Lake Pūkaki Reservoir Hydro Storage and Dam Resilience Works

Groundwater Assessment

Meridian Energy Limited

16 September 2025

→ The Power of Commitment

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1. Introduction

Meridian Energy Limited (Meridian) have engaged GHD Limited (GHD), to assist with obtaining consents to authorise the operation of Lake Pūkaki below the current normal minimum level of 518 m above mean sea level (m RL), for a three-year period, and for civil works at Pūkaki Dam to improve the structures resilience to wave action during lower lake operational levels.

1.1 Project Background

1.1.1 Waitaki Power Scheme

The Waitaki Power Scheme (WPS) is a nationally and regionally significant component of New Zealand's electricity supply infrastructure. It is New Zealand's largest and most flexible hydroelectricity power scheme and therefore has a critical role to play in the electricity system and economy. It consists of eight power stations (two owned by Genesis Energy and six owned by Meridian Energy), commissioned between 1935 and 1985, together having an installed capacity of 1,761 MW, being ~32% of New Zealand's installed hydro capacity.

Lake Pūkaki is a modified natural lake and is managed as part of the WPS. It is New Zealand's largest hydro storage lake and provides an average of 1,767 GWh of stored water in normal operating conditions, with an additional 545 GWh available during a national electricity shortage.

Meridian is currently authorised to dam the Pūkaki River to control and operate Lake Pūkaki between the levels of 518 m RL (normal consented minimum lake level) and 532.5 m RL (maximum consented storage level).

1.1.2 Previous Plan Changes - Waitaki Catchment Allocation Regional Plan (WAP)

The WAP is a sub regional plan and provides objectives, policies and rules for the use and development of water resources within the Waitaki Catchment. Prior to 2012, it was a prohibited activity in the WAP for Meridian to draw the lake level below 518 m RL.

1.1.2.1 Plan Change 1 (PC1)

In 2012, Meridian initiated Plan Change 1 (PC 1) to the WAP which sought to introduce a new minimum lake level for Lake Pūkaki during circumstances when the System Operator (SO) had commenced an Official Conservation Campaign (OCC) in regard to electricity supply. PC1 allowed additional water from Lake Pūkaki to be used for generating electricity as a permitted activity when an OCC is declared by the SO.

When assessing the potential operation of Lake Pūkaki below 518m for PC1, the duration of an entire event (time below 518 m RL) was considered likely to be between 4-7 months (this includes the time spent operating below 518 m RL, as well as the time required to restore the lake level to above 518 m RL once an electricity supply emergency ended). Supporting technical effects assessments were submitted as part of this plan change process. It was ultimately concluded that allowing access for electricity generation purposes to water stored between 513 and 518 m RL, as a permitted activity once an electricity supply emergency had been declared, was appropriate and promoted the sustainable management purpose of the RMA. PC1 was adopted by Environment Canterbury on 27 September 2012.

This report relies on the PC1 2012 effects assessments as being appropriate and focus on both the changes that have occurred since 2012, and the differences between the activities permitted by PC 1 and the proposed activities. This is the 'Baseline' that is referred to throughout this report.

1.1.2.2 Plan Change 3 (PC3)

PC3 included a new rule regarding the use of Lake Pūkaki between 518 m RL and 515 m RL. In addition to the PC1 Permitted Activity rule, at times of a Security of Supply Alert (SSA) initiated by the SO, the lake may be operated between the alert minimum control level of 515 m RL and 518 m RL. The rule is not a permitted activity and to implement this, Meridian applied for and was a granted resource consent in 2018 (CRC185833). This consent expired on 30 April 2025 but has been granted a section 124 continuance while the new replacement consent (CRC240441) is being processed.

1.1.3 Meridan's Application

Meridian is seeking approvals under the Fast Track Approvals Act (FTAA) to enable access to water stored in Lake Pūkaki below 518 m RL, without the currently applicable security of supply triggers, thereby enabling the better planning and utilisation of the available stored generating capacity. Further information on the background to the proposal and the benefits of allowing access to additional water is provided in the Substantive Application[1] document that supports the FTAA application.

Meridian is proposing to access the additional storage for a time-bound period of three years, until the end of 2028. For the purpose of this report 'Eased Access', refers to the ability to use water from Lake Pūkaki between 513 m RL and 518 m RL without a SSA or OCC being initiated by the SO. The ability to access stored water below 518 m RL will be incorporated into Meridian's electricity generation models and water stored in Lake Pukaki (both above and below 518 m RL) will continue to be managed to supply the market. The three-year period is to allow for additional generation capacity that is currently being built, to come online. For further clarification, the existing lake operation framework and proposed activity is detailed below in Table 1.

Existing Framework	Proposed Activity
Operation of Lake above 518 m RL (CRC905321.7).	Operation of Lake above 518 m RL (CRC905321.7). UNCHANGED.
Operation of Lake between 518 m RL and 515 m RL as a discretionary activity at times of a Security of Supply Alert initiated by the System Operator (CRC185833).	Operation of Lake between 518 m RL and 513 m RL for a period of 3 years without a Security of Supply Alert or Official Conservation Campaign being initiated by the System Operator.
Operation of Lake between 518 m RL and 513 m RL as permitted activity during an Official Conservation Campaign initiated by the System Operator (Permitted Activity).	

Table 1 Proposed Activity – Eased Access

In addition to the temporary ability to lower the lake level, Meridian seeks consent for the installation of rip-rap on the face of the Pūkaki dam and its left and right abutments to provide protection from wave erosion, when operating the lake below 518 m RL. Rip-rap will be placed to a maximum depth of 510.5 m RL, with earthworks/site preparation activities extending to a maximum depth of 509.6 m RL. Rock armouring will take a total of 12-18 weeks to complete but is expected to be done over multiple stages over several years and works may be required to be completed beyond 2028.

Meridian has stockpiled rock for this purpose on its land adjacent to the Pūkaki dam since 2014, but the rock armouring has not been undertaken due to the existing supply triggers never being initiated by the SO, with the result that the lake level has not been low enough over that period to allow the works to be completed.

1.2 Purpose of this report

The purpose of this report is to briefly describe the proposal, the current environment setting focusing on the groundwater system, document an assessment of effects of the proposal on groundwater users and wetland hydrology.

1.3 Scope of this Report

The hydrogeology scope is:

- Literature and data review to inform a conceptual groundwater model.
- Site visit with Tonkin and Taylor ecologists, undertaken between 23 and 24 January 2025.

[1] FOOTNOTE OF SA HERE

– Preparation of an assessment of environment effects focusing on:
  - Existing groundwater users.
  - Changes in wetland hydrology, in wetlands near the lake margins.
– Comparison between the proposed activity and PC1 assessment.
– Production of this technical report.

1.4 Assumptions

– It is assumed that the aquifers near the lake are primarily driven by gravity and therefore likely follow topographic gradients.
– The information and assessment presented in this report rely on the accuracy of Canterbury Maps, specifically elevation information, and information pertaining to bores (locations, levels, geological logs etc).
– Meridians Lake level and electricity demand modelling has been used in this assessment to anticipate effects. The Meridian Lake Level and Electricity Demand Modelling Report (Meridian, 2025 and summarised in Section 2.1) is to be read in conjunction with this report, taking note of the assumptions they have used.
– Other assumptions are listed in this report, particularly in Section 4 (Assessment of environmental effects).

1.5 Report Author and Contributions

The qualifications and experience of the report authors are set out in Appendix C. The author confirms that they have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (2023) and agree to comply with it. In that regard the lead author confirms that this groundwater report is written within their expertise, except where stated that the author is relying on the assessment of another person. The author confirms that they have not omitted to consider material facts known to them that might alter or detract from the opinions expressed.

1.6 Limitations

This report has been prepared by GHD Limited on the instructions of Meridian Energy, in accordance with the agreed scope of work. It is intended to support Meridian's application under the Fast-track Approvals Act 2024 and may be relied upon by the Expert Panel and relevant administering agencies for the purposes of assessing the application.

While GHD Limited has exercised due care in preparing this report, it does not accept liability for any use of the report beyond its intended purpose. Where information has been supplied by the Client or obtained from external sources, it has been assumed to be accurate unless otherwise stated.

2. Proposed activities

Meridian is proposing two activities, being:

– Over a three-year period, having the ability to lower the lake levels below 518 m RL to a minimum level of 513 m RL, so that stored lake water can be used to generate electricity.
– When the lake levels are low, this enables civil works near the Pūkaki Dam, specifically extending rip-rap armouring to reduce the risk of erosion on the dam face and other critical infrastructure.

The focus of this report will be on the short-term change to the lake operating level for electricity generation, as groundwater is unlikely to be impacted during the civil works.

2.1 Short-term change to lake operating level

Meridian undertook modelling to understand potential changes to lake levels from the proposed activity (Meridian, 2025). The modelling draws on 91 years of hydrological and meteorological data for the lake, and the current understanding of the NZ energy system (supply and demand analysis) resulting in forecasts of stored water (energy), which can be used to understand potential changes to lake levels (Figure 1). The Meridian modelling indicates the following:

Modelled First Year of Eased Operation (2026)

– Under eased conditions of operation, typically lake levels are held lower, but still within the normal operating range above 518 m RL most of the time, only falling below 518 m RL on occasion.
– There is approximately a 3% probability that lake levels in any given week will be below 518 m RL. Therefore, on average the lake level will be below 518 m RL for approximately 1.5 weeks in the first year of operation.
– 23% of the modelled hydrological sequences dip below 518 m RL in the first year. However, most instances are short duration and not deep. Of the 91 hydrological sequences modelled, 21 sequences fall below 518.0m and of these 21 sequences:
  - 9 fall between 518 – 517 m
  - 6 fall between 517 m – 516.5 m
  - 3 fall between 516.5 m – 516 m
  - 2 fall between 516 m - 515 m
  - 1 falls below 515 m

– In terms of duration, in the worst-case scenario, the lake level falls below 518 m RL in early September and does not return above 518 m RL until December (a duration of no more than 4 months). However, the likelihood of this scenario is extremely low – approximately 1% (1 of the 91 hydrological sequences modelled).

Modelled Subsequent Years of Eased Operation (2027 and 2028)

– The pattern is broadly the same in subsequent years although the probability of falling below 518 m RL in any given week increases very slightly to 3.5% in 2027 and 4% in 2028.

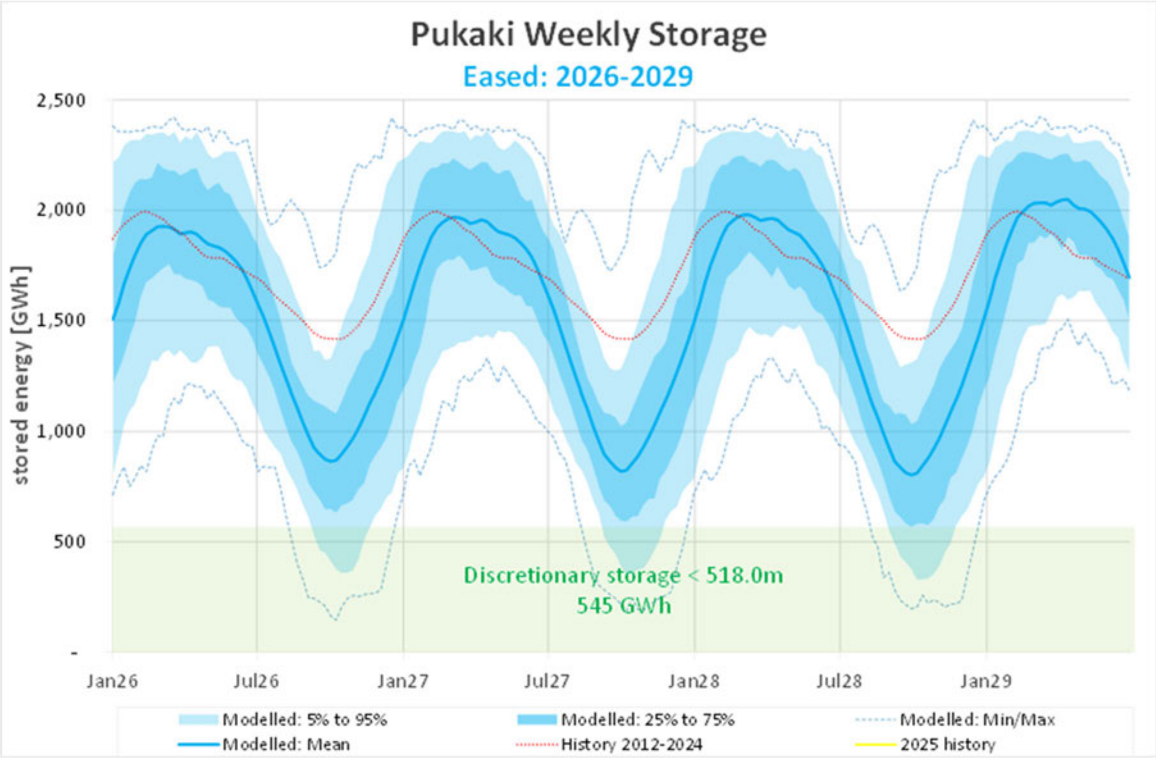

Figure 1 Meridian (2025) modelling results for stored lake water

2.2 Plan Change 1

The PC1 application stated:

- The duration of an event (time below 518 m) is likely to be between 4-7 months, with 7 months being an extreme scenario. Refilling of the lake to return above 518 m was by late December and sometimes into early January.
- The rate of drawdown of lake levels was estimated to be 1.5 m to 3 m per month in low flow conditions.
- The PC1 application did not consider the frequency of lake levels going below 518 m RL.

CPG (2012) provided analysis on potential effects of PC1 on groundwater and surface water users and concluded that:

- *"The Irrigation and Horticultural takes are unlikely to be affected;*
- *Consented stockwater takes are not going to be affected;*
- *Unconsented but registered domestic and stockwater takes are not likely to be affected;*
- *The effect on unconsented and unregistered domestic and stockwater takes is unknown; and,*
- *One registered observation well could potentially be affected. However, this belongs to Meridian".*

PC1 occurred prior to the National Environmental Standards for Freshwater (2020) therefore, impacts on wetlands were not explicitly assessed, although it is noted that CPG (2012) implicitly assumed that effects on the groundwater system would be minimal.

3. Environmental setting

This section provides a summary of the environmental setting, to provide context for the assessment of environmental effects in Section 4.

3.1 Topography

The topography around Lake Pūkaki is shown in Figure 2. To the north is Aoraki / Mount Cook at an elevation of approximately 3,700 m. The peaks of Ben Ohau Range to the west of Lake Pūkaki, reach elevations between approximately 2,263 m to 2,627 m and are generally steeper than the hills to the east of the lake. The difference in elevation between peaks of Ben Ohau Range and lake are in the order of 1,700 m or more.

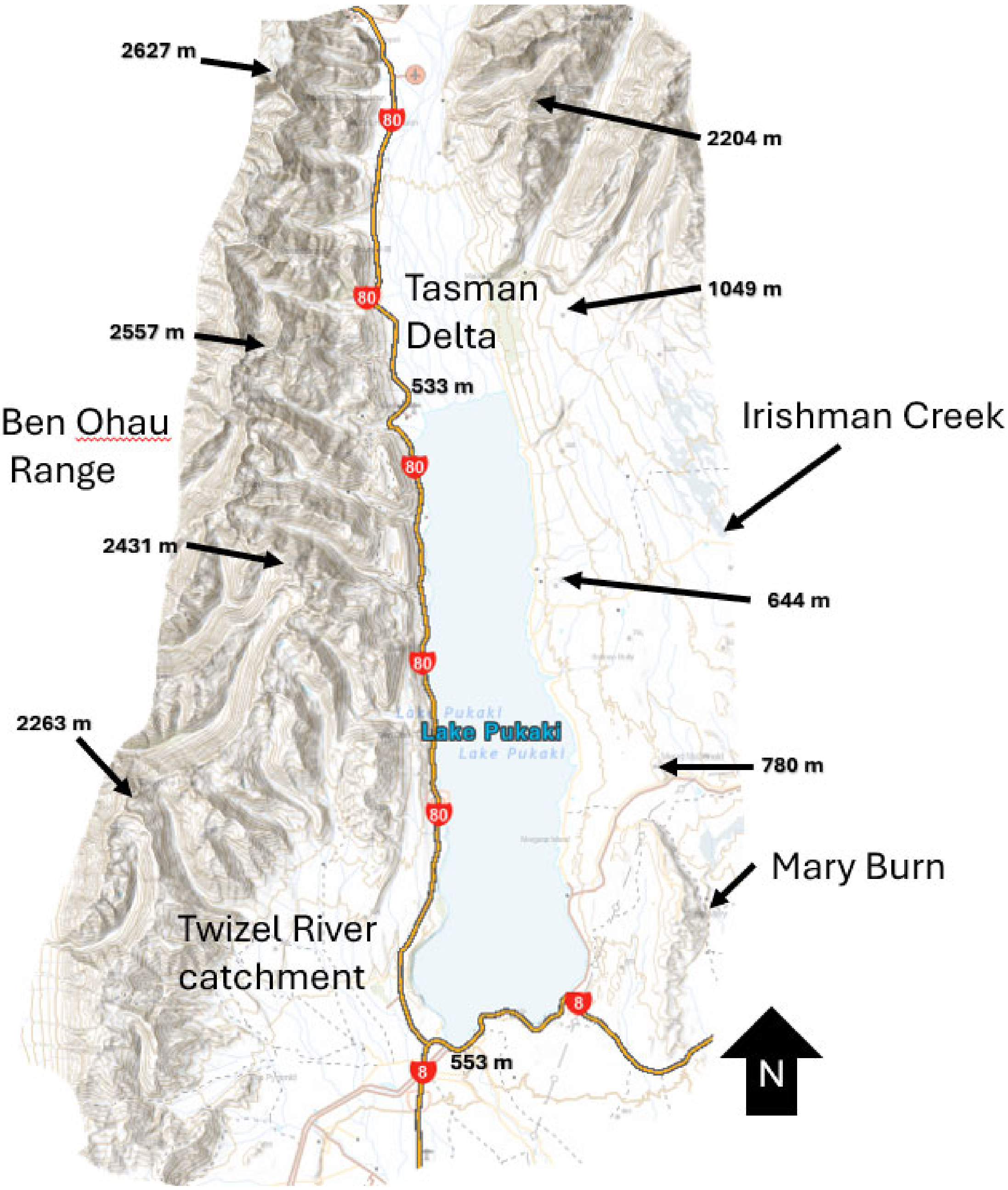

Figure 2 Topographic map with spot heights (relative to mean sea level) and selected features

3.2 Climate and hydrology

The climate of the Mackenzie basin is dominated by westerly winds and the Southern Alps, that creates a föhn effect resulting in steep rainfall and temperature gradients near to the divide (Kerr, 2009). As an example, the annual rainfall varies throughout the basing from 4,586 mm at Aoraki / Mount Cook village[2] to 663 mm at Pūkaki-Twizel airport[3], (Figure 3 A). Monthly average precipitation in the Mackenzie district (excluding Aoraki / Mount Cook village site) is relatively consistent year-round, but with a clear seasonal change in temperature (Figure 3 B and Boffa Miskell, 2023a). Aoraki / Mount Cook village mean monthly rainfall is an order of magnitude higher than the Mackenzie district average (Figure 3 B and C), with maximum daily rainfall per month demonstrating that large rainfall events (>100 mm/day) occur reasonably often in the upper catchment. In the upper catchments of Lake Pūkaki, there are also numerous glaciers, indicating permanent snow and ice cover. Permanent snow and ice cover decreases southward, due to change in elevation and climate.

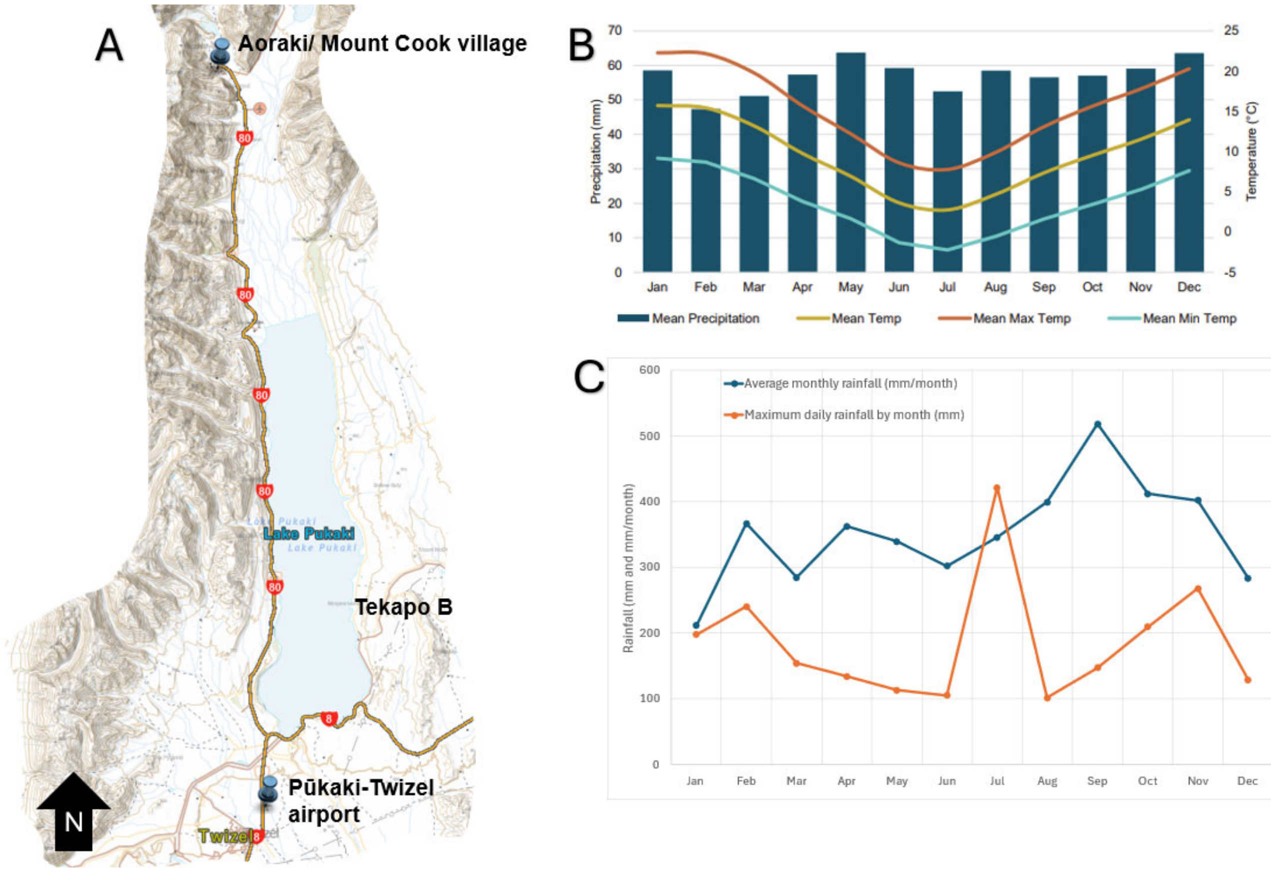

Figure 3 *A) Map showing the locations of rainfall station discussed in this report. B) Average monthly mean, maximum, minimum temperature, and precipitation for the Mackenzie District 1991- 2020 (excludes Aoraki Mount Cook; Source Boffa Miskell, 2023a). C) Monthly mean and maximum daily rainfall by month at Aoraki/ Mount Cook village*

Drainage patterns show that waterways with their headwaters on the eastern side of Ben Ohau Range, except for the Twizel River and tributaries (Figure 2), drain into Lake Pūkaki. As do most of the streams on the eastern side of the lake, north of Tekapo B (Figure 3) with headwater below approximately 791 m elevation.

East of the lake, Irishman Creek and Mary Burn flow southwards (Figure 2) and feed into the Tekapo River (which is located to the south of the lake) and outside of the area considered in this report. There is limited recent publicly available flow gauging data for waterways draining into the lake from the Ben Ohau Range or the hills to the east. However, many of the streams were flowing during the January 2025 site visit, suggesting that some may be permanently flowing.

[2] Environment Canterbury rainfall site 307001 Hooker at Aoraki/ Mount Cook **Rainfall data | Environment Canterbury**, 2024 total
[3] Pūkaki Aerodrome AWS, H40214, average 2009 to 2019.

Kerr (2009) reviewed and presented flow statistics for the Lake Pūkaki outflow, Hooker River and Jellie River in the upper catchment above the lake (Table 2). The data shows a relatively large number of flood flows per year, and an order of magnitude difference between the mean flow to the mean annual flood.

Table 2 Flow statistics from Kerr (2009), rounded to whole numbers.

Flow statistics	Unit	Lake Pūkaki	Hooker River	Jollie Stream
Mean annual 7-day low flow	m^3/s	18	4	3
Mean flow	m^3/s	133	25	8
Mean annual flood	m^3/s	1033	378	69
Mean number of flood events per year		9	14	7

3.3 Lake levels

Meridians consented operating range for Lake Pūkaki is between 518 to 532.5 m RL. As discussed in Section 1.1.2, there is a process to access water between a lake level of 513 to 518 m RL, dependant on permissions of other entities. Figure 4 shows the lake level from late July 2024 to July 2025, with the lake level in late July 2025 being 527.41 m RL. During the site visit on 23 and 24 January 2025, the lake level was approximately 531 m RL. The consented operating range for Lake Pūkaki is 14.5 m, increasing to 19.5 m for this application.

Due to the shape of the lakebed and low angle of the Tasman Delta (Figure 2), changes in lake level are most prominent at the northern end of the lake. For instance, publicly available aerial photographs show that at low lake levels, more of the Tasman Delta is exposed (as discussed in Section 5.3.2 of Tonkin and Taylor, 2025).

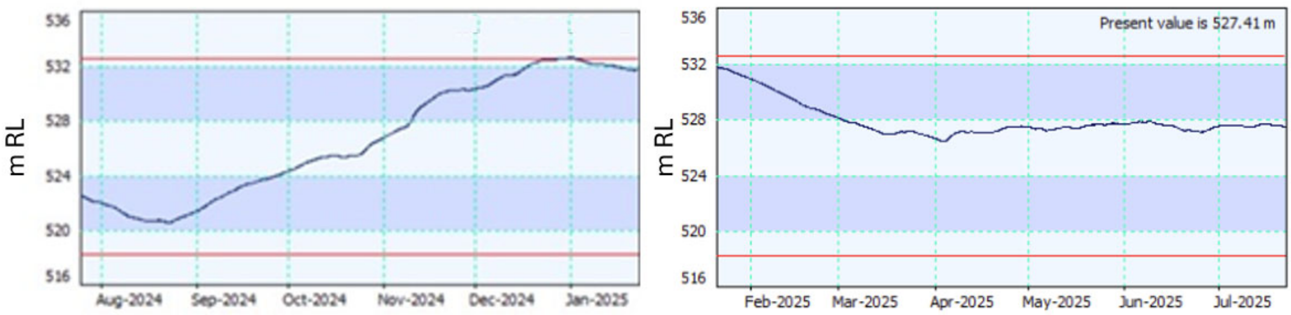

*Figure 4 Lake levels – Late July 2024 to July 2025. Source: **Meridian website**[4]*

3.4 Geology

The geology of the study area is described in Cox *et al.,* (2001), Fosyth (2001), URS (2003), Cooksey (2008), Barrell and Read (2013), and GHD (2023a), which is summarised here. A geological map of the study area is presented in Figure 5.

3.4.1 Basement

The Torlesse supergroup forms the basement rocks throughout the study area. Torlesse supergroup comprises greywacke and with low-grade schist present around Lake Ōhau and further south. The basement rock is generally hard and intact at depth but becomes increasingly weathered and fractured near the surface. The basement rock is effectively impermeable to groundwater flows. However, fractures may allow rainfall to infiltrate with the development of localised springs (Cooksey, 2008).

[4] **Lake levels - renewable energy generation | Meridian Energy**, accessed 22 July 2025

3.4.2 Tertiary

The Kowai Formation (Cox *et al.,* 2007), also known locally as the Glentanner Formation and Maniototo Conglomerate (Forsyth, 2001), is a weathered conglomerate derived from Torlesse supergroup rocks. The conglomerate is interbedded with very compact sands, silts and silty clays. The Kowai Formation occurs on the up thrown side (west) of the Ostler Fault Zone (west of Ōmārama; discussed further in Section 3.4.4). Other Tertiary rock units are inferred based on geophysical studies and/or occurrence further to the east, but do not out crop near the lake. The low permeability layers within the Kowai Formation are considered to be a barrier to groundwater flow (Cooksey, 2008).

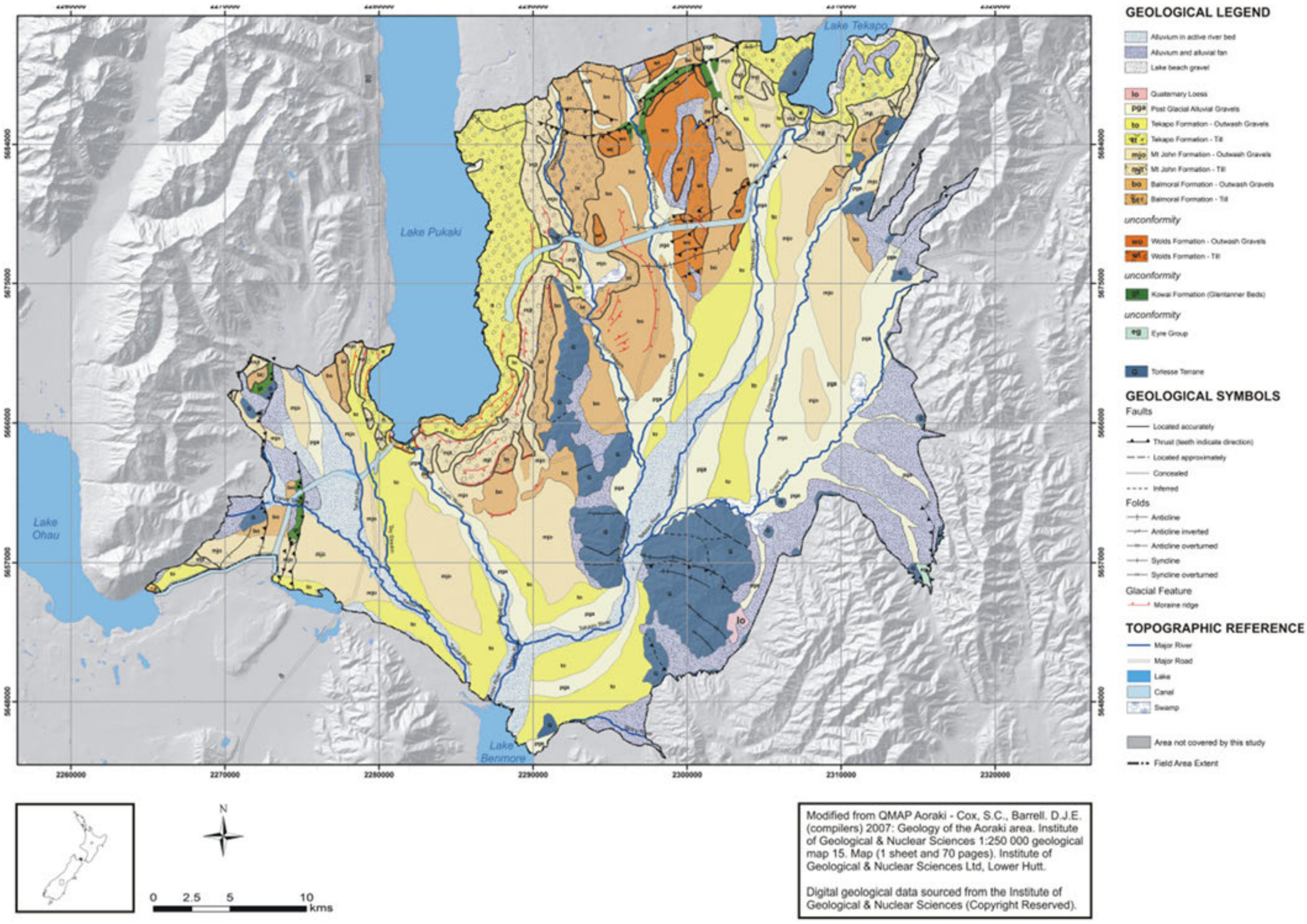

Figure 5 ***Geological map from Cooksey (2008)***

3.4.3 Quaternary

The Quaternary deposits are associated with four main glacial advances; Wolds, Balmoral, Mt John and Tekapo Formations, and recent post glacial gravels (Table 3). The advance and retreat of the glaciers has resulted in a complex geology. With the advance of a glacier scouring out the valley and then backfill with till during retreat. The spatially variable glacial sediments include moraine, till and outwash gravels. In general, the older deposits (Wolds and Balmoral) are more compacted and have a higher fines content and are considered to be less permeable.

Post glacial gravels occur predominantly within and around present-day river systems. The gravels comprise unweathered sandy gravel with lenses of well sorted gravels and sands. Higher silt content has been observed in the lower gravels, limiting downwards infiltration of shallow groundwater (Cooksey, 2008).

Table 3 Quaternary Glacial Deposits (summarised from Cooksey, 2008)

Formation	Description	
Wolds	Brown, moderate to highly weathered sandy gravel, voids filled with sandy clay. Thin interglacial unit overlying Wolds in Twizel area	Older ↓
Balmoral	Till and outwash gravels, lake moraines. Outwash gravels –sandy gravels with voids filled with silt and clay. Rare layers/lenses of well sorted gravels.	
Mt John	Till – gravelly sandy silt Outwash gravels- fine to coarse gravel with some sand. Sand lenses. Silts and clays are common at the base of the openwork layers due to percolating groundwater.	
Tekapo	Outwash gravels – unweathered sandy gravels with rare silt. Similar to Mt John gravels.	Younger

3.4.4 Lakebed and margins

The lake and surrounding area have been formed by glacial processes and tectonic uplift (Barrell and Read, 2014). Near the southern edge of the lake, near the dam, there is a complex arrangement of sediments with sands and silts underlying the dam, with outwash gravels occurring to the south (Figure 6). The silt (CSS in Figure 6) can be seen in outcrop to the north of the dam and are assumed to be present along the southern margin of the lake.

Due to the presence of glacial flour within the lake water and frequent flood events, the lakebed is covered in a layer of silt and clay (Irwin, 1972), acting as a hydraulic barrier between the lake and underlying groundwater system. It is likely that the lakebed sediment grain-size decrease southwards, down the lake.

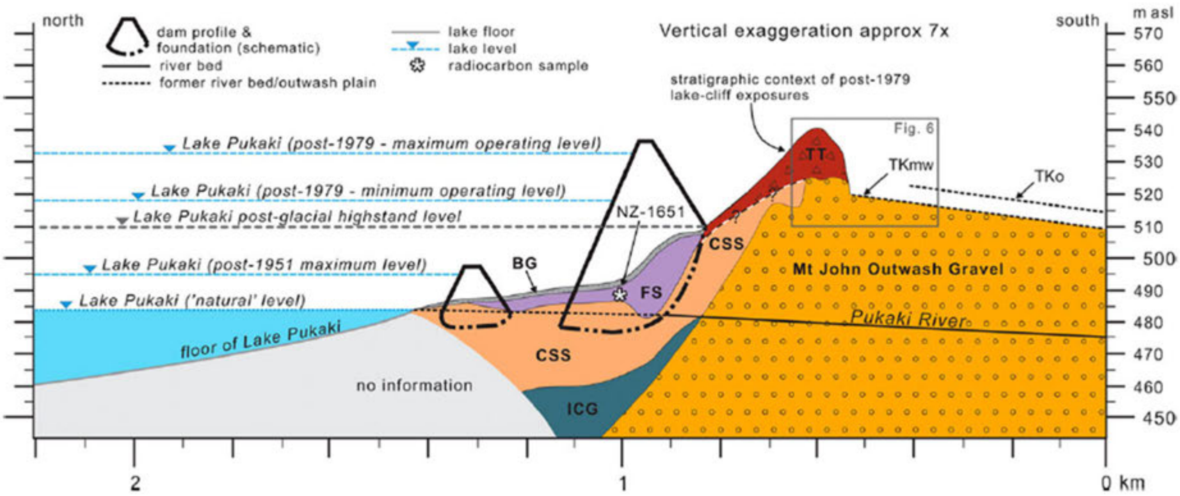

Figure 6 Schematic of the geology near the dam. From Barrell and Read (2014). TKmw, Tekapo meltwater terrace surface; TT, Tekapo Till; ICG, Ice Contact Gravel; CSS, Contorted Sediments Silt; FS, Fancy Sands; BG, Beach Gravel.

3.4.5 Structures

The Ostler Fault zone strikes north-northeast on the western side of the Mackenzie Basin and Lake Pūkaki (Jack, 2023; and Appendix A). Movement on the fault has uplifted lower permeability Kowai Formation, which likely acts as a barrier to shallow groundwater flow, with ponding and springs observed on the up-thrown side (Cooksey, 2008). Irishman Creek Fault strikes northeast-east on the eastern side of Lake Pūkaki, with movement on the fault throwing up Kowai Formation to the southeast (Appendix A). Bedrock highs within the basin, (e.g. Mary Range) likely provide an impermeable barrier to groundwater flow, with swampy areas common at the base of the ranges.

3.5 Wetlands

High level wetland studies have been conducted by the Department of Conservation (DOC), Boffa Miskell (2020) and Tonkin and Taylor (2025). This information is summarised below.

3.5.1 DOC desktop study

Department of Conservation (DOC) undertook a desktop study to identify "possible" wetland type features, which is published on Canterbury Maps[5]. It is understood that the information in the wetland layer has not been field verified (Figure 7). Figure 7 shows the location of "possible" wetlands around the lake, many of the wetlands are located at elevation above the current lake level.

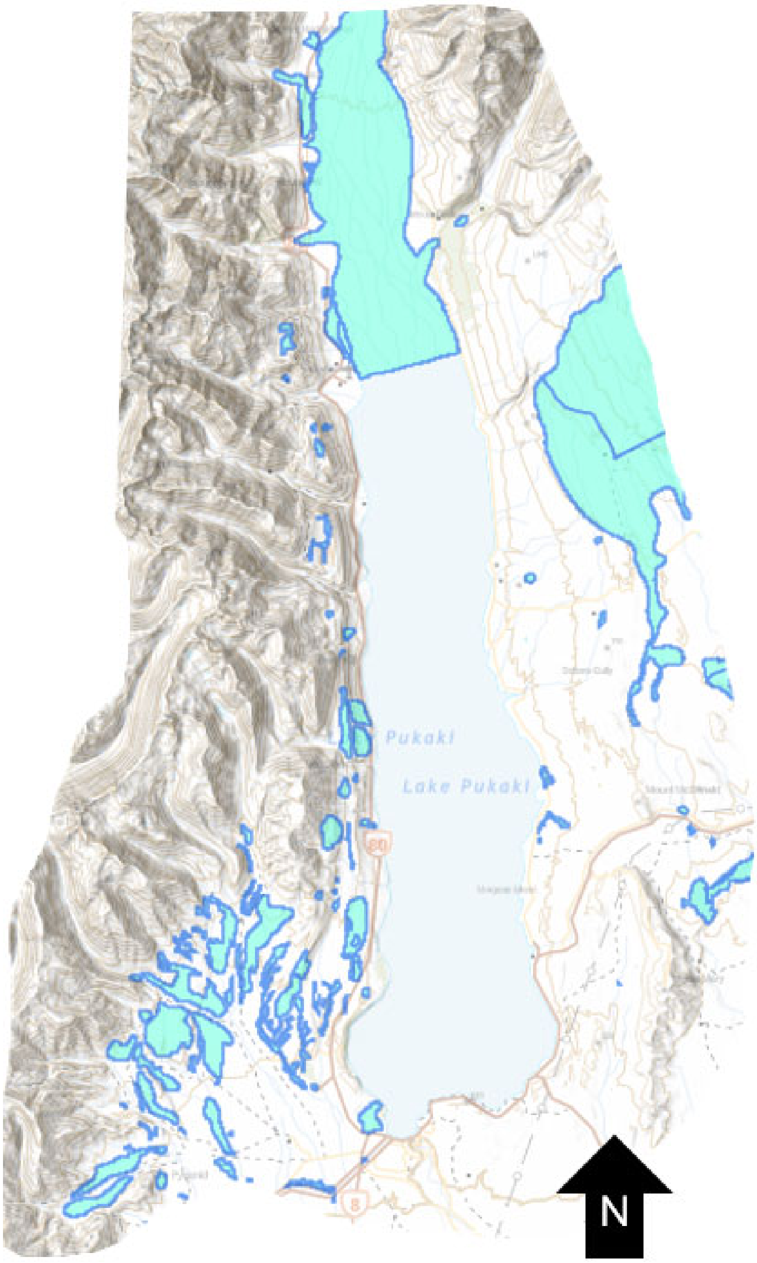

Figure 7 DOC wetland type features

[5] Wetland Areas (DOC) **https://ecan.maps.arcgis.com/home/item.html?id=1c000e74de364770bf85f6a9f5517d68**, accessed on 17 July 2025.

3.5.2 Boffa Miskell – rapid assessment

Boffa Miskell (2020) undertook a rapid assessment of accessible wetlands, near the margins of the lake. The assessment involved a desktop assessment to identify potential sites of interest, site investigations, analysis and reporting. The rapid assessment of accessible wetlands concentrated on publicly accessible wetlands near the margins of Lake Pūkaki. Boffa Miskell (2020) used the RMA (1991) and National Planning Standards wetland definition of '*permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet cond*itions' to inform the delineation of the wetlands.

The site investigation occurred in early December 2019 and late January 2020. These investigations coincided with very high lake levels, due to a very large rainfall event in early December 2019 which raised the lake to the Maximum Control Level (i.e. 532.5 m RL). These conditions allowed a robust assessment of the connection between the wetlands and Lake Pūkaki. However, the Tasman River Delta was submerged during the site investigations and was not surveyed. Boffa Miskell (2020) identified 22 wetlands along the margins of Lake Pūkaki including the Tasman River Delta (Figure 8). A summary of the 21 surveyed wetlands in is provided in Table 4.

Boffa Miskell (2020) was incorporated into Boffa Miskell (2023b), which was written to support the reconsenting of the WPS.

Table 4 Wetland type summary from Boffa Miskell (2020)

Totals number of wetlands by class [1 2]
Marsh = 17
Shallow water = 8
Swamp = 3
Ephemeral = 2
Seepage = 1
[1] Wetland class as per Johnston and Gerbeaux (2004). [2] Wetlands can have more than one class or hydrological connection, hence why the totals add up to more than 21.

3.5.3 Tonkin and Taylor

Tonkin and Taylor (2025) assessed wetlands for this fast-track consent, using the information from Boffa Miskell (2020) and Boffa Miskell (2023b), and their observations from the site visit. Tonkin and Taylor (2025) largely agreed with the Boffa Miskell (2020) assessment; however, they amended some of the wetland value results.

Totals number of wetlands by class [1 2]
Marsh = 17
Shallow water = 8
Swamp = 3
Ephemeral = 2
Seepage = 1
[1] Wetland class as per Johnston and Gerbeaux (2004). [2] Wetlands can have more than one class or hydrological connection, hence why the totals add up to more than 21.

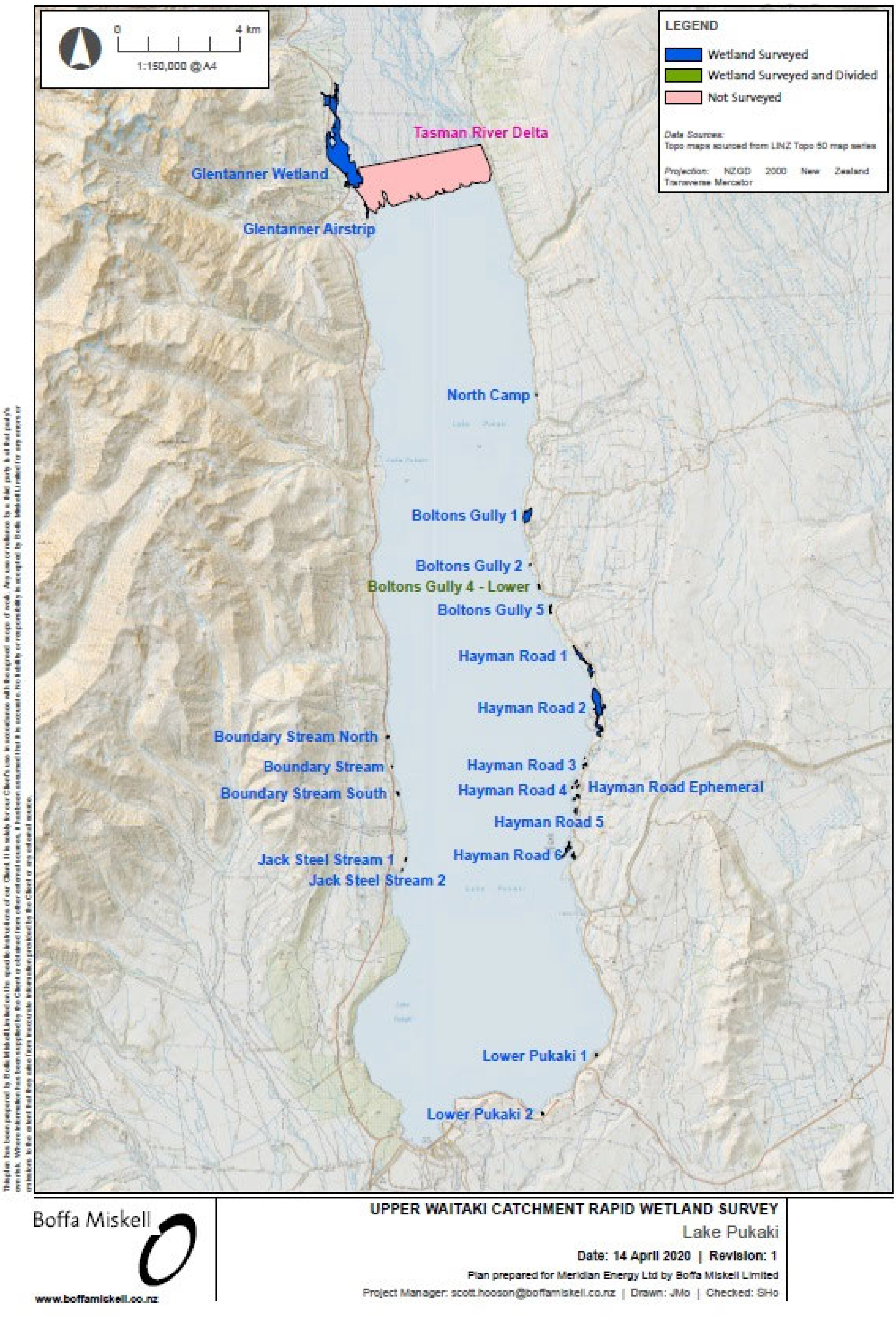

Figure 8 ***Wetlands identified as part of Boffa Miskell (2020) Rapid Assessment of Accessible Wetlands***

3.6 Hydrogeology

There is very limited historic groundwater information around Lake Pūkaki (groundwater levels, aquifer test results, groundwater quality data etc.), except for five piezometric surveys that cover or partially cover the area, discussed briefly later in Section 3.6.1 (SKM, 2004; two completed by Cooksey, 2008; GHD, 2009; URS, 2010).

Cooksey (2008) suggested that the permeability of the formations decreased with depth (see Table 3), with the most permeable unit being the Post Glacial Alluvial Gravels located close to active rivers. The Tekapo formation is generally considered to be quite thin and generally similar in outcrop to the Mt John formation. The Mt John formation is considered to contain a semi-confined regionally significant aquifer.

To the northwest side of the lake, due to the steep topography and geology in Ben Ohau Range, it is assumed that rainfall dominates the hydrological cycle. Groundwater most likely occurs within the recent boulder dominated sediments located near active river channels, as shown in Figure 11. Further south towards the upper Twizel catchment (Figure 2), groundwater is also likely to be found in the Tekapo and Mt John formations, recharged from both rainfall and losses from streams. On the eastern side of the lake rainfall recharge is likely to dominates as there are few streams or rivers.

3.6.1 Groundwater flow direction

Just south of the Pūkaki dam, URS (2010) undertook a piezometric survey of regional groundwater probably within the Mt John Outwash Gravels with a perched system within the recent post glacial gravels. The survey found that regional groundwater had levels approximately 40 to 50 m below ground level (near the lake), with a perched shallow groundwater system near the canal. Other piezometric survey contours are available, noting they have been created for a range of reasons using different methods. Generally, the groundwater flow direction follows topographic gradients, with groundwater generally flowing towards the south- southeast, as demonstrated in Cooksey (2008) September 2007 survey (Figure 9).

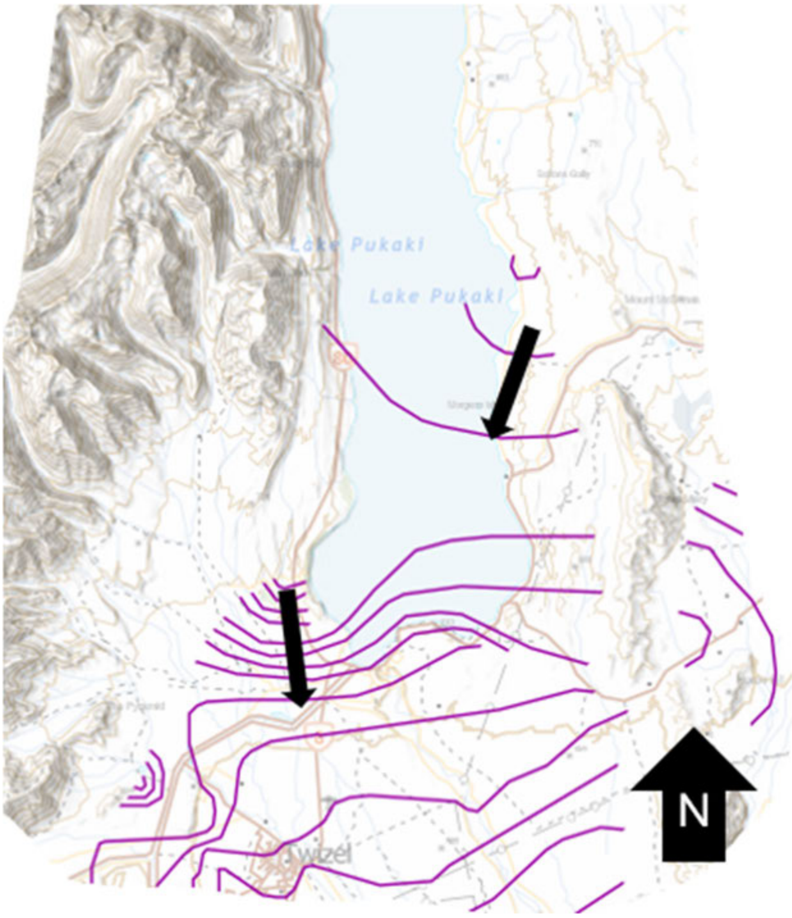

Figure 9 Piezometric contours, from Cooksey (2008)

Mapping by Boffa Miskell (2020) identified several wetlands near or on the margin of the lake and it is assumed that many of these wetlands are groundwater fed (Figure 8). The location of many of these wetlands at the base of a slope, or where there is a change in slope, suggests a flow path similar to what is shown in Figure 10. The conceptualisation in Figure 10 indicates that rainfall and localised groundwater inflow are the dominant water sources, with evapotranspiration and some lateral groundwater flow from the wetland to the lake, being the dominant outflows.

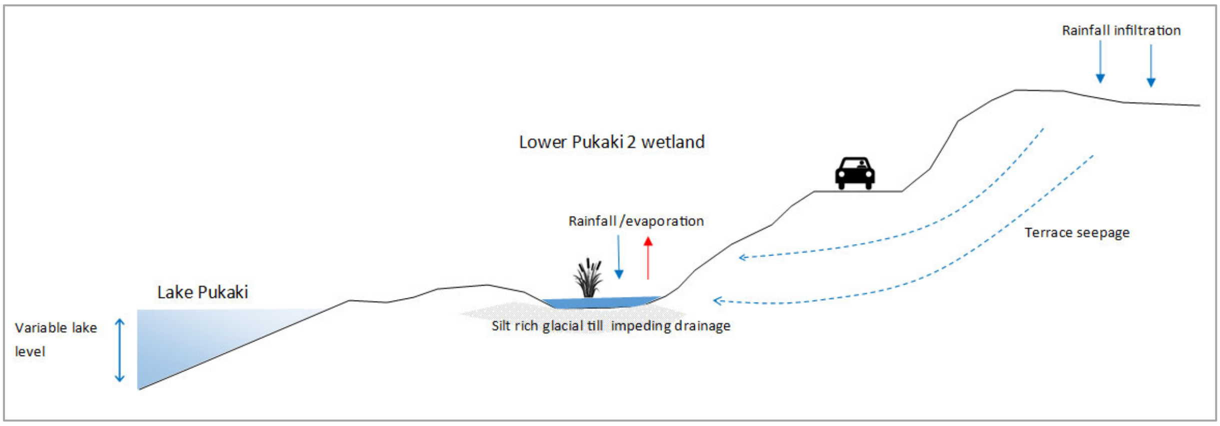

Figure 10 ***Schematic of Pūkaki 2 wetland groundwater flow path***

Figure 11 ***Photo taken near State Highway 80, looking up Twin Stream, just south of Glentanner. Greywacke (basement) form the valley sides, with the valley alluvium dominated by boulders and cobbles.***

3.6.2 Existing groundwater users

An assessment on existing groundwater users was undertaken using information from Canterbury Maps[6]. There are 34 existing bores located close to the margins of the lake (Figure 12 and Table 5). Of the 34 bores, 21 are likely to be or are owned by Meridian (for instance, bores with Ministry of Works listed as owner have been assumed to be owned by Meridian). Of the remaining 13 bores, one is listed as not used and therefore excluded from further analysis (H37/0001), with the remainder being active and used for domestic (6 bores), domestic and stockwater (4 bores) or irrigation (BZ15/5196) purposes. There are two active bores without a stated purpose (BY15/5001 and BY15/5002). BZ15/5196 irrigation take is authorised by CRC250571 at a maximum rate of take of 5 L/s.

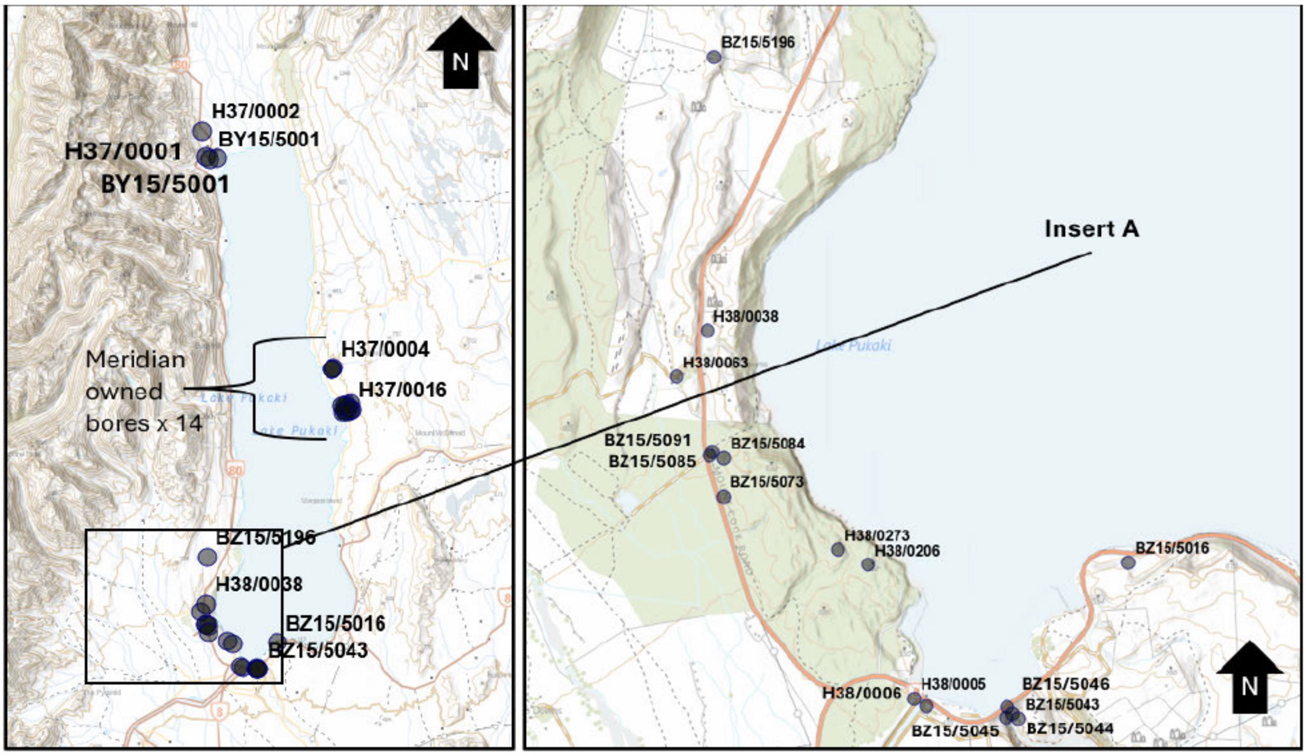

Figure 12 Existing bores near the lake margin, with Insert A showing bores close to the dam. Source Canterbury Maps

Table 5 Summary of bores near Lake Pūkaki

Well number	Status	Owner	Use	Depth (m)	Estimated distance between the bore and a lower lake level (m)[1]
H38/0273	Active	Mt Cook Lakeside Retreat	Domestic Supply	96.0	270
H38/0206	Active	Lakeshore Estates Limited	Domestic and Stockwater	108.5	230
H38/0063	Active	Mr A E Tibby	Domestic Supply	48.0	810
H38/0038	Active	Mr R J Houston	Domestic Supply	36.2	500
H38/0006	Active	Meridian	Water Level Observation	20.3	270
H38/0005	Active	Meridian	Water Level Observation	20.5	220
H37/0021	Not Used	Meridian	None listed	61.0	580
H37/0018	Not Used	Meridian	None listed	51.8	700

[6] Wells and bores – Existing **https://ecan.maps.arcgis.com/home/item.html?id=03919d3fe9df4306b418b8df7fb0bcdf**, accessed on 17 July 2025.

Well number	Status	Owner	Use	Depth (m)	Estimated distance between the bore and a lower lake level (m)[1]
H37/0014	Active	Meridian	Water Level Observation and Stock Supply	68.0	430
H37/0013	Active	Meridian	Water Level Observation and Stock Supply	83.5	280
H37/0012	Not Used	Meridian	None listed	70.1	530
H37/0011	Not Used	Meridian	Water Level Observation	32.9	120
H37/0010	Not Used	Meridian	Water Level Observation	34.7	160
H37/0009	Not Used	Meridian	Water Level Observation	51.8	310
H37/0008	Not Used	Meridian	None listed	3.4	-
H37/0007	Not Used	Meridian	Water Level Observation	25.0	160
H37/0006	Not Used	Meridian	None listed	38.4	130
H37/0005	Not Used	Meridian	None listed	46.9	120
H37/0004	Not Used	Meridian	None listed	13.1	200
H37/0002	Active	The Helicopter Line	Domestic Supply	37.0	2,340
H37/0001	Not Used	Glentanner Park	Domestic and Stockwater	21.0	1,260
BZ15/5196	Active	NZ Alpine Lavender	Irrigation (authorised by CRC250571)	49.7	1,880
BZ15/5091	Active	Matt Hurst	Domestic and Stockwater	47.1	810
BZ15/5085	Active	Matt Hurst	Domestic and Stockwater	53.0	810
BZ15/5084	Active	Matt Hurst	Domestic and Stockwater	53.0	720
BZ15/5073	Active	Charlie Hobbs	Domestic Supply	35.5	870
BZ15/5046	Active	Meridian Energy Ltd	Geotechnical / Geological Investigation	30.5	60
BZ15/5045	Active	Meridian Energy Ltd	Geotechnical / Geological Investigation	35.0	130
BZ15/5044	Active	Meridian Energy Ltd	Geotechnical / Geological Investigation	35.2	140
BZ15/5043	Active	Meridian Energy Ltd	Geotechnical / Geological Investigation	30.2	210
BZ15/5016	Active	Nomadic Yurts Limited	Domestic Supply	96.1	200
BY15/5002	Active	Glentanner Station Limited	None listed	15.6	580
BY15/5001	Active	Glentanner Station Limited	None listed	20.5	1,040

[1] Low lake level was the level shown in the "latest imagery" shown in Canterbury Maps, accessed 17 July 2025

3.6.3 Groundwater conceptual model

A stylised groundwater conceptual model for the lake and surrounding area is presented in Figure 13, based on information presented in Section 3. The groundwater conceptual model for the lake and surrounding area is:

- Groundwater mostly occurs in the gravels associated with recent post glacial, till and outwash deposits.
- The recent post glacial, tills and outwash are likely recharged from rainfall and/or stream losses.
  - Rainfall recharge likely dominants on the eastern side of the lake, where there are few streams/rivers.
  - Ben Ohau Range contains steep, relatively narrow and thin boulder dominated valley aquifers that are likely hydraulically connected to the streams. The streams are likely fed by a combination of rainfall and snow/ice.
  - Recharge to the aquifer in the Twizel River catchment (Figure 2) is likely a combination of rainfall and stream losses.
- Groundwater flow generally follows topography.
- Boffa Miskell (2020) mapping, aerial photographs and topography maps (Section 3.1), show wetlands and wet areas located above the lake levels. This observation supports the interpretation that groundwater is flowing downslope, towards the lake, and discharging to the surface in places, as shown in Figure 10.
- The lakebed has a cover of silts and clays (Irwin, 1972), which inhibits the interaction between the lake and aquifers.
- Near the dam, Barrell and Read (2014) identified a silt layer around the margins of the lake.
- This layer, the presence of fine-grained lakebed sediments (Irwin, 1972), and the piezometric survey result from URS (2010) suggests that limited interaction between the groundwater system and lake.
- The Tasman Delta is composed of recent river deposits, fed by a range of water sources, such as river and rainfall recharge.

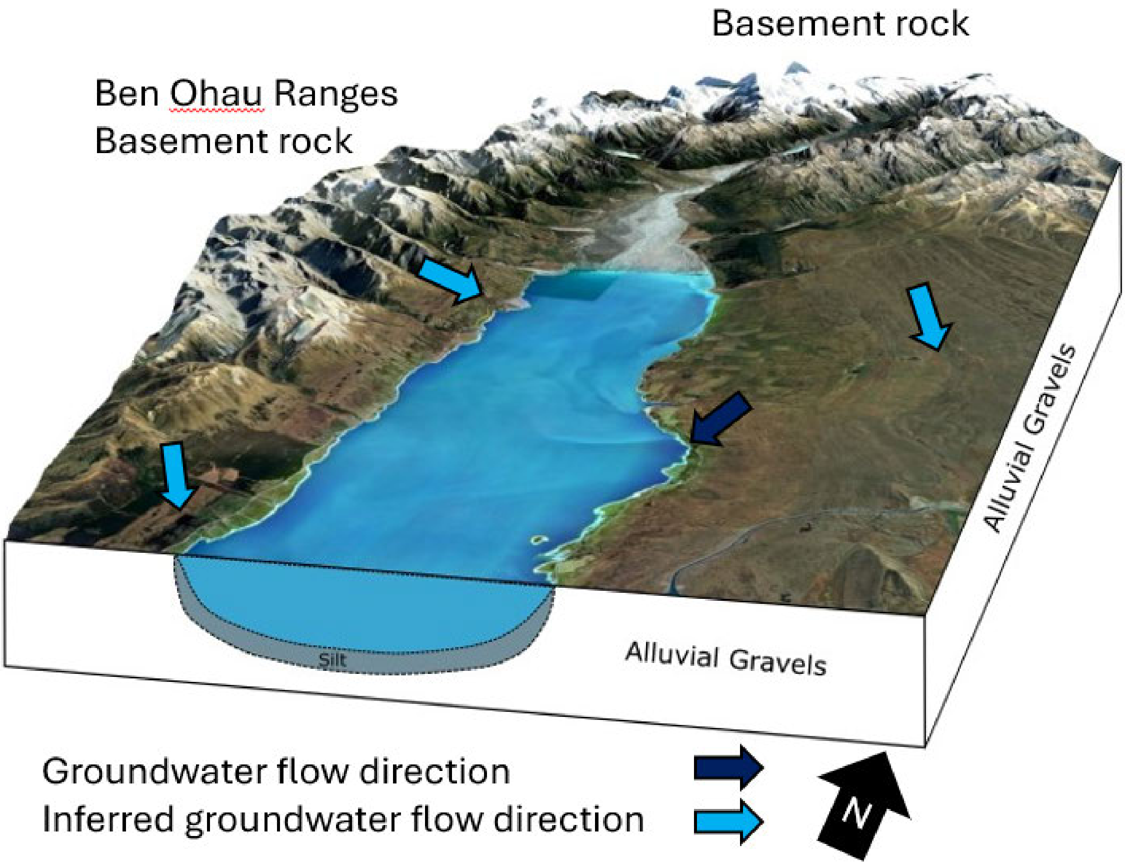

Figure 13 *Stylised groundwater conceptual model. Groundwater flow directions from Cooksey (2008) and inferred groundwater flow directions assumed from topography and drainage patterns. Note the thickness of the silt layer at the base of the lake is unknown, depicted in the image to indicate its presence (Irwin, 1972)*

4. Assessment methodology

This section describes the methods used to determine potential and actual effects described in Section 5, specifically relating to if a lower of lake level could impact:

- the groundwater levels in nearby bores (groundwater users)
- the water level range or function of wetlands.

4.1 Groundwater users

The groundwater user assessment seeks to understand the hydraulic connection between privately owned active bores and the lake level, to evaluate if:

- Lowering the lake level could potentially reduce the groundwater levels in nearby bores, and
- If there is a hydraulic connection between the lake levels and bores, to estimate changes in groundwater levels in those bores.

The first step in the groundwater user assessment was to identify the privately owned active bores near the lake edge. It is highly likely that if a hydraulic connection between lake levels and bores exists, changes in levels will be most obvious in bores closest to the lake edge. Therefore, the assessment concentrated on bores within 500 m of the lake edge but excludes bores that are or likely owned by Meridian (Figure 14).

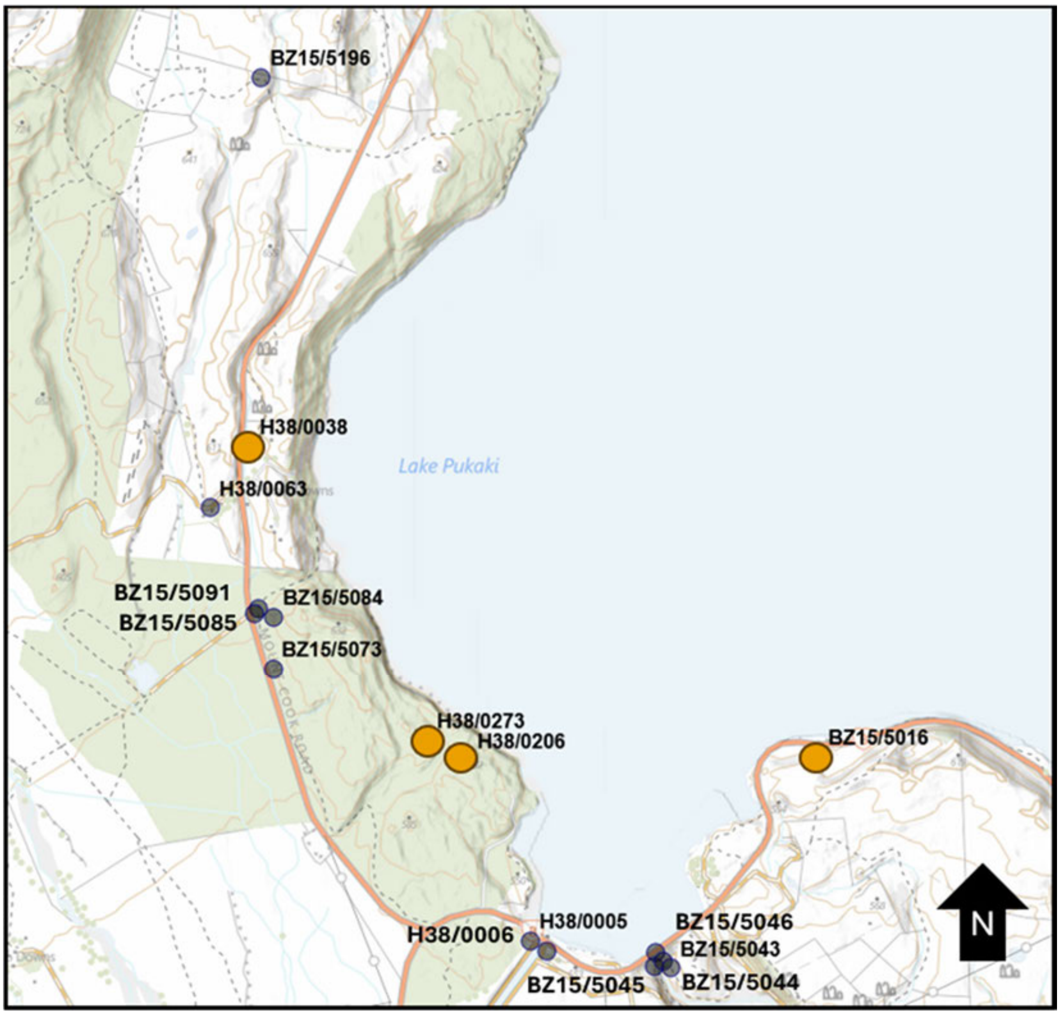

Figure 14 ***Privately owned active bores within 500 m of the lake indicated with orange dots***

After the bores had been identified, the following tasks were completed:

- Key details and groundwater level information were summarised (Table 6), so that they could be directly related to lake levels. Noting that the key details and groundwater level information of all the bores listed in Table 5 are shown in Appendix B for completeness.
- Review of bore logs (Appendix A) to understand the geology.
- Review of yield test information and results where available.

To identify a bore that may be affected by changes in the lake level, it would be expected that:

- The top of the screen would be within or near the proposed operating level for the lake (the proposed minimum level being sort is 513 m RL, maximum lake level of 532.5 m RL), noting the screened interval is where groundwater enters the bore
- The bore log indicates potential for hydraulic connection to the lake, for instance gravels from land surface to below the bottom of the screen
- The yield test indicates a recharge boundary, which is inferred to be the lake.

Table 6 Bores within 500 m of lake

Well number	Distance (m) [1]	Depth (m)	Screen interval (m RL) [2]		Initial groundwater level (m RL)	Lowest and highest groundwater level (m RL)		Groundwater level count
			Top	Bottom		Highest	Lowest	
H38/0273	270	96.00	488.0	484.0	508.2			1
H38/0206	230	108.50	471.0	469.0	507.1			1
H38/0038	500	36.20	559.1	558.4	574.0	572.6	570.1	15
BZ15/5016	200	96.06	510.3	500.3	515.5			1

[1] Estimated distance between the bore and a lower lake level, where low lake level was the level shown in the "latest imagery" shown in Canterbury Maps, accessed 17 July 2025

[2] Bore m RL from Canterbury Maps

4.2 Wetland hydrology

The wetland hydrological assessment seeks to understand if there is a hydraulic connection between the wetlands and lake, and if a connection does exist, over what range of lake levels.

The wetland hydrological assessment was informed by:

- Review of the Boffa Miskell (2020) report.
- Site visit to see most of the wetlands described in Boffa Miskell (2020). The site visit occurred on the 23 and 24 January 2025. Site visit accompanied by ecologists from Tonkin and Taylor (2025).
- Estimate the lowest elevations of the wetlands, using elevation available in Canterbury Maps.
- Review aerial photographs to understand how different lake levels relate to the wetlands. GHD concentrated on the following aerial photographs, available in Canterbury Maps:
  - "Imagery 2010-2014" series which shows a relatively high lake level.
  - "Infrared imagery" which is based on the imagery 2010-2014 series, but allows wet areas to be readily identified.
  - "Latest imagery" series which shows a low relatively low lake level.
- Review of all the data and images described above to understand the most likely hydrological source/s to the wetlands, their connection to the lake and understand if the proposed activity may influence wetland hydrology.

It is considered that a wetland with a strong hydraulic connection to the lake would be located at a similar level to the lake, for all, or part of the time.

5. Assessment of environmental effects

The assessment of environmental effects presented here focuses on the impacts of the proposed activity on groundwater users and wetland hydrology, along with a comparison of anticipated effects between this application and PC1.

5.1 Groundwater users

This section summarised the result of the method described in Section 4.1, shown in Table 7, and concentrates on four privately owned active bores within 500 m of the lake margin (H38/0273, H38/0206, H38/0038 and BZ15/5016).

H38/0273 and H38/0206 screens are located well below the proposed low operating level. As such they are unlikely to be directly hydraulic connected to the lake. H38/0038 bottom screen is at approximately 558.4 m RL, being 26 m above the maximum lake level of 532.5 m RL, and 45 m above the proposed lower operating level of 513 m RL. Again, these values suggest this bore is unlikely to be directly hydraulic connected to the lake.

BZ15/5016 is located on the southern edge of the lake (Figure 14), and piezometric contours suggest groundwater flow in this area is southwards from the lake towards the bore. However, BZ15/5016 bore log shows 9 m thick sandy silt layers between 519 to 510 m RL, with its screen installed below the silt from 510 to 500 m RL. The BZ15/5016 bore log (Appendix A) is consistent with Barrell and Read (2014) schematic presented in Figure 6 and is evidence that there is a clear sedimentary barrier between the lake and BZ15/5016 restricting any significant hydraulic connection.

The yield test undertaken on BZ15/5016 (available via ECan's well search tool[7]) was reviewed as part of this assessment. The yield test results show large drawdowns for small yields (54.3 m of drawdown for less than 0.51 L/s), consistent with it being installed into a low permeable material. If the lake acted as a recharge boundary to the bore, we would expect much higher yields and smaller drawdowns. Given the evidence presented above, it is unlikely that BZ15/5016 is hydraulic connected to the lake.

Table 7 Analysis summary

Well number	Distance to lake	Depth (m)	Top of screen (m RL)	Difference between the top of screen and the 513 m RL operating level	Initial groundwater level (m RL)
H38/0273	270	96.00	488.0	-29.0	508.2
H38/0206	230	108.50	471.0	-44.0	507.1
H38/0038	500	36.20	559.1	45.4	574.0
BZ15/5016	200	96.06	510.3	-12.7	515.5

5.2 Wetland hydrology

This section summarised the result of the method described in Section 4.2, and focuses on wetlands near the lake margins.

The analysis is presented in Table 8 and in summary:

– 14 wetlands are inundated at high lake levels but not at lower lake levels, suggesting they are hydraulically connected to the lake at times, but that they continue to function over a large range of water levels (for instance the current operating range of 532.5 to 518 m RL)

– 5 wetlands that are considered to be not hydrologically connected to the lake, similar to what is shown in Figure 10

[7] **Well search | Environment Canterbury** **https://www.ecan.govt.nz/data/well-search/welldetails/QloxNS81MDE2/QloxNS81MDE2IA%3D%3D**

- 2 wetlands may be inundated by waves at high lake levels but not at lower lake levels, suggesting they are connected to the lake at times, but that they continue to function over a large range of water levels (for instance the current operating range of 532.5 to 518 m RL)
- The Tasman Delta is directly connected to the lake and how much land is exposed depends on lake levels (Boffa Miskell, 2023b; Tonkin and Taylor, 2025). As the delta already experiences changes in lake level, the wetland hydrology to the Tasman Delta is not expected to change from Baseline conditions due to the proposed activity.

From this analysis, it is concluded that 17 wetlands are occasionally inundated by the lake. With the exception of the Tasman Delta, these wetlands interact with lake at approximately 525 m RL and above. Given the large range of lake levels that occur now (518 to 532.5 m RL), it is considered unlikely that there will be a change to wetland hydrology if the lake operates between 518 and 513 mRL for limited periods of time over the next three years.

5.3 Comparison to PC1

Sections 2.1 and 2.2 describe the proposed activities for this application and what was considered as part of PC1. PC1 anticipated lake levels below 518 m RL for 4 to 7 months, with 7 months considered an extreme scenario. In comparison, this proposal anticipates lake levels under 518 m RL for approximately 39 days over three years, and a low probability worst case scenario of less than 4 months (Section 2.1). CPG (2012), who supported the PC1 process on behalf of Meridian, found effects on groundwater users are unlikely (see Section 2.2). The analysis undertaken in Sections 5.1 of this report came to a similar conclusion, that groundwater users are unlikely to be impacted by this proposal. CPG (2012) did not explicitly consider impacts on wetlands because PC1 was before the release of the National Environmental Standard for Freshwater.

5.4 Summary of Effects

- This report concentrates on assessing the potential effects of the activity on existing groundwater users and wetlands and compares the anticipated effects of this proposal to what was considered in PC1. The effects assessment concluded that:
- Groundwater users will not be impacted, as the closest bores are screened above or below lake levels, or the bores are located further than 500 m from the lake edge.
- Except for the Tasman Delta, many of the wetlands are occasionally inundated by the lake at higher lake levels but continue to function over a large range of water levels. The Baseline conditions for the environment already experiences a range of lake levels from 532.5 to 518 m RL.
- The Tasman Delta is hydraulically connected to the lake but again, continues to function over a large range of water levels (Tonkin and Taylor, 2025).
- This proposal anticipates that lake levels will on average be below 518 m RL for periods much less than the 4 to 7 months considered during PC1. CPG (2012) concluded effects of PC1 on will be minimal on groundwater users. This report came to a similar conclusion for this proposal.

*Table 8 Summary of the wetland analysis. * directly from Boffa Miskell (2020) and GW = groundwater*

Wetland Name*	Classes*	Landform*	Hydrological connection to the lake	Other influences	Hydrology description*	Wetland hydrological assessment updated	Aerial photograph analysis	Estimated minimum elevation (m RL)	Expected change in GW system
Glentanner Wetland	Marsh	Floodplain, Shore	Lake inundation at high lake levels	Stream Inflows, Groundwater	Dead Horse Creek and other stream inflows are the main wetland driver. Lake Pūkaki inundation is important at the shore edge	Wetland located above high lake level observed on site visit (January 2024). Stream inflows likely main driver, some groundwater input likely	2010-2014 lake level near to the margin of mapped wetland. Latest imagery lake level is approx. 1,100 m away from the edge of the wetland	~530-535	No change expected
Tasman River Delta	Not surveyed by Boffa Miskell (2020) due to high lake level	Delta	Lake inundation	Stream Inflows	Not surveyed by Boffa Miskell (2020) due to high lake level	Wetland likely fed by a combination of sources	Shoreline varies by approx. 1,000 m between 2010-2014 and latest imagery	~515-525 at low lake levels	No change expected
Glentanner Airstrip	Marsh	Shore	Lake inundation at high lake levels	Groundwater	Inundation from Lake Pūkaki is the main wetland driver, there are no obvious major upslope water sources	Wetland likely fed by a combination of lake inundation and groundwater discharge	2010-2014 lake level near to the margin of mapped wetland. Latest imagery lake level is approx. 470 m away from the edge of the wetland	~525-530	No change expected
North Camp	Marsh, Shallow water	Shore, Riparian	Lake inundation at high lake levels	Stream Inflows	Inflows from a rapidly flowing stream are the main riparian wetland driver. Lake inundation is important for the small shore wetland	Wetland hydrology likely dominated by stream inflow. Potential for groundwater to supplement stream baseflow	At or just above high lake level (2010-2014 imagery)	~530-535	No change expected
Boltons Gully 1	Seepage, Shallow Water	Depression	None	Groundwater and rainfall	Wetland is on terrace slopes fed by seepages. No culvert or evidence of a direct connection to lake could be found, but based on wetland elevation and water levels a groundwater connection is possible	Wetland located above high lake level observed on site visit (January 2024), as such very likely fed from groundwater and rainfall runoff. Road potential acts as a flow barrier to groundwater flow	Above high lake level (2010-2014 imagery)	~550	No change expected
Boltons Gully 2	Marsh, Shallow water	Channel	Lake inundation at high lake levels	Groundwater and lakeshore gravels	No surface connection to lake at maximum consented lake level but waves would likely reach the wetland. Lake water probably percolates through gravels and contributes groundwater	Given the wetlands location at the base of slope, the wetland is likely fed by a combination of groundwater discharge and interacts with the lake through lakeshore gravel barrier	2010-2014 wetland partially inundated Latest imagery lake is approx. 145 m away from the edge of the wetland	~530-540	No change expected
Boltons Gully 4 lower	Marsh, Shallow water	Shore	Lake inundation at high lake levels	Groundwater and lakeshore gravels	Wetland likely to be driven by groundwater from upslope except during high lake level when lake groundwater is important, lake inundation may occur on very rare occasions	Given the wetlands location at the base of slope, the wetland is likely fed by a combination of groundwater discharge and interactions with the lake during high lake levels	2010-2014 wetland partially inundated Latest imagery lake is approx. 85 m away from the edge of the wetland	~530-540	No change expected.
Boltons Gully 5	Marsh?	Shore	Lake inundation at high lake levels	Groundwater	If the area is a wetland, lake inundation is likely to be the main hydrological driver (it was inundated during the survey)	Given location of the area, likely occasionally inundated by the lake, with potential for some groundwater inputs	2010-2014 wetland partially inundated Latest imagery lake is approx. 100 m away from the closest edge of the wetland	~530-540	No change expected.
Hayman Road 1	Marsh, Swamp	Shore, Terrace	Lake inundation at high lake levels	Groundwater	Terrace seepage is likely the main wetland driver, with springs emergent under poplar forest contributing minor surface flows to the lower wetland. Lake shore extent inundated at maximum consented lake level, but this is unlikely to be of importance	Given location and Boffa Miskell (2020) description, likely groundwater fed. Topo map shows wetlands uphill from the wetland	Above high lake level (2010-2014 imagery)	~530-540	No change expected.
Hayman Road 2	Marsh, Swamp	Channel, Shore, Terrace	Lake inundation at high lake levels	Groundwater	Terrace seepage likely the main wetland driver, especially for the upslope shrubland and tussockland areas of highest biodiversity value. Some areas at lake level including tussocklands are influenced by groundwater and lake inundation at high lake level	Given location and Boffa Miskell (2020) description, likely groundwater fed	Shoreward edge of wetland appears to be at or about high lake (2010-2014 imagery)	~530-540	No change expected.
Boundary Stream North	Marsh	Riparian	None	Stream Inflows	Stream inflows are the main wetland driver - the small, perched wetland flows steeply into the lake	Wetland hydrology likely dominated by stream inflow and located above high lake levels	Difficult to see in aerials, but appears to be above high lake level (2010-2014 imagery)	~535-540	No change expected.
Hayman Road 3	Marsh, Shallow water	Channel, Shore	Lake inundation at high lake levels	Stream Inflows, Groundwater	Stream inflows likely the main wetland driver, there was no surface water connection at high lake level (although wave ingress across gravel bar is possible, and water table is likely elevated)	Wetland hydrology likely dominated by stream inflow, also likely to be fed partially by groundwater and potentially wave inundation from the lake	2010-2014 wetland partially inundated Latest imagery lake is approx. 150 m away from the edge of the wetland	~530-540	No change expected.

Wetland Name*	Classes*	Landform*	Hydrological connection to the lake	Other influences	Hydrology description*	Wetland hydrological assessment updated	Aerial photograph analysis	Estimated minimum elevation (m RL)	Expected change in GW system
Boundary Stream	Shallow Water	Shore	Lake inundation at high lake levels	Stream Inflows	The wetland is a shallow water area at lake level likely created by stream flows that are impounded somewhat by a gravel bar. Stream inflows are probably the main water source, but the wetland water level will likely be driven primarily by lake level	Wetland hydrology likely dominated by stream inflow, and interaction with the lake through the gravel bar at higher lake levels	At or just above high lake level (2010-2014 imagery)	~530-540	No change expected.
Hayman Road Ephemeral Wetlands	Ephemeral, Marsh	Depressions	None	Rainfall, Groundwater	These ephemeral wetlands are elevated well above the lake	Given its position in the landscape, it is likely fed by rainfall and potentially groundwater.	N/A	~540-550	No change expected.
Boundary Stream South	Marsh, Shallow water	Shore	Wave inundation possible at high lake levels	Groundwater	Terrace seepage is likely the main wetland driver, and there was no surface water connection observed during high lake level. However, wave ingress across the narrow gravel bar is possible, and at high lake level the wetland water table is likely elevated	Given the wetlands location at the base of slope, the wetland is likely fed by a combination of groundwater discharge and interactions with the lake	At or just above high lake level (2010-2014 imagery)	~530-540	No change expected.
Hayman Road 4	Marsh	Shore	Lake inundation at high lake levels	Stream Inflows, Groundwater	The wetland was inundated by the lake during the survey. Low-lying areas of this small wetland associated with minor stream inflows are likely to be driven by these inflows and by lake levels. Where wetland vegetation extends beyond the point where stream flows would be important, the lake is likely the primary wetland driver	Located on the edge of the lake, with a small stream flowing into the wetland. Aerial photography suggests groundwater input likely further inland	At or just above high lake level (2010-2014 imagery)	~530-540	No change expected.
Hayman Road 5	Marsh	Shore	Lake inundation at high lake levels	Stream Inflows, Groundwater	Stream inflows are likely the main wetland driver in riparian marsh areas and for the shore wetlands, except during high lake level when the shore is inundated	Located on the edge of the lake, with a small stream flowing into the wetland. Aerial photography suggests groundwater input likely further inland	2010-2014 wetland inundated Latest imagery lake is approx. 80 m away from the edge of the wetland	~530-535	No change expected.
Hayman Road 6	Marsh	Depression	Lake inundation at high lake levels	Groundwater/ rainfall	Lake is connected to an ephemeral ponded area at high lake level; this wetland is likely driven mostly by rain or upslope groundwater at normal times when the lake level is below its maximum	Located on the edge of the lake, with a small stream (perhaps intermittent/ephemeral) flowing into the wetland. Aerial photography suggests groundwater input likely further inland	2010-2014 one of the wetlands is partially inundated Latest imagery lake is approx. 300 m away from the edge of the wetland that was partially inundated at high lake level	~530-535	No change expected.
Jack Steel Stream 1	Marsh, Shallow water	Shore	Lake inundation at high lake levels	Stream Inflows, Groundwater	Stream inflows with associated herbfield and sedgeland are visible in drone imagery - there was no connection to lake at maximum consented lake level. Stream inflows are likely the main wetland driver	Wetland formed behind the gravel bar. Likely fed by a combination of stream flow and groundwater	At or just above high lake level (2010-2014 imagery)	~530-540	No change expected
Jack Steel Stream 2	Marsh, Shallow water	Marsh, Shallow water	Wave Inundation possible at high lake levels	Stream Inflows, Groundwater	Stream inflows are likely the main wetland driver - there is a surface connection to lake at maximum consenting lake level which may periodically raise the water table, but a net flow of water to the lake was observed	Wetland formed behind the gravel bar. Likely fed by a combination of stream flow and groundwater	At or just above high lake level (2010-2014 imagery)	~530-540	No change expected
Lower Pūkaki 1	Ephemeral	Depression	None	Groundwater/ rainfall	Wetland is elevated well above the lake; groundwater from hillslopes above is the primary wetland driver - it is possible that the wetland receives water impounded by the A2O trail	Elevation relative to lake indicates groundwater source, no obvious surface water inputs identified	Above high lake level (2010-2014 imagery)	~535-540	No change expected
Lower Pūkaki 2	Swamp	Shore	None	Groundwater	It is suspected that lake groundwater is of importance in the maintenance of ponded water in reedland but that other water sources from upslope terrace contribute. Reedland elevation was measured as being similar to the maximum operational lake level	GHD (2023b) indicate that this wetland is fed by groundwater and likely rainfall as well	As per GHD (2023b)	As per GHD (2023b)	No change expected

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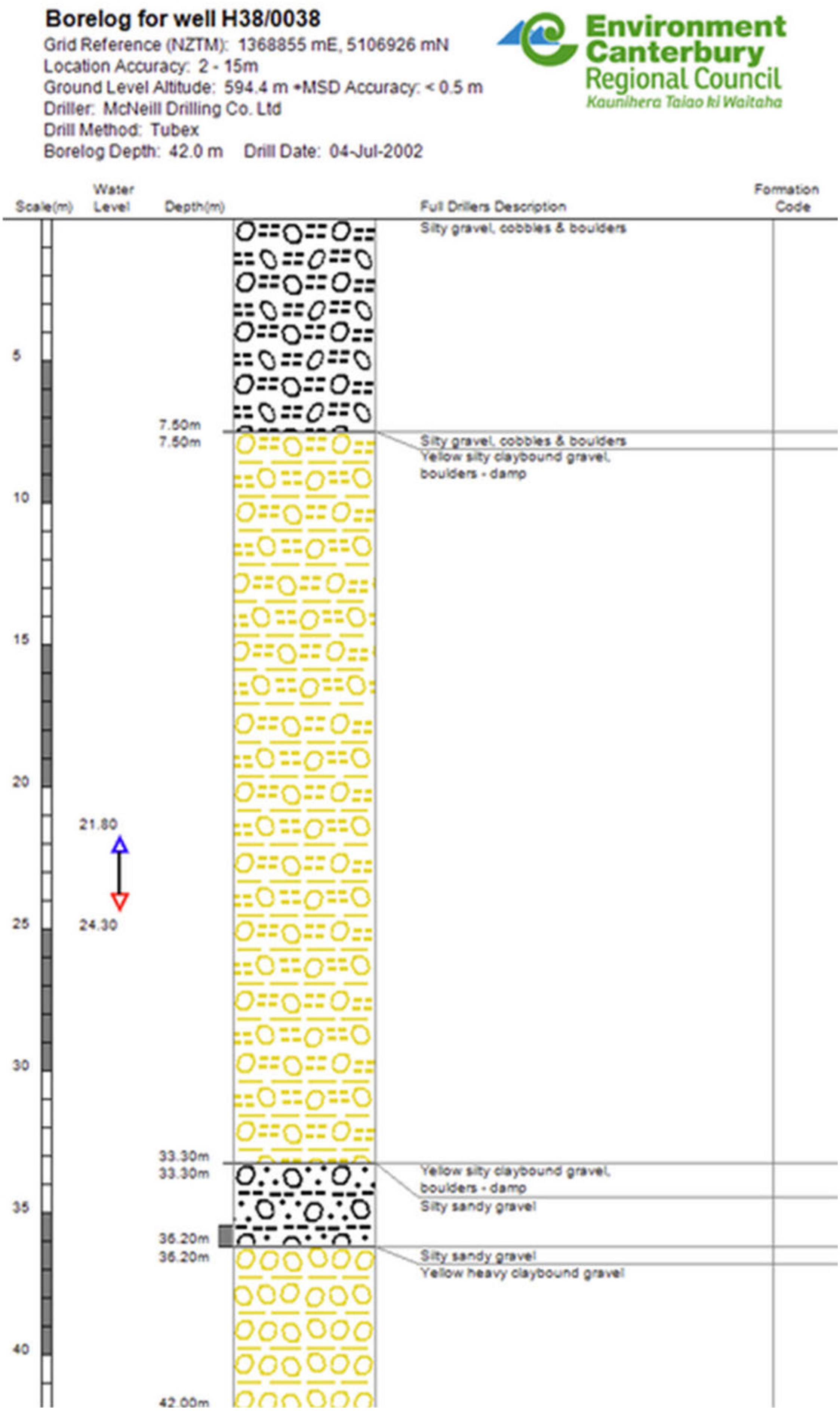
Appendix A

Selected bore logs

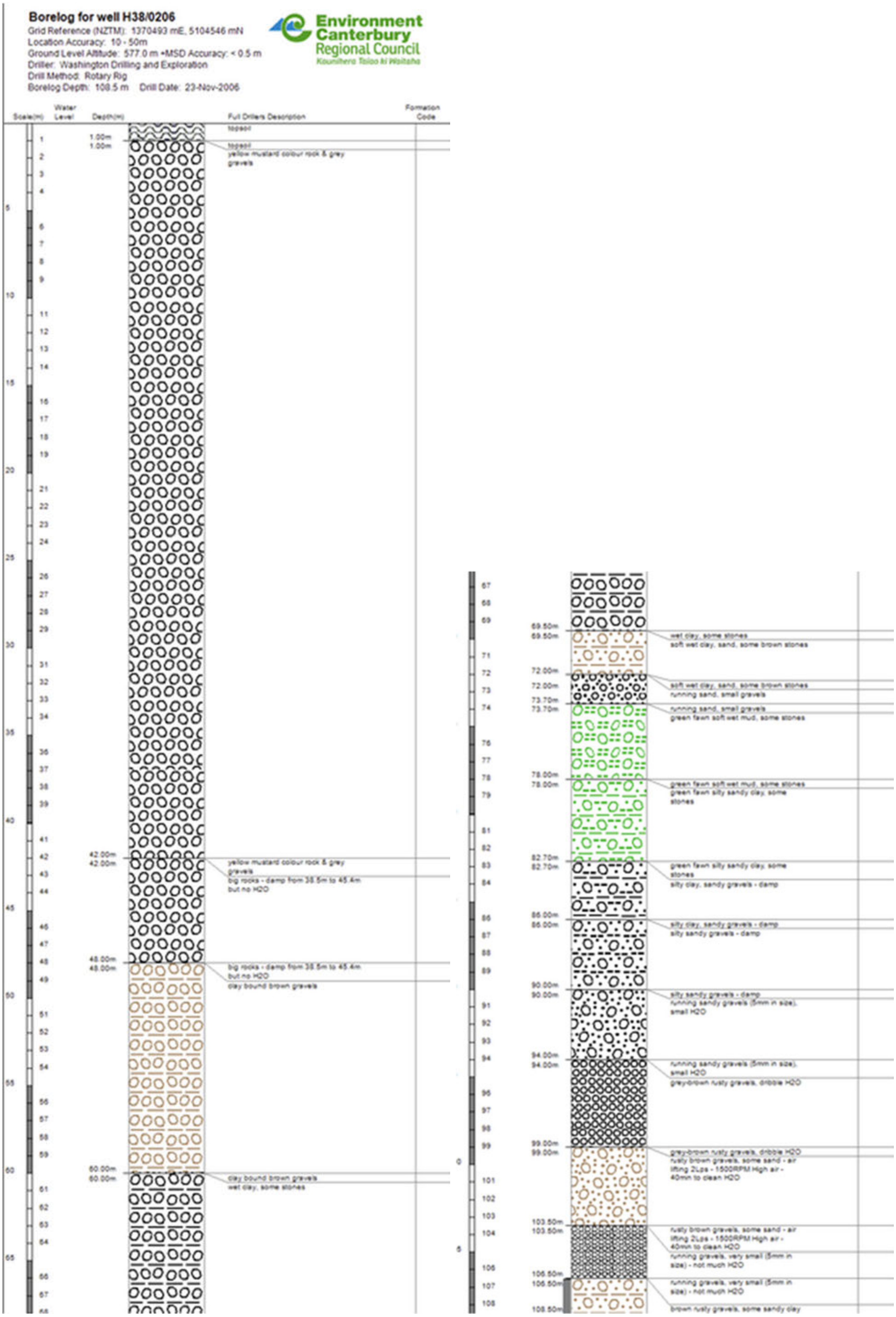

Borelog for well H38/0038
Grid Reference (NZTM): 1368855 mE, 5106926 mN
Location Accuracy: 2 - 15m
Ground Level Altitude: 594.4 m +MSD Accuracy: < 0.5 m
Driller: McNeill Drilling Co. Ltd
Drill Method: Tubex
Borelog Depth: 42.0 m Drill Date: 04-Jul-2002
Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha
Scale(m)
Water Level
Depth(m)
Full Drillers Description
Formation Code
Silty gravel, cobbles & boulders
5
7.50m
7.50m
Silty gravel, cobbles & boulders
Yellow silty claybound gravel, boulders - damp
10
15
20
21.80
25
24.30
30
33.30m
33.30m
Yellow silty claybound gravel, boulders - damp
Silty sandy gravel
35
36.20m
36.20m
Silty sandy gravel
Yellow heavy claybound gravel
40
42.00m

Borelog for well H38/0273

Grid Reference (NZTM): 1370188 mE, 5104701 mN
Location Accuracy: 2 - 15m
Ground Level Altitude: m +MSD Accuracy:
Driller: Washington Drilling and Exploration
Drill Method: Rotary Rig
Borelog Depth: 96.5 m Drill Date: 12-Dec-2011

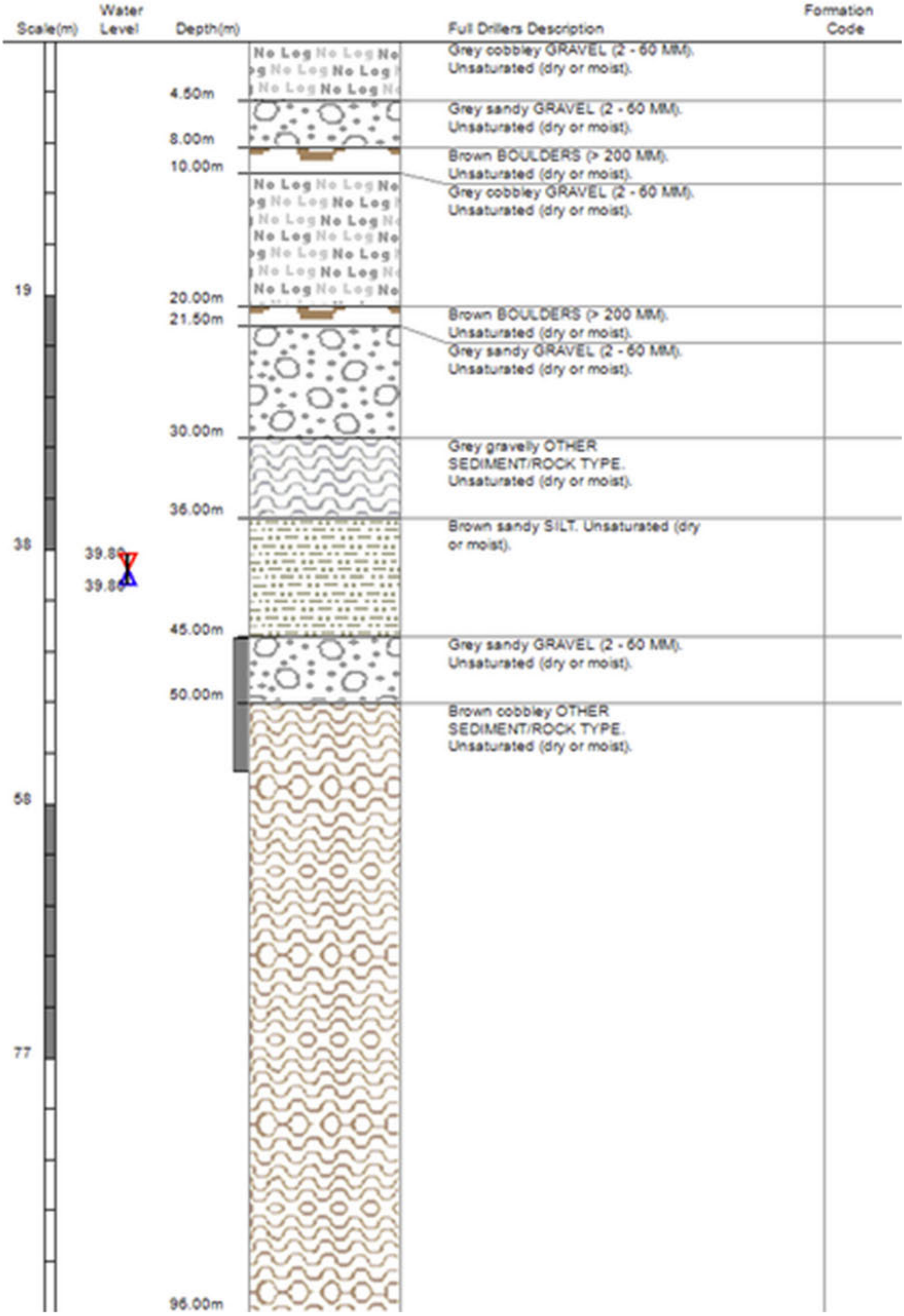
Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		0.10m	Light brown TOPSOIL. Unsaturated (dry or moist).	
19		18.70m	Grey silty, sandy GRAVEL (2 - 60 MM) with some boulders. Well sorted. Sand is fine to coarse-grained (0.06 - 2 mm), gravel is . Gravels are rounded. Unsaturated (dry or moist).	
39			Brown silty, sandy GRAVEL (2 - 60 MM) with some cobbles, minor boulders. Well sorted. Sand is fine to coarse-grained (0.06 - 2 mm), gravel is medium to coarse-grained (20 - 60 mm). Unsaturated (dry or moist).	
58				
77		86.70m		
		96.50m	Grey silty, sandy GRAVEL (2 - 60 MM) with some cobbles. Well sorted. Sand is fine to coarse-grained (0.06 - 2 mm), gravel is . Saturated (water bearing).	


Borelog for well H38/0206
Grid Reference (NZTM): 1370493 mE, 5104546 mN
Location Accuracy: 10 - 50m
Ground Level Altitude: 577.0 m +MSD Accuracy: < 0.5 m
Driller: Washington Drilling and Exploration
Drill Method: Rotary Rig
Borelog Depth: 108.5 m Drill Date: 23-Nov-2006
Environment Canterbury Regional Council
Scale(m)
Water Level
Depth(m)
Full Drillers Description
Formation Code
topsoil
yellow mustard colour rock & grey gravels
big rocks - damp from 38.5m to 45.4m but no H2O
clay bound brown gravels
wet clay, some stones
soft wet clay, sand, some brown stones
running sand, small gravels
green fawn soft wet mud, some stones
green fawn silty sandy clay, some stones
silty clay, sandy gravels - damp
silty sandy gravels - damp
running sandy gravels (5mm in size), small H2O
grey-brown rusty gravels, dribble H2O
rusty brown gravels, some sand - air lifting 2Lps - 1500RPM High air - 40mn to clean H2O
running gravels, very small (5mm in size) - not much H2O
brown rusty gravels, some sandy clay

Borelog for well BZ15/5016

Grid Reference (NZTM): 1373140 mE, 5104571 mN
Location Accuracy: 10 - 50m
Ground Level Altitude: 555.3 m +MSD Accuracy: < 2.5 m
Driller: Washington Drilling and Exploration
Drill Method: Rotary Rig
Borelog Depth: 96.0 m   Drill Date: 04-Feb-2014



Appendix B

Bore level information

Table 9 ***Bore details summary***

Well number	Status	Owner	Primary use	Estimated distance from lower lake level (m)	Depth (m RL)	Top of screen (m RL)	Bottom of screen (m RL)	Initial groundwater level (m RL)	Highest groundwater level (m RL)	Lowest groundwater level (m RL)	Level count
H38/0273	Active	Mt Cook Lakeside Retreat	Domestic Supply	270	484.00	488.0	484.0	508.20			0
H38/0206	Active	Lakeshore Estates Limited	Domestic and Stockwater	230	469.00	471.0	469.0	507.10			0
H38/0063	Active	Mr A E Tibby	Domestic Supply	810	533.00	543.5	533.5	565.50	567.35	558.30	14
H38/0038	Active	Mr R J Houston	Domestic Supply	500	558.39	559.1	558.4	574.02	572.79	570.29	15
H38/0006	Active	Meridian	Water Level Observation	270	503.55	505.3	503.8	511.96			0
H38/0005	Active	Meridian	Water Level Observation	220	509.59	511.4	509.9	516.63			0
H37/0021	Not Used	Meridian		580	520.80						0
H37/0018	Not Used	Meridian		700	519.22						0
H37/0014	Active	Meridian	Water Level Observation and Stock Supply	430	495.00						0
H37/0013	Active	Meridian	Water Level Observation and Stock Supply	280	477.50						0
H37/0012	Not Used	Meridian		530	489.21						0
H37/0011	Not Used	Meridian	Water Level Observation	120	512.10						0
H37/0010	Not Used	Meridian	Water Level Observation	160	504.30						0
H37/0009	Not Used	Meridian	Water Level Observation	310	495.20						0
H37/0008	Not Used	Meridian		0	520.60						0
H37/0007	Not Used	Meridian	Water Level Observation	160	516.00						0
H37/0006	Not Used	Meridian		130	500.01						0
H37/0005	Not Used	Meridian		120	491.00						0
H37/0004	Not Used	Meridian		200	523.38						0
H37/0002	Active	The Helicopter Line	Domestic Supply	2,340	510.66			537.66			0
H37/0001	Not Used	Glentanner Park	Domestic and Stockwater	1,260	580.21	582.3	580.2	589.41			0
BZ15/5196	Active	NZ Alpine Lavender	Irrigation	1,880	590.35	593.3	590.3	598.10			1
BZ15/5091	Active	Matt Hurst	Domestic and Stockwater	810	512.94	515.9	512.9	527.22			1
BZ15/5085	Active	Matt Hurst	Domestic and Stockwater	810	507.00	510.0					0
BZ15/5084	Active	Matt Hurst	Domestic and Stockwater	720	527.00	530.0		580.00			0
BZ15/5073	Active	Charlie Hobbs	Domestic Supply	870	519.46	521.9	519.5	526.36			1
BZ15/5046	Active	Meridian	Geotechnical / Geological Investigation	60	506.16			536.66			0

Well number	Status	Owner	Primary use	Estimated distance from lower lake level (m)	Depth (m RL)	Top of screen (m RL)	Bottom of screen (m RL)	Initial groundwater level (m RL)	Highest groundwater level (m RL)	Lowest groundwater level (m RL)	Level count
BZ15/5045	Active	Meridian	Geotechnical / Geological Investigation	130	468.86	471.9	468.9	503.86			0
BZ15/5044	Active	Meridian	Geotechnical / Geological Investigation	140	466.34	469.3	466.3	501.54			0
BZ15/5043	Active	Meridian	Geotechnical / Geological Investigation	210	455.26	458.3	455.3	485.46			0
BZ15/5016	Active	Nomadic Yurts Limited	Domestic Supply	200	459.22	510.3	500.3	515.48			1
BY15/5002	Active	Glentanner Station Limited		580	524.40	530.4	524.4	529.80			0
BY15/5001	Active	Glentanner Station Limited		1,040	531.50	543.0	531.5	536.90			0

Appendix C

CVs

GHD

Matt Dodson

Technical Lead - Hydrogeology

Location

Christchurch

Experience

15 years

Qualifications/accreditations

- MSc (1st Class Hons.) Engineering Geology, 2009
- BSc, Geology, 2005

Key technical skills

- Source Water Risk Management Planning
- Well condition surveys
- Aquifer testing, resource management and consenting
- Municipal well installation

Memberships

- International Association of Hydrogeologists
- New Zealand Hydrological Society
- Drinking Water Quality Special Interest Group, Water New Zealand

Relevant experience summary

Matt is a hydrogeologist with significant experience helping clients locate, install, consent, and maintain municipal water supply wells in New Zealand. He has enabled clients to get the most out of their critical assets and ensure safe drinking water by undertaking Source Water Risk Management Plans, well condition surveys, sanitary bore head surveys, undertaking and analysing aquifer tests, and preparing reports to aid in resource consent processes.

Matt previously worked for more than 10 years in regional government, and he has developed robust relationships with staff at most of the regional councils within New Zealand. He has a sound understanding of resource management and of regional council functions. He has significant expertise in providing technical advice to support regional planning processes, designing groundwater monitoring networks, locating municipal bores, water resource investigations exploring the impact of land use on water quality, auditing and preparing groundwater technical information for resource consents (including municipal water supplies, stormwater, wastewater, and other discharges) and co-ordinating collaboratively focused complex environmental projects. Matt is experienced at presenting complex information to mana whenua, decision makers and communities.

Tahuna Bore 4 and Consenting

Matamata-Piako District Council | 2023 - present
Project manager and Hydrogeologist

Matamata-Piako District Council engaged GHD to assist them in installing a new municipal water supply well in the Tahuna township and to compete the renewal of their groundwater take consent. GHD have undertaken a multi-criteria assessment to identify suitable locations, supervised the drilling of a pilot bore to ensure the site meets the client's expectation around yield and water quality (particularly iron and manganese), and supervised the installation and aquifer testing of the production well.

Matt's role is to manage the project and collaborate with the client, develop the criteria for the multi-criteria assessment (which include indications of yield and water quality from existing wells, existing risks to source water and practical considerations such as distance to existing infrastructure), assist with the multi-criteria assessment itself and leading the workshop with the client. Matt also oversaw the drillers to ensure the successful installation and testing of the pilot and production bores.

Te Aroha Long-Term Water Source Plan

Matamata-Piako District Council | 2024 – 2025
Lead Hydrogeologist

Matamata-Piako District Council engaged GHD to support them in the development of a long-term water source plan for their Te Aroha supply. The project involved reviewing existing water sources, undertaking a multicriteria assessment to identify potential new sources and preparing a report discussing viable water sources and a long-term water source plan.

Matt's role in the project was to review source water information related to the existing supply, including completing a risk and opportunity assessment; lead the groundwater aspects of the multicriteria assessment including developing the criteria, interpretation of the results and reporting; and supporting the final deliverable.

Gear Island and Waterloo Well Condition Survey

Wellington Water Limited | 2022-2023
Project manager and Hydrogeologist

Some of Wellington Water Limited wells in the Waterloo and Gear Island wellfields are approaching their end of design life. The aim of this project was to provide information to the client around the condition of their critical assets, so they could undertake a replacements strategy.

Matt's role was to project manage an extensive field programme collecting field data, analyse the data and provide a report, including recommendations to the client. The Waterloo wells are located on the side of the road in busy residential areas, meaning we had to prepare Traffic Management Plans, consult with neighbours including an intermediate school, and design the works programme to be efficient and minimize impacts on others. The work was well received by the client and allowed them to redirect capital funds to other more urgent projects. And Matt, with the client's permission, presented a summary of the finding of this project to the New Zealand Hydrological Society conference in Auckland in 2023.

Sanitary bore head survey

Palmerston North City Council | 2022 – 2023
Project manager and Hydrogeologist

Palmerston North City Council engaged GHD to undertake a sanitary bore head survey of their wells, to understand if they meet Taumata Arowai Drinking Water Quality Assurance Rules.

Matt's role was to manage the project, analyse the data, present the work to the client in a workshop and in a written report. The project identified several issues around the clients' wells, which were detailed in a format that allowed Palmerston North City Council to prioritise the improvement in terms of cost and complexity. The recommendations were accepted by the client, and they have incorporated them into their long-term work programme.

Drinking Water Safety Plan preparation

Whanganui District Council | 2022
Project manager and Hydrogeologist

Whanganui District Council engaged GHD to develop Water Safety Plans, including Source Water Risk Management Plans, for all their supplies, in line with the new Water Services Act 2021 and Taumata Arowai Drinking Water Quality Assurance Rules.

Matt's role was to liaise with the client and help prepare the Source Water Risk Management Plans. This involved reviewing existing information, sourcing information from councils, mapping potential hazards, undertaking risk assessments, undertaking a workshop with Whanganui District Council staff around the risk assessment and identification, and identifying improvements. The Drinking Water Safety Plans were completed on time, meaning that Whanganui District Council were able to meet Taumata Arowai regulatory timelines for submission.

Mays Pumping Station: Aquifer Test Analysis for New Supply bore (Well #6)

Christchurch City Council | 2021 – 2022
Hydrogeologist

Christchurch City Council engaged GHD to supervise an aquifer test for this new well, analyse the data and then prepare a report for Environment Canterbury. The results of the project were used by the council to add the new well to their global groundwater take resource consent. GHD were also engaged by the client to design the pump for the well.

Matt's role was to work with the driller and the client to determine the safe yield of the well (based on the results of the step-drawdown and sand tests), supervise the constant aquifer test and analyse and report on the results. Matt also worked alongside the mechanical engineers to inform the design of the pump and related structures. As a result of the project the well has been included in the global groundwater take resource consent with limited delay and the well is now operational.

Water bore supply review: desktop assessment

Western Bay of Plenty District Council | 2021 – 2022
Hydrogeologist

GHD was engaged by the client to undertake a desktop assessment of wells within the Kaituna, Maketu and Pongakawa Water Management Area to provide information for council's decision making. Western Bay of Plenty District Council were exploring different avenues to meet demand, while meeting environmental limits set out by the Bay of Plenty Regional Council.

Matt analysed well, groundwater consent and geological data within a Geographical Information System environment to identify potential water supply bores for council. Matt embedded practical considerations into the assessment methodology (distance from the network, depth to groundwater level, water temperature), along with regional rule considerations, to provide options for council to consider.

Career history

2023 - present	GHD, Technical Lead
2021 – 2024	GHD, senior Hydrogeologist
2018 – 2021	Environment Canterbury, Science team Leader - Groundwater
2014 – 2018	Environment Canterbury, Technical Lead
2011 – 2014	Environment Canterbury, Hydrogeologist
2009 - 2011	Hawke's Bay Regional Council, Groundwater Resource Analyst

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