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# memorandum

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| TO | Shawn McLean | FROM | Parviz Namjou |
| | Gleeson Quarries Ltd | DATE | 28 June 2022 |
| RE | GENERAL HYDROGEOLGCAL SETTING OF MANAGED FILLS – GLEESON QUARRY | | |

Please find below a general conceptual groundwater conceptual model based on the available information for the proposed managed Fills north of the Gleeson Quarry. This is in response to s92 request received from WRC (technical review of groundwater effects by SLR dated 10 June 2022).

## 1.0 Hydrogeological Setting

In general, the proposed manged Fills are underlain by three geological units.

1) Existing Fill (only within Fill Area 3): These sediments are sourced from nearby coal mine stripping operation and based on the site investigation (Gaia 2021) predominantly consists of silty clay and mudstone remnants occasionally minor sands or gravel lenses have been logged. However, based on the test pit data these lenses are not forming any continues layer. The exact thickness of this unit is unknown but based on the topography of the surrounding catchments may be about 20m.

2) Waikato Coal Measures (WMC) which is part of the Te Kuiti Group consists of up to 6m of weathered sediments consist of silt and clay and minor fine sand which overlie mudstones and fine grain sandstones. No coal or carbonaceous sediments was observed in this units at this site (Gaia 2021).

3) Newcastle Greywacke: WMC is underlain by the highly weathered greywacke (silt and clay) and moderately to fresh greywacke. The thickness of highly weathered greywacke is estimated to be up to 14 to 30m (Stevens and Fulton 2006).

From bore depths, geology and responses to groundwater pumping (PDP 2020), two groundwater systems can be identified. These are referred to as:

- Perched/shallow groundwater (discontinuous zones of saturation);
- Regional groundwater (continuous zone of saturation).

The regional and perched groundwater along an east-west schematic cross section (AA’) across the quarry is shown in Figure 1.

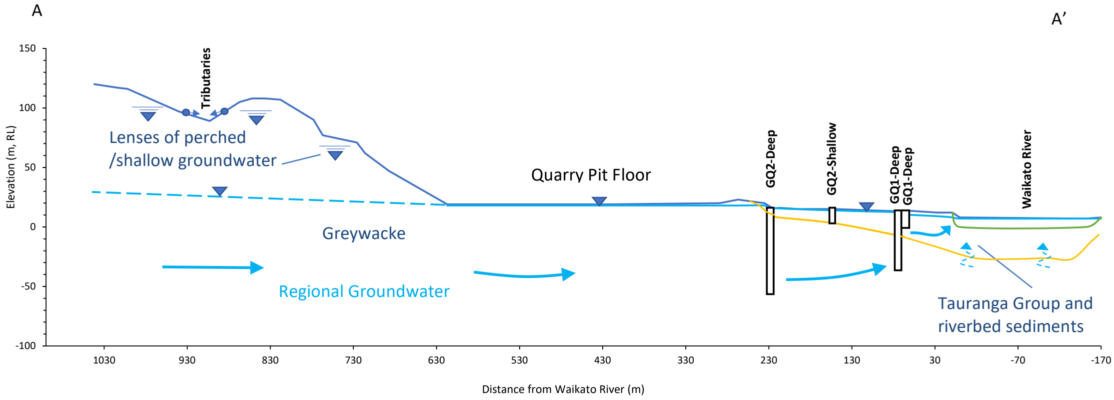


**Figure 1: Schematic East West Hydrogeological Cross Section**

The perched/shallow groundwater occurs within the Existing Fill, Tauranga Group (including Taupo Pumice Ash), Te Kuiti Group (coal measures) and the greywacke at shallow depths and are characterised by discontinuous zones of saturation, which respond and behave according to rainfall patterns.

The regional groundwater is defined as the zone of continuous saturation that extends to full depth within the greywacke across the region. The regional groundwater is likely to occur within the fractured greywacke and discharges predominantly to the Waikato River or lower reaches of the permanent streams in the area. The regional groundwater level elevation ranges between RL8m (next to the Waikato River) to RL20m (below the proposed Fill areas) (PDP 2020) and is confined in some areas by highly weathered greywacke, or clay layers within the coal measures and Tauranga Group.

It is likely that the perched groundwater has been developed in local high permeability pockets (lenses) especially within the Existing Fill over low permeability clays. Lenses of mudstone gravels and boulders (Gaia 2021) have been identified in the Existing Fill (Fill Area 3). Based on the borehole logs drilled in 2006 for rock resource evaluation (Stevens and Fulton 2006) fragmented coal and sandstone gravels have been also identified locally in the coal measures which can potentially form pockets of perched groundwater.

Note that mudstone gravels are reported to be bounded by a matrix of completely weathered coal measures silt. Considering the predominant lithology (clay and silt) surrounding these gravels and their laterally discontinuous nature, the groundwater within these perched layers is likely to be predominantly stagnant. The discontinuous nature of such perched groundwater minimises the horizontal movement of groundwater away from the managed Fill areas.

The ephemeral nature of the tributaries in the vicinity of the proposed Fill areas demonstrates that these pockets of saturation or lenses are not laterally continuous, limited in their extent and not likely to form an aquifer in the area.

The likely stagnant perched groundwater is supported by the test pit data (Gaia 2021). No water table has been encountered in test pits within the coal measures down to 5.5m depth (TP308 and TP311, TP312 and TP313). The water table has been detected in test pits within the Existing Fill at various depths generally above RL60m and between 1m to 5mbgl (TP301, TP303, TP305 and TP308). But no water table is encountered in TP314 within the same unit (Existing Fill) down to 12m depth. TP314 is located only about 3m from TP301 with recorded water table at 5mbgl. This clearly demonstrated the discontinuous nature of these pockets of saturation developed in localised and isolated perched groundwater.

Some vertical infiltration through the above lenses of groundwater toward the regional groundwater in the greywacke and then towards the main groundwater sink (Waikato River) is possible. However, considering the silt and clay layers that underlies the above perched groundwater, the recharge contribution from the above lenses to the main aquifer (regional groundwater) will be small. Based on the lithology (silty clay and remnant of mudstones), the permeability of the sediments underlying the perched layers is likely to be very low (< 10 x $10^{-8}$ m/s) and similar to weathered WMC, minimising the infiltration. Recharge to the regional groundwater predominantly occurs in areas when the greywacke is close to the ground surface.

Based on the logs (Gaia 2021), the above lenses of perched groundwater are also overlain by silt and clay at the surface (i.e. low permeability sediments). This minimises rainfall infiltration and recharge to perched groundwater lenses and increases the run-off (quick flows) following the rainfalls. This is supported by well-developed natural surface drainage system in the proposed Fill area.

Note that the above pockets of saturation at the proposed Fill is above the low permeability clays layers within the highly weathered greywacke and coal measures. This limits hydraulic interactions between the regional groundwater and the above pockets of saturation.  Therefore, the regional groundwater dewatering at the quarry and its subsequent recovery is not likely to have any effects on the above pockets of perched groundwater.

## 2.0 Hydraulic Properties

The hydraulic conductivity values stated in Table 2 are based on preliminary slug tests carried out by PDP in 2015 (unpublished results) using 4 percussion bores in greywacke. Considering the bores were not screened (open hole) and were close to the blasting area, the results are likely to overestimate the hydraulic conductivity of the greywacke.  Based on the more recent pumping tests carried out in the greywacke within the quarry floor, the mean hydraulic conductivity is assessed to be about 5.2 x $10^{-7}$m/s (PDP 2020).

The percussion bore coordinates and the slug test results are presented in Table 1. The test data time - displacement plots) are shown in Appendix A.

**Table 1: Slug Test Results (20 Feb 2015)**

| Bore | Easting | Northing | RL Approx | GWL (mbgl) | GWL (mRL) | Bore Depth (m) | K (m/s) |
|---|---|---|---|---|---|---|---|
| 1 | 1790241 | 5837299 | 16 | DRY | | | |
| 2 | 1789945 | 5837242 | 20 | 1 | 19 | 9.21 | 4.4 x $10^{-6}$ |
| 3 | 1789623 | 5837224 | 20 | 1.065 | 18.935 | 6.63 | 1.4 x $10^{-4}$ |
| 4 | 1789765 | 5837327 | 20 | 0.64 | 19.36 | 5.78 | 8.0 x $10^{-5}$ |

## 3.0 Summary

In summary based on the available hydrogeological data, there is no shallow aquifer (continuous zone pf saturation) below the proposed Fill area and the laterally discontinuous lenses pr pockets of perched groundwater minimise lateral groundwater flow away from the site. This is supported by the logs and ephemeral nature of the tributaries at the site (lack of baseflow).  Considering the lenses are discontinuous and are bounded by low permeability sediments, the perched groundwater is considered to be predominantly stagnant. Vertical infiltration from the perched groundwater lenses to the regional groundwater in the greywacke is possible. However, considering these lenses of perched groundwater are underlain by clays and silts (e.g. completely weathered coal measures) with low vertical hydraulic conductivity, the infiltration is likely to be low.

Following rainfall some minor discharge from the perched groundwater lenses to the watercourses is possible if any of these perched groundwater lenses intercept the ground surface. However, considering widespread occurrence of clay and silt at shallow depths, these ephemeral tributaries predominantly act as run-off watercourses and surface water drainage system rather than a discharge zone for groundwater.

## 4.0 References

Gaia (2021) Huntly Quarry Disposal Sites – Geotechnical Assessment (Draft), prepared for Gleeson Quarries Ltd November 2019.

Pattle Delamore Partners (2020) Huntly Quarry Expansion 2020 Groundwater and Surface Water Effects Assessment, Prepared for Gleeson Quarries Huntly Limited, December 2020.

Stevens M and Fulton G (2006) Stevenson Geological and Resource Assessment of Huntly Quarry, Prepared for Stevenson Resources Ltd, July 2006.

## 5.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Gleeson Quarries Ltd. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Please contact me if you require any other information.

Prepared by

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## Appendix A: Slug Tests Data (20 Feb 2015)

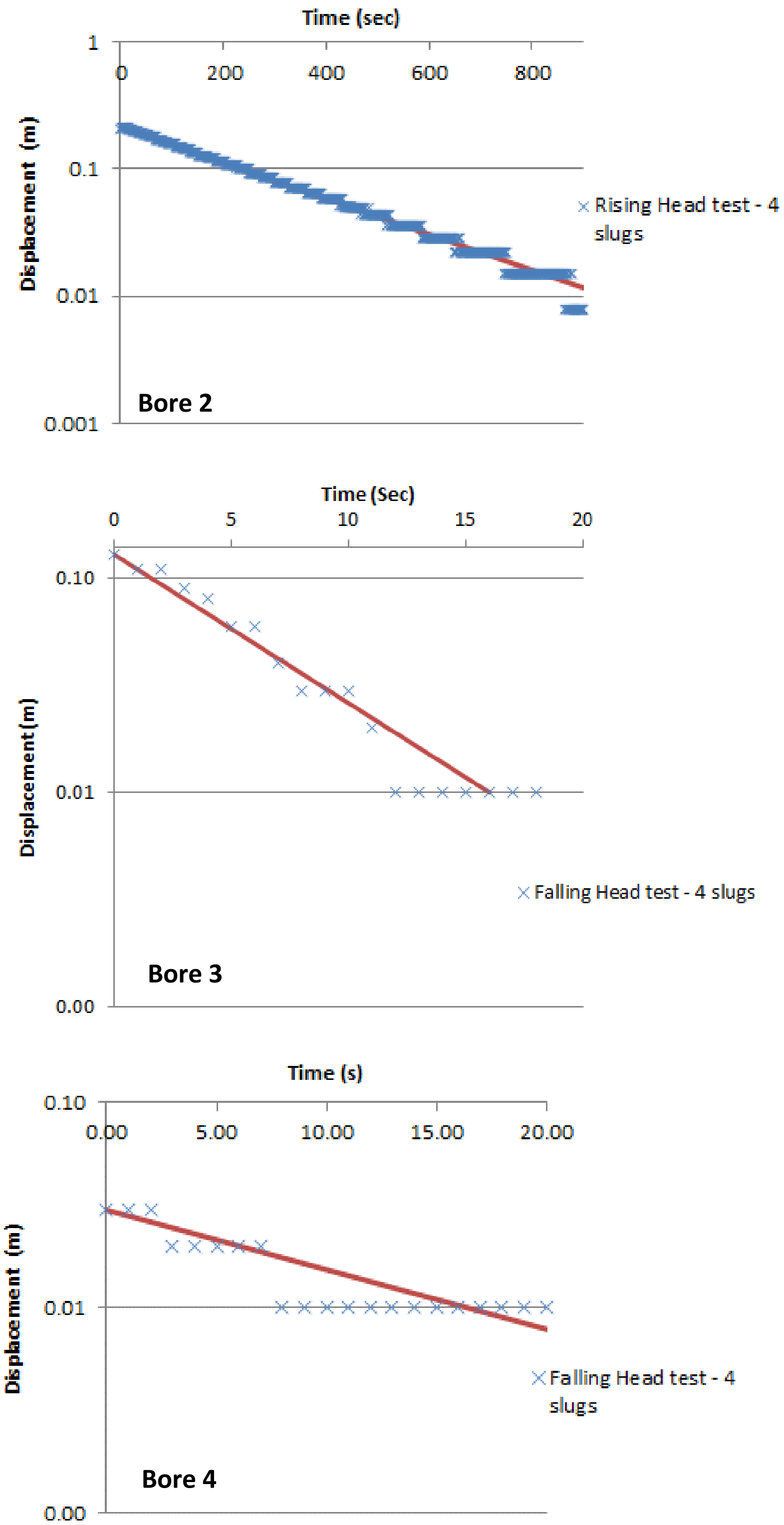


**Figure 2: Slug Test Time and Displacement (20 Feb 2015)**