D

APPENDIX D

Groundwater Assessment

WILLIAMSON
WATER & LAND ADVISORY

Groundwater Take - Assessment of Environmental Effects

Sand Quarry Bore Water Supply

SHAWS QUARRIES LIMITED

WWLA1774 | Rev. 4

17 June 2026



Sand Quarry Bore Water Supply

Project no:	WWLA1774
Revision:	4
Date:	17 June 2026
Client name:	Shaws Quarries Limited
Project manager:	Jon Williamson
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File name:	G:\Shared drives\Projects\Shaws Quarries Limited\WWLA1774_Sand Quarry Bore Water Supply\Deliverables\Reports\WWLA Report_Groundwater Take AEE - Shaws Quarries_v3_110626.docx

Williamson Water & Land Advisory

Auckland | Whangārei | Tauranga
New Zealand
www.wwla.kiwi

Document history and status

Rev	Date	Description	By	Review	Approved
1	25 May 2026	Groundwater Take Report Draft	Brooke James	Jon Williamson	Jon Williamson
2	28 May 2026	Groundwater Take Report Draft_v2	Brooke James	Jon Williamson	Jon Williamson
3	11 June 2026	Groundwater Take Report Final	Brooke James	Josh Mawer	Jon Williamson
4	17 June 2026	Groundwater Take Report Final	Brooke James		Jon Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
1	25 May 2026	Shaws Quarries Limited	First draft issued to client
2	28 May 2026	Shaws Quarries Limited	Second draft issued to client
3	11 June 2026	Shaws Quarries Limited	Final Report
4	17 June 2026	Shaws Quarries Limited	Updated figures

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1. Introduction

1.1 Overview

Williamson Water and Land Advisory (WWLA) was commissioned by Shaws Quarries Limited (the Applicant) to prepare a technical hydrogeological assessment to support a resource consent application to Waikato Regional Council for a proposed sand quarry operation to be located at 1466 Cambridge Road, Cambridge, Waikato (the Site). The technical assessment compromises two parts:

- a dewatering assessment; and
- a groundwater effects assessment associated with a groundwater take.

1.2 Background

The Applicant proposes a sand quarry at the Site. The Applicant proposes to dry-mine the sand layers (Hinuera Formation) in designated areas within the property as displayed in **Figure 1**. As the quarry is to be dry-mined, mining is intended to continue above the groundwater table.

The quarry will be backfilled with clean fill as part of the process to rehabilitate the land. Rehabilitation of the land will be undertaken in a manner that allows for future use of the land for ongoing rural processes and potential subdivision.

This application is for a groundwater take which will be used for quarry activities such as wheel wash, dust suppression, and processing. The applicant proposes to take no more than 900 m^3/day and no more than 328,500 m^3/year.

The site falls within the Hamilton Basin - South Aquifer which has an allocation limit of 42,000,000 m^3/year (42 Mm^3/year), and a remaining available allocation of 38,685,000 m^3/year (38.7 Mm^3/year) as of April 2026.

1.3 Site Location & Description

The Site is located at 1466 Cambridge Road, Cambridge, Waikato (refer to **Figure 1** below). The site is located in a rural area and consists of multiple properties, farm land, dairy pasture and a number of rural residential dwellings and buildings. The nearest watercourse is the Waikato River which borders the southern end of the Site.

WellsNZ[1] shows seven bores of shallow to medium depth (approximately 8-26 m depth) located on the property as displayed in **Figure 1**. All of the bores are categorised as Legacy wells on WellsNZ. The property owner confirmed presence of all the bores except bore 70_146 of which the owner had no knowledge of; thus this bore location is likely incorrect.

[1] https://wellsnz.teurukahika.nz/



Map Title:
Site Overview

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- **Borehole**
- **Proposed Bore**
- **River/Stream**
- **Road**
- **The Site**

Preliminiary Proposed Quarry Plan

- **Access**
- **Paper Road Exclusion Area**
- **Approx. Quarry Boundary**

Stages

- **Stage 1**
- **Stage 2**
- **Stage 3**
- **Stage 4**
- **Mobile Processing**

Data Provenance
Aerial imagery sourced from LINZ.
Bore locations sourced from WellsNZ Teurukahika.

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 1.

2. Environmental Setting

2.1 Geomorphology and Surface Water Features

The Cambridge area is characterised by flat to gently undulating terrain formed by river deposits, incised by the Waikato River. Land evaluations range from 50-65 mNZVD, down to 15 mNZVD at the river.

The northern end of the Site is mostly flat, with elevations ranging from 59-62 mNZVD. Terraces are located from the central to southern end of the property. The topmost terrace lays at 58.3 mNZVD, the second at 50-52 mNZVD and a sloped terrace from approximately 29-39 mNZVD located at the River's edge. The River is deeply incised into the terrane at about 10-15 m NZVD with a width of approximately 60 m at the Site. The Waikato River is 425 km long, beginning at Lake Taupo and discharges into the west coast at Port Waikato.

Two gullies are located on the property draining south into the Waikato River. Small tributaries of the Waikato River are located within the gullies, which are likely to be spring fed. Small lakes are observed in the eastern gully via aerial imagery. The landowner noted that seepages occur approximately 10 m down from the top of the escarpment in the eastern gully.

There are no wetlands located on the Site, however there is a wetland located on the other side of the River, 700 m to the south[2]. Additionally, there are significant natural areas bordering the River and within the western gully consisting of terrestrial regenerating scrublands[3].

Topography and surface features are demonstrated in **Figure 2**.

[2] From the Wetlands 2012 layer located in the WRC Biodiversity and Environment Map https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=49a72640c5474484b156d453144044a3#
[3] Recorded by Waikato District Council and Waipa District Council.

N

HOOKER ROAD

SH 1

RACECOURSE ROAD

BANKS ROAD

CAMBRIDGE ROAD

FORREST ROAD

Waikato River

Mangawhero Stream

KAIPAKI ROAD

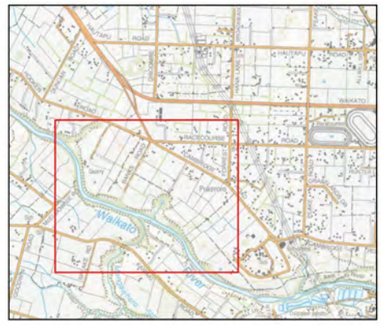
SPEAKE ROAD

0 0.25 0.5 km

Map Title:
Geomorphology and Surface Features

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- 5 m Interval Surface Contour
- River/Stream
- Road
- The Site
- Significant Natural Area
- Wetland

Elevation (mNZVD)

70

15

Data Provenance
LiDAR sourced from LINZ New Zeland 1 m DEM.

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 2.

2.2 Surrounding Bores and Groundwater Takes

A review of bore logs from WellsNZ[1] and NZGD[4] for bores within a 2 km radius of the Site confirmed there are 67 bores within a 2 km radius of the centre quarry footprint (**Figure 3**). The Waikato Regional Council groundwater consent database shows seven consented near-by groundwater permits within 2 km of the proposed bore, the location of the proposed bore is shown on **Figure 3**. The potential effects on other groundwater users are discussed further in **Section 4.2**.

The bore logs indicated that near-by bores are drilled to depths between 4.5 to 45 m deep, with two bores drilled to over 80 m deep. The bores are typically around 10-20 m in depth.

Figure 3 shows the nearby bores and water takes.

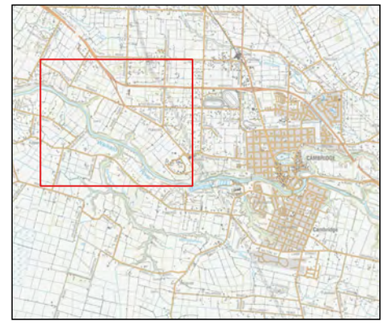
[4] New Zealand Geotechnical Database.



Map Title:
Bores and Groundwater Takes

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- Borehole
- Proposed Bore
- Groundwater Take Consent
- River/Stream
- Road
- State Highway
- 2 km Radius
- The Site

Data Provenance
Aerial imagery sourced from LINZ.

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 3.

2.3 Geology

The surface geology is dominated by Hinuera Formation consisting of interbedded sands, silts, gravels, and peat deposited by the ancestral Waikato River braided river systems. The Hinuera Formation can be highly variable laterally and vertically[5,6]

The gully located to the southeast of the Site, and the gully that the Waikato River runs through has surface geology of Holocene river deposits. Lithology from nearby bores were assessed to determine the underlying geology. Underlying the surface geology, there is approximately 5 m of clay likely to be from the Walton Subgroup. There were no nearby bores that were sufficiently deep enough to assess the depth of geology below the Walton Subgroup clays, however, pumice is typically underlying the clay layer shown in the bore log lithology to an unknown depth. The pumice may also be from the Walton Subgroup.

Surface geology within the Site area is presented in **Table 1** and **Figure 4.**

Table 1. Summary of surface geology within the project area.

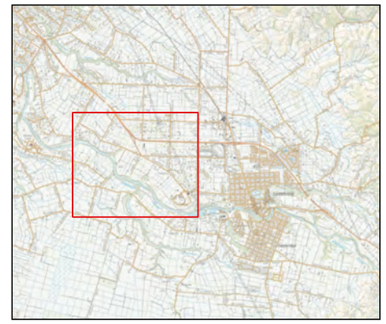
Name	Unit	Main Rock	Key Group	Stratigraphic Age [Age Million Years Min.-Max.]	Lithology	Description
Recent Alluvium	Q1.alvgvl	Mud	Holocene sediments	Q1 [0-0.014]	Mud, sand, silt, clay, peat	Holocene river deposits. Alluvial and colluvial sand, silt, mud and clay with local gravel and peat beds.
Taupo Pumice Alluvium	Q1.alvpum	Pumice	Holocene sediments	Q1 [0.0008-0.014]	Sand, silt, gravel	Holocene river deposits. Predominantly pumice sand, silt and gravel alluvium with charcoal fragments.
Recent Swamp Deposits	Q1.swp	Peat	Holocene sediments	Q1 [0-0.014]	Peat, mud	Soft, dark brown to black, organic mud, muddy peat and woody peat.
Hinuera Formation River Deposits	Q3Q2.alvpum	Sand	Late Pleistocene sediments	Q3, Q2 [0.012-0.027]	Sand, silt, gravel, peat	Late Pleistocene river deposits. Cross-bedded pumice sand, silt and gravel with interbedded peat,
Older River Deposits and Ignimbrite	Q14+Q12.alvsnd	Ignimbrite	Early Pleistocene – Middle Pleistocene sediments and igneous rocks	eQ, Q13, Q12 [0.423-2.588]	Pyroclastic material, sand, gravel, tephra	Early Pleistocene to Middle Pleistocene Alluvium dominated by primary and reworked, non-welded ignimbrite.
Manaia Hill Group Sandstone and Siltstone (Waipapa Composite Terrane)	lJeK.sst	Sandstone	Waipapa Composite Terrane	mJ, lJ [145-174.1]	Sandstone, mudstone	Massive fine to medium sandstone with interbedded thin argillite; some alternating sandstone and argillite.

[5] Tonkin + Taylor. April 2025. IAF – Waitawhiriwhiri/Central City ICMP. https://hamilton.govt.nz/assets/Uploads/Documents/Parking-and-Transportation/Appendix-E-Waitawhiriwhiri-Geotech-and-Hydrogeology-Interpretive-Report .pdf
[6] Hume., et al. 2011. Alluvial sedimentology of the Upper Pleistocene Hinuera formation, Hamilton Basin, New Zealand. https://www.tandfonline.com/doi/abs/10.1080/03036758.1975.10419362

Map Title:
Geology

Project:
Sand Quarry Bore Water Supply

Client:
Shaw Quarries Limited



Legend

- Nearby Bores
- River/Stream
- Road
- State Highway
- Cross Section Line
- 2 km radius
- The Site

Geological Unit

- IJeK.sst
- Q1.alvgvl
- Q1.alvpum
- Q1.swp
- Q14+Q12.alvsnd
- Q3Q2.alvpum

Data Provenance
Geology map sourced from GNS Science 250k map

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 4.

2.4 Hydrogeology

2.4.1 Aquifers

The Hinuera formation has an interbedded nature of fine-grained and coarse-grained sediments. Higher permeability lenses tend to be located within uniformly graded sands, separated by lower permeability silts which can result in perched groundwater at shallow depths, thus the hydraulic conductivity is variable[7].

Waikato Regional Council has mapped aquifers present in the Waikato Region. Under this framework, the Site falls within the Hamilton Basin – South aquifer as presented in **Figure 5**.

Under the Waikato Regional Plan, the management level for the Hamilton Basin – South aquifer is 42,000,000 m^3/year (42 Mm^3/year). As of 20 April 2026, 7.9% of the Hamilton Basin – South aquifer was allocated, thus 38,682,000 m^3/year (38.682 Mm^3/year) was available for allocation.

[7] Tonkin + Taylor. April 2025. IAF – Waitawhiriwhiri/Central City ICMP. https://hamilton.govt.nz/assets/Uploads/Documents/Parking-and-Transportation/Appendix-E-Waitawhiriwhiri-Geotech-and-Hydrogeology-Interpretive-Report .pdf



Map Title:
Hydrogeology

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- Borehole
- Proposed Bore
- Groundwater Flow Direction
- 5 m Interval Surface Topography
- Indicative Groundwater Level mNZVD (5 m Interval)
- River/Stream
- Cross Section Line
- The Site

Aquifer Allocation

- Hamilton Basin - South
- Hamilton Basin - West

Data Provenance

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 5.

2.4.2 Groundwater Levels

The static water level (SWL) recorded as the depth to groundwater from bores on the Site (72_3226, 72_3228, 70_934) ranges from 10-12.3 mBGL. The SWL in bore 70_146 was not considered as this is the bore that the Landowner does not believe is located on the Site. This data was used to determine that the groundwater level is at approximately 50 mNZVD across the site on average.

An indicative groundwater level or piezometric surface is presented in **Figure 5** based on these bore logs and hydrogeological intuition. Groundwater is likely to be approximately 5 mBGL in the north-east, and approximately 10 mBGL in the central area of the Site. Groundwater flow directs towards the Waikato River and springs in the eastern gully. Groundwater is also likely to spring in the western gully.

Cross-sections of indicative groundwater levels and approximate geology are presented below. Cross sections that runs through the site perpendicular and parallel to the Waikato River is presented in **Figure 6** and **Figure 7**, respectively. The location of the cross-sections is presented in **Figure 4** and **Figure 5**..

As shown in the indicative cross-sections, the incised topography where the streams/rivers and gullies are located causes a natural drawdown of the groundwater table.

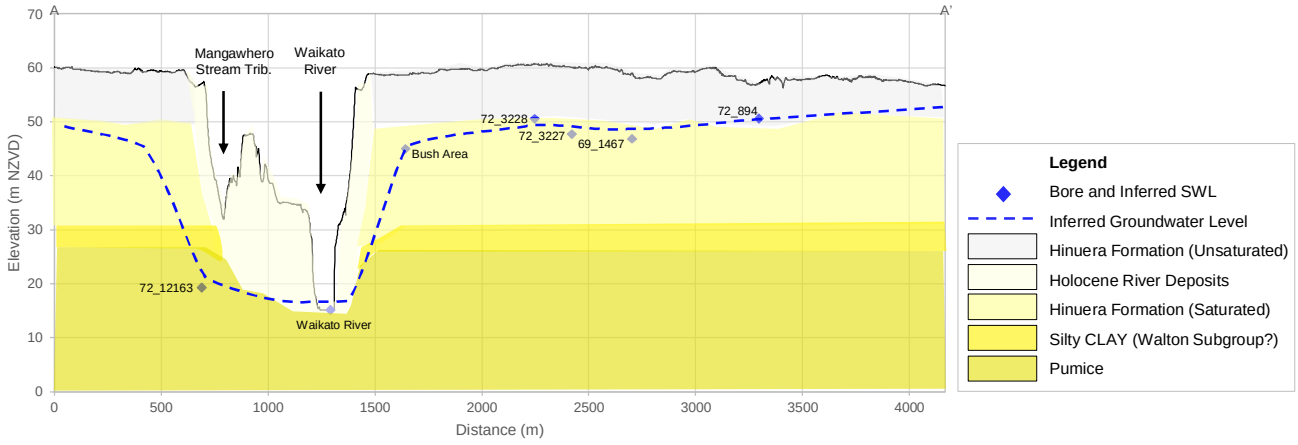


Figure 6. Indicative hydrogeological cross section perpendicular to Waikato River.

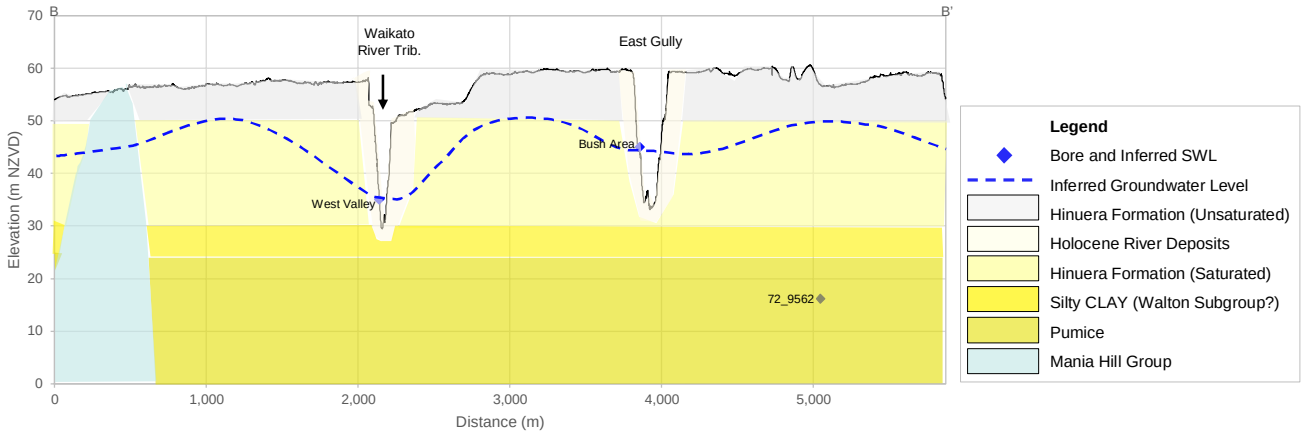


Figure 7. Indicative hydrogeological cross section parallel to Waikato River.

A cross-check was performed on the hydraulic gradient of the groundwater table using Darcy's law[8] (**Figure 8**) along a cross-section through the site (location presented in **Figure 9**). The calculations were undertaken assuming 30% of annual rainfall (1,162.9 mm/year[9]) recharged (Q) the aquifer on average. 40% and 22% of annual rainfall was utilised for winter and summer[10] aquifer recharge, respectively.

Typical hydraulic conductivity (K value) for the Hinuera Formation is highly variable due to the interbedded nature, ranging from $1.2x10^{-6}$ m/s for silty sands to $1.0x10^{-3}$ m/s for clean gravelly sands. A value of $3.4x10^{-5}$ m/s was utilised for this assessment, which was calculated using Darcy's Law to match the indicative groundwater table interpolated from nearby bore logs. The resulting cross section and calculated water table profile is displayed in **Figure 8**.

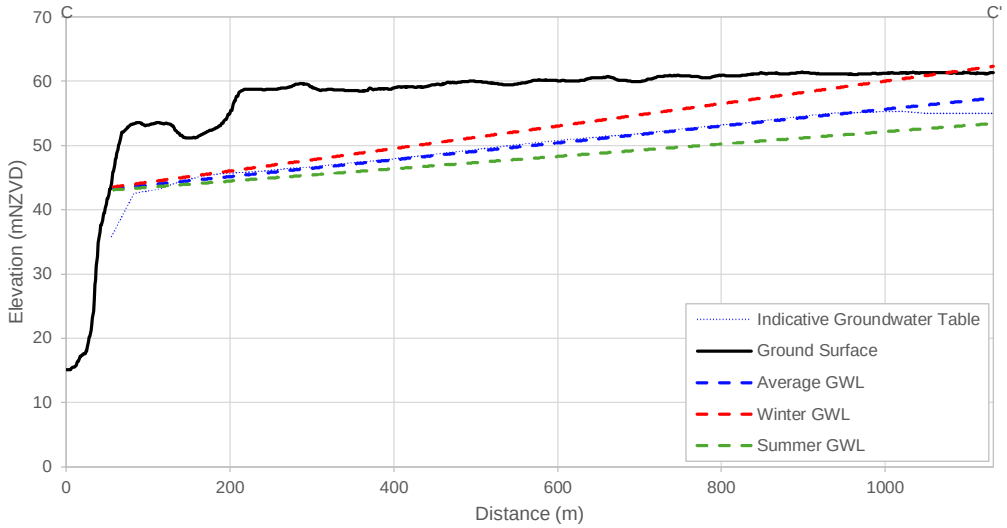


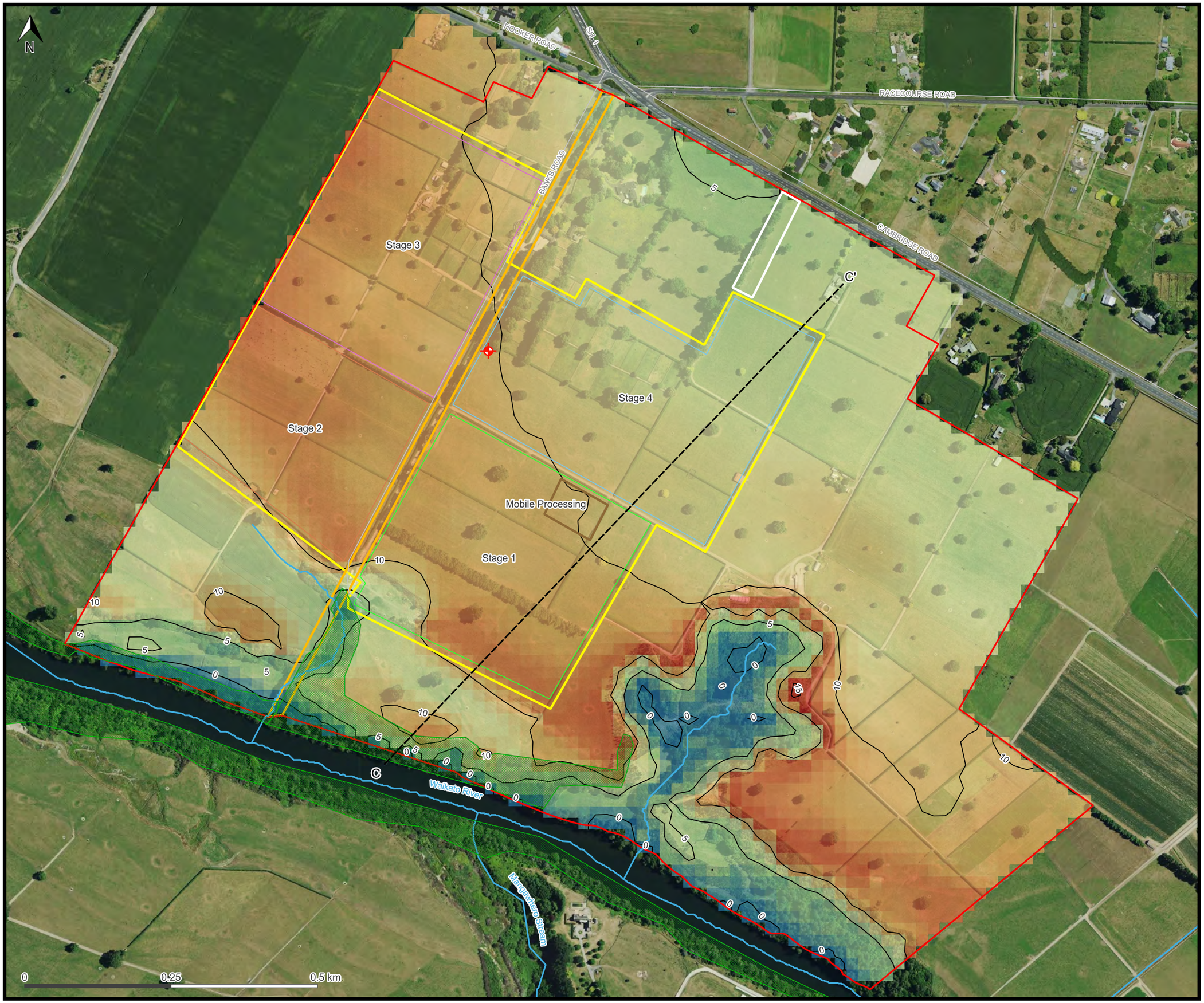
Figure 8. Indicative groundwater level.

2.4.3 Depth to Groundwater

The groundwater piezometric surface contours from **Figure 5** were used along with LINZ 1m DEM LiDAR topography to back calculate the depth to groundwater as shown in **Figure 9**. The calculation used interpolation performed with the Kriging geospatial technique on a 20 m grid resolution.

Depth to groundwater is governed by topography, with the groundwater surface typically mimicking the land surface, except in areas where there are steep land surface gradients such as gullies or ravines. As indicated above, groundwater is shallowest (5 mBGL) in the south adjacent to the river and in the gully. Over much of the site the depth to is deepest at approximately 10 mBLG. Groundwater shallow further to the northeast of the site, where it is close to 5 mBGL.

[8] Q = k x A x (Δh / ΔL)
[9] MfE. Average annual rainfall based on data from 1972-2016.
[10] https://www.waikatoregion.govt.nz/environment/water/groundwater-monitoring/groundwater-availability/



Map Title:
Depth to Groundwater Map

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- **Proposed Bore**
- **Depth to Groundwater (5 m Interval)**
- **River/Stream**
- **Road**
- **Cross-Section**
- **Significant Natural Area**
- **The Site**

Preliminary Proposed Quarry Plan

- **Access**
- **Paper Road Exclusion Area**
- **Approx. Quarry Boundary**

Stages

- **Stage 1**
- **Stage 2**
- **Stage 3**
- **Stage 4**
- **Mobile Processing**

Depth to Groundwater
Depth (mBGL)
15
0

Data Provenance
Aerial imagery sourced from LINZ

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

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Figure 9.

3. Description of Proposed Activity

3.1 Overview

The applicant proposes to undertake sand quarrying at 1466 Cambridge Road, Cambridge, Waikato (the Site), following the stages set out in **Figure 1**. In order to carry out the sand quarrying activities, access to water will be required. Thus, a groundwater take is also proposed.

3.2 Quarry Requirements

The sand quarried will be dry mined to avoid dewatering, hence mining downwards will cease prior to intersecting the groundwater table as the sands start to become more saturated. The depths to the groundwater table and sand quarrying effects on the groundwater table is detailed in **Section 4.1**.

3.3 Water Take Requirements

A groundwater bore is proposed (**Figure 1**) for the purposes of wheel wash, dust suppression and processing at the proposed sand. The proposed groundwater take volumes are as follows:

- A maximum daily volume of 900 m^3/day; and
- A maximum annual volume of 328,500 m^3/year.

The recommended bore design is detailed in the **Section 3.3.2**.

3.3.1 Allocation Limits

The site lies within the Hamilton Basin – South Aquifer, which has a total availability of 42,000,000 m^3/year (42 Mm^3/year). According to information provided by Waikato Regional Council on 20 April 2026, the remaining groundwater availability in this aquifer is 38,685,000 m^3/year (38.7 Mm^3/year), as presented in **Table 2**.

The proposed water take requires 328,500 m^3/year of groundwater allocation, therefore there is available allocation within the aquifer to meet the full demand. This leaves 38,356,500 m^3/year (38.4 Mm^3/year) remaining within the aquifer allocation for other future water users.

Table 2. Allocation status of Hamilton Basin – South Aquifer (April 2026).

Parameter	Value (m^3/year)	Percentage (%)
Management Level (total aquifer allocation)	42,000,000	
Total Allocated as Permitted Activities	1,310,000	3.1
Total Allocated as Discretionary (or other) Activities	3,315,000	7.9
Total Remaining Available	38,685,000	92.1

3.3.2 Bore Design

The design of the proposed bore is based on the geologic logs and construction details of neighbouring bores and was verified as appropriate to meet the water demand using an analytical model (the Feather-Williamson Model – refer **Appendix A**).

The proposed position of the bore is shown in **Figure 1**, and the proposed construction details for the bore are provided in **Table 3**.

The location of the proposed bore was chosen for the following reasons:

- Centralised location to the intended quarry plan/stages; and
- Maximised distance from near-by surface water features while considering proximity to existing bores on the property.

Table 3. Proposed bore construction details.

Parameter	Bore	Unit
NZTM Easting	1811701	m
NZTM Northing	5804905	m
Ground Elevation	60.15	mNZVD
Diameter	200	mm
Depth	101	mBGL
Static Water Level	10	mBGL
Casing Depth	20	mBGL
Casing Type	Galvanised steel	-
Pump Depth	20	m
Pump Submergence	10	m
Predicted Drawdown	5	m
Screen length	80	m
Screen type	Screen assembly comprising either i) machine slotted PVC or ii) alternating stainless steel wedge wire screens and mild steel casing, with 2 m header (with j-latch) and 2 m sump at base.	

4. Assessment of Effects on the Environment

4.1 Sand Quarrying

4.1.1 Overview

The following assessment (**Section 4.1**) identifies any actual and potential effects on groundwater that may arise from the proposed sand quarrying activity.

As the sand is proposed to be dry-mined, the sand will only be mined above the groundwater table. Allowing for 0.5 m separation between the base of the quarry pit and the average groundwater table, the greatest maximum mining depth is 12.4 m in the south of the Stage 1 area, and the shallowest mining depth is 5.3 m in the north of the Stage 4 area. Stage 2 and 3 can be mined to depths ranging from 10-12 mBGL. The proposed maximum quarry depths are shown in **Figure 10**.

However, mining depth will need to be adjusted in order to avoid intersection with the groundwater table during high-recharge months (winter).

4.1.2 Effects of Dry Mining on Groundwater

As the sand quarry is proposed to be dry mined, the groundwater table will not be intersected, thus there will be no effects on groundwater associated with the quarrying.

Map Title:
Proposed Maximum Quarry Depth Contour Plan

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- River/Stream
- Road
- 5 m Current Surface Contour
- Maximum Mining Depth mBGL (1 m Interval)
- The Site

Preliminary Proposed Quarry Plan

- Access
- Paper Road Exclusion Area
- Approx. Quarry Boundary

Stages

- Stage 1
- Stage 2
- Stage 3
- Stage 4
- Mobile Processing

Maximum Mining Depth (0.5 m above inferred GWL)

Mining Depth (mBGL)
15
0

Data Provenance
Aerial imagery sourced from LINZ

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

WILLIAMSON WATER & LAND ADVISORY

Figure 10.

4.2 Groundwater Take

4.2.1 Overview

The following assessment identifies and assesses the potential effects that may arise from the groundwater take associated with the bore. This assessment also outlines the measures that the applicant proposes to avoid, remedy or mitigate any potential adverse effects on the environment.

Actual and potential effects on the environment associated with the proposed groundwater take include:

- Groundwater drawdown effects;
- Effects on groundwater users
- Stream depletion effects;
- Wetland effects; and
- Ground settlement effects.

To assist in the assessment of pumping effects on the proposed water take, an analytical groundwater model was developed to simulate the groundwater drawdown response from the proposed maximum abstraction rate of 900 m^3/day for 150 days. The model developed comprised five-layers based on lithological information observed in near-by bores. Details of the model construction, methodology and results are included in **Appendix A**.

The potential effects predicted by the analysis are summarised in the following sections.

4.2.2 Groundwater Drawdown

The calculated maximum drawdown after continuous pumping at a rate of 900 m^3/day for 365 days directly adjacent to the proposed bore in each model layer is presented in **Figure 12** (**Appendix A**). The greatest magnitude of drawdown is 5.37 m, which is predicted to occur in the aquifer within the production zone. The magnitude of drawdown reduces towards the surface, with the model indicating minimal drawdown to the surface (0.18 m).

Figure 14 (**Appendix A**) presents the lateral extent of drawdown within the aquifer production zone as simulated for the requested groundwater take. The key findings are summarised as follows:

- The maximum drawdown is 5.37 m, within the production zone immediately adjacent to the bore;
- The drawdown calculated in Layer 1 is 0.18 m immediately adjacent to the bore, which corresponds to the layer where groundwater – surface water interaction occurs; and
- The drawdown calculated in Layer 2 and 4 is 1.36 m, and 0.39 m, respectively, immediately adjacent to the bore.

While drawdown is not considered an effect in itself, it has the potential to affect other groundwater users and surface water features. This is considered in further detail below.

4.2.3 Other Groundwater Users

Based on the data available in the WellsNZ database and NZGD, there are currently 67 bores within 2 km from the proposed bore. Of these bores, only seven are currently consented for abstraction of groundwater. **Table 4** lists the interference effects on neighbouring bores from pumping of the Applicant's bore and the estimated available drawdown remaining in these bores.

Table 4. Maximum drawdown in neighbouring bores based on pumping in the proposed bore.

Bore ID	Distance from Applicant bore	Easting	Northing	Bore Depth	Base of Casing*	Static Water Level	Available Drawdown**	Drawdown from proposed take	Remaining available drawdown	% of impact
	(m)	(m)	(m)	(mBGL)	(mBGL)	(mBGL)	(m)	(m)	(m)	
72_3228	161	1811791	5805039	*18.0*	15.0	10.08	7.92	0.95	6.97	11.94%
72_3227	296	1811675	5805200	*18.0*	15.0	12.30	5.70	0.61	5.09	10.65%
72_3226	307	1811667	5805210	*18.0*	15.0	12.34	5.66	0.59	5.07	10.39%
70_146	414	1812075	5805085	8.2	7.0	4.50	3.70	0.42	3.28	11.35%
70_934	521	1812175	5804685	25.9	22.9	11.90	9.00	0.31	8.69	3.44%
72_8899	566	1812193	5804623	18.0	15.0	**10.91**	7.09	0.27	6.81	3.87%
69_1467	588	1811734	5805492	21.0	13.0	12.00	9.00	0.27	8.73	2.99%
70_143	687	1812274	5805286	18.2	14.9	**5.11**	13.09	0.19	12.90	1.48%
70_102	696	1812375	5805086	9.8	6.8	**5.00**	4.80	0.20	4.61	4.11%
72_12187	753	1812353	5805285	17.0	11.0	5.00	12.00	0.17	11.83	1.38%
70_33	772	1812374	5805286	8.8	5.8	**4.83**	4.00	0.16	3.85	3.93%
69_251	790	1811574	5805685	8.8	5.8	**10.89**	1.00	0.15	0.85	14.70%
72_3229	809	1811516	5805692	*18.0*	15.0	43.78	1.00	0.14	0.86	13.97%
69_1384	874	1810874	5805184	7.4	4.4	**3.92**	3.47	0.12	3.35	3.34%
69_246	874	1810874	5805184	*18.0*	15.0	**3.92**	14.08	0.12	13.96	0.82%
72_7267	936	1812613	5805122	23.0	2.6	3.40	19.60	0.10	19.50	0.50%
69_669	1,080	1811673	5805985	12.8	11.2	**8.72**	4.08	0.07	4.01	1.71%
70_807	1,088	1812775	5805087	5.7	3.7	**3.64**	2.06	0.08	1.98	3.88%
72_11567	1,137	1812629	5805564	14.0	7.0	3.27	10.73	0.05	10.68	0.48%
70_346	1,175	1812875	5804987	*18.0*	15.0	**3.73**	14.27	0.06	14.21	0.42%
72_894	1,180	1811673	5806085	12.8	12.4	8.20	4.60	0.05	4.55	1.09%
70_256	1,233	1812875	5805287	7.0	4.0	**4.77**	2.23	0.07	2.16	3.32%
69_1572	1,238	1812073	5806086	8.0	6.0	5.00	3.00	0.04	2.96	1.33%
98224	1,242	1811615	5806144	30.5	27.5	**8.31**	1.00	0.04	0.96	4.00%
92755	1,255	1811635	5806156	33.4	9.0	**8.17**	1.00	0.04	0.96	4.00%
72_11125	1,266	1812954	5805096	*18.0*	15.0	**3.32**	14.68	0.05	14.63	0.34%
92756	1,270	1811556	5806167.04	6.0	0.2	**8.44**	1.00	0.06	0.95	5.50%
62_173	1,308	1812874	5805487	7.2	4.2	**5.62**	1.53	0.05	1.48	3.35%
69_84	1,309	1811973	5806186	6.0	3.0	**5.95**	0.05	0.03	0.02	52.57%
70_820	1,328	1812975	5805287	9.0	6.0	**4.73**	4.27	0.07	4.20	1.56%
70_350	1,328	1812975	5805287	19.8	18.2	**4.73**	15.07	0.07	15.00	0.44%
70_942	1,331	1811877	5803585	*18.0*	15.0	**12.01**	5.99	0.04	5.95	0.67%
92754	1,352	1811576	5806251	34.9	9.0	**8.20**	1.00	0.02	0.98	2.00%
72_3933	1,360	1812974	5805387	13.0	8.5	7.00	6.00	0.06	5.94	0.94%
70_691	1,400	1813075	5805187	7.6	5.7	2.40	5.20	0.05	5.15	0.87%
92753	1,425	1811602	5806327	30.5	27.5	**7.90**	17.55	0.00	17.55	0.00%
72_12163	1,434	1811910	5803486	88.5	74.0	38.00	34.00	0.03	33.97	0.09%

Bore ID	Distance from Applicant bore	Easting	Northing	Bore Depth	Base of Casing*	Static Water Level	Available Drawdown**	Drawdown from proposed take	Remaining available drawdown	% of impact
	(m)	(m)	(m)	(mBGL)	(mBGL)	(mBGL)	(m)	(m)	(m)	
72_5084	1,481	1810593	5803923	8.9	6.0	**13.07**	1.00	0.01	0.99	1.19%
70_674	1,499	1813175	5805187	8.0	6.0	**3.74**	4.26	0.00	4.26	0.08%
72_6348	1,501	1810652	5805978	15.0	12.0	**8.70**	6.30	0.01	6.29	0.17%
72_6347	1,505	1810673	5806003	12.5	8.5	**8.91**	3.59	0.01	3.57	0.31%
72_5085	1,510	1810443	5804071	18.0	12.0	**13.00**	5.00	0.03	4.97	0.53%
70_56	1,542	1810275	5804321	8.1	5.1	**12.84**	1.00	0.02	0.98	2.19%
72_10612	1,548	1810269	5804320	8.6	2.6	**12.96**	1.00	0.02	0.98	2.31%
69_880	1,549	1813175	5805387	11.2	9.7	3.90	7.30	0.00	7.30	0.05%
72_521	1,549	1813175	5805387	10.5	8.0	5.50	5.00	0.00	5.00	0.07%
69_252	1,565	1810673	5806084	5.5	2.5	**9.47**	1.00	0.01	0.99	1.46%
72_1665	1,586	1810249	5804269	*18.0*	15.0	**13.21**	4.79	0.03	4.76	0.57%
70_40	1,588	1813276	5804687	5.5	2.5	**5.11**	0.39	0.00	0.39	0.84%
70_491	1,588	1813276	5804687	10.0	6.0	**5.11**	4.89	0.00	4.89	0.07%
72_2484	1,601	1810174	5805383	45.0	42.0	26.50	13.50	0.00	13.50	0.02%
70_663	1,621	1811677	5803284	42.7	41.2	**20.42**	18.73	0.00	18.73	0.02%
72_12200	1,681	1813369	5805127	23.7	11.8	6.40	17.30	0.00	17.30	0.02%
70_1184	1,695	1813307	5805453	13.7	12.4	5.70	8.00	0.00	8.00	0.04%
70_651	1,696	1813375	5805187	5.5	2.5	**5.89**	1.00	0.00	1.00	0.33%
70_904	1,770	1813374	5805488	5.5	3.5	**5.84**	1.00	0.00	1.00	0.33%
70_436	1,777	1813476	5804787	10.0	6.4	4.20	5.80	0.00	5.80	0.06%
72_4263	1,787	1813476	5804687	9.0	7.5	3.40	5.60	0.00	5.60	0.06%
70_488	1,802	1813476	5804587	15.0	12.0	**5.43**	9.57	0.00	9.57	0.03%
70_60	1,805	1813374	5805588	4.9	1.9	**5.82**	1.00	0.06	0.94	5.58%
72_12290	1,829	1813501	5805241	20.0	14.0	6.00	14.00	0.00	14.00	0.02%
175019	1,874	1813325	5805843	19.7	16.7	3.80	15.90	0.00	15.90	0.00%
72_9562	1,878	1812887	5803447	85.0	71.0	38.40	30.60	0.00	30.60	0.00%
72_10425	1,903	1811734	5803002	75.0	64.0	**21.85**	40.15	0.00	40.15	0.01%
70_717	1,930	1809774	5804982	7.0	4.0	**7.29**	1.00	0.00	1.00	0.33%
70_943	1,978	1812178	5802985	24.0	22.8	**20.33**	3.67	0.00	3.67	0.09%
70_915	2,059	1809976	5803782	4.5	1.5	**14.27**	1.00	0.00	1.00	0.00%

* If there is no casing data the casing was assumed as follows: If bore depth is > 100 m, base of casing is 80 mBGL, else base of casing is 3 m above bore depth.

**Available drawdown calculation assumes the full water column is available in a shallow bores (<25 m) using suction and/or vertical piston shaft pumps (e.g. "Davies" Piston Pumps). For deep bores (>25 m) assumed submersible pump is 2 m above the bottom of the casing.

Italic - Assumed bore depth of 18 m (average known bore depth within the 2 km radius).

Underline - Assumed bore casing depth values.

Bold - Interpolated Static Water Level (SWL).

Remaining Allowable Drawdown (m) - is the drawdown available accounting for the drawdown from the proposed applicants bore.

The assumptions applied for the calculations in **Table 4** are as follows:

- If the bore depth is >25 m, the bore pump is assumed to be positioned 2 m above the casing bottom, if the bore depth is <25 m, it is assumed that the full water column is available for drawdown;
- Where the interpolated SWL is lower than the bore depth, the available drawdown is assumed to be 1m. Possible perched water tables within the Hinuera Formation may lend to inconsistencies between the interpolated SWL and bore depths;
- The FWM (as described in **Appendix A**) has been used to calculate drawdown directly adjacent to the bore;
- The cumulative drawdown at neighbouring bores was determined from FWM results at the radius corresponding to the distance between the given bore and the proposed bore.

All bores outside of the 0.5 m drawdown contour are considered to have negligible effects from the proposed abstraction.

Available static water level (SWL) measurements were interpolated to estimate the SWL of all 28 bores within the potentially affected area, which was then used to assess the potential drawdown impact from the proposed take.

Based on the drawdown assessment, the effects on neighbouring bores are <1 m, and the average percent of impact is 0.03%. The largest percent of impact occurs at bore 69_84 (52.57% of impact), the remaining bores have a precent of impact <15%. The information stored on WellsNZ indicate that the bore 69_84 is a legacy bore, and a bore cannot be observed at its location from Google Streetview and aerial imagery, thus it is possible that this bore may no longer exist.

All of the bores would have adequate pump submergence remaining to continue operating. For that reason, we consider the effects on other groundwater users to be very low.

4.2.4 Effects on Surface Water

East and West Gullies

Surface water effects were considered by calculating the portion of the groundwater take that is derived from each groundwater layer within the model, which is presented in **Figure 13** (**Appendix A**). For the purpose of assessing stream depletion, it was conservatively assumed that all of the water deriving from Model Layer 1 was directly contributing to stream depletion effects for the two gullies located at the southern end of the Site.

The simulation results indicate that after 365 days of continuous pumping, 8.6% of the abstraction volume derives from Layer 1. The proportion of the drawdown cone that feeds to the east gully is approximately 13% and to the west gully is 15%, this equates to a stream depletion effect of 10.44 m^3/day (0.12 L/s), and 11.3 m^3/day (0.13 L/s) for the east and west gullies respectively.

The effects on the MALF (Mean Annual Low Flow) of these streams were considered in order to assess effects on stream wetted perimeter and depth, which related to habitat extant for instream ecology. The MALF and catchment size statistics were obtained from NIWA's NZ Rivers Maps[11]. The statistics and percentage of impact on the MALF is presented in **Table 5**.

Table 5. MALF Gully Statistics.

Gully	MALF (m^3/day)[11]	Upstream Catchment (km^2)[11]	Percentage of Impact (%)
East	399	1.609	3
West	128	0.629	9

[11] https://shiny.niwa.co.nz/nzrivermaps/

The percentage of impact on the MALF of the eastern gully is very low and thus considered to be less than minor.

The percentage of impact on the MALF of the western gully is higher, thus this was assessed further. The channel flow was assessed to determine the change in water level within the channel of the western gully. It was determined that the effect on the water level would result in approximately 1 mm of lowered water level for a channel of 0.5 m width (**Figure 11**). It is unlikely that this change in water level would impact the ecology of the stream. As such, the impact on the MALF in the western gully is considered to be less than minor.

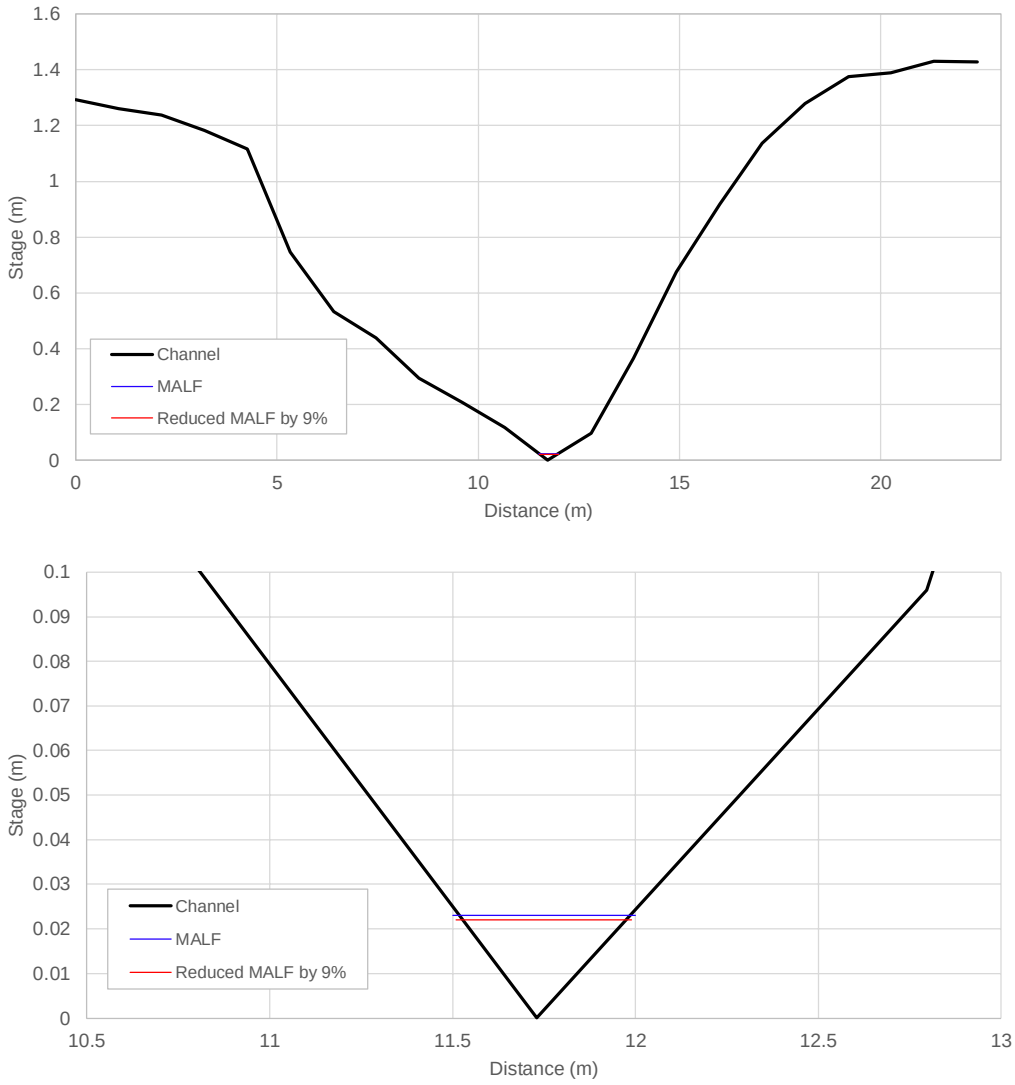


Figure 11. Western Gully channel cross section and water level height. (note bottom graph is zoomed in).

In summary, the surface water flow potentially affected is considered to be less than minor in the western and eastern gullies.

Waikato River

The FWM model Layers 1-3 are likely to be connected to the Waikato River (i.e., the Hamilton Basin – South Aquifer and the Waikato River are connected). All pumping therefore will deplete the Waikato River, however, as there is allocation available within the aquifer, this will not have adverse effects on the River as the allocation accounts for this under the WRP.

It is also important to note that the FWM is conservative as the Waikato River is not set as a boundary condition, even though the river and rainfall would recharge the aquifer.

Conclusion

On the basis set out above, effects on surface water, and in particular stream depletion effects, are considered to be less than minor.

4.2.5 Effects on Wetlands

Based on the WRC Biodiversity and Environment Map[2] there is one wetland located 1.3 km south of the proposed bore, which is also separated from the Site by the Waikato River.

As the wetland is separated from the Site by the Waikato River, and given that the wetland is located on and supported by the Mangawhero Stream (a tributary to the Waikato River), abstraction from the proposed bore is unlikely to result in adverse effects on wetland hydrology, vegetation, or ecological values.

4.2.6 Ground Settlement Effects

Land settlement effects have the potential to occur when compressible layers within the ground are dewatered. The site is dominated by sands of the Hinuera Formation, including sand, silt, gravel, and peat. Within this sequence, peat is the only material considered highly compressible, while others are considered to have generally moderate to low compressibility.

As the surface is dominated by sands, which have low compressibility, any peat horizons present are expected to be thin, discontinuous and at shallow depth. Based on available geological information and assuming limited hydraulic connectivity to any peat horizons, these conditions limit the potential for significant consolidation. Therefore, land settlement is not expected to be a relevant factor for the proposed groundwater bore.

5. Conclusions

This assessment has been prepared on behalf of Shaws Quarries Limited to accompany a resource consent application for a proposed groundwater take and sand quarry activity at 1466 Cambridge Road, Cambridge, Waikato, within the Hamilton Basin – South aquifer.

The sand quarry is proposed to be dry mined, limiting effects on groundwater resulting from dewatering.

The proposed groundwater take is for sand quarry activities requiring 900 m^3/day and 328,500 m^3/year of water. The Hamilton Basin – South aquifer currently (as of April 2026) has 38,685,000 m^3/year (38.7 Mm^3/year) of allocation available, thus the take is within the allocation limits.

The AEE of the groundwater take draws the following conclusions:

- Effects on other groundwater users is considered to be very low;
- Effects on surface water, and in particular stream depletion effects, are considered to be less than minor;
- Abstraction from the proposed bore is unlikely to result in adverse effects on near-by wetlands; and
- Land settlement is not expected to be a relevant factor for the proposed groundwater bore.

In summary, we consider the effects on the environment from the proposed groundwater take and dry sand quarrying will be negligible.

Appendix A. Groundwater Response Modelling

A.1 Introduction

The assessment used the Feather Williamson Analytical Model to simulate the potential groundwater effects resulting from the proposed take.

A.2 Feather Williamson Analytical Model

The Feather and Williamson Model (FWM) is an analytical solution for drawdown calculation in a multi-layer aquifer system. By assigning the hydrogeologic parameters and thickness of individual layers based on the documented geology, drawdown is calculated for each individual layer in the inverse Laplace transform of the groundwater flow equation. The model is available as freeware at https://www.wwla.kiwi/softwaredetail/fwm and we encourage Council staff or appointed peer reviewers of this report to download the software and confirm/test sensitivity of our predictions if desired.

In response to s92 requests on other groundwater take applications, which sought a comparison of the FWM to the Theis model, we provide the following comments:

- The Feather-Williamson Model (FWM) computes the drawdown through multiple layers in the bore;
- This approach is more accurate then Theis due to consideration of storage and leakage effects from overlying and underlying layers;
- The model provides a similar response to that of a numerical model;
- The FWM has been used widely throughout New Zealand for groundwater take applications and has passed scrutiny through the technical reviewer at Northland Regional Council, Auckland Council, Waikato Regional Council, Bay of Plenty Regional Council, Hawkes Bay Regional Council, Gisborne District Council and Greater Wellington Regional Council by virtue of numerous consents being granted in these regions.

A.3 Model Setup and Calibration

Model Setup

Groundwater abstraction, at a rate of 900 m^3/day (equal to the maximum daily take for the proposed bore) was simulated for 365 days to provide the annual volume (**Section 3**).

The model is comprised of four layers, with each layer assigned hydraulic parameters to represent the geological units at the site and is based on the geological log for existing near-by bores. These layers, as represented in the model are presented in **Table 6**. Abstraction is assigned to Model Layer 3, which represents the bore production zone.

The following assumptions were applied:

- There is no recharge to the aquifer; and
- Each unit is assumed to be homogeneous across the model domain.

The geological material and thickness for each modelled layer was determined based on the geological profile developed from the nearby bores and our understanding of the underlying aquifers. The transmissivity of the Tauranga Group (equivalent group name for the geology at the site ranges from 10 to 1000 m^2/d [12].

[12] John Hadfield. 2001. Waikato - Groundwaters of New Zealand. ISBN 0-473-07816-3

Considering that specific yield applies to unconfined aquifer layers and specific storage applies to confined aquifer layers, the storability of layer 1 was defined based on the aquifer specific yield reflecting sands[13]. Layers 2-4 are confined and have specific storage calculated from publicised rock compressibility values[14]

Table 6. Hydrogeologic parameterisation in the FWM.

Layer	Transmissivity (m^3/day)	Storativity (-)	Layer Thickness (m)	Total Thickness (m)	Kh:Kv (-)	Kh (m/s)	Geology
0	0	1	10	10	0	0	Unsaturated Hinuera Formation
1	17.3	0.25	5	15	10	$4x10^{-5}$	Saturated Hinuera Formation
2	0.05	0.0366	5	20	10	$1.16x10^{-7}$	Silty CLAY (Walton Subgroup?)
3	238	0.261	81	101	10	$3.4x10^{-5}$	Pumice
4	10	0.00156	200	301	10	$5.79x10^{-7}$	Dense Pumice

A.4 Simulation Results

Groundwater Drawdown

The estimated drawdown within each aquifer layer at the bore location, where the maximum drawdown will occur, is shown in **Figure 12**. The peak volume of abstraction in a given year will vary based on climatic factors like rainfall and temperature, however the simulated condition where maximum abstraction is applied on a daily basis will not occur in practice and assures that the drawdown estimation can be considered conservative.

The greatest drawdown is simulated within the pumped aquifer, as would be expected, and amounts to 5.37 m at the proposed pumping rate. The estimated drawdown in Model Layer 1 is 0.18 m which is conservatively assumed to be directly connected to surface water. Model Layers, 2, and 4, have drawdowns of 1.36 m, and 0.39 m, respectively, at the bore.

It is noted that all predicted drawdowns can be considered a conservative estimate because the FWM model does not account for any rainfall recharge.

[13] Freeze, R. A., Cherry, J. A. (1979). Groundwater. Englewood Cliffs, NJ: Prentice-Hall.
[14] Domenico, P. A, Mifflin, M. D. (1965). Water from low-permeability sediments and land subsidence. Water Resources Research, 1(4), 563-576. https://doi.org/10.1029/WR001i004p00563

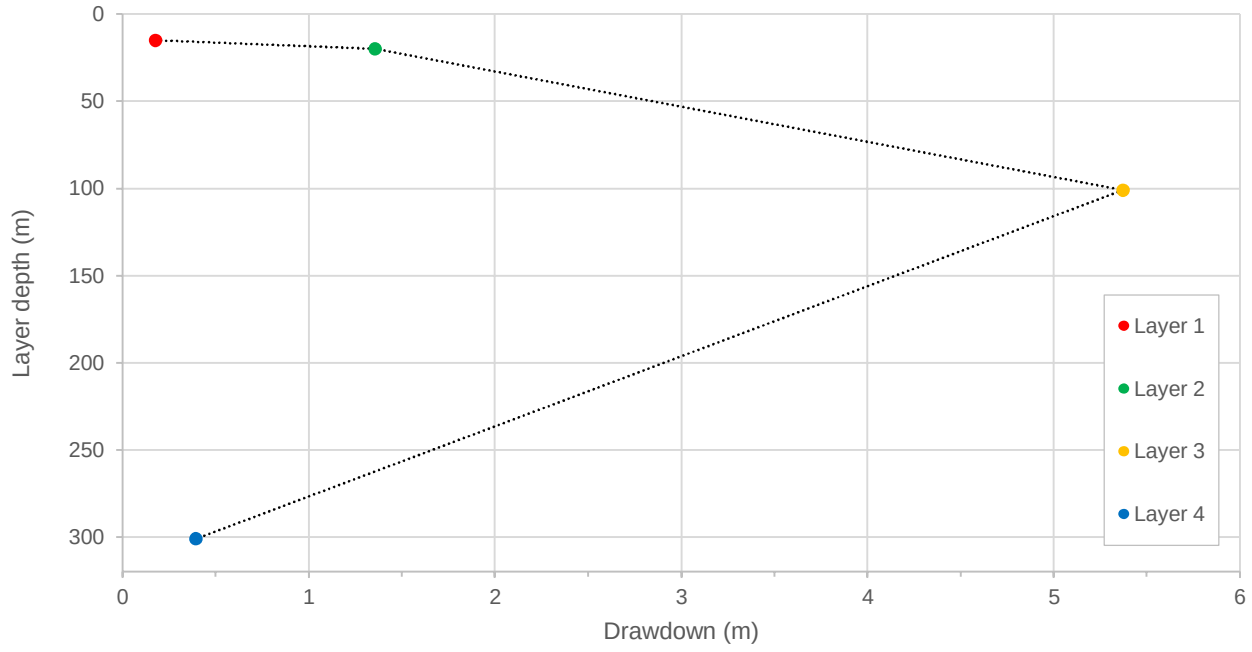


Figure 12. Simulated drawdown in each model layer (900 m^3/day for 365 days, at 0.1 metres).

The lateral extent of drawdown in the production zone is presented in **Figure 14**. The drawdown is greatest in close proximity to the proposed bore, reducing with distance. These results indicated that bore interference effects will be limited to within a close proximity to the proposed bore, as shown in **Figure 14**. The implication of the groundwater drawdown in terms of the potential effects on other groundwater users is discussed in **Section 4.2.3.**.

Surface Water Connectivity

The FWM calculates the percentage of pumped groundwater derived from each layer in the model as shown in **Figure 13**. For the purpose of assessing the potential impact of the groundwater abstraction on surface water features, it is assumed that Layer 1 is connected to surface water bodies, and Layers 1, 2, and 3 are connected to the Waikato River.

The key features to note from this analysis are as follows:

- As pumping begins 100% of the pumped water is derived from the production zone (Layer 3);
- After 365 days of pumping, Layer 1 and Layer 2 increases while Layer 3 decreases in contribution, as the cone of depression migrates upwards. The model has been calibrated for the maximum pumping scenario; therefore, this magnitude of abstraction is rare to occur.
- Contribution of Layer 3 is approximately 85.2% after continuous pumping at 900 m^3/day for 365 days.
- Contribution of Layers 1 and 2 are 8.6% and 5.7%, respectively, after continuous pumping at 900 m^3/day for 365 days.
- Contribution of Layer 4 is minor at 0.4% after continuous pumping at 900 m^3/day for 365 days.

The implications of this analysis for surface water depletion are discussed further in detail in the assessment of surface water effects section (**Section 4.2.4**).

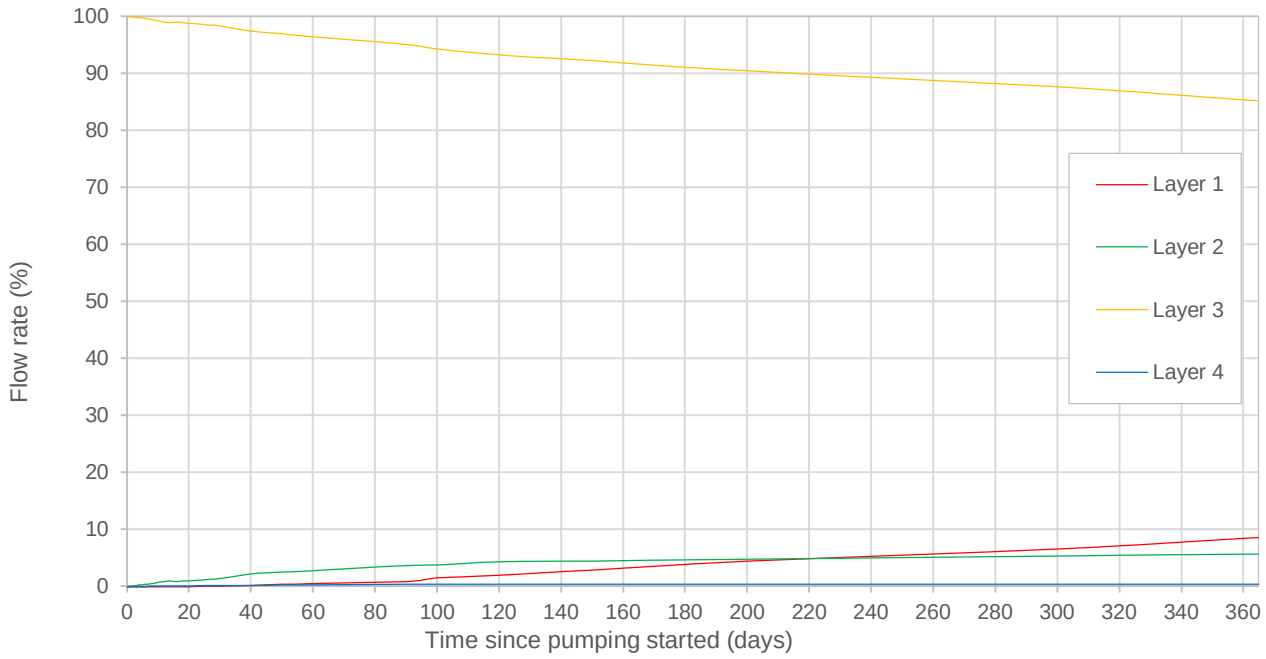
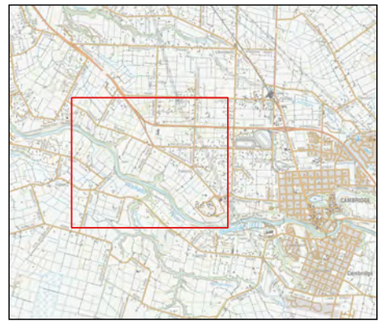


Figure 13. Flow partitioning of abstracted groundwater within the FWM layers.

Map Title:
Drawdown Contours of Proposed Bore (Layer 3)

Project:
Sand Quarry Bore Water Supply

Client:
Shaws Quarries Limited



Legend

- Existing Bore
- Proposed Bore
- Drawdown Contour Line
- 2 km radius

Data Provenance
Aerial imagery sourced from LINZ.

Drawn by: Brooke James
17/06/2026

Layout & Project File
A3 Landscape Template

WILLIAMSON WATER & LAND ADVISORY

Figure 14.