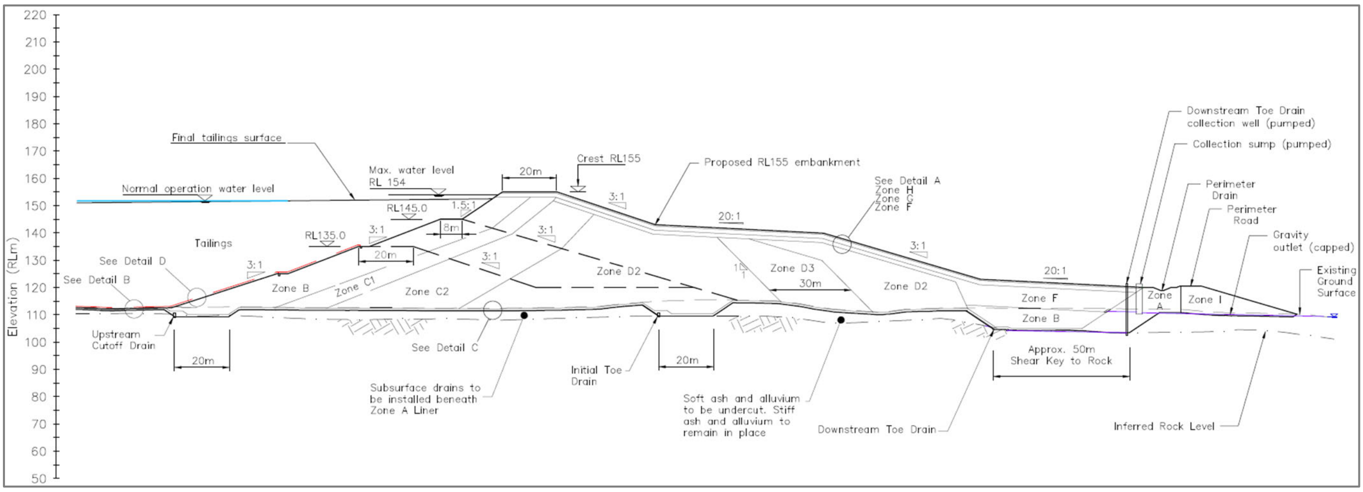


*Figure 5.12 Iteration 1 typical embankment profile section (EGL, 2021)*

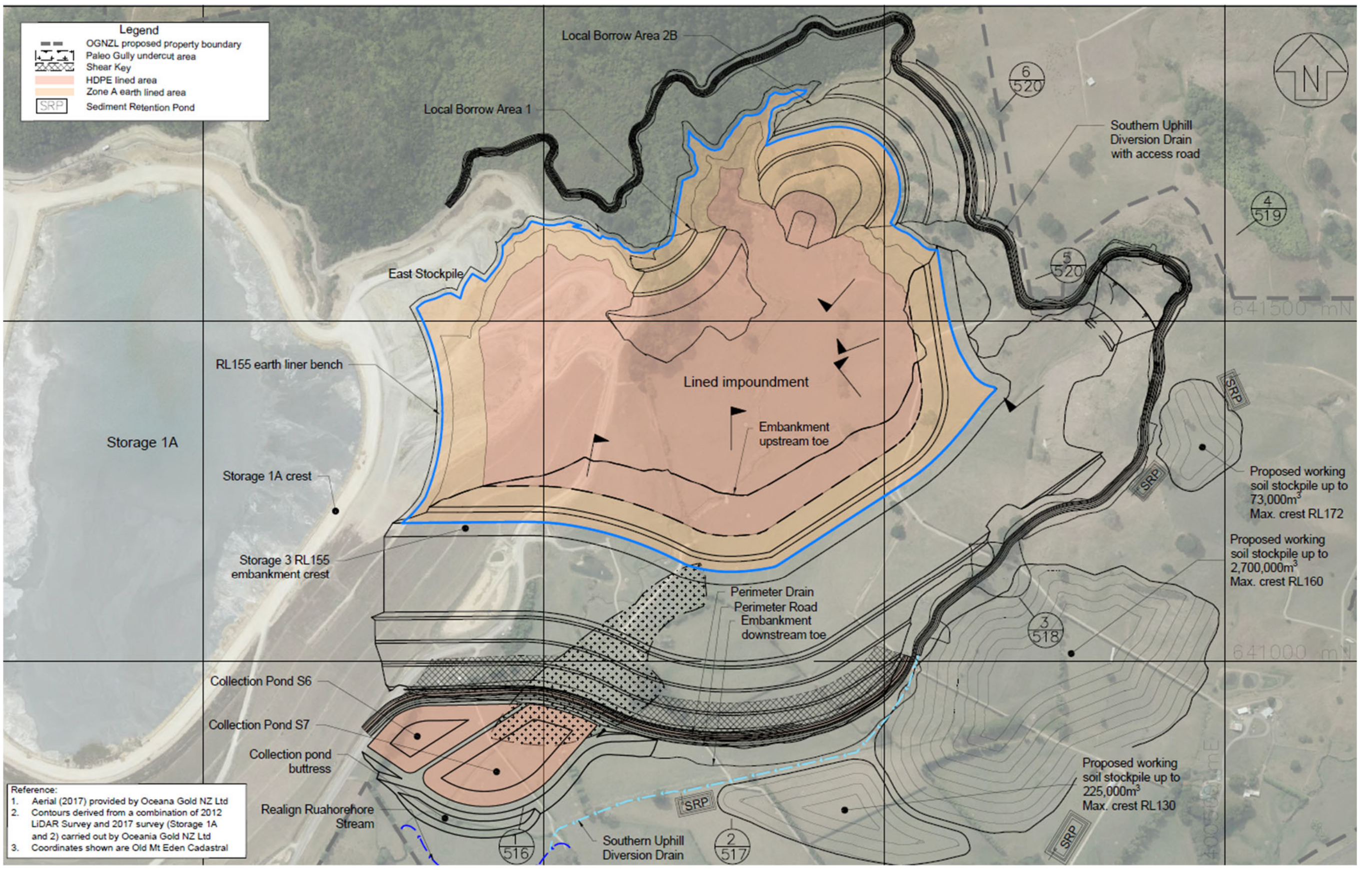


*Figure 5.13 Iteration 2 TSF3 layout plan (EGL, 2025b)*

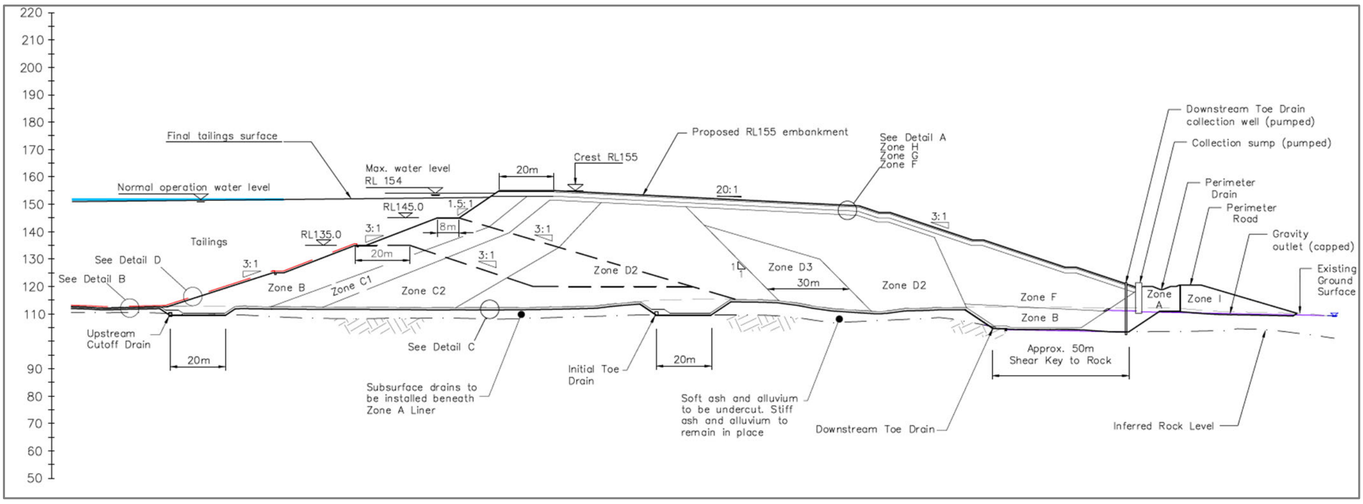


*Figure 5.14 Iteration 2: TSF3 typical embankment profile section (EGL, 2025b)*

The key differences between the two design iterations are summarised below:

– In both design iterations, the tailings will be placed on a HDPE liner to an elevation of RL 1,135. Between RL 1,135 and maximum height of RL 1,155, the tailings will be placed on a low permeability Zone A liner. Iteration 2 includes two quarry / borrow areas. These areas, along with the existing East Stockpile, are proposed to be excavated prior to construction of the TSF3 to provide NAF material for the starter embankment. In comparison to Iteration 1, these excavation works for Iteration 2 will result in a larger area of the tailings being placed between RL 1,135 and RL 1,155 in the northeast of the TSF3 (Borrow Area 2), however a reduced area of tailings will be placed between these elevations in the north (Borrow Area 1) and northwest (East Stockpile) of the TSF3. Overall, the total area of TSF3 between RL 1,135 and RL 1,155 has decreased from 127,000 $m^2$ in iteration 1 to 82,700 $m^2$ in Iteration 2 (Table 5.6).

– While the maximum height of the TSF3 embankment crest is proposed to remain the same between Iteration 1 and Iteration 2 (RL 1,155), in Iteration 2 the area of the embankment south of the crest is proposed to be constructed to a higher elevation in comparison to Iteration 1 (approximately up to an additional 10 m). No changes are proposed in width/length of the embankment.

*Table 5.6 Footprint area of TSF3 design features ($m^2$) (EGL, 2021; EGL, 2025b)*

| TSF3 | Iteration 1 | Iteration 2 |
|---|---|---|
| TSF3 tailings at RL 1,155 | 348,000 | 372,000 |
| HDPE liner (to RL 1,135) | 162,000 | 231,000 |
| Between RL 1,135 – RL 1,155 where tailings will be placed on Zone A liner immediately above natural ground | 127,000 | 82,700 |

The potential effects to groundwater and surface water in relation to the change in design are summarised as follows:

– Seepage to ground is expected to be greater through the Zone A liner (between RL 1,135 – RL 1,155) than through the HDPE liner (placement to RL 1,135). Between design Iterations 1 and 2 there has been an increase in the area of HDPE liner and a decrease in the area of Zone A liner.

– Seepage through areas of Zone A liner where it is placed upon the embankment is expected to be captured by sub-soil drains.

– The increased height of the embankment may result in slightly longer travel times for infiltration to percolate through the embankment, however this seepage is expected to be captured by sub-soil drains.

The assessment of effects undertaken using Iteration 1 is considered to remain appropriate when considering potential impacts to groundwater and surface water due to the following:

– Although there is an increase in total area of the TSF3 tailings to RL 1,155, the existing modelling approach (a 1 m wide two-dimensional cross section model) scaled the results by approximate width of the TSF3 (1000 m), which remains unchanged.

– The model section adopted for the assessment is considered to remain representative when considering the average extent of HDPE and Zone A liner at the TSF3.

– The changes to the height of the embankment are not expected to result in seepage to ground and are not expected to meaningfully impact the rate of seepage to sub-soil drains.

### 5.4.2 Approach

An assessment of impacts to groundwater and surface water associated with TSF3 was undertaken through conceptual interpretation, supported by the use of 2D numerical groundwater model with Geostudio 2019 R2 SEEP/W finite element numerical modelling software.

The assessment comprised development of the following models:

– **Conceptual**: Development of a conceptual model for the TSF3 site (Section 5.3).

– **Dewatering and TSF3 construction:** Development of a steady-state 2D cross-sectional model using Geostudio SEEP/W (Cross-section 1, Figure 5.15), representing the facility through different stages of life (construction, filling and post closure). This steady-state model was set-up using average annual rainfall rates. The base model calibration was set to measured site conditions, focusing on:
  - Groundwater levels (Appendix C) measured in the primary TSF3 site aquifer (the deeper groundwater system) and the horizontal gradient across the TSF3 site.
  - Comparative vertical gradients within well pairs at TSF3.
  - Neutral to losing conditions in the Ruahorehore Stream (Figure 5.8).

These model scenarios were used to predict the following at different TSF3 construction stages:

a. Tailings porewater leakage rates.

b. Embankment leakage rates.

c. Changes in groundwater recharge, levels and flow associated with TSF3 construction.

d. Changes to surface water flow and levels.

– **Additional construction dewatering:** An additional construction dewatering analysis using a transient 2D SEEP/W cross-sectional numerical model (Cross-section 2, Figure 5.15) and analytical (Theis, 1935) model. This was to further support estimation of groundwater inflows and drawdowns during the preparation and foundation works stages (Section 5.5.1).

– **Water quality:** Development of a simplistic mixing model to predict impacts of TSF3 seepage to groundwater and surface water quality. This model considered seepage rates from the above models and chemistry of discharges from TSF3 (from AECOM, 2025) for mixing with the existing water quality of receiving groundwater and surface water.

Refer to Appendix I for detailed description of the assessment methodology.

## 5.4.3 Rationale

The TSF3 site comprises a complex setting, which has been assessed using simplified methods:

– **Steady state 2D cross-section:** The primary purpose of this 2D model (Cross-section 1) is to quantify model TSF3 seepage out of the facility. It represents the groundwater movements in the direction of groundwater flow through the paleo-gully, which (combined with drains) is inferred to effectively channel groundwater from the TSF3 footprint to the drains beneath the embankment. This analysis is used in combination with the CGM to provide assessment.

– **Transient 2D cross section and Theis (1935):** The purpose of these models was to predict potential groundwater drawdown, resulting from construction dewatering, near TSF3 including under the TSF1a for settlement calculation purposes. Cross-section 2 was oriented approximately perpendicular to Cross-section 1 through the sensitive tuff as shown in Figure 5.15, which is perpendicular to groundwater flow direction. This set-up provides potential for inconsistencies when predicting groundwater drawdown with distance from the excavation. Cross-section 2 was therefore used primarily to assess groundwater drawdown in close proximity to the excavation, where the excavation locally controls the hydraulic gradient and groundwater flow direction. Outside of this area, the model is expected to over predict drawdown (and also inflows).

  - Theis was used as a “first principles” check from the deepest point of the excavation to assist with defining the ZOI at distance (see Section 5.5.1). It is noted that the cross section alignments only allowed for up to 15 m thickness of sensitive for removal. Theis was applied to a full 20 m excavation depth.

The approaches adopted are considered to provide an appropriately conservative assessment.

The predicted effects (Section 5.6) are provided in the context of effects also identified to have resulted from operation of the existing TSF1A and TSF2 facilities.

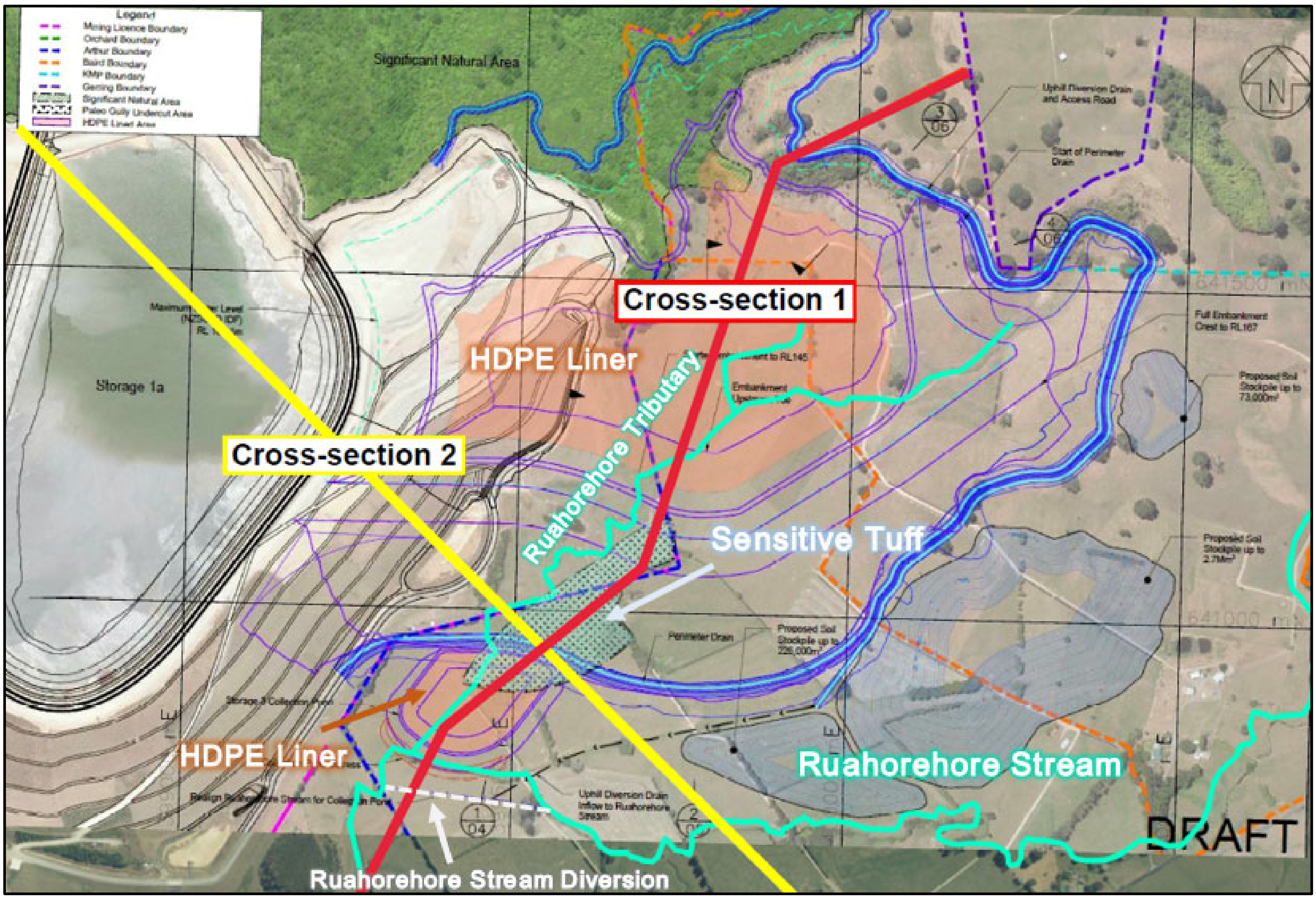


*Figure 5.15 TSF3 cross-section locations*

# 5.5 TSF3 analysis results

The below sections provide summarised assessment results, with additional detail provided in Appendix I.

## 5.5.1 Construction dewatering

### Inflows

Given the large nature of the proposed excavation and variable geology, there is some degree of uncertainty around the actual volume of water to be dewatered. A range of predicted inflows is provided in Table 5.7.

The actual inflows are expected to:

– Occur at the lower end of the ranges presented. The results for Cross-section 2 provide the upper limit of inflows presented for the reasons provided in Section 5.4.3.

– Be greatest at the initial period of each stage, reducing as groundwater levels (and water held in aquifer storage) reduces over time.

– Be greatest at the deepest and widest section of the undercut (20 m bgl), where higher permeability materials and upward gradients are expected to be encountered.

– The undercut will be backfilled with structural fill before the construction of the embankment and drainage systems. This structural fill material will be NAF.

Detailed model outputs are provided in tables within Appendix I.

*Table 5.7 Summary of dewatering results*

| Excavation Stages (days) | Expected inflow ranges* | Predicted upper bound** |
|---|---|---|
| Initial partial excavation (0-30 d) | <10 – 25 $m^3$/day | 510 $m^3$/day |
| Full excavation (30-75 d) | 30 – 330 $m^3$/day | 2,450 $m^3$/day |
| Partial backfilled (75-120 d) | 0 – 10 $m^3$/day | 100 $m^3$/day |
| Sum for construction period | 1,970 - 16,130 $m^3$ total | 130,000 $m^3$ total |
| Portion of Available Aquifer Management Level# | 0.1% – 0.9% | 7% |

Notes:
* Ranges based on values provided by Cross-section 1 (including sensitivity testing) and Theis (1935).
** Predicted upper bound provided by Cross-Section 2.
# WRC Waihi Basin (1,845,000 $m^3$/year)

## Groundwater level drawdown

The predicted groundwater level drawdowns are illustrated in Figure 5.16 and Figure 5.17, where:

– The drawdown ZOI is predicted to extend up to 610 m. The ZOI reflects the distance from the deepest point of excavation to the distance at which predicted groundwater drawdown becomes less than 0.5 m. The ZOI is mapped and discussed further in Section 5.6.
– The ZOI is not circular and is expected to be influenced by the shape of the excavation and subsurface features (e.g. changes in lithology, paleo-gullies, paleo-ridges). However, the limitations of the approaches adopted provide a conservative, circular ZOI.
– EGL have considered the drawdown results for settlement effects to TSF1A. The drawdown in Figure 5.17 is expected to produce settlement of less than 50 mm (EGL, 2021). To have a material effect, settlement would need to be greater than 100 mm, and EGL concluded that settlements in the range calculated will not have an effect of the TSF1A Zone A liner or Zone G capping.

Following backfilling of the excavation, groundwater levels are expected to increase to levels reported in the future operational TSF3 scenarios.

## Changes to groundwater recharge and flow regime

The potential effects associated with the TSF3 construction dewatering include changes to aquifer recharge, groundwater flow directions, and subsequent impacts on the Ruahorehore Stream where groundwater is in direct hydraulic connection:

– **Groundwater:** The groundwater flow regime will be temporarily altered near the excavation during the construction period, with ground flows locally directed to the excavation. Recharge to the broader groundwater system will be reduced by the volume of dewatered groundwater during construction. The majority of groundwater removed during dewatering is expected to come from the deeper aquifer. This results in an approximate reduction in recharge of 0.2% of the Waihi Basin aquifer management level (Table 5.7). The upper limit of this reduction may potentially be up to 2.1% but is unlikely to occur.
– **Surface water:** The Ruahorehore Stream will be diverted to approximately 40 m south of its current location at the toe of the TSF3 embankment (Figure 5.15). Without this diversion the Ruahorehore Stream would be significantly adversely affected by TSF3 construction dewatering. Whilst the stream is considered to be losing at this location (Figure 5.8), the rate of loss may increase due to dewatering of the shallow groundwater system, as well as underdrainage which may occur due to dewatering. Rates of stream depletion have not been quantified, as any effects to the Ruahorehore Stream are expected to be mitigated by diverting clean abstracted groundwater into the stream to maintain stream flows.

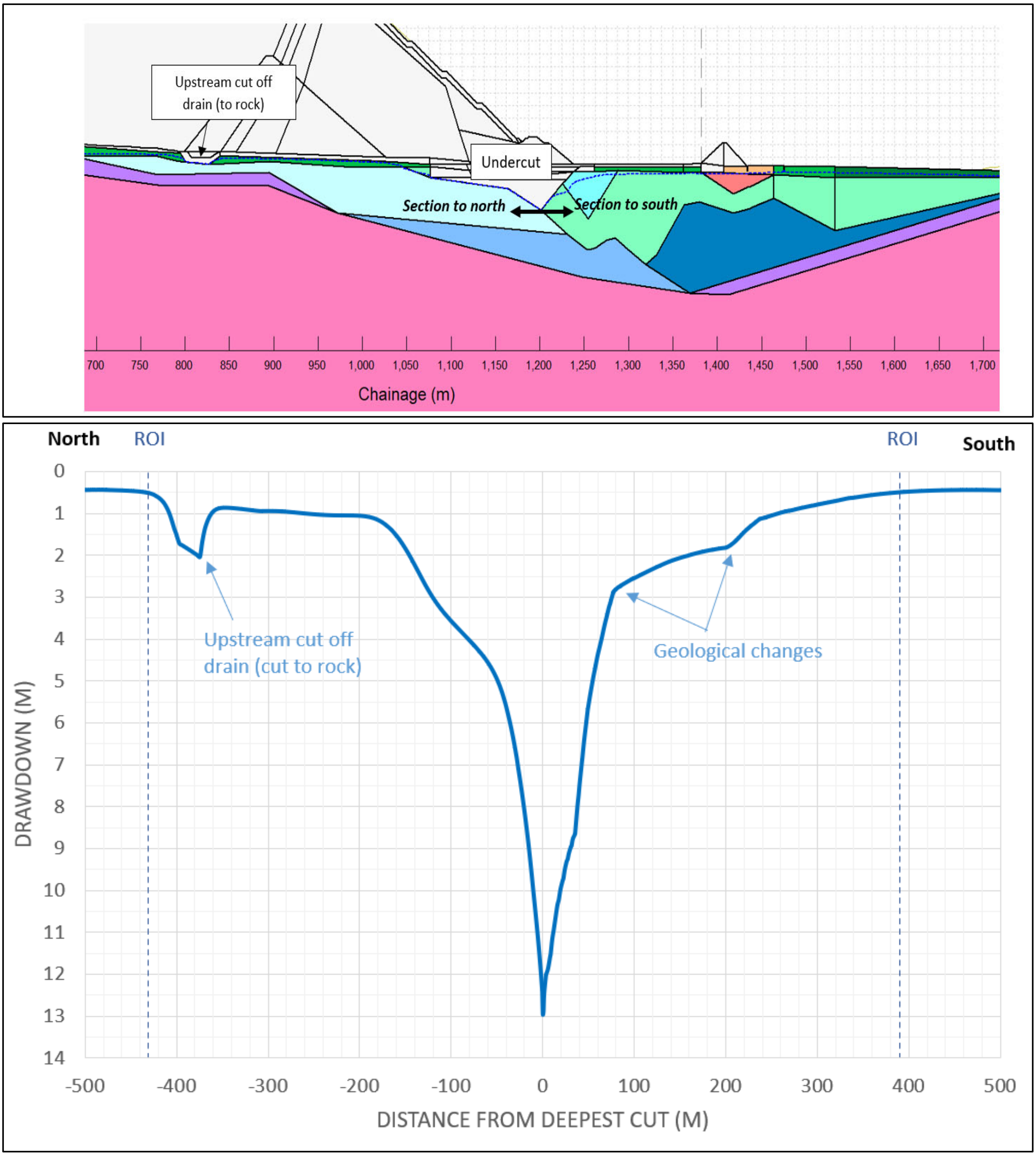


*Figure 5.16* ***Predicted groundwater level drawdown the undercut excavation (SEEP/W Cross-Section 1)***

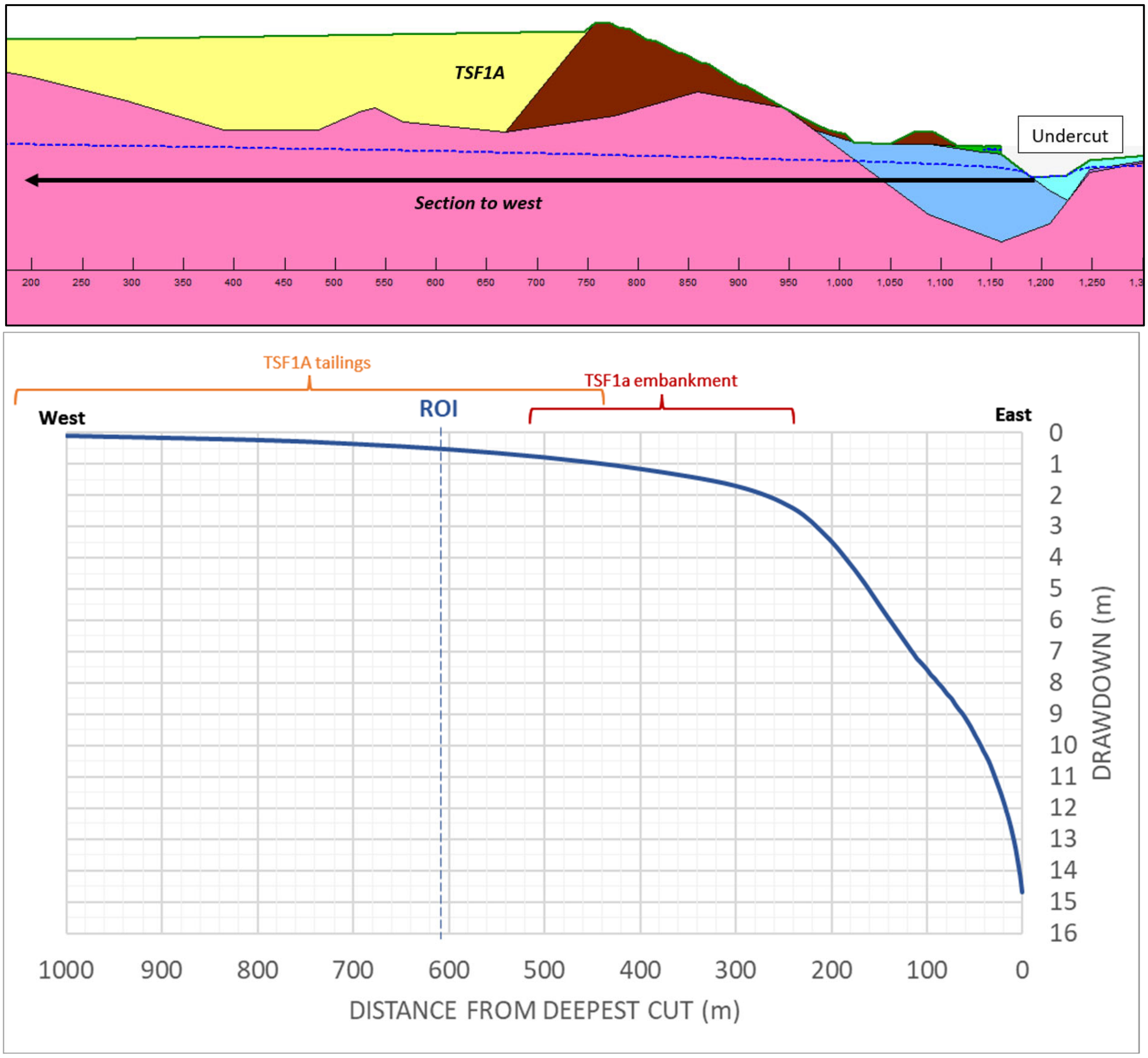


*Figure 5.17* ***Predicted groundwater level drawdown beneath TSF1A (SEEP/W Cross-Section 2 and Theis, 1935)***

## 5.5.2 Tailings discharge

Leakage of tailings porewater is expected to occur as seepage through HDPE liner defects and through the Zone A soil liner below the HDPE liner and on the upper sections of the embankments. Seepage rates through the HDPE liner has been suggested by EGL (2019b) based on work carried out by others (e.g. Kerry Rowe) to be between 42 to 170 L/ha/d due to defects or holes within the liner. The upper limit has been conservatively adopted for this analysis.

Downward gradients are predicted to dominate through the Zone A liner during all stages of TSF3 life. A portion of tailings porewater is therefore expected to seep to ground beneath the proposed TSF3, and residual soluble components of the tailings porewater may migrate with groundwater flow.

Groundwater impacted by tailings porewater, at the northern extent of TSF3, is predicted to discharge to the deeper aquifer (Figure 5.18). This is indicated by flow paths within the SEEP/W model and the conceptual understanding provided in 5.3.5.

During initial construction stages, the tailings discharge is predicted to be captured by the TSF3 drainage system (Figure 5.18). As TSF construction progresses through to full embankment (1,155 m RL crest height), the tailings will be emplaced above the top elevation of the HDPE liner (1,135 m RL) to approximately 2 m below the crest level. For conservatism, the tailings are modelled at the full crest heigh for each scenario. Some of the tailings porewater leaving the facility along the northern edge of the HDPE liner is predicted to bypass the TSF3 drainage system for the operational/closure and long-term scenarios. This porewater is predicted to recharge deeper groundwater, and ultimately discharge some distance downgradient of the site via existing deeper groundwater flow paths to the Ohinemuri River (the receiving environment). This interpretation is supported by flow paths within the SEEP/W model and the conceptual understanding provided in Section 5.3.5.

The following discharge rates are predicted for TSF3 and summarised in Table 5.8:

– **Starter embankment (1,135 m RL):** Tailings are least consolidated at this stage and have the greatest hydraulic conductivity ($K_H = 1x10^{-7}$ m/s). The discharge rate from the TSF3 at this stage is 10 $m^3$/day, all of which is through both the HDPE and Zone A soil liners. All of this discharge is predicted to be captured by the drains and prevented from downward infiltration, due to the upward hydraulic gradients at this location.
– **Closure (1,135 m RL):** As TSF construction progresses through to full embankment, the tailings consolidate, becoming less permeable ($K_H = 5x10^{-8}$ m/s). The volume of tailings porewater predicted to discharge through the Zone A soil liner is 115 $m^3$/day, with 70% captured by drains and the remainder (45 $m^3$/day) entering the deeper groundwater system.
– **Long-term (post-closure):** Over time, the tailings are expected to consolidate further to a final $K_H$ value of $1x10^{-8}$ m/s. All drains (except for the downstream toe drain) are assumed to have failed through sedimentation or collapse. At this stage of the TSF3 life, 60 $m^3$/day discharge through the Zone A soil liner is predicted, with no capture by drains. It is therefore predicted that 60 $m^3$/day of tailings porewater will enter the deeper groundwater and flow to the receiving environment in the long-term phase of the TSF3.

The HDPE liner provides an effective reduction of tailings porewater discharge to the environment. Without this liner, the discharge to the receiving environment under the starter embankment stage (when tailings are least consolidated) is expected to be over 500 times (540 $m^3$/day) the predicted volume without the liner (0 $m^3$/day).

*Table 5.8 TSF3 tailings porewater discharge*

| Stage (Tailings height) | Tailings permeability (m/s) | Tailings discharge through liners ($m^3$/d) | Proportion captured by drains | Discharged to the receiving environment |
|---|---|---|---|---|
| Starter embankment (1,135 m RL) | $K_H = 1x10^{-7}$<br>$K_V = 2x10^{-8}$ | 10 | 100% | 0% |
| Operational to closure<br>(1,155 m RL) | $K_H = 5x10^{-8}$<br>$K_V = 1x10^{-8}$ | 115 | 70%<br>(70 $m^3$/day) | 30%<br>(45 $m^3$/day) |
| Long-term / post-closure<br>(1,155 m RL) | $K_H = 1x10^{-8}$<br>$K_V = 5x10^{-9}$ | 60 | 0% | 100% |
| *Comparison scenario – no HDPE liner:*<br>*Starter embankment* | *$K_H = 1x10^{-7}$*<br>*$K_V = 2x10^{-8}$* | *700* | *25%*<br>*(160 $m^3$/day)* | *75%*<br>*(540 $m^3$/day)* |

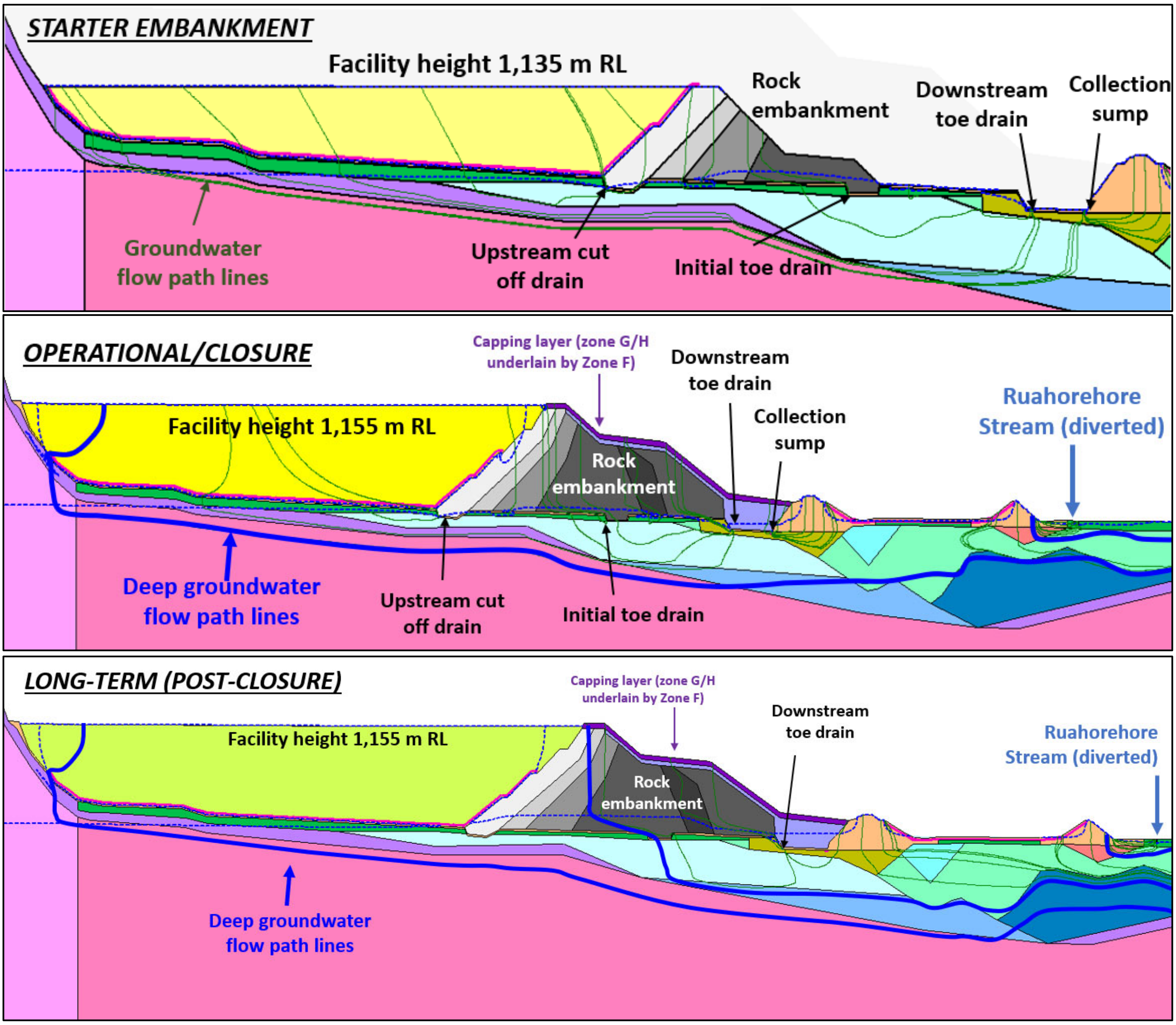


*Figure 5.18 Groundwater flow paths for the key TSF3 scenarios*

## 5.5.3 Embankment infiltration

Rainwater that infiltrates through the embankment is expected to be influenced by the rock geochemistry. The predicted rates of infiltration through the embankment, to the receiving environment, are summarised in Table 5.9:

– **Starter embankment (1,135 m RL):** As no capping layer is emplaced at this stage, rainfall has been applied at 35% of the average annual rainfall rate (740 mm/year; seepage face review). The resulting infiltration rate is 30% of rainfall (600 mm/year), which is expected to generate 230 $m^3$/day of flow through the embankment.
  - The remainder of applied recharge to the embankment is inferred to go to surface runoff and be captured by the surface drainage. As with the tailings discharge, all of the embankment infiltration at this stage is predicted to be captured by the TSF3 drain system and prevented from downward migration due to upward hydraulic gradients present beneath the toe of the embankment; this is illustrated by the flow lines in Figure 5.18.

– **Operational to closure (1,135 m RL):** On closure, after the capping layers are emplaced (Zones G and H), an infiltration rate of 370 mm/year has been applied as infiltrating through into Zone D. This value has been applied in accordance with that derived by AECOM (2020) for the existing TSF1A. This value is approximately 20% of the applied rainfall and is predicted to generate 270 $m^3$/day of water through the full embankment. All embankment infiltration is predicted to be captured by the drains for this scenario.

– **Post-closure (1,155 m RL):** The rate of infiltration for the long-term scenario is the same as for closure (270 $m^3$/day). Assuming drain failure (with only the downstream toe operating), 30 $m^3$/day (~10%) of this is predicted to discharge to the receiving environment. As indicated by the flow lines in Figure 5.18, and supported by the conceptual model (Section 5.3), none of the embankment infiltration is expected to discharge locally to the Ruahorehore Stream.

*Table 5.9 TSF3 rock embankment infiltration**

| Stage (Tailings height) | Embankment length along model alignment (m) | Infiltration rate (mm/year) | Water flow through embankment ($m^3$/day) | Proportion captured by drains | Discharged to the receiving environment |
|---|---|---|---|---|---|
| Starter embankment (1,135 m RL) | 140 | 600 (~30% of rainfall)** | 230 | 100% | 0% |
| Operational to closure (1,155 m RL) | 260 | 370 (~20% of rainfall)# | 270 | 100% | 0% |
| Long-term / post-closure (1,155 m RL) | | | | ~90% (240 $m^3$/day) | ~10% (30 $m^3$/day) |

* Values presented are rounded.
** Resulting infiltration after applying 35% rainfall as seepage face review.
# From AECOM (2020) for TSF1a

## 5.5.4 Collection pond leakage

The collection ponds (S6 and S7; Figure 5.19) will both be fully lined with a 1.5 mm HDPE on a 0.6 m thick earthfill liner (Zone A material). The collection ponds are sized to manage runoff from a 1 in 10-year 24-hour rainfall event, so that dilution is effective to ensure that any discharge will have less than minor effect on the receiving environment (EGL, 2021). The operational requirement is that they are to be pumped dry as soon as practicable after rainfall events. As such, when dry, no pond leakage is expected to occur.

The seepage rate from the ponds when full are estimated using the lower limit of liner leakage due to defects (42 L/ha/d; Section 5.5.2). This value is adopted due to the significantly lower pressure head on the pond liner when full compared with the tailings. It is considered to be appropriately conservative given the temporary nature of the full ponds, which will limit the driving head on the pond liners.

Across the total lined pond area of 3.3 ha, this results in an estimated temporary leakage rate of 140 L/day. This leakage is expected to discharge to the deeper groundwater system, as indicated by the flow lines in Figure 5.18. For conservatism, this discharge is assumed to discharge to the realigned Ruahorehore Stream.

The water quality in the pond, for conservatism, is assumed to be impacted by the embankment rock for the starter and operational phases. An assessment of the potential impact to the Ruahorehore stream is included in Section 5.6.2 below. From closure, the rock embankment will be capped. The pond water quality is expected to be minimally impacted by the underlying Zone A material (NAF).

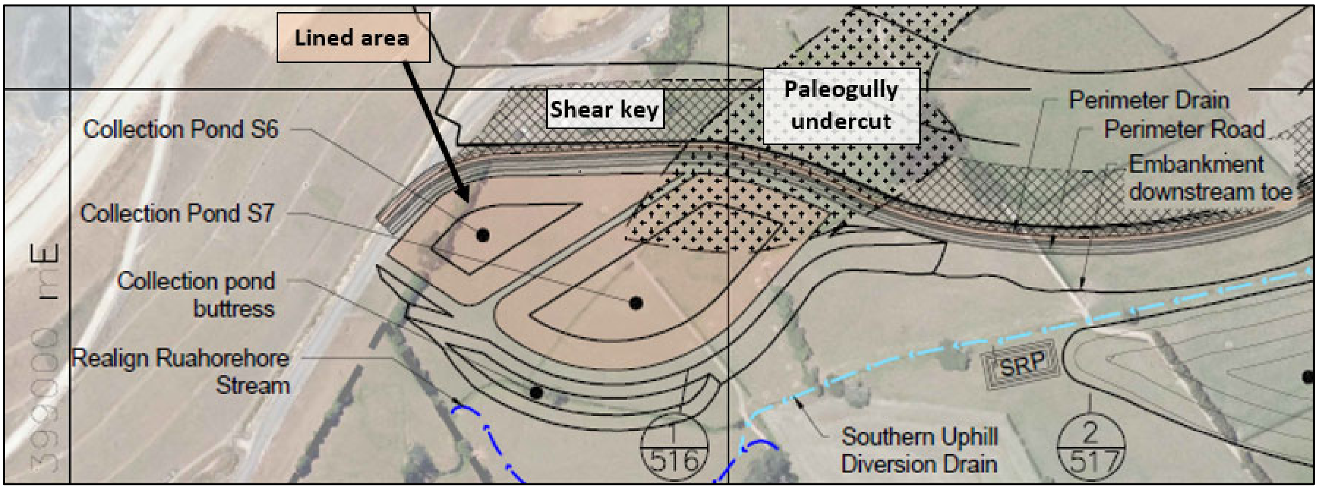


*Figure 5.19 Collection ponds S6 and S7 (EGL, 2021)*

## 5.5.5 Drain Capture

### Volumes

The volumes of groundwater captured by the subsurface drains is required for input into the water management assessment (Water Management Report (GHD, 2025a), and will be sent to the WTP for treatment. The captured water will include a mix of tailings seepage, embankment rock infiltration and groundwater. The predicted model results are summarised in Table 5.10 below.

– **Starter embankment:** All drains are assumed to be operational and capture 100% of tailings and embankment rock seepage from TSF3 (240 $m^3$/day). In addition to this, groundwater contributions are expected in the order of 50 $m^3$/day.
– **Operational to closure:** As above, all drains are assumed to be operational and capture 100% TSF3 seepage (295 $m^3$/day). In addition to this, groundwater contributions are expected in the order of 65 $m^3$/day.
– **Post-closure:** All drains, except the downstream toe drain, are assumed to have failed for this scenario. No tailings seepage is predicted to be captured as noted in Section 5.5.2, and 240 $m^{3/}$day of embankment rock infiltration is predicted to be captured by the drains. In addition to this, groundwater contributions are expected in the order of 30 $m^3$/day.

*Table 5.10 Predicted drain capture volumes and sources*

| Stage | Total TSF3 seepage to drains ($m^3$/day)* | Total drain capture ($m^3$/day) | Water/seepage source (Proportions) | | | |
|---|---|---|---|---|---|---|
| | | | Tailings | Embankment rock | Ground-water | Portion of groundwater allocation** |
| Starter embankment | 240 | 290 | <5% | 80% | 15 - 20% | 1.1% |
| Operations to closure | 340 | 360 | 20% | 75% | 5% | 0.4% |
| Post-closure | 240 | 260 | 0 | 90% | 10% | 0.4% |

* From values provided in Table 5.8 and Table 5.9.
** Percentage of the available groundwater within the Waihi Basin (1,845,000 $m^3$year)

# 5.6 TSF3 effects summary and discussion

The predicted influence on key environmental aspects is provided in the following sections. Recommendations are made throughout the following sections, with a summary of proposed monitoring provided in Section 5.6.4.

## 5.6.1 Groundwater water levels, flows and recharge

During the following stages, the groundwater regime is expected to be altered. The expected effects, magnitude and management of these are discussed below.

### Construction dewatering

The key potential effects of this activity are summarised and qualified with respect to the analysis provided in Section 5.5.1:

– **A reduction in recharge of the deeper aquifer**: The proposed water take, with an upper bound in the order of 2,500 $m^3$/day, is predicted to be less than 1% of the aquifer management level and temporary in nature (120 days) (Table 5.7). It is acknowledged that the surface water catchment (Ohinemuri River at Waihi Terrace) is overallocated, however, the dewatered groundwater will be returned to the catchment via one of two means:
  - Dirty water via the WTP after treatment; and/or

- Clean water to the Ruahorehore Stream to maintain stream flows.

  The amount of water taken from this groundwater and surface water catchment is there considered to be a net zero take.

– **Reduction in recharge to the shallow aquifer and Ruahorehore Stream flows:** The lowering of shallow groundwater levels during dewatering are expected to influence the flow within the Ruahorehore Stream. As above, any reduction in stream flow is expected to be mitigated by clean water diversion from the excavation back into the stream. The effect of dewatering on the Ruahorehore Stream flows are expected to be monitored, manageable and thus minimal.

– **Soil moisture:** Whilst there may be some localised changes in soil moisture in close proximity to areas of earthworks and dewatering, no impacts are expected beyond the immediate vicinity of the works during the temporary nature of the works. Intermittent wetting by rainfall is considered to provide the greatest influence on soil moisture levels across the WNP area.

– **Effects to groundwater quality:** Abstraction of groundwater during construction dewatering is not expected to adversely impact the aquifer water quality. The depth and volume of the take is not considered sufficient to induce saline intrusion from deep basement rock or the coast.

– **Effects to Ohinemuri River flows:** A loss of deeper groundwater recharge is expected to occur. The estimated reduction in flow to the Ohinemuri River median flow, if unmitigated, is estimated to be 0.4%. Although minor, this influence on river flow is expected to be mitigated by clean water diversion from the TSF3 catchment to the stream and discharge to the river following treatment at the WTP. This is anticipated to result in a net neutral effect to the Ohinemuri River flow.

**Effects to private water resources:** Groundwater users are discussed in Section 5.3.6 and are shown on Figure 5.20, which also presents the 610 m TSF3 dewatering ZOI (from Figure 5.17). One groundwater user is registered within the ZOI (AUTH131303), but the bore for this take (Well ID 56609) is located outside of the ZOI. Therefore, no significant effects are reported to water users resulting from groundwater level drawdowns.

- Reductions in stream flow are not expected to impact the downstream surface water user (AUTH120591), based on the proposed diversion of groundwater to the stream. They are also located downstream of the Waione confluence, which contributes significantly higher flows than might be reduced through the TSF3 part of the catchment.


Paper Size A3

0 100 200 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

LEGEND

Registered bores (WRC Well ID) - excluding OGL bores

**Authorised Takes - excluding OGL takes**

Groundwater take (AUTH = WRC consent ID)

Surface water take (AUTH = WRC consent ID)

Zone of Influence (ZoI)

Shed Spring

Farm pond

Rivers (LINZ)

Site Locations.csv Events

GHD

Oceana Gold Limited
Waihi North

TSF3 Dewatering
Zone of Influence

| | |
|---|---|
| Job Number | 12590241 |
| Revision | 1 |
| Date | 13 Feb 2025 |

Figure 5.20

N:\NZ\NZ GIS\Auckland\Projects\Projects\12526951_OceanaGold\12526951_SW_GW_updates_2024.aprx

Level 3, 138 Victoria Street, PO Box 13 468, Christchurch 8141, New Zealand **T** 64 3 378 0900 **F** 64 3 378 8001 **E** chcmail@ghd.com **W** www.ghd.com



Data source: LINZ (cc-by): Aerial imagery (NZ - Imagery: Classic Basemap Server - Deprecated Basemap - Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors), Rivers - https://services7.arcgis.com/jI87xPT7G1AGV8Uo/arcgis/rest/services/, Roads - 20200216; GHD: Bores_TSF3, Consents_TSF3, Dewatering ZoI. Created by:nrama

## Operational stages and final landform

Changes to the overall groundwater flow regime are expected to result from construction of the TSF3 facility (1,155 m RL). While there is expected to be less groundwater recharge beneath the HDPE liner than current conditions, greater recharge across the lower valley floor (beneath the embankment) is predicted, resulting in a net increase in recharge to the groundwater system from the baseline condition. Some local changes in hydraulic gradients of the deeper aquifer are expected as a result. The gradients are expected to vary spatially across the different TSF3 stages as the height of the TSF increases, and as drains become operational and then fail. The changes in gradient are expected to be greatest directly beneath the TSF and become subdued with distance from the facility.

The greater recharge is expected to increase groundwater flows, locally increase water levels and increase surface water flow of the Ruahorehore Stream. The changes to the groundwater system are summarised below.

– **Groundwater recharge:** Whilst the drains are predicted to capture and remove 1% of the groundwater from the Waihi Basin (Table 5.10), the proportion of combined TSF3 seepage (tailings seepage and embankment rock infiltration) within the groundwater system is expected to increase over the life of the TSF3, from 5% during operation to 10% in the long-term scenario (Table 5.11). As noted previously, this additional recharge is inferred to discharge to the Ohinemuri River. Therefore the drains are overall not expected to reduce the volume of groundwater in the catchment.
  - For comparison, without an HDPE liner, the TSF3 seepage is expected to comprise 65% of the total groundwater source.

– **Groundwater levels:** Groundwater levels south of the diverted Ruahorehore Stream are predicted to increase up to 0.25 m for the post-closure scenario (Appendix I). This level is below the adopted ZOI influence definition of 0.5 m. However, the area is flood-prone and has a shallow water table, so this increase may be influential for farm drainage and the Ruahorehore Stream. The area is more likely to be impacted during high-rainfall seasons (e.g. winter), when it is already impacted. Periods of seasonal surface flooding may be lengthened. To avoid extended periods of flooding, drains can be installed as needed, as is the current practice in the area. This is expected to be able to occur within OGNZL land and mitigate the potential effect of increased groundwater levels.

– **Surface water:** Overall, the Ruahorehore stream is neutral to losing with a very low net groundwater baseflow of 2 $m^3$/day for the length of stream running adjacent to the facility (1,000 m) (Table 5.12). Over the life of the TSF, the flows are predicted to increase slightly as the TSF is constructed, to 2.5 $m^3$/day for the final landform. The source of the increased stream flow volumes is expected to be due to clean water infiltration and run off from the adjacent collection pond crest. This minor addition of flow is expected to be within the margin of error of model predictions. Maintenance of a general neutral to slightly increased stream flow condition is an expected outcome of the TSF3 operation. Potential impacts to overall stream flow rates are not expected to be measurable at the downstream monitoring location (Ruddocks Gauge).

*Table 5.11 TSF3 seepage as a proportion of groundwater flow*

| Stage | TSF3 total seepage ($m^3$/day) | TSF3 seepage in groundwater |
|---|---|---|
| Starter embankment (1,135 m RL) | 0 | 0% |
| Operations to closure (1,155 m RL) | 45 | 5% |
| Post-closure (1,155 m RL) | 95 | 15% |
| *Comparison scenario – no HDPE liner: Starter embankment (1,135 m RL)* | *540* | *65%* |

*Table 5.12 Ruahorehore Stream flow rates*

| Stage | Modelled groundwater contribution to stream flow ($m^3$/day) | Proportion of minimum stream flow* |
|---|---|---|
| Pre-TSF3 (calibrated base model) | 2.0 | 0.4% |
| Diverted stream (pre-TSF3) | 1.0 | 0.2% |
| Operations to closure (1,155 m RL) | 1.5 | 0.3% |
| Post-closure (1,155 m RL) | 2.5 | 0.5% |
| * 540 $m^3$/day; refer to Section 5.3.5 | | |

## 5.6.2 Water quality

### Influence on groundwater quality

The predicted groundwater concentrations resulting from TSF3 discharges are presented in Table 5.13. Values for the starter embankment are not provided on the basis that the drains are predicted to capture all seepage (Section 5.5.5). The following key comments are made:

– Almost all parameter concentrations are predicted to increase in groundwater.
– The results are based on the predicted mean tailings and median embankment seepage quality values provided in the AECOM (2025a) report.
– The assessment considers mixing and dilution only. No attenuation processes are allowed for in predicting a mixed water quality. As such, the predicted values are considered to be conservative. For this reason, review of TSF1A and TSF2 groundwater quality after tailings seepage mixing has been included in Table 5.13; the influence of these TSFs on groundwater at these locations provides context of likely impact to water quality.
– A range of groundwater flows were considered, from limited mixing beneath the TSF to full aquifer mixing prior to discharge to the Ohinemuri River. The larger predicted values in Table 5.13 would be expected in groundwater close to TSF3 and these are generally consistent with the reported values from existing TSF1A and TSF2 long-term monitoring wells. This is with the exception of iron and manganese in a limited number of wells adjacent to TSF2[1], which have measured in the upper ranges of that predicted for TSF3. Concentrations of these trace elements in groundwater tend to decrease with increasing distance from the TSFs due to hydrogeochemical processes within the subsurface (Section 2.5).
– In terms of effects to nearby groundwater users, the long-term predictions of effects to groundwater quality are considered to be more reflective of likely impacts.

The nearest downgradient groundwater user is a farm bore located over 1 km away. The concentrations in groundwater that might be seen at this location are the lower ranges provided in Table 5.13, after full aquifer mixing has occurred.

These values are likely to be much higher than expected at the bore, as no geochemical processes have been accounted for in the results. Trace elements and metals such as aluminium, iron, manganese, nickel, cobalt and chromium are expected to be significantly reduced along the 1 km flow path by the added combination of processes such as precipitation, co-precipitation reactions, and adsorption. These processes are seen in other mine areas (such as TSF1A and rock stacks, refer Section 2.5) to significantly attenuate contaminant migration in groundwater in relatively close proximity to the facilities. As such, trace element concentrations are not expected to measurable increase at the farm bore.

It is possible that some increases in major ions reporting to the farm bore may occur, such as calcium, sodium, magnesium and/or sulphate. Based on the existing TSF groundwater measurements, it is expected that any concentration increases to the bore water are likely to remain well below levels that would cause issues like corrosion or plumbosolvency. The impact to this bore is therefore considered to be minimal.

Monitoring of groundwater is proposed (Section 5.6.4) to evaluate the expected changes to groundwater quality over time.

[1] Monitoring wells MW1D2S, MW1C9S/D, MW1D11S and MW1D18D; refer to OGNZL (2020) for locations and data.

*Table 5.13 Actual and predicted groundwater quality concentrations (mg/L)*

| Parameter | Existing water quality at TSF3 (AP01 median values) | Predicted values after mixing from TSF3 seepage* | | Existing groundwater quality after mixing at TSF1A and TSF2 (MW02 and MW06 median values) |
|---|---|---|---|---|
| | | Operational to closure | Long-term (post-closure) | |
| Al | 0.004 | 0.004 - 0.005 | 0.03 - 0.1 | 0.009 - 0.01 |
| As | <0.001 | 0.003 - 0.01 | 0.004 - 0.01 | 0.001 |
| Ba | 0.08 | 0.06 - 0.07 | 0.04 - 0.07 | 0.1 - 0.2 |
| Ca | 1.1 | 2 - 7 | 21 - 98 | 6.4 - 6.6 |
| Cd | <0.00005 | <0.0001 | 0.00009 - 0.0003 | 0.00008 - 0.0001 |
| Co | <0.0002 | 0.003 - 0.01 | 0.02 - 0.08 | 0.0004 - 0.005 |
| Cr | <0.0005 | 0.002 - 0.008 | 0.003 - 0.01 | < 0.0005 |
| Cu | <0.0005 | <0.0005 | 0.0008 - 0.002 | 0.0007 - 0.001 |
| Fe | <0.02 | 0.8 - 3.6 | 4.4 - 22 | 0.04 - 21 |
| Hg | <0.00008 | <0.0001 | <0.0001 | 0.0001 |
| K | 3.0 | 3.6 - 5.8 | 4.2 - 9.1 | 3.3 - 3.9 |
| Mg | 0.5 | 0.8 - 2.0 | 5.2 - 24 | 4.0 - 4.5 |
| Mn | 0.0009 | 0.1 - 0.6 | 0.7 – 3.6 | 0.1 - 1.9 |
| Na | 10 | 24 - 75 | 30 – 110 | 9.3 - 12 |
| Ni | <0.0005 | 0.0007 - 0.001 | 0.003 - 0.01 | 0.001 - 0.002 |
| Pb | <0.0001 | 0.0003 - 0.0008 | 0.0003 - 0.001 | 0.0003 - 0.001 |
| $SO_4$ | 5.0 | 31 - 128 | 95 - 452 | 10 - 22 |
| Sb | <0.0002 | <0.0002 | 0.0002 - 0.0003 | 0.0004 - 0.0006 |
| Zn | 0.003 | 0.002 - 0.003 | 0.004 - 0.009 | 0.003 - 0.01 |

* Ranges are provided based on a range of groundwater flows, from direct mixing beneath the TSF to full mixing prior to discharge to the Ohinemuri River. The larger values are expected to be encountered closest to TSF3.

## Influence on surface water quality – Ohinemuri River

As noted in Section 5.3.5, the Ohinemuri River is considered to form the primary environmental receptor for TSF3 discharges. The duration of the TSF3 operation is expected to be short relative to travel times for contaminants in groundwater to receiving surface water. The predicted water quality values are presented in Table 5.14 for the TSF3 operational/closure and long-term stages under steady-state conditions. Values for the starter embankment are not provided, for the reason noted above. The values presented are based on only on mixing and dilution of the TSF3 seepage from the tailings and embankment rock infiltration; no further groundwater dilution or attenuation is allowed for.

The results indicate that:

– Dilution in the Ohinemuri River is significant. Any increases predicted (as denoted by "↑" in Table 5.14) are so minor that they are unlikely to be detected within laboratory analytical margins of error.

– The RWQC are not expected to be exceeded.

– The mass flux leaving the TSF3 and expected to enter the Ohinemuri River is provided in Table 5.15. These values are presented for inclusion in the Water Management Report for the assessment of cumulative effects to the Ohinemuri River catchment and are not discussed further in this report.

The predicted concentrations of mercury are greater than the RWQC as the laboratory detection limit of this parameter is greater than the criterion. Mercury is typically immobile in groundwater due to volatilisation and/or precipitation processes and has not been reported in significant, persistent concentrations by OGNZL (2020).

The effect of changes to surface water quality resulting directly from TSF3 groundwater discharges is therefore considered to be negligible. Review of water quality predictions in the context of the impacts on groundwater from TSF1A and TSF2 operation is provided below to support the interpretation.

*Table 5.14 Ohinemuri River water quality (values in mg/L)*

| Parameter | Existing water quality (OH1 median values) | Predicted water quality | | Receiving water quality criteria |
|---|---|---|---|---|
| | | Operational to closure | Long-term (post-closure) | |
| Al | 0.03 | 0.03 | 0.03 | |
| As | <0.001 | <0.001 | <0.001 | 0.19 |
| Ba | 0.03 | 0.03 | 0.03 | |
| Ca | 42 | 42 | 42 | |
| Cd | <0.00005 | <0.00005 | <0.00005 | 0.0003 |
| Co | <0.0002 | <0.0002 | <0.0005 | |
| Cr | <0.0005 | <0.0005 | <0.0005 | 0.01 |
| Cu | <0.0005 | <0.0005 | <0.0005 | 0.003 |
| Fe | 0.15 | 0.2 ↑ | 0.2 ↑ | 1.0 |
| Hg | ***<0.00008**** | ***<0.00008**** | ***<0.00008**** | 0.000012 |
| K | 3.4 | 3.4 | 3.4 | |
| Mg | 3.5 | 3.5 | 3.6 ↑ | |
| Mn | 0.015 | 0.02 ↑ | 0.05 ↑ | 2.0 |
| Na | 14.5 | 14.6 ↑ | 14.7 ↑ | |
| Ni | <0.0005 | <0.0005 | <0.0007 ↑ | 0.04 |
| Pb | <0.0001 | <0.0001 | <0.0001 | 0.0004 |
| $SO_4$ | 145 | 145 | 146 ↑ | |
| Sb | <0.0002 | <0.0002 | <0.0002 | 0.03 |
| Zn | 0.0013 | 0.0013 | 0.0014 ↑ | 0.027 |

*Notes:*
Receiving water quality criteria values for hardness 20 g/m$^3$ $CaCO_3$
Values in **bold** indicate an exceedance of the receiving water quality criteria
* The mercury (Hg) criterion is lower than available laboratory detection limits
↑ Denotes a predicted increase from existing surface water quality

*Table 5.15 Mean predicted mass flux (kg/day) from TSF3 to the Ohinemuri River*

| Parameter | Operational to closure | Long-term (post-closure) |
|---|---|---|
| **Al** | 0.0004 | 0.02 |
| **As** | 0.001 | 0.002 |
| **Ba** | 0.001 | 0.002 |
| **Ca** | 1.0 | 16 |
| **Cd** | 0.00002 | 0.00004 |

| Parameter | Operational to closure | Long-term (post-closure) |
|---|---|---|
| **Co** | 0.002 | 0.01 |
| **Cr** | 0.001 | 0.002 |
| **Cu** | 0.00002 | 0.0003 |
| **Fe** | 0.6 | 3.6 |
| **Hg** | 0.00001 | 0.00002 |
| **K** | 0.6 | 1.28 |
| **Mg** | 0.3 | 3.9 |
| **Mn** | 0.09 | 0.58 |
| **Na** | 11 | 17 |
| **Ni** | 0.0002 | 0.002 |
| **Pb** | 0.0001 | 0.0002 |
| **SO4** | 20 | 73 |
| **Sb** | 0.00001 | 0.00003 |
| **Zn** | 0.00004 | 0.001 |

### Influence on surface water quality – Ruahorehore Stream

As outlined in Section 5.5.4, this assessment is presented to provide an understanding of potential effects to the Ruahorehore Stream should leakage from the collection ponds (influenced by embankment rock) enter the stream. The analysis considers 140 L/day of water quality equivalent to embankment rock infiltration entering the stream at low flow (540 $m^3$/day). Such an event would be periodic and limited in timeframe, given that the pond is intended to be emptied when full.

The results presented in Table 5.16 therefore represent the most conservative potential scenario for a single point in time. Only minor increases are reported, as denoted by "↑". These increases are unlikely to be detected from baseline values within the laboratory analytical margins of error.

*Table 5.16 Ruahorehore Stream water quality (values in mg/L)*

| Parameter | Existing water quality (RU03 and RU10)* | Predicted water quality** | | Receiving water quality criteria |
|---|---|---|---|---|
| | | Operational | Long-term | |
| Al | 0.01 | 0.02 ↑ | 0.01 | |
| As | 0.001 | 0.001 | 0.001 | 0.19 |
| Ba | 0.01 | 0.01 | 0.01 | |
| Ca | 3.4 | 3.5 ↑ | 3.5 ↑ | |
| Cd | 0.00005 | 0.00005 | 0.00005 | 0.0003 |
| Co | 0.0002 | 0.001 ↑ | 0.0003 ↑ | |
| Cr | 0.01 | 0.01 | 0.01 | 0.01 |
| Cu | 0.0005 | 0.0005 | 0.0005 | 0.003 |
| Fe | 0.1 | 0.2 ↑ | 0.1 | 1.0 |
| Hg | ***<0.00008#*** | ***<0.00008#*** | ***<0.00008#*** | 0.000012 |
| K | 3.0 | 3.0 | 3.0 | |
| Mg | 2.0 | 2.0 | 2.0 | |
| Mn | 0.04 | 0.04 | 0.04 | 2.0 |
| Na | 10.0 | 10.0 | 10.0 | |
| Ni | 0.0005 | 0.0007 ↑ | 0.0005 | 0.04 |

| Parameter | Existing water quality (RU03 and RU10)* | Predicted water quality** | | Receiving water quality criteria |
|---|---|---|---|---|
| | | Operational | Long-term | |
| Pb | 0.0001 | 0.0001 | 0.0001 | 0.0004 |
| Sb | 0.0002 | 0.0002 | 0.0002 | 0.03 |
| SO4 | 7.0 | 7.4 ↑ | 7.4 ↑ | |
| Zn | 0.004 | 0.004 | 0.004 | 0.027 |

*Notes:*
Receiving water quality criteria values for hardness 20 g/m$^3$ $CaCO_3$
Values in **bold** indicate an exceedance of the receiving water quality criteria
* These values represent the median of all samples from RU3 and RU10 (combined), which have similar water quality.
** The minimum stream flow measured has been considered.
# The mercury (Hg) criterion is lower than available laboratory detection limits
↑ Denotes a predicted increase from existing surface water quality

## 5.6.3 Consideration of existing TSFs

The influence of the existing tailings storage facilities on the environment provides insight into how TSF3 is likely to impact the environment. Section 2.5 outlines a high-level summary of the performance of existing TSFs. The following information is also reported in the EGL (2021) TSF3 technical report

– The existing TSFs do not have a liner over the base of the impoundment and rely on hydraulic containment of the site and the cutoff and associated drain at the upstream toe of the embankment and subsurface drains to intercept and collect groundwater seepage.
– Additional controls in the form of a lined impoundment are proposed for TSF3 as an improvement over the previous facilities to limit seepage into the natural environment, and because the depth to rock for a cutoff is too deep to be practical. The proposed lining of the impoundment while still retaining the upstream cutoff drain provides an additional level of protection during this early stage of deposition and for the long term. The HDPE geomembrane will also limit seepage to the subsurface drains located beneath the liner.

The effects to the environment will be cumulative from all three TSFs. As noted previously the reader should refer to the GHD (2025a) Water Management Report, which considers the results from Table 5.15.

## 5.6.4 Monitoring recommendations

Environmental monitoring is likely to be a required condition of consent, as per the existing TSFs. This section provides only a high-level overview of monitoring recommendations. Specific requirements should be provided in a detailed monitoring plan, which should include baseline monitoring (for future effects to be assessed against), trigger levels, and mitigation/contingency measures to manage any potential exceedances.

– **Construction dewatering:**
  - **Flow monitoring:** Flow gauging of the Ruahorehore Stream should be undertaken prior to and during the dewatering works. This information should be used to assess whether diversion of groundwater into the stream is required to maintain stream flow volumes.
  - **Groundwater quality:** Water quality monitoring of the dewatered groundwater during the excavation period should be undertaken to determine whether the water needs to be diverted to the WTP, or if it can be diverted to the Ruahorehore Stream.
– **TSF3 construction through to post-closure:**
  - **Groundwater quality:** It is anticipated that a groundwater well network will be established around TSF3 for frequent long-term monitoring. It is also recommended that the nearest private bore users are included, but this sampling may be at a reduced frequency compared to the site monitoring wells. Water samples are expected to be analysed for a similar suite of parameters as the existing TSFs and included in the annual interpretation of water quality data for the wider site.

- **Groundwater levels:** Groundwater levels should also be monitored at selected monitoring wells. In addition to this, site inspections of low-lying areas. The monitoring plan should include mitigation/management measures where saturated ground conditions downgradient of the TSF are exacerbated, e.g. shallow drainage channels can be installed to manage groundwater levels, as is common in local farms.
- **Surface water quality:** Surface water quality sampling regularly occurs at RU03, RU1, RU1b and RU10. It is recommended that the sampling locations, parameter suite and frequency of these be reviewed for TSF3. The results of this sampling can be used to evaluate the water quality received by the downstream surface water users.
- **Surface water flow:** Daily monitoring of the Ruahorehore Stream is undertaken at Ruddock's gauge and at Shed Spring. It is expected that this will continue to occur and be reviewed throughout the life of TSF3. The existing monitoring regime should be reviewed to consider if an additional flow gauging location further upstream is required, such as near the diverted stream section.
- **Spring monitoring:** As no effects are predicted to Shed Spring from the works, and monitoring is already proposed in relation of TSF1A, further monitoring is not proposed at this location.

# 6. Willows Rock Stack

## 6.1 Site overview

### 6.1.1 General site setting

The location of the Wharekirauponga Portal (next to WRS) is presented in Figure 1.2. Existing land use comprises dry stock and dairy farmland on the slopes of the Mataura and Walmsley Streams, both tributaries of the Ohinemuri River. The proposed WRS is located within the Mataura Stream catchment, which is approximately 6.6 $km^2$, with steep slopes and the upper catchment covered in native vegetation. The grade of the slopes reduces at the location of the proposed Wharekirauponga infrastructure across the terrace deposits. The northern boundary of the site runs along the bottom of the 1.5 km wide Mataura Stream valley.

There are several unnamed tributaries of the Mataura Stream, some of which intermittently flow with others appearing to be spring fed. There is a small existing area of wetland adjacent to the Mataura Stream, with the infrastructure proposed to be placed to avoid impact on the identified wetland areas.

### 6.1.2 Summary of proposed activity

WUG will comprise surface infrastructure, tunnel portals, a tunnelling system and the mine itself. Up to 1,100,000 $m^3$ of both PAF and NAF materials from the WUG Access tunnels and mine development will be stored at the WRS. The WRS is proposed to be located within a steep-sided gully (up to 56º slopes; the WRS gully) which forms a tributary of the Mataura Stream (Figure 6.1) (referred to as “R11”, as explained in Section 6.2.2).

In summary, the development of the WRS is understood to require:

– Minimal removal of topsoil across the WRS site.
– A shear cut through the residual soils to completely weathered rock will be installed along the north slope toe to minimise risks associated with geotechnical instability. The shear cut and construction of the toe of the WRS will use material sourced from the box cut for the tunnel portal, which is weathered andesite rock and will provide a source of NAF low permeability (Zone A) material.
– Establishment of a main collection pond to collect runoff from the rock stack, which will have capacity for a 1 in 10-year 24-hour storm event. The pond will overflow to land and flow to the Mataura Stream. The pond is proposed to be HDPE lined at least across its base.
– Installation of an initial silt pond at toe embankment of the proposed WRS.
– Placement of rock, including within the WRS gully, to a maximum stack height of 1,265 m RL over a 4-year period.
– Lime will be introduced progressively as required to assist in neutralising PAF contact waters.
– A seepage drain system will be constructed beneath the WRS north slope, within the WRS gully and within the shear key. Contact water will be directed through the drainage system and ultimately to the WTP.
– Catchment water will be partially directed back to the Mataura Stream through an existing wetland area. The water collected in the main collection pond will be directed to the WTP for treatment.

WRS is intended to be a temporary rock stack, with the rock returned to the WUG as backfill on completion of mining, which is currently scheduled for a period of 13 years. On exhaustion of the rock from this stack, the site will be rehabilitated and returned largely to its original configuration, with improved riparian areas and stock exclusion fencing to protect waterways.

There is no groundwater dewatering or diversion activity proposed for this WNP area.

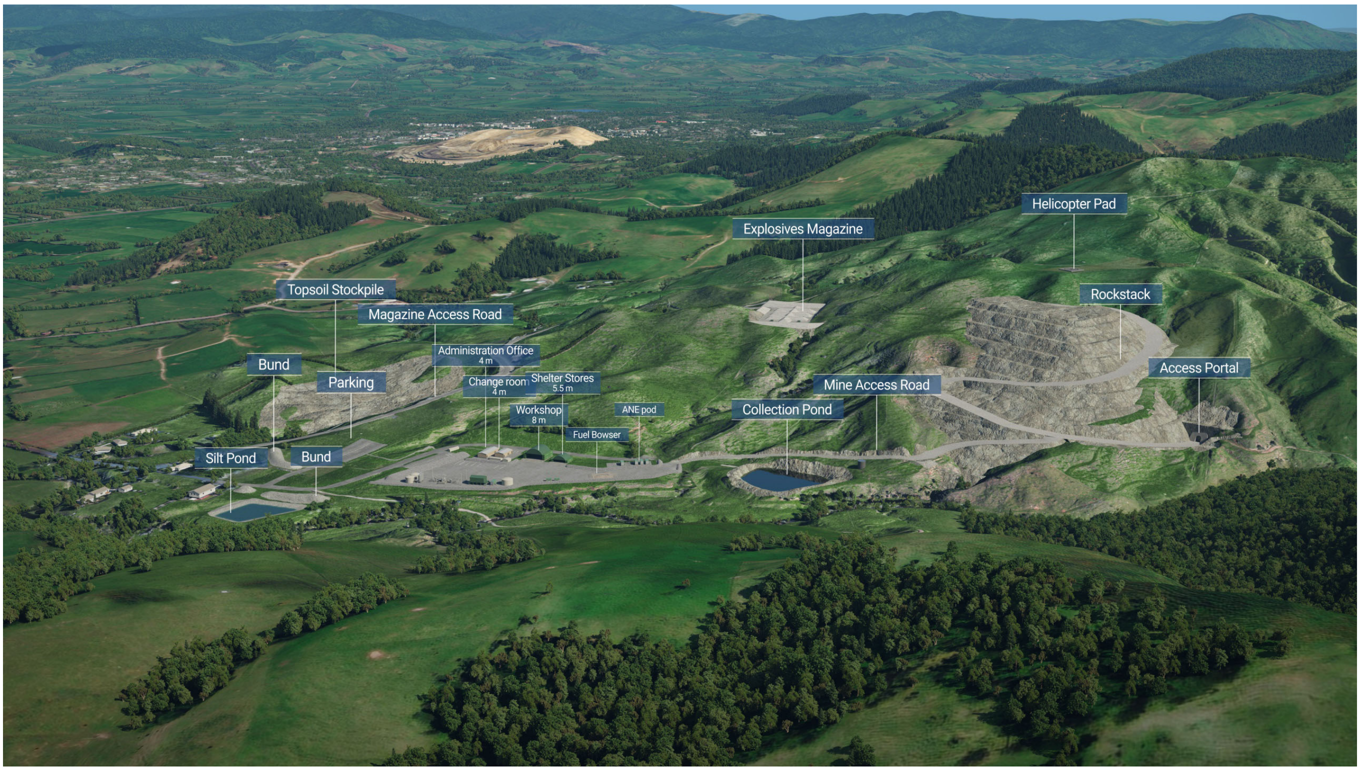


*Figure 6.1* ***Proposed Willows Rock Stack and surrounding infrastructure***

### 6.1.3 Potential influences on groundwater and surface water

This assessment of effects has focused on the potential for the proposed WRS to influence:

– Groundwater levels and baseflow to the Mataura Stream.
– Long-term groundwater and river water quality changes resulting from leachate seepage from the rock stack.

Potential effects resulting from other components of WUG have been assessed by WWLA (2025a; 2025b) and are not included in this assessment.

## 6.2 Conceptual groundwater model

The CGM for the WRS and WUG site is sourced from WWLA (2025a) and EGL (2025c). A summary of the key conceptual understanding is provided below.

### 6.2.1 Local geology

The regional geology is presented in Section 2.3. The local geology for the WRS gully is presented in Figure 6.2. A detailed description of the geology between the Wharekirauponga portal and mine is provided in the WKP Conceptual Geological Model Data Report (GHD, 2020), with geotechnical site investigation results from the proposed WRS site presented by EGL (2025c).

Whiritoa Andesite lies beneath the proposed WRS site, which is comprised of highly weathered regolith soils at the surface, some weathered tuff, and slightly to completely weathered andesite at depth. Observations of outcropping completely to highly weathered andesite rock by EGL (2025c) indicated the presence of near vertical joints. The residual cover (including tuff) is present at varying thicknesses in the WRS gully. In the centre of the WRS gully, there is no residual soil cover, with the andesite rock exposed at the base of the R11 stream (Figure 6.3). Laboratory particle size distribution (PSD) testing indicates that the residual soils predominantly comprise sandy clayey silts with high plasticity.

Further down towards the Mataura Stream, downgradient of the WRS, where topography comprises relatively gentle river terraces, surface alluvium terrace deposits are present. Colluvium is also expected to be present in the bottom of gullies and near the bank of the Mataura Stream (EGL, 2025c).

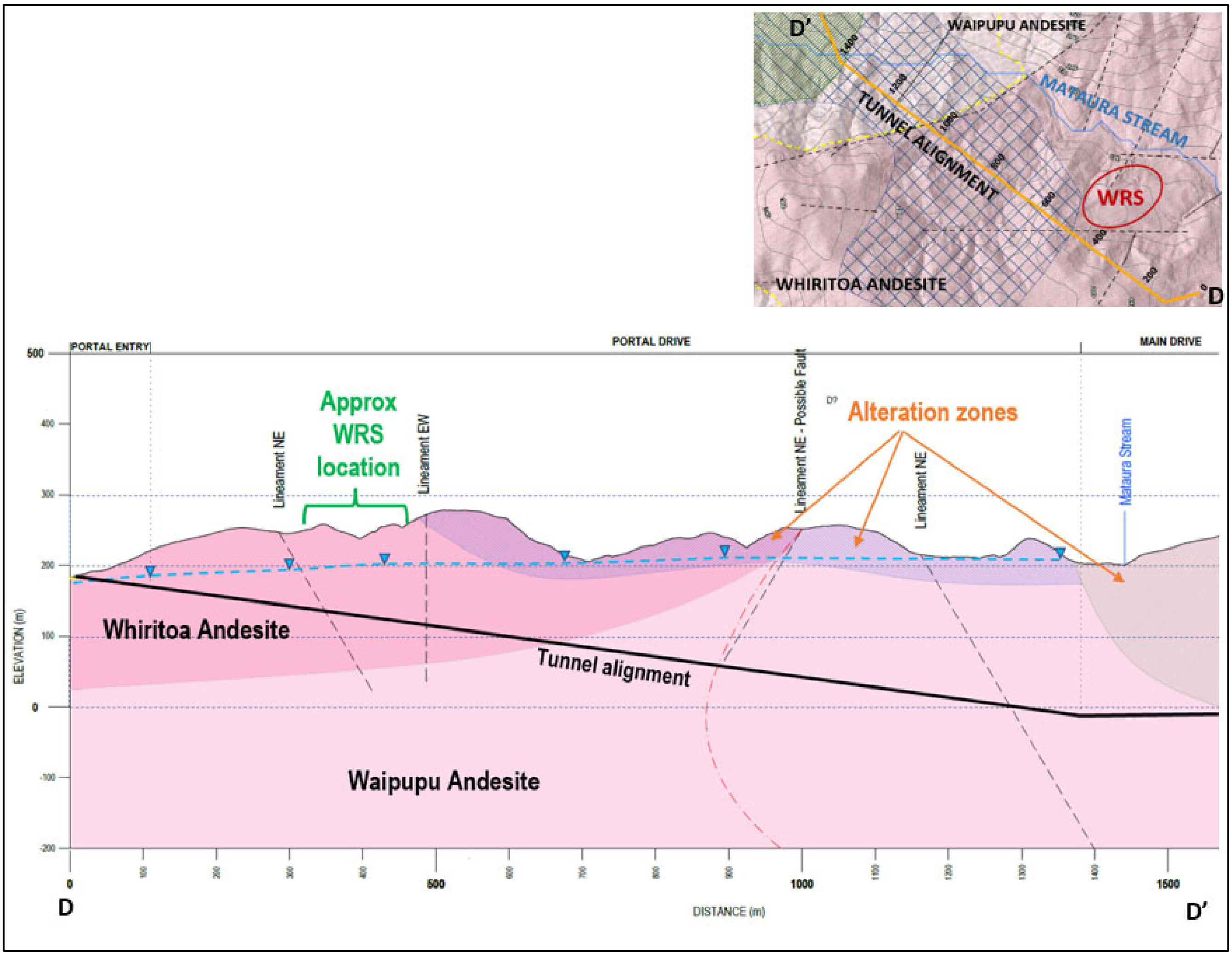


*Figure 6.2 WRS Geological section (from GHD, 2020 (refer to Appendix C of Golder/WSP 2022b)) (elevations in m asl)*


*Figure 6.3 The WRS gully stream (left: lower R11 stream near Mataura Stream confluence; right: 150 m upstream) (WSP, 2021a)*

## 6.2.2 Mataura Stream and wetland

Based on the conceptual model (Figure 6.5), the Mataura Stream is considered to form the primary environmental receptor of potential WRS discharges. The stream catchment has a total area of 6.6 $km^2$ with 85% of this being upstream of the proposed portal infrastructure. The catchment can be described as steep and rugged with the majority of its coverage being native vegetation. The Mataura Stream has a number of small tributaries and flows southeast to join the Ohinemuri River.

Baseline flow data for the Mataura Stream has been collected between 2020 and 2024. The water levels have also been monitored using a pressure transducer at location M12 (Figure 6.4) and converted to flow rates using a combination of methods (modelled and converted using a site-specific rating curve; GHD, 2024). Based on the flow calculated from the rating curves, the flow through to October 2023 was estimated to range from 2,000 – 135,000 $m^3$/day and median flow in the order of 19,000 $m^3$/day. Flow in the WRS gully tributary (R11 in Figure 6.4) has been measured between 1% and 2% of the total Mataura Stream flow (Table 6.1). R11 stream flow was not measured during the March 2021 or 9 September 2022 monitoring events, however the WSP (2021a) report notes that the tributary does not dry out in summer. The results of the flow gauging indicate that the WRS gully baseflow is approximately 0.7 – 1 L/s.

***Table 6.1 Flow gauging measurements (L/s) (WSP, 2021a and 2021b; WWLA, 2024)***

| Date | Mataura Stream (M12) | R11 | R11 percentage of M12 |
|---|---|---|---|
| 10 July 2020 | 355 | 3 | 1% |
| 30 July 2020 | 242 | 3.3 | 1% |
| 17 August 2020 | 187 | 3.6 | 2% |
| 3 September 2020 | 194 | 4.1 | 2% |
| 16 March 2021 | 54 | Not measured | - |
| 21 September 2021 | 343 | 4 | 1% |
| 8 December 2021 | 73 | 1.3 | 2% |
| 30 March 2022 | 104 | 1.1 | 1% |
| 29 June 2022 | 218 | 5.3 | 2% |
| 9 September 2022 | 214 | Not measured | - |
| 29 November 2022 | 270 | 5.3 | 2% |
| 22 August 2023 | 121 | 2 | 2% |
| 14 November 2023 | 146 | 3 | 2% |
| 30 January 2024 | 75 | 1.2 | 2% |
| 25 March 2024 | 58 | 0.7 | 1% |
| 4 June 2024 | 108 | 1.6 | 1% |
| 27 August 2024 | 191 | 2.5 | 1% |

Water quality data has been collected periodically from the Mataura Stream since 2006, with smaller data sets available from 2020 for its tributaries. The water quality from these sites is summarised in the Water Management Report (GHD, 2025a). Trace elements within the stream are not notably different from the Ohinemuri River, adjacent to the other mine components. However, major ion concentrations (such as calcium, chloride, magnesium, sodium and sulphate) are considerably lower in the Mataura Stream.


*Figure 6.4 Mataura Stream monitoring locations (WWLA, 2024)*

The Mataura Wetland is located on a river terrace on the true right of the Mataura Stream, close to the confluence of Mataura Tributary R12. Further discussion of the Mataura Wetland is provided in the GHD (2025d) Mataura Wetland Assessment Technical Memorandum, which is appended to this report as Appendix M.

### 6.2.3 Groundwater and surface water interactions

Given the steep topography and low permeability of the surface materials at the proposed WRS, much of the rainfall that occurs directly across the proposed WRS footprint is expected to form run-off that is diverted through the base of the WRS gully, toward the Mataura Stream.

A conceptual cross section developed by WWLA (2025a) is presented in Figure 6.5. The conceptual section is an amalgamation of information from the two sections denoted on the map provided in Figure 6.6. The WWLA (2025a) conceptual ground model, groundwater level monitoring undertaken in bores recently installed by EGL (Figure 6.7) and topography of the proposed WRS site, indicate that groundwater flow directions are towards the Mataura Stream. However, in close proximity of the gully, groundwater levels recorded within the shallow andesite unit (Figure 6.7) indicate localised groundwater flow towards the gully stream (tributary of the Mataura Stream). The presence of seeps along the gully at higher elevations than the recorded groundwater table also indicates the presence of localised perched groundwater within the low permeability residual soils/ash that overlies the andesite (Figure 6.5).

Downwards vertical hydraulic gradients are typically recorded within the andesite (Figure 6.7), confirming the conceptual understanding that a portion of groundwater is also discharged directly to the Mataura Stream.

Trace elements in groundwater are naturally detectable due to the natural catchment conditions (e.g. aluminium, iron, manganese, zinc; refer to water quality data in Appendix E).

### 6.2.4 Hydraulic parameters

Permeability testing (packer testing and falling head tests) of boreholes drilled at the proposed WRS site is reported by EGL (2025c). The values presented in Table 6.2 were adopted within the groundwater modelling assessment based on the information provided and through model calibration to recorded shallow groundwater levels, vertical hydraulic gradients and gully stream base flow.

*Table 6.2 Hydraulic conductivity values*

| Geological unit | Hydraulic conductivity (m/s) | Anisotropy | Source |
|---|---|---|---|
| Ash / Residual soil | $2 \times 10^{-8}$ | 0.3 | PSD analysis permeability test results (EGL, 2025c) |
| Extremely – very weak Andesite | $9\times10^{-7}$ | 0.6 | Permeability test results (EGL, 2025c) |
| Weak – moderately strong Andesite | $1\times10^{-6}$ | 1.0 | Permeability test results (EGL, 2025c) |
| Andesite basement rock | $1 \times 10^{-9}$ | 1.0 | Considered appropriate for basement rock |

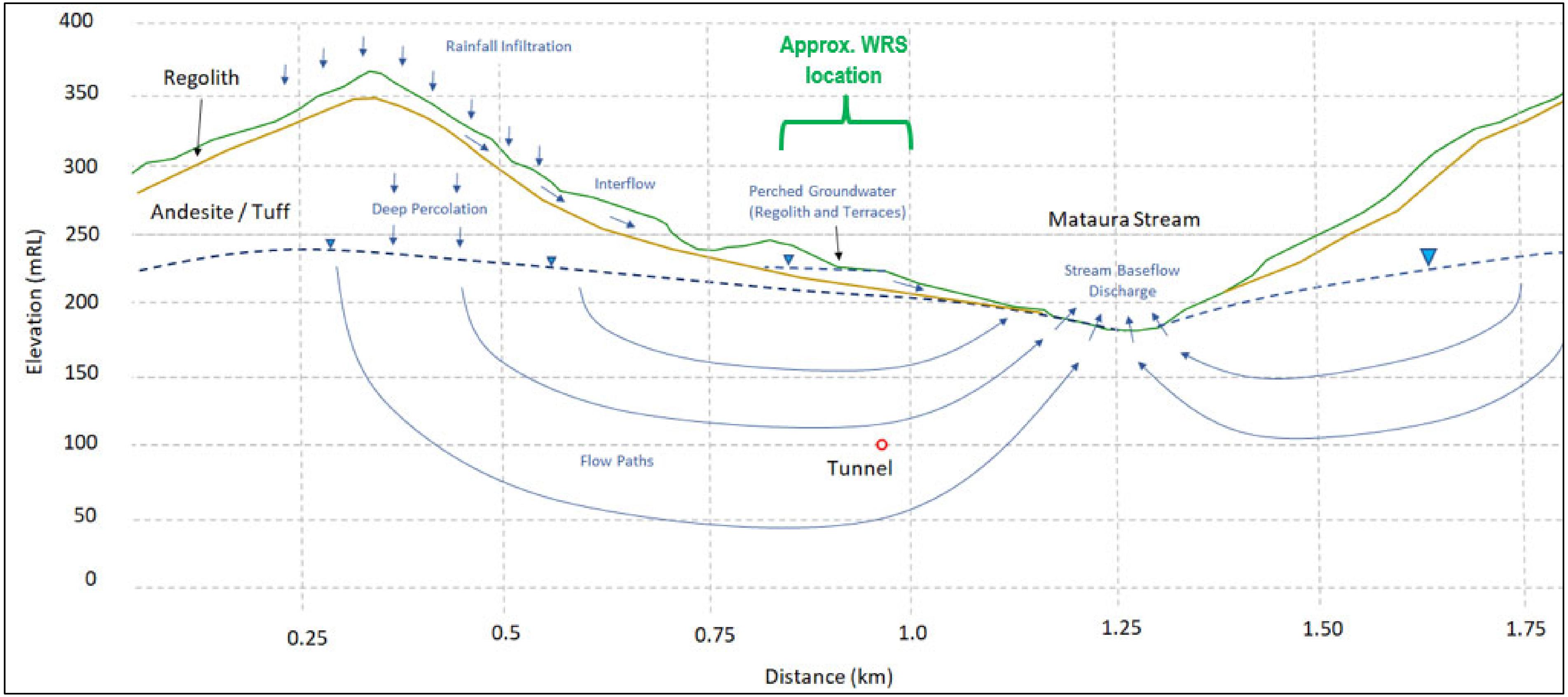


*Figure 6.5 West – East Conceptual cross section (from WWLA, 2025a). (Note: Elevation not referenced to Mine Datum of +1,000 mRL).*

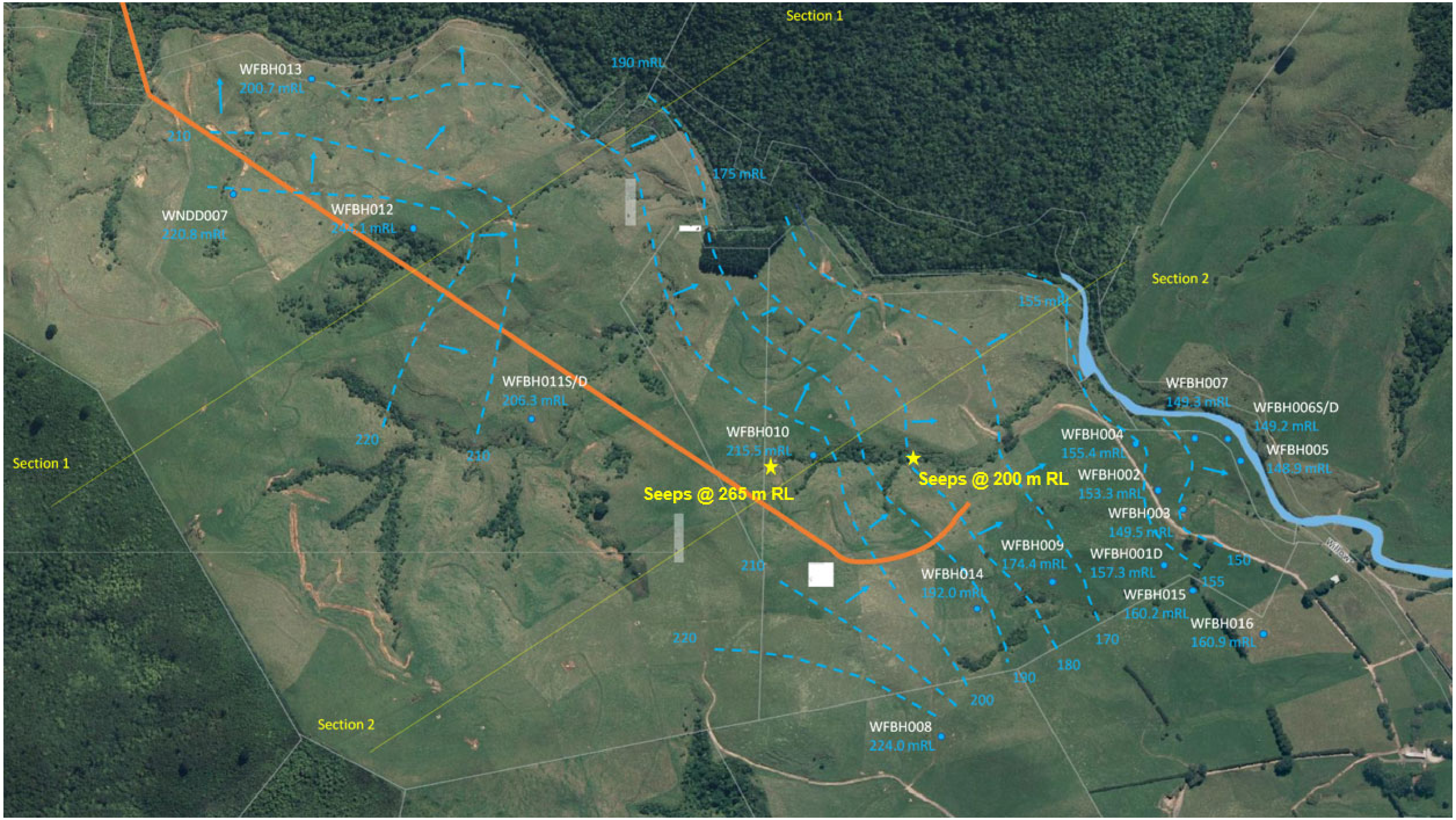


*Figure 6.6* *Groundwater monitoring well locations, interpreted piezometric contours (sourced from WWLA, 2025a) with seeps interpreted by GHD from WSP (2021). (Note: Groundwater level and seep elevations not referenced to mine datum of +1,000 mRL).*


Paper Size A3

0 10 20 30

Metres

Map Projection: Transverse Mercator
Horizontal Datum: New Zealand 1949
Grid: NZGD 1949 Mount Eden Circuit

N

LEGEND

GWL = groundwater level (mRL), S = Shallow, M = Mid, D = Deep
Cross section
Inferred groundwater flow direction
Rock stack within catchment
Rivers (LINZ)
Contour (20m)

GHD

Oceana Gold Limited
Waihi North

Groundwater levels within WRS footprint

| | |
|---|---|
| Job Number | 12590241 |
| Revision | 1 |
| Date | 17 Feb 2025 |

Figure 6.7

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Level 3, 138 Victoria Street, PO Box 13 468, Christchurch 8141, New Zealand **T** 64 3 378 0900 **F** 64 3 378 8001 **E** chcmail@ghd.com **W** www.ghd.com



Data source: LINZ (cc-by): Aerial imagery (NZ - Imagery: Classic Basemap Server - Deprecated Basemap - Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors), Rivers - https://services7.arcgis.com/jI87xPT7G1AGV8Uo/arcgis/rest/services/, Roads - 20200216; GHD: Bores_TSF3, Consents_TSF3, Dewatering Zol. Created by:nrama

### 6.2.5 Water resource users

Registered bores and water take consents in proximity of the proposed WRS are presented in Figure 6.8.

The nearest registered bore is 1.0 km to the southeast (Well ID 57759)), with a recorded bore depth of 88.5 m. One municipal surface water take for HDC is located on Walmsley Stream (AUTH130392.01.01). This is a tributary located within a separate sub-catchment of the Ohinemuri River. It is not considered to be connected to the WRS catchment.

The nearest downstream take on the Ohinemuri River (AUTH130392.03.01) is a HDC supply take, located approximately 5 km downstream of the WRS. This consent is presented in the Gladstone and NRS water users plan (Figure 3.11).


Paper Size A3

0 100 200 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

LEGEND

Registered bores (WRC Well ID) - excluding OGL bores

**Authorised Takes - excluding OGL takes**

Groundwater take (AUTH = WRC consent ID)

Surface water take (AUTH = WRC consent ID)

Rivers (LINZ)

SiteLocations

Oceana Gold Limited
Waihi North

WRS Surface Water and Groundwater Takes

| | |
|---|---|
| Job Number | 12590241 |
| Revision | 1 |
| Date | 19 Feb 2025 |

Figure 6.8

N:\NZ\NZ GIS\Auckland\Projects\Projects\12526951_OceanaGold\12526951_SW_GW_updates_2024.aprx

Level 3, 138 Victoria Street, PO Box 13 468, Christchurch 8141, New Zealand T 64 3 378 0900 F 64 3 378 8001 E chcmail@ghd.com W www.ghd.com



Data source: LINZ (cc-by): Aerial imagery (NZ - Imagery: Classic Basemap Server - Deprecated Basemap - Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors), Rivers - https://services7.arcgis.com/jI87xPT7G1AGV8Uo/arcgis/rest/services/, Roads - 20200216; GHD: Bores_TSF3, Consents_TSF3, Dewatering ZoI. Created by:nrama

# 6.3 WRS assessment

## 6.3.1 Approach

An assessment of impacts to groundwater and surface water associated with WRS was undertaken through conceptual interpretation, supported by the use of 2D numerical groundwater model with Geostudio 2024 SEEP/W finite element numerical modelling software.

The assessment comprised development of the following models:

– **Model set up and calibration:** Development of a steady state 2D cross-sectional model using Geostudio SEEP/W along the section presented in Figure 6.7, representing the WRS at the fully constructed height. The cross-section is perpendicular to the WRS gully and extended to the elevated ridge lines to the north and south, which are inferred to represent the hydraulic boundaries of the groundwater catchment. This steady-state model was set-up using a constant head base boundary to provide a consistent downward gradient to the deeper aquifer level, with groundwater in the shallow andesite discharging to the stream in the gully. The model was calibrated to shallow groundwater levels in the andesite, the presence of downwards vertical hydraulic gradients and baseflow discharge to the stream in the gully (R11) (Figure 6.9)

– **Operational**: To assess the impact of the waste rock, the calibrated model was adjusted to represent the emplaced WRS. Recharge was applied to the emplaced rock, with a shear key drain placed at the base of the proposed shear key (above the Zone A liner) and a rock drain placed in the WRS gully beneath the rock stack.

  The model was used to predict WRS leachate generation rates, drain capture rates and loss of leachate that is not captured by the drainage system.

– **Water quality:** Due to the low volume of predicted seepage (in relation to the flow in the receiving environment) equilibrium modelling was not undertaken and a simple mass balance approach was utilised. This model considered seepage rates from the above models and chemistry of discharges provided in the Water Management Report (GHD, 2025a) for mixing with the existing water quality of receiving groundwater and surface water. The 95$^{th}$ percentile values for TSF1A have been conservatively applied, due to limited data available on the leachability of the WKP materials.

  The contaminants of concern listed for the WRS are limited compared with the other project areas (e.g. barium and chromium are not included). The parameters presented focus on the likely consented elements in the receiving environment and are adopted here as presented in the GHD (2025a) Water Management Report.

Refer to Appendix J for detailed description of the assessment methodology.

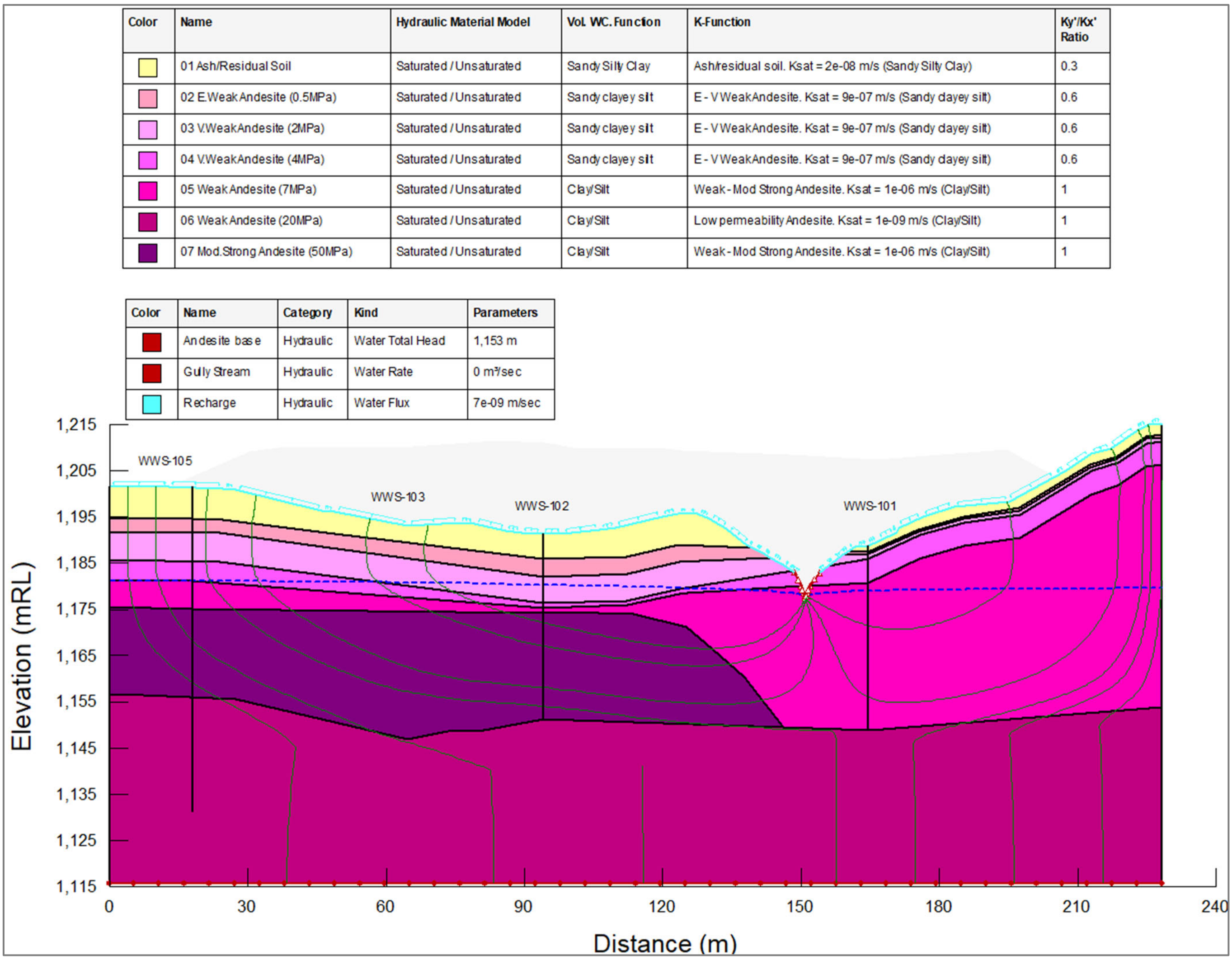


***Figure 6.9*** ***Calibrated numerical groundwater model (base model). Dashed blue line = phreatic groundwater surface. Solid green lines = groundwater flow paths.***

### 6.3.2 Rationale

As noted above, the cross-section is perpendicular to the WRS gully, as well as the deeper groundwater flow direction towards the Mataura Stream. The purpose of this model is to understand seepage from the rock stack to the drains and losses through the base of the model (to the Mataura Stream). This model set up is considered appropriate as the rock drain will have the strongest hydraulic influence on the water flow in the rock stack and create an inward gradient to the base of the WRS gully (high degree of hydraulic containment).

## 6.4 WRS analysis results

### 6.4.1 Leachate capture and discharge assessment results

The results of the numerical groundwater model indicate that some of the leachate generated within the WRS is likely to report directly to the shear key drain. The majority of leachate generated however is expected to seep through the base of the WRS into the underlying groundwater, before being captured by the rock drain in the base of the WRS gully (providing a high degree of hydraulic containment). The results do not differentiate between rates of leachate captured by the shear key drain and the gully drain, as the shear key drain will only be present within a small section of the WRS. Where the shear key is not present, groundwater flow paths indicate that seepage will be captured by the gully drain.

A small portion of leachate that seeps to ground is not expected to be captured by the rock drain and is predicted to follow deeper groundwater flow paths towards the Mataura Stream. The phreatic groundwater surface and groundwater flow paths for the 30% and 50% recharge scenarios are presented in Figure 6.10 and Figure 6.11, respectively.

| Color | Name | Hydraulic Material Model | Vol. WC. Function | K-Function | Ky/Kx' Ratio |
|---|---|---|---|---|---|
| | 00 WRS Rockfill (16th) | Saturated / Unsaturated | Silty Sand | Waste Rock, Ksat = 1e-5 m/s (Silty Sand) | 0.5 |
| | 01 Ash/Residual Soil | Saturated / Unsaturated | Sandy Silty Clay | Ash/residual soil. Ksat = 2e-08 m/s (Sandy Silty Clay) | 0.3 |
| | 02 E.Weak Andesite (0.5MPa) | Saturated / Unsaturated | Sandy clayey silt | E - V Weak Andesite. Ksat = 9e-07 m/s (Sandy clayey silt) | 0.6 |
| | 03 V.Weak Andesite (2MPa) | Saturated / Unsaturated | Sandy clayey silt | E - V Weak Andesite. Ksat = 9e-07 m/s (Sandy clayey silt) | 0.6 |
| | 04 V.Weak Andesite (4MPa) | Saturated / Unsaturated | Sandy clayey silt | E - V Weak Andesite. Ksat = 9e-07 m/s (Sandy clayey silt) | 0.6 |
| | 05 Weak Andesite (7MPa) | Saturated / Unsaturated | Clay/Silt | Weak - Mod Strong Andesite. Ksat = 1e-06 m/s (Clay/Silt) | 1 |
| | 06 Weak Andesite (20MPa) | Saturated / Unsaturated | Clay/Silt | Low permeability Andesite. Ksat = 1e-09 m/s (Clay/Silt) | 1 |
| | 07 Mod.Strong Andesite (50MPa) | Saturated / Unsaturated | Clay/Silt | Weak - Mod Strong Andesite. Ksat = 1e-06 m/s (Clay/Silt) | 1 |
| | 09 Zone A | Saturated / Unsaturated | Clayey silt | Zone A Liner. Ksat=1e-08m/s (Clayey silt) | 1 |
| | 10 Rock Drain | Saturated / Unsaturated | Uniform sand | Rock Drain, Ksat=1.0e-02m/s (Uniform sand) | 1 |

| Color | Name | Category | Kind | Parameters |
|---|---|---|---|---|
| | 30% WRS recharge | Hydraulic | Water Flux | 2.3e-08 m/sec |
| | Andesite base | Hydraulic | Water Total Head | 1,153 m |
| | Recharge | Hydraulic | Water Flux | 7e-09 m/sec |
| | Rock drain | Hydraulic | Water Rate | 0 m³/sec |
| | Shear key drain | Hydraulic | Water Rate | 0 m³/sec |

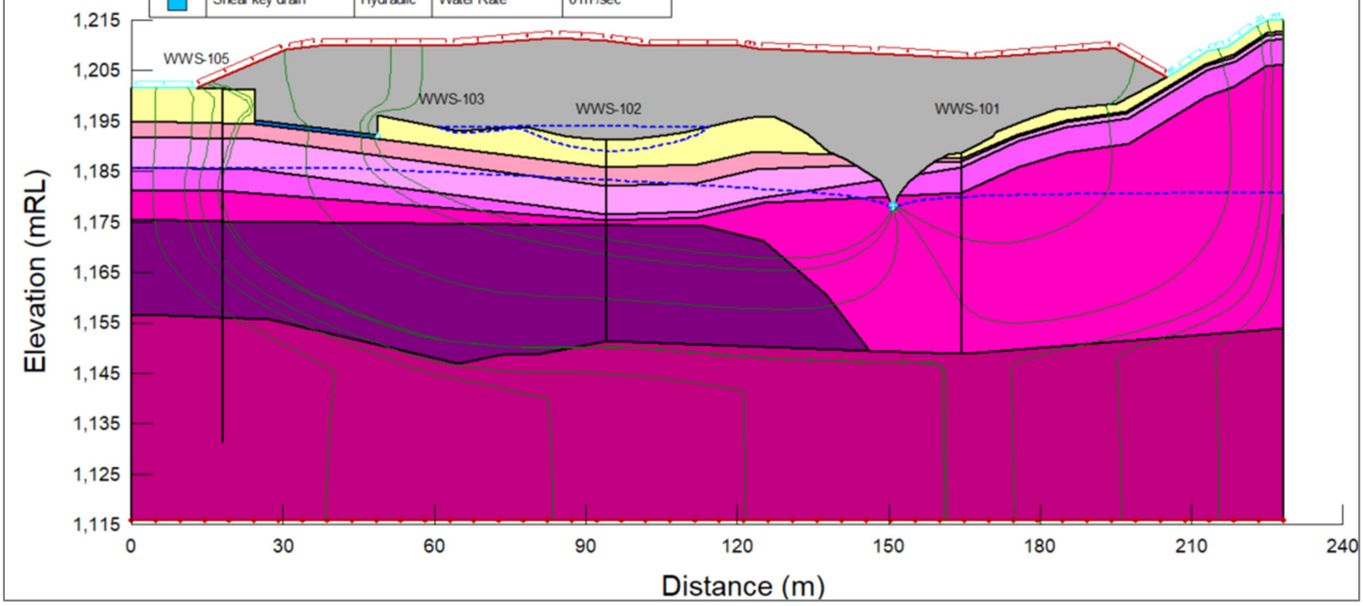


*Figure 6.10 WRS rock stack (30% recharge). Dashed blue line = phreatic groundwater surface. Solid green lines = groundwater flow paths.*

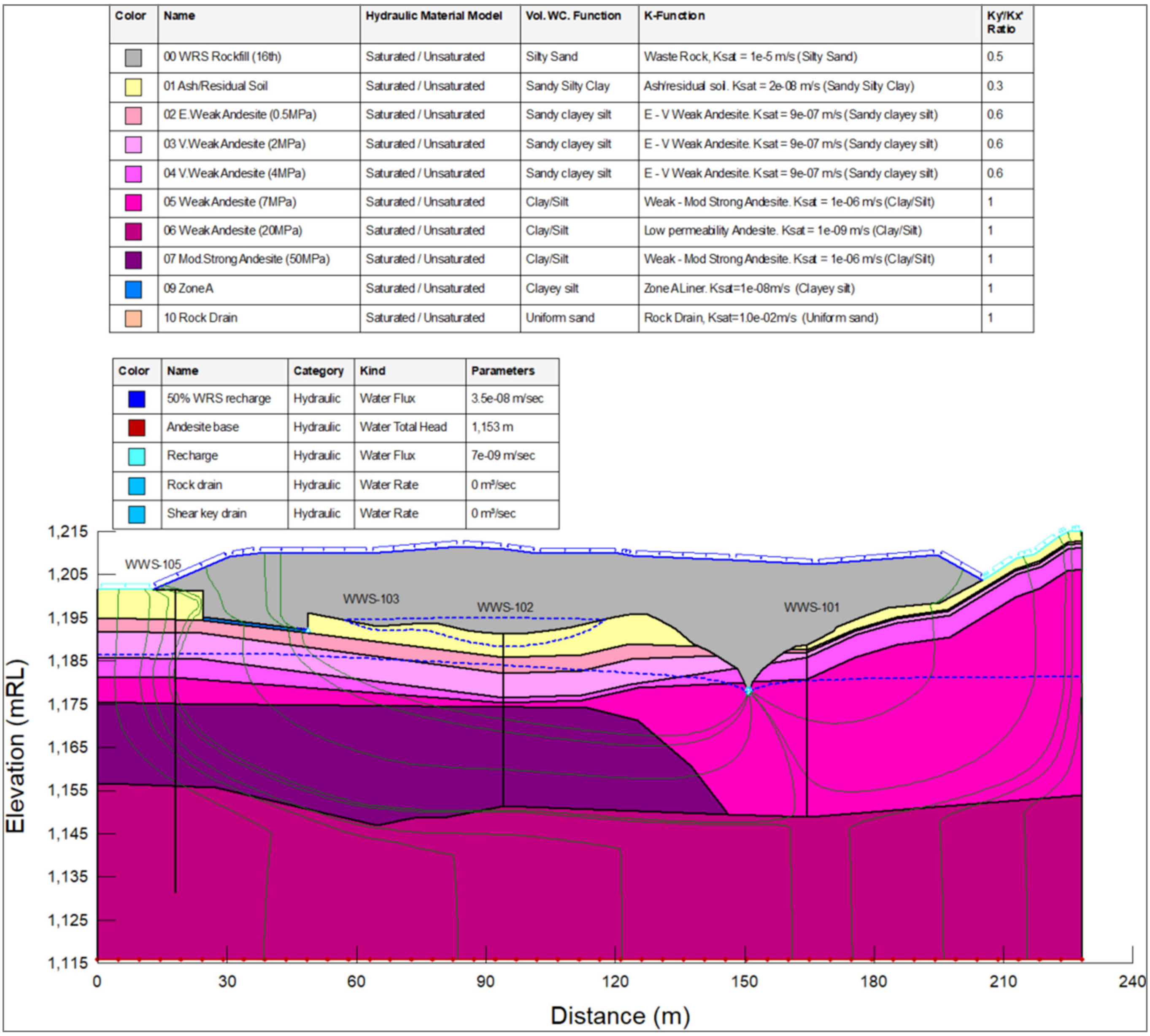


*Figure 6.11* ***WRS rock stack (50% recharge). Dashed blue line = phreatic groundwater surface. Solid green lines = groundwater flow paths.***

The results of the leachate assessment are presented in Table 6.3 and Table 6.4. It is noted that the combined volume of captured and non-captured leachate is greater than total infiltration through the WRS due to a small volume of groundwater recharged from outside the footprint of the WRS being predicted to be captured within the rock drain in the WRS gully. While mixing with groundwater beneath the WRS, and contribution of groundwater recharged outside the WRS footprint, is expected to provide a degree of dilution of the leachate, for conservatism, this has not been considered when predicting the mass flux of leachate captured in the drainage system (Table 6.4).

*Table 6.3* ***Leachate generation and discharge from WRS ($m^3$/day)***

| WRS recharge | Total infiltration through WRS | Leachate captured by shear key drain and rock drain | Leachate seepage not captured by drains |
|---|---|---|---|
| 30% | 175 | 178 | 2.2 |
| 50% | 267 | 270 | 1.2 |

*Table 6.4 Mass flux of leachate captured by shear key and rock drain (50% recharge scenario) assuming leachate quality of 95th percentile values for TSF1A*

| Parameter | Mass flux (kg/d) |
|---|---|
| Al | 0.089 |
| As | 0.00081 |
| Cu | 0.00081 |
| Fe | 5.1 |
| Hg | 0.00015 |
| Mn | 12.9 |
| Ni | 0.081 |
| Pb | 0.00011 |
| Se | 0.0013 |
| Sb | 0.0013 |
| SO4 | 647 |
| Zn | 0.051 |

## 6.4.2 Water quality assessment results

The predicted water quality values presented in Table 6.5 are for the WRS at maximum construction height, before it is removed and the catchment remediated. The values presented are based only on mixing and dilution of the WRS seepage. No groundwater dilution or attenuation is allowed for.

The mass flux leaving the WRS and expected to directly discharge to the Mataura Stream, and ultimately enter the Ohinemuri River, is provided in Table 6.6. These values are presented for inclusion in the Water Management Report (GHD, 2025a) for the assessment of cumulative effects to the Ohinemuri River catchment.

*Table 6.5 Mataura Stream estimated water quality (values in mg/L) assuming leachate quality of 95th percentile values for TSF1A*

| **Parameter** | **Existing water quality*** (median values) | **Predicted water quality after WRS seepage mixing** | | **Receiving water quality criteria** |
|---|---|---|---|---|
| | | **Median flow conditions (19,000 m$^3$/day)** | **Low flow conditions (2,000 m$^3$/day)** | |
| Al | 0.03 | 0.03 | 0.03 | |
| As | 0.001 | 0.001 | 0.001 | 0.19 |
| Ca | 2.3 | 2.4 ↑ | 2.9 ↑ | |
| Cd | 0.00005 | 0.00005 | 0.00005 | 0.0003 |
| Co | 0.0002 | 0.0002 | 0.0004 ↑ | |
| Cu | 0.0005 | 0.0005 | 0.0005 | 0.003 |
| Fe | 0.03 | 0.03 | 0.05 ↑ | 1.0 |
| Hg | ***0.00008*** | ***0.00008*** | ***0.00008*** | 0.000012 |
| K | 1.0 | 1.0 | 1.0 | |
| Mg | 1.3 | 1.3 | 1.6 ↑ | |
| Mn | 0.002 | 0.0076 ↑ | 0.055 ↑ | 2.0 |
| Na | 6.9 | 6.9 | 7.0 ↑ | |

| Parameter | Existing water quality* (median values) | Predicted water quality after WRS seepage mixing | | Receiving water quality criteria |
|---|---|---|---|---|
| | | Median flow conditions (19,000 $m^3$/day) | Low flow conditions (2,000 $m^3$/day) | |
| $NH_3$-N | No data | No result<br>(*increase of 0.0003*) ↑ | No result<br>(*increase of 0.003*) ↑ | 0.19 |
| Ni | 0.0005 | 0.0005 | 0.0008 ↑ | 0.04 |
| Pb | 0.0001 | 0.0001 | 0.0001 | 0.0004 |
| Se | No data | No result<br>(*increase of 0.0000006*) ↑ | No result<br>(*increase of 0.000006*) ↑ | 0.02 |
| Sb | 0.0002 | 0.0002 | 0.0002 | 0.03 |
| $SO_4$ | 9.0 | 9.3 ↑ | 11.6 ↑ | |
| Zn | 0.001 | 0.001 | 0.001 | 0.027 |

*Notes:*
Receiving water quality criteria values for hardness 20 g/$m^3$ $CaCO_3$
Values in **bold** indicate an exceedance of the receiving water quality criteria
* Median from sampling results at Mataura Stream M12 2020 – 2024
** The mercury (Hg) criterion is lower than available laboratory detection limits
↑ Denotes a predicted increase from existing surface water quality (note: not all increases are expected to be measurable)

*Table 6.6 Predicted mass flux to the Mataura Stream (kg/day) assuming leachate quality of 95th percentile values for TSF1A*

| Parameter | Mass flux (kg/d) |
|---|---|
| **Al** | 0.00073 |
| **As** | 0.0000066 |
| **Ca** | 1.2 |
| **Cd** | 0.0000022 |
| **Co** | 0.00031 |
| **Cu** | 0.000007 |
| **Fe** | 0.042 |
| **Hg** | 0.0000012 |
| **K** | 0.041 |
| **Mg** | 0.55 |
| **Mn** | 0.11 |
| **Na** | 0.28 |
| **$NH_3$-N** | 0.006 |
| **Ni** | 0.00066 |
| **Pb** | 0.00000088 |
| **Se** | 0.000011 |
| **Sb** | 0.000011 |
| **SO4** | 5.3 |
| **Zn** | 0.00042 |

# 6.5 WRS effects summary and discussion

## 6.5.1 Groundwater levels, flows and recharge

- **Groundwater recharge:** The presence of the WRS is expected to provide additional recharge to the groundwater catchment; an increase from approximately 64 $m^3$/day (base model) to 181 $m^3$/day (30% recharge) or 271 $m^3$/day (50% recharge). The majority of this is expected to be captured by the WRS drainage system and pumped to the WTP during WRS operation with ultimate discharge to the Ohinemuri River. Given the steep horizontal hydraulic gradient down the slope any increases in groundwater levels due to the increased recharge is not expected to impact the overall groundwater flow regime east toward the Mataura Stream.
- **Perched groundwater**: Localised perched groundwater is currently assumed to discharge into the WRS gully as seeps. During operation, WRS infiltration water that does not discharge to the andesite aquifer is expected to continue to flow along the perched groundwater system and discharge via existing flow paths into the underlying rock drain system. This water will be captured by the WRS collection pond and be pumped to the WTP during WRS operation.
- **Stream**: The capture of the R11 stream water through the rock drain in the WRS gully is expected to result in the loss of up to 2% of flow from the Mataura Stream (based on flow gauging results in Table 6.1). In addition, groundwater recharge that discharges directly to the Mataura Stream is estimated to reduce from approximately 8 $m^3$/day to 2 $m^3$/day (30% recharge) or 1 $m^3$/day (50% recharge). Even when combined with loss of stream flow, this reduction is expected to be less than 2.5% of the Mataura Stream flow. This is within the uncertainty of flow gauging devices (2.7%) reported by WSP (2021a and 2021b) and therefore not expected to be a measurable loss. On remediation of the site, it is expected that both groundwater and surface water flow to the gully stream and Mataura Stream will be restored.
- **Wetland**: Discussion of impacts to the Mataura Wetland is provided in the GHD (2025d) Mataura Wetland Assessment Technical Memorandum, which is appended to this report as Appendix M.

## 6.5.2 Water quality

### Influence on groundwater quality

Up to 2 $m^3$/day of WRS seepage is predicted to discharge to ground. It is not expected that any groundwater users will be impacted due to distance to the nearest bore user (1.0 km away); this bore is also not considered to be located down hydraulic gradient of the proposed WRS site (Figure 6.8). Any discharge will also be subject to significant dilution and attenuation processes.

### Influence on surface water quality – Mataura Stream

As noted in Section 6.2, the Mataura Stream is considered to form the primary environmental receptor for WRS seepage to ground. The duration of the WRS operation is expected to be short relative to travel times for contaminants in groundwater to receiving surface water. As such, the steady-state analysis approach is considered to be conservative.

Seepage is very low relative to flow in the Mataura Stream. The seepage is estimated to comprise up to 0.1% of the Mataura stream low flow condition, and 0.01% of the median condition. The predicted water quality values presented in Table 6.5. The dilution in the stream is significant, so that increases predicted (as denoted by "↑") for trace elements are expected to be so minor they are unlikely to be detected within laboratory analytical margins of error. This is particularly the case where further attenuation by geochemical processes is considered. Increases in major ions (such as sulphate) may however, be measurable. This conclusion is consistent with observations in the Ohinemuri catchment near the WTP and existing mine elements. RWQC are not expected to be exceeded.

As noted in the above assessments, the predicted concentrations of mercury are greater than the RWQC as the laboratory detection limit of this parameter is greater than the criterion. Mercury has not been reported in significant persistent concentrations by OGNZL (2020).

The effect of changes to surface water quality to the Mataura Stream resulting directly from WRS groundwater discharges is therefore considered to be limited. The resulting effect to the nearest authorised surface water user

(HDC water take AUTH130392.03.01), 5 km downstream on the Ohinemuri River, is similarly negligible, due to further dilution within the river.

### 6.5.3 Monitoring recommendations

Environmental monitoring is likely to be a required condition of consent similar to other mine elements. This section provides only a high-level overview of monitoring recommendations. Specific requirements should be provided in a detailed monitoring plan, which should include baseline monitoring (for future effects to be assessed against), trigger levels, and mitigation/contingency measures to manage any potential exceedances.

– **Groundwater quality and water levels:** It is anticipated that selected groundwater monitoring wells from the established well network near the proposed WRS can be utilised to provide baseline data and long-term monitoring. The wells should include both shallow and deeper aquifer wells. Water samples are expected to be analysed for a suite of key indicator parameters indicated by the leachate testing of the WKP rock.
– **Surface water quality:** Surface water quality monitoring has periodically occurred within the Mataura Stream and WRS gully. It is recommended that existing locations, and possibly an additional site on the Mataura stream (immediately after the R11 tributary confluence), be considered for the monitoring schedule. The parameters to be analysed should be considered in conjunction with the key leachate parameters.
– **Surface water flow:** Continuous monitoring of the Mataura Stream is undertaken at location M12. Periodic flow gauging of the stream and the lower WRS tributary have also been undertaken. It is expected that the M12 monitoring will continue to occur. A formal gauging programme should also be considered for the lower WRS gully tributary, including assessment of the R11 stream baseflow. This would allow for assessment of WRS mass flux seepage through the shallow groundwater system to surface water.

# 7. Conclusions and recommendations

This report provides assessment of four of the components of WNP: The Gladstone Open Pit (GOP) and tailings storage facility (TSF), Northern Rock Stack (NRS), Tailings Storage Facility 3 (TSF3) and the Willows Road rock stacks (WRS) associated with Wharekirauponga underground mine (WUG).

It is concluded that the potential effects to groundwater and surface water quality associated with development, operation and closure of these mine components may be measurable in localised areas, but are no more than minor. Each mine component is recommended to have a monitoring plan, outlining requirements for monitoring (for effects to be assessed against), site-specific trigger levels, and mitigation / contingency measures to manage unexpected adverse outcomes.

The assessment conclusions and recommendations for each mine component are summarised below. The cumulative assessment of discharges to the Ohinemuri River catchment is provided in the GHD (2025a) Water Management Report.

## 7.1 Gladstone Open Pit and Tailings Storage Facility

Excavation of the Gladstone Open Pit (GOP) is proposed to comprise two conjoined pits over Gladstone Hill and Winner Hill to a maximum depth of 1,005 mRL. While existing mine dewatering activities are considered to have largely created a situation where the shallow groundwater system is under-drained in close vicinity of the proposed GOP, the Gladstone vein system southwest of the pit is not expected to be currently dewatered. Following excavation to maximum pit depth, the pit will be developed as a TSF, including a drainage system to contain tailings seepage until a significant improvement in seepage water quality is apparent. Rewatering of the deep groundwater system will occur after all mine dewatering activities at Waihi cease, restoring deep groundwater levels to those similar to pre-mining conditions. Groundwater levels and flow direction will be influenced by the proposed elevation of the Martha Pit Lake (1,104 mRL) and the hydraulic connections created by underground mining. This is expected to have a controlling influence on groundwater pressure beneath the Gladstone TSF in the long-term.

The assessment of effects on groundwater and surface water for Gladstone Open Pit and the Tailings Storage Facility is provided in Section 3.7, with the below summarising the predicted effects.

– Excavation of the GOP and dewatering of the Gladstone vein system:
  - Assuming the veins are currently saturated, groundwater inflow to the excavated pit from the vein is estimated to be up to 1,100 $m^3$/day during initial inflow as groundwater is drained from storage, reducing to up to 325 $m^3$/day as equilibrium conditions are achieved. Given the limited extent of ore body southwest of the proposed GOP and generally limited hydraulic connection outside of the immediate vein system, these estimates are expected to represent an upper bound. Inflow from the shallow groundwater system is expected to be small, and in the order of 9 $m^3$/day.
  - Is predicted to reduce groundwater discharge to the Ohinemuri River by up to 55 $m^3$/day to the west (towards monitoring location OH6) and <1 $m^3$/day to the east (towards monitoring location OH3) and 20% reduction in stormwater runoff and interflow. Such reductions in river flow are expected to be unmeasurable as the area of the OH3 and OH6 sub-catchments that interact with Gladstone Hill total approximately 30 ha, which is very small in the context of the total Ohinemuri River catchment of approximately 29,000 ha.
  - Dewatering of the vein system is expected to result in limited impact on the deep groundwater system. Assuming the vein is currently saturated to the southwest of the proposed GOP, mining is predicted to see the desaturated zone extend to the southwest just beyond the Ohinemuri River. Loss of water from the Ohinemuri River due to dewatering in the andesite is predicted to be minimal, owing to relative separation of the shallow and deep groundwater systems. No groundwater or surface water users are predicted to be impacted by dewatering within the vein system.

- Gladstone wetland water levels are controlled by culvert level, with stormwater and interflow dominating the water flow to the wetland. A reduction in groundwater baseflow to the Gladstone wetland of approximately <0.5 $m^3$/day is predicted to occur during excavation of the pit, with this change in baseflow being very small in the context of the wetland water balance and expected to result in only minor change in the wetland water balance under drought conditions (GHD, 2022 (Appendix L)). Diversion of water to the wetland to support flow is expected to mitigate meaningful reduction in levels and flow.

– Operation of the Gladstone TSF:
  - Due to the use of drainage during TSF development and into closure, predicted effects are effectively limited to those predicted as a result of dewatering during GOP excavation.
  - No discharge of water from the tailings or placed rock to shallow groundwater system or surface water is predicted to occur. Instead seepage through the TSF is expected to percolate to the deep groundwater system where it will migrate with groundwater through the network of hydraulically connected veins, fracturing and workings towards the deeper underground mine dewatering locations, captured and directed to the WTP. Discharge via of tailings porewater via this flow path is predicted to be in the order of 187 $m^3$/day, with effects to groundwater quality expected to be at most minor when considering the influence of underground mining and backfilling activities.

– TSF after mine closure and rewatering of the deep groundwater system:
  - Rewatering of the underground mines and formation of Martha Lake will see changes in groundwater levels and hydraulic gradients across the wider Waihi area, resulting in small increases in total groundwater discharge to the surface water receiving environment. Following closure, the TSF drainage system will control groundwater levels and create inward hydraulic gradients. This is expected to provide hydraulic containment of the TSF, effectively limiting the potential for discharges to the environment. Effects to groundwater and surface water quality during this stage are therefore expected to be negligible.
  - In total, approximately 1,250 $m^3$/day of water is predicted to be captured by the drains, with this comprising predominantly deep groundwater (upwelling via the vein network) with a small proportion of tailings porewater (infiltrating downwards).
  - For mine closure the TSF cover will be contoured to allow stormwater discharge to the south, to the Gladstone Wetland. This reinstatement of the wetland catchment is expected to mitigate the temporary reductions in run-off generated flow experienced during mining of GOP and development of the TSF (GHD, 2022 (Appendix L)). The cover layer is also predicted to provide effective separation of stormwater from tailings, ensuring that the wetland water quality can be effectively managed.

– Long term effects of the TSF following cessation of drainage:
  - Where drainage ceases control on groundwater levels within the deeper andesite, the hydraulic connection to underground workings and Martha Lake will result in deeper groundwater flowing up into the TSF.
  - Discharge from the TSF is predicted to occur to the shallow groundwater system west of the Gladstone TSF, where it will ultimately flow to the Ohinemuri River. This discharge is predicted to comprise a mixture of upwelled deep groundwater that migrates through rock backfill, a small volume of water that infiltrates through the tailings and water that infiltrates the TSF cover and flows through the capping layer to the west.
  - Changes to the Ohinemuri River water quality as a function of the discharge, even when excluding potential attenuation of contaminants during migration to the river, is predicted to be negligible and within the RWQC. No groundwater or surface water users are predicted to be impacted by discharges from TSF.

## 7.2 Northern Rock Stack

Storage of rock from WNP mining activities is proposed at the Northern Rock Stack (NRS), with this to be constructed over the existing northern stockpile north of TSF2. Placement of a low permeability soil liner and installation of leachate and sub-soil collection drains is proposed to limit the potential for leachate to impact the environment. Prior to closure, a portion of the rock will be used to backfill GOP and underground mining stopes. The remaining rock will then be covered with a low permeability capping layer and rehabilitated.

The assessment of effects on groundwater and surface water for the operational and closure phases of NRS is provided in Section 4.6, with the below summarising the predicted effects:

– During operation of the NRS, leachate generated by rainwater infiltration is predicted to seep through the Zone A soil liner, however, the majority of leachate seeping through the liner, and mixed with groundwater, will be captured by sub-soil drains and diverted for treatment at the WTP as necessary. During NRS operation a residual 70 – 100 $m^3$/day of leachate is predicted to migrate with groundwater towards the Ohinemuri River, with this reducing to approximately 50 $m^3$/day after closure.
– Water quality within the Ohinemuri River is expected to remain within the RWQC, with minimal change in trace element concentrations predicted as a result of NRS discharges, even when excluding adsorption reactions that occur with contaminant migration. An increase in sulphate may be measurable within the river, with this conservatively estimated to be an increase of between 1 – 2 mg/L. This is considered to be minor in the context of the downstream water quality changes.
– No groundwater or surface water users are expected to be influenced by operation, or after closure, of the NRS.

# 7.3 Tailings Storage Facility 3

Development of TSF3 is proposed to accommodate tailings generated from the WNP. TSF3 will be positioned within the Ruahorehore Stream catchment and the stream will require diversion to accommodate construction dewatering during removal of weak deposits beneath the proposed embankment. To be developed in stages, the TSF3 will include both a low permeability soil liner and use of the HDPE liner across the base and starter embankment to control discharges. Sub-surface drains will be used to control groundwater pressure on the liner, and also allow capture of seepage through the liner.

The assessment of effects resulting from construction of TSF3 is provided in Section 5.6, with the below summarising the predicted effects:

– Construction dewatering:
    - During excavation of the week deposits, dewatering to approximately 20 m below ground level will be required. The upper bound of the predicted take/diversion for dewatering is estimated to be 2,500 $m^3$/day, which is less than 1% of the available aquifer management level and temporary in nature (120 days). The dewatering is predicted to have a zone of influence of up to approximately 610 m, within which no groundwater users have been identified.
    - To accommodate the excavation, the Ruahorehore stream will be diverted to a new channel. Potential impacts of dewatering to the Ruahorehore stream and Ohinemuri River flow will be mitigated by diversion of abstracted groundwater to the stream. As such, the construction dewatering is considered unlikely to adversely affect the stream flow.
– Tailings and embankment placed rock seepage:
    - Construction of TSF3 is predicted to locally increase groundwater levels by up to 0.2 m. Mitigation for extended periods of flooding can be provided (if needed) by installing shallow drains, as is the current practice to allow farming in the area.
    - During operation of TSF3 drains are predicted to capture all of the discharges from the tailings and the embankment. On closure, with ongoing operation of the toe drain only, approximately 60 $m^3$/day of tailings porewater is predicted to discharge to ground and influence the deep groundwater quality. Water infiltrating through the embankment is predicted to continue to be intercepted by the toe drain following closure.
    - Due to separation of the Ruahorehore stream catchment from the deeper groundwater, the changes to deeper groundwater quality are not expected to measurably impact surface water quality.
    - Major ions (such as sulphate) may increase in deep groundwater to small degree down gradient from TSF3. The nearest groundwater user is located more than 1 km from TSF3 and any minor change is not expected to cause adverse effects to groundwater users.

- The TSF3 discharges to groundwater are inferred to ultimately discharge to the Ohinemuri River via a long flow path. Whilst the conservative assessment suggests there may be some minor increases in major ion concentrations (such as sulphate) in the river, such changes would be significantly delayed and if allowing for attenuation reactions would likely to be unmeasurable by the time discharge to the river occurs. It is considered unlikely that parameter concentrations in the river would exceed the RWQC as a direct result of the TSF3 groundwater discharges.
- While the Ruahorehore stream is not predicted to be a receptor of discharges from the tailings or TSF3 embankment, run-off from the pond buttress may flow to the stream. Given the small area of contact and degree of dilution expected during periods of stormwater run-off, the stream quality is expected to remain well within the RWQC.

## 7.4 Willows Rock Stack

WRS will be a temporary storage area, with rock ultimately being used to backfill underground workings. No liner is proposed for the WRS, given the existing presence of low permeability residual soil/ash and constraints on constructing an effective liner in the steep sided gullies. Instead, a leachate collection drainage system will be installed within the shear key and at the base of the gullies, where erosion has exposed the underlying andesite.

The assessment of effects resulting from construction of WRS are discussed in in Section 6.5, with the below summarising the predicted effects:

– A loss of tributary flow from the WRS gully is expected, due to capture of seepage through the rock by the WRS drainage system. In addition, a reduction in groundwater discharge is expected to the Mataura Stream. The combined reduction in gully stream flow and groundwater discharge is expected to be less than 2.5 % of the Mataura Stream flow. Such reductions in stream flow are considered unlikely to be discernible from the background variability in flow to the Mataura Stream.

– The WRS discharge to the Mataura Stream (via groundwater) is expected to comprise <0.1% of the stream low flow. Whilst there may be some measurable increases in major ion concentrations (such as sulphate) in the stream, no parameter concentrations are expected to exceed the RWQC.

– There are no water users reported within 1.0 km of the site. The nearest downstream surface water users is 5 km downstream of the site. No water users are expected to be measurably affected by the WRS seepage.

– Potential effects to the wetland are considered within GHD (2025d) (Appendix M).

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# Appendices

**Refer to separate Appendices document: Groundwater Assessment Appendices WAI-985-000-REP-LC-0012**

# Appendix A

## Site Investigation Methodology

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# Appendix B

## Borehole Data

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# Appendix C

## Groundwater Level Data

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# Appendix D

## Permeability Analyses

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# Appendix E

## Water Quality

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# Appendix F

## Surface Water Flow Data

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# Appendix G

## Gladstone Pit Technical Assessment

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# Appendix H

## NRS Technical Assessment

**Refer to separate Appendices document: Groundwater Assessment Appendices WAI-985-000-REP-LC-0012**

# Appendix I

## TSF3 Technical assessment

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# Appendix J

## Wharekirauponga WRS Technical Assessment

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# Appendix K

## Water Resource Users

**Refer to separate Appendices document: Groundwater Assessment Appendices WAI-985-000-REP-LC-0012**

# Appendix L

## Gladstone Wetland Groundwater Assessment Summary

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# Appendix M

## Mataura Wetland Assessment

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