



Matakanui Gold Limited

Report No: Z24019SML-3

**Bendigo–Ophir Gold Mine Project, Bendigo Groundwater
Bore Take Effects Assessment**

30 April 2025

Kōmanawa:

1. *(verb) spring, well up (of water)*
2. *(verb) to spring, well up (of thoughts, ideas)*

Kōmanawa Solutions Limited (KSL) is a water resource consultancy and research company specialising in water resource investigation and modelling, environmental limit setting and water resource impact assessment. Our goal is to provide excellent science to facilitate the robust management of natural resources in our changing climate. Clients include New Zealand enterprises in the private sector, central and local government agencies and community groups.

Our vision & mission

KSL delivers high quality science and research. We aspire to be at the forefront of creativity and innovation to address our increasingly complex water resource challenges; *mō tatou, ā, mō kā uri ā muri ake nei* (for us and our children after us). Our mission is to develop solutions to the increasingly challenging water resource management issues we now face by providing a clear vision of the pathway from problem to solution. We work closely with our partners, communities, and stakeholders, deploying state-of-the-art scientific methods and building trust through knowledge and honest science communication.

Limitations

Kōmanawa Solution Ltd (KSL) has prepared this Report in accordance with the usual care and thoroughness of the consulting profession for the use of Matakānui Gold Limited for the Bendigo-Ophir Gold Project.

This Report has been prepared in accordance with the scope of work and for the purpose outlined at the start of this report and is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

Where this Report indicates that information has been provided to KSL by third parties, KSL has made no independent verification of this information except as expressly stated in the Report. KSL assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 13 May 2024 and 30 April 2025 and is based on the conditions encountered and information reviewed at the time of preparation. KSL disclaims responsibility for any changes that may have occurred after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this Report in any other context or for any other purpose. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

The professional advice and opinions expressed herein are provided for the benefit of the applicant and any panel, hearing, or authority for which this report is required. No warranty, expressed or implied, is made as to its suitability for other purposes or for reliance by parties other than those named above. This Report may only be used in the context for which it was commissioned, and any use outside this scope or for other purposes is not authorised.

To the extent permitted by law, KSL expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. KSL does not admit that any action, liability or claim may exist or be available to any third party.

The author of this report acknowledges that this report will be relied on by a Panel appointed under the Fast-Track Approvals Act 2024 and these disclaimers do not prevent that reliance.

Version control

Date	Report no	Issue notes
17/07/2024	Z24019SML-Rev0	Initial draft of effects assessment
3/09/2024	Z24019SML-Rev1	Draft for Client issued to Matakanui Gold Ltd (<i>edits and comments of Mary Askey addressed in Rev1 on 24 September 2024, additional editing also</i>)
22/09/2024	Z24019SML-Rev1b	Addition of Figure 3
7/02/2025	Z24019SML-Rev2	Reviewed by Zeb Etheridge on 5 February 2025. Changes agreed and made in response. Report issued as Draft for Client.
21/02/2025	Z24019SML-Rev3	Revision of Draft For Client to reflect pumping rate of 110 litres per second.
11/04/2025	Z24019SML-3	Report for inclusion in AEE and approval applications
30/04/2025	Z24019SML-3	Minor changes to the Executive Summary
19/08/2025	Z24019SML-3	Disclaimer adjusted in line with Panel Convener's practice and procedure guidance, July 2025

Authors

Jens Rekker

Principal Hydrogeologist, Kōmanawa Solutions Ltd

Contributors

The following individuals and organisations have generously contributed their time and expertise to this project.

- Hamish McLauchlan, Chief Geologist, Matakanui Gold Ltd
- Paul Becker, Geologist, Matakanui Gold Ltd
- Mary Askey, Environmental Manager, Matakanui Gold Ltd
- Alistair Snow, Infrastructure Manager, Santana Minerals Ltd
- Evan Pascoe and Chris Sinclair, SouthDrill Ltd

Citation

Rekker, J.H. (2025). *Bendigo–Ophir Gold Mine Project – Bendigo Groundwater Bore Take Effects Assessment* Kōmanawa Solutions (KSL) Report No. Z24019SML-3 prepared by KSL for Matakanui Gold Ltd, Christchurch. 73 pp, including appendices.

Executive Summary

This is an assessment of mine bore water supply effects, plus providing key inputs to other experts work including mine planning, and environmental geochemistry modelling undertaken separately by Mine Waste Management (MWM) to determine solute concentrations and mitigation. This assessment concludes the abstraction of groundwater at a proposed bore field tapping the Bendigo Aquifer with the proposed mitigations will result in an acceptable outcome.

The Bendigo Aquifer source is a composite of Albert Town, Hāwea and Holocene Clutha outwash alluvium in three valley floor terraces tiered towards the river. The Clutha River / Mata Au is known to be the principal source of replenishment for this aquifer. The derived transmissivity and hydraulic conductivity of 4,500 square metres per day and 250 metres per day were obtained in the analysis of step rate and constant rate pumping testing of the 400 millimetre test production bore. The associated storage coefficient of 0.25 as specific yield was estimated from the same testing. These parameters were consistent with other bore testing undertaken at locations throughout the Bendigo Aquifer. A grab sample of groundwater was also taken during step rate testing and analysed for key water quality parameters, indicating very dilute concentrations of the main groundwater salts.

Matakanui Gold Ltd (MGL) holds the Bendigo – Ophir Gold Mine Project, which encompasses proposals for four hard-rock mining areas and a mineral processing plant in the Dunstan Mountains near Bendigo. The proposed mining complex located 6.5 kilometres to the east of the bore site requires a water supply, particularly for make-up process water and dust suppression over disturbed surfaces such as haul roads. The peak water supply requirement of the proposed mining complex is estimated to be 110 litres per second and consent is sought for this quantity accordingly.

Initial drilling investigations comprised a pilot bore that was later used as an aquifer test observation bore, which is available to become the reserve water supply bore. Pilot bore drilling utilising 150 millimetre diameter steel casing penetrated silty, sandy gravels to a depth of 42 metres below ground while demonstrating suitable groundwater yield in test pumping. The water table was found to rest at about 20 metres below ground. Subsequently, a 400 millimetre diameter test production bore was drilled and installed. Drilling and pumping tests of the 400 millimetre diameter test production bore about 13 metres laterally to the east of the reserve bore encountered similar hydrogeological conditions but also confirmed a closer estimate of groundwater potential at 100 to 110 litres per second. The reserve bore could provide an additional 20 litres per second to raise the total bore field capacity to 110 litres per second on a daily basis, if required.

The high permeability and strong connection of the Bendigo Aquifer to sources of recharge, such as Clutha River / Mata Au, Bendigo Creek and irrigation losses to ground, result in the substantive drawdown effect being restricted to a narrow radius surrounding the proposed bore field. Accordingly, the projected drawdown effects on the nearest neighbouring water bore was less than 0.85 metres. The proposed groundwater taking from the bore field would increase the net depletion effect on the Clutha River / Mata Au but would fall within the bands of sustainable allocation for the Bendigo Aquifer or future limits for the Clutha River / Mata Au. There is also adequate natural water to be allocated to the proposed water take within allocation limits specified for the Bendigo Aquifer, and the Clutha River / Mata Au in terms of projected surface water depletion.

On this basis of capacity determinations and tested water quality, the preliminary indication is that the groundwater at the future bore field would be suitable for the proposed uses of water in the Bendigo – Ophir Gold Project, including drinking water provision at the mine site. Opportunities exist for the aggregate effects of taking groundwater at the MGL bore field being lessened through water conservation and water source substitution. Monitoring opportunities exist for ensuring that actual effects intensities are no more than predicted intensities of effects, including metering of groundwater abstraction rates and volumes, and monitoring of surrounding groundwater level in the Bendigo Aquifer at up to three separate locations. **Overall,**

the proposal for a bore field in the current location at a maximum rate of 110 litres per second is assessed to have environmental effects in terms of groundwater levels, surface water depletion and groundwater resource allocation that are less than minor.

This report relies on the following reports specifically commissioned for this project:

- Bendigo – Ophir Gold Mine Project – Groundwater Existing Environment & Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Surface Water & Catchment Existing Environment & Effects Assessment, Kōmanawa Solutions Ltd (KSL).
- Source Term Definition Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.
- Water Load Balance Model Report – Bendigo-Ophir Gold Project, Mine Waste Management (MWM) Ltd.

Contents

Executive Summary	1
1 Background	8
1.1 Outline & Problem Definition	8
1.2 Report Structure	8
2 Site Setting & Existing Environment	10
2.1 Location & Communications	10
2.2 Geography of Site & Environs	10
2.3 Geology	10
2.3.1 Bedrock	10
2.3.2 Tertiary Sediments	11
2.3.3 Quaternary Glacial and Post-Glacial Sediments	11
2.3.4 Geological Structure	11
2.4 Soils & Drainage	12
2.4.1 Lowland Soils	12
2.4.1.1 Riverine alluvium	12
2.4.1.2 Till Terraces	12
2.4.2 Upland Soils	12
2.4.2.1 Semi-Arid Soils	12
2.5 Climate	13
2.6 Surface Hydrology & Water Resources	13
2.7 Groundwater & Associated Water Resources	13
2.7.1 Fractured Rocks	14
2.7.2 Lindis Alluvium	14
2.7.3 Bendigo Creek Alluvium	14
2.7.4 Bendigo Outwash & Aquifer	14
2.8 Groundwater Domains & Permeability Contrasts	15
2.8.1 Saturated & Fractured Rock	15
2.9 Depths of Saturation & Groundwater Flows	15
2.10 Beneficial Uses of Groundwater	19
2.11 Water Resource Infrastructure in Wider District	19
2.11.1 History of Water Races	19
2.11.2 Contemporary Water Uses	19

2.12	Aquatic Ecology & Wetlands.....	20
2.12.1	Aquatic Values	20
2.12.2	Regional Wetland	20
3	Drilling Project Hydrogeology and Aquifer Testing.....	21
3.1	Pilot Hole / Reserve Bore Installation	21
3.2	Test Production Bore Installation	21
3.3	Constant Rate Test.....	21
3.3.1	Drawdown and Recovery Phase Responses	21
3.3.2	Need for Corrections to Level Data	22
3.3.3	Examination of Corrected Drawdown Responses	23
3.4	Aquifer Test Analysis.....	23
3.4.1	Ideal Aquifer and Implications for Test Data Analysis	23
3.4.2	Pumping Phase Observation Bore Analysis	24
3.4.3	Non-Pumping Phase (Recovery) Analysis	25
3.5	Step Rate Test	26
3.5.1	Test Description and Raw Data	26
3.5.2	Pumped Bore Step Drawdown Analysis	28
3.5.2.1	Eden-Hazel Analysis	28
3.5.3	Observation Bore Step Drawdown Analysis	31
3.6	Summary of Aquifer Testing and Pumping Tests	32
3.7	Test Site Groundwater Quality	33
3.8	Indicated Bore Capacity	36
3.8.1	400 mm Diameter Bores	36
3.8.2	150 mm Diameter Bore	37
4	Project Description & Proposals for Bendigo – Ophir Gold Project.....	38
4.1	Proposed Water Supply	38
4.1.1	Clean Water Requirement.....	38
4.1.2	Bore Field.....	39
4.1.3	Water Conveyance & Storage Infrastructure	39
4.1.4	Water Supply Bore Field Rehabilitation	39
5	Assessment of Groundwater Effects Arising from Proposed Activities	40
5.1	Effects Section Structure	40
5.2	Potential Effects of Water Supply Bore Field Abstraction	40

5.3	Prediction of Effects.....	40
5.3.1	Drawdown Effects on Surrounding Groundwater Users	41
5.3.1.1	Calculation of Drawdown Effects	41
5.3.1.2	The Interpretation of Effects from Calculated Drawdown.....	44
5.3.1.3	Estimated Effect of Drawdown on Surrounding Bores	45
5.3.2	Groundwater Depletion Effects on Surrounding Water Bodies	46
5.3.2.1	Ephemeral Creeks	47
5.3.2.2	Clutha River / Mata Au.....	47
5.3.3	Groundwater Sustainability in Terms of the Wider Aquifer.....	49
5.3.3.1	Groundwater Allocation Cap Settings.....	50
5.3.3.2	Current or Future Groundwater Allocation Status	50
5.3.3.3	Current or Future Surface Water Allocation Status	50
5.3.3.4	Comparison of Proposed Bendigo – Ophir Gold Project Water Take and Allocation Regime.....	51
5.3.3.5	Contact Energy Ltd.....	51
5.3.3.6	Depletion and/or water level lowering within groundwater-connected wetlands	52
5.3.3.7	Aquifer Stabilisation.....	53
6	Steps to Avoid, Mitigate and Monitor Potential Effects	54
6.1	Background.....	54
6.2	Bore Field Pumping (Groundwater Taking)	54
6.2.1	Avoid or Minimise Effects.....	54
6.2.1.1	Water Conservation	54
6.2.1.2	Mine Water Substitution	55
6.2.2	Monitoring Effects (Water Level)	55
6.2.3	Monitoring Effects (Water Quality).....	56
6.2.4	Summary of Monitoring	56
7	Concluding Remarks	57
8	References Cited.....	58
	Appendices	61
	Appendix 1. Bore Logs	61
	Appendix 1.1. Bore Log: CB13/0215 (400 mm diameter Test Production Bore).....	61
	Appendix 1.2. Bore Log: CB13/0216 (150 mm diameter Observation or Monitoring Bore)	64
	Appendix 2. Pumping Test Data.....	66
	Appendix 2.1. Step Rate (Drawdown) Test Manual Data	66

Appendix 2.2. Constant Rate Test Observation Bore Manual Data	68
Appendix 3. Water Analysis Laboratory Certificate	69

Figures

Figure 1: Location and elements of the Bendigo-Ophir Gold Mine Project, including the mining areas to the east, and SH8 and Clutha River / Lake Dunstan to the west	9
Figure 2: Location of the bore site, test production and observation (Obs) bore elements of a future bore field	10
Figure 3: Three year record of groundwater level elevation at ORC monitoring bore CB13/0159	16
Figure 4: Bendigo Aquifer plus December 2009 measured groundwater elevation contours	18
Figure 5: Pumped bore and observation bore corrected drawdown responses during the 48 hour CRT	23
Figure 6: Schematic representation of an unconfined aquifer (Neuman, 1974)	24
Figure 7: Neuman test drawdown data point matching against Neuman well function type curves	25
Figure 8: Pumped bore matching late-time residual drawdown data for recovery analysis (Theis, 1935)	25
Figure 9: Observation bore matching late-time residual drawdown data for recovery analysis (Theis, 1935)	26
Figure 10: Recorded water level, to plotted as drawdown for pumped bore during SRT	27
Figure 11: Recorded water level, to plotted as drawdown for observation bore during SRT	28
Figure 12: Eden-Hazel Step 1 curve matching with one fit line per step (Eden & Hazel, 1973)	29
Figure 13: Eden-Hazel Step 2 plotting of final drawdown / pumping rate versus pumping rate as per (Logan, 1964)	29
Figure 14: Matched theoretical drawdown versus field step drawdown data on linear axes	30
Figure 15: Plot of projected short-term drawdown versus bore pumping rate, from Eden – Hazel Method	31
Figure 16: Combined plot of pumped bore (blue) and observation bore (red) drawdown in SRT	31
Figure 17: Linear axes plot of matched and field drawdown using the Neuman Method	32
Figure 18: Schematic diagram of test production bore dimensions	36
Figure 19: Distance – Drawdown plot of surrounding bore radii for 1-week, 3-month, and 365-day durations	42
Figure 20: Mapping of the extent of Bendigo Aquifer and potentially affected registered bores within 2.34 km	43
Figure 21: Radial profile of drawdowns calculated with the Eden - Hazel (pumping bore) or Theis equations	43
Figure 22: Depletion analytical calculation of the effect of MGL production bore on the Clutha River / Mata Au	48
Figure 23: Modelling of the effect of an imposed 3 week duration minimum flow on surface water depletion	49

Tables

Table 1: Summary of Flow Statistics for Upper Clutha Lakes (Wānaka & Hāwea)	13
Table 2: Summary of Different Down-Hole Water Level Measurement Systems	22
Table 3: Summary of Pump Rate Metering	22
Table 4: Manually recorded Depths To Water, Drawdown and Specific Capacity for 48 hour CRT (Uncorrected)	22
Table 5: Summary of Aquifer Test Analysis Results for Constant Rate Test	26
Table 6: Summary of Step Rate Test data, including Pumped Bore Specific Capacity	27
Table 7: Summary of Hydraulic Properties indicated by Eden-Hazel Method	30
Table 8: SRT Observation Bore and Neuman Method derived Transmissivity	32
Table 9: Summary of derived Aquifer Test and Step Rate Test Hydraulic Properties	33
Table 10: Analytical Results of Groundwater Sample taken on 25 July 2024.....	34
Table 11: Proposed Consent Pumping Rate and Volume Requirement	38
Table 12: Summary of Groundwater Properties estimated from Field Determinations	41
Table 13: Estimates of Drawdown for Surrounding Bores with 2.34 kilometres of Production Bore (CB13/0215)	42
Table 14: Listing of Bores within 1.2 kilometres of MGL Production Bore, plus Freeboard, & Drawdown.....	45
Table 15: Approximate Bendigo Aquifer Water Balance: ORC Numerical Modelling (Houlbrooke, 2010)	49
Table 16: Comparison of Groundwater and Surface Water Consent Requirement versus associated Limits.....	51
Table 17: Sample Condition applied to larger Water Takes specifying relief for Contact Energy	52

1 Background

1.1 Outline & Problem Definition

Matakanui Gold Ltd (MGL) proposes to develop open cut and underground mining areas linked to an ore processing plant in close proximity, located in the Dunstan Mountains near Bendigo. The processing plant would obtain the bulk of its water supply from the Bendigo Aquifer in a location proximal to the current test production bore site. Water supply would thus be drawn from outwash gravels in hydraulic connection to the major Clutha River / Mata Au. The proposed bore field would result in some degree of environmental effect in terms of groundwater levels, surface water depletion or water quality. The purpose of this assessment document is to outline the existing hydro-geological environment and characterise environmental effects relating to proposed groundwater take activities, including foreshadowing the effectiveness of mitigation, monitoring and offsets / compensation deployed.

1.2 Report Structure

The objectives of this document are tailored to provide the information required by the Fast-track Approvals Act 2024. This report includes the requirement to include the following:

- A description of the proposal,
- A description of any possible alternative locations or methods, where an activity will result in significant adverse effects,
- An assessment of the actual or potential effects on the environment of the proposed activity;
- A description of the mitigation measures to be undertaken,
- Identification of persons interested in or affected by the proposal, consultation undertaken if any, and response to the views of those consulted, and
- How monitoring will be carried out if required and by whom.

This assessment document focuses on the groundwater and hydrogeology discipline and addressing the above assessments in relation to the proposed taking of groundwater.

This report is arranged as follows:

1. Background
 - a. *Outline, Problem Definition, and Report Structure*
2. Site Setting and Existing Environment
 - a. *Placing the Project in a geographical context*
 - b. *Outlining the groundwater and adjoining environments in which the project is found*
3. Drilling Project Hydrogeology and Testing
 - a. *A test production bore was installed for aquifer testing*
 - b. *Aquifer testing was undertaken, water sample taken, and combined data analysed*
4. Bendigo – Ophir Gold Project Description
 - a. *Characterisation of water supply requirements, and proposed groundwater extraction systems*
5. Assessment of Groundwater Arising from Proposed Activities
 - a. *The potential effects of the proposed groundwater take was numerically assessed*
6. Steps to Avoid, Mitigate and Monitor Effects
 - a. *Water supply source selection, water conservation, and monitoring of pumping & water level variation*
7. Conclusions
 - a. *Including summarising the effects and impact assessment*

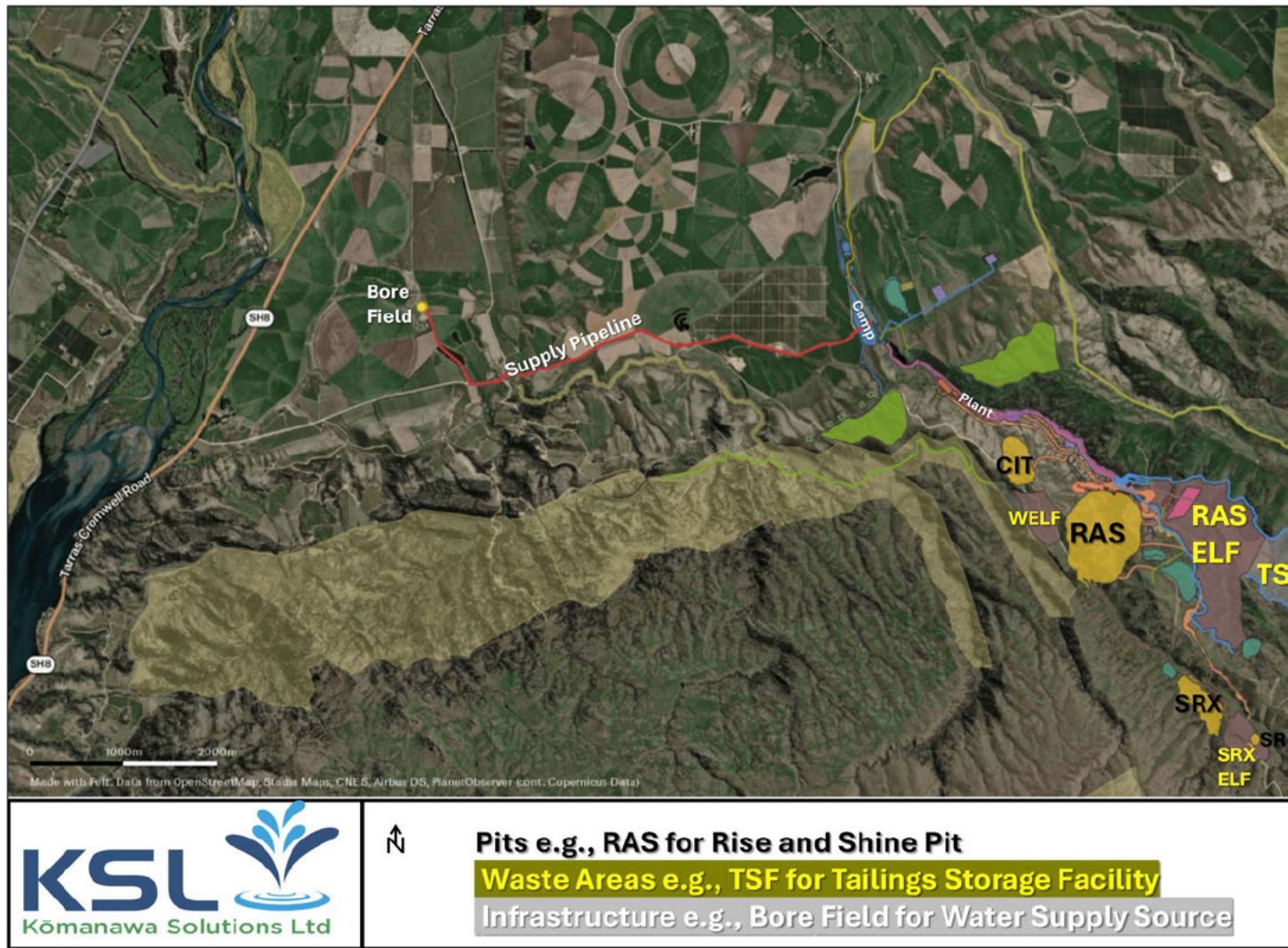


Figure 1: Location and elements of the Bendigo-Ophir Gold Mine Project, including the mining areas to the east, and SH8 and Clu

2 Site Setting & Existing Environment

Bendigo district is located in the Central Otago District Council territory in the Upper Clutha Valley between Cromwell and the locality of Tarras. The bore site and proposed bore field are located to the immediate north of the Santana Minerals Ltd exploration base (as shown in Figure 1 and Figure 2) and Bendigo Loop Road. The land around the bore site is owned by Bendigo Station Limited and has the address of 305 Bendigo Loop Road. The land parcel has a certificate of title referenced Lot 2 DP 316 124. The pasture immediately surrounding the bore site lies in a broad gully defined by bluffs in the adjoining terrace, to either side of the dry Bendigo Creek.



Figure 2: Location of the bore site, test production and observation (Obs) bore elements of a future bore field

2.1 Location & Communications

The bore site is located 1.6 kilometres to the east of State Highway 8 (SH8) that crosses the lower elevation terraces over the Bendigo Aquifer. A local, partially sealed road called Bendigo Loop Road traces the southern and eastern margins of this aquifer, making a 7.5 kilometre excursion from SH8. This proposed bore field is located 950 metres from the property entrance on Bendigo Loop Road and is adjacent to the Santana Minerals exploration base as mapped in Figure 2 and Figure 4.

2.2 Geography of Site & Environs

The Bendigo Locality includes the agricultural / viticultural area of the Bendigo Flats adjoining SH8 and historic hard-rock gold mining areas of Welshtown and Bendigo Workings within historic reserves, plus the more elevated Bendigo Terrace further east that is largely pasture. The area is 20 kilometres from the regional centre of Cromwell in Central Otago District and 42 kilometres from Wānaka in Queenstown Lakes District.

2.3 Geology

2.3.1 Bedrock

The geological framework of the Bendigo district is based in the Otago Schist bedrock (the geological basement). The Otago or Haast Schist is up to 18 kilometres thick, making up much of the crust and composed of regionally metamorphosed sediment, originally sandstone (psammitic) and mudstone (pelitic) schist rock. Schist of the

textural zone 4 (TZ 4) zone crops out along the southern margin of the Bendigo Aquifer and is found at the base of a small number of the southern-most drill holes that have extended to basement.

2.3.2 Tertiary Sediments

While Tertiary sediments may not crop out at the surface in the Bendigo district, these sediments have been deposited onto the top of the schist during the Miocene and early Pliocene epochs¹. The sediments are inferred to have been preserved in localised structural basins in the upper Clutha Valley (see section 2.3.4). Restricted surface outcrops of Tertiary sediments are found in the Tarras Creek basin and the lower Lindis River valley as Dunstan Formation quartz sand and gravel with lignite seams, plus the Maniototo Conglomerate weathered in a sandy matrix, respectively. The sediments are considered likely to be present beneath glacial till and outwash, providing a low permeable base to the Bendigo Aquifer (Houlbrooke, 2010).

2.3.3 Quaternary Glacial and Post-Glacial Sediments

Beginning in Early Pleistocene, glaciations related to global glacial impulses developed valley glaciers in the catchments upstream of Bendigo. As a result of the earlier plate collision, a re-energised tectonic period termed the Kaikoura Mountain-Building Phase (Orogeny) began in the early Pleistocene, which resulted in accelerated land surface uplift, the formation of ranges beginning with the proto-Southern Alps, and erosion of chlorite grade schist. The mountain building elevated the heads of valley drainages and provided channels for valley glaciers during glacial maxima. De-glaciation and glacier collapse during interglacial periods fed the outwash of glacial till, meltwater deposits and further down-valley, riverine gravels. These riverine gravel deposits are termed glacial outwash. The Bendigo district has a pattern of glacial outwash remnant terraces and deposition surfaces from various interglaciation phases, with surfaces ranging in age and elevation.

The earliest and oldest outwash terraces in the Bendigo district relate to the Lowburn till where remnants scattered along the valley edges onto schist. The Lowburn outwash and till dates from earlier Pleistocene (650,000 – 620,00 years before present, BP) and includes boulders and gravels in a silty clay matrix. Next in age is the Lindis till of similar material but correlated with middle Pleistocene (477,000 – 423,000 years BP). The Lindis surface forms the Bendigo Terrace that overlooks the river terraces and flats towards the Clutha River / Mata Au.

The Bendigo Aquifer comprises river terraces and flats as a stepped sequence of Albert Town (71,000 – 59,000 years BP) and Hāwea (17,000 – 12,000 years BP) outwash, plus Holocene (14,000 years BP to Present) tiered from the east to the west and towards the Clutha River / Mata Au. The combined Albert Town – Holocene outwash sequence share similar grainsize and texture properties, which has allowed the combined sequence to be combined into the groundwater management zone, the Bendigo Aquifer. These combined deposits have been set down by the Clutha River / Mata Au since a time 70,000 years before present and thus included thick channel deposits of the river, including very coarse small boulders, cobbles and sandy gravels, including open framework gravel textures. Weathering or alteration was slight, preserving primary permeability characteristics.

2.3.4 Geological Structure

The surface trace of the Thomsons Gorge Fault (TGF) crosses from the Manuherikia River catchment near Thomson Saddle, passes northwest along the floor of Rise & Shine Creek before crossing into the lower Shepherds Creek drainage until becoming covered by late Pleistocene gravel sediments in the Lindis Valley northeast of Bendigo. The Thomson Gorge Fault is low angle (approximately 35°) with a strike of 050°. The fault

¹ An epoch in geochronology is a period of geological time, typically in the order of tens of millions of years. The current epoch is the Holocene.

itself is reverse, downthrown to the southwest, and inactive since the strain orientation is no longer in operation. The TGF is instrumental in the evolution of the historic gold-forming environment at Bendigo.

The upper Clutha Valley was formed by a combination of tectonic down-warp and the erosive action of large river down-cutting. The basin defining fault on the western side of the Upper Clutha Valley is the Pisa Fault, which is a reverse, high angle fault, and active in the last 10,000 years. A deepened basin filled with Tertiary and Quaternary terrestrial sediments is centred on the Bendigo - Tarras area.

2.4 Soils & Drainage

The Bendigo district has contrasting soil types and classes divided by the following distinctions:

- Lowland soils covering alluvium, outwash and till terraces, or
- Upland soils covering Otago Schist of the Dunstan Ranges.

2.4.1 Lowland Soils

2.4.1.1 Riverine alluvium

Swan Loam and Matapihi Loam are formed over schist alluvium and are poorly drained due to high soil-moisture retention. Ripponvale and Manuherikia loams a typical immature semi-arid soils that are by definition well drained. Waenga silt loam is found in geographical association with the other alluvial soils but differs by being shallow and moderately stoney. Finally, the Gees sand is commonly very stoney, well drained and very shallow. In the river terraces and flats adjacent the main stem river and State Highway the Gees sand soils are restricted to the dry bed of Bendigo Creek as it crosses the surface to Lake Dunstan.

2.4.1.2 Till Terraces

The Bendigo Terrace surface is covered with a range of soil classes, all falling into the category of shallow, well drained sands or loams –

- Molyneux shallow, well drained, sand
- Clyde shallow, well drained loam,
- Ardgour shallow, well drained loam,
- Bendigo moderately deep, well drained loam.

These soil types carry on along the face of the Dunstan Range creek catchments, punctuated by ribbons of Waenga soils associated with Shepherds Creek.

2.4.2 Upland Soils

2.4.2.1 Semi-Arid Soils

Well drained soils with moderate fertility limited by rooting depth due to density, stoniness and dryness. The following semi-arid soils are found on the lower slopes of the Dunstan Range -

- Lowburn,
- Clyde,
- Alexandra, and
- Conroy Hill

2.5 Climate

The following summary is adapted from *The Climate and Weather of Otago* by Greg Macara of NIWA (Macara, 2015). The Otago region is in the latitudes of prevailing westerlies with lighter winds inland compared to the coast. Annual precipitation in Otago typically decreases with distance from the Alps, as spill-over rain declines and a series of rain shadows impose themselves. Inland Otago is the driest region in the country and the valley floors of the Bendigo – Tarras districts among the driest in Otago. Dry spells of more than two weeks occur frequently in the area. At the same time temperatures are on average lower than over the rest of the country with frosts and snowfalls occurring relatively frequently each autumn – winter – spring period. During summer hot dry conditions exceeding 30° Celsius are normal during summer and early autumn.

2.6 Surface Hydrology & Water Resources

The two glacial lakes, Wānaka and Hāwea, feed approximately 260 cubic metres per second (260,860 L/s) on average to the downstream river system *via* the Hāwea and Upper Clutha / Mata Au rivers, representing more than 42% of the river system's total discharge at the Pacific coast. Estimates of mean, median and 7-day Mean Annual Low Flow are made using measurement site historic data provided by Contact Energy Ltd in Table 1, below.

Table 1: Summary of Flow Statistics for Upper Clutha Lakes (Wānaka & Hāwea)

	NZ Segment #	Area (km ²)	Start	End	Area (km ²)	No. of years	Mean (L/s)	Median (L/s)	MALF _{7d} (L/s)
Lake Wanaka at Roys Bay	14196259	2,564	1/02/33	12/01/17	2,564	84	198,482	177,327	81,300
Lake Hawea at Dam	14192731	1,281	1/01/33	9/04/14	1,385	81	62,376	58,763	29,900

Note: No. of years = Number of years of flow record. MALF_{7d} means Mean Annual Low Flow statistic

The mean outflows from the lakes also equate to a combined specific discharge of 66 litres per second per square kilometre (L/s/km²) of upstream lake catchment, substantially more than the specific discharge of the Lindis River at Lindis Peak at 11.2 L/s/km². This disparity is indicative of the spill-over precipitation characteristic of this segment of the Southern Alps plus rain shadowing provided by the Grandview Range lowering precipitation to the upper Lindis catchment. Downstream of the lake outlets, the Cardona River, Luggate Creek, Crook Burn and Lindis River tributaries join the flow of the Upper Clutha main stem, which collectively may increase the main stem mean flow by another 10,150 L/s before the river reaches the Bendigo district. The Upper Clutha main stem downstream of Lindis River confluence has a measured mean annual flow of 271 cubic metres per second (270,992 litres per second) as measured at the now-closed Lowburn hydrological site. To allow a comparison with groundwater system water balances, the mean annual flow can be expressed as an 8,546 million cubic metres per annum.

2.7 Groundwater & Associated Water Resources

Groundwater in the Bendigo district has two principal domains for groundwater occurrence –

- Saturated consolidated rocks, generally schist basement, or
- Alluvium or outwash sediments, generally coarse sandy gravels.

Saturated consolidated rocks in the area are largely the schist shield that forms the basement of the area. Alluvium and voluminous glacial outwash gravel deposits are concentrated within the valley systems such as the Lindis Valley and Upper Clutha Valley. As detailed in the next sections, the alluvium and outwash gravel deposits

have high permeability and porosity, allowing the conveyance of copious quantities of groundwater through the deposits.

2.7.1 Fractured Rocks

The use of groundwater from basement rocks is incidental, primarily following groundwaters' emergence from said rocks as diffuse seepage, spring flow and baseflow in water courses. There are very few bores or wells outside of historic mine shafts that tap the fractured schist in the Bendigo area. While there is appreciable deep circulation, passage of water through fractured basement rocks due to the rocks' wide and pervasive distribution across the Dunstan and Pisa ranges, much of the potential groundwater recharge of excess precipitation is rejected at the soil / regolith interface due to the generally low permeability of the fractured rock, and feeds surface stream flow instead. The schist – alluvium contact can be considered as an impermeable interface in the context of this assessment.

2.7.2 Lindis Alluvium

The Lindis River in its lower reaches winds between basement highpoints and older outwash terraces as it traverses between the Lindis Range front and its confluence with the Clutha River / Mata Au. The river has reworked alluvium and deposited an alluvial floodplain on either side of its course. The associated alluvial ribbon aquifer following the Lindis River is intimately associated with the river hydrology. In late summer low flow, surface flows in the lower Lindis River can entirely revert to subsurface flow leaving the water course dry. The Lindis River provides quantities of water infiltration that enters the top of the Bendigo Aquifer (Houlbrooke, 2010) at the Clutha river confluence (see Figure 4 and Table 15). Southeast of the lower Lindis River, an outwash gravel deposits of Q4 (Alberttown) oxygen isotope stage is located that has been deposited and preserved from later erosion. The outwash is classed within the Ardgour Alluvium or Alluvial groundwater management zone.

2.7.3 Bendigo Creek Alluvium

In the middle reaches of Bendigo Creek upstream of the Bendigo Loop Road ford crossing, sandy gravel alluvium has accumulated as a veneer of gravel within a dip in the basement schist and between bedrock gorges. This Bendigo Creek Alluvium has high permeability and porosity. In similar fashion to the Lindis Alluvium and alluvial aquifer, low flows in Bendigo Creek results in loss of surface flow when the creek water soaks into the alluvium. Higher and flood flows in the creek allow visible creek flow to extend further downstream, although parallel subsurface flow (interflow) continues underground.

2.7.4 Bendigo Outwash & Aquifer

Post-glacial outwash associated with the Hāwea, and Albert Town glacial advances (and these advances' collapse) have accumulated between the Clutha River / Mata Au and the terrace riser of the Bendigo Terrace. The higher elevation (340 m AMSL) Bendigo Terrace is correlated with the Lindis Glacial Advance and comprised lower permeability glacial till and is distinct from the Bendigo outwash. The vertical height difference between the upper surfaces of the Lindis Glacial Advance at the Bendigo Terrace and Albert Town outwash gravel deposits over the Bendigo Aquifer is approximately 80 metres. The Hāwea and Albert Town outwash gravel deposits host the Bendigo Aquifer with a roughly triangular outline approximately delineated by Bendigo Loop Road and the Clutha River / Mata Au.

The Bendigo Aquifer has a measured mean depth of 33 m, and a mean depth to the water table of 12 m. Approximately 30 production bores are scattered across the surface of the Bendigo Aquifer. The aquifer has some of the highest well yields of aquifers in Otago Regional comparable to the Hāwea groundwater basin, up to 120 litres per second. The water table is less variable than the land surface across the aquifer, with the water table elevation ranging between 195 m above mean sea level (AMSL) to 201 m AMSL in the core of the aquifer and 210 metres AMSL further upgradient at the Lindis – Clutha confluence (see Figure 4).

2.8 Groundwater Domains & Permeability Contrasts

2.8.1 Saturated & Fractured Rock

The original or primary porosity of the sediments forming the Otago schist was lost in deep burial and regional metamorphism, although subsequently successive phases of uplift and crustal flexure led to the penetration of several generations of fractures and joints throughout the rock mass. These fractures and joints, plus fault brecciation and shear zones where these are not mineralised, have provided the sole permeability and (secondary) porosity to the schist rock underlying all of the Bendigo District, particularly the Dunstan Range. Measured hydraulic conductivity within the schist rock is generally less than 1×10^{-6} metres per second (0.09 metres per day), which is a substantial contrast in permeability compared to the predominant 1×10^{-3} metres per second (90 metres per day) of the adjoining alluvium or outwash sediment. Accordingly, the schist rock is often considered to be functionally impermeable and a barrier to groundwater flow when assessing the geo-hydrology of the overlying alluvial and outwash groundwater systems.

2.9 Depths of Saturation & Groundwater Flows

The source aquifer of the Matakanaui Gold Ltd water supply bores are proposed to be drawn from the Bendigo Aquifer, which is primarily outwash sediments (specifically coarse sandy, cobbly gravels) of the Albert Town Outwash. The land surface follows the influence of the depositional processes that formed the aquifer atop the Miocene aged mudstone/sandstone and Triassic aged schist basement. The Bendigo Aquifer east of State Highway 8 (SH8) comprises Albert Town Advance outwash and the Hāwea Advance outwash. To the west of SH8, the aquifer generally comprises Holocene alluvium of the Clutha River / Mata Au.

All of these gravelly deposits are grouped into a water resource named the Bendigo Aquifer and are composed of cobble, gravel, sand and silt sized grains, largely devoid of densely packed silt or clay that otherwise constrains alluvial hydraulic conductivity. The resulting combined deposit groundwater system facilitates elevated transmission of groundwater throughout the Bendigo Aquifer. The water table surface is between 210 m to 195 m AMSL, approximating the Clutha River and Lake Dunstan water elevations adjacent to the aquifer (see Figure 4).

Otago Regional Council (ORC) has maintained a groundwater level monitoring bore in the Bendigo Aquifer adjacent to Bendigo Loop Road with a depth of 46.1 metres and initial depth to water of 29.4 metres below ground level. This bore CB13/0159 has been level logged by a telemetered level transducer since 16 August 2021 to present, a period of over three years. Figure 3 displays the monitoring bore hydrograph from 16 August 2021 to August 2024, in metres above mean sea level.

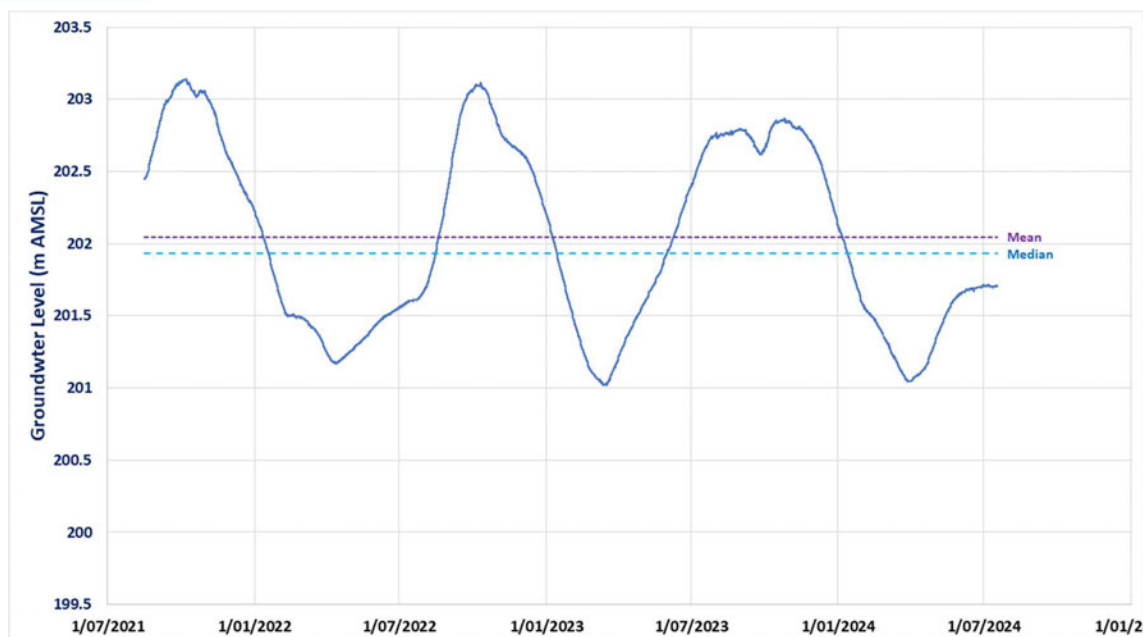


Figure 3: Three year record of groundwater level elevation at ORC monitoring bore CB13/0159

The groundwater hydrograph of the monitoring bore describes an annual level fluctuation in the following statistical measures:

- Mean 202.04 m AMSL
- Median 201.93 m AMSL
- Minimum 201.02 m AMSL
- Maximum 203.14 m AMSL
- 3 Year Range 2.12 m
- Std. Deviation 0.65 m

So, measured annual variation in the order of 2.0 metres is indicated by the three year hydrograph at the site in the east of the Bendigo Aquifer. Bore CB13/0159 is the sole ORC monitoring bore within the Bendigo Aquifer core and it is located in the Albert town Outwash portion of the Bendigo Aquifer, which is the same outwash formation tapped by the Matakanui Gold Ltd production bore. It is worthwhile noting from Figure 3 that for each of the three hydrological years of record, the groundwater levels peaked in September – October (spring) and dipped in March – April. Such seasonal polarity of fluctuation peaking in late winter – early spring is more typical of a climate-driven recharge patterns than irrigation recharge driven water level patterns seen in the Alexandra Basin as per (Rekker, 2012) and (Garden, 2022). The seasonal pattern of variation may also reflect the general drawdown effect of summer irrigation pumping of the aquifers irrigation bores. Whatever the case of climate or bore pumping mechanism for summer groundwater level decline, the monitoring bore record has allowed the characterisation of seasonal groundwater level variation.

The southeast quadrant of the Bendigo Aquifer has the unique feature of infiltration of Bendigo Creek water to the aquifer as a locally significant source of recharge. Bendigo Creek flow rate would peak in late winter due to lower evapotranspiration prevailing then, and dip in late summer or autumn due to elevated evapotranspiration combined with net abstraction at the Bendigo Station irrigation intake under summer – autumn irrigation demand. Bendigo Creek mean flow and Mean Annual Low Flow (MALF_{7d}) were estimated at 120 and 33 litres per second, respectively (Stewart, 2021). Thus the mean annual volume lost to the Bendigo Aquifer may approach 3.7 million cubic metres per annum.

The water table within the Bendigo Aquifer is relatively consistent, ranging spatially across approximately 15 metres, from elevations of 195 m near Lake Dunstan in the south, to 210 m AMSL to the north near the Lindis – Clutha river confluence. The land surface follows the influence of the depositional processes that formed the aquifer atop the Miocene aged mudstone and Triassic aged schist basement, whereas the water table follows the slope of the Clutha River / Mata Au. Accordingly, there is a wide range in the depths to water table across the aquifer.

The outwash gravels have pervasively high hydraulic conductivity within the saturated parts of the Bendigo Aquifer, as measured in numerous pumping tests conducted in irrigation bores at commissioning. In turn, this results in elevated groundwater transmission rates and a relatively low gradient to the water table. Figure 4 maps the Bendigo Aquifer water level contours, specifically from December 2009 measured water table elevations at 22 individual bores (Houlbrooke, 2010). Figure 4 also interpolates the surveyed December 2009 water table and includes hand-sketched 1-metre interval contour lines over the aquifer surface.

The water table contouring of Figure 4 provides indications as to the aquifer's hydrology, including

- Hydraulic gradient, and
- Implied flow pattern.

The water table drops about 15 metres over a distance of 6.7 kilometres, implying an average gradient of 0.0022 metres per metre. In this case, Figure 4 supports the view that water enters the aquifer in the northern (upstream) margin with the Clutha / Mata Au and Lindis rivers, while the same water leaves the aquifer along the lower river / wetlands or Lake Dunstan in the south. The Bendigo – Ophir Gold Mine Project water supply is proposed to be taken from a bore field in the southeast of the Bendigo Aquifer, as marked in Figure 1, Figure 2, and Figure 4 (see also section 4.1.2). The depth of the water table is deepest (up to 30 metres) in the southeast within the older Albert Town outwash and shallowest (as low as 1.7 metres) along the river and lake margins, typically within the Holocene terraces and floodplain.

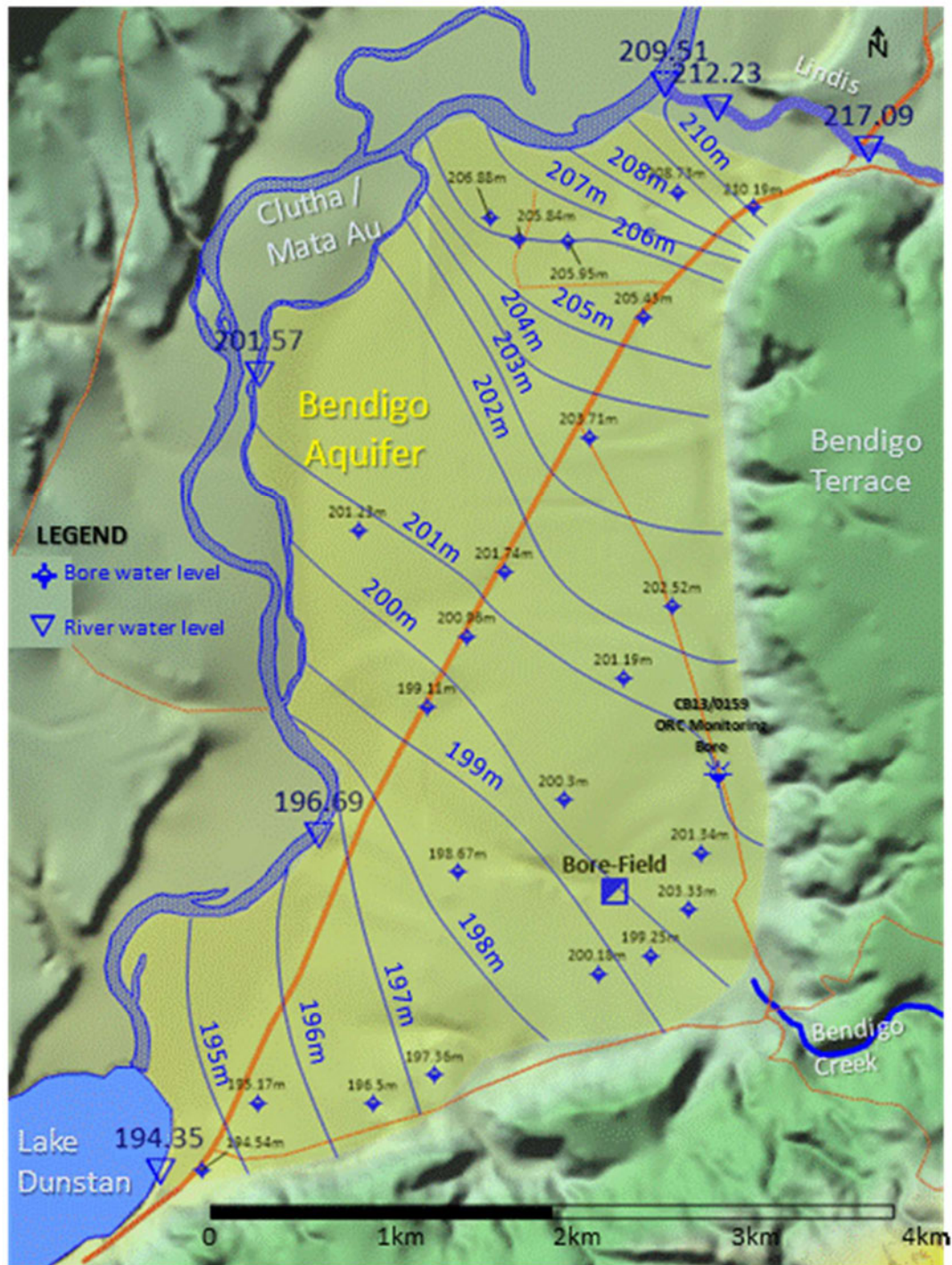


Figure 4: Bendigo Aquifer plus December 2009 measured groundwater elevation contours

2.10 Beneficial Uses of Groundwater

Groundwater from the Lindis Alluvium and Bendigo Aquifer provides beneficial quantities of water for a range of rural water uses. Human requirements for groundwater utilised for drinking, domestic, stock, frost fighting, and irrigation water are readily available from these aquifers providing the bores, wells or infiltration galleries can be deployed to allow their extraction. The Bendigo district is a water-short part of the Otago Region, as detailed in the above section on Climate, so the ability to access plentiful sources of water, including groundwater, are highly valued. The shortness of water in the district also arises from low soil retention capacities generally, the regional rain-shadow effect leading to lengthy soil-moisture deficits, and high rates of evapotranspiration driven by high air temperatures and wind-run. Accordingly, several land uses in the area exploit the lower rainfall, growing days, and low soil-moisture content, especially grape growing and cherry horticulture. Groundwater within the basement schist is not able to meet human requirements for water, due to the low transmission rates within these rocks.

Volumetrically, irrigation of pasture and horticultural or viticultural plantings are the dominant uses of water in the Bendigo district. The district is lightly populated, so the domestic and drinking water demand is similarly lightly distributed, but the availability of groundwater from bores is highly valued by the district's inhabitants. Groundwater from the alluvium and outwash aquifers is the preferred source of domestic and drinking water for dwellings. Dwellings tend to collocate with these areas of groundwater availability on the valley floors. In several instances of water bore development, the groundwater pumped from a single bore serves a range of water end uses, including domestic, stock and irrigation requirements for the attached land holding.

Frost-fighting water use is made almost exclusively from groundwater in the lower Lindis Valley and Bendigo Aquifer areas. At least five properties over the Bendigo Aquifer cite frost-fighting as one of the water uses sought from the water take. Frost-fighting requires access to water in early to middle spring in any year, primarily to apply water through high-level sprinklers within orchards or vineyards and thus provide latent heat for the protection of bursting buds during morning frost events.

2.11 Water Resource Infrastructure in Wider District

2.11.1 History of Water Races

Water use in the district began as water races to be used in hydraulic sluicing of gold-bearing gravel terraces around Logantown and the Bendigo Creek catchment. While the Lindis River and Tarras Creek catchments were largely barren in terms of gold, graziers eventually adopted the use of water races diverting water from the Lindis River, Shepherds Creek and Bendigo Creek to pastures. Wild flood irrigation was the ubiquitous method of irrigating pastures. Later in the 20th Century, constructed and graded border dyke fields were developed over parts of the district using the same race water, notably at Ardour. Currently, water race diversions and direct pump intakes on the Lindis River deliver irrigation to most of the lower Lindis and Tarras catchments, although supplies from large capacity bores, wells and infiltration galleries are increasingly assuming more importance.

2.11.2 Contemporary Water Uses

Large capacity water bores at diameters from 300 mm to 400 mm have also spread across the Bendigo Aquifer surface to service changes in land use from sheep fattening to a range of more intensive dairy, horticultural and viticultural land uses. More than 30 irrigation bores have been established and attached to water take consents across the aquifer. In recent years, it has become recognised that for the irrigation bores that are sufficiently close to the Clutha River / Mata Au to induce the infiltration of river water, and a calculated 533 L/s of surface water depletion is attributed by ORC to this mode of abstraction during peak pumping periods. Up to 17.4 million cubic metres of groundwater per annum is allocated to current groundwater take consents from the Bendigo Aquifer, much of it inducing inflow from the Clutha River / Mata Au. The aquifer is also relied upon for domestic,

stock and frost-fighting at lower rates of abstraction, often from smaller diameter bores under various lawful water use authorisations, including permitted activity rules.

2.12 Aquatic Ecology & Wetlands

2.12.1 Aquatic Values

Richard Allibone of Water Ways Consulting describes the aquatic ecology of the Bendigo district, which can be summarised as follows:

- Limited fish values confined to minor trout populations in Bendigo Creek,
- Regionally significant trout fishery in the Lindis River and some tributaries,
- Nationally significant populations of non-migratory *Galaxiids* in the upper reaches of Lindis catchment tributaries,
- A significant lake trout fishery in the Upper Clutha River / Mata Au delta and Lake Dunstan, and
- A regionally significant wetland complex at the river delta to Lake Dunstan, including the presence of the Great Crested Grebe (*Podiceps cristatus australis*).

The Bendigo Creek trout population is very small and landlocked to the flowing parts of the upland creek water course due to the infrequent and intermittent flow and nature of the creek drying downstream of the Bendigo Loop Road crossing, thus imposing obstacles to fish passage.

2.12.2 Regional Wetland

The Bendigo Wetlands are an area of riverine and lake margin wetlands formed in its current configuration with the raising of Lake Dunstan behind the Clyde Dam in 1992. The area is listed in Schedule 9 of the Regional Plan: Water as a regionally significant wetland. Due to the placement of the wetland within the large Clutha River / Mata Au and lake delta the wetland is not vulnerable to induced water levels fluctuation related to groundwater abstraction. This relative invulnerability results from the strong hydraulic connection between river, lake and wetlands, and the overwhelming fixed head imposed by the river and lake preventing any appreciable groundwater level fluctuations independent of the river and lake.

3 Drilling Project Hydrogeology and Aquifer Testing

3.1 Pilot Hole / Reserve Bore Installation

On 24 June 2024, drilling work began, with SouthDrill Ltd as the contractor, mobilising the drilling and support equipment to the nominated exploration site (see Figure 2). The first task was drilling the pilot hole and installing the observation bore (ORC well record number CB13/0216), which also served the purposes of pilot hole and reserve capacity water bore. Logging of drill cuttings indicated a sequence of mixed brown sandy gravels with variable silt content (see Appendix 1). Drilling in these broad class of alluvial sediments extended to 41.9 metres depth, below which grey silty sand was encountered, initially weathered but exhibiting increasing consolidation with depth. This stiff, silty sand was inferred to indicate the contact between the overlying glacial outwash and the underlying Miocene epoch terrestrial lake sediments (Manuherikia Group). Drilling was terminated on 25 June at a depth of 42 metres, and work began on installing a 150 millimetre diameter steel-cased bore in the hole.

Air-lift pumping during observation bore development was indicative of high yield. A temporary submersible sampling pump hung in the bore provided water level decline (drawdown) data over 2 hours of operation that was indicative of a specific capacity of 7.8 litres per second per metre of drawdown. The pilot hole would become a reserve capacity water bore for the provision of additional water, combined with the 400 millimetre production bore up to the pipe line capacity of 110 litres per second.

3.2 Test Production Bore Installation

Work began on drilling for the installation of a test production bore on 26 June 2024. This bore was placed 13.2 metres to the east of the observation bore. A sanitary seal was applied as a 508 millimetre diameter pre-collar casing section to a depth of 6 metres. The pre-collar casing enclosed the 400 millimetres diameter main casing. The drill string and main casing was extended to 42 metres. A 6 metre section of 2.5 millimetre slot size stainless steel Johnson screen was installed at the base of the drill hole and casing pulled back to expose the screen to the formation. The screen was then developed² by air-lift and over-pumping, over a period of 56 hours until turbidity and sand content of the discharge declined to negligible levels.

3.3 Constant Rate Test

An initial constant rate test of the 400 millimetre test production bore was commenced at 11:30am on Monday 8 July 2024 and run for 21.22 hours averaging 22.0 litres per second. However, the generator powering the submersible pump for the initial test failed, could not be restarted, and the test was halted. A second test was commenced on Tuesday 9 July at 8:30 am and ran for 48 hours (2 days) at a mean rate of 20.6 litres per second. The constant rate test (CRT) was also observed within the pumped bore and the observation bore; 13.2 metres distant. All tests observed the requirements set out in the Otago Regional Council bore consent application form and the permitted activity rule within the Otago Regional Plan: Water for down-hole testing.

3.3.1 Drawdown and Recovery Phase Responses

The pumped bore responded instantaneously to the onset of pumping with an average rate of 20.6 litres per second, and the observation bore responded a minute later. The Van Walt transducers in the pumped bore and observation bore supplied by SouthDrill used the Seametrics LevelScout units with 20 metre and 10 metre measuring range for the pumped bore and observation bore, respectively. The LevelScouts have a precision of 0.05% of full measuring range, meaning that the measurements were accurate to within 10 mm to 5 mm for the

² 'Development' is a term in bore installation that refers to the intentional agitation and over-pumping of water in the bore that results in the flushing of fine materials and sorting of grains adjacent to the bore screen that are most conducive to higher efficiency bore operation. At the completion of 'development', the bore under pumping should be relatively free of entrained sand or grit, and turbidity in pumped water, plus it should display improved bore screen hydraulic characteristics, i.e., less self-induced drawdown for the same rate of pumping.

200 metre and 10 metre range transducers, respectively. Manual dipping has a precision of approximately 0.01 m (or 10 mm) but requires a testing technician to be on-site to take measurements. Summary information on the level and pump rate measurements are supplied in Table 2 and Table 3, below.

Table 2: Summary of Different Down-Hole Water Level Measurement Systems

	Frequency	Sites & Duration
Manual dipping	As required, up to half minute	In test bores, before, during and after the CRT
Van Walt Loggers	½ minute	In test bores from 9 to 12 July

The Van Walt transducer – logger was installed in the pumped bore at midday on Friday 5 July, allowing a three day period of ambient water level recording prior to initial test CRT pumping the following Monday (8 July). The Van Walt logger for the observation bore was installed only an hour before the CRT test on Monday 8 July, allowing the logger body to thermally stabilise and collect initial level measurements. The headline results of the constant rate test are summarised in Table 4.

Table 3: Summary of Pump Rate Metering

	Frequency	Sites & Duration
SouthDrill's Mag-Flow Meter	Observation and manual recording (no auto logging)	In test production bore while testing, during CRT and SRT.

Table 4: Manually recorded Depths To Water, Drawdown and Specific Capacity for 48 hour CRT (Uncorrected)

Bore Label (and ORC Well Record Number)	Initial Manual Depth To Water (m ToC)	Mean Pump Rate (L/s)	Final Manual Depth To Water (m ToC)	Drawdown (uncorrected) (m)	Specific Capacity (L/s/m)
PB-1 (CB13/0215)	20.96	20.67	22.53	1.57	18.1
Obs-1 (CB13/0216)	20.62	0	21.06	0.44	—

Note: ToC = with respect to or below Top of Casing. PB = Pumped Bore. Obs = Observation bore

3.3.2 Need for Corrections to Level Data

Reference to the Otago Regional Council (ORC) State of the Environment (SOE) water level monitoring bore CB13/0159 (located 860 metres to the northeast), and ambient bore water level monitoring in the pumped bore prior to the start of constant rate pumping indicated that a steady decline in background groundwater before the CRT testing. The inferred rate of decline lay between 9 and 18 millimetres per day. The mechanisms of the observed declines were not obvious. Possible mechanisms of the decline are proposed as follow:

- Decline in flow and stage of the Clutha River / Mata Au at the riparian aquifer margin to the northwest,
- Decline in the flow of Bendigo Creek that infiltrates to the Bendigo Aquifer at Bendigo Loop Road in the east,
- Recession of the water table following a period of more intense land surface recharge or,
- The influence of a rising atmospheric pressure (e.g., an anticyclone).

Corrections were made to the pumping phase and recovery phase water level measurements in the bore site water levels to remove the external influence of this antecedent, background trend. These corrections resulted in adjusted final drawdowns of the pumped and observation bores being changed to 1.52 metres and 0.39 metres (c.f., “Drawdown” column of Table 4), respectively. The corrections resulted in an adjusted final drawdowns lying up to 50 millimetres lower than indicated from manual and electronic measurements. The test data following corrections were used in CRT interpretation.

3.3.3 Examination of Corrected Drawdown Responses

The water level response in both bores was initially rapid but thereafter manifested a relatively low gradient of increasing drawdown over 48 hours (see Figure 5). Following initial drawdown over 2 minutes where 80% of the final drawdown occurred, the measured drawdown crept upwards at a rate of only 40 millimetres per day (0.04 m/d). This ‘tooth shaped’ drawdown response curve is suggestive of hydrologic conditions characteristic of a high transmissivity, unconfined aquifer.

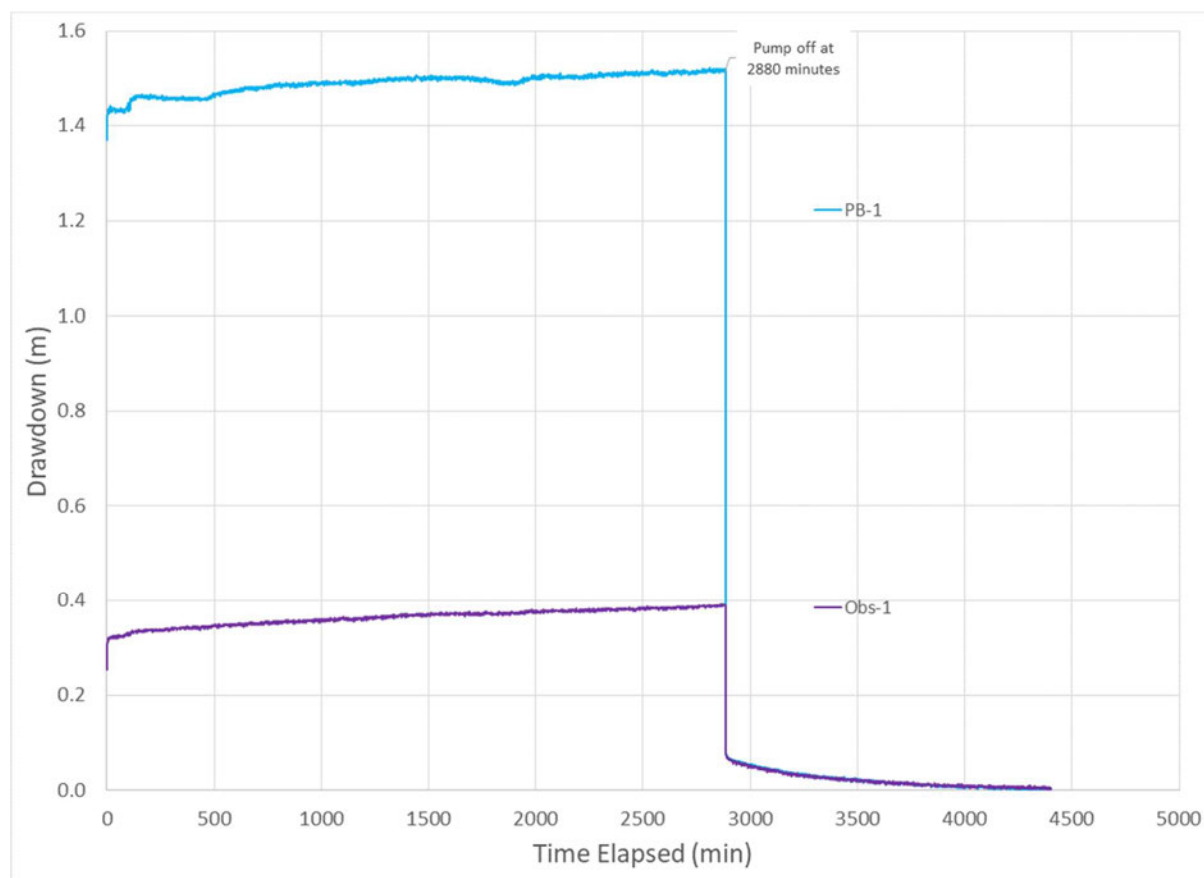


Figure 5: Pumped bore and observation bore corrected drawdown responses during the 48 hour CRT

3.4 Aquifer Test Analysis

3.4.1 Ideal Aquifer and Implications for Test Data Analysis

The proposed ideal aquifer is unconfined, as shown schematically in Figure 6, below. According to the ideal aquifer illustrated in Figure 6, the water table is a free surface lapping around grains of the aquifer material (sand, gravel, or cobbles) and does not drain instantaneously in response to sudden water table decline (i.e.,

pumping related drawdown). Therefore, the decline in the water table in response to bore pumping is initially time-lagged, leading to delayed yield due to the delayed draining of moisture downwards to the water table following the start of the pumping test. Accordingly, the standard method (Theis, 1935) of pumping test mathematical solutions requires adaptation to account for this delayed yield.

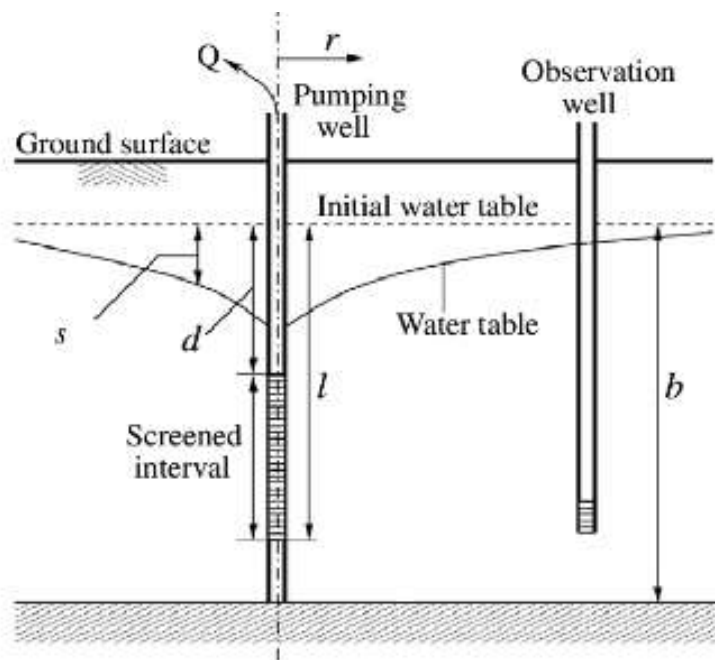


Figure 6: Schematic representation of an unconfined aquifer (Neuman, 1974)

The Neuman method (Neuman, 1974) pumping test analysis solution is one of those that account for the above interpretation of aquifer tests conducted in unconfined aquifers with delayed yield characteristics. Accordingly, aquifer test analysis of the bore site drawdown data employed the Neuman method. The recovery phase of the observed pumping test involves a rising water level and hence does not trigger delayed yield, therefore the Theis method in its post-pumping recovery implementation may be validly used for test analysis. As the pumping rate during the recovery (non-pumping) is zero and the return bore inflow rate infinitesimally small, interfering well screen head losses are largely inactive. Therefore, the Theis recovery implementation may also be used to interpret pumped bore recovery, without interference from delayed yield or well screen head losses. The ideal aquifer also assumes isotropic hydraulic properties and infinite extent. These conditions are not met at the bore site, but the boundaries and variabilities in these properties and anisotropies are sufficiently distant and their effect on water level response mild, so that the test analysis solution is still largely valid. The relatively uniform high hydraulic conductivity or transmissivity of the Bendigo Aquifer in proximity to the bore site also reduces the drawdown sensitivity of test data.

3.4.2 Pumping Phase Observation Bore Analysis

The observed test data points (in red) were matched against five principal Neuman beta type curves, as displayed in Figure 7. The match was optimised against the 0.007 beta curve, highlighted in blue in Figure 7, below.

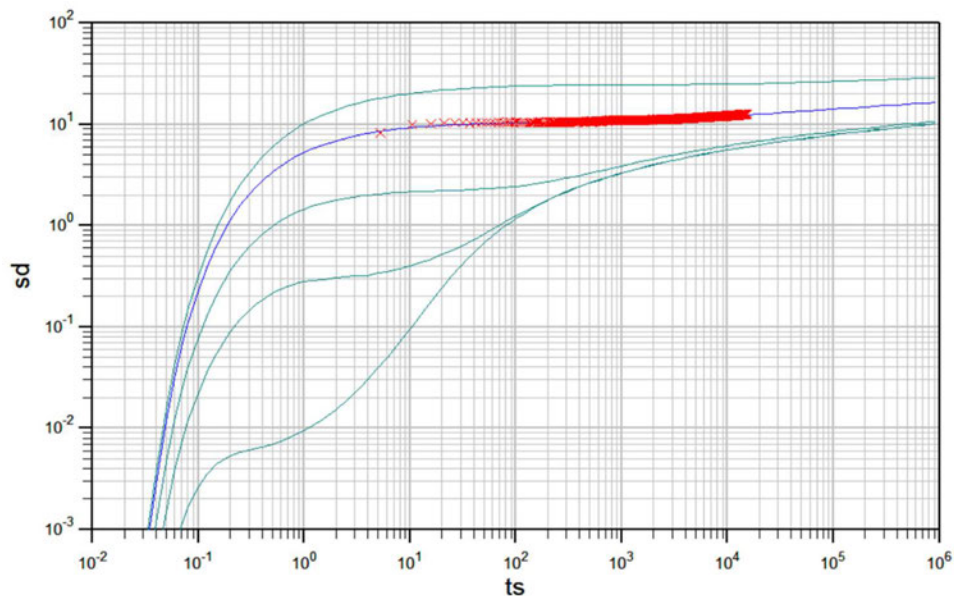


Figure 7: Neuman test drawdown data point matching against Neuman well function type curves

The displayed curve match equates to an indicated transmissivity of 4,508 square metres per day, hydraulic conductivity of 250 m/d and a specific yield (unconfined storage coefficient) of 0.30 (30%) as listed overleaf in Table 5.

3.4.3 Non-Pumping Phase (Recovery) Analysis

Recovery analyses with pumped bore and observation bore residual drawdown data points traced virtually identical curves, as could be discerned from the overprinting of recovery curves in Figure 5. Figure 8 and Figure 9, below, follow the Theis Recovery method with late-time residual drawdown data for the pumped bore and observation bore, respectively.

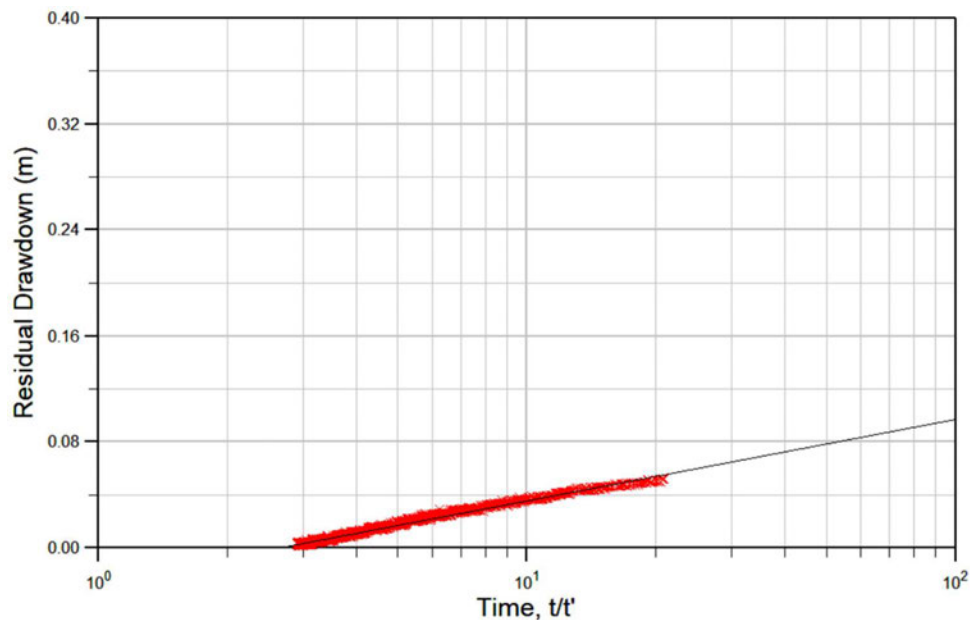


Figure 8: Pumped bore matching late-time residual drawdown data for recovery analysis (Theis, 1935)

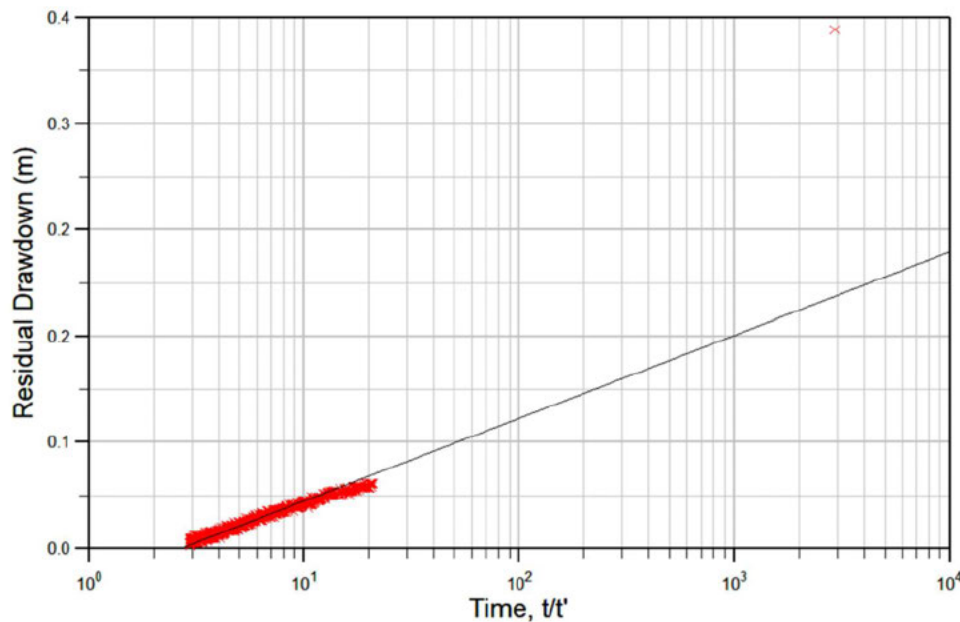


Figure 9: Observation bore matching late-time residual drawdown data for recovery analysis (Theis, 1935)

The threshold between early-time and late-time was set at a t/t' ratio of 20, which equates to a time elapsed value of 3,030 minutes from the start of the test (i.e., t' of 150 minutes). The well function type curve was matched against late-time beyond the above threshold. Table 5 lists the aquifer test analysis results for pumping and recovery phase analyses.

Table 5: Summary of Aquifer Test Analysis Results for Constant Rate Test

Bore	Phase	Analysis Method	Transmissivity, T (m ² /d)	Hyd. Conductivity, K (m/d)	Specific Yield, S _y
Observation Bore	Pumping	Neuman	4,508	250	0.31
Pumped Bore PB-1	Recovery	Theis (Rec)	5,323	295	*
Observation Bore	Recovery	Theis (Rec)	5,235	290	*

Note: * A storage coefficient ratio (S/S') of 2.65 was derived from each Theis recovery analysis, which is indicative of an unconfined aquifer. Otherwise, specific yield could not be derived from recovery phase curve matching analysis.

3.5 Step Rate Test

3.5.1 Test Description and Raw Data

A step drawdown or step rate test (SRT) was conducted on 25 July 2024 comprising four 2-hour pump rate steps targeting rates from 35 to 100 L/s. The almost 8 hour (476.5 minutes) test was measured as follows:

- At an inline flow meter,
- Using level measurements in the pumped bore, and
- Using level measurements in the observation bore, at 13.2 m radius.

The test summary data is provided in Table 6. Pumping rate was manipulated by the opening of a gate valve downstream of the flow meter. The water discharge was conducted away from the bore site in a 6-inch diameter fabric hose ('Layflat') and allowed to spread onto the down-gradient pasture. Little soakage was observed and

after overland flow, surplus groundwater entered the Bendigo Creek channel sustaining creek flow in an otherwise dry creek for at least one kilometre.

The pumping test resulted in the pumping of 1,885 cubic metres out of the Bendigo Aquifer over 476.5 minutes. The drawdown increased with each succeeding increase in pumping rate. During the beginning of Step-2 and Step-3 a readjustment of the pumping rate was undertaken due to the target rate being overshot.

Table 6: Summary of Step Rate Test data, including Pumped Bore Specific Capacity

Step No.	Interval (min)	Duration (min)	Mean Rate (L/s)	Final DTW (m)	Final Drawdown		PB-1
					PB-1 (m)	Obs-1 (m)	SPC (L/s/m)
Step-1	1 - 121	121	36.67	23.74	2.77	0.58	13.2
Step-2	122 – 242	121	56.73	25.46	4.51	0.88	12.6
Step-3	242 - 352	110	75.56	27.53	6.59	1.16	11.5
Step-4	352 - 476	125	95.00	30.33	9.40	1.48	10.1
Recovery	476 - 486	10	0	21.10			

Note: DTW is Depth To Water in terms of the ground level reference level. Final Drawdown includes decline from estimated static water level above top of casing. SPC is the Specific Capacity as the ratio of pump rate divided by final drawdown in litres per second per metre of drawdown. PB-1 refers to the pumped bore CB13/0215, while Obs-1 refers to the observation bore CB13/0216.

Figure 10 displays a composite plot of pumped bore drawdown and pumping rate as a time series. The drawdown profiles for the first three steps were relatively flat. The drawdown timeseries for the fourth step showed a more rounded rise.

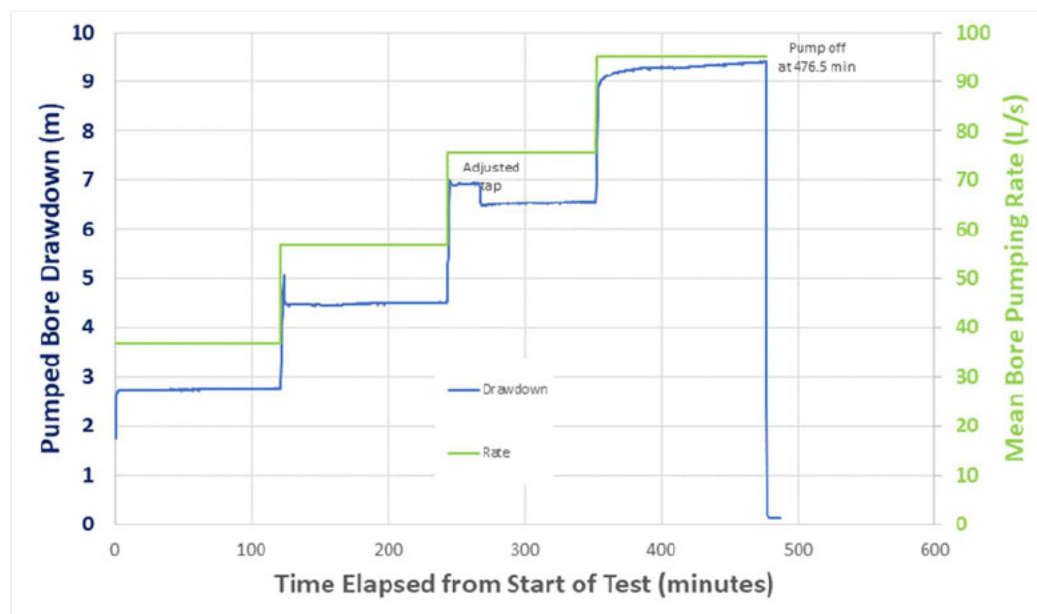


Figure 10: Recorded water level, to plotted as drawdown for pumped bore during SRT

Recovery from pumping was rapid, mostly within 2 minutes after the pump was stopped. The mean pumping rate is plotted in Figure 10 and Figure 11, however variability in the measured instantaneous pumping rates was at a range of standard deviations of 2.5 to 5.7 L/s (i.e., total range per step between 10% and 20% of the

mean). In order to provide a simplified plot of pumping rate, a simple mean of recorded measurement with each step was carried forward into analysis of the step rate test.

The observation bore recorded lesser drawdown due to both the lack of well screen head losses and the offset distance of 13.2 m away from the pumped bore (see Figure 11).

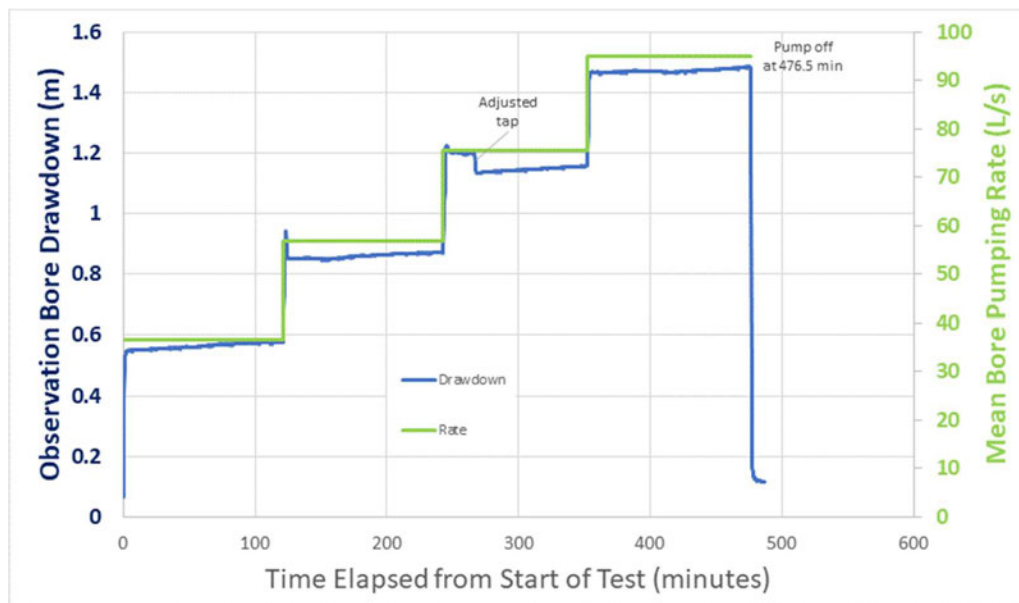


Figure 11: Recorded water level, to plotted as drawdown for observation bore during SRT

3.5.2 Pumped Bore Step Drawdown Analysis

3.5.2.1 Eden-Hazel Analysis

The step drawdown analysis displayed in Figure 10 used conventional methods (Eden & Hazel, 1973). Figure 12, Figure 13, and Figure 14 each show the results of curve matching using the Eden-Hazel method and the Aquifer^{Win32} package (Rumbaugh & Rumbaugh, 2013).

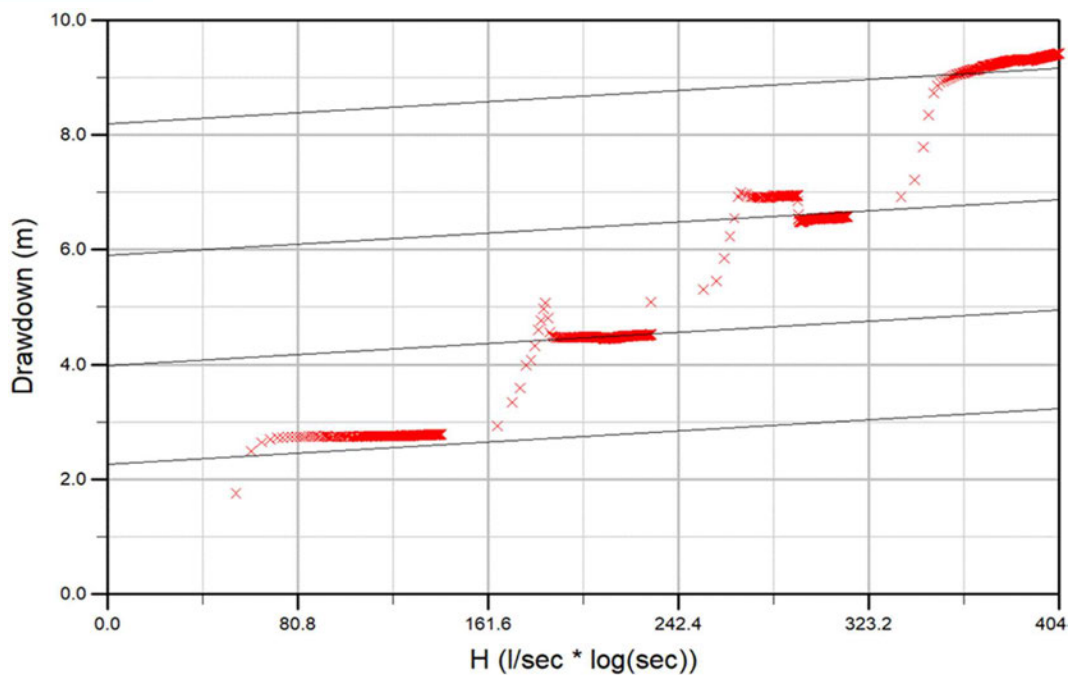


Figure 12: Eden-Hazel Step 1 curve matching with one fit line per step (Eden & Hazel, 1973)

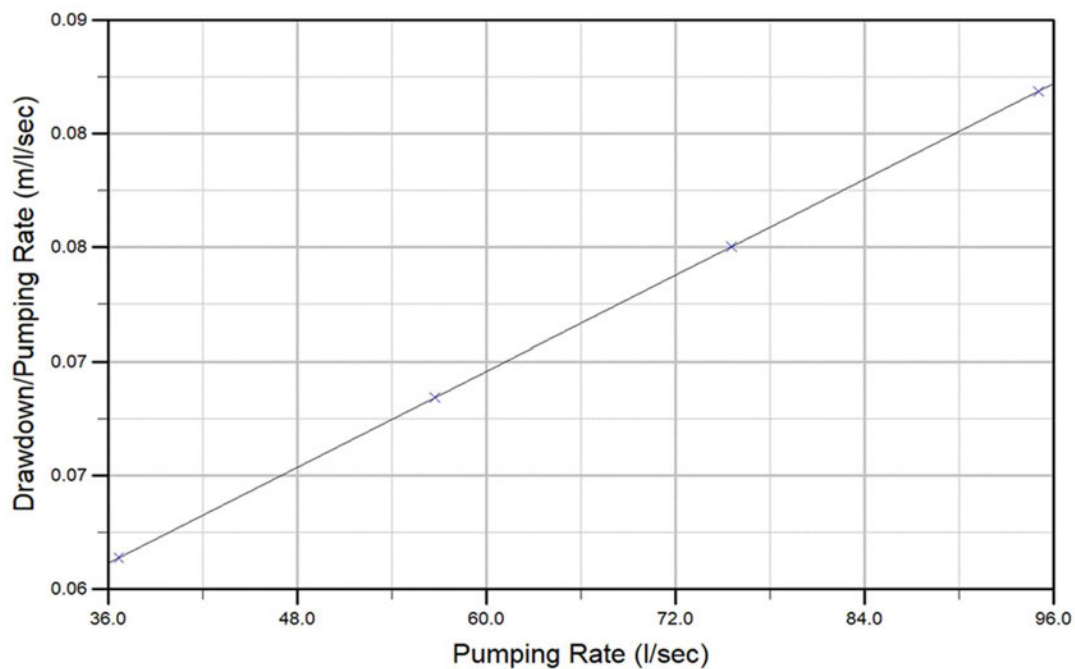


Figure 13: Eden-Hazel Step 2 plotting of final drawdown / pumping rate versus pumping rate as per (Logan, 1964)

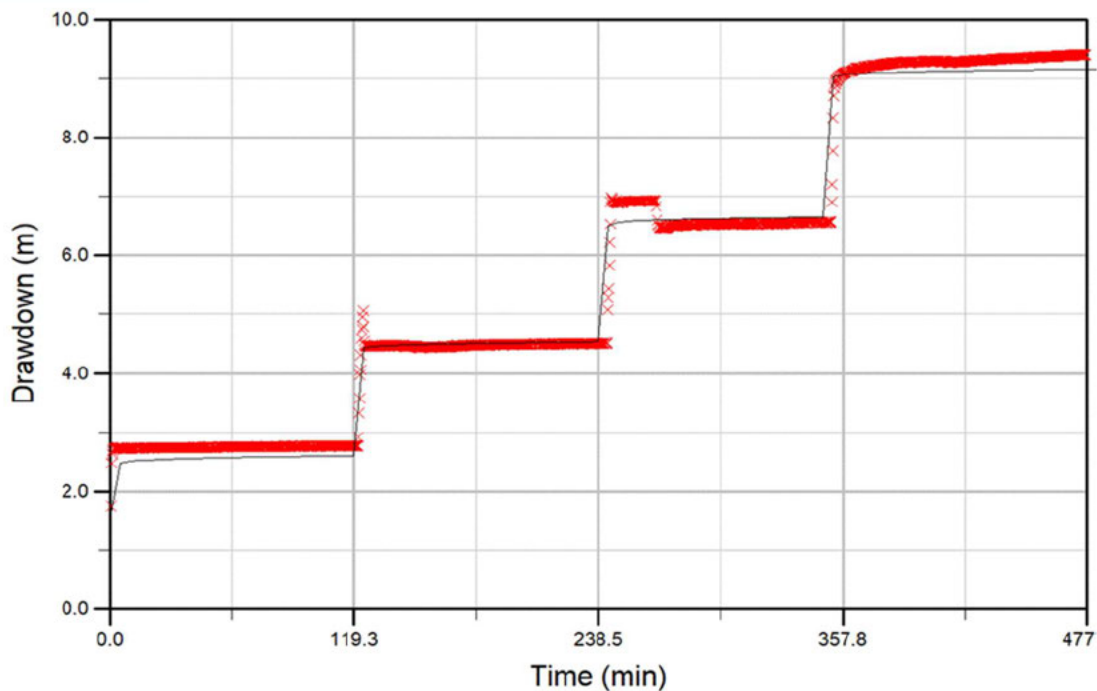


Figure 14: Matched theoretical drawdown versus field step drawdown data on linear axes

The above curve matches, and as reinforced in Figure 14, show a reasonably good match between recorded field data and the Eden-Hazel generated profiles of the drawdown timeseries. The mean of errors and absolute mean of errors are 0.07 metres and 0.17 metres, respectively. The curve match allows the conversion to predicted hydraulic properties in Table 7, which reference the Eden – Hazel Equation.

Table 7: Summary of Hydraulic Properties indicated by Eden-Hazel Method

Hydraulic Property	Derived Value	Remarks
Aquifer Transmissivity (m ² /d)	6,580	Eden – Hazel transmissivity derivation is often at odds with the same property derived by other means, especially observation bore drawdown and recovery analysis.
A coefficient	5.35E-04	Coefficients in Eden – Hazel equation
B coefficient	2.78E-05	
C coefficient	5.64E-08	

The Eden – Hazel equation defines pumped bore drawdown as follows:

$$S_w = [A + B \cdot \log(t)] \cdot Q + CQ^2$$

Equation 3

Where:

- S_w = Drawdown in the pumped bore (m)
- Q = Bore pumping rate (m³/d)
- t = time from start of pumping (days)
- A, B, C = Derived coefficients in the Eden – Hazel equation (dimensionless, no units)

The Eden – Hazel Equation (Eden & Hazel, 1973) thus defines the short-term capacity of the 400 mm diameter bore. The Aquifer^{Win32} package also provides plot of bore yield versus drawdown for periods of time equivalent to the duration of the step rate test. Figure 15 illustrates this projection of bore capacity from step test data.

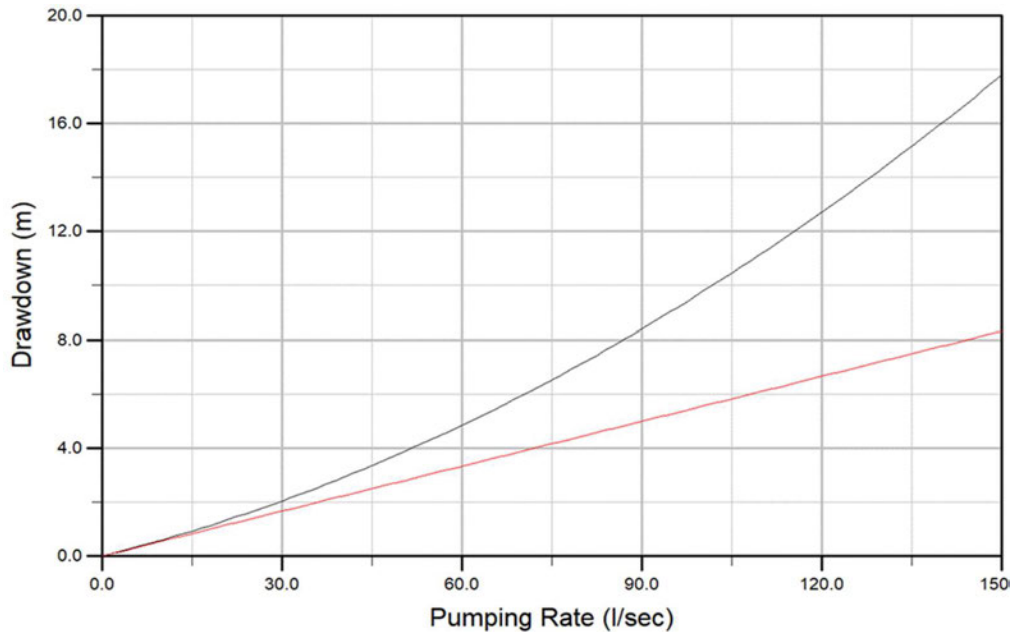


Figure 15: Plot of projected short-term drawdown versus bore pumping rate, from Eden – Hazel Method

3.5.3 Observation Bore Step Drawdown Analysis

Step rate testing groundwater levels were also measured at the observation bore. The trend in water level response is also shown in Figure 11. The water level trend followed that of the pumped bore but at a drawdown between 15% – 20% of the magnitude measured in the pumped bore as shown in Figure 16.

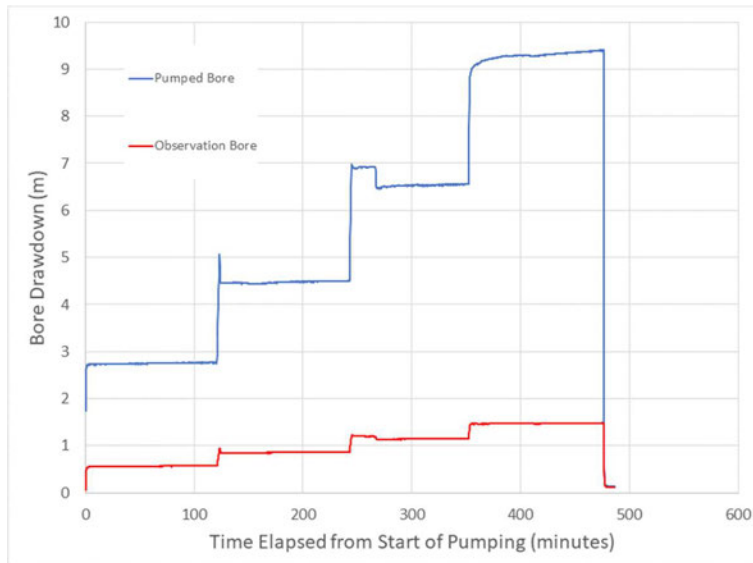


Figure 16: Combined plot of pumped bore (blue) and observation bore (red) drawdown in SRT

The observation bore drawdown timeseries may be analysed as a variable rate test with AQTESOLV, where the applied pumping rates and the separation distance between the pumped bore and point of observation are used to derive hydraulic properties. Figure 17 shows the curve match using the Neuman Method (Neuman, 1974).

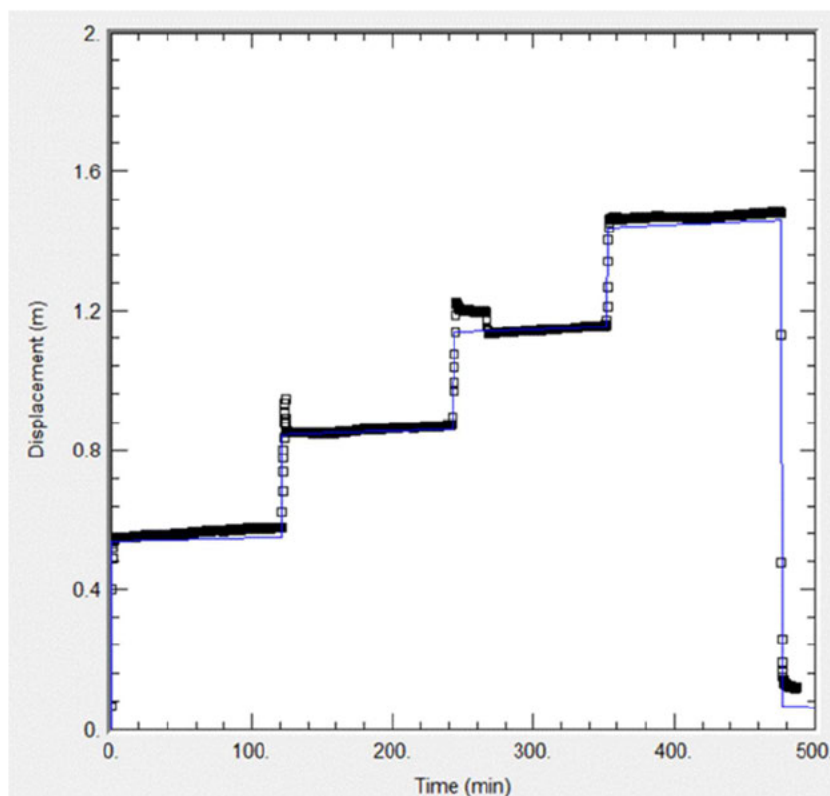


Figure 17: Linear axes plot of matched and field drawdown using the Neuman Method

The result in terms of aquifer transmissivity is provided in Table 8, below.

Table 8: SRT Observation Bore and Neuman Method derived Transmissivity

Hydraulic Property	Derived Value
Aquifer Transmissivity (m ² /d)	4,674

Test analysis results for storativity and specific yield were 1.16×10^{-32} and 0.001, respectively. However, these values for storage coefficients fall well outside plausible limits. Accordingly, these derived values were left out of Table 8.

3.6 Summary of Aquifer Testing and Pumping Tests

The constant rate test was undertaken at a low rate (20.6 litres per second) of pumping compared to the inferred full capacity of the test production bore. The step rate test traversed pumping rates closer to that of near full capacity, from 36 to 95 litres per second, considerably higher than that of the constant rate test. Each test was designed to fit within the limit of 2,000,000 litres per day (2,000 cubic metres per day) set in Otago Regional Plan: Water rule 12.2.2.3(a) that states down-hole pump testing is a permitted activity provided the taking of groundwater does not exceed 2,000,000 litres per day (23.15 litres per second) and no longer than three consecutive days. The constant rate test was respectively run at 1,780 cubic metres and the step rate test at

1,885 cubic metres, for each day of each test. Even with the generator failure and false start to the CRT, the total length of test pumping was 70 hours, which falls within the 72 hours permitted under Rule 12.2.2.3(a). The minimum length of a constant rate pumping test in an unconfined aquifer recommended by ORC groundwater technical officers is 48 hours. The minimum length of a step rate pumping test in a bore proposed for use above 750 cubic metres per day (8.68 litres per second) recommended by ORC groundwater technical officers is 4 hours. The respective tests met the ORC requirements for maximum pumping rate and minimum pumping duration.

The testing reinforced the conclusion arrived at in drilling that the aquifer at the bore site is unconfined. The constant rate test observation bore drawdown data plotted best against the Neuman Beta curve of 0.007 and the derived specific yield was given as 0.31 (31%), which are both indicative of a water table aquifer of enhanced effective porosity. The storage ratios from the recovery analyses were also consistent with unconfined conditions.

The constant rate testing and step rate test analyses pointed to transmissivity between 4,500 to 6,500 square metres per day. The accepted value for transmissivity was set at 4,500 square metres per day for the conservatism that this value will exert on external groundwater drawdown assessments. Similarly, the specific yield was adjusted to 0.25 (25%) to centre it in the range of historic recorded values. This recognises the role of Open Framework Gravels in the lithologies drilled and logged between the water table at 20.4 m BGL and base of coarse, cobbly gravels at 41 m BGL. The derived hydraulic property values derived in all interpretation analyses is summarised in Table 9.

Table 9: Summary of derived Aquifer Test and Step Rate Test Hydraulic Properties

Bore	Test	Method (& Phase)	T (m ² /d)	K (m/d)	S _y
Observation Bore	Constant Rate	Neuman (Drawdown)	4,508	250	0.31
Pumped Bore	Constant Rate	Theis (Recovery)	5,323	295	–
Observation Bore	Constant Rate	Theis (Recovery)	5,235	290	–
Pumped Bore	Step Rate	Eden – Hazel (Drawdown)	6,580	365	–
Observation Bore	Step Rate	Neuman (Variable rate)	4,674	260	–
Accepted Value			4,500	250	0.25

3.7 Test Site Groundwater Quality

A water sample was taken from the discharge manifold during the second flow step of the 25 July 2024 step rate test while the bore was being pumped at 75.5 L/s and after at least 340 cubic metres of groundwater had been purged from the aquifer that day. The sample was dispatched to the Hills Laboratory in Christchurch overnight and was received for analysis by 10:30 am the next day (26 July 2024). The intended uses of the groundwater within the Bendigo – Ophir Gold Mine Project would be as follows:

- Drinking and hygiene (washing) water in the administration block, operations lunch room and toilet blocks,
- Dust suppression of haul roads and other disturbed surfaces, and
- Make-up water for the ore processing plant.

The drinking water use tends to set the standard or guideline as to acceptability of the water analysed. Therefore, the New Zealand Drinking Water Standard (2018) would be referred to in terms of the health concern and aesthetic Maximum Acceptable Values (MAVs). The health MAVs are the more consequential standards, whereas the aesthetic MAVs are closer to guidelines affecting the palatability or other practical consideration relating to domestic water quality (e.g., visual appearance, odour or potential staining of laundry). Table 10 lists the laboratory results obtained for the above mentioned groundwater sample, alongside the detection limit, health concern, aesthetic, freshwater Default Guideline Values (DGV) for 99% species protection.

Table 10: Analytical Results of Groundwater Sample taken on 25 July 2024

Analyte	Units	Test Production Bore CB13/0215	Detection Limits	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99 th %ile DGV (2023)
Sum of Anions	meq/L	1	<0.07	–	–	–
Sum of Cations	meq/L	1	<0.07	–	–	–
Turbidity	NTU	0.48	<0.05	–	≤ 5	–
pH	pH Units	7.8	<0.1	–	7 - 8.5	–
Total Alkalinity	g/m ³ as CaCO ₃	42	<1.0	–	–	–
Bicarbonate	g/m ³ at 25°C	51	<1.0	–	–	–
Total Hardness	g/m ³ as CaCO ₃	37	<1.0	–	≤ 200	–
Electrical Conductivity	(EC) mS/m	9.8	<0.0	–	–	–
Dissolved Aluminium	g/m ³	<0.003	<0.003	1	≤ 0.1	0.027
Dissolved Boron	g/m ³	0.01	<0.005	2.4	–	0.34
Dissolved Calcium	g/m ³	10.8	–	–	–	–
Dissolved Iron	g/m ³	< 0.02	<0.02	–	–	–
Dissolved Magnesium	g/m ³	2.5	<0.02	–	–	–
Dissolved Manganese	g/m ³	0.0007	<0.0005	0.4	≤ 0.04	1.2
Dissolved Potassium	g/m ³	0.8	<0.05	–	–	–
Dissolved Sodium	g/m ³	5.3	<0.02	–	≤200	–
Bromide	g/m ³	< 0.05	<0.05	–	–	–
Total Cyanide	g/m ³	< 0.002	<0.002	0.6	–	–
Chloride	g/m ³	2.2	<0.5	–	≤250	–
Fluoride	g/m ³	0.08	<0.05	1.5	–	–
Nitrite-N	g/m ³	< 0.002	<0.002	0.92	–	–
Nitrate-N	g/m ³	0.46	<0.001	11.3	–	–
Nitrate-N + Nitrite-N	g/m ³	0.46	<0.002	11.3	–	–
Reactive Silica	g/m ³ as SiO ₂	13.1	<0.1	–	–	–
Sulphate	g/m ³	3.2	<0.5	–	≤ 250	–
Dissolved Organic Carbon (DOC)	(DOC) g/m ³	0.5	<0.5	–	–	–
Total Organic Carbon (TOC)	(TOC) g/m ³	0.7	<0.5	–	–	–
Absorbance at 254 nanometre	AU cm ⁻¹	0.003	<0.002	–	–	–
Transmittance at 254 nm	%T, 1 cm cell	99.4	<0.5	–	–	–
Dissolved Arsenic	g/m ³	< 0.0010	< 0.0010	0.01	–	0.0008
Dissolved Cadmium	g/m ³	< 0.00005	< 0.00005	0.004	–	0.00006
Dissolved Chromium	g/m ³	< 0.0005	< 0.0005	0.05	–	0.00001
Dissolved Copper	g/m ³	< 0.0005	< 0.0005	2	≤ 1	0.001
Dissolved Lead	g/m ³	< 0.00010	<0.00010	0.01	–	0.001
Dissolved Nickel	g/m ³	< 0.0005	< 0.0005	0.08	–	0.008
Dissolved Zinc	g/m ³	< 0.0010	< 0.0010	–	≤ 1.5	0.024

Note: Any exceedance of a drinking water standard or ANZG95 guideline would be highlighted in **bold** or **red** script, respectively.

Notably, not one of the laboratory concentrations in Table 10 exceed any of the relevant standards or guidelines. The water sample reported as a laboratory analysis in Table 10 is atypical for Otago groundwater. The dissolved solids content is significantly lower than typical for groundwater in Otago (Levy et al., 2021), as suggested by the sum of cations and anions of 1 milliequivalents per litre (meq/L) each, plus the measured electrical conductivity of less than 10 milliseimens per metre (mS/m). Notably, the iron and manganese concentrations were low, below their respective detection limits, suggesting the oxygen content of the groundwater is higher than typical for deep groundwater. Despite the oxygenation, the nitrate nitrogen concentration equated to 0.4 g/m³, which is very low, indicating 'minimally impacted nutrient status' (Daughney et al., 2023). Not one of the seven dissolved heavy metals exceeded the analytical detection limit to register a concentration.

The water typing and chemical indications from the groundwater analysis while being atypical for groundwater were more typical of surface water in the Upper Clutha Valley, with the possible exception of the elevated reactive silica concentration. Given the predominant sources of groundwater replenishment for the Bendigo Aquifer are Bendigo Creek, Lindis and Clutha rivers, the chemical characteristics of the water taken at the Matakanui Gold Ltd production bore were not surprising.

3.8 Indicated Bore Capacity

3.8.1 400 mm Diameter Bores

The capacity of the 400 mm diameter test production bore was governed by a number of interacting factors:

- The pump intake depth setting, as the pump cannot be operated with the water level too close to the intake depth setting,
- The initial (static or natural) water level in the bore, and
- The internal drawdown or operating water level decline,

The internal drawdown has been correlated to the pumping rate in the step drawdown testing and development of the Eden – Hazel Equation (see section 3.5.2.1). Figure 18 illustrates the relationship of screening, pump intake setting, initial water level and maximum drawdown.

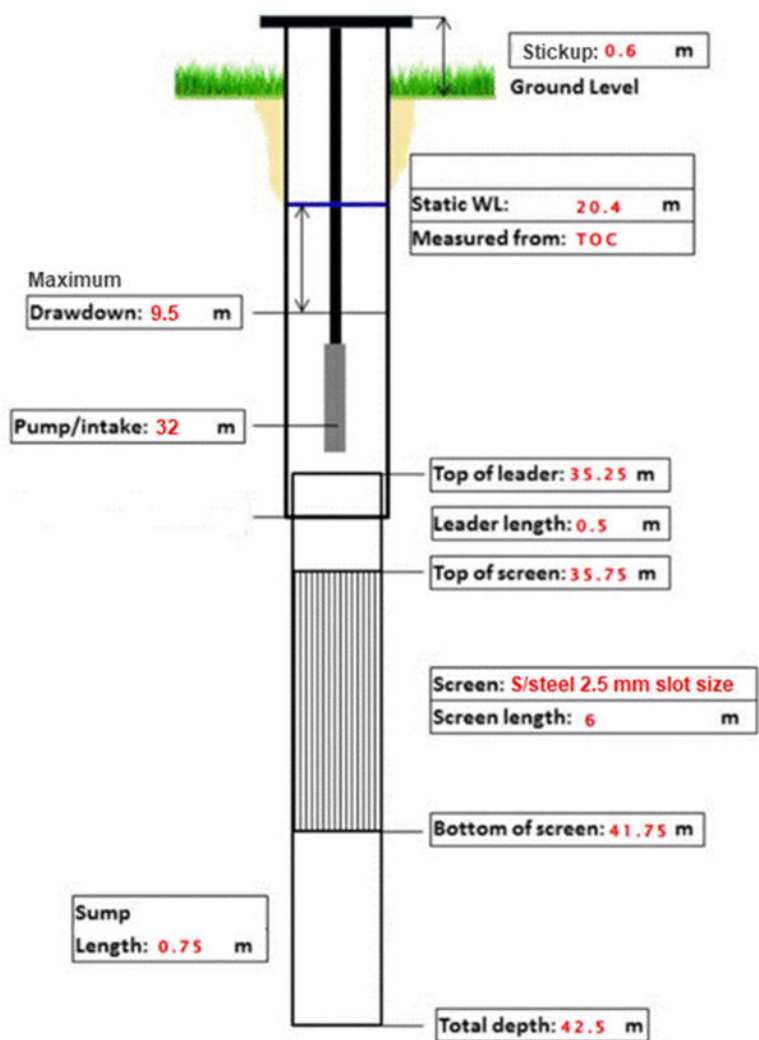


Figure 18: Schematic diagram of test production bore dimensions

Figure 18 indicates that the maximum long-term drawdown is indicated as 9.5 metres which maintains a 2 metre water depth above the pump intake setting. This is feasible since the top of leader is located clear of the pump end at 35.25 m BGL.

The Eden – Hazel Equation calculates the maximum 365 day (1-year) pumping rate of 100 litres per second as inducing 9.45 metres of drawdown (S_w):

$$S_w = [A + B \cdot \log(t)] \cdot Q + CQ^2 \quad (\text{Equation 3})$$

$$S_w = 9.45 \text{ m}$$

Where:

A =	5.35E-04	(from
B =	2.78E-05	Eden-
C =	5.64E-08	Hazel)
t =	365	days
Q =	8,640	m ³ /d
Q =	100	L/s

As a secondary check of the above calculation, Figure 15 plotting pumping rate versus bore internal drawdown defines a rate of 100 litres per second as closer to 10 metres total drawdown. The above dimensioning and calculation would indicate that maximum drawdown of 9.5 metres is consistent with a rate of 95 L/s and this is a feasible medium term pumping rate for the 400 mm diameter production bore. Short-term periods of hours to a few days of pumping rates slightly higher than 100 litres per second are likely to still be within the indicated well screen hydraulic characteristics determined in testing. All such projections of well screen hydraulic coefficients into long-term pumping capacity is uncertain, especially in relation to well screen efficiency related to the C coefficient. It should be stressed that the proposed operational production bores installed to provide the design water supply rates would require to be tested by pumping trials following the grant of consent approval to confirm their capacity with greater precision.

3.8.2 150 mm Diameter Bore

The 150 millimetre diameter bore has the capacity to provide future reserve pumping capacity. This resulting 150 millimetre diameter bore was extended to the full depth of the aquifer and was fitted with a 2 metre length of 138 millimetre diameter stainless screen. The well screen was developed by airlift over-pumping for five hours at approximate rates of flow of 20 litres per second. Subsequently, a short, 2-hour specific capacity test using a single phase submersible pump unit was run at 2.0 litres per second for a final drawdown of 0.26 metres. A specific capacity of 7.7 litres per second per metre of drawdown was derived. The indications from the specific capacity test suggest that the consequent total drawdown with the reserve bore pumped at 20 litres per second would be approximately 3.0 metres

The aquifer transmissivity of 4,500 to 5,500 m²/d derived from the analysis of the test production bore, and the dimensions of the bore construction indicate that a high performance 6-inch bore pump could be installed and operate at pumping rates up to 20 litres per second for extended periods. While this capacity has not been specifically confirmed in testing nor have environmental effects been individually assessed, the pumping capacity of 20 litres per second from the monitoring bore (CB13/0216) is a reasonable expectation. The pumping capacity limitation is also most likely to be imposed by the ability to accommodate a small diameter electric submersible pump (5-inch bore pumps reach their maximum pumping rate at approximately 22 litres per second) rather than well screen hydraulics.

4 Project Description & Proposals for Bendigo – Ophir Gold Project

4.1 Proposed Water Supply

A number of mine operations and ancillary services would require make-up water as part of their process. While many of the processes, such as ore processing or dust suppression, may be capable of utilising mine-impacted water. Some other uses of water supply such as drinking water at mine offices and staff facilities would specify alluvial groundwater for its low mineral content, water clarity, and security against microbial contamination.

At different stages of the project operations, the mine water available as mine-impacted water from dewatering, mine site runoff or tailings decant would also be insufficient. External make-up water would be required to fill out the water requirement, especially in the early years and later years of mining. So, the balancing of water requirements and mine water availability would necessitate the securing of clean water top-up from the proposed bore field. The initial commissioning phase of the ore processing plant operation would also ideally be provided by the clean water supply.

Water supply options study identified that obtaining water supply from surface water other than the Clutha River / Mata Au would run into challenges of limited allocation, environmental effects sensitivity, and competition for water with irrigators. This study was formulated in the context of the tributary catchments of the Clutha River / Mata Au in the Bendigo – Tarras district as being water-short, and there being ongoing competition for water resources. Water plan restrictions on granting water permits are merely the regulatory expressions of this situation. Smaller creeks and river tributaries in Central Otago tended to be fully allocated in the water resource context, therefore potential sources such as the Lindis River mainstem, upper Thomsons Creek, Bendigo Creek, or Lindis catchment tributaries were excluded from the options short-list. At the conclusion of the analysis, the Bendigo Aquifer or the Clutha River / Mata Au were the singular water resources envisaged in reasonable proximity to the Bendigo – Ophir Gold Project mining complex.

4.1.1 Clean Water Requirement

The mine water balance model (Mine Waste Management, 2025) was used to estimate the clean water requirement for the main phases of mining operations, including construction, commissioning, continuing operations, wind-down and decommissioning. It was found that the projected peak clean water make-up water requirement for the Bendigo – Ophir Gold Project would be 97 L/s, providing some nominal water storage was available closer to the points of use. Much of the water requirement would arise in the first years of mine operation during a period that mine water³ availability from pit and underground dewatering surplus would be lowest. Seasonally, the summer and late summer period would entail the highest demand for water for use in dust suppression, although the preferred source of water for dust suppression would be mine-impacted water. Ore processing plant through-put rates and therefore water demand would be variable in accordance with the short-term stripping ratio, but not seasonal other than the increase in dust suppression water demand in hot, windy conditions.

Table 11: Proposed Consent Pumping Rate and Volume Requirement

	Rate or Volume	Explanation
Maximum Instantaneous (L/s)	120	Estimated maximum demand and an allowance for instantaneous overshoot.
Maximum Daily (L/s)	110	Based on water demand indications
Maximum Daily (m ³ /d)	9,504	Daily rate multiplied by 86.4
Maximum Monthly (m ³ /month)	285,120	Daily rate multiplied by 30
Maximum Annual (m ³ /year)	3,153,600	100 L/s multiplied by 86.4, multiplied by 365

³ Mine water = mine-impacted water, including mine workings pumping of groundwater, processing decant water or runoff from within the mine perimeter. Mine water could in most instances be used for ore processing make-up water or dust suppression.

Table 11 outlines the proposed consent envelope rather than the estimated rates of actual use. The bore field and clean water reservoir would be operated to smooth out water throughput and facilitate water conservation. Environmental assessments would refer to the values other than the maximum instantaneous rate provided in Table 11, above.

4.1.2 Bore Field

It is proposed to install a bore field tapping the Bendigo Aquifer between Bendigo Loop Road and State Highway 8 at the site of the current test production bore. Comprising two bores, a duty and stand-by bore, with individual instantaneous capacities of 120 L/s, the bores would be fitted with electric submersible pumps controlled by Variable Speed Drives (VSDs) for flexibility of the rate of bore pumping. The production bores of the eventual bore field may be constructed to optimise the water bore efficiency and pumping rate, including optimising the depth of submersible pump intake, well screen length and the possible use of larger screen diameters with a basal pump housing. By such measures, the eventual production bores would have higher instantaneous and long-term pumping capacity than the 400 millimetre test production bore.

To be clear, the duty and stand-by production bores are not intended or anticipated to be operated except as in turn, meaning that when one bore was pumping the other on stand-by would be inoperative. The sole simultaneous operation of two bores might be the 400 millimetre diameter test production bore and the 150 millimetre diameter reserve bore. Bore to bore competitive drawdown between the test production bore and reserve bore is assessed to be low and consistent with efficient operation of both bores. The external effects of groundwater level decline as a result of pumping at rates of 110 litres per second (for short periods up to a month) and 100 litres per second (for longer periods beyond one month) is dealt with in more detail in the effects sections (see section 5.3).

4.1.3 Water Conveyance & Storage Infrastructure

The bore field site lies approximately 6.5 kilometres from the main ore processing area and the clean water reservoir. The supply bore field would connect with the mining complex by a buried HPDE pipeline to the clean water reservoir, and then reticulated to points of use. Figure 1 maps the alignment of the supply pipeline between the bore field and water reservoir at the mine site.

4.1.4 Water Supply Bore Field Rehabilitation

Disused water bores would be decommissioned by extraction of screen and casing, if physically feasible. The screen or casing may become bonded to surrounding soil particles making the removal of these infeasible. In this case, the residual casing and screen would be filled with impermeable bentonite cement and capped to prevent the ingress of contaminants in accordance with the New Zealand Environmental Standard for drilling of soil and rock (NZS 4411:2001). If the casing and screen can be recovered, then the open hole would be filled with impermeable bentonite cement and capped to prevent the ingress of contaminants in accordance with the New Zealand Environmental Standard for drilling of soil and rock (NZS 4411:2001). Authorising consent application to Otago Regional Council may be required to ensure the bore rehabilitation proposal is adequate, and to trigger monitoring of the finished decommissioning work.

5 Assessment of Groundwater Effects Arising from Proposed Activities

5.1 Effects Section Structure

Having outlined the nature and scale of proposed activities within the context of the existing environment, the task of this section of the document is to define and make predictions of consequent effects. The opportunities to avoid, mitigate, and monitor potential effects are further examined in the following section.

5.2 Potential Effects of Water Supply Bore Field Abstraction

A bore field of two large capacity bores (one duty, one reserve) would be developed in the mid-southern part of the Bendigo Aquifer and connected by a pipeline to the BOGMP mine site clean water reservoir. The principal potential effects of large groundwater abstractions from highly permeable and porous aquifers are as follow:

- Groundwater level lowering (water table drawdown),
 - Lowering of the water table in neighbouring bores or wells
- Depletion of surface water flows (pumping induced interception or drainage of flow that might otherwise support surface flow),
- Long-term depletion of the state of the aquifer due to imbalances in the water balance imposed by bore abstraction.
- Depletion and/or water level lowering within groundwater-connected wetlands,
- Potential subsidence effects.

Summarising the Existing Environment section, the Bendigo Aquifer has been most recently investigated by Clare Houlbrooke (Houlbrooke, 2010) as part of the Bendigo - Tarras groundwater zones administered by Otago Regional Council. The Bendigo Aquifer is bounded by the Clutha River / Mata Au in the west, older less permeable glacial till of the Bendigo Terrace to the east, the Lindis River and alluvium to the north, and Haast Schist rock hills to the south. The base of the Bendigo Aquifer onto which the gravel deposits directly rests is low permeability Tertiary sediments (silty sand lithology) or schist. The wider aquifer as defined by ORC has an extent of 16.9 square kilometres (km²), however a stricter delineation of the accepted aquifer extent is 14.1 km². The Bendigo Aquifer comprises Albert Town and Hāwea outwash, plus Holocene river alluvium outside of the active Clutha River / Mata Au flood plain. There are in excess of 30 actively utilised water bores in the Bendigo Aquifer. There are also a dozen or so bores of large diameter within 100 metres of the true left edge of the Clutha River / Mata Au deployed to side-drain the river for pumping to irrigated pasture or viticulture and horticultural blocks. These riparian bores, while falling within regulatory boundaries of the Bendigo Aquifer, have little impact up on the hydrology of the core aquifer.

5.3 Prediction of Effects

Standard approaches to prediction of effects were employed to predict potential impacts:

- Field determinations using the bore field's bores and observation bores,
 - Geological logging,
 - Sampling and laboratory analysis for groundwater chemistry,
 - Step drawdown pumping test analysis, and
 - Constant rate pumping test analysis.
- Analytical equations for predicting effects such as drawdown between bores (Theis, 1935), and surface flow depletion (Jenkins, 1977).

The field determinations obtained in drilling / aquifer testing investigations in June and July 2024 used conventional logging, pumping tests with observation bores and sampling of groundwater. The result of analysis indicated the following groundwater properties, as listed in Table 12.

Table 12: Summary of Groundwater Properties estimated from Field Determinations

Property or Parameter	Value	Unit	Remarks
Aquifer Transmissivity, T	4,500	m ² /d	The lower of interpreted values in pumping test analysis
Saturated Thickness, b	18	m	As per bore logs
Horizontal Hydraulic Conductivity, K	250	m/d	K = T/b
Aquifer Storage, S _s	0.0001 (1 x 10 ⁻⁴)	(1 dimensionless	Specific storage
Aquifer Storage, S _y	0.25 (25%)	dimensionless	Specific yield, adjusted downward from test derived specific yield of 0.31 (31%)
Pressure State	Unconfined		Unconfined state is specified in predictive equation calculations by using a specific yield of 0.25.

5.3.1 Drawdown Effects on Surrounding Groundwater Users

5.3.1.1 Calculation of Drawdown Effects

Drawdown effect prediction points to concentric rings of water table lowering surrounding the water supply bore during short and long-term pumping in line with the proposed abstraction proposal. Calculations of drawdown using the conventional Theis method (Theis, 1935) were undertaken using the hydraulic properties set out in Table 12, the proposed consented pumping rate of 110 litres per second (see discussion below) and measured distances between lawful water users that use bores screened in the same aquifer and are mostly located within 2.34 kilometres of the proposed Matakanui Gold Ltd (MGL) production bore. The list of potentially drawdown-affected bores is included in Table 13.

Further dimensions are set in the calculation of estimated drawdown at distance; namely the time of continuous pumping and the radius or distance from the MGL production bore and the potentially drawdown-affected bore owned by neighbours. For illustrative purposes, 90 days and 365 days are assessed for time intervals. Irrigation takes often set the duration of pumping at the ratio of maximum annual volume and maximum daily volume. For example, a hypothetical proposed annual volume for an irrigation consent application would be 1 million cubic metres and the daily maximum 4,762 cubic metres (equivalent to 55 litres per second), implying a 210 day pumping duration at maximum rates. The maximum annual and daily maximum rates would be set quite differently for the mining complex due to the more continuous operation of the mine, while also recognising the shifts in water demand in response to changing dust suppression requirements. Therefore, the pumping duration to be used in estimation drawdown is as yet uncertain. The drawdown effects associated with continuous pumping at 110 litres per second throughout the year is specified in Table 13.

For further perspective, the Eden - Hazel equation (Equation 3) was used to calculate the internal drawdown, within the MGL production bore casing, which includes screen head losses, is also listed in Table 13 and plotted in Figure 21. The aquifer-only head losses as calculated with the Eden - Hazel equation using the relevant step

drawdown test-derived 'A' coefficient is provided in brackets to illustrate the estimated drawdown at the pumping centre without the impact of the screen related head losses.

Table 13: Estimates of Drawdown for Surrounding Bores with 2.34 kilometres of Production Bore (CB13/0215)

ORC Bore No.	Radius from Centre of Bore (m)	Drawdown @ 90 days (m)	Drawdown @ 365 days (m)
MGL Production Bore (CB13/0215)	0.2	9.3* (5.09)	9.45* (5.24)
CB13/0156	236	0.704	0.938
G41/0206	422	0.512	0.744
G41/0225	434	0.502	0.734
G41/0262	497	0.458	0.689
G41/0332	547	0.428	0.657
G41/0270	617	0.389	0.617
G41/0373	624	0.386	0.613
CB13/0159	876	0.281	0.502
G41/0230	928	0.264	0.483
G41/0181	951	0.257	0.475
G41/0203	1,513	0.132	0.328
G41/0387	1,800	0.094	0.275
0.2 m Threshold	2,340	0.048	0.200

Note: * indicates that the Eden – Hazel Equation was used to calculate estimated total production bore drawdown, with the aquifer-only drawdown in (brackets).

Drawdowns at surrounding bores are all at less than 1 metre of effect. The estimated effect at the closest neighbouring bore (CB13/0156) is 0.94 metres by one year of pumping, while the distance out to the 0.2 metre effect by 365 days would be 2,340 metres distant from the MGL production bore (see Figure 19, Figure 20 and Figure 21).

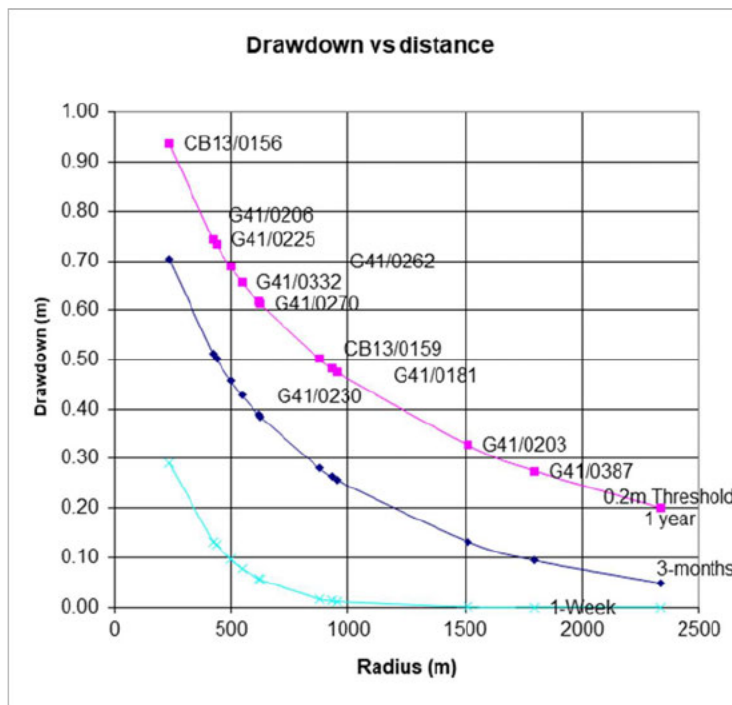


Figure 19: Distance – Drawdown plot of surrounding bore radii for 1-week, 3-month, and 365-day durations

A profile of drawdown versus distance is provided in Figure 21 that illustrates the decreasing drawdown intensity radiating outwards from the MGL production bore pumping at the maximum rate over a full year of operation.

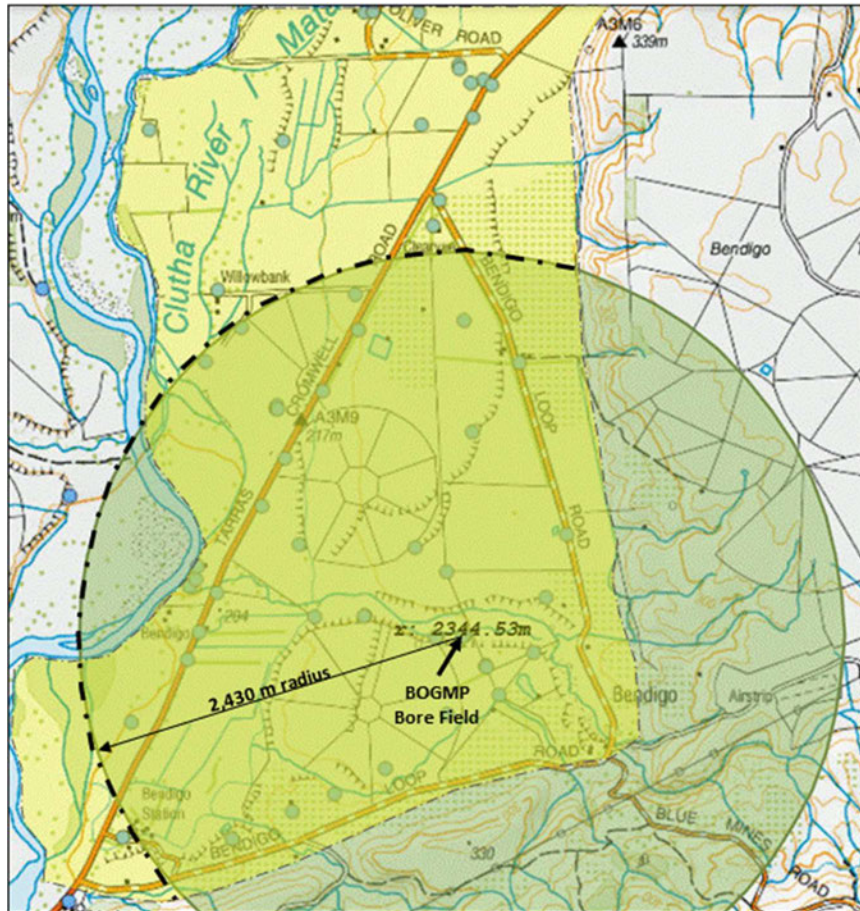


Figure 20: Mapping of the extent of Bendigo Aquifer and potentially affected registered bores within 2.34 km

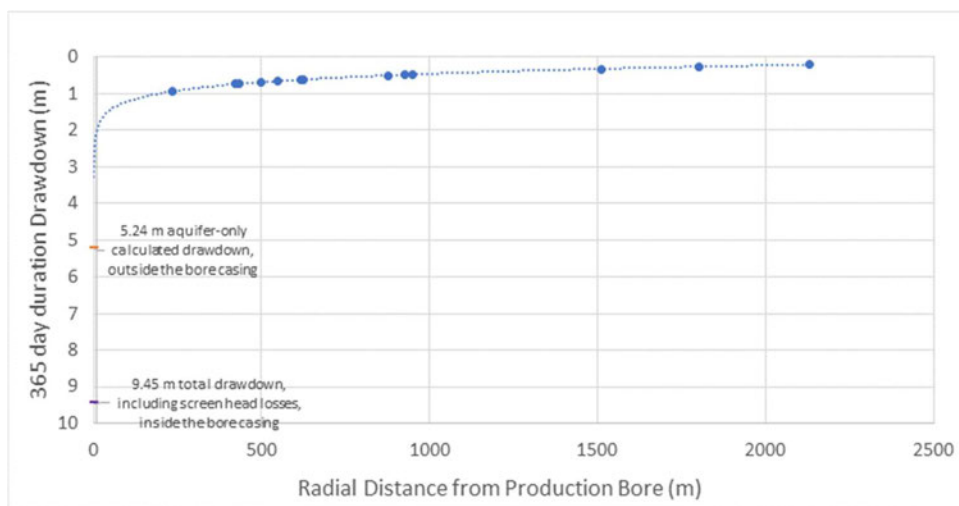


Figure 21: Radial profile of drawdowns calculated with the Eden - Hazel (pumping bore) or Theis equations

It is worthwhile noting that the Theis equation calculations assume an infinite aquifer, while the Bendigo Aquifer is inferred to have strong recharge, recharge boundary, and barrier boundary conditions active in mediating hydrologic response. Expanding on this tendency of the Theis Equation, the calculations using the equation makes no account of vertical recharge to the water table nor the lateral recharge of river or lake water, which makes the prediction of drawdown an over-estimate and conservative. This could result in existing bores lying between the proposed production bore and the boundary conditions differing very slightly from the values of drawdown provided in Table 13, Figure 19, and Figure 21, but particularly at the extremes of distance.

5.3.1.2 The Interpretation of Effects from Calculated Drawdown

Calculated drawdowns for specified external pumping rates and specified periods of pumping are not directly transferable into external effects of the pumping (taking / abstraction) of groundwater by a bore. Each one of the large diameter bores in the Bendigo Aquifer exert drawdown effects and absorb drawdown effects from surrounding bores in the Bendigo Aquifer and have done so for as many years as bore development has gone on in the area. There are no reports or complaints of bore failure in the Bendigo Aquifer, and as a result the aquifer has received little attention from the regional water authority, ORC. The sum total of groundwater science applied to Bendigo Aquifer has been a reconnaissance study in the early 2000s (Sinclair Knight Merz, 2004), a characterisation and steady state modelling study five years later (Houlbrooke, 2010), and the installation of a groundwater level monitoring bore in line with regional monitoring policy some ten years later (ORC monitoring bore CB13/0159 installed in August 2021). ORC as consent authority has since 2001, steadily approved consents to take groundwater for the aquifer to at least 37 large diameter bores, eight of which are so close to the Clutha River / Mata Au that the bulk of the water taken is calculated to be derived from the river rather than solely the aquifer. In the absence of reports or complaints of bore failure registered with the regional water authority, it can be surmised that competitive bore interference does not play a large part in the operation of the Bendigo Aquifer as a water resource.

For competitive bore to bore interference to occur, the following factors are needed to be present:

- A bore (individually) or many bores (cumulatively) cause a drawdown effect that extends to an affected bore,
- The combination of additional water level lowering factors affect the bore –
 - Self-induced hydraulic water level lowering due to habitual pumping, and
 - External environmental water level lowering due to climate, surface water or drainage, and
- A vulnerability due to the height of the bore pump unit intake exists.

Where the aggregate of these factors result in the operating bore water level approaching the depth of the bore pump unit intake, the pump may begin vortexing and sucking air, causing flow reduction and in extreme cases the failure of pumping all together. The Bendigo Aquifer has anomalously high permeability, access to recharge and saturated depth for an unconfined aquifer such that self-induced hydraulic water level lowering in any efficient bore is small to negligible. As a consequence high pumping rate bore have been installed to draw on the aquifer.

ORC has a measure of competitive bore to bore interference in Schedule 5B of the Otago Regional Plan: Water. The schedule is titled “Schedule for the method for identifying groundwater takes potentially affected by bore interference.” It specifies that the Theis equation is to be used to calculate drawdown effect from a neighbouring bore. It also states, “the radius (for identifying parties considered affected) will be determined using a significant interference of $d \geq 1$ m for confined aquifers or $d \geq 0.2$ m for unconfined aquifers, and the ‘Theis’ equation”. In some cases, this has been misinterpreted to indicate a radius with which drawdown effects are ‘significant.’ This interpretation does not follow. Instead ORC use Schedule 5B to set a radius around the site of an application to take groundwater commensurate with the conditions of the aquifer and the application, such as proposed pumping rate, for identifying potentially affected surrounding groundwater users. Once the list of potentially

affected groundwater users and their bores are whittled down, the task of assessing drawdown effects may begin.

Assessing the effect of proposed new groundwater pumping is not cut and dried. The most important part of any such assessment is obtaining valid aquifer parameters, primarily hydraulic conductivity, transmissivity and storage coefficients for rigorous aquifer testing. This was the subject of the foregoing chapter of this document and obtained accurate estimates for these parameters at an intensity of pumping roughly equivalent to the proposed maximum rates of use. The remainder of the assessment is outlined in the following section 5.3.1.3.

5.3.1.3 Estimated Effect of Drawdown on Surrounding Bores

All bores in the Bendigo Aquifer are to some extent resilient to variation in groundwater level. Measured groundwater level annual variation is in the order of 2 metres with peaks in early spring followed by dips in autumn. The maximum departure below the mean in the three year groundwater level record shown in Figure 3 was 1.02 metres, indicating the normal lows in groundwater levels beneath the water table fluctuation mid-point. The groundwater level variations displayed in Figure 3 also include the effects of the existing intensity of drawdown effect due to consented groundwater extraction by surrounding bores. Table 14 lists the relevant bores surrounding the MGL production bore field to a distance of 1.2 kilometres.

Table 14: Listing of Bores within 1.2 kilometres of MGL Production Bore, plus Freeboard, & Drawdown

Radius (m)	Well No.	Depth (m)	Owner Name or Entity (as recorded in the original bore survey or consent application)	Use of Water	DTW (m)	Screen Top Depth (m)	Freeboard* (m)	Calculated Drawdown @ 365 days (m)	Dd % of FB [‡]
236	CB13/0156	49.22	Peregrine Estate Ltd	Irr, Stock	28.85	46.23	13.38	0.94	7.01%
422	G41/0206	29.41	Waitata Investments Ltd	Dom, Irr	16.92	26.28	5.36	0.74	13.9%
434	G41/0225	48.4		Dom, Irr	30.78	45.7	10.92	0.73	6.7%
497	G41/0262	46.15		Dom, Irr	28.05	41.35	9.3	0.69	7.4%
547	G41/0332	49.05		Dom, Irr	29	45.95	12.95	0.66	5.1%
617	G41/0270	36.4	Zebra NZ Vineyards Ltd	Dom, Ind	20.86	34.75	9.89	0.62	6.2%
625	G41/0373	35.68		Irr	15.25	26.7	7.45	0.61	8.2%
876	CB13/0159	43.16	Otago Regional Council	SOE	29.38	40.23	6.85	0.50	7.3%
928	G41/0230	29.7		Irr	12.4	21.2	4.8	0.48	10.0%
951	G41/0181	38.44	Quartz Reef Vineyard	Dom, Irr	21.72	35.44	9.72	0.47	4.9%
1,158	G41/0402/1	25.75	Bendigo Terrace GP Ltd	Irr	7.1	17.75	6.65	0.41	6.2%

Note: DTW = Depth To Water. * Freeboard is defined as the depth of water above the critical pump unit depth setting (4 m above screen top). Use of water shorthand: Irr = Irrigation, Dom = Domestic, SOE = State of Environment Monitoring, Stock = Stock water, and Comm/Ind = Commercial or Industrial. [‡]"Dd % of FB" = Drawdown (Dd, from Table 13) as a percentage of freeboard (FB).

Specific examination of two surrounding irrigation bores is provided below:

Bore G41/0206

The highest drawdown as a percentage of freeboard at 13.9% relates to bore G41/0206. The records for G41/0206 indicate a specific capacity of 11.76 Litres per second per metre of drawdown while pumping at 10 litres per second, meaning 1.28 metre of drawdown at the maximum instantaneous pumping rate of 15 litres per second specified in the attached groundwater take consent. Therefore, the freeboard of 5.36 metres would sustain 1.28 metres of self-induced drawdown, plus 0.74 metres of MGL production bore drawdown, plus 1.1 metres of natural water table variation, totalling 3.12 metres and retaining a calculated **2.24 metres of freeboard**.

Bore G41/0230

All other bores within 1.2 kilometres have a drawdown as a percentage of freeboard less than the 8.9% for bore G41/0230. The records for G41/0230 indicate a specific capacity of 77.7 Litres per second per metre of drawdown while pumping at 80 litres per second, meaning 0.98 metre of drawdown at the maximum instantaneous pumping rate of 76.31 litres per second specified in the attached groundwater take consent. Therefore, the freeboard of 4.8 metres would sustain 0.98 metres of self-induced drawdown, plus 0.48 metres of MGL production bore drawdown, plus 1.1 metres of natural water table variation, totalling 2.5 metres and coincidentally also retaining a calculated **2.24 metres of freeboard**.

All other assessed bores would comfortably operate within their consented pumping rates while sustaining the calculated drawdown effect. Bores beyond 1.65 kilometres would have a calculated drawdown effect less than 0.3 metres, which falls into the category of low effect. The Otago Regional Council assessment threshold for drawdown in an unconfined aquifer is 0.2 metres (from Regional Plan: Water, Schedule 5B), which lies beyond a calculated radius of 2.34 kilometres surrounding the MGL proposed bore field (see Figure 20). The place of this calculated drawdown threshold is outlined in 5.3.1.2, but in summary the 0.2 metre drawdown threshold does not indicate the drawdown is significant. Rather, the threshold and radius around a non-notified groundwater take application provides an indication as to the need for limited notification.

The assessment pathway followed in this section that includes comparison of factors of external drawdown, internal / self-induced lowering and natural variation against the available freeboard in the assessed neighbouring bores provides the more realistic approximation of actual effect. Furthermore, environmental factors and potential over-sensitivity to existing bore configurations should be included in the weighing of any assessment of drawdown effects (see next paragraph).

It is also worthwhile noting that while it is standard practice to examine the interests of existing groundwater users against the potential effect of a newcomer groundwater user, there are limits to the extent to which existing water users access to current water flows are required to be preserved. (see for example, *Opiki Water Action Group vs Manawatu—Wanganui Regional Council*, 2004).

Those bores immediately adjacent to the fixed heads of Clutha River / Mata Au or Lake Dunstan would be both distant from the proposed MGL groundwater take, and substantially more influenced by the fixed head of the adjacent water body. Such gallery wells or bores are demonstrably unaffected by the proposed MGL groundwater use. Overall, the high transmissivity and high specific yield storage coefficient of the Bendigo Aquifer, plus the ready hydraulic connection with large water bodies as the Clutha River / Mat Au, lead to conditions where drawdown is on one hand widespread, but on the other hand intensities of induced drawdown are relatively low. Available information points to the proposed MGL production bore pumping at rates up to 110 litres per second over 365 days not affecting surrounding bores to an extent that is more than minor.

5.3.2 Groundwater Depletion Effects on Surrounding Water Bodies

The water bodies surrounding the proposed MGL bore field include the following:

- Bendigo Creek
 - The flowing portions of Bendigo Creek over the basement schist,
 - The intermittent reaches of the creek crossing alluvium and eventually the Bendigo Aquifer.
- School Creek or Chinamans Creek,

- Lindis River between Lindis Crossing (SH8) and the Clutha Confluence,
- Clutha River / Mata Au and Lake Dunstan.

Ephemeral or intermittent creeks cross the Bendigo Aquifer outwash gravel deposits. Bendigo Creek, School Creek and Chinamans Creek all rise in the Dunstan mountains or foothills to the east and south. Only in downpour or extended flooding conditions do the outwash portions of the creeks briefly maintain flow across the aquifer.

5.3.2.1 Ephemeral Creeks

The creek beds of ephemeral or intermittent water courses passing over the Bendigo Aquifer, which include Bendigo Creek, School Creek and Chinamans Creek, are routinely dry and when flowing the creeks are perched above the regional water table. Due to small, dry catchments, riparian evapotranspiration and the tendency for these creeks to lose any surface flow by infiltration on reaching the outwash edge, the creeks are routinely dry aside from periods of flooding. Infiltration would not therefore increase due to MGL bore pumping than currently occurs as the creeks cross onto the Bendigo Aquifer. Therefore, the ephemeral or intermittent creek flow would not be any more affected by the proposed MGL groundwater use.

Furthermore, the presence of an unsaturated zone detachment between the creek beds and Bendigo Aquifer water table means that bore pumping would exert no influence on creek flow or bed infiltration rate. In view of the low and losing flow characteristics of the ephemeral creeks or intermittent plus perching of flood waters above the regional water table, the pumping of the proposed MGL production bore is highly unlikely to have any effect on the water resources or aquatic ecology of these creeks.

5.3.2.2 Clutha River / Mata Au

The Clutha River / Mata Au maintains consistent, perennial flow as outlined in section 2.6, and is in hydraulic connection with the western margin of the alluvial / outwash aquifer. Previous conceptual models, including (Sinclair Knight Merz, 2004), and the 2010 numerical model by ORC (Houlbrooke, 2010) had each determined the Bendigo Aquifer was in intimate hydrological connection with the Clutha River / Mata Au, and to a lesser extent, the lower Lindis River.

Declines in the relatively flat water table gradients that reach the aquifer – river boundaries tend to induce unimpeded infiltration of (Clutha / Mata Au) river water to the aquifer. In this respect the aquifer groundwater flow pattern and state are not dependent on recharge through the aquifer capping soils (in other words Land Surface Recharge). Numerical modelling including (Houlbrooke, 2010), demonstrated that projected groundwater drawdown of substantial bore abstraction would be of light intensity and would be fully compensated by inflow of the Clutha River / Mata Au to the Bendigo Aquifer. There would be few and only low intensity changes to the existing groundwater flow pattern throughout the aquifer as a result of distributed pumping of groundwater up to the groundwater allocation limit (see section 5.3.3.1).

In view of the already high degree of groundwater connection with the larger rivers in contact with the Bendigo Aquifer, the determination of surface water flow depletion due to groundwater bore pumping is theoretical rather than tangible. The surface water resource management effects of groundwater bore pumping are diffuse and dwarfed by the river flows passing the Bendigo Aquifer in the Clutha River / Mata Au.

The theoretical surface water depletion of the Clutha River / Mata Au may be estimated using the Theis-Jenkins Equation (Jenkins, 1977). Figure 22 displays the input data and Theis – Jenkins equation estimation of depletion at the major river margin. The measured distance between the production bore and the closest approach of the river is 1,700 metres (1.7 kilometres). The transmissivity and specific yield derived and accepted from the CB13/0215 pumping tests is specified in the calculation, as is the specific yield. The maximum pumping rate of 110 litres per second is set to evaluate maximum annual depletion effect.

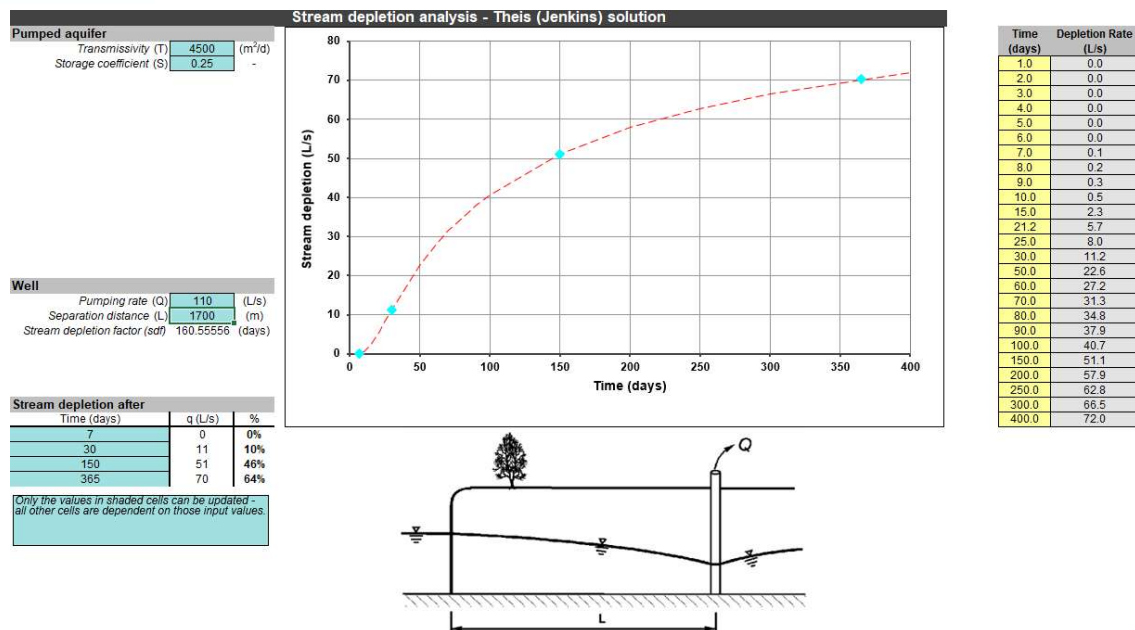


Figure 22: Depletion analytical calculation of the effect of MGL production bore on the Clutha River / Mata Au

The Theis – Jenkins calculations suggest a Stream Depletion Factor (SDF) of 160 days, therefore a significant lag of up to a week (7 days) would pass before any appreciable depletion effect would be exerted on the river. Indeed, three weeks (21 days) would need to pass before the 6 litres per seconds depletion effect is estimated to be exerted. In long-term groundwater pumping, the annual (365 day) estimated surface water depletion of the Clutha River / Mata Au would assume 64% of the total 110 litres per second pumping, i.e., 70 litres per second.

A notable corollary of the time lag for onset is that in the reverse direction, the shutdown of pumping would not result in immediate cessation of surface water depletion effect extending to the river. Instead there would be a period of a week or more following long periods of pumping at consented rates when there is little or no change in the drag on river flow due to depletion. An arising consequence is that minimum flow requirements on the operation of the MGL bore field would provide very little benefit for the Clutha River when the low flow or low lake (Hāwea) level period is of limited duration of say 3 weeks.

To explore the significance of improvement in depletion from a theoretical a minimum flow curtailment of pumping of 3 week duration, Figure 23 is provided as an illustrative plot of the modelling framed around such a 21 day pumping curtailment. The modelled surface water depletion considers pumping at the full rate of 110 litres per second in the preceding 400 days. The hypothetical bore pumping at the Bendigo – Ophir Gold Mine Project bore field would be shut down in response to the minimum flow and the modelled response in reduced depletion is displayed in Figure 23. The modelled depletion rate would plateau for the first week, followed by mild reductions up to 0.5 litres per second at the end of the second week, with reduction in surface water depletion peaking at 5.7 litres per second at the end of the third week.

A reduction in depletion effect on the Clutha River / Mata Au would be undetectable by any direct measurement means such as flow gauging. Thus modelling indicates that minimum flow or minimum lake level conditions of consent restricting the ability to pump Bendigo Aquifer groundwater at the BOGMP bore field would have less than minor benefit in restoring river flow to the Clutha catchment for periods of limited duration.

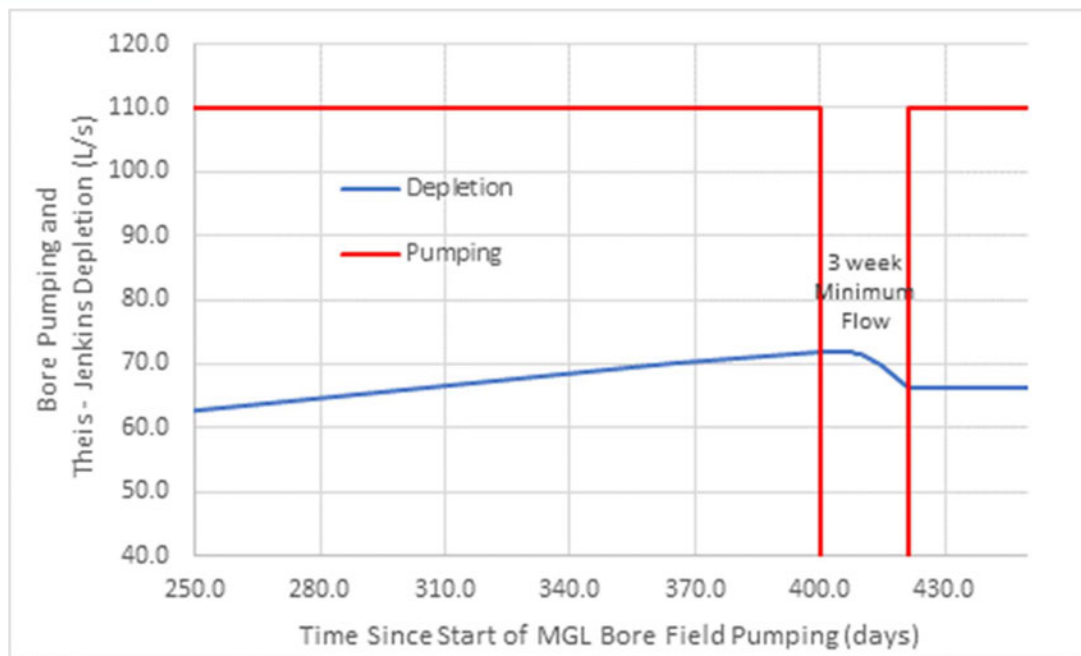


Figure 23: Modelling of the effect of an imposed 3 week duration minimum flow on surface water depletion

5.3.3 Groundwater Sustainability in Terms of the Wider Aquifer

The Bendigo Aquifer is fully bounded, including the Lindis Till to the east and Mesozoic schist to the south, plus the recharge boundaries of the lower Lindis River and Clutha River / Mata Au to the north and west. Vertically, the aquifer is bounded by largely impermeable sediments at its base plus the water-table, free surface at the top. Therefore, the water budget of the Bendigo Aquifer has been quantifiable, pointing to substantial throughflows of groundwater provided by adjoining freshwater bodies listed in above report sections.

The most recent water balance for the Bendigo Aquifer (Houlbrooke, 2010) indicates the land surface recharge is a relatively minor part of the water balance (1.7 million cubic metres versus 47.4 million cubic metres per annum from the rivers, see Table 15). Inflows and outflows with the major rivers, riparian wetland and Lake Dunstan make up the bulk of exchanges with the Bendigo Aquifer as it was estimated with the assistance of numerical modelling (Houlbrooke, 2010).

Table 15: Approximate Bendigo Aquifer Water Balance: ORC Numerical Modelling (Houlbrooke, 2010)

	Inflows (million m ³ /year)	Outflows (million m ³ /year)
Rivers:		
Lindis	+10.9	-3.1
Clutha / Mata Au	+36.5	-37.1
Bendigo Spring (Bendigo Wetland)	–	-6.2
Lake Dunstan	–	-2.7
Rainfall Recharge	+1.7	–
Aquifer Total	+49.1	-49.1

It is notable that the 2010 water balance by ORC failed to include the infiltration of Bendigo Creek water into the Bendigo Aquifer as outlined in sections 2.7.3 and 2.9 of this document. The omission of this source local to

the MGL bore field with the estimated 3.7 million cubic metres of annual recharge from the 2010 water balance listed in Table 15 makes the 2010 assessments of aquifer allocation limit even more conservative in terms of protection against generalised water level lowering.

5.3.3.1 Groundwater Allocation Cap Settings

Recognising the dominance of riverine exchanges and the large volume flowing in the Clutha River / Mata Au main stem (8,546 million cubic metres per annum), the ORC groundwater scientists opted to adopt the groundwater pumping total that would induce a generalised water level lowering throughout the Bendigo Aquifer of no more than 2.0 metres (Houlbrooke, 2010). A series of virtual pumping wells were added as drain (DRN) cells to the model, with levels at approximately 2 metres below static water levels. The virtual pumping wells were spread evenly across the Bendigo groundwater allocation zone and groundwater levels tended to reflect the hydraulic gradients seen in the water table under normal conditions. A buffer without wells was given to the surrounding rivers, as this reflected ORC policies in terms of restricting groundwater takes close to rivers (Houlbrooke, 2010).

This numerical model scenario found that 58.1 million cubic metres per annum could be extracted from the Bendigo Aquifer for a 2.0 metre water level drop. In line with ORC water policy (Plan Change 1C policies; specifically policy 6.4.10A1, 6.4.10A2, rule 12.2.1A.3, Method 15.8.3.1, and Schedule 4A of the Regional Plan: Water), 50% of the “recharge” was set as the allocation limit. This was adopted by ORC as a so-called ‘Blue Book’ allocation limit and is also proposed as the limit within the proposed Otago Land & Water Regional Plan that was scheduled for notification on 31 October 2024⁴. Therefore, this tailored groundwater allocation cap of 29 million cubic metres per annum (July to June) is the existing and potentially the future limit on the groundwater that may be issued in restricted discretionary or discretionary resource consents to take groundwater. Beyond that allocation cap, groundwater take consent applications when the limit would be exceeded may still be considered for granting as a non-complying activity.

5.3.3.2 Current or Future Groundwater Allocation Status

Currently, 16,245,966 cubic metres (i.e., 16.25 million cubic metres) of groundwater are allocated in 30 valid groundwater take consents across the Bendigo Aquifer. This leaves 12,754,034 cubic metres per annum (12.75 million cubic metres annum) for potential allocation in new consents within the Bendigo Aquifer. It is expected that this allocation regime would continue for the foreseeable future, unless the proposed allocation framework is amended in path of the proposed Otago Land & Water Regional Plan through notification, consultation, hearing decision or appeals.

5.3.3.3 Current or Future Surface Water Allocation Status

The Bendigo – Ophir Gold Mine Project water supply groundwater abstraction was calculated to induce up to 62 litres per second depletion of Clutha River / Mata Au over the course of a year using the Jenkins Equation in the relevant section of predicting effects. The Clutha River / Mata Au main stem currently has no allocation limit in the context of the Otago Regional Plan: Water. Therefore, while water allocation may be granted in applications for resource consents, the total of granted and current allocations is not set against any limit.

The Otago Land and Water Regional Plan proposal has a draft surface water allocation setting for rivers with mean annual low flow greater than 5 cubic metres per second (5,000 litres per second):

- Surface water primary **allocated take limit** set as 30% of the Mean Annual Low Flow, and

⁴ Since delayed pending reform of the Resource Management Act (1991) and changes to the previous National Policy Statement – Freshwater Management (2020).

- Surface water controlled for lows with a **minimum flow** set as 80% of the Mean Annual Low Flow⁵

The clearest indication of Mean Annual Low Flow is the sum of the outflows of Lake Wānaka and Lake Hāwea (see Table 1: Summary of Flow Statistics for Upper Clutha Lakes (Wānaka & Hāwea)). The combined MALF_{7d} for these lakes equates to 111.2 cubic metres per second⁶ (111,200 litres per second). Thus the estimated MALF_{7d} in the Clutha River / Mata Au downstream of the glacial lakes and upstream of Lake Dunstan would have default **allocated take limit of 33.36 cubic metres per second** (33,360 litres per second) and potentially subject to a **minimum flow rate of 89 cubic metres per second** (88,960 litres per second).

Current estimates of the surface water consented for consumptive abstraction in the main stem and tributaries of the Clutha River / Mata Au upstream of Lake Dunstan are **22.9 cubic metres per second** (22,900 litres per second). Subtracting the default allocated take limit of 33,360 litres per second from the sum of takes issued in surface water take consents of 22,900 litres per second indicates a remaining allocable total of 10,520 litres per second available to be issued in new water take consents. The balance of water resource effects predictions are that the Matakanui Gold Ltd water supply would induce surface water depletion of 72 litres per second from the Clutha River / Mata Au through groundwater – surface water connection, with the upper limit being the proposed consented pumping rate of 110 L/s.

5.3.3.4 Comparison of Proposed Bendigo – Ophir Gold Project Water Take and Allocation Regime

The proposed water supply to the Bendigo – Ophir Gold Project, including Rise and Shine Pit, Rise and Shine Underground, Come In Time Pit, Srex Pit, Srex East Pit, and associated plant is estimated to peak at a rate of 120 litres per second (instantaneous) with lesser rates and volume over longer time periods. A groundwater take rate of 110 litres per second could prevail over periods up to 1 month and for abstractions periods of a year or more would be limited to 100 litres per second. Table 16 lists the instantaneous, daily, and monthly rates plus annual volume limits on groundwater consent proposed for the mining complex water supply bores from the Bendigo Aquifer.

Table 16: Comparison of Groundwater and Surface Water Consent Requirement versus associated Limits

Source / Allocation Block	Proposed Allocation Required	Available for Allocation
Surface Water (Clutha River / Mata Au u/s of Lake Dunstan)	72 to 100 L/s	Currently no limit (possibly 10,520 L/s available in future within a 33,360 limit)
Groundwater (Bendigo Aquifer)	3,153,600 m ³ /year	12,754,034 m ³ /year

On the basis of prediction of groundwater abstractive effects and the currently available water resource management regime, the proposed Matakanui Gold Ltd water supply from bores adjoining bore CB13/0215 in the Bendigo Aquifer would readily conform with relevant water allocation settings currently set, including those envisaged for future water plans but not yet notified or operative.

5.3.3.5 Contact Energy Ltd

The suite of 17 resource consents granted in the 2000s by ORC to Contact Energy for its three hydroelectricity generation facilities on the Clutha River / Mata Au river system include minimum flow and lake level

⁵ Sourced from: <https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/cluthamata-au/upper-lakes-rohe/>

⁶ Litres per second are used in place of cubic metres per second due to the desirability of consistency with foregoing descriptions and assessments using the former unit of flow or discharge rate.

requirements. Between 2013 and 2017 conditions were being applied to larger surface water and groundwater take applications in the Upper Clutha catchments. These cited minimum lake level restrictions on the operation of Lake Hawea (consent numbers 2001.383, 2001.389, and 2001.392) and minimum flow conditions for the operation of the Roxburgh power station (consent numbers 2001.386, 388, 391, and 394) applying to Contact Energy through its various structures. Table 17 is an example of a condition that ORC applied to a number of groundwater takes in line with Contact Energy's consultation or submissions.

Table 17: Sample Condition applied to larger Water Takes specifying relief for Contact Energy

4. (a) No water shall be taken for the purpose of irrigation between 1 May and 31 August in any calendar year; and
- (b) At all other times, water shall not be taken when:
 - (i) The combined flow levels in the following rivers are below 250 cubic metres per second:
 - Clutha River at Cardrona (NIWA Hydrological Recording Site No. 75282) plus 10 cubic metres per second, less the mean Hawea River flow as measured at the Camp Hill (NIWA Hydrological Recording Site No. 75287); and
 - Kawarau River at Chards Road (NIWA Hydrological Recording Site No. 75262); and
 - Nevis River at Wentworth (NIWA Hydrological Recording Site No. 75265); and
 - Manuherikia River at Ophir (NIWA Hydrological Recording Site No. 75253); and
 - (ii) The level of Lake Hawea is at or below 338.2 m above datum (based on a 3 hour rolling average), as measured at Hawea Dam Site (NIWA Hydrological Recording Site No. 75288).

Contact Energy has sought and achieved the restriction of irrigation taking in the Clutha River system to avoid a 4 month period from 1 May to 31 August in any calendar year. As such this restriction is not overly onerous for irrigation takes since little if any irrigation demand falls within this period. The Contact Energy submissions for the above conditions of water take consent would conflict with the water requirements of the Bendigo – Ophir Gold Mine Project (BOGMP), as proposed. Once operational, the BOGMP would operate throughout the year, including 24 hours of operation. While maintenance shut downs of the ore processing plants would be feasible and dust suppression water demand would lessen in the cooler months, full access to the MGL Bendigo bore field is the strong preference for the mining operation and its attendant drinking water supply. It is also noted that the groundwater take for the Cromwell water supply bores, held by Cromwell District Council and located within 100 metres of Lake Dunstan, do not have any such curtailment conditions on the current consent (consent number RM22.319.01).

The imposition of bore field pumping shut off for a minimum lake level or minimum river flow may not be effective in any meaningful way for the MGL Bendigo bore field due to 1.7 kilometre distance to the river and lake, and the time lag in surface water depletion being exerted through the Bendigo Aquifer. The depletion would continue in largely full effect for 1 – 3 weeks and lessen only progressively over months (see Figure 23 for guidance). For a lake level emergency or period of low river inflows of a discrete period, applying a pumping cut-off condition may serve little useful purpose in terms of ameliorating low lake or flow conditions.

5.3.3.6 Depletion and/or water level lowering within groundwater-connected wetlands

The sole wetlands with hydraulic connection to the Bendigo Aquifer are wetlands directly tied to the floodplain and flowing reaches of the Clutha River / Mata Au. Since these wetlands, including the regional significant wetland complex termed the Bendigo Wetlands and the zone of springs noted in ORC groundwater investigations (Houlbrooke, 2010) are strongly tied to the flows of the river, therefore the influence of the groundwater system from additional groundwater pumping could not be anticipated to be in any way more than minor.

The assessment of annual surface water depletion from the Clutha River / Mata Au, arising from the proposed water supply pumping at 110 litres per second was made at 70 litres per second (see section 5.3.2.2). As the river would remain within Otago's water allocation limit, any potentially proposed minimum flow limit, and the river would physically continue flowing at rates in excess of 8,000 million cubic metres per annum (or 254,000 litres per second instantaneous), it is foreseeable that the riparian wetlands between the river and Bendigo Aquifer would continue to be hydrologically sustained by this river flow and unaffected by the aquifer. Therefore any effects of surface water depletion or reduced water levels induced by the proposed mining complex water supply bore field are expected to be less than minor.

5.3.3.7 Aquifer Stabilisation

The aquifer from which the MGL production bore would abstract groundwater is predominantly composed of gravel with minor silt. Such gravels have a high (modulus of) elasticity and the area of highest drawdown is limited to the direct proximity of the bore, thus the potential for settlement and compaction as a result of the abstraction is considered to be very small, and if it were to occur limited to an area close to the bore. There are no other associated materials in the groundwater system such as aquitards composed of fine sediments that are sensitive in terms of depressurisation, dehydration or subsidence effects. Therefore, the effects on aquifer stability are considered to be less than minor.

For other reasons related to water quality protection, a pre-collar seal and concrete pad have been installed surrounding the surface bore head around the main bore casing. These measures would also have the benefit of stabilising the bore head from any minor effects of ground subsidence in the bore head zone, where it is more likely to occur if at all.

6 Steps to Avoid, Mitigate and Monitor Potential Effects

6.1 Background

The Resource Management Act 1991 does not stop at assessing the potential effects of a proposed activity and predicting the extent or intensity of those impacts. The Act includes requirements to evaluate the ability to avoid, minimise, mitigate, and offset / compensate. Monitoring these effects is required to ensure the anticipated outcomes are achieved. The purpose of this section is to set out the further evaluation of groundwater-related effects and indicate the proposals for such environmental effects mitigation.

6.2 Bore Field Pumping (Groundwater Taking)

6.2.1 Avoid or Minimise Effects

Most groundwater take effects are directly proportional to the instantaneous or median pumping rate, plus the long-term volume across a seasonal cycle. Short-term rates of water take from a bore field are more influential in short-distance drawdown effects. Seasonal or annual abstraction volumes are more influential in the bore field's effect on long-distance effects, such as surface water depletion or aquifer sustainability, in avoiding aquifer overdraft. Therefore, reductions in groundwater pumping in either short or long timeframes would lead to beneficial reduction in the intensity of any effects.

6.2.1.1 Water Conservation

Water conservation is a targeted strategy to minimise the requirement to draw groundwater from the bore field. The Water Management Plan may set out the criteria for projecting the dust suppression on the following basis:

- Moving-average soil moisture status,
- Frequency of suppression water application and application rate (mm/application),
- Relevant plant factor,
- Extent of land area requiring dust suppression and practically available for application,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water.

Similarly, the water requirement from the ore processing plant would be variable. The Water Management Plan may set out the criteria for projecting the ore processing plant water requirements on the following basis:

- The scheduled throughput of the ore processing plant,
- Projected total daily water requirement, and
- Daily quantity of mine water that can be used to substitute for fresh make-up water.

The remaining water demands associated with the Bendigo – Ophir Gold Project could also be subject to water conservation measures. Such measures may include:

- Reduce water consumption while meeting the same demand by installing high water use efficient appliances and practices,
- Plant indigenous drought-resistant plantings in planted areas,
- Catch rainwater from structure roofs, where doing so is appropriate, and use in watering plantings, and
- Reuse relatively clean grey water for use in appropriate uses of water.

6.2.1.2 Mine Water Substitution

As outlined above, waste streams of mine-impacted water and mining affected stormwater at appropriate water quality norms would be deployed in augmenting mining complex water requirements.

The principal substitutions of water with mine-impacted water would include –

- Dust suppression water,
- Ore processing make-up water,
- Watering of plantings.

The sources of mining-impacted water would include –

- Pit dewatering pumping,
- Underground mine water surplus,
- Seepage Collection Drain and Shepherds Creek Silt Pond decant water,
- Collected storm water.

Protocols would be developed to allow appropriate substitution of water source to water requirement, as set out above.

6.2.2 Monitoring Effects (Water Level)

There is always a degree of uncertainty inherent in assessing environmental effects and / or assessing the effectiveness of strategies to Avoid, Remedy, Mitigate, Compensate or Offset (ARMCO) identified potential effects. One means of reducing the impact of such uncertainty is to monitor the relevant environment, in this case the groundwater system. In the case of the proposed groundwater take for water supply and the Bendigo Aquifer, there is an existing context for monitoring levels. Three water table snap-shot surveys were undertaken in 2009 and 2010 (Houlbrooke, 2010), and time-series groundwater level monitoring at bore CB13/0159 has been undertaken by ORC since 2021. Water metering of all consented groundwater takes greater than 5 litres per second, including those in the Bendigo Aquifer, has also been taking place since 2015. Ongoing groundwater level monitoring surrounding the proposed bore field would highlight actual water table lowering induced by groundwater pumping.

The reserve supply bore (CB13/0216) is available for electronic monitoring of bore field pumping effects. If the reserve bore is pressed into use in water supply, then a secondary groundwater level monitoring bore would be installed at appropriate distance from the test production and reserve bores and equipped to monitor groundwater levels. Another bore in proximity to the closest operational water supply bore owned by Peregrine Estates is labelled G41/0263. It has an equivalent depth to CB13/0156 at 49.7 metres but is reportedly no longer used. With permission from the owner, electronic monitoring could be added to the disused bore, which lies 220 metres from the MGL production bore(s). Further out, the ORC SOE monitoring bore CB13/0159 would continue to record groundwater levels at a distance of 876 metres from the MGL water supply bore field. The ORC SOE monitoring bore has groundwater level data available in real time from its data portal, which could be readily linked to the MGL environmental monitoring database. However, given the high freeboard available to surrounding water bores, proximity of river recharge boundaries and low magnitude of conservatively assessed effects, monitoring is not considered necessary beyond 876 metres from the proposed MGL bore field but could be undertaken if the outcome of the consenting process considers it so.

Metering of the rates and volume of water taken using the MGL production bore(s) would be undertaken in the context of the National Environmental Standard for Water Metering and proposed conditions of consent for metering by MGL's nominated contractor. The water metering of the groundwater take would be available to make correlations between the occurrence of bore pumping and any discernible water level fluctuations.

6.2.3 Monitoring Effects (Water Quality)

The MGL bore field would have the status as a drinking water supply in the context of the Health Act 1956 and the drinking water standard (Ministry of Health, 2005) and the minimum standards set out in the Water Services Act 2021 (NZ Drinking Water Standards, 2022). As such the water quality of the groundwater taken from the bore field bores would be subject to periodic sampling and analysis. The frequency and analytes included in analysis of sampled water would be governed by a complex set of determinations. However it is foreseeable that the priority 1 analytes would be the most frequently sampled. The monitoring requirements cover *E. coli* and turbidity as surrogates for water-borne bacteria, or viruses, plus large body pathogens, respectively. Priority 2 analytes cover chemical constituents, including common water pollutants, organic compounds and heavy metals. A structured system of sampling and providing public health risk assessments would fall to the bore field operator or the nominated contractor, in addition to source protection requirements assessed by nominated public health engineering experts.

All of the above requirements attached to the Health Act and drinking water status under the Water Services Act 2012 would result in frequent monitoring of groundwater quality followed by reporting to public agencies such as Taumata Arowai. This would provide a degree of reassurance that any arising or adverse groundwater quality effects could be avoided and if not, early warning provided to the bore field operator, regional authorities, and affected parties. The operation of the bore field and the water quality management of the infrastructure to the point of consumption would also be subject to public health risk assessments to the level appropriate to the scale of water supply provision. These aspects of the water supply management are largely outside of the Resource Management Act, with the exception of the National Environmental Standard – Drinking Water.

6.2.4 Summary of Monitoring

- Monitoring of the following groundwater phenomena would be maintained –
 - Groundwater level at
 - BOGMP bore field monitoring bore (CB13/0216)
 - Additional neighbouring bore (potentially G41/0263)
 - ORC SOE monitoring bore CB13/0159
 - Groundwater pumping Rate and Volume at
 - BOGMP bore field production bore (CB13/0215)
 - Groundwater water quality at
 - BOGMP bore field production bore (CB13/0215) and one other

7 Concluding Remarks

The following concluding remarks summarises the results of the hydrogeological studies for the Bendigo Aquifer test production bore and projected groundwater abstraction up to 110 litres per second for a Bendigo – Ophir Gold Mine Project water supply.

1. The capacity of the test production bore (CB13/0215) is projected to be approximately 110 litres per second, indicating the feasibility of establishing a water supply bore field with duty and reserve bores of similar capacity to meet the instantaneous water demand.
2. Projection of drawdown effects by an operational Matakanui Gold Ltd bore field in the location of the test production bore would have discernible effects on the dozen operating bores within 1.65 kilometres of the MGL bore field, however the assessed drawdown in the context of self-induced and natural bore water level fluctuations would not interfere with the bore operation of surrounding bores after allowing for a significant margin of safety.
3. Projection of surface water depletion effects by an operational Matakanui Gold Ltd bore field in the location of the test production bore would have a flow depleting effect on the Clutha River / Mata Au, calculated to be up to 72 litres per second of the 110 litres per second abstracted at the bore field in the instance of long-term, annual pumping.
4. The surface water depletion effect by an operational Matakanui Gold Ltd bore field on Bendigo Creek, School Creek, or Chinaman Creek would be less than minor, due to inherent hydrological conditions of groundwater – surface water disconnection imposed by the thick unsaturated zone above the Bendigo Aquifer water table.
5. The effect of the new groundwater abstraction of the MGL bore field on the connected Bendigo Aquifer and its sustainable water balance would be less than minor, as the established long-term groundwater allocation limit would not be reached or exceeded.
6. The effect of the new groundwater abstraction of the MGL bore field on the connected Clutha River / Mata Au and its sustainable water balance would be less than minor, as the estimated surface water depletion effect would not exceed the current or projected future surface water allocation limit.
7. Minimum flows in the Clutha catchment or minimum Lake Hāwea water levels, such as imposed in past conditions of consent on irrigation water take permits at the request of Contact Energy would provide little benefit in terms of reduced surface water depletion during MGL bore field operation. This lack of benefit would be unless the restriction was required over an extended period, due to the particular hydro-dynamics of surface water connected groundwater in the Bendigo Aquifer and the significant distance between the river and the MGL bore field.
8. Accordingly, the proposal for a bore field in the current location at a maximum daily rate equivalent to 110 litres per second is assessed to have environmental effects in terms of groundwater levels, surface water depletion and groundwater resource allocation that are less than minor.
9. Opportunities exist for aggregate effects of taking groundwater at the MGL bore field being lessened through water conservation and water source substitution within the BOGMP mine site.
10. Monitoring opportunities exist for ensuring that actual effect intensities are no more than predicted, including metering of groundwater abstraction rates and volumes, and monitoring of surrounding groundwater level and groundwater quality in the Bendigo Aquifer at up to three separate locations.

8 References Cited

- Daughney, C. J., Morgenstern, U., Moreau, M., & McDowell, R. W. (2023). Reference conditions and threshold values for nitrate-nitrogen in New Zealand groundwaters. *Journal of the Royal Society of New Zealand*, 1–31. <https://doi.org/10.1080/03036758.2023.2221034>
- Eden, R. N., & Hazel, C. P. (1973). Computer and Graphical Analysis of Variable Discharge Pumping Tests of Wells. *Civil Engineering Transactions*, 15, 5–10.
- Garden, T. (2022). *Dunstan—Earnsclough Groundwater Basin: Conceptual Model* (Client Report for Otago Regional Council CO3577507R001; p. 40). Pattle Delamore Partners Ltd.
- Houlbrooke, C. (2010). *Bendigo and Tarras Groundwater Allocation Study* (Otago Regional Council RSU Technical Report ISBN 978-0-478-37601-2; p. 69). Otago Regional Council.
- Jenkins, C. T. (1977). *Computation of rate and volume of stream depletion by wells* (“Techniques of Water Resource Investigations of the United States Geological Survey” Chapter 4, Book 4; HYDROLOGIC ANALYSIS AND INTERPRETATION, p. 21). USGS, Department of Interior. https://pubs.usgs.gov/twri/twri4d1/pdf/twri_4-D1_a.pdf
- Levy, A., Ettema, M., & Lu, X. (2021). *State of the Environment Groundwater Quality in Otago* (p. 270) [Technical Report for Otago Regional Council]. Otago Regional Council. <https://www.orc.govt.nz/media/9785/otago-groundwater-soe-report-march-2021.pdf>
- Logan, J. (1964). Estimating Transmissibility from Routine Production Tests of Water Wells. *Ground Water*, 2(1), 35–37. <https://doi.org/10.1111/j.1745-6584.1964.tb01744.x>
- Macara, G. R. (2015). *The Climate and Weather of Otago* (NIWA Science and Technology Series No. 67, p. 44) [NIWA Science and Technology Series]. National Institute of Water and Atmosphere. <https://niwa.co.nz/sites/default/files/Otago%20Climate%20book%20WEB%202021.pdf>

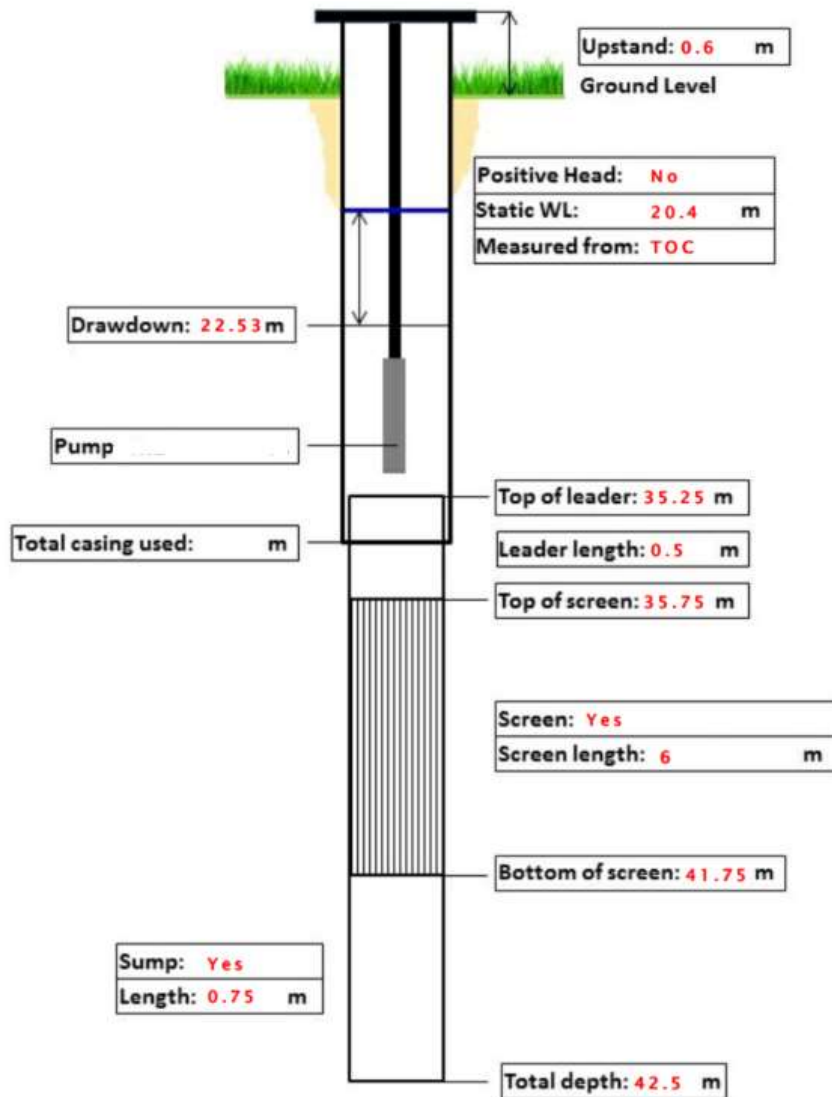
- Mine Waste Management. (2025). *Water Load Balance Model Report – Bendigo-Ophir Gold Project* (Client Report for Matakanui Gold Ltd J-NZ0233-016-Rev0). Mine Waste Management Ltd.
- Ministry of Health. (2005). *Drinking-water Standards for New Zealand 2005 (revised 2018)* (p. 128) [Standards]. Ministry of Health. <https://support.esdat.net/Environmental%20Standards/nz/dwsnz-2005-revised-mar2019.pdf>
- Neuman, S. P. (1974). Effect of partial penetration on flow in unconfined aquifers considering delayed gravity response. *Water Resources Research*, 10(2), 303–312. <https://doi.org/10.1029/WR010i002p00303>
- Opiki Water Action Group vs Manawatu - Wanganui Regional Council, Law-KG-342-N5 New Zealand Legal Information Institute NZEnvC 276 (Environment Court of NZ 2004). <https://www.nzlii.org/nz/cases/NZEnvC/2004/276.html>
- Rekker, J. (2012). *Alexandra Groundwater Basin Allocation Study* (p. 62) [Prepared for ORC by the Resource Science Unit]. Otago Regional Council. <https://www.orc.govt.nz/media/3804/alexandra-groundwater-basin-allocation-study.pdf>
- Rumbaugh, D., & Rumbaugh, J. (2013). *Guide to Using AquiferWin32, Version 5* (Version 5) [Computer software]. Environmental Simulations, Inc. : <http://www.groundwatersoftware.com/ftp/aquiferwin32-4.pdf>
- Sinclair Knight Merz. (2004). *Bendigo and Tarras Groundwater Investigation* (p. 37) [Unpublished consultancy report to Otago Regional Council].
- Stewart, D. W. (2021). *Review of Bendigo Creek Hydrology*. Raineffects Ltd / Otago Regional Council.
- Theis, C. (1935). The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. *American Geophysical Union Transactions*, 16, 519–524.
- Water Services (Drinking Water Standards for New Zealand) Regulations 2022, 2022/168 Order In Council § 47 (2022). These regulations are made under section 47 of the Water Services Act 2021— (a) on the advice and with the consent of the Executive Council; and (b) on the recommendation of the Minister of Local Government; and (c) following consultation in accordance with section 53 of that Act. <https://www.legislation.govt.nz/regulation/public/2022/0168/latest/whole.html>

Appendices

Appendix 1. Bore Logs

Appendix 1.1. Bore Log: CB13/0215 (400 mm diameter Test Production Bore)

BORE LOG (METRES BELOW REFERENCE POINT)	
0m	sandy gravels
10.2m	cobble
10.6m	sands fine gravels
11.8m	sand coarse gravels
30.7m	sand and fine gravels
37m	coarse sandy gravels
41m	tight gravels
42m	blue silts
42.5m	
Do you intend to drill more bores under this Land Use Consent number? No	
If yes, number of bores drilled:	Number of bore logs provided:



Bore Construction Report

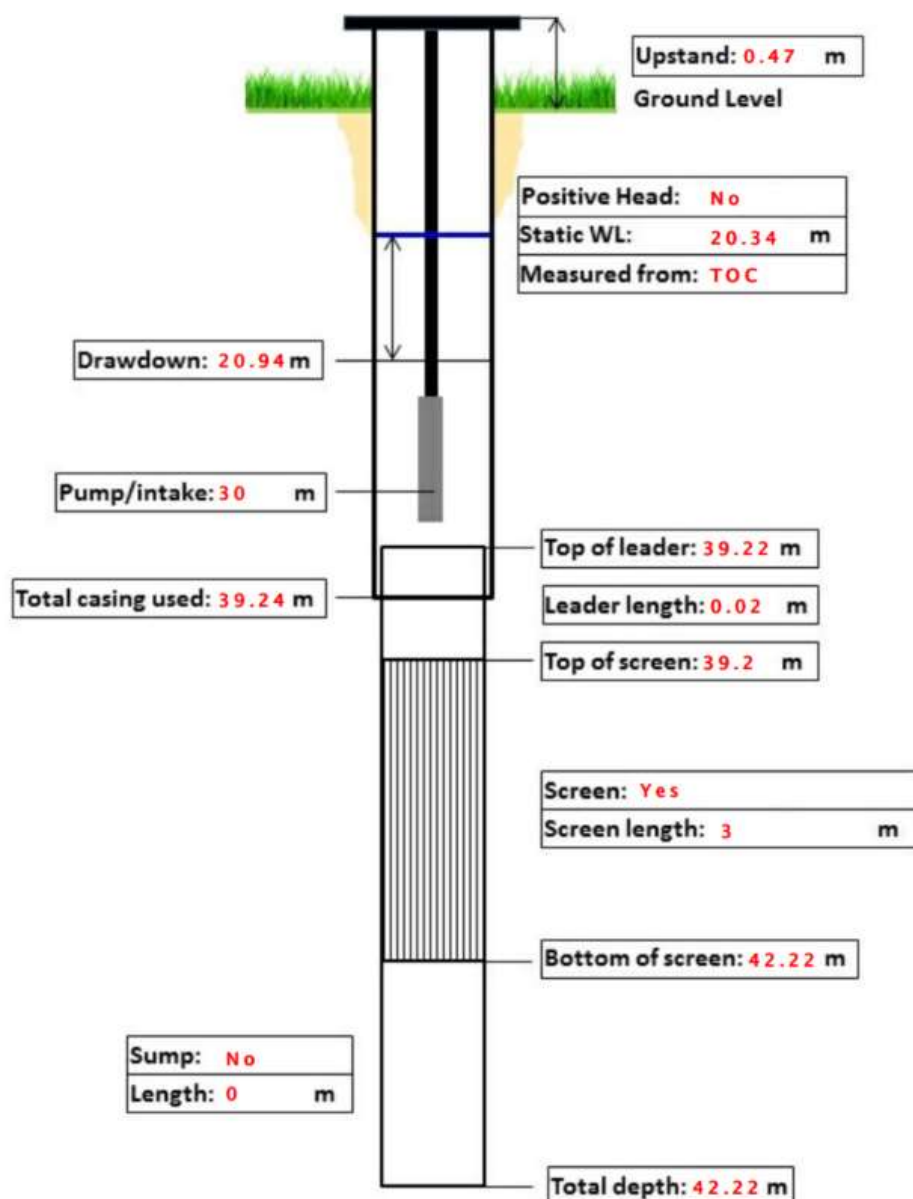


OFFICE USE ONLY		
Date received:	Accession number:	Signed:
Bore number: 2661	Entered IRIS date:	Invoice date:

GENERAL DETAILS		
Client/Consent holder's name: Santana Gold		Consent number: RM24.272.10
Location/Address: santana gold mine		
Grid reference - Easting: 1310616m E	Northing: 5019488m N	Mobile phone:
Sketch plan attached:	Photos attached: Yes	Home phone:
DRILLING DETAILS		
Drilling company: SouthDrill Ltd		
Machine/Rig: Western Star Drilling Rig [QCL493]		Fleet no. 2030
Drill method(s): Air Rotary		
BORE CONSTRUCTION DETAILS		
Start date: 24/06/2024	Finish date: 04/07/2024	
Bore diameter: 400mm	Casing material: Steel	
Screen material: s/s		
Screen diameter (inside): 350mm	Screen diameter (outside): 370mm	
Screen slots: 2.5mm	Overdrilled: No	
PUMPING/WATER DETAILS		
Dry bore: No	If dry, was casing retrieved?	Bore filled in:
Development period: 54 hours	Development method: Airlifted	
Yield/test pumping: Pumped	Test pump period: 56 hours	
Test pump rate: 21 litres/second	Method of measuring rate: flow meter	
Comments:		
Pumped water level: 22.53 metres		
WATER QUALITY ETC		
Bacterial water test: No	Chemical water test: No	
Casing top sealed: Yes	Impervious seal at ground: Yes	

Appendix 1.2. Bore Log: CB13/0216 (150 mm diameter Observation or Monitoring Bore)

BORE LOG (METRES BELOW REFERENCE POINT)	
0m	coarse sandy gravels
10.3m	cobble
10.6m	sandy fine gravels
11.8m	sandy coarse gravels
30.7m	sands fine gravels
37m	tight coarse gravels
42m	blue silts
42.5m	
Do you intend to drill more bores under this Land Use Consent number? No	
If yes, number of bores drilled:	Number of bore logs provided:



Bore Construction Report



OFFICE USE ONLY		
Date received:	Accession number:	Signed:
Bore number: 2661 150mm tubex test hole	Entered IRIS date:	Invoice date:

GENERAL DETAILS		
Client/Consent holder's name: Santana Gold Mine Matakanaui Gold Ltd		Consent number: RM24.272.01
Location/Address: 305 Bendigo Loop Road		
Grid reference - Easting: 1310607m E	Northing: 5019489m N	Mobile phone:
Sketch plan attached: Yes	Photos attached: Yes	Home phone:
DRILLING DETAILS		
Drilling company: SouthDrill Ltd		
Machine/Rig: Western Star Drilling Rig [QCL493]		Fleet no. 2030
Drill method(s): Tubex		
BORE CONSTRUCTION DETAILS		
Start date: 24/06/2024		Finish date: 25/06/2024
Bore diameter: 150mm		Casing material: Steel
Screen material: s/s		
Screen diameter (inside): 138mm		Screen diameter (outside): 140mm
Screen slots: 2.5mm		Overdrilled: No
PUMPING/WATER DETAILS		
Dry bore: No	If dry, was casing retrieved?	Bore filled in:
Development period: 5 hours	Development method: Airlifted	
Yield/test pumping: Pumped	Test pump period: 3 hours	
Test pump rate: 2 litres/second	Method of measuring rate: Volumetric test	
Comments: test hole didnt do large pump test just clean up for test hole for 400mm pump hole		
Pumped water level: 20.94 metres		
WATER QUALITY ETC		
Bacterial water test: No	Chemical water test: No	
Casing top sealed: Yes	Impervious seal at ground: Yes	

Appendix 2. Pumping Test Data

Appendix 2.1. Step Rate (Drawdown) Test Manual Data

Date & Time	Step t (min)	t (min)	Obs. Bore DTW (m)	Pumped Bore DTW (m)	Flow (L/s)	Mean Flow (L/s)
25/07/2024 8:04	1	1	–	–	–	
25/07/2024 8:06	2	2	–	23.69	–	
25/07/2024 8:07	3	3	–	23.7	–	
25/07/2024 8:08	4	4	–	23.7	–	
25/07/2024 8:09	5	5	21.19	23.7	–	
25/07/2024 8:14	10	10	–	23.715	37	
25/07/2024 8:19	15	15	21.19	23.7	–	
25/07/2024 8:24	20	20	–	23.71	–	
25/07/2024 8:34	30	30	21.19	23.715	32	
25/07/2024 8:49	45	45	21.2	23.715	38	
25/07/2024 8:25	60	21.2	21.2	23.72	36	
25/07/2024 9:34	90	90	21.2	23.73	39	
25/07/2024 10:04	120	120	21.2	23.735	38	36.67
25/07/2024 10:05	1	121	–	25.43	–	
25/07/2024 10:06	2	122	–	25.435	59	
25/07/2024 10:07	3	123	21.5	25.43	56	
25/07/2024 10:08	4	124	–	25.43	–	
25/07/2024 10:09	5	125	21.5	25.43	54	
25/07/2024 10:14	10	130	21.5	25.43	55	
25/07/2024 10:19	15	135	21.5	23.435	53	
25/07/2024 10:24	20	140	21.5	23.425	61	
25/07/2024 10:34	30	150	21.5	25.405	59	
25/07/2024 10:49	45	165	–	23.435	57	
25/07/2024 11:04	60	180	21.5	23.44	53	
25/07/2024 11:34	90	210	21.51	25.455	58	
25/07/2024 12:04	120	240	21.52	25.465	59	56.73
25/07/2024 12:05	1	241	21.86	27.89	80	
25/07/2024 12:06	2	242	21.85	27.86	79	
25/07/2024 12:07	3	243	21.85	27.86	73	
25/07/2024 12:08	4	244	21.85	27.88	77	
25/07/2024 12:09	5	245	21.85	27.88	74	
25/07/2024 12:14	10	250	21.85	27.88	–	
25/07/2024 12:19	15	255	21.85	27.88	–	
25/07/2024 12:24	20	260	21.85	27.88	76	
25/07/2024 12:34	30	270	21.8	27.5	74	
25/07/2024 12:49	45	285	21.79	27.45	75	
25/07/2024 13:04	60	300	21.79	27.45	72	

Date & Time	Step t (min)	t (min)	Obs. Bore DTW (m)	Pumped Bore DTW (m)	Flow (L/s)	Mean Flow (L/s)
25/07/2024 13:34	90	330	21.79	27.53	–	
25/07/2024 14:04	120	360	21.8	27.53	–	75.56
25/07/2024 14:05	1	361	–	29.09	–	
25/07/2024 14:06	2	362	22.11	29.095	91	
25/07/2024 14:07	3	363	22.11	30	–	
25/07/2024 14:08	4	364	–	30.05	91	
25/07/2024 14:09	5	365	22.12	30.15	100	
25/07/2024 14:14	10	370	22.12	30.165	95	
25/07/2024 14:19	15	375	22.12	30.21	91	
25/07/2024 14:24	20	380	22.12	30.24	94	
25/07/2024 14:34	30	390	22.12	30.8	105	
25/07/2024 14:49	45	405	22.12	30.5	93	
25/07/2024 15:04	60	420	22.12	30.33	105	
25/07/2024 15:34	90	450	22.12	30.335	90	
25/07/2024 16:04	120	480	22.14	–	90	95.00
25/07/2024 16:09	125	485	–	–	–	Shutdown

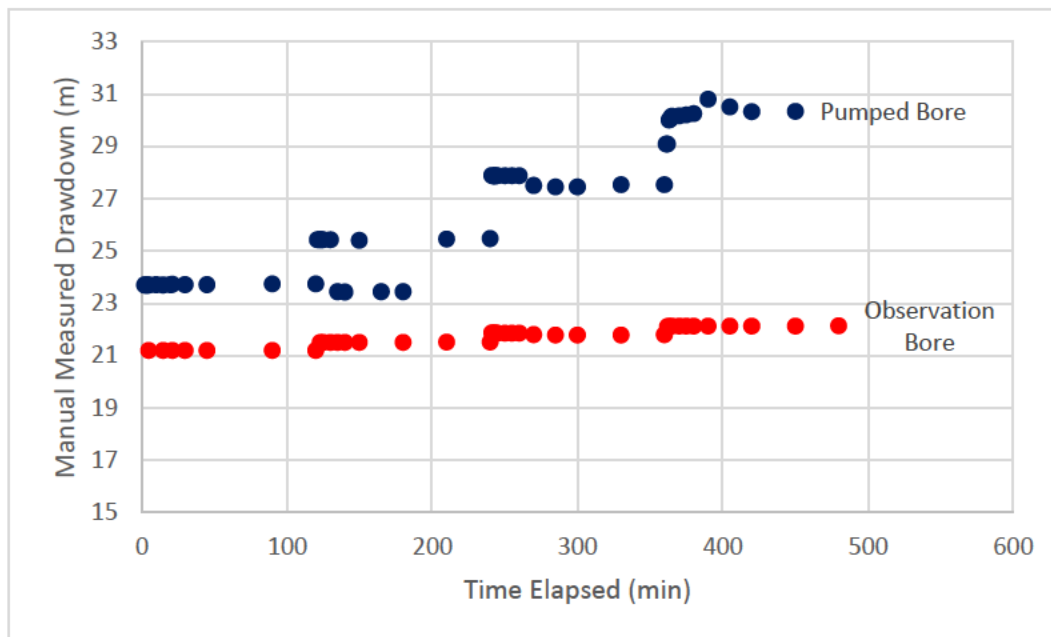


Figure A2.1: Step Rate Test drawdown plot for pumped and observation bore manual data.

Electronic data at 30 second frequency were also recorded and is plotted in Figure 10 and Figure 11.

Appendix 2.2. Constant Rate Test Observation Bore Manual Data

Data	Clock time	Time elapsed (min)	Obs. Bore DTW (m)	Pumped Bore DTW (m)	Flow (L/s)	Remarks
9-Jul-2024	8:30		20.610	21.400	0.000	
	8:35	5	21.000	22.465	20.050	
	8:45	15	21.005	22.470	20.400	
	9:00	30	21.005	22.460	21.500	
	9:30	60	21.010	22.470	20.200	
	10:00	90	21.000	22.400	20.051	
	10:30	120	21.015	22.480	21.320	
	11:00	150	21.020	22.480	20.300	
	12:00	210	21.031	22.490	20.759	
	13:00	270	21.020	22.480	21.049	
	14:00	330	21.020	22.480	20.571	
	15:00	390	21.035	22.480	21.208	
	16:00	450	21.000	22.500	21.242	
	17:00	510	21.000	22.500	21.688	
	18:00	570	21.005	22.515	21.024	
	19:00	630	21.005	22.520	20.004	
10-Jul-2024	6:00	1,290	21.050	22.520	21.149	
	7:00	1,350	21.050	22.520	20.305	
	8:00	1,410	21.050	22.520	21.046	
	9:00	1,470	21.055	22.520	20.040	
	10:00	1,530	21.055	22.520	19.925	
	11:00	1,590	21.055	22.520	21.200	
	12:00	1,650	21.057	22.520	21.516	
	13:00	1,710	21.055	22.520	19.948	
	14:00	1,770	21.052	22.520	20.705	
	15:00	1,830	21.052	22.520	20.644	
	16:00	1,890	21.055	22.520	19.996	
	17:00	1,950	21.055	22.520	20.334	
	18:00	2,010	21.050	22.520	20.500	
	19:00	2,070	21.052	22.520	19.755	
11-Jul-2024	6:00	2,730	21.055	22.520	21.090	
	7:00	2,790	21.055	22.525	21.334	
	8:00	2,850	21.060	22.525	20.397	
	8:30	2,880	21.060	22.53	20.917	

Electronic data at 30 second frequency were also recorded, corrections made for an ambient trend and used in the main test interpretations / analyses. The corrected data for electronic, high frequency drawdown of the observation bore recorded in the CRT are plotted in Figure 5.

Appendix 3. Water Analysis Laboratory Certificate



R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Page 1 of 3

Client:	Komanawa Solutions Limited	Lab No:	3636177	SPv1
Contact:	[REDACTED]	Date Received:	26-Jul-2024	
	C/- Komanawa Solutions Limited	Date Reported:	01-Aug-2024	
	4 Ash Street	Quote No:	132135	
	Christchurch Central City	Order No:		
	Christchurch 8011	Client Reference:		
		Submitted By:	[REDACTED]	

Sample Type: Aqueous

Sample Name:		Bendigo PB-1 25-Jul-2024 12:00 pm	
Lab Number:		3636177.1	
Individual Tests			
Sum of Anions	meq/L	1.00	
Sum of Cations	meq/L	1.00	
Turbidity	NTU	0.48	
pH	pH Units	7.8	
Total Alkalinity	g/m ³ as CaCO ₃	42	
Bicarbonate	g/m ³ at 25°C	51	
Total Hardness	g/m ³ as CaCO ₃	37	
Electrical Conductivity (EC)	mS/m	9.8	
Dissolved Aluminium	g/m ³	< 0.003	
Dissolved Boron	g/m ³	0.010	
Dissolved Calcium	g/m ³	10.8	
Dissolved Iron	g/m ³	< 0.02	
Dissolved Magnesium	g/m ³	2.5	
Dissolved Manganese	g/m ³	0.0007	
Dissolved Potassium	g/m ³	0.80	
Dissolved Sodium	g/m ³	5.3	
Bromide	g/m ³	< 0.05	
Total Cyanide	g/m ³	< 0.002	
Chloride	g/m ³	2.2	
Fluoride	g/m ³	0.08	
Nitrite-N	g/m ³	< 0.002	
Nitrate-N	g/m ³	0.46	
Nitrate-N + Nitrite-N	g/m ³	0.46	
Reactive Silica	g/m ³ as SiO ₂	13.1	
Sulphate	g/m ³	3.2	
Dissolved Organic Carbon (DOC)	g/m ³	0.5	
Total Organic Carbon (TOC)	g/m ³	0.7	
Absorbance at 254 nm	AU cm ⁻¹	0.003	
Transmittance at 254 nm*	%T, 1 cm cell	99.4	
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn			
Dissolved Arsenic	g/m ³	< 0.0010	
Dissolved Cadmium	g/m ³	< 0.00005	
Dissolved Chromium	g/m ³	< 0.0005	
Dissolved Copper	g/m ³	< 0.0005	
Dissolved Lead	g/m ³	< 0.00010	
Dissolved Nickel	g/m ³	< 0.0005	
Dissolved Zinc	g/m ³	< 0.0010	



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised. The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked * or any comments and interpretations, which are not accredited.

Analyst's Comments

Sample 1 Comment:

Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (up to 200-300% at the 95% confidence level).

Sample 1 Comment:

Please note that the level of Uncertainty of Measurement (UOM) for the DOC result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Franklin, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As, Cd, Cr, Cu, Ni, Pb, Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m ³	1
Filtration, Glass Fibre	Sample filtration through glass fibre filter.	-	1
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry, Unit 1, 17 Print Place, Middleton, Christchurch.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N, Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1
Turbidity	Analysis by Turbidity meter. Analysed at Hill Laboratories - Chemistry, Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2130 B (modified) : Online Edition.	0.05 NTU	1
pH	pH meter. Analysed at Hill Laboratories - Chemistry, Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H ⁺ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry, Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m ³ as CaCO ₃	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D : Online Edition.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium, APHA 2340 B : Online Edition.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry, Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	1
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B : Online Edition.	-	1
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m ³	1
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m ³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m ³	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m ³	1
Bromide	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.05 g/m ³	1
Total Cyanide Trace	On-line distillation, colorimetry, trace level. ISO 14403:2012(E) (modified).	0.002 g/m ³	1
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m ³	1
Fluoride	Direct measurement, ion selective electrode. APHA 4500-F ⁻ C : Online Edition.	0.05 g/m ³	1
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry. Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) : Online Edition.	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m ³	1
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) : Online Edition.	0.002 g/m ³	1
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Flow Injection Analyser APHA 4500-SiO ₂ F (modified) : Online Edition.	0.10 g/m ³ as SiO ₂	1
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m ³	1
Dissolved Organic Carbon (DOC)	Filtered sample. Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC - TIC. APHA 5310 C (modified) : Online Edition.	0.5 g/m ³	1
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC - TIC. The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) : Online Edition.	0.5 g/m ³	1
Absorbance at 254 nm	Filtered sample. Spectrophotometry, 1cm cell. APHA 5910 B : Online Edition.	0.002 AU cm ⁻¹	1
Transmittance at 254 nm [*]	Calculation from Absorbance at the specified wavelength.	0.5 %T, 1 cm cell	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 27-Jul-2024 and 01-Aug-2024. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.



Ara Heron BSc (Tech)
Client Services Manager - Environmental