Waihi North

Groundwater Assessment Appendices
WAI-985-000-REP-LC-0012_Rev2

Oceana Gold (New Zealand) Ltd

26 February 2025

→ **The Power of Commitment**

GHD Limited [626860]
27 Napier Street, GHD Centre Level 3
Freemans Bay, Auckland 1010, New Zealand
T +64 9 370 8000 | **F** +64 9 370 8001 | **E** aklmail@ghd.com | **ghd.com**

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Author	Zoe Pattinson, Remalia Sharplin and Anthony Kirk
Project manager	Tim Mulliner
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LIMITATIONS

This document provides the appendices for the Waihi North Groundwater Assessment **WAI-985-000-REP-LC-0012**.

These appendices must be reviewed in conjunction with the disclaimers and limitations provided within Section 1 of the main report.

References are provided in Section 8 of the main report.

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Appendices

Appendix A

Site investigation methodology

A.1 Introduction

Site investigations have been carried out to support the assessment of proposed activities for the Waihi North Project (WNP). These investigations were undertaken to:

- Refine the conceptual understanding of each area, where changes to the site have occurred since previous studies were completed (particularly in response to changes in site operations, such as dewatering).
- Provide sufficient information to assess effects on groundwater and surface water that may be associated with the proposed activities.
- The site investigations focused on assessing the geology to up to 80 m depth in the areas of new mine components. Nested monitoring wells were installed to assess groundwater levels, hydraulic gradients, hydraulic conductivities, as well as identify groundwater recharge/discharge areas and surface water/groundwater interactions.

Details of the site investigation are provided in the following appendices:

- Appendix A: Site investigation methodology.
- Appendix B: Borehole data, concluding maps of well locations, noting:
  - Bore series "DH" refers to EGL bores drilling in 1995-1996 across NRS and TSF3 sites.
  - Bore series "P" refers to OGNZL bores drilled for site monitoring at Waihi East (Favona and TSF2).
  - Bore series "GLD" refers to GHD drilled bores at Gladstone.
  - Bore series "AP" refers to GHD and EGL bores drilled at TSF3 for the current assessment.
  - Bore series "WRS" refers to the previous naming convection for NRS.
- Appendix C: Groundwater level data (monitoring data, contour maps).
- Appendix D: Permeability testing results.
- Appendix E: Water quality results
- Appendix F: Surface water flow data.

TSF3: Additional investigations that have informed the geological understanding include sterilisation drilling undertaken between TSF3 and TSF1A by OGNZL in 2017 and drilling of two new bores (AP21 and AP22) in October 2020. The EGL GFR (EGL, 2018) provides a detailed description of the local geology and origins; Figure 12 of the 2018 EGL report provides the geology for the proposed TSF3 area.

WRS: Additional investigations that have informed the geological and hydrogeological understanding including the site investigations undertaken at the WRS site are presented in the EGL geotechnical factual report (EGL, 2025c).

The wellhead elevations of the installed groundwater monitoring wells were surveyed by OGNZL and are presented in mRL to the mine datum, which is 1,000 m above sea level (asl).

A.2 Review of existing data

Groundwater monitoring wells

OGNZL have an extensive network of existing groundwater monitoring wells and drill hole data. Existing data was reviewed from the following locations:

- DH-series wells, which are detailed in an older report prepared by Engineering Geology Limited (EGL; Volume 2 of EGL,1996);
- P-series wells, which are regularly monitored for groundwater levels by OGNZL; and
- Other wells (MW, FAV series wells), regularly monitored for groundwater level and water quality.

This information was used to inform the 2017 drilling programme described below.

Surface water flow and quality

OGNZL undertake daily monitoring of flow rates at the Ohinemuri River and the Ruahorehore Stream (a tributary of the Ohinemuri), and regular monitoring at various surface water locations across the wider site. Data is provided in Appendix F.

A.3 2017 Drilling programme

Well installation

A total of 46 groundwater monitoring wells were installed between 10 May 2017 and 27 October 2017 in the vicinity of the new mine components:

- 31 wells installed by GHD.
- 15 wells installed by EGL.

Core was recovered using HQ coring method, and 32 mm PVC piezometers (with machine slotted screens) were installed in the 96 mm diameter boreholes.

The detailed lithology and well construction detailed are provided in the Appendix B bore logs.

The wells were generally installed as paired units, where deep wells are denoted by an "a" in the well ID label. In some locations where existing OGNZL wells were present, an adjacent well was installed to act as the paired (or third) well (e.g as shown in Figure A.1). Where used, the existing wells are included in the groundwater monitoring data (Appendix C).

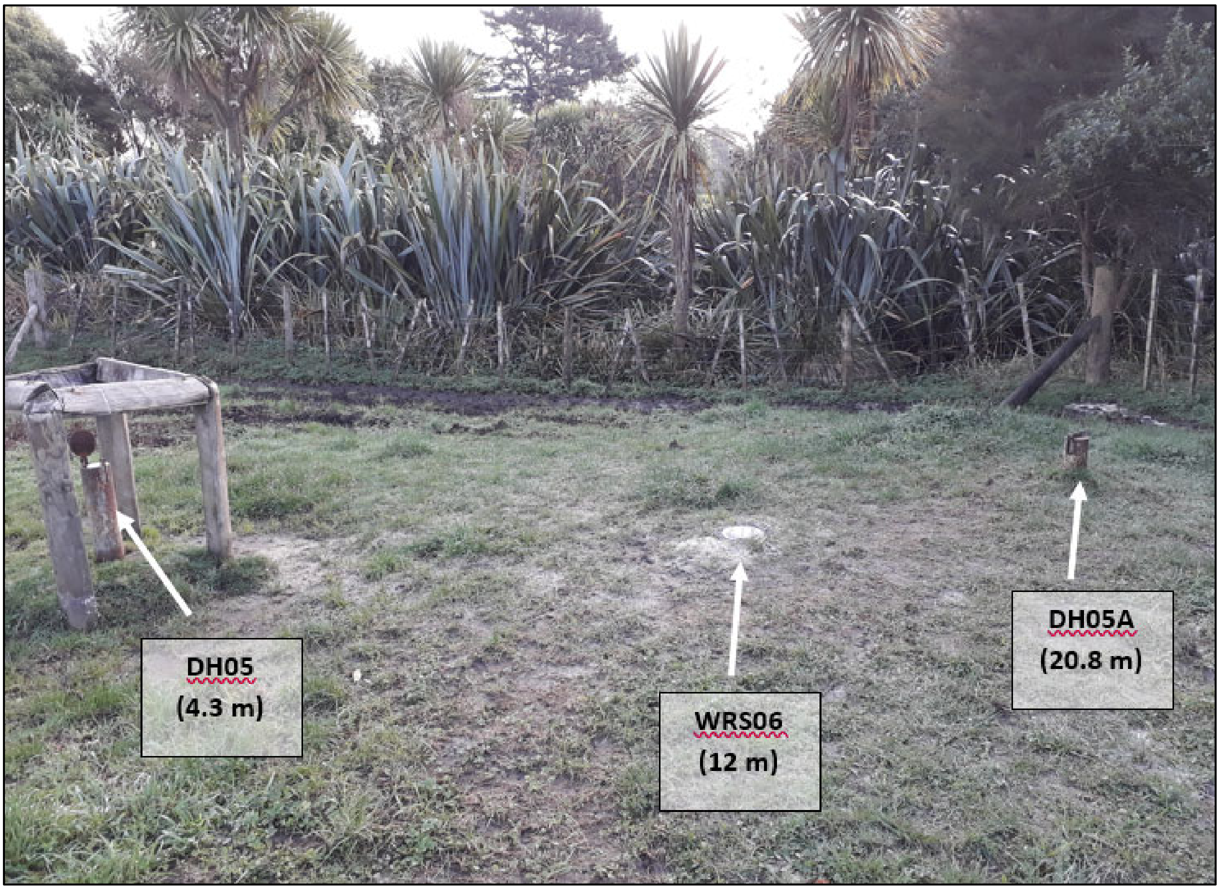


Figure A.1 Three wells showing older OGNZL well pair (shallow DH05 and deeper well DH05A) and GHD intermediate well (WRS06)

Well survey

Each well was surveyed by OGNZL to the Old Cadastral Mt Eden Coordinates and Martha Mine elevation datum, which is presented in metres reduced level (mRL). The full list of these wells including level survey results are summarised in (Appendix B).

The locations of all wells used in the assessment are provided in figures within the report.

Well development

Following installation, and prior to monitoring and/or testing, the installed wells (and any OGNZL wells used in the programme) were developed using the most suitable purging methodology per well (i.e. total depth, water level, diameter). The methods used included: waterra footvalve combined with additional lift from a Honda WX10 Water Pump; Monsoon Pump; or airlift pump.

A.4 Water level monitoring

Groundwater level monitoring

A series of groundwater level monitoring events were carried out, including:

- Manual groundwater level measurements: These were collected either during dedicated groundwater level monitoring events, or as part of the earlier well development work, between June 2016 and 2020. The water levels are provided in metres below ground level (m bgl) and/or metres below top of casing (m btoc) and are converted to the Martha Mine datum (mRL). Refer to the tables provided in Appendix C for a summary of all manual measurement data.
- Automated groundwater level measurements: Continuous water levels were recorded across the site using Solinst pressure transducers and a barologger to allow for atmospheric compensation. Selected locations were monitored across variable timeframes in mid-late 2017, depending on the following factors: equipment availability; site accessibility; comparison between locations; and assessment of rainfall event response. Manual measurements were used to calibrate the recorded water levels, which are presented in Appendix C.

Surface water

To support the assessment of the hydraulic connection between groundwater and the Ohinemuri River, surface water level monitoring stations were installed:

- In the Ohinemuri River (Figure A.2) between the Favona and NRS sites and at TB1a.
- Gladstone at one site (TB4).
- TSF3 at several sites (RU6, RU7, RU13, RU15;).

The locations and results are shown in Appendix F.

Monitoring of each surface water level site was carried out using a solinst pressure transducer, and the river level was surveyed by OGNZL to Martha Mine datum. The survey level was used to calibrate the recorded river levels, which are presented in Appendix F.

Figure A.2 Surface water level monitoring site installed in Ohinemuri River

A.5. Aquifer testing

Testing at selected well locations was carried out using falling and rising head methodologies to obtain the hydraulic conductivity of the screened well sections. The methodology involved the lowering and raising of solid PVC slugs below the groundwater level to displace the water. Lowering of the slug provided a falling head test; and raising the slug out of the water provided a rising head test. The groundwater level response for each test was recorded using a pressure transducer.

The resulting displacement curve for each tests was analysed using Aqtesolv (version 4.5) and AquiferWin32 aquifer test software to provide an estimate of the hydraulic conductivity (K).

The test results are provided in Appendix D.

A.6 Water quality sampling

Sample methodology

Groundwater quality sampling was carried out over December 2017 and January 2018 in selected wells across the site. Locations within each area were selected in relation to proximity of the proposed activities (upgradient, downgradient) and intended for monitoring before (baseline), during, and after completion of the proposed activities. Numerous wells and surface water locations were selected for sampling/monitoring and are listed in the tables in Appendix E.

Sampling was carried out using standard low flow purging methodology (EPA 1996a and EPA 1996b), where the formation recharge and groundwater depths allowed. Where recharge was too slow and/or the groundwater level was too deep, more suitable alternative methods were used, which included purging the well until dry and using low flow methodology to collect recharge water, or the use of Hydrasleeves^{TM}.

Sample analyses

The parameters that each sample was analysed for are listed in Table A.1 below. All sites (where possible) were analysed at least once for the comprehensive suite before changing to a reduced suite. Interpretation of water quality is provided in Appendix E.

Table A.1 Analytical suites

Comprehensive Suite
pH
Electrical Conductivity (EC)
Total Suspended Solids
Total Alkalinity
Major Cations and Anions
Dissolved metals (As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sb, Se, Ag, Zn)
Dissolved Mercury
WAD Cyanide Distillation
Weak Acid Dissociable (WAD) Cyanide
Nutrient Suite (TN, TKN, NO2-N + NO3-N, Amm-N)

A.7 Stream flow gauging

Opus carried out stream flow gauging on behalf of OGNZL between January 2019 and January 2020 at GHD's request. Stream flow gauging was carried out once every two weeks from late January until end of March to capture baseflow conditions, with subsequent monitoring carried out quarterly. The gauging reports and results summary are provided in Appendix F.

A.8 Willows Farm investigation

A site investigation was undertaken at Willows Farm by Golder in October 2020. A total of 13 boreholes were drilled and installed as groundwater monitoring wells. Groundwater level and hydraulic conductivity data collected by Golder in October 2020 has been summarised by WWLA (2025a). EGL undertook additional site investigations in 2024 – 2025. This included hand augers, test pits, drilling of boreholes, packer testing, falling head testing and installation of standpipe piezometers and vibrating wire piezometers. The results of the investigation are presented in EGL (2025c).

Appendix B

Borehole data

Contents:

Note:

– All bore locations are provided within site setting figures within the main report.

– EGL bore logs for NRS and TSF3 from 1996, 2017 and 2018 investigations can be found in Appendix A in the respective Geotechnical Factual Reports

– EGL bore logs for WRS from 2024 – 2025 can be found in the appendices of the WRS Geotechnical Factual Report (EGL, 2025c).

Table B 1 Bore details for all locations included in the assessment

Location	ID	Date of Installation	Easting (NZTM)	Northing (NZTM)	Easting (MtEden Old Cadastral)	Northing (MtEden Old Cadastral)	Elevation (mRL)	Drilled Depth (m bgl)	Measured Depth (m btoc)	Base of bore (m RL)	Piezo Screen (m bgl)	PVC Upstand (m agl)
TSF3 Hydro Boreholes	AP01	25/05/2017	1855661.1	5856236.2	399490.9	640874.9	1110.50	6.0	5.0	1105.5	3-5	-0.055
	AP01a	9/05/2017	1855656.9	5856258.8	399486.3	640897.4	1110.55	40.7	40.7	1069.8	37-40	-0.03
	AP02	25/05/2017	1855848.1	5856317.3	399676.3	640959.5	1112.34	5.0	4.7	1107.6	3-5	-0.05
	AP02a	29/05/2017	1855848.8	5856316.5	399677.0	640958.6	1112.28	30.1	30.1	1082.1	27-30	-0.08
	AP03	29/05/2017	1856115.6	5856417.4	399941.8	641064.5	1120.36	5.0	4.0	1116.3	3-5	-0.04
	AP03a	30/05/2017	1856115.0	5856416.5	399941.2	641063.6	1120.28	30.5	30.1	1090.1	27-30	-0.06
	AP04	31/05/2017	1855553.0	5856136.1	399384.8	640772.7	1109.53	6.0	5.8	1103.7	4-6	-0.06
	AP04a	1/06/2017	1855551.8	5856136.4	399383.6	640773.1	1109.53	30.1	29.6	1079.8	27-30	-0.05
	AP05	25/05/2017	1855683.5	5856122.2	399515.4	640761.3	1110.17	6.0	4.9	1105.1	3-5	-0.14
	AP05a	25/05/2017	1855683.8	5856121.6	399515.7	640760.7	1110.22	22.5	21.9	1088.2	19-22	-0.12
	AP06	3/06/2017	1855920.6	5856502.4	399745.3	641145.8	1113.54	5.0	4.7	1108.8	3-5	-0.04
	AP06a	7/06/2017	1855921.3	5856502.8	399746.0	641146.1	1113.54	24.0	23.6	1089.9	21-24	-0.05
	AP07	26/05/2017	1855703.2	5856555.2	399527.1	641194.4	1114.96	6.0	5.4	1109.4	2.5-5.5	-0.14
	AP07a	26/05/2017	1855703.2	5856555.2	399527.1	641194.5	1114.96	27.3	26.9	1087.9	24-27	-0.12
	AP08	30/05/2017	1855978.2	5856619.3	399800.7	641263.7	1115.88	6.0	5.5	1110.3	2.5-5.5	-0.1
	DH12	3/03/1995	1855979.5	5856623.3	399801.9	641267.7	1115.83	21.0	20.9	1095.4	20-21	0.49
	AP09	1/06/2017	1856159.0	5856685.5	399980.2	641333.2	1119.46	21.0	20.1	1099.3	17-20	-0.1
	DH11	25/02/1995	1856153.4	5856685.5	399974.5	641333.1	1119.21	11.0	6.8	1112.9	5.5-6.5	0.48
	AP10	30/05/2017	1856213.8	5856566.1	400037.2	641214.9	1132.07	7.5	6.9	1125.1	4-7	-0.08
	AP10a	30/05/2017	1856214.1	5856565.7	400037.5	641214.5	1132.12	19.5	18.4	1113.6	15.5-18.5	-0.10
	AP11	6/06/2017	1855907.7	5856823.1	399726.4	641466.0	1123.83	7.5	7.0	1116.8	4-7	-0.11
	AP11a	6/06/2017	1855908.1	5856823.6	399726.8	641466.6	1123.83	21.0	20.4	1103.4	17-20	-0.02
	DH10	-	1856608.2	5856776.9	400427.4	641433.0	1166.15	-	8.3	1158.3	-	0.5
	DH10A	-	1856609.5	5856781.2	400428.6	641437.3	1166.46	37.7	34.2	1132.8	32.5-34.5	0.55
	DH13	28/02/1995	1856038.2	5856398.8	399884.9	641069.2	118.40	22.3	-	-	18.3-22.3	0.4
	DH14	29/02/1995	1855661.6	5856264.6	399490.9	640903.2	1110.61	-	10.1	1100.5	-	0
	DH14A	29/02/1995	1855656.4	5856261.7	399485.7	640900.2	1110.58	24.0	37.4	1073.2	23.0-24.0	0
	DH23	-	1856509.9	5856547.4	400333.5	641201.8	1158.02	-	18.5	1139.7	-	0.22
	DH23A	-	1856512.5	5856542.8	400336.1	641197.2	1157.20	29.2	29.4	1128.3	26.9-28.9	0.48
WRS Hydro Boreholes	WRS01	11/05/2017	1854208.92	5858184.96	398003.07	642795.37	1105.55	8.0	7.9	1097.6	5-8	-0.01
	WRS01a	11/05/2017	1854209.49	5858184.18	398003.65	642794.60	1105.51	19.8	19.7	1085.7	16.7-19.7	-0.05
	WRS02	22/05/2017	1854428.67	5858090.06	398224.48	642704.63	1105.28	8.0	6.7	1098.5	5-8	-0.03
	WRS02a	22/05/2017	1854429.83	5858089.56	398225.65	642704.16	1105.32	19.6	19.7	1085.6	16.5-19.5	-0.035
	WRS03	22/05/2017	1854812.03	5858016.73	398609.01	642638.51	1132.15	8.0	5.6	1126.5	5-8	-0.07
	WRS03a	24/05/2017	1854811.01	5858016.16	398607.99	642637.92	1132.21	19.6	19.6	1112.5	16.5-19.5	-0.06
	WRS04	8/06/2017	1853969.82	5858257.34	397762.75	642863.24	1097.87	6.0	5.4	1092.4	2.5-5.5	-0.06
	WRS04a	8/06/2017	1853969.22	5858257.13	397762.15	642863.01	1097.86	21.0	19.2	1078.5	17-20	-0.1
	WRS05	9/06/2017	1854227.99	5858417.34	398017.78	643027.97	1101.06	6.0	5.5	1095.5	2.5 - 5.5	-0.100
	WRS05a	9/06/2017	1854228.53	5858417.66	398018.31	643028.30	1101.06	21.0	16.3	1084.6	13.5-16.5	-0.100
	WRS06	12/06/2017	1854280.60	5858328.62	398072.02	642940.28	1099.38	12.0	12.0	1087.3	10-12	-0.06
	DH05A	21/02/1995	1854280.37	5858325.91	398071.84	642937.58	1099.32	21.3	20.8	1079.1	18.5-20.5	0.58
	DH05	21/02/1995	1854280.22	5858330.57	398071.61	642942.23	1099.41	4.5	4.3	1095.3	-	0.19
	DH04	-	1854430.68	5858389.86	398220.88	643004.30	1105.01	26.7	25.3	1080.1	24.5-25.5	0.43
	WRS07	13/06/2017	1854509.27	5858387.30	398299.48	643003.22	1108.54	7.5	5.9	1102.6	3-6	-0.06
	DH09	-	1854505.82	5858390.53	398295.96	643006.38	1108.30	19.3	19.0	1089.7	12.0-14.0	0.45
	WRS08	13/06/2017	1854550.10	5858039.30	398346.80	642656.17	1108.87	9.0	8.9	1099.9	7-9	-0.07
	DH08	24/02/1995	1854539.05	5858057.17	398355.55	642698.69	1103.88	25.9	19.5	1084.8	18.0-20.0	0.40
Gladstone Hydro Boreholes	GLD01	14/06/2017	1853274.29	5857687.01	397078.26	642280.20	1126.53	7.5	7.5	1119.0	5.5-7.5	-0.06
	GLD01a	14/06/2017	1853273.94	5857686.65	397077.92	642279.83	1126.55	13.7	13.7	1112.8	11.7-13.7	-0.09
	GLD01b	19/06/2017	1853275.47	5857684.31	397079.49	642277.52	1126.48	33.0	29.7	1096.7	27-30	-0.09
	GLD02	16/06/2017	1853262.60	5857611.69	397067.99	642204.70	1119.47	9.0	7.8	1111.6	6-8	-0.08
	GLD02a	15/06/2017	1853258.89	5857614.46	397064.22	642207.40	1119.67	30.0	24.4	1095.2	22-25	-0.07
	GLD03	20/06/2017	1853348.94	5857653.70	397153.49	642248.30	1113.38	9.0	8.0	1105.3	6-8	-0.05
	GLD03a	20/06/2017	1853349.62	5857653.98	397154.17	642248.59	1113.37	21.0	20.0	1093.3	17-20	-0.05
	P79s	Jul-04	1852914.84	5857719.62	396718.39	642306.07	1102.88	12.0	-	#VALUE!	11-12	0.73
	P79i	Jul-04	1852916.69	5857720.39	396720.23	642306.87	1102.95	41.5	-	#VALUE!	40.5-41.5	0.73
	P79d	Jul-04	1852918.25	5857721.17	396721.77	642307.68	1102.99	55.0	-	#VALUE!	52-55	0.73
Favona Hydro Boreholes	FVN01	21/06/2017	1853785.67	5858332.69	397577.29	642935.10	1098.87	9.0	8.0	1090.8	6-8	-0.15
	FVN01a	21/06/2017	1853785.54	5858332.00	397577.17	642934.41	1098.83	21.0	18.0	1080.8	15-18	-0.07
	FVN01b	28/06/2017	1853785.25	5858330.83	397576.90	642933.23	1098.84	30.0	29.6	1069.1	27-30	-0.095
	FVN02	22/06/2017	1853769.81	5858340.28	397561.29	642942.39	1098.34	9.0	8.0	1090.3	6-8	-0.135
	FVN02a	22/06/2017	1853769.58	5858339.76	397561.07	642941.86	1098.31	21.0	18.0	1080.3	15-18	-0.08
	FVN03a	27/06/2017	1853713.80	5858351.25	397505.11	642952.30	1097.24	21.0	18.2	1079.0	15-18	-0.03
	P89	-	1853716.35	5858350.55	397527.81	642976.52	1098.03	-	8.5	1090.6	-	1.06
	P87	-	1853768.46	5858285.56	397581.11	642912.54	1098.10	-	7.3	1092.2	-	1.35

BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **AP01**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

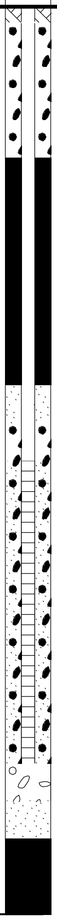
Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 25-May-17
Completed: 25-May-17
Datum: Mine (1000 m)
Total Depth: 6.0m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.5	HQ Coring	12		▽	TS	MH	TOPSOIL: Clayey SILT, with minor fine to medium sand, trace rootlets; dark brown. Very soft, wet, high plasticity.	W	VS					
1.0					Alluvium		NO CORE (0.5-1.0m)							
1.5		79				CH	Silty CLAY, with trace black organics (wood fibres); grey with orange brown staining. Very soft, wet, high plasticity.							
2.8						ML	SILT with some clay and fine to medium pale grey sand; grey. Very soft, wet, low plasticity.							
6.0		100 100			Homunga Rhyolite - Tuff		Grey with greenish staining, fine to medium grained CRYSTAL TUFF, very weak. Breaks down to Silt, with some clay and fine to medium poorly graded sand. Very stiff, low plasticity, spongey. From 4.28m: becomes brown. Breaks down to Clayey Silt, with minor fine sand, high plasticity. White grey, fine to medium grained CRYSTAL TUFF, Very weak. Breaks down to silt with some clay and fine to coarse sand, very stiff. from 5.02 m: bands of orange staining							-NOTE: Defects not discernable in completely weathered rock at 2.82m Joint @ 5.48, undulating, iron oxide staining Joint @ 5.89, undulating, iron oxide staining
							Termination Depth = 6m							

Piezometer



Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP-1 CORE BOX PHOTOGRAPHS**				

Depth: 0 m to 4.17m

Depth: 4.17m to 6.00m

GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP05**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 24-May-17
Completed: 25-May-17

Datum: Mine (1000 m)
Total Depth: 6.0m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.1	HQ Coring	91			Ash	CH	TOPSOIL, Clayey SILT, with minor fine to medium grained sand, trace rootlets; dark brown to black. Very soft, wet to saturated, high plasticity.	W-S	VS						
							Silty CLAY, with minor fine sand; brown. Soft, wet, high plasticity.	W	S						
1		89					from 1.05m: becomes firm from 1.18m: becomes light brown with orange mottling, moderate plasticity [poss. volcanic ASH?]		F						
1.5		100			Alluvium	SW	Fine to medium SAND, with minor silt, light grey with orange staining. Very loose to loose, wet.		'VL'-'L'						
2							from 2.35m: becomes poorly graded mostly fine grained								
2.7					Homunga Rhyolite - Tuff	SP	Fine to medium grained poorly graded SAND, with minor silt, grey brown. Very loose, wet.		'VL'						
2.9 3.0		100					from 2.88m: Fine to coarse SAND, with minor gravel, white grey with greenish inclusions, dense, wet, fine sub angular to sub rounded gravel. from 2.88-3.0m: layer of grey brown material		D						
						ML	from 3.0m: becomes brown from 3.32m: becomes grey brown SILT, with some fine to coarse poorly graded sand, grey with greenish inclusions. Very stiff, wet, moderate plasticity.		VSt						
3.7 4							Greenish grey, RHYOLITE, TUFF very weak, widely spread joints. Breaks down to sandy/clayey silt. from 3.75m: becomes orange brown. from 3.83m: becomes greenish grey. from 4.05m: becomes brown					88		Joint at 4.36m, very narrow to tight, very steeply inclined, smooth, stepped, trace Manganese mineralization	
5		100					from 5.0m: becomes weak from 5.03m: becomes brown from 5.5m: becomes dark greenish grey with brown mottling, more welded/crystaline. breaks down to sand					100		-Joint at 5.78m, very steeply inclined, undulating, smooth, very narrow to tight, brown silt and black Manganese	
6.0							Termination Depth = 6m								
7															
8															
9															
10															

GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP05a**

Sheet 1 of 3

Project:	Project Quattro	**Coordinates:** Refer to attached Table	**Datum:** Mine (1000 m)
Client:	OceanaGold Ltd	**Elevation:** Refer to attached Table	**Total Depth:** 22.5m
Site:	Waihi - TSF3	**Commenced:** 24-May-17	**Contractor:** Perry Geotech
Job No.:	51/37083	**Completed:** 25-May-17	

Equipment: tractor JD Tractor Rig
Inclination: -90
Shear Vane:
Comments:
Bore Diameter (mm): 96

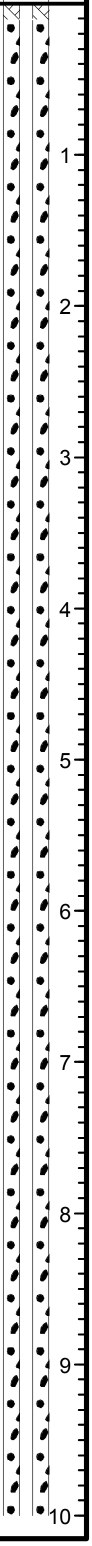
Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.1	HQ Coring	91	Ash	CH	TOPSOIL, Clayey SILT, with minor fine to medium grained sand, trace rootlets; dark brown to black. Very soft, wet to saturated, high plasticity.	W-S	VS			
1		89			Silty CLAY, with minor fine sand; brown. Soft, wet, high plasticity. from 1.05m: becomes firm from 1.18m: becomes light brown with orange mottling, moderate plasticity [poss. volcanic ASH?]	W	S F			
1.5 2		100	Alluvium	SW	Fine to medium SAND, with minor silt, light grey with orange staining. Very loose to loose, wet. from 2.35m: becomes poorly graded mostly fine grained		'VL'-'L'			
2.7 2.9 3 3.0			Homunga Rhyolite - Tuff	SP	Fine to medium grained poorly graded SAND, with minor silt, grey brown. Very loose, wet. from 2.88m: Fine to coarse SAND, with minor gravel, white grey with greenish inclusions, dense, wet, fine sub angular to sub rounded gravel. from 2.88-3.0m: layer of grey brown material		'VL' 'D'			
3.7		100		ML	from 3.0m: becomes brown from 3.32m: becomes grey brown SILT, with some fine to coarse poorly graded sand, grey with greenish inclusions. Very stiff, wet, moderate plasticity.		VSt			
4 5		100			Greenish grey, RHYOLITE TUFF, very weak, widely spread joints. Breaks down to sandy/clayey silt. from 3.75m: becomes orange brown. from 3.83m: becomes greenish grey. from 4.05m: becomes brown from 5.0m: becomes weak from 5.03m: becomes brown from 5.5m: becomes dark greenish grey with brown mottling, more welded/crystaline. breaks down to sand				88 100	Joint at 4.36m, very narrow to tight, very steeply inclined, smooth, stepped, trace Manganese mineralization Joint at 5.78m, very steeply inclined, undulating, smooth, very narrow to tight, brown silt and black Manganese
6 6.0		100	Homunga Rhyolite - Lava	SW	Fine to coarse grained angular well graded SAND, with some fine to medium-grained angular gravel, trace silt, grey with white and orange brown gravel. Loose, wet.		'L'			
6.6 7		100			Moderately weathered to slighly weathered, dark green brown, grey, RHYOLITE FROTH FLOW, moderately strong, crumbles to sand, dark phenocrysts visible from 7.55m: becomes orange, crumbles to silt. from 7.7m: becomes brown, weak, massive.			MW-SW	100	-at 7.5m, Completely Weathered: fractures indeterminate
8 9 10		100 85 100			Completely weathered, brown, massive RHYOLITE, weak.			CW	100	-Note at 8m: Completely weathered so fracture indeterminate -No loss of circulation at 9m

Estimated Rock Strength: EW VW W MW S VS ES

Defect Spacing (mm): 20 60 200 600 2000

Piezometer



GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP05a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 24-May-17
Completed: 25-May-17

Datum: Mine (1000 m)
Total Depth: 22.5m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Column headings: Depth (m)/ [Elev.] | Drilling Method | Core Run / Recovery (%) | Support / Casing (m) | Water | Geological Fm | Classification | Graphic Log | SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name) | Moisture Condition | Consistency/ Relative Density | Weathering | Estimated Rock Strength (EW VW W MS S VS ES) | RQD (%) | Defect Spacing (mm) (20 60 200 600 2000) | TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating | Piezometer

Depth (m): 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Drilling Method: HQ Coring

Core Run / Recovery (%): 100, 100, 83, 100, 96, 100, 100

Geological Fm: Homunga Rhyolite - Tuff

Grey brown, fine to medium grained, RHYOLITE FROTH FLOW, moderately strong to weak, white and black phenocrysts in grey ground mass.

Dark green brown, grey, RHYOLITE FROTH FLOW, moderately strong, crumbles to sand, dark phenocrysts visible from 10.18m: becomes grey with fine black phrenocrysts, moderately weathered.
from 11.01-11.06m: soft layer (possibly caused by drilling)
from 11.17m: becomes grey brown.

Completely weathered, brown, massive to fine grained, RHYOLITE TUFF, moderately strong to weak, Breaks down to silty fine to medium SAND, orange brown.
from 12m: weak

Completely weathered, light grey, fine to medium-grained, RHYOLITE, weak to very weak.

from 14.65m: becomes yellowish grey

from 17.23m: greeenish staining.

from 17.52m: becomes grey.

Completely weathered to highly weathered, grey with dark and light phenocrysts and greenish staining, fine to medium-grained, RHYOLITE, weak. Breaks down to fine to coarse grey quartz sand, coarse sand, larger phenocrysts up to 3 cm.

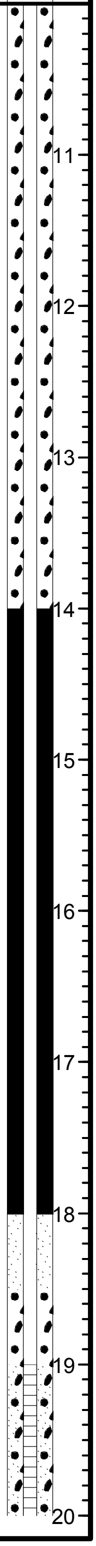
Weathering: CW-HW

RQD (%): 100, 100, 83, 100, 96, 100, 100

-Note at 13m: Completely weathered so fracture indeterminate

-Note at 15m: Completely weathered so fracture indeterminate

-Relic joint at 19.31m, Steeply Inclines, Very Narrow, Smooth, Undulating, Iron Staining



BOREHOLE with Piezo LOG

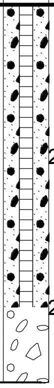
Site Identification: **AP05a**

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 24-May-17
Completed: 25-May-17
Datum: Mine (1000 m)
Total Depth: 22.5m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
21 22	HQ Coring	65						Moderately weathered to slighly weathered, dark green brown, grey, RHYOLITE, moderately strong, crumbles to sand, dark phenocrysts visible from 20.46m: becomes brownish grey from 20.7m: large 4cm purple grey phenocrysts from 21.07m: becomes greenish grey			MW-SW		65			
22.5 23 24 25 26 27 28 29 30								Termination Depth = 22.5m,								

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017

Title:

AP5A CORE BOX PHOTOGRAPHS

Depth: 0 m to 3.00m

Depth: 3.00 m to 6.00 m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP5A CORE BOX PHOTOGRAPHS**				

Depth: 6.00m to 9.00m

Depth: 9.00m to 12.00m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**

Title: AP5A CORE BOX PHOTOGRAPHS

Depth: 12.00m to 15.00m

Depth: 15.00m to 18.00m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP5A CORE BOX PHOTOGRAPHS**				

Depth: 18.00 m to 21.00m

Depth: 21.00 m to 22.50 m

GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP07**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 26-May-17
Completed: 26-May-17

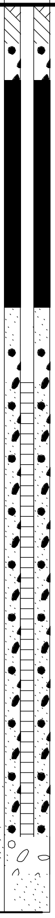
Datum: Mine (1000 m)
Total Depth: 6.0m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MW MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0 1	HQ Coring	93 100	HQ		Fill			FILL: SILT, with some sand and gravel, trace clay, trace rootlets; brown. Soft, low plasticity. sand, well graded fine to coarse grained, fine to medium-grained well graded angular gravel, trace clay, trace rootlets. FILL **0.16m**: Fine to coarse-grained, well-graded angular gravelly cobbles; grey, dense, wet.	W	S 'D'						
1.4					Ash	OL		Organic SILT, with some clay; black, minor fine to medium sand, firm, wet, low plasticity. (inferred buried topsoil).		F						
1.5 2		100 50				ML		SILT with minor clay and trace of fine sand; light brown, firm, wet, low plasticity. 1.5 - 1.6 appears friable								
2.5		100			Alluvium	SP		Silty fine to medium, well graded SAND; light brown. Loose, wet.		'L'						
3.0 3						ML		SILT with some clay and minor fine sand; grey, soft, wet, moderate plasticity.		S						
3.4 4		75			Homunga Rhyolite - Tuff	SP		Fine to coarse-grained SAND; with some silt, light grey brown. Loose, wet. from 4.3m: minor fine to coarse grained weathered rhyolite gravel from 4.5-4.6m: dense		'L' 'D'						
5.0 5		87						Fine to medium-grained, light greyish brown RHYOLITE CRYSTAL TUFF; very weak; Breaks down to fine to coarse-grained sand, trace fine to coarse-grained gravel and some silt.					14		-Joint 2 @5.68m, very steeply inclined, undulating, smooth, very narrow -Note: abundant drill breaks as material is fragile, not logged as defects	
6.0 6 7 8 9 10								Termination Depth = 6m								



BOREHOLE with Piezo LOG

Site Identification: **AP07a**

Sheet 1 of 3

Project:	Project Quattro	**Coordinates:**	Refer to attached Table
Client:	OceanaGold Ltd	**Elevation:**	Refer to attached Table
Site:	Waihi - TSF3	**Commenced:**	26-May-17
Job No.:	51/37083	**Completed:**	26-May-17

Datum: Mine (1000 m)
Total Depth: 27.3m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Inclination: -90
Shear Vane:
Comments:
Bore Diameter (mm): 96

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.2	HQ Coring	93	HQ		Fill		FILL: SILT, with some sand and gravel, trace clay, trace rootlets; brown. Soft, low plasticity. sand, well graded fine to coarse grained, fine to medium-grained well graded angular gravel, trace clay, trace rootlets.	W	S						
							FILL **0.16m**: Fine to coarse-grained, well-graded angular gravelly cobbles; grey, dense, wet.		'D'						
1		100													1
					Ash	OL	Organic SILT, with some clay; black, minor fine to medium sand, firm, wet, low plasticity. (inferred buried topsoil).		F						
1.5		100				ML	SILT with minor clay and trace of fine sand; light brown, firm, wet, low plasticity. 1.5 - 1.6 appears friable								
2	Push tube	50												-Push Tube at 2m	2
2.5	HQ Coring	100			Alluvium	SP	Silty fine to medium, well graded SAND; light brown. Loose, wet.		'L'						
3.0						ML	SILT with some clay and minor fine sand; grey, soft, wet, moderate plasticity.		S						3
3.4		75				SP	Fine to coarse-grained SAND; with some silt, light grey brown. Loose, wet. from 4.3m: minor fine to coarse grained weathered rhyolite gravel from 4.5-4.6m: dense		'L' 'D'						4
5.0		87	HQ		Homunga Rhyolite - Tuff		Fine to medium-grained, light greyish brown RHYOLITE CRYSTAL TUFF; very weak; Breaks down to fine to coarse-grained sand, trace fine to coarse-grained gravel and some silt.					14		5.68-,JT, 80,sm,u,, VN,Joint set 1 at 5.68m	5
6		93					from 6m: becomes weak.					27		-Note: abundant drill breaks as material is fragile, not logged as defects/ weakness set or drill break set along weakness from 6m 1. Very closely spaced to closely spaced, narrow, subhorizontal, undualting, rough, tight -Manganese staining on Joint set 1 @ 7.47m	6 7
8		107					from 8.31m: becomes very weak.					21		8.31-8.49,JT, undulating, rough, Manganese, very narrow, 8.63-,JT, undulating, rough, Manganese, very narrow	8
9.0		93				SM	Silty fine to coarse SAND, with trace fine gravel; light grey brown. Loose.		'L'						9
10															10

BOREHOLE with Piezo LOG

Site Identification: **AP07a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 26-May-17
Completed: 26-May-17
Contractor: Perry Geotech
Datum: Mine (1000 m)
Total Depth: 27.3m

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
	HQ Coring	93	HQ			SM		Silty fine to coarse SAND, with trace fine gravel; light grey brown. Loose.		'L'						
11		97														11
12																12
12.2		100			Homunga Rhyolite - Lava			Light grey brown, fine to medium grained, RHYOLITE FROTH FLOW, weak.					15		-at 12.15m, banding/weakness set 1 continuous (subhorizontal planes at weakness)	
13																13
14		87											14			14
15		100						from 15m: weak to moderately strong					29			15
16								from 16.15m: becomes very closely spaced with 1-2cm thick bands weathered to form defect/weakness planes								16
16.5						SP		Fine SAND, with some silt; light greyish brown, soft, loose, low plasticity (slightly dialatant)	S	'L'					-Drilling ceased for weekend @ 16.5m -16.5-17.25m: soft patch believed to be from upwell	
17																17
17.3		75						Highly weathered, light grey brown, fine to medium grained, RHYOLITE, FLOW weak-very weak. Moderately -widely spaced banding.			HW		29		Jointing at 17.79-18.0, subvertical, undulating-planar, rough	
								from 17.74m: become purpleish grey, moderately weathered.								
18		95											25			18
19		42						from 19.64m: becomes moderately weathered.			MW		0			19
20																20

BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **AP07a**

Sheet 3 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 26-May-17
Completed: 26-May-17

Datum: Mine (1000 m)
Total Depth: 27.3m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
21 22 23 24 25 26 27 27.3 28 29 30	HQ Coring	42 37 85 38 100 79 100	HQ		Homunga Rhyolite - Lava			Highly weathered, light grey brown, fine to medium grained, RHYOLITE FLOW, weak-very weak. Moderately -widely spaced banding. from 21m: becomes moderately weathered to slighly weathered, defects closely spaced. from 24.36m: becomes highly weathered to completely weathered, weak to very weak. from 27m: orange brown staining. Termination Depth = 27.25m			MW MW-SW HW-CW		0 35 0 0 65 62 0		-at 21m, bands of soft material causing lower recovery - weakness/joint set 1 becomes closely spaced from 21.0 m -vein at 21.24-21.52m, very steeply inclined, undulating, smooth, narrow, white mineralization infill -NOTE: slightly reducing circulation since 15m -Crushed zone at 22.92-23.0m, fine to coarse gravel 23-23.1,JT, subvertical, smooth, undulating, very narrow-tight, Fe staining -Joint set 2 very closely spaced to closely spaced from 24.0	21 22 23 24 25 26 27 28 29 30

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP7A CORE BOX PHOTOGRAPHS				

Depth: 0 m to 2.50m

Depth: 2.50 m to 5.68 m

Client Name.	**OGC**	**Job No.**	**8332**	
GHD Limited		**Address**	**Arthur Property**	
		Photographer:		**Date:** May 2017

Title: AP7A CORE BOX PHOTOGRAPHS

Depth: 5.68m to 8.55m

Depth: 8.55m to 11.63m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**

Title: AP7A CORE BOX PHOTOGRAPHS

Depth: 11.63m to 14.80m

Depth: 14.80m to 18.00m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017

Title: AP7A CORE BOX PHOTOGRAPHS

Depth: 18.00 m to 22.70m

Depth: 22.70 m to 26.35 m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP7A CORE BOX PHOTOGRAPHS				

Depth: 26.35m to 27.25m

GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP08**

Sheet 1 of 1

Project:	Project Quattro	**Coordinates:**	Refer to attached Table
Client:	OceanaGold Ltd	**Elevation:**	Refer to attached Table
Site:	Waihi - TSF3	**Commenced:**	30-May-17
Job No.:	51/37083	**Completed:**	30-May-17

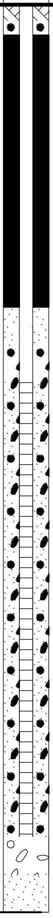
Datum: Mine (1000 m)
Total Depth: 6.0m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.2	HQ Coring	100			TS	ML	TOPSOIL: SILT, with some fine to medium grained sand and clay, trace rootlets; dark brown. Soft, wet, low plasticity.	W	S					
0.7					Ash		SILT, with minor clay; brown, soft, wet, low plasticity. from 0.5m: with minor fine to medium sand.							
1.3					Alluvium	CL	Silty CLAY; light brown with orange and white mottling. Soft, wet, high plasticity. from 1.05m: with some fine sand							
2.2	Push tube	100				ML	Fine to coarse sandy SILT, with minor clay; brown with grey and orange mottling, soft, wet, medium plasticity. from 1.65m: with some sand.							-Push tube at 2.0m
6.0	HQ Coring	83 80			Homunga Rhyolite - Tuff		White grey RHYOLITE CRYSTAL TUFF; extremely weak. Light grey with orange staining, fine to medium, RHYOLITE CRYSTAL TUFF, very weak, closely spaced bedding. from 3 m: extremely weak to very weak, breaks down fine to coarse Sand with some silt, Firm-hard, wet.					86 21 9		weakness set from 2.95m Crushed zone, subhorizontal, undulating, smooth 3.17-,Joint, very steeply inclined, undulating, rough, very narrow
							Termination Depth = 6m							

Piezometer



Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**

Title:

AP8 CORE BOX PHOTOGRAPHS

Depth: 0 m to 2.77m

Depth: 2.77 m to 6.00 m

GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP09**

Sheet 1 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 01-Jun-17
Completed: 01-Jun-17

Datum: Mine (1000 m)
Total Depth: 21.0m
Contractor: Perry Geotech

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

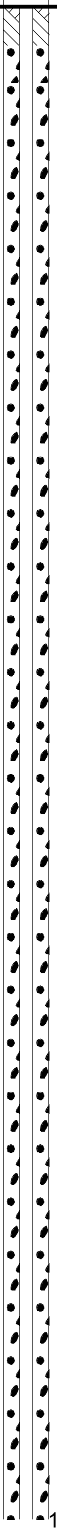
Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring	107				OL	TOPSOIL: Organic SILT, trace sand and rootlets; black, soft to very soft, wet, non plastic, sand, fine to medium grained.	W	S-VS			
0.2					Ash	ML	SILT, with some clay and trace fine to medium grained sand; brown, soft, wet, high plasticity. from 0.6m: minor fine to coarse sand from 1.0m: trace fine gravel.		S			
1.1					Alluvium	SM	Silty fine to coarse poorly graded SAND, with trace gravel; light brown, loose, wet, fine to medium grained poorly graded gravel.		'L'			
1.3							from 1.3m: with some silt, orange brown with grey mottling.					
1.5		80					from 1.5m: Very loose, saturated.	S	'VL'			
2.0	Push Tube	0										-Push tube at 2 m (low recovery)
2.5	HQ Coring	120					from 2.5m: with some silt, minor fine to coarse poorly graded angular gravel. Loose.		'L'			
2.65							from 2.65m: becomes dark brown, medium dense, minor silt.		'MD'			
3.0		95					from 3.0m: light brown, trace silt. Loose		'L'			
3.7							from 3.7m: becomes medium dense.		'MD'			
3.8					Homunga Rhyolite - Lava		Silty fine to coarse poorly graded SAND, with trace gravel; purplish grey. Medium dense, wet, fine to coarse grained poorly graded completely weathered rhyolite gravel. Completely weathered, fine to medium, purpleish grey RHYOLITE FLOW; weak; very closely spaced-closely spaced horizontal deflects/weakeness derived bedding; breaks down with pressure fine to coarse-grained sand with some gravel and silt	W		CW		-Joint set 1, sub horizontal, undulating, smooth, narrow, closed (weakness likely caused by drilling)
4.5		78									20	
5.0							Fine to coarse poorly-graded subrounded GRAVEL, orange to grey. Loose, wet.		'L'			
5.2							Completely weathered, fine to medium, purpleish grey RHYOLITE FLOW; weak; very closely spaced-closely spaced horizontal deflects/ weakeness derived bedding; breaks down with pressure fine to coarse-grained sand with some gravel and silt					
6.0		78									12	
6.22							from 6.22m: becomes white.					
6.5							from 6.5m: becomes grey, highly weathered.			HW		
7.5		107									77	-Joint set 1 ends at 7.74m -Joint at 8.03m, steeply inclined, moderately weathered (closed), undulating, smooth, very strong iron staining -Joint at 8.19m, very strong iron staining
7.92							from 7.92m: grey with orange staining, completely weathered			CW		
9.0		97					from 9.0m: becomes highly weathered			HW	51	
9.65							from 9.65m: becomes completely weathered			CW		

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

Piezometer



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BOREHOLE with Piezo LOG

Site Identification: **AP09**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 01-Jun-17
Completed: 01-Jun-17

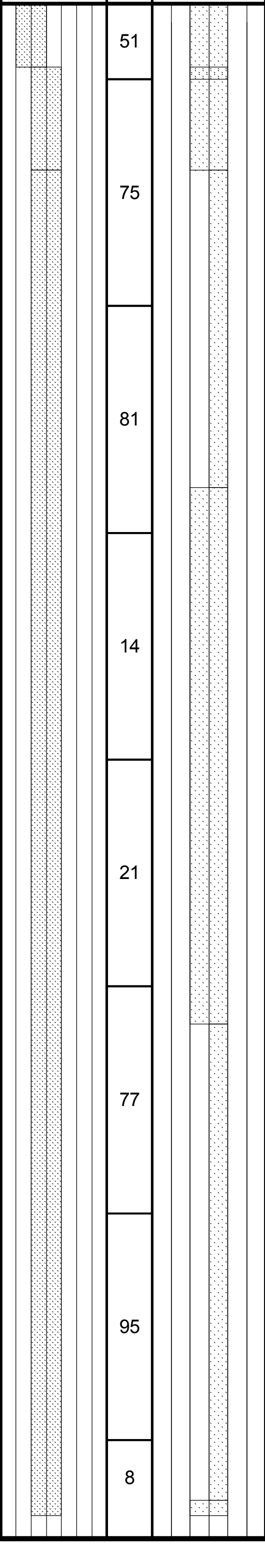
Datum: Mine (1000 m)
Total Depth: 21.0m
Contractor: Perry Geotech

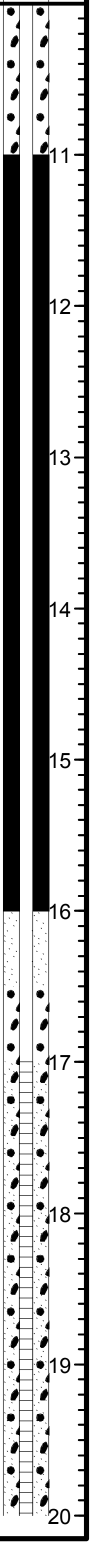
Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
	HQ Coring	97			Homunga Rhyolite - Lava		+ + + +						51		-Crushed zone at 9.78-10.4m (possibly caused by drilling weak rock)	
		91						from 10.42m: becomes grey, moderately to slightly weathered, moderately strong to weak			MW		75		- From 10.42m Joint set 1 continues closely spaced, steeply inclined to moderately inclined, undulating, rough to smooth (potentially drill breaks along planes of weakness) - Other fractures to 10.5m were drill breaks - 11.15m set 1 becomes closely spaced- moderately widely spaced	
11																
12		107											81		-Joint set 1 becomes gently inclined	
13								from 13.3m: moderately to slightly weathered, , orange white staining. NOTE: significant water loss from about 13.5m, low recovery, inferred fines from completely weathered rhyolite washed out							-13.2m, Joint Set 1 becomes very closely spaced to closely spaced/crushed zone to 13.65m -Crushed zone from 13.5-15.0m	
14		47											14			
15		77											21		-Crushed zone from 15.25-15.68m	
16								from 16.5m: no staining, moderately to slightly weathered							-Crushed zone from 15.98-16.68m -Joint set 1 from 16.4m becomes steeply inclined -16.75m Joint set 1 becomes closely spaced- moderately widely spaced	
17		103											77			
18		100						from 18.25m: becomes grey with orange staining					95		-,, ,,,, ,Note: Conjugate fractures visble at 18.25m -,, ,,,, ,18.25-18.38m: Very steeply inclined, very narrow, undulating to stepped, rough, white mineralization	
19		80											8		-Crushed zone from 19.3-19.4m -9.5m break up by drilling at start of run	
20																





BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **AP09**

Sheet 3 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 01-Jun-17
Completed: 01-Jun-17
Contractor: Perry Geotech
Datum: Mine (1000 m)
Total Depth: 21.0m

Equipment: tractor JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	LP

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
21 21.0	HQ Coring	80					+ + + +						8		-,Joint set 1 from 19.9m becomes very closely spaced-closely spaced	
21								Termination Depth = 21m								
22																
23																
24																
25																
26																
27																
28																
29																
30																

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP9 CORE BOX PHOTOGRAPHS				

Depth: 0 m to 3.15m

Depth: 3.15 m to 5.70 m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP9 CORE BOX PHOTOGRAPHS**				

Depth: 5.70m to 9.72m

Depth: 9.72m to 12.59m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**

Title: AP9 CORE BOX PHOTOGRAPHS

Depth: 12.59m to 16.50m

Depth: 16.50m to 19.40m

Client Name.	OGC	**Job No.**	8332		
GHD Limited		**Address**	Arthur Property		
		Photographer:		**Date:**	May 2017
Title:	**AP9 CORE BOX PHOTOGRAPHS**				

Depth: 19.40 m to 21.00m

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BOREHOLE with Piezo LOG

Site Identification: **AP10**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 30-May-17
Completed: 30-May-17

Datum: Mine (1000 m)
Total Depth: 7.5m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.3 0.4	HQ Coring	35			Fill	ML		FILL: SILT with some clay and fine to medium-grained sand, angular gravel and trace rootlets; dark brown,very soft, wet, low plasticity	W	VS						
						SM		Fine sandy SILT; brown soft, wet, no plasticity		S						
								Silty fine to medium-grained SAND; brown, wet, loose.		L						
1								Coreless (Approx. 0.9 m) In contact with highly weathered rhyolite (appears crumbled, light brown) [poss. volcanic ASH?]								
2		70			Homunga Rhyolite - Lava			Moderately weathered, fine to medium- grained, purplish grey RHYOLITE FLOW; moderately strong; with very closely spaced dark banding and widely spaced, white banding			MW		42		-Joint set (1), Closely spaced, subhorizontal-gently inclined, undulating-stepped, rough ery narrow - moderately narrow, Iron staining and white mineralisation -Joint at 1.58-1.87 Sub vertical, undulating, rough, Manganese and Iron staining + white mineralisation -No push tube at 2m (too hard)	
								from 2.38m: becomes highly weathered, white, weak to very weak			HW				-NOTE: crushed rock at 2.4 m broken in situ -,2.42-2.43 washed off soft material or crushed zone	
3		88						Approx. 0.5 m coreless above 3.0 m					108		-lost circulation at 3m	
4								from 3.6m: becomes moderately weathered, purplish grey, moderately strong to weak			MW					
								from 4.15m: becomes highly weathered-completely weathered, whitish grey, weak to very weak			HW-CW					
		95						NOTE: drilling after 4.5 m very slow			MW-SW		87		-Joint set (1) from 4.5 iron staining more pronounced with some defects -Joint set (1) defect from 5.5 very weathered into surrounding rocks, strong iron staining	
5								from 4.6m: becomes moderately weathered-slightly weathered, purplish grey, moderately strong								
6		105											73			
7													100			
7.5								Termination Depth = 7.5m,								
8																
9																
10																

BOREHOLE with Piezo LOG

Site Identification: **AP10a**

Sheet 1 of 2

Project:	Project Quattro	**Coordinates:**	Refer to attached Table
Client:	OceanaGold Ltd	**Elevation:**	Refer to attached Table
Site:	Waihi - TSF3	**Commenced:**	30-May-17
Job No.:	51/37083	**Completed:**	30-May-17

Datum: Mine (1000 m)
Total Depth: 19.5m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Inclination: -90
Shear Vane:
Comments:
Bore Diameter (mm): 96

Logged:	JM
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.] | **Drilling Method** | **Core Run / Recovery (%)** | **Support / Casing (m)** | **Water** | **Geological Fm** | **Classification** | **Graphic Log** | **SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)** | **Moisture Condition** | **Consistency/ Relative Density** | **Weathering** | **Estimated Rock Strength** (EW VW W MS S VS ES) | **RQD (%)** | **Defect Spacing (mm)** (20 60 200 600 2000) | **TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating** | **Piezometer**

Depth: 0.1, 0.3, 0.4, 1, 2, 3, 4, 5, 6, 6.0, 7, 8, 9, 10

Drilling Method: HQ Coring

Core Run / Recovery (%): 35, 70, 88, 95, 105, 98, 98

Geological Fm: Fill; Homunga Rhyolite - Lava

Classification: ML

Soil / rock description:

SILT with some clay and fine to medium-grained sand, angular gravel and trace rootlets; dark brown,very soft, wet, low plasticity

Fine sandy SILT; brown soft, wet, no plasticity

Silty fine to medium-grained SAND; brown, wet, loose

Coreloss (Approx. 0.9 m)
In contact with highly weathered rhyolite (appears crumbled, light brown) [poss. volcanic ASH?]

Moderately weathered, fine to medium- grained, purplish grey RHYOLITE FLOW; moderately strong; with very closely spaced dark banding and widely spaced, white banding

from 2.38m: becomes highly weathered, white, weak to very weak

Note: logging finished at 3m

from 3.6m: becomes moderately weathered, purplish grey, moderately strong to weak

from 4.15m: becomes whitish grey, weak to very weak

NOTE: drilling after 4.5 m very slow.
Brecciated 4.5 - 5.5 m. Weathered, purplish grey, moderately strong

Moisture Condition: W

Consistency/ Relative Density: VS, S, L

Weathering: MW, HW, MW, MW-SW

RQD (%): 0, 58, 84, 87, 73, 100, 63

Tests & samples / rock mass defects:

-Joint set (1), Closely spaced, subhorizontal-gently inclined, undulating-stepped, rough ery narrow - moderately narrow, Iron staining and white mineralisation

-Joint at 1.58-1.87 Sub vertical, undulating, rough, Manganese and Iron staining + white mineralisation
-No push tube at 2m (too hard)

-NOTE:
crushed rock at 2.4 m broken in situ
-2.42-2.43m washed off soft material or crushed zone

-lost circulation at 3m

-Joint set (1) from 4.5 iron staining more pronounced with some defects
-Joint set (1) defect from 5.5 very weathered into surrounding rocks, strong iron staining

-2cm vein: 6.95-7.22, white mineralization, moderately weathered, very steeply inclined, undulating, smooth to rough
-NO push tube at 7m too hard

-Joint at 8m (1) up to 2 cm white mineral infill (weathered material) + strong Iron staining

-Vein at 8.85-
9.0 m, Very steeply inclined, undulating to planar, smooth, very narrow
-Joint set (1) becomes gently inclined to moderately inclined, undulating-planar, smooth to rough, very narrow to narrow

Piezometer depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

BOREHOLE with Piezo LOG

GHD Limited

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Auckland 1141

Site Identification: **AP10a**

Sheet 2 of 2

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 30-May-17
Completed: 30-May-17

Datum: Mine (1000 m)
Total Depth: 19.5m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged: JM
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
10.0	HQ Coring	98			Homunga Rhyolite - Lava			10.4 m: possible tuff layer 100 mm thick from 10.5m: slightly weathered, moderately strong-strong, closely spaced to moderately widely spaced			SW				-Vein at 10.31 in 5 cm wide white (weathered) phenocrysts, moderately narrow, weak, rough	
11		100						from 11.38m: becomes brownish grey					93		Vein/ Joint at 11.20-12.11, Very steeply inclined, narrow-moderately narrow, undulating, smooth, weathered, grey infill breakdown to silt Vein/ Joint from 11.34-11.86, Sub vertical, moderately narrow, undulating, smooth, weathered grey min infill to silt breakdown Joint set (1) from 12.0m becomes gently inclined to moderately inclined	
12–13		99											91		+ conjugate joints 30-45 difference to approx 15 m equally spaced (Moderately widely spaced)	
14		90											62			
15–16		103											84		-Joints/vein, 15.55 and 15.62, 15.6-15.75, Very steeply Inclined, moderately narrow, undulating, smooth, narrow, weathered grey minerals and infill of weathered material -Crushed zone at 16.5-16.54, likely caused by drilling	
17		100											70		-Joint/vein at 16.86-16.945, Very steeply inclined, moderately narrow to narrow, undulating, smooth, weathered grey min -Joint at 16.93-17.06, Sub vertical, undulating, smooth, narrow, white mineral infill weathering -Joint at 17.1- 17.17, fine to coarse-grained gravel vein, smooth, very narrow, undulating, grey phenocrysts -Joint at 17.25-17.93, Subvertical, undulating, smooth, very narrow to narrow, weathered white mineral infill, breaks down to silt	
18–19		100											80		-Vein at 18.05-18.21, Moderately weathered, narrow, undulating, smooth, very steeply inclined,grey mineralisation -Vein at 18.31-18.61, Subvertical, undulating, smooth- rough, manganese, grey minerals / phenocrysts -Joint set (1) end 18.44	
19.5								Termination Depth = 19.5m,								
20																

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP10A CORE BOX PHOTOGRAPHS				

Depth: 0 m to 4.50m

Depth: 4.50 m to 7.27 m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP10A CORE BOX PHOTOGRAPHS				

Depth: 7.27m to 10.15m

Depth: 10.15m to 13.00m

Client Name.	**OGC**	**Job No.**	**8332**	
GHD Limited		**Address**	**Arthur Property**	
		Photographer:		**Date:** May 2017

Title:	**AP10A CORE BOX PHOTOGRAPHS**

Depth: 13.00m to 15.85m

Depth: 15.85m to 18.45m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP10A CORE BOX PHOTOGRAPHS**				

Depth: 18.45 m to 19.50m

GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **AP11**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 06-Jun-17
Completed: 06-Jun-17

Datum: Mine (1000 m)
Total Depth: 7.5m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged: JM
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)
0.0–0.28	HQ Coring	81	TS	ML	TOPSOIL: SILT with minor fine to coarse sand, trace clay and rootlets; dark brown to black, very soft, wet, poorly-graded, low plasticity to no plasticity	W	VS		
0.28–0.7			Ash		**0.28:** VOLCANIC ASH. Silt with minor fine to medium grained poorly graded sand, trace clay; brown, soft, wet, low plasticity		S		
0.7–7.5		81 (0–1.5) 100 (1.5–3.0) 95 (3.0–4.5) 95 (4.5–6.0) 93 (6.0–7.5)	Homunga Rhyolite - Lava		Completely weathered, fine to medium grained, brownish grey RHYOLITE; extremely weathered; breaks down with pressure to fine to coarse SAND with some fine to coarse, poorly graded angular gravel with minor silt, firm in cohesive dominant areas and loose granular zones, wet from 0.9m: becomes weak to very weak from 1.79m: becomes extremely weak to very weak, breaks down to fine to coarse GRAVEL, minor fine to coarse sand, trace silt, loose to medium dense from 2.02m: breaks down to fine to coarse gravelly SAND with some silt; loose from 2.31m: becomes highly weathered to completely weathered, weak to moderately strong 3.09m: becomes moderately weathered, grey, weak from 3.30m: becomes brownish grey, weak to moderately strong 4.67m: moderately strong,grey,moderately weathered from 5.8m: trace brownish Iron Staining			CW HW-CW MW HW MW	33 (1.5–3.0) 64 (3.0–4.5) 50 (4.5–6.0) 55 (6.0–7.5)
7.5					Termination Depth = 7.5m,				

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-Joint/Break from 0.7-2.88, sub horizontal, very narrow, undulating, smooth, very closely spaced (likely breaks along weaknesses or bedding)

-Joint at 1.5 m, steeply inclined, undulating, smooth, very narrow, Iron Staining

-Too hard for push tube @ 2.0 m

-Joint at 2.42 m, moderately inclined, undulating, rough, narrow, weathered, white material, Iron Staining
- DB at 2.52
-Joint at 2.62, steeply Inclined, undulating, smooth, very narrow to narrow, weathered, white mineral + Iron
-3.0, 3.25, 3.5, 4.07, 4.5, subhorizontal to gently inclined, undulating to stepped, smooth to rough, very narrow, grey, weakening penetrated into rock
-Breakset from 3.85, very closely spaced, sub horizontal, undulating to stepped, smooth to rough
-Crushed zone from 4.5: becomes coarse sand, medium to coarse gravel + cobbles

-Joint at 4.75, gently inclined, undulating, smooth, Iron Staining

-from 5.15: becomes gently inclined, very closely spaced to closely spaced

-Joint @ 6.54-6.58: Very steeply inclined, undulating, smooth, very narrow, Iron Staining

-Ends at 7.5, a 4 cm vein with white mineralizatin, sub vertical, very narrow, undulating, smooth

Piezometer

GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: AP11a

Sheet 1 of 3

Project:	Project Quattro	**Coordinates:**	Refer to attached Table
Client:	OceanaGold Ltd	**Elevation:**	Refer to attached Table
Site:	Waihi - TSF3	**Datum:**	Mine (1000 m)
Job No.:	51/37083	**Total Depth:**	21.0m
		Commenced:	06-Jun-17
		Completed:	06-Jun-17
		Contractor:	Perry Geotech

Equipment:	JD Tractor Rig	**Inclination:**	-90	**Logged:**	JM
Shear Vane:		**Comments:**		**Processed:**	AS
Bore Diameter (mm):	96			**Checked:**	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring		TS	ML	TOPSOIL: SILT with minor fine to coarse sand, trace clay and rootlets; dark brown to black, very soft, wet, poorly-graded, low plasticity to no plasticity	W	VS			
0.28			Ash		**0.28:** VOLCANIC ASH. Silt with minor fine to medium grained poorly graded sand, trace clay; brown, soft, wet,		S			
0.7		81	Homunga Rhyolite - Lava		Completely weathered, fine to medium grained, brownish grey RHYOLITE FLOW; breaks down with pressure to fine to coarse SAND with some fine to coarse, poorly graded angular gravel with minor silt, firm in cohesive dominant areas and loose granular zones, wet from 0.9m: becomes weak to very weak			CW		-Joint/Break from 0.7-2.88m, sub horizontal, very narrow, undulating, smooth, very closely spaced (likely breaks along weaknesses or bedding) -Joint at 1.5 m, steeply inclined, undulating, smooth, very narrow, Iron Staining
1.5		100			from 1.79m: becomes extremely weak to very weak, breaksdown to fine to coarse GRAVEL, minor fine to coarse sand, trace silt, loose to medium dense from 2.02m: breaks down to fine to coarse gravelly SAND with some silt; loose from 2.31m: becomes highly weathered to completely weathered, weak to moderately strong			HW-CW	33	-Too hard for push tube @ 2.0 m -Joint at 2.42 m, moderately inclined, undulating, rough, narrow, weathered, white material, Iron Staining -DB at 2.52 -Joint at 2.62, steeply Inclined, undulating, smooth, very narrow to narrow, weathered, white mineral + Iron
3.0		95			from 3.09m: becomes moderately weathered, grey, very weak from 3.30m: becomes brownish grey, weak to moderately strong			MW	64	-3.0, 3.25, 3.5, 4.07, 4.5m, subhorizontal to gently inclined, undulating to stepped, smooth to rough, very narrow, grey, weakening penetrated into rock -Breakset from 3.85m, very closely spaced, sub horizontal, undulating to stepped, smooth to rough
4.5		95			4.67m: moderately strong,grey,slightly weathered from 5.8m: trace brownish Iron Staining			MW	50	-Crushed zone from 4.5: becomes coarse sand,medium to coarse gravel and cobbles -Joint at 4.75, gently inclined,undulating, smooth, Iron Staining -Joint at 5.15: becomes gently inclined, very closely spaced to closely spaced
6.0		93							55	-Joint @ 6.54-6.58: Very steeply inclined, undulating, smooth, very narrow, Iron Staining
7.5		100			from 7.6m: moderately to slightly weathered, areas with light grey staining			MW	81	-Ends at 7.5; 4 cm vein with white mineralization, sub vertical, narrow, undulating, smooth -Joint set from 7.68, 7.76, 7.78,8.27, very closely spaced to moderately widely spaced -7.8-7.95 Vein with white mineral, very steeply inclined, undulating, rough, very narrow (closed) -8.22-8.8 Thin vein, white mineral, sub vertical, undulating, rough, very narrow (closed)
9.0		93							76	
10										

Graphic Log | Estimated Rock Strength: EW VW W MS S VS ES | Defect Spacing (mm): 20 60 200 600 2000 | Piezometer

BOREHOLE with Piezo LOG

Site Identification: **AP11a**

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - TSF3
Job No.: 51/37083

Coordinates: Refer to attached Table
Elevation: Refer to attached Table
Commenced: 06-Jun-17
Completed: 06-Jun-17

Datum: Mine (1000 m)
Total Depth: 21.0m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged: JM
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
10	HQ Coring	93			Homunga Rhyolite - Lava						MW		76			
11		97						from 10.5m: Moderately strong to weak from 11.6m: becomes brownish grey with light grey, white and brown staining and banding					53		-11.04-11.39 Break set, very closely spaced, sub horizontal, stepped, rough, very narrow to tight -Joint at 11.38, sub horizontal, stepped, rough, very narrow, light brown, silt or clay in CIL (weathered minerals) -Joint at 11.55 as above but Steeply Inclined -Crushed zone at 11.68-12, fine to coarse grained gravel and minor cobbles	11
12		96						NOTE: from 12m, no circulation from 12m: weathered veins with white phenocrysts from 13.15m: becomes brownish grey					51		-from 12 m break set, closely spaced, smooth, very narrow to narrow, stepped, smooth, light grey staining -Joint at 12.11, 12.6, gently inclined, very narrow, undualting to stepped, rough, Iron staining, and traces of clay -Crushed zone between 12.86-13 m: fine to coarse poorly-graded gravel, light grey -NOTE: Breaks from 13.15-14.53 =DB	12 13
14		74											69			14
15		107						DRILLERS NOTE: Additional core at 17 m likely due to shorter runs at 14 m which weren't all drilled at the 16 m run					109		-Break/Weakness: 15.29: Sub horizontal, Undulating to Stepped, Rough 15.39: Very Narrow to Tight -DB at 15.87 -Joint at 16.0, gently inclined, undulating, rough, very narrow, Iron Staining, grey silt -DB at 16.2 -Joint at 16.5	15 16
17		114											57		-Joint at 16.55-16.9: Very steeply inclined, very narrow, undulating, smooth, associated DBs. Light brown, silt/clay infill -Joint at 16.95-17.57: Sub vertical, very Narrow, undulating, smooth, light brown, silt/clay -Joint at 17.14-17.57 as above -Crushed zone @17.3-17.57; likely round by drilling, fine to coarse gravel with minor cobbles -Hairline fractures (closed), clay infil 17.37-17.72	17
18		95						from 18.15 m: light grey banding					86		-Joint @ 17.9-18.15, 18.12-18.16: Sub vertical, narrow, undulating, smooth (closed), grey mineral infill -Hairline fractures 18.45-18.65: with trace infill -Joint @ 18.58-18.85: sub vertical, very narrow, to tight, undulating, smooth, light brown, silt/clay infill -Joint at 18.87-19.4 as above very narrow -Joint at 19.07: Steeply inclined to very steeply inclined, very narrow to tight 19.15 Undulating, smooth, trace light brown, silt/clay and Iron	18 19
20		102											102		-Hairline fractures from 19.5-20.25 and 20.4-20.6 with silt clay infill -Weakness break 19.7, 20.17, 20.4 Gently Inclined,very narrow to tight	20

BOREHOLE with Piezo LOG

Project: Project Quattro	**Coordinates:** Refer to attached Table	**Datum:** Mine (1000 m)	
Client: OceanaGold Ltd	**Elevation:** Refer to attached Table	**Total Depth:** 21.0m	
Site: Waihi - TSF3	**Commenced:** 06-Jun-17	**Contractor:** Perry Geotech	
Job No.: 51/37083	**Completed:** 06-Jun-17		

Equipment: JD Tractor Rig	**Inclination:** -90	**Logged:** JM
Shear Vane:	**Comments:**	**Processed:** AS
Bore Diameter (mm): 96		**Checked:** HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
20.0 – 21.0	HQ Coring	102									MW		102			
21.0								Termination Depth = 21m,								21
22																22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP11A CORE BOX PHOTOGRAPHS**				

Depth: 0 m to 3.00m

Depth: 3.00 m to 6.00 m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017
Title:	AP11A CORE BOX PHOTOGRAPHS				

Depth: 6.00m to 8.70m

Depth: 8.70m to 11.43m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	Arthur Property		
		Photographer:		Date:	May 2017

Title: AP11A CORE BOX PHOTOGRAPHS

Depth: 11.43m to 14.39m

Depth: 14.39m to 17.59m

Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**Arthur Property**		
		Photographer:		**Date:**	**May 2017**
Title:	**AP11A CORE BOX PHOTOGRAPHS**				

Depth: 17.59 m to 20.16m

Depth: 20.16 m to 21.00 m

BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **WRS04**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083

Datum:
Total Depth: 6.0m
Commenced: 08-Jun-17
Completed: 08-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged: JM/HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering
	HQ Coring	Alluvium	ML	TOPSOIL: SILT with minor clay and trace rootlets; dark brown, soft, wet, low plasticity	W	S	
				SILT with minor fine sand; brown, iron staining, firm to stiff, moist, no plasticity	M	F-St	
				from 0.56m: becomes fine, some fine to medium poorly graded sand with minor clay		F	
	Push tube			from 0.96m: becomes some clay with trace fine sand, soft		S	
1.3			SM	Silty fine to medium SAND; brown, loose, wet (behaves cohesively), poorly graded	W	'L'	
1.5	HQ Coring	Coromandel Volcanics	ML	SILT with some fine sand and trace clay; light grey, soft, moist, no plasticity-low plasticity, (Ash?)	M	S	
1.8				Moderately weathered, fine to medium fabric, dark grey DACITE; strong; closely spaced fractures			MW
2.1				Completely weathered to residual soil, fine to medium fabric with mottling, reddish brown DACITE; very weak-extremely weak; breaks down with pressure to fine to coarse well-graded sand with some silt and minor fine angular gravel			CW-RS
				from 3.09m: becomes completely weathered, light brown, weak-very weak			CW
				from 3.46m: becomes completely weathered - residual soil, brown, very weak-extremely weak			CW-RS
				from 4.5m: becomes completely weathered, extremely coarse to very coarse SAND, banding that forms planes of weakness, light brown, weak to very weak from 4.96m: banding ceased			CW
6.0				Termination Depth = 6m,			

Core Run / Recovery (%)	RQD (%)
106	
83	54
84	43
76	26

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

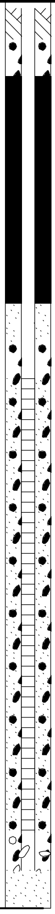
-Push tube

-Crushed zone at 1.94-2: fine to coarse angular gravel, gently inclined, undulating, smooth, strong Iron (Fe) staining
-Push tube at 2.00m too hard
-Joint at 2.17: Steeply inclined, undulating, smooth, very narrow (closed), strong Iron and Manganese
-Joint at 3.09: Gently inclined to moderately inclined, stepped, smooth, very narrow

-Joint at 4.06-4.51: Very steeply inclined, undulating, smooth, very narrow (closed), strong Manganese
-Joint set 1 at 4.5-4.96: Extremely closely spaced to very closely spaced, subhorizontal to gently inclined, undulating, rough, vein, strong Manganese

-Joint at 5.41: Subhorizontal, undulating, rough, very narrow, strong Manganese

Piezometer



BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **WRS04a**

Sheet 1 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 08-Jun-17
Completed: 08-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged: JM/HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
	HQ Coring	106			Alluvium	ML		TOPSOIL: SILT with minor clay and trace rootlets; dark brown, soft, wet, low plasticity	W	S						
								SILT with minor fine sand; brown, iron staining, firm to stiff, moist, no plasticity	M	F-St						
								from 0.56m: becomes fine, some fine to medium poorly graded sand with minor clay		F						
1	Push tube							from 0.96m: becomes some clay with trace fine sand, soft		S					-Push tube	1
1.3						SM		Silty fine to medium SAND; brown, loose, wet (behaves cohesively), poorly graded	W	'L'						
1.5		83			Coromandel Volcanics	ML		SILT with some fine sand and trace clay; light grey, soft, moist, no plasticity-low plasticity, (Ash?)	M	S						
1.8 2	HQ Coring							Moderately weathered, fine to medium fabric, dark grey DACITE; strong; closely spaced fractures			MW				-Crushed zone at 1.94-2: fine to coarse angular gravel, gently inclined, undulating, smooth, strong Iron staining -Push tube at 2.00m too hard -Joint at 2.17: Steeply inclined, undulating, smooth, very narrow (closed), strong Iron and Manganese	2
2.1								Completely weathered to residual soil, fine to medium fabric with mottling, reddish brown DACITE; very weak-extremely weak; breaks down with pressure to fine to coarse well-graded sand with some silt and minor fine angular gravel			CW-RS		54			
3		84						from 3.09m: becomes completely weathered, light brown, weak-very weak			CW				-Joint at 3.09: Gently inclined to moderately inclined, stepped, smooth, very narrow	3
								from 3.46m: becomes completely weathered - residual soil, brown, very weak-extremely weak			CW-RS		43			
4 5		76						from 4.5m: becomes completely weathered, extremely coarse to very coarse SAND, banding that forms planes of weakness, light brown, weak to very weak from 4.96m: banding ceased			CW		26		-Joint at 4.06-4.51: Very steeply inclined, undulating, smooth, very narrow (closed), strong Manganese -Joint set 1 at 4.5-4.96: Extremely closely spaced to very closely spaced, subhorizontal to gently inclined, undulating, rough, vein, strong Manganese -Joint at 5.41: Subhorizontal, undulating, rough, very narrow, strong Manganese	4 5
6		80						from 6.21m: becomes completely weathered-residual soil, brown with occasional black staining, extremely weak, breaks down to soil as above (@21m)			CW-RS		21		-Joint at 6.13: Subhorizontal, undulating, smooth, very narrow, Manganese -Joint at 6.19: Gently inclined, stepped, smooth-rough, very narrow, Manganese -6.20-10.5: Too weathered to discern joints	6
7								from 6.97m: becomes compeletely weathered, weak-very weak, light brown with mottling			CW					7
8		82						from 8.43m: completely weathered-residual soil, extremely weak-very weak, brown			CW-RS		51			8
9		83						from 8.73m: completely weathered, weak-very weak, light brown			CW CW		41			9
10								from 9.68m: becomes residual soil , extremely weak, breaks down as above			RS					10

BOREHOLE with Piezo LOG

Site Identification: **WRS04a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083
Commenced: 08-Jun-17
Completed: 08-Jun-17
Contractor: Perry Geotech
Datum:
Total Depth: 21.0m

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

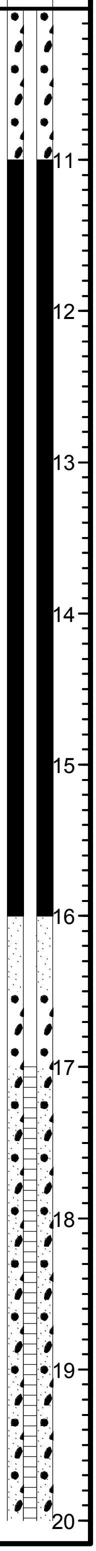
Logged:	JM/HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
10.0–10.5	HQ Coring	83			Coromandel Volcanics					RS	41	
10.5–12.0		80					from 10.5m: becomes completely weathered, very weak from 10.6m: becomes residual soil, extremely weak from 10.69m: becomes completely weathered, very weak			CW RS CW	55	-Extremely Weathered (EW) material not counted as > 100mm for RQD -Only Drill Break (DB) observed (No evidence of staining etc in breaks) -Crushed zone caused by drilling at 11.11-11.20: Subhorizontal, stepped, rough, fine to coarse sand + gravel -Crushed zone caused by drilling at 11.35-11.59: Subhorizontal, stepped, rough, fine to coarse sand + gravel, no staining in either crushed zone
12.0–13.5		88					from 12.66m: becomes completely weathered-residual soil, extremely weak from 13.1m: becomes completely weathered, weak-very weak			CW-RS CW	67	-NOTE: DB had not been included in RQD
13.5–15.0		75					from 13.5m: becomes highly weathered			HW	94	-DB at 14.5-14.56
15.0–16.5		105					from 15.7m: becomes weak			HW	92	-Joint at 15.03: Steeply inclined, narrow, undulating, rough, Manganese staining
16.5–18.0		80									70	-Crushed zone at 17.2-17.32: Subhorizontal, stepped, rough, medium to coarse gravel, no staining present
18.0–19.5		91									77	-Joint at 18.08: Steeply inclined to very steeply inclined, narrow, undulating, rough, minor Mn staining -Joint at 18.38: Steeply inclined to very steeply inclined, narrow, inclined, rough, no staining present
19.5–20.0		99					from 19.5m: becomes highly weathered-moderately weathered, weak-moderately strong			HW-MW	87	

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

Piezometer



BOREHOLE with Piezo LOG

Site Identification: **WRS04a**

Sheet 3 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 08-Jun-17
Completed: 08-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	JM/HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
21 21.0	HQ Coring	99						from 20.3m: becomes moderately weathered			HW-MW MW		87			
								Termination Depth = 21m,								
22																
23																
24																
25																
26																
27																
28																
29																
30																

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	North Rock Stack		
		Photographer:		Date:	May 2017
Title:	WRS4A CORE BOX PHOTOGRAPHS				

Depth: 0 m to 3.09m

Depth: 3.09 m to 6.6 m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	North Rock Stack		
		Photographer:		Date:	May 2017

Title: WRS4A CORE BOX PHOTOGRAPHS

Depth: 6.6m to 10.5m

Depth: 10.5m to 13.82m

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	North Rock Stack		
		Photographer:		Date:	May 2017

Title: WRS4A CORE BOX PHOTOGRAPHS

Depth: 13.82m to 16.93m

Depth: 16.93m to 19.63m

Client Name.	OGC	**Job No.**	8332		
GHD Limited		**Address**	North Rock Stack		
		Photographer:		**Date:**	May 2017
Title:	**WRS4A CORE BOX PHOTOGRAPHS**				

Depth: 19.86m to 21m

BOREHOLE with Piezo LOG

GHD Limited

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Auckland 1141

Site Identification: **WRS05**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - Waste Rock Stack
Job No.: 51/37083

Datum:
Total Depth: 6.0m
Commenced: 09-Jun-17
Completed: 09-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged: HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.1	HW Casing	91			Alluvium	ML		TOPSOIL: SILT, minor fine sand; brown, very soft, saturated, rootlets present	S	VS						
								SILT, some fine to coarse sand, poorly-graded, trace clay; brown, very soft, saturated, minor rootlets present								
0.5						MH		SILT, some clay, minor fine sand; brown, moist, high plasticity	M	F						
1	Push tube														-NOTE: Push Tube in 2nd BH (WRS05)	
1.5		55				ML		SILT, some fine sand and clay; brown, very soft, saturated	S	VS						
								from 1.7m: soft, wet	W	S						
1.8	HW Casing				Coromandel Volcanics			Completely weathered-residual soil, fine to medium grained, reddish grey DACITE; very weak to extremely weak; closely spaced joints (joints not easily distinguished) in CW-RS Soil Silty fine to coarse SAND, poorly-graded, wet, soft to very soft			CW-RS		0		-1.8-1.9m NOTE: Encountered rock	
2																
3		82						from 3.0m: becomes completely weathered, very weak			CW		55		-Jointing, gently to steeply inclined, smooth to rough, iron and manganese staining at: 3.15m 3.3m 3.67m 3.83m 3.91m 3.96 m 4.12m 4.15m 4.2 m 4.67m 4.85m 5.35m 5.62m 5.79m	
											CW-RS					
4																
4.5		101											68			
5								from 4.83m: becomes completely weathered, very weak to extremely weak from 5.09m: becomes very weak			CW					
								from 5.6m: becomes highly weathered, color changed to grey with distinct shade of white phenocrysts (weathered), slight reddish colour, weak			HW					
6.0								Termination Depth = 6m,								
7																
8																
9																
10																

GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **WRS05a**

Sheet 1 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - Waste Rock Stack
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 09-Jun-17
Completed: 09-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.1	HW Casing	91			Alluvium	ML	TOPSOIL: SILT, minor fine sand; brown, very soft, saturated, rootlets present	S	VS			
							SILT, some fine to coarse sand, poorly-graded, trace clay; brown, very soft, saturated, minor rootlets present					
0.5	Push tube					MH	SILT, some clay, minor fine sand; brown, moist, high plasticity	M	F			-NOTE: Push Tube in 2nd BH (WRS05)
1.5		55				ML	SILT, some fine sand and clay; brown, very soft, saturated from 1.7m: soft, wet	S	VS			
1.8	HW Casing				Coromandel Volcanics		Completely weathered-residual soil, fine to medium grained, reddish grey DACITE; very weak to extremely weak; closely spaced joints (joints not easily distinguished) in CW-RS Soil Silty fine to coarse SAND, poorly-graded, wet, soft to very soft			CW-RS	0	-1.8-1.9m NOTE: Encountered rock
3		82					from 3.0m: becomes completely weathered, very weak			CW	55	-Jointing, gently to steeply inclined, smooth to rough, iron and manganese staining at: 3.15m 3.3m 3.67m 3.83m 3.91m 3.96 m 4.12m 4.15m 4.2 m 4.67m 4.85m 5.35m 5.62m 5.79m
							from 3.53m: becomes completely weathered to highly weathered, weak			CW-RS		
		101					from 4.83m: becomes completely weathered, very weak to extremely weak from 5.09m: becomes very weak			CW	68	
							from 5.6m: becomes highly weathered, color changed to grey with distinct shade of white phenocrysts (weathered), slight reddish colour, weak			HW		-Joint at 6.11-6.18m: Gently inclined, fine to coarse angular gravel, Iron staining
		85					from 6.5m: becomes moderately strong to strong				83	
		104					from 7.5m: completely weathered to highly weathered, increased red color, weak			CW-HW	91	-Joint at 8.12m: Very steeply inclined, undulating, rough, narrow -Joint at 8.26m: Subhorizontal, undulating , rough, tight, Iron staining -Joint at 8.28m: Gently inclined, undualting, rough, very narrow to tight -Joint at 8.47m: Undulating to stepped, smooth to rough, Manganese and minor Iron, subhorizontal, very narrow -Joint at 9.17m, subhorizontal, gently inclined, undulating, rough, Iron staining
		99					from 9.1m: residual soil, SILT, some fine to medium sand, poorly graded, moist, soft to very soft, extremely weak from 9.18m: completely weathered to highly weathered, very weak to weak, grey with shade red staining, weathered grains			RS CW-HW HW	89	-Joint at 9.4m, Gently inclined to moderately inclined, undulating, rough, Iron and Manganese staining, very narrow -Joint at 10.0m, minor Iron staining, very narrow
10												

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

Piezometer

GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **WRS05a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 09-Jun-17
Completed: 09-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged: HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)
	HW Casing	99			Coromandel Volcanics		from 9.5m: highly weathered, weak to moderately strong Completely weathered-residual soil, fine to medium grained, reddish grey DACITE; very weak to extremely weak; closely spaced joints (joints not easily distinguished) in CW-RS Soil Silty fine to coarse SAND, poorly-graded, wet, soft to very soft			HW	89
11 12		95									91
13	HQ Coring	97					from 12.6m: becomes moderately weathered, color change from reddish grey + mottled to light grey, strong from 13.0m: becomes highly weathered, colour grey-mottling (orange Fe weathering), reddish, weak			MW HW	79
14 15		91									91
16		108					from 15.3m: moderately weathered, light grey, strong from 15.9m: highly weathered, dark grey, slight red,mottled, weak to moderately strong			MW HW	62
17 18		86					from 16.5m: moderately weathered, grey, strong			MW	100
19		107									100
20		105									100

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-Joint at 10.2m, Gently inclined, undulating, rough, Iron staining, narrow
-Joint at 10.4m, Subhorizontal, undulating, rough, minor Iron staining, tight
-Joint at 11.25m: Subhorizontal, undualting, smooth to rough, tight, Iron staining
-Joint at 11.5m: Subhorizontal, undualting, smooth to rough, tight, minor Iron (DB?)
-Joint at 11.9m: Gently inclined to moderately inclined, undulating to stepped, rough, minor Iron and Manganese, tight to very narrow
-Joint at 12.5m: Very steeply inclined, undulating, rough, very narrow to narrow, minor Iron staining
-Joint at 12.8m: Gently inclined, undulating to stepped, rough, Manganese and Iron staining
-Joint at 13m: Moderately inclined to steeply inclined, planar, smooth to rough, narrow, Iron and Manganese staining
-Joint at 13.45m: Sub horizontal, undulating, smooth, tight, Iron staining

-Joint at 13.92m: Sub horizontal, undulating, rough, tight, Iron staining
-Joint at 14.62m: Sub horizontal, undulating, smooth, tight, Iron staining, minor Manganese
-Joint at 15.3m: Sub horizontal, undulating, smooth to rough, tight, Iron staining
-Crushed zone at 16.00-16.04m: Sub horizontal, fine to coarse sand, minor gravel, sub angular Iron staining
-Joint at 16m: Steeply inclined to very steeply inclined, planar to stepped, smooth, very narrow, Iron and Manganese staining
-Joint at 16.4m: Sub vertical, stepped, very narrow, Iron and Manganese staining

Piezometer: 11 12 13 14 15 16 17 18 19 20

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BOREHOLE with Piezo LOG

Site Identification: **WRS05a**

Sheet 3 of 3

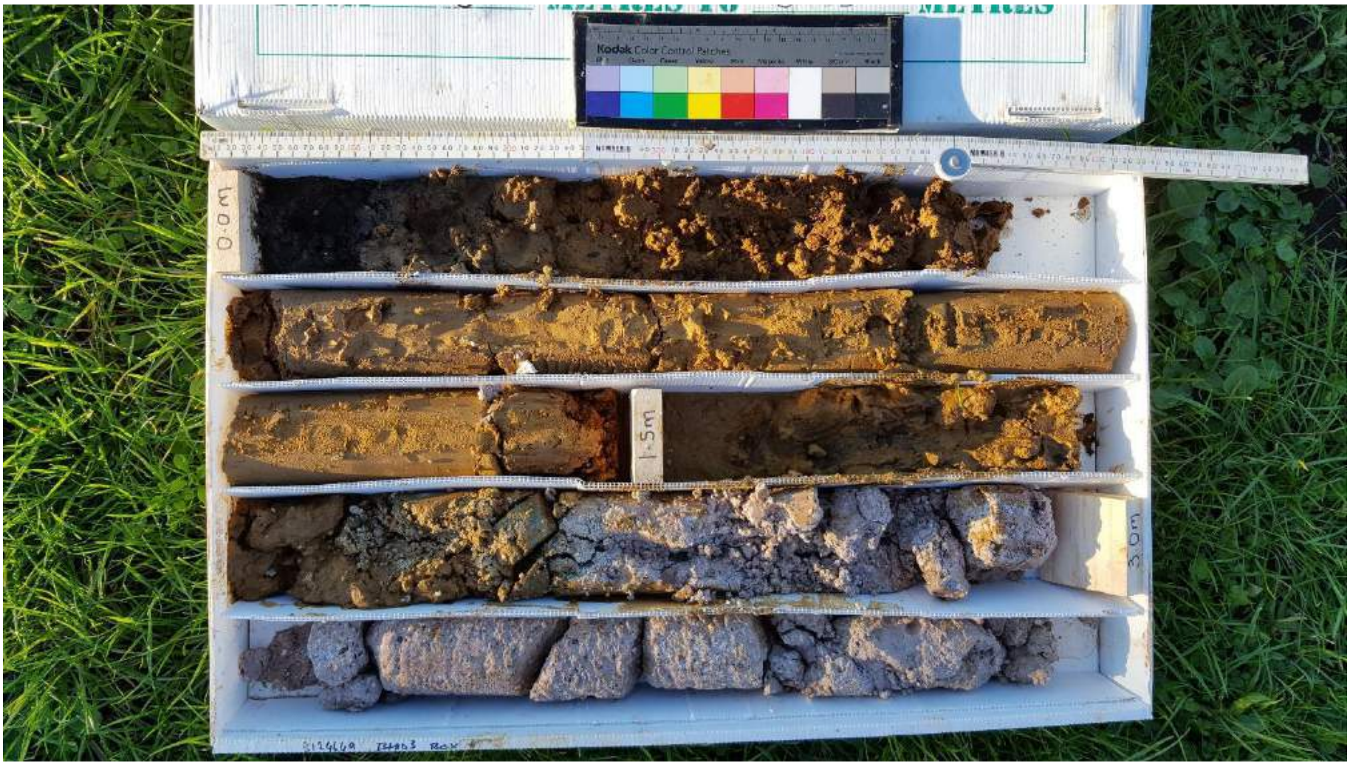
Project:	Project Quattro
Client:	OceanaGold Ltd
Site:	Waihi - Waste Rock Stack
Job No.:	51/37083
Datum:	
Total Depth:	21.0m
Commenced:	09-Jun-17
Completed:	09-Jun-17
Contractor:	Perry Geotech
Equipment:	JD Tractor Rig
Shear Vane:	
Bore Diameter (mm):	96
Inclination:	-90
Comments:	
Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
20.0 – 21.0	HQ Coring	105					+ + + +				MW		100			
21.0								Termination Depth = 21m								

Depth scale: 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Client Name.	OGC	Job No.	8332	
GHD Limited		Address	North Rock Stack	
		Photographer:		Date: May 2017

Title: WRS5A CORE BOX PHOTOGRAPHS



Depth: 0 m to 3.53m

Depth: 3.53 m to 6.53 m

Client Name.	OGC	**Job No.**	**8332**		
GHD Limited		**Address**	**North Rock Stack**		
		Photographer:		**Date:**	**May 2017**
Title:	**WRS5A CORE BOX PHOTOGRAPHS**				

Depth: 6.53m to 9.63m

Depth: 9.63m to 12.60m

Client Name.	OGC	Job No.	8332	
GHD Limited		Address	North Rock Stack	
		Photographer:	Date:	May 2017

Title: WRS5A CORE BOX PHOTOGRAPHS

Depth: 12.60m to 15.32m

Depth: 15.32m to 18.40m

Client Name.	OGC	**Job No.**	8332	
GHD Limited		**Address**	North Rock Stack	
		Photographer:		**Date:** May 2017
Title:	**WRS5A CORE BOX PHOTOGRAPHS**			

Depth: 18.40m to 21.0m

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BOREHOLE with Piezo LOG

Site Identification: **WRS06**

Sheet 1 of 2

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - Waste Rock Stack
Job No.: 51/37083

Datum:
Total Depth: 12.0m
Commenced: 12-Jun-17
Completed: 12-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring	131			Alluvium	ML	TOPSOIL: ORGANIC SILT, minor fine sand; black, wet, firm, low plasticity SILT, minor fine to medium sand, trace of clay; brown, firm, moist, low plasticity	W M	F					
0.8						MH	SILT, some clay, some fine to coarse sand; brown, wet, firm, high plasticity	W						
0.9	Push Tube	60				SP	Fine to coarse SAND, minor silt; grey to light brown, firm, wet - saturated, well graded	W-S						
1.5	HQ Coring	73				SP	Medium to coarse SAND; light brown, soft, wet-saturated, poorly graded gravel-small gravel @1.5-1.55m (bgl)		S					
1.7						ML	SILT, minor fine to coarse sand, trace clay; brown, wet, soft, low plasticity	W						
2.0						SP	Fine to coarse SAND, minor silt; black (organic), poorly graded, soft, wet- saturated	W-S						
3.0	Push Tube													
3.5	HQ Coring	110												
4.0					Coromadel Volcanics		Silty fine to medium SAND; greenish grey, poorly-graded, soft to firm, wet- saturated, [weathered IGNIMBRITE]		S-F					
4.5		77					from 4.5m: becomes soft to very soft		S-VS					-N-B, NO RQD, Completely weathered- residual soil, completely weathered to detect any rock defects
6.0		52					from 6.0m: becomes firm, saturated	S	F					-NOTE: Saturated soil @ 6.0m (water table)
7.5		117					from 7.5m: becomes soft		S					
9.0		87					from 9m: becomes very soft		VS					
9.5							from 9.5m: becomes soft to firm		S-F					

Piezometer

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BOREHOLE with Piezo LOG

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Site Identification: **WRS06**

Sheet 2 of 2

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi - Waste Rock Stack
Job No.: 51/37083

Commenced: 12-Jun-17
Completed: 12-Jun-17

Datum:
Total Depth: 12.0m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
10.0	HQ Coring	87			Coromadel Volcanics			Completely weathered, fine to medium grained, greenish grey IGNIMBRITE; weak; breaks down with pressure and water from 10.5m: becomes weak-very weak			CW					
11		87													-Joint at 11.8m: Moderately inclined, undulating-stepped, rough, very narrow, Manganese Staining	11
12 12.0								Termination Depth = 12m,								12
13																13
14																14
15																15
16																16
17																17
18																18
19																19
20																20

Client Name.	OGC	**Job No.**	8332		
GHD Limited		**Address**	North Rock Stack		
		Photographer:		**Date:**	May 2017
Title:	**WRS6 CORE BOX PHOTOGRAPHS**				

Depth: 0 m to 3.0m

Client Name.	OGC	**Job No.**	8332		
GHD Limited		**Address**	North Rock Stack		
		Photographer:		**Date:**	May 2017
Title:	**WRS6 CORE BOX PHOTOGRAPHS**				

Depth: 3.0 m to 5.65 m

Depth: 5.65m to 9.00m

Depth: 9.0m to 12.0m

BOREHOLE with Piezo LOG

GHD Limited

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Auckland 1141

Site Identification: **WRS07**

Sheet 1 of 1

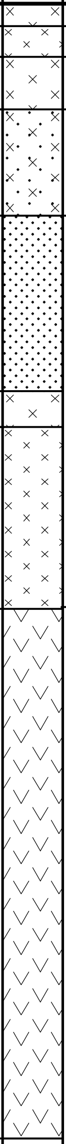
Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083

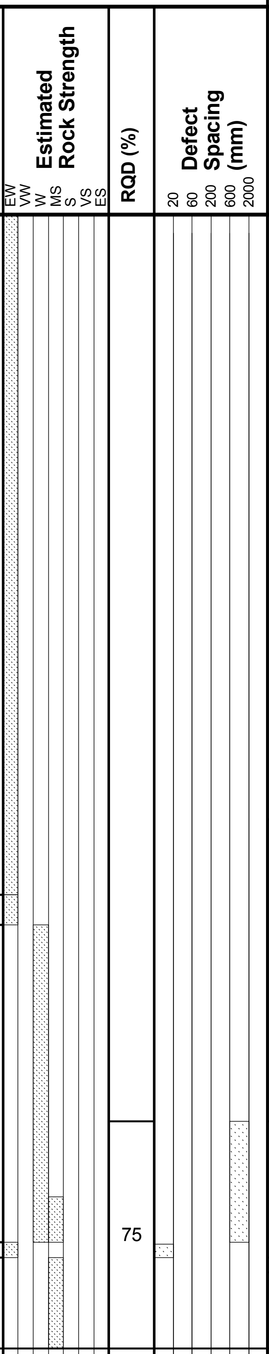
Datum:
Total Depth: 7.5m
Commenced: 13-Jun-17
Completed: 13-Jun-17
Contractor: Perry Geotech

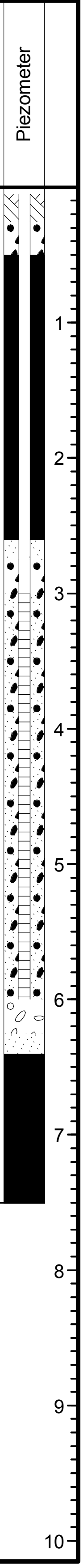
Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring	97			Alluvium	ML	SILT, minor fine sand; black, very soft, wet, low	W	VS	CW		
0.2						MH	plasticity, rootlets		S			
0.4						ML	SILT, some clay, trace fine sand; brown, soft, wet, moderate plasticity	M	'D'			
0.7						SM	Fine to coarse SAND, minor silt; brown, dense, moist, poorly graded	W	S			
							Silty medium to coarse SAND, trace clay, wet, soft, low plasticity					
1.4						SP	Medium to coarse SAND, some silt, minor clay; brown, soft, wet					
1.5		87										
1.9				▽								
2.0							from 2.0m: very soft, saturated	S	VS			
2.3							from 2.3m: soft, wet to saturated	W-S	S			
2.6						ML	Fine to coarse sandy SILT, minor clay; brown, soft to firm, wet, low plasticity	W	S-F			
2.8						MH	from 2.8m: some clay; grey, high plasticity					
3.0		105										
3.5							from 3.5m: becomes brown					
4.0					Coromandel Volcanics		Completly weathered, greenish/greyish brown DACITE BRECCIA; extremely weak; breaks down into a medium to very coarse SAND					-at 4.0m: ROCK Note: Completely weathered hard to detect defects
4.4							from 4.4m: becomes residual soil, extremely weak, SILT, some clay and fine sand; low plasticity			RS		
4.5		107					from 4.5m: becomes fine to coarse SAND, some silt; poorly graded					
4.7							from 4.7m: becomes highly weathered, fine to coarse grained, reddish brown DACITE BRECCIA; weak			HW		
6.0		115									75	-Joint at 6.0: Subhorizontal, undulating, rough, tight, Iron and Manganese staining
6.5							from 6.5m: becomes highly weather to moderately weathered, very coarse grey [GRAVEL]; moderately strong; Iron and Manganese staining					
6.8							from 6.8m: becomes residual soil, extremely weak, SILT, some fine to coarse sand; very soft to soft, low plasticity			RS		
6.9							from 6.9m: becomes highly weathered, moderately strong, joints present			HW		-Joint at 6.9: Gently inclined, undulating, smooth, tight, Iron and Manganese staining -Joint at 6.9-7.1: Steeply inclined- very steeply inclined, undulating, stepped, very narrow, Iron and Manganese staining
7.0							from 7.0m: joints present (Iron and Manganese staining)					
7.5							Termination Depth = 7.5m,					







Client Name.	**OGC**	**Job No.**	**8332**		
GHD Limited		**Address**	**North Rock Stack**		
		Photographer:		**Date:**	**May 2017**
Title:	**WRS7 CORE BOX PHOTOGRAPHS**				

Depth: 0 m to 3.0m

Depth: 3.0 m to 5.77 m

Client Name.	OGC	**Job No.**	8332		
GHD Limited		**Address**	North Rock Stack		
		Photographer:		**Date:**	May 2017

Title:	**WRS7 CORE BOX PHOTOGRAPHS**

Depth: 5.77m to 7.50m

GHD Limited
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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **WRS08**
Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi
Job No.: 51/37083
Datum:
Total Depth: 9.0m
Commenced: 13-Jun-17
Completed: 13-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Drilling Method: HQ Coring

Depth (m)/ [Elev.]	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering
0.0–0.2	Alluvium	ML	TOPSOIL FILL: SILT, some fine to coarse sand, trace clay; brown, soft to firm, moist, low plasticity, rootlets, gravel (rooting aggregates present)	M	S-F	
0.2–0.6		MH	SILT, some clay, minor fine sand; grey, firm, moist to wet, moderate plasticity	M-W	F	
0.6–1.0		ML	SILT, some fine to medium sand; brown, firm, wet, low plasticity	W		
1.0–1.5		SP	Fine to coarse SAND, some to minor silt; greyish brown, soft to firm, moderately dense, wet, poorly graded		'MD'	
1.5–2.5		SM	Silty fine to coarse SAND; brown, soft to firm, moderately dense, wet, well-moderately graded			
2.5–3.1		MH	SILT, some fine to coarse sand, some clay; greyish brown, soft to firm, wet, moderate to high plasticity			
3.1–4.0		CI	CLAY, some silt, trace of fine to medium sand; grey, soft, wet, high plasticity from 3.5m: becomes firm		S F	
4.0–5.5		ML	SILT, some clay, minor fine to coarse sand; grey, firm, wet, low plasticity from 5.0m: becomes some medium to coarse sand, grey, well-graded, saturated, stiff to very stiff	S	St-VSt	
5.5–9.0	Coromandel Volcanics		Completely weathered, medium grained, light brownish grey RHYOLITE; very weak from 6.0m: becomes moderately weathered to highly weathered, moderately strong to strong			CW MW-HW
9.0			Termination Depth = 9m,			

Water: ∇ at 5.0 m

Core Run (m)	Core Run / Recovery (%)	RQD (%)
0.0–1.5	103	
1.5–3.0	105	
3.0–4.5	94	
4.5–6.0	61	
6.0–7.5	73	38
7.5–9.0	32	0

Estimated Rock Strength: EW VW W MW MS S VS ES
Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-No defects detected rock -too weathered
-Joint at 6.0: Very steeply inclined, undulating, rough-smooth, tight, Iron staining
-Crushed zone at 6.1-6.2: Sub-angular, angular gravel, Fe Staining
-Joint at 6.46: Subhorizontal-gently inclined, undualting-stepped, rough, very narrow-narrow, Iron staining
-Joint at 6.8: Subhorizontal-gently inclined, undualting-smooth, rough, very narrow-narrow, Iron staining
-Joint at 7.0: Very steeply inclined-sub-vertical, planar-smooth, tight, minor Iron
-Crushed zone at 7.1-7.22: Sub-angular, cobbles , Iron staining, (weathered joint)
-Joint at 7.22: Very steeply inclined to sub-vertical, stepped, smooth, tight to very narrow, Iron staining
-Crushed zone at 7.4-8.0: Sub-rounded, sub angular cobbles-boulders
-Joint at 7.6: Very coarse gravel-cobbles-angular Iron staining
-Joint at 8.5: Very steeply inclined, undulating to stepped, rough, tight, with Iron staining
-Crushed zone at 8.6-9.0: Very coarse cobbles, boulders, sub-angular-subrounded, Iron staining

Piezometer

Client Name.	OGC	Job No.	8332		
GHD Limited		Address	North Rock Stack		
		Photographer:		Date:	May 2017
Title:	WRS8 CORE BOX PHOTOGRAPHS				

Depth: 0 m to 2.87m

Depth: 2.87 m to 6.0 m

Client Name.	OGC	Job No.	8332	
GHD Limited		Address	North Rock Stack	
		Photographer:	Date:	May 2017

Title:	WRS8 CORE BOX PHOTOGRAPHS

Depth: 6.0m to 9.0m

GHD Limited

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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **GLD01**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Commenced: 20-Jun-17
Completed: 20-Jun-17

Datum:
Total Depth: 7.5m
Contractor: Perry Geotech

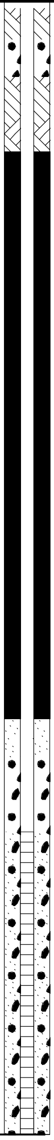
Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring	103	HW		Weathered Volcanics	GP	FILL: Fine to coarse GRAVEL; grey, sub-angular, dense, moist, [road aggregate fill]	M	'D'					
0.1						ML	SILT, minor clay, trace fine sand; brown, soft to firm, moist to wet, low plasticity	M-W	S-F					
1.2						MH	Clayey SILT; brown, firm, wet, medium to high plasticity from 1.9m: some coarse sand, fine to coarse gravel (weathered material) sub angular to angular grains present in fabric	W	F					
1.5		57												
2.0						ML	SILT, some fine to coarse sand, trace clay; brown, very soft to soft, wet to saturated, non plastic	W-S	VS-S					
2.5						CH	CLAY, some silt, trace fine to medium sand; brown, stiff, moist to wet, medium to high plasticity	M-W	St					-N.B at 2.5m uncertain depth due to core loss
3.0		43				MH	SILT, minor fine sand, trace clay; reddish-orange brown, soft, wet to saturated	W-S	S					
3.4							from 3.4m: firm		F					
3.5						CH	CLAY, some silt, wet, firm, medium to high plasticity	W						
4.5		106												-Decrease water circulation drill
5.0														-Attempted push tube at 5.0m but soil too firm
6.0		0												-N.B large recovery (core expanding) 6.0-7.5m -Push tube at 6.0- 6.5m
6.5		169												
6.6							Silty CLAY, trace fine to medium sand, pink, wet, soft to firm, high plasticity		S-F					
7.0							from 7.0m: grey							
7.5							Termination Depth = 7.5m							

Piezometer



BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **GLD01a**

Sheet 1 of 2

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 13.7m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.1	HQ Coring	103	HW		Weathered Volcanics	GP	FILL: Fine to coarse GRAVEL; grey, sub-angular, dense, moist, [road aggregate fill]	M	'D'						
						ML	SILT, minor clay, trace fine sand; brown, soft to firm, moist to wet, low plasticity	M-W	S-F						
1.2						MH	Clayey SILT; brown, firm, wet, medium to high plasticity from 1.9m: some coarse sand, fine to coarse gravel (weathered material) sub angular to angular grains present in fabric	W	F						
2.0		57				ML	SILT, some fine to coarse sand, trace clay; brown, very soft to soft, wet to saturated, non plastic	W-S	VS-S						
2.5						CH	CLAY, some silt, trace fine to medium sand; brown, stiff, moist to wet, medium to high plasticity	M-W	St					-Note: at 2.5m uncertain depth due to core loss	
3.0		43				MH	SILT, minor fine sand, trace clay; reddish-orange brown, soft, wet to saturated	W-S	S						
3.4							from 3.4m: firm		F						
3.5						CH	CLAY, some silt, wet, firm, medium to high plasticity	W							
														-Decrease water circulation drill	
		106												-Attempted push tube at 5.0m but soil too firm	
6.0	Push Tube	0												-Note: large recovery (core expanding) at 6.0-7.5m -Push tube at 6.0- 6.5m	
	HQ Coring	169	HW				Silty CLAY, trace fine to medium sand, pink, wet, soft to firm, high plasticity from 7.0m: grey from 7.5m: brown		S-F						
8.0		95				ML	SILT, some clay, minor trace fine to medium sand; brown, soft to firm, wet, low plasticity								
8.5						CH	Silty CLAY, trace fine to medium sand; grey, firm to stiff, wet, high plasticity		F-St						
9.0		14				ML	Very poor core recovery between 9.0m-10.5m: SILT, some clay, some fine to coarse sand; grey, stiff to very stiff, wet, non plastic [residual soil weathering from parent rock]		St-VSt						

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BOREHOLE with Piezo LOG

Site Identification: **GLD01a**

Sheet 2 of 2

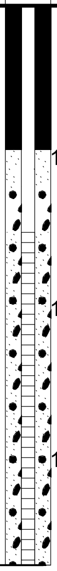
Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 13.7m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
10.0	HQ Coring	14	HW		Weathered Volcanics											
10.5		80														
10.6						CH		CLAY, some silt; grey with pink streaks, very stiff, wet, high plasticity [residual soil weathering from parent rock] from 11.2m: dark grey	W	VSt					-At 11m attempted push tube but soil too firm/ hard	
11.5						ML		SILT, some fine to coarse sand, some clay; grey, soft, wet, low plasticity [residual weathering from parent rock]		S						
12.0		33				CH		CLAY, some silt; dark grey, very stiff, wet, high plasticity [residual soil weathering from parent rock]		VSt					-Note: at 12.0m water pressure increase and loss of water circulation in drill- potentially artesian	
13.5						ML		SILT, minor fine to coarse sand, trace clay; blackish grey, firm, wet, non plastic [residual soil weathering from parent rock] ... increasing to minor clay content; grey, firm, wet, low plasticity [residual soil weathering]		F					-at 13.5m water pressure increase -at 13.7m further increase of water pressure	
13.7								Termination Depth = 13.7m								



BOREHOLE with Piezo LOG

Site Identification: **GLD01b**

Sheet 1 of 4

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 33.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114
Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating
0.0	HQ Coring	103	HW		Weathered Volcanics	GP	FILL: Fine to coarse GRAVEL; grey, sub-angular, dense, moist, [road aggregate fill]	M	'D'	-Note: GLD01b wash drill 0.0-13.5m, start log at 13.5- 40m; commenced 19/6/2017 ~ 1.5m south of GLD01a
0.1						ML	SILT, minor clay, trace fine sand; brown, soft to firm, moist to wet, low plasticity	M-W	S-F	
1.2		57				MH	Clayey SILT; brown, firm, wet, medium to high plasticity from 1.9m: some coarse sand, fine to coarse gravel (weathered material) sub angular to angular grains present in fabric	W	F	
2.0						ML	SILT, some fine to coarse sand, trace clay; brown, very soft to soft, wet to saturated, non plastic	W-S	VS-S	
2.5						CH	CLAY, some silt, trace fine to medium sand; brown, stiff, moist to wet, medium to high plasticity	M-W	St	-Note: at 2.5m uncertain depth due to core loss
3.0		43				MH	SILT, minor fine sand, trace clay; reddish-orange brown, soft, wet to saturated from 3.4m: firm	W-S	S F	
3.5		106				CH	CLAY, some silt, wet, firm, medium to high plasticity	W		-Decrease water circulation drill
6.0	HQ Coring	0 169	HW				Silty CLAY, trace fine to medium sand, pink, wet, soft to firm, high plasticity from 7.0m: grey from 7.5m: brown		S-F	-Note: large recovery (core expanding) at 6.0-7.5m
8.0		95				ML	SILT, some clay, minor trace fine to medium sand; brown, soft to firm, wet, low plasticity			
8.5						CH	Silty CLAY, trace fine to medium sand; grey, firm to stiff, wet, high plasticity		F-St	
9.0		14				ML	Very poor core recovery between 9.0m-10.5m: SILT, some clay, some fine to coarse sand; grey, stiff to very stiff, wet, non plastic [residual soil weathering from parent rock]		St-VSt	
10										

Weathering: EW VW W MS S VS ES
Estimated Rock Strength
RQD (%)
Defect Spacing (mm): 20 60 200 600 2000
Piezometer

BOREHOLE with Piezo LOG

GHD Limited

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Auckland 1141

Site Identification: **GLD01b**

Sheet 2 of 4

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 33.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114
Inclination: -90
Comments:

Logged: HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
10.0	HQ Coring	14	HW		Weathered Volcanics	ML		Very poor core recovery between 9.0m-10.5m: SILT, some clay, some fine to coarse sand; grey, stiff to very stiff, wet, non plastic [residual soil weathering from parent rock]	W	St-VSt						
10.6		80				CH		CLAY, some silt; grey with pink streaks, very stiff, wet, high plasticity [residual soil weathering from parent rock] from 11.2m: dark grey		VSt						
11.5						ML		SILT, some fine to coarse sand, some clay; grey, soft, wet, low plasticity [residual weathering from parent rock]		S						
12.0		33				CH		CLAY, some silt; dark grey, very stiff, wet, high plasticity [residual soil weathering from parent rock]		VSt					-Note: at 12.0m water pressure increase and loss of water circulation in drill- potentially artesian	
13.5		98				ML		SILT, minor fine to coarse sand, trace clay; blackish grey, firm wet, non plastic [residual soil weathering from parent rock from13.7m: minor clay; grey, firm, wet, low plasticity [residual soil weathering]	W	F					-at 13.5m water pressure increase -at 13.7m further increase of water pressure	
14.0						CI		Clayey SILT, some fine to coarse sand; grey, moist, stiff to very stiff, medium to high plasticity [residual soil weathering from parent rock] - slight white mottling in core [weathered phenocryst of Na plagioclase from volcanic rock]	M	St-VSt						
		51						from 15.1m: moist to wet, very stiff to hard	W	VSt-H					-from 15.0-16.5m: low recovery [drill encountered bands of softer silty layers during run]	
16.0								Residual soil, extremely weathered, grey with white mottles, clayey SILT, minor fine to coarse sand, wet, hard, moderate to hard plasticity [VOLCANIC ROCK]		H	RS					
16.5		65			Coromandel Volcanics	ML		SILT, some fine to coarse sand, brown, very soft, wet to saturated, non plastic	W-S	VS						
16.7								SILT, some clay, minor fine sand, dark greyish brown, wet, firm, low plasticity	W	F						
								Clayey SILT, trace fine to coarse sand, grey, wet, stiff, moderate to high plasticity, mottled white [weathered phenocrysts]		St						
								from 17.5m: very stiff, dark brownish grey		VSt						
								from 17.7m: hard, greenish staining/ colouring (mainly dark brownish grey)		H						
		89						from 18m: very stiff, dark brownish grey		VSt						
		100														

BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **GLD01b**

Sheet 3 of 4

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

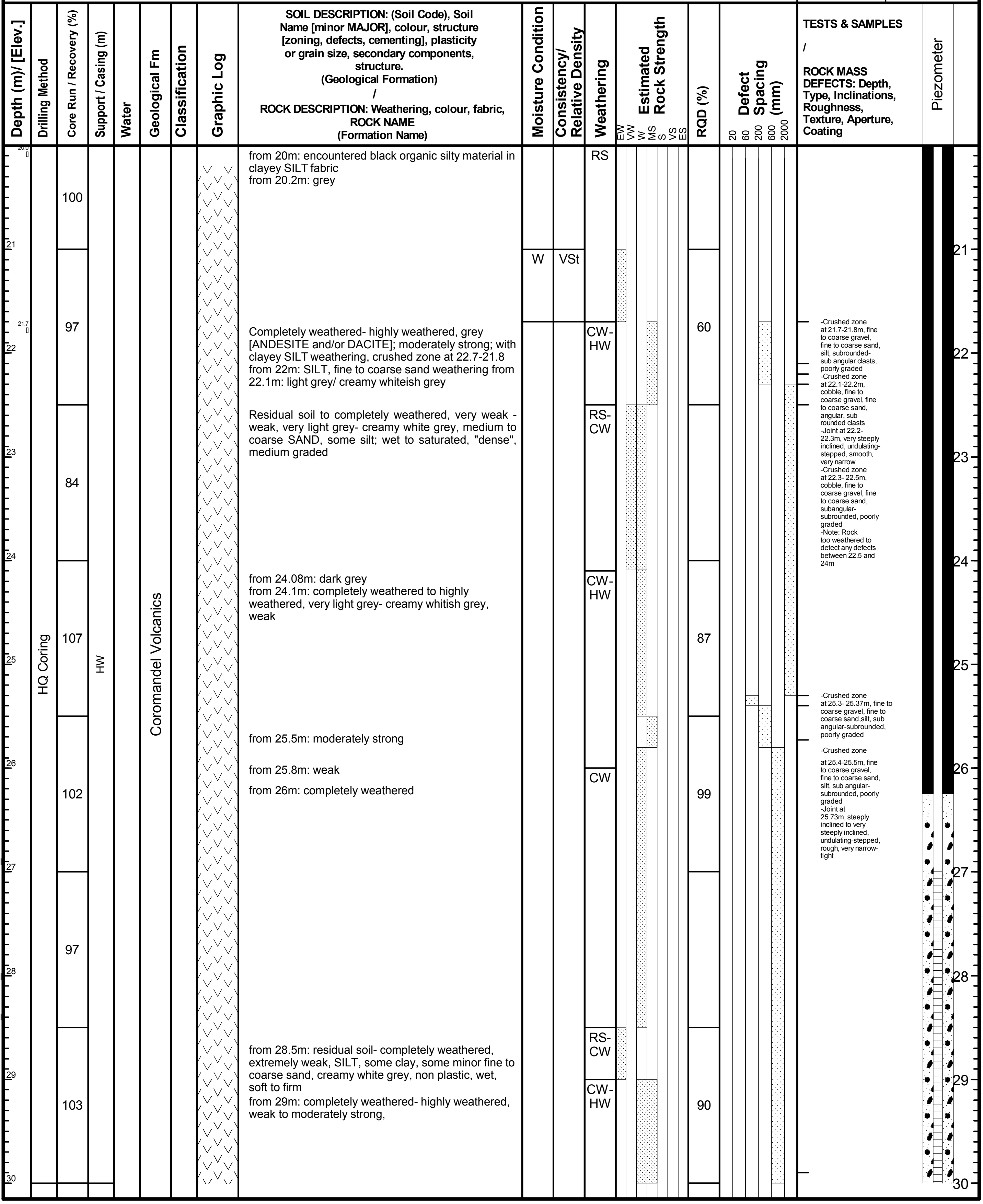
Commenced: 20-Jun-17
Completed: 20-Jun-17

Datum:
Total Depth: 33.0m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114

Inclination: -90
Comments:

Logged:	HB
Processed:	AS
Checked:	HB



SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / **ROCK DESCRIPTION:** Weathering, colour, fabric, ROCK NAME (Formation Name)

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

Depth (m)	Core Run / Recovery (%)	Description	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)	Tests & Samples / Rock Mass Defects
20.0	100	from 20m: encountered black organic silty material in clayey SILT fabric from 20.2m: grey			RS		
21.0	97		W	VSt		60	
21.7		Completely weathered- highly weathered, grey [ANDESITE and/or DACITE]; moderately strong; with clayey SILT weathering, crushed zone at 22.7-21.8 from 22m: SILT, fine to coarse sand weathering from 22.1m: light grey/ creamy whiteish grey			CW-HW		-Crushed zone at 21.7-21.8m, fine to coarse gravel, fine to coarse sand, silt, subrounded-sub angular clasts, poorly graded -Crushed zone at 22.1-22.2m, cobble, fine to coarse gravel, fine to coarse sand, angular, sub rounded clasts -Joint at 22.2-22.3m, very steeply inclined, undulating-stepped, smooth, very narrow -Crushed zone at 22.3- 22.5m, cobble, fine to coarse gravel, fine to coarse sand, subangular-subrounded, poorly graded -Note: Rock too weathered to detect any defects between 22.5 and 24m
22.5	84	Residual soil to completely weathered, very weak - weak, very light grey- creamy white grey, medium to coarse SAND, some silt; wet to saturated, "dense", medium graded			RS-CW		
24.0	107	from 24.08m: dark grey from 24.1m: completely weathered to highly weathered, very light grey- creamy whitish grey, weak			CW-HW	87	
25.3							-Crushed zone at 25.3- 25.37m, fine to coarse gravel, fine to coarse sand,silt, sub angular-subrounded, poorly graded -Crushed zone at 25.4-25.5m, fine to coarse gravel, fine to coarse sand, silt, sub angular-subrounded, poorly graded -Joint at 25.73m, steeply inclined to very steeply inclined, undulating-stepped, rough, very narrow-tight
25.5	102	from 25.5m: moderately strong from 25.8m: weak from 26m: completely weathered			CW	99	
27.0	97						
28.5	103	from 28.5m: residual soil- completely weathered, extremely weak, SILT, some clay, some minor fine to coarse sand, creamy white grey, non plastic, wet, soft to firm			RS-CW	90	
29.0		from 29m: completely weathered- highly weathered, weak to moderately strong,			CW-HW		

BOREHOLE with Piezo LOG

GHD Limited

PO Box 6543
Auckland 1141

Site Identification: **GLD01b**

Sheet 4 of 4

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 33.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96 and 114
Inclination: -90
Comments:

Logged: HB
Processed: AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
30.0	HQ Coring	105	HW								CW-HW		57		-Crushed zone at 29.9-30m, cobble, fine to coarse gravel, fine to coarse sand, silt, loose, poorly graded	
30.8															-Crushed zone at 30.8-30.9m, very fine gravel, fine to coarse sand, silt, sub angular clasts, poorly graded	
31								from 31m: grey, weak to moderately strong							-Joint at 31.0m, very steeply inclined- subvertical, undulating to stepped, rough, smooth, very narrow- tight	
31.2															-Joint at 31.2, moderately inclined	
31.3															-Crushed zone at 31.3- 31.45m, cobble, fine to coarse gravel, fine to coarse sand, silt, angular- sub rounded clasts, poorly graded	
31.5		102														
32.6								from 32.6m: pale grey/ creamy whitish grey								
32.8															-Drill Break (DB) at 32.8m	
33.0								Termination Depth = 33m								

BOREHOLE with Piezo LOG

GHD Limited

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Auckland 1141

Site Identification: **GLD02**

Sheet 1 of 1

Project:	Project Quattro	**Datum:**	
Client:	OceanaGold Ltd	**Total Depth:**	9.0m
Site:	Waihi- Gladstone	**Commenced:**	15-Jun-16
Job No.:	51/37083	**Completed:**	16-Jun-17
Contractor:	Perry Geotech		

Equipment:	JD Tractor Rig	**Inclination:**	-90	**Logged:**	HB
Shear Vane:		**Comments:**		**Processed:**	CDM/AS
Bore Diameter (mm):	96			**Checked:**	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	RQD (%)
0.0–1.5	HQ Coring	88	66
1.5–3.0	HQ Coring	149	
3.0–4.5	HQ Coring	79	
4.5–5.0	Push Tube		
5.0–6.0	HQ Coring	138	
6.0–7.5	HQ Coring	100	
7.5–9.0	HQ Coring	85	

Water: ▽ at approx. 4.0m

Geological Fm: Weathered Volcanics; Coromandel Volcanics

Depth (m)	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering
0.0	ML	TOPSOIL: SILT, minor fine to medium sand; dark brown, very stiff to stiff, wet, non plastic, spongy, rootlets	W	VSt-St	
0.15		**0.15m:** SILT, some fine to coarse sand, minor clay; brown, wet, stiff to firm, non plastic [residual soil]		St-F	
0.3		**0.3m:** Moderately weathered to slightly weathered, pale greyish white BOULDER [VOLCANIC]; strong to very strong, moderately widely spaced defects			MW-SW
2.0	SW	Coarse SAND; brown, loose, wet to saturated, well graded	W-S	'L'	
2.1	CI	CLAY, some silt, trace fine to medium sand; grey, firm, wet, medium to high plasticity.	W	F	
2.9		from 2.9m: reddish brown			
3.0	ML	SILT, some clay, some fine to coarse sand; reddish brown, stiff, wet, low plasticity.		St	
3.3	ML	SILT, some fine to coarse sand, minor trace clay; grey with pinkish red staining and reddish streaks, stiff, wet, non plastic			
4.4		from 4.4m: very stiff, wet to saturated	W-S	VSt	
5.3		from 5.3m: very stiff, wet, [residual soil weathering from parent rock]	W		
5.8		from 5.8m: soft, [residual soil weathering from parent rock]		S	
6.1		from 6.1m: firm to stiff, [residual soil weathering from parent rock]		F-St	
6.3		from 6.3m: very stiff to stiff [residual soil weathering from parent rock]		VSt-St	
6.6		from 6.6m: firm to stiff [residual soil weathering]		F-St	
8.5		from 8.5: grey, stiff to very stiff [residual soil weathering]		St-VSt	
8.9		Residual soil to completely weathered, grey with minor pink staining, mottled fabric [ANDESITE and/or DACITE]; extremely weak; SILT, some fine to coarse sand; white, black weathered phenocrysts (weathered)			RS-CW
9.0		Termination Depth = 9m			

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-Note: 870 cm Rock material does not account for soil in 1.5m drill run recovery

-*No PT taken due to rock @0.3mbgl

-Joint @ 1.27m, steeply inclined, undulating, rough, narrow, weathering
-Joint @ 1.35m, steeply inclined, undulating, rough, narrow, weathering
-Joint @ 1.4m, gently to moderately inclined, undulating, rough, very narrow, Manganese and Iron Oxide
-Joint @ 1.55m, sub-horizontal, undulating to stepped, rough, very narrow to tight, Manganese and Iron Oxide
-Joint @ 1.6m, sub-horizontal, undulating to stepped, smooth, very narrow to tight, Manganese and Iron Oxide
-Joint @ 1.7m, moderately inclined, stepped, smooth, very narrow to narrow, weathering
-Joint @ 1.8m, moderately inclined, stepped, smooth, very narrow, clay w.
-Joint @ 1.9m-2.0m, very steeply inclined to sub-vertical, smooth, very narrow, clay w.
-at 2.0m coarse sand potential drilling residue from drilling strong to very strong
-Push tube at 4.5m-5.0m

Piezometer

GHD Limited
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Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **GLD02a**

Sheet 1 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 30.0m
Commenced: 15-Jun-16
Completed: 16-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	CDM/AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)
0.0	HQ Coring	88		Weathered Volcanics	ML	TOPSOIL: SILT, minor fine to medium sand; dark brown, very stiff to stiff, wet, non plastic, spongy, rootlets	W	St VSt-		66
0.15						**0.15m:** SILT, some fine to coarse sand, minor clay; brown, wet, stiff to firm, non plastic [residual soil]				
0.3						**0.3m:** Moderately weathered to slightly weathered, pale greyish white BOULDER [VOLCANIC]; strong to very strong, moderately widely spaced defects		St-F	MW-SW	
2.0		149			SW	Coarse SAND; brown, loose, wet to saturated, well graded	W-S	'L'		
2.1					CI	CLAY, some silt, trace fine to medium sand; grey, firm, wet, medium to high plasticity.	W	F		
						from 2.9m: reddish brown				
3.0		79			ML	SILT, some clay, some fine to coarse sand; reddish brown, stiff, wet, low plasticity.		St		
3.3			▽		ML	SILT, some fine to coarse sand, minor trace clay; grey with pinkish red staining and reddish streaks, stiff, wet, non plastic				
4.4	Push Tube					from 4.4m: very stiff, wet to saturated	W-S	VSt		
	HQ Coring	138				from 5.3m: very stiff, wet, [residual soil weathering from parent rock]	W			
						from 5.8m: soft, [residual soil weathering from parent rock]		S		
		100				from 6.1m: firm to stiff, [residual soil weathering from parent rock]		F-St		
						from 6.3m: very stiff to stiff [residual soil weathering from parent rock]		VSt-St		
						from 6.6m: firm to stiff [residual soil weathering]		F-St		
		85				from 8.5: grey, stiff to very stiff [residual soil weathering]		St-VSt		
8.9		101				Residual soil to completely weathered, grey with minor pink staining, mottled fabric [ANDESITE and/or DACITE]; extremely weak; SILT, some fine to coarse sand; white, black weathered phenocrysts (weathered)			RS-CW	
10										

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-Note: 870 cm Rock material does not account for soil in 1.5m drill run recovery

-,, ,,,, ,*No PT taken due to rock @0.3mbgl

-Joint @ 1.27m, steeply inclined, undulating, rough, narrow, weathering
-Joint @ 1.35m, steeply inclined, undulating, rough, narrow, weathering
-Joint @ 1.4m, gently to moderately inclined, undulating, rough, very narrow, Manganese and Iron Oxide
-Joint @ 1.55m, sub-horizontal, undulating to stepped, rough, very narrow to tight, Manganese and Iron Oxide
-Joint @ 1.6m, sub-horizontal, undulating to stepped, smooth, very narrow to tight, Manganese and Iron Oxide
-Joint @ 1.7m, moderately inclined, stepped, smooth, very narrow to narrow, weathering
-Joint @ 1.8m, moderately inclined, stepped, smooth, very narrow, clay weathering
-Joint @ 1.9m-2.0m, very steeply inclined to sub-vertical, planar, smooth, very narrow, clay weathering
-at 2.0m coarse sand potential drilling residue from drilling strong to very strong rock encountered between 0.3m and 2.0m
-Push tube at 4.5m-5.0m

Piezometer

1 2 3 4 5 6 7 8 9 10

BOREHOLE with Piezo LOG

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Auckland 1141

Site Identification: **GLD02a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 30.0m
Commenced: 15-Jun-16
Completed: 16-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	CDM/AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Geological Fm	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Weathering
10.0	HQ Coring	101	Coromandel Volcanics		RS-CW
		95		from 10.6m: pink staining grey residual soil	
11					
12		102			
13					
14		101			
15		89		from 15.0m: grey	
16					
17		100			
18		111		Completely weathered, light brown with mottled weathered white phenocrysts, weak, CLAY, some silt, trace fine sand; high plasticity.	CW
19					
19.1				Completely weathered, dark grey with mottled white weathered phenocrysts, very weak to weak, no defects present, too weathered to detect.	
20		95			

Moisture Condition | Consistency/ Relative Density | Estimated Rock Strength (EW VW W MS S VS ES) | RQD (%) | Defect Spacing (mm) (20 60 200 600 2000) | TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating | Piezometer

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BOREHOLE with Piezo LOG

Site Identification: **GLD02a**

Sheet 3 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 30.0m
Commenced: 15-Jun-16
Completed: 16-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	CDM/AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
20.0 21	HQ Coring	95			Coromandel Volcanics		+ + + +	from 20.0m: completely weathered to moderately weathered. Completely weathered, very weak to weak, dark grey with mottled white weathered phenocrysts, no defects present, too weathered to detect.			CW-HW					
22		88						from 21.8m: pale greenish grey staining.					98		-Joint @ 21.63m, gently to moderately inclined, planar, smooth, very narrow, no coating	
23 24		104						from 22.8m: grey from 23.4m: weak					95		-Joint @ 22.8m, steeply inclined, planar, smooth, very narrow, no coating -Joint @ 23.3m, steeply inclined, planar, smooth, very wide, no coating -Crush zone @ 23.60m-23.66m coarse sand fine to medium cobble, sub-angular to sub-rounded, Iron Oxide staining -Joint @ 23.8m, steeply inclined, planar, smooth, very narrow, no staining	
25		81						from 24.5: very weak to weak from 25.0m: completely weathered (crystals not distinct in rock- very weathered. from 25.4: weak			CW		93		-Crush zone @ 25.0m-25.04m weathered cobble, coarse sand, fine sand, silt -Crush zone @ 25.30m-25.35m boulder, cobble, silt, minor brown silty clay weathering	
26 27		54						from 25.6m: very weak to weak from 25.8m: brown grey weathering					53		-Joint @ 26.0m, gently inclined, planar, smooth, very narrow to tight -Joint @ 26.2m, moderately inclined, stepped, smooth, very narrow to narrow, minor Manganese staining -Crush zone @ 26.8m-26.4m cobble, coarse to fine gravel, medium to fine sand, silt, minor brown silt-clay weathering of crystals -Joint @ 27.0m, steeply inclined, stepped, smooth, very narrow to tight -Joint @ 27.4m, moderately to slightly inclined, undulating, very wide, minor Manganese staining	
28		84						from 27.5m: residual soil, weak, extremely weak, SILT, some fine to coarse sand, some minor clay; greyish brown; non plastic from 27.8m: completely weathered, weak to very weak from 28.0m: creamy white grey, moderately strong to strong			RS CW		73		-Crush zone @ 27.7m-27.88m boulder, cobbles, fine to coarse gravel sand, silt, narrow, no staining present - -Joint @ 28.2m, steeply inclined, undulating to stepped, rough, very narrow to narrow, general weathering silt/clay material -Crush zone @ 28.4m-28.5m, cobble, fine to coarse gravel, fine to coarse sand, no staining present	
29 30		99						from 28.5m: dark grey, very weak from 28.9m: dark grey, moderately strong to strong from 29.0m: residual soil to completely weathered, extremely weak from 29.8m: completely weathered, weak.					57		-Joint @ 28.8m, steeply to very steeply inclined, undulating to stepped rough, very narrow, silt-clay weathering -Crush zone @ 30.0m-30.5m, boulders between 30.0-30.1m, cobble, fine to coarse gravel, fine to coarse sand, silt 30.1m-30.5m, no staining present	
								Termination Depth = 30m,								

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BOREHOLE with Piezo LOG

Site Identification: **GLD03**

Sheet 1 of 1

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 9.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	CDM/AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	RQD (%)
0.0	HQ Coring	66			Weathered Volcanics	ML	TOPSOIL: SILT, minor fine to coarse sand; black (organic), very stiff, wet, non plastic, rootlets	W	VS		
0.2							from 0.2m, stiff, moist	M	St		
0.4							SILT, some fine to medium sand, minor clay; brown, stiff to firm, moist, low plasticity		St-F		
1.4						MH	Clayey SILT, minor fine to coarse sand; grey, stiff to firm, wet, medium plasticity	W			
1.5		29					from 1.5m, very stiff to stiff, saturated	S	VSt-St		
1.8							from 1.8m, stiff to firm, wet	W	St-F		
2.0							Completely weathered to highly weathered, light grey [Boulder]; moderately strong to strong			CW-HW	
3.0	Push Tube	40									
3.5	HQ Coring	152			Coromandel Volcanics		Residual soil, very light grey - creamy greyish white with some brownish orange mottled [weathered ANDESITE and/or DACITE]; extremely weak; fine to coarse SAND, some silt; poorly graded, moderately dense, saturated, too weathered to detect rock defects.	S	'MD'	RS	86
3.9							from 3.9m, completely weathered to highly weathered, very weak			CW-HW	
4.0							from 4.0m, residual soil to completely weathered, extremely weak			RS-CW	
4.5		103									99
4.7							from 4.7m, brown				
5.5							from 5.5m, brownish staining/colouring weathered grey rock				
5.95							from 5.95m, completely weathered, extremely weak to very weak			CW	
6.0		105									90
7.5		102									83
7.6							from 7.6m, very weak to weak				
9.0							Termination Depth = 9m,				

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

- -N.B* poor core recovery at 1.5-3.0m run-drill encountered rock at ~2.0m-3.0m (boulder) could not recover softer material
- -inferred boundary unknown boulder depth to softer material
- -Push tube @ 3.0m-3.5m
- -Joint @ 3.91m, steeply inclined, undulating, rough to smooth, very narrow, Iron Oxide staining
- -Joint @ 4.0m, steeply to very steeply inclined, undulating to stepped, rough, very narrow, minor Iron Oxide staining
- -Crush zone @ 5.10m-5.14m, fine to coarse gravel, fine to coarse sand, silt, sub rounded to angular clasts, poorly graded, minor Iron Oxide
- -Joint @ 5.24m, sub-horizontal to gently inclined, undulating, smooth, very narrow, Iron Oxide staining
- -Joint @ 6.15m, sub-horizontal, undulating, rough, very narrow to tight, Iron Oxide staining
- -Joint @ 6.34m, sub-horizontal, undulating, rough, very narrow to tight, Iron Oxide staining
- -Joint @ 6.52m, sub-horizontal, undulating, rough, tight, Iron Oxide
- -Crush zone @ 6.52m-6.54m, fine to coarse gravel, medium to coarse sand, sub rounded to sub angular clasts, poorly graded, minor Iron Oxide
- -Crush zone @ 6.80m-6.83m, fine to coarse gravel, medium to coarse sand, silt, sub rounded to sub angular clasts, medium graded, Iron Oxide staining
- -Joint @ 7.75m, gently inclined, undulating to stepped, rough , narrow, iron
- -Joint @ 7.90m, very gently to gently inclined, undulating to stepped, rough to smooth, narrow, Iron Oxide staining
- -Crush zone @ 8.63m-8.67m, fine fine to coarse sand,sub rounded to subangular clasts,medium graded, iron oxide staining
- -Joint @ 8.75m, moderately steeply to steeply inclined, undulating to stepped, rough to smooth, narrow
- -Joint @ 8.93m, gently inclined, undulating smooth to rough, very narrow, Iron Oxide
- -Joint @ 8.99m, sub-horizontal, undulating smooth to rough, very narrow to tight, Iron Oxide staining or DB?

Piezometer

BOREHOLE with Piezo LOG

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Auckland 1141

Site Identification: **GLD03a**

Sheet 1 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Commenced: 20-Jun-17
Completed: 20-Jun-17

Datum:
Total Depth: 21.0m
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96

Inclination: -90
Comments:

Logged: HB
Processed: CDM/AS
Checked: HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength (EW VW W MS S VS ES)	RQD (%)	Defect Spacing (mm) (20 60 200 600 2000)	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
0.0	HQ Coring	66			Weathered Volcanics	ML	TOPSOIL: SILT, minor fine to coarse sand; black (organic), very stiff, wet, non plastic, rootlets	W	VS						
0.2							from 0.2m, stiff, moist	M	St						
0.4							SILT, some fine to medium sand, minor clay; brown, stiff to firm, moist, low plasticity		St-F						
1.4						MH	Clayey SILT, minor fine to coarse sand; grey, stiff to firm, wet, medium plasticity	W							
1.5		29					from 1.5m, very stiff to stiff, saturated	S	VSt-St					-N.B* poor core recovery at 1.5-3.0m run-drill encountered rock at ~2.0m-3.0m (boulder) could not recover softer material	
1.8							from 1.8m, stiff to firm, wet	W	St-F						
2.0							Completely weathered to highly weathered, light grey [Boulder]; moderately strong to strong			CW-HW				-inferred boundary unknown boulder depth to softer material	
3.0	Push Tube	40												-Push tube @ 3.0m-3.5m	
3.5	HQ Coring	152			Coromandel Volcanics		Residual soil, very light grey - creamy greyish white with some brownish orange mottled [weathered ANDESITE and/or DACITE]; extremely weak; fine to coarse SAND, some silt; poorly graded, moderately dense, saturated, too weathered to detect rock defects.	S	'MD'	RS		86			
3.9							from 3.9m, completely weathered to highly weathered, very weak			CW-HW				-Joint @ 3.91m, steeply inclined, undulating, rough to smooth, very narrow, Iron Oxide staining	
4.0							from 4.0m, residual soil to completely weathered, extremely weak			RS-CW				-Joint @ 4.0m, steeply to very steeply inclined, undulating to stepped, rough, very narrow, minor Iron Oxide staining	
4.5		103										99			
4.7							from 4.7m, brown								
5.1														-Crush zone @ 5.10m-5.14m, fine to coarse gravel, fine to coarse sand, silt, sub rounded to angular clasts, poorly graded, minor Iron -Joint @ 5.24m, sub-horizontal to gently inclined, undulating, smooth, very narrow, Iron Oxide staining	
5.5							from 5.5m, brownish staining/colouring weathered grey rock								
5.95							from 5.95m, completely weathered, extremely weak to very weak			CW					
6.0		105										90		-Joint @ 6.15m, sub-horizontal, undulating, rough, very narrow to tight, Iron Oxide staining -Joint @ 6.34m, sub-horizontal, undulating, rough, very narrow to tight, Iron Oxide staining -Joint @ 6.52m, sub-horizontal, undulating, rough, tight, Iron Oxide -Crush zone @ 6.52m-6.54m, fine to coarse gravel, medium to coarse sand, sub rounded to sub angular clasts, poorly graded, minor Iron Oxide -Crush zone @ 6.80m-6.83m, fine to coarse gravel, medium to coarse sand, silt, sub rounded to sub angular clasts, medium graded, Iron Oxide staining	
7.5		102										83			
7.6							from 7.6m, very weak to weak							-Joint @ 7.75m, gently inclined, undulating to stepped, rough, narrow, Iron -Joint @ 7.90m, very gently to gently inclined, undulating to stepped, rough to smooth, narrow, Iron Oxide staining -Crush zone @8.63m-8.67m, fine to coarse gravel, fine to coarse sand,sub rounded to subangular clasts, iron staining -Joint @ 8.75m, moderately steeply to steeply inclined, undulating to stepped, rough to smooth, narrow -Joint @ 8.93m, gently inclined, undulating smooth to rough, very narrow, Iron -Joint @ 8.99m, sub-horizontal, undulating smooth to rough, very narrow to tight, Iron Oxide staining or DB?	
9.0		99					from 9.0m, residual soil to completely weathered, extremely weak, SILT, some sand, very soft, saturated	S	VS	RS-CW		58			
9.1							from 9.1m, completely weathered, very weak			CW				-DB set @ 9.29m-9.67m horizontal cuts-weathered surface difficult to detect, minor Iron Oxide staining	
9.8							from 9.8m, completely weathered, weak								
10															

BOREHOLE with Piezo LOG

Site Identification: **GLD03a**

Sheet 2 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged: HB
Processed: CDM/AS
Checked: HB

Drilling Method	Core Run / Recovery (%)	Geological Fm	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Weathering	RQD (%)
HQ Coring	99	Coromandel Volcanics		CW	58
			from 10.3m, highly weathered, weak	HW	
	92				84
	109		from 12.4m, completely weathered to highly weathered, very weak	CW-HW	63
	99		from 13.7m, highly weathered, weak	HW	82
	94				39
	103		from 16.5m, completely weathered to highly weathered, extremely weak to very weak	CW-HW	94
			from 17.0m, highly weathered, weak	HW	
	99				78
	90				83

Estimated Rock Strength: EW VW W MS S VS ES

Defect Spacing (mm): 20 60 200 600 2000

TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating

-Joint @ 10.2m, steeply inclined, undulating smooth to rough, narrow, Iron Oxide staining
-Joint @ 10.32m, gently inclined, undulating to stepped, rough, very narrow, IronOxide staining
-Joint @ 10.41m, moderately inclined, undulating, smooth to rough, narrow to moderately narrow, minor Manganese, Iron staining
-Joint @ 11.0m, gently to moderately inclined, stepped, rough to smooth, narrow, Iron Oxide staining (mottled)
-Joint @ 11.3m,steeply inclined, undulating to stepped, rough to smooth, very narrow, Iron staining
-Joint @ 11.8m, gently to moderately inclined, stepped, rough, narrow, Iron Oxide staining
-Joint @ 12.1m, very steeply inclined to sub-vertical, undulating to stepped, rough, narrow,iron staining (mottled)
-Joint @ 12.36m, gently inclined, undulating, rough to smooth, narrow, Iron Oxide
-Crush zone @ 12.4m-12.5m, cobble, fine to coarse gravel, fine to coarse sand, silt, poorly graded, sub rounded to sub angular clasts, minor Iron staining
-Joint @ 12.8m gently inclined, undulating to stepped, smooth, very narrow, minor iron staining
-Joint @ 12.9m, steeply to very steeply inclined, undulating, smooth to rough, very narrow, Iron Oxide
-Joint @ 13.0m, sub-horizontal to gently inclined, stepped, rough, narrow to moderately narrow, Iron
-Joint @ 13.2m, very steeply inclined, undulating, rough, very narrow to narrow, Iron
-Joint @ 14.06m, sub-horizontal to gently inclined, undulating to stepped, rough,very narrow, Iron
-Joints @ 14.22, 14.28 & 14.4 m, gently inclined, undulating, rough, very narrow to narrow, Iron Oxide
-**Joints** @ 14.6, 14.7 & 14.8 m, moderately to steeply inclined, stepped to undulating, smooth, very narrow, Iron oxide
-**Joints** @ 15.08m, 15.18 & 15.23 m gently inclined, stepped to undulating, rough, very narrow, Iron Oxide
-**Joint** @ 15.4m [or DB], sub-horizontal, undulating, rough, moderately wide, Iron Oxide
-@ 16.0m, very steeply inclined to sub-vertical, undulating to stepped, smooth, very narrow, Iron
-**Joint** @ 16.2m, gently inclined, undulating to stepped, rough to smooth, narrow, Iron Oxide
-**Joint** @ 16.3m, sub-horizontal to gently inclined, stepped, rough to smooth, very narrow to narrow, Iron
-Joints @ 17.5m, 17.81 and 17.97 m, sub-horizontal to gently inclined, undulating to stepped, rough, very narrow to tight, iron
-Joints @ 18.2m, 18.25m & 18.3m gentle to moderately inclined, undulating, rough, very narrow to tight, Iron Oxide
-
-**Joints** @ 19.15m and 19.35m, sub-horizontal, undulating, rough, very narrow to tight, DB?
-Joints @ 19.4m &19.77m, moderately inclined, undulating, rough, narrow to moderately wide, minor Iron Oxide

Piezometer

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GHD Limited

PO Box 6543
Auckland 1141

BOREHOLE with Piezo LOG

Site Identification: **GLD03a**

Sheet 3 of 3

Project: Project Quattro
Client: OceanaGold Ltd
Site: Waihi- Gladstone
Job No.: 51/37083

Datum:
Total Depth: 21.0m
Commenced: 20-Jun-17
Completed: 20-Jun-17
Contractor: Perry Geotech

Equipment: JD Tractor Rig
Shear Vane:
Bore Diameter (mm): 96
Inclination: -90
Comments:

Logged:	HB
Processed:	CDM/AS
Checked:	HB

Depth (m)/ [Elev.]	Drilling Method	Core Run / Recovery (%)	Support / Casing (m)	Water	Geological Fm	Classification	Graphic Log	SOIL DESCRIPTION: (Soil Code), Soil Name [minor MAJOR], colour, structure [zoning, defects, cementing], plasticity or grain size, secondary components, structure. (Geological Formation) / ROCK DESCRIPTION: Weathering, colour, fabric, ROCK NAME (Formation Name)	Moisture Condition	Consistency/ Relative Density	Weathering	Estimated Rock Strength EW VW W MS S VS ES	RQD (%)	Defect Spacing (mm) 20 60 200 600 2000	TESTS & SAMPLES / ROCK MASS DEFECTS: Depth, Type, Inclinations, Roughness, Texture, Aperture, Coating	Piezometer
20.0	HQ Coring	90						from 20.8m, completely weathered, extremely weak to weak			CW-HW CW		83		-Joints @ 20.1m and 20.7 m, gently to moderately inclined, undulating to stepped, rough, narrow, Manganese, Iron Oxide - -Crush zone @ 20.8m-20.9m, fine to coarse SAND, silt, rounded -angular clasts, loose, poorly graded	
21 21.0								Termination Depth = 21m								
22																
23																
24																
25																
26																
27																
28																
29																
30																

Source: OGNZL, 2017. Summary Report on Sterilization Drill- Hole GT020 (Proposed TSF3 Area). File name "TSRF3_Maps and Section_14Aug2017 for EngGeol.PDF". Provided by OGNZL to GHD via email on 25/11/2017.

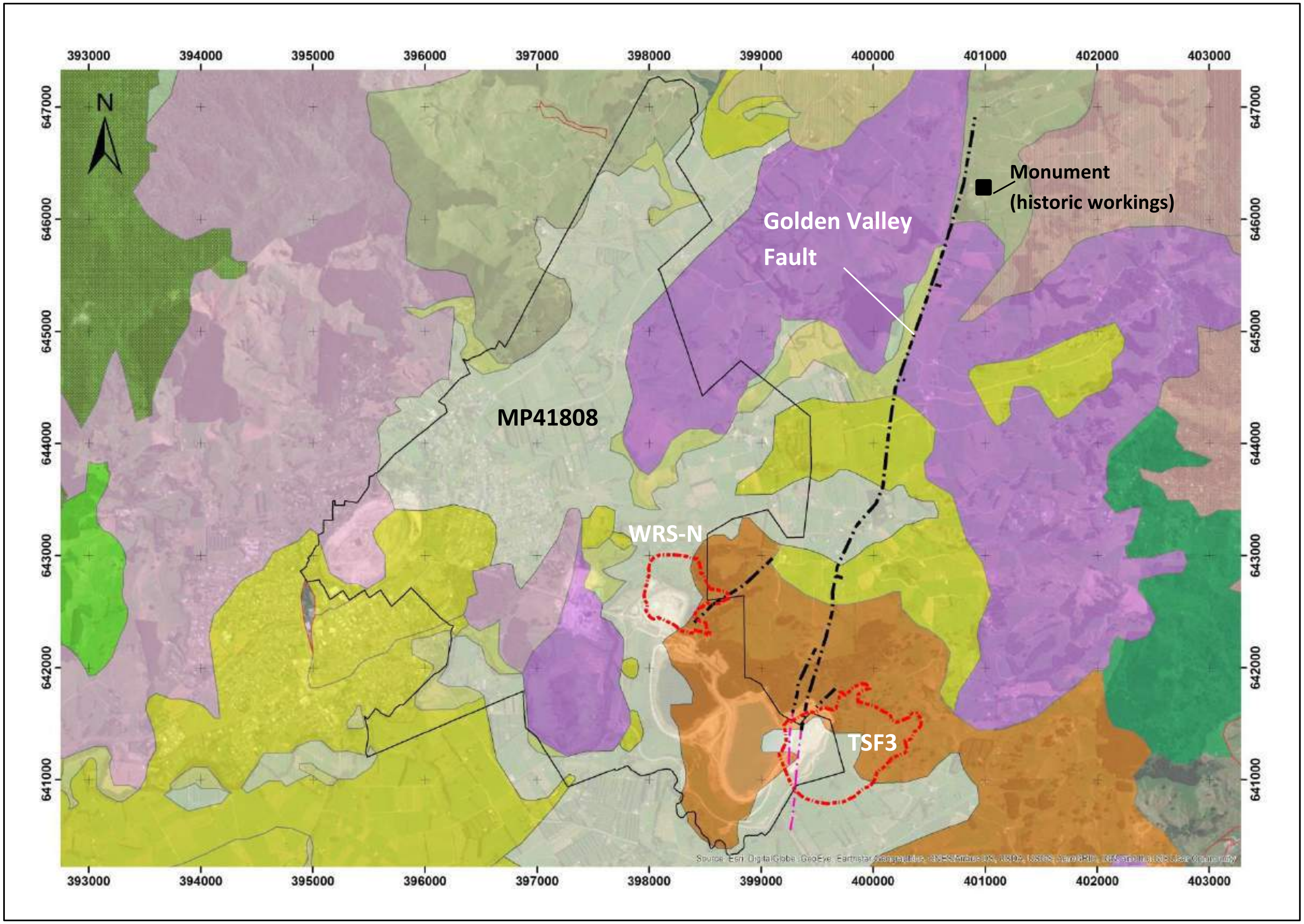
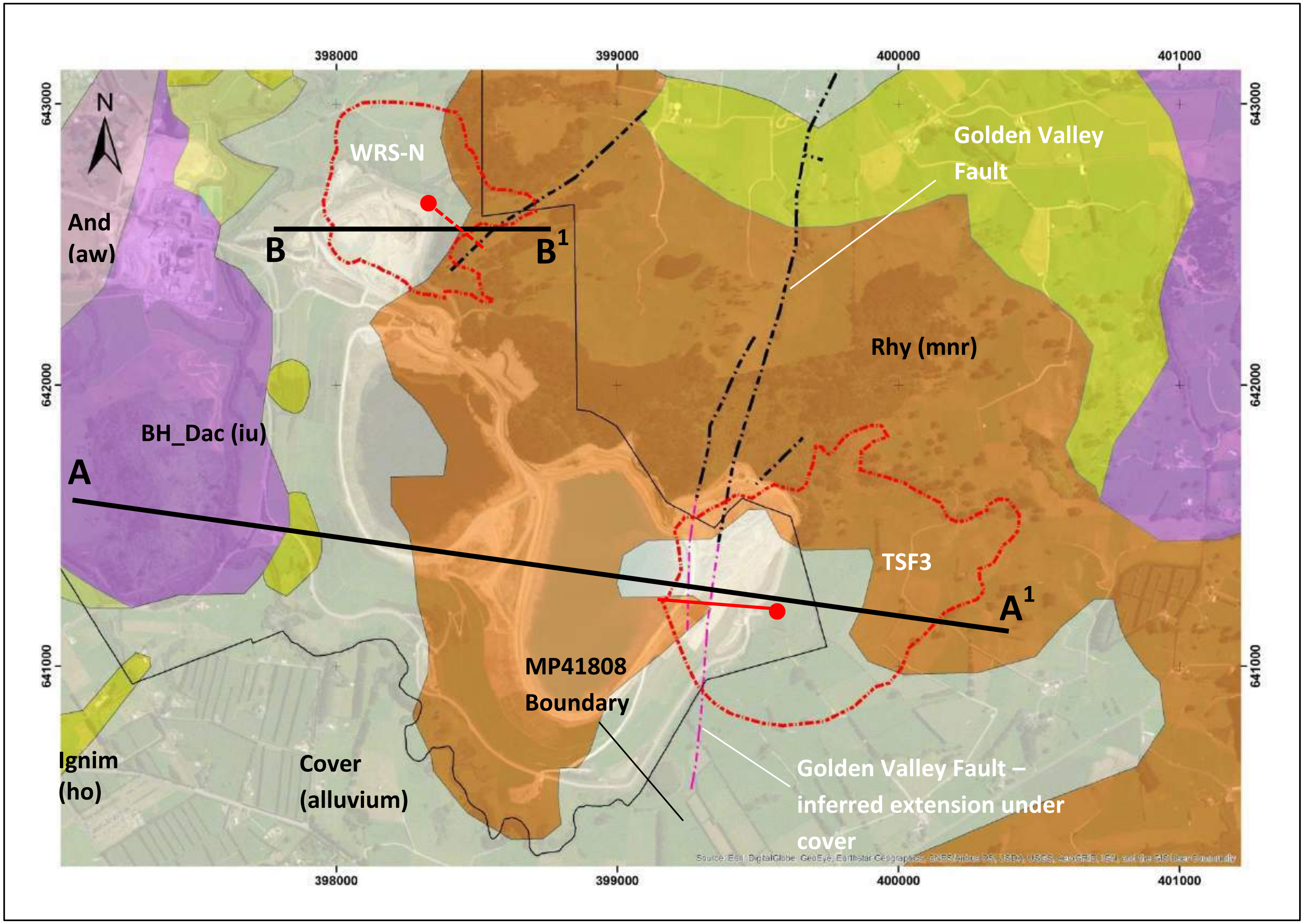


Figure 2: Geology of the Waihi Area (derived from GNS 1:50 000 mapping) indicating regional extent of the Golden Valley Fault. Geological units and structures are further detailed in Fig. 3 below.

OGNZL, 2017. Summary Report on Sterilization Drill- Hole GT020 (Proposed TSF3 Area). File name "TSRF3_Maps and Section_14Aug2017 for EngGeol.PDF". Provided by OGNZL to GHD via email on 25/11/2017.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3: Geological map of waste rock and tailings storage area (proposed WRS-N and TSF-3 outlined in red). Permit boundary in solid black. Geological Section lines are annotated A-A^1; B-B^1. Note inferred extension of Golden Valley fault through tails facility (pink, dashed). Proposed TSF-3 test hole is indicated by a solid red dot and tail.

OGNZL, 2017. Summary Report on Sterilization Drill- Hole GT020 (Proposed TSF3 Area). File name "TSRF3_Maps and Section_14Aug2017 for EngGeol.PDF". Provided by OGNZL to GHD via email on 25/11/2017.

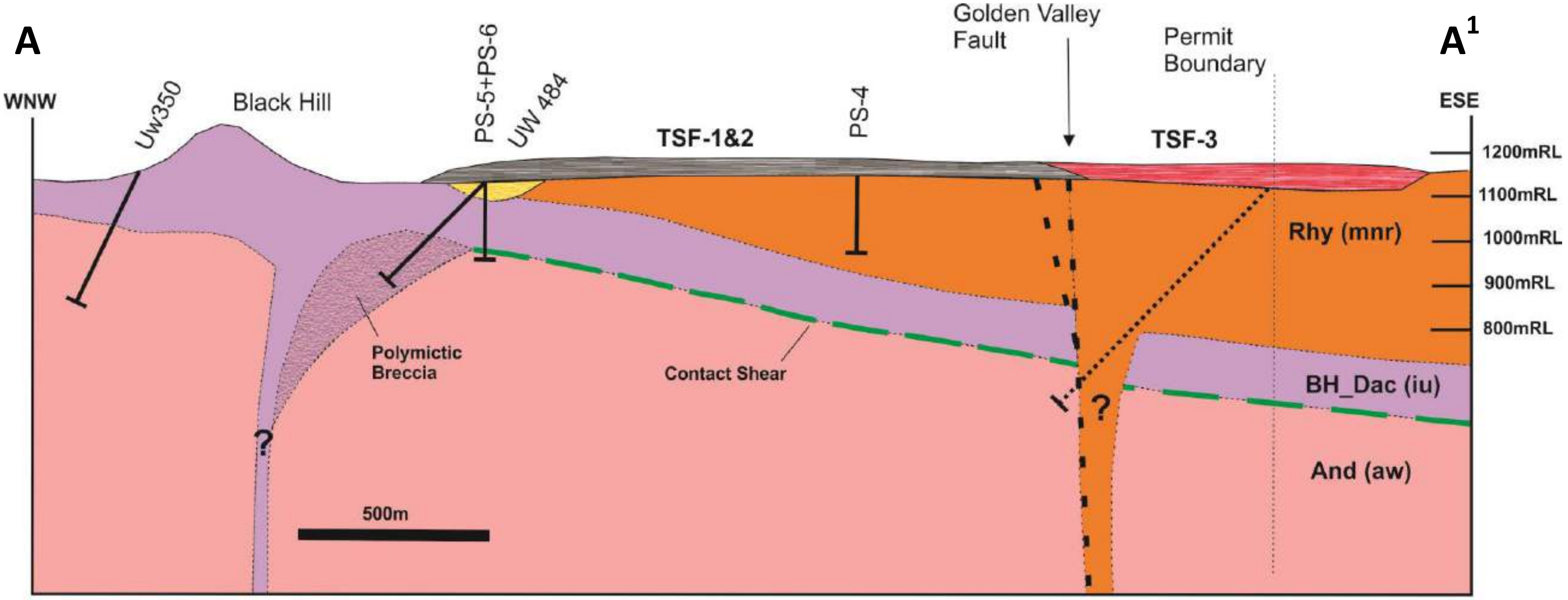


Figure 4: Cross Section A-A^1 through proposed TSF-3 area. Drill data west of PS-4 indicates easterly dip of ~ 15°. There is no reliable drilling data east of PS-4 and thickening particularly of the mnr (Ruahorohore) Rhyolite unit to the east is inferred from the lateral extent of the Ruahorhore dome . Width of Rhyolite unit underlying TSF-3 is likely to significantly exceed the drilled width of 150m in PS-4. Note the Golden Valley Fault (GVF) is inferred to transect the western part of TSF-3. The GVF may be prospective at depth and a drill hole is proposed to test this structure within the upper Andesite unit.

Appendix C

Groundwater level data

Contents:

Table C 1 Gladstone Groundwater Level Data

GWLs in m RL	Borehole	No. of records	Min (m RL)	Max (m RL)	Average	Fluctuation (m)	19/06/2017	27/06/2017	29/06/2017	30/06/2017	10/07/2017	11/07/2017	13/09/2017	24/10/2017	24/11/2017	13/12/2017	22/01/2018	5/03/2018	20/03/2018	3/05/2018	6/06/2018	5/07/2018	2/08/2018	5/09/2018
Gladstone Hydro Boreholes	GLD01	14	1123.27	1126.53	1124.08	3.26	1124.73	1124.15	1126.53		1124.26	1124.03	1123.97	1123.57		1123.269	1123.289	1123.359	1123.629	1123.994			1124.299	1124.059
	GLD01a	14	1121.52	1125.59	1123.55	4.07	1122.85	1124.68	1122.06		1124.26	1124.01	1125.59	1123.64		1121.52	1123.13	1123.26	1123.38	1123.705			1123.78	1123.77
	GLD01b	2	1096.70	1117.98	1107.34	21.28	1117.98	DRY	DRY	DRY		DRY		DRY					1096.698					
	GLD02	12	1112.79	1115.13	1114.06	2.34					1115.04		1114.57	1113.90	1114.11	1112.88	1112.79	1113.39	1113.35	1115.02	1115.13	1114.205		1114.32
	GLD02a	12	1112.06	1115.59	1113.64	3.53					1115.23		1115.02	1113.04	1113.327	1112.057	1112.447	1112.607	1112.317	1115.307	1115.587	1113.352		1113.457
	GLD03	14	1108.45	1110.46	1109.86	2.01		1109.95	1109.89		1110.14	1110.17	1109.78	1110.09			1108.452	1109.427	1109.152	1109.902	1110.462	1110.102	1110.242	1110.212
	GLD03a	13	1104.85	1109.51	1106.81	4.66		1109.51	1106.78		1107.15	1107.05	1107.07	1106.45			1104.853		1105.428	1106.558	1107.223	1106.703	1106.988	1106.773
	P79s	12	1096.53	1100.04	1097.52	3.50							1097.51	1096.88	1096.94	1096.53	1096.74	1096.97	1097.06	1099.7	1100.035	1097.105	1097.14	1097.63
	P79i	3	1090.15	1093.30	1092.03	3.15							1092.63	1093.30					1090.15					
	P79d	3	1080.84	1084.88	1083.29	4.04							1084.15	1084.88					1080.84					

GWLs in m bgl	Borehole	No. of records	Min (m RL)	Max (m RL)	Average	Fluctuation (m)	19/06/2017	27/06/2017	29/06/2017	30/06/2017	10/07/2017	11/07/2017	13/09/2017	24/10/2017	24/11/2017	13/12/2017	22/01/2018	5/03/2018	20/03/2018	3/05/2018	6/06/2018	5/07/2018	2/08/2018	5/09/2018
Gladstone Hydro Boreholes	GLD01	12	1.80	3.26	2.59	1.46	1.80	2.38			2.27	2.50	2.56	2.96		3.26		3.17	2.90	2.535			2.23	2.47
	GLD01a	13	0.96	5.03	2.97	4.07	3.70	1.87	4.49		2.29	2.54	0.96	2.91		5.03		3.29	3.17	2.845			2.77	2.78
	GLD01b	2	8.50	29.78	19.14	21.28	8.50	DRY	DRY	DRY		DRY		DRY					29.78					
	GLD02	12	4.34	6.68	5.41	2.34					4.43		4.90	5.57	5.36	6.59	6.68	6.08	6.12	4.45	4.34	5.265		5.15
	GLD02a	12	4.08	7.61	6.02	3.53					4.44		4.65	6.63	6.34	7.61	7.22	7.06	7.35	4.36	4.08	6.315		6.21
	GLD03	13	2.92	4.23	3.42	1.31		3.43	3.49		3.24	3.21	3.60	3.29				3.96	4.23	3.48	2.92	3.28	3.14	3.17
	GLD03a	12	3.86	7.95	6.40	4.09		3.86	6.59		6.22	6.32	6.30	6.92					7.95	6.815	6.15	6.67	6.385	6.6
	P79s	11	2.85	6.35	5.29	3.51							5.37	6.00	5.94	6.35		5.91	5.82	3.18	2.845	5.775	5.74	5.25
	P79i	3	9.65	12.80	10.92	3.15							10.32	9.65					12.80					
	P79d	3	18.11	22.15	19.70	4.04							18.84	18.11					22.15					

Table C 2 NRS Groundwater Level Data

GWLs in m RL	Borehole	No. of records	Min (m RL)	Max (m RL)	Average	Fluctuation (m)	16/03/1995	16/06/2017	20/06/2017	27/06/2017	30/06/2017	5/07/2017	11/07/2017	8/08/2017	8/09/2017	24/11/2017	29/11/2017	4/12/2017	8/02/2018	12/02/2018	19/02/2018	20/03/2018	26/04/2018	8/05/2018	17/05/2018	29/05/2018	8/06/2018	6/07/2018	17/07/2018	16/08/2018	28/08/2018	13/09/2018
WRS Hydro Boreholes	WRS01	3	1099.25	1102.79	1100.54	3.54												1099.247		1102.792		1099.572										
	WRS01a	3	1099.06	1100.80	1099.72	1.74												1099.059		1100.799		1099.294										
	WRS02	4	1100.66	1101.12	1100.90	0.46												1100.655		1101.118		1100.78			1101.06							
	WRS02a	4	1096.36	1101.10	1097.74	4.74												1096.356		1097.079		1096.411			1101.101							
	WRS03	7	1129.28	1130.25	1129.78	0.97				1130.09		1130.25		1130.00				1129.625		1129.397		1129.275				1129.85						
	WRS03a	7	1129.23	1130.31	1129.90	1.07				1130.07		1130.31		1130.07				1129.678		1130.148		1129.233				1129.813						
	WRS04	14	1095.19	1097.26	1096.08	2.07		1095.44	1095.32	1096.44		1096.61		1095.69	1096.42					1097.26	1096.395	1095.19		1095.75			1096.57		1096.52	1096.25		1095.31
	WRS04a	14	1094.90	1096.70	1095.67	1.81		1095.23	1095.03	1095.82		1096.06		1095.29	1095.85					1096.703	1095.743	1094.898		1096.213			1095.988		1095.888	1095.688		1095.018
	WRS05	8	1096.39	1097.99	1096.86	1.60				1096.90	1096.75		1096.81	1096.67	1096.85				1096.386	1097.989		1096.501										
	WRS05a	10	1095.91	1096.95	1096.32	1.03				1096.52	1096.40		1095.97	1096.26	1096.52				1095.914	1096.947		1096.004			1096.324					1096.354		
	WRS06	13	1097.53	1098.40	1098.00	0.86				1098.22	1098.18	1098.12						1097.534	1097.574	1098.397	1098.114	1097.704		1098.114			1098.209	1097.904		1098.114		1097.784
	DH05A	15	1095.00	1098.40	1097.53	3.40	1097.59				1097.04	1098.07	1095.00	1097.59			1097.263		1097.334	1098.243	1097.784	1097.444		1097.894			1098.034	1097.714		1098.404		1097.524
	DH05	14	1095.36	1098.71	1098.30	3.35					1098.48	1098.71	1095.36	1098.41			1098.229		1098.248	1098.688	1098.598	1098.568		1098.608			1098.643	1098.568		1098.618		1098.528
	DH04	3	1096.59	1097.55	1096.95	0.96							1097.55					1096.585				1096.725										
	WRS07	11	1104.83	1106.08	1105.24	1.25				1105.20	1105.17	1105.35		1106.08				1104.826		1106.044		1104.931	1104.826				1105.256	1105.046				1104.976
	DH09	6	1105.40	1106.07	1105.69	0.67					1105.63	1105.81	1105.73	1105.52						1106.069		1105.397										
	WRS08	13	1104.84	1105.94	1105.20	1.10					1105.11	1105.44		1105.10			1104.841		1105.201	1105.939	1105.051	1105.091		1105.071			1105.301		1105.451		1105.041	1104.951
	DH08	13	1101.43	1102.88	1101.85	1.45	1101.88					1101.98				1101.497	1101.427		1101.647	1101.997	1101.447	1101.602		1101.842			1102.157		1101.967		1102.877	1101.707

GWLs in mbgl	Borehole	No. of records	Min (mbgl)	Max (mbgl)	Average	Fluctuation (m)	16/03/1995	16/06/2017	20/06/2017	27/06/2017	30/06/2017	5/07/2017	11/07/2017	8/08/2017	8/09/2017	24/11/2017	29/11/2017	4/12/2017	8/02/2018	12/02/2018	19/02/2018	20/03/2018	26/04/2018	8/05/2018	17/05/2018	29/05/2018	8/06/2018	6/07/2018	17/07/2018	16/08/2018	28/08/2018	13/09/2018
GWLs in m bgl	WRS01	3	2.76	6.30	5.01	3.55												6.3		2.755		5.975										
	WRS01a	3	4.71	6.45	5.79	1.74												6.45		4.71		6.215										
	WRS02	4	4.16	4.62	4.37	0.46												4.62		4.157		4.495			4.215							
	WRS02a	4	4.22	8.97	7.58	4.75												8.965		8.242		8.91			4.22							
	WRS03	7	1.90	2.87	2.36	0.97				2.06		1.90		2.15				2.52		2.748		2.87				2.295						
	WRS03a	7	1.90	2.98	2.31	1.08				2.14		1.90		2.14				2.53		2.06		2.975				2.395						
	WRS04	14	0.61	2.68	1.79	2.07		2.43	2.55	1.43		1.26		2.19	1.45					0.61	1.475	2.68		2.12			1.3		1.35	1.62		2.56
	WRS04a	14	1.16	2.96	2.19	1.81		2.63	2.83	2.04		1.80		2.57	2.01					1.155	2.115	2.96		1.645			1.87		1.97	2.17		2.84
	WRS05	8	3.07	4.67	4.20	1.60				4.16	4.31		4.25	4.39	4.21				4.67	3.067		4.555										
	WRS05a	10	4.12	5.15	4.74	1.03				4.54	4.67		5.09	4.81	4.55				5.15	4.117		5.06			4.74					4.71		
	WRS06	13	0.99	1.85	1.39	0.86				1.16	1.20	1.26						1.85	1.81	0.987	1.27	1.68		1.27			1.175	1.48		1.27		1.6
	DH05A	15	0.92	4.41	1.83	3.49	1.82				2.37	1.34	4.41	1.82			2.15		1.99	1.081	1.54	1.88		1.43			1.29	1.61		0.92		1.8
	DH05	14	0.62	3.97	1.08	3.35					0.85	0.62	3.97	0.91			1.095		1.165	0.725	0.815	0.845		0.805			0.77	0.845		0.795		0.885
	DH04	3	7.46	8.42	8.05	0.96							7.46					8.42				8.28										
	WRS07	11	2.46	3.71	3.29	1.25				3.34	3.37	3.19		2.46				3.71		2.492		3.605	3.71				3.28	3.49				3.56
	DH09	6	2.23	2.90	2.61	0.67					2.67	2.49	2.57	2.78						2.228		2.9										
	WRS08	13	2.93	4.03	3.67	1.10					3.76	3.43		3.77			4.03		3.67	2.932	3.82	3.78		3.8			3.57		3.42		3.83	3.92
	DH08	13	1.00	2.45	2.03	1.45	2.00					1.90				2.38	2.45		2.23	1.88	2.43	2.275		2.035			1.72		1.91		1	2.17

Table C 3 TSF3 Groundwater Level Data

GWLs in m RL	Borehole	No. of records	Min (m RL)	Max (m RL)	Average	Fluctuation (m)	16/03/1995	16/06/2017	30/06/2017	4/07/2017	11/07/2017	24/11/2017	5/12/2017	8/12/2017	14/12/2017	23/01/2018	12/02/2018	21 - 22/02/2018	20-22/03/2018	4/05/2018	10-11/05/2018	16/05/2018	21-28/05/2018	14/06/2018	20/06/2018	19-23/07/2018	31/07/2018	28-31/08/2018	14-21/09/2018	19-20/02/2019
TSF3 Hydro Boreholes	AP20	2	1110.56	1110.75	1110.66	0.19																						1110.75	1110.56	
	AP01	11	1109.10	1110.23	1109.76	1.13				1110.11	1109.94		1109.46				1110.23	1109.74	1109.68		1109.683					1109.918		1109.743	1109.703	1109.098
	AP01a	7	1109.89	1110.58	1110.39	0.69				1110.25	1109.89		1110.55				1110.45	1110.58	1110.52											1110.478
	AP02	5	1110.66	1111.47	1111.02	0.81							1110.96				1111.47		1110.88				1111.13							1110.66
	AP02a	5	1110.98	1112.17	1111.49	1.19							1111.31				1112.17		1111.28				1111.723							1110.983
	AP03	5	1117.05	1119.58	1117.79	2.52					1117.90		1117.12				1119.58		1117.28											1117.051
	AP03a	5	1113.67	1119.17	1115.68	5.50					1117.51		1114.10				1119.17		1113.93											1113.669
	AP04	4	1108.06	1109.40	1108.61	1.34							1108.57				1109.40		1108.42											1108.063
	AP04a	4	1108.77	1109.47	1109.12	0.71							1109.14				1109.47		1109.08											1108.768
	AP05	13	1108.37	1109.82	1109.08	1.45		1108.98	1109.16	1109.39	1109.28		1108.86				1109.82		1108.88		1108.982				1109.202	1109.282		1109.027	1108.837	1108.372
	AP05a	11	1109.73	1110.13	1110.00	0.40		1110.02	1110.09	1109.95	1110.10		1110.06				1110.13		1110.02		1109.978					1109.978		1109.978		1109.728
	AP06	6	1111.86	1113.05	1112.38	1.20							1112.20				1113.05		1112.26									1112.525	1112.365	1111.855
	AP06a	6	1111.69	1112.67	1112.16	0.98							1112.04				1112.67		1112.03									1112.316	1112.236	1111.686
	AP07	10	1112.54	1113.69	1113.21	1.15		1113.17	1113.30	1113.41	1113.35		1112.86				1113.31		1112.54			1113.332	1113.157							1113.687
	AP07a	8	1112.52	1113.43	1112.89	0.91		1112.71	1112.89	1112.98	1113.43		1112.84				1113.19		1112.59											1112.519
	AP08	5	1113.06	1114.11	1113.56	1.05					1113.88		1113.36				1114.11		1113.37											1113.06
	DH12	7	1112.91	1114.05	1113.54	1.14	1113.67				1114.05								1113.24				1113.645		1113.685		1113.56			1112.91
	AP09	5	1112.35	1113.76	1112.94	1.41					1113.76		1112.83				1112.99		1112.73											1112.353
	DH11	5	1117.05	1118.29	1117.91	1.24	1117.99				1118.29								1118.00				1118.245							1117.045
	AP10	8	1128.00	1129.49	1128.43	1.49		1128.28	1128.40	1128.48	1128.57		1128.11				1129.49		1128.11											1128.001
	AP10a	8	1113.62	1115.19	1114.41	1.57		1115.19	1114.92	1115.19	1114.78		1114.13				1113.81		1113.66											1113.617
	AP11	13	1118.77	1123.03	1119.89	4.26		1119.92	1119.97	1121.04	1120.95		1118.92				1123.03		1118.98	1119.372				1120.322			1119.062	1119.142	1119.027	1118.772
	AP11a	11	1114.51	1116.23	1115.51	1.71		1115.48	1115.79	1115.95	1116.17		1114.88				1116.23	1115.36	1114.89	1116.196									1115.181	1114.511
	DH10	6	1158.26	1161.53	1159.62	3.27					1161.53	1159.17			1159.72				1158.77									1160.257		1158.257
	DH10A	7	1140.11	1142.15	1141.40	2.04					1142.15	1141.80				1141.52			1141.02									1142.102	1140.112	1141.112
	DH14	4	1109.49	1109.89	1109.70	0.40					1109.69			1109.49			1109.89		1109.73											
	DH14A	6	1110.08	1110.58	1110.43	0.50	1110.08				1110.58			1110.50			1110.56		1110.56											1110.262
	DH23	4	1145.55	1147.73	1146.68	2.18					1147.73								1146.46										1146.962	1145.552
	DH23A	6	1131.88	1133.24	1132.74	1.36	1131.88				1133.24	1132.91							1132.68										1133.096	1132.636

orange cell indicates water level was above ground level

GWLs in mbgl	Borehole	No. of records	Min (mbgl)	Max (mbgl)	Average	Fluctuation (m)	16/03/1995	16/06/2017	30/06/2017	4/07/2017	11/07/2017	24/11/2017	5/12/2017	8/12/2017	14/12/2017	23/01/2018	12/02/2018	21 - 22/02/2018	20-22/03/2018	4/05/2018	10-11/05/2018	16/05/2018	21-28/05/2018	14/06/2018	20/06/2018	19-23/07/2018	31/07/2018	28-31/08/2018	14-21/09/2018	19-20/02/2019
TSF3 Hydro Boreholes	AP20	2	1.55	1.74	1.65	0.19																						1.55	1.74	
	AP01	11	0.27	1.40	0.72	1.14				0.39	0.56		1.04				0.27	0.76	0.82		0.76					0.525		0.7	0.74	1.40
	AP01a	11	0.00	0.66	0.21	0.66				0.30	0.66		0.00				0.10	0.03	0.03		0.06					0.58		0.06	0.37	0.07
	AP02	5	0.87	1.68	1.31	0.81							1.38				0.87		1.46				1.16							1.68
	AP02a	5	0.11	1.30	0.77	1.19							0.97				0.11		1.01				0.48							1.30
	AP03	5	0.79	3.31	2.54	2.53					2.38		3.16				0.79		3.08											3.31
	AP03a	5	1.11	6.61	4.64	5.50					2.85		6.26				1.11		6.35											6.61
	AP04	4	0.13	1.47	0.92	1.34							0.96				0.13		1.11											1.47
	AP04a	4	0.06	0.77	0.42	0.71							0.39				0.06		0.45											0.77
	AP05	14	0.35	1.80	1.03	1.45		1.19	1.01	0.78	0.89		1.31				0.35	1.00	1.29		1.045				0.825	0.745		1	1.19	1.80
	AP05a	14	0.00	0.49	0.15	0.49		0.20	0.13	0.27	0.12		0.16				0.09	0.09	0.20		0.12				0	0.12		0.12	0	0.49
	AP06	6	0.49	1.68	1.15	1.20							1.34				0.49		1.28									0.97	1.13	1.68
	AP06a	6	0.87	1.85	1.36	0.99							1.50				0.87		1.51									1.17	1.25	1.85
	AP07	10	1.27	2.42	1.72	1.15		1.79	1.66	1.55	1.61		2.10				1.65		2.42			1.485	1.66							1.27
	AP07a	8	1.53	2.44	2.07	0.91		2.25	2.07	1.98	1.53		2.12				1.77		2.37											2.44
	AP08	5	1.77	2.82	2.32	1.05					2.00		2.52				1.77		2.51											2.82
	DH12	7	1.78	2.92	2.50	1.14	2.16				1.78								2.60				2.675		2.635		2.76			2.92
	AP09	5	5.70	7.11	6.53	1.41					5.70		6.63				6.47		6.73											7.11
	DH11	5	0.92	2.16	1.39	1.24	1.22				0.92								1.20				1.44							2.16
	AP10	8	2.58	4.07	3.64	1.49		3.79	3.67	3.59	3.50		3.96				2.58		3.96											4.07
	AP10a	8	16.93	18.50	17.71	1.57		16.93	17.20	16.93	17.34		17.99				18.31		18.46											18.50
	AP11	13	0.80	5.06	3.90	4.26		3.91	3.87	2.79	2.88		4.91				0.80		4.85	4.35				3.4			4.66	4.58	4.695	5.06
	AP11a	11	7.61	9.32	8.31	1.72		8.35	8.04	7.88	7.66		8.95				7.61	8.47	8.94	7.615									8.63	9.32
	DH10	6	4.62	7.89	6.70	3.27					4.62	6.98			6.93				7.38									6.39		7.89
	DH10A	7	24.31	26.90	25.29	2.59					24.31	24.66				25.49			25.44									24.91	26.9	25.35
	DH14	4	0.72	1.12	0.91	0.40					0.92			1.12			0.72		0.88											
	DH14A	6	0.00	0.50	0.16	0.50	0.50				0.00			0.08			0.02		0.02											0.32
	DH23	4	10.29	12.47	11.40	2.18					10.29								11.56										11.28	12.47
	DH23A	6	23.96	25.32	24.54	1.36	25.32				23.96	24.29							24.52										24.58	24.56

Table C.4 Minimum and maximum vertical hydraulic gradients – Gladstone Shallow Groundwater System

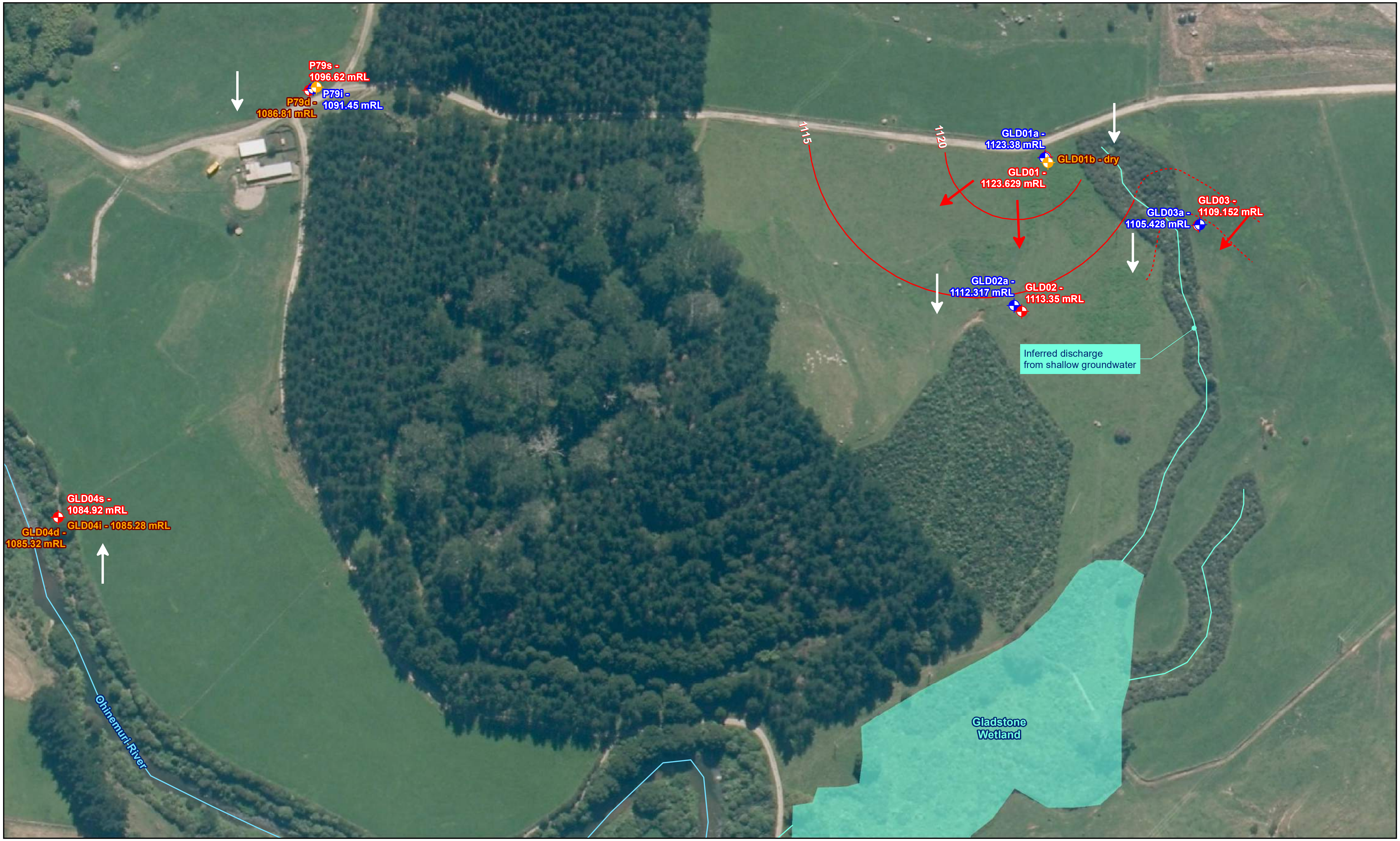
Well Pair	**Date**	**Water Level Difference (m)**	**Vertical Distance (m)**	**Vertical Gradient (up/down)**
GLD01 – GLD01a	29/06/17	4.47	4.2	1.1 (down)
	5/03/18	0.1		0.02 (down)
GLD02 – GLD02a	23/03/18	1.03	14.0	0.07 (down)
	10/07/18	0.19		0.01 (up)
GLD03 – GLD03a	20/03/18	3.72	9.0	0.4 (down)
	27/06/17	0.44		0.05 (down)
P79s – P79i	20/03/18	6.91	28.5	0.2 (down)
	24/10/17	3.58		0.1 (down)

Table C.5 Minimum and maximum vertical hydraulic gradients – Gladstone Deep Groundwater System

Well Pair	**Date**	**Water Level Difference (m)**	**Vertical Distance (m)**	**Vertical Gradient (up/down)**
P79s – P79d (shallow - deep)	20/03/18	16.22	40	0.4 (down)
	07/11/20	9.5		0.2 (down)
P79i – P79d (shallow - deep)	20/03/18	9.31	10.5	0.9 (down)
	07/11/20	4.95		0.5 (down)
GLD01 – GLD01b (shallow - deep)	29/06/17	>30	19.5	> 1.5 (down)
GLD01a – GLD01b (shallow - deep)	13/09/17	>29	13.3	> 2.2 (down)
P68s – P68d (Shallow to deep system)	2001* (URS, 2003)	0.55	5.0	0.1 (down)
		0.72		0.1 (down)
P61s – P61 (shallow - deep)	13/10/2020	38.03	32.6	1.2 (down)
	2003 (URS, 2003)	38.65		1.2 (down)
GLD04s – GLD04d (shallow - deep)	29/10/2020	0.39	52.6	0.007 (up)
GLD04i – GLD04d (deep system)	29/10/2020	0.03	36.9	0.0008 (up)
* Recent data not available for P68s due to damage to the piezometer.				

Table C.6 Minimum and maximum vertical hydraulic gradients – NRS Shallow Groundwater System

Well Pair	Date	Water Level Difference (m)	Vertical Distance (m)	Vertical Gradient (up/down)
WRS01 – WRS01a	4/12/2017	0.188	8.7	0.02 (down)
	12/02/2018	1.993		0.2 (down)
WRS02 – WRS02a	17/05/2018	0.041	8.5	0.005 (up)
	20/03/2018	4.369		0.51 (down)
WRS03 – WRS03a	29/05/2018	0.037	8.5	0.004 (down)
	12/02/2018	0.751		0.09 (up)
WRS04 – WRS04a	16/06/2017	0.212	11.5	0.02 (down)
	19/02/2018	0.652		0.06 (down)
WRS05 – WRS05a	8/09/2017	0.33	8	0.04 (down)
	12/02/2018	1.04		0.1 (down)
DH05 – WRS06	12/02/2018	0.29	5.7	0.05 (down)
	20/03/2018	0.86		0.2 (down)
WRS06 – DH05a	5/07/2017	0.05	6.5	0.01 (down)
	30/06/2017	1.14		0.2 (down)
WRS07 – DH09	20/03/2018	0.47	6.0	0.08 (up)
	8/08/2017	0.56		0.09 (down)
WRS08 – DH08	28/08/2018	2.16	9.0	0.2 (down)
	12/02/2018	3.94		0.4 (down)



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Metres

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

N

LEGEND

───	Actual Groundwater Contours - Shallow System
- - - -	Inferred Groundwater Contours - Shallow System
➡	Inferred Shallow Groundwater Flow Direction
⇨	Direction of Vertical Gradient

Available Groundwater Data

⊕	Shallow
⊕	Intermediate
⊕	Deep

Ohinemuri River Tributary

───	River
🟦	Wetland

GHD

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	25 Nov 2021

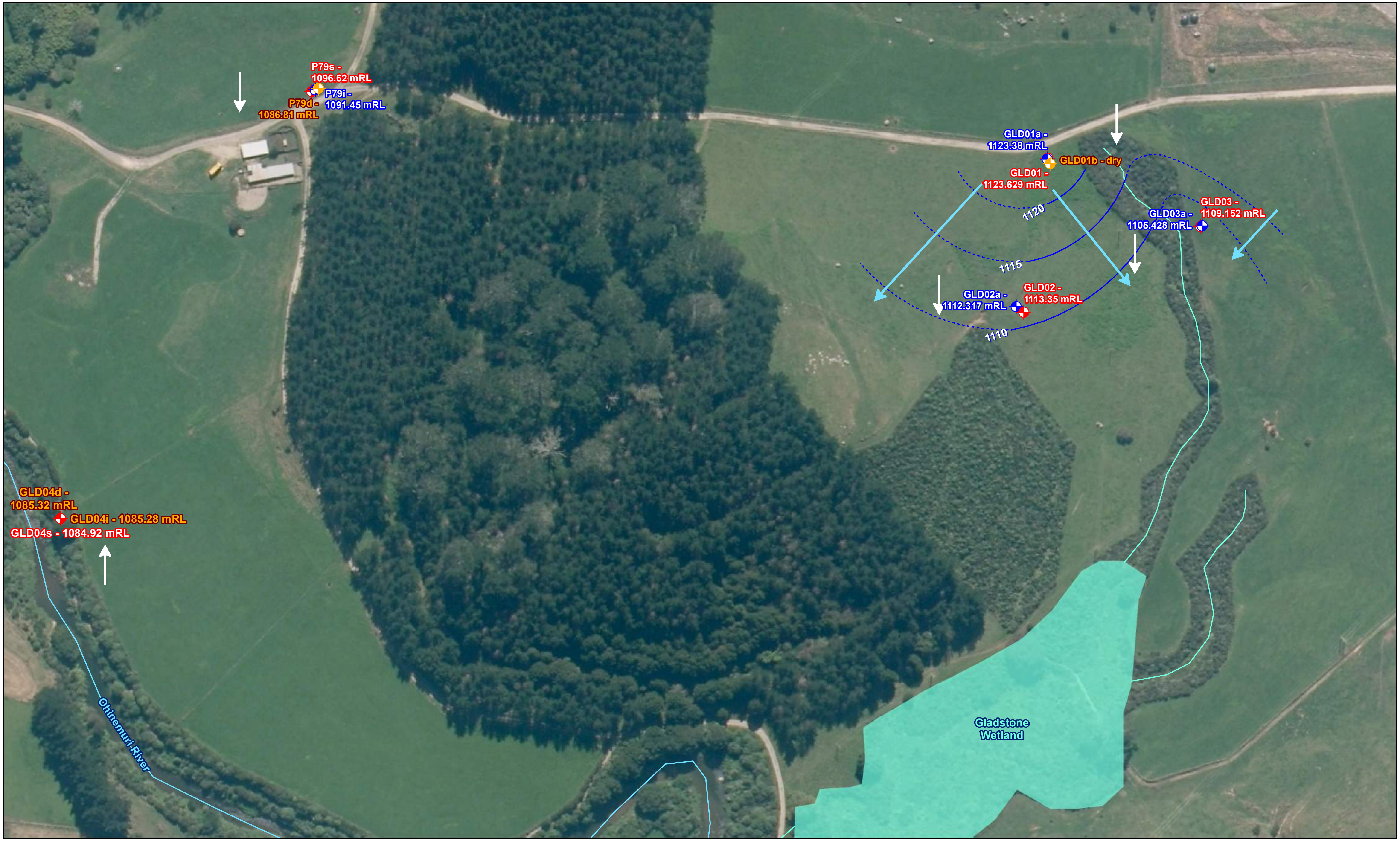
Groundwater contours - Gladstone Shallow Groundwater System

Figure C.1

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C1_GladstoneShallowGWSystem.mxd

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: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin



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Metres

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

N

LEGEND

—	Actual Groundwater Contours - Intermediate System
- - -	Inferred Groundwater Contours - Intermediate System
→	Inferred Intermediate Groundwater Flow Direction
⇨	Direction of Vertical Gradient

Available Groundwater Data

⊕	Shallow
⊕	Intermediate
⊕	Deep

Ohinemuri River Tributary

—	River
🟩	Wetland

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	25 Nov 2021

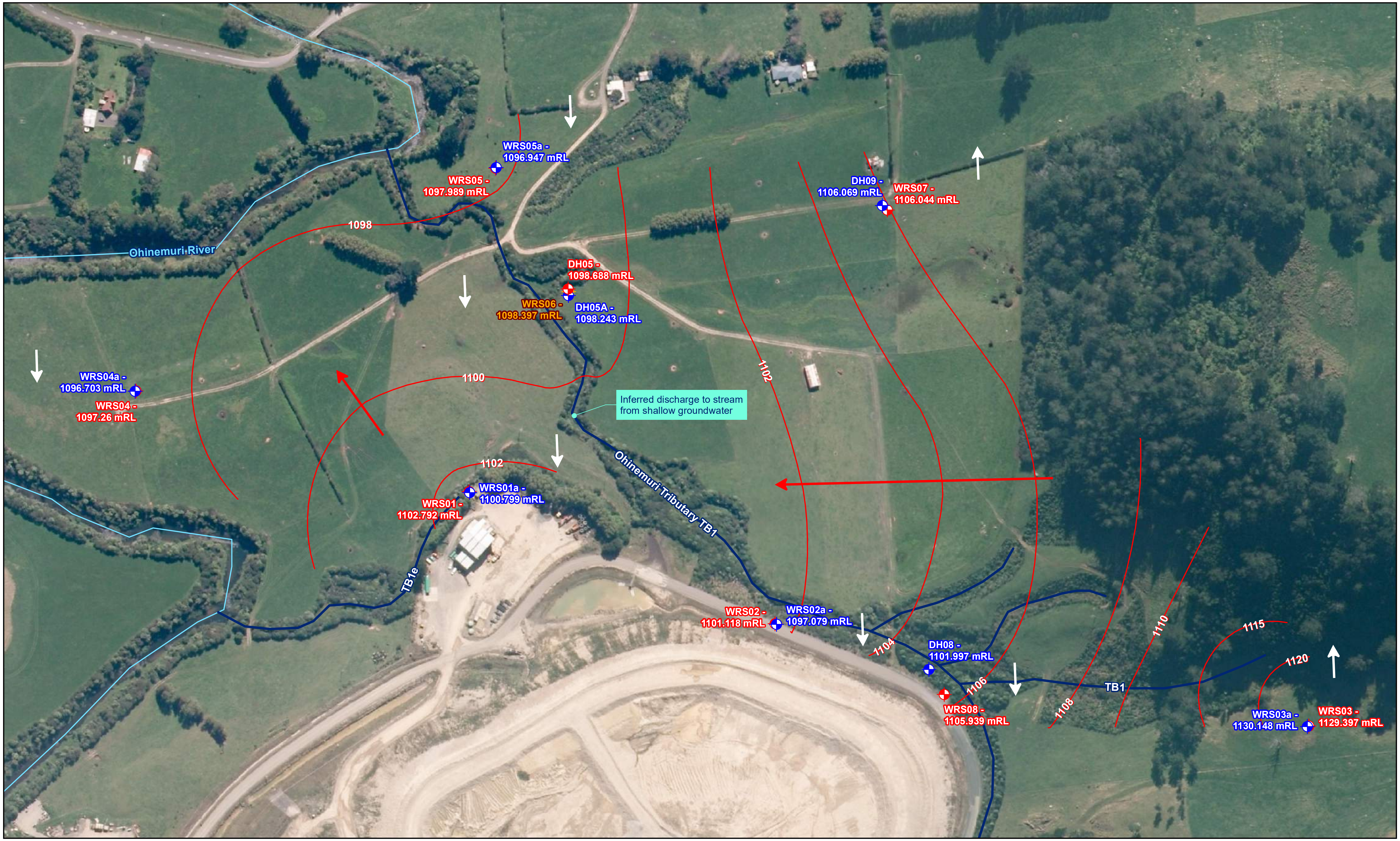
Groundwater contours - Gladstone Intermediate Groundwater System

Figure C.2

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C2_GladstoneIntermediateGWSystem.mxd

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: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin



Paper Size A3

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Metres

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

N

LEGEND

🟥	Groundwater Contours - Shallow System
→	Inferred Shallow Groundwater Flow Direction
→	Direction of Vertical Gradient

Available Groundwater Data

⊕	Shallow Wells
⊕	Intermediate Wells
⊕	Deep Wells

Ohinemuri River Tributary

—	River
—	Tributary

Oceana Gold Limited
Waihi North

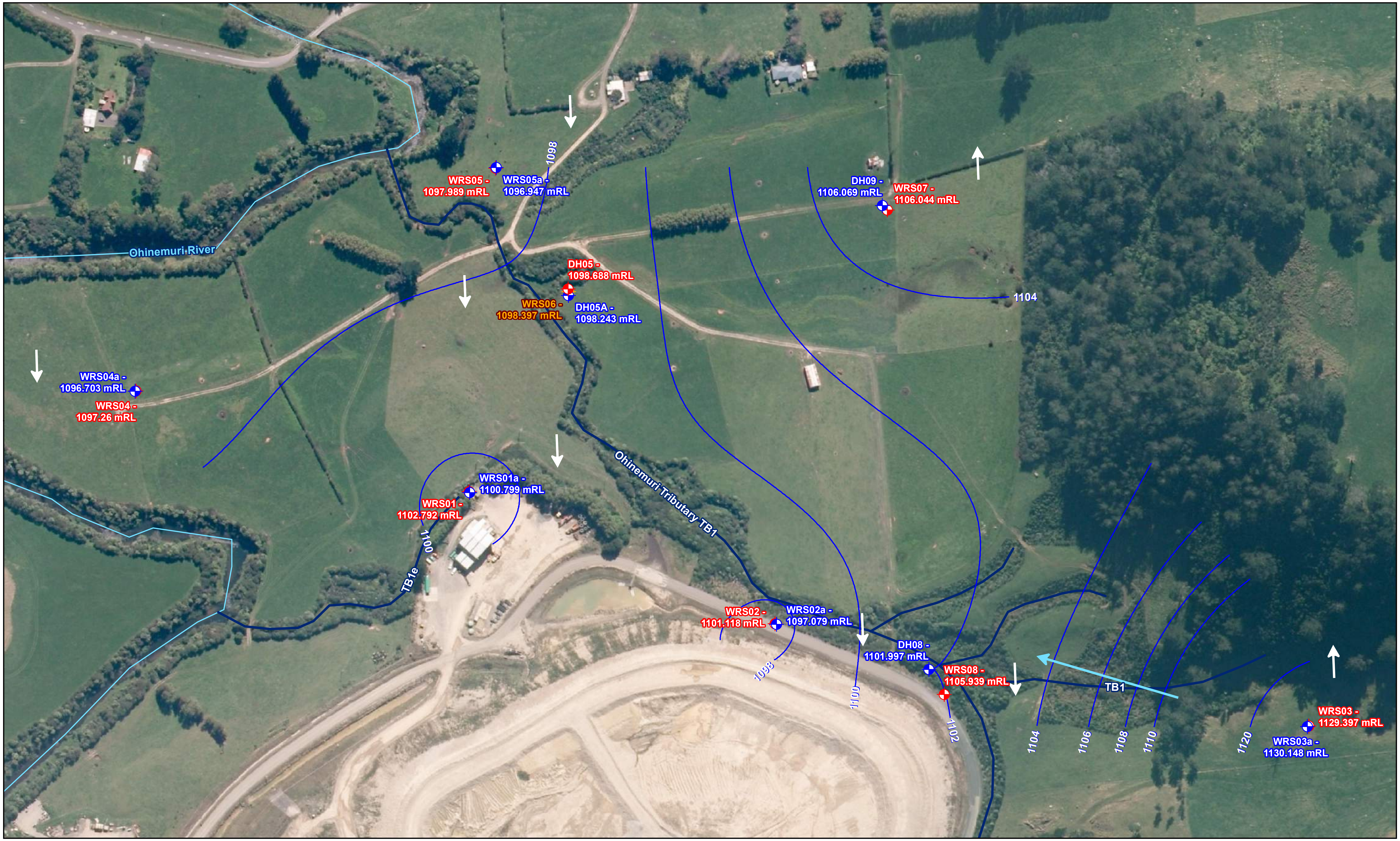
Job Number	12552081
Revision	0
Date	25 Nov 2021

Groundwater contours - NRS Shallow Groundwater System

Figure C.3

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C3_NRS_ShallowGWSystem.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin



Paper Size A3

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Metres

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

N

LEGEND

— Groundwater Contours - Deep System

→ Inferred Deep Groundwater Flow Direction

⇨ Direction of Vertical Gradient

Available Groundwater Data

⊕ Shallow Wells

⊕ Intermediate Wells

⊕ Deep Wells

Ohinemuri River Tributary

— River

— Tributary

Oceana Gold Limited
Waihi North

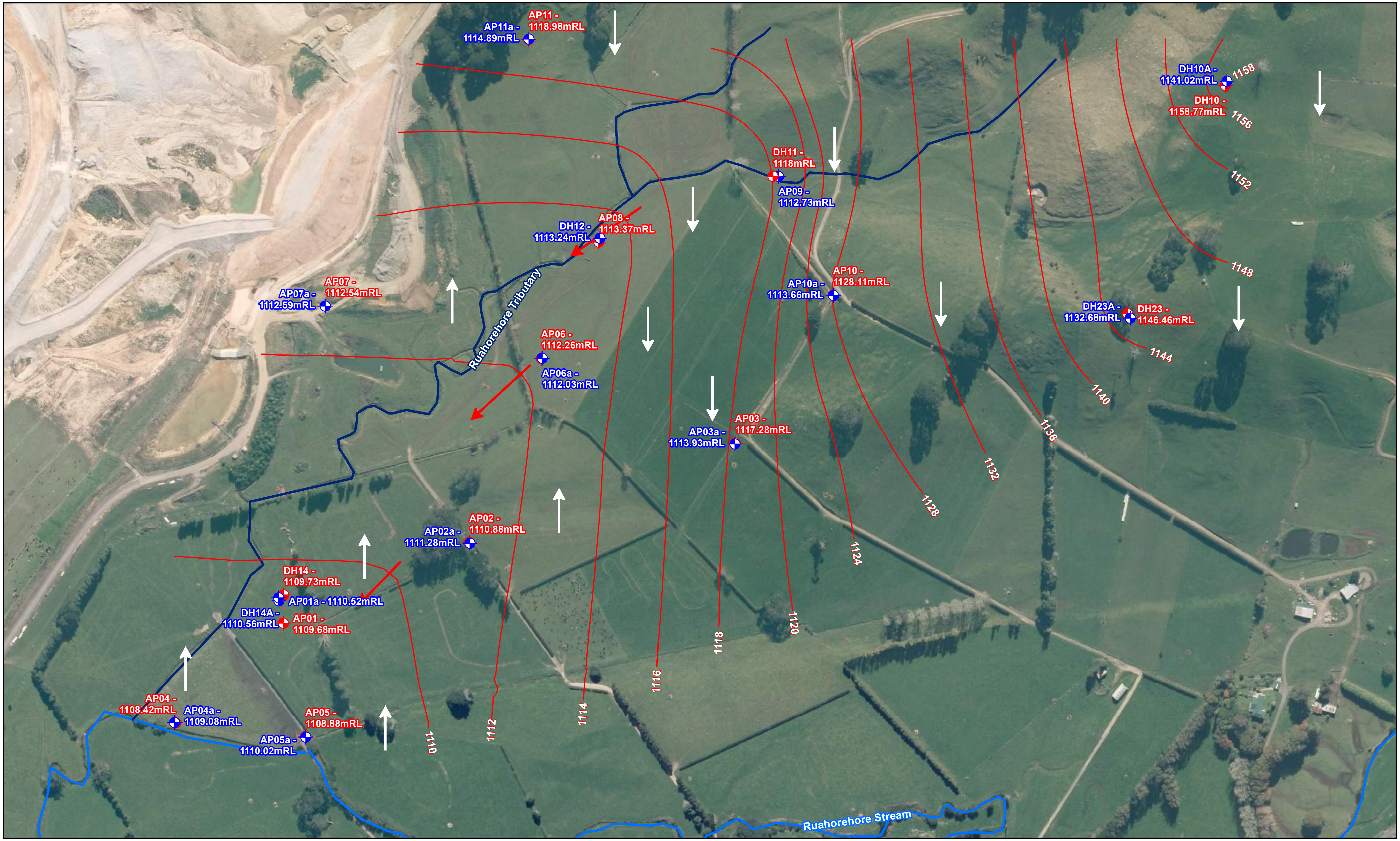
Groundwater contours - NRS Deeper Groundwater System

Job Number	12552081
Revision	0
Date	25 Nov 2021

Figure C.4

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C4_NRS_DeepGWSystem.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin



Paper Size A3

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Metres

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

N

LEGEND

- Groundwater Contours - Shallow System
- Inferred Shallow Groundwater Flow Direction
- Direction of Vertical Gradient

Groundwater Available Data

- Shallow Wells
- Deep Wells

Ohinemuri River Tributary

- Stream
- Tributary

GHD

Oceana Gold Limited
Waihi North

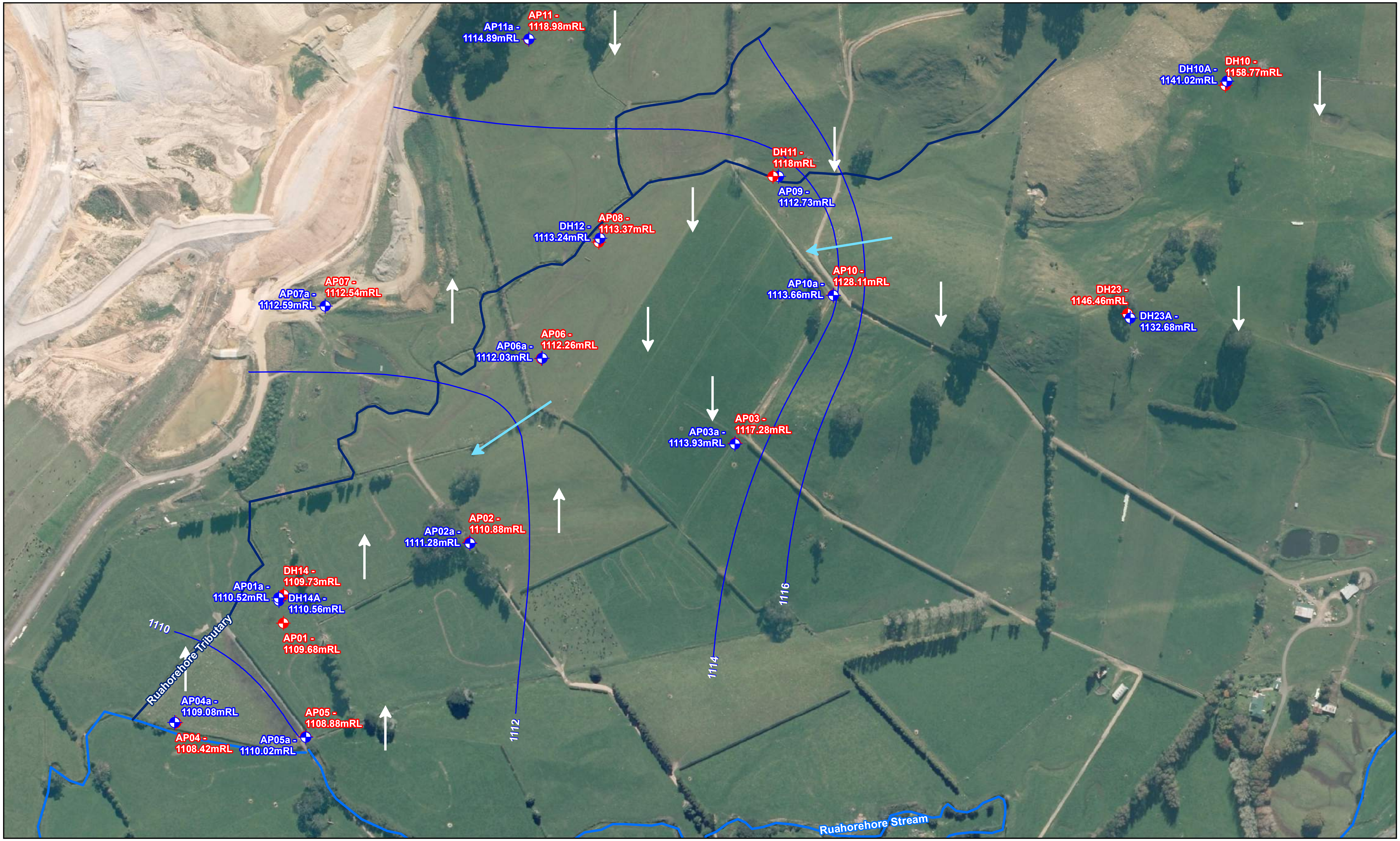
Job Number	12552081
Revision	0
Date	25 Nov 2021

Groundwater contours - TSF3
Shallow Groundwater System

Figure C.5

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C5_TSF3_ShallowGWSystem.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin



Paper Size A3

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Metres

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

N

LEGEND

Groundwater Contours - Deep System

Inferred Deep Groundwater Flow Direction

Direction of Vertical Gradient

Groundwater Available Data

Shallow Wells

Deep Wells

Ohinemuri River Tributary

Stream

Tributary

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	25 Nov 2021

Groundwater contours - TSF3
Deeper Groundwater System

Figure C.6

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_C6_TSF3_DeepGWSystem.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bores - OGL. Created by:dbbanatin

Appendix D

Permeability analyses

Contents:

Table D.1 Gladstone Permeability Test Data

Bore ID - Shallow Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Comments
GLD01	FHT 1	Unconfined	4.5E-08	Bouwer and Rice, 1976 (Unconfined)	2 m Screen 5.5 - 7.5 m	Alluvial silt/clay
	RHT 1		2.8E-08			
	FHT 2		3.6E-08			
	RHT 2		2.5E-08			
	Geomean		**3.3E-08**			
	Range:	**Min**	**2.5E-08**			
		Max	**4.5E-08**			
GLD03	FHT 1	Unconfined	2.0E-08	Bouwer and Rice, 1976 (Unconfined)	2 m Screen 6 - 8 m	Volcanics (Completely weathered, very narrow - tight joints with iron oxide staining, crush zones with iron oxide staining).
	RHT 1		7.7E-08	for all GLD03:		
	FHT 2		<4E-08	*Recovery did not reach 70%*		
	RHT 2		<4E-08	*Recovery did not reach 70%*		
	FHT 3		6.0E-08			
	RHT 3		<4E-08	*Recovery did not reach 70%*		
	Geomean		**<4E-08**			
	Range:	**Min**	**2.0E-08**			
		Max	**7.7E-08**			

Bore ID - Deep Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Comments
GLD01a	FHT 1 - FHT2	Confined	*Not analysed*	*Recovery did not reach 50%*	2 m Screen 11.7 - 13.7 m	Alluviual silt/clay (water pressure increase noted during drilling).
	RHT 1 -RHT 3		*Not analysed*	*Recovery did not reach 50%*		
	FHT 3		3.8E-08	Hyder et al, 1994 (KGS model)		
	Geomean		**n/a**			
	Adopted value		**<1E-08**			
GLD03a	FHT 1	Confined	9.8E-08	Butler, 1998 (Confined)	3 m Screen 17 - 20 m	Volcanics (highly weathered, tight to narrow joints with iron oxide staining).
	RHT 1		2.3E-08	Hyder et al, 1994 (KGS model)		
	FHT 2		1.2E-07	Butler, 1998 (Confined)		
	RHT 2		3.8E-08	Hyder et al, 1994 (KGS model)		
	FHT 3		1.1E-07	Butler, 1998 (Confined)		
	RHT 3		2.6E-08	Hyder et al, 1994 (KGS model)		
	Geomean		**5.5E-08**			
	Range:	**Min**	**2.3E-08**			
		Max	**1.2E-07**			

Table D.2 NRS Permeability Test Data

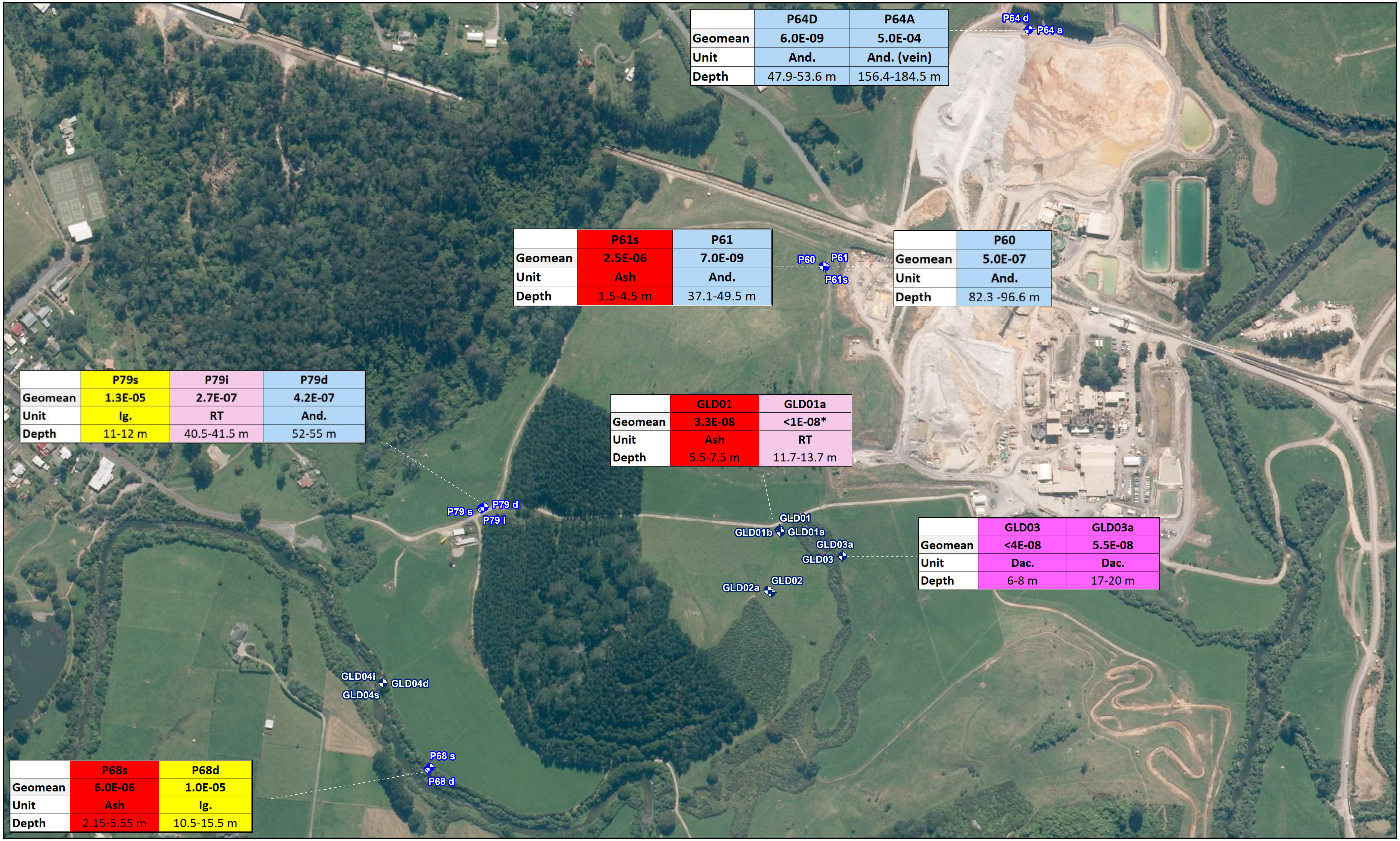
Bore ID - Shallow Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Comments
WRS04	FHT 1	Unconfined	9.6E-06	Bouwer and Rice, 1976 (Unconfined)	3 m Screen 2.5 - 5.5 m	Ignimbrite (Completely weathered - Residual Soil, very narrow - closed joints with strong manganese staining).
	RHT 1		8.9E-06			
	FHT 2		9.9E-06			
	RHT 2		8.1E-06			
	FHT 3		8.4E-06			
	RHT 3		8.2E-06			
	FHT 4		8.8E-06			
	RHT 4		8.7E-06			
	Geomean		**8.8E-06**			
	Range:	**Min**	**8.1E-06**			
		Max	**9.9E-06**			
WRS05		**Adopted Value**	**1.0E-06**	n/a	3 m Screen 2.5 - 5.5 m	Dacite (Completely weathered - Residual). Data lost; field records noted "similar response to FVN02 time-wise", supported by <10 minute test runs. Rounded value similar to FVN02 adopted, which is consistent with dacite WRS results.
WRS06	FHT 1	Unconfined	1.4E-06	Bouwer and Rice, 1976 (Unconfined)	2 m Screen 10 - 12 m	Ignimbrite (completely weathered, very narrow join with manganese staining).
	RHT 1		1.4E-06			
	FHT 2		1.5E-06			
	RHT 2		1.2E-06			
	Geomean		**1.4E-06**			
	Range:	**Min**	**1.2E-06**			
		Max	**1.5E-06**			
WRS07	FHT 1 - FHT 4	Unconfined	*Not analysed*	*Rapid response*	3 m screen 3.0 - 6.0 m	Screened across Alluvium (sandy SILT) /Ignimbrite contact (completely weathered - residual soil). Rapid WL response, screen limited; could not be analysed. Adopted K value > 1x10^{-4} m/s.
	RHT 1 - RHT 4		*Not analysed*	*Rapid response*		
		Geomean	**n/a**			
		Adopted value	**>1.0E-04**			

Bore ID - Deep Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Comments
WRS04a	FHT 1	Confined	1.3E-06	Hyder et al, 1994 (KGS model)	3 m Screen 17 - 20 m	Ignimbrite (highly weathered, crush zone with no staining).
	RHT 1		1.3E-06			
	FHT 2		6.3E-07			
	RHT 2		1.4E-06			
	FHT 3		1.2E-06			
	RHT 3		1.2E-06			
	Geomean		**1.1E-06**			
	Range:	**Min**	**6.3E-07**			
		Max	**1.4E-06**			
WRS05a	FHT 1	Confined	2.1E-06	Hyder et al, 1994 (KGS model)	3 m Screen 13.5 -16.5 m	Dacite (moderately weathered - highly weathered, crush zone with iron staining, very narrow - tight fractures with iron and manganese staining).
	RHT 1		1.3E-07	Butler, 1998 (Confined)		
	FHT 2		1.2E-06	Butler, 1998 (Confined)		
	RHT 2		7.5E-07	Hyder et al, 1994 (KGS model		
	FHT 3		1.3E-06	Butler, 1998 (Confined)		
	RHT 3		1.2E-06	Hyder et al, 1994 (KGS model		
	Geomean		**8.5E-07**			
	Range:	**Min**	**1.3E-07**			
		Max	**2.1E-06**			

Table D.3 TSF3 Permeability Test Data

Bore ID - Shallow Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Lithology
AP01	FHT 1	Unconfined	*Not analysed*	*Test too short, did not reach full recovery*	2 m Screen 3 - 5 m	Rhyolite - Tuff
	RHT 1		3.4E-07	Bouwer and Rice, 1976 (Unconfined)		
	FHT 2		1.9E-07			
	RHT 2		2.2E-07			
	Geomean		**2.4E-07**			
	Range:	**Min**	**1.9E-07**			
		Max	**3.4E-07**			
AP05	FHT 1	Unconfined	1.7E-05	Bouwer and Rice, 1976 (Unconfined)	2 m Screen 3 - 5 m	Rhyolite - Tuff
	RHT 1		1.3E-05			
	FHT 2		8.5E-06			
	RHT 2		2.1E-05			
	FHT 3		1.9E-05			
	RHT 3		1.8E-05			
	FHT4		1.1E-05			
	RHT4		2.0E-05			
	Geomean		**1.5E-05**			
	Range:	**Min**	**8.5E-06**			
		Max	**2.1E-05**			
AP07	FHT 1	Unconfined	6.1E-06	Bouwer and Rice, 1976 (Unconfined)	3 m Screen 2.5 - 5.5 m	1.0 m alluvium; 2.0 Rhyolite - Tuff
	RHT 1		5.5E-06			
	FHT 2		5.4E-06			
	RHT 2		9.0E-06			
	FHT 3		5.7E-06			
	RHT 3		7.2E-06			
	FHT4		6.3E-06			
	RHT4		7.7E-06			
	Geomean		**6.5E-06**			
	Range:	**Min**	**5.4E-06**			
		Max	**9.0E-06**			
AP10	FHT 1	Unconfined	1.7E-06	Bouwer and Rice, 1976 (Unconfined)	3 m Screen 4 - 7 m	Flow rhyolite, MW-SW
	RHT 1		5.1E-06			
	FHT 2		1.5E-06			
	RHT 2		3.9E-06			
	FHT 3		1.6E-06			
	RHT 3		2.2E-06			
	FHT 4		2.7E-06			
	Geomean		**2.4E-06**			
	Range:	**Min**	**1.5E-06**			
		Max	**5.1E-06**			
AP11	FHT 1	Unconfined	*Not analysed*	*Rapid response*	3 m Screen 4 - 7 m	Flow rhyolite, MW-SW
	RHT 1		*Not analysed*	*Rapid response*		
	FHT 2		*Not analysed*	*Rapid response*		
	RHT 2		9.2E-05	Springer-Gelhar, 1991 (Unconfined, inertial)		
	FHT 3		*Not analysed*	*Rapid response*		
	RHT 3		1.2E-04	Springer-Gelhar, 1991 (Unconfined, inertial)		
	Geomean		**n/a**			
	Adopted value		**>1.0E-04**			
DH14	FHT 1	Unconfined	1.8E-06	Hyder et al, 1994 (KGS model)	No log (3 m screen assumed)	Rhyolite - Tuff
	RHT 1		8.6E-07			
	FHT 2		2.0E-06			
	RHT 2		5.2E-07			
	FHT 3		2.0E-06			
	RHT 3		7.7E-07			
	Geomean		**1.2E-06**			
	Range:	**Min**	**5.2E-07**			
		Max	**2.0E-06**			

Bore ID - Deep Wells	Test	Aquifer Type Assessed	Permeability (m/s)	Solution	Screen	Comments
AP01a	FHT 1	Confined	6.4E-06	Hyder et al, 1994 (KGS model)	3 m Screen 36.5 - 39.5	Flow rhyolite, MW-SW
	RHT 1		6.3E-06			
	FHT 2		6.6E-06			
	RHT 2		5.3E-06			
	FHT 3		6.4E-06			
	RHT 3		6.5E-06			
	FHT4		6.0E-06			
	RHT4		6.3E-06			
	Geomean		**6.2E-06**			
	Range:	**Min**	**5.3E-06**			
		Max	**6.6E-06**			
AP05a	RHT 1	Confined (artesian)	1.4E-06	Hyder et al, 1994 (KGS model)	3 m Screen 19 - 22 m	Rhyolite - Tuff
	RHT 2		*Not analysed*	*Rapid response*		
	RHT 3		*Not analysed*	*Rapid response*		
	Geomean		**n/a**			
	Adopted value		**>1.0E-04**			
AP07a	FHT 1	Confined	1.4E-06	Hyder et al, 1994 (KGS model)	3 m Screen 24 - 27 m	Flow rhyolite, CW-HW
	RHT 1		3.4E-06			
	FHT 2		*Not analysed*	*Logger shifted / moved*		
	RHT 2		2.3E-06	Hyder et al, 1994 (KGS model)		
	FHT 3		*Not analysed*	*Logger shifted / moved*		
	RHT 3		3.4E-06	Hyder et al, 1994 (KGS model)		
	FHT 4		2.1E-06			
	RHT 4		3.4E-06			
	Geomean		**2.5E-06**			
	Range:	**Min**	**1.4E-06**			
		Max	**3.4E-06**			
AP10a	FHT 1	Unconfined	*Not analysed*	*WL within screen; screen not developed above WL*	3 m Screen 15.5 - 18.5 m	Flow rhyolite, MW-SW
	RHT 1		2.5E-04	Springer-Gelhar, 1991 (Unconfined, inertial)		
	FHT 2		*Not analysed*	*WL within screen; screen not developed above WL*		
	RHT 2		9.1E-05	Springer-Gelhar, 1991 (Unconfined, inertial)		
	Geomean		**n/a**			
	Adopted value		**>1.0E-04**			
AP11a	FHT 1	Confined	*Not analysed*	*Response too slow for meaningful analysis*	3 m Screen 17 - 20 m	Flow rhyolite, MW-SW
	RHT 1		*Not analysed*	*Response too slow for meaningful analysis*		
	FHT 2		1.80E-08	Hyder et al, 1994 (KGS model)		
	RHT 2		*Not analysed*	*Response too slow for meaningful analysis*		
	Geomean		**n/a**			
	Adopted value		**<1.0E-08**			
DH14a*	RHT 1	Confined (artesian)	2.14E-04	Butler, 1998 (Confined)	No log (assumed 23-24 m from EGL table)	Redeposited Tuff - sesnsitive (inferred from AP01a log located 2.8 m away)
	RHT 2		*Not analysed*	*Rapid response*		
	RHT 3		*Not analysed*	*Rapid response*		
	Geomean		**n/a**			
	Adopted value		**>1.0E-04**			



	P64D	P64A
Geomean	6.0E-09	5.0E-04
Unit	And.	And. (vein)
Depth	47.9-53.6 m	156.4-184.5 m

	P61s	P61
Geomean	2.5E-06	7.0E-09
Unit	Ash	And.
Depth	1.5-4.5 m	37.1-49.5 m

	P60
Geomean	5.0E-07
Unit	And.
Depth	82.3 -96.6 m

	P79s	P79i	P79d
Geomean	1.3E-05	2.7E-07	4.2E-07
Unit	Ig.	RT	And.
Depth	11-12 m	40.5-41.5 m	52-55 m

	GLD01	GLD01a
Geomean	3.3E-08	<1E-08*
Unit	Ash	RT
Depth	5.5-7.5 m	11.7-13.7 m

	GLD03	GLD03a
Geomean	<4E-08	5.5E-08
Unit	Dac.	Dac.
Depth	6-8 m	17-20 m

	P68s	P68d
Geomean	6.0E-06	1.0E-05
Unit	Ash	Ig.
Depth	2.15-5.55 m	10.5-15.5 m

Paper Size A3

0 50 100 200

Metres

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

N

LEGEND

⊕ OGL Bores

⊕ Quattro Bores

Symbol	Geology
Dac.	Dacite
RT	Rhyolitic Tuff
Ash	Ash/Regolith
Ig.	Sandy Ignimbrite
And	Andesite

Note:
- All results are presented in m/s.
- P60, P61, P64, and P68 data source: URS 2003. Favona Underground Mine Assessment of Groundwater Issues
* Test was screen limited and a single value greater or less than is provided

Oceana Gold Limited
Waihi North

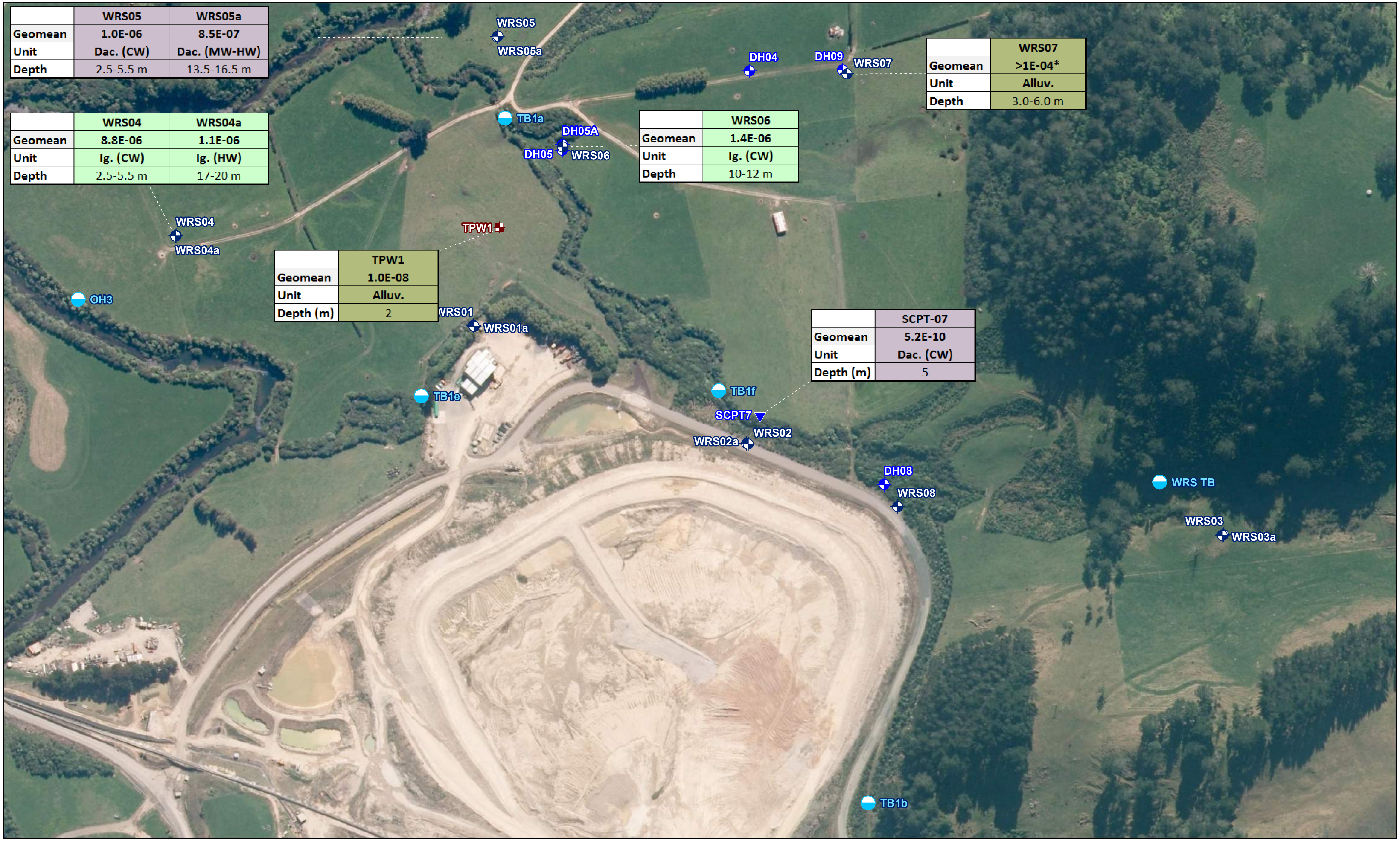
Job Number	12552081
Revision	0
Date	25 Nov 2021

Plan showing distribution of Gladstone permeability results

Figure D.1

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_D1_GladstonePermeabilityResults.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:dbbanatin



	WRS05	WRS05a
Geomean	1.0E-06	8.5E-07
Unit	Dac. (CW)	Dac. (MW-HW)
Depth	2.5-5.5 m	13.5-16.5 m

	WRS07
Geomean	>1E-04*
Unit	Alluv.
Depth	3.0-6.0 m

	WRS04	WRS04a
Geomean	8.8E-06	1.1E-06
Unit	Ig. (CW)	Ig. (HW)
Depth	2.5-5.5 m	17-20 m

	WRS06
Geomean	1.4E-06
Unit	Ig. (CW)
Depth	10-12 m

	TPW1
Geomean	1.0E-08
Unit	Alluv.
Depth (m)	2

	SCPT-07
Geomean	5.2E-10
Unit	Dac. (CW)
Depth (m)	5

Paper Size A3

0 25 50 100

Metres

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

N

LEGEND

⊕ OGL Bores

⊕ Quattro Bores

◓ Surface Water Locations

EGL

▼ CPT

▪ Test Pit

Symbol	Geology
Alluv.	Alluvium
Ig. (CW)	Ignimbrite (Completely Weathered)
Ig. (HW)	Ignimbrite (Highly Weathered)
Dac. (CW)	Dacite (Completely Weathered)
Dac. (MW-HW)	Dacite (Moderately Weathered - Highly Weathered)

Note:
All results are presented in m/s
* Test was screen limited and a single value greater or less than is provided

Oceana Gold Limited
Waihi North

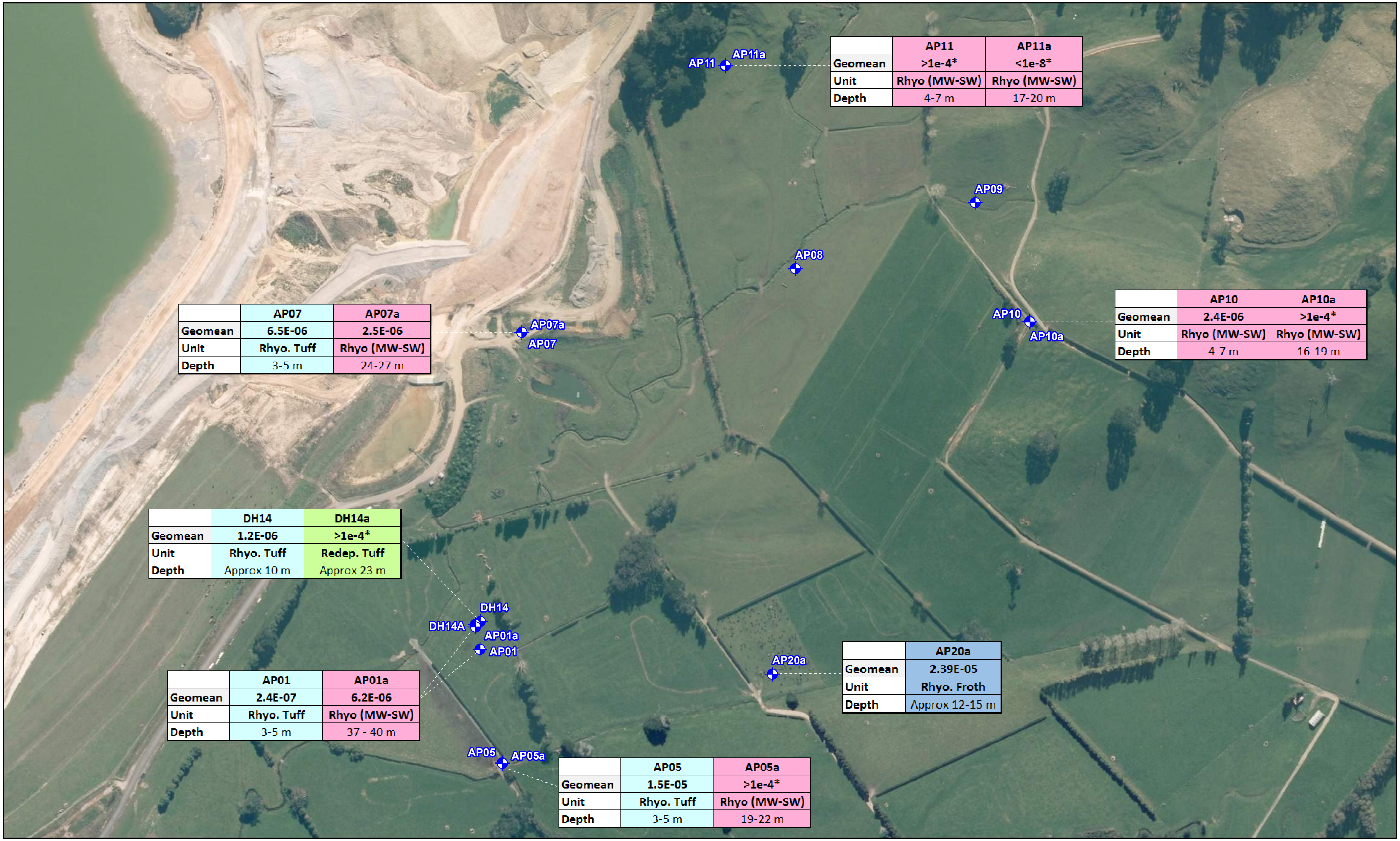
Job Number	12552081
Revision	0
Date	25 Nov 2021

Plan showing distribution of NRS permeability results

Figure D.2

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_D2_NRSPermeabilityResults.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:dbbanatin



	AP11	AP11a
Geomean	>1e-4*	<1e-8*
Unit	Rhyo (MW-SW)	Rhyo (MW-SW)
Depth	4-7 m	17-20 m

	AP07	AP07a
Geomean	6.5E-06	2.5E-06
Unit	Rhyo. Tuff	Rhyo (MW-SW)
Depth	3-5 m	24-27 m

	AP10	AP10a
Geomean	2.4E-06	>1e-4*
Unit	Rhyo (MW-SW)	Rhyo (MW-SW)
Depth	4-7 m	16-19 m

	DH14	DH14a
Geomean	1.2E-06	>1e-4*
Unit	Rhyo. Tuff	Redep. Tuff
Depth	Approx 10 m	Approx 23 m

	AP20a
Geomean	2.39E-05
Unit	Rhyo. Froth
Depth	Approx 12-15 m

	AP01	AP01a
Geomean	2.4E-07	6.2E-06
Unit	Rhyo. Tuff	Rhyo (MW-SW)
Depth	3-5 m	37 - 40 m

	AP05	AP05a
Geomean	1.5E-05	>1e-4*
Unit	Rhyo. Tuff	Rhyo (MW-SW)
Depth	3-5 m	19-22 m

Paper Size A3

0 25 50 100

Metres

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

N

LEGEND

⊕ OGL Bores

Rhyo. Tuff	Rhyolite Tuff
Alluv.	Alluvium
Redep. Tuff	Redeposited / Sensitive Tuff
Rhyo (CW-HW)	CW-HW Flow Rhyolite
Rhyo. Froth	Rhyolite - Froth Flow
Rhyo (MW-SW)	MW-SW Flow Rhyolite

Note:
All results are presented in m/s
*Test was screen limited and a single value greater or less than is provided

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	25 Nov 2021

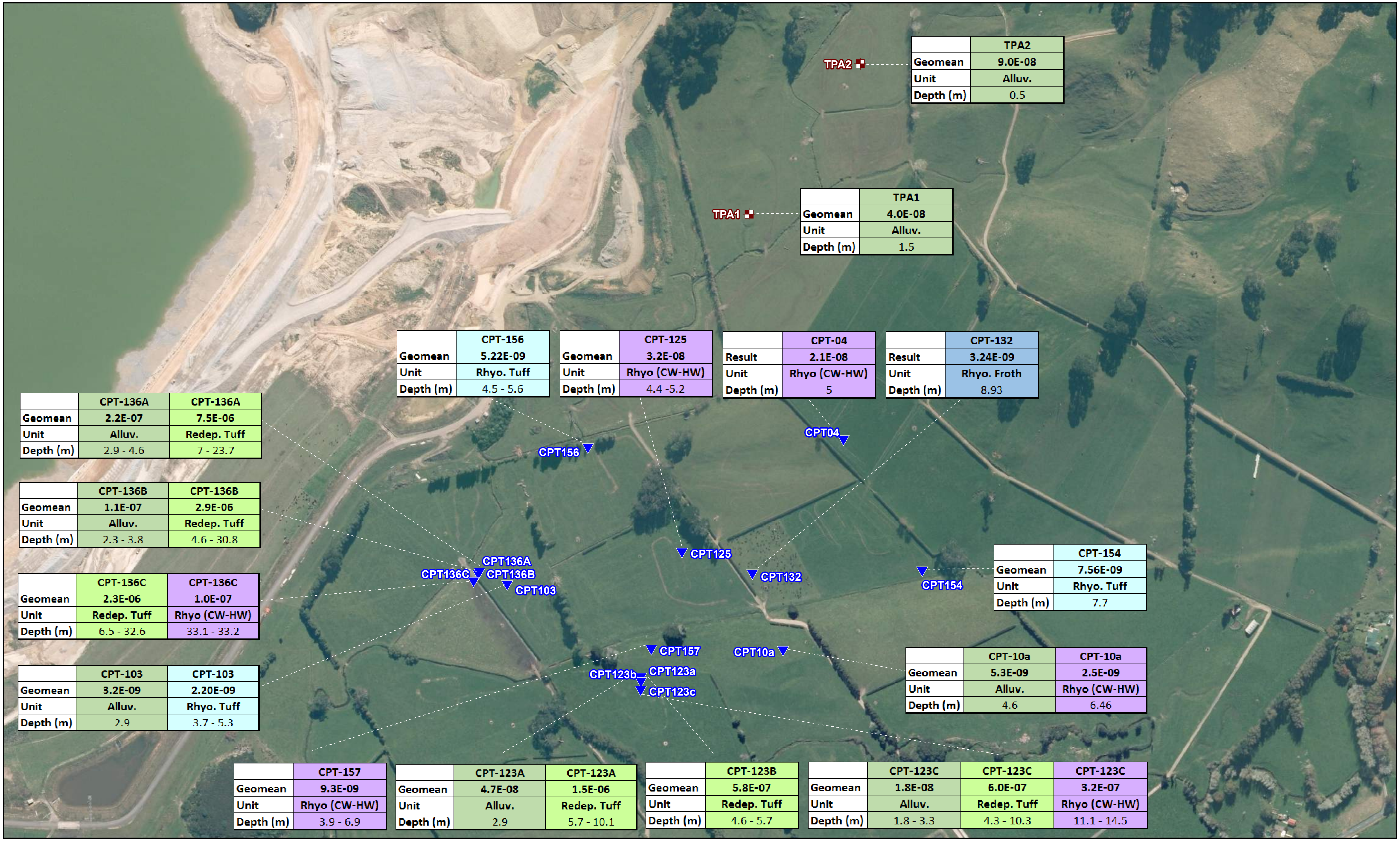
Plan showing distribution of TSF3 permeability results (GHD data)

Figure D.3

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_D3_GHD_TSF3PermeabilityResults.mxd

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: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:dbbanatin



	TPA2
Geomean	9.0E-08
Unit	Alluv.
Depth (m)	0.5

	TPA1
Geomean	4.0E-08
Unit	Alluv.
Depth (m)	1.5

	CPT-156
Geomean	5.22E-09
Unit	Rhyo. Tuff
Depth (m)	4.5 - 5.6

	CPT-125
Geomean	3.2E-08
Unit	Rhyo (CW-HW)
Depth (m)	4.4 -5.2

	CPT-04
Result	2.1E-08
Unit	Rhyo (CW-HW)
Depth (m)	5

	CPT-132
Result	3.24E-09
Unit	Rhyo. Froth
Depth (m)	8.93

	CPT-136A	CPT-136A
Geomean	2.2E-07	7.5E-06
Unit	Alluv.	Redep. Tuff
Depth (m)	2.9 - 4.6	7 - 23.7

	CPT-136B	CPT-136B
Geomean	1.1E-07	2.9E-06
Unit	Alluv.	Redep. Tuff
Depth (m)	2.3 - 3.8	4.6 - 30.8

	CPT-136C	CPT-136C
Geomean	2.3E-06	1.0E-07
Unit	Redep. Tuff	Rhyo (CW-HW)
Depth (m)	6.5 - 32.6	33.1 - 33.2

	CPT-103	CPT-103
Geomean	3.2E-09	2.20E-09
Unit	Alluv.	Rhyo. Tuff
Depth (m)	2.9	3.7 - 5.3

	CPT-154
Geomean	7.56E-09
Unit	Rhyo. Tuff
Depth (m)	7.7

	CPT-10a	CPT-10a
Geomean	5.3E-09	2.5E-09
Unit	Alluv.	Rhyo (CW-HW)
Depth (m)	4.6	6.46

	CPT-157
Geomean	9.3E-09
Unit	Rhyo (CW-HW)
Depth (m)	3.9 - 6.9

	CPT-123A	CPT-123A
Geomean	4.7E-08	1.5E-06
Unit	Alluv.	Redep. Tuff
Depth (m)	2.9	5.7 - 10.1

	CPT-123B
Geomean	5.8E-07
Unit	Redep. Tuff
Depth (m)	4.6 - 5.7

	CPT-123C	CPT-123C	CPT-123C
Geomean	1.8E-08	6.0E-07	3.2E-07
Unit	Alluv.	Redep. Tuff	Rhyo (CW-HW)
Depth (m)	1.8 - 3.3	4.3 - 10.3	11.1 - 14.5

Paper Size A3

0 50 100 200

Metres

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

N

LEGEND

▼ CPT

▣ Test Pit

Rhyo. Tuff	Rhyolite Tuff
Alluv.	Alluvium
Redep. Tuff	Redeposited / Sensitive Tuff
Rhyo (CW-HW)	CW-HW Flow Rhyolite
Rhyo. Froth	Rhyolite - Froth Flow
Rhyo (MW-SW)	MW-SW Flow Rhyolite

Note:
All results are presented in m/s

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	25 Nov 2021

Plan showing distribution of TSF3 permeability results (EGL data)

Figure D.4

N:\NZ\Christchurch\Projects\51\12552081\GIS\Maps\Deliverables\12552081_D4_EGL_TSF3PermeabilityResults.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:dbbanatin

Appendix E

Water quality

Contents:

Table E.1 Summary of Gladstone sampling

Location	Type	Total samples	Sampling commenced	Frequency
GLD01	GWQ	6	Dec-17	Bi-monthly
GLD01a	GWQ	6	Dec-17	Bi-monthly
GLD02	GWQ	8	Dec-17	Monthly
GLD02a	GWQ	8	Dec-17	Monthly
GLD03	GWQ	9	Jan-18	Monthly
GLD03a	GWQ	8	Jan-18	Monthly
P79-s	GWQ	10	Dec-17	Monthly
P79-i	GWQ	3	May-18	Periodic (Quarterly)
p79-d	GWQ	2	Jun-18	Periodic
OH6	SWQ	800+	Oct-94	Weekly
OH11	SWQ	4	Sep-18	Periodic
Glad Springs	SWQ and flow	4 / 1	Sep-17	Periodic / One-off
TB4	SWQ and flow	4 / 1	Sep-17	Quarterly / One-off (low flow)

Table E.2 Summary of NRS sampling

Location	Type	Total samples	Sampling commenced	Frequency
WRS02	GWQ	2	May-18	Periodic
WRS03	GWQ	2	May-18	Periodic
WRS03a	GWQ	2	Feb-18	Periodic
WRS04	GWQ	8	Feb-18	Monthly
WRS04a	GWQ	8	Aug-18	Monthly
WRS05	GWQ	1	May-18	One-off
WRS05a	GWQ	2	Feb-18	Monthly
WRS06	GWQ	8	Feb-18	Monthly
DH05a	GWQ	8	Feb-18	Monthly
DH05	GWQ	9	Apr-18	Monthly
WRS07	GWQ	5	Feb-18	Bi-monthly
WRS08	GWQ	8	Feb-18	Monthly
DH08	GWQ	8	May-06	Monthly
OC2	SWQ	500+	May-06	Weekly
TB1a	SWQ and Flow	200+ / 4	Mar-06 / Oct-18	6 monthly / Periodic
WRS TB	SWQ	3	Aug-18	Periodic
OH3	SWQ	1000+	Aug-07	Monthly
Frendrups	Flow	4000+	Oct-07	Daily

Table E.3 TSF3 sampling

Location	Type	Total Events	Sampling commenced	Frequency
AP01	GWQ	6	Feb-18	Periodic (bi-monthly)
AP01a	GWQ	6	Feb-18	Periodic (bi-monthly)
AP02	GWQ	1	May-18	One-off
AP02a	GWQ	1	May-18	One-off
AP05	GWQ	1	Apr-19	First sample
AP05a	GWQ	1	Apr-19	First sample
AP06	GWQ	8	Feb-18	Monthly
AP06a	GWQ	8	Feb-18	Monthly
AP07	GWQ	2	Aug-18	Monthly
AP07a	GWQ	2	Aug-18	Monthly
DH10	GWQ	2	May-18	Periodic
DH10a	GWQ	2	May-18	Periodic
AP11	GWQ	2	Jan-18	Periodic (6 monthly)
AP11a	GWQ	3	Aug-18	Periodic (6 monthly)
AP20	GWQ	7	Apr-18	Monthly
DH23	GWQ	5	Apr-18	Periodic
DH23A	GWQ	3	Aug-18	monthly
DH12	GWQ	3	Aug-18	monthly
DH11	GWQ	2	Sep-18	Periodic
RU1	SWQ	3	May-18	Monthly
RU3	SWQ	1	May-18	One-off
RU6	Flow	500+	Feb-94	Monthly
TB1b***	SWQ	100+	Feb-94	Monthly
RU7	Flow	3	Oct-18	Periodic
RU10	SWQ	150+	Mar-06	Periodic
Ruddocks	Flow	3	Oct-18	Periodic
OH5	SWQ	200+	Jul-07	Monthly
Shed Springs	SWQ	4000+	Oct-07	Daily

Table E.4 Summary of Gladstone groundwater quality

2017-2019 Water Quality Sampling

Parameter	GLD01	n= 7		GLD01a	n= 7		GLD02	n= 10		GLD02a	n= 10		GLD03	n= 10		GLD03a	n= 9	
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	3.2	3.4	9	11	19.1	50	1.7	3	4.3	39	53	70	5.6	7.75	20	3.8	4.9	28
Aluminium-Dissolved(g/m3)	0.032	0.036	0.168	0.01	0.017	0.106	0.007	0.046	0.164	0.003	0.003	0.005	0.011	0.015	0.141	0.004	0.012	0.016
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0002	0.0002	0.0002	0.001	0.00175	0.069	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.0015	0.0014	0.0022	0.0051	0.001	0.001	0.0014	0.034	0.072	0.147	0.001	0.001	0.0012	0.001	0.001	0.0031
Barium-Dissolved(g/m3)	0.055	0.073	0.082	0.057	0.058	0.068	0.027	0.0365	0.053	0.023	0.026	0.031	0.031	0.033	0.034	0.027	0.0285	0.031
Bicarbonate (g/m3 at 25Â°C)	3.9	4.1	11	13.4	23	60	2.1	3.7	5.2	47	65	85	6.8	9.45	25	4.6	6	34
Boron-Dissolved(g/m3)	0.008	0.01	0.01	0.011	0.013	0.02	0.006	0.008	0.009	0.008	0.014	0.018	0.006	0.0085	0.01	0.006	0.008	0.009
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0001	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Caesium - Dissolved (g/m3)(g/m3)	0.00038	0.000495	0.00052	0.00078	0.000805	0.00127	0.00055	0.000665	0.00082	0.005	0.0055	0.0091	0.00071	0.00076	0.00082	0.00058	0.0006	0.00062
Calcium-Dissolved(g/m3)	3.1	4.6	6	4.7	6.9	14.3	0.56	1.54	4.9	29	80	142	0.82	1.285	3.5	0.61	0.83	1.98
Chloride(g/m3)	14	19	22	12	15	16	10	13	14	5	28	34	11	13	15	6	7.9	9
Chromium-Dissolved(g/m3)	0.0005	0.0005	0.001	0.0005	0.0005	0.0006	0.0005	0.0005	0.0008	0.0005	0.0005	0.0013	0.0005	0.0005	0.0007	0.0005	0.0005	0.001
Cobalt-Dissolved(g/m3)	0.0006	0.0008	0.0013	0.0002	0.0005	0.0027	0.0005	0.0011	0.0186	0.0003	0.0114	0.029	0.0002	0.0003	0.001	0.0002	0.0005	0.0008
Copper-Dissolved(g/m3)	0.0005	0.002	0.046	0.0005	0.0005	0.0011	0.0005	0.00065	0.0015	0.0005	0.0005	0.0035	0.0005	0.0005	0.0024	0.0005	0.0005	0.0009
Electrical Conductivity (EC) (mS/m)	14	19.1	24.5	14.4	20.2	33.3	0.1	7.9	11.3	21.9	96.35	134.2	8.2	9.1	13	4.8	5	10.8
Hardness-Total(g/m3 as CaCO3)	20	21	31	28	32	56	3	9	21	91	360	400	7.8	9.1	13.3	3.4	4.6	7.1
Iron-Dissolved(g/m3)	0.05	0.08	0.26	0.35	3.6	5.2	0.02	0.02	1.2	0.02	0.045	0.7	0.02	0.02	0.07	0.02	0.02	0.02
Lanthanum - Dissolved (g/m3)(g/m3)	0.00013	0.000215	0.00027	0.00022	0.000245	0.00026	0.0001	0.00013	0.00042	0.00027	0.00064	0.00106	0.0001	0.00012	0.00025	0.00013	0.000135	0.00032
Lead-Dissolved(g/m3)	0.00013	0.00016	0.00023	0.0001	0.0001	0.0001	0.0001	0.0001	0.00031	0.0001	0.0001	0.00013	0.0001	0.0001	0.00011	0.0001	0.0001	0.00014
Lithium - Dissolved (g/m3)(g/m3)	0.0011	0.0019	0.0021	0.0113	0.0127	0.0163	0.0013	0.00165	0.0033	0.0063	0.076	0.1	0.0012	0.00315	0.0034	0.0022	0.0034	0.0041
Magnesium-Dissolved(g/m3)	2.4	3.3	3.9	3.9	5.4	9.1	0.4	1.4	2.1	4.4	45.5	66	1.12	1.235	1.34	0.43	0.47	1.17
Manganese-Dissolved(g/m3)	0.022	0.04	0.063	0.057	0.11	0.3	0.0076	0.0255	0.79	0.0042	0.149	0.27	0.0031	0.0055	0.048	0.0024	0.0087	0.0142
Mercury-Dissolved(g/m3)	0.0042	0.0055	0.0119	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0006	0.0002	0.0002	0.0002	0.0004	0.0008	0.0049	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0019	0.0025	0.0034	0.0019	0.0035	0.062	0.0005	0.00055	0.0049	0.0018	0.01005	0.024	0.0005	0.0005	0.0035	0.0005	0.0005	0.0066
Nitrate-N(g/m3)	0.76	2.6	3.4	0.002	0.02	0.089	1.66	1.75	3.6	0.002	0.019	1.64	1.76	2.2	2.8	0.048	0.11	0.171
Nitrate-N + Nitrite-N(g/m3)	0.36	2.6	4.5	0.002	0.002	0.095	1.61	1.76	3.6	0.002	0.0215	1.64	1.76	2.2	2.8	0.021	0.091	0.22
Nitrite-N(g/m3)	0.003	0.014	0.034	0.002	0.006	0.02	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002
Nitrogen-Total(g/m3)	0.49	2.85	4.6	0.26	0.39	3.6	1.77	2.5	3.3	0.35	0.87	1.63	2.2	2.4	2.6	0.11	0.135	0.3
Nitrogen-Total Ammoniacal(g/m3)	0.035	0.0625	0.073	0.17	0.285	3.1	0.01	0.011	0.018	0.039	0.189	0.37	0.01	0.01	0.01	0.01	0.01	0.01
pH(pH units)	5.1	5.4	6	5.8	6	6.5	4.8	5	5.7	6.2	6.45	7.2	5.6	6	6.3	5.4	5.8	6.6
Potassium-Dissolved(g/m3)	2.2	3	4.8	3.1	3.6	4.6	0.64	1.365	4.2	7.6	12.55	15.6	0.81	0.925	10.3	0.49	0.76	1.92
Rubidium - Dissolved (g/m3)(g/m3)	0.0057	0.0073	0.0079	0.0118	0.01195	0.0154	0.0028	0.0031	0.004	0.05	0.058	0.075	0.00198	0.0021	0.0025	0.00193	0.002065	0.0042
Selenium-Dissolved(g/m3)	0.001	0.001	0.0011	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	13.6	22	32	13.8	19.4	22	7.3	9.05	9.7	8	48.5	52	8.7	13	15.9	6.4	7	15.9
Strontium-Dissolved(g/m3)	0.028	0.0365	0.039	0.044	0.0555	0.092	0.0105	0.0124	0.0175	0.51	0.64	0.9	0.0082	0.0096	0.0098	0.0064	0.0064	0.0173
Sulphate(g/m3)	17	37	48	28	47	76	5	6	9	25	410	650	5	6.5	8	3.5	6	8
Sum of Anions(meq/L)	1.03	1.44	1.97	1.15	1.42	2.4	0.56	0.655	0.81	2.2	10.2	10.6	0.77	0.85	1.1	0.39	0.45	0.51
Sum of Cations(meq/L)	1.14	1.43	2.1	1.25	1.57	2.4	0.42	0.62	0.88	2.4	9.5	10.5	0.56	0.84	1.12	0.39	0.43	0.74
Thallium-Dissolved(g/m3)	0.00008	0.000095	0.00011	0.00005	0.00005	0.00005	0.00006	0.000075	0.00054	0.00005	0.00009	0.00042	0.00005	0.00005	0.00005	0.00007	0.00007	0.00007
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0018	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.12	0.13	0.16	0.26	0.385	3.6	0.15	0.16	1.45	0.34	0.52	0.86	0.1	0.13	0.19	0.1	0.1	0.1
Total Suspended Solids(g/m3)	3	3	11	4	12.5	117	25	139	1760	14	37	154	3	4	20	3	3	3
Uranium-Dissolved(g/m3)	0.00002	0.000025	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Vanadium - Dissolved (g/m3)(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Weak Acid Dissociable (WAD) Cyanide(g/m3	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.0029	0.001	0.001	0.002	0.001	0.0015	0.002
Zinc-Dissolved(g/m3)	0.0029	0.0057	0.0093	0.0014	0.0027	0.051	0.0025	0.0047	0.03	0.0068	0.01695	0.074	0.0034	0.0043	0.013	0.0024	0.003	0.0054

Notes:
** Only one sample round from 2020*
Blank cells indicate parameter not tested
Sample number indicates max sample size for individual parameters
Not all parameters tested during each sample round

Table E.4 Summary of Gladstone groundwater quality

2017-2019 Water Quality Sampling

Parameter	P79-s	n= 12		P79-i	n= 4		P79-d	n= 2		GLD04-s	GLD04-i	GLD04-d
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Median*	Median*	Median*
Alkalinity - Total (g/m3 as CaCO3)	4.9	5.7	6.9	49	50.5	52	30	32	34	65	22	39
Aluminium-Dissolved(g/m3)	0.012	0.014	0.087	0.003	0.003	0.009	0.003	0.004	0.005	0.088	0.057	0.06
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0007	0.00425	0.0078	0.0002	0.0003	0.0015
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.0192	0.0235	0.029	0.0054	0.0083	0.0112	0.001	0.0016	0.001
Barium-Dissolved(g/m3)	0.09	0.1	0.103							0.14	0.081	0.107
Bicarbonate (g/m3 at 25Â°C)	6	6.9	8.4	60	61	63	37	39	41	79	27	47
Boron-Dissolved(g/m3)	0.007	0.0115	0.016	0.015	0.016	0.017	0.021	0.0225	0.024	0.088	0.023	0.038
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00008	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Caesium - Dissolved (g/m3)(g/m3)	0.00089	0.001015	0.00109							0.00094	0.00145	0.002
Calcium-Dissolved(g/m3)	5.1	5.45	6.1	13.1	13.7	14.2	6.2	8	9.8	10.5	7.5	25
Chloride(g/m3)	19	23	29	8	9	11.5	11	11.5	12	9	10	11
Chromium-Dissolved(g/m3)	0.0005	0.0005	0.0007	0.0005	0.0005	0.0006	0.0005	0.00055	0.0006	0.0005	0.0005	0.0005
Cobalt-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0165	0.0165	0.0032
Copper-Dissolved(g/m3)	0.0005	0.0005	0.001	0.0005	0.0005	0.0011	0.0005	0.00055	0.0006	0.0014	0.0005	0.0005
Electrical Conductivity (EC) (mS/m)	14.8	16.7	17.2	15.9	16.45	17.1	16	16.35	16.7	19.2	15.9	29.4
Hardness-Total(g/m3 as CaCO3)	23	24.5	27	41	45	46	32	35	38			
Iron-Dissolved(g/m3)	0.02	0.02	0.02	0.33	1.19	1.74	0.08	0.54	1	0.03	0.57	1.18
Lanthanum - Dissolved (g/m3)(g/m3)	0.00014	0.000155	0.00018							0.00024	0.0001	0.0001
Lead-Dissolved(g/m3)	0.0001	0.0001	0.00011	0.0001	0.000155	0.00033	0.0001	0.00013	0.00016	0.0001	0.0001	0.0001
Lithium - Dissolved (g/m3)(g/m3)	0.0008	0.0009	0.001	0.014	0.0161	0.0168	0.025	0.028	0.031	0.0179	0.0176	0.027
Magnesium-Dissolved(g/m3)	2.4	2.8	3.1	2.1	2.65	2.7	3.4	3.7	4	2.8	4.4	7.7
Manganese-Dissolved(g/m3)	0.0142	0.0157	0.0168	0.036	0.0785	0.141	0.038	0.1055	0.173	0.43	0.81	0.25
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.00025	0.0003	0.0002	0.0002	0.0002	0.0007	0.0004	0.0026
Nickel-Dissolved(g/m3)	0.0005	0.0005	0.002	0.0005	0.0005	0.0005	0.0006	0.00075	0.0009	0.0089	0.0081	0.0033
Nitrate-N(g/m3)	2.3	2.7	2.9	0.002	0.005	0.039	0.002	0.07	0.138			
Nitrate-N + Nitrite-N(g/m3)	2.1	2.55	2.9	0.003	0.007	0.039	0.002	0.0705	0.139	0.121	0.02	0.012
Nitrite-N(g/m3)	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002			
Nitrogen-Total(g/m3)	2.1	2.3	3.1							0.27	0.14	0.17
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.01	0.01							0.01	0.01	0.013
pH(pH units)	5.4	5.6	6	7.4	7.8	8	6.8	6.9	7	6.8	6.6	6.8
Potassium-Dissolved(g/m3)	4.8	5.5	5.9	3.7	3.85	3.9	2.7	2.75	2.8	3.5	4.6	6.3
Rubidium - Dissolved (g/m3)(g/m3)	0.0148	0.016	0.0171							0.0157	0.0173	0.028
Selenium-Dissolved(g/m3)	0.001	0.001	0.001							0.001	0.001	0.001
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001							0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	13.7	16.25	17.5	13	13.8	14	14.8	15.75	16.7	24	11.6	15
Strontium-Dissolved(g/m3)	0.033	0.036	0.038							0.085	0.049	0.104
Sulphate(g/m3)	12	17	20	12.4	14.5	16	19	21.5	24	17	31	78
Sum of Anions(meq/L)	1.16	1.285	1.47	1.5	1.58	1.59	1.39	1.41	1.43			
Sum of Cations(meq/L)	1.19	1.37	1.44	1.53	1.655	1.68	1.48	1.485	1.49			
Thallium-Dissolved(g/m3)	0.00005	0.00005	0.00005							0.00026	0.00127	0.00014
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00065	0.0008	0.0008	0.0008	0.0038
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.1	0.16							0.15	0.13	0.16
Total Suspended Solids(g/m3)	3	3	3							430	14	61
Uranium-Dissolved(g/m3)	0.00003	0.00003	0.00004							0.00003	0.00002	0.00003
Vanadium - Dissolved (g/m3)(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Weak Acid Dissociable (WAD) Cyanide(g/m3	0.001	0.001	0.002							0.002	0.002	0.002
Zinc-Dissolved(g/m3)	0.0038	0.00555	0.0111	0.001	0.0024	0.0154	0.0088	0.0654	0.122	0.13	0.05	0.17

Notes:
** Only one sample round from 2020*
Blank cells indicate parameter not tested
Sample number indicates max sample size for individual parameters
Not all parameters tested during each sample round

Table E.5 Summary of Gladstone surface water quality

2017-2019 Water Quality Sampling

Parameter	OH6	n= 188		OH11	n= 7		TB4	n= 7		TB5	n= 2		GLAD Spring A	n= 4		GLAD Spring B	n= 4	
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	8.3	15.8	26	12.5	16.7	27	6.4	8	19.7		3		5.7	6.15	6.9	4.1	4.75	5.9
Aluminium-Dissolved(g/m3)				0.005	0.01	0.017	0.032	0.07	0.077		0.066		0.017	0.0295	0.051	0.013	0.03	0.044
Antimony-Dissolved(g/m3)	0.0002	0.0006	0.0034	0.0002	0.0011	0.0067	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)				0.03	0.033	0.034	0.037	0.041	0.048				0.019	0.024	0.031	0.02	0.029	0.03
Bicarbonate (g/m3 at 25Â°C)	10.1	19.2	32	15.2	20	33	7.8	9.8	24		3.7		6.9	7.5	8.4	5	5.8	7.2
Boron-Dissolved(g/m3)				0.012	0.013	0.047	0.007	0.0075	0.009		0.017		0.006	0.009	0.009	0.005	0.009	0.009
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.000085	0.00011	0.00005	0.00005	0.00005	0.00005	0.000055	0.00006
Calcium-Dissolved(g/m3)	3.3	48	169	33	68	270	2.2	2.8	3.2	4.6	5.3	6	5.4	6.5	7.9	4.7	5.05	5.8
Carbonate (g/m3 at 25Â°C)	1	1	1					1						1			1	
Chloride(g/m3)	11	16	27	12	16	27	7	12	16		8		10.7	12	14	10.2	12.5	14
Chromium-Dissolved(g/m3)				0.0005	0.0007	0.0009		0.0005			0.0005		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chromium-Hexavalent(g/m3)	0.001	0.01	0.01					0.001			0.01			0.001			0.001	
Chromium-Total(g/m3)							0.00053	0.00053	0.00053					0.00053			0.0024	
Cobalt-Dissolved(g/m3)	0.0002	0.0009	0.0026	0.0003	0.0006	0.0046	0.0002	0.0002	0.0015	0.0005	0.0005	0.0005	0.0003	0.00045	0.0006	0.0002	0.0002	0.0004
Copper-Dissolved(g/m3)	0.0005	0.0005	0.0102	0.0005	0.0014	0.0062	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Cyanide-Total(g/m3)	0.001	0.002	0.003					0.001						0.001			0.001	
Electrical Conductivity (EC) (mS/m)	7.5	36.9	107.6	31.3	50.7	150	7.4	8	9.4	9.5	10.3	11.1	10.3	11.85	13.5	10.1	10.25	11
Fluoride (g/m3)	0.05	0.05	0.11					0.05						0.05			0.05	
Hardness-Total(g/m3 as CaCO3)	13.9	138	510	101	300.5	730	11.6	14.3	15.6	19.3	22.15	25	30	31	32	19.9	21.95	24
Iron-Dissolved(g/m3)	0.03	0.08	0.27	0.04	0.06	0.11	0.21	0.3	2.4	0.02	0.02	0.02	0.02	0.02	0.05	0.02	0.06	0.2
Iron-Total(g/m3)								0.38						0.09			3	
Lead-Dissolved(g/m3)	0.0001	0.0001	0.00028	0.0001	0.0001	0.00013	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Magnesium-Dissolved(g/m3)	1.2	4.4	21	4.3	5.3	15.8	1.46	1.56	1.89	1.89	2.195	2.5	1.87	2.4	3	1.7	1.89	2.3
Manganese-Dissolved(g/m3)	0.0114	0.01925	0.113	0.0101	0.0154	0.022	0.025	0.03	0.44	0.0141	0.01445	0.0148	0.0139	0.01535	0.025	0.0136	0.01485	0.042
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)				0.0002	0.0005	0.0064	0.0002	0.0002	0.0002		0.0002		0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0007	0.0005	0.0005	0.0005	0.0005	0.00065	0.0008	0.0008	0.0011	0.0014	0.0005	0.0005	0.0007
Nitrate-N(g/m3)	0.12	0.81	1.41	0.45	1.145	2.2	0.049	0.146	0.32		1.14			0.78			0.39	
Nitrate-N + Nitrite-N(g/m3)	0.12	0.98	1.42	0.32	1.06	2.6	0.051	0.32	0.65		1.14		0.59	0.9	1.65	0.39	0.87	1.27
Nitrite-N(g/m3)	0.054	0.1	0.33	0.015	0.089	0.42	0.002	0.006	0.1		0.002			0.1			0.1	
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.121	0.69	0.038	0.13	0.26	0.01	0.016	0.022	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.011	0.019
pH(pH units)	6.5	7.1	7.8	7	7.2	7.6	6	6.6	6.7	5.6	6.05	6.5	5.5	5.8	6	5.6	5.95	6.3
Phosphorus-Total (g/m3)	0.004	0.01	0.44					0.012			0.007			0.004			0.018	
Potassium-Dissolved(g/m3)	2.5	3.6	9.4	2.7	3.7	12	1.08	1.56	2.3		2.1		1.35	1.785	1.97	1.15	1.445	4.3
Reactive Phosphorus-Dissolved(g/m3)	0.004	0.004	0.012		0.004		0.004	0.004	0.004		0.004			0.004			0.004	
Selenium-Dissolved(g/m3)	0.0002	0.001	0.0048	0.001	0.001	0.0013	0.001	0.001	0.001		0.001		0.001	0.001	0.001	0.001	0.001	0.001
Silica-Reactive(g/m3 as SiO2)	16.3	25	31					16.1						14.2			13	
Silver-Dissolved(g/m3)	0.0001	0.0001	0.00015	0.0001	0.0001	0.00014	0.0001	0.0001	0.0001		0.0001		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	8.4	17.7	50	13	20	62	7.9	8.5	9.3		8.3		8.8	9.35	10.3	8.9	9.45	9.5
Strontium-Dissolved(g/m3)				0.193	0.22	0.5	0.0163	0.0174	0.021				0.022	0.023	0.03	0.02	0.021	0.021
Sulphate(g/m3)	16	210	520	93	192	720	0.9	6	10		18		18	20.85	30	14.8	16	27
Thallium-Dissolved(g/m3)				0.00005	0.00006	0.00008	0.00005	0.00005	0.00005				0.00006	0.00007	0.00009	0.00005	0.00005	0.00009
Tin-Dissolved(g/m3)				0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		0.0005		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.415	1.43	0.16	0.28	0.58	0.13	0.195	0.2		0.2		0.1	0.185	0.22	0.15	0.46	0.82
Total Suspended Solids(g/m3)	3	3	230	3	3	3	3	3	5		3		3	15	40	28	50	109
Uranium-Dissolved(g/m3)				0.00002	0.00002	0.00002	0.00002	0.00002	0.00002				0.00002	0.00002	0.00002	0.00002	0.00002	0.00004
Weak Acid Dissociable (WAD) Cyanide(g/m3	0.001	0.002	0.007	0.002	0.002	0.005	0.001	0.001	0.003		0.001		0.001	0.001	0.002	0.001	0.001	0.002
Zinc-Dissolved(g/m3)	0.001	0.0023	0.055	0.001	0.0018	0.0038	0.0026	0.004	0.0105	0.0145	0.0147	0.0149	0.0021	0.00315	0.004	0.0023	0.003	0.0037

Notes:
Blank cells indicate parameter not tested, median only indicates only one sample for specific parameter
Sample number indicates max sample size for individual parameters - Not all parameters tested during each sample round

Table E.5 Summary of Gladstone surface water quality

2017-2019 Water Quality Sampling

Parameter	GLAD Spring C	n= 4		GLAD Spring D	n= 4	
	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	3.5	3.7	4.1	6.8	8.2	9.6
Aluminium-Dissolved(g/m3)	0.019	0.0275	0.032	0.036	0.073	0.094
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)	0.019	0.026	0.033	0.036	0.039	0.042
Bicarbonate (g/m3 at 25Â°C)	4.3	4.5	5	8.3	9.95	11.7
Boron-Dissolved(g/m3)	0.007	0.009	0.01	0.008	0.008	0.01
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Calcium-Dissolved(g/m3)	2.1	2.85	3.9	2.7	2.75	3
Carbonate (g/m3 at 25Â°C)		1			1	
Chloride(g/m3)	12.7	13.6	15	15	16	17.2
Chromium-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006
Chromium-Hexavalent(g/m3)		0.001			0.001	
Chromium-Total(g/m3)		0.00053			0.00053	
Cobalt-Dissolved(g/m3)	0.0002	0.00025	0.0003	0.0002	0.0002	0.0002
Copper-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Cyanide-Total(g/m3)		0.001			0.001	
Electrical Conductivity (EC) (mS/m)	7.4	8.35	10.4	9.1	9.45	9.7
Fluoride (g/m3)		0.05			0.05	
Hardness-Total(g/m3 as CaCO3)	11.6	14.75	17.9	15.4	16.05	16.7
Iron-Dissolved(g/m3)	0.02	0.02	0.02	0.04	0.045	0.05
Iron-Total(g/m3)		0.035			0.084	
Lead-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Magnesium-Dissolved(g/m3)	1.12	1.465	1.94	1.91	1.98	2.2
Manganese-Dissolved(g/m3)	0.0036	0.0061	0.0082	0.0099	0.01125	0.0155
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Nitrate-N(g/m3)		0.9			0.63	
Nitrate-N + Nitrite-N(g/m3)	0.77	1.035	1.59	0.63	0.755	0.87
Nitrite-N(g/m3)		0.1			0.1	
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.01	0.01	0.01	0.01	0.012
pH(pH units)	5.3	5.7	6.2	5.5	5.75	6
Phosphorus-Total (g/m3)		0.004			0.006	
Potassium-Dissolved(g/m3)	1.48	1.855	2.2	1.66	1.83	2.2
Reactive Phosphorus-Dissolved(g/m3)		0.004			0.004	
Selenium-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001
Silica-Reactive(g/m3 as SiO2)		11.2			18.6	
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	8.2	8.55	9.9	9.7	10.25	10.5
Strontium-Dissolved(g/m3)	0.0112	0.0148	0.0187	0.019	0.0191	0.022
Sulphate(g/m3)	6.5	9.75	13	7	7.4	9
Thallium-Dissolved(g/m3)	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.25	0.37	0.12	0.215	0.23
Total Suspended Solids(g/m3)	3	52	71	3	10.5	16
Uranium-Dissolved(g/m3)	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
Weak Acid Dissociable (WAD) Cyanide(g/m3	0.001	0.001	0.002	0.001	0.001	0.003
Zinc-Dissolved(g/m3)	0.0017	0.00225	0.0049	0.0023	0.0024	0.0028

Notes:
Blank cells indicate parameter not tested, median only indicates only one sample for specific parameter
Sample number indicates max sample size for individual parameters - Not all parameters tested during each sample round

Table E.6 Summary of NRS groundwater quality

2017-2019 Water Quality Sampling

Parameter	DH05	n= 10		WRS06	n= 10		DH05a	n= 10		WRS08	n= 10		DH08	n= 10		WRS07	n= 7	
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	6.1	6.55	7.8	23	25	27	28	33	37	27	38	55	19.1	23.5	24	2.4	3.6	4.4
Aluminium-Dissolved(g/m3)	0.012	0.017	0.039	0.003	0.003	0.011	0.003	0.003	0.006	0.013	0.037	0.159	0.006	0.0345	0.074	0.023	0.028	0.033
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0096	0.0152	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)	0.053	0.055	0.055	0.191	0.196	0.2	0.6	0.67	0.77	0.055	0.0575	0.058	0.093	0.105	0.112		0.169	
Bicarbonate (g/m3 at 25Â°C)	7.4	8	9.5	28	30.5	33	35	40	45	33	46	67	23	28.5	30	2.9	4.4	5.4
Boron-Dissolved(g/m3)	0.012	0.0135	0.017	0.008	0.012	0.014	0.005	0.008	0.01	0.009	0.012	0.013	0.011	0.0145	0.015	0.13	0.2	0.37
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Caesium - Dissolved (g/m3)(g/m3)	0.00184	0.0023	0.0023	0.0016	0.00163	0.00168	0.00119	0.001255	0.00128	0.00097	0.001955	0.002	0.0001	0.0001	0.0001		0.00064	
Calcium-Dissolved(g/m3)	1.96	2.1	2.3	1.77	1.83	2.1	2.5	2.7	6.1	5	6.95	12.9	3.1	4.7	5.1	3.7	4	5.6
Chloride(g/m3)	11	14	16	7	10.5	12	7	9	11	5	10	14	8	10	13	15	18	19
Chromium-Dissolved(g/m3)	0.0005	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0008	0.0005	0.0005	0.0007	0.0005	0.00055	0.0011	0.0005	0.0005	0.0005
Cobalt-Dissolved(g/m3)	0.0002	0.0002	0.0003	0.0046	0.00535	0.0057	0.0002	0.0405	0.063	0.0002	0.0002	0.0008	0.0002	0.0002	0.0002	0.0004	0.0005	0.0005
Copper-Dissolved(g/m3)	0.0005	0.00055	0.0013	0.0005	0.0005	0.0007	0.0005	0.0005	0.0008	0.0008	0.00105	0.0019	0.0005	0.00055	0.0011	0.0005	0.0005	0.0005
Electrical Conductivity (EC) (mS/m)	7.7	8.35	8.6	8	8.7	8.9	9.6	10.25	11	21.2	23	27.4	8.4	9.15	9.4	12.3	13.5	15.7
Hardness-Total(g/m3 as CaCO3)	12.3	12.5	14.6	7.5	7.95	8.9	11.5	12.55	23	23	30.5	43	10	13.55	15.5	23	25.5	33
Iron-Dissolved(g/m3)	0.02	0.02	0.02	4.9	5.5	6.2	0.02	6.8	11.2	0.02	0.025	0.17	0.02	0.02	0.03	0.02	0.02	0.02
Lanthanum - Dissolved (g/m3)(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00011	0.000175	0.00026	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
Lead-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.000155	0.00064	0.0001	0.0001	0.0001	0.00049	0.00076	0.00186	0.0001	0.00013	0.00015
Lithium - Dissolved (g/m3)(g/m3)	0.0018	0.0019	0.0021	0.0019	0.0021	0.0022	0.0021	0.0023	0.0027	0.0047	0.00825	0.0112	0.0065	0.007	0.0075	0.0022	0.0024	0.0032
Magnesium-Dissolved(g/m3)	1.67	1.8	2.1	0.69	0.76	0.88	1.12	1.205	1.9	2.4	2.7	4	0.55	0.685	0.82	3.2	3.9	4.6
Manganese-Dissolved(g/m3)	0.0166	0.02	0.024	0.4	0.42	0.45	0.0088	1.535	2.7	0.0027	0.01025	0.043	0.0005	0.0005	0.0017	0.0042	0.0051	0.0069
Mercury-Acid Soluble(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.001	0.0012	0.0002	0.00035	0.0005	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0005	0.0005	0.0006	0.0007	0.00195	0.0173	0.0005	0.00505	0.011	0.0014	0.0027	0.0072	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Nitrate-N(g/m3)	0.64	0.92	1.16	0.002	0.003	0.016	0.012	0.0505	1.39	0.64	0.815	0.96	0.065	0.088	0.21	2.5	3.2	3.9
Nitrate-N + Nitrite-N(g/m3)	0.64	1.04	1.19	0.002	0.0025	0.016	0.009	0.0185	1.39	0.59	0.87	1.14	0.065	0.0795	0.21	2.5	3.3	3.9
Nitrite-N(g/m3)	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.0055	0.023	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nitrogen-Total(g/m3)	1.06	1.2	1.27	0.11	0.11	0.11	0.1	0.105	0.12	0.71	0.975	1.2	0.11	0.125	0.16		3.7	
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.01	0.011	0.015	0.0175	0.018	0.06	0.0635	0.067	0.01	0.01	0.01	0.01	0.01	0.01		0.01	
pH(pH units)	5.4	5.75	6.1	6.2	6.4	6.7	6.4	6.5	7	6.1	6.7	7	6.3	6.55	7.2	5	5.4	5.7
Potassium-Dissolved(g/m3)	1.77	2	2.3	2	2.1	2.2	2.1	2.25	4.5	8	9.3	11.8	4	4.2	4.5	5.9	6.4	7.3
Rubidium - Dissolved (g/m3)(g/m3)	0.0062	0.0067	0.0069	0.0086	0.0089	0.009	0.011	0.01145	0.0115	0.023	0.0345	0.036	0.0161	0.01635	0.0166		0.0135	
Selenium-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0012	0.0014	0.0019	0.001	0.001	0.001		0.001	
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.0001	
Sodium-Dissolved(g/m3)	7.9	8.85	9.5	8.4	9.5	11.1	9.3	9.9	10.9	24	28.5	34	9.3	9.9	10.4	8.6	9.3	9.7
Strontium-Dissolved(g/m3)	0.021	0.022	0.024	0.0162	0.01655	0.0171	0.022	0.0235	0.025	0.043	0.0465	0.118	0.037	0.0385	0.04		0.049	
Sulphate(g/m3)	4.2	6	7	5	5	7	5	5	6	30	42	75	2.1	5	7	10.7	13	17
Sum of Anions(meq/L)	0.63	0.7	0.72	0.79	0.86	0.95	0.97	1.015	1.06	1.93	2.045	2.3	0.64	0.78	0.86	0.93	1.06	1.16
Sum of Cations(meq/L)	0.65	0.67	0.75	0.78	0.825	0.85	1	1.02	1.15	2	2.15	2.4	0.72	0.82	0.85	0.99	1.07	1.25
Thallium-Dissolved(g/m3)	0.00005	0.00005	0.00006	0.00008	0.00009	0.00012	0.00074	0.000835	0.00101	0.00024	0.00036	0.00039	0.00005	0.00005	0.00005		0.00005	
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.12	0.1	0.1	0.1		0.19	
Total Suspended Solids(g/m3)	3	3	3	3	8.5	10	3	4	27	5	16.5	112	4	10	175		3	
Uranium-Dissolved(g/m3)	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00009	0.000105	0.00017	0.00005	0.00006	0.00007		0.00002	
Vanadium - Dissolved (g/m3)(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0012	0.00205	0.0028	0.001	0.001	0.001	0.001	0.001	0.001
Weak Acid Dissociable (WAD) Cyanide(g/m3)	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.002		0.001	
Zinc-Dissolved(g/m3)	0.0046	0.00505	0.0062	0.001	0.00125	0.0028	0.0039	0.01605	0.035	0.0032	0.00445	0.0058	0.0034	0.0049	0.0096	0.0044	0.0055	0.0088

Notes:
Blank cells indicate parameter not tested, median only indicates only one sample for specific parameter
Sample size (n) indicates max sample size for sample location - Not all parameters tested during each sample round

Table E.6 Summary of NRS groundwater quality

2017-2019 Water Quality Sampling

Parameter	DH09	n=	3	WRS02	n=	4	WRS02a	n=	3	WRS03	n=	3	WRS03a	n=	3	WRS04	n=	10
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	18.3	19.2	19.4	9.9	20.5	26	57	72	74	6	6	6.5	14.4	14.8	16.9	2.4	2.95	4.2
Aluminium-Dissolved(g/m3)	0.004	0.004	0.005	0.031	0.038	0.06	0.015	0.041	0.069	0.01	0.011	1.36	0.012	0.026	0.047	0.04	0.0825	0.31
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.0018	0.0068	0.001	0.001	0.0021	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)					0.082						0.04			0.106		0.157	0.1665	0.184
Bicarbonate (g/m3 at 25Â°C)	22	23	24	12.1	25	31	69	87	90	7.3	7.3	7.9	17.6	18	21	2.9	3.6	5.1
Boron-Dissolved(g/m3)	0.016	0.016	0.018	0.016	0.022	0.039	0.012	0.013	0.017	0.009	0.01	0.01	0.012	0.013	0.013	0.006	0.009	0.01
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00005	0.00005	0.000105	0.00017	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Caesium - Dissolved (g/m3)(g/m3)					0.0005						0.00027			0.00045		0.00024	0.00028	0.00034
Calcium-Dissolved(g/m3)	2.1	2.1	2.3	2.8	3.25	6.1	23	33	61	0.57	0.58	0.66	1.3	1.47	2	1.55	1.795	2.4
Chloride(g/m3)	9	11	11	12	16	21	9	10	14	13	13	14	10	12	12	9	14.45	16
Chromium-Dissolved(g/m3)	0.0008	0.0008	0.001	0.0005	0.00055	0.0007	0.0005	0.0005	0.0007	0.0005	0.0005	0.0035	0.0005	0.0005	0.0008	0.0005	0.0007	0.0011
Cobalt-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0093	0.0395	0.054	0.0004	0.0031	0.0086	0.0002	0.0002	0.0009	0.0002	0.0002	0.0019	0.0008	0.0009	0.0011
Copper-Dissolved(g/m3)	0.0005	0.0005	0.0008	0.0005	0.0008	0.0014	0.0005	0.0005	0.0016	0.0005	0.0005	0.0009	0.0005	0.0008	0.0009	0.0005	0.0005	0.0005
Electrical Conductivity (EC) (mS/m)	8.6	9	9.2	13.6	17.1	24.4	26.1	34.9	51.8	7.5	7.7	7.8	7.8	8.1	8.4	9.1	10.1	11.5
Hardness-Total(g/m3 as CaCO3)	8.3	8.9	9.2	18.5	18.8	24	84	115	196	5.2	5.25	5.3	6	6.25	6.5	14.9	16.7	21
Iron-Dissolved(g/m3)	0.02	0.02	0.02	1.31	1.735	2.6	0.02	0.04	1.29	0.02	0.02	1.33	0.02	0.02	0.02	0.02	0.05	0.27
Lanthanum - Dissolved (g/m3)(g/m3)					0.00054						0.0098			0.0001		0.0001	0.000165	0.00038
Lead-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00018	0.00019	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.00012
Lithium - Dissolved (g/m3)(g/m3)	0.0042	0.0048	0.0051	0.007	0.00745	0.0104	0.0065	0.0076	0.0082	0.001	0.001	0.0014	0.0027	0.0029	0.0032	0.0023	0.00255	0.0028
Magnesium-Dissolved(g/m3)	0.77	0.85	0.87	2.8	3.1	3.7	6.6	7.6	10.6	0.89	0.9	1.06	0.68	0.68	0.83	2.6	2.95	3.7
Manganese-Dissolved(g/m3)	0.0005	0.0005	0.0005	1.01	2.86	4.1	0.28	2.1	2.5	0.0052	0.0058	0.023	0.0171	0.029	0.067	0.0146	0.01885	0.023
Mercury-Acid Soluble(g/m3)	0.00008	0.00008	0.00008	0.00097	0.0049	0.0076	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00015	0.00605	0.0111	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0004	0.0005	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0005	0.0009	0.001	0.0041	0.0197	0.03	0.0005	0.001	0.0014	0.0005	0.0005	0.0028	0.0007	0.001	0.0016	0.0005	0.0005	0.0006
Nitrate-N(g/m3)	0.4	0.6	0.78	0.003	0.006	0.018	0.061	0.079	0.67	0.57	0.625	0.68	0.144	0.147	0.15	1.89	2.6	5.4
Nitrate-N + Nitrite-N(g/m3)	0.4	0.6	0.78	0.003	0.0125	0.032	0.061	0.08	0.67	0.52	0.58	0.68	0.144	0.15	0.155	1.89	2.7	5.4
Nitrite-N(g/m3)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nitrogen-Total(g/m3)					0.22						0.59			0.24		2.3	2.8	5.1
Nitrogen-Total Ammoniacal(g/m3)					0.119						0.01			0.01		0.01	0.01	0.01
pH(pH units)	6.4	6.6	6.9	5.2	5.85	6.2	6.7	6.7	6.9	5.6	5.9	6.5	6	6.3	6.9	4.8	5.25	5.6
Potassium-Dissolved(g/m3)	4.7	5.3	6	3	3.2	3.4	5.9	6.2	6.2	2.6	2.7	2.7	2.9	3	3.1	1.19	1.375	1.57
Rubidium - Dissolved (g/m3)(g/m3)					0.0116						0.0095			0.012		0.0035	0.0037	0.0037
Selenium-Dissolved(g/m3)					0.001						0.001			0.001		0.001	0.001	0.001
Silver-Dissolved(g/m3)					0.0001						0.0001			0.0001		0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	10.6	10.8	11.5	13.6	16.75	31	14.7	17.6	21	10.4	10.4	10.6	11	11	11.6	8.5	10	11
Strontium-Dissolved(g/m3)					0.035						0.008			0.0155		0.02	0.024	0.031
Sulphate(g/m3)	5	5	6	16	26	41	40	75	155	5	5	5	5	5	6	5	7.5	14
Sum of Anions(meq/L)	0.8	0.81	0.83	1.08	1.25	1.37	2.6	3.3	4.8	0.62	0.62	0.62	0.69	0.705	0.72	0.66	0.835	0.87
Sum of Cations(meq/L)	0.76	0.79	0.82	1.19	1.28	1.54	2.6	3.3	5	0.63	0.63	0.63	0.68	0.685	0.69	0.71	0.835	0.96
Thallium-Dissolved(g/m3)					0.00078						0.00005			0.00015		0.00005	0.00005	0.00005
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0013	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)					0.18						0.1			0.1		0.1	0.1	0.12
Total Suspended Solids(g/m3)					52						9			3		3	53.5	73
Uranium-Dissolved(g/m3)					0.00004						0.00004			0.00007		0.00002	0.000025	0.00005
Vanadium - Dissolved (g/m3)(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0022	0.001	0.001	0.0018	0.001	0.001	0.0011
Weak Acid Dissociable (WAD) Cyanide(g/m3)					0.0032						0.001			0.001		0.001	0.001	0.002
Zinc-Dissolved(g/m3)	0.0101	0.012	0.0125	0.0103	0.0124	0.0167	0.0056	0.0144	0.028	0.0012	0.0014	0.0032	0.0033	0.0045	0.0069	0.0022	0.0031	0.0045

Notes:
Blank cells indicate parameter not tested, median only indicates only one sample for specific parameter
Sample size (n) indicates max sample size for sample location - Not all parameters tested during each sample round

Table E.6 Summary of NRS groundwater quality

2017-2019 Water Quality Sampling

Parameter	WRS04a	n= 10		WRS05	n= 3		WRS05a	n= 5	
	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	33	35.5	49	6.4	7.6	11.1	6.4	7.6	11.1
Aluminium-Dissolved(g/m3)	0.038	0.127	0.195	0.019	0.033	0.091	0.019	0.033	0.091
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.0011	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)	0.117	0.167	0.2	0.09	0.09	0.09		0.09	
Bicarbonate (g/m3 at 25Â°C)	40	43	59	7.8	9.3	13.5	7.8	9.3	13.5
Boron-Dissolved(g/m3)	0.006	0.009	0.01	0.008	0.009	0.009	0.008	0.009	0.009
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Caesium - Dissolved (g/m3)(g/m3)	0.00074	0.000875	0.00094	0.00015	0.00015	0.00015		0.00015	
Calcium-Dissolved(g/m3)	4.8	5.4	7.4	2.4	2.8	3.8	2.4	2.8	3.8
Chloride(g/m3)	7	10	26	10	13	13	10	13	13
Chromium-Dissolved(g/m3)	0.0006	0.00095	0.0018	0.0005	0.0007	0.0009	0.0005	0.0007	0.0009
Cobalt-Dissolved(g/m3)	0.0002	0.0007	0.0039	0.0002	0.0002	0.0003	0.0002	0.0002	0.0003
Copper-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Electrical Conductivity (EC) (mS/m)	10.7	11.05	13.5	8.9	9	10.6	8.9	9	10.6
Hardness-Total(g/m3 as CaCO3)	18.7	20.5	22	16.8	18.35	19.9	16.8	18.35	19.9
Iron-Dissolved(g/m3)	0.03	0.075	1.75	0.02	0.02	0.05	0.02	0.02	0.05
Lanthanum - Dissolved (g/m3)(g/m3)	0.0001	0.000185	0.00025	0.0001	0.0001	0.0001		0.0001	
Lead-Dissolved(g/m3)	0.0001	0.0001	0.00013	0.0001	0.0001	0.00019	0.0001	0.0001	0.00019
Lithium - Dissolved (g/m3)(g/m3)	0.0068	0.0071	0.0081	0.0029	0.0034	0.006	0.0029	0.0034	0.006
Magnesium-Dissolved(g/m3)	1.63	1.79	2.1	2.4	2.5	2.6	2.4	2.5	2.6
Manganese-Dissolved(g/m3)	0.034	0.0685	0.56	0.0047	0.0108	0.024	0.0047	0.0108	0.024
Mercury-Acid Soluble(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)	0.0002	0.0004	0.0012	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0007	0.00155	0.0059	0.0005	0.0005	0.0007	0.0005	0.0005	0.0007
Nitrate-N(g/m3)	0.124	0.1835	0.47	2.8	3.35	3.9	2.8	3.35	3.9
Nitrate-N + Nitrite-N(g/m3)	0.024	0.1415	0.48	2.8	3.3	3.9	2.8	3.3	3.9
Nitrite-N(g/m3)	0.002	0.002	0.007	0.002	0.002	0.002	0.002	0.002	0.002
Nitrogen-Total(g/m3)	0.13	0.18	0.21	3.3	3.3	3.3		3.3	
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.0175	0.046	0.01	0.01	0.01		0.01	
pH(pH units)	6.2	6.65	7	5.7	5.8	5.9	5.7	5.8	5.9
Potassium-Dissolved(g/m3)	2.1	2.35	3	2.2	2.3	2.3	2.2	2.3	2.3
Rubidium - Dissolved (g/m3)(g/m3)	0.0074	0.0085	0.0092	0.006	0.006	0.006		0.006	
Selenium-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001		0.001	
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.0001	
Sodium-Dissolved(g/m3)	12.2	14.3	16.9	6.6	7.5	10.1	6.6	7.5	10.1
Strontium-Dissolved(g/m3)	0.036	0.0455	0.05	0.025	0.025	0.025		0.025	
Sulphate(g/m3)	2.8	5.5	8	5	5	6	5	5	6
Sum of Anions(meq/L)	0.97	1.075	1.57	0.74	0.825	0.91	0.74	0.825	0.91
Sum of Cations(meq/L)	1	1.075	1.16	0.73	0.82	0.91	0.73	0.82	0.91
Thallium-Dissolved(g/m3)	0.00006	0.0003	0.00039	0.00005	0.00005	0.00005		0.00005	
Tin-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.1	0.15	0.1	0.1	0.1		0.1	
Total Suspended Solids(g/m3)	5	7.5	79	9	9	9		9	
Uranium-Dissolved(g/m3)	0.00003	0.000035	0.00004	0.00003	0.00003	0.00003		0.00003	
Vanadium - Dissolved (g/m3)(g/m3)	0.001	0.0026	0.0032	0.001	0.001	0.001	0.001	0.001	0.001
Weak Acid Dissociable (WAD) Cyanide(g/m3)	0.001	0.001	0.002	0.002	0.002	0.002		0.002	
Zinc-Dissolved(g/m3)	0.0018	0.00285	0.0061	0.0029	0.0031	0.0034	0.0029	0.0031	0.0034

Notes:
Blank cells indicate parameter not tested, median only indicates only one sample for specific parameter
Sample size (n) indicates max sample size for sample location - Not all parameters tested during each sample round

Table E.7 Summary of NRS surface water quality

2017-2019 Water Quality Sampling

Parameter	OH3	n= 48		WRS TB	n= 7		TB1b	n= 8		TB1f	n= 6		TB1a	n= 9	
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Alkalinity - Total (g/m3 as CaCO3)	7.7	13.8	24	6.5	13	13.5	7.3	10.45	32	13.5	16	28	11.5	15.2	27
Aluminium-Dissolved(g/m3)				0.007	0.018	0.023	0.012	0.0175	0.05	0.013	0.019	0.021	0.011	0.026	0.042
Antimony-Dissolved(g/m3)	0.0002	0.0002	0.0007	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Arsenic-Dissolved(g/m3)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium-Dissolved(g/m3)				0.045	0.046	0.05	0.029	0.031	0.033	0.035	0.036	0.037	0.029	0.0305	0.032
Bicarbonate (g/m3 at 25Â°C)	9.4	16.8	29	7.9	15.8	16.4	8.9	12.7	38	16.4	19.5	34	14	18.5	33
Boron-Dissolved(g/m3)				0.01	0.012	0.012	0.009	0.012	0.013	0.012	0.012	0.013	0.011	0.012	0.012
Cadmium-Dissolved(g/m3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00009	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Calcium-Dissolved(g/m3)	2.6	2.95	28	0.91	1.13	2.6	2.1	5.95	25	2.5	2.8	21	3	3.7	20
Carbonate (g/m3 at 25Â°C)	1	1	1.1												
Chloride(g/m3)	9	12	14	8	10	28	6	12	16	7	10.5	22	9	11	14.7
Chromium-Dissolved(g/m3)				0.0005	0.0005	0.0007	0.0005	0.0005	0.0006	0.0005	0.0005	0.0007	0.0005	0.0005	0.0009
Chromium-Hexavalent(g/m3)	0.001	0.01	0.01				0.01	0.01	0.01				0.01	0.01	0.01
Cobalt-Dissolved(g/m3)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Copper-Dissolved(g/m3)	0.0005	0.0005	0.0011	0.0005	0.0005	0.0006	0.0005	0.0005	0.0016	0.0005	0.0005	0.0016	0.0005	0.0005	0.0013
Cyanide-Total(g/m3)	0.001	0.002	0.002												
Electrical Conductivity (EC) (mS/m)	7.9	8.45	25.3	6.7	7.2	11.8	8	11.7	21.7	7.9	8.65	20.3	8.5	10	19.9
Fluoride (g/m3)	0.05	0.05	0.05												
Hardness-Total(g/m3 as CaCO3)	12.2	15.05	83	5.4	5.95	14.1	10.3	33.5	85	10.8	12.15	73	12.9	18.9	71
Iron-Dissolved(g/m3)	0.03	0.1	0.21	0.02	0.06	0.08	0.02	0.03	0.95	0.02	0.285	0.3	0.02	0.25	0.53
Lead-Dissolved(g/m3)	0.0001	0.0001	0.00016	0.0001	0.0001	0.0001	0.0001	0.0001	0.00011	0.0001	0.0001	0.0001	0.0001	0.0001	0.00021
Magnesium-Dissolved(g/m3)	1.4	1.86	4.3	0.7	0.81	1.85	1.25	2.7	8.5	1.12	1.305	5.1	1.34	1.95	4.9
Manganese-Dissolved(g/m3)	0.0016	0.01005	0.087	0.001	0.0076	0.0178	0.0005	0.047	0.162	0.0006	0.095	0.115	0.0129	0.064	0.14
Mercury-Dissolved(g/m3)	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008
Molybdenum-Dissolved(g/m3)				0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel-Dissolved(g/m3)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00065	0.0037	0.0005	0.0005	0.0017	0.0005	0.0005	0.0023
Nitrate-N(g/m3)	0.1	0.5	1.67	0.064	0.089	0.81	0.057	0.1735	0.35	0.046	0.0975	0.21	0.074	0.135	0.4
Nitrate-N + Nitrite-N(g/m3)	0.1	0.51	1.68	0.065	0.095	0.82	0.057	0.2745	0.93	0.047	0.117	0.27	0.076	0.148	0.4
Nitrite-N(g/m3)	0.1	0.1	0.1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nitrogen-Total Ammoniacal(g/m3)	0.01	0.01	0.23	0.01	0.01	0.01	0.01	0.011	0.054	0.015	0.049	0.069	0.015	0.032	0.074
pH(pH units)	6.6	7.2	8.7	6.8	7	7.3	5.7	6.9	7.7	6.7	7	7.5	6.5	7	7.6
Phosphorus-Total (g/m3)	0.004	0.012	0.47				0.034	0.0435	0.053				0.04	0.0435	0.047
Potassium-Dissolved(g/m3)	1.75	2	5.3	2	2.9	3.1	2.5	2.55	2.9	2.4	2.7	2.8	2.4	2.8	2.8
Reactive Phosphorus-Dissolved(g/m3)	0.004	0.004	0.034	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004		0.004	
Selenium-Dissolved(g/m3)	0.0002	0.0002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Silica-Reactive(g/m3 as SiO2)	16.2	25	33												
Silver-Dissolved(g/m3)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sodium-Dissolved(g/m3)	8	9.2	10.8	9.4	9.9	17.9	6.6	10.1	11.1	6.9	9.9	10.3	6.9	9.7	10.4
Strontium-Dissolved(g/m3)				0.0103	0.0139	0.0142	0.02	0.0245	0.029	0.0156	0.0167	0.0178	0.0158	0.01735	0.0189
Sulphate(g/m3)	3.4	5	44	5	5	7	6	15.5	61	5	6.5	42	5	8	46
Thallium-Dissolved(g/m3)				0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Tin-Dissolved(g/m3)				0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Kjeldahl Nitrogen (TKN)(g/m3)	0.1	0.15	1.19	0.1	0.1	0.28	0.1	0.205	0.47	0.11	0.115	0.12	0.12	0.235	0.42
Total Suspended Solids(g/m3)	3	3	197	3	3	10	3	6	64	3	3	3	3	12	53
Uranium-Dissolved(g/m3)				0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Weak Acid Dissociable (WAD) Cyanide(g/m3	0.001	0.002	0.002	0.002	0.002	0.003	0.001	0.0015	0.002	0.002	0.002	0.002	0.001	0.0015	0.002
Zinc-Dissolved(g/m3)	0.001	0.0019	0.0081	0.0011	0.0014	0.0022	0.001	0.00225	0.0073	0.001	0.00115	0.0019	0.001	0.0013	0.0067

Notes:

TB1e - no data available

Blank cells indicate parameter not tested

Sample number indicates max sample size for individual parameters - Not all parameters tested during each sample round

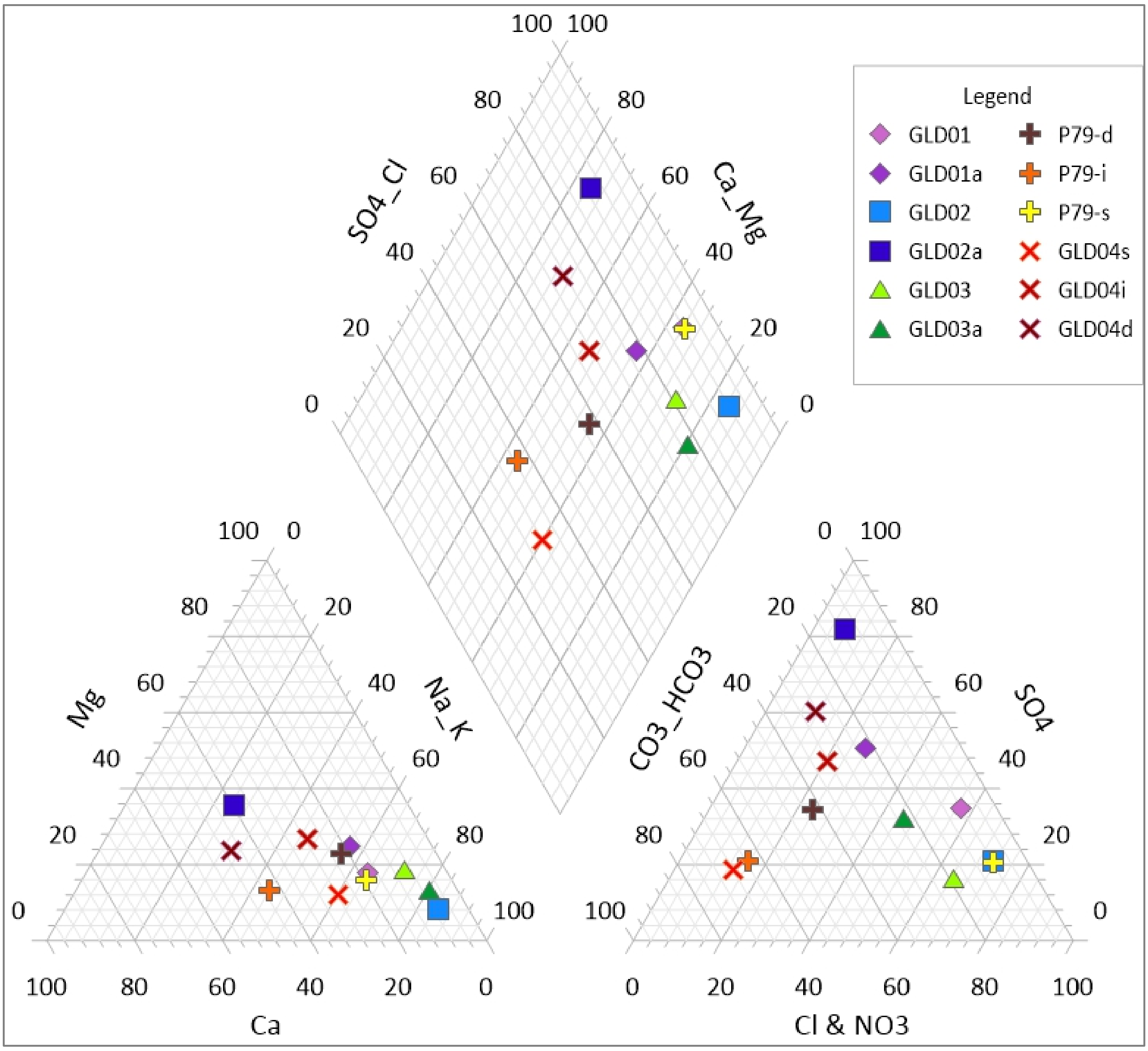


Figure E.1 *Piper Plot – Gladstone Groundwater Quality (P79-d June 2018. GLD04 well series October 2020. All other bores September 2018). (Excludes GLD01b which is recorded as dry).*

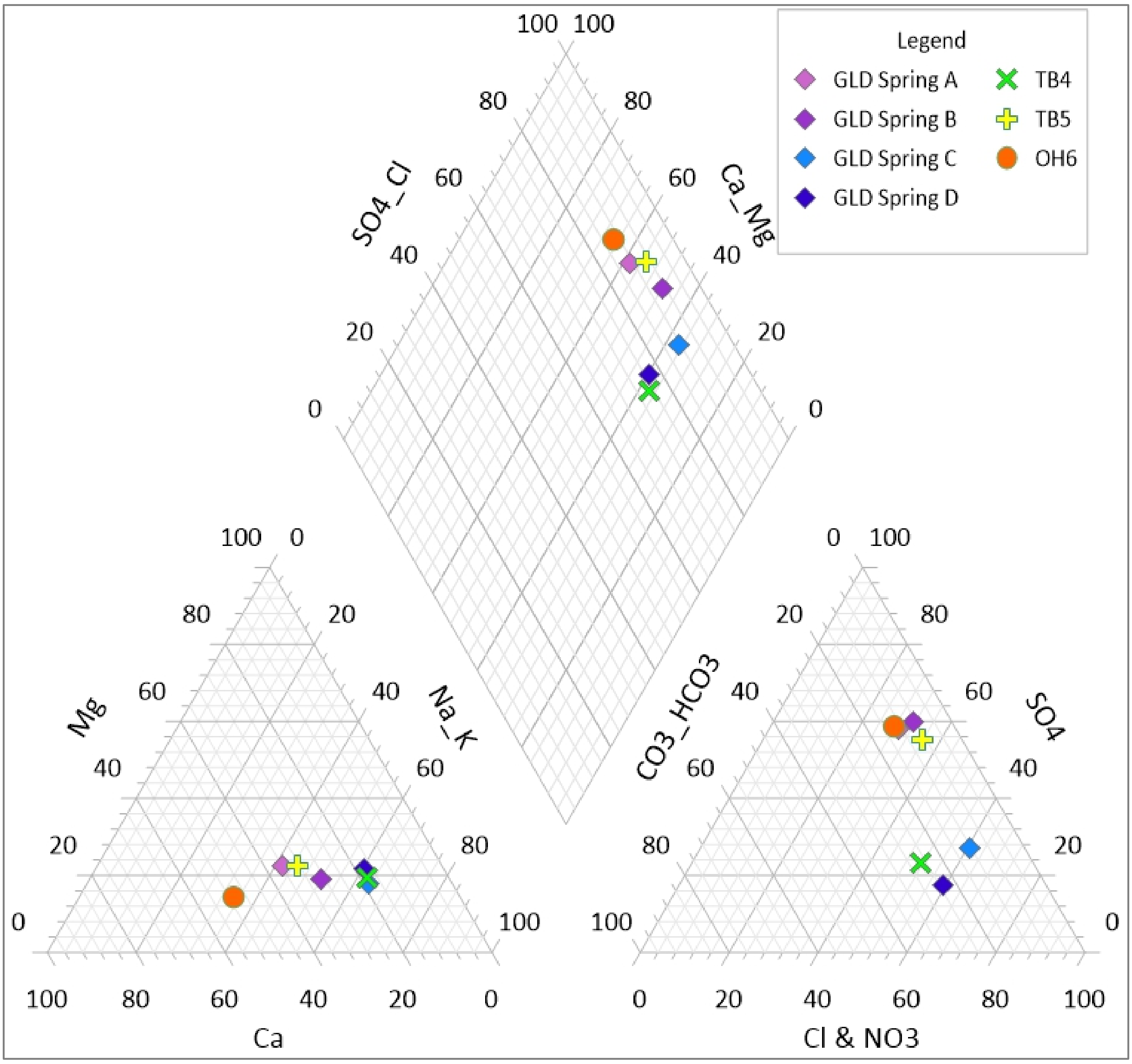


Figure E.2 *Piper Plot – Gladstone surface water quality (TB5 September 2019. All other samples September 2017)*

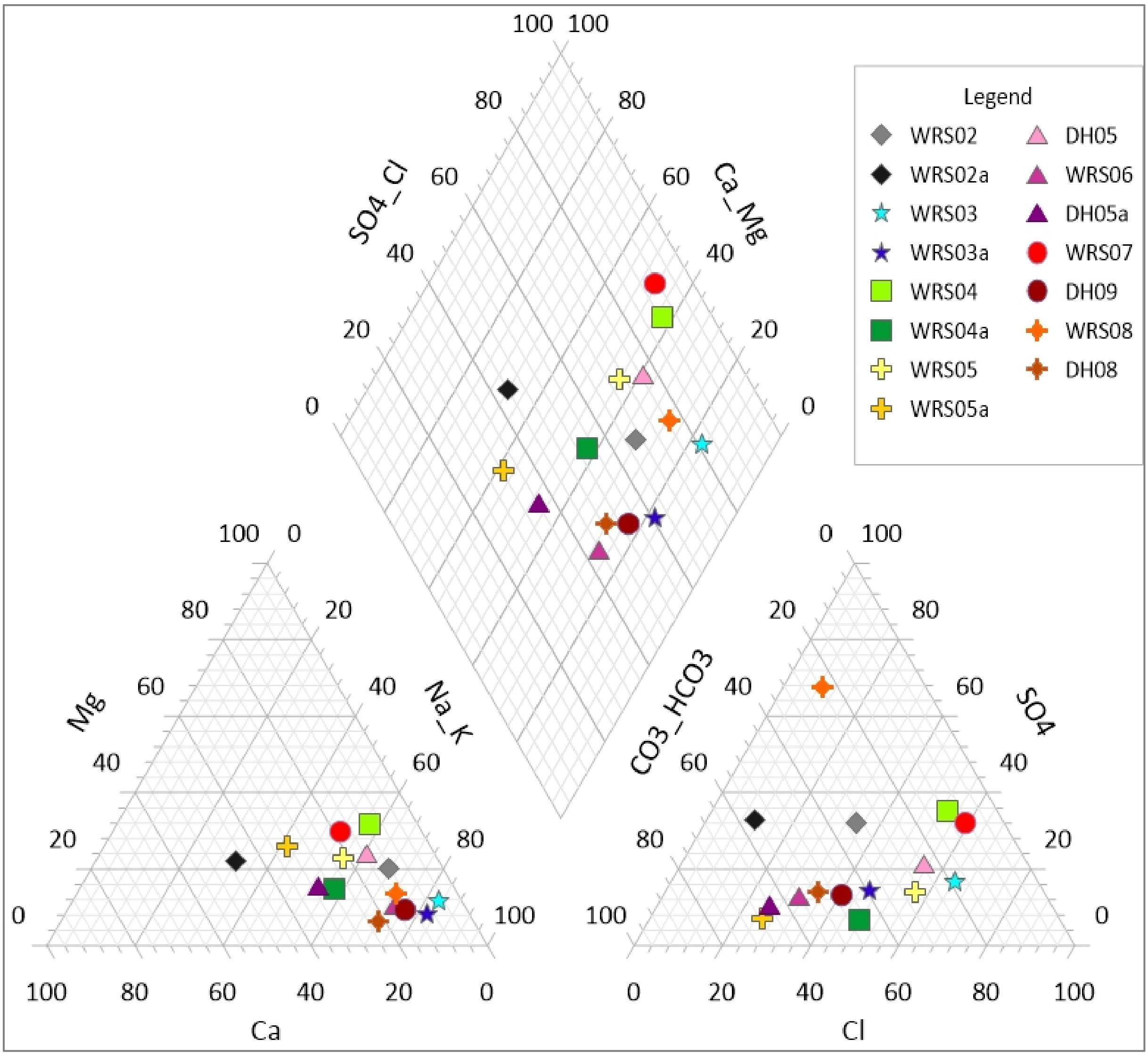


Figure E.3 *Piper Plot – NRS groundwater quality (November 2019)*

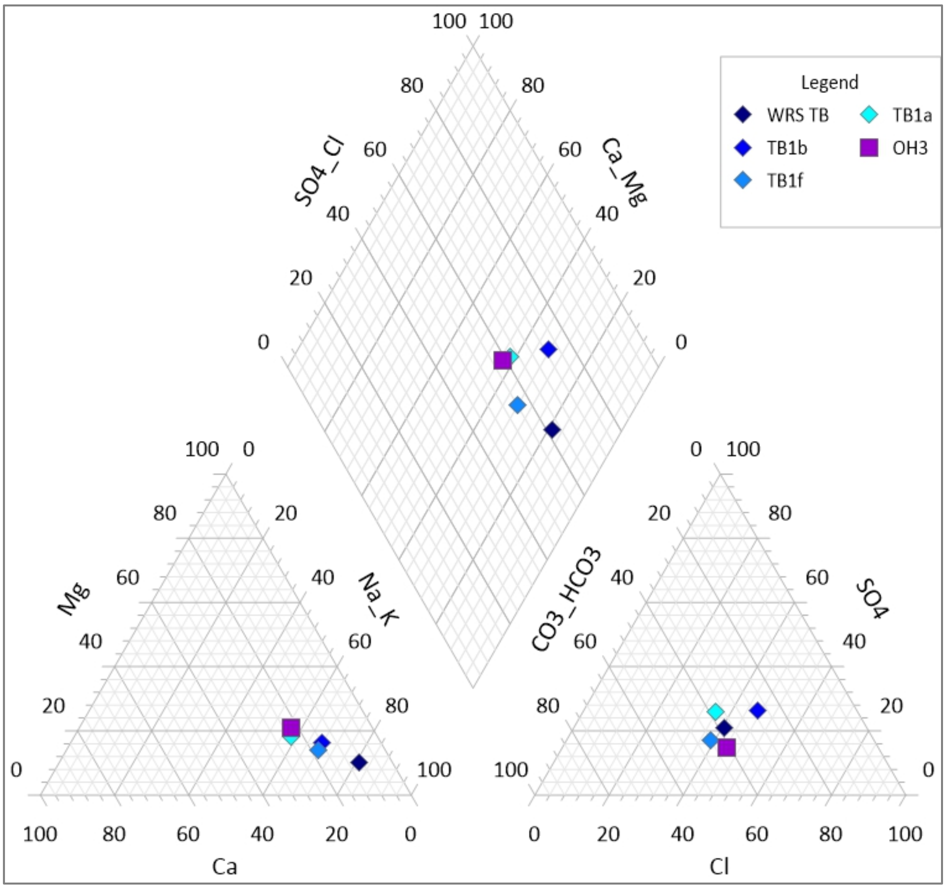


Figure E.4 *Piper Plot – NRS surface water quality (June 2019)*

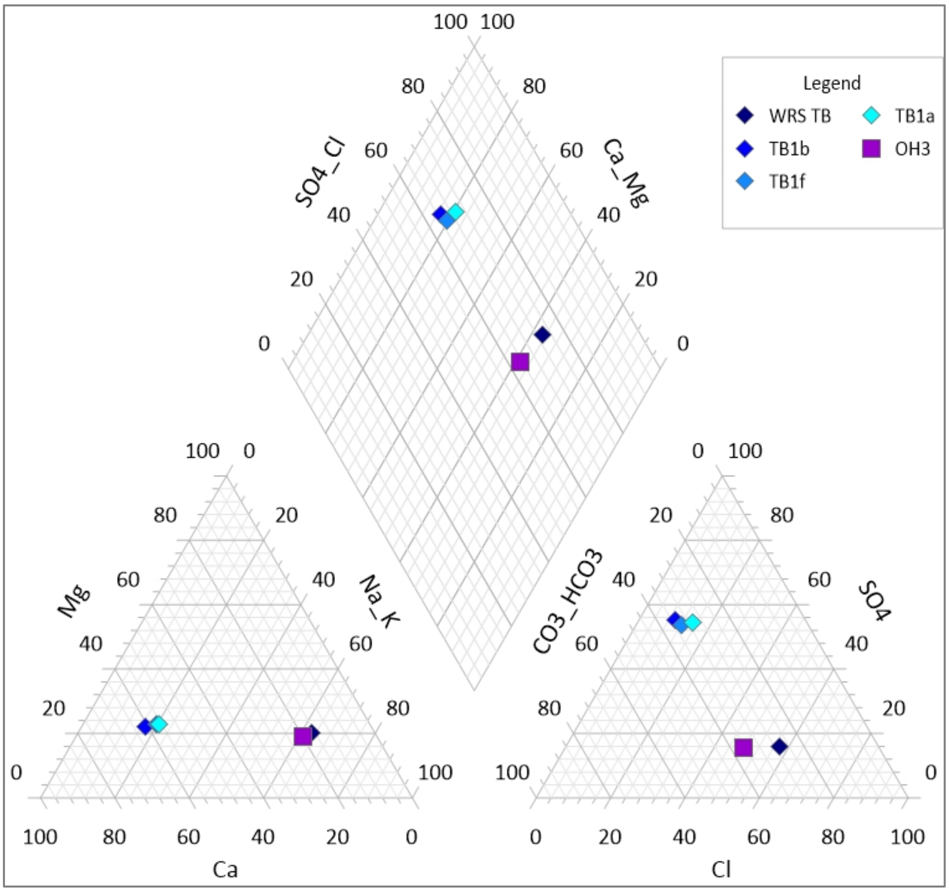


Figure E.5 *Piper Plot – NRS surface water quality (September 2019)*

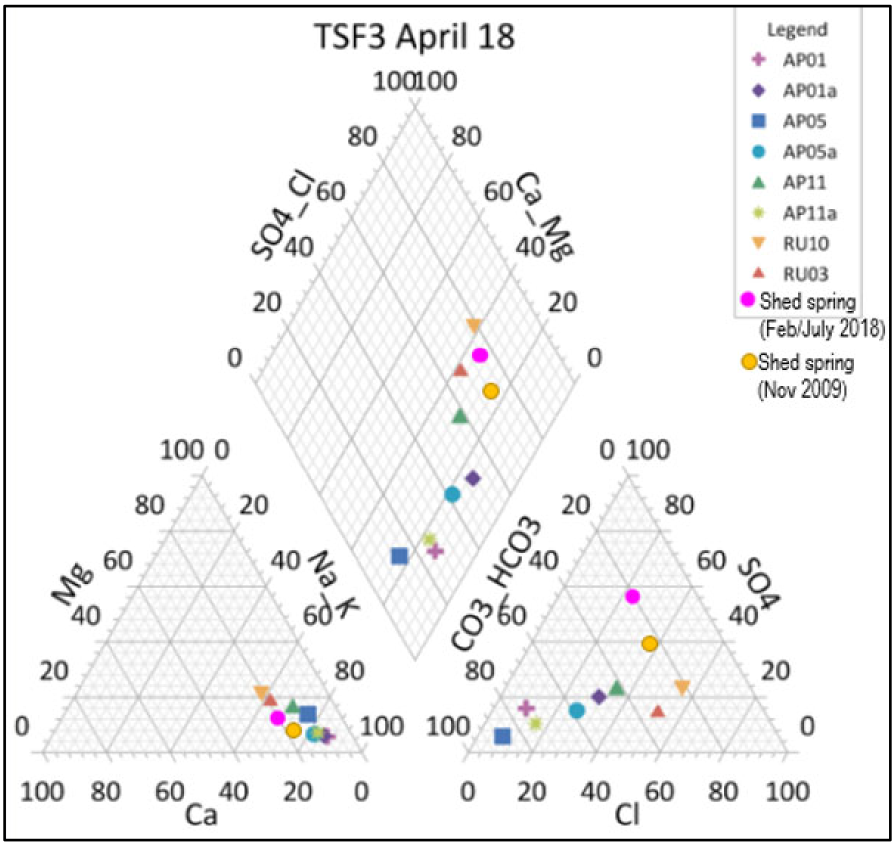


Figure E.6 *Piper plot – TSF3 water quality (April 2018)*

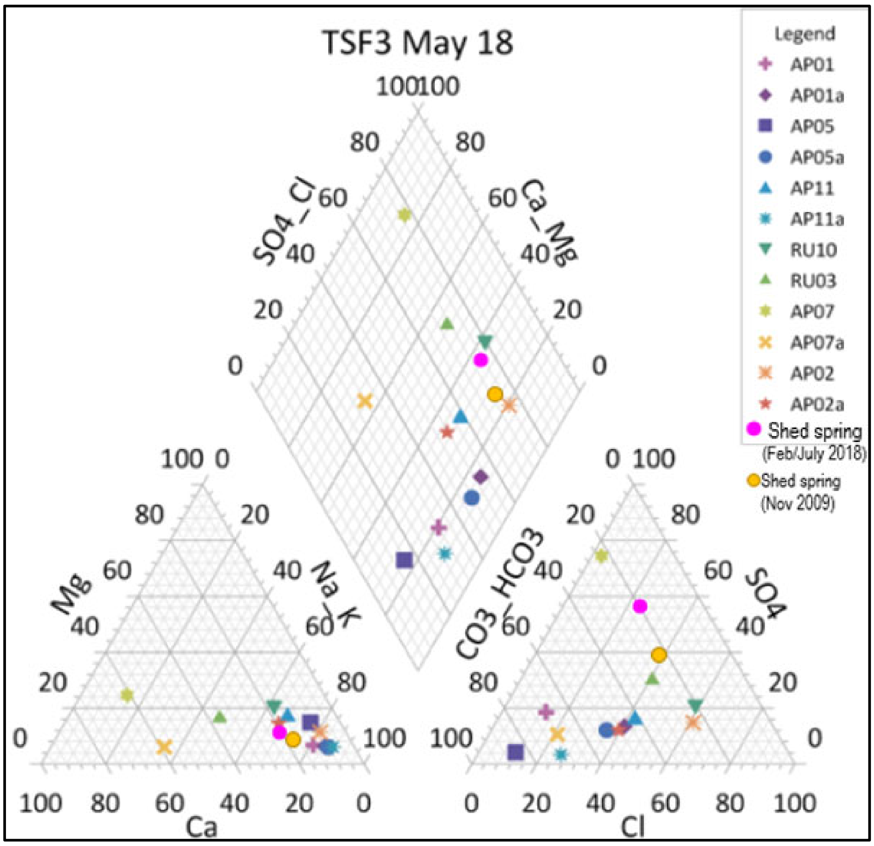


Figure E.7 *Piper plot – TSF3 water quality (May 2018)*

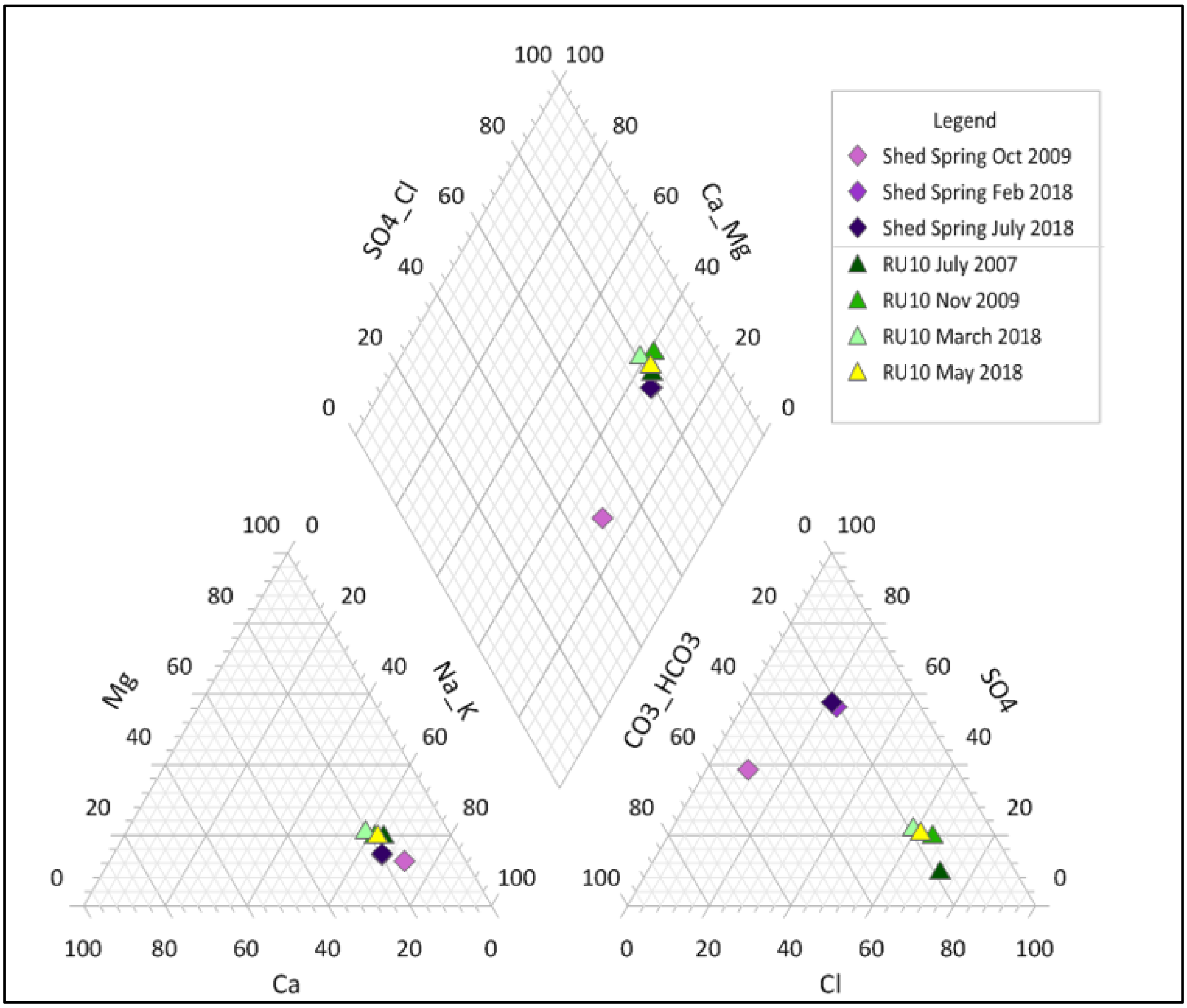


Figure E.8 *Piper plot – TSF3 water quality (shed spring vs. RU10)*

Appendix F

Surface water flow data

Contents:

Table F.1 Summary of Gladstone Stream Flow Gauging results (Opus, 2019)

Water Body	February 2019 Water Level (mRL)	Flow (L/s)								
		24/01/19	07/02/19	21/02/19	07/03/19	21/03/19	04/04/19	19/06/19	19/09/19	22/1/20
Tributary TB4 3 m upstream of twin culvert under access road	1087.04	0.017	0	Dry	Dry	0	0.05	0.006	2.6	Dry
Tributary TB5		-	-	-	Dry	Dry	Dry	Dry	3.5	Dry
Ohinemuri River OH11	1085.75	746	501	467	268 / 305.4*	357.5	574.2	438.4 / -*	2759.9	234.8
Ohinemuri River OH6	1084.65	-	-	-	-	367.7	598.5	421.9	2831.7	218.9
* upstream/downstream of water treatment plant discharge										

Table F.2 Summary of NRS Stream Flow Gauging results (Opus, 2019)

Water body	Gauging Location	Flow (L/s)								
		24/01/19	07/02/19	21/02/19	07/03/19	21/03/19	04/04/19	19/06/19	19/09/19	22/01/20
TB1	WRSTB	2.5	2.1	1.9	1.8	1.4	2.1	1.8	8.2	1.3
	TB1B	-	-	-	-	0.53	1.3	0.48	64.0	0.38
	TB1F	3.4	3.0	2.6	2.2	2.0	3.2	2.3	70.5	1.6
	TB1A	4.9	3.1	2.7	2.0	1.8	3.3	2.2	84.8	1.6
TB1E	TB1E	Dry	Dry	Dry	Dry	Dry	Dry	Dry	-	-

Table F.3 Summary of TSF3 Stream Flow Gauging Results (Opus, 2019)

Water Body	Gauging Location	Flow (L/s)								
		24/01/19	07/02/19	21/02/19	06/03/19	20/03/19	03/04/19	18/06/19	16/09/19	21/01/20
Ruahorehore Tributary	RU10	-	-	-	0.38	0.15	0.2	0.08	35.9	0
	RU6	2.5	1.6	0.8	0.4	0.22	0.7	0.5	40.4	0
Ruahorehore Stream	RU14	29.7	19.9	17.6	14.3	12.8	21.3	14.6	173.6	11.1
	RU13	36.5	17.9	15.7	12.7	11.0	20.0	12.9	170.7	7.5
	RU11	34.7	13.7	15.9	13.9	12.9	19.6	15.4	-	7.1
	RU12	30.7	21.4	15.6	14.2	14.0	21.8	14.3	205.9	7.0
	RU7	29.8	14.8	15.2	12.2	10.4	20.4	15.5	219.4	8.5
	RU5	-	-	-	13.5	12.3	24.1	16.50	273.8	6.3
Shed Spring	RU15	-	-	31.7	37.5	38.1	55.2	39.9	446.3	27.3

Table F.4 Summary of historic surface water flow data used in the assessment

Water Body	Gauging Location	Flow (m^3/sec)		
		24 & 25/02/2014	**14/08/2015**	**17/12/2015**
Ohinemuri River (1)	16 (OC2)	0.31	-	-
	15 (OH3)	0.31	-	-
	11 (OH5)	0.37	-	-
	12 (OH11)	0.45	-	-
Ruahorehore Tributary (1)	1 (RU10)	0.002	-	-
	2 (RU6)	0.002	-	-
Ruahorehore Stream (1)	3 (RU7)	0.025	-	-
	5 (RU3A)	0.028	-	-
Shed Spring	1(2) (upstream of Shed Spring)	0.028	0.31	0.013
	2(2) (upstream of Shed Spring)	-	0.27	0.019
	9(1) (Tributary upstream of Shed Spring)	0.004	-	-
	6(1) (Shed Spring)	0.003	-	-
	10(1) / 3(2) (RU15)	0.05	0.35	0.038

(1) Hydrologic, 2014

(2) Hydrologic, 2015

Figure F.1 *Plan showing Gladstone baseflow data (TB4 June 2017, Ohinemuri June 2019 & January 2020)*

Figure F.2 *Plan showing NRS tributary TB1 baseflow data*

Appendix G

Gladstone Open Pit and Tailings Storage Facility technical assessment

This appendix presents the methodology and results for technical assessment for excavation of the Gladstone Open Pit (GOP) and development as a Tailings Storage Facility (TSF).

All elevations are presented in metres reduced level (mRL) with reference to Waihi Mine datum, which is 1,000 metres below sea level.

Appendix G Contents
G.1 Assessment methodology
G.1.1 GOP and TSF groundwater assessment methodology *Groundwater modelling and simplistic groundwater catchment model for excavation of the GOP and development of a TSF, considering a situation where the shallow groundwater system is currently under-drained as a result of existing mine dewatering.*
G.1.2 Gladstone vein dewatering assessment methodology *Groundwater modelling and empirical assessment for dewatering of the Gladstone vein system, considering a situation where the deep groundwater system southwest of the proposed GOP is not currently dewatered.*
G.1.3 Surface water catchment assessment methodology *Simplistic surface water catchment model to predict changes in catchment area following excavation of the GOP.*
G.1.4 Water quality assessment methodology *Simplistic contaminant mass mixing model to predict impacts to groundwater and surface water quality after development of the TSF.*
G.2 Assessment results
G.2.1 GOP and TSF assessment results
G.2.2 Gladstone vein dewatering assessment results
G.2.3 Surface water catchment assessment results
G.2.4 Water quality assessment results

G.1 Assessment methodology

G.1.1 GOP and TSF groundwater assessment

Groundwater flow paths and discharges under current conditions, GOP excavation, operational TSF, TSF closure and long-term TSF were predicted utilising two methodologies: groundwater modelling and groundwater catchment assessments. This assessment considers a scenario where the shallow groundwater system is currently under-drained as a result of existing mine dewatering

GOP vein dewatering assessment is discussed in Section G.1.2.

G.1.1.1 Groundwater modelling methodology

Groundwater modelling was undertaken using GeoStudio 2021 SEEP/W finite element numerical modelling software. Two two-dimensional (2D) sections were developed to model cross sections through a north-south orientation and east-west orientation through the proposed GOP and TSF (Figure G.1). The model orientations were selected to understand how future mining works may impact shallow groundwater and surface water.

- North-south cross section: 1.1 km in length, considers shallow groundwater flow towards local tributaries (at TB4 and TB5) and the Gladstone wetland. The model was oriented through the deepest pit section, starting from Union Hill to the north, through to the watercourses and wetland south of the pit.
- East-west cross section: 1.4 km in length, considers shallow groundwater flow towards the Ohinemuri River. The model was oriented through the deepest pit section, starting from the Ohinemuri River to the east (near sampling location OH3), through to the Ohinemuri River to the west (near OH6). This model alignment also incorporates the locations where the pit shell intersects with the lowest elevations of the adjacent shallow groundwater systems, as well as an extensive unit of permeable sandy ignimbrite west of the pit.

The assessment was undertaken for the scenarios presented in Table G.1.

Table G.1 GOP and TSF assessment – model scenario summary

Model scenario	Description
Current conditions – steady state (Parent model for assessment scenarios)	Calibrated base model, representing the existing natural geology and hydrogeological setting which includes the shallow groundwater system being currently under-drained due to dewatering of the Favona portal infrastructure.
GOP excavation – steady state	The pit is excavated to the maximum depth of 1,005 mRL. Groundwater from the shallow system can flow to the pit through the pit walls.
Operational TSF – steady state	The pit is backfilled with NAF and PAF rock to a minimum elevation of 1,060 mRL, and on the pit walls to a minimum width of 10 m at the crest. The rock backfill is amended with limestone and compacted in situ. A liner subgrade and geosynthetic liner are placed on top of the backfill. The TSF drainage system is located beneath the geosynthetic liner at the base of the tailings. Emplacement of tailings to a maximum of 1,103 mRL. Tailings pond level set to 1,103 mRL. Shallow groundwater system remains under-drained due to Favona dewatering.
TSF closure – steady state	The tailings pond has been drained and the tailings are covered with a capping layer comprising a minimum 1 m thickness of NAF rockfill. The TSF drainage system remains operational. Rewatering of the deep groundwater system has occurred following the end of underground mining operations, therefore the shallow groundwater system is no longer underdrained. Groundwater pressure within the andesite set to 1,106 mRL to represent the influence of Martha pit lake (proposed level of 1,104 mRL allowing for a degree of water table increase within underground workings).
Long term TSF – steady state	Tailings are covered with a NAF rockfill capping layer between 1,104 – 1,107 mRL contoured towards the southern pit boundary. The TSF drainage system is no longer operational. Groundwater pressure within the andesite set to 1,106 mRL to represent influence of Martha pit lake (proposed level of 1,104 mRL allowing for a degree of water table increase within underground workings).

The 2D groundwater model cross sections were used to predict groundwater levels, flow paths and fluxes:

1. Groundwater modelling
   a. Predicted groundwater flow across the pit boundary, broken down into:
      i. groundwater predicted to discharge to surface water receiving environments during current conditions and the full life cycle of the GOP and TSF.
      ii. groundwater flow from the shallow groundwater system into the pit during GOP excavation.
      iii. groundwater flow predicted to discharge to the deep groundwater system during current conditions and the full life cycle of the GOP and TSF.
   b. Predicted groundwater flow to surface water receiving environments, including the breakdown of flow predicted to have interacted with tailings or rock backfill of the TSF.
   c. Predicted changes in groundwater levels.
   d. Predicted tailings and groundwater flow to, and total discharge from, the TSF drainage system proposed beneath the geosynthetic liner at the base of the tailings.

Paper Size A3

0 50 100 200

Metres

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

N

LEGEND

🟧	Proposed Gladstone Pit
🟨	Inferred mineralised vein system
- - -	Cross section locations
—	Contour (20m)

Ohinemuri River Tributary

—	River
—	Stream
—	Tributary

🟩	Wetland

Oceana Gold Limited
Waihi North

Gladstone cross-section locations (N-S and W-E)

Job Number	12552081
Revision	0
Date	13 Dec 2021

Figure G1

N:\NZ\Christchurch\Projects\51\12526951\GIS\Maps\Deliverables\12552081\12552081_Z006_GladstoneCrossSectionLocations.mxd

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: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:jrprice

The 2D groundwater model cross sections were used to predict groundwater levels, flow paths and fluxes as follows:

Groundwater flow scaling for current conditions and GOP excavation scenario

For the purposes of estimating groundwater discharges across the pit boundary, which is extracted from the groundwater models on a per unit metre basis in the four directions modelled (north, east, south and west), these fluxes have been scaled up to represent the full water balance of the pit. These fluxes were scaled up using the adopted pit perimeter sections presented in Figure G.2. The justification for each adopted section is presented in Table G.2.

While providing appropriate analysis of change in water levels, to provide balanced flow estimates the circular the area represented by each model required further scaling (flow scaling) to accommodate the circular nature of Gladstone Hill and the proposed GOP. This change addresses the inconsistencies in simulating radial discharge using a cross sectional model approach.

To determine the degree of scaling required the following was undertaken:

- Modified long-term cross section models were developed including NAF rockfill above the tailings to match the existing landform. A closure cap infiltration rate of 1x10-8 m/s (AECOM, 2020) was applied to these models.
- The total modelled discharge from the pit to shallow groundwater was determined as the sum of the discharge to each perimeter area (each determined by factoring the cross section model discharge by the pit perimeter lengths detailed in Table G.2).
- Total recharge to the pit area was estimated by applying the adopted recharge rate ($1x10^{-8}$ m/s) and factoring it by the total pit area.
- The scaling factor was determined by dividing the total recharge to the pit area by the total modelled discharge.

The scaling factor was applied to all estimates of flow from the model area, including the simulation of current conditions.

Groundwater flow scaling for TSF discharges

For the purposes of estimating total groundwater discharge through the base of the pit and towards the TSF drainage system for the operational TSF and TSF closure scenarios, the flow results from each cross-section were scaled up using the average dimensions of the TSF:

- An average of the following:
  - North-south model discharge flux was multiplied by 520 m (dimension of TSF in east-west direction)
  - East-west model discharge flux was multiplied by 262 m (dimension of TSF in north-south direction)

Due to the influence of greater deep groundwater pressures on groundwater flows and TSF discharges for the TSF closure scenario, which considers complete cessation of TSF drainage after rewatering of the deep groundwater system, groundwater flows were assessed differently from the other TSF scenarios. The methodology for the long-term TSF scenario comprised comparison of results from the two cross section models. The modelled lowest point of groundwater discharge from the pit, that could accommodate all groundwater discharge from the TSF, was adopted as the preferential location for water discharge from the pit. The cross section representing this discharge was scaled as per the TSF dimensions provided above.

Scaling of groundwater flow to surface water bodies during all GOP and TSF scenarios

Total groundwater discharge to each surface water receiving environment from each model section was multiplied by the length of the water body anticipated to be receiving groundwater discharges from the full modelled area during all model scenarios. The following lengths were adopted:

- Gladstone wetland / Ohinemuri tributary (TB4) – 280 m
- Ohinemuri tributary (TB5) – 230 m
- Ohinemuri River east of Gladstone (OH3) – 247 m
- Ohinemuri River west of Gladstone (OH6) – 342 m

Table G.2 Gladstone pit perimeter section lengths for scaling flux across the pit boundary

Pit section	Measured pit section perimeter length (m)	Adopted pit section justification
North	380	Includes shallow aquifer units of similar thickness, and regions of inferred andesite outcrop, from the north-western side of the pit to approximate topographic divide on north-eastern side of the pit.
East	247	Includes shallow aquifer units of similar thickness between the two approximate topographic divides on the north-eastern and south-eastern sides of the pit.
South	425	Includes shallow aquifer units of similar thickness between the two approximate topographic divides between the south-eastern side of the pit and Winner Hill on the south-western side of the pit.
West	510	Incorporates relatively thick shallow aquifer units on the south-western side of the pit between elevated Winner Hill and where andesite is indicated to outcrop on the north-western side of the pit.

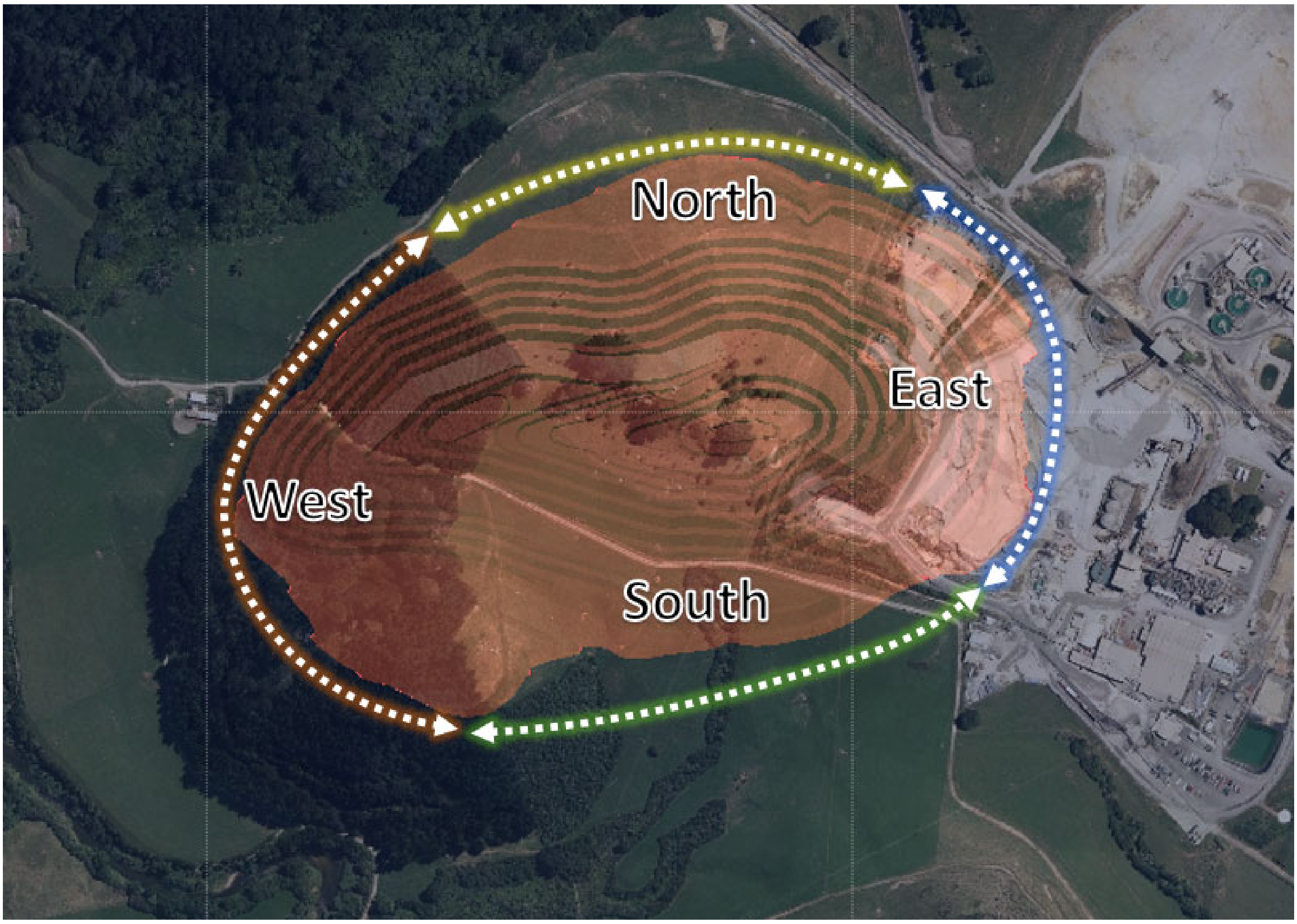


Figure G.2 Adopted perimeter sections for scaling flux across the pit boundary

G.1.1.2 Groundwater catchment methodology

To compare the results of groundwater modelling, a comparative assessment was undertaken for changing groundwater recharge catchment areas. A groundwater recharge catchment area for each surface water body was defined using conceptual understanding, with flow paths determined from groundwater modelling and topographic contours. The catchment areas change during each scenario assessed due to changing groundwater levels and groundwater flow paths. Following rewatering of the deep groundwater system and cessation of TSF drainage assumed for the long-term TSF scenario, recharge to each groundwater catchment will no longer be solely from rainfall recharge. Therefore, this scenario has been excluded from the catchment calculations assessment.

The adopted catchment areas for the assessed scenarios are presented in Table G.3.

Table G.3 Gladstone groundwater catchment areas

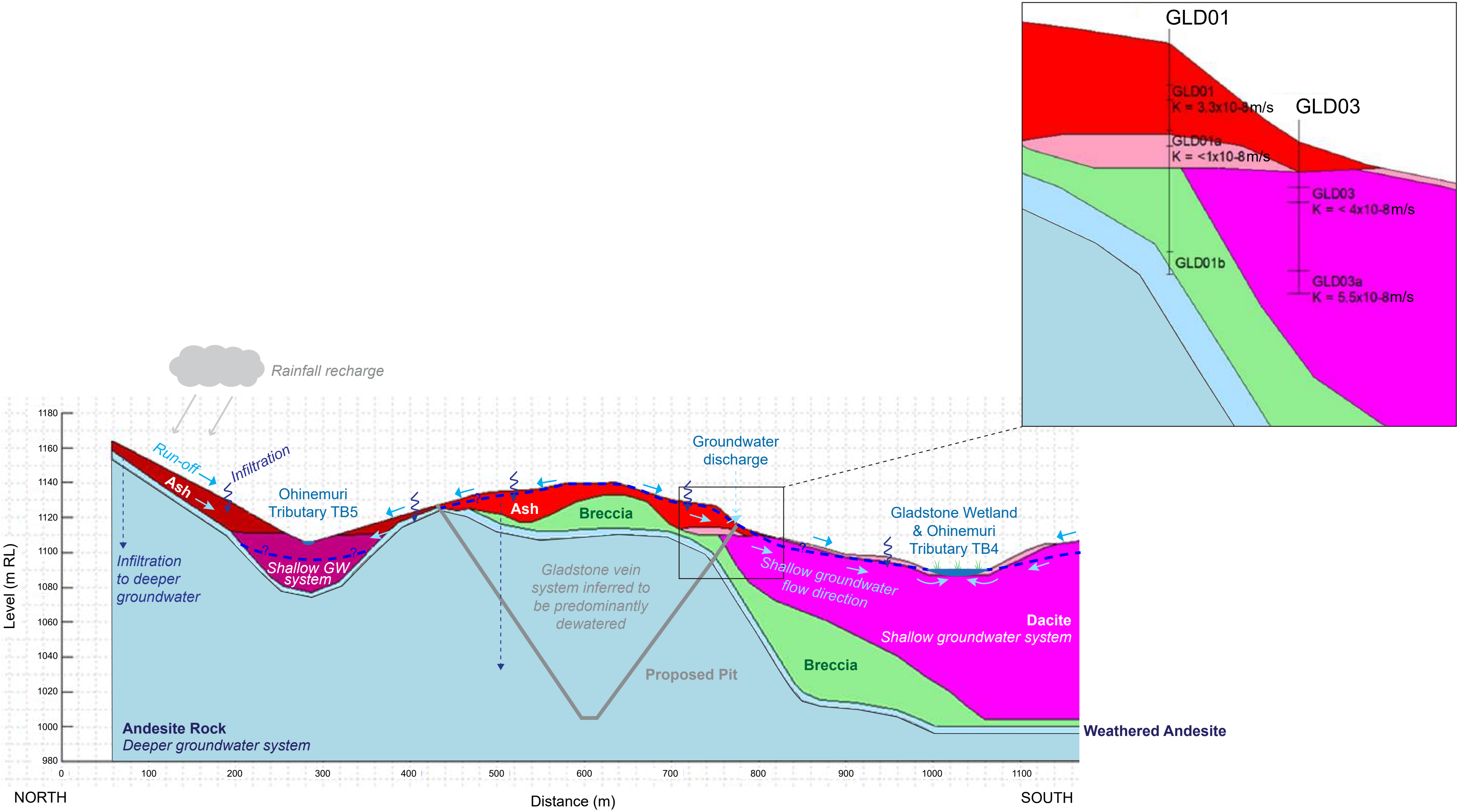
Groundwater catchment area	**Groundwater catchment area (m^2)[1]**			
	Current conditions	**GOP Excavation**	**Operational TSF**	**TSF Closure**
Gladstone Wetland / Ohinemuri tributary (TB4)	33,654	26,129	26,129	62,084
Ohinemuri tributary (TB5)	0	0	0	0
Ohinemuri River east of Gladstone (OH3)[2]	141,814	125,274	125,274	155,916
Ohinemuri River west of Gladstone (OH6)[2]	70,673	57,035	57,035	65,683

1. Catchment areas delineated by the interpreted groundwater recharge areas
2. Constrained to the area between the Gladstone Open Pit and Ohinemuri River

G.1.1.3 Groundwater model set-up

Each SEEP/W section was initially constructed to represent current groundwater conditions, with calibration achieved using site data, including geology within the OGNZL Leapfrog model (2021) and bore logs, as well as permeability and water level data from monitoring bores and recorded river and wetland water levels and flow. The model structure, materials and boundary conditions were then modified to represent the GOP and TSF scenarios. Annotated SEEP/W sections are presented in Figure G.3 and Figure G.4. Model set up information is provided in Table G.4 and Table G.5.

Bore logs, groundwater levels and permeability test results from monitoring bores are presented in Appendix B, Appendix C and Appendix D, respectively.



LEGEND

🟦 Andesite

🟥 Ash / Regolith (N)

🟥 Ash / Regolith (S)

🟪 Dacite

🟩 Hydrothermal Breccia

🟪 RT (N)

🟪 RT (S)

🟦 Weathered Andesite

— Proposed Gladstone Pit

- - - Potentiometric groundwater level

∿∿▸ Groundwater Recharge

→ Shallow Groundwater Flow Direction

→ Rainfall Runoff

Wetland / tributory

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Job Number	12552081
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North - South
Model Cross Section

Figure G.3

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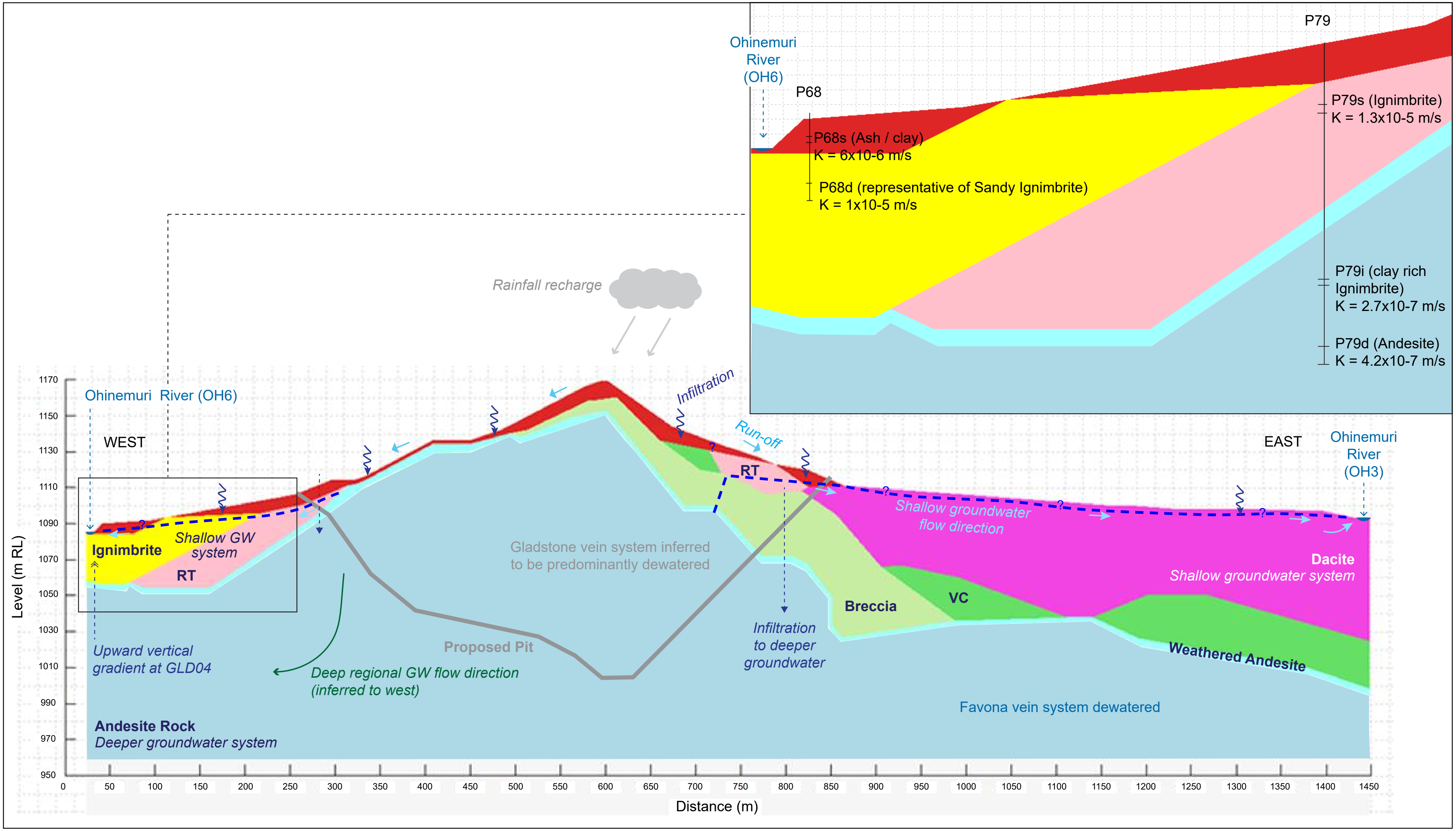
Data source: GHD. Created by:jrprice



LEGEND

Andesite		RT		Proposed Gladstone Pit	→	Rainfall Runoff
Ash / Regolith		Sandy Ignimbrite	- - -	Potentiometric groundwater level		Wetland / tributory
FVN Dacite		Volcaniclastic		Groundwater Recharge		
Hydrothermal Breccia		Weathered Andesite	→	Shallow Groundwater Flow Direction		

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Revision 0
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West - East
Model Cross Section

Figure G.4

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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: GHD. Created by:jrprice

Table G.4 Gladstone Pit north - south model section parameters and boundary conditions

Parameter / boundary	Adopted condition	Justification	Model scenario
Rainfall recharge	Water flux (potential seepage face review) – 9 x 10^{-10} m/s	1.3 % of rainfall. Considered appropriate given low permeability materials and gradient of hillside.	All model scenarios
Gladstone wetland	Water total head – 1,090 mRL	Elevation from topography and leapfrog model (OGNZL geological model, 2021)	
Ohinemuri tributary north of Gladstone Hill (TB5)	Potential seepage face review – 1,106 mRL	Elevation taken from topography and leapfrog model (OGNZL geological model, 2021)	
Andesite underdrainage	Base of model: Water rate – potential seepage face review	Shallow system is underdrained due to existing below ground workings	Current conditions, GOP excavation and operational TSF
Pit dewatering	Interface between pit and adjacent shallow units: Water rate – potential seepage face review	Shallow groundwater discharge into the pit will be removed through pit dewatering	GOP excavation
Rock backfill	Kx 1 x 10^{-5} m/s Kx/Ky 0.1 VWC – Sandy loam	Considered appropriate for rock backfill after placement, amendment with limestone and compaction.	Operational TSF, TSF closure and long-term TSF
Liner subgrade	Kx 1 x 10^{-5} m/s Kx/Ky 1.0 VWC - sand	Sub-20 mm crushed and screened high quality rock from mining operations	
Geosynthetic liner	Kx 1 x 10^{-10} m/s Kx/Ky 1.0 VWC – clayey silt	Expected seepage rate approximately 5x10^{-9} – 3.5x10^{-8} m/s depending on hydraulic gradient across the liner	
TSF drainage	Water rate – potential seepage face review	TSF drainage system beneath the geosynthetic liner at the base of the tailings	Operational TSF and TSF closure
Tailings	Kx 1 x 10^{-7} m/s Kx/Ky 0.2 VWC – sandy silt (coarse tailings)	Hydraulic conductivity and VWC based on EGL unconsolidated tailings description (email communication 28/02/2019 (EGL 2019b))	Operational TSF
Operational tailings pond	Water total head at top of tailings – 1,103 mRL	Max. tailings emplacement height	
Tailings	Kx 1 x 10^{-8} m/s Kx/Ky 0.5 VWC – sandy silt (coarse tailings)	Hydraulic conductivity and VWC based on EGL consolidated tailings description (email communication 28/02/2019 (EGL 2019b))	TSF closure
Tailings cap infiltration	Water flux – 1 x 10^{-8} m/s	5-year average cap infiltration rate (AECOM, 2020)	TSF closure and long-term TSF
Tailings cover (rockfill)	Kx 1 x 10^{-5} m/s Kx/Ky 0.1 VWC – Sandy loam	Considered appropriate for rock after placement, amendment with limestone and compaction.	
Martha pit lake water pressure within andesite	Water total head – 1,106 mRL	Proposed Martha Pit Lake level (1,104 mRL) after rewatering of deep groundwater system. An additional 2 m of water head is added to allow for influence of groundwater recharge between the Martha and Gladstone workings.	

Kx = horizontal hydraulic conductivity. Ky = vertical hydraulic conductivity.

VWC = Volumetric water content function (SEEP/W 2012 database)

Table G.5 *Gladstone Pit west – east model section parameters and boundary conditions*

Parameter / boundary	Adopted condition	Justification	Model scenario
Rainfall recharge	Gladstone Hill, Winner Hill and south of pit: Water flux (potential seepage face review) – 9 x 10^{-10} m/s	Calibrated to 1.3 % rainfall. Considered appropriate given low permeability materials and gradient of hillside.	All model scenarios
	East and west of pit: Water flux (potential seepage face review) – 3 x 10^{-8} m/s	Calibrated to 45% rainfall. Considered appropriate given higher permeability materials and lower slope gradients.	
Ohinemuri River (OH3)	Water total head – 1,092.85 mRL	Surveyed elevation close to OH3 sample point (08/08/2017)	
Ohinemuri River (OH6)	Water total head – 1,084.65 mRL	Surveyed elevation close to OH6 sample point (21/02/2019)	
Andesite underdrainage	Base of Model: Water rate – potential seepage face review	Shallow system is underdrained due to existing below ground workings	Current conditions, GOP excavation and operational TSF
Pit dewatering	Interface between pit and adjacent shallow units: Water rate – potential seepage face review	Shallow groundwater discharge into the pit will be removed through pit dewatering	GOP excavation
Rock backfill	Kx 1 x 10^{-5} m/s Kx/Ky 0.1 VWC – Sandy loam	Considered appropriate for rock backfill after placement, amendment with limestone and compaction.	Operational TSF, TSF closure and long-term TSF
Liner subgrade	Kx 1 x 10^{-5} m/s Kx/Ky 1.0 VWC - sand	Sub-20 mm crushed and screened high quality rock from mining operations	
Geosynthetic liner	Kx 1 x 10^{-10} m/s Kx/Ky 1.0 VWC – clayey silt	Expected seepage rate approximately 5x10^{-9} – 3.5x10^{-8} m/s depending on hydraulic gradient across the liner	
TSF drainage	Water rate – potential seepage face review	TSF drainage system beneath the geosynthetic liner at the base of the tailings	Operational TSF and TSF closure
Tailings	Kx 1 x 10^{-7} m/s Kx/Ky 0.2 VWC – sandy silt (coarse tailings)	Hydraulic conductivity and VWC based on EGL unconsolidated tailings description (email communication 28/02/2019 (EGL 2019b))	Operational TSF
Operational tailings pond	Water total head at top of tailings – 1,103 mRL	Max. tailings emplacement height	
Tailings	Kx 1 x 10^{-8} m/s Kx/Ky 0.5 VWC – sandy silt (coarse tailings)	Hydraulic conductivity and VWC based on EGL consolidated tailings description (email communication 28/02/2019 (EGL 2019b))	TSF closure
Tailings cap infiltration	Water flux – 1 x 10^{-8} m/s	5-year average cap infiltration rate (AECOM, 2020)	TSF closure and long-term TSF
Tailings cover (rockfill)	Kx 1 x 10^{-5} m/s Kx/Ky 0.1 VWC – Sandy loam	Considered appropriate for rock after placement, amendment with limestone and compaction.	
Martha pit lake water pressure water pressure	Water total head – 1,106 mRL	Proposed water level of Martha Pit Lake (1,104 mRL) after rewatering of the deep groundwater system	

Kx = horizontal hydraulic conductivity. Ky = vertical hydraulic conductivity.

VWC = Volumetric water content function (SEEP/W 2012 database)

G.1.1.4 Groundwater model calibration

The two SEEP/W model cross sections that represent the current conditions scenario were calibrated to measured groundwater levels and vertical hydraulic gradients. To achieve model calibration, and in line with the conceptual site understanding, hydraulic conductivity and anisotropy of geological units were iteratively adjusted within reasonable ranges based on field investigation data, as well as recharge rates across the ground surface. Additionally, observed groundwater discharge locations and flow gauging results were taken into consideration. The calibrated anisotropy and hydraulic conductivity values for each geological unit are presented in Table G.6. The measured and modelled groundwater levels after calibration are presented in Table G.7.

Table G.6 Gladstone Pit calibrated hydrogeological parameters

Unit	Adopted volumetric water content function(1)	Calibrated anisotropy (Ky/Kx)	Calibrated hydraulic conductivity (m/s)(2)	Justification
Ash/Regolith	Clayey silt	0.5 (N, E, W)	6.0 x 10^{-6} (N, E, W)	P68s and P61s hydraulic tests(3). P68s water level(3)
		1.0 (S)	1.5 x 10^{-8} (S)	GLD01 hydraulic test and water level
Rhyolitic Tuff (RT)	Clayey silt	0.5 (N, E, W)	2.7 x 10^{-7} (N, E, W)	P79i hydraulic test. P79s and P68s(3) water levels
		0.1 (S)	5.5 x 10^{-9} (S)	GLD01a hydraulic test and water level
Sandy Ignimbrite	Silty sand	0.5	1.0 x 10^{-5}	P79s and P68d(3) hydraulic tests and water levels
Volcaniclastic	Silty sand	0.3	1.0 x 10^{-6}	Shallow groundwater system water levels. Similar properties to dacite.
Hydrothermal Breccia	Clayey silt	0.1	5.0 x 10^{-10}	Shallow groundwater system water levels
Dacite	Sandy clayey silt	0.1 (S)	5.0 x 10^{-8} (S)	GLD03 and GLD03a hydraulic tests and water levels
		0.1 (E)	3 x 10^{-6} (E)	Favona wells hydraulic testing(4)
Weathered Andesite	Silty sand	0.1	5 x 10^{-9}	Shallow groundwater system water levels. P61 hydraulic test(3)
Andesite	Silty sand	1.0 (E, W)	4.2 x 10^{-7}	Upper end of recorded range away from faults/crush zones (1 x 10^{-8} – 1 x 10^{-5} m/s)(3)
		2.0 (N, S)		Anisotropy reflects expected fracture alignment associated with Gladstone vein.

1. SEEP 2012 materials database
2. N, E, S, W refer to geology on different sides of the pit where material properties differ.
3. URS, 2003. Favona Underground Mine. Assessment of Groundwater Issues.
4. Geomean shallow dacite hydraulic conductivity from hydraulic testing by GHD in 2017 in OGNZL bores P87 & P89 and GLD bores FVN01 and FVN02 (installed by GHD in 2017).

Table G.7 Gladstone Pit model calibration target groundwater levels (current conditions scenario)

Piezometer	Target level (mRL)	Modelled level (mRL)	Calibration residual (m)
North-south model			
GLD01	1123.63 (1)	1123.68	+0.05
GLD01a	1123.38 (1)	1123.38	0.0
GLD01b	Dry (1096.0) (1)	1095.63	NA
GLD03	1109.15 (1)	1108.98	-0.17
GLD03a	1105.43 (1)	1105.33	-0.10
West-east model			
P79s	1093.1 – 1100.6 (2)	1094.42	Calibrated to lower end of range for summer level
P68s	1086.55 (3)	1085.87	-0.7 (summer level likely to be lower than target level).

1. Water levels recorded 20/3/2018
2. Range of values recorded 2018 – 2020
3. Recorded level date unknown. Assumed November 2001 following monitoring well installation (URS, 2003).

G.1.2 Gladstone vein dewatering assessment

G.1.2.1 Groundwater modelling methodology

Groundwater modelling was undertaken using GeoStudio 2021 SEEP/W finite element numerical modelling software. One two-dimensional (2D) section was developed to model a cross section perpendicular to the strike of the Gladstone vein system where it passes beneath the Ohinemuri River southwest of the proposed GOP (Figure G.5). The assessment considers a situation where the deep groundwater southwest of the proposed GOP is not currently dewatered. The model was used to undertake an assessment of groundwater drawdown of the water table, and within the andesite of the deep groundwater system, as well as the potential for loss of surface water flow from the Ohinemuri River (OH6). The model is 950 m in length, orientated northwest-southeast perpendicular to the Gladstone vein system along the stretch of the Ohinemuri River southwest of the proposed GOP

The model was set up to represent current conditions and used to assess the influence on groundwater and surface water as per the following scenarios:

- **Current conditions:** To represent upwards vertical hydraulic gradients between the deep and shallow groundwater systems at the location of Ohinemuri River monitoring location OH6 and nearby GLD04 well series.
- **Gladstone vein dewatering:** To predict groundwater drawdown within the shallow and deep groundwater systems and potential changes in Ohinemuri River flow in response to dewatering the Gladstone vein system to a maximum depth of 1,005 mRL, should the groundwater levels assuming a strong hydraulic connection along the vein system between the GOP and the Ohinemuri River southwest of the pit (OH6).

Ohinemuri River scaling

For the purposes of estimating the change in Ohinemuri River flow during the Gladstone vein dewatering scenario it was assumed that the river was located at the surface across the full length of the 950 m model section. As the results are extracted from the model on a per unit metre basis, the results were multiplied by 15 m to represent the width of the Ohinemuri River.

G.1.2.2 Groundwater inflow to GOP methodology

Existing data recorded during mine dewatering of the Favona system was used to undertake an empirical assessment to predict groundwater inflow rates from the deep groundwater system during excavation of the GOP. This assessment considered a scenario where the deep groundwater system southwest of the proposed GOP is not currently dewatered as a result of mine dewatering. As this assessment is supported by existing data the results are presented directly within the main body of the report and not with this technical appendix.

G.1.2.3 Groundwater model set up

Development of the steady-state cross-sectional numerical model (SEEP/W) representing existing shallow and deep groundwater systems and the Gladstone vein system. The model is orientated perpendicular to the strike of the Gladstone vein system where it passes beneath the Ohinemuri River southwest of the proposed GOP. The model was used to predict changes in groundwater levels and surface water depletion of the Ohinemuri River, considering a scenario where the deep groundwater system is not currently dewatered as a result of current mine dewatering.

The geology of the SEEP/W model was sourced from the OGNZL leapfrog model (2021), with groundwater conditions reflective of measured within the GLD04 well series, and a surveyed level of the Ohinemuri River. The models were then modified to represent dewatering of the vein system to an elevation of 1,005 mRL during the GOP excavation.

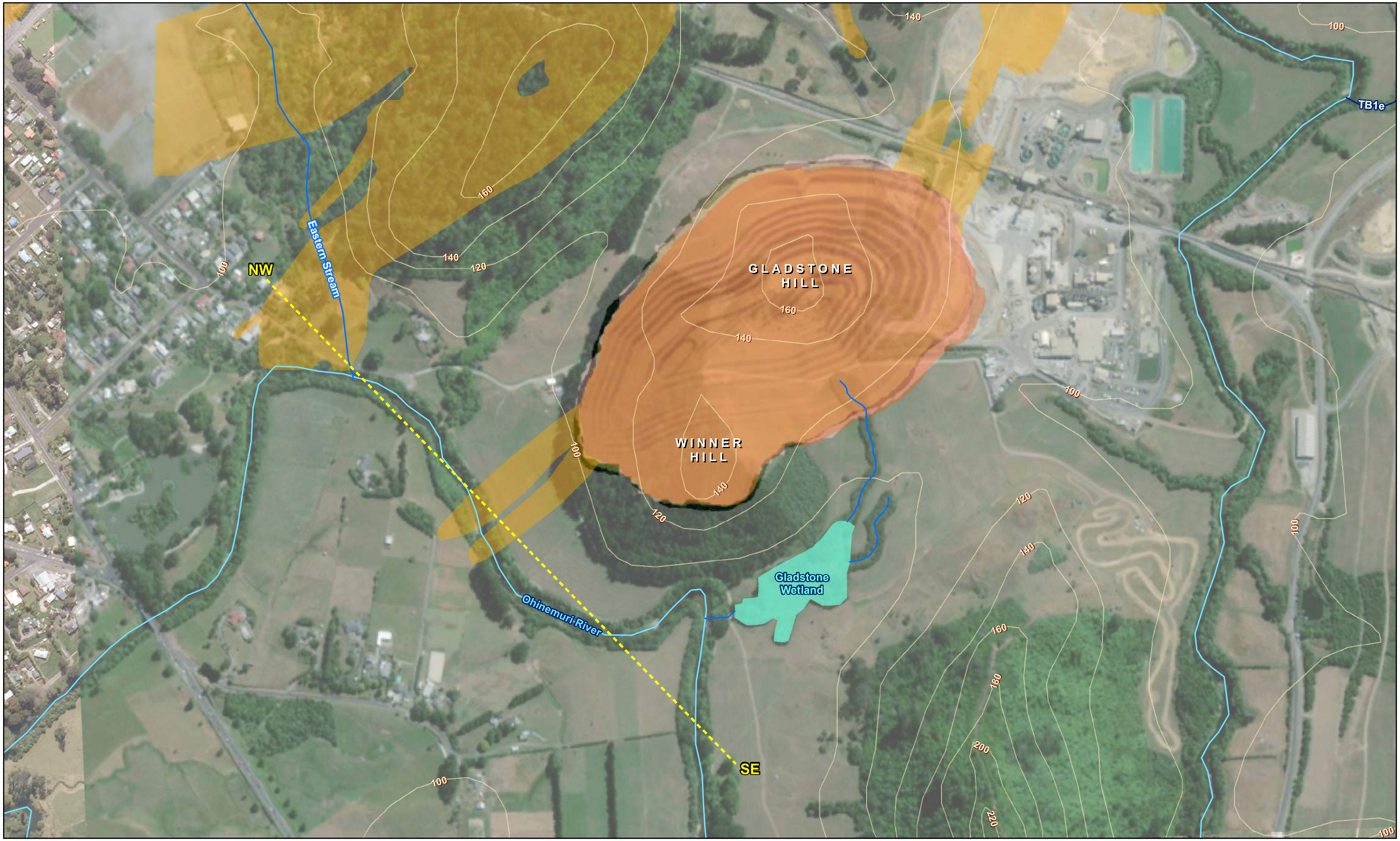
An annotated SEEP/W section is presented in Figure G.5. Model set up information is provided in Table G.8 and Table G.9.

Table G.8 Gladstone vein dewatering – model section perpendicular to vein boundary conditions

Boundary condition	Adopted condition	Justification	Model scenario
Ohinemuri River	Water total head – 1,084.65 mRL	Surveyed elevation close to OH6 sample point (21/02/2019)	Current conditions and vein dewatering scenarios
Andesite groundwater level	Water total head – 1085.5 mRL	Groundwater level recorded in GLD04d (October 2020)	
Gladstone dewatering	Water pressure head – 0 m	Set at 1,005 mRL within vein - assumes strong hydraulic connection along the vein system between GOP and Ohinemuri River to the southwest.	Vein dewatering scenario

Table G.9 Gladstone vein dewatering – adopted hydrogeological parameters

Unit	Hydraulic conductivity (m/s)	Anisotropy	Justification
Ash/Regolith	6.0×10^{-6}	0.5	Calibrated in GOP and TSF model assessment (G.1.1.4)
Rhyolitic Tuff (RT)	2.7×10^{-7}	0.5	
Sandy ignimbrite	1.0×10^{-5}	0.5	
Weathered andesite	5×10^{-9}	0.1	
Andesite	4.2×10^{-7}	1.0	Recorded range away from faults/crush zones 1 x 10^{-8} – 1 x 10^{-5} m/s(1)
Fractured Andesite	4.2×10^{-7}	2.0	Anisotropy reflects expected fracture alignment associated with Gladstone vein.
Gladstone Vein	1×10^{-5}	1.0	Fault / crush zone(1)
1. URS, 2003. Favona Underground Mine. Assessment of Groundwater Issues.			



Paper Size A3

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

LEGEND

- 🟧 Proposed Gladstone Pit
- 🟨 Inferred mineralised vein system
- - - - Model section perpendicular to Gladstone Vein
- — Contour (20m)

Ohinemuri River Tributary

- — River
- — Stream
- — Tributary

- 🟩 Wetland

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Gladstone vein dewatering model cross-section location

Figure G.5

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Data source: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:jrprice

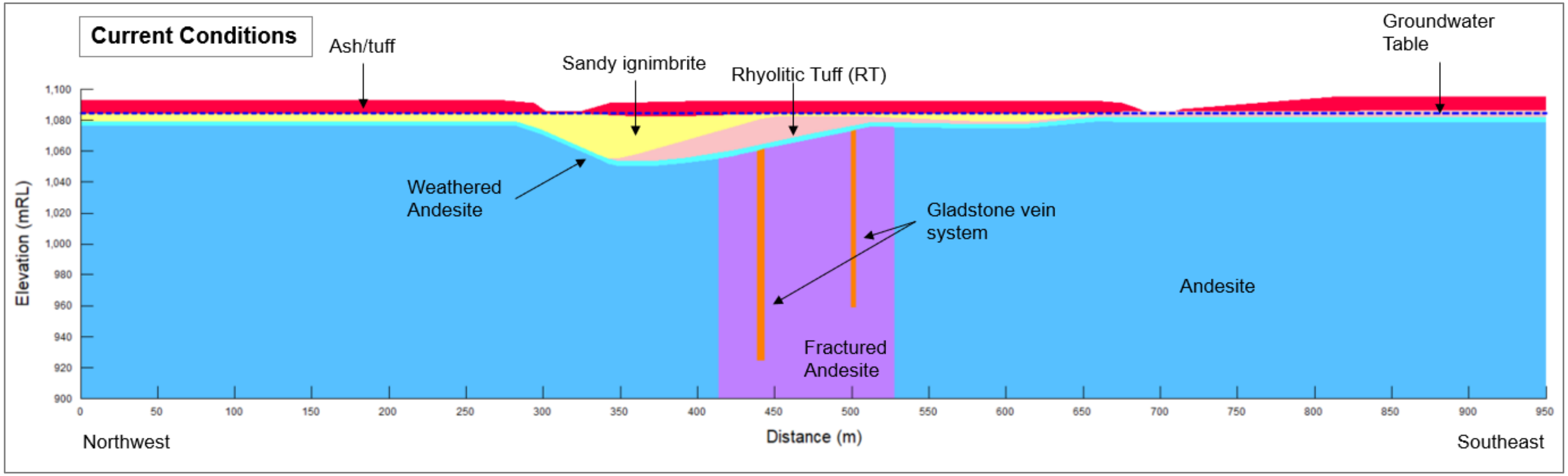

Figure G.6 *Gladstone vein dewatering – SEEP/W model cross section perpendicular to vein (NE - SW in Figure G.5)*

G.1.3 Surface water catchment assessment methodology

Surface water catchment calculations were undertaken to understand the relative potential loss of contributions (including interflow) to flow in the Ohinemuri River and local tributaries.

Figure G.7 presents the existing surface water catchment areas within which the proposed Gladstone Pit is located. As the summit of Gladstone Hill forms a high point in the central eastern area of the proposed pit, stormwater runoff and interflow are separated between the four water bodies defined for the purposes of this assessment. This allows assessment for two separate areas of the Ohinemuri River (OH3 and OH6), as well as the Gladstone wetland and intermittent Ohinemuri tributaries TB4 and TB5.

Changes in catchment area due to excavation of the proposed GOP and contouring of the tailings capping layer have been used to predict the reduction in stormwater runoff and interflow to each surface water catchment.

The surface water catchments for four key areas (OH3, OH6, TB5 and TB4) were estimated based on topographic contours, and design of the tailings capping layer to direct all runoff and interflow towards the Gladstone wetland and TB4 catchment south of the pit.

G.1.4 Water quality assessment methodology

Water quality assessment is not required for the GOP excavation or operational and TSF closure scenarios, as there are no predicted discharges to the environment.

After the TSF drainage system is no longer operation (long-term TSF scenario), discharge of groundwater which has interacted with the backfilled rock and tailings porewater is predicted to occur to the shallow groundwater adjacent to the pit.

An assessment was undertaken to predict receiving water quality within the Ohinemuri River (OH6), which utilised the following information:

- AECOM results (2021a) from geochemical equilibrium modelling to generate a groundwater quality equilibrated for mineral saturation for the TSF discharge.
- Existing groundwater quality adopted from the concentrations measured in a groundwater sample from piezometer GLD04s.
- Existing Ohinemuri River water quality adopted from the median concentrations measured in samples collected from OH6 (2017 – 2020).
- Predicted groundwater discharge to the Ohinemuri River (derived from groundwater modelling results).
- Ohinemuri River: Flow rates from the FRENDRUPS flow gauge station. The median flow rate (63,200 m^3/day) from available data recorded between 1 October 2017 and 30 April 2020 was applied.

Figure G.7 Surface water catchments that intersect with the proposed Gladstone Pit

G.2 Assessment results

G.2.1 GOP and TSF assessment results

Current conditions

The predicted groundwater discharges to each of the surface water bodies within the calibrated current conditions cross sectional groundwater models are presented in Table G.10.

Table G.10 Predicted groundwater discharge to surface water bodies during current conditions (SEEP/W)

Surface water body	Estimated groundwater discharge to surface water body (m^3/day)
Gladstone Wetland / Ohinemuri tributary (TB4)	1.1
Ohinemuri tributary (TB5)	0
Ohinemuri River east of Gladstone (OH3)	49
Ohinemuri River west of Gladstone (OH6)	215

GOP excavation

The groundwater discharges that are predicted to each of the surface water bodies during GOP excavation are presented in Table G.11. The results have been estimated using two different methods, groundwater modelling (G.1.1.1) and groundwater catchment (G.1.1.2) assessments.

Table G.11 Predicted groundwater discharge to surface water bodies during GOP excavation

Surface water body	Estimated groundwater discharge to surface water body (m^3/day) (SEEP/W)	Percentage change in groundwater discharge from current conditions (SEEP/W)	Percentage change in groundwater catchment
Gladstone Wetland / Ohinemuri tributary (TB4)	0.7	-33%	-22%
Ohinemuri tributary (TB5)	0	0%	0%
Ohinemuri River east of Gladstone (OH3)	49	<-1%	-12%
Ohinemuri River west of Gladstone (OH6)	157	-27%	-19%

The predicted groundwater discharge into the pit from the shallow groundwater system during GOP excavation is presented in Table G.12.

The predicted groundwater drawdown from current conditions and groundwater zone of influence during GOP excavation are presented in Table G.13. Predicted shallow groundwater drawdown during GOP excavation, and the predicted shallow groundwater table during all assessment scenarios, are presented in Figure G.8 and Figure G.9.

Table G.12 Estimated inflows to GOP from shallow groundwater system during GOP excavation (SEEP/W)

Pit section	Pit inflow	
	Per unit metre (m^3/s)	Total pit section (m3/day)
North	Negligible	
East	7.2×10^{-7}	8.8
South	Negligible	
West	Negligible	

Table G.13 Predicted shallow groundwater table drawdown at the edge of the pit and drawdown zone of influence during GOP excavation (SEEP/W)

Orientation from Pit	Groundwater drawdown at edge of pit (m)	Zone of influence (m)*
North	2.9	56
East	6.1	155
South	7.9	288
West	5.9	212
* Where drawdown > 0.5 m		

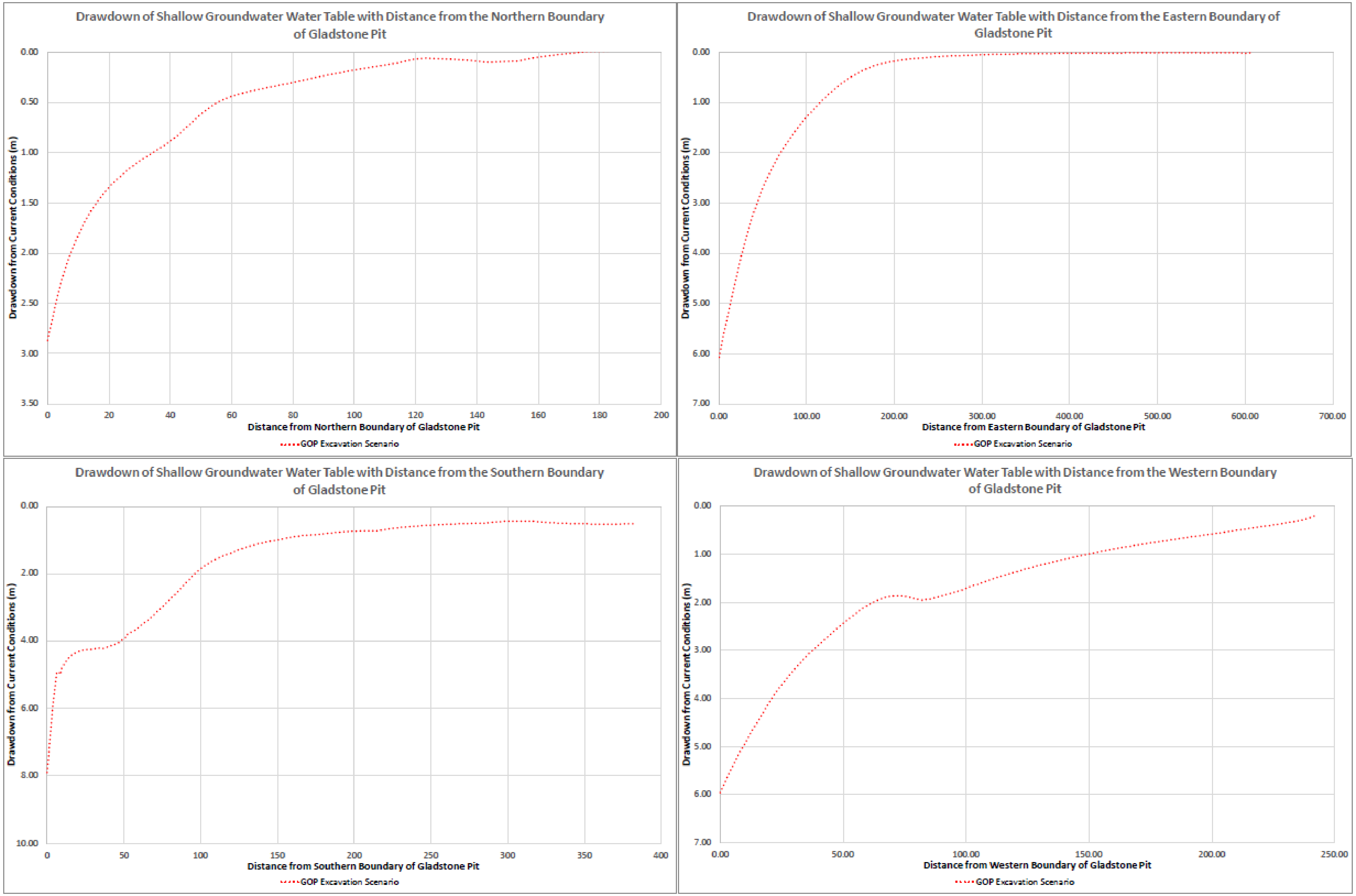

Figure G.8 Predicted shallow groundwater drawdown from current conditions during GOP excavation scenario (SEEP/W)

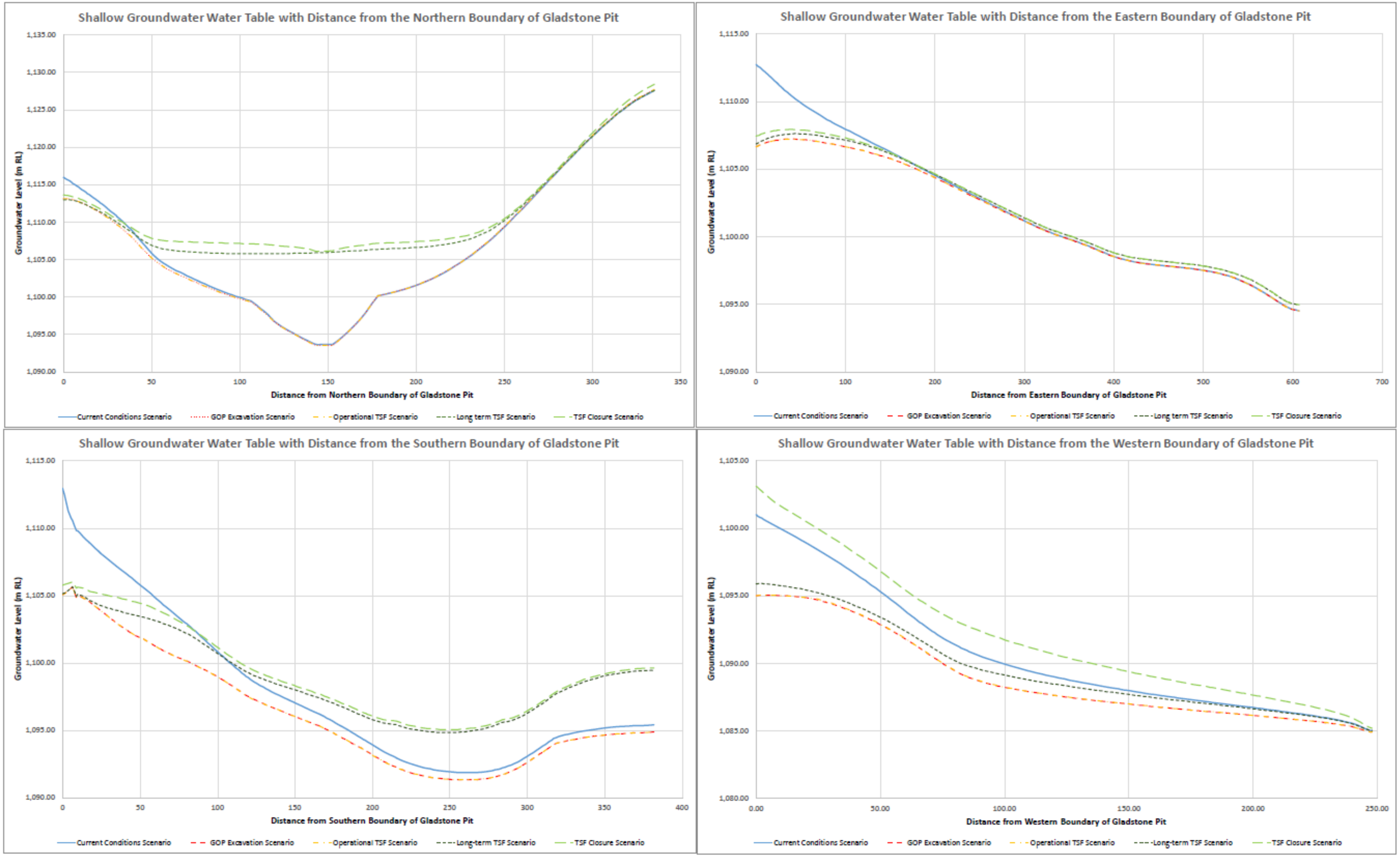

Figure G.9 Current and predicted groundwater water table during current conditions, GOP excavation and TSF scenarios (SEEP/W)

Operational TSF, TSF Closure and Long-term TSF

Groundwater discharges to each of the surface water bodies from the Gladstone Pit under current conditions and from the TSF during each TSF scenario are presented in Table G.14. The results have been estimated using the groundwater modelling methodology (G.1.1.1).

The predicted changes in groundwater levels and the predicted groundwater zone of influence after development of the TSF are presented in Table G.15. The predicted shallow groundwater table during all assessment scenarios, are presented in Figure G.9.

Table G.14 Predicted groundwater discharge from the pit area to surface water receiving environments under current conditions and after development of the TSF (SEEP/W)

Pit section	Estimated groundwater discharge to surface water from proposed pit area (current conditions) and from the TSF (TSF scenarios) (m^3/day)			
	Current scenario	Operational TSF	TSF closure	Long-term TSF
North (TB5)	0	0	0	0
East (OH3)	0	0	0	0
South (TB4)	0	0	0	0
West (OH6)	3.8	0	0	64.8 total (4.5 - Tailings porewater)
Total	**3.8**	**0**	**0**	**64.8**

Table G.15 Predicted change in shallow groundwater level at the edge of the pit compared to current conditions, and zone of influence, after development of the TSF (SEEP/W).

Orientation from Pit	Operational TSF		TSF closure		Long-term TSF	
	Groundwater drawdown at edge of pit (m)	Zone of influence (m)*	Groundwater drawdown at edge of pit (m)	Zone of influence (m)*	Groundwater drawdown at edge of pit (m)	Zone of influence (m)*
North	2.9	56	2.9	36	2.4	28
East	6.1	155	5.9	120	5.3	99
South	7.9	288	7.9	88	7.2	69
West	5.9	212	5.1	124	-2.1	-
* Where drawdown > 0.5 m						

The predicted groundwater discharges to each of the surface water bodies after development to a tailings storage facility are presented in Table G.16, Table G.17 and Table G.18.

Table G.16 ***Predicted groundwater discharge to surface water bodies during operational TSF scenario***

Surface water body	Estimated groundwater discharge to surface water body (m^3/day) (SEEP/W)	Percentage change in groundwater discharge from current conditions (SEEP/W)	Percentage change in groundwater catchment
Gladstone Wetland / Ohinemuri tributary (TB4)	0.7	-33%	-22%
Ohinemuri tributary (TB5)	0	0%	0%
Ohinemuri River east of Gladstone (OH3)	49	-<1%	-12%
Ohinemuri River west of Gladstone (OH6)	157	-27%	-19%

Table G.17 ***Predicted groundwater discharge to surface water bodies during TSF closure scenario***

Surface water body	Estimated groundwater discharge to surface water body (m^3/day) (SEEP/W)	Percentage change in groundwater discharge from current conditions (SEEP/W)	Percentage change in groundwater catchment
Gladstone Wetland / Ohinemuri tributary (TB4)	2.7	+156%	+84%
Ohinemuri tributary (TB5)	0	0%	0%
Ohinemuri River east of Gladstone (OH3)	57	+15%	+10%
Ohinemuri River west of Gladstone (OH6)	211	-2%	-7%

Table G.18 ***Predicted groundwater discharge to surface water bodies during long-term TSF scenario***

Surface water body	Estimated groundwater discharge to surface water body (m^3/day) (SEEP/W)	Percentage change in groundwater discharge from current conditions (SEEP/W)
Gladstone Wetland / Ohinemuri tributary (TB4)	3.2	+197
Ohinemuri tributary (TB5)	5	NA*
Ohinemuri River east of Gladstone (OH3)	57	+15%
Ohinemuri River west of Gladstone (OH6)	314	+46%
* Calculation not undertaken as no groundwater baseflow predicted during current conditions		

The predicted flux of tailings porewater to the deep groundwater system, and discharge through the drainage system installed beneath the geosynthetic liner at the base of the tailings during the operational TSF and TSF closure scenarios is presented in Table G.19.

Table G.19 Predicted flux to the deep groundwater system and TSF drainage system during operational TSF and TSF closure scenarios (SEEP/W)

Receiving environment	Flux (m^3/day)	
	Operational TSF	TSF Closure
Deep groundwater system	187 (tailings porewater)	0
TSF drainage system	0	58 (tailings porewater) 1,194 (deep groundwater)
Total	**187**	**1,252**

Sensitivity Analysis

Sensitivity analysis has been undertaken to inform an uncertainty assessment. This provides a range of results which may be realised following development of the GOP as a TSF, and the sensitivity of the assessment results to variations in parameter values.

The sensitivity analysis has been undertaken for the two Geostudio 2021 SEEP/W cross section models radial from Gladstone Hill for the TSF closure scenario. The following parameters were assessed:

- Hydraulic conductivity of the geosynthetic liner (Table G.20)
- Tailings cap infiltration rate (Table G.21)

Table G.20 Sensitivity analysis of TSF Closure model scenario – hydraulic conductivity of the geosynthetic liner (SEEP/W)

Flux to TSF drainage	Hydraulic conductivity reduced – $5x10^{-11}$ m/s	Base model – $1x10^{-10}$ m/s	Hydraulic conductivity increased – $5x10^{-10}$ m/s
Tailings porewater	54	58	59
Groundwater	1193	1194	1192
Total drain discharge	**1247**	**1252**	**1250**

Table G.21 Sensitivity analysis of TSF Closure model scenario – TSF capping layer infiltration rate (SEEP/W)

Flux to TSF drainage	Infiltration rate reduced – $9x10^{-9}$ m/s	Base model – $1x10^{-8}$ m/s	Infiltration rate increased – $2x10^{-8}$ m/s
Tailings porewater	56	58	60
Groundwater	1183	1194	1220
Total drain discharge	**1239**	**1252**	**1280**

The results of the sensitivity analysis indicate that the flux of tailings porewater and groundwater to the TSF drainage system beneath the geosynthetic liner has low sensitivity to the hydraulic conductivity of the liner, and to the infiltration rate of the TSF capping layer. It is also noted that altering these parameters did not impact the groundwater flow regime outside of the TSF, with no tailings or rock backfill impacted porewater predicted to discharge to the shallow groundwater system or the surface water receiving environment.

G.2.2 Gladstone vein dewatering assessment results

The predicted groundwater table during current conditions and in the Gladstone vein dewatering scenario is presented in Figure G.10. The predicted unsaturated zone within the andesite (where pore-water pressure is less than zero Kpa) is presented in Figure G.11, and Table G.22.

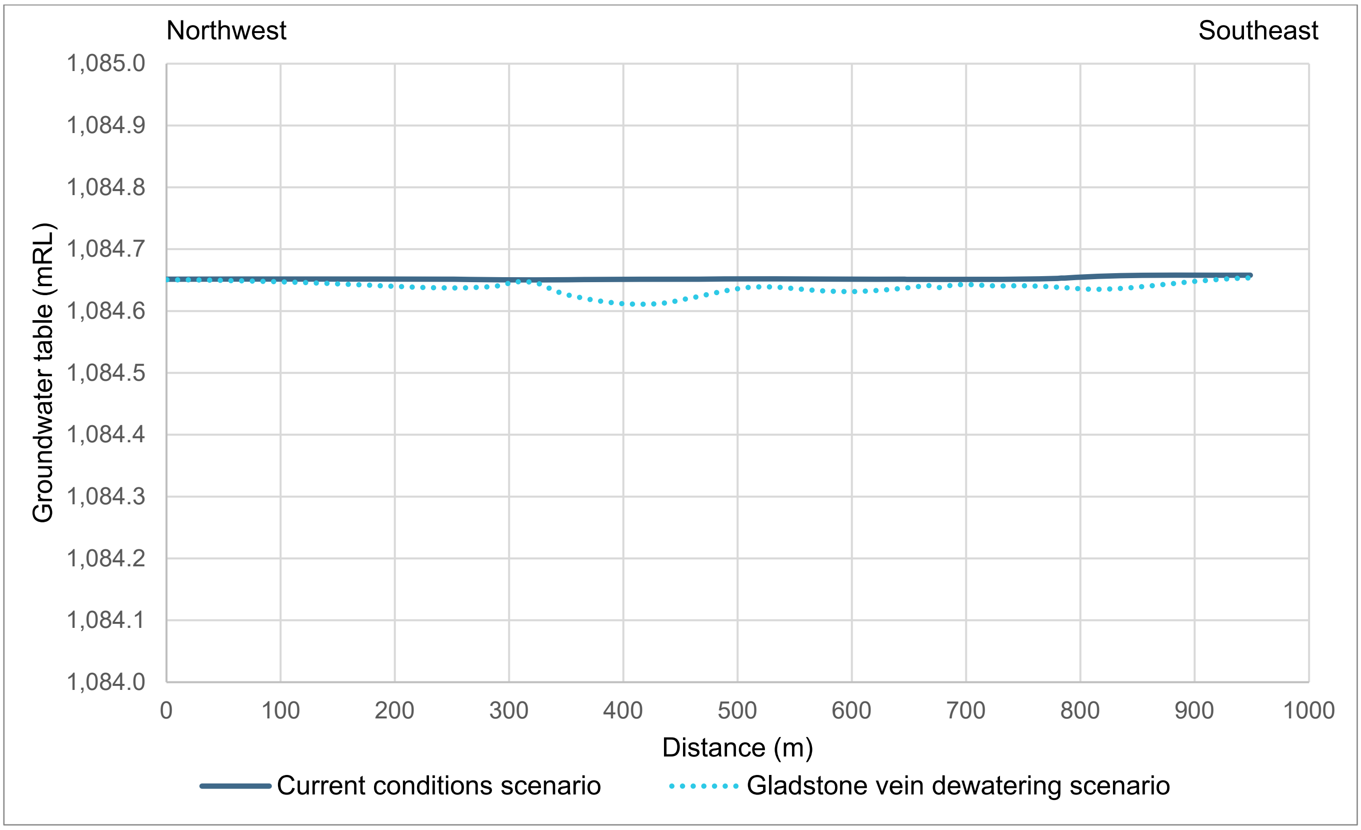

Figure G.10 Current and predicted groundwater table during current conditions and Gladstone vein dewatering (SEEP/W)

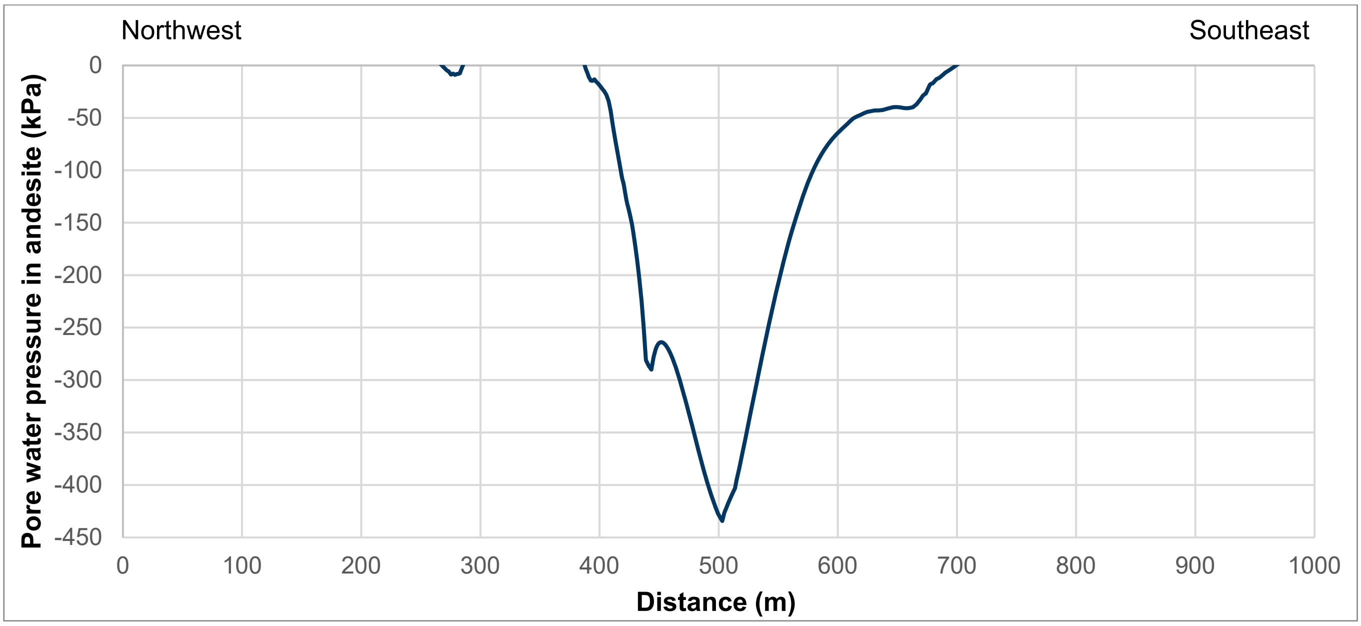

Figure G.11 Predicted unsaturated zone (pore water pressure less than zero kPa) within deep andesite in Gladstone vein dewatering scenario (SEEP/W)

The predicted extent of the unsaturated zone within the andesite from the centre of the vein system is presented in Table G.22. The predicted change in Ohinemuri River flow in the Gladstone vein dewatering scenario is presented in Table G.23. The predicted rate of groundwater inflow per 1 m section of the vein is 1.25 x 10^{-4} m^3/sec (10.8 m^3/day).

Table G.22 Predicted extent of unsaturated andesite from the centre of the Gladstone vein system (modelled at distance 471 m)

Orientation from Gladstone Vein system	Predicted extent of unsaturated andesite within deep groundwater system (m)*
Northwest	83 (with additional unsaturated area between 183 – 202)
Southeast	228
* Where pore water pressure is less than zero	

Table G.23 Predicted change in Ohinemuri River flow compared to current conditions in Gladstone vein dewatering scenario

Location	Predicted change in Ohinemuri River flow (m^3/day)
Ohinemuri River	-1.5

G.2.3 Surface water catchment assessment results

The current and predicted surface water catchment areas during all assessment scenarios for TB5, OH3 and OH6 are presented in Table G.24. The current and predicted surface water catchment areas during each assessment phase for TB4 are presented in Table G.25.

Table G.24 Results of GOP excavation and development as a TSF impact on surface water catchment areas for TB5, OH6 and OH3

Surface water catchment	Surface water catchment area (ha)		Percentage reduction from current conditions
	Current conditions	All GOP excavation and TSF scenarios	
Ohinemuri Tributary (TB5)	48.8	41.0	16%
Ohinemuri River west of Gladstone (OH6)	5.9	4.7	20%
Ohinemuri River east of Gladstone (OH3)	24.4	19.5	20%

Table G.25 Results of GOP excavation and development as a TSF impact on surface water catchment areas for TB4

Surface water catchment	TB4 Surface water catchment area (ha)	Percentage change from current conditions
Current scenario	18.6	-
GOP Excavation / Operational TSF	13.8	-26%
TSF Closure / Long-term TSF	32.5	+74%

G.2.4 Water quality assessment results

All groundwater that discharges into the GOP during excavation, and any surface water runoff within the pit, will be treated at the water treatment plant prior to discharge to the Ohinemuri River. There are therefore no notable water quality effects to the receiving environment predicted during GOP excavation.

The TSF drainage system is predicted to provide a high degree of hydraulic containment of the tailings porewater during the operational TSF and TSF closure scenarios, with seepage through the backfilled rock and tailings not predicted to migrate to the shallow groundwater system or the surface water receiving environment. While discharge of tailings impacted porewater to the deep groundwater system is predicted to occur prior to rewatering of the deep system, this discharge is predicted to migrate towards other mine dewatering systems that control deep groundwater flow directions. There are therefore no notable water quality effects to the receiving environment predicted during the operational TSF and TSF closure scenarios.

After an improvement in water quality is observed within the discharge from the TSF drainage system, operation of the drainage will be discontinued (long-term TSF scenario). The water quality assessment has therefore assessed the potential impact of tailings porewater discharge on shallow groundwater and the surface water receiving environment.

As presented in Table G.14, approximately 4.5 m3/day of tailings porewater is predicted to discharge west to the Ohinemuri (OH6) catchment in the long-term TSF scenario. Table G.26 presents the predicted water quality of the total groundwater discharge (64.8 m^3/day) to this groundwater catchment from the TSF, and subsequent mixing within the Ohinemuri River.

Table G.26 Predicted receiving water quality in the long-term TSF scenario (values in mg/L)

Parameter	Existing shallow groundwater quality (GLD04s)	Predicted values after equilibration of TSF discharge with shallow groundwater	Existing Ohinemuri River quality (OH6 median)	Predicted values after mixing with Ohinemuri River	Receiving water quality criteria
pH	6.8	7.7	7.1	-	6.5 – 9.0
Al	0.088	0.07	0.016	0.016	
As	0.001	0.0012	0.0010	0.0010	0.19
Ba	0.14	0.109	0.038	0.038	
Total Alkalinity	65	42	15.4	15.6	
Ca	10.5	79	43.5	43.8	
Cd	<0.00005	0.0001	<0.00005	<0.00005	0.0003
Cl	9	11	16.4	16.4	
Co	0.017	0.04	0.0009	0.0011	
Cr	<0.0005	<0.0005	<0.00050	<0.00050	0.01
Cu	0.0014	0.0008	0.0005	0.00050	0.003
Fe	0.03	***2.2***	0.09	0.098	1
Hg	***<0.00008****	***0.00011***	***<0.00008****	***<0.00008****	0.000012
K	3.5	6	3.6	3.6	
Mg	2.8	12	3.1	3.1	
Mn	0.43	1.5	0.019	0.024	2
Na	24	27	17.1	17.2	
Ni	0.0089	0.007	0.0005	0.00053	0.04
Pb	<0.0001	<0.0001	<0.0001	<0.0001	0.0004

Parameter	Existing shallow groundwater quality (GLD04s)	Predicted values after equilibration of TSF discharge with shallow groundwater	Existing Ohinemuri River quality (OH6 median)	Predicted values after mixing with Ohinemuri River	Receiving water quality criteria
SO4	17	263	148	149.0	
Sb	0.0002	0.0007	0.00055	0.00055	0.03
Se	<0.001	<0.001	<0.001	<0.001	0.02
Zn	***0.13***	***0.12***	0.0024	0.0028	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

Appendix H

Northern Rock Stack Technical Assessment

This appendix presents the methodology and results for technical assessment of the proposed Northern Rock Stack (NRS). All elevations are presented in metres reduced level (mRL) with reference to Waihi Mine datum, which is 1,000 metres below sea level.

H.1 Assessment methodology

H.1.1 Groundwater flow assessment

Groundwater flow from upgradient of the NRS footprint under existing conditions has been estimated using Darcy's Law analytical solution[1]:

$$Q = AKi$$

Where:

Q = Volumetric groundwater flow rate (m^3/day)
A = Cross sectional area of groundwater flow (m^2)
K = Saturated hydraulic conductivity (m/day)
i = Groundwater hydraulic gradient (dimensionless)

The following inputs were adopted for assessment using Darcy's Law:

– 25 m average shallow aquifer thickness based on geology encountered during drilling.
– 557 m approximate length of NRS perpendicular to groundwater flow.
– 6×10^{-6} m/s shallow aquifer hydraulic conductivity, based on hydraulic testing undertaken in monitoring wells.
– 0.1 hydraulic gradient at base of Rhyolite Dome east of proposed NRS.
– Total groundwater flow to the Ohinemuri River has been calculated by including the additional recharge expected across the alluvial flats; multiplying the recharge rate 2×10^{-8} m/s (30% of rainfall) by the approximate footprint area of the NRS (260,000 m^2).

H.1.2 Construction dewatering assessment

Groundwater is anticipated to be intercepted by the uphill diversion drains at the south-eastern boundary of the NRS, approximately between chainage 400 – 630. Construction of the drains will involve excavation of rhyolite rock in this area, with dewatering likely to be required where the design invert levels of the uphill diversion drain are below the existing groundwater table. Initial groundwater inflow rates and groundwater drawdown distance of influence have been estimated using the Sichardt analytical solutions[2]:

$$L = C\ (H - h)\sqrt{k}$$

Where:

L = Distance of influence (m)
C = Empirical calibration factor (1750 for planar flow cases)
H-h = Target drawdown in excavation (m)
k = Saturated hydraulic conductivity (m/sec)

$$Q = \frac{Kx\ (H^2 - h^2)}{L}$$

Where:

Q = Volumetric groundwater inflow to excavation (m^3/sec)
x = Length of slot (trench) (m)

– The following inputs were adopted for assessment using the Sichardt solution:
– 2 m of groundwater drawdown at the location of the excavation/drain invert.
– 230 m section (length of trench) along which dewatering is anticipated.
– 1×10^{-7} m/s – 1×10^{-5} m/s range of rhyolite hydraulic conductivity, based on hydraulic testing undertaken in monitoring wells.

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[1] Darcy, H. 1856. Les fontaines publiques de la vile de Dijon. Paris:Dalmont.
[2] Preene, M., Robers, T.O.L., Powrie, W. 2016. Groundwater control: design and practice, second edition. CIRIA, C750. London, 2016.

H.1.3 NRS assessment

Flow paths of infiltrating rock stack recharge, rates of leachate capture and seepage through the Zone A liner, rates of sub-soil drain capture and migration of groundwater and leachate seepage beneath the NRS were predicted using groundwater modelling for NRS operation and closure.

Groundwater modelling was undertaken using GeoStudio 2021 SEEP/W finite element numerical modelling software. A two-dimensional (2D) section was developed to model a cross section through an approximately east-west orientation through the proposed NRS. The model orientation was selected to represent the average distance between leachate collection drains and sub-soil drains allowing estimation of the average pressure head generated by a build-up of leachate on the liner and resulting leachate seepage and capture. The model considered a 467 m cross section of the proposed rock stack across an area where existing ground level slopes from the base of the elevated rhyolite dome in the east, with topography reducing to the west. An annotated plan view diagram of the location and orientation of the cross section is presented in Figure H.1.

The NRS assessment was undertaken for the scenarios presented in Table H.1.

Table H.1 NRS assessment – model scenario summary

Scenario	Description
NRS Operation (steady state)	Rock stack to maximum elevation 1,173 mRL placed on Zone A liner. Rainfall recharge applied to exposed rock stack. Rainfall recharge rate for Zone F representative of overlying Zone G & H capping layer. Leachate collection drains located on top of Zone A liner surrounded by Zone F material, and sub-soil drains located beneath the liner. Groundwater flow east to west, with groundwater levels approximating existing conditions.
NRS Closure (steady state)	Rock stack and Zone F to maximum elevation of 1,146 mRL. Rainfall recharge rate for Zone F representative of overlying Zone G & H capping layer. Leachate collection drains located on top of Zone A liner surrounded by Zone F material, and sub-soil drains located beneath the liner. Groundwater flow east to west, with groundwater levels approximating existing conditions.
Zone A: A 0.75 m thick low permeability soil liner at the base of the rock stack. Zone F: A 1.5 m minimum thickness layer separating the rock from the capping layer. This material forms a drainage layer and is a permeable slightly silty, sandy gravel PAF material.	

The 2D groundwater model was used to predict:

- Leachate flux to leachate collection drains.
- Seepage rate of leachate through the Zone A liner.
- Leachate and groundwater flow to sub-soil drains.
- Leachate and groundwater migration within the shallow aquifer west of the NRS.

As the results are extracted from the groundwater model on a per unit metre basis, they were scaled up to represent the whole NRS. Results from the model section were therefore multiplied by 557 m (approximate width of NRS perpendicular to groundwater flow).

The SEEP/W model was structured using EGL design drawings (EGL, 2025a) to represent conditions after construction of the NRS. Site data, including geology, permeability and water levels from monitoring wells was utilised to model the shallow groundwater system. Bore logs, groundwater levels and permeability test results from monitoring bores are presented in Appendix B, Appendix C and Appendix D, respectively. Annotated SEEP/W sections are presented in Figure H.2. Model set up information is provided in Table H.2. The adopted hydrogeological properties are presented in Table H.3.

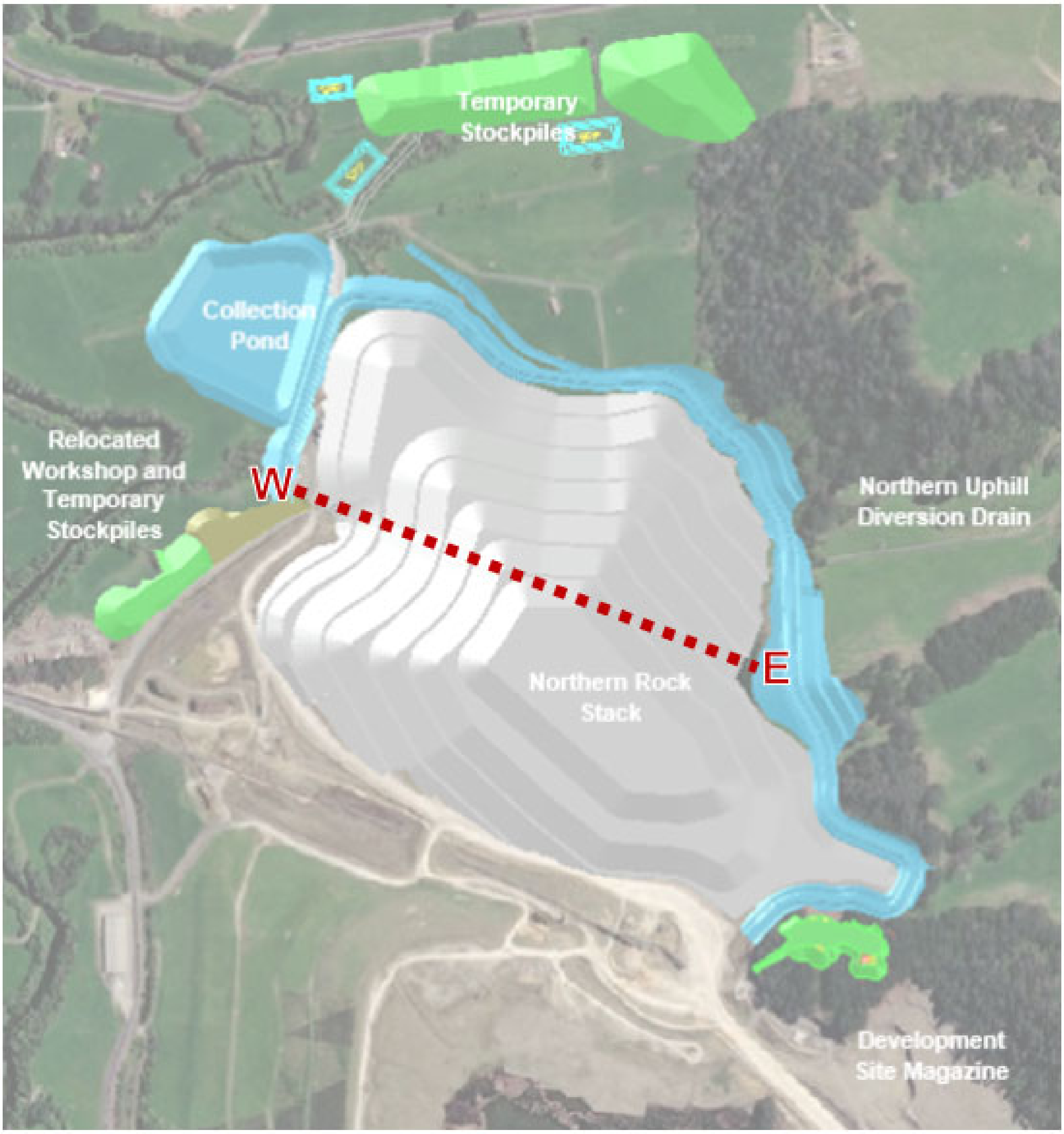

Figure H.1 Annotated plan view of east-west NRS model section (modified from OGNZL Project description, 2021)

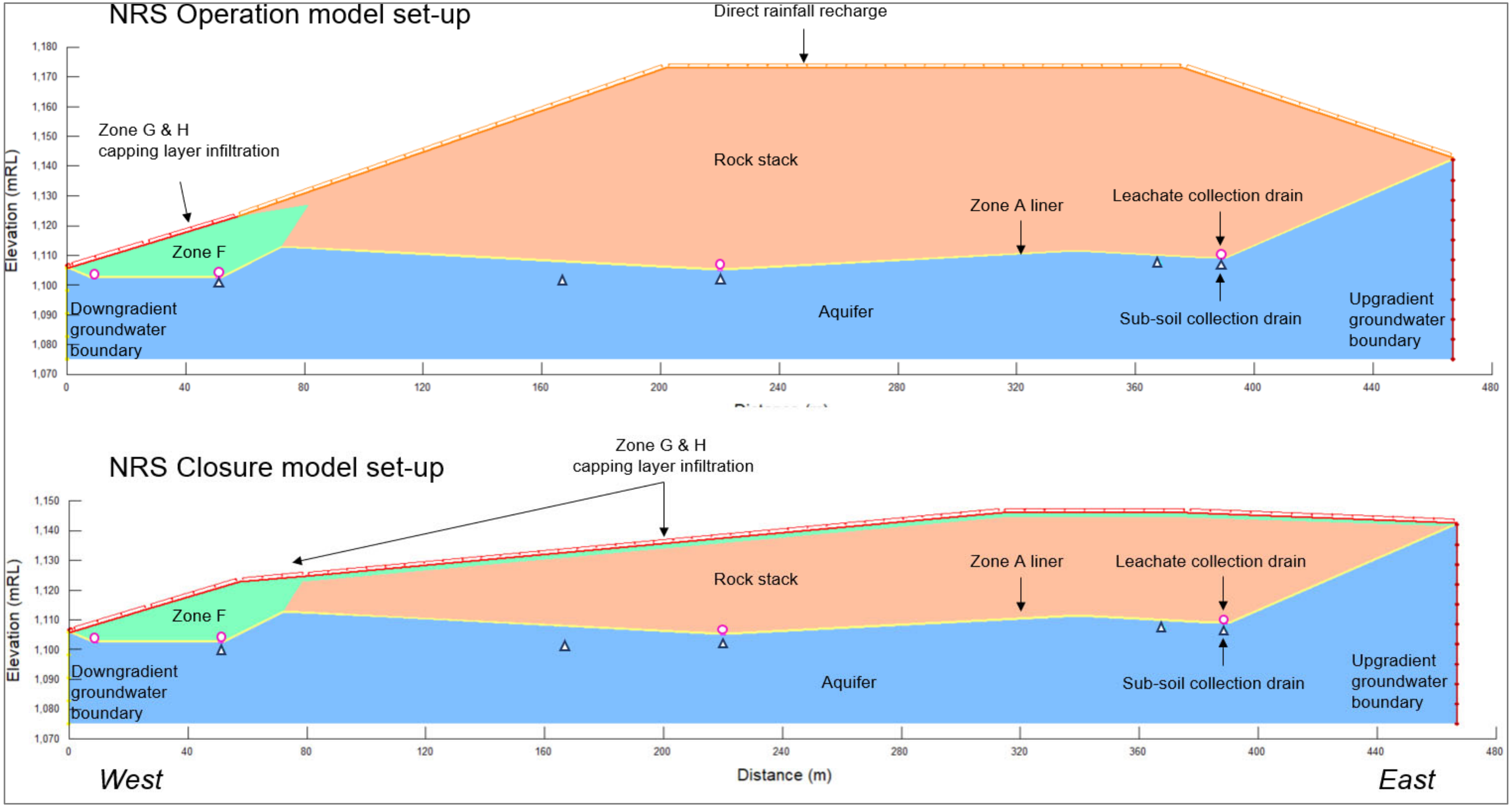

Figure H.2 Annotated NRS east-west SEEP/W model cross section

Table H.2 NRS model set-up

Boundary type	Adopted boundary condition	Justification	Model scenario
Rainfall recharge	Two recharge rates applied to rock stack: Water flux – 2×10^{-8} & 3×10^{-8} m/s	30 & 50 % of average rainfall at the site (2,110 mm/year[3])	NRS operation
Infiltration through capping layer	Applied to surface of Zone F: Water flux – 1×10^{-8} m/s	5-year average cap infiltration rate[4] for Zones G & H	NRS operation & closure
Upgradient groundwater boundary (east)	Constant Head – 1,115 mRL	Based on piezometric groundwater contours (Appendix C).	
Downgradient groundwater boundary (west)	Constant Head – 1,100 mRL		
Leachate collection drains	Water Rate – potential seepage face review	Removal of leachate through collection drains	
Sub-soil collection drains	Water Rate – potential seepage face review	Removal of groundwater through sub-soil drains	

Table H.3 NRS model adopted hydrogeological material parameters

Geological unit	Hydraulic conductivity (m/s)	Anisotropy (Ky/Kx)	Volumetric water content and hydraulic conductivity function(1)	Hydraulic conductivity justification
Shallow aquifer	6×10^{-6}	0.5	Silty sand	Geomean of hydraulic test results in shallow aquifer piezometers
Zone A liner	1×10^{-8}	1.0	Clayey silt	As per design specification
Zone F drainage layer	1×10^{-4}	1.0	Uniform sand	Considered appropriate for Zone F materials
Rock stack	1×10^{-5}	0.5	Silty sand	Considered appropriate for rock stack materials
1. SEEP 2012 materials database				

H.1.4 Water quality assessment

Seepage of leachate through the Zone A liner to the underlying groundwater is predicted to occur. A mixing assessment has been undertaken to predict the impact this may have on the water quality of groundwater, as well as the receiving water quality of the Ohinemuri River. This assessment utilised the following information:

- AECOM results (2021b) of geochemical equilibrium modelling to generate a groundwater quality equilibrated for NRS leachate through the Zone A liner and mineral saturation in the NRS closure scenario.
- Existing Ohinemuri River water quality adopted from the median sample concentrations at OH3 (2017 – 2020; for parameters not analysed during this period, older sample data was used to inform median concentrations).
- Existing groundwater quality adopted from the median sample concentrations collected from DH05a (2017 – 2020).
- Predicted leachate discharge to groundwater and predicted migration of leachate to the Ohinemuri River (derived from groundwater modelling results).
- Ohinemuri River: Flow rates from the FRENDRUPS flow gauge station. The median flow rate (63,212 m^3/day) from available data recorded between 1 October 2017 and 30 April 2020 was applied.

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[3] NIWA, 2019. Climate data obtained from Waihi, Station Agent No. 1550.

[4] AECOM, 2020. Infiltration rates provided for TSF1A embankment slope. Email communication provided by AECOM, 27 July 2020.

H.2 NRS assessment results

H.2.1 Groundwater flow assessment results

Shallow groundwater flow upgradient of the NRS site is predicted to be approximately 722 m^3/day. Additional recharge across the alluvial flats under existing conditions is estimated at approximately 449 m^3/day, with a predicted total groundwater discharge to the Ohinemuri River of approximately 1,171 m^3/day.

H.2.2 Construction dewatering assessment results

Construction of uphill stormwater diversion drains will involve excavation of rhyolite rock at the south-eastern extent of the NRS. Interception of groundwater is anticipated, with estimated initial groundwater inflow rates and distance of influence of groundwater drawdown presented in Table H.4. The inflow rates determined assume that the full length of excavation required will be undertaken at the same time, however it is considered likely that the excavation will be progressively advanced. Groundwater inflow rates are also predicted to reduce over time as groundwater levels and gradients towards the uphill diversion drains reduce as the system equilibrates to the change in conditions.

Table H.4 NRS groundwater inflow rates and distance of influence of dewatering for uphill diversion drain construction

Uphill Diversion Drain Groundwater Assessment	Result range
Initial groundwater inflow rate (m^3/day)	7 - 70
Distance of influence of dewatering (m)	1 – 11

H.2.3 NRS assessment results

The predicted rock stack leachate captured by leachate collection drains seepage through the Zone A liner are presented in Table H.5. The predicted leachate and groundwater captured in the sub-soil drains is presented in Table H.6. The predicted groundwater and leachate flow within the groundwater system to the Ohinemuri River is presented in Table H.7.

Table H.5 Predicted leachate capture and leachate seepage through zone A liner

Infiltration conditions	Leachate captured by leachate collection drains (m3/day)	Leachate seepage through Zone A liner (m^3/day)
NRS operation		
30% rainfall	29	413
50% rainfall	109	605
NRS closure		
5-year average cap infiltration (369 mm/year)	2	262

Table H.6 Predicted groundwater and leachate captured in sub-soil drains

Infiltration conditions	Groundwater captured by sub-soil drains (m^3/day	Leachate captured by sub-soil drains (m^3/day)	Total sub-soil drains capture (m^3/day)
NRS operation			
30% rainfall	744	342	1087
50% rainfall	736	508	1244
NRS closure			
5-year average cap infiltration (369 mm/year)[2]	751	212	963

Table H.7 Predicted leachate flow to Ohinemuri River within groundwater

Infiltration conditions	Leachate flow to Ohinemuri River (m^3/day)
Operational scenario	
30% rainfall	71
50% rainfall	97
Closure scenario	
5-year average cap infiltration (369 mm/year)[2]	49

H.2.4 Water quality assessment results

As presented in Table H.5*,* approximately 262 m^3/day of rock stack leachate is predicted to seep through the Zone A liner in the NRS closure scenario. A large proportion of this leachate is then predicted to be captured by the sub-soil drains (Table H.6), with the remaining 49 m^3/day then anticipated to flow west towards the Ohinemuri River within the shallow groundwater system (Table H.7).

Table H.8 presents the predicted water quality beneath the NRS following mixing and equilibration of the groundwater with leachate seepage through the Zone A liner in the NRS closure scenario, and the predicted water quality following mixing with the Ohinemuri River.

Table H.8 Predicted receiving water quality in the NRS closure scenario (values in mg/L)

Parameter	Existing shallow groundwater quality (DH05a median)	Predicted values after equilibration of NRS leachate with shallow groundwater	Existing Ohinemuri River quality (OH3 median)	Predicted values after mixing with Ohinemuri River	Receiving water quality criteria
pH	6.5	7.4	7.2	-	
Al	0.003	0.011	0.013	0.013	
As	0.0096	<0.001	<0.0010	<0.0010	0.19
Ba	0.67	0.02	0.027	0.027	
Ca	2.7	116.0	3.1	3.6	
Cd	<0.00005	0.000010	<0.00005	<0.000050	0.0003
Co	0.041	0.020	<0.00020	0.00028	
Cr	<0.0005	<0.0005	<0.0005	<0.00050	0.01
Cu	<0.0005	0.000060	<0.0005	<0.00050	0.003
Fe	***6.8***	***21.0***	0.10	0.19	1
Hg	***<0.00008****	***<0.00008****	***<0.00008****	***<0.00008****	0.000012
K	2.3	3.0	2.0	2.0	
Mg	1.2	28.0	1.9	2.0	
Mn	1.5	***4.0***	0.010	0.027	2
Na	9.9	11.0	9.2	9.2	
Ni	0.0051	<0.003	<0.0005	<0.00051	0.04
Pb	0.00016	<0.0001	<0.0001	<0.0001	0.0004
SO4	5.0	338.0	5.0	6.4	

Parameter	Existing shallow groundwater quality (DH05a median)	Predicted values after equilibration of NRS leachate with shallow groundwater	Existing Ohinemuri River quality (OH3 median)	Predicted values after mixing with Ohinemuri River	Receiving water quality criteria
Sb	<0.0002	0.00030	<0.0002	<0.00020	0.03
Se	<0.001	<0.001	<0.0002	<0.00020	0.02
Zn	0.016	<0.003	0.0019	0.0019	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

H.3 NRS assessment sensitivity analysis

Sensitivity analysis has been undertaken for a number of parameters to inform an uncertainty assessment of the groundwater modelling used for the NRS assessment. This provides a range of results which may be realised for the NRS, and the sensitivity of the assessment results to variations in parameter values. The sensitivity analysis has been undertaken using the Geostudio 2021 SEEP/W cross section model for the NRS Closure scenario as a base model. The parameters assessed are presented in Table H.9.

Table H.9 Sensitivity analysis for NRS Closure scenario

Sensitivity parameter	Initial base model parameter value	Modified parameter value
Rock stack hydraulic conductivity function (AEV)	Silty sand[1]	Silty sand with AEV[2] reduced (see Figure H.3)
		Silty sand with AEV[2] increased (see Figure H.3)
Aquifer hydraulic conductivity function	Silty sand[1]	Sand[1] (see Figure H.4)
		Clayey Silt[1] (see Figure H.4)
Zone A liner hydraulic conductivity function	Clayey silt	Sandy clayey silt[1] (see Figure H.5)
		Clayey silt (fine tailings)[1] (see Figure H.5)
Rock stack hydraulic conductivity	1 x 10^{-6} m/s	1 x 10^{-5} m/s
		1 x 10^{-7} m/s
Aquifer hydraulic conductivity	6 x 10^{-6} m/s	6 x 10^{-5} m/s
		6 x 10^{-7} m/s
Zone A liner hydraulic conductivity	1 x 10^{-8} m/s	1 x 10^{-7} m/s
		1 x 10^{-9} m/s
Groundwater table elevation	Upgradient groundwater boundary – 1,115 mRL Downgradient groundwater boundary – 1,100 mRL	Upgradient groundwater boundary – 1,114 mRL Downgradient groundwater boundary – 1,099 mRL
		Upgradient groundwater boundary – 1,116 mRL Downgradient groundwater boundary – 1,101 mRL

1. SEEP/W 2012 Database
2. AEV = Air entry value (minimum matrix suction at which point air enters the pores and saturation reduces)
2. AECOM 2020. Infiltration rates provided for TSF1A embankment slope. Email communication provided by AECOM, 27 July 2020.

The groundwater model sensitivity analysis results have been assessed by comparing the predicted rock stack leachate seepage rates through the Zone A liner and the predicted leachate capture at the leachate collection drains. The results are presented in Figure H.6. Increased leachate capture at the leachate collection drains is largely controlled by the potential for perching on the Zone A liner, which promotes greater saturation and horizontal flow towards the leachate drains.

The modelled results have greatest sensitivity to hydraulic conductivity of the Zone A liner, with leachate capture increasing from 2 m^3/day to 177 m^3/day when the hydraulic conductivity is reduced by one order of magnitude, causing perching of leachate on the liner. To a lesser degree, reducing the hydraulic conductivity of the shallow aquifer also results in an increase in the predicted leachate captured at the leachate drains, as a result of reducing the vertical hydraulic gradient across the liner.

The results demonstrate moderate sensitivity to altering the hydraulic conductivity function of the shallow aquifer and the Zone A liner. By reducing the AEV, this increases the pore sizes and reduces the hydraulic conductivity of these materials.

Although the sensitivity analysis results indicate relatively low sensitivity to changes in groundwater level beneath the rock stack, the results indicate that the closer the groundwater table is to the Zone A liner, the more leachate is predicted to be captured. This is because higher groundwater levels reduce the vertical hydraulic gradient across the Zone A liner.

The sensitivity analysis results indicate low sensitivity to the rock stack parameters assessed.

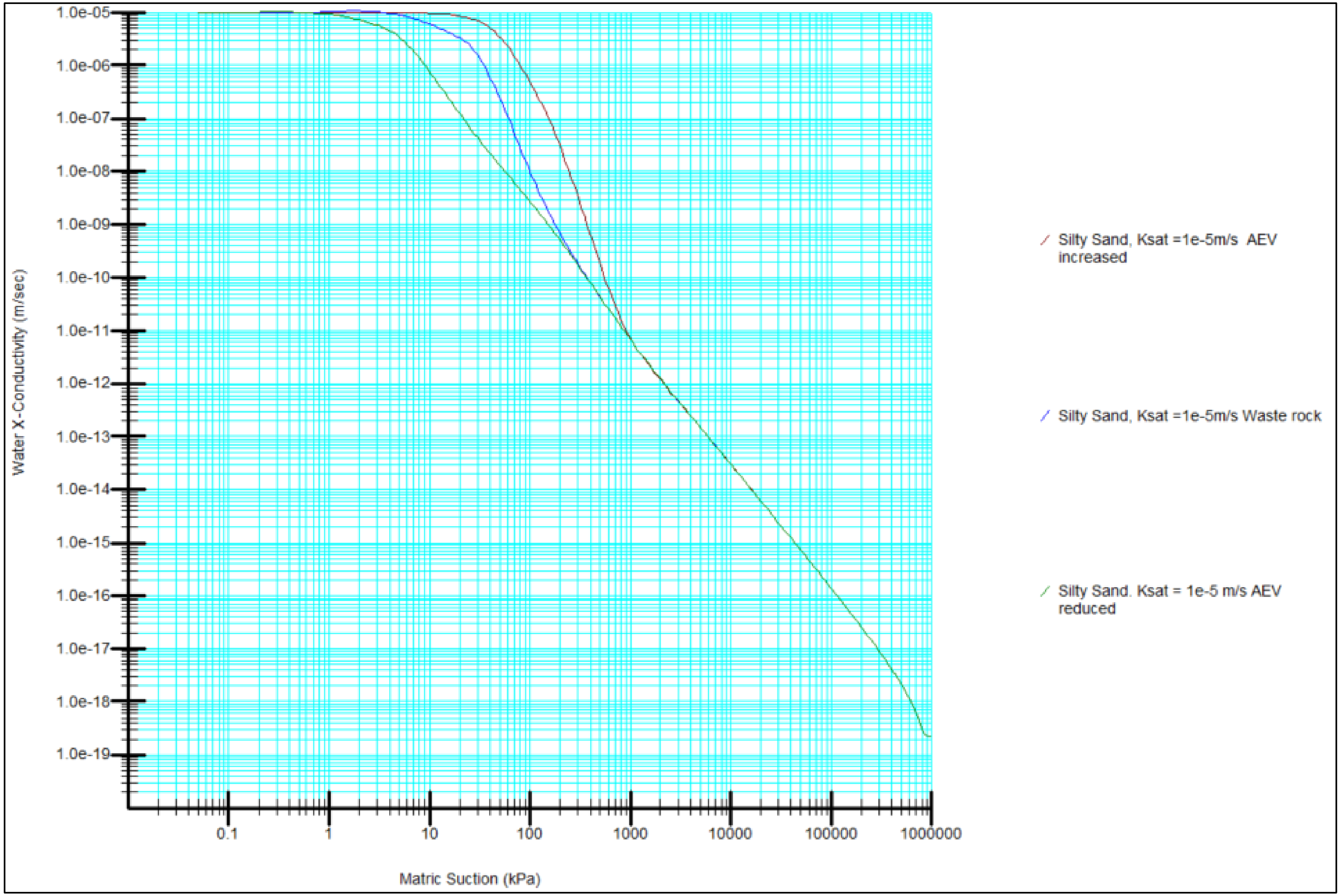


Figure H.3 *Rock stack hydraulic conductivity function sensitivity analysis – Silty sand SEEP/W database (blue) with AEV increased (red) and reduced (green).*

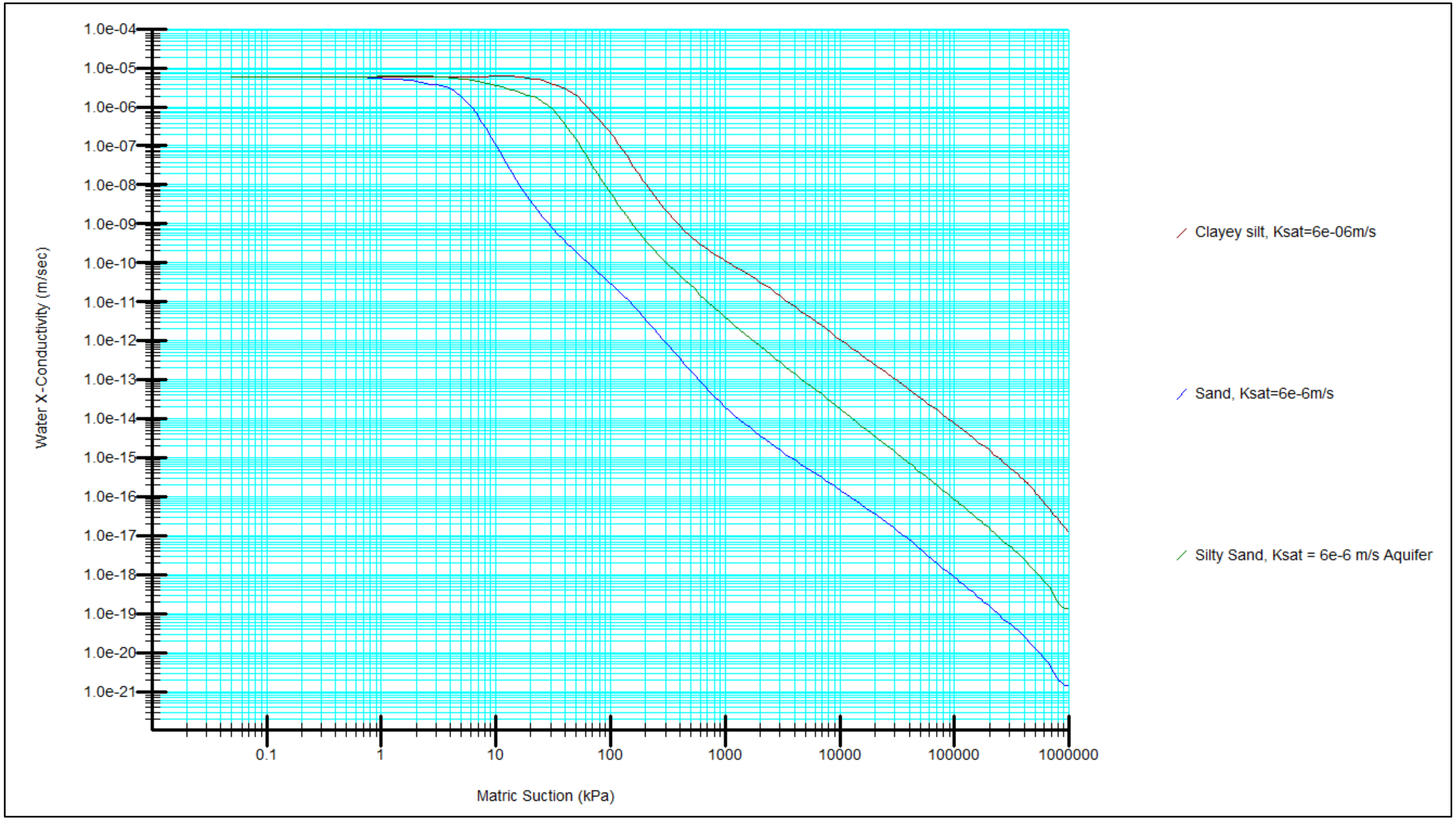


Figure H.4 ***Shallow Aquifer hydraulic conductivity function sensitivity analysis – clayey silt (red), sand (blue) and silty sand (green).***

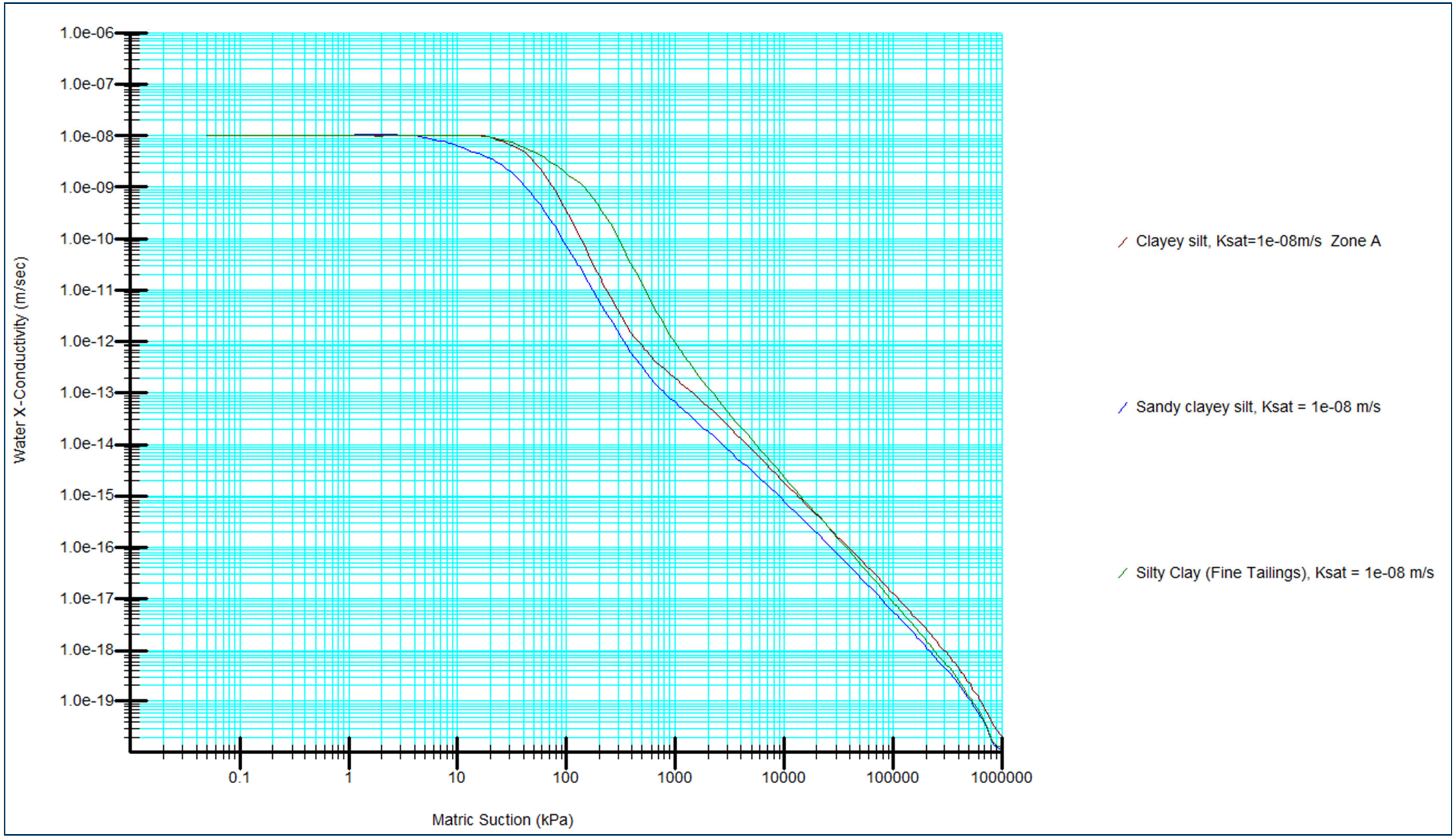


Figure H.5 Zone A liner hydraulic conductivity function sensitivity analysis – clayey silt (red), sandy clayey silt (blue) and silty clay (fine tailings) (green).

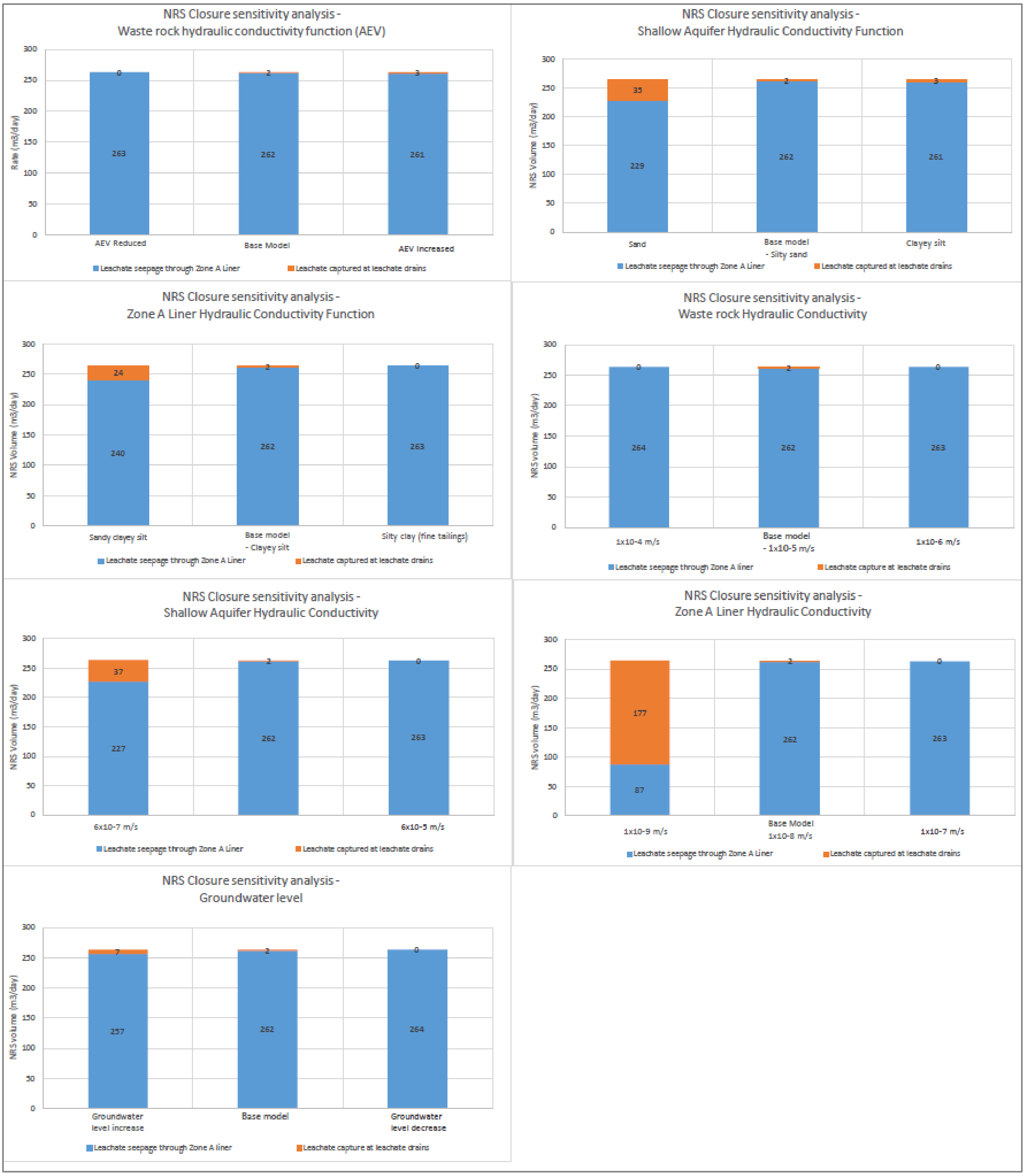


Figure H.6 *NRS sensitivity analysis results*

Appendix I

TSF3 Technical assessment

This appendix presents the methodology and results for technical assessment of the proposed TSF3. All elevations are presented in metres reduced level (mRL) with reference to Waihi Mine datum, which is 1,000 metres below sea level.

I.1 Introduction

This technical appendix provides the details of the TSF3 analysis presented in Section 5.5 of the Waihi North Groundwater Assessment report.

The outline of this appendix is as follows:

- I.2 Assessment methodology (model set up, calibration, scenarios)
- I.3 Analysis results
- I.4 Water quality assessment
- I.5 Sensitivity testing

I.2 Groundwater modelling methodology

The rationale for the model set up is described in Section 5.4 of the Groundwater Assessment report. This section describes the physical model set up, how calibration was achieved, and the scenarios applied.

I.2.1 Cross-section 1 (SEEP/W)

Base model set up

The base model comprised a steady-state 2D cross-sectional model using Geostudio 2019 R2 SEEP/W. The section length was 2.1 km, starting from the rhyolite hills north of the TSF3 site through to the Ruahorehore Stream south of the TSF3 embankment toe (See Figure I.1 and Figure I.2). The cross-section was aligned in the direction of dominant groundwater flow of the primary (deeper) aquifer and through the paleogully infilled with sensitive tuff, which will be excavated to approximately 20 m below ground level. The undercut will require dewatering to this depth and will be backfilled during the foundation works phase.

For consistency with the Waihi North TSF3 geotechnical assessment, the geology represented in the hydrogeological model was provided as a direct export from the EGL Geostudio SLOPE/W ground model (as reported in the EGL TSF3 technical report (EGL, 2021)). Minor edits to the geology were made for the groundwater assessment, including merging regions of the same or hydraulically similar materials; applying a single surface material to represent alluvium, ash and colluvium given the limited surficial geological information (i.e. upper 2 m); and creating a separate “hard rock” rhyolite region under the northern hills to reflect the rhyolite ridge, where site-specific groundwater and geological information was limited.

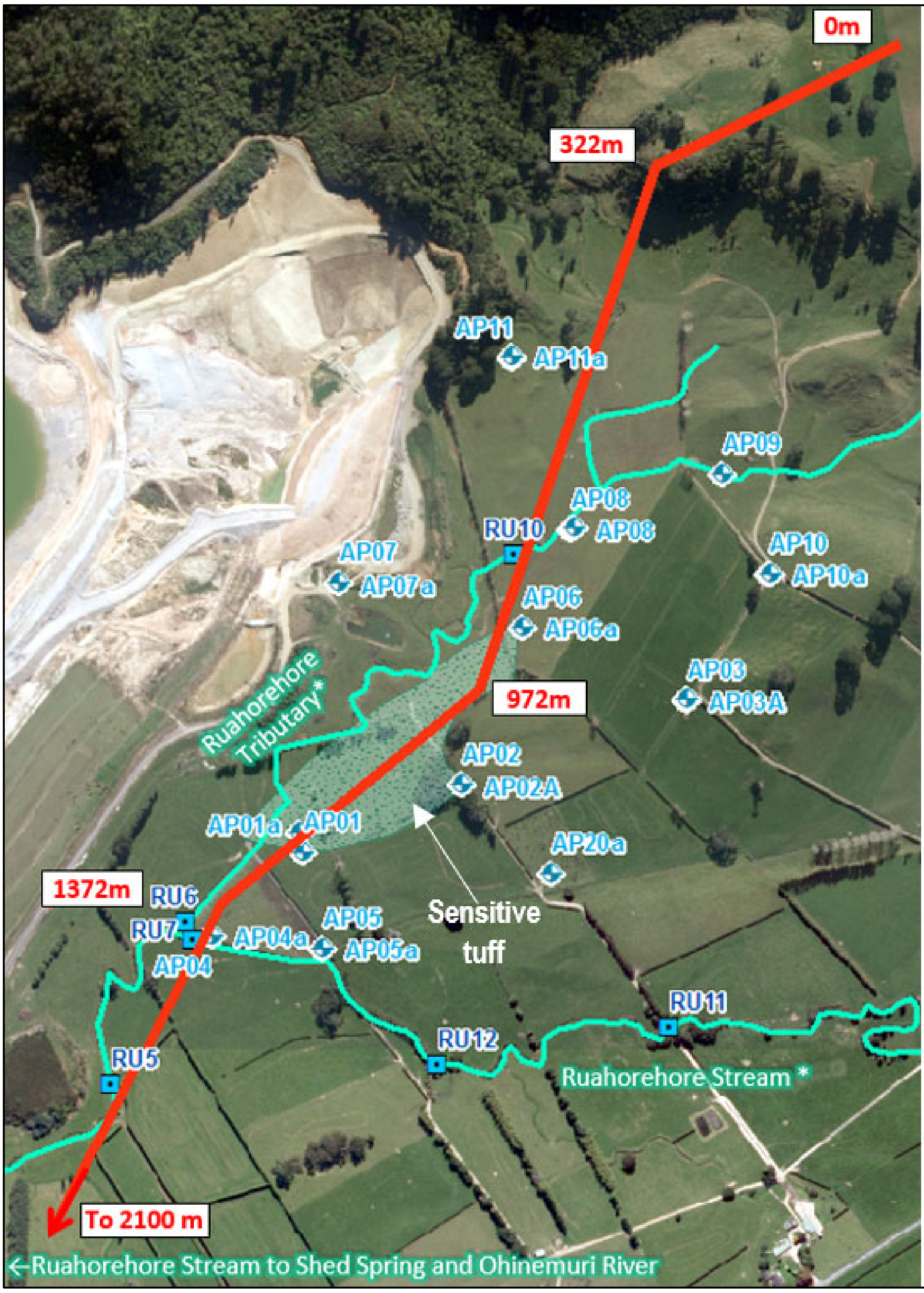
Parameters and boundary condition calibration

Through an iterative process, the input values for the final base model were derived by applying values from within measured ranges of parameters such as rainfall and hydraulic conductivity for each geological unit. The input values were varied in order to achieve base model calibration, focusing on:

- A horizontal hydraulic gradient in the primary (deeper) groundwater system beneath the TSF3 site consistent with that measured during site investigations (Appendix C)
- Downward vertical gradients at the northern edge of the TSF3 site, and upward gradients at the embankment toe, whilst achieving minimal flow to the Ruahorehore Stream (i.e. interflow only).

To achieve this, the following boundary conditions (Table I.1) were applied in conjunction with the hydraulic parameters provided in Table I.2:

- 740 mm/year (35% average annual rainfall) to groundwater at the valley ridges.
- 11 mm/year (0.5%) within the TSF3 valley.
- No recharge in the lower valley floor, where upward vertical gradients are present and surface ponding occurs.
- Constant head boundaries at either end of the model to achieve artesian conditions at depth below the toe of the TSF3 valley.



**Note: the extent of the Ruahorehore Stream and tributaries shown in this map extent are generally neutral to losing under baseflow conditions (except at the tributary head waters, which are spring fed)*

Figure I.1 TSF3 Cross-section 1 alignment showing relevant monitoring locations for calibration

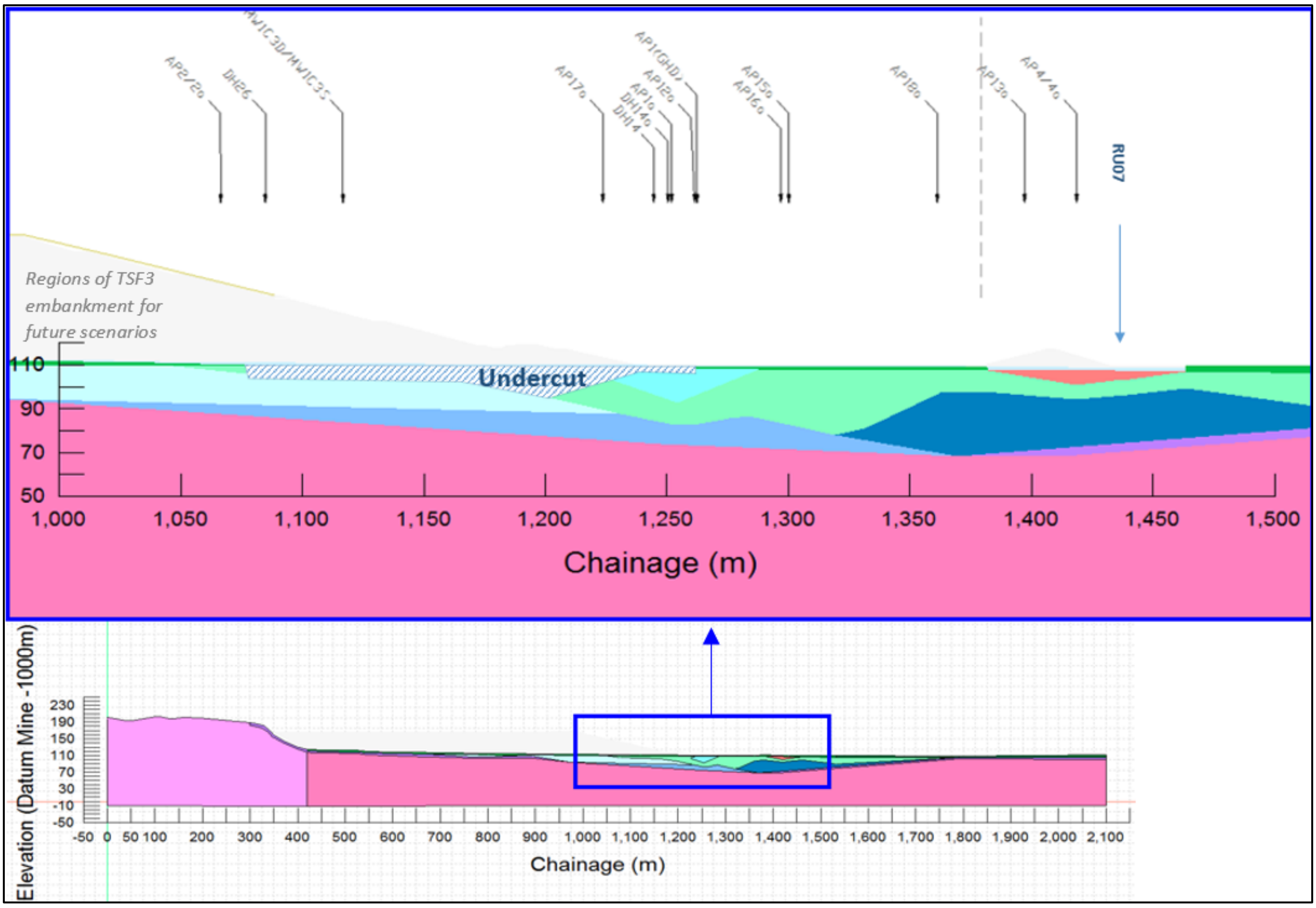


Figure I.2 *TSF3 Cross-section 1 SEEP/W model set-up with close up of undercut and key monitoring locations*

Table I.1 *TSF3 base model set-up*

Boundary type	Adopted boundary conditions	Justification
Rainfall recharge	Water flux - potential seepage face review: – Upper catchment: 2 x 10^{-3} m/d (35% average annual rainfall) – Lower catchment: 3 x 10^{-5} m/d (0.5% average annual rainfall) – Lower catchment, artesian conditions: 0 m/d	Values adjusted to achieve sufficient flow through the aquifer and artesian conditions in the lower TSF3 valley, where adopted rainfall = 2,110 mm/year[5] These values are considered appropriate where recharge is inferred to occur across the upper catchment (rhyolite ridge) where downward gradients occur, versus the lower valley where very low permeability surface cover is present and surface ponding occurs.
Upgradient groundwater boundary (north)	Constant Head – 1,117 mRL	Values were derived by calibration in conjunction with rainfall, to achieve measured groundwater levels and gradients (Appendix C) and low stream flow.
Downgradient groundwater boundary (southeast)	Constant Head – 1,104 mRL	
Ruahorehore Stream	Water rate – potential seepage face review set to 1,108 m RL	Set to the elevation measured during the January 2019 stream survey (Appendix F).

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[5] NIWA, 2019. Climate data obtained from Waihi, Station Agent No. 1550.

Table I.2 TSF3 base model adopted material parameters

Geological unit *	K_H (m/s)	Measured K values**		Anisotropy (K_V/K_H)	VWC and K function#
		Geomean	Range		
Ash/alluvium/colluvium	9.3×10^{-8}	4.5×10^{-8}	3.2×10^{-9} to 8.5×10^{-7}	1	Sandy Loam
Rhyolite Lava Flow (CW-MW)	5.8×10^{-7}	1.3×10^{-7}	1.2×10^{-9} to 1.0×10^{-4}	1	Sandy silt
Rhyolite Lava Flow (MW-SW)	1.2×10^{-5}	5.0×10^{-6}	1.0×10^{-8} to 1.0×10^{-4}	1	Sandy silt
Rhyolite Rock	1.3×10^{-5}	No data. Value calibrated based on SW Lava Flow and adjusted to achieve downgradient artesian conditions		1	Sandy silt
Rhyolite Lava Froth Flow	6.3×10^{-6}	No data. Value calibrated based on SW-CW Lava Flow values and adjusted to achieve downgradient artesian conditions		1	Sand
Rhyolite Lava Froth pulse	1.2×10^{-7}	2.8×10^{-7}	3.2×10^{-9} to 2.4×10^{-5}	1	Sandy silt
Rhyolite Porphyritic Tuff	1.2×10^{-5}	No data. Value calibrated based on tuff values and adjusted to achieve groundwater level calibration.		1	Silty Sand
Rhyolite Redeposited Tuff	1.1×10^{-6}	2.2×10^{-6}	3.2×10^{-9} to 1.0×10^{-4}	0.01	Silty Sand
Rhyolite Tuff - Unit at DH14/AP01/AP05	2.3×10^{-6}	1.6×10^{-6}	2.4×10^{-7} to 1.5×10^{-5}	0.01	Silty Sand
Rhyolite Tuff - all other locations	1.0×10^{-7}	1.6×10^{-8}	5.7×10^{-10} to 6.5×10^{-6}	0.1	Sandy silt

* Geological units are colour coded as per the SEEP/W cross section

** Permeability values are from the results provided in Appendix D and CPT dissipation testing by EGL (2018).

VWC = Volumetric water content function (SEEP/W 2012 materials database)

Base model calibration

The results of base model calibration is presented in Table I.3 to

Table I.5. The relationship between the measured and modelled results are presented in Figure I.3.

Table I.3 Calibrated horizontal gradient across the TSF3 site

Well ID	Location	Total head	
		Modelled value:	Measured (Feb-Mar 2018):
AP11a	Upgradient (ridge)	1,114.3 m RL	1,115.0 m RL
AP04a	Down gradient (near RU07)	1,108.5 m RL	1,109.5 m RL
	ΔH	-5.5 m	-5.5 m

Table I.4 Calibrated stream baseflow

Stream baseflow (RU07)	Modelled value	Measured (Feb-Mar 2018):
Stream length[(1)]	350 m	
Baseflow (per meter stream length)	0.002 m^3/d	-0.4 to 0.2 m^3/d [(2)]
Baseflow along 350 m stream length	0.01 L/s	-1.5 to 0.7 L/s
Regime	Neutral [(3)]	Neutral to losing

1 Between RU07 and upstream gauging location RU12.

2 Measured values from baseflow monitoring between RU12 and RU07 in February 2019. The range of values provided represents the range of error.

3 The results indicate only very slightly gaining, but are considered within the magnitude of the model and error to be neutral.

Table I.5 Calibrated groundwater levels and well pair vertical gradients

Wells (screen depth)	Groundwater Level (mRL unless otherwise noted)	Modelled value	Measured (Feb-Mar 2018)
Northern Ridge	Deep	1,115.88	-
ΔH	*Downward gradient*	*down*	*n/a*
AP11 well pair			
AP11 (3-5 m)	*Water table - in m bgl**	*3.9*	*4.9*
AP11a (17-20 m)	Deep well	1,114.33	1,114.89
ΔH	*Downward gradient*	*down*	*n/a*
AP08 / DH12 well pair			
AP08 (2.5 - 5.5 m)	Shallow well	1,113.90	1,114.11
DH12 (20-21 m)	Deep well	1,113.24	1,113.20
ΔH	*Downward gradient*	*-0.7*	*-0.9*
AP06 well pair			
AP06 (3-5 m)	Shallow well GWL	1,112.94	1,113.05
AP06a (21 - 24 m)	Deep well GWL	1,112.40	1,112.67
ΔH	*Downward gradient*	*-0.5*	*-0.4*
AP02 well pair			
AP02 (3-5 m)	Shallow well GWL	1,110.35	1,111.47
AP02a (27-30 m)	Deep well GWL	1,111.21	1,112.17
ΔH	*Upward gradient*	*+0.9*	*+0.7*
AP1a well pair			
AP01 (3-5 m)	Shallow well GWL	1,109.20	1,110.23
AP01a (37-40 m)	Deep well GWL	1,109.91	1,110.45
ΔH	*Upward gradient*	*+0.7*	*+0.2*
AP04 well pair			
AP04 (4-6 m)	Shallow well GWL	1,108.56	1,109.40
AP04a (27-30 m)	Deep well GWL	1,108.62	1,109.47
ΔH	*Upward gradient*	*+0.1*	*+0.1*
	Groundwater levels R^2 =	0.98 (refer to Figure I.3)	
	Vertical ΔH R^2 =	0.88 (refer to Figure I.3)	

* The cross section does not fully align with the AP11 well pair, which is elevated in comparison to the cross section at this location. The AP11 well water levels are perched at this location, with the base of the shallow well located above the measured deeper wells water level. Further, the corresponding water level elevations at the shallow well exceed the model ground surface at this location. Calibration at this location focused on the primary aquifer (deeper well AP11a), and a water table within 5 mbgl (as measured).

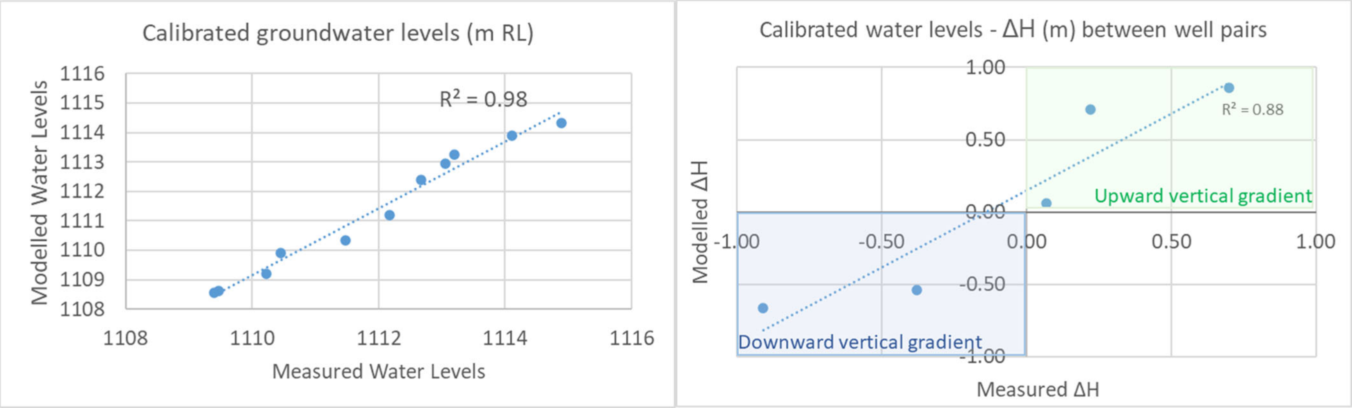


Figure I.3 Goodness of fit – Cross-section 1 (SEEP/W) base model

Scenarios

Multiple scenarios were assessed from the Cross-section 1 base model. These were split into two different model types:

- **Steady-state (Table I.6):** Full TSF3 construction from foundation works to post-closure. This model provides outputs for predicting:
  - Tailings porewater leakage rates.
  - Embankment leakage rates.
  - Changes in groundwater recharge, levels and flow associated with TSF3 construction.
  - Changes to surface water flow and levels.

  The recharge input provided relates to average annual recharge. The daily outputs provided for these analyses are therefore based on average annual recharge, rather than transient or seasonal variations.

  The scenarios assessed using this model are summarised in Table I.6. Scenarios 3-5 were developed on the basis that the tailings permeability will change over the life of the facility, and changes to drains will occur. Tailings toward the base of TSF3 are expected to have a lower permeability than the material at surface, consistent with a silty clay-type material. On disposal, the mine tailings will consolidate, releasing porewater to decant. This is expected to reduce the permeability of tailings throughout the operational period of the facility.

  The following drains are proposed to intercept discharges from TSF3 (Figure I.4):
  - Leachate drains in the embankment above the Zone A pad. These are expected to intercept embankment infiltration and tailings pore water beneath the embankment.
  - Sub-soil and toe drains (beneath the Zone A liner) are intended to intercept leachate that infiltrates through the soil liner and embankment.

  Over time, drains may become crushed during consolidation, or become filled with fines and fail to adequately capture leachate seepage. If this occurs where groundwater conditions are not artesian, seepage will percolate downwards until groundwater is encountered. Tailings toward the base of TSF3 are expected to have a lower permeability than at the top, and consistent with a silty clay-type material. To some extent, this will limit the potential discharge through any liner defects.

  The uphill diversion drain is interpreted to not intercept groundwater (or perched water only). No analysis has been carried out for this drain.

  An additional model was developed to understand the influence of Zone B within the shear key, which is only present for half of the embankment width. The location of Zone B is presented in Figure I.5.
- **Transient (Table I.10):** Construction dewatering only. The timeframes for each scenario were provided by EGL (pers.comm. EGL, email dated 10 June 2020). This transient model allows for more refined outputs for predicting groundwater inflows and ZOI. It is noted that the thickness of the sensitive tuff for removal along the cross-section alignment is only present to 15 m bgl.

The added material properties and boundary conditions for these scenarios are in Table I.8 and Table I.9. The constant head boundaries, recharge and material properties remain as per the base model unless provided below.

Table I.6 Summary of steady state model scenarios for Cross-section 1 (all stages of TSF3 construction)

Scenario	Stage of work	Description
1 (Parent for Scenario 2)	Ruahorehore Stream Diversion	The calibrated base model was updated to relocate the Ruahorehore Stream approximately 40 m to the south and the surface alluvium replaced with Zone A material. This formed the base model for the following scenarios.
2 (Parent for Scenario 3)	Construction dewatering	Construction dewatering as a parent model for the proposed starter embankment. Included fully dewatered excavation of the sensitive tuff to 15 m depth without backfill.
3 (Parent for Scenario 4)	Starter Embankment (1,135 mRL)	Scenario 3 considers completed foundations works with tailings placed to the full height of the starter rock embankment (1,135 mRL). The HDPE liner is emplaced to 1,135 mRL and all drains are assumed to be operational. The tailings at this stage of construction have the least amount of consolidation and therefore the greatest applied K_V of all scenarios.
4 (Parent for Scenario 5)	Operational to closure (1,155 m RL)	Embankment height and tailings increased to 1,155 m RL. A lower tailings K_V was applied to represent the modelled tailings consolidation by EGL (see Table I.9).
5	Long-term / Post closure (1,155 m RL)	As per Scenario 4, with further decreased tailings K_V to represent 90% tailings consolidation. In this scenario, drains are removed from the analysis to simulate potential drain failure, except for the downstream toe drain which remained operational within the scenario.

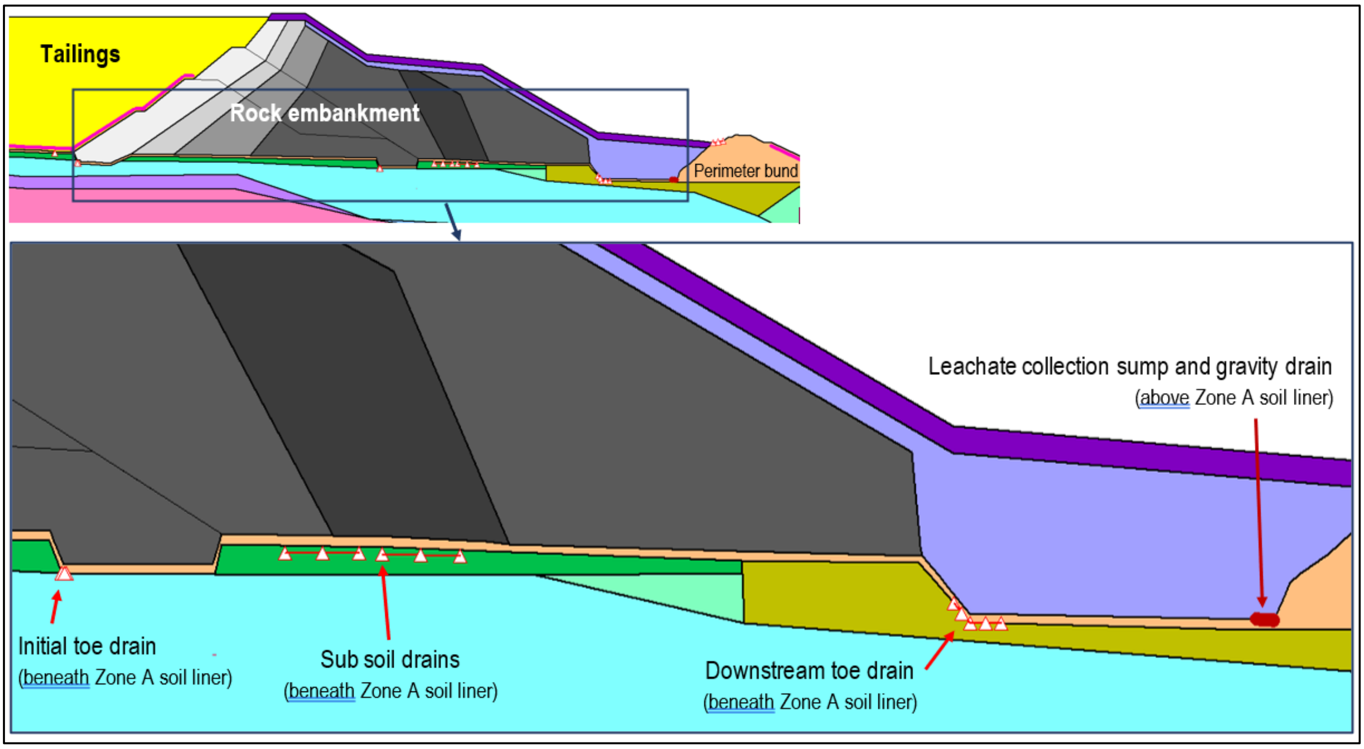


Figure I.4 TSF3 Cross-section 1 SEEP/W model set-up with close up of drains beneath the embankment

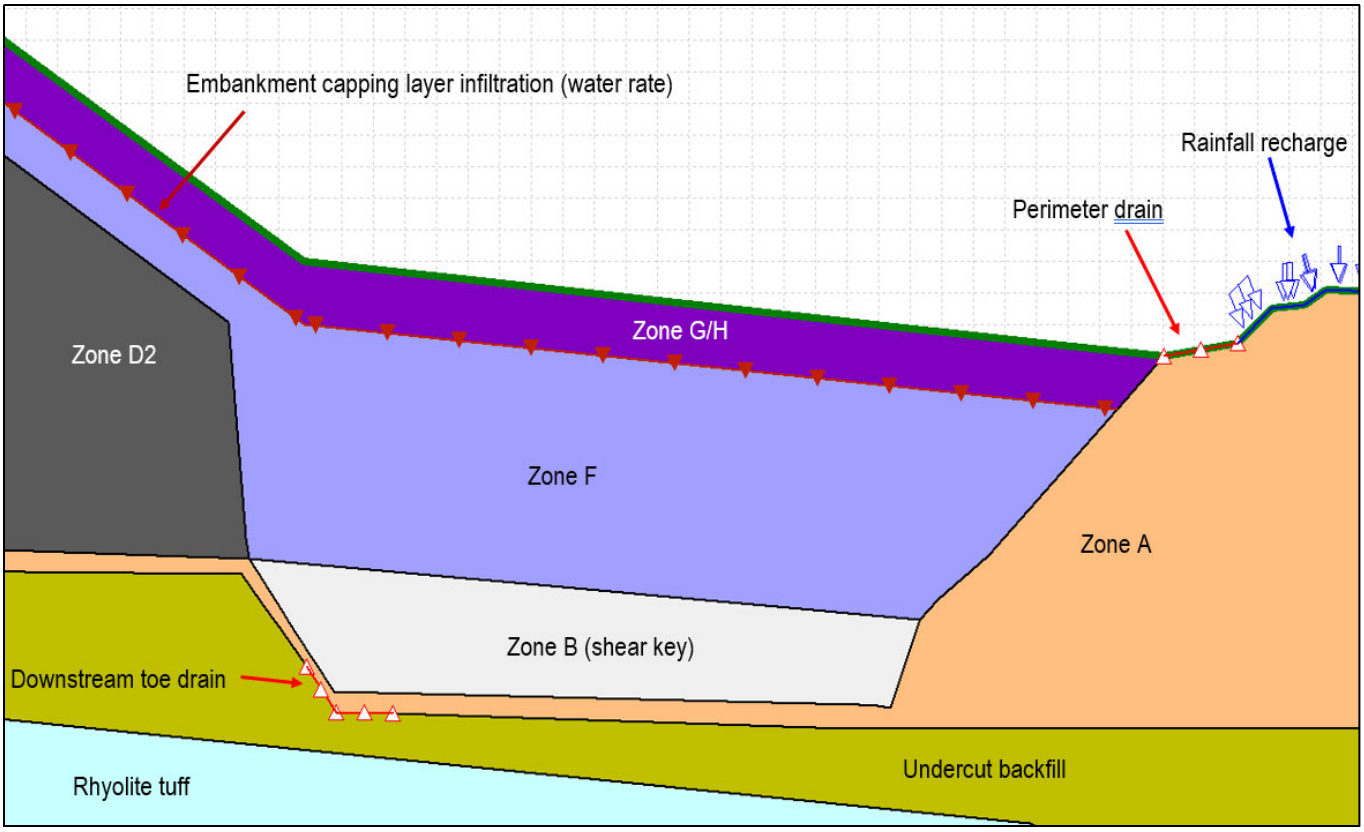


Figure I.5 TSF3 Cross-section 1 SEEP/W model set-up with close up of undercut and key monitoring locations

Table I.7 Summary of transient model scenarios for Cross-section 1 (construction dewatering)

Scenario	Stage of work	Days	Description
2A (Parent for 2B)	Partial excavation	0 - 30	Removal of surficial alluvium down to sensitive tuff, and includes excavations for the cut off and toe drains, and shear key.
2B (Parent for 2C)	Full excavation	30 - 75	Removal of sensitive tuff to maximum depth present in model (15 m). Assumes no inflow mitigation (such as piling).
Scenario 2C (75-120 d)	Partial backfilled	75 - 120	Backfill to original sensitive tuff surface, using NAF structural backfill (to be subsequently overlain by the Zone A soil liner).
* As discussed in the Rationale (Section 5.4.2) of the main report, additional analyses were run to provide a range of potential effects. Refer to appendix sections I.2.2 and I.2.3.			

Table I.8 Boundary conditions for TSF3 model scenarios (where different from Table I.1)

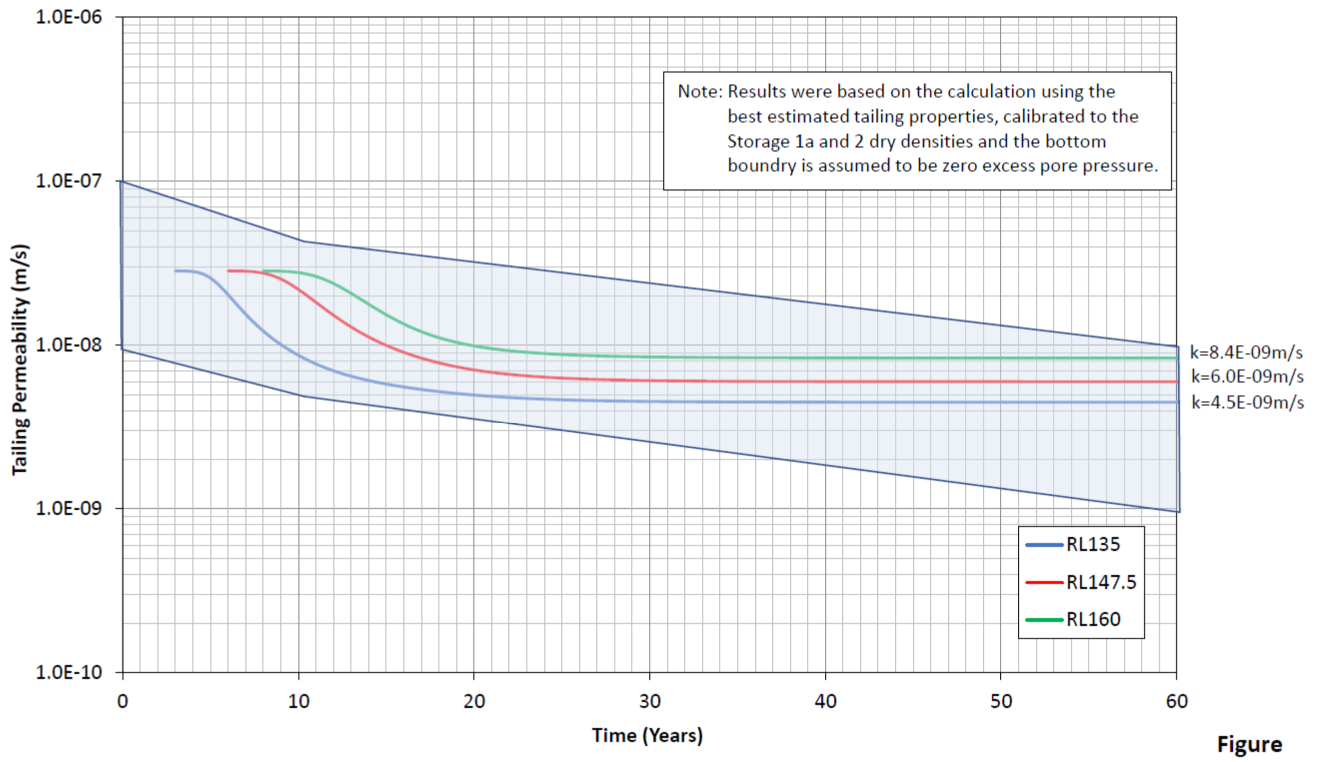
Boundary type	Scenario/s applied to	Adopted boundary conditions	Justification
Construction dewatering	2 (steady state) 2a-c (transient)	Water rate – potential seepage face review set 0 m^3/day	Removal of water from model where dewatering required. Applied to excavations: sensitive tuff, cut off drain, toe drain, shear key.
Recharge to tailings	3-5	Water flux – potential seepage face review: 3 x 10^{-3} m/day	Sufficiently large value (70% of rainfall) applied to achieve saturation at tailings surface.
HDPE liner leakage	3-5	Water flux - 1.7 x 10^{-5} m/d	Upper limit as provided by EGL (2019b). Refer to Section 5.5.2 of the main report.

Boundary type	Scenario/s applied to	Adopted boundary conditions	Justification
Drains	3 and 4	Water rate – potential seepage face review set 0 m^3/day. Applied to drains: sub soils, upstream cut off, initial and downstream toe)	Removal of leachate and embankment rock infiltration through drains. Locations of drains adopted from EGL (2021).
		Water total head – 1,108.5 m RL. Leachate collection sump drain	Gravity outlet, as per EGL design.
	5	Water rate – potential seepage face review set 0 m^3/day Applied only to downstream toe drain.	Assumes multiple drain failure for long-term scenario.
Embankment rock infiltration	3	Water flux – potential seepage face review: 2 x 10^{-3} m/d (35% average annual rainfall)	Upper catchment rainfall recharge value applied directly to the embankment rock (Zones B – D)
	4 and 5	Water flux: 1 x 10^{-3} m/d	5-year average cap infiltration rate for Zones G & H, which is 370 mm/yr (17% of GHD's adopted average rainfall value) (AECOM, 2020)

Table I.9 Adopted material parameters for TSF3 model scenarios (where additional to Table I.2)

Material (1) (2)	Scenario/s applied to	K_H (m/s)	K_V (m/s)	VWC and K function(3)	Hydraulic conductivity justification
Tailings:					
HDPE liner Material applied as a line: —	3-5	2 x 10^{-15}	2 x 10^{-15}	Well graded clay	Sufficiently low to enable liner leakage boundary condition in Table I.8 to provide the dominant leakage mechanism.
Starter embankment tailings	3	1 x 10^{-7}	2 x 10^{-8}	Sandy silt (coarse tailings)	K_V provided by EGL (2019b). Modelling outputs for estimated consolidation provided in Figure I.6. Note: The K_V values indicated for closure in Figure I.6 remain applicable to the current proposed height of 1,155 m RL (pers. comm. EGL, email dated 12/07/2021).
Operational – closure tailings	4	5 x 10^{-8}	1 x 10^{-8}	Sandy silt (coarse tailings)	
Long-term / Post closure tailings	5	1 x 10^{-8}	5 x 10^{-9}	Sandy silt (coarse tailings)	
Embankment rock					
NAF undercut structural backfill	3-5	1 x 10^{-6}	1 x 10^{-6}	Well graded #2	Based on embankment material information provided by EGL (2019c).
Zone A	1-5	1 x 10^{-8}	1 x 10^{-8}	Clayey silt	
Zone B	3-5	1 x 10^{-8}	1 x 10^{-8}	Clayey silt	
Zone C1	3-5	1 x 10^{-6}	1 x 10^{-6}	Silty sand	
Zone C2	3-5	1 x 10^{-6}	1 x 10^{-6}	Silty sand	
Zone D2	3-5	1 x 10^{-5}	1 x 10^{-6}	Silty sand	
Zone D3	4-5	1 x 10^{-6}	1 x 10^{-7}	Silty sand	
Zone F	4-5	1 x 10^{-4}	1 x 10^{-5}	Uniform sand	
Zone G/H	4-5	1 x 10^{-8}	1 x 10^{-8}	Clayey silt	

1. Geological units are colour coded as per the SEEP/W cross section (Figure 5.15 of the main report).
2. TSF construction materials are described in Table 5.1 (Section 5.1.2) of the main report.
3. VWC = Volumetric water content function (SEEP/W 2012 database), selected based on EGL descriptions of materials provided by email (EGL 2019b and 2019c).

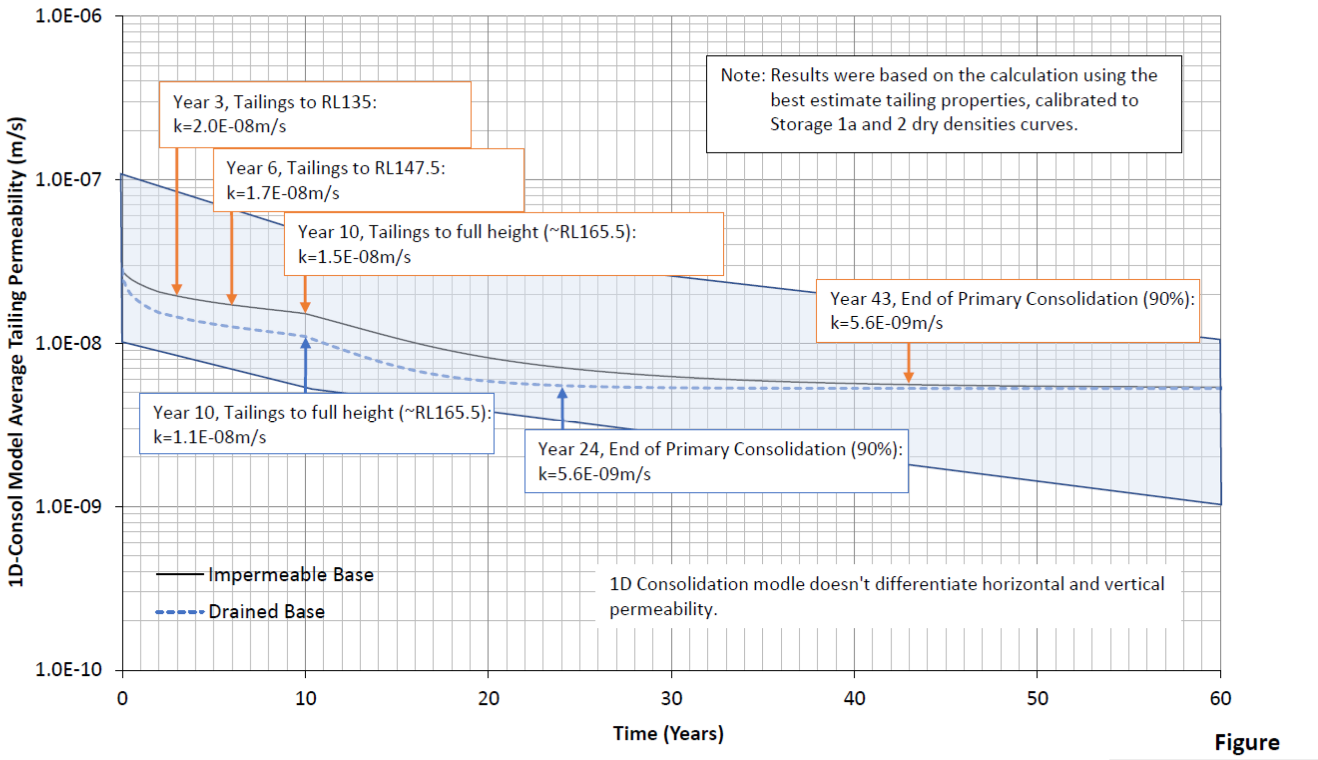


Note: Results were based on the calculation using the best estimated tailing properties, calibrated to the Storage 1a and 2 dry densities and the bottom boundry is assumed to be zero excess pore pressure.

Engineering Geology Ltd
Unit 7C, 331 Rosedale Rd, PO Box 301054,
Albany, Auckland

OCEANA GOLD CORPORATION
OGC Quattro Project
Tailings Consolidation
Tailings Permeability at Critical Elevations

Ref. No: 8332
Date: Feb 2019
Drawn: YC



Note: Results were based on the calculation using the best estimate tailing properties, calibrated to Storage 1a and 2 dry densities curves.

Year 3, Tailings to RL135:
k=2.0E-08m/s

Year 6, Tailings to RL147.5:
k=1.7E-08m/s

Year 10, Tailings to full height (~RL165.5):
k=1.5E-08m/s

Year 43, End of Primary Consolidation (90%):
k=5.6E-09m/s

Year 10, Tailings to full height (~RL165.5):
k=1.1E-08m/s

Year 24, End of Primary Consolidation (90%):
k=5.6E-09m/s

1D Consolidation modle doesn't differentiate horizontal and vertical permeability.

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Unit 7C, 331 Rosedale Rd, PO Box 301054,
Albany, Auckland

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Tailings Consolidation
Average Tailings Permeability

Ref. No: 8332
Date: Feb 2019
Drawn: YC

Figure I.6 Tailings consolidation modelling results showing K_V (EGL, 2019b) for various potential tailings height

I.2.2 Cross-section 2 (SEEP/W)

Base model set up

The model length was 3.6 km, beyond the northwestern crest north of the site and through to the Ruahorehore Stream southeast of TSF3 (Figure I.7 and Figure I.8). The cross-section was aligned perpendicular to the direction of dominant groundwater flow of the primary aquifer. However, the purpose of this assessment was to assess potential excavation inflows and drawdown associated with dewatering to 20 m depth during removal of the sensitive tuff. During this time the groundwater flow regime will change locally so that groundwater flow becomes parallel to the cross-section (towards the excavation) and the use of the model to predict drawdown is considered to be acceptable when considering results within close proximity to the excavation. As discussed in the Rationale (Section 5.4.3 of the main report), this analysis is supported by Theis (1935) for drawdown further away from the excavation (Section I.2.3 below).

Parameter inputs, calibration and scenarios

Cross-section 2 comprised a transient model, set up using the inputs from the calibrated Cross-section 1 model for hydrogeological properties (Table I.2). Boundary conditions were set to achieve a high groundwater table through the sensitive tuff, as per the existing site conditions for the base model and achieve water the presence of water in the Ruahorehore Stream.

As with Cross-Section 1, the geological structure for the model was provided by EGL. In this model, the sensitive tuff thickness was only present to 15 m depth. For the purpose of estimating drawdown and allowing settlement analysis, a more conservative 20 m excavation scenario was assessed (Figure I.9).

A constant head boundary was applied to the Ruahorehore Stream for the dewatering scenarios to simulate the expected discharge of dewatered groundwater through the initial construction stage of works.

A summary of the model scenarios is provided in Table I.10 and model inputs is provided in Table I.8 and Table I.9.

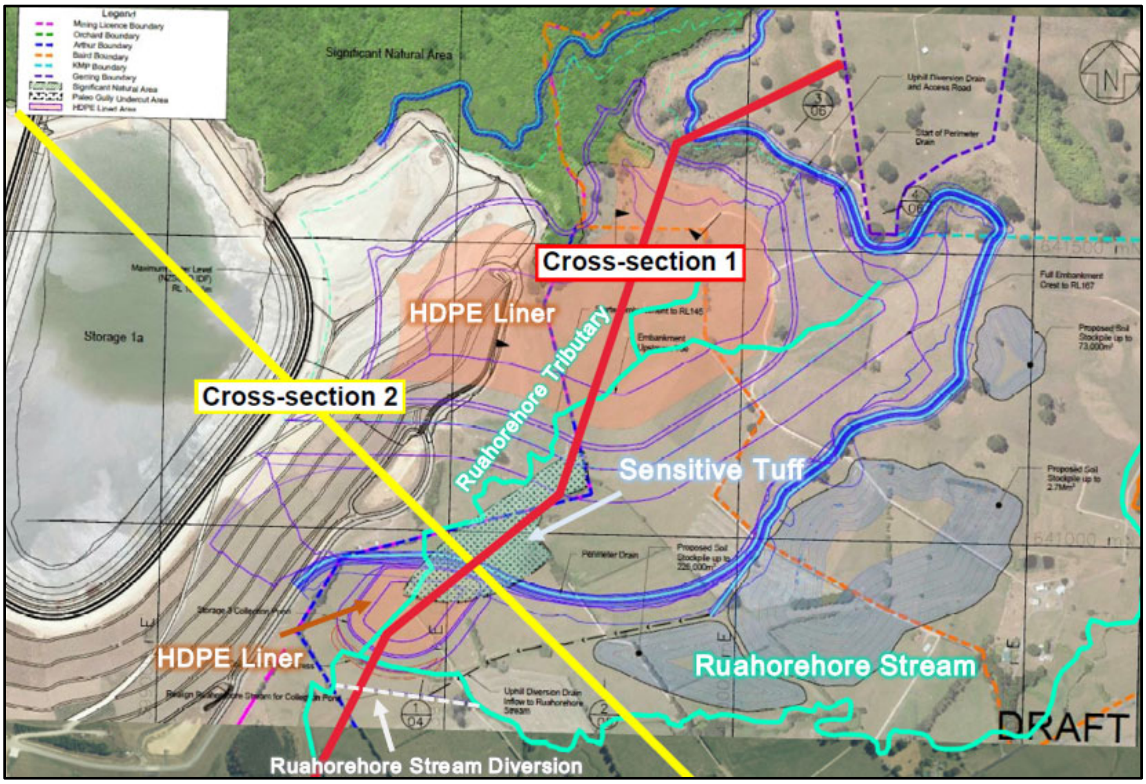


Figure I.7 ***SEEP/W Cross-section 2 location compared with the primary section (Cross-section 1)***

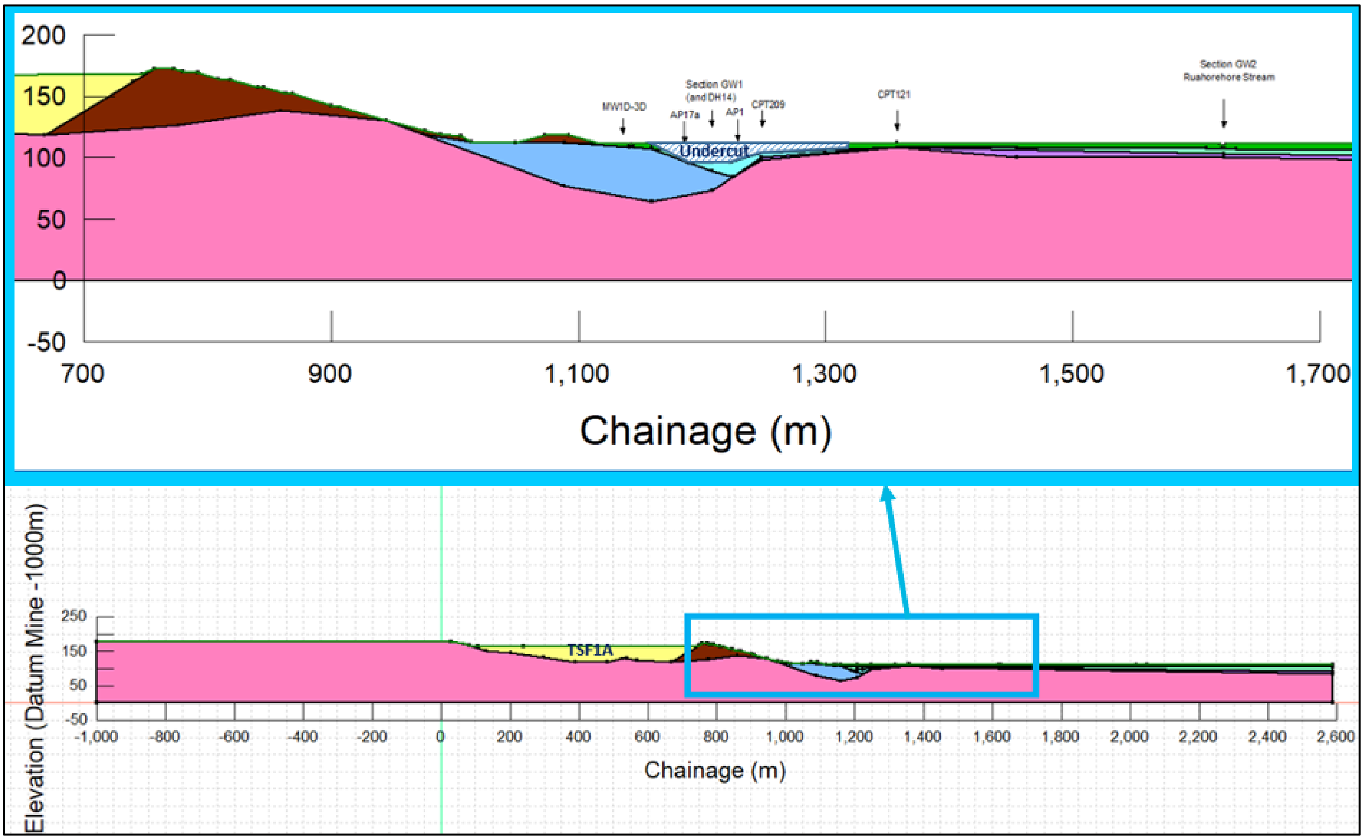


Figure I.8 TSF3 cross-section 2 SEEP/W model set-up

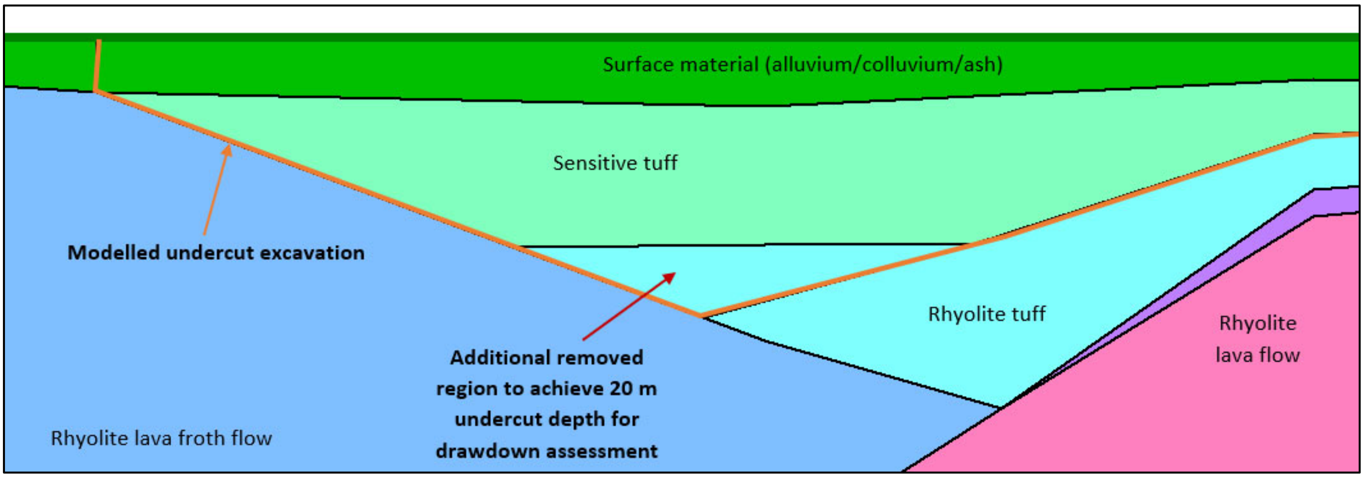


Figure I.9 TSF3 cross-section 2 SEEP/W model set-up

Table I.10 ***Summary of steady transient model scenarios for Cross-section 2 (construction dewatering)***

Scenario	Stage of work	Days	Description
1 – Steady state (Parent for 2B and 3)	Base model	0	Material properties as per Cross-Section 1 calibration. Boundary conditions provided in Table I.8.
2A - Transient (Parent for 2B)	Partial excavation (15 m)	0 - 30	Removal of surficial alluvium down to sensitive tuff, and includes excavations for the cut off and toe drains, and shear key.
2B - Transient (Parent for 2C)	Full excavation (15 m)	30 - 75	Removal of sensitive tuff to maximum depth present in model (15 m). Assumes no inflow mitigation (such as piling).
2C - Transient	Partial backfilled (15 m)	75 - 120	Backfill to original sensitive tuff surface, using NAF structural backfill (to be subsequently overlain by the Zone A soil liner).
3 - Transient	Full excavation (20 m)	0 – 75	As per above full excavation to 15 m, but with additional region removed into underlying rhyolite tuff to achieve 20 m excavation depth. Analysis undertaken for drawdown only.
* As discussed in the Rationale (Section 5.4.2) of the main report, additional analyses were run to provide a range of potential effects. Refer to appendix sections I.2.2 and I.2.3.			

Table I.11 ***Cross-Section 2 model set-up***

Boundary type	Scenario	Adopted boundary conditions	Justification
Rainfall recharge	All	Water flux - potential seepage face review: 3 x 10^{-5} m/d (Lower catchment rate)	As per Cross-section 1.
Upgradient groundwater boundary (NW)	All	Constant Head – 1,108 m RL	To achieve groundwater flow direction toward the SE, and a high water table near ground level at the area of the excavation, as per existing site conditions.
Downgradient groundwater boundary (SE)	All	Constant Head – 1,113.5 m RL	
Ruahorehore Stream	2 and 3	Constant Head – 1,109.1 m RL	Set to nominal stream depth of 1 m assuming discharge of dewatering groundwater will occur to the stream.
Dewatering	2 and 3	Water rate – potential seepage face review: 0 m^3/day	Removal of water from undercut.

Table I.12 ***Adopted material parameters for Cross-Section 2 (where additional to Table I.2)***

Material (1) (2)	Scenario/s applied to	K_H (m/s)	K_V (m/s)	VWC and K function(3)	Hydraulic conductivity justification
Tailings	All	8 x 10^{-9}	8 x 10^{-10}	Sandy silt (coarse tailings)	Long-term consolidation as per Figure I.6
Operational – closure tailings	All	1 x 10^{-6}	1 x 10^{-6}	Silty sand	As per Zone D2 of Cross-section 1.
1. Geological units are colour coded as per the SEEP/W cross section 3. VWC = Volumetric water content function (SEEP/W 2012 database), selected based on EGL descriptions of materials provided by email (EGL 2019b and 2019c).					

I.2.3 Theis drawdown analysis

The Theis model supports the Cross section 2 model in predicting excavation drawdown effects on water levels. Where the cross section model was used to predict local drawdown near the excavation, the Theis model was used to predict effects to groundwater levels more distant from the excavation. It was also used to provide a comparative analysis for the SEEP/W modelling approach. The Theis model set up, outputs and sensitivity analysis are presented in this methodology section, with the outputs presented here are incorporated into the assessment results provided below (Section I.3).

Theis model set-up

This 1-D analytical solution allows only for dewatering from a single point, which is assumed here to be the deepest point of the undercut excavation, under unsteady state conditions. Inherent assumptions of this analysis include that the aquifer is confined, has a seemingly infinite areal extent, is homogeneous, isotropic, and of uniform thickness over the area influenced by dewatering. Prior to dewatering, the piezometric surface is assumed to be horizontal over the area that will be influenced, is pumped at a constant discharge rate, and the excavation penetrates the entire thickness of the aquifer, receiving water only from horizontal flow (i.e. does not consider recharge).

Theis model input parameters

The following inputs and assumptions were adopted from the information obtained from site data and the conceptual model:

- A range of T values were applied to provide sensitivity analysis, with these representing the measured range of permeability values at the site (2, 20 and 200 m^2/day), with rounding to account for uncertainty of the thickness of the affected saturated aquifer.
- A range of nominal S values (0.1 and 0.01) were also tested to reflect unconfined fractured rock aquifer conditions to semi-confined conditions (respectively).

Using the above inputs parameters, the model outputs (discharge, Q; and ZOI) were determined from the back-calculation of expected groundwater levels after 75 days continuous dewatering for the following aims:

- Discharge (Q): Achieve a maximum drawdown of 20 m at 0.1 m radial distance from the abstraction point.
- ZOI: Achieve a drawdown of 0.5 m (defined as the ZOI) in metres distance from the abstraction point.

Theis scenarios and outputs

A summary of the applied scenarios and results are in Table I.13 and Figure I.11. Values are rounded to account for uncertainty.

The geomean of permeability results is considered to be represented by T = 2 m^2/day and T = 20 m^2/day. The results for T = 20 m^2/day are generally in line with the outputs for Cross-Section 1. The analysis of T = 200 m^2/day represents the upper limit of permeability measured at the site, and is consistent with Cross-section 2 (Scenario 2) outputs.

Table I.13 Theis (1935) solution inputs and outputs

T:	2 m^2/d		20 m^2/d		200 m^2/d	
S:	0.1	0.01	0.1	0.01	0.1	0.01
Q	30 - 40 m^3/d		290 - 330 m^3/d		2,560 - 2,900 m^3/d	
ZOI	70 - 210 m		210 - 610 m		610 - 1,840 m	

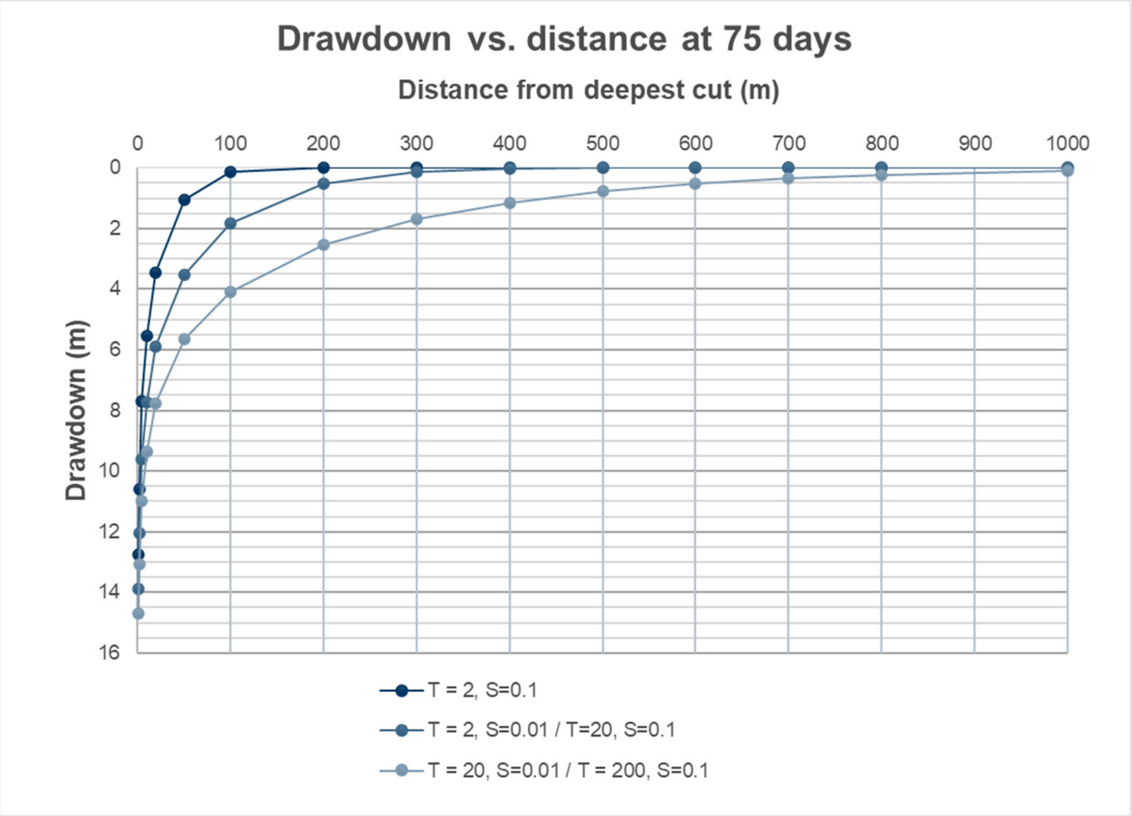


Figure I.10 TSF3 Theis model outputs

Theis sensitivity analysis

Sensitivity testing is covered by the above analysis, which indicates the solution is sensitive to the range of K (and therefore T) measured at site.

A graphed comparison of the results to assess for sensitivity presented above are presented below in Figure I.11. This indicates that:

– For ZOI, the solution is sensitive to both S and T.

– For inflows, the solution is not very sensitive to changes in adopted S values, but is sensitive to the applied T.

The upper end of the results range is expected to be overly conservative, given that only four test locations from a total of 27 locations reported a result greater than 3 x 10^{-5} m/s (estimated results of 1 x 10^{-4} m/s), likely due to localised fracturing. The geomean of all results was 5 x 10^{-7} m/s. Based on the CGM, an applied T of 20 m^2/day is expected to be more representative of the bulk permeability of the geology influenced by dewatering and is therefore adopted for the assessment. To maintain conservatism for the ZOI, an S of 0.01 has been adopted. The drawdown results there adopted for this assessment is the blue graph line presented in Figure I.12.

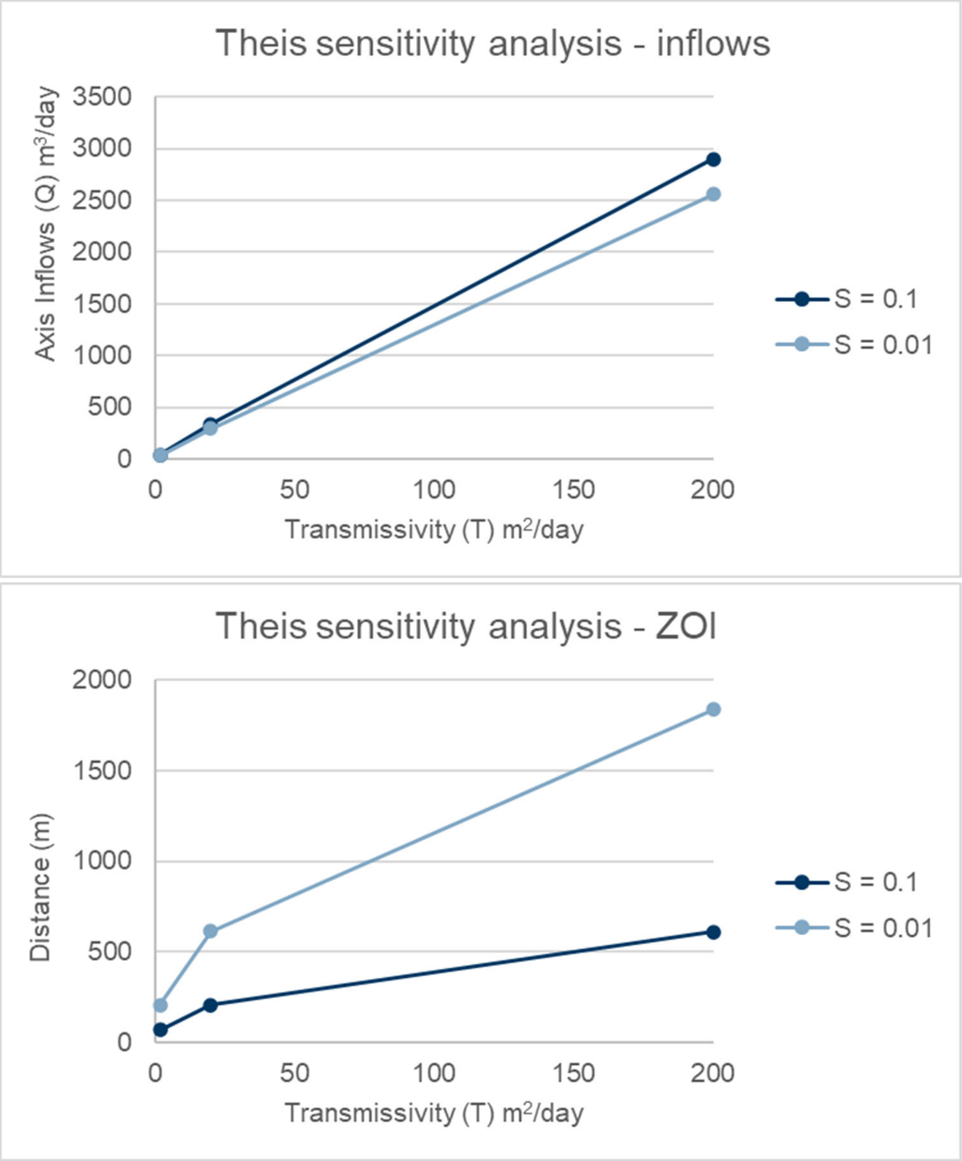


Figure I.11 Comparison of input parameters for Theis solution

I.3 TSF3 analysis results

I.3.1 Construction dewatering

The two key outputs of the construction dewatering analyses are groundwater inflows to the excavation and groundwater level drawdowns.

A breakdown of the results from the modelling are provided below in Table I.14 and Table I.15.

Figure I.12 demonstrates how the drawdown curve and ROI (presented in Figure 5.14 of the main report) were derived.

Table I.14 ***Summary of modelling outputs for predicted inflows to excavation***

Scenario	**Expected inflow ranges in m³/day***		**Upper bound**	**Cumulative inflows**		
	Cross-section 1 (to 15 m depth)	Theis (to 20 m depth) (T = 2 and 20)	Cross-section 2 (to 15 m depth)	Expected minimum	Expected maximum	Upper bound
Scenario 2A (0-30 d)	16 - 23		402 - 511	480	690	15,290
Scenario 2B (30-75 d)	100 - 120	33 - 334	1,465 - 2,445	1,485	15,030	110,250
Scenario 2C (75-120 d)	0 - 9		4 - 96	0	405	4,500
		SUM:		1,965	16,125	130,040
		Portion of aquifer management level:		0.1%	0.9%	7%
*Ranges given for Day vs. end of scenario						

Table I.15 ***Summary of modelling outputs for ZOI for dewatering at 75 days***

Analysis	**Result**	**ZOI (from deepest point of excavation)**
Cross-section 1 (to 15 m depth)	North direction	430 m
	South direction	390 m
Cross-section 2 (to 20 m depth)	West direction	Not considered. As the model is parallel to groundwater flow direction, the model is expected to over-estimate drawdown. Only the drawdown within 200 m of the excavation is considered. See Figure I.12.
	East direction	
Theis (to 20 m depth) (T = 2 and 20)	Radial for T = 20 m²/day	610 m
Adopted ZOI		610 m

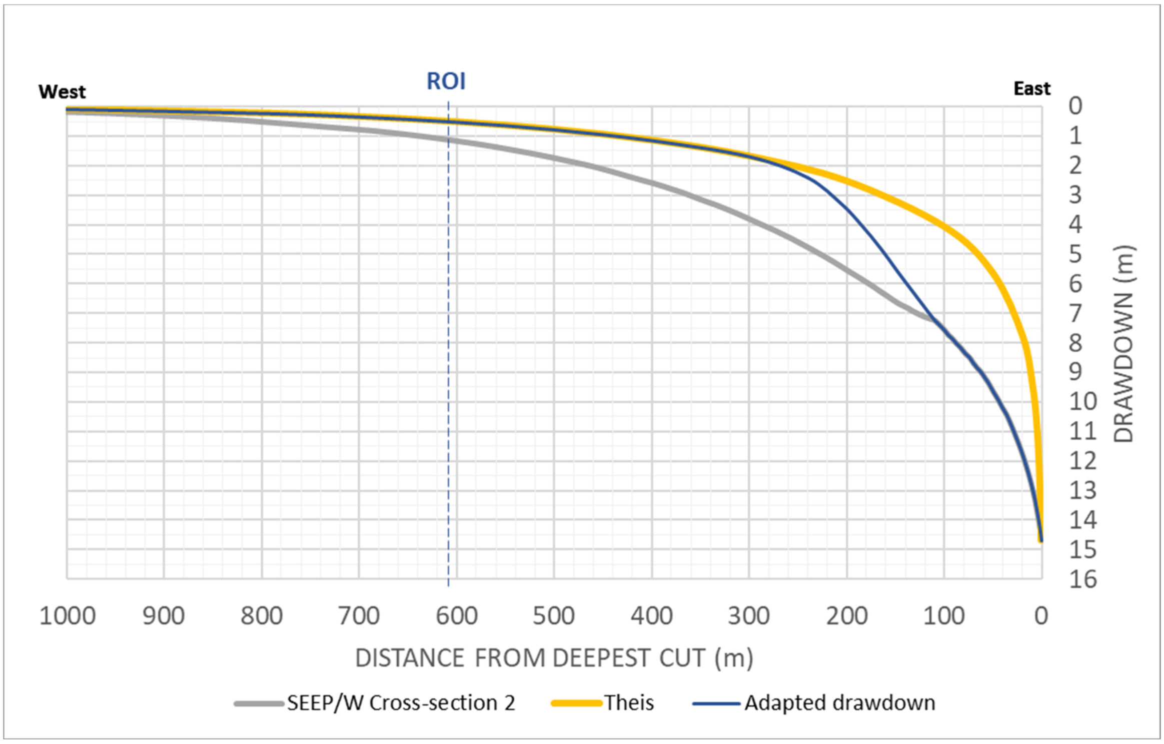


Figure I.12 ***Drawdown curves for the TSF3 undercut dewatering***

I.3.2 TSF3 discharges

The modelled discharge rates were extracted in m^3/day per 1 m model width. The extracted results have been multiplied by 1,000 m, which is the approximate width of TSF3 perpendicular to the cross-section line, to provide results for the entire facility. Where appropriate, the results for the shear key model were considered for 500 m.

Tailings

As drains also capture groundwater, flow lines predicted by the SEEP/W models (refer to Figure 5.15 of the main report) were used to assist in estimating water sources and discharge rates. The modelled tailings discharge rates are provided in Table I.16. Where the discharge through the Zone A soil liner is:

- Less than that of the HDPE liner, this is due to the some of the discharge through the HDPE liner being captured by the upstream cut-off drain.
- Greater than the HDPE liner, this is where the tailings are emplaced above the HDPE liner (Scenarios 4 and 5), and where tailings discharge occurs over the top of the liner. More tailings discharge is captured in Scenario 4 where the drains are operational. Note: Discharge from the facility is captured during Scenario 5 (post-closure, where only the downstream toe drain is operational), but this is only embankment infiltration.

Embankment

The model embankment infiltration and discharge values are provided in Table I.17. The results indicate:

- The total infiltration through the embankment is increased for Scenarios 4 and 5, which is expected due to full embankment construction (260 m), which is longer than Scenario 3 (140 m).
- The discharge values (267 m^3/day) are the same for Scenarios 4 and 5 (within rounding), as the same infiltration rate has been applied, across the same embankment construction.
- The operational drains through Scenarios 3 and 4 are indicated to effectively capture the embankment rock infiltration, whereas only a small portion (~10%) of the discharge is captured by the downstream toe drain in Scenario 5.

Collection pond

Leakage from the ponds was calculated from the following inputs:

- Total pond area = 33,000 m^2 = 3.3 ha
  - Pond S6 area = 11,500 m^2
  - Pond S7 area = 21,500 m^2
- Leakage rate = 42 L/ha/day
- So that 42 L/ha/day x 3.3 ha = 139 L/day or 0.14 m^3/day.

Drain capture

Drain widths across the embankment vary from 500 - 1200 m. For simplicity, and for direct comparison to the above seepage results, all values extracted from SEEP/W were multiplied by 1,000 m.

The individual drain capture results are provided in Table I.19. The details of final drain capture composition is provided in Table I.20. Mass flux to the drains (Table 5.10 of the main report) was calculated from the following inputs:

- Geochemistry of the discharges:
  - Tailings pore water quality – predicted mean value from AECOM (2025) report.
  - Embankment leachate water quality – predicted median values for the development stage (Scenarios 3 and 4) and closure stage (Scenario 5) from AECOM (2025) report.
  - Groundwater quality – the median of water quality from AP01a was used.
- Drain capture volumes for each component in Table I.20.

So that: (predicted concentrations in g/m^3 x drain volumes in m^3/day) / 1000 = mass flux in kg/day to the WTP.

Table I.16 *Summary of modelling outputs for tailings discharge for full facility width*

Analysis	Discharge through HDPE liner (m^3/day)	Discharge through the Zone A soil liner to ground* (m^3/day)	To drains		To receiving environment	
Scenario 3	10	5	Flow lines indicate all discharge to drains			
Scenario 4	21	116	71 m^3/day	70%	45 m^3/day	30%
Scenario 5	16	62	0 m^3/day	0%	62 m^3/day	100%
Comparison Scenario 3 – no HDPE liner	n/a	700	161 m^3/day	23%	539 m^3/day	77%

Table I.17 *Summary of modelling outputs for embankment rock infiltration for full facility width*

Analysis	Emb. length (m)	Height (m RL)	Total infiltration through embankment (m^3/day)	To drains		To receiving environment	
Scenario 3	140	1,135	230	Flow lines indicate all discharge to drains			
Scenario 4	260	1,155	267	Flow lines indicate all discharge to drains			
Scenario 5		1,155	267	237 m^3/day	89%	30 m^3/day	11%

Table I.18 *Summary of combined tailings and embankment discharge to the receiving environment from TSF3 (m^3/day)*

Analysis	Tailings	Embankment	Total discharge to receiving environment
Scenario 3	0	0	Flow lines indicate all discharge to drains
Scenario 4	45	0	45
Scenario 5	62	30	92

Table I.19 *Summary of modelling outputs for drain capture (m^3/day) for full facility width*

Analysis	Subsoil drains	Upstream cut off	Initial toe drain	Final downstream toe	Leachate sump collection	Sum drain capture
Scenario 3	164	4	31	92	n/a	291
Scenario 4	119	4	34	1	7	355
Scenario 5	n/a	n/a	n/a	0	n/a	260
Components of drain capture*	Mix (tailings, embankment, groundwater)	Tailings	Embankment	Mix (tailings, embankment, groundwater)	Tailings and embankment	
*as determined by SEEP/W flow lines						

Table I.20 *Summary of modelling outputs for drain capture for full facility width*

Analysis	Discharges to drains (m^3/day)			Sum drain capture (m^3/day) (Table I.19)	*Groundwater component** (m^3/day)	Drain water composition		
	Tailings	Emb.	Total			Tailings	Emb.	GW
Scenario 3	10	230	240	291	*51*	3%	79%	18%
Scenario 4	21	267	288	355	*67*	6%	75%	19%
Scenario 5	0	237	237	260	*23*	0%	91%	9%
*The difference between drain capture and total discharges to drains								

I.3.3 Water levels and flow rates

The total groundwater flows measured in SEEP/W downgradient of TSF3 are provided in Table I.21, along with the proportion of TSF3 seepage in groundwater. It is noted that the total groundwater flow is not necessarily equivalent to TSF3 total seepage plus the base model groundwater flow. This is due to minor changes in the hydraulic gradient across the model as the TSF is constructed where the groundwater levels re-equilibrate to accommodate the added recharge to the groundwater system. The proportion of TSF3 seepage as groundwater has been calculated from the above discharge values from the down gradient flow rate.

Groundwater flows used for groundwater quality analysis below are presented in Table I.22. Comparison of the upgradient flow in this table (715 m^3/day) to the down gradient flow in Table I.21 provides recharge of 4 m^3/day of the TSF3 site prior to construction, which is consistent with the conceptual model.

Table I.21 Summary of modelling outputs for proportion of groundwater flow

Analysis	TSF3 total seepage* (m^3/day)	Total Groundwater Flow** (m^3/day)	Proportion of flow as TSF3 seepage
Base model	0	719	0%
Scenario 3	0	723	0%
Scenario 4	45	743	6%
Scenario 5	95	766	13%
Comparison Scenario 3 – no HDPE liner	539	838	64%
*Combined tailings and embankment infiltration to the receiving environment, from Table I.18. ** Result extracted from SEEP/W at the same location downgradient of TSF3 for all scenarios.			

Table I.22 Summary of groundwater flow volumes for water quality assessment

Aspect	Groundwater flow
Base model upgradient flow for mixing analysis (all flow for full aquifer mixing)	715 m^3/day
Flow extracted from beneath tailings area based on flow lines (limited flow for direct/local groundwater mixing)	118 m^3/day

I.4 Water quality assessment

I.4.1 Methodology

A mixing assessment has been undertaken to predict the impact that the leachate (Section J.2) may have on the water quality of the receiving environment. The analytical model allows for only mixing (dilution). Other processes that influence water quality such as adsorption to aquifer materials are not adequately represented in the model. As such, the predicted results are considered to be highly conservative, providing confidence that actual effects are likely to be less than predicted in this assessment. The following mass balance analytical solution was used:

$$\boxed{C_3V_3 = C_1V_1 + C_2V_2}$$

Where:

C = Concentration of parameter in g/m^3	1 = Existing water conditions
V = Flow volume in m^3/day	2 = TSF3 discharge
CV = Mass flux of parameter in g/day	3 = Water quality after mixing of 1 and 2

The following scenarios analysed are provided in Table I.23. No analysis is provided for the starter embankment on the basis that no discharge is predicted to discharge to the receiving environment (Table I.18). For added conservatism, the analysis considered straight mixing of the TSF3 leachate into surface water, i.e., dilution by groundwater not considered as part of the analysis for the Ohinemuri River or Ruahorehore Stream.

Table I.23 Water quality assessment scenarios and input sources

Scenario	Concentrations	Volume
1. The influence of all TSF3 discharges on local groundwater: a. Operational to closure b. Long-term	C_1 = Groundwater well AP01a median water quality values	V_1 = Groundwater flow for both local and full aquifer mixing (Section I.3.3).
	C_2 = Mean tailings pore water quality and median embankment leachate median water quality (AECOM, 2025)	V_2 =TSF3 discharges (Table I.18)
2. The influence of all TSF3 discharges on the Ohinemuri River: a. Operational to closure b. Long-term	C_1 = Ohinemuri River OH1 median water quality values	V_1 = Median flow data from the OGNZL FRENDRUPS gauge on the Ohinemuri River (Section 2.2.1 of the main report).
	C_2 = Mean tailings pore water quality and median embankment leachate median water quality (AECOM, 2025)	V_2 =TSF3 discharges (Table I.18)
3. The influence of collection pond leakage on the Ruahorehore Stream: a. Operational to closure b. Long-term	C_1 = Ruahorehore Stream RU03 and RU10 median water quality values	V_1 = Measured stream baseflow (Section 5.3.5 of the main report).
	C_2 = Median embankment leachate median water quality (AECOM, 2025)	V_2 =Collection pond discharge (Section I.3.3)

I.4.2 Results

The predicted water quality outputs from the mixing analysis are presented in full in Section 5.6.2 of the main report. The ranges provided in the groundwater results table (Table 5.13 of the report) reflect the results for local/direct mixing to groundwater versus full mixing within the aquifer (refer to Table I.22).

The mass flux of parameters entering the Ohinemuri River catchment via groundwater discharge were calculated by multiplying the predicted leachate concentrations in Table 5.14 of the main report with the volume of leachate discharged to the receiving environment (Table I.18). The results are provided in Table 5.15 of the main report.

I.5 Sensitivity testing

This sensitivity testing focuses on the primary analysis, Cross-section 1, which has informed the key assessment of tailings discharge to the receiving environment. The key aspects considered are (Table I.23):

- Leakage through the HDPE liner.
- Tailings permeability, which provides one of the key controls on the volume of tailings seepage leaving the facility.
- Hydraulic conductivity of the geology underlying the tailings (rhyolite tuff), which is interpreted to provide TSF3 discharge from directly entering the Ruahorehore Stream at the embankment toe. Due to the complexity of the model, it was not recalibrated for the K change.

Table I.23 TSF3 sensitivity testing scenarios

Model aspect:		Boundary condition - water flux (m/d)	Tailings K (m/s)		Rhyolite tuff K (m/s)
			Scenario 3	Scenario 5	
Base model values:		**1.7 x 10^{-5}**	**1 x 10^{-5}**	**1 x 10^{-8}**	**1 x 10^{-7}**
Sensitivity test no.	Change to model				
Sens.1	Liner leakage ↓	4.3 x 10^{-6}			
Sens.2	Tailings ↑		1 x 10^{-6}	1 x 10^{-7}	
Sens.3	Tailings ↓		1 x 10^{-8}	1 x 10^{-9}	
Sens.4	Geology K ↑				1 x 10^{-6}
Sens.5	Geology K ↓				1 x 10^{-8}

The results of the sensitivity testing are summarised as follows:

- **Leakage rates of the liner:** Estimated by EGL (2019b) to range from 42 to 170 L/ha/d. Both upper and lower bound values were assessed and applying the lower leakage rates provided the following general results (Table I.24):
  - The leakage of tailings through the liner decreases by 48% (Scenario 5) to 58% (Scenario 3) with the lower leakage limit.
  - Drains are the primary recipient of the upper leakage limit in Scenario 3. Tailings discharge is to ground in Scenario 5 for both the base model and sensitivity analysis.
  - Neither analysis results in flow lines to the Ruahorehore Stream from beneath the TSF.
  - The greatest effect of increasing the liner leakage is to increase groundwater flow the deep groundwater receptor, and inferred discharge to the Ohinemuri River. The upper leakage value was reported in the assessment for conservatism.

Table I.24 Sens.1 results – liner leakage

Scenario	Water rate (m/d)	Scenario 3 – Tailings discharge (m^3/day)			Scenario 5 – Tailings discharge (m^3/day)		
		Through Zone A	To drains	To receiving environment	Through Zone A	To drains	To receiving environment
Sens.1	4.3×10^{-6}	2	2	0	7	0	7
Base model	**1.7×10^{-5}**	**5**	**5**	**0**	**13**	**0**	**13**
Decrease under lower leakage:		58%			48%		

- **Permeability of the tailings:** The scenario testing analysed an order of magnitude higher and lower than the base model K. The results (Figure I.13) showed:
  - The flow directions of the tailing pore water changes so that is more horizontal under the highest K applied, and more vertical under the lowest K applied (Figure I.14).
  - No change in seepage volume from TSF3 (including the embankment) under Scenario 3, as the liner leakage is controlled by the applied liner rate and the drains are operational.
  - Sensitivity to changes in K for Scenario 5 tailings, where:
    - An increase of tailings discharge to the environment 12 times that of the base model is reported for the increased K (Sens.2).
    - The total volume of embankment infiltration does not change (controlled by the applied infiltration rate through the capping layer; AECOM 2020), but the changes in discharge from the tailings influences the proportion of embankment infiltration that goes to the drains. Under the higher K scenario (Sens.2), all embankment infiltration reports to the one active drain (downstream toe drain); whereas under decreased tailings K conditions, the majority discharges to the receiving environment.
  - Neither analysis results in flow lines to the Ruahorehore Stream from beneath the TSF.

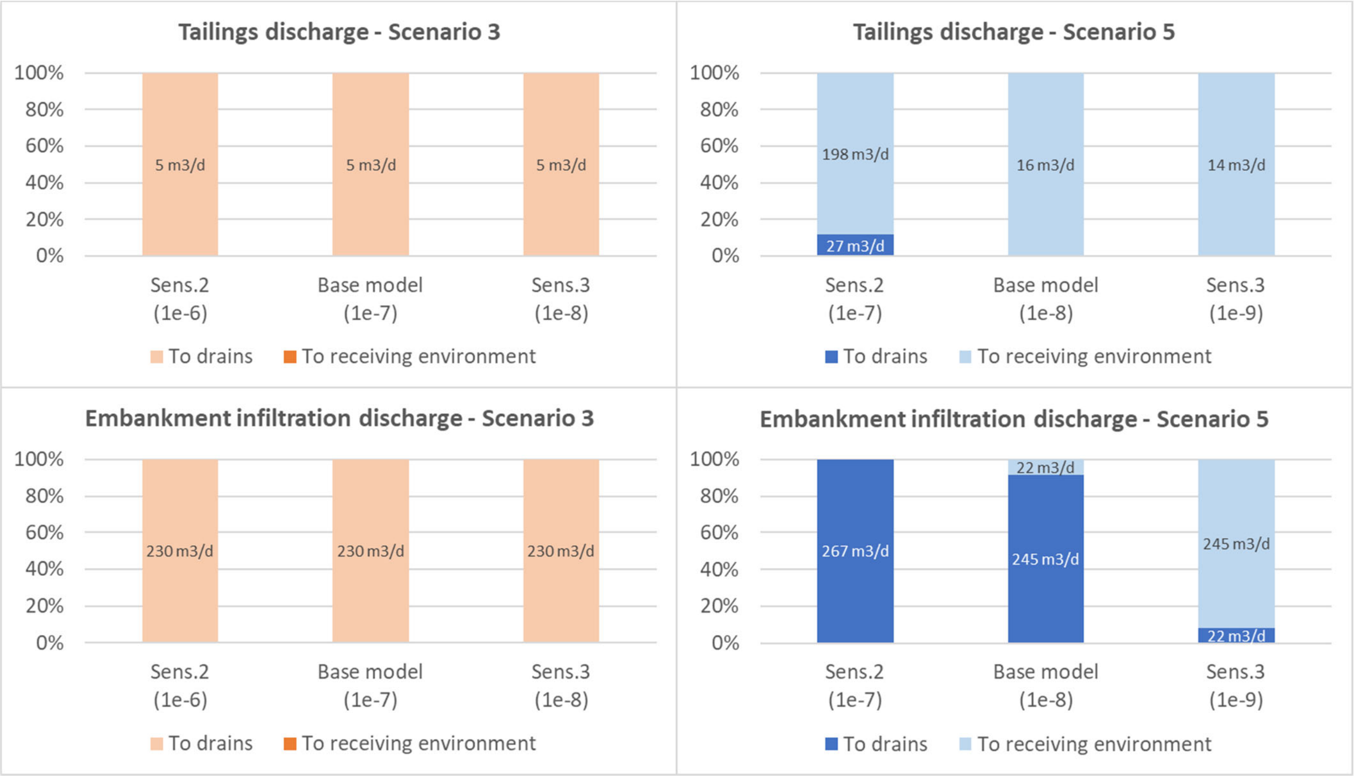


Figure I.13 *Sensitivity testing outputs for changes to tailings K (Sens.2 and Sens.3)*

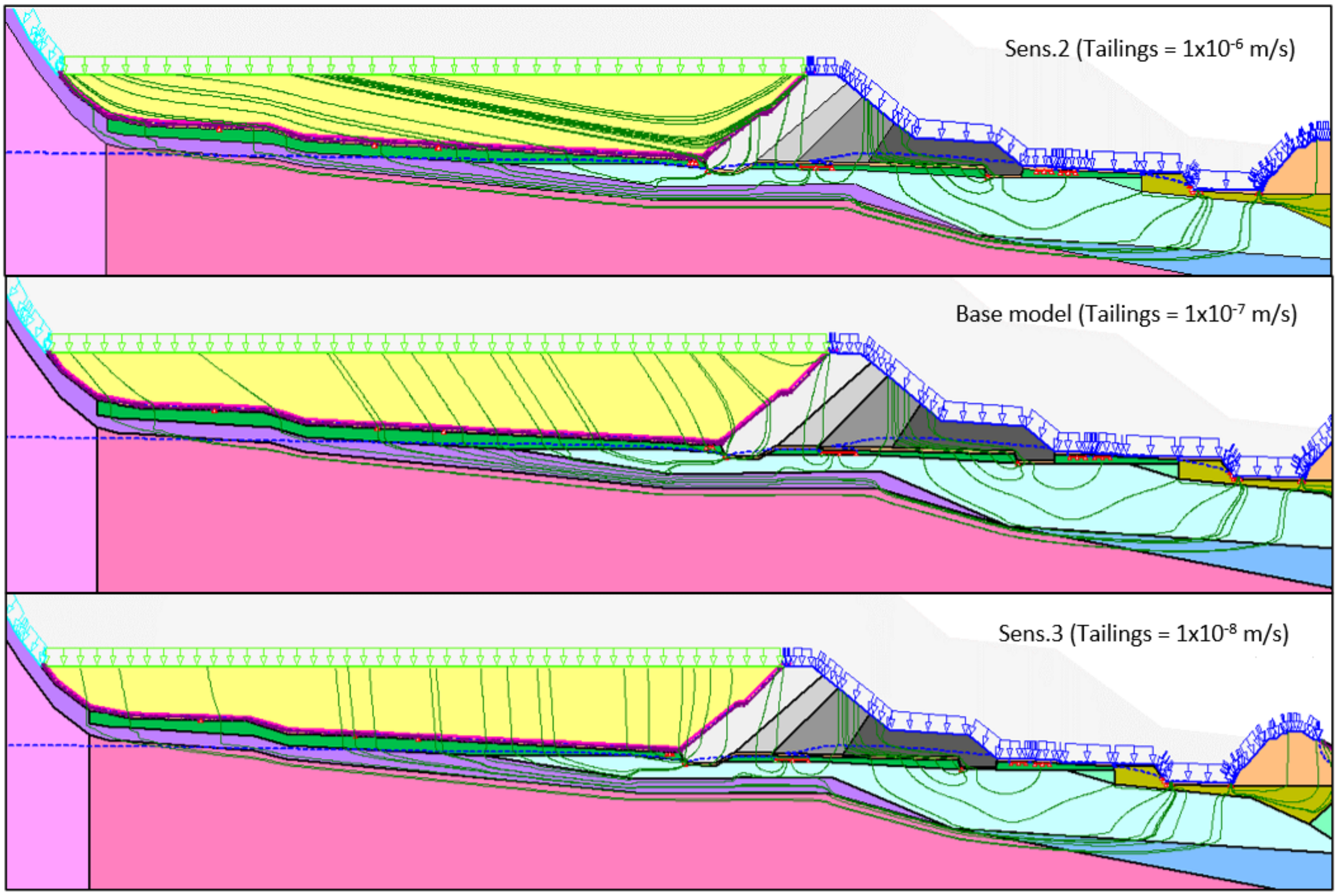


Figure I.14 *Sensitivity testing outputs for changes to tailings K (Sens.2 and Sens.3)*

- **Permeability of the rhyolite tuff:** The scenario testing analysed an order of magnitude higher and lower than the base model K for this rock unit. The results (Figure I.15) showed a change in groundwater flow paths was the key change resulting from the sensitivity tests, which influenced the results as follows:
  - Scenario 3:
    - A moderate change in tailings volume from TSF3 under Scenario 3, with the lower K value (Sens.5) allowing some tailings porewater (31% of total discharge) to bypass the drains and enter the receiving environment. There was no change reported for the increased K value (Sens.4).
    - The response of infiltration (which is applied as rainfall recharge) through the embankment was slightly influenced by the underlying rhyolite unit, with a minor increase in embankment discharge under higher K (Sens.4) of 12 m^3/day more than the base model; whereas a lower K (Sens.5) decreased by 4 m^3/day against the base model.
  - Scenario 5:
    - The increase and decrease to K both allow for drainage capture of tailings, but a similar order of discharge occurs to the receiving environment.
    - The same volume of embankment infiltration occurs (as per AECOM 2020), but with the sensitivity test results reporting all captured by drain.
  - Neither analysis results in flow lines to the Ruahorehore Stream from beneath the TSF.

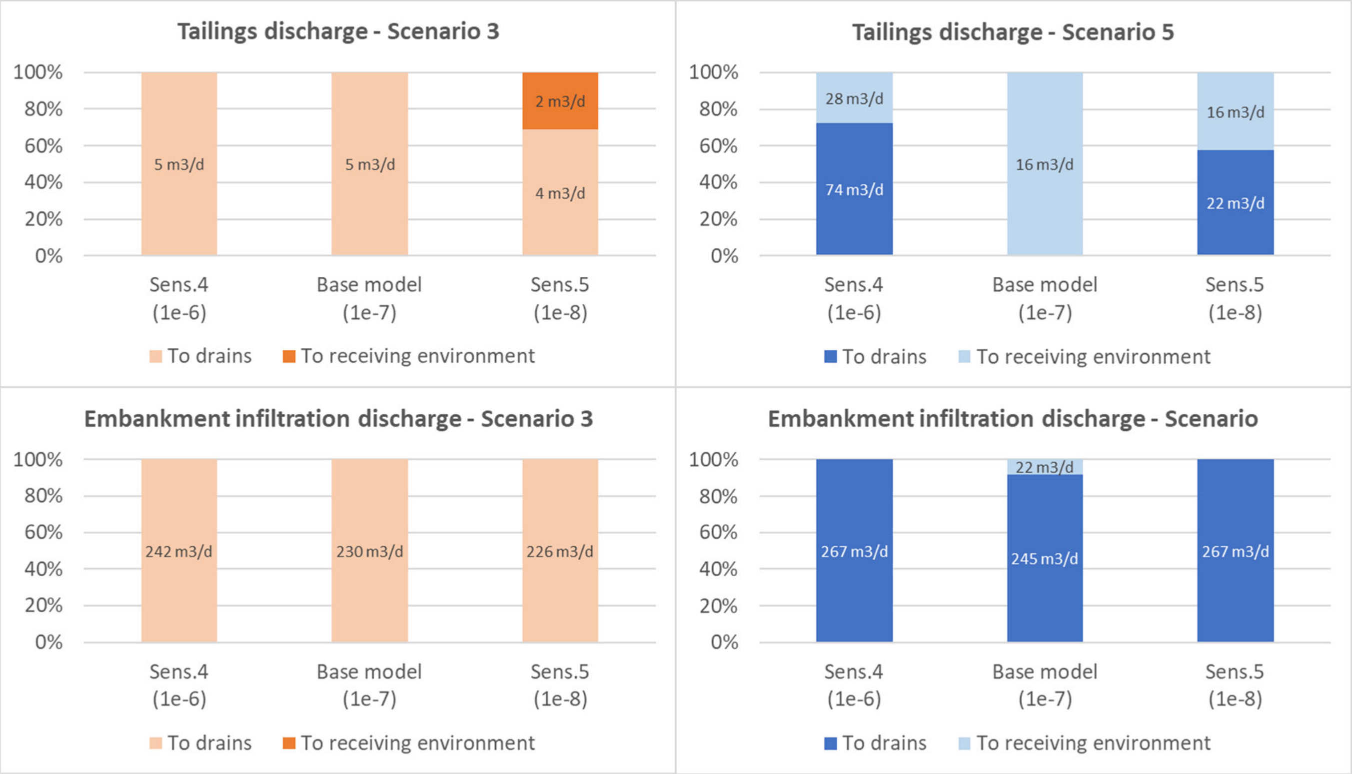


Figure I.15 Sensitivity testing outputs for changes to rhyolite tuff K (Sens.4 and Sens.5)

Appendix J

Wharekirauponga Willows Rock Stack

Technical assessment

This appendix presents the methodology and results for technical assessment of the proposed Wharekirauponga Willows Waste Rock Stack (WRS). All elevations are presented in metres reduced level (mRL) with reference to Waihi Mine datum, which is 1,000 metres below sea level.

J.1 Introduction

This technical appendix provides the details of the Wharekirauponga Willows WRS analysis presented in Section 6.4 of the Waihi North Groundwater Assessment report.

The outline of this appendix is as follows:

- J.2 Numerical analysis (methodology and results)
- J.3 Water quality assessment
- J.4 Sensitivity analysis

J.2 Numerical analysis

J.2.1 Methodology

The rationale for the model set up is described in Section 6.3 of the Groundwater Assessment report. This section describes the physical model set up, how calibration was achieved, and the scenarios applied.

The base model comprised a steady-state 2D cross-sectional model using Geostudio 2024 SEEP/W (see Figure 6.7 in main report for section location). The section length was 228 m, with the gully located approximately 151 m along the X axis. The model boundaries represent the ridges and were approximated from topography. The model was calibrated to shallow groundwater levels recorded within the andesite, downwards vertical hydraulic gradients and baseflow discharge to the gully stream.

The model scenarios are summarised in Table J.1. Model set up details are provided in Table J.2, base model calibration results are provided in Table J.3 and calibrated hydraulic properties of the geology and WRS material are provided in Table J.4.

Table J.1 WRS base model calibration and scenario summary (steady state)

Scenario		Description
Base model		– Base of gully set to 1,177.5 m RL. – Ground model provided by EGL. Whiritoa Andesite rock as primary geology, with overlying ash/residual soils. – Rainfall recharge applied to full model (10% of annual rainfall) – Model calibrated to shallow groundwater levels within the andesite, downwards vertical hydraulic gradients and baseflow discharge to the gully stream.
WRS operation	Scenario 1: 30% rainfall recharge	– Rock placed to maximum height directly on ash/residual soil, and within shear key underlain by Zone A liner. – Rainfall recharge rate applied directly to surface of the rock stack. – Rock drain at base of gully (assumed 0.5 m thick). – Shear key drain at southern extent of above Zone A liner. – Results multiplied by 450 m (length of WRS perpendicular to model section)
	Scenario 2: 50% rainfall recharge	

Table J.2 WRS model set-up

Boundary type	Adopted boundary condition	Justification	Model scenario
Groundwater boundary (base of model)	Constant head – 1,153 mRL	Calibrated to shallow groundwater levels within Andesite, downwards vertical hydraulic gradients and baseflow to gully stream.	Base model and WRS operation
Rainfall recharge	Water flux – 7x10^{-9} m/s (10% annual rainfall)		
Recharge to the rock stack	Two recharge rates applied to the rock stack: Water flux – – 30% recharge: 2.3x10^{-8} m/s – 50% recharge: 3.5x10^{-8} m/s	30 & 50 % of average rainfall at the site (2,110 mm/year; NIWA 2019)	WRS operation
Shear key and rock drains	Water rate – 0 m^3/day with potential seepage face review	Removal of leachate through drains	WRS operation

Table J.3 WRS base model calibration results

Parameter	Measured	Modelled
Groundwater levels within shallow andesite		
WWS101 VWP2	1,180.3	1,179.0
WWS102S	1,179.5	1,180.3
WWS105 VWP3	1,183.8	1,181.2
Downwards vertical hydraulic gradients	Deep andesite groundwater levels 1,172.6 mRL (WWS107) 1,174 mRL (WWS105)	1,153 – 1,181 mRL within Low Permeability Andesite unit at base of model
Baseflow discharge to gully stream	0.7 L/s(1)	0.69 L/s(2)
1) Baseflow adopted from lowest measured flow gauging result 24 March 2024 (WWLA, 2024) 2) Assumes 470 m length of stream receiving baseflow discharge within gully		

Table J.4 WRS model calibrated hydrogeological material parameters

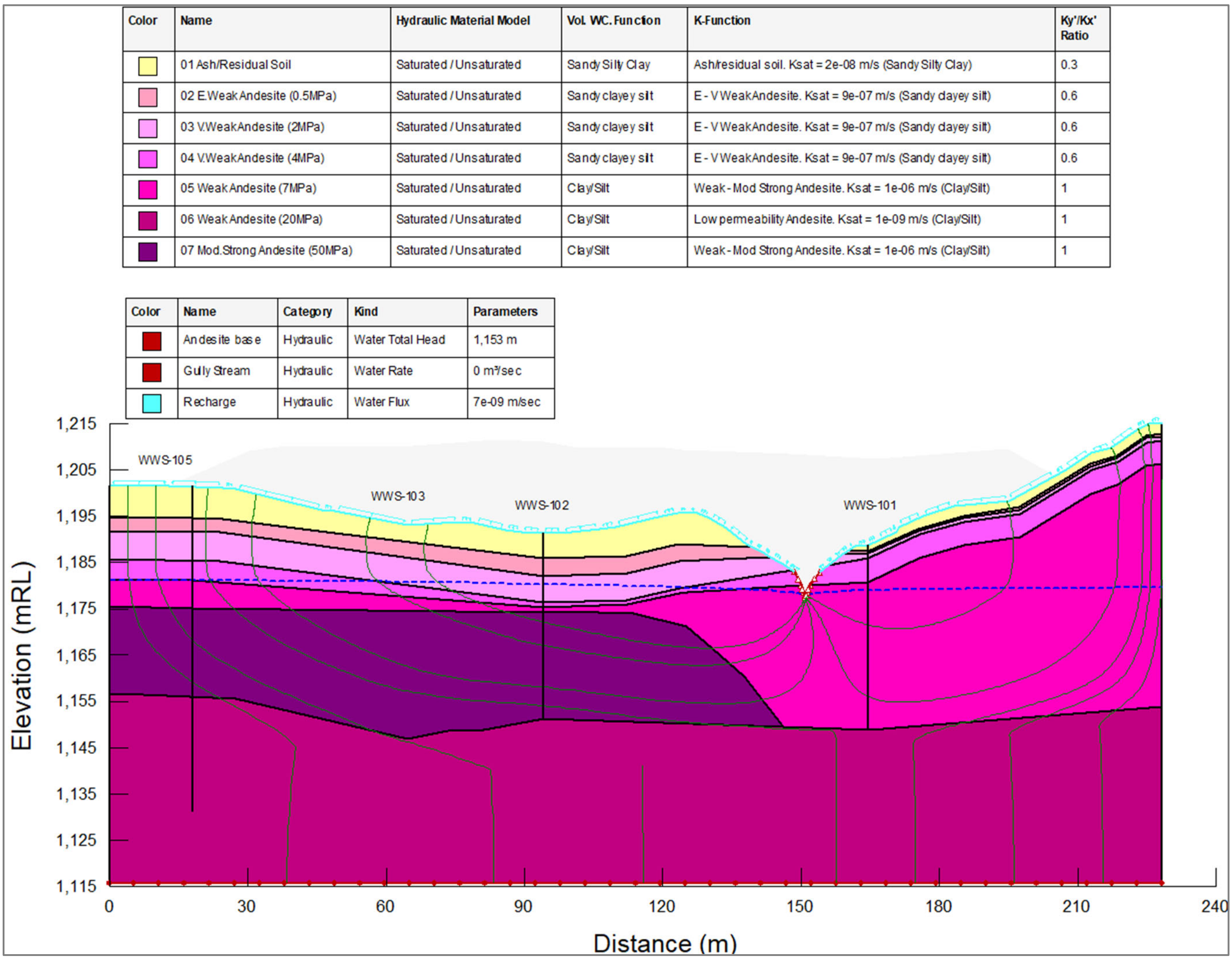
Material unit	Hydraulic conductivity (m/s)	Anisotropy (K_V/K_H)	Hydraulic conductivity justification
Residual soil	2 x 10^{-8}	0.3	EGL (2025c) geotechnical site investigation results and calibrated to shallow groundwater levels within Andesite, downwards vertical hydraulic gradients and baseflow to gully stream.
Extremely – Very Weak Andesite	9 x 10^{-7}	0.6	
Weak – Moderately Strong Andesite	1 x 10^{-6}	1.0	
Low permeability Andesite	1 x 10^{-9}	1.0	
Rock drain	1 x 10^{-2}	1.0	Nominal value considered appropriate for rock drain
Rock stack	1 x 10^{-5}	0.5	Considered appropriate for emplaced rock materials (as applied for NRS).
** VWC = Volumetric water content function (SEEP/W 2012 materials database)			

J.2.1 SEEP/W outputs

The phreatic groundwater surface and groundwater flow paths for the calibrated base model are presented in Figure J.1, and groundwater recharge and discharge per 1 m section of the model are presented in Table J.5.

Table J.5 Groundwater recharge and discharge in calibrated base model (m^3/day per 1 m section)

Recharge	Discharge to WRS gully	Discharge to base of model (Mataura Stream)
0.14	0.13	0.017



Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio
🟨	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

Color	Name	Category	Kind	Parameters
🟥	Andesite base	Hydraulic	Water Total Head	1,153 m
🟥	Gully Stream	Hydraulic	Water Rate	0 m³/sec
🟦	Recharge	Hydraulic	Water Flux	7e-09 m/sec

Figure J.1 Calibrated numerical groundwater model (base model). Dashed blue line = phreatic groundwater surface. Solid green lines = groundwater flow paths.

Following development of the rock stack, the proportion of predicted rock stack leachate captured by the seepage drains is presented in Table J.6 (results scaled by 450 m length of WRS perpendicular to model section). The predicted leachate not captured by the drains is the volume predicted to enter the Ohinemuri River catchment via the Mataura Steam.

Table J.6 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

J.2.1 Drain capture – mass flux calculation

The mass flux of parameters to the drains was calculated by multiplying the predicted leachate concentrations by the maximum predicted drain capture (270 m^3). The leachate parameter concentrations were sourced from the water balance model, provided in the GHD (2025a) water management report. These values are based on the 95th percentile for TSF1A seepage data. The results are presented in Table J.7.

Table J.7 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

J.3 Water quality assessment

J.3.1 Methodology

A mixing assessment has been undertaken to predict the impact that the leachate (Section J.2) may have on the water quality of the receiving environment. This has been determined to be the Mataura Stream, which is part of the Ohinemuri River catchment (Section 6.2.3 of the main report). The analysis conservatively considered straight mixing of the leachate into the stream (i.e. dilution by groundwater not considered) using the following mass balance analytical solution:

$$\boxed{C_3V_3 = C_1V_1 + C_2V_2}$$

Where:

C = Concentration of parameter in g/m^3
V = Flow volume in m^3/day
CV = Mass flux of parameter in g/day

1 = Existing stream quality
2 = WRS leachate discharge
3 = Stream water quality after mixing of 1 and 2

This analysis considers the following inputs:

- Existing Mataura Stream water quality (C_1): The background stream quality was adopted from the median concentrations from samples collected at M12 between 2020 – 2024.
- Leachate parameter concentrations (C_2): Sourced from the water balance model, provided in the GHD (2025a) water management report (as per the drain capture mass flux analysis above; Section J.2.1). For this analysis leachate quality of 95th percentile values for TSF1A was adopted.
- Mataura Stream flow (V_1): A range of (rounded) flows was considered, based on the lowest predicted flow (2,000 m^3/day) and median stream flow (19,000 m^3/day) (GHD, 2024).
- Maximum predicted leachate not captured by drainage system (V_2): From groundwater modelling results above (2.2 m^3/day).

J.3.2 Results

The results are presented in Table J.8. Due to the relatively low discharge volume to ground, most predicted parameter concentrations report no differences between the analysed scenarios within the levels of accuracy available. The key parameters that do vary across the scenarios are iron, manganese and sulphate.

The mass flux of parameters entering the Ohinemuri River catchment via groundwater discharge were calculated by multiplying the predicted leachate concentrations with the volume of leachate discharged to ground. The results are provided in Table J.9.

Table J.8 Mataura Stream estimated water quality (values in mg/L)

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

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)**	
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 ↑	
NH_3-N	No data	No result (*increase of 0.0003*) ↑	No result (*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 *(increase of 0.0000006)* ↑	No result *(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 J.9 Predicted mass flux to the Mataura Stream (kg/day)

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

J.4 Sensitivity analysis

Sensitivity testing was undertaken for hydraulic conductivity of the following:

- The emplaced waste rock.
- The underlying geology.

The applied hydraulic conductivity values for each material tested are presented in Table J.10, with the results presented in Figures J.2 – J.6.

Table J.10 Sensitivity analysis parameters

Scenario	Waste rock	Ash/Residual soil	E - V Weak Andesite	Weak - Mod Strong Andesite	Low permeability Andesite
Base model hydraulic conductivity (m/s)	1x10^{-05}	2x10^{-08}	9x10^{-07}	1x10^{-06}	1x10^{-09}
Sensitivity analysis					
Hydraulic conductivity increase (m/s)	1 x10^{-04}	2 x10^{-07}	9x10^{-06}	1x10^{-05}	1x10^{-08}
Hydraulic conductivity decrease (m/s)	1x10^{-06}	1 x10^{-09}	9x10^{-08}	1x10^{-07}	1x10^{-10}

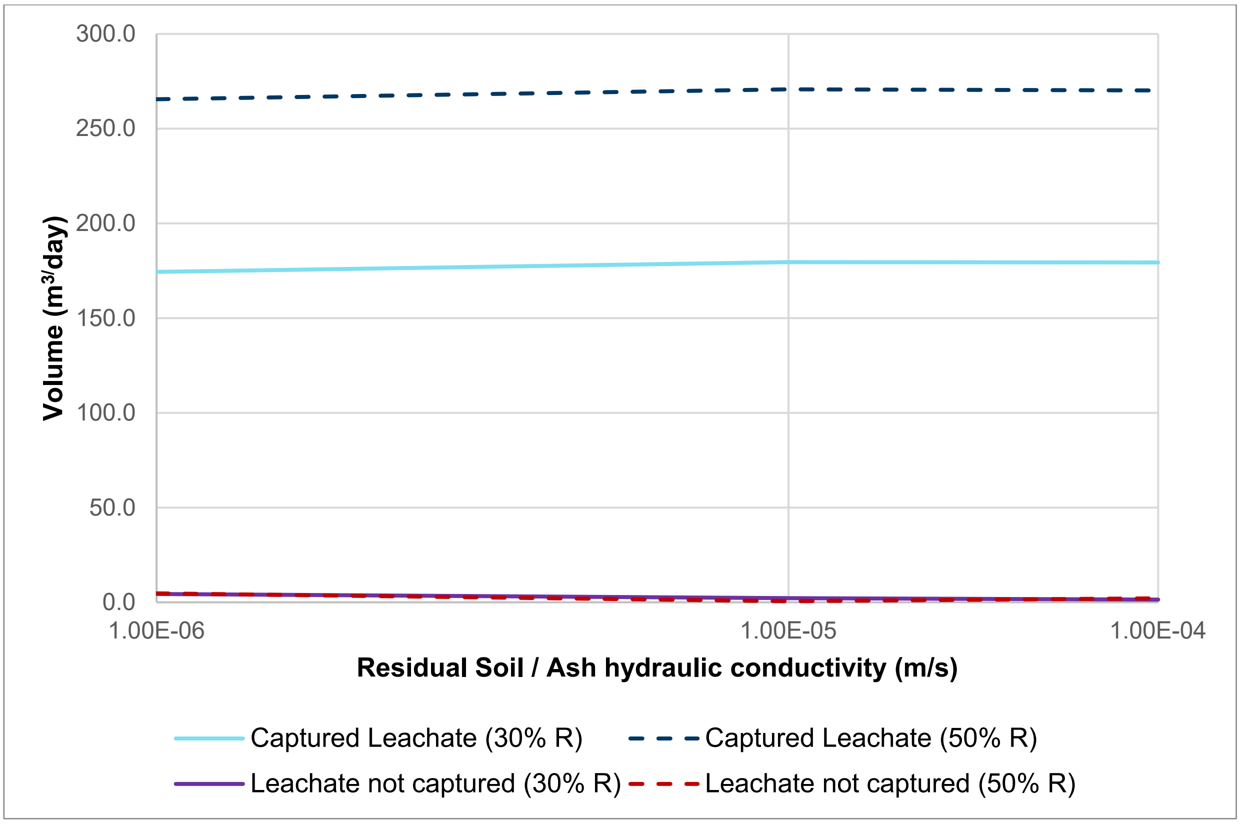


Figure J.2 Sensitivity analysis – hydraulic conductivity of residual soil / ash

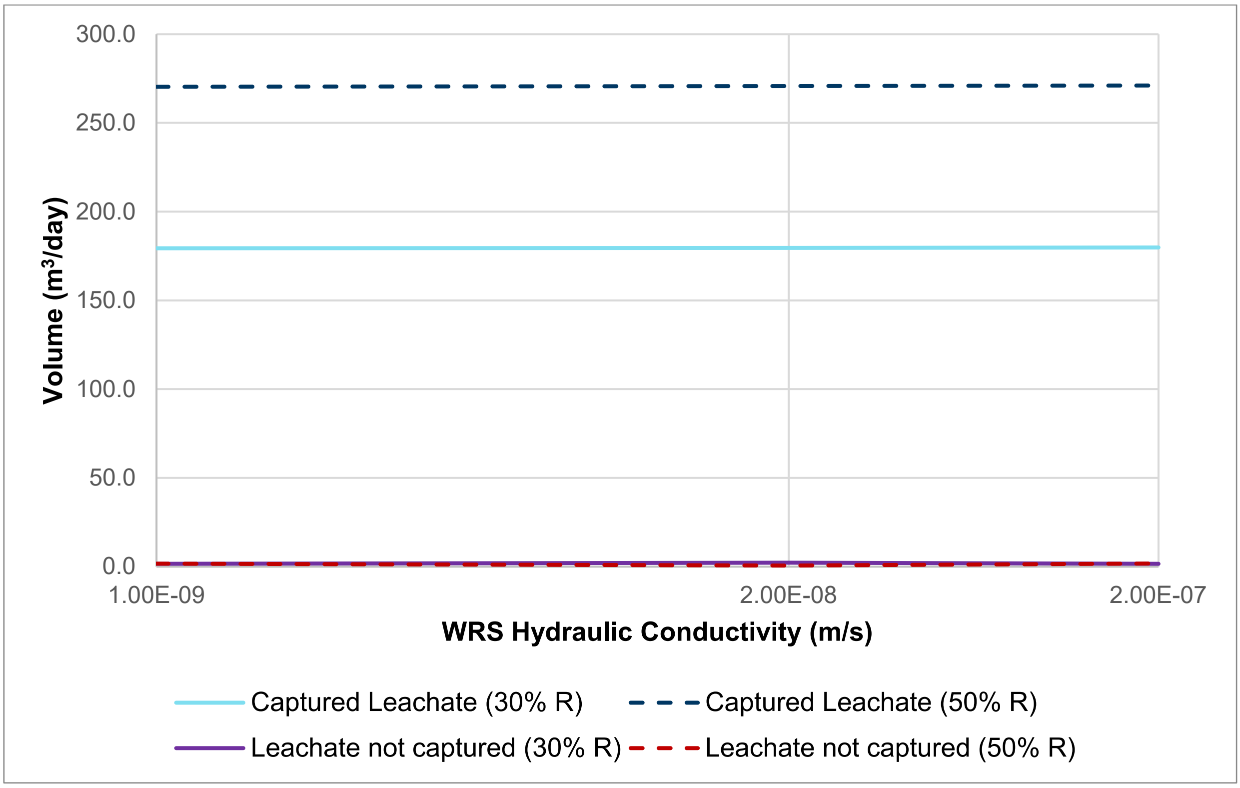


Figure J.3 *Sensitivity analysis – hydraulic conductivity of waste rock*

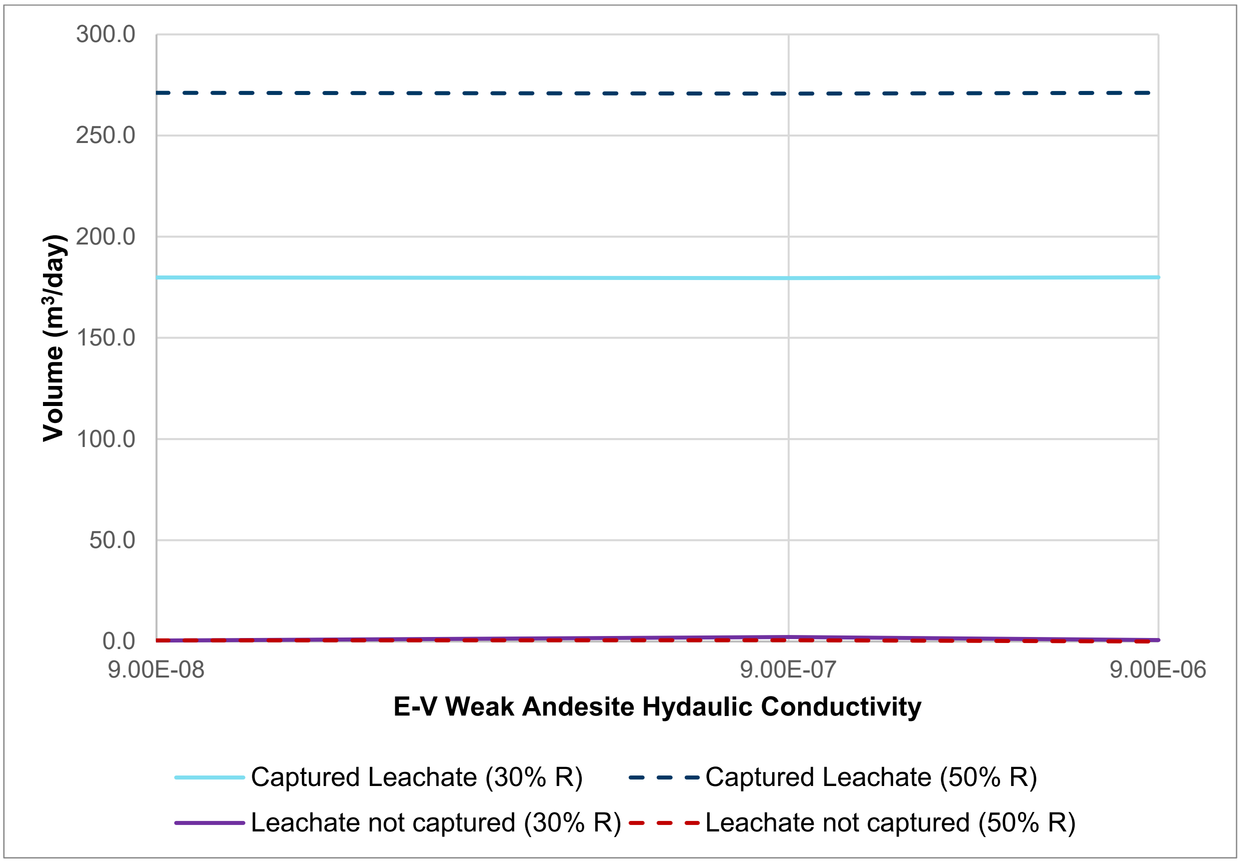


Figure J.4 *Sensitivity analysis – hydraulic conductivity of Extremely – Very Weak Andesite*

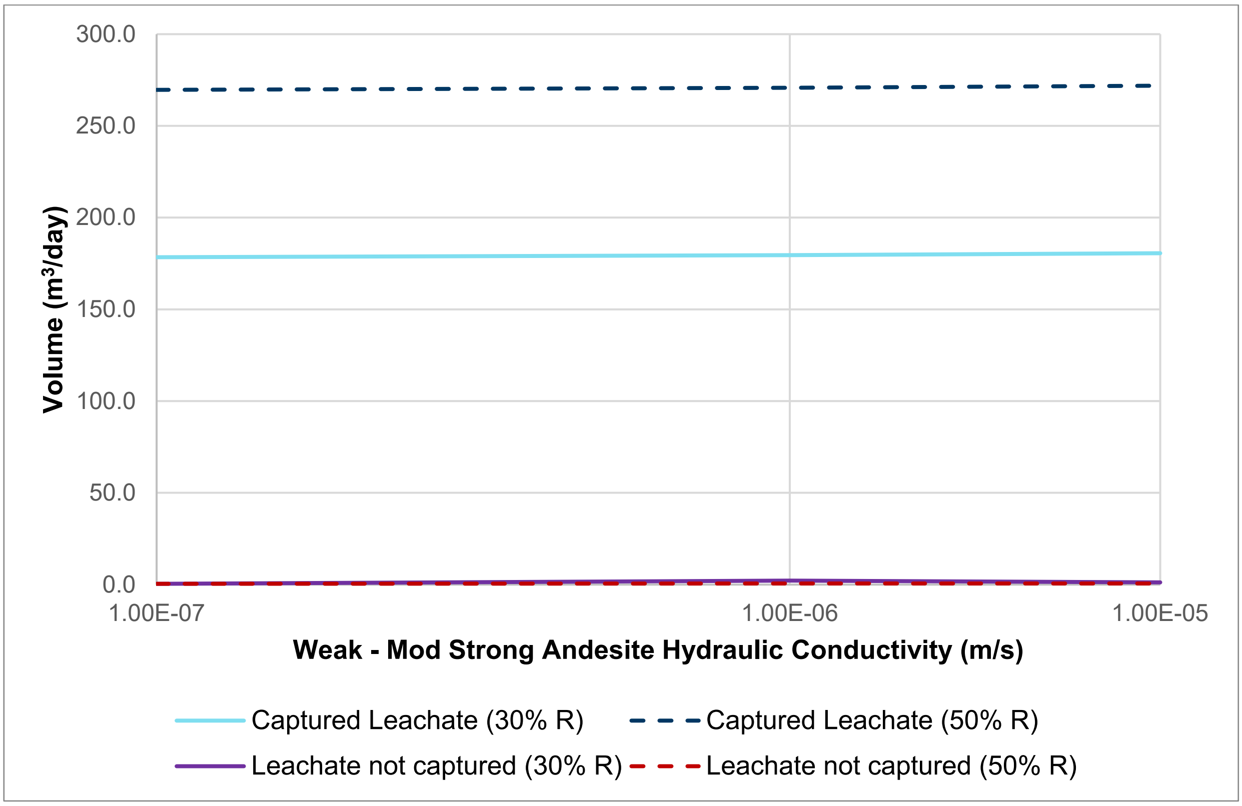


Figure J.5 *Sensitivity analysis – hydraulic conductivity of weak – moderately strong andesite*

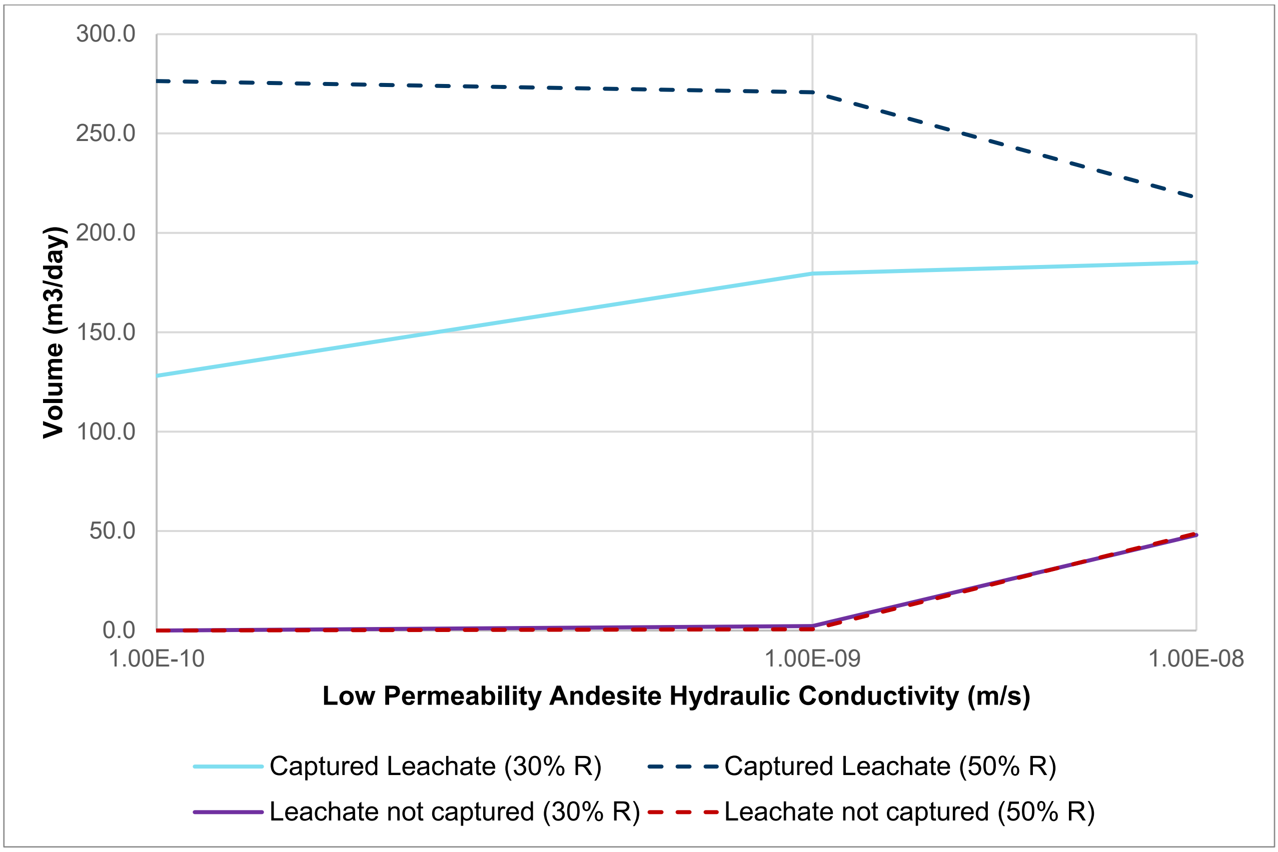


Figure J.6 *Sensitivity analysis – hydraulic conductivity of low permeability andesite*

The results of the sensitivity analysis indicate that for all scenarios tested, excluding the low permeability andesite, the volume of leachate seepage not captured by the drains only varies by a small amount (0 – 4.7 m^3/day). However, where the hydraulic conductivity of the low permeability andesite was increased by an order of magnitude, the volume of leachate seepage not captured by the drains increased to 49 m^3/day (18 – 27% of total infiltration through the waste rock stack for the 50% and 30% recharge scenarios, respectively). While these sensitivity analysis results are based on an uncalibrated model scenario, review of the potential impact the increased leachate discharge may have on the water quality of the Mataura Stream has been undertaken. The results indicate that with the exception of mercury, for which the RWQC is lower than available laboratory detection limits, no exceedances of the RWQC are estimated when considering 49 m^3/day of leachate discharge to the Mataura Stream during low flow conditions.

Appendix K

Water resource users

Table K.1 *Registered groundwater bore (WRS database) within the WNP area (excluding OceanaGold bores)*

Well ID	Identifier	Location description	Drilling date	Company name	Easting	Northing	Diameter	Depth drilled	Casing bottom	Screen inside diameter	Screen top	Screen bottom
38314	63_4		30/10/1984	Brown Bros (N.Z.) Limited	1854108	5855876		106.29				
38444	63_11		19/10/1984	Brown Bros (N.Z.) Limited	1852107	5855872	100	169.7				
38542	63_124	Ford Road Waihi	22/05/1991	Tauranga Drilling Co Limited	1852808	5855673	100	110	78			
38544	63_136	Waihi Rubbish Dump	25/02/1996	Perry Geotech Limited	1851801	5859173	50	12.5	10.5	50	10.5	12.5
38557	63_2		24/10/1984	Brown Bros (N.Z.) Limited	1855410	5855178	100	116.57				
39141	63_388	Bulltown Road, Waihi	8/10/1982	Radial Drilling	1851601	5858973	100	50				
39142	63_392	In school grounds	1/01/1945	Benton & Son Limited	1853908	5853933	150	126.7	76.6			
39856	63_200	Old Tauranga Road Waihi	22/01/1990	Barham United Welldrillers Limited	1851711	5853470	100	123				
40006	63_249	WARMSLEY RD, WAIHI	8/12/1994	Barham United Welldrillers Limited	1852400	5859974	100	74	45.5	65	45.5	74
40258	63_328	Golden Valley Road Waihi	3/05/1991	Tauranga Drilling Co Limited	1856283	5859856	100	49	19.5			
40350	63_305	TRIG RD, WAIHI	13/04/1995	Barham United Welldrillers Limited	1857306	5857782	100	66	36			
40701	63_351	MAIN RD, WAIHI	29/09/1983	Rex Brown Drilling (2012) Limited (Ceased Trading)	1853912	5853974	100	125	71.68			
41068	63_370	Waihi Rubbish Dump	26/02/1996	Perry Geotech Limited	1851801	5859173	50	8	6	50	6	8
41117	63_95	Crean"s Rd, Waihi	10/05/1991	Barham United Welldrillers Limited	1851406	5856271	100	105	17			
41127	63_113	TAURANGA RD, WAIHI	5/10/1993	Barham United Welldrillers Limited	1853711	5854074	100	122	84.5			
41128	63_237	WHANGAMATA RD, WAIHI	9/11/1993	Barham United Welldrillers Limited	1856197	5862883	100	33	16.1	80	21	33
41675	63_78	Waihi Beach Road	9/09/1992	Tauranga Drilling Co Limited	1856828	5854849	100	24	13			
41676	63_266	Baxter Rd Waihi.	29/08/1983	Barham United Welldrillers Limited	1854107	5856776	100	128.02	36.57			
41703	63_310	Tauranga Road Waihi	1/05/1987	Ken Garnett Drilling Limited	1854112	5853875	100	130	72			
41738	63_207	Kingsley Road Waihi	8/09/1992	Tauranga Drilling Co Limited	1853607	5856475	100	46	33			
41814	63_319	GOLDEN VALLEY RD, WAIHI	15/10/1993	Barham United Welldrillers Limited	1856715	5859753	100	78	58.5			
41860	63_128	Kingsley Rd	31/08/1990	Tauranga Drilling Co Limited	1853607	5856275	100	43	32.5			
42537	72_16		12/10/1999	Ken Garnett Drilling Limited	1851405	5856871	150	55	39			
42545	63_96	FRANKTON RD, WAIHI	12/10/1994	Tauranga Drilling Co Limited	1851206	5856270	100	140	91			
42563	63_381	Waihi	13/02/1997	Perry Geotech Limited	1851902	5858573	50	7	4	50	4	5.5
42683	63_264	Waihi Beach Rd	10/09/1992	Barham United Welldrillers Limited	1855711	5854878	100	156	65			
42945	63_234	S H 2 WAIHI	6/06/1985	Ken Garnett Drilling Limited	1853107	5856274	100	87.8	52			
43476	63_267	Whangamata Highway	8/01/1991	Tauranga Drilling Co Limited	1853801	5859777	100	53	32.5			
43700	72_666		26/02/2001	Geo Hutchinson (1984) Limited	1857205	5858683	100	42.6	19.6			
44074	63_385	Katikati-Waihi Road, Waihi	1/01/1985	Ken Garnett Drilling Limited	1854134	5853766	100	129	70			
44107	72_1332		25/03/2003	Drillwell Holdings New Zealand Limited	1855610	5855178	150	139.5				
44244	63_125	Trig Rd Waihi.	21/04/1985	Carlyle Drilling Limited	1854370	5853739	150	161				
44282	63_198	TAURANGA RD, WAIHI	1/12/1983	Thames Valley Welldrillers Ltd	1853509	5855574	100	98	52			
44283	63_201	WAIHI BEACH RD	1/01/1982	Thames Valley Welldrillers Ltd	1855436	5855078	100	48	26			
44284	63_235	TAURANGA RD, WAIHI	6/06/1985	Ken Garnett Drilling Limited	1853307	5856174	100	87.8	52			
44285	63_236	TAURANGA RD, WAIHI	15/06/1985	Ken Garnett Drilling Limited	1853168	5856185	112	88	52.5			
44295	63_389	HASZARD STREET, WAIHI	19/08/1997	Perry Geotech Limited	1851503	5858072	50	6	4.5	50		
44384	72_1360		30/03/2003	Ewen Cameron Welldrilling	1853710	5855074	150	167.64	58			
44385	72_1361		8/04/2003	Ewen Cameron Welldrilling	1855510	5855178	105	125	71.5			

Well ID	Identifier	Location description	Drilling date	Company name	Easting	Northing	Diameter	Depth drilled	Casing bottom	Screen inside diameter	Screen top	Screen bottom
44541	72_961		17/02/2000	Perry Geotech Limited	1852891	5857203	100	126				
44641	72_959		30/10/1999	Perry Geotech Limited	1853005	5857174	100	72				
44664	72_960		14/02/2000	Perry Geotech Limited	1853005	5857174	100	85				
44748	72_1223		22/11/1988	Tauranga Drilling Co Limited	1853668	5859634	120	92.5	19.1			
45418	72_762		17/12/1997	Barham United Welldrillers Limited	1855698	5861982	100	172	65			
45427	72_771		20/11/1998	Barham United Welldrillers Limited	1854004	5858477	100	86	50			
45546	72_3954		24/07/2000	Ewen Cameron Welldrilling	1854112	5854075	100	130				
45772	72_3562		10/07/2007	Geo Hutchinson (1984) Limited	1856204	5858681	100	55	23			
45983	72_3956		22/08/2008	Carlyle Drilling Limited	1853207	5856174	100	60	31.5			
46126	72_2437		16/05/2005	Carlyle Drilling Limited	1856539	5854901	100	124	65			
46537	72_4839		14/01/2005	Barham United Welldrillers Limited	1853508	5856075	100	84	65	65	64	84
46679	72_4879		21/04/2005	Barham United Welldrillers Limited	1854100	5860178	100	30	16			
46800	72_5193		16/12/1988	Tauranga Drilling Co Limited	1853001	5859475	120	86	56			
46975	72_3985		17/07/2007	Boart Longyear Drillwell	1853080	5858797	125	95			92.9	94.9
46976	72_3986		20/07/2007	Boart Longyear Drillwell	1853074	5858795	125	49.9	47.9		47.9	49.9
46977	72_3987		20/07/2007	Boart Longyear Drillwell	1853066	5858791	125	9.4	7.4	25	7.4	9.4
46978	72_3988		20/07/2008	Boart Longyear Drillwell	1852894	5858463	125	68			64.4	66.4
47131	72_3338		19/06/2007	Geo Hutchinson (1984) Limited	1856204	5858681	100	55	23			
47327	72_5196		6/03/1989	Tauranga Drilling Co Limited	1855898	5861982	120	82	60			
47610	72_5195			Tauranga Drilling Co Limited	1855698	5862182	120	73	43			
47647	72_5742		20/07/2011	Boart Longyear Drillwell	1852703	5858674		144.7				
47648	72_5743		24/08/2011	Boart Longyear Drillwell	1852502	5858674						
47649	72_5744		15/09/2011	Boart Longyear Drillwell	1852602	5858974						
47966	72_5738		16/08/2011	Boart Longyear Drillwell	1852502	5858974		144.6				
48022	72_5081		28/02/2007	Barham United Welldrillers Limited	1855614	5853277	100	11	5	100	5	11
48149	72_5739		3/08/2011	Boart Longyear Drillwell	1852702	5858874		158				
48150	72_5740		11/07/2011	Boart Longyear Drillwell	1852803	5858675		122				
48258	72_5963		7/11/2010	Ken Garnett Drilling Limited	1856267	5858213	100	47	45	100		
48428	72_6078		27/07/2012	Boart Longyear Drillwell	1852602	5858974		265				
48598	72_8975		28/09/1989	Tauranga Drilling Co Limited	1856412	5862701	100	57.5	12			
49453	72_9336		1/01/1965	Carlyle Drilling Limited	1852920	5856804	100	183	61			
49743	72_10626		18/12/2020	Brown Bros (N.Z.) Limited	1855116	5861496	100	120	84			
49763	72_9795		29/03/2017	Brown Bros (N.Z.) Limited	1852343	5854046	250	119	41.25			
49991	72_10628		27/07/2020	Brown Bros (N.Z.) Limited	1855829	5854773	200	244.6	172.5			
50038	72_10251		24/01/2020	Brown Bros (N.Z.) Limited	1855830	5859751	100	82.9	58.2			
50238	72_10064		28/04/1988	Ewen Cameron Welldrilling	1856790	5857987	120	63	42			
50412	72_10311		10/10/1989	Tauranga Drilling Co Limited	1853811	5861066	120	200	34			
50430	72_9798		15/09/2018	Brown Bros (N.Z.) Limited	1852938	5856790	200	350.03	173.5			
50701	63_5		30/10/1984		1854108	5855976						
50707	63_71				1856711	5854980						
50855	63_12		19/10/1984		1852107	5855972	100	169.7				
51151	63_3		30/10/1984		1854208	5856076	100	106.29				
53626	63_398		0/01/1900		1854109	5855776		80				
54017	72_1822		1/12/1983		1853509	5855474	100	98	58.5			
54889	72_6162				1855370	5858492	100					

Well ID	Identifier	Location description	Drilling date	Company name	Easting	Northing	Diameter	Depth drilled	Casing bottom	Screen inside diameter	Screen top	Screen bottom
54890	72_6163				1855431	5858341	100	95	45			
54891	72_6164				1855812	5858480	100					
55438	72_9209				1853845	5854095	100	139	133.3			
55525	72_9253		1/01/1986		1853897	5855233	100					
55566	72_8777				1855671	5853176						
56607	72_8693				1854698	5855477	100	30				
56609	72_8695				1856244	5855738						
56910	72_9048				1856339	5853381						
57150	72_6232		1/01/1988		1851395	5853809	150	120	120			
57452	72_10865		9/02/2022	Brown Bros (N.Z.) Limited	1853894	5856217	100	120	78		78	120
57642	72_11017		23/05/2022	Barham United Welldrillers Limited	1856519	5862801	100	58	13		13	38
57759	72_11440		30/09/2018	Rig Rentals Limited	1853820	5861463	100	88.5	64.5			
58672	72_12076		11/12/2023	Brown Bros (N.Z.) Limited	1856680	5859842	100	122.27	122.27			
118774	72_12391		25/09/2024	Brown Bros (N.Z.) Limited	1856238	5862822	100	50.7	37.8	100	38.7	50.7

Table K.2 Water take consents (WRS database) located within the WNP project area (excluding OceanaGold consents)

Authorisation ID	Activity	Commenced	Expiry date	Holder	Authorisation Address	Easting	Northing
AUTH131303.01.01	Ground water take	4/12/2015	31/12/2030	Arthur Farms Limited	95 Trig Road, Waihi	1855738	5855738
AUTH131595.01.01	Ground water take	28/04/2016	31/12/2030	B McLean & AE Gaddes	87 Mathers Road, RD 1, Waihi 3681	1856339	5853381
AUTH142870.01.01	Ground water take	27/07/2021	31/07/2036	Black Hill Orchard Limited	9477 Tauranga Road, Waihi	1852939	5856790
AUTH141021.01.01	Ground water take	9/12/2019	30/11/2034	Chris McHardy	24 Waihi Beach Road, RD 1, Waihi, Waihi 3681	1853168	5856185
AUTH131596.01.01	Ground water take	23/11/2015	30/11/2030	GK & MH Mathers	88 Mathers Road, RD 1, Waihi 3681	1855671	5853176
AUTH137051.01.01	Ground water take	22/07/2016	31/07/2031	Goldmine Developments Limited	State Highway 2, Waihi	1853890	5855250
AUTH130392.01.01	Surface water take	16/05/2014	16/05/2034	Hauraki District Council (Paeroa Office)	Walmsley Road, Waihi	1851558	5861828
AUTH130392.03.01	Surface water take	16/05/2014	16/05/2034	Hauraki District Council (Paeroa Office)	Walmsley Road, Waihi	1853973	5858554
AUTH119346.01.01	Ground water take	19/08/2009	1/08/2027	Hauraki District Council (Paeroa Office)	Bulltown Rd, Waihi (Waihi Closed Landfill)	1851801	5859173
AUTH131201.01.01	Ground water take	23/11/2015	30/11/2030	JG & JM Wright	159-179 Waihi Beach Road, Waihi	1854698	5855477
AUTH146468.01.01	Ground water take	26/02/2024	26/02/2039	Macedonian Properties Limited	436 Golden Valley Rd, Waihi (Fonterra 75911)	1856680	5859842
AUTH125743.01.01	Ground water take	27/09/2013	30/09/2028	MT & JL Gerring	Trig Rd, Waihi (Fonterra 75920)	1856267	5858213
AUTH125803.01.01	Ground water take	9/04/2014	9/04/2029	Orchard Dairies Limited	Trig Road North, Waihi (Fonterra 75923)	1855370	5858491
AUTH125803.01.01	Ground water take	9/04/2014	9/04/2029	Orchard Dairies Limited	Trig Road North, Waihi (Fonterra 75923)	1855812	5858480
AUTH125803.01.01	Ground water take	9/04/2014	9/04/2029	Orchard Dairies Limited	Trig Road North, Waihi (Fonterra 75923)	1855431	5858341
AUTH143325.01.01	Ground water take	11/08/2021	1/07/2036	Protective Cropping Limited	232 Trig Road South, RD 1, Waihi, Waihi 3681	1855830	5854770
AUTH120591.01.01	Surface water take	1/08/2010	1/07/2027	RG McIntyre Farms Limited	Fisher Road, Waihi	1854107	5856376
AUTH147307.01.01	Ground water take	20/12/2024	13/08/2039	SMAC Holdings 2001 Limited	25A Fisher Road, RD 1, Waihi 3681	1853894	5856217
AUTH146708.01.02	Surface water take	14/08/2024	13/08/2039	SMAC Holdings 2001 Limited	25A Fisher Road, RD 1, Waihi 3681	1853900	5856301
AUTH139076.01.01	Ground water take	22/01/2018	1/02/2033	Taran and Arash Sunner Limited	263 Waihi Beach Rd, RD 1, Waihi	1855410	5855078
AUTH126104.01.01	Ground water take	27/09/2013	30/09/2028	Tavuna Farm Limited	Old Tauranga Rd, Waihi (Fonterra 75928)	1851395	5853809
AUTH136827.01.01	Ground water take	8/06/2016	31/12/2030	Vale Green Services Limited	Ford Road, Waihi	1853845	5854095
AUTH132325.01.01	Ground water take	4/12/2015	31/12/2030	VM Jensen	730 Waihi Whangamata Road, RD 1, Waihi 3681	1856412	5862701
AUTH125719.01.01	Surface water take	7/06/2017	31/12/2030	Waihiki Holdings Limited	Waihi Beach Road, Waihi (Fonterra 755961)	1856073	5855066
AUTH142291.01.01	Ground water take	22/10/2020	31/10/2035	Waitui Trust	11 Trig Road South, Waihi	1854134	5853767

Appendix L

Gladstone Wetland Groundwater Assessment Summary

Technical Memorandum

01 March 2022

To	Oceana Gold (New Zealand) Limited	**Tel**	093708208
Copy to	Ethan Glover and Adrian Low (Mitchell Daysh)	**Email**	zoe.pattinson@ghd.com; anthony.kirk@ghd.com
From	Zoe Pattinson and Anthony Kirk	**Ref. No.**	12552081
Subject	Gladstone Wetland Groundwater Assessment Summary		

Document Status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S3	Draft (Rev A)	Z. Pattinson	A. Kirk	Record on file	A. Kirk	Record on file	21/01/2022
S3	Draft (Rev B)	Z. Pattinson	A. Kirk	Record on file	A. Kirk	Record on file	01/03/2022

1. Introduction

GHD was commissioned by Oceana Gold New Zealand Limited (OGNZL) to deliver a study relating to groundwater and surface water for the proposed excavation of the Gladstone Open Pit (GOP) and development as a Tailings Storage Facility (TSF) as part of the wider “Waihi North Project” (WNP).

This technical memorandum presents a summary of the assessment of effects on the Gladstone Wetland as a result of the proposed activities. The full assessment is presented in the following report which must be read in conjunction with this technical memorandum:

– Waihi North Groundwater Assessment WAI-985-000-REP-LC-0012. Prepared for Oceana Gold (New Zealand Limited).

This technical memorandum is subject to, and must be read in conjunction with, the limitations set out in Section 2 and the assumptions and qualifications contained throughout.

2. Limitations

The following limitations are reproduced in this technical memorandum from the Groundwater Assessment Report (WAI-985-000-REP-LC-0012). This technical memorandum is subject to, and must be read in conjunction with, the following limitations as well as the assumptions and qualifications contained throughout the Groundwater Assessment Report (WAI-985-000-REP-LC-0012).

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The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report and in the appendices. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Oceana Gold (New Zealand) Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

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GHD has not been involved in the preparation of the Assessment of Environmental Effects (AEE), prepared by Mitchell Daysh and has had no contribution to, or review of the AEE other than in this technical report for groundwater assessment. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the AEE. The GHD document containing the disclaimer is to be included in any other document, the entirety of GHD's report must be used (including the disclaimers contained herein), as opposed to reproductions or inclusions solely of sections of GHD's report.

3. Gladstone Wetland

3.1 Site setting and current conditions

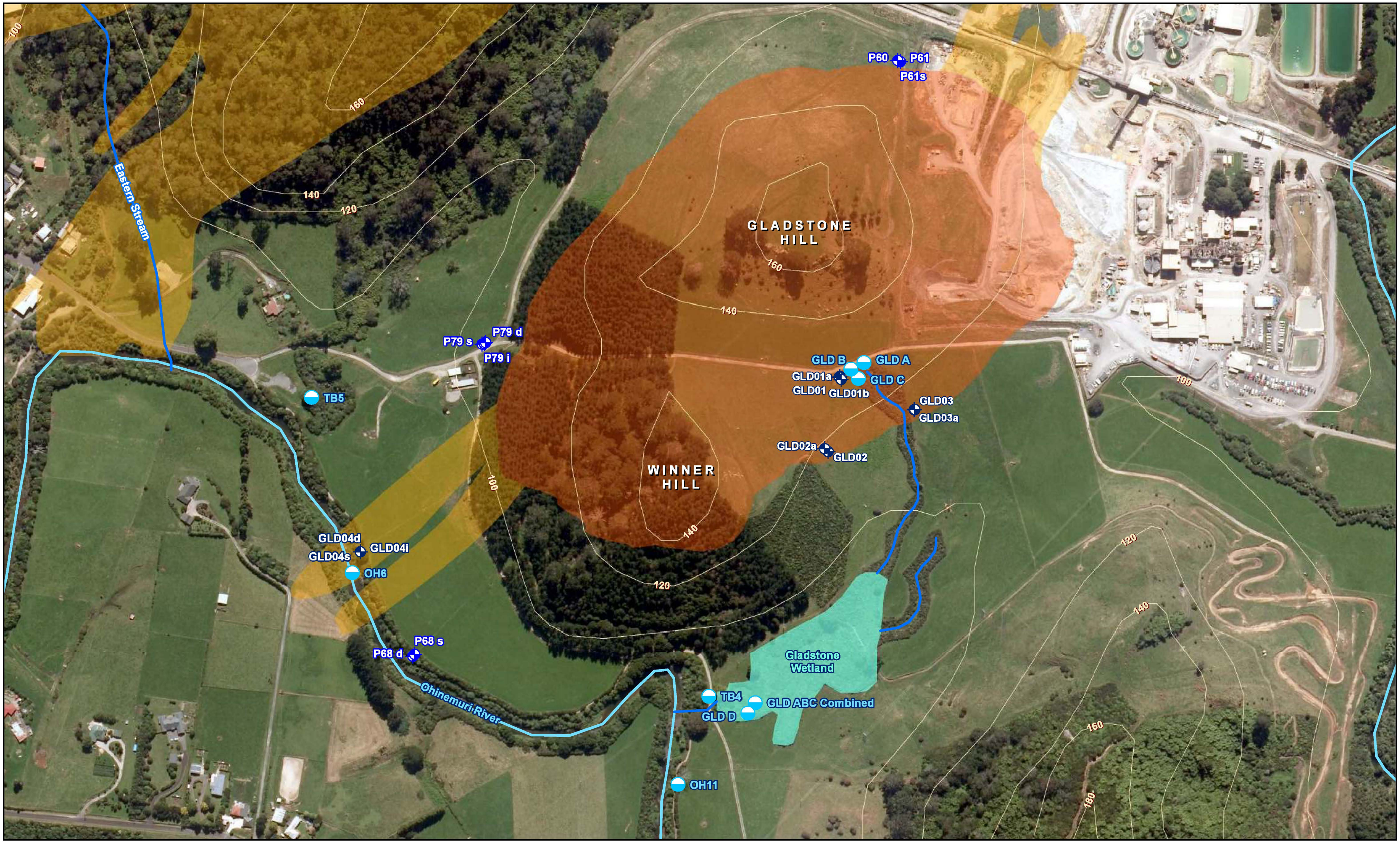
The Gladstone site setting and water level and quality monitoring locations are presented in Figure 1. Two watercourses are present at the southern extent of the proposed Gladstone Pit, which feed a small wetland at the foot of the valley. The watercourses are intermittent, with no measurable baseflow during dry summer periods.

Water discharged from the wetland flows to the southwest through monitoring site TB4 before discharging to the Ohinemuri River. A culvert at the down gradient edge of the wetland provides water level and discharge control on the wetland, with TB4 located immediately upstream of this feature (Figure 2).

The tributary culvert elevation is approximately 1.5 m above the local Ohinemuri River gauging station (OH11), and the wetland slopes upwards to the east, being some meters above the culvert at its most distant extent.

Water levels at the tributary remain relatively constant, controlled by the culvert, except:

1. Under high flow conditions, with catchment run-off significantly increasing flow and water level.
2. Following prolonged periods without rain



Paper Size A3

0 25 50 100

Metres

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

N

LEGEND

🟧 Proposed Gladstone Pit

🟨 Inferred mineralised vein system

⊕ OGL Bores

⊕ Quattro Bores

◒ Surface Water Locations

— Contour (20m)

Ohinemuri River Tributary

— River

— Stream

🟩 Wetland

Oceana Gold Limited
Waihi North

Job Number	12552081
Revision	0
Date	13 Dec 2021

Gladstone site setting and monitoring locations

Figure 1

N:\NZ\Christchurch\Projects\51\12526951\GIS\Maps\Deliverables\12552081\12552081_Z001_GladstoneSiteSetting.mxd

Data source: Aerial imagery - LINZ; General topo - LINZ; Bore locations - OGL. Created by:jrprice

Figure 2 TB4 monitoring location upstream of culvert

3.2 Wetland conceptual hydrology

The wetland provides both a path for overland flow and dynamic storage for water which flows to the tributary and the Ohinemuri River.

Flow from the catchment to the wetlands and drainage of stored water from the wetlands, which influences water levels and wetland drying, occurs via different modes and at different rates, creating a flow and water level recession response. The outcomes of this are not uniformly evidenced within the wetland and tributary, primarily owing to differences in wetland elevation.

Conceptually, the wetland response is considered to occur as follows:

- Significant rain events create rapid catchment run-off and saturation of soils and organic litter within the wetland. Excess water is rapidly passed through the wetlands, as high rates of surface water flow and water levels measured at TB4. Residual water, whether ponded or in wetland soils or litter, remains as stored water within the wetland.
- Delayed flow from the catchment, such as from interflow, continues after rapid run-off has ceased. This continued inflow maintains effective saturation of the wetland. The catchment inflow reduces over a period of days to weeks since rainfall.
- Water stored within the wetland drains from soils and organic litter at a slower rate than surface water flow. Water drains from the upper wetland areas towards lower parts of the wetland, where it contributes surface water flow in lower parts of the wetland and in the tributary, maintaining a higher degree of saturation in these areas.
- The drainage of stored water is buffered by groundwater inflow to the wetland, any residual interflow from the catchment and any subsequent inflow created by rain events. The rate of drainage from wetland soils exceeds the rate of groundwater inflow.
- During dry periods, sub-surface drainage continues to remove stored water, with greater reductions in stored water in the upper areas of the wetland first. Prolonged periods without rain see this ongoing drainage result in drying of the wetland, first at the upper wetland extents, and ultimately in lower areas, including at the tributary.

- The occurrence of no-flow or dry conditions at the tributary coincides with that point in time when the rate of drainage from the wetlands has reduced to the point that it can be passed as groundwater flow beneath the tributary culvert i.e. there is no excess to generate surface water flow.
- Re-saturation of the wetland is readily achieved by rainfall after a drought period.

Water level data recorded in TB4 between February 2019 – April 2021 is presented in Figure 3. The data collected at this monitoring location indicates that the tributary discharging from the wetland is occasionally present as a stagnant pond with no flow or dries up completely.

It is expected that when the tributary is dry, the wetland itself can be considered to have minimal standing water i.e. the wetland is dry also. However, during such times the soil moisture within the wetland may still remain high.

Over the period of monitoring the tributary appears to have experienced dry periods as follows:

- Summer 2019 – dry for approximately 1 day on 2 occasions.
- Summer 2020 – dry for approximately 5 months.
- Summer 2021 – dry for approximately 2 weeks.

In each case, re-saturation of the wetland and commencement of flow from the tributary occurred with a rain event greater than approximately 40 mm/day.

3.3 Wetland water quality

Surface water quality recorded during summer conditions within and downstream of the wetland at monitoring locations GLD D and TB4, respectively, is presented in Table 1.

Samples from both locations had pH below (more acidic) the range outlined in the existing consent compliance receiving water quality criteria (RWQC). No other parameters are recorded to exceed the RWQC.

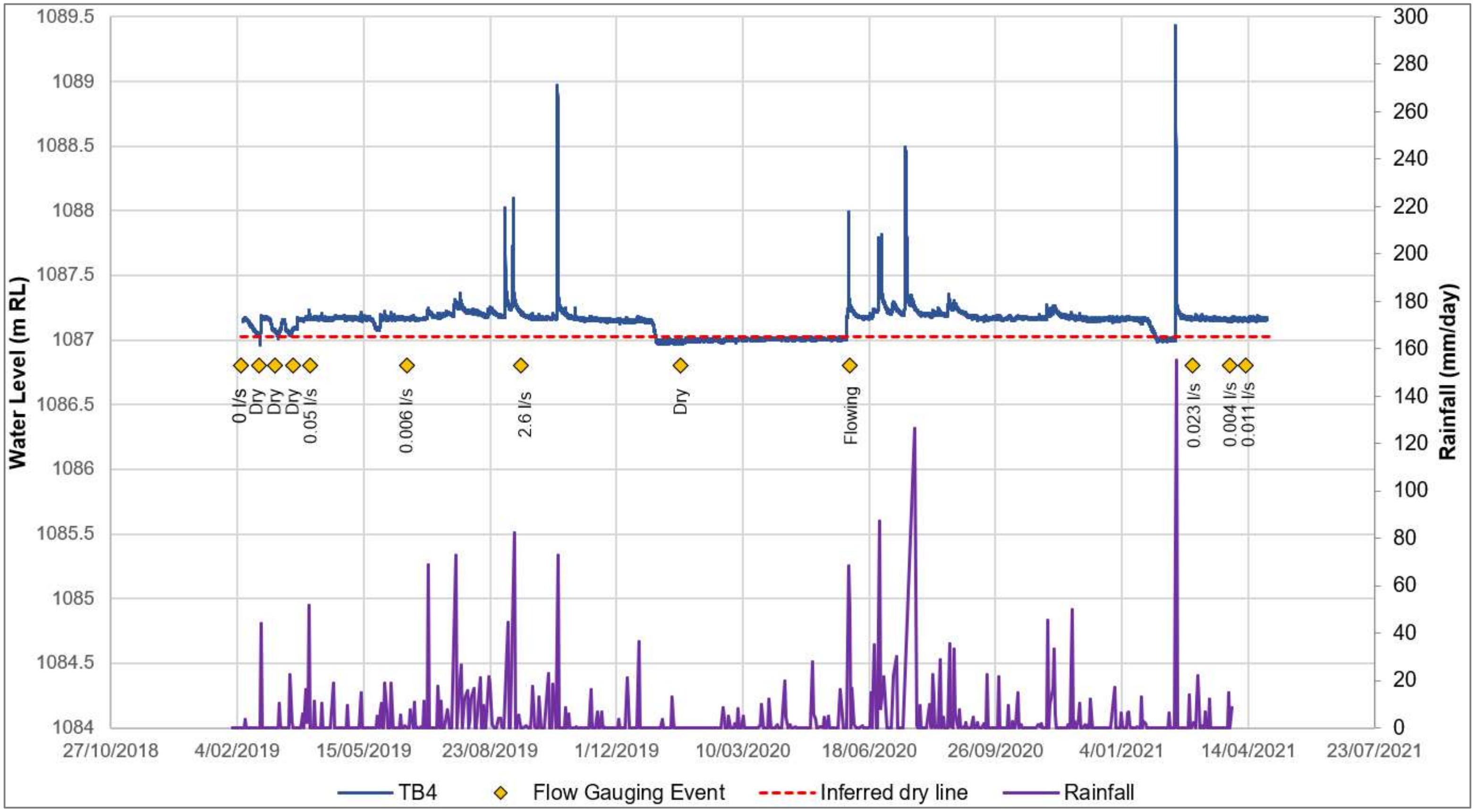


Figure 3 *Water level and flow gauging data at TB4 presented with daily rainfall*

→ The Power of Commitment

Table 1 Gladstone wetland water quality sampled 14/02/2018

Parameter	Units	Glad spring D	TB4	Receiving water quality criteria
pH	pH units	***5.5***	***6.0***	6.5 - 9.0
Electrical Conductivity (EC)	mS/m	9.7	9.4	
Total Suspended Solids	mg/l	11	5	
Alkalinity - Total	mg/l as CaCO3	7.5	7.3	
Bicarbonate	mg/l at 25C	9.1	8.9	
Hardness-Total	mg/l as CaCO3	15.4	15	
Aluminium-Dissolved	mg/l	0.067	0.073	
Antimony-Dissolved	mg/l	<0.0002	<0.0002	0.03
Arsenic-Dissolved	mg/l	<0.001	<0.001	0.19
Barium-Dissolved	mg/l	0.042	0.048	
Boron-Dissolved	mg/l	0.008	0.009	
Cadmium-Dissolved	mg/l	<0.00005	<0.00005	0.0003
Calcium-Dissolved	mg/l	2.8	2.9	
Chromium-Dissolved	mg/l	0.0006	<0.0005	0.01
Cobalt-Dissolved	mg/l	<0.0002	0.0003	
Copper-Dissolved	mg/l	<0.0005	<0.0005	0.003
Iron-Dissolved	mg/l	0.05	0.27	1
Lead-Dissolved	mg/l	<0.0001	<0.0001	
Magnesium-Dissolved	mg/l	2	1.89	
Manganese-Dissolved	mg/l	0.010	0.025	2
Mercury-Dissolved	mg/l	***<0.00008****	***<0.00008****	0.000012
Molybdenum-Dissolved	mg/l	<0.0002	<0.0002	
Nickel-Dissolved	mg/l	<0.0005	<0.0005	0.04
Potassium-Dissolved	mg/l	2.2	2.3	
Selenium-Dissolved	mg/l	<0.001	<0.001	0.02
Silver-Dissolved	mg/l	<0.0001	<0.0001	0.0002
Sodium-Dissolved	mg/l	10.1	9.3	
Strontium-Dissolved	mg/l	0.022	0.021	
Thallium-Dissolved	mg/l	0.00005	0.00005	
Tin-Dissolved	mg/l	0.0005	0.0005	
Uranium-Dissolved	mg/l	0.00003	0.00003	
Weak Acid Dissociable (WAD) Cyanide	mg/l	0.001	0.001	0.093
Zinc-Dissolved	mg/l	0.0024	0.004	0.027
Sulphate	mg/l	9	10	
Chloride	mg/l	16	16	
Nitrate-N + Nitrite-N	mg/l	0.83	0.65	

Parameter	Units	Glad spring D	TB4	Receiving water quality criteria
Nitrogen-Total Ammoniacal	mg/l	0.012	0.015	
Total Kjeldahl Nitrogen (TKN)	mg/l	0.23	0.19	
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				

3.4 Assessment of effects summary

Potential impacts on the wetland associated with the proposed GOP and TSF were assessed using conceptual interpretation, supported by the use of 2D numerical groundwater models and analytical models. The predicted changes to groundwater discharge, groundwater and surface water catchment areas and groundwater levels during each scenario assessed are presented in Table 2.

Table 2 Predicted groundwater and surface water change from current conditions

Gladstone scenario	Percentage change in groundwater discharge	Percentage change in surface water catchment$^{(1)}$	Percentage change in groundwater catchment area	Groundwater level change at upper extent of wetland
GOP excavation	-33%	-26%	-22%	- 0.5 m
Operational TSF				
TSF closure	+156%	+74%	+84%	+ 2.5 m
Long-term TSF	+197%	+74%	Not assessed	+ 3.0 m
1) Catchment for both stormwater and interflow				

GOP Excavation and Operational TSF

The predicted effects on the Gladstone Wetland as a result of pit excavation and operation of the subsequent TSF are very similar. The reduction in groundwater discharge by approximately 33% and reduction in groundwater level of approximately 0.5 m adjacent to the wetland is expected to be unmeasurable given the natural variability within the wetland.

The reduction in surface water catchment area is predicted to result in a reduction in stormwater and interflow to the wetland of approximately 26%, which will result in changes in peak flows and recession. Monitoring at TB4 (Figure 2) indicates that during current conditions rainfall events have only a short-term influence on surface water levels, due to the level control provided by the culvert. While the reduction in stormwater and interflow as a result of the proposed activity will reduce the total wetland through flow and the period of time of rainfall recession, the reduction in surface water catchment on flows at TB4 is considered unlikely to have a measurable impact on surface water levels within the wetland.

The reduction in catchment and groundwater inflow may result in less frequent saturation of the wetland and reduced buffering of drainage from the wetland. However, the level control on the tributary provides a degree of protection for the wetland against more frequent or more prolonged periods of drying. The wetland is expected to continue to dry each summer. Some small increase in the duration of wetland drying may be evident in the more elevated (eastern) areas of the wetlands, however, as only a modest rainfall is required to re-saturate the wetland following dry conditions, the duration of complete wetland drying would likely only be influenced to a small degree on occasional years.

Changes in the duration the full extent of wetland remains dry are unlikely to be discernible from the natural variability between summer conditions. Increased average duration of drying at the very upper extents of the wetland may be discernible with monitoring over a long time period but is unlikely to deviate from the range of conditions that has occurred historically in that location.

TSF Closure and Long-term TSF

Following closure of the TSF, the capping layer is proposed to be contoured to direct rainfall runoff towards the Gladstone Wetland catchment via a culvert in the rim of Gladstone pit. This will result in an increase in catchment area for surface water in comparison to current conditions. In addition, it is understood that rewatering of the deep groundwater system will occur following cessation of underground mine dewatering. As the shallow groundwater system is currently under-drained by the deep groundwater system, rewatering is predicted to result in an increase in shallow groundwater levels as downwards vertical hydraulic gradients are reduced or reversed in low lying areas. Discharge of groundwater, stormwater and interflow to the wetland is therefore predicted to increase in comparison to current conditions, returning deep and shallow groundwater levels to those similar to pre-mining conditions.

3.5 Wetland mitigations

Diversion of stormwater to the Gladstone wetland or provision of an alternate water source, such as groundwater, may provide the means of mitigating wetland drying if considered necessary. Additionally, increasing the invert level of the culvert in the tributary may assist by promoting higher water levels and reduced rates of drainage from the wetland.

Regards

Zoe Pattinson
Senior Hydrogeologist

Anthony Kirk
Technical Director – Environment

Appendix M

Mataura Wetland Assessment

Technical Memorandum

24 February 2025

To	Oceana Gold (New Zealand) Limited	**Tel**	029 355 1207
Copy to	Ethan Glover and Adrian Low (Mitchell Daysh)	**Email**	tim.mulliner@ghd.com; anthony.kirk@ghd.com
From	Tim Mulliner and Anthony Kirk	**Ref. No.**	12552081
Subject	Mataura Wetland Assessment		

Document Status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	Rev 1	Tim Mulliner Zoe Pattinson	A. Kirk		A. Kirk		24/02/2025

1. Introduction

GHD was commissioned by Oceana Gold New Zealand Limited (OGNZL) to deliver a study relating to mine water management relating to the Willows Rock Stack (WRS) and the Willows Portal associated with the proposed tunnelling activity at the Willows Road Surface Facility Area (WSFA) which is part of the wider "Waihi North Project" (WNP). The Water Management for WNP is described in detail in GHD, 2025[1].

A small wetland has been characterised down catchment of the proposed WRS collection pond between the collection pond and the Mataura Stream (herein referred to as the Mataura Wetland). This technical memorandum presents a desktop assessment of effects on the Mataura Wetland (in terms of hydraulic load) as a result of the proposed activities in the immediate vicinity and within the defined catchment area of the wetland.

This technical memorandum is subject to, and must be read in conjunction with, the limitations set out in Section 2 and the assumptions and qualifications contained throughout.

2. Limitations

The following limitations are reproduced in this technical memorandum from the Water Management Study Report (WAI-985-000-REP-LC-0011_RevD.1). This technical memorandum is subject to, and must be read in conjunction with, the following limitations as well as the assumptions and qualifications contained throughout the Water Management Studies Report (WAI-985-000-REP-LC-0012).

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[1] GHD, 2025. Waihi North Project. Water Management Studies. WAI-985-000-REP-LC-0011.

other than Oceana Gold New Zealand Ltd. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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3. Mataura Wetland

3.1 Site setting

The Mataura Wetland is located on a river terrace of the Mataura Stream down hydraulic gradient of both the proposed collection pond and infrastructure area associated the WSFA. The defined Wetland area and associated 20 m setback in relation to the river, surrounding topography and key infrastructure elements are shown in Figure 1.

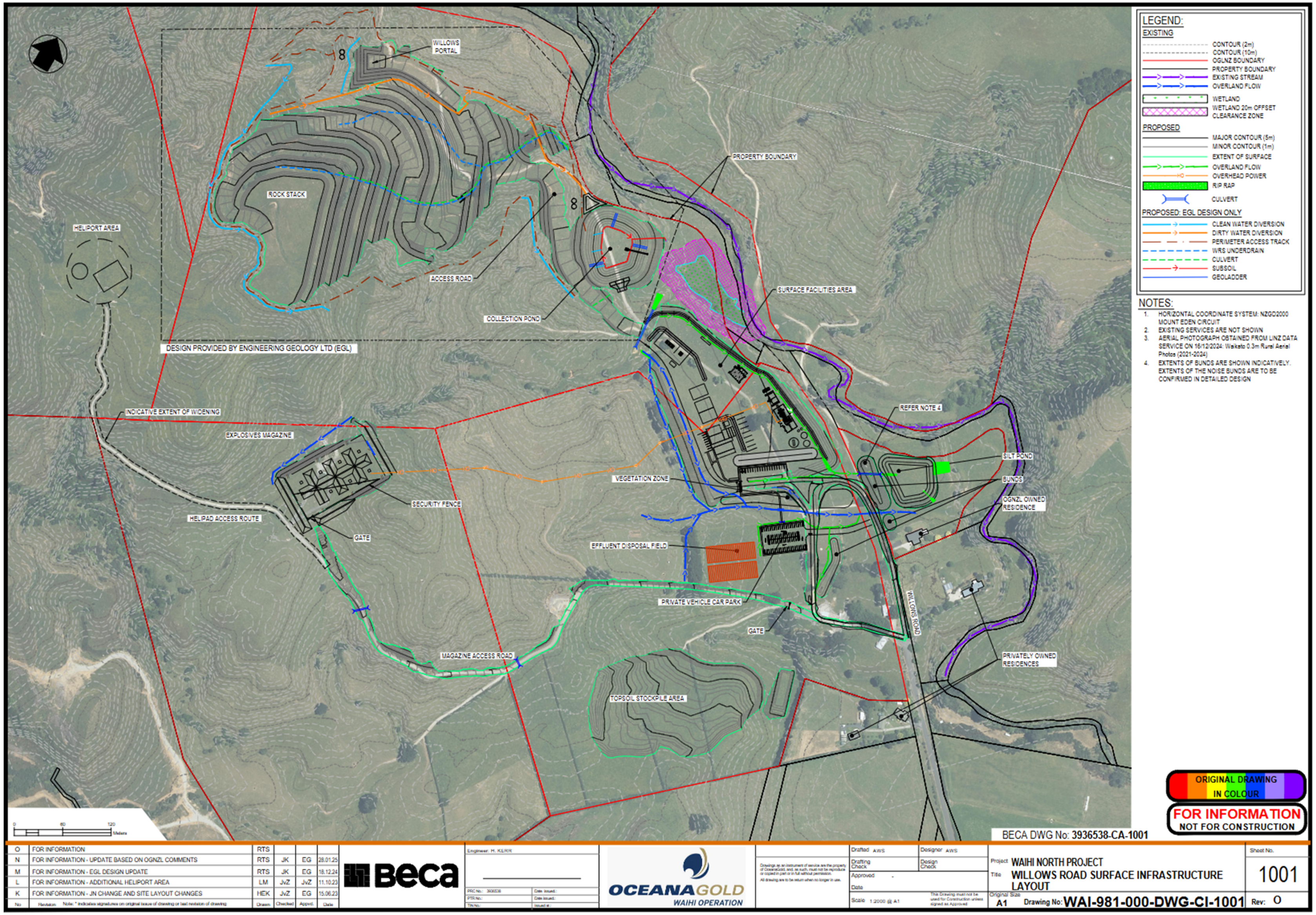

Figure 1 *Willows Road Surface Infrastructure Layout including existing wetland adjacent to Mataura Stream (Beca Drawing No. WAI-981-000-DWG-CI-1001)*

3.2 Wetland conceptual hydrology and hydrogeology

Based on the topography of the site (steep relatively incised valley), surface water is inferred to be predominantly channelled to the terrace and wetland area via the unnamed tributary flowing in from the south-west corner of the identified wetland area.

Groundwater levels beneath the site have been recorded at 1 to 2 m below surface level (WWLA,2025)[2]. Groundwater monitoring wells and contours are presented in Figure 2, with relative levels for a number of monitoring wells and the Mataura Stream presented alongside rainfall in Figure 3 and Figure 4.

Figure 2 Groundwater monitoring wells and contours (WWLA, 2025) modified to include Mataura Stream M12 monitoring location and seeps interpreted by GHD from WSP (2021). (Note: Groundwater level and seep elevations in metres above mean sea level). Mataura Wetland located west of monitoring location M12.

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[2] WWLA, 2025. Waihi North Project. Assessment of Groundwater Effects – Tunnel Elements. Prepared for Oceana Gold (New Zealand) Limited. (WAI-985-000-REP-LC-0040).

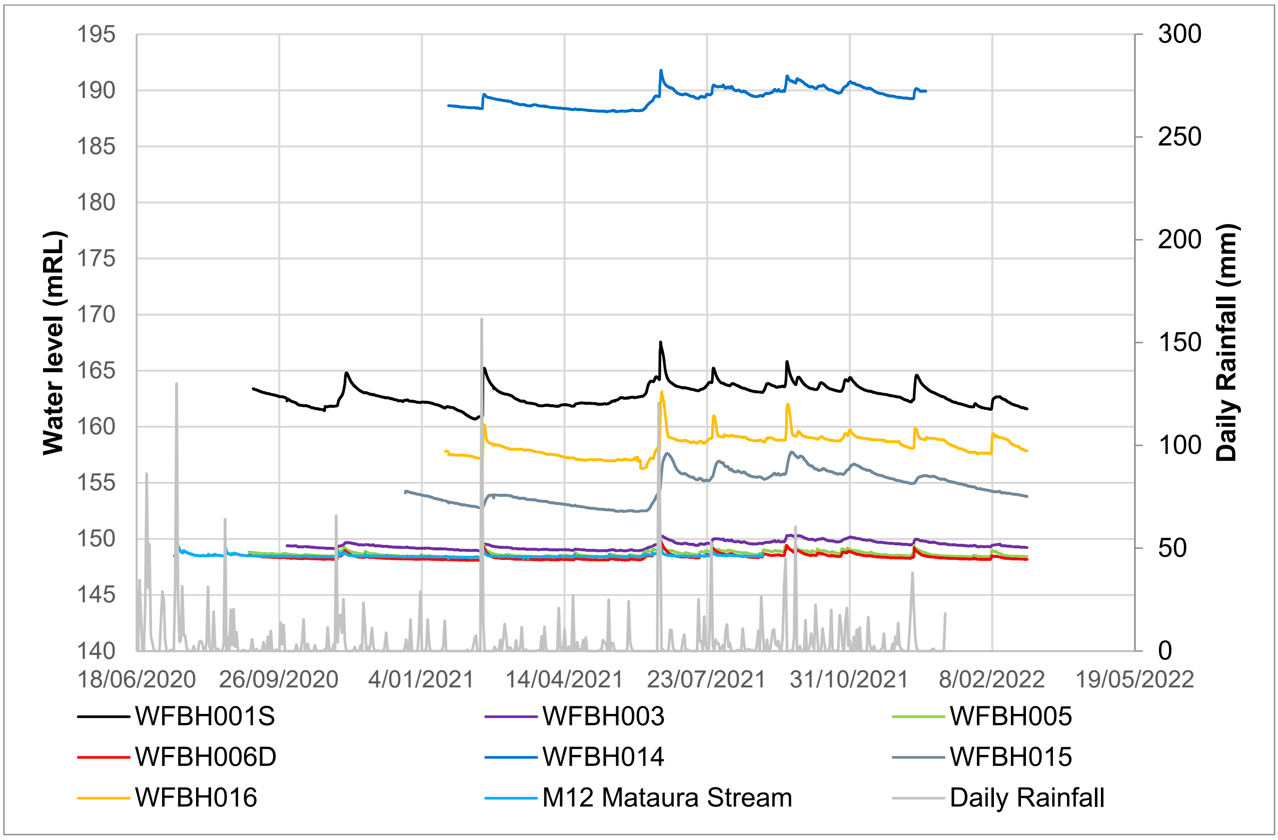

Figure 3 *Groundwater and Mataura Stream levels presented alongside daily rainfall.*

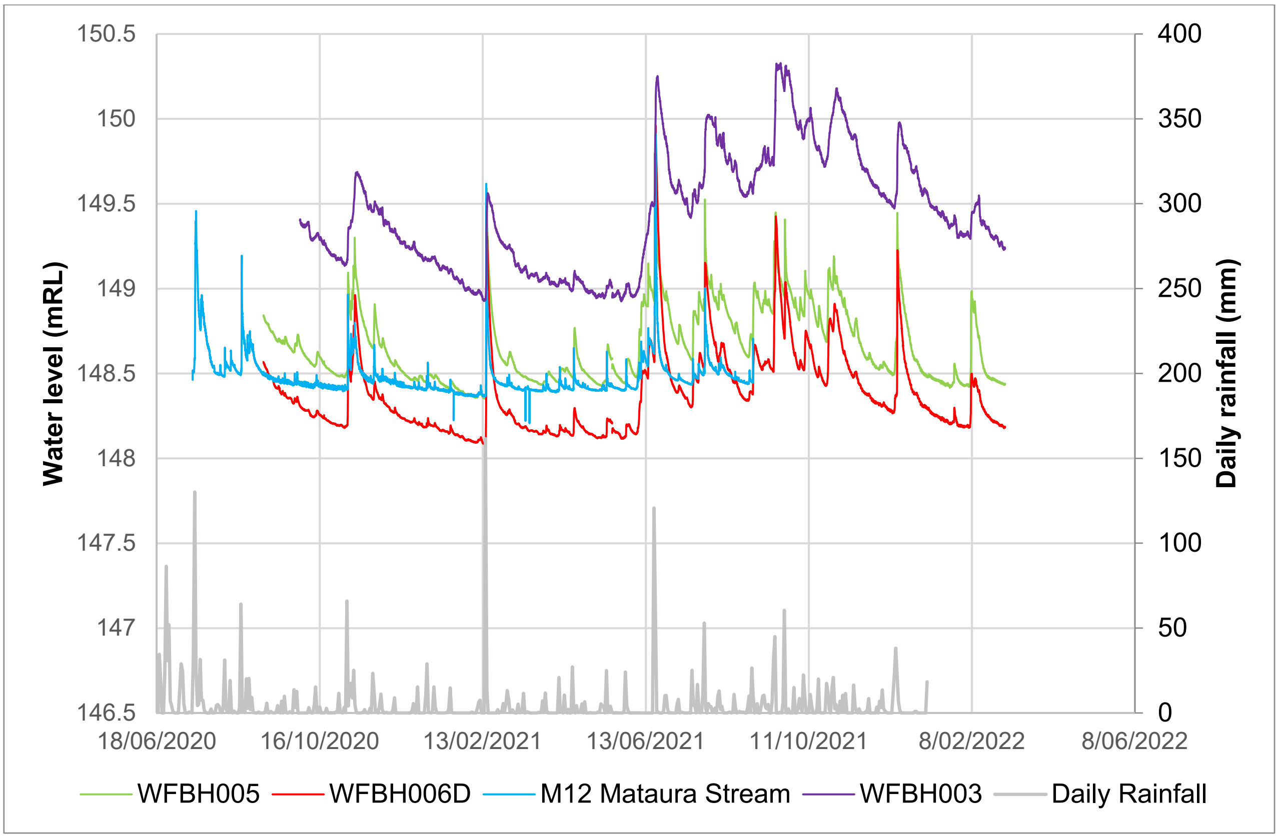

Figure 4 *Groundwater levels in close vicinity to the wetland and Mataura Stream level presented alongside daily rainfall.*

The wetland is inferred to be connected to the shallow groundwater system within the terraced gravels adjacent to the Mataura Stream. WFBH005 was screened within this unit between the wetland and the Mataura stream, and downwards hydraulic gradients are present as indicated by the difference in water levels recorded in this monitoring well and nearby monitoring well WFBH06D installed in the underlying weathered tuff. These downwards gradients are also present between WFBH06S and WFBH06D, as confirmed through manual groundwater level monitoring. WFBH003 is installed within weathered tuff up hydraulic gradient of the wetland adjacent to the unnamed tributary that flows to the wetland from the southwest.

Groundwater and Mataura Stream level response to rainfall in Figure 3 and Figure 4 indicates the following:

- The peaky response to rainfall within deeper monitoring well WFBH06D indicates a strong hydraulic connection to the shallow system. The large magnitude of groundwater level response within this well also demonstrates lower storage within the weathered tuff when compared to the shallower terraced gravels (WFBH005).
- During periods of low rainfall groundwater levels continue to decline until the next significant rainfall event. This is not observed within the Mataura Stream, which maintains a relatively stable baseflow, indicating that during these periods the stream is being recharged from further up the catchment.
- Elevated groundwater levels recorded further upgradient in the catchment (WFBH014, WFBH01S, WFBH015 and WFBH016) indicate that prolonged baseflow is likely to be discharged to the wetland and Mataura Stream.

The inferred water source for the defined wetland is a combination of surface water via runoff and direct rainfall, interflow from infiltrating rainfall within the catchment and groundwater baseflow.

There is no known water quality data directly associated with the defined wetland.

3.3 Assessment of effects summary

The current surface water catchment area draining to the wetland has been approximated to an area of 12.7 ha (Figure 5). During mining the catchment is expected to decrease to an estimated 10.5 ha (Figure 5), equating to an approximate 17% decrease. Surface water runoff volumes reporting to the wetland from the upper catchment is therefore estimated to decrease by a similar proportion. This is expected to be similar for groundwater recharge, as the catchment area for shallow groundwater is anticipated to be similar to the surface water catchment.

The greatest loss of catchment is expected to occur in the vicinity of the collection pond, a portion of the haul road leading to the Willow's Rock Stack (WRS) and the magazine storage area. A small increase in catchment area will occur southwest of the surface facilities area, where overland flow which would usually discharge to the Mataura Stream will be directed northwest towards the existing unnamed tributary.

The reduction in Mataura Wetland catchment area assumes no leakage will occur from the collection pond, which will be dependent on liner design and construction. Post development, the WRS, haul road and collection pond are expected to be decommissioned and it is understood that the catchment area will revert to pre-mining boundaries / areas.

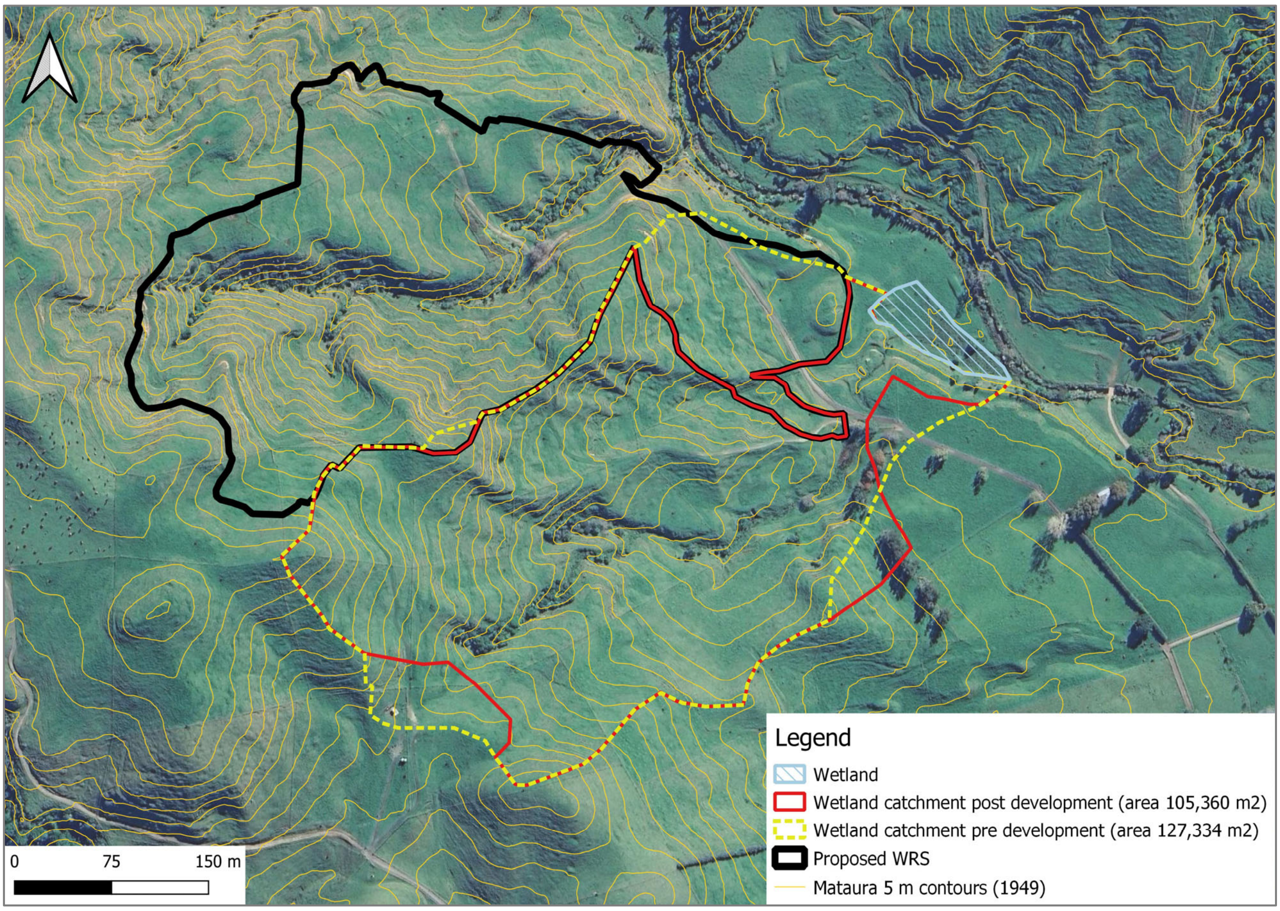

Figure 5 *Estimated wetland catchment pre and post development of the proposed WRS*

WWLA (2025) predicts that the baseflow loss in the Matarua Stream due to the construction of the WUG tunnel would be 15 m^3/d in the long term. In terms of the Mataura Stream flow (lowest gauged flow is estimated at >4,500 m^3/day (GHD, 2025)), this amount of water loss is limited and on that basis WWLA considers the effects to surface water due to the construction of the tunnel to be less than minor. On the basis of this assessment, it is considered unlikely that an adverse effect on groundwater beneath and within the vicinity of the wetland will occur due to reduced stream flow and groundwater connectivity.

Overall, a reduced source volume of surface water runoff, interflow and groundwater recharge is expected, on account of the reduced catchment size. The extent of this impact will depend on the connection of the Wetland with the Mataura Stream and the relative contribution of these flow sources. The worse-case, conservative estimate of effects suggests an approximately 17% reduction in flow. This is anticipated to manifest in reduced peak levels in groundwater response to rainfall events. During wetter winter periods, this is unlikely to result in measureable impact to the wetland hydrology. During drier summer periods, the reduction in peak flows may result in an extended periods of lower groundwater levels and dry conditions within the wetland. However, this is expected to be unlikely to be discernible from natural variability between summer conditions.

Overflow from the collection pond following significant rainfall events is likely to discharge to the Mataura Wetland. Overflow events will coincide with elevated flows within the Mataura Stream and its tributaries, and elevated water levels in the wetland. Considerable dilution of the water discharging from the collection ponds is likely during these conditions. Furthermore, based on the conceptual understanding of the planned developments and appropriate diversion and/or collection of potentially impacted seepage and runoff water, it is expected that the effect on the receiving surface water environment in terms of water quality is likely to be limited.

3.4 Recommendations

It is recommended that continuous surface and groundwater water level monitoring within and surrounding the defined wetland area be undertaken to refine the understanding of the Mataura Stream / groundwater interactions in the area, and the relative contribution of stream water / catchment water to the wetland.

Diversion of stormwater to the wetland, or provision of an alternate water source, may provide the means of mitigating wetland drying if considered necessary.

Regards

Tim Mulliner
Technical Lead - Environment

Anthony Kirk
Technical Director – Environment

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