

Appendix 10: Groundwater assessment



Environment Canterbury

Seadown Main Drain Realignment Groundwater Effects Assessment

TECHNICAL REPORT

WGA251860

WGA251860-RP-HG-0002_A

April 2026



Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	09/04/2026	DRAFT	WED	BS	BS

CONTENTS

1	EXECUTIVE SUMMARY	6
2	INTRODUCTION	7
2.1	Background	7
2.2	Scope of Work	7
3	HYDROLOGICAL ENVIRONMENT	10
3.1	Topography	10
3.2	Climate	10
3.2.1	Rainfall	10
3.2.2	Evapotranspiration	10
3.3	Coastline	10
3.4	Rivers and Streams	11
3.4.1	Ōpihi River	11
3.4.2	Waitarakao/Washdyke Lagoon and Washdyke Stream	11
3.4.3	Horseshoe Creek and Philips Creek	12
3.4.4	Levels Plain Irrigation Scheme	12
3.5	Drainage Network	12
3.5.1	Seadown Main Drain	12
3.5.2	Water Levels and Flow Rates	13
3.5.3	Base Flows	15
4	GEOLOGICAL SETTING	16
4.1	Regional Geological Setting	16
4.2	Local Lithological Setting	18
4.2.1	Topsoils	18
4.2.2	Loess	18
4.2.3	Quaternary Gravels	18
4.3	Leapfrog Geological Model	19
4.3.1	Geological Model Development	19
4.4	MODFLOW-USG Conversion	21
5	HYDROGEOLOGICAL SETTING	22
5.1	Hydraulic Characteristics of Lithological Units	22
5.1.1	Soils	22
5.1.2	Aquifers	22
5.1.3	Aquitards	26
5.2	Groundwater Recharge	26
5.3	Groundwater Level Monitoring	27
5.4	Piezometric Surface	29
5.5	Groundwater Takes	29
5.6	Groundwater Salinity	29
5.7	Conceptual Groundwater Model	33
5.7.1	Conceptual Model Layout	33

5.7.2	Geological Units	33
5.7.3	Aquifer and Aquitard Characteristics	33
5.7.4	Boundary Conditions	33
5.7.5	Groundwater Throughflows	34
6	NUMERICAL GROUNDWATER MODEL	36
6.1	Introduction	36
6.2	Software	36
6.3	Model Discretisation	37
6.4	Boundary Conditions	37
6.5	Calibration Process	39
6.5.1	Calibration Data Weighting	39
6.5.2	Pilot Point Targets	39
6.5.3	Parameter Estimation Settings	40
6.6	Calibration Results	40
6.6.1	Calibration Statistics	40
6.6.2	Head Targets	40
6.6.3	Flux Targets	42
6.6.4	Hydraulic Conductivity Distribution	42
6.7	Groundwater Balance	42
6.8	Sensitivity Analysis	42
6.9	Model Uncertainty	45
6.10	Model Confidence Level Classification	45
7	GROUNDWATER EFFECTS ASSESSMENT	49
7.1	Overview	49
7.2	Proposed Drain Configurations	49
7.2.1	Stage 1 Drain Configuration	49
7.2.2	Stage 2 Drain Configurations	49
7.2.3	Simulation of Proposed Stopbank Alignment	50
7.3	Projected Groundwater Drawdown	50
7.4	Effects on Drain Baseflows	55
7.5	Effects on Washdyke Lagoon	55
7.6	Effects on Nearby Bores	56
7.6.1	Drawdown at Nearby Bores	56
7.6.2	Discussion	56
7.7	Effects from Stopbank Realignment	59
7.7.1	Hydrogeological Context and Connectivity	59
7.7.2	Infiltration and Recharge	59
7.7.3	Compaction of Underlying Material	59
7.7.4	Summary	59
7.8	Saline Water Interface	59
8	GROUNDWATER MONITORING PLAN	61
8.1	Groundwater Drawdown	61
8.2	Surface Water Monitoring Sites	61

9	SUMMARY	62
10	REFERENCES	63
11	LIMITATIONS	64

Figures

Figure 1: Study Area and Key Features	8
Figure 2: Options for Proposed Seadown Main Drain Alignment	9
Figure 3: Historical Coastline Alignment and Wetland Extents (from ECan, 2025).....	11
Figure 4: Layout of Existing Drainage System Between Washdyke Lagoon and Ōpihi River	14
Figure 5: Surficial exposure of water-bearing strata in the Timaru area (Cox and Barrell, 2007)	17
Figure 6: Surficial Geological Units and Locations of Drillholes with Geological Logs	20
Figure 7: Shallow Aquifer (<10 m BGL) Transmissivity and Hydraulic Conductivity Distribution	23
Figure 8: Shallow Aquifer (<10 m BGL) Hydraulic Conductivity Spatial Distributions	25
Figure 9: Reliable Reported Aquitard Conductances Against Depth (Lough & Williams 2009).....	26
Figure 10: Groundwater Level Monitoring Sites	28
Figure 11: Groundwater Contours (de Joux, 1987).....	30
Figure 12: Nearby Bores and Consented Groundwater Takes	31
Figure 13: Shallow Groundwater Salinity Map	32
Figure 14: Groundwater Numerical Model Boundary Conditions	38
Figure 15: Steady-state Modelled vs Observed Heads	41
Figure 16: Modelled Heads and Calibration Targets.....	43
Figure 17: Hydraulic Conductivity Distribution and Pilot Point Locations	44
Figure 18: Seadown Main Drain Alignment A Scenario.....	51
Figure 19: Seadown Main Drain Alignment B Scenario.....	52
Figure 20: Seadown Main Drain Alignment C Scenario.....	53
Figure 21: Seadown Main Drain Alignment D Scenario.....	54

Tables

Table 1: Surface Water Level Automated Recording Stations	13
Table 2: Average Measured Flows in Seadown Main Drain at Gauging Station 69803	15
Table 3: Late Cenozoic Lithological Stratigraphy of the Study Area.....	16
Table 4: Lithological Variation with Depth	19
Table 5: Indicative Hydraulic Conductivity Ranges for Loess Soils	22
Table 6: Aquifer Hydraulic Properties for Wells with and without Lithological Logs	23
Table 7: Aquifer Hydraulic Conductivity Variation with Depth	24
Table 8: Conceptual Estimate for Model Area Groundwater Throughflows	35
Table 9: Model Boundary Parameters Subject to Calibration and Adopted Values	40
Table 10: Optimised Model Calibration Statistics.....	41
Table 11: Seadown Main Drain to Phillips Lagoon Steady State Baseflow	42

Table 12: Calibration Model Mass Balance.....	45
Table 13: Model Confidence Level Classification (Barnett et al, 2012)	47
Table 14: Drain Configuration Baseflow Changes	55
Table 15: Proposed Drain Configurations and Washdyke Lagoon Mass Balance Changes.....	55
Table 16: Modelled Drawdown (greater than 0.1 m) on Water Supply Bores for Proposed Configuration B and C.....	57
Table 17: Modelled Drawdown (greater than 0.1 m) on Water Supply Bores for Proposed Configuration D	57
Table 18: Analytical Approximation of Saltwater/Freshwater Interface Position	60

Appendices

Appendix A GROUNDWATER LEVEL DATA

Appendix B SURFACE WATER LEVEL AND FLOW RECORDS

Appendix C SOILS FACT SHEETS

Appendix D DRILLHOLE LITHOLOGICAL LOG SUMMARY

Appendix E NUMERICAL GEOLOGICAL MODEL

Appendix F PUMPING TEST RESULTS

Appendix G GROUNDWATER CHLORIDE MONITORING DATA

Appendix H CONSENTED TAKES

Appendix I FIELD IMAGES

Appendix J SENSITIVITY ANALYSIS

Appendix K PILOT POINT TARGETS

1 EXECUTIVE SUMMARY

Environment Canterbury is proposing the managed retreat and realignment of the Seadown Main Drain and associated coastal stopbanks between the Ōpihi River and the Waitarakao/Washdyke Lagoon in response to ongoing coastal erosion and increasing risk to existing drainage and flood protection assets. An investigation was undertaken to understand the current groundwater conditions and likely responses to drain realignment to support the consenting process and broader coastal adaptation decision-making.

This report presents the development and application of a steady-state numerical groundwater model for the Seadown area, extending from the Washdyke Lagoon to the Ōpihi River and inland across the coastal plains. The model integrates available geological, hydrogeological, surface water and monitoring data, and explicitly represents the interaction between the shallow alluvial aquifer, the drainage network, the Ōpihi River, the ocean boundary and Washdyke Lagoon.

The baseline model was calibrated to observed groundwater levels and measured baseflow in the Seadown Main Drain. Four alternative Stage 2 Seadown Main Drain realignment configurations were simulated to assess their potential effects on groundwater levels, drain baseflows, nearby water supply bores, Washdyke Lagoon and the saline interface. The modelling indicates that all proposed configurations result in relatively minor and localised long-term drawdown of the shallow water table. The magnitude and spatial extent of drawdown increase with drain length and deeper intersection of the groundwater table, with the most inland configuration producing the largest increase in groundwater interception. Despite these changes, simulated drawdowns at existing water supply bores are small and within the range of natural variability, and no material effects on bore yield or reliability are anticipated.

The simulations suggest that any minor reduction in direct groundwater inflow to Washdyke Lagoon caused by local drawdown is offset by increased freshwater discharge delivered via the realigned drains, resulting in a net increase in freshwater input to the lagoon system. Stopbank realignment scenarios show no measurable effect on groundwater levels, reflecting the fact that the stopbanks are constructed above the saturated zone and do not impede saturated groundwater flow or significantly alter recharge. Analytical models indicate that all proposed drain configurations maintain groundwater heads above mean sea level and preserve a positive seaward gradient, such that the risk of saltwater intrusion to the shallow aquifer remains low.

Overall, the modelling demonstrates that the proposed Seadown Main Drain realignment can be undertaken with less than minor effects on groundwater resources, while supporting the long-term resilience of critical drainage and coastal protection infrastructure.

2 INTRODUCTION

2.1 Background

Canterbury Regional Council (ECan) manages existing land drainage and stopbank assets, primarily running parallel to the coast between the Ōpihi River and Washdyke/Waitarakao Lagoon (Figure 1). The Seadown Main Drain, which is aligned parallel to the coast and an existing coastal stopbank, as well as lateral drains that feed that Main Drain, play a critical role in providing land drainage. These drains enable farming, help protect infrastructure from seawater inundation and provide a critical freshwater inflow to the Waitarakao lagoon at Washdyke.

Coastal erosion of between 1.5 and 2 m per year puts these drainage and stopbank assets at risk from damage, breach and/or overtopping of seawater to the land. The stopbank and the Main Drain have been moved landward at least twice in the past to protect these assets and maintain their functionality.

ECan is planning to retreat/realign the stopbank and drainage infrastructure inland (Figure 2) to ensure ongoing protection of private, public, and natural assets. Consequently, ECan is seeking to:

1. Consent and reconstruct an inland version of the Seadown Main Drain and coastal and freshwater flooding defences in the area between the northern end of the Timaru Wastewater Treatment Facility (approximately 400 m north of Aorangi Road) and the northern end of the Waitarakao Lagoon to the south.
2. Extend the protective works from the northern end of the Wastewater Treatment Facility to the Ōpihi River. However, ECan's consent application to enable construction works is to cover the area from the northern end of the Wastewater Treatment to Beach Road only.

A key decision on Stage 2 works between the Wastewater Ponds and Beach Road is how far inland to shift a new "Seadown Main Drain". Several options have been considered by ECan, locally up to hundreds of metres inland. Complexities to the overall coastal adaptation project require an improved understanding of current groundwater conditions, to support an assessment of potential impacts from future works on groundwater and on a range of related consent issues.

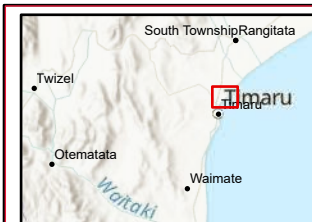
2.2 Scope of Work

To support the consenting of the proposed relocation of the Seadown Main Drain, ECan is seeking to understand:

- The current and future conditions of multiple lateral drains and abstraction wells in the area of interest.
- The potential changes in drain flows and groundwater levels arising from the relocation.
- The potential for groundwater mounding effects from the proposed relocated stopbanks.
- The potential for saltwater intrusion into the shallow aquifer due to the drainage and stopbanks relocation.
- The staging of the engineering works and variant options proposed.

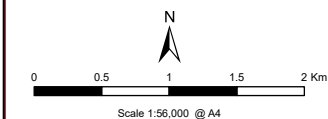
ECan has retained Wallbridge Gilbert Aztec (WGANZ Pty Ltd; WGA) to develop a 3D groundwater numerical model of the area, including simulation of the existing and proposed drains. Detailed documentation of the model and the simulation outcomes is to be used to support the consenting process for the Seadown Main Drain realignment. The model assesses engineering works and local conditions, including the drainage works, coastal stopbanks, and the hydraulic behaviour of the ocean boundary. The coverage area for the model (the model domain) extends from the Waitarakao Lagoon to the Ōpihi River, and inland toward Waipopo and Seadown Roads.

This report documents the groundwater model and simulated scenarios produced for ECan and the information used to support the modelling process.



LEGEND

- Existing Stopbank
- Seadown Drainage Network
- Existing Main Drain Channel

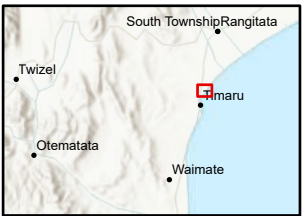
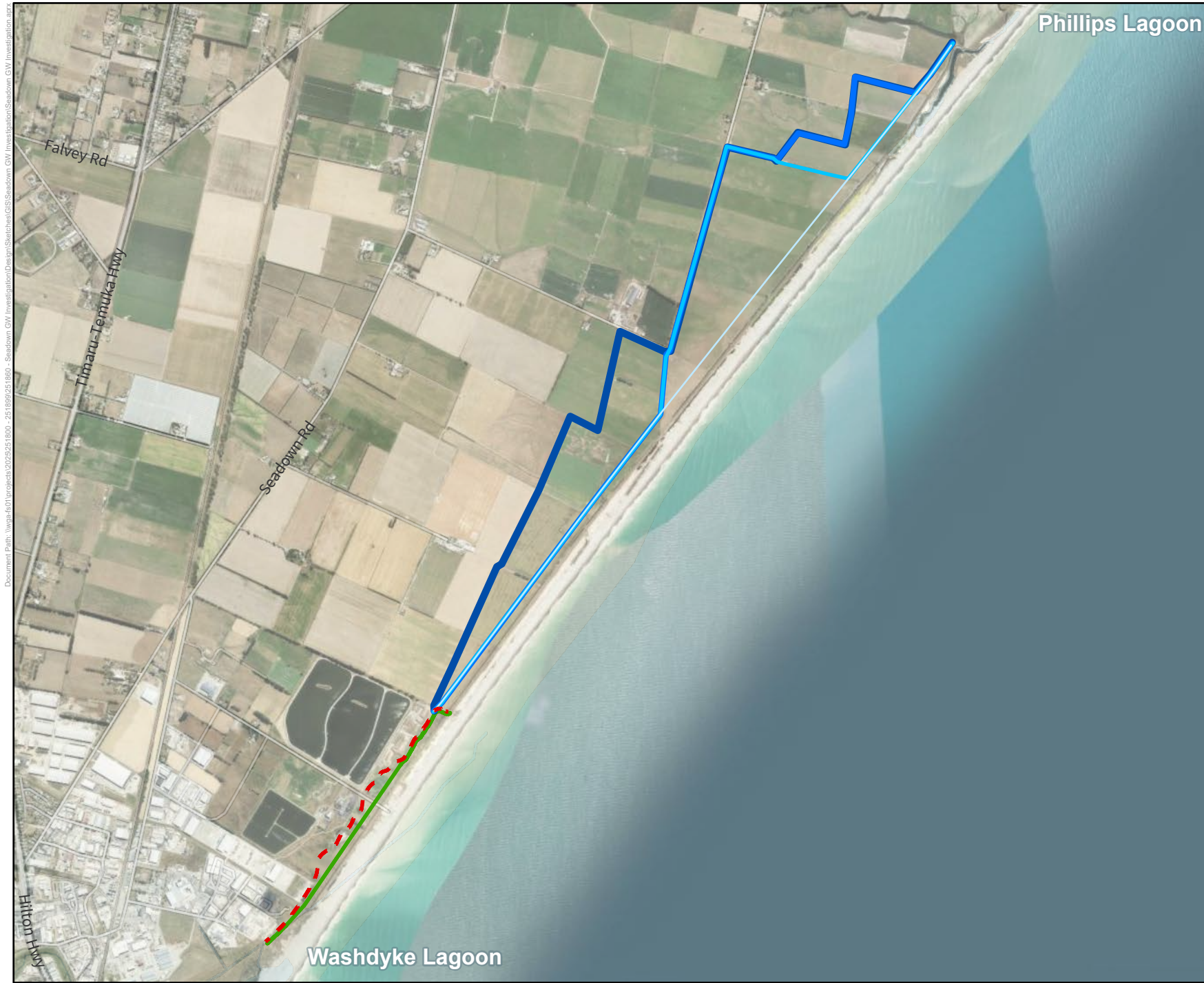


Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

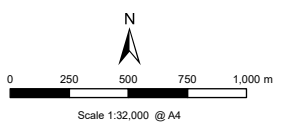
Figure 1 Seadown Groundwater Investigation Study Area and Key Features

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026



LEGEND

- Stage 1 Proposed Channel
- Stage 2 Poss New Channel Alignment A
- Stage 2 Poss New Channel Alignment B
- Stage 2 Poss New Channel Alignment C
- Stage 2 Poss New Channel Alignment D
- Proposed Stopbank



Coordinate System: NZGD 2000 New Zealand Transverse Mercator



Figure 2
Seadown Groundwater Investigation
Options for Proposed Seadown Main Drain Alignment

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026

3 HYDROLOGICAL ENVIRONMENT

3.1 Topography

The study area is defined by a triangular region bounded by the Pacific Ocean coastline, the Ōpihi River, and State Highway 8. Within this area, the land surface rises from sea level (0 m RL) at the coast to approximately 50 m RL near Pleasant Point, situated roughly 12 km inland.

The regional topography exhibits a steady south-eastward gradient of approximately 0.004 m/m, although this slope is subject to local variation influenced by specific geomorphological features.

A site visit was conducted on 16 October 2025 for the purpose of catchment familiarity and stream documentation. Imagery collected from the site visit (i.e., between the Ōpihi River and Washdyke Lagoon) is provided in Appendix I and referenced in the report.

3.2 Climate

3.2.1 Rainfall

Long-term records indicate rainfall in southern Canterbury decreases with increasing distance from the Pacific coast. Yearly average rainfall ranges from 550 mm at the coast to 1,250 mm at the foothills of the Southern Alps (Flintoft and Weir, 2019).

The mean annual rainfall is a critical driver for the groundwater system. However, within the specified model domain, the presence of low-permeability gley soils (refer to Sections 4.2.1 and 5.1.1) is expected to limit direct infiltration to the underlying aquifer (refer to Section 5.2). The hydraulic gradient across the model domain is expected to be less influenced by local rainfall than by groundwater sources outside the modelled area. Therefore, for the purposes of this assessment, rainfall recharge has not been used as a model input parameter (refer to Section 5.7.4).

3.2.2 Evapotranspiration

Potential evapotranspiration (PET) is relatively uniform across the study area, ranging from 700 to 800 mm per year (Flintoft and Weir, 2019).

Similar to rainfall, the spatial distribution of PET across the Seadown area influences the net water balance. However, the direct impact of PET on groundwater recharge is mitigated by the presence of low-permeability gley soils across much of the model domain (refer to Sections 4.2.1 and 5.1.1). Therefore, for the purposes of this assessment, PET has not been used as a model input parameter (refer to Section 5.7.4) and no further information on rainfall patterns is required.

3.3 Coastline

The coastline north of Timaru has been progressively eroded over a considerable period (Figure 3), with the shoreline retreating toward the current seawall and Seadown Main Drain alignment. The coastline along the stretch between Washdyke and the Ōpihi River consists of a generally straight sand and gravel beach of low gradient. The beach is in the order of 50 m wide between the normal high tide mark and the landward edge of the unvegetated beach section.

Hydraulically, it is expected that the groundwater within the shallow unconfined aquifer is directly connected to the ocean, without restriction. The sands and gravels of the ocean beach are not incorporated in the conceptual groundwater model or simulated as a separate unit in the numerical groundwater model. As the groundwater model is designed as a steady-state simulation, the hydraulic effects of tidal fluctuations are also not incorporated into the simulation. The ocean boundary is defined hydraulically as mean sea level (0 m RL).

The groundwater model provides inputs for an analogue assessment of the effects of the drain realignment on the saline water/freshwater interface within the shallow aquifer. These calculations will be based on simulated groundwater throughflows for different drainage configurations. The assumed densities for saline ocean water and fresh water are 1,025 kg/m³ and 1,000 kg/m³, respectively.

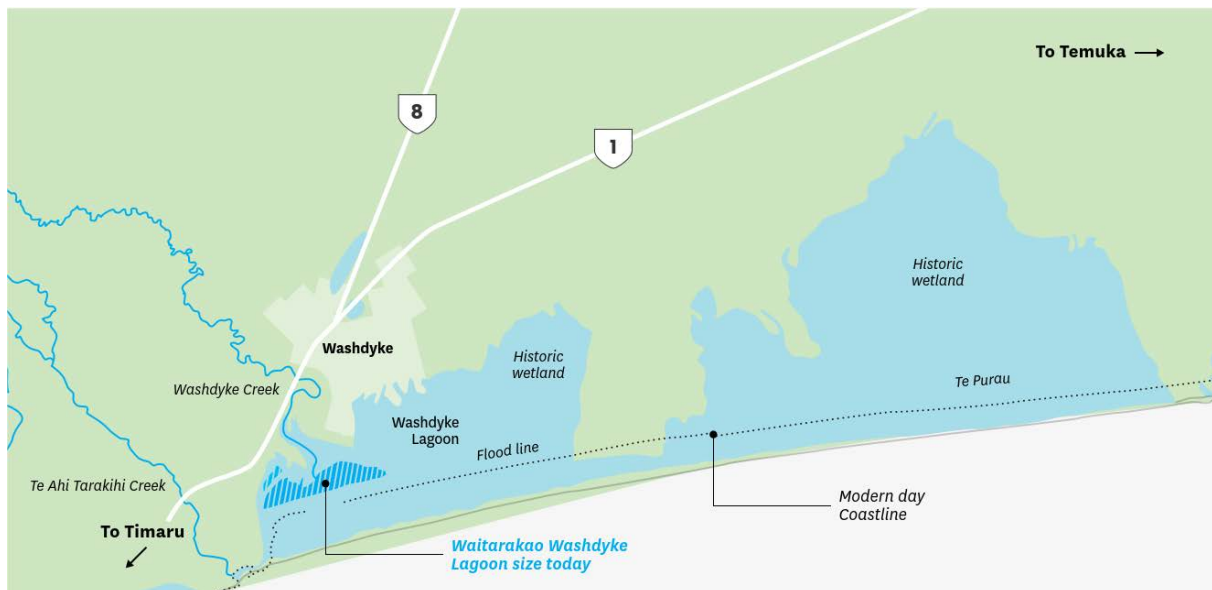


Figure 3: Historical Coastline Alignment and Wetland Extents (from ECan, 2025)

3.4 Rivers and Streams

3.4.1 Ōpihi River

The Ōpihi River has been used to define the northern boundary of the groundwater model domain (Section 5.7). The river flows from west to east, with the water level dropping from approximately 16 m RL at the State Highway 1 bridge to 0 m RL at the coast. Morphologically, the river is a braided river with a sandy gravel bed. For the purposes of this assessment, it is assumed that the hydraulic connection between the shallow groundwater system and the river is unrestricted.

Approaching the coast, the Ōpihi River starts to widen approximately 750 m from the coastline. The river mouth is often partially or completely closed off from the coast by a sand and gravel bar. The river at the mouth is predominantly fresh but occasionally receives seawater inflows through an opening in the bar or overtopping of the bar from the sea. When the bar is closed, the river mouth acts more like a lagoon than a river channel (Robson-Williams & Clark, 2019).

3.4.2 Waitarakao/Washdyke Lagoon and Washdyke Stream

The shallow brackish coastal Waitarakao/Washdyke Lagoon (Figure 1) is separated from the ocean by a mixed sand and gravel bank along the coastline. Pipes have been installed through this coastal bank, enabling water to flow from the lagoon via the 'Ring Drain' to the sea and vice versa under most tidal conditions (Robson-Williams & Clark, 2019). The Seadown Main Drain discharges to the Waitarakao/Washdyke Lagoon (Figure 4).

The Washdyke Stream discharges to the northern side of the Waitarakao/Washdyke Lagoon. It carries permanent flows and has been utilised as a boundary condition to the groundwater model (Section 5.7).

Water levels in the Waitarakao/Washdyke Lagoon and both flows and levels in the Washdyke Stream have been monitored. Further information regarding the monitoring programme and results is presented in Section 3.5.2.

3.4.3 Horseshoe Creek and Philips Creek

Horseshoe Creek and Philips Creek are natural drainage systems crossing the area of interest. The outlets from Horseshoe Creek (Horseshoe Lagoon) and Philips Creek (Philips Lagoon) to the ocean have both been closed off from the ocean by naturally occurring mixed sand and gravel banks. Water discharging from Horseshoe Lagoon ponds against the landward side of the gravel bank parallel to the coastline, and seeps through the gravel to the ocean. Philips Lagoon forms the starting point for the Seadown Main Drain and discharges via that route, although it is likely water also seeps through the gravel bank to the ocean (Figure 1).

3.4.4 Levels Plain Irrigation Scheme

The Seadown Main Drain receives an unquantified contribution from the local irrigation scheme at the connection on Beach Road and Aorangi Road. While the primary focus of this assessment is on natural groundwater interactions, the operational reality of the Seadown area includes the discharge of excess irrigation water and scheme-related bypass flows into the drainage network.

While this scheme-related water was not quantified as part of this assessment, the potential for increased hydraulic loading from these sources should be considered in future work to ensure drain capacities are accurately reflected.

3.5 Drainage Network

3.5.1 Seadown Main Drain

Seadown Main Drain extends 7.16 km from the inlet at Philips Lagoon to the connection at Washdyke Lagoon. The main drain is connected by a series of laterals that drain the surrounding lands (Figure 4). The drain configuration and laterals were explored across a field trip that has been documented in Appendix I.

The channel width is approximately 4.5 m wide at the Philips Lagoon end, increasing to approximately 7.5 m where the main drain enters Washdyke Lagoon. Across the length of the drain, the channel width is generally 6 m.

Anecdotally, local landowners have reported seepage discharges along the beach, presumably originating from Seadown Drain during periods of high flow. It is therefore likely that the recorded water levels and calculated flows for Seadown Drain do not fully represent all groundwater flows that discharge to the drain.

3.5.2 Water Levels and Flow Rates

Water level records have been provided by ECan for several surface flow gauging stations close to Washdyke (Table 1). The levels at each of the gauging stations are referenced to local station datum levels rather than to mean sea level (RL). At the time of modelling, these local datum elevations have not been surveyed with reference to the mean sea level or with reference to each other. Therefore, these water level records have not been used to calculate water elevations and hydraulic gradients in the monitored drains and streams. The summary information presented in Table 1 is provided for completeness of documentation.

Table 1: Surface Water Level Automated Recording Stations

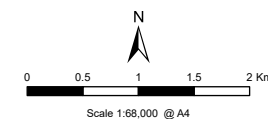
STATION NAME AND ECAN ID	ECAN STATION ID	RECORDING START DATE	RECORDING END DATE	NUMBER OF RECORDS
Washdyke Lagoon	69801	31 May 2012	9 Sept 2025	4,798
Washdyke Creek	1698008	10 June 2017	11 May 2020	1,063
Washdyke Creek	69802	8 June 2017	8 Sept 2025	2,986
No. 1 Drain	1698007	5 Oct 2016	2 July 2018	636
No 1a Drain	1698010	8 June 2017	25 March 2019	656
Upstream Seadown Drain	69804	8 Feb 2025	8 Sept 2025	213
Seadown Drain	69803	8 Aug 2015	8 Sept 2025	3,565
Seadown Main Drain	1698006	10 June 2017	28 July 2019	779

Note: Monitoring stations identified in shaded rows remain active at the time the data was provided by ECan.



LEGEND

- Seadown and Phillips Lagoon Watercourses
- Horseshoe Lagoon Catchment Watercourses
- Opihi Catchment Watercourses



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 4

Seadown Groundwater Investigation

Layout of Existing Drainage System Washdyke to Ōpihi River

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

In order to provide an estimate for surface water levels across the catchment, the New Zealand 1 m DEM Survey dataset sourced from LINZ was interrogated to identify likely water levels in the larger drains. Water elevations estimated from the LIDAR dataset for the ends of drain reaches were then interpolated on a linear basis to provide an indication of the water levels along each drain (Figure 4). At the time the LIDAR survey was flown (based on the Canterbury LiDAR 1m DEM (2010)), South Canterbury was under extremely dry conditions with severe soil moisture deficits¹. On that basis, it is assumed that the interpreted water levels are indicative of low base flow conditions with no surface runoff contributions.

3.5.3 Base Flows

Flow monitoring stations have been installed and monitored on several drains and streams around Washdyke. However, most of the resulting records are short, with monitoring now discontinued. The only flow monitoring site installed on a drain or creek crossing the area of interest with a record covering several years is Station 69803, installed by ECan on the Seadown Main Drain. The flow record for this station covers the period from 8 August 2015 to 8 September 2025, with monitoring ongoing. Due to significant gaps in the early monitoring dataset, the base flow analysis has been undertaken covering the period from 1 May 2017 to 8 September 2025, during which there were only a few inconsequential data gaps that needed to be filled.

A simple base flow analysis has been undertaken using the Broughton (1988) method for daily stream flow partitioning (Appendix B). The analysis indicates that daily base flows averaged across full calendar years during the period from 2018 to 2024 ranged from approximately 10,600 m³/day (123 L/s) to 33,100 m³/day (383 L/s) (Table 2). Over the seven-year period, the average calculated base flow of approximately 19,360 m³/day was substantially greater than the calculated average surface runoff contribution to flows passing the monitoring station of 6,716 m³/day. The base flow index (BFI) derived for the catchment upstream from this gauging station was approximately 0.742.

Table 2: Average Measured Flows in Seadown Main Drain at Gauging Station 69803

PERIOD	AVERAGE BASE FLOW COMPONENT		AVERAGE RUNOFF FLOW COMPONENT	
	(m³/day)	(L/s)	(m³/day)	(L/s)
2018	33,100	383	9,300	108
2019	22,000	255	4,300	50
2020	10,600	123	3,200	37
2021	15,100	175	10,300	119
2022	26,900	311	11,000	127
2023	17,200	199	6,300	72
2024	10,800	124	2,700	30
2018 – 2024	19,360	224	6,716	78

As noted in Section 3.5, it is likely that the recorded flows for Seadown Main Drain may not fully represent all flows that discharge to the drain. Seepage losses from the drain to the ocean may have resulted in an under-reporting of both surface water and groundwater contributions to the tributary drains.

¹ <https://niwa.co.nz/climate-and-weather/monthly/climate-summary-march-2010#:~:text=Very%20dry%20in%20the%20northeast,of%20Gisborne%20and%20Hawke's%20Bay.>

4 GEOLOGICAL SETTING

4.1 Regional Geological Setting

Holocene age braided river channel and floodplain terrace deposits of mixed gravels, sands and silts form the most recent alluvial strata of the coastal Canterbury Plains in the Washdyke to Ōpihi River area (Figure 5). Abandoned river channels with coarser paleochannel deposits are distributed laterally and vertically within and on top of finer floodplain deposits. These Holocene alluvial deposits form the low terraces predominantly associated with current river and stream alignments (Cox & Barrell, 2007; Forsyth, 2001; Zarour et al, 2018).

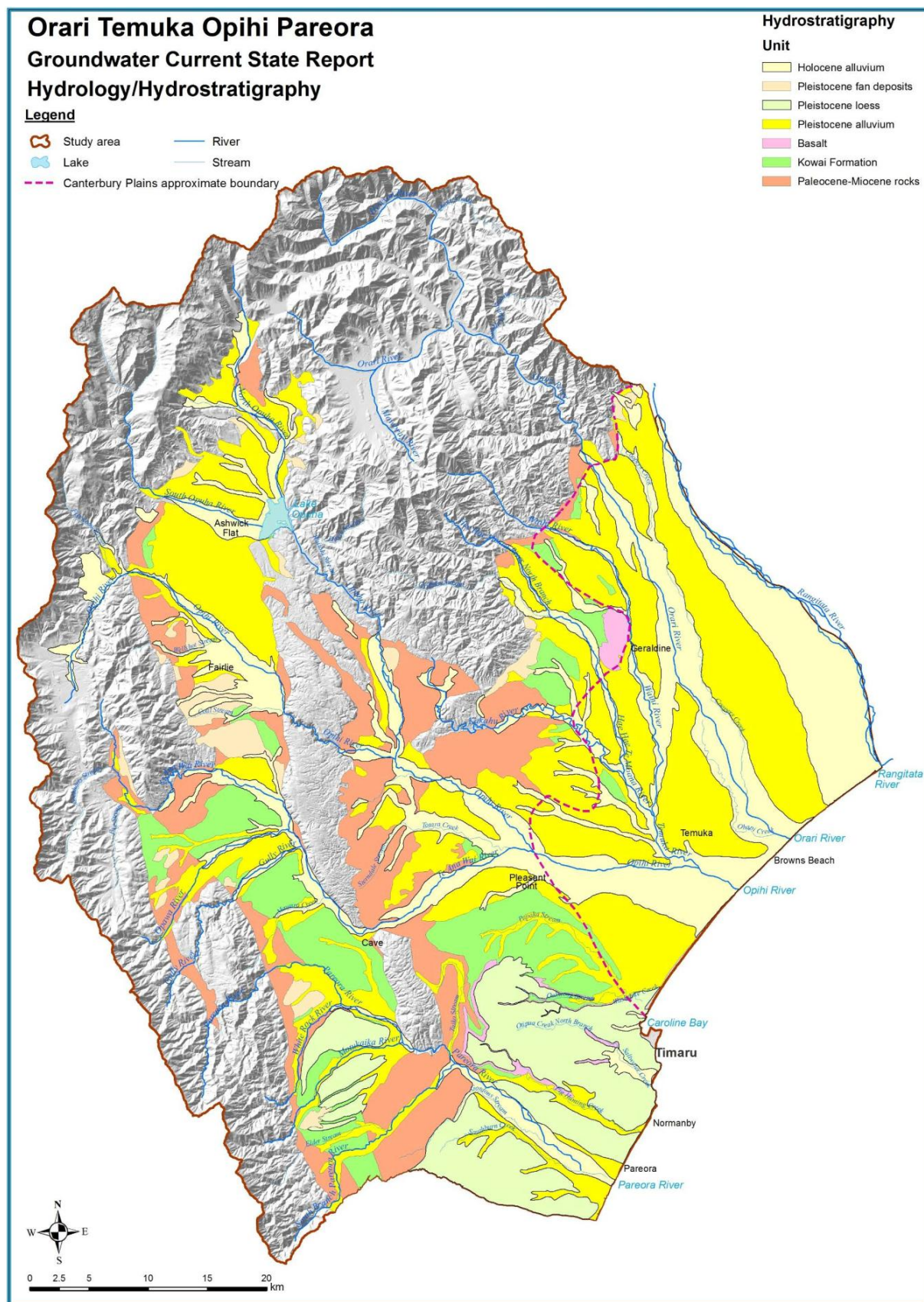
Pleistocene age braided river channel and floodplain terrace deposits of mixed gravels, sands and silts underlie the Holocene alluvial deposits and form higher level terraces across the coastal Canterbury Plains (Table 3). Abandoned river channels with coarser paleochannel deposits are distributed laterally and vertically within and on top of finer floodplain deposits. These alluvial deposits cannot be readily differentiated from Holocene age strata in drillhole samples and geological logs. At the surface, these deposits are principally identified through aerial geomorphological mapping of terraces combined with confirmation through field investigations.

The Pliocene age Kowai Formation consists principally of greywacke-derived gravels with clay, silt and sand beds (Table 3). The Kowhai Formation cannot be readily differentiated from Holocene and Pleistocene age strata in drillhole geological logs. However, the Kowhai Formation is interpreted to unconformably underlie the younger sedimentary deposits across the area of interest and dip toward the east (Flintoff & Weir, 2019). Kowhai Formation deposits are present at surface and define the edge of the Canterbury Plains, a short distance to the southwest of the area of interest (Zarour et al, 2018). However, the Kowhai Formation does not appear at surface within the area of interest.

The combined thickness of Kowai Formation and younger deposits is approximately 175 m near Temuka. The thickness increases to the northeast, reaching approximately 640 m at Ealing, on the north bank of the Rangitata River (Zarour et al, 2018).

Table 3: Late Cenozoic Lithological Stratigraphy of the Study Area

AGE	FORMATION	QMAP IDENTIFIER	DESCRIPTION
Holocene	-	Q1a	River gravels, sands and silts associated with active river channels, floodplains or low-level river terraces.
Pleistocene	-	Q2a – Q8a	River gravels, sands and silts associated with abandoned river channels and higher river terraces.
Pliocene	Kowhai Formation	Pk	Weathered conglomerate with sandstone, mudstone and minor lignite.



4.2 Local Lithological Setting

4.2.1 Topsoils

Humic topsoils and loess-rich silty subsoils dominate the uppermost metre of the subsurface across the study area. The loess soils are generally of low permeability, resulting in gley soil profiles across much of the model domain. A soils map of the area of interest is provided in Appendix C, sourced from the Landcare Research online map facility².

The soils identified by colour in the soils map may be summarised as:

- **Dark Blue:** Shallow to deep, poorly drained, silty gley soils
- **Light Blue:** Shallow to moderately deep, imperfectly to moderately drained, silty pallic soils
- **Dark Brown:** Shallow, silty, moderately well drained, pallic soils
- **Light Brown:** Shallow, silt, well drained, brown soils

Although the drillhole data summarised in the following Sections is not highly descriptive for topsoils across this area, the above soil descriptions appear to be consistent with the available data. Geotechnical investigation data that may provide more detailed descriptions for topsoils within the model domain have not been accessed for the purposes of this groundwater modelling project.

Overall, the coastal soils that would be intersected by the existing and proposed Seadown Main Drain are expected to be predominantly moderately deep to deep gley soils, with low permeability and poor recharge. Inland, the topsoils described by Landcare Research (Appendix C) are more permeable and enable increased recharge to the shallow groundwater system.

4.2.2 Loess

A statistical assessment of the lithological descriptions from drillholes in the area of interest (Table 7) suggests the presence of loess underlying topsoils across much of the model domain. This is consistent with the description of the extent of surficial loess deposits across Canterbury provided by Poulsen (2013), and in the Ōpihi area by Flintoff & Weir (2019).

4.2.3 Quaternary Gravels

A statistical assessment of the grain size descriptives used in the drill hole logs (see Appendix D) has been undertaken to provide guidance on the general nature of the sediments underlying the area of interest. The results presented in Table 4 should be considered taking into account the likely under-reporting of fines in many drillhole logs. It is also important to recognise that the great majority of drillholes are less than 10 m deep, which means the summary information from deeper lithological units should be interpreted with caution.

The uppermost metre of many drillholes is predominantly described in terms of soil, topsoils, loam and similar words, which are collectively presented under the column “other” in Table 4. The described lithologies are predominantly fine grained (silts and clays) to a depth of approximately two metres, which is consistent with the soils described in Section 4.2. Below 20 m BGL, the classifications generally become a mixture of clay and gravels as the major descriptive text.

² <https://smap.landcareresearch.co.nz/maps-and-tools/app>

Table 4: Lithological Variation with Depth

DEPTH (m BGL)	CLAY	GRAVEL	SAND	SILT	OTHER
0 - 2	12%	18%	3%	23%	44%
2 - 4	9%	72%	4%	9%	6%
4 - 6	13%	79%	3%	2%	4%
6 - 8	7%	81%	4%	7%	1%
8 - 10	12%	80%	5%	2%	0%
10 - 15	10%	75%	2%	7%	7%
15 - 20	19%	51%	5%	22%	3%
20 - 100	38%	46%	12%	1%	3%
> 100	42%	31%	27%	0%	0%

Interpretation of the descriptions, combined with a check on the drillhole logs, indicates:

- Gravels are reported from depths of 2 to 5 m in the majority of drillholes. This observation indicates the potential for surface drains to have hydraulic connections to the underlying shallow aquifer.
- 2 – 10 m: Dominated by gravel (70 to 80%) representing the main coarse alluvial aquifer.
- 10 – 20 m: Gravel remains dominant but with increasing silt and clay described as matrix material, suggesting potentially decreasing bulk sediment permeability.
- 20 – 100 m: Coarse deposits still prevalent. Increased frequency of clay and sand.

It is important to note that the number of logged bores intersecting the deeper intervals described above is small. Therefore, this preliminary assessment of grain size distribution within the subsurface does not represent a definitive description of aquifer lithologies underlying the modelled area. The interpretation of aquifer units is addressed in Section 5.

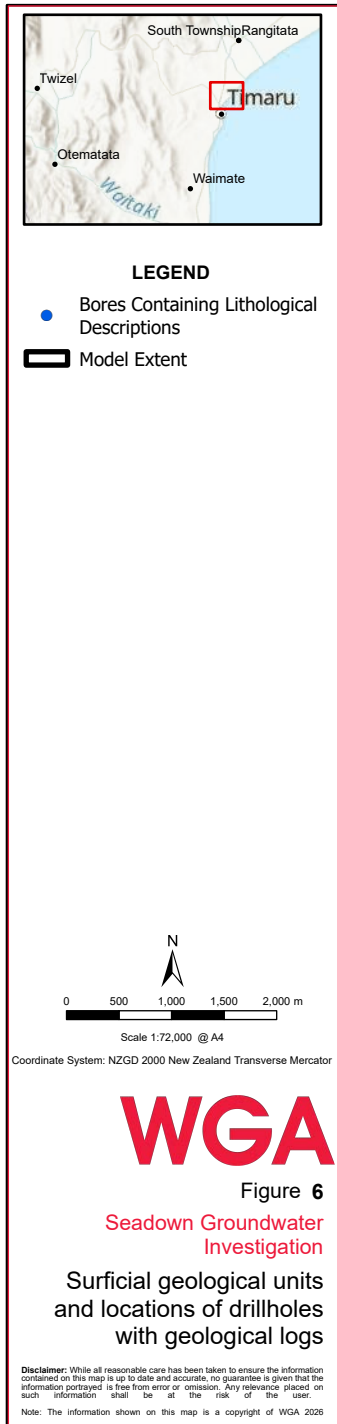
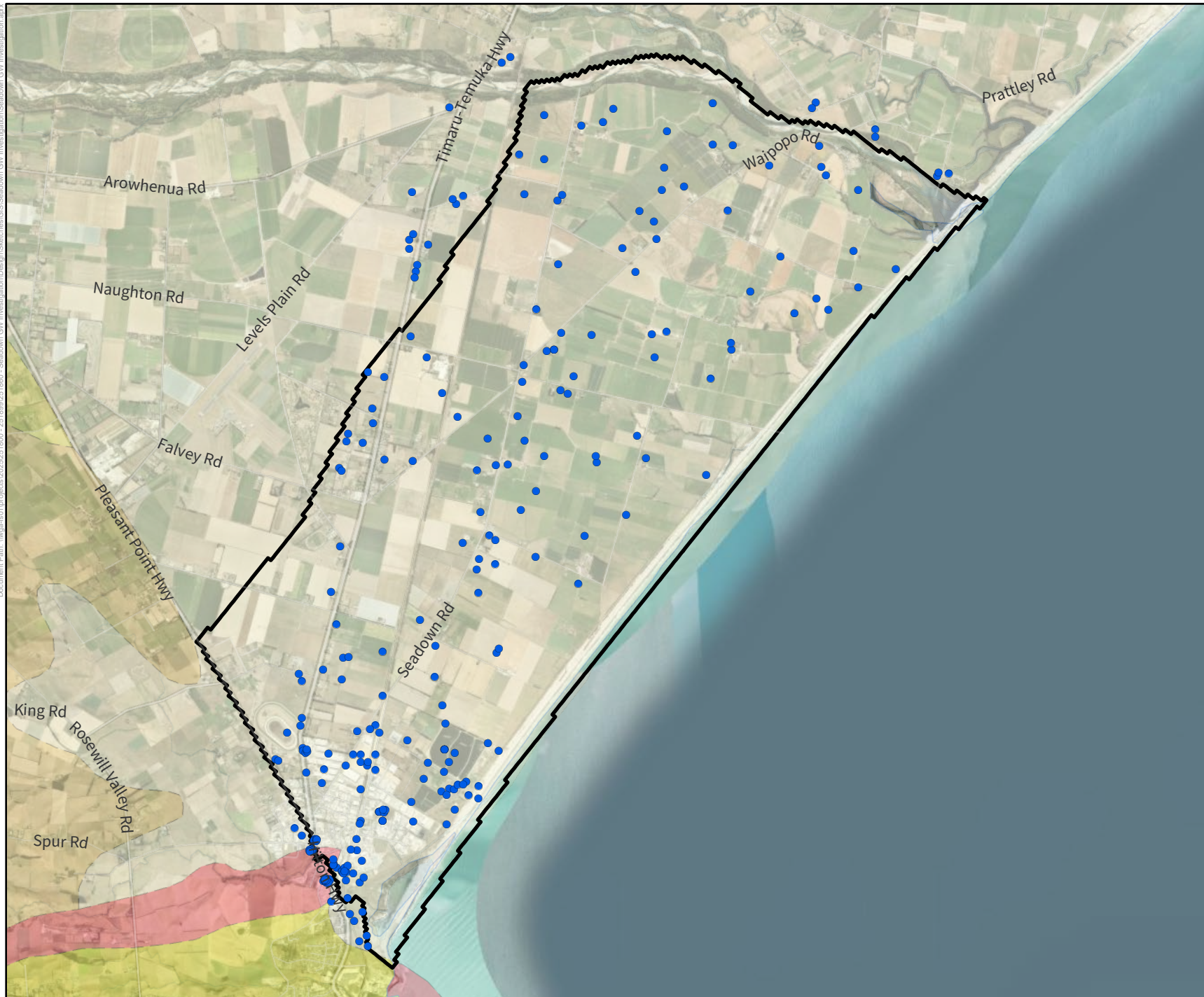
4.3 Leapfrog Geological Model

4.3.1 Geological Model Development

Initial attempts to construct a structural geological model were undertaken in Leapfrog Works™ using the bore log descriptions provided in Appendix D and shown in Figure 6. The geological model was constructed with an upper surface topography corresponding to a one metre LIDAR dataset obtained from LINZ. The base of the model is defined as a smoothed iteration of the topographic surface defined at a consistent depth of approximately 20 m BGL.

This process focused on correlating discrete lithological units (such as gravels, sands, and silts) to define coherent stratigraphic surfaces and volumes across the model domain. The resulting cross sections, provided in Appendix E, demonstrate the complex alluvial architecture of the area. The high degree of vertical and lateral heterogeneity characteristic of these braided river deposits meant that linking lithological descriptions between individual bores was physically inconsistent.

Due to the high degree of uncertainty with lithological geometry, a parameter-based representation of heterogeneity was considered a more appropriate approach for this modelling exercise and was adopted instead of a structural approach. That is, rather than forcing the model to follow predefined and potentially inaccurate geological boundaries, the spatial distribution of hydraulic conductivity (K) was modelled using pilot points, described further in Section 6.



4.4 MODFLOW-USG Conversion

The geological model boundary was converted to a MODFLOW-USG model within Leapfrog Works™ for the purpose of generating a 3D domain on which to base the groundwater flow model. This was achieved using the hydrogeological package within Leapfrog Works™.

Discretisation was performed at a 10 x 10 m horizontal resolution as a single layer. Model files were exported from Leapfrog™ in MODFLOW-Unstructured Grid format and were successfully imported directly into the groundwater modelling package Groundwater Vistas™. Development of the numerical flow model is described in Section 6.

5 HYDROGEOLOGICAL SETTING

5.1 Hydraulic Characteristics of Lithological Units

5.1.1 Soils

As described in Section 4.2, the soil horizons in the area of interest are dominated by loess and loess-rich topsoils. A review of field hydraulic tests undertaken on similar topsoils in the Canterbury region by Poulsen (2013) indicated that the hydraulic conductivity of the loess below the topsoils is in the range of 1×10^{-8} to 1×10^{-9} m/s (Table 5).

Table 5: Indicative Hydraulic Conductivity Ranges for Loess Soils

SOIL HORIZON	HYDRAULIC CONDUCTIVITY (m/s)
A Horizon	1×10^{-5} to 1×10^{-6}
B Horizon	1×10^{-6} to 1×10^{-7}
Loess	1×10^{-8} to 1×10^{-9}

Source: Poulsen (2013).

The topsoils described by Poulsen (2013) are generally of moderate permeability. However, it is not clear that the hydraulic conductivity values for the A and B horizons listed in Table 5 would be representative of the gley soils expected to be intersected by the existing or proposed Seadown Main Drain. Gley soils form where soils have remained saturated over long periods due to a very shallow groundwater table. In general, the gley soils in the modelled area are indicative of the original extent of wetlands, most of which have been drained to enable farming operations. Additionally, gley topsoils are susceptible to pugging as a result of stock movement and vehicle traffic. For the purposes of this assessment, it is considered unlikely that the gley soils present within the modelled area are more permeable than the loess from which they are partially derived.

The expected low permeability of the gley soils is likely to translate to low distributed rainfall recharge to the underlying groundwater system across areas where these soils are present. This expected low recharge is reflected in the groundwater model conceptualisation presented in Section 5.7. The soils on the plains to the west of the modelled area are more permeable brown soils that are likely to contribute more to distributed groundwater recharge.

5.1.2 Aquifers

A total of 81 groundwater wells listed in the ECan database as being within the area of interest have associated aquifer hydrogeological characteristics (Refer to Appendix F). Of these, most (50) are taking water from aquifers at depths of less than 10 m (Table F1). The remainder of the wells within the area of interest are screened at depths distributed from 10 m to 250 m.

The frequency exceedance curve for hydraulic conductivity values for the uppermost 10 m BGL (Figure 7) indicates 80 % of the results for the shallow aquifer fall within the range of approximately 150 m/day and 1,700 m/day: a little more than one order of magnitude range. This range is consistent with hydraulic conductivity values expected for sandy gravels (Freeze & Cherry, 1979). Values higher than this range are likely to be more representative of clean gravel channel deposits (Dann et al, 2008).

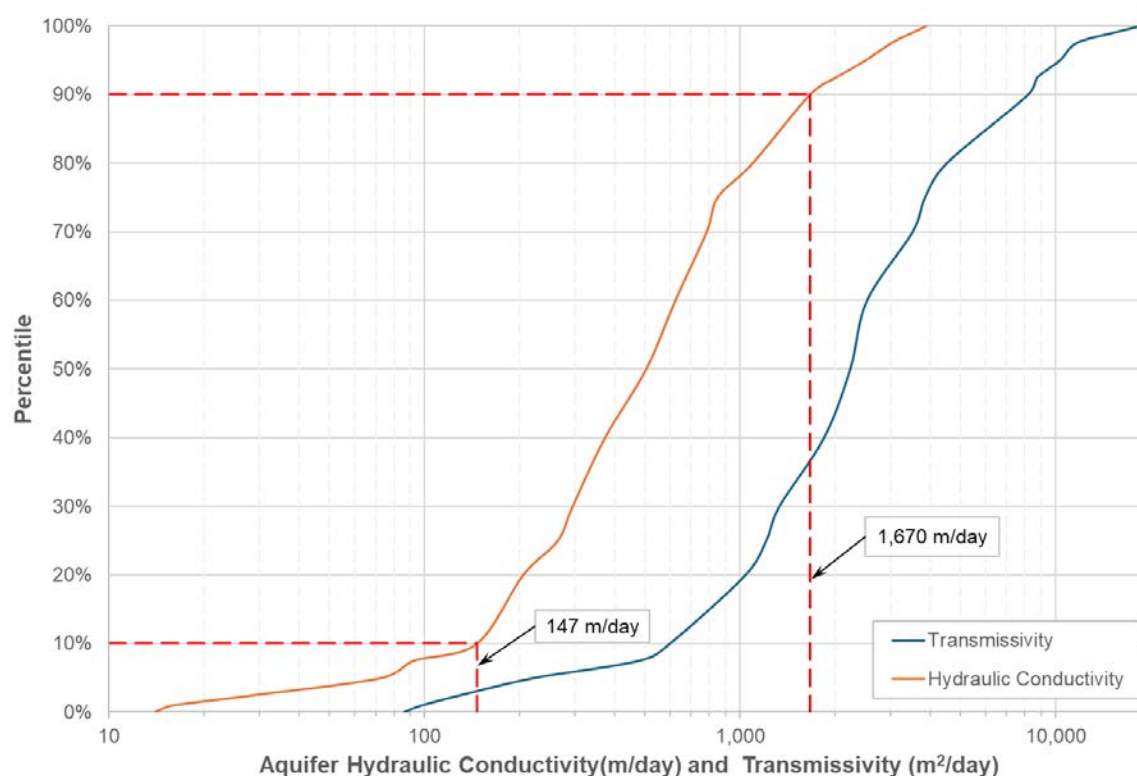


Figure 7: Shallow Aquifer (<10 m BGL) Transmissivity and Hydraulic Conductivity Distribution

The hydraulic conductivity and transmissivity exceedance curves presented in Figure 7 include the results from all groundwater wells in the area of interest, irrespective of whether a lithological log is available for the well or not. A check was made on whether the results from wells with logs are different from those without logs. The results (Table 6) indicate the wells without logs provide significantly higher mean and median results for both hydraulic conductivity and transmissivity. The reason for the difference is unclear, as it does not appear to be related to uncertainty regarding well screen lengths.

For modelling purposes, the median value for hydraulic conductivity (532 m/day) has been accepted as a starting indicator of aquifer permeability for the shallowest aquifer within the area of interest. The indicative range of shallow aquifer hydraulic conductivity is from 150 m/day to 1,700 m/day. These values appear consistent with pumping tests review of the Rangitata-Ōpihi Plains from Aitchison-Earl (1999).

Table 6: Aquifer Hydraulic Properties for Wells with and without Lithological Logs

WELL LOGS?	COUNT	TRANSMISSIVITY (m ² /day)		HYDRAULIC CONDUCTIVITY (m/day)	
		Average	Median	Average	Median
Y	13	2,016	1,875	414	395
N	37	3,734	2,500	885	556
Total	50	3,287	2,235	762	532

An initial assessment of aquifer permeability changes with depth has been summarised in Table 7. There are relatively few wells screened at any 10 m depth interval below the first 10 m. However, the overall distribution of results clearly suggests aquifer permeabilities decline significantly with increasing depth, below the uppermost 20 m in the alluvial sequence.

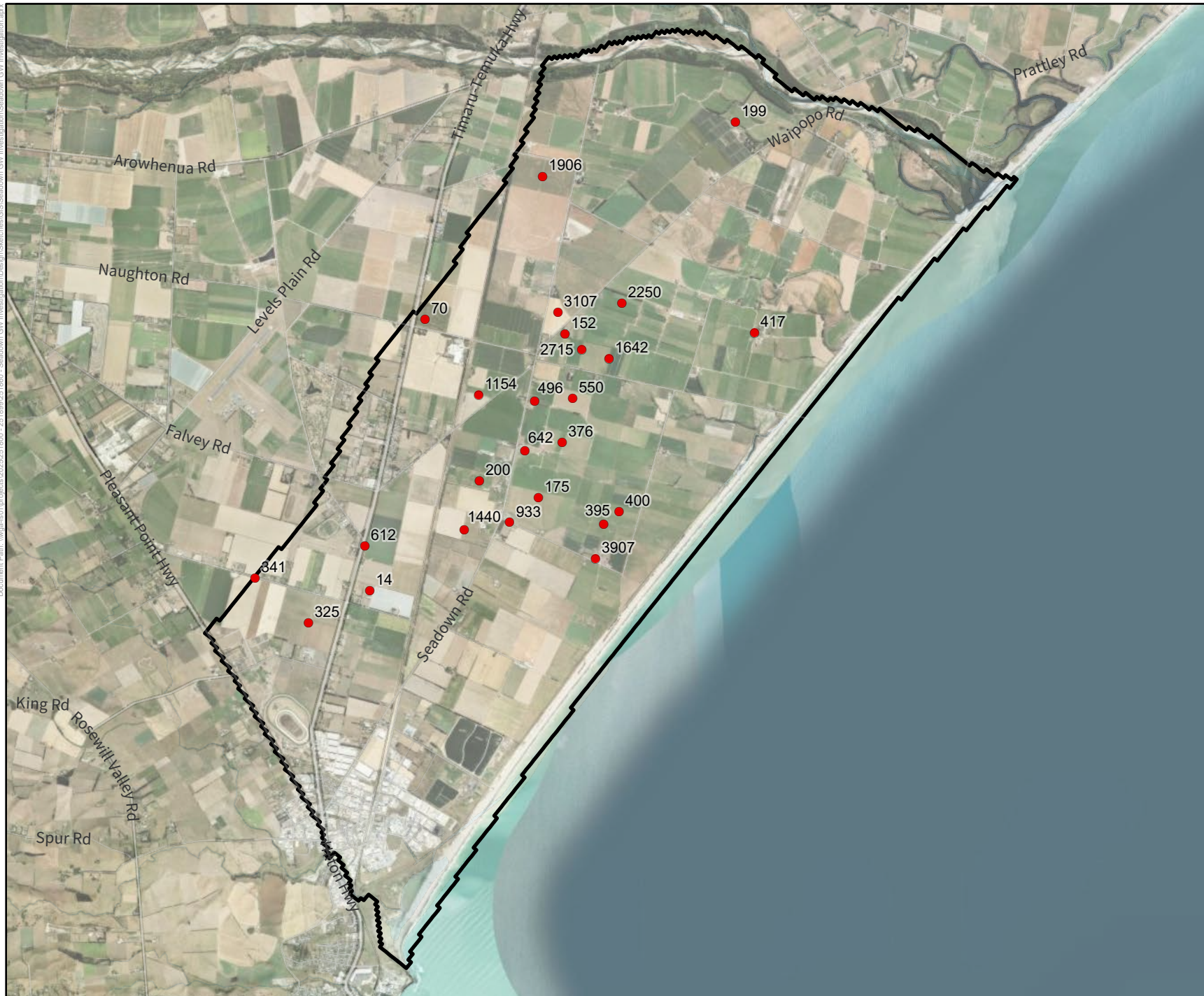
Table 7: Aquifer Hydraulic Conductivity Variation with Depth

WELL DEPTH (m)	NUMBER OF WELLS	HYDRAULIC CONDUCTIVITY ⁽¹⁾ (m/day)		
		Average	Median	Interpreted Range
<10	50	762	532	150 – 1,700
10 – 20	6	243	213	130 – 300
20 – 40	2	9	3	1 – 25
40 – 50	3	14	8	5 – 25
50 – 60	4	32	15	1 – 100
60 – 100	4	41	20	1 – 50
100 – 150	4	11	4	1 – 10
150 – 200	5	29	6	1 – 10
>200	3	47	44	15 – 80

Note: 1) The hydraulic conductivity values and ranges presented do not include the behaviour of aquitard layers, as it is assumed that the water wells are screened to target the most productive layers in the stratigraphic sequence.

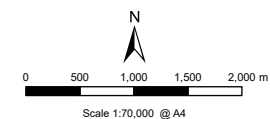
Only six bores with screens at depths of between 10 m and 20 m BGL have associated hydraulic parameters (Table 7). Five of these six bores are bunched in a small area along the Timaru Temuka Highway within 600 m of each other. These five bores were drilled at approximately the same time by the same owner (Table E2). Consequently, the results from these tests and the indicative range presented in Table 7 cannot be taken as indicative of the hydraulic behaviour of sediments within the depth range from 10 m and 20 m BGL across the full area of interest.

An interpretation of the spatial distribution of aquifer hydraulic conductivity for lithologies within the uppermost 10 m is presented in Figure 8. The interpreted distribution has been done using a kriging algorithm that does not take into account the depositional environment at the time these sediments were emplaced. A conceptual interpretation of the hydraulic conductivity distribution is provided in Section 5.7 later in this report.



LEGEND

- Hydraulic Conductivity
Derived from Pumping Tests
(m/day)
- Model Extent



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 8

Seadown Groundwater
Investigation

Shallow Aquifer (<10 m bgl)
Hydraulic Conductivity
Spatial Distributions

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

5.1.3 Aquitards

Vertical seepage flows through aquitard materials have a significant effect on groundwater management across the Canterbury Plains. However, as far as WGA is aware, no pumping tests undertaken within the area of interest have returned aquitard conductance (K'/B') or leakance (L) factors.

A review of aquitard conductance and leakance for the Canterbury region (Lough and Williams, 2009) produced a chart indicating a trend of decreasing conductance with increasing screen depth below the phreatic groundwater surface (Figure 9). The shallowest results, below a saturated aquifer thickness of 15 m, are unlikely to be of relevance to the current modelling as no surficial aquitard has been identified in the area of interest. The results for wells screened at greater depths may be usefully compared to the hydraulic test results summarised in Table 7.

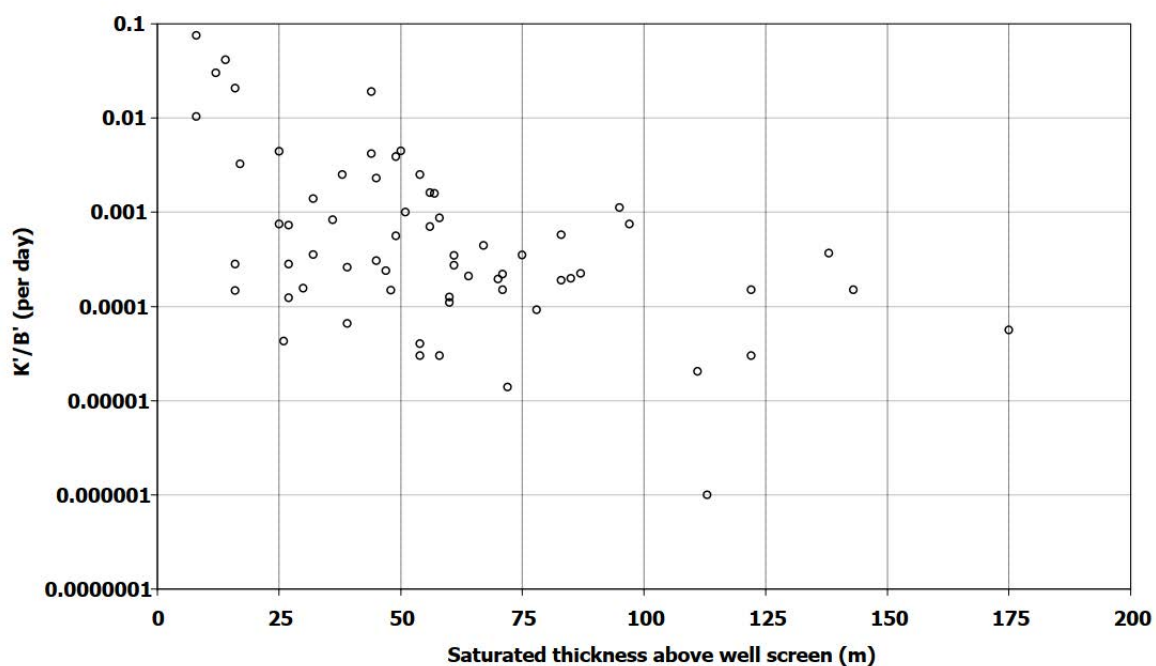


Figure 9: Reliable Reported Aquitard Conductances Against Depth (Lough & Williams 2009)

5.2 Groundwater Recharge

The loess deposits blanketing much of the model domain (Section 4.2.2) are considered to be of low permeability (Section 5.1.1) and are expected to limit potential stormwater infiltration rates. Rainfall infiltration applied to past modelling of the groundwater system for the Ōpihi and Pareora area (Flintoff & Weir, 2019) was capped at 3 mm/day, above which any excess was assumed to run off to the nearest surface waterway.

It is uncertain whether the above limitation is appropriate for the gley soils covering much of the model domain for this report. The gley soils are of lower permeability than the brown soils that are developed on loess sediments, draping Quaternary terrace areas that are not subject to continuous waterlogging. Gley soils cover most of the groundwater model domain and, for the purposes of this assessment, are assumed to effectively prevent the infiltration of incipient rainwater to the underlying groundwater system. This assumption is not critical to the performance of the groundwater model, as the application of lateral hydraulic boundaries will control the hydraulic gradient across the model domain.

5.3 Groundwater Level Monitoring

Groundwater level information was compiled from a total of 43 observation bores, drilled to depths less than 20 m below ground level, in locations across the model area, extending from the coastal margin inland across the lower coastal plain. The dataset includes groundwater level records from both long-standing monitoring bores and more recently installed bores. A list of the bores is provided in Appendix A1, and the locations of these bores are presented in Figure 10. This list of bores excludes those with only a single observation.

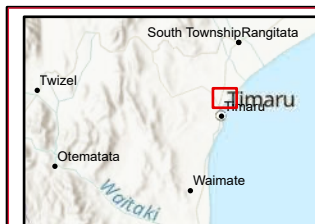
The compilation includes a small number of paired bore records that share identical coordinates. These paired records are interpreted to represent replacement bores installed at the same locations, rather than separate monitoring points. For the purposes of describing groundwater conditions, these paired records are therefore considered to represent the same hydrogeological locations.

Median observed groundwater levels range from approximately 1.8 m RL in the vicinity of the coast to around 13.0 m RL at the inland boundary. This inland-to-coastal pattern reflects the regional topographic setting and the overall hydraulic gradient toward the coastline and associated drainage features.

Temporal variability in observed groundwater levels varies across the area, although it is generally low with fluctuations of up to approximately 1 m.

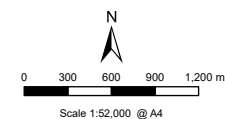
Three piezometers (BZ19_0513, BZ19_0514, and BZ19_0515), installed in the Washdyke area, provide a continuous dataset and were reviewed as part of this project. However, water levels were captured from June to November 2025, equating to five months of data. As such, the data from these piezometers were not adopted for the purpose of steady-state modelling.

Overall, the groundwater level dataset provides a clear and coherent picture of shallow groundwater conditions within the Seadown area. The observed groundwater levels define a consistent regional gradient and delineate the shallow freshwater system that interacts with the drainage network and coastal environments. The spatial and temporal characteristics of the observed groundwater levels provide an appropriate basis for assessing groundwater behaviour at the scale relevant to the Seadown coastal setting and associated management decisions.



LEGEND

- Medium Groundwater Level (m RL)



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 10
Seadown Groundwater Investigation
Groundwater Levels Points

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

5.4 Piezometric Surface

Figure 11 illustrates the interpreted groundwater table, showing that the groundwater system is strongly influenced by the Ōpihi River to the north and the drainage network throughout the Seadown area. The regional groundwater flow is oriented toward the southeast with an average topographic gradient of approximately 0.004 m/m. The piezometric surface indicates a direct hydraulic connection between the shallow aquifer and the ocean at the coast, where groundwater levels approach mean sea level (0 m RL).

5.5 Groundwater Takes

There are 364 bores designated as 'Active (exist, present)' within the model domain, based on the ECan bores database³. Of those bores, 291 are documented as water supply bores. Of those, 197 bores are drilled less than 20 m below ground level, and 75 have an unknown depth. A full list of bores is provided in Appendix H and their locations are presented in Figure 12.

A full list of resource consents to take groundwater within the model domain is provided in Appendix H. For the purpose of this assessment, bore interference effects associated with a proposed drain realignment and stopbank retreat were assessed against all permitted and consented takes.

5.6 Groundwater Salinity

ECan has a database of groundwater quality measurements including salinity. The groundwater salinity data for the area between the Okari River and Washdyke has been reviewed to aid in the interpretation of groundwater flow patterns across this area. The bores considered in this review have been limited to those that:

1. Are screened at depths less than 20 m; and
2. Have at least 10 salinity measurements covering a period of several years

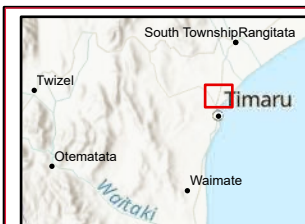
The intent of this review was not to provide a detailed assessment of groundwater quality and trends but rather to determine if a high-level review of the dataset could inform an understanding of how the groundwater system is functioning.

The review outcomes indicate there is a pattern of increasing groundwater salinity close to the coast (Figure 13). This trend may be a result of saline water intrusion to the shallow aquifer, either natural or through pumping induced intrusion. However, the detection of slightly increased salinity close to the shore may also result from onshore winds depositing salty ocean spray onto the coastal areas.

Groundwater hydraulic gradients indicate the northern half of the model area is receiving recharge from the Ōpihi River. This observation is consistent with the low chloride concentrations detected in bores located close to the river reach, where groundwater recharge is interpreted to occur (Figure 13).

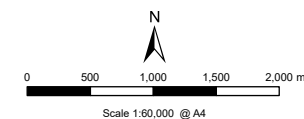
The colours shown within the oval identifiers for each bore in Figure 13 indicate trends from older water (left end of oval) to younger water (right end of oval). In general, most monitored bores do not show trends of increasing or decreasing chloride concentrations. Although a few isolated bores show an indication of increasing concentrations, it was not clear why these trends have been occurring.

³ <https://opendata.canterburymaps.govt.nz/datasets/ecan::wells-and-bores-all-1/about>



LEGEND

- Groundwater Contours (mRL)

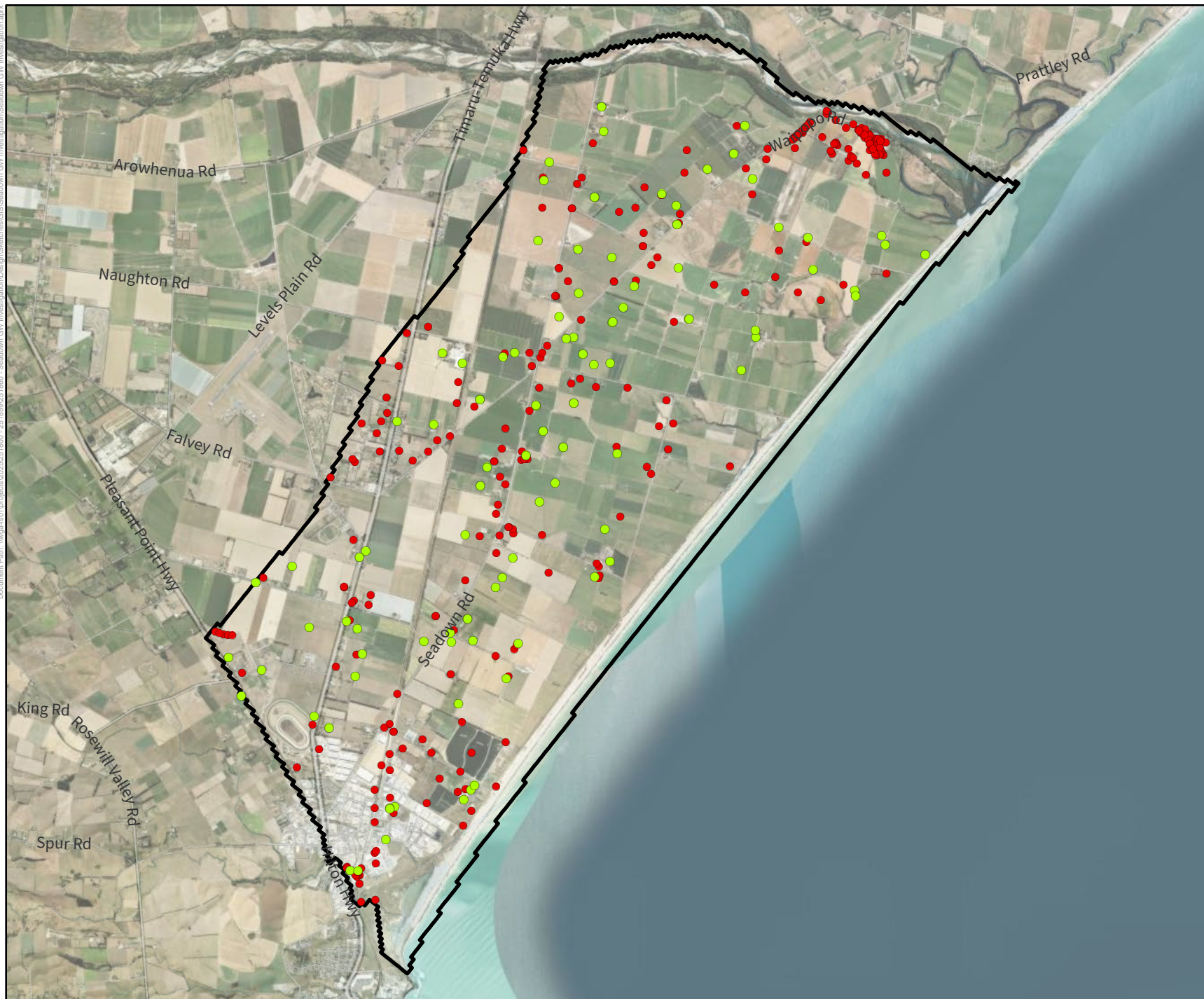


Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

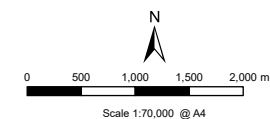
Figure 11
Seadown Groundwater Investigation
Groundwater Contours

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026



LEGEND

- Active Bores
- Consented Groundwater Takes
- ▭ Model Extent



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

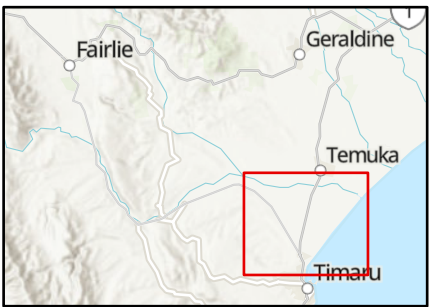
WGA

Figure 12

Seadown Groundwater Investigation

Nearby Bores and
Consented Groundwater
Takes Within Model Domain

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026



LEGEND

○ Bores

○ Noteworthy Trends

<10 mg/L CL

10 - 25 mg/L CL

25 - 50 mg/L CL

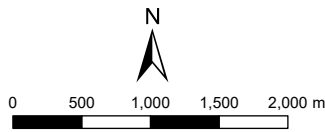
50 - 100 mg/L CL

> 100 mg/L CL

--- Interpreted Paleo Channels

➡ FlowArrows

■ River



Scale 1:55,000 @ A3

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 13

Seadown Groundwater
Investigation

Groundwater Salinity

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2025

5.7 Conceptual Groundwater Model

The conceptual groundwater model for the Seadown area integrates the stratigraphic, hydraulic, and hydrological data described in previous sections to provide a simplified representation of the physical system. The model focuses on the interaction between the shallow Quaternary gravels, the existing drainage network, and the coastal boundary. Given the on-going requirements of coastal adaptation planning, the model has been designed to simulate density dependent flow and potential saline intrusion for future use.

5.7.1 Conceptual Model Layout

The model domain encompasses the area between the Ōpihi River in the north and the Waitarakao Lagoon in the south. Vertically, the conceptual model is defined as a 20 m thick sequence, representing the most active portion of the shallow unconfined to semi-confined aquifer system. This thickness captures the primary drainage-connected gravels (upper 10 m) and the transitional, higher-fines gravels (10 to 20 m) that provide the base of the modelled system. The ground surface is defined by the 2010 LIDAR survey, with the model base set at a constant 20 m below this surface or at a fixed elevation of -20 m RL, depending on the final numerical discretisation.

5.7.2 Geological Units

The model represents the Holocene (Q1a) and Pleistocene (Q2a to Q8a) alluvial deposits as a single, vertically integrated but horizontally heterogeneous hydrostratigraphic unit:

- **Upper 0 to 10 m:** Characterised by high-permeability, clast-supported gravels associated with active and abandoned braided river channels. This zone has the highest degree of hydraulic connection to the Seadown Main Drain and tributary laterals.
- **Lower 10 to 20 m:** Comprises similar alluvial gravels but with an increasing proportion of silt and clay matrix material. While still part of the productive aquifer system, the bulk permeability is expected to be lower than the uppermost 10 m.

5.7.3 Aquifer and Aquitard Characteristics

To represent the lateral heterogeneity of the Canterbury Plains aquifers, the model adopts a pilot point approach for hydraulic conductivity parameterisation. This method allows for a continuous, spatially varying field that reflects the complex depositional environment of the Ōpihi River fan. A median starting value of 500 m/day is used for the shallowest deposits, with the final distribution determined through automated calibration to reflect suspected paleochannels.

No surficial aquitard has been defined to represent the loess deposits and gley soil.

5.7.4 Boundary Conditions

The conceptual model boundary conditions are tied to the regional hydrology and physical geography of the Seadown area:

- The Ōpihi River forms the northern boundary as a head-dependent river condition, assuming an unrestricted hydraulic connection with the shallow gravels.
- To the east, the Pacific Ocean is represented as a general head boundary at 0 m RL, incorporating a density-dependent component of 1,025 to simulate the freshwater-seawater interface.
- The southern model limits are defined by the Waitarakao Lagoon and Washdyke Stream.

The western (up-gradient) boundary to the model is defined as a General Head Boundary (GHB) to account for regional groundwater throughflow from the upper plains. This was set at an initial elevation of 15 m RL in the model, based on the groundwater contours from de Joux (1987) shown in Figure 11. Because the study area is a subset of a much larger hydrological system, simulating the entire catchment was neither practical nor necessary for the scope of the coastal adaptation assessment. By using the GHB approach, the model can account for lateral inflows consistent with the observed hydraulic gradient without requiring a simulation of the entire catchment.

Internal drainage features, including the Seadown Main Drain, are simulated as head-dependent sinks where discharge is governed by the relationship between groundwater head and drain bed elevation. These drainage boundary conditions cannot provide recharge to the modelled groundwater system.

5.7.5 Groundwater Throughflows

Conceptual estimates for groundwater throughflows have been calculated for the 20 m thick model domain using the hydraulic gradients and conductivities identified across the catchment. These flows represent an indication of the total volume of water moving through the shallow groundwater system toward the coast and the coastal drainage network.

The total groundwater throughflow for the upper 20 m of the modelled area is estimated at approximately 289,944 m³/day (Table 8). Most of this flow is interpreted to discharge offshore, while approximately 19,360 (250 L/s) is captured as baseflow within the Seadown Drain system (Section 3.5.3).

Table 8: Conceptual Estimate for Model Area Groundwater Throughflows

PARAMETER	UNITS	SEADOWN DRAIN TO PHILLIPS LAGOON			PHILLIPS LAGOON TO HORSESHOE LAGOON		HORSESHOE LAGOON TO ŌPIHI RIVER	TOTAL
Cross Section Component		1	2	3	4	5	6	
Section Length	m	2,800	1,000	2,200	800	1,200	2,200	
Section Thickness	m	10	10	10	10	10	10	
Depth to Groundwater	m	1	1	1	1	1	1	
Hydraulic Conductivity	m/day	300	3900	400	2300	400	300	
Hydraulic Gradient	m/m	0.0042	0.0042	0.0042	0.0031	0.0031	0.0023	
Passing Flow Per Section	m ³ /day	31,500	146,250	33,000	51,750	13,500	13,944	
	L/s	365	1,693	382	599	156	161	
Totals	m³/day			210,750		65,250	13,944	289,944
	L/s			2,439		755	161	3,356
Drain baseflow^(1,2)	m³/day			19,360		-	-	19,360
	L/s			250		-	-	250
Offshore discharge⁽³⁾	m³/day			189,300		65,250	13,944	268,494
	L/s			2,189		755	161	3,106

Note: 1) Baseflow values from Seadown Drain baseflow assessment (Section 3.5.3)

2) Discharges to drains other than those passing the Seadown Drain gauging station 69803 are excluded from this conceptual estimate

3) Calculated as total flows less drain baseflows

6 NUMERICAL GROUNDWATER MODEL

6.1 Introduction

This section details the development of the 3D numerical groundwater model used to simulate the Seadown hydrogeological system. The model was constructed to support the consenting process for the realignment of the Seadown Main Drain and to provide a tool for evaluating coastal adaptation strategies. It integrates local lithological data, LIDAR-derived topography, and historical flow records to create a representative simulation of the interaction between the shallow aquifer and the drainage network

6.2 Software

Groundwater Vistas (GV) is an industry standard software package for 3D groundwater flow and contaminant transport modelling, calibration and optimisation. This package utilises a suite of MODFLOW software codes for various purposes. GV Version 9.08 Build 1 Premium was used for the construction of this numerical model.

The groundwater flow code MODFLOW-USG, developed by the US Geological Survey, enables modelling of groundwater flow in layered three-dimensional systems using structured or unstructured grids. This is the base code used for groundwater flow simulation in this project.

The numerical packages available in GV and used to simulate the groundwater flow processes in this model include:

- Basic (BAS)
- Output Control (OC)
- Layer Property Flow (LPF)
- Solver (PCG2)
- Discretisation (DIS)
- River (RIV)
- Drain (DRN)
- Grid Specification File (GSF)
- Block-Centred Transport (BCT)
- Density Drive Flow (DDF)

The PCG2 solver is used as the mathematical solver in this model. The solver parameter settings applied for this modelling process are summarised in Table A1.

Table A1: Solver Parameters

PARAMETER	VALUE
Max outer iterations	100
Max inner iterations	25
Head change criterion	0.001
Residual criterion for convergence	1
Relaxation parameter	1
Matrix preconditioning method	Cholesky
Maximum bound of Eigenvalue	Equal to 2

6.3 Model Discretisation

A numerical groundwater model provides an approximation of a complex natural system. Finite difference numerical modelling codes such as MODFLOW require spatial discretisation both horizontally and vertically. Discretisation is achieved by specifying an orthogonal set of rows and columns to form a grid (mesh).

The groundwater model constructed for this project consists of 1-layer model. The model top is based on the LIDAR datasets. The base of the model is set at -20 m below topography.

The MODFLOW model domain is rectangular, extending 13.8 km by 6.8 km. The model consists of 1,379 rows and 680 columns (10 m x 10 m cell size). The total model cell count is 937,720, of which 557,691 are active. The grid is oriented with a -38.6 rotation from NZMG North, to align with the flow of groundwater.

6.4 Boundary Conditions

The numerical model incorporates three primary boundary condition packages to represent the regional hydrology and the specific coastal features of the Seadown area. These boundary conditions are illustrated in Figure 14

General Head Boundary (GHB)

The GHB package was utilised to simulate regional groundwater throughflow, the coastal interface, and the Washdyke Lagoon.

- **Inland Boundary:** The western upgradient boundary was set at 15 m RL, consistent with the regional groundwater contours identified by de Joux (1987). This allows for the simulation of flux into the model domain from the upper Canterbury Plains.
- **Coastal Boundary:** A constant head of 0 m RL was applied along the eastern margin to represent the mean sea level interface.
- **Washdyke Lagoon:** The lagoon was assigned a head value of 0.6 m RL, matching the stage at the confluence of the Seadown Main Drain and the lagoon system.

River Package (RIV)

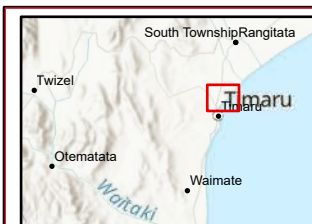
The Ōpihi River was simulated using the RIV package. The spatial extent of the river cells was delineated using high-resolution satellite imagery to capture the main river stem. River stage values were derived from the 2010 LIDAR dataset, ensuring the hydraulic gradient between the river and the shallow aquifer reflects the local topography.

Drain Package (DRN)

The DRN package represents the extensive coastal waterway network, which was subdivided into four distinct hydrological catchments. These catchments were defined using catchment delineation (see Figure 4), and defined into four subcatchments:

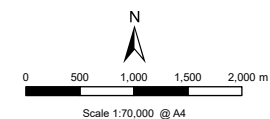
1. **Washdyke Stream**
2. **Seadown Main Drain (including all laterals)**
3. **Horseshoe Lagoon**
4. **Waterways discharging to the Ōpihi River**

For each drain cell, the conductance was based on the length of the waterway centreline intersecting the cell. This setup allows the model to calculate groundwater discharge (baseflow) as a function of the elevation difference between the water table and the drain bed.



LEGEND

- Drain Cells
- General Head Boundary Cells
- River Cells



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 14

Seadown Groundwater Investigation

Groundwater Numerical Model and Boundary Conditions

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

6.5 Calibration Process

Calibration of groundwater models, or more specifically, inverse modelling, is a process whereby a range of model parameters are adjusted to produce a match between simulated and observed data. The process begins with the initial estimate of parameters (such as hydraulic conductivity and boundary conditions). The parameters subject to calibration are principally hydraulic conductivity and boundary condition conductance.

For the purposes of this modelling project, the calibration of the steady state model using a deterministic approach is considered acceptable when:

1. The calculated groundwater heads are in 'reasonable' agreement with observed heads.
2. The modelled groundwater discharge flux to the Seadown Main Drain is in 'reasonable' agreement with calculated base flows (Section 3.5.3). A secondary flux check was compared between the modelled offshore discharge and that estimated in Table 8.

6.5.1 Calibration Data Weighting

A statistical weighting scheme was applied to all 43 calibration targets. Weights were derived using the inverse of the standard deviation for each observation site. This approach meant that bores with high temporal stability (low variance) have a greater influence on the model. The weighting is shown in Appendix A1.

The calibration utilised inverse standard deviation weighting for the 19,360 m³/day flux target to provide statistical consistency within the objective function. That is, the flux residual is reduced to a value that is comparable with head residuals measured in metres. This method prevents the large numerical magnitude of the volumetric flux from dominating the parameter estimation process.

6.5.2 Pilot Point Targets

Horizontal hydraulic conductivity within the model was parameterised using a pilot point approach to reflect the highly heterogeneous nature of the coastal gravel aquifer and to make effective use of available field data. Pilot points were primarily based on hydraulic conductivity values derived from pumping test data from the upper 20 m of aquifer material.

At locations where pumping test data were available, pilot point target hydraulic conductivity values were assigned directly from the interpreted pumping test results (see locations in Figure 17 and values in Appendix K). Vertical hydraulic conductivity was assumed as a factor of 10 less than the horizontal value. To allow reasonable adjustment during calibration while maintaining physical plausibility, upper and lower bounds were applied to each pilot point. These bounds were set at a factor of three above and below the target hydraulic conductivity value, to allow for uncertainty associated with pumping test interpretation in highly permeable, heterogeneous gravel aquifers.

In areas where no pumping test data exists, additional "fill" pilot points were introduced to provide spatial continuity and prevent unrealistic extrapolation between data-constrained areas. The hydraulic conductivity range for these fill pilot points was defined using the 5th and 95th percentiles of hydraulic conductivity values reported for the wider Seadown and coastal plain area (Figure 7). This approach ensured that interpolated hydraulic conductivity values remained consistent with the broader body of measured data, while allowing sufficient flexibility to represent local variability in aquifer properties.

The combined use of pumping-test-based and fill pilot points enabled the model to honour known hydraulic conductivity values where data were available, while smoothly interpolating between them in poorly constrained areas. This parameterisation approach provides a defensible balance between data-driven realism and numerical stability and is well suited to modelling groundwater flow in braided-river gravel systems where aquifer properties vary at scales finer than can be explicitly represented in the numerical grid.

6.5.3 Parameter Estimation Settings

The steady-state numerical model was calibrated using a combination of manual adjustments and automated parameter estimation (PEST). The objective was to achieve a robust match between simulated and observed groundwater levels (heads) and surface water baseflows (fluxes) within the Seadown area.

The key parameters subject to calibration, along with their adopted bounds and optimised values, are summarised in Table 9. Drain stage elevation was not subject to calibration as these values were assumed fixed, being adopted from LIDAR data. This parameter was explored within the sensitivity analysis.

Table 9: Model Boundary Parameters Subject to Calibration and Adopted Values

PARAMETER TYPE	PARAMETER	UNIT	LOWER LIMIT	UPPER LIMIT	OPTIMISED VALUE
Hydraulic Conductivity	Drain Boundary Conductivity	m/day	0.01	86.4	1.6
Conductance	Inland Boundary Conductance	m ² /day	1,400	16,700	12,500
Conductance	Coastal Boundary Conductance	m ² /day	1,400	16,700	1,470
Conductance	River Boundary Conductance	m ² /day	1,400	16,700	1,630
Head	Inland Boundary Head	mRL	13	17	13.9

Note: 1) Value represents the average hydraulic conductivity calculated model wide from pilot point calibration. The spatial variation is described in Figure 17.

6.6 Calibration Results

6.6.1 Calibration Statistics

The quantitative performance of the model was assessed using standard residual statistics across 43 observation points. These statistics, summarised in Table 10, indicate a high degree of correlation between the modelled and measured data. The Absolute Residual Mean of 0.34 m and a Residual Standard Deviation of 0.44 m are well within acceptable limits for a regional steady-state simulation in this hydrogeological setting.

The Scaled RMS Error of 3.95% falls below the generally accepted 5% threshold for calibration agreement (Barnett et al., 2012). This indicates that the model effectively captures the regional hydraulic gradient toward the coast. The Scaled Residual Mean of 0.14% indicates that there is no significant systematic bias (over-prediction or under-prediction) in the model results.

6.6.2 Head Targets

The relationship between modelled and observed heads is visually represented in Figure 15. The scatter plot demonstrates that the majority of the data points cluster closely along the 1:1 line of parity ($R^2 = 97.8$). This alignment indicates that the pilot point distribution reasonably replicates the water table slope across the model domain, from the higher elevations near State Highway 1 to the coastal margin.

The piezometric contours generated from the calibrated groundwater model (Figure 16) differ in detail but not overall trends from the piezometric contours presented in Figure 11. However, the groundwater level measurements used as model calibration targets also differ from those used to produce the piezometric surface represented in Figure 11 (de Joux, 1987). Therefore, the differences between the two maps are not considered significant.

Table 10: Optimised Model Calibration Statistics

STATISTICS	VALUES
Residual Mean (m)	0.02
Absolute Residual Mean (m)	0.34
Residual Std. Deviation (m)	0.44
Sum of Squares	8.42
RMS Error (m)	0.44
Min. Residual (m)	-1.07
Max. Residual (m)	1.14
Number of Observations (#)	43
Range in Observations (m)	11.2
Scaled Residual Std. Deviation (%)	3.95%
Scaled Absolute Residual Mean (%)	3.03%
Scaled RMS Error (%)	3.95%
Scaled Residual Mean (%)	0.14%

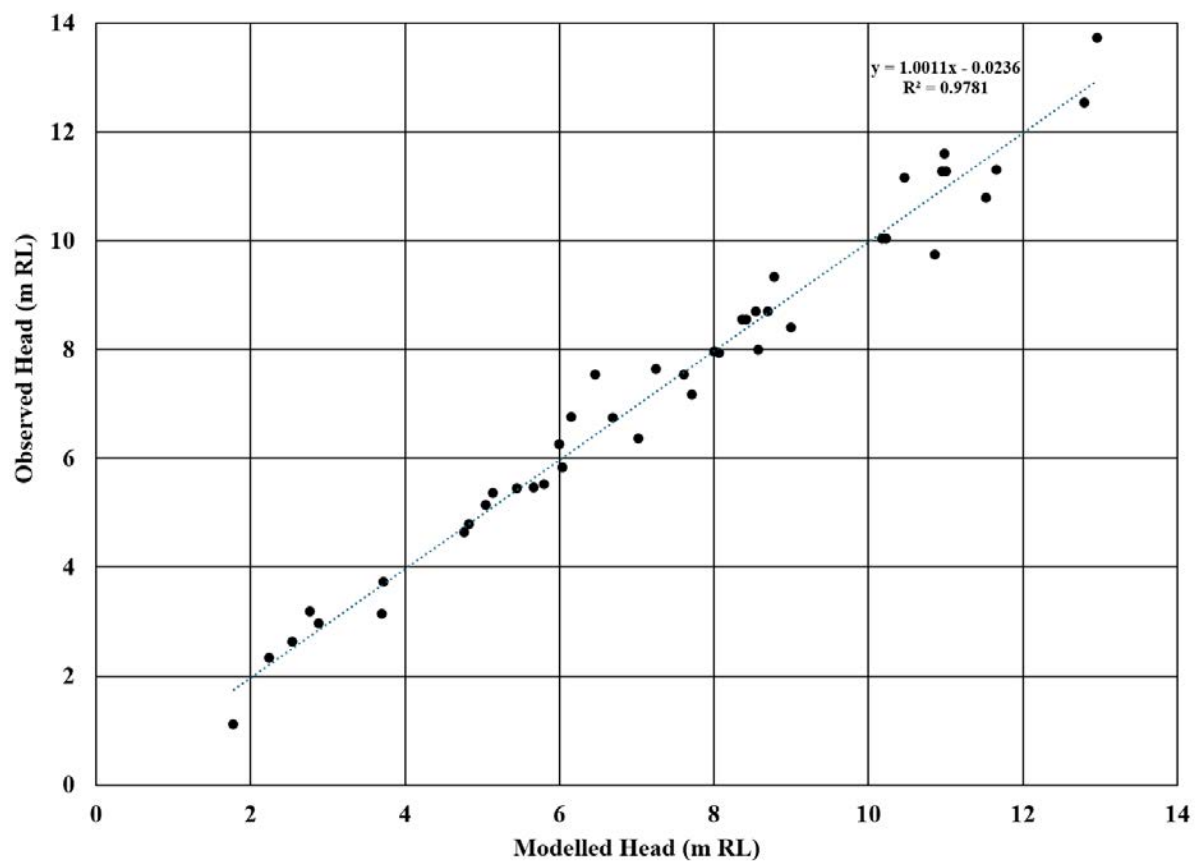


Figure 15: Steady-state Modelled vs Observed Heads

6.6.3 Flux Targets

A groundwater flux target, derived from the flow records for the Seadown Main Drain catchment, was used to constrain the model's mass balance. This target was interrogated for specific reaches using the Drain Package. Because groundwater discharge to the drainage network is a key driver for this project, achieving a close match for flux was a priority during the calibration process.

As detailed in Table 11, the simulated baseflow for the Seadown Main Drain to Phillips Lagoon reach is 19,339 m³/day, representing a residual of 24 m³/day.

Table 11: Seadown Main Drain to Phillips Lagoon Steady State Baseflow

OBSERVED TARGET (m ³ /day)	MODELLED TARGET (m ³ /day)	RESIDUAL (m ³ /day)
19,360	19,339	24

Offshore discharge was estimated for the conceptual model at 268,494 m³/day (Table 8) and simulated by the numerical groundwater model at 267,218 m³/day. While this value was not included as a calibration target, given the uncertainty of the calculation, it provides a reality check on the model-wide mass balance.

6.6.4 Hydraulic Conductivity Distribution

The hydraulic conductivity distribution within the simulated aquifer is derived from the pilot point calibration process for the numerical model (Figure 17). Consequently, the hydraulic conductivity distribution result provides a good match to the groundwater level and flux targets described above.

The fluvial depositional environment for the aquifer has not been taken into account by the calibration process. Depositional anisotropy that result from this environment, such as elongate paleochannel deposits, are poorly represented because the available hydraulic test data also do not clearly identify such features. Irrespective of this limitation, the hydraulic conductivity distribution presented in Figure 17 is defensible and provides an acceptable model outcome for the purposes of this assessment.

6.7 Groundwater Balance

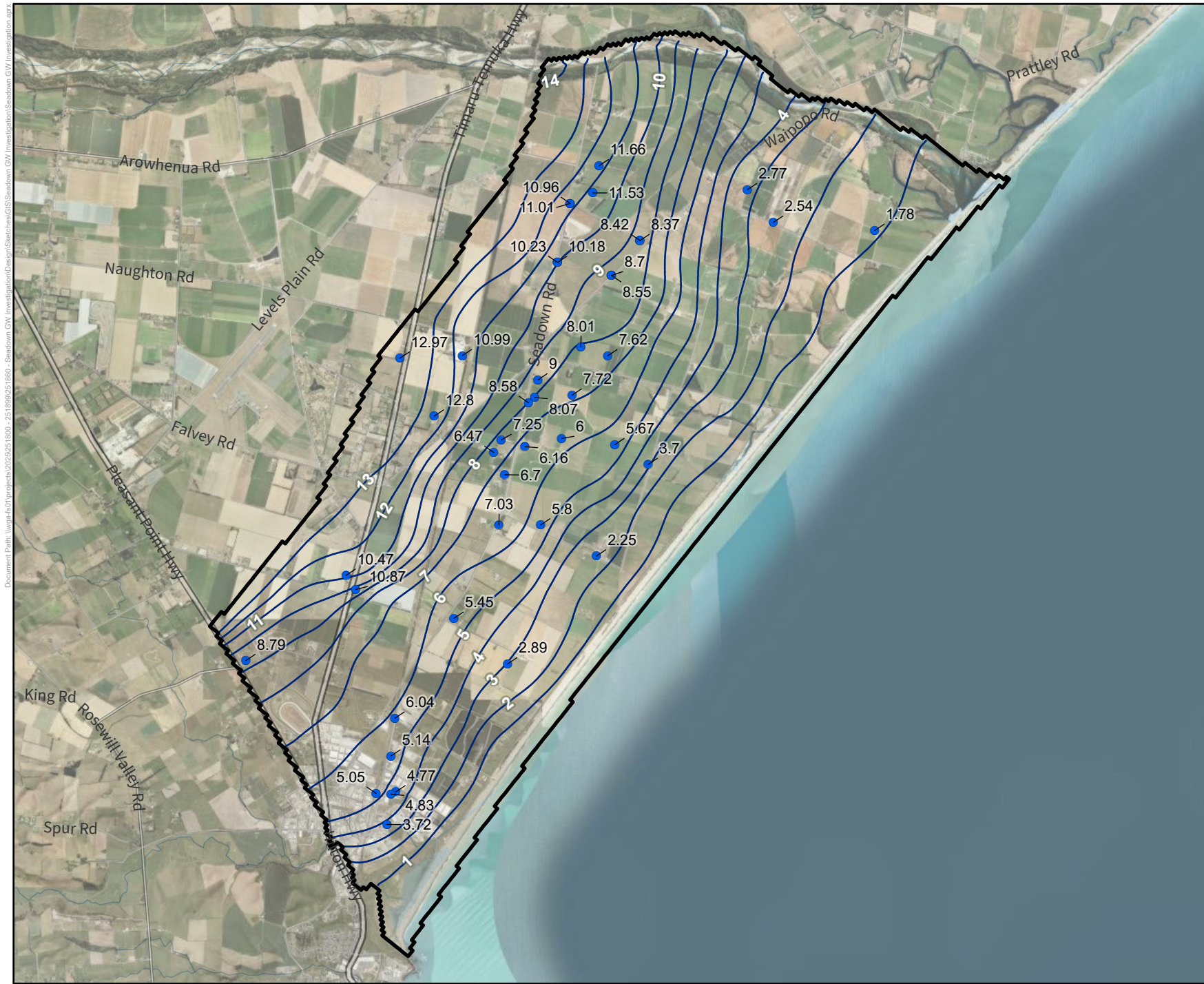
The steady-state water budget indicates a numerically stable simulation, with a negligible mass balance error of -0.013% (Table 12).

The combined groundwater discharge to the simulated drains totalled 28,825 m³/day. Of this total, the waterways connected to the Seadown Main Drain were simulated as gaining 19,339 m³/day from groundwater (Table 11).

6.8 Sensitivity Analysis

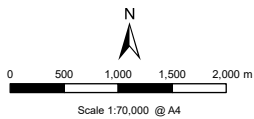
A sensitivity analysis was performed to evaluate how uncertainty in the model's input parameters influences the calibration. This was achieved by applying a multiplier (ranging from 0.8 to 1.2) to key boundary conditions and hydraulic parameters and measuring the resulting impact on the residual mean. This statistic indicates the direction and magnitude of the model's bias in response to parameter changes.

The results of the sensitivity analysis, provided in Appendix J, indicate that the model is most sensitive to the head elevations applied to the Inland General Head Boundary (GHB) and the Seadown Waterways. Significant fluctuations in the residual mean occurred when these parameters were adjusted, confirming they are primary factors controlling the regional groundwater gradient. The head applied to the coastal boundary was not tested in the sensitivity analysis process.



LEGEND

- Heads Targets (m RL)
- Modelled Heads (m RL)
- ▭ Model Extent

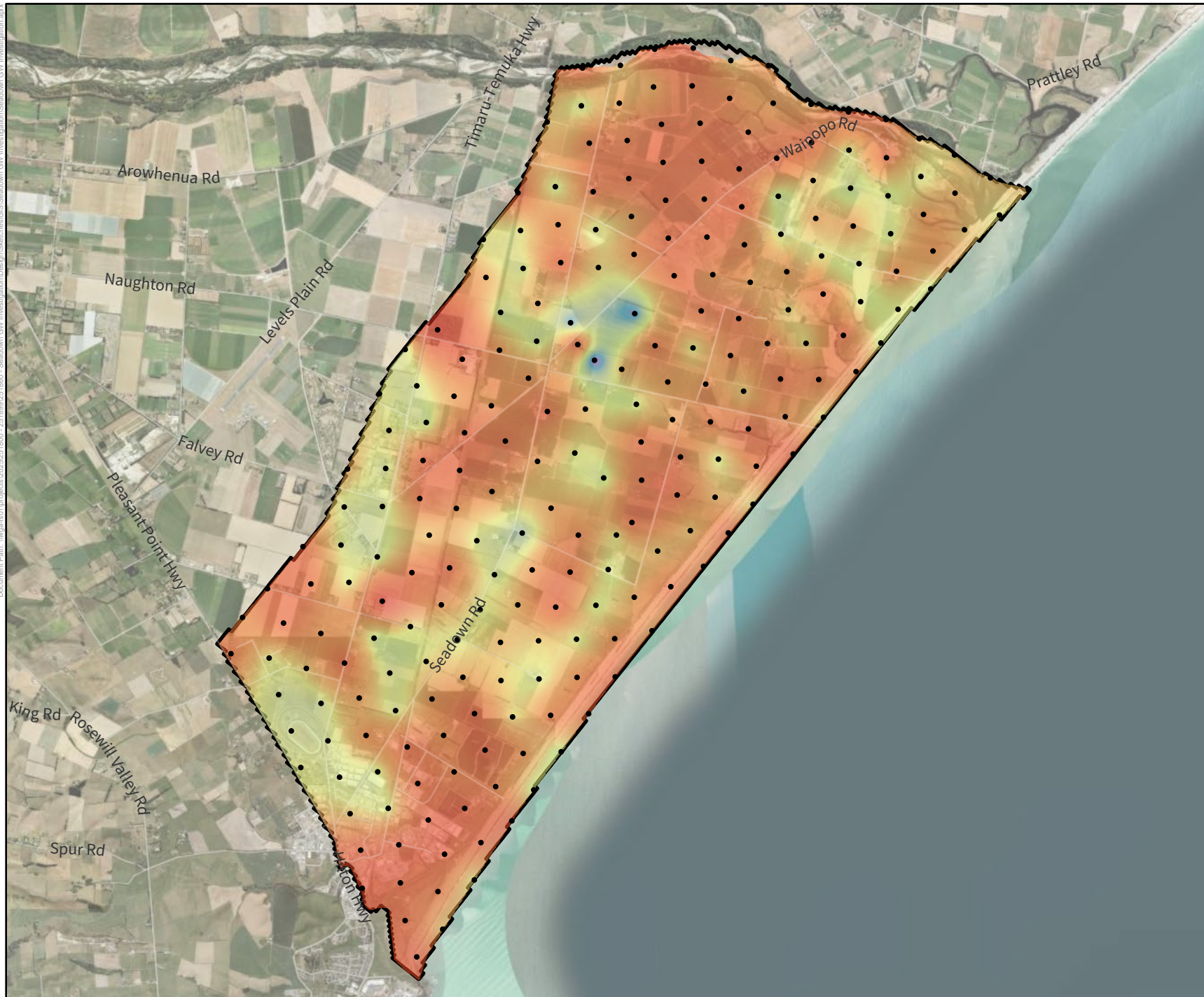


Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 16
Seadown Groundwater Investigation
Modelled Heads and Calibration Targets

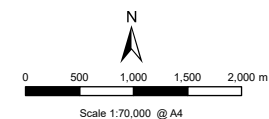
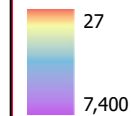
Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.
Note: The information shown on this map is a copyright of WGA 2026



LEGEND

- Pilot Points
- ▭ Model Domain

Hydraulic Conductivity (m/day)



Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 17

Seadown Groundwater
Investigation

Hydraulic Conductivity
Distribution and Pilot
Point Locations

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any reliance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

Table 12: Calibration Model Mass Balance

PARAMETER	IN (m ³ /day)	OUT (m ³ /day)	NET FLOW (m ³ /day)
River	453,918	433,599	20,320
Drain	-	28,825	-28,825
General Head	281,346	272,939	8,407
Total	735,265	735,363	-98
Error (%)	-0.013		

Conversely, the model showed high stability regarding conductance across the various drainage features and the Ōpihi River boundary, where residual mean values remained consistently low. Hydraulic conductivity and coastal boundary parameters also exhibited relatively moderate sensitivity.

6.9 Model Uncertainty

Model uncertainty is generally grouped into two categories: a deficiency in our knowledge of the natural system and the inherent failure of any numerical tool to capture the full complexity of the natural world. For this project, the four main sources of uncertainty identified by IESC (2023) have been addressed as follows:

1. **Structural and Conceptual:** While Leapfrog™ was used to evaluate bore logs, the high heterogeneity of the Canterbury gravels makes a rigid structural model impractical. To address this, a pilot point approach was adopted to represent hydraulic conductivity as a continuous field rather than discrete geological units. The variability in the aquifer base and, therefore, saturated aquifer thickness and transmissivity has been addressed in the model through calibration of the hydraulic conductivity field rather than through adjustment of the 3D model structure.
2. **Parameterisation:** Representing complex 3D alluvial fans requires significant simplification. The use of PEST-calibrated pilot points reduces the bias of traditional "zonal" models, though it remains a proxy for the true distribution of heterogeneous fluvial deposits.
3. **Measurement Error:** Uncertainty exists in the head and flux data used for calibration. While a Scaled RMS of 3.95% indicates that measurement errors have been minimised, the underlying calibration data, such as old groundwater level targets and measurement points, cannot be fully verified.
4. **Scenario Uncertainties:** Predictions regarding stopbank retreat and drain realignment assume that future boundary conditions remain consistent with current observations.

6.10 Model Confidence Level Classification

The model construction and calibration have been undertaken in a manner consistent with the recommended approach outlined in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012). A model confidence level classification was considered for this modelling project using the guidelines provided by Barnett et al (2012).

Factors that should be considered in establishing the model confidence-level classification (Class 1, Class 2, and Class 3) are presented in Table 13. The level of confidence, as described by Barnett et al (2012), typically depends on:

"The available data (and the accuracy of that data) for the conceptualisation, design and construction. Consideration should be given to the spatial and temporal coverage of the available datasets and whether or not these are sufficient to fully characterise the aquifer and the historic groundwater behaviour that may be useful in model calibration

- *The calibration procedures that are undertaken during model development. Factors of importance include the types and quality of data that is incorporated in the calibration, the level of fidelity with which the model is able to reproduce observations, and the currency of calibration, that is, whether it can be demonstrated that the model is able to adequately represent present-day groundwater conditions. This is important if the model predictions are to be run from the present day forward.*

- *The consistency between the calibration and predictive analysis. Models of high confidence level classification (Class 3 models) should be used in prediction in a manner that is consistent with their calibration. For example, a model that is calibrated in steady state only will likely produce transient predictions of low confidence. Conversely, when a transient calibration is undertaken, the model may be expected to have a high level of confidence when the time frame of the predictive model is of less or similar to that of the calibration model.*
- *The level of stresses applied in predictive models. When a predictive model includes stresses that are well outside the range of stresses included in calibration, the reliability of the predictions will be low and the model confidence level classification will also be low.”*

The available data, calibration, prediction, key performance indicators and intended use of the model developed for this project were considered predominantly Class 2, with some Class 1 elements. As such, the model should be considered Class 1-2 when considering the model outcomes and their use.

Table 13: Model Confidence Level Classification (Barnett et al, 2012)

<i>Confidence level classification</i>	<i>Data</i>	<i>Calibration</i>	<i>Prediction</i>	<i>Key indicator</i>	<i>Examples of specific uses</i>
Class 3	• Spatial and temporal distribution of groundwater head observations adequately define groundwater behaviour, especially in areas of greatest interest and where outcomes are to be reported. • Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry. • Reliable metered groundwater extraction and injection data is available. • Rainfall and evaporation data is available. • Aquifer-testing data to define key parameters. • Streamflow and stage measurements are available with reliable baseflow estimates at a number of points. • Reliable land-use and soil-mapping data available. • Reliable irrigation application data (where relevant) is available. • Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation.	• Adequate validation* is demonstrated. • Scaled RMS error (refer Chapter 5) or other calibration statistics are acceptable. • Long-term trends are adequately replicated where these are important. • Seasonal fluctuations are adequately replicated where these are important. • Transient calibration is current, i.e. uses recent data. • Model is calibrated to heads and fluxes. • Observations of the key modelling outcomes dataset is used in calibration.	• Length of predictive model is not excessive compared to length of calibration period. • Temporal discretisation used in the predictive model is consistent with the transient calibration. • Level and type of stresses included in the predictive model are within the range of those used in the transient calibration. • Model validation* suggests calibration is appropriate for locations and/or times outside the calibration model. • Steady-state predictions used when the model is calibrated in steady-state only.	• Key calibration statistics are acceptable and meet agreed targets. • Model predictive time frame is less than 3 times the duration of transient calibration. • Stresses are not more than 2 times greater than those included in calibration. • Temporal discretisation in predictive model is the same as that used in calibration. • Mass balance closure error is less than 0.5% of total. • Model parameters consistent with conceptualisation. • Appropriate computational methods used with appropriate spatial discretisation to model the problem. • The model has been reviewed and deemed fit for purpose by an experienced, independent hydrogeologist with modelling experience.	• Suitable for predicting groundwater responses to arbitrary changes in applied stress or hydrological conditions anywhere within the model domain. • Provide information for sustainable yield assessments for high-value regional aquifer systems. • Evaluation and management of potentially high-risk impacts. • Can be used to design complex mine-dewatering schemes, salt-interception schemes or water-allocation plans. • Simulating the interaction between groundwater and surface water bodies to a level of reliability required for dynamic linkage to surface water models. • Assessment of complex, large-scale solute transport processes.
Class 2	• Groundwater head observations and bore logs are available but may not provide adequate coverage throughout the model domain.	• Validation* is either not undertaken or is not demonstrated for the full model domain. • Calibration statistics are generally reasonable but may suggest significant errors in parts of the	• Transient calibration over a short time frame compared to that of prediction. • Temporal discretisation used in the predictive model is different from that used in transient	• Key calibration statistics suggest poor calibration in parts of the model domain. • Model predictive time frame is between 3 and 10 times the duration of transient calibration. • Stresses are between 2 and 5 times greater than those	• Prediction of impacts of proposed developments in medium value aquifers. • Evaluation and management of medium risk impacts.
<i>Cont'd overleaf</i>					

<i>Confidence level classification</i>	<i>Data</i>	<i>Calibration</i>	<i>Prediction</i>	<i>Key indicator</i>	<i>Examples of specific uses</i>
Class 2 <i>Cont'd</i>	- Metered groundwater-extraction data may be available but spatial and temporal coverage may not be extensive. - Streamflow data and baseflow estimates available at a few points. - Reliable irrigation-application data available in part of the area or for part of the model duration.	- model domain(s). - Long-term trends not replicated in all parts of the model domain. - Transient calibration to historic data but not extending to the present day. - Seasonal fluctuations not adequately replicated in all parts of the model domain. - Observations of the key modelling outcome data set are not used in calibration.	- calibration. - Level and type of stresses included in the predictive model are outside the range of those used in the transient calibration. - Validation* suggests relatively poor match to observations when calibration data is extended in time and/or space.	- included in calibration. - Temporal discretisation in predictive model is not the same as that used in calibration. - Mass balance closure error is less than 1% of total. - Not all model parameters consistent with conceptualisation. - Spatial refinement too coarse in key parts of the model domain. - The model has been reviewed and deemed fit for purpose by an independent hydrogeologist.	- Providing estimates of dewatering requirements for mines and excavations and the associated impacts. - Designing groundwater management schemes such as managed aquifer recharge, salinity management schemes and infiltration basins. - Estimating distance of travel of contamination through particle-tracking methods. Defining water source protection zones.
Class 1	- Few or poorly distributed existing wells from which to obtain reliable groundwater and geological information. - Observations and measurements unavailable or sparsely distributed in areas of greatest interest. - No available records of metered groundwater extraction or injection. - Climate data only available from relatively remote locations. - Little or no useful data on land-use, soils or river flows and stage elevations.	- No calibration is possible. - Calibration illustrates unacceptable levels of error especially in key areas. - Calibration is based on an inadequate distribution of data. - Calibration only to datasets other than that required for prediction.	- Predictive model time frame far exceeds that of calibration. - Temporal discretisation is different to that of calibration. - Transient predictions are made when calibration is in steady state only. - Model validation* suggests unacceptable errors when calibration dataset is extended in time and/or space.	- Model is uncalibrated or key calibration statistics do not meet agreed targets. - Model predictive time frame is more than 10 times longer than transient calibration period. - Stresses in predictions are more than 5 times higher than those in calibration. - Stress period or calculation interval is different from that used in calibration. - Transient predictions made but calibration in steady state only. - Cumulative mass-balance closure error exceeds 1% or exceeds 5% at any given calculation time. - Model parameters outside the range expected by the conceptualisation with no further justification. - Unsuitable spatial or temporal discretisation. - The model has not been reviewed.	- Design observation bore array for pumping tests. - Predicting long-term impacts of proposed developments in low-value aquifers. - Estimating impacts of low-risk developments. - Understanding groundwater flow processes under various hypothetical conditions. - Provide first-pass estimates of extraction volumes and rates required for mine dewatering. - Developing coarse relationships between groundwater extraction locations and rates and associated impacts. - As a starting point on which to develop higher class models as more data is collected and used.

7 GROUNDWATER EFFECTS ASSESSMENT

7.1 Overview

The groundwater effects assessment evaluates the potential impacts of retreating the Seadown Main Drain and coastal stopbanks inland. Four primary drain configurations were simulated using the groundwater numerical model to determine changes in regional groundwater levels, drain baseflows, and the risk of saltwater intrusion. The assessment compares these predictive scenarios against the baseline steady-state model to quantify the magnitude and extent of hydrogeological changes resulting from the proposed coastal adaptation works.

7.2 Proposed Drain Configurations

Four proposed replacement drain configurations for Seadown Main Drain, under Stage 2 of the Waitarakao/Washdyke/Seadown works, were simulated within the MODFLOW model and compared to the baseline model, described in Section 6. The proposed drain configurations are shown in Figure 2.

7.2.1 Stage 1 Drain Configuration

The Stage 1 drain configuration originates at Washdyke Lagoon, the current discharge point for the Seadown Main Drain (Figure 2). This alignment extends northeast for approximately 1,750 m and is positioned roughly 100 m inland from the existing channel (Figure 2).

While the Stage 1 configuration was assessed in a separate Assessment of Environmental Effects (AEE), this section is included in the Stage 2 simulations and effects assessment to ensure a comprehensive analysis of the system.

7.2.2 Stage 2 Drain Configurations

The proposed drain configurations for Stage 2 connect the Stage 1 drain to Philips Lagoon. The four options are as follows:

- **Configuration A:** Approximately 5,150 m in length, following a linear path roughly 80 m inland of the current channel.
- **Configuration B:** Approximately 5,740 m in length, partially following the alignment of Kereta Road.
- **Configuration C:** Approximately 5,950 m in length, also partially following Kereta Road.
- **Configuration D:** Approximately 6,300 m in length. This is the most inland of the designs, with a circuitous pathway that results in a greater channel length between Stage 1 and Philips Lagoon.

To represent these configurations within the MODFLOW framework, the drain stage for each configuration was linearly interpolated between the Stage 1 Drain and the Seadown Main Drain connection at Philips Lagoon. Specifically, the stage was set at 0.95 mRL and 1.65 mRL at the respective connection points. Consequently, the drain stage and hydraulic gradient for each configuration are defined by its total channel length.

7.2.3 Simulation of Proposed Stopbank Alignment

To evaluate the potential hydraulic impacts of the proposed coastal adaptation works, a predictive scenario was developed to simulate the inland retreat of the stopbank infrastructure. The methodology involved modifying the baseline steady-state model by adjusting the top elevation. Specifically, a 2 m increase was applied to the topography across the designated footprint of the proposed stopbank alignment. This change was applied by updating the surface elevation (Z-top) of the relevant cells while maintaining the existing hydraulic parameters and boundary conditions used in the baseline simulation.

It is important to note that any ground compaction that may arise from the construction of the new stopbank or from any associated increase in lithostatic loads to the underlying sediments has not been considered in this assessment. Therefore, any potential changes in the hydraulic characteristics arising from ground compaction have also not been incorporated in this model.

The potential for the physical weight of the stopbank to compact the underlying aquifer material has been considered. It is unlikely that ground traffic and the additional lithostatic loading associated with construction of the stopbank would result in substantial changes to the degree of consolidation and porosity of the gravels representing the shallow aquifer underlying the site. Any minor reduction in porosity due to the loading of the stopbank or traffic disturbance during construction is unlikely to measurably alter the local transmissivity of the aquifer. Consequently, there appears to be no probable mechanism for the stopbank to create an underlying low permeability zone via sub-surface compaction that would significantly influence regional groundwater gradients.

Following the modification of the topography, the model was executed to achieve a new steady-state solution. The results were then compared to the baseline model to quantify any changes in groundwater heads or the overall water balance. This comparison was performed by subtracting the baseline head values from the stopbank scenario heads to generate a differential (drawdown/mounding) map. This approach allows for the direct identification of even minor localized changes in the phreatic surface that might result from the proposed structural changes at the coast.

7.3 Projected Groundwater Drawdown

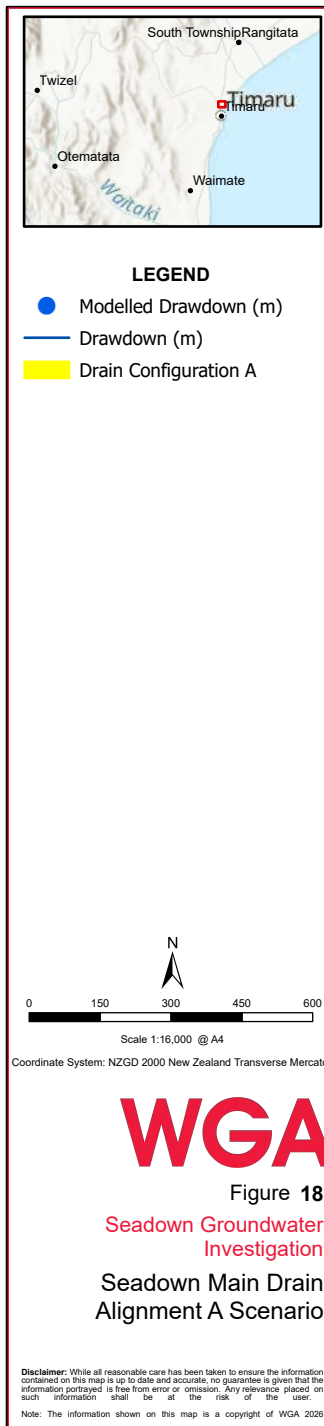
The predictive simulations assess the long-term hydraulic response of the shallow aquifer to the proposed realignment of the Seadown Main Drain. By comparing the baseline steady-state heads against the four proposed configurations, the model identifies potential changes in the water table and the spatial extent of any resulting drawdown.

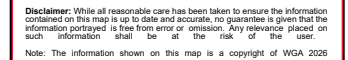
Simulated drawdown patterns for the four drain configurations are illustrated in Figure 18 through Figure 21. Overall, the results indicate that the proposed works will result in relatively minor long-term impacts on regional groundwater levels for each configuration.

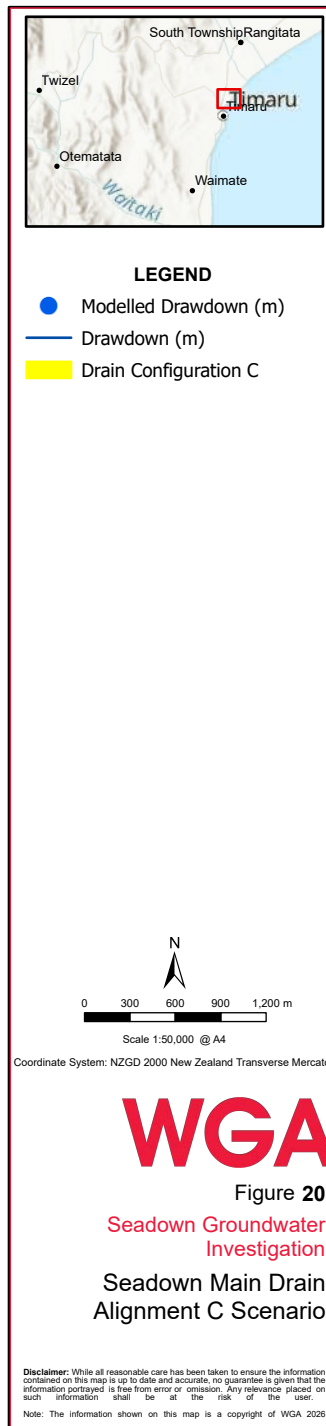
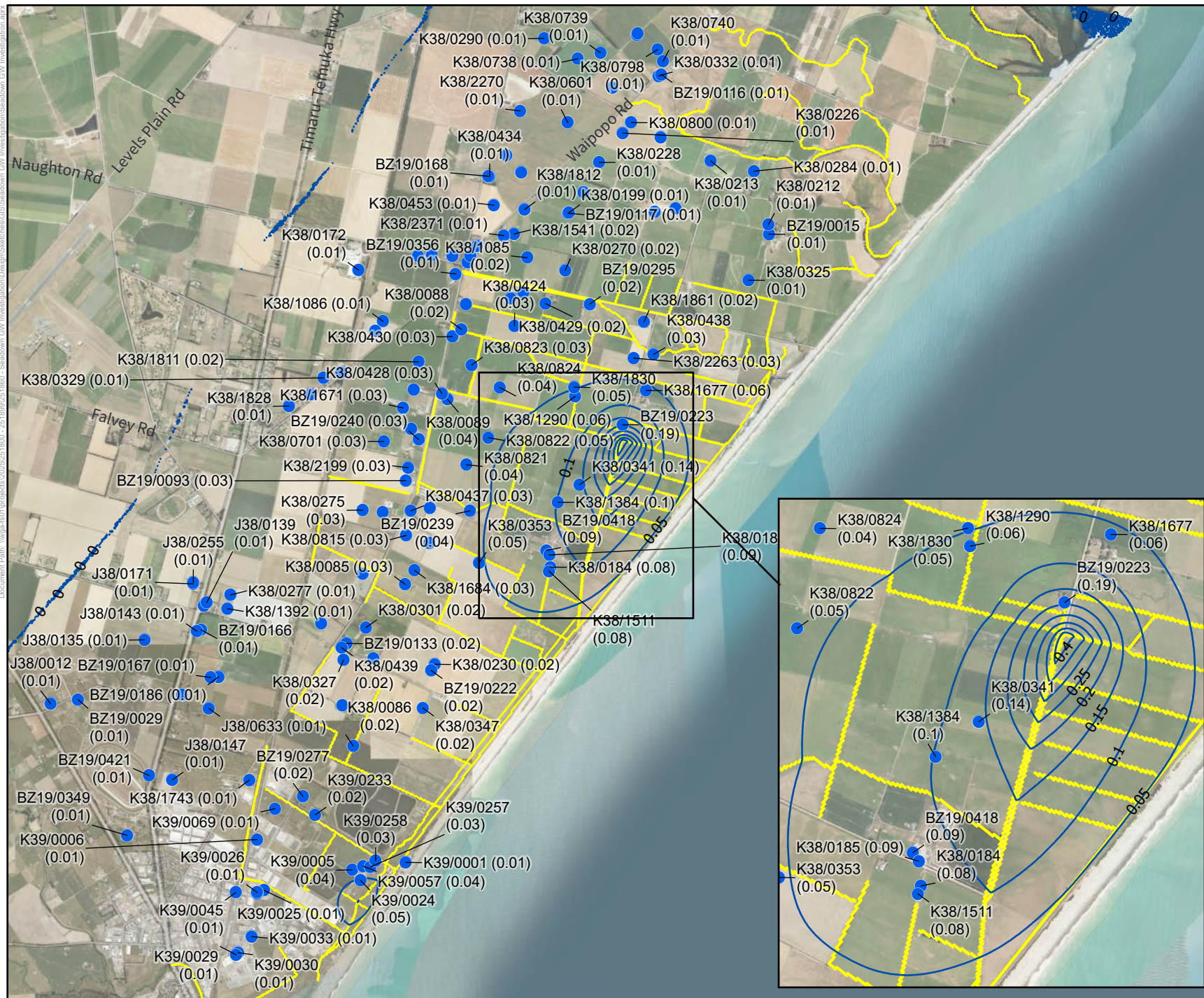
Configuration A generates the least impact on the groundwater system, with a nominal drawdown of less than 0.1 m (Figure 18).

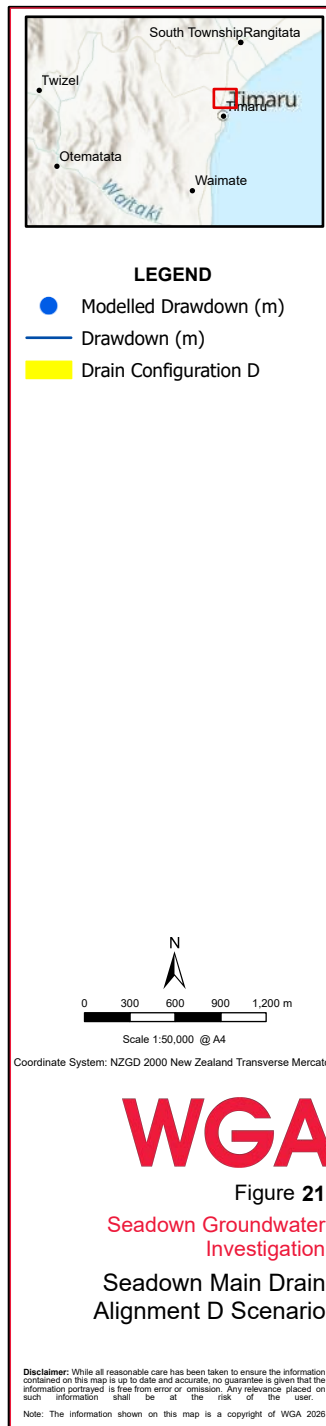
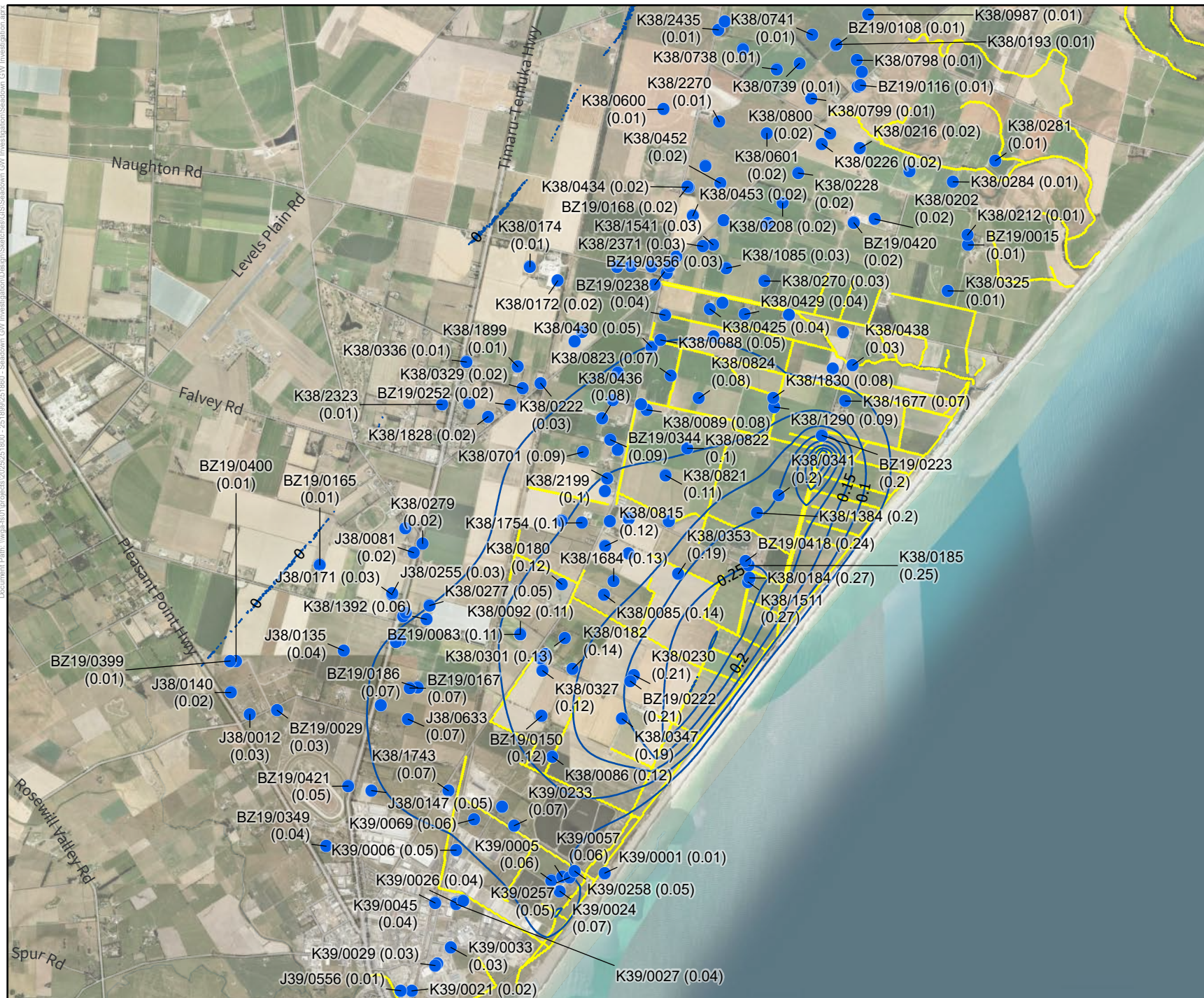
Configurations B and C produced similar results, both simulating a maximum drawdown of approximately 0.4 m. The drawdown impact is primarily centred near the intersection of Beach Road and Kereta Road (Figure 19 and Figure 20). In these scenarios, the drain alignment is more deeply incised into the water table, leading to localised dewatering and a more pronounced steepening of the local hydraulic gradient.

Configuration D also simulated a peak drawdown of 0.4 m, but the resulting cone of depression is more widespread (Figure 21). This broader footprint is a direct consequence of the longer drain design and drain stage which intersects the water table over a greater distance. While the magnitude of drawdown remains moderate, the total area influenced by the lowered water table is larger than in the other three configurations.









7.4 Effects on Drain Baseflows

The potential effects of each proposed drain realignment on baseflows were assessed by comparing the simulated mass balance of each predictive scenario against the baseline model. This methodology allows for the isolation of additional groundwater intercepted by the new configurations as they intersect the water table at various depths and locations. The resulting changes in baseflow, as summarised in Table 14, provide a quantitative measure of the hydraulic impact each design has on the shallow aquifer system.

Configuration A results in the least change in drain baseflow; an increase of 1,496 m³/day (17.3 L/s). This small change indicates that the new alignment for this scenario results in groundwater levels that are largely consistent with the existing water table (Section 7.3), causing minimal disruption to the baseline groundwater flows.

Configurations B and C results indicate a projected change of approximately 7,410 m³/day and 7,516 m³/day, respectively (approximately 86 to 87 L/s). The focused groundwater drawdowns near the intersection of Beach Road and Kereta Road (Section 7.3) steepen the local hydraulic gradients and draw more groundwater into the drainage network compared to the baseline condition.

Configuration D indicates the greatest impact on the groundwater system, with a projected baseflow increase of 19,999 m³/day (231.5 L/s). This increase is a direct consequence of the configuration's extended length and its deeper intersection with the water table over a much broader area.

Table 14: Drain Configuration Baseflow Changes

SCENARIO	PROJECTED CHANGE (m ³ /day)	PROJECTED CHANGE (L/s)
Configuration A	1,496	17.3
Configuration B	7,410	85.8
Configuration C	7,516	87.0
Configuration D	19,999	231.5

7.5 Effects on Washdyke Lagoon

The proposed realignments induce localised drawdown that results in minor losses to groundwater from Washdyke Lagoon. As detailed in Table 15, these projected losses are relatively small, ranging from 54 m³/day (0.6 L/s) in Configuration A to 106 m³/day (1.2 L/s) in Configuration D. However, these surface water losses to groundwater are entirely offset by the larger increases in baseflow captured by the new drain configurations (refer to Table 14). As the realigned drains ultimately discharge into the lagoon system, there is a net increase in total freshwater flows through the lagoon across all proposed configurations.

Table 15: Proposed Drain Configurations and Washdyke Lagoon Mass Balance Changes

SCENARIO	PROJECTED CHANGE (m ³ /day)	PROJECTED CHANGE (L/s)
Configuration A	54	0.6
Configuration B	60	0.7
Configuration C	59	0.7
Configuration D	106	1.2

7.6 Effects on Nearby Bores

7.6.1 Drawdown at Nearby Bores

To evaluate the potential impact on local groundwater users, a drawdown assessment was conducted for all recorded water supply bores within the model domain. For a conservative estimate, this assessment includes all bores regardless of depth, including those screened deeper than the 20 m primary aquifer unit simulated in the model. This approach ensures that any potential vertical leakage or regional pressure changes are accounted for.

Configuration A

Configuration A resulted in the least impact on existing groundwater infrastructure. No bores experienced drawdown exceeding 0.1 m. The maximum simulated drawdown for this configuration was 0.05 m at bore K39/0024.

Configurations B and C

Configurations B and C produced similar drawdown results. Only three bores were identified with simulated drawdowns greater than 0.1 m, as summarised in Table 16. The maximum impact was observed at bore BZ19/0223, with a drawdown of 0.19 m.

Configuration D

Configuration D resulted in the most widespread impact, with 32 bores experiencing drawdown greater than 0.1 m. The increased footprint and magnitude of drawdown are attributed to the longer drain alignment and deeper intersection with the water table. The maximum simulated drawdown was 0.27 m at bores K38/1511 and K38/0184.

7.6.2 Discussion

Overall, the maximum absolute simulated groundwater drawdown of 0.27 m would appear to be less than minor, bearing in mind that seasonal groundwater level fluctuations within the modelled area exceed this range. However, a few of the bores potentially impacted by groundwater drawdown are less than 5 m deep (BZ19/0223; K38/0184; BZ19/0223). The security of supply at these bores and perhaps some of the other shallowest bores (Table 16, Table 17) may be impacted by even small drawdowns. Site visits would be needed to confirm bore locations as well as bore and pump layouts to confirm a lack of impact on water supply security.

Table 16: Modelled Drawdown (greater than 0.1 m) on Water Supply Bores for Proposed Configuration B and C

NAME	NZTM X	NZTM Y	DEPTH (m)	DIAMETER (mm)	USE_CODE	BASLINE HEADS (m RL)	CONFIGURATION B DRAWDOWN (m)	CONFIGURATION C DRAWDOWN (m)
BZ19/0223	1463905	5091996	4.4	150	Domestic Supply	3.16	0.19	0.19
K38/0341	1463497	5091430	6	150	Irrigation	3.06	0.14	0.14
K38/1384	1463292	5091264	10.7	500	Irrigation	3.12	0.10	0.10

Table 17: Modelled Drawdown (greater than 0.1 m) on Water Supply Bores for Proposed Configuration D

NAME	NZTM X	NZTM Y	DEPTH (m)	DIAMETER (mm)	USE_CODE	USE_CODE_2	BASLINE HEADS (m RL)	CONFIGURATION D DRAWDOWN (m)
K38/1511	1463208	5090612	9.8	500	Irrigation		2.15	0.27
K38/0184	1463222	5090650	4.65	350	Irrigation	Water Level Observation	2.18	0.27
K38/0185	1463212	5090767	9.7	100	Domestic and Stockwater		2.34	0.25
BZ19/0418	1463184	5090808	9.3	100			2.43	0.24
K38/0230	1462128	5089732	12	600	Irrigation		3.32	0.21
BZ19/0222	1462095	5089675	80.72	300	Irrigation		3.30	0.21
K38/0341	1463497	5091430	6	150	Irrigation		3.06	0.20
BZ19/0223	1463905	5091996	4.4	150	Domestic Supply		3.16	0.20
K38/1384	1463292	5091264	10.7	500	Irrigation		3.12	0.20
K38/0347	1462016	5089319	6.9	750	Irrigation		2.97	0.19
K38/0353	1462547	5090690	8.2	230	Irrigation		4.06	0.19
K38/0182	1461548	5089790	5	150	Irrigation		4.79	0.14
K38/0085	1461847	5090490	6.41	200	Irrigation		5.51	0.14
K38/0301	1461477	5090080	9.14	150	Irrigation		5.32	0.13
K38/1684	1461937	5090620	10	500	Irrigation		5.65	0.13
BZ19/0133	1461294	5089930	5	50			5.45	0.12

NAME	NZTM X	NZTM Y	DEPTH (m)	DIAMETER (mm)	USE_CODE	USE_CODE_2	BASLINE HEADS (m RL)	CONFIGURATION D DRAWDOWN (m)
K38/0327	1461265	5089773	10	150	Irrigation		5.35	0.12
BZ19/0150	1461256	5089345	17.6	150	Domestic Supply		4.94	0.12
K38/0439	1461248	5089890	10	100	Irrigation		5.49	0.12
K38/0759	1462077	5090880	9.5	400	Irrigation		5.92	0.12
BZ19/0239	1462460	5091183	9	100	Domestic Supply		5.54	0.12
K38/0180	1461447	5090590	6.4		Domestic and Stockwater		6.05	0.12
K38/0086	1461358	5088960	8.08	150	Irrigation		4.12	0.12
K38/0815	1461857	5090950	5.5	150	Stock Supply		6.20	0.12
BZ19/0289	1462081	5091208	10.04	150	Domestic and Stockwater		6.22	0.11
BZ19/0083	1461054	5090118	9	500	Irrigation		5.98	0.11
K38/0092	1461054	5090118	4.8	750	Irrigation		5.98	0.11
K38/0437	1461901	5091183	6.5	100	Domestic Supply		6.35	0.11
K38/0821	1462428	5091619	9.5	500	Irrigation	Dairy Use	5.98	0.11
K38/1754	1461637	5091170	10.2	200	Irrigation	Stock Supply	6.65	0.11
BZ19/0093	1461855	5091468	9	70	Domestic and Stockwater		6.57	0.10
K38/2199	1461877	5091590	9	200	Domestic Supply		6.63	0.10

7.7 Effects from Stopbank Realignment

The simulation results indicate that the increase in surface topography required for stopbank construction has a negligible effect on the underlying groundwater system. No discernible mounding or drawdown was observed in the head distribution (with changes of less than 0.001 m), and the net groundwater discharge to the coastal boundary remained unchanged from the baseline scenario.

7.7.1 Hydrogeological Context and Connectivity

From a hydrogeological perspective, this lack of model response is due to the stopbank being positioned entirely within the unsaturated (vadose) zone or above the existing ground surface. In the MODFLOW simulation, flow equations are solved based on the saturated thickness and the hydraulic gradient within the aquifer. Because the stopbank does not physically intersect the saturated zone, it does not impede the lateral movement of groundwater.

7.7.2 Infiltration and Recharge

The shallow, poorly drained gley soils in the area naturally exhibit low permeability and likely provide low vertical recharge. Similarly, the stopbank structure will be constructed from compacted material designed to provide a low-permeability barrier against surface water ingress. Assuming both the natural soil profile and the compacted stopbank will exhibit similarly low infiltration rates, the net change in distributed recharge to the underlying shallow gravels is expected to be minimal. While recharge was not explicitly simulated in the model, the relative similarity between the pre-existing and post-construction surface conductivities suggests that groundwater levels will not be impacted by changes in vertical seepage.

7.7.3 Compaction of Underlying Material

As previously noted, (Section 7.2.3) the model used to generate this outcome does not take into account possible ground compaction and associated changes to aquifer characteristics related to the proposed stopbank. While the added load may cause some minor settlement of the near-surface soils, any effect on the hydraulic properties of the underlying Quaternary gravels and therefore the behaviour of groundwater flows under the stopbank is expected to be negligible.

7.7.4 Summary

While a stopbank is a significant feature for managing surface water and preventing marine inundation, it is effectively hydraulically neutral regarding the saturated groundwater flow system. Without a physical intersection with the saturated zone or a significant alteration to the recharge profile, the construction remains a passive feature in the context of groundwater levels.

7.8 Saline Water Interface

As the numerical groundwater model consists of a single-layer simulation of the groundwater system, it cannot effectively simulate the saline water/freshwater interface within the aquifer. Consequently, the Strack (1976) analogue method has been utilised to estimate the inland extent of the saltwater interface in the shallow aquifer, and the changes that would arise due to the drain realignment. While this analytical solution is traditionally applied to determine the critical discharge of a pumping well, it has been adapted here to assess the dewatering impact of the proposed drain configurations. By treating the baseflow in the Seadown Main Drain as a linear sink, we can estimate the landward migration of the interface relative to the coast.

The assessment assumed an average hydraulic conductivity (K) of 636 m/day, as derived from the calibrated numerical model, and an aquifer thickness of 20 m within an unconfined system. Each modelled drain configuration resulted in drawdown affecting a different stretch of coastline (Figure 18 to Figure 21). The Strack (1976) assessment methodology is based on calculating the saline water interface in a cross section oriented perpendicular to the coastline. By default, the cross section is 1 m thick. Therefore, each of the analogue calculations summarised in Table 18 relate to a cross section through the area of maximum groundwater drawdown generated by the relevant drain configuration. All of the flow rates presented in Table 18 are calculated on the basis of a 1 m length of coastline or a corresponding 1 m length of the proposed drain alignment.

Table 18: Analytical Approximation of Saltwater/Freshwater Interface Position

PARAMETER ⁽¹⁾	CONFIGURATION				
	Baseline	A	B	C	D
Length of coastline impacted by drawdown (m)	-	400	1000	1000	3000
Offshore discharge (m ³ /day)	31.55	27.8	24.14	24.03	24.88
Drain baseflow contribution (m ³ /day)	3.27	6.97	10.64	10.74	9.89 ⁽²⁾
Increase in drain baseflow (m ³ /day)	-	3.7	7.37	7.47	6.62 ⁽²⁾
Decrease in offshore discharge (m ³ /day)	-	3.75	7.41	7.52	6.67 ⁽²⁾
Saline wedge interface at base of aquifer - distance inland from coast (m)	103	117	135	136	131 ⁽²⁾
Saline wedge interface at base of aquifer - increase in interface distance from coast (m)	-	14	32	33	28

Note: 1) All parameter values calculated for a 1 m wide cross section oriented perpendicular to the coastline positioned where the most induced drawdown is occurring for each configuration.

2) Effects are reduced compared to configurations B and C because drawdown is distributed along a substantially longer section of coastline.

The analytical model indicates that the baseline saline water/freshwater interface intersects the base of the shallow aquifer approximately 103 m inland from the coast. Under the proposed configurations, the increase in groundwater abstraction by the relocated drain leads to a landward migration of this interface.

A single bore (K39/0001) listed on the ECan database as active is located on the coastal side of the existing stopbank. However, a site investigation indicates that this bore is situated within an abandoned coastal building, located at the end of Aorangi Road. As such, this bore is considered no longer in use.

Despite this inland migration, the interface within the shallow aquifer remains localised to the immediate vicinity of the coastal drainage corridor. Because the primary water supply bores and critical infrastructure are located further inland, the risk of salinity impacting existing users remains low.

8 GROUNDWATER MONITORING PLAN

8.1 Groundwater Drawdown

The relocation of the Seaward Main Drain is expected to result in localised groundwater drawdown. The key issues arising in terms of groundwater drawdown relate to reduced water supply security in local bores. More specifically, supply security may be an issue for very shallow bores that may not have a large standing water column to support the existing pumping rates at each of these bores.

It is not clear that the potential effects justify the installation of new monitoring wells specifically to verify the extent and magnitude of the effects on the groundwater system. We suggest instead that water levels in selected shallow bores that may be adversely impacted by the drawdown (Section 7.6) be monitored in advance of the start of drain realignment and through the construction period. If the drain realignment has a clear impact on water supply security in these bores, options for mitigation may be discussed at that stage with the landowner.

Monitoring of water levels in active bores should be undertaken using automated pressure transducers, with data initially being recorded in perhaps one-minute intervals to enable an understanding of the effects of self-induced drawdown in the bore. Once this understanding has been gained, recording may be reduced to a lower frequency, such as 15-minute intervals, to gain an understanding of the longer-term variability of water levels in the bore and subsequently distinguish the long-term drawdown induced by the realigned drains.

8.2 Surface Water Monitoring Sites

Surface water level and flow monitoring has been undertaken at sites within the modelled area for various reasons in the past. The key surface flow monitoring site is currently on the Seadown Drain (ECan ID 69803). Realignment of the drain will mean this monitoring site will also need to be relocated, and a new rating curve for the site established. We recommend this shift be undertaken as soon as Stage 1 of the drain realignment has been completed. Although the datasets from the old and new monitoring sites will not overlap, the new site will be in place to monitor the effects of Stage 2 of the drain realignment.

9 SUMMARY

The Seadown coastal aquifer system is characterised by shallow, highly permeable alluvial gravels that are strongly connected to both the regional groundwater system and the coastal drainage network. Groundwater flow through the area is dominated by throughflow from further inland. The Seadown Main Drain captures a comparatively small component of this groundwater throughflow, which reposes as drain baseflow discharging to Washdyke Lagoon.

The numerical groundwater model developed for this assessment provides a representation of the groundwater flows and interactions with surface water bodies. The model reproduces observed groundwater levels and drain baseflows to an acceptable standard for regional-scale impact assessment.

Model simulations of the proposed Seadown Main Drain realignment indicate that the assessed drain realignment configurations would result in only minor long-term changes to regional groundwater levels. The maximum simulated drawdowns, which result from the drain Configuration D, are less than 0.3 m and are restricted to areas close to the new drain alignments. The smaller drawdown effects are associated with the realignment closer to the coast (Configuration A). The greater effects are associated with the longest, furthest inland option (Configuration D).

The absolute magnitudes of projected drawdowns at nearby bores are small. However, a few bores close to the drain realignments are less than 5 m deep. Even small groundwater drawdowns in groundwater levels may impact water supply security from these very shallow bores. For most bores within the modelled area, the predicted drawdowns are not sufficient to cause more than minor interference effects at existing groundwater supply bores and are unlikely to affect water availability or security of supply at these bores.

Changes to simulated groundwater discharge patterns indicate that relocating the drain inland increases groundwater interception by the drain. This increase consequently results in additional baseflows discharging to Washdyke Lagoon. The projected increases in baseflow across the four drain configurations range from approximately 1,500 m³/day for Configuration A, to approximately 20,000 m³/day for Configuration D.

Stopbank retreat and construction are assessed to be hydraulically neutral with respect to the hydraulic performance of the saturated groundwater system. It is considered unlikely that traffic disturbance and lithostatic loading that arises from construction operations and fill placement would have an effect on the gravel aquifer characteristics more than a couple of metres below ground level. The stopbanks themselves do not intrude into the saturated zone of the shallow aquifer. On this basis, it is expected that the new stopbanks will not result in induced groundwater mounding, alter regional hydraulic gradients, or materially affect recharge to the shallow aquifer.

Assessment of saline intrusion risk using analytical methods indicates that the saline water/freshwater interface will locally migrate inland as a result of the proposed drain realignment under each of the tested configurations. Groundwater heads remain above mean sea level across the coastal margin, ensuring that a seaward hydraulic gradient is maintained. The saline water/freshwater interface, where it intersects the base of the simulated shallow aquifer, is calculated to migrate between 14 m and 33 m inland from its current position. This projected inland migration is not expected to result in water quality impacts to existing bores.

On the basis of the modelling undertaken, the proposed Seadown Main Drain realignment and associated coastal stopbank works are assessed to result in less than minor adverse effects on groundwater levels, groundwater users, Washdyke Lagoon and the coastal freshwater–saltwater balance.

10 REFERENCES

Aitchison-Earl, P. 1999. Rangitata-Opihi and Levels Plains Aquifer Test Review. U99/29. Prepared for Canterbury Regional Council, July 1999.

Barnett, B., Townley, L., Post, V., Evans, R., Hunt, R., Peters, L., Richardson, S., Werner, A., Knapton, A., Boronkay, A. 2012. Australian Groundwater Modeling Guidelines. National Water Commission. Retrieved from: <https://www.epa.govt.nz/assets/FileAPI/proposal/NSP000028/Hearings-Week-01/c2cd52352e/02-Australian-Groundwater-modelling-guidelines.pdf>

Boughton WC 1988. Partitioning streamflow by computer. Inst. Eng. Civ. Eng. Trans. CE30(5), 285-291.

Burbury L, Ritson J 2010. Integrated study of surface water and shallow groundwater resources of the Orari catchment. Environment Canterbury Report R10/36.

Cox S C, Barrell D J A (compilers) 2007. Geology of the Aoraki area, Institute of Geological & Nuclear Sciences 1:250,000 Geological Map 15.

Dann R L, Close M E, Pang L, Flintoft M J, Hector R P 2008. Complementary use of tracer and pumping tests to characterize a heterogeneous channelized aquifer system in New Zealand. Hydrogeology Journal 16(6) 1177-1191.

de Joux, 1987. Groundwater behaviour between the Ashburton and Rakaia Rivers. SCCB Publication No. 53, ISBN 0111-7335.

ECan 2025. Our Waitarakao: Waitarakao Washdyke Lagoon catchment strategy. Report downloaded from <https://www.ecan.govt.nz/your-region/your-environment/water/whats-happening-in-my-water-zone/orari-temuka-opihi-pareora-water-zone/our-waitarakao>.

Flintoft M, Weir J 2019. Opihi and Pareora limit setting, surface water – groundwater modelling. Report prepared for Environment Canterbury by Aqualinc Research Ltd. Aqualinc report C16027.

Forsyth P J (compiler) 2001. Geology of the Waitaki Area. Institute of Geological & Nuclear Sciences 1:250,000 Geological Map 19.

Freeze R A, Cherry J A 1979. Groundwater. Englewood Cliffs, NJ: Prentice-Hall. 606 p.

IESC 2023. Information Guidelines and Explanatory Note – Uncertainty Analysis for Groundwater Modelling. Report produced by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development 2023. Retrieved from <https://www.iesc.gov.au/sites/default/files/2022-07/information-guidelines-explanatory-note-uncertainty-analysis.pdf>.

Lough H, Williams H 2009. Vertical flow in Canterbury groundwater systems and its significance for groundwater management. Environment Canterbury Report R09/45.

Poulsen D 2013. The hydrogeological significance of loess in Canterbury. Environment Canterbury Report R13/60.

Robson-Williams M, Clark D 2019. Overview technical report to support the Orari-Temuka-Opihi-Pareora limit-setting process. Environment Canterbury Report R19/71.

Strack, O. (1976). A single-potential solution for regional interface problems in coastal aquifers. Water Resources Research, 12(6), 1165–1174. <https://doi.org/10.1029/WR012i006p01165>.

Zarour H, Aitchison-Earl P, Scott M, Peaver L, De Silva J 2018. Current state of the groundwater resource in the Orari-Temuka-Opihi-Pareora area. Environment Canterbury Report R16/41.

11 LIMITATIONS

The hydrogeological assessment has been undertaken in accordance with standard industry practice and is based on the best available information at the time of reporting. However, inherent limitations in the data and modelling approach introduce a degree of uncertainty to the findings, and these should be considered when interpreting the results. This report has been prepared specifically to assess the potential hydrogeological effects of the Seadown Main Drain realignment and the proposed stopbank retreat.

The numerical model is a simplified representation of a dynamic system, particularly through its use of steady-state simulations, which do not capture short-term fluctuations such as tidal influences or seasonal rainfall events. These modelling limitations were mitigated through a calibration process, where the model was tested against a variety of historical targets to reduce uncertainty. Sensitivity analysis was also employed to identify which assumptions had the greatest impact on the results, allowing for a more robust interpretation of the predicted effects despite the inherent uncertainties.

The primary limitation for this study relates to degree of surface water monitoring data along the drainage network. While automated recording stations provided data for the Washdyke and Seadown areas, the total volume of groundwater discharging into the drainage network remains difficult to quantify precisely due to unmeasured seepage, potential contributions from connecting irrigation infrastructure (i.e., irrigation by-wash) and potential seepage from the Main Drain along the coastal area, as reported by local landowners.

The geological setting presents challenges due to the natural variability of alluvial deposits. The complex layering of gravels and silts makes it difficult to define distinct, continuous aquifer boundaries. Additionally, the lack of testing for aquitard leakance introduces uncertainty regarding vertical water movement. To address this, the numerical modelling approach moved away from a rigid geological framework in favour of a more flexible parameter-based system. The modelling process also adopted a conservative approach by simulating a 20 m thick domain with not vertical connectivity to a deeper system. This approach provided a conservatively large drawdown extent and magnitude for the purpose of simulating effects on nearby features.

APPENDIX A

GROUNDWATER LEVEL DATA



Table A1: Groundwater Level Head and Calibration Results

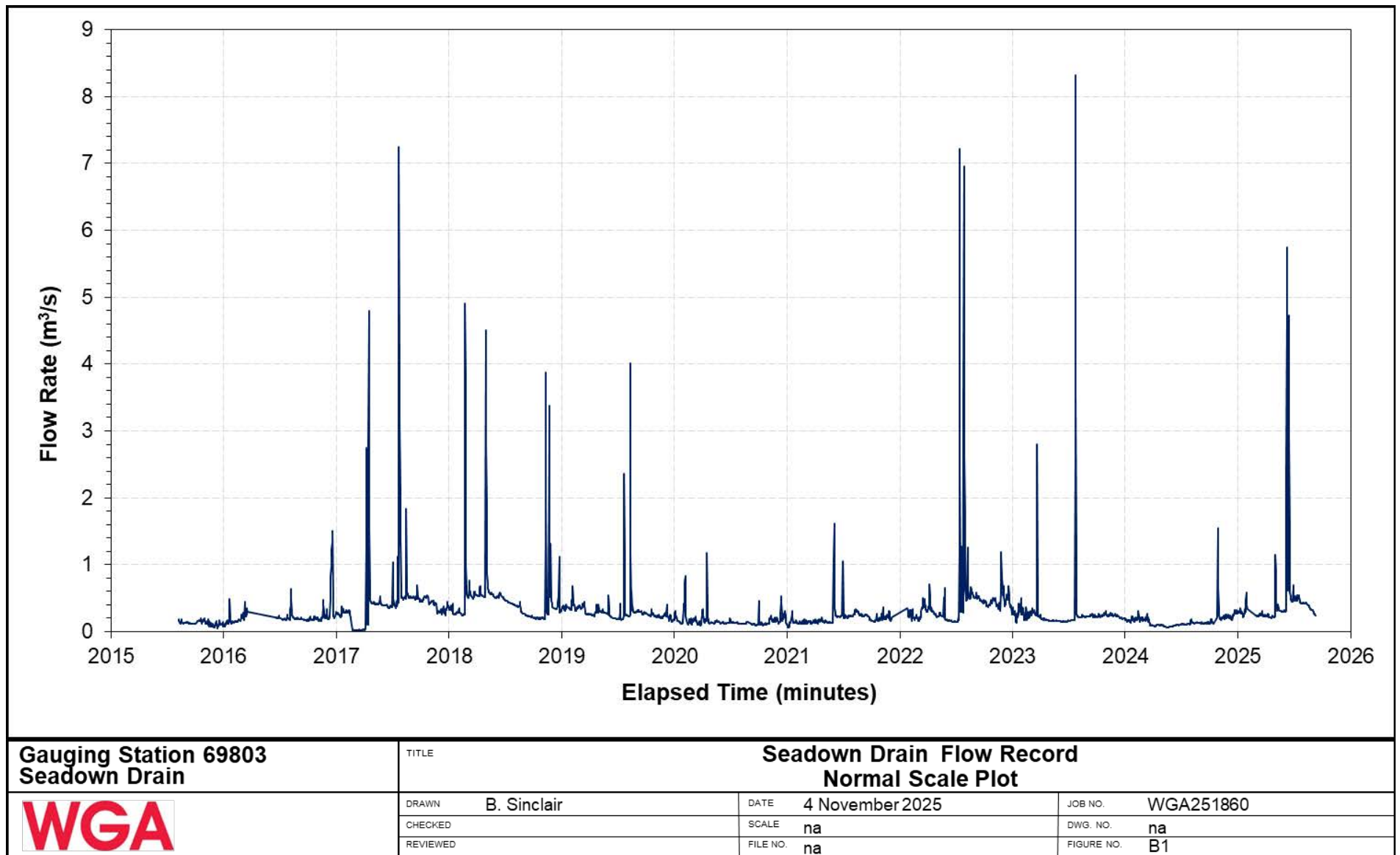
BORE LOCATION	NZTMX	NZTMY	MEDIUM HEAD (m RL)	STD DEV (m)	VARIANCE	INVERSE OF STANDARD DEVIATION	WEIGHT (CAPPED AT 5)	COMPUTED (m RL)	RESIDUAL (m)
K38/2300	1466952	5095141	1.78	0.51	0.26	1.98	1.98	1.12	0.66
K38/0185	1463212	5090768	2.25	0.14	0.02	7.07	5.00	2.34	-0.09
K38/0860	1465589	5095249	2.54	0.14	0.02	7.07	5.00	2.63	-0.09
K38/0087	1465240	5095688	2.77	0.14	0.02	7.07	5.00	3.18	-0.41
K38/0347	1462016	5089319	2.89	0.28	0.08	3.54	3.54	2.97	-0.08
BZ19/0223	1463906	5091997	3.70	0.89	0.80	1.12	1.12	3.14	0.56
K39/0033	1460397	5087161	3.72	0.24	0.06	4.16	4.16	3.74	-0.02
K39/0025	1460515	5087600	4.77	0.32	0.10	3.13	3.13	4.64	0.13
K39/0027	1460449	5087570	4.83	0.14	0.02	7.07	5.00	4.78	0.05
K39/0045	1460249	5087580	5.05	0.50	0.25	1.99	1.99	5.14	-0.09
K39/0006	1460449	5088080	5.14	0.42	0.17	2.40	2.40	5.35	-0.21
BZ19/0133	1461295	5089931	5.45	0.92	0.85	1.09	1.09	5.44	0.01
K38/1290	1463457	5092265	5.67	0.10	0.01	10.51	5.00	5.46	0.21
BZ19/0239	1462461	5091184	5.80	0.28	0.08	3.54	3.54	5.52	0.28
K38/0824	1462743	5092348	6.00	0.45	0.20	2.21	2.21	6.26	-0.26
BZ19/0416	1460502	5088590	6.04	0.82	0.67	1.23	1.23	5.83	0.21
K38/0089	1462250	5092238	6.16	0.21	0.05	4.71	4.71	6.75	-0.59
K38/0436	1461830	5092158	6.47	0.49	0.25	2.02	2.02	7.54	-1.07
BZ19/0240	1461978	5091858	6.70	0.42	0.18	2.36	2.36	6.74	-0.04
K38/0437	1461901	5091183	7.03	1.19	1.41	0.84	0.84	6.35	0.68
K38/2358	1461931	5092329	7.25	0.35	0.13	2.83	2.83	7.64	-0.39
K38/0270	1463363	5093456	7.62	0.78	0.61	1.29	1.29	7.54	0.08

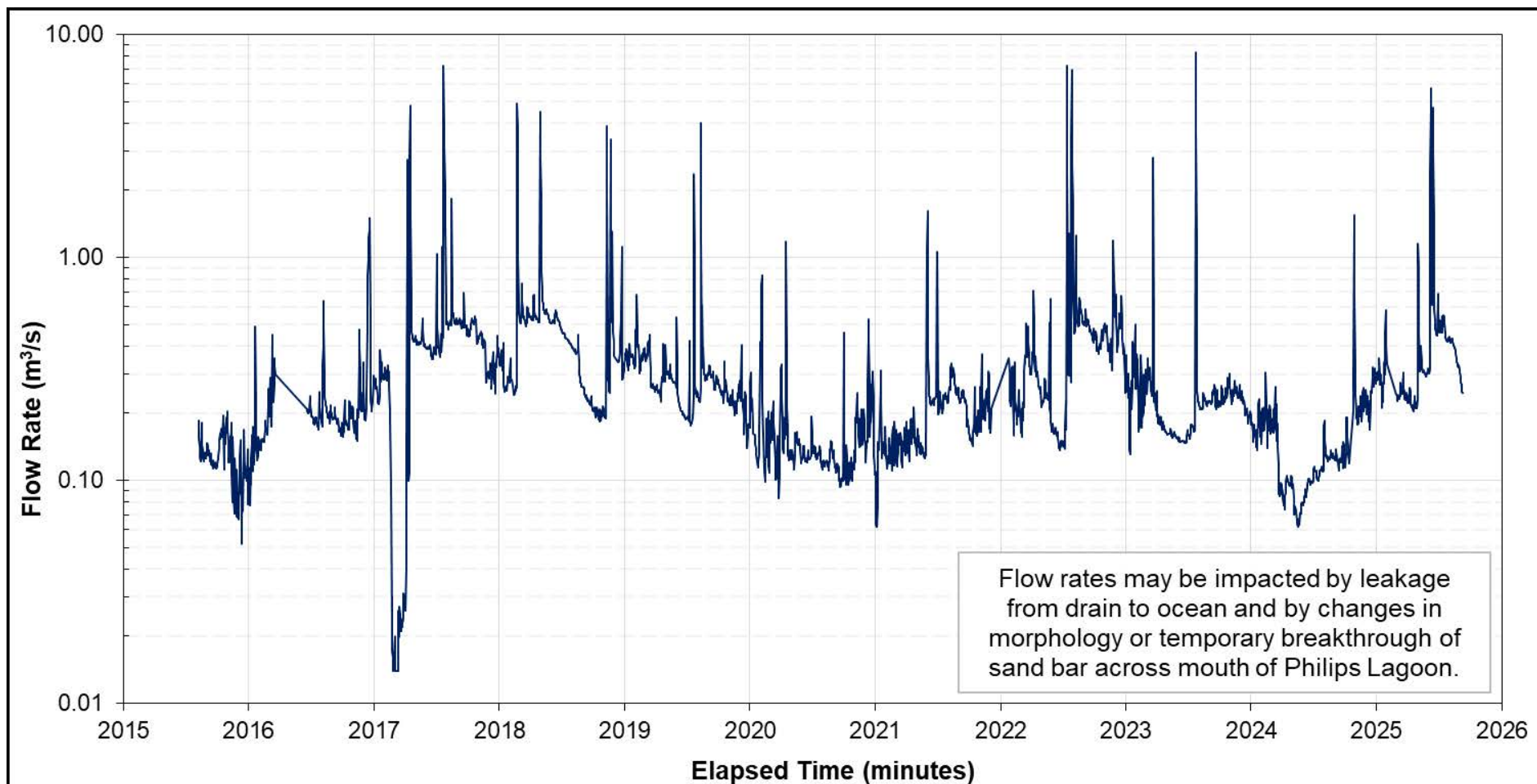
BORE LOCATION	NZTMX	NZTMY	MEDIUM HEAD (m RL)	STD DEV (m)	VARIANCE	INVERSE OF STANDARD DEVIATION	WEIGHT (CAPPED AT 5)	COMPUTED (m RL)	RESIDUAL (m)
K38/0424	1462883	5092929	7.72	0.38	0.15	2.62	2.62	7.16	0.56
K38/1085	1463002	5093575	8.01	0.23	0.05	4.33	4.33	7.97	0.04
K38/0088	1462381	5092897	8.07	1.61	2.59	0.62	0.62	7.93	0.14
K38/2420	1463796	5095006	8.37	0.48	0.23	2.09	2.09	8.56	-0.19
BZ19/0250	1463796	5095006	8.42	0.48	0.23	2.08	2.08	8.56	-0.14
K38/2419	1463413	5094535	8.55	0.61	0.37	1.65	1.65	8.70	-0.15
K38/0430	1462297	5092828	8.58	0.73	0.53	1.38	1.38	7.99	0.59
BZ19/0249	1463413	5094535	8.70	0.61	0.37	1.64	1.64	8.70	0.00
J38/0012	1458498	5089362	8.79	0.28	0.08	3.54	3.54	9.32	-0.53
BZ19/0238	1462424	5093133	9.00	0.42	0.18	2.36	2.36	8.40	0.60
BZ19/0248	1462687	5094711	10.18	0.65	0.42	1.55	1.55	10.04	0.14
K38/2418	1462687	5094711	10.23	0.64	0.41	1.57	1.57	10.04	0.19
J38/0255	1459846	5090507	10.47	1.04	1.07	0.97	0.97	11.15	-0.68
J38/0139	1459973	5090318	10.87	1.56	2.42	0.64	0.64	9.73	1.14
K38/2417	1462857	5095504	10.96	0.40	0.16	2.50	2.50	11.27	-0.31
K38/0172	1461409	5093458	10.99	0.87	0.77	1.14	1.14	11.60	-0.61
BZ19/0247	1462857	5095504	11.01	0.40	0.16	2.51	2.51	11.27	-0.26
K38/0290	1463162	5095645	11.53	0.64	0.41	1.56	1.56	10.79	0.74
K38/0289	1463245	5096011	11.66	0.46	0.21	2.18	2.18	11.30	0.36
K38/1899	1461031	5092646	12.80	0.11	0.01	9.35	5.00	12.54	0.26
K38/2210	1460569	5093424	12.97	0.98	0.96	1.02	1.02	13.73	-0.76

APPENDIX B

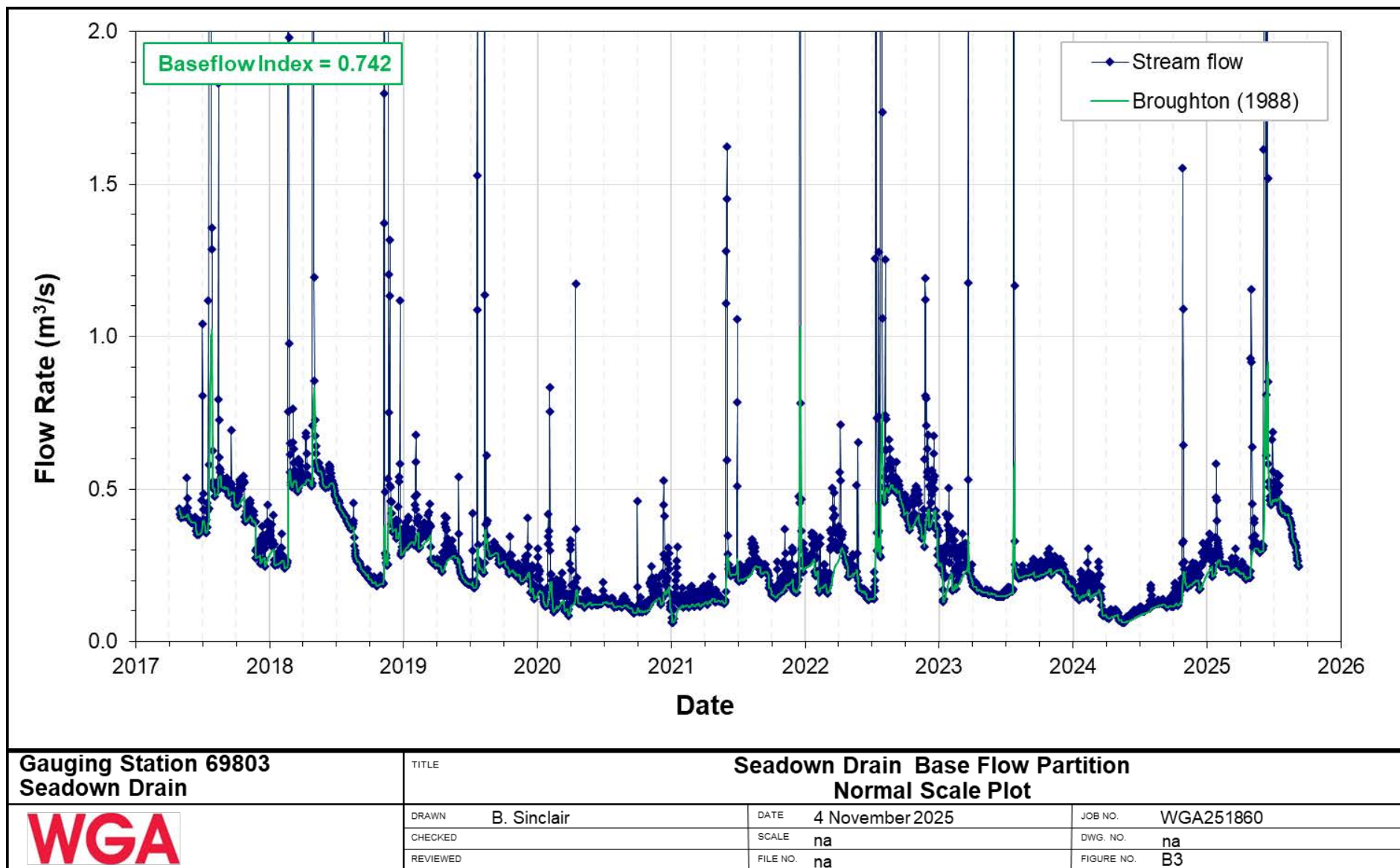
SURFACE WATER LEVEL AND FLOW RECORDS

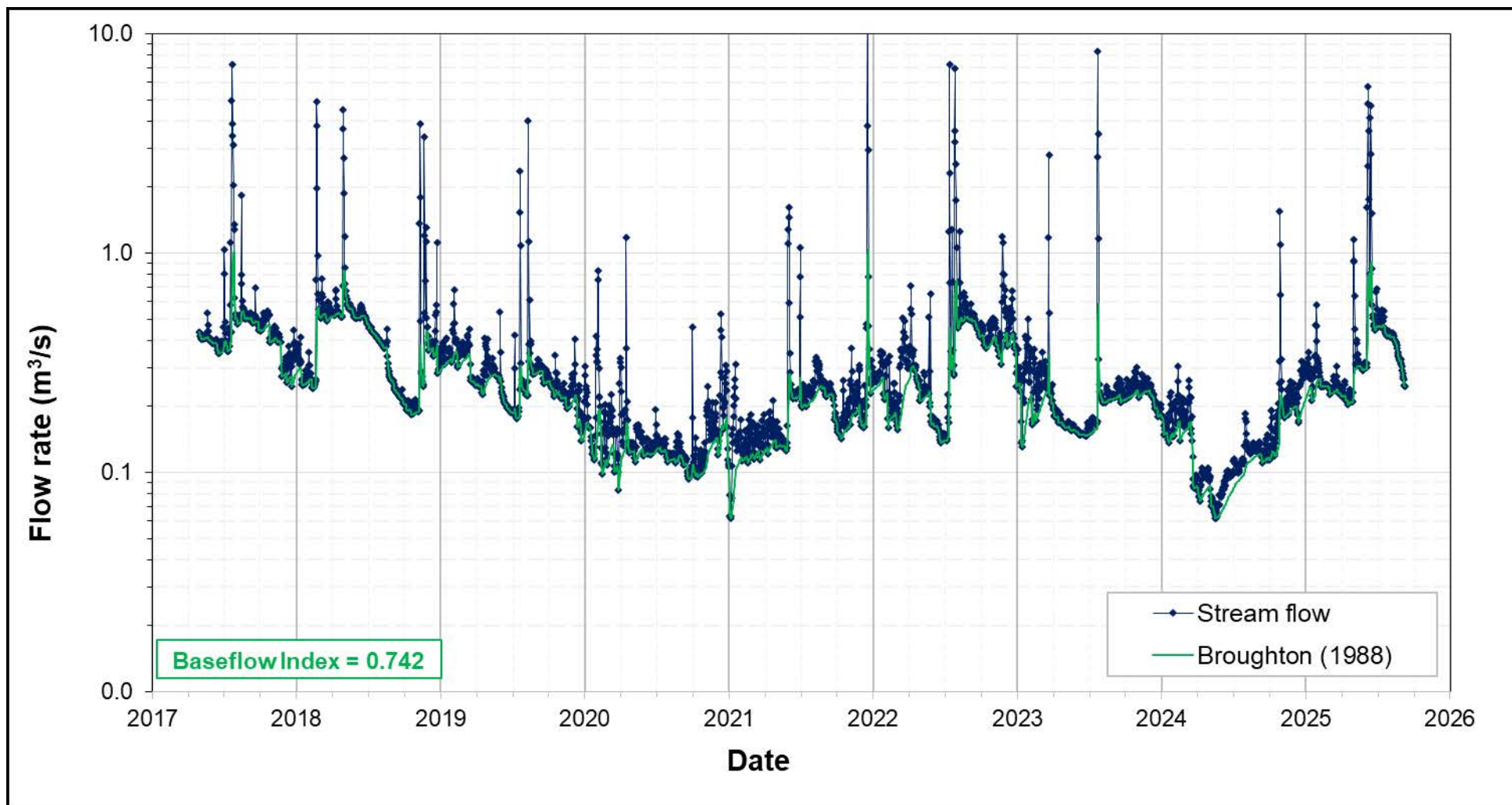




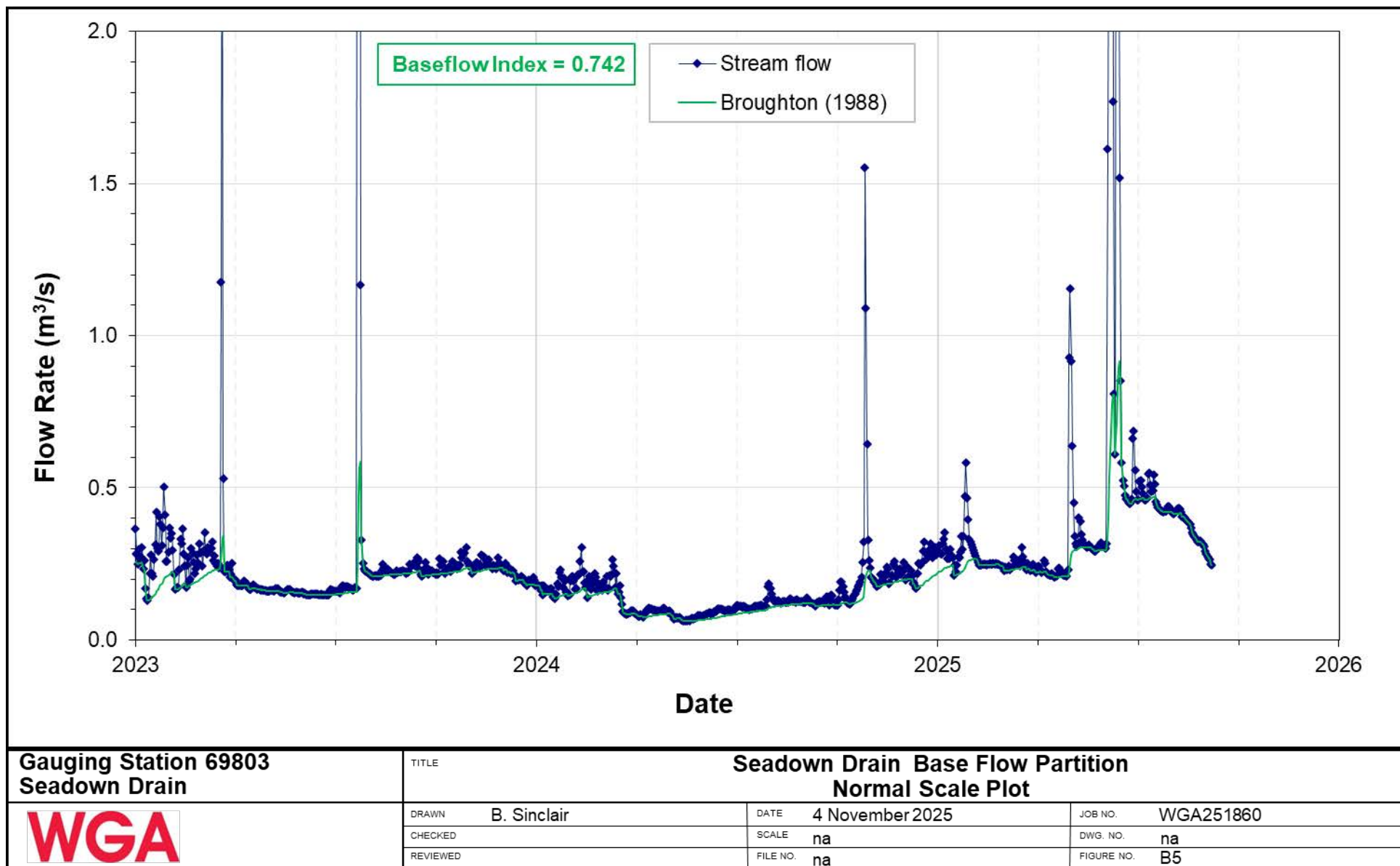


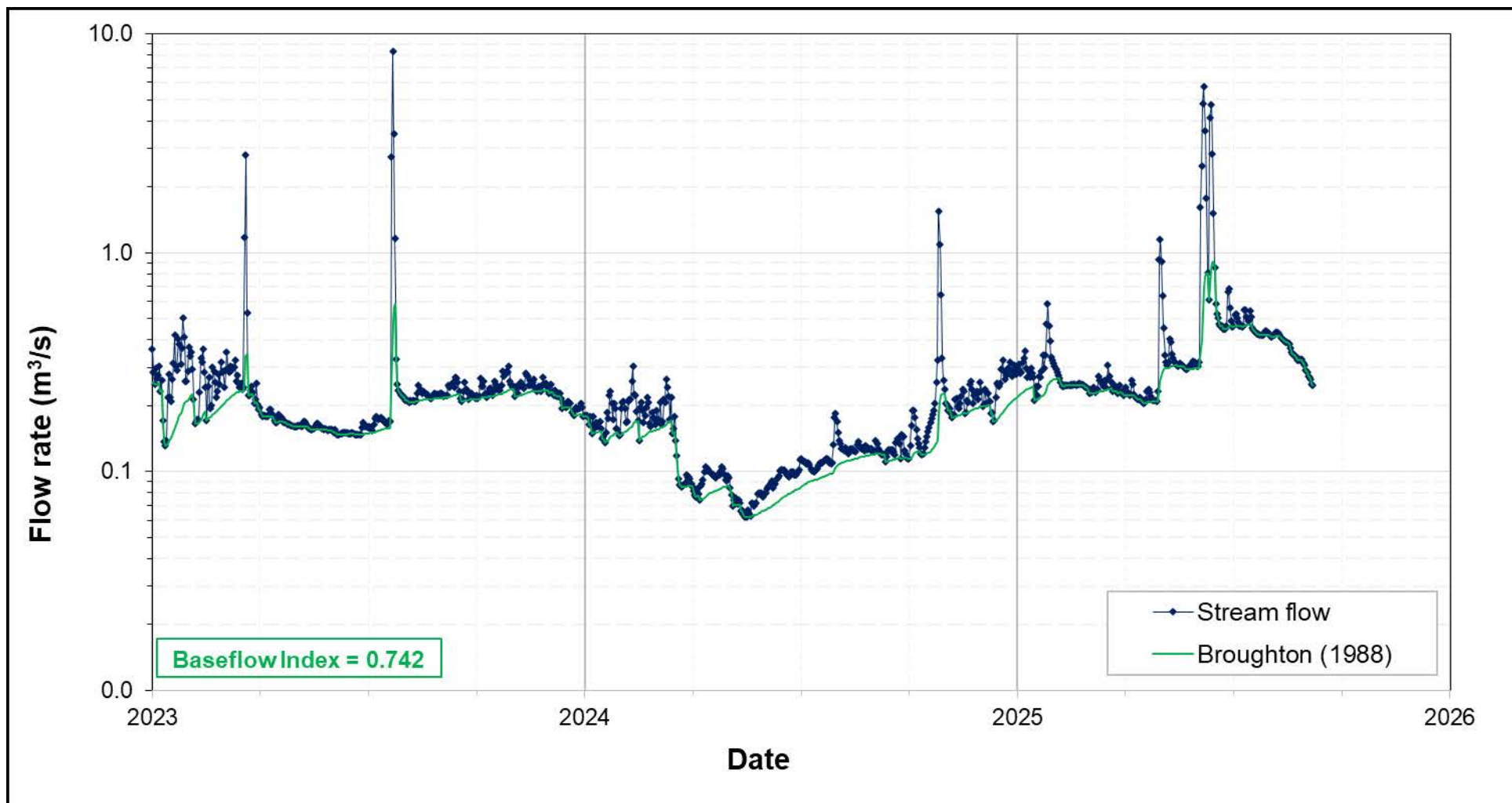
Gauging Station 69803 Seadown Drain	TITLE Seadown Drain Flow Record Log Scale plot					
	DRAWN	B. Sinclair	DATE	4 November 2025	JOB NO.	WGA251860
	CHECKED		SCALE	na	DWG. NO.	na
	REVIEWED		FILE NO.	na	FIGURE NO.	B2





Gauging Station 69803 Seadown Drain	TITLE Seadown Drain Base Flow Partition Log Scale plot		
	DRAWN B. Sinclair	DATE 4 November 2025	JOB NO. WGA251860
	CHECKED	SCALE na	DWG. NO. na
	REVIEWED	FILE NO. na	FIGURE NO. B4





Gauging Station 69803 Seadown Drain	Seadown Drain Base Flow Partition Log Scale plot			
	DRAWN	B. Sinclair	DATE	4 November 2025
	CHECKED		JOB NO.	WGA251860
	REVIEWED		DWG. NO.	na
			FILE NO.	na
			FIGURE NO.	B6

APPENDIX C

SOILS FACT SHEETS



Legend

Soil Drainage

-  Very Poorly Drained
-  Poorly Drained
-  Imperfectly drained
-  Moderately well drained
-  Well drained

Polygons & Labels

-  S-map soil data

S-MAPONLINE



© Basemap & context layers contains data sourced from the LINZ Data Service licensed for reuse under CC BY 4.0.
© Landcare Research NZ Limited 2009-2025.
Licensed under Creative Commons Attribution-NonCommercial-NoDerivs 3.0 New Zealand.

The information depicted in this map has been derived from numerous sources. It may not be complete, correct or up to date. This map is licensed by Landcare Research NZ Limited on an "as is" and "as available" basis and without any warranty of any kind, either express or implied.

Landcare Research shall not be liable on any legal basis (including without limitation negligence) and expressly excludes all liability for loss or damage howsoever and whenever caused to a user of this map.

Printed: 14:39:48 PM Wed, 11 Feb 2026

APPENDIX D

DRILLHOLE LITHOLOGICAL LOG SUMMARY



WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0015	0.2	Topsoil				
BZ19/0015	0.5	Silt				
BZ19/0015	3.5	Gravel				
BZ19/0015	4	Gravel				
BZ19/0015	6	Gravel				
BZ19/0015	7.5	Silt				
BZ19/0015	8.5	Gravel				
BZ19/0015	9.7	Gravel	Silty			
BZ19/0057	1.6	Topsoil	Clayey, gravelly			
BZ19/0057	5.9	Gravel	Silty, sandy			
BZ19/0057	10.5	Gravel		Sand		
BZ19/0057	42.59	Gravel	Clayey, sandy			
BZ19/0057	47.5	Sand		Gravel		
BZ19/0057	48.29	Clay				
BZ19/0057	82.5	Gravel				
BZ19/0083	0.91	Topsoil	Clayey			
BZ19/0083	7.61	Gravel	Clayey			
BZ19/0083	7.92	Gravel				
BZ19/0083	9.14	Gravel	Clayey			
BZ19/0083	9.44	Gravel				
BZ19/0108	0.2	Topsoil				
BZ19/0108	1	Clay	Silty			
BZ19/0108	4	Gravel				
BZ19/0108	8	Gravel				
BZ19/0108	9.5	Gravel	Silty			
BZ19/0108	10.5	Gravel	Clayey			
BZ19/0109	0.4	Topsoil				
BZ19/0109	2.1	Clay				
BZ19/0109	6.1	Gravel				
BZ19/0109	8	Silt	Clayey			
BZ19/0109	11.6	Gravel				
BZ19/0116	0.2	Topsoil				
BZ19/0116	1	Gravel	Silty			
BZ19/0116	5	Gravel				
BZ19/0116	9	Gravel				
BZ19/0116	10.3	Gravel	Clayey			
BZ19/0117	0.2	Topsoil				
BZ19/0117	1	Silt				
BZ19/0117	3.5	Gravel				
BZ19/0117	6.5	Gravel				
BZ19/0117	12	Clay	Gravelly			
BZ19/0137	0.2	Topsoil				
BZ19/0137	4	Silt				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0137	5.5	Gravel	Clayey			
BZ19/0137	12	Gravel	Clayey			
BZ19/0138	1	Topsoil				
BZ19/0138	5.5	Clay				
BZ19/0138	8	Clay				
BZ19/0138	12	Gravel	Clayey			
BZ19/0138	17	Gravel				
BZ19/0138	18	Clay				
BZ19/0138	23	Gravel	Sandy			
BZ19/0138	32	Sand	Cobbley			
BZ19/0138	34	Sand	Cobbley			
BZ19/0138	36	Sand	Cobbley			
BZ19/0150	0.2	Topsoil				
BZ19/0150	2.7	Gravel	Silty			
BZ19/0150	10.4	Gravel	Silty			
BZ19/0150	11.4	Clay				
BZ19/0150	15	Gravel	Silty		Clay	
BZ19/0150	17.5	Gravel		Sand		
BZ19/0150	18	Sand				
BZ19/0156	0.1	Topsoil				
BZ19/0156	3.1	Gravel		Silt		
BZ19/0156	4.2	Gravel			Silt	
BZ19/0156	11.5	Gravel		Silt and sand		
BZ19/0156	12	Gravel	Silty	Clay		
BZ19/0166	0.2	Topsoil				
BZ19/0166	5	Clay				
BZ19/0166	7	Gravel				
BZ19/0166	8.5	Gravel				
BZ19/0166	12.5	Gravel	Clayey			
BZ19/0167	0.2	Topsoil				
BZ19/0167	5	Clay				
BZ19/0167	6	Gravel	Clayey			
BZ19/0167	8	Gravel				
BZ19/0167	10.5	Gravel	Clayey			
BZ19/0167	11.5	Gravel				
BZ19/0168	0.2	Topsoil				
BZ19/0168	0.4	Clay				
BZ19/0168	8	Gravel	Silty	Clay		
BZ19/0168	14.5	Gravel	Silty	Sand		
BZ19/0174	0.5	Topsoil		Gravel		
BZ19/0174	10	Clay		Gravel		
BZ19/0174	13	Gravel				
BZ19/0174	15	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0174	17.5	Clay		Gravel		
BZ19/0186	0.3	Topsoil				
BZ19/0186	1	Clay				
BZ19/0186	9	Gravel	Cobbley	Sand		
BZ19/0186	10	Gravel	Sandy			
BZ19/0186	44	Gravel	Clayey	Sand	Cobbles	
BZ19/0186	46	Gravel	Gravelly	Sand		
BZ19/0186	51	Clay				
BZ19/0186	52	Gravel		Sand		
BZ19/0186	56	Gravel		Sand		
BZ19/0186	61	Clay				
BZ19/0186	64	Gravel			Sand	
BZ19/0186	78	Clay	Silty			
BZ19/0186	79	Gravel		Sand		
BZ19/0186	82	Clay				
BZ19/0186	84	Gravel	Sandy			
BZ19/0195	0.2	No Log				
BZ19/0195	0.65	No Log				
BZ19/0195	1.4	No Log				
BZ19/0196	0.3	No Log				
BZ19/0196	0.5	No Log				
BZ19/0196	1.8	No Log				
BZ19/0197	0.2	No Log				
BZ19/0197	0.9	No Log				
BZ19/0197	2.3	No Log				
BZ19/0198	0.25	No Log				
BZ19/0198	0.5	No Log				
BZ19/0198	1.1	No Log				
BZ19/0198	2.8	No Log				
BZ19/0199	0.25	No Log				
BZ19/0199	0.5	No Log				
BZ19/0199	1.1	No Log				
BZ19/0199	2.8	No Log				
BZ19/0201	0.25	No Log				
BZ19/0201	0.45	No Log				
BZ19/0201	0.9	No Log				
BZ19/0201	2.6	No Log				
BZ19/0221	6	Gravel				Silt
BZ19/0221	52	Clay		Gravel		
BZ19/0221	54	Gravel			Silt	
BZ19/0221	66	Clay		Gravel		
BZ19/0221	72	Clay		Gravel		
BZ19/0221	78	Clay		Gravel		

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0221	84	Clay			Gravel	
BZ19/0221	90	Clay			Gravel	
BZ19/0221	99	Gravel		Clay		
BZ19/0221	102	Gravel		Clay		
BZ19/0221	111	Clay	Gravelly			
BZ19/0221	114	Gravel	Sandy			
BZ19/0221	120	Clay		Gravel		
BZ19/0222	1	Topsoil				
BZ19/0222	5	Gravel			Silt	
BZ19/0222	11	Gravel			Silt	
BZ19/0222	30	Clay		Gravel		
BZ19/0222	36	Clay	Gravelly			
BZ19/0222	50	Clay	Gravelly			
BZ19/0222	54	Gravel				
BZ19/0222	66	Clay		Gravel		
BZ19/0222	74	Clay		Gravel		
BZ19/0222	81	Gravel		Sand		
BZ19/0225	3	Topsoil				
BZ19/0225	6	Gravel			Silt	
BZ19/0225	10	Gravel				
BZ19/0225	31	Gravel				
BZ19/0225	34	Sand		Gravel		
BZ19/0225	65	Gravel			Clay	
BZ19/0225	118	Gravel	Clayey			
BZ19/0225	124	Gravel		Sand		
BZ19/0225	132	Clay	Gravelly			
BZ19/0252	0.5	Topsoil				
BZ19/0252	4	Gravel			Silt	
BZ19/0252	6	Gravel			Silt	
BZ19/0252	7	Gravel			Clay	
BZ19/0252	12	Boulders				Silt
BZ19/0253	0.1	Silt				Sand
BZ19/0253	0.3	Gravel	Sandy			
BZ19/0253	0.7	Silt				Sand
BZ19/0253	1.2	Silt				Sand
BZ19/0253	3	Gravel	Sandy			
BZ19/0254	0.2	Gravel	Sandy			
BZ19/0254	0.5	Silt				Sand
BZ19/0254	0.9	Silt				Sand
BZ19/0254	3	Gravel	Sandy			
BZ19/0255	0.5	Gravel	Sandy			
BZ19/0255	0.7	Silt				Sand
BZ19/0255	1.3	Silt			Sand	

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0255	3	Gravel	Sandy			
BZ19/0256	0.3	Gravel	Sandy			
BZ19/0256	0.7	Silt				Sand
BZ19/0256	1.3	Silt			Sand	
BZ19/0256	3	Gravel	Sandy			
BZ19/0257	0.2	Gravel	Sandy			
BZ19/0257	0.4	Silt			Sand	
BZ19/0257	0.7	Silt		Sand		
BZ19/0257	1.5	Gravel	Sandy			
BZ19/0257	2	Gravel	Sandy			Silt
BZ19/0257	6.55	Gravel	Sandy			
BZ19/0257	7.1	Silt			Clay	
BZ19/0257	7.5	Sand			Silt	
BZ19/0257	7.6	Silt		Sand		Gravel
BZ19/0257	9	Gravel	Sandy			
BZ19/0257	10	Gravel	Silty			
BZ19/0257	10.6	Gravel	Sandy			
BZ19/0277	0.2	Topsoil				
BZ19/0277	0.8	Clay				
BZ19/0277	3.2	Gravel	Silty			
BZ19/0277	5	Gravel				
BZ19/0285	0.3	Topsoil				
BZ19/0285	6	Clay				
BZ19/0285	8	Clay				Silt and sand
BZ19/0285	12	Gravel			Clay	Sand
BZ19/0289	0.4	Topsoil				
BZ19/0289	3	Clay				
BZ19/0289	4	Gravel				Sand
BZ19/0289	12	Gravel			Clay	Sand
BZ19/0290	3	Sand	Clayey			
BZ19/0290	6	Clay				
BZ19/0290	9	Gravel	Sandy			
BZ19/0290	12	Cobbles			Sand	
BZ19/0294	0.3	Topsoil				
BZ19/0294	3	Gravel		Sand		Clay
BZ19/0294	6	Gravel		Clay	Sand	
BZ19/0310	0.5	Topsoil				
BZ19/0310	2.5	Clay				
BZ19/0310	9	Gravel	Clayey	Sand		
BZ19/0310	10.1	Gravel	Sandy			
BZ19/0312	1	Topsoil				
BZ19/0312	8	Sand	Gravelly			
BZ19/0312	12	Sand	Gravelly			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0312	45	Sand	Gravelly			
BZ19/0312	51	Gravel	Sandy			
BZ19/0333	0.15	Topsoil				
BZ19/0333	1.2	Sand				
BZ19/0333	3.6	Sand	Silty			
BZ19/0333	4.6	Clay				
BZ19/0333	5.9	Clay				
BZ19/0333	9.1	Gravel	Silty			
BZ19/0333	11.8	Gravel	Sandy			
BZ19/0403	0.2	Topsoil				
BZ19/0403	1	Clay				
BZ19/0403	7	Gravel	Silty			
BZ19/0403	8	Gravel	Silty			
BZ19/0403	16.9	Gravel	Silty	Sand		
BZ19/0403	17.46	Gravel	Silty			
BZ19/0416	0.3	Topsoil				
BZ19/0416	1.7	Gravel	Sandy			
BZ19/0417	0.6	Topsoil				
BZ19/0417	1.2	Silt				
BZ19/0417	1.9	Sand	Silty			
BZ19/0417	2.1	Gravel	Sandy			
BZ19/0420	5	Cobbles				
BZ19/0420	12	Cobbles				
BZ19/0420	15	Other Sediment/Rock Type	Cobbley			
BZ19/0421	3	Gravel				
BZ19/0421	7	Clay	Gravelly			
BZ19/0421	11.5	Clay			Gravel	
BZ19/0421	40	Clay				
BZ19/0421	53	Clay				
BZ19/0439	0.3	Topsoil				
BZ19/0439	1.5	Gravel	Clayey			
BZ19/0439	5	Gravel		Clay		
BZ19/0439	9	Gravel		Clay		
BZ19/0439	17.32	Gravel		Clay		
BZ19/0440	0.3	Topsoil				
BZ19/0440	1.5	Gravel	Clayey			
BZ19/0440	9	Gravel		Clay		
BZ19/0440	17.29	Gravel		Clay		
BZ19/0441	0.3	Topsoil				
BZ19/0441	1.5	Gravel	Clayey			
BZ19/0441	9	Gravel		Clay		
BZ19/0441	17.29	Gravel		Clay		

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
BZ19/0447	0.3	Topsoil				
BZ19/0447	5	Clay	Gravelly			
BZ19/0447	9	Gravel	Clayey			
BZ19/0447	17.43	Sand	Gravelly			
BZ19/0513	0.3	Topsoil				
BZ19/0513	0.5	Silt	Clayey			
BZ19/0513	1	Gravel	Sandy	Silt		
BZ19/0514	0.4	Topsoil				
BZ19/0514	0.7	Silt	Clayey			
BZ19/0514	0.9	Gravel	Silty	Sand		
BZ19/0514	1	Gravel		Sand		
BZ19/0515	0.7	Topsoil				
BZ19/0515	1	Gravel	Sandy	Silt		
J38/0019	0.5	Topsoil				
J38/0019	4	Gravel				
J38/0019	4.3	Gravel	Clayey			
J38/0019	6.19	Gravel		Boulders		
J38/0019	8.19	Gravel	Clayey	Boulders		
J38/0019	9	Gravel	Clayey			
J38/0022	1	Topsoil				
J38/0022	2	Gravel				
J38/0022	4	Gravel	Clayey			
J38/0022	5	Gravel				
J38/0022	8.19	Clay				
J38/0104	3.05	Gravel				
J38/0104	5.79	Clay				
J38/0104	18.29	Gravel				
J38/0104	20.12	Clay				
J38/0104	27.43	Other Sediment/Rock Type				
J38/0104	53.34	Clay				
J38/0104	53.63	Sand				
J38/0104	96.32	Clay				
J38/0104	96.62	Sand				
J38/0104	99.36	Topsoil	Sandy			
J38/0104	108.51	Clay	Sandy			
J38/0110	6	Gravel	Sandy			
J38/0110	8	Gravel	Clayey			
J38/0110	9	Clay				
J38/0110	10	Gravel	Clayey			
J38/0111	0.15	Topsoil				
J38/0111	0.69	Clay				
J38/0111	6	Gravel	Clayey			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J38/0111	7	Gravel	Sandy			
J38/0111	9.8	Clay				
J38/0114	0.3	Topsoil				
J38/0114	1.2	Clay				
J38/0114	3.8	Gravel	Sandy			
J38/0114	5.8	Gravel				
J38/0114	9	Gravel	Clayey			
J38/0114	9.8	Gravel	Sandy			
J38/0114	13.8	Gravel	Clayey			
J38/0255	0.4	Topsoil				
J38/0255	1.9	Clay				
J38/0255	4.5	Gravel	Silty, sandy			
J38/0255	11	No Log				
J38/0255	17	Gravel	Silty, sandy			
J38/0255	20.2	Gravel	Silty, sandy			
J38/0255	21.9	Gravel	Clayey, silty			
J38/0255	23	Gravel	Silty			
J38/0255	24.79	Gravel	Silty			
J38/0255	25.1	Gravel	Clayey, silty			
J38/0633	0.2	Topsoil				
J38/0633	0.5	Clay				
J38/0633	6.2	Gravel				
J38/0633	7.5	Gravel	Clayey			
J38/0660	0.25	Topsoil				
J38/0660	1.5	Gravel				
J38/0660	3	Gravel	Clayey			
J38/0660	5.5	Gravel	Clayey			
J38/0660	9	Gravel	Clayey	Boulders		
J38/0660	10	Clay		Gravel		
J38/0897	3	Gravel	Sandy			
J38/0897	4.6	Gravel	Clayey			
J38/0897	6	Gravel				
J38/0897	9	Gravel	Sandy	Boulders		
J39/0001	0.15	Fill				
J39/0001	0.3	Topsoil				
J39/0001	4.27	Gravel				
J39/0001	5.79	Gravel	Clayey			
J39/0001	8.84	Gravel				
J39/0001	9.75	Clay				
J39/0002	0.61	Fill				
J39/0002	7	Gravel				
J39/0002	14.02	Clay				
J39/0002	19.82	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0002	23.17	Clay				
J39/0002	23.78	Gravel				
J39/0002	48.77	Silt	Clayey			
J39/0002	51.22	Sand				
J39/0002	60.98	Clay				
J39/0031	0.76	Topsoil	Clayey			
J39/0031	3.35	Gravel				
J39/0031	7.62	Clay				
J39/0031	8.83	Clay	Sandy			
J39/0031	9.75	Gravel	Clayey			
J39/0031	13.4	Gravel	Clayey			
J39/0031	16.1	Clay	Sandy			
J39/0031	21.3	Clay			Sand	
J39/0032	0.6	Clay				
J39/0032	3	Clay	Gravelly			
J39/0032	6.1	Clay				
J39/0032	13.1	Gravel	Sandy			
J39/0034	0.61	Topsoil				
J39/0034	1.22	Gravel	Sandy			
J39/0034	3.96	Gravel				
J39/0034	4.27	Gravel	Clayey			
J39/0034	7.01	Gravel	Sandy			
J39/0034	8.22	Clay				
J39/0088	0.5	Topsoil	Clayey			
J39/0088	3.5	Gravel	Sandy			
J39/0088	5	Gravel	Sandy	Clay		
J39/0088	7.3	Gravel	Sandy			
J39/0433	0.05	Fill				
J39/0433	0.5	Fill				
J39/0433	0.8	Silt				
J39/0433	3	Gravel	Clayey, silty			
J39/0433	5	Gravel	Sandy			
J39/0433	5.5	Gravel	Sandy	Clay		
J39/0434	0.05	Fill				
J39/0434	0.8	Gravel	Sandy			
J39/0434	1.4	Silt				
J39/0434	2.5	Silt				
J39/0434	4.6	Gravel	Sandy			
J39/0434	5.2	Gravel	Clayey			
J39/0435	0.05	Fill				
J39/0435	0.4	Fill				
J39/0435	2.2	Silt				
J39/0435	5.2	Gravel	Sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0436	0.1	Fill				
J39/0436	0.7	Fill				
J39/0436	1.8	Silt				
J39/0436	2.4	Silt				
J39/0436	5	Gravel	Sandy			
J39/0437	0.05	Fill				
J39/0437	1	Gravel	Sandy			
J39/0437	2.2	Silt				
J39/0437	5.1	Gravel				
J39/0463	0.3	Topsoil				
J39/0463	0.4	Silt			Gravel	
J39/0463	0.85	Gravel			Sand	
J39/0463	4.85	Gravel		Sand	Silt	
J39/0474	0.05	Fill				
J39/0474	0.7	Gravel	Sandy			
J39/0474	0.9	Silt				
J39/0474	1.8	Silt				
J39/0474	5.1	Gravel				
J39/0475	0.1	Fill				
J39/0475	0.4	Gravel	Sandy			
J39/0475	1	Silt				
J39/0475	1.8	Silt				
J39/0475	5.1	Gravel	Sandy			
J39/0476	0.2	Topsoil	Silty			
J39/0476	0.5	Fill				
J39/0476	1.7	Silt				
J39/0476	4.1	Gravel	Sandy			
J39/0477	0.2	Silt				
J39/0477	0.6	Gravel	Sandy			
J39/0477	1.7	Silt				
J39/0477	4	Gravel	Sandy			
J39/0478	0.1	Fill				
J39/0478	0.5	Gravel	Sandy			
J39/0478	1	Silt				
J39/0478	1.6	Silt				
J39/0478	5.3	Gravel	Sandy			
J39/0479	0.2	Fill				
J39/0479	0.8	Fill				
J39/0479	3.4	Gravel	Sandy			
J39/0479	6	Gravel	Sandy			
J39/0502	0.4	Fill				
J39/0502	0.8	Fill				
J39/0502	2	Silt				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0502	5.1	Gravel	Sandy			
J39/0503	0.05	Fill				
J39/0503	0.38	Fill				
J39/0503	0.5	Clay	Silty			
J39/0503	1.7	Silt				
J39/0503	4.5	Gravel	Sandy			
J39/0503	5	Sand	Silty			
J39/0504	0.05	Fill				
J39/0504	0.2	Fill				
J39/0504	0.4	Clay	Silty			
J39/0504	1.3	Silt				
J39/0504	1.5	Sand	Silty			
J39/0504	4.5	Gravel	Sandy			
J39/0504	5	Clay		Gravel		
J39/0505	0.3	Topsoil				
J39/0505	0.5	Silt		Gravel		
J39/0505	1.5	Silt				
J39/0505	1.7	Gravel	Silty			
J39/0505	5	Gravel	Sandy			
J39/0556	0.7	Fill				
J39/0556	3	Gravel				
J39/0556	10	Gravel	Clayey			
J39/0556	11	Gravel	Sandy			
J39/0556	15	Gravel	Sandy			
J39/0556	29	Clay				
J39/0556	32	Gravel	Sandy			
J39/0556	35.5	Clay				
J39/0556	37.5	Gravel				
J39/0556	40	Clay				
J39/0556	44	Gravel				
J39/0556	54	Clay				
J39/0556	60	Clay				
J39/0556	61	Sand				
J39/0556	64	Clay				
J39/0556	71.5	Clay				
J39/0556	72	Sand				
J39/0556	77.5	Clay				
J39/0556	79.2	Sand				
J39/0556	88.7	Clay				
J39/0556	90.2	Sand				
J39/0556	110.3	Clay				
J39/0556	137.6	Sand	Woody	Shells		
J39/0556	146.7	Clay				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0556	152.4	Sand				
J39/0556	156.3	Sand	Shelly			
J39/0556	159.2	Clay				
J39/0556	166.6	Gravel	Sandy			
J39/0556	168	Clay				
J39/0557	0.4	Fill				
J39/0557	0.9	Silt				
J39/0557	6.1	Gravel	Sandy			
J39/0558	0.4	Fill				
J39/0558	0.9	Silt	Gravelly			
J39/0558	6.1	Gravel	Sandy			
J39/0559	0.4	Fill				
J39/0559	0.9	Silt				
J39/0559	6	Gravel	Sandy			
J39/0560	0.25	Fill				
J39/0560	0.7	Silt				
J39/0560	6	Gravel	Silty	Sand		
J39/0561	0.1	Fill				
J39/0561	0.9	Fill				
J39/0561	1.2	Silt				
J39/0566	0.75	Fill				
J39/0566	1.2	Silt				
J39/0566	5.9	Gravel	Sandy			
J39/0567	0.8	Fill				
J39/0567	1.1	Silt				
J39/0567	6	Gravel	Sandy			
J39/0568	0.05	Fill				
J39/0568	0.9	Fill				
J39/0568	1.5	Silt				
J39/0568	5.9	Gravel		Silt and sand		
J39/0569	0.1	Fill				
J39/0569	0.9	Fill				
J39/0569	1.5	Silt				
J39/0569	1.6	Silt		Gravel		
J39/0569	6	Gravel	Sandy	Silt		
J39/0631	0.8	Fill				
J39/0631	2.3	Silt				
J39/0631	6.5	Gravel	Sandy			
J39/0632	0.8	Fill				
J39/0632	1.8	Silt				
J39/0632	6.5	Gravel	Sandy			
J39/0633	3.8	Fill				
J39/0633	6.5	Gravel	Sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0675	0.2	Fill				
J39/0675	1.2	Silt	Sandy			
J39/0675	6	Gravel	Sandy	Silt	Boulders	
J39/0734	1.9	Gravel	Sandy			
J39/0734	2	Silt	Gravelly			
J39/0734	2.6	Silt				
J39/0734	3	Gravel	Sandy			
J39/0734	3.2	Silt	Gravelly			
J39/0734	3.7	Gravel	Sandy			
J39/0734	4.2	Gravel	Sandy			
J39/0734	5	Gravel				
J39/0735	0.5	Gravel	Sandy			
J39/0735	0.55	Silt	Gravelly			
J39/0735	1.8	Silt	Gravelly			
J39/0735	2.2	Gravel	Sandy			
J39/0735	2.9	Silt	Gravelly			
J39/0735	2.95	Silt	Gravelly			Wood
J39/0735	3	Gravel	Sandy			
J39/0735	4.8	No Recovery				
J39/0736	0.5	Gravel	Sandy			
J39/0736	0.6	Silt	Gravelly			
J39/0736	2	Silt	Gravelly			
J39/0736	3	No Recovery				
J39/0736	4	Gravel	Sandy			
J39/0736	5	No Recovery				
J39/0742	0.05	Topsoil				
J39/0742	1.6	Cobbles	Sandy			
J39/0742	2	Clay				
J39/0742	4	Gravel	Sandy			
J39/0743	0.2	Fill				
J39/0743	1.3	Gravel	Sandy	Cobbles		
J39/0743	1.8	Gravel	Clayey			
J39/0743	2.2	Sand				
J39/0743	4	Gravel	Sandy			
J39/0744	0.2	Fill				
J39/0744	0.5	Gravel	Sandy			
J39/0744	0.8	Clay				
J39/0744	4.8	Gravel	Sandy			
J39/0744	5	Sand	Gravelly			
J39/0745	0.2	Fill				
J39/0745	1.05	Clay				Cobbles
J39/0745	4	Gravel	Sandy			
J39/0746	0.05	Gravel	Sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0746	0.1	Fill				
J39/0746	0.35	Gravel	Sandy			
J39/0746	0.85	Clay				
J39/0746	4	Gravel	Sandy			
J39/0747	0.05	Fill				
J39/0747	0.3	Gravel	Sandy			
J39/0747	0.8	Clay				
J39/0747	3.8	Gravel	Sandy			
J39/0747	4	Sand				
J39/0748	0.05	Fill				
J39/0748	0.5	Gravel	Sandy			
J39/0748	0.85	Clay				
J39/0748	4	Gravel	Sandy			
J39/0811	0.1	Gravel	Sandy		Cobbles	
J39/0811	0.11	Fill				
J39/0811	0.8	Gravel	Sandy			
J39/0811	1.2	Clay	Silty		Gravel	
J39/0811	4.3	Gravel	Clayey, sandy			
J39/0811	4.8	Silt	Clayey			
J39/0812	0.5	Fill				
J39/0812	1.1	Clay	Silty			
J39/0812	1.4	Gravel	Silty, sandy		Clay	
J39/0812	1.9	Gravel	Sandy			
J39/0812	2.2	No Log				
J39/0812	2.6	Gravel	Sandy			
J39/0812	4.1	Gravel	Sandy			
J39/0812	4.4	Clay	Silty			
J39/0812	4.9	Gravel	Silty			Clay
J39/0813	0.5	Fill	Sandy	Gravel		
J39/0813	1.1	Clay	Silty			
J39/0813	1.4	Gravel	Sandy			Clay and silt
J39/0813	1.9	Gravel				
J39/0813	2.6	Gravel	Sandy			
J39/0813	4.1	Gravel	Sandy			
J39/0813	4.4	Clay	Silty			
J39/0813	5	Gravel	Silty			Clay
J39/0814	0.3	Fill	Sandy	Gravel		
J39/0814	1.1	Clay	Silty			
J39/0814	1.4	Gravel	Silty, sandy		Clay	
J39/0814	2.6	Gravel	Sandy			
J39/0814	4.1	Gravel	Sandy			
J39/0814	4.4	Clay	Silty			
J39/0814	4.9	Gravel	Silty			Clay

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
J39/0815	0.3	Fill	Sandy	Gravel		
J39/0815	0.9	Clay	Silty			
J39/0815	1.4	Gravel	Sandy			Clay and silt
J39/0815	3.6	Gravel	Sandy			
J39/0815	4.1	Gravel	Sandy			
J39/0815	4.4	Clay	Silty			
J39/0815	5	Gravel	Silty			Clay
J39/0816	0.6	Fill	Sandy	Gravel		
J39/0816	0.9	Clay	Silty			
J39/0816	1.4	Gravel	Sandy			Clay and silt
J39/0816	2.6	Gravel	Sandy			
J39/0816	4	Gravel	Sandy			
J39/0816	4.4	Clay	Silty			
J39/0816	4.9	Gravel	Silty			Clay
J39/0817	0.4	Fill	Sandy	Gravel		
J39/0817	0.8	Clay	Silty			
J39/0817	1.4	Gravel	Sandy			Clay and silt
J39/0817	2.6	Gravel	Sandy			
J39/0817	4.1	Gravel	Sandy			
J39/0817	4.4	Clay	Silty			
J39/0817	4.9	Gravel	Silty			Clay
K38/0073	4.8	Sand	Gravelly			
K38/0073	6.19	Gravel	Sandy			
K38/0074	0.3	Topsoil				
K38/0074	2.13	Clay	Silty			
K38/0074	4.27	Gravel	Sandy			
K38/0074	4.88	Gravel	Sandy			
K38/0074	5.17	Gravel	Sandy			
K38/0074	6.09	Gravel	Sandy			
K38/0074	6.55	Gravel	Sandy	Clay		
K38/0075	0.61	Topsoil				
K38/0075	2.13	Clay	Silty			
K38/0075	3.96	Gravel	Sandy			
K38/0075	5.79	Gravel				
K38/0075	6.09	Gravel	Clayey			
K38/0076	0.91	Topsoil				
K38/0076	3.34	Gravel	Clayey			
K38/0076	5.79	Gravel				
K38/0076	6.09	Gravel	Sandy			
K38/0077	0.3	Topsoil	Clayey			
K38/0077	2.74	Gravel				
K38/0077	3.34	Gravel	Sandy			
K38/0077	5.79	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0077	6.09	Gravel	Clayey			
K38/0078	0.91	Topsoil	Clayey			
K38/0078	1.22	Gravel	Clayey			
K38/0078	3.96	Gravel				
K38/0078	5.79	Gravel	Clayey			
K38/0078	6.69	Gravel				
K38/0078	7.61	Gravel	Clayey			
K38/0079	0.3	Topsoil				
K38/0079	1.5	Gravel				
K38/0079	4.11	Gravel	Sandy			
K38/0079	6.69	Gravel				
K38/0079	7.61	Gravel	Clayey			
K38/0085	0.3	Topsoil				
K38/0085	0.91	Clay				
K38/0085	2.44	Gravel				
K38/0085	4.57	Gravel	Clayey, sandy			
K38/0085	5.48	Gravel				
K38/0085	6.09	Gravel				
K38/0085	6.4	Gravel	Clayey			
K38/0086	1.22	Topsoil	Clayey			
K38/0086	5.48	Gravel	Clayey			
K38/0086	6.09	Gravel				
K38/0086	7.01	Gravel	Clayey			
K38/0086	8.07	Gravel				
K38/0087	5.17	Gravel				
K38/0087	5.79	Clay				
K38/0087	7.92	Gravel	Sandy			
K38/0088	1.2	Topsoil	Clayey			
K38/0088	1.7	Gravel	Clayey			
K38/0088	6	Gravel	Clayey, sandy			
K38/0088	10.5	Gravel	Sandy			
K38/0088	11	Clay				
K38/0089	2.2	Topsoil	Silty, sandy			
K38/0089	4.59	Gravel	Clayey			
K38/0089	7	Gravel				
K38/0089	10.2	Clay				
K38/0089	10.6	Clay				
K38/0090	7	Clay	Gravelly			
K38/0170	6.5	No Log				
K38/0170	8	Gravel				
K38/0170	9	Gravel	Clayey			
K38/0195	2.13	Clay				
K38/0195	3.34	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0195	3.96	Gravel				
K38/0195	6.09	Gravel				
K38/0195	6.4	Sand				
K38/0202	0.3	Topsoil				
K38/0202	3.05	Clay				
K38/0202	7.01	Gravel				
K38/0202	7.3	Gravel	Sandy			
K38/0203	1.22	Clay				
K38/0203	1.83	Gravel				
K38/0203	5.48	Gravel				
K38/0203	7.92	Gravel	Clayey			
K38/0203	8.52	Gravel				
K38/0212	0.3	Topsoil				
K38/0212	0.89	Sand	Silty			
K38/0212	1.83	Gravel				
K38/0212	2.74	Gravel				
K38/0212	7.01	Gravel	Sandy			
K38/0229	1.3	No Log				
K38/0229	2.09	Clay				
K38/0229	2.9	Silt				
K38/0229	3.09	Gravel	Silty			
K38/0229	7	Gravel				
K38/0229	12	Gravel	Clayey			
K38/0230	2	Gravel	Sandy			
K38/0230	7	Gravel	Clayey			
K38/0230	9	Gravel				
K38/0230	9.75	Gravel	Clayey			
K38/0230	12	Gravel	Clayey			
K38/0272	0.15	Topsoil				
K38/0272	0.3	Silt				
K38/0272	3	Gravel				
K38/0272	3.2	Gravel				
K38/0272	5.5	Silt	Clayey			
K38/0272	9	Gravel				
K38/0272	9.8	Gravel	Clayey			
K38/0281	7.9	Gravel	Sandy			
K38/0286	0.3	Topsoil				
K38/0286	2.13	No Log				
K38/0286	7.92	Gravel	Sandy			
K38/0299	0.4	Topsoil				
K38/0299	5.09	Sand				
K38/0299	6.5	Gravel				
K38/0299	8.5	Silt				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0299	9.1	Gravel				
K38/0327	0.91	Topsoil	Clayey			
K38/0327	7.61	Gravel	Clayey			
K38/0327	7.92	Gravel				
K38/0327	9.14	Gravel	Clayey			
K38/0327	9.44	Gravel				
K38/0456	1.8	Clay				
K38/0456	8.5	Gravel				
K38/0536	0.2	Topsoil				
K38/0536	3.4	Clay				
K38/0536	4.19	Gravel	Clayey			
K38/0536	7.59	Gravel	Sandy			
K38/0536	8	Gravel	Silty			
K38/0536	9	Gravel	Silty			
K38/0537	0.3	Topsoil				
K38/0537	1.5	Silt				
K38/0537	3	Gravel				
K38/0537	3.8	Silt	Clayey			
K38/0537	7.5	Gravel				
K38/0608	0.2	Topsoil				
K38/0608	3.5	Gravel	Clayey			
K38/0608	9	Gravel				
K38/0689	0.2	Topsoil				
K38/0689	3.4	Clay				
K38/0689	4.19	Gravel	Clayey			
K38/0689	7.59	Gravel	Sandy			
K38/0689	8	Gravel	Silty			
K38/0689	9	Gravel	Silty			
K38/0758	34.09	No Log				
K38/0758	34.5	Gravel	Clayey			
K38/0758	35	Gravel	Sandy			
K38/0758	35.4	Gravel	Clayey			
K38/0758	36.2	Gravel	Sandy			
K38/0758	36.4	Gravel	Clayey			
K38/0758	37.09	Gravel	Sandy			
K38/0758	37.2	Gravel	Clayey			
K38/0758	37.5	Gravel	Sandy			
K38/0758	38	Gravel	Clayey			
K38/0758	39.4	Gravel	Sandy			
K38/0759	0.25	Topsoil				
K38/0759	0.85	Clay				
K38/0759	3	Gravel	Clayey			
K38/0759	6.5	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0759	9.5	Silt	Clayey		Gravel	
K38/0766	0.2	Topsoil	Silty			
K38/0766	1	Silt				
K38/0766	1.5	Gravel	Silty			
K38/0766	1.8	Silt	Clayey			
K38/0766	2	Gravel	Silty			
K38/0766	2.2	Gravel	Silty, sandy			
K38/0767	0.2	Topsoil	Silty			
K38/0767	0.8	Silt				
K38/0767	1.35	Gravel	Clayey, silty			
K38/0767	1.6	Gravel	Silty, sandy			
K38/0768	0.2	Topsoil	Silty			
K38/0768	0.5	Silt				
K38/0768	0.69	Gravel	Clayey, silty			
K38/0768	1.2	Gravel	Clayey, silty			
K38/0768	1.6	Gravel	Silty, sandy			
K38/0768	2	Gravel	Silty, sandy			
K38/0769	0.2	Fill				
K38/0769	0.75	Silt				
K38/0769	1.4	Silt	Clayey			
K38/0769	1.7	Silt				
K38/0769	2.09	Gravel	Clayey, silty			
K38/0769	2.4	Gravel	Clayey, silty			
K38/0771	0.2	Topsoil	Silty			
K38/0771	0.8	Silt				
K38/0771	1.3	Silt	Clayey			
K38/0771	1.45	Silt	Clayey			
K38/0771	1.65	Gravel	Clayey, silty			
K38/0771	2.4	Gravel	Silty, sandy			
K38/0772	0.2	Topsoil	Silty			
K38/0772	0.6	Silt				
K38/0772	1.2	Silt	Clayey			
K38/0772	1.85	Gravel	Clayey, silty			
K38/0772	2.2	Gravel	Clayey, sandy			
K38/0773	0.3	Topsoil	Silty			
K38/0773	0.69	Gravel	Sandy			
K38/0773	1.3	Gravel				
K38/0773	1.7	Gravel	Clayey, silty			
K38/0794	0.4	Topsoil				
K38/0794	2	Gravel				
K38/0794	6.8	Gravel				
K38/0794	8	Gravel	Clayey			
K38/0795	0.2	Topsoil				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0795	0.7	Clay				
K38/0795	1.2	Gravel	Clayey			
K38/0795	3	Gravel	Sandy			
K38/0795	4.5	Gravel				
K38/0795	6.8	Gravel	Sandy			
K38/0795	8.2	Gravel	Clayey			
K38/0795	9.5	Gravel	Clayey			
K38/0796	0.2	Topsoil				
K38/0796	0.8	Silt				
K38/0796	3	Gravel				
K38/0796	6.2	Gravel				
K38/0796	7	Silt	Clayey			
K38/0796	9	Gravel				
K38/0797	0.2	Topsoil				
K38/0797	0.89	Silt				
K38/0797	3.2	Gravel				
K38/0797	7.8	Gravel				
K38/0797	8.5	Gravel	Clayey			
K38/0798	0.2	Topsoil				
K38/0798	0.4	Clay				
K38/0798	1	Silt				
K38/0798	4	Gravel				
K38/0798	6.8	Gravel				
K38/0798	7.69	Gravel	Clayey			
K38/0798	10	Gravel				
K38/0799	0.2	Topsoil				
K38/0799	1	Silt				
K38/0799	4.09	Gravel				
K38/0799	5.9	Gravel				
K38/0799	6.19	Gravel	Clayey			
K38/0799	9.5	Gravel				
K38/0800	0.2	Topsoil				
K38/0800	0.89	Silt				
K38/0800	5	Gravel				
K38/0800	7	Gravel				
K38/0800	7.8	Silt	Clayey			
K38/0800	10	Gravel				
K38/0815	0.2	Silt				
K38/0815	2.4	Gravel	Silty, sandy			
K38/0815	5.5	Gravel	Silty, sandy			
K38/0821	0.2	Topsoil				
K38/0821	1.2	Gravel				
K38/0821	3.5	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/0821	5	Gravel				
K38/0821	7.5	Gravel				
K38/0821	9.5	Gravel	Clayey			
K38/0822	0.2	Topsoil				
K38/0822	0.8	Gravel				
K38/0822	4	Gravel				
K38/0822	4.8	Gravel				
K38/0822	6.5	Gravel	Clayey			
K38/0822	6.9	Silt	Clayey			
K38/0822	9	Gravel	Clayey			
K38/0822	10	Clay				
K38/0823	0.25	Topsoil				
K38/0823	1.6	Gravel				
K38/0823	4	Gravel				
K38/0823	5.19	Gravel				
K38/0823	6	Clay				
K38/0823	9.39	Gravel	Clayey			
K38/0823	10	Clay				
K38/0824	0.3	Topsoil				
K38/0824	1.2	Clay				
K38/0824	4.09	Gravel				
K38/0824	5	Gravel				
K38/0824	9	Gravel	Clayey			
K38/0824	10	Clay				
K38/0850	0.2	Silt				
K38/0850	3.8	Gravel	Silty			
K38/0850	9.19	Gravel	Silty, sandy			
K38/0850	9.6	Sand	Silty			
K38/0850	11.5	Gravel	Silty			
K38/0919	1.5	Clay				
K38/0919	3	Sand				
K38/0919	6	Gravel				
K38/0919	7.5	Sand				
K38/0919	9	Silt				
K38/0987	1.5	Clay				
K38/0987	8.52	Gravel				
K38/0988	9.14	Clay	Gravelly			
K38/0999	0.9	Clay				
K38/0999	2.6	Gravel	Clayey			
K38/0999	4.26	No Log				
K38/1083	0.2	Topsoil				
K38/1083	0.6	Silt				
K38/1083	1.8	Sand				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/1083	3.8	Gravel				
K38/1083	7.4	Gravel	Silty			
K38/1083	9	Gravel				
K38/1084	0.2	Topsoil				
K38/1084	0.8	Silt				
K38/1084	1.9	Sand				
K38/1084	4.6	Gravel				
K38/1084	7	Silt	Woody			
K38/1084	9.2	Gravel				
K38/1091	0.6	Topsoil				
K38/1091	1.9	Silt				
K38/1091	3.6	Gravel	Silty			
K38/1091	5	Gravel	Sandy			
K38/1091	6.7	Gravel	Sandy			
K38/1091	11	Gravel	Silty, sandy			
K38/1289	0.2	Topsoil				
K38/1289	2.4	Gravel	Clayey			
K38/1289	4.8	Gravel	Clayey			
K38/1289	5	Clay				
K38/1289	7	Gravel				
K38/1289	10.2	Gravel	Clayey			
K38/1289	11	Gravel				
K38/1290	0.2	Topsoil				
K38/1290	0.6	Clay				
K38/1290	3	Gravel	Clayey			
K38/1290	3.5	Clay				
K38/1290	4	Gravel	Clayey			
K38/1290	10	Gravel	Clayey			
K38/1370	0.3	Topsoil				
K38/1370	11	Gravel	Silty, sandy			
K38/1384	0.25	Topsoil				
K38/1384	1.4	Clay				
K38/1384	1.9	Gravel				
K38/1384	2.4	Gravel				
K38/1384	4.6	Gravel				
K38/1384	8.1	Gravel				
K38/1384	9	Gravel				
K38/1384	10.7	Gravel	Clayey			
K38/1405	7.5	Gravel	Silty, sandy			
K38/1405	8.5	Clay				
K38/1405	12	Gravel	Clayey	Sand		
K38/1432	3.1	Gravel	Silty, sandy			
K38/1432	6.8	Gravel				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/1432	10	Gravel	Sandy			
K38/1511	0.2	Topsoil				
K38/1511	0.5	Silt	Clayey			
K38/1511	1.8	Gravel				
K38/1511	4	Gravel	Clayey			
K38/1511	4.1	Gravel				
K38/1511	4.3	Clay				
K38/1511	6.8	Gravel	Clayey			
K38/1511	7.3	Gravel				
K38/1511	10.5	Gravel	Clayey			
K38/1523	5	Gravel				
K38/1523	7.1	Gravel	Clayey			
K38/1523	11.1	Gravel	Clayey			
K38/1541	0.25	Topsoil				
K38/1541	1.6	Clay				
K38/1541	4	Gravel				
K38/1541	4.5	Gravel				
K38/1541	6.2	Gravel	Clayey			
K38/1541	7.5	Gravel	Clayey	Boulders		
K38/1541	10.3	Gravel	Clayey			
K38/1671	0.1	Topsoil				
K38/1671	2.4	Gravel				
K38/1671	2.8	Clay				
K38/1671	6	Gravel	Clayey			
K38/1671	7.5	Gravel				
K38/1671	9	Gravel	Clayey			
K38/1671	11.4	Gravel	Clayey			
K38/1677	0.2	Topsoil				
K38/1677	1.2	Silt	Clayey			
K38/1677	1.5	Gravel				
K38/1677	7	Gravel	Clayey			
K38/1677	8	Clay				
K38/1677	10	Gravel	Clayey			
K38/1743	10	Gravel				
K38/1754	0.2	Topsoil				
K38/1754	0.9	Clay				
K38/1754	4	Gravel	Clayey			
K38/1754	7.2	Gravel	Clayey			
K38/1754	10.2	Gravel	Clayey	Boulders		
K38/1811	0.2	Topsoil				
K38/1811	1.5	Gravel				
K38/1811	4.5	Gravel	Clayey			
K38/1811	5.2	Clay				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/1811	9	Gravel	Clayey			
K38/1812	0.15	Topsoil				
K38/1812	2.5	Clay				
K38/1812	3.6	Gravel				
K38/1812	10.7	Gravel	Clayey			
K38/1827	0.2	Topsoil				
K38/1827	8	Clay				
K38/1827	9	Gravel	Clayey, silty			
K38/1827	11.34	Gravel				
K38/1830	0.15	Topsoil				
K38/1830	0.5	Clay				
K38/1830	1.6	Gravel				
K38/1830	3.5	Gravel	Clayey			
K38/1830	4	Gravel	Clayey			
K38/1830	5.2	Gravel				
K38/1830	10.3	Gravel	Clayey			
K38/1897	6	Topsoil	Gravelly			
K38/1897	9	Gravel				
K38/1897	11	Gravel				
K38/1897	12	Gravel	Clayey			
K38/1897	15	Gravel	Clayey			
K38/1897	18	Gravel				
K38/1897	22	Gravel				
K38/1897	24	Gravel	Clayey			
K38/1897	36	Gravel	Clayey			
K38/2075	0.3	Topsoil				
K38/2075	2	Clay				
K38/2075	4.2	Gravel				
K38/2075	11	Gravel	Clayey			
K38/2075	12.5	Gravel	Clayey			
K38/2076	0.3	Topsoil				
K38/2076	1.2	Clay				
K38/2076	4.8	Gravel				
K38/2076	12.5	Gravel	Clayey			
K38/2077	0.3	Topsoil				
K38/2077	1.2	Clay				
K38/2077	5	Gravel				
K38/2077	7	Gravel	Clayey			
K38/2077	8.5	Gravel				
K38/2077	10	Gravel	Clayey			
K38/2077	11	Gravel				
K38/2113	1	Topsoil				
K38/2113	11.5	Topsoil	Gravelly			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/2113	13	Gravel				
K38/2113	20	Gravel	Clayey			
K38/2113	49	Cobbles	Clayey			
K38/2113	106	Clay		Gravel		
K38/2113	116	Gravel	Clayey			
K38/2113	122	Gravel				
K38/2113	126	Gravel	Clayey			
K38/2163	0.2	Topsoil				
K38/2163	5.5	Gravel	Clayey			
K38/2163	11	Gravel	Clayey			
K38/2163	11.8	Gravel	Clayey			
K38/2199	0.2	Topsoil				
K38/2199	0.4	Clay				
K38/2199	1.1	Gravel	Clayey			
K38/2199	2.5	Gravel				
K38/2199	7	Gravel	Clayey			
K38/2199	7.8	Gravel				
K38/2199	9	Gravel	Clayey			
K38/2210	0.2	Topsoil				
K38/2210	3	Gravel	Clayey			
K38/2210	6	Gravel				
K38/2210	8.2	Gravel				
K38/2210	10.5	Gravel	Clayey			
K38/2263	0.3	Topsoil				
K38/2263	1.6	Clay				
K38/2263	1.8	Clay				
K38/2263	3.5	Gravel	Silty			
K38/2263	10.1	Gravel	Silty			
K38/2263	10.5	Clay				
K38/2263	12.3	Gravel				
K38/2263	16	No Log				
K38/2270	2.5	Topsoil				
K38/2270	3	Clay				
K38/2270	4.5	Gravel				
K38/2270	7	Gravel				
K38/2270	8.5	Gravel				
K38/2270	10	Clay	Gravelly			
K38/2290	0.3	Topsoil				
K38/2290	3.1	Gravel	Silty			
K38/2290	5.9	Gravel	Silty			
K38/2290	13.1	Gravel	Sandy			
K38/2290	14.2	Gravel	Clayey			
K38/2290	16	Gravel	Sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/2290	18	Gravel	Sandy			
K38/2292	0.25	Silt			Sand	
K38/2292	0.8	Silt		Clay		
K38/2292	2.5	Gravel	Sandy		Silt	
K38/2293	0.2	Silt		Sand		Clay
K38/2293	0.3	Silt		Sand		Clay
K38/2293	0.9	Silt	Sandy			
K38/2293	1.9	Gravel	Sandy	Silt		
K38/2293	2.5	Gravel	Sandy	Silt		
K38/2300	4.3	Clay				
K38/2300	9	Sand	Clayey			
K38/2300	11	Gravel	Clayey			
K38/2300	11.8	Clay				
K38/2300	19.5	Gravel	Sandy			
K38/2300	20.2	Clay				
K38/2300	30	Gravel	Sandy			
K38/2310	0.6	Topsoil				
K38/2310	1.1	Sand	Silty			
K38/2310	5.1	Gravel				
K38/2310	9.3	Gravel	Sandy		Wood	
K38/2310	12.1	Gravel	Sandy			
K38/2310	33.4	Gravel	Sandy			
K38/2349	0.2	Topsoil				
K38/2349	3	Silt				
K38/2349	5.5	Gravel	Sandy			
K38/2349	8	Gravel	Clayey			
K38/2349	8.5	Gravel	Clayey	Boulders		
K38/2349	11.5	Gravel	Clayey			
K38/2371	0.4	Topsoil				
K38/2371	2	Clay				
K38/2371	3.5	Gravel				
K38/2371	7	Gravel				
K38/2371	8.5	Gravel	Clayey			
K38/2371	10.3	Gravel	Clayey			
K38/2377	0.3	Clay				
K38/2377	0.5	Gravel				
K38/2377	3.1	Gravel	Silty			
K38/2377	4.9	Gravel	Silty			
K38/2377	6.8	Gravel	Silty			
K38/2377	12.2	Gravel	Clayey			
K38/2377	12.4	Gravel	Silty			
K38/2377	24	Gravel	Silty			
K38/2435	0.2	Topsoil				

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K38/2435	0.6	Clay				
K38/2435	4.4	Gravel		Silt and sand		
K38/2435	7.8	Gravel		Silt and sand		
K38/2435	12.32	Gravel	Silty	Sand		
K39/0001	0.5	Fill				
K39/0001	1.5	Clay	Silty			
K39/0001	3	Gravel				
K39/0001	4	Gravel	Clayey			
K39/0001	5.5	Gravel	Sandy			Clay
K39/0001	7	Gravel	Clayey			
K39/0001	8	Gravel	Sandy			
K39/0001	10	Gravel	Silty			
K39/0001	12.7	Gravel	Silty			
K39/0002	0.3	Topsoil	Clayey			
K39/0002	3.05	Gravel	Clayey			
K39/0002	3.66	Gravel	Sandy			
K39/0002	5.79	Gravel	Clayey			
K39/0002	8.84	Gravel	Clayey			
K39/0004	0.61	Topsoil	Gravelly			
K39/0004	3.05	Gravel				
K39/0004	9.44	Gravel	Clayey			
K39/0004	10.06	Gravel				
K39/0005	1	Topsoil	Clayey			
K39/0005	8.5	Gravel	Sandy			
K39/0005	11.5	Gravel	Clayey			
K39/0005	12	Silt	Clayey			
K39/0006	0.5	Topsoil	Clayey			
K39/0006	2	Gravel	Clayey			
K39/0006	8	Gravel	Clayey, sandy			
K39/0006	15.5	Gravel	Clayey, sandy			
K39/0006	16	Clay				
K39/0011	0.9	Topsoil				
K39/0011	2.13	Gravel	Clayey			
K39/0011	3.05	Gravel	Sandy			
K39/0011	5.79	Gravel		Clay and sand		
K39/0011	6.24	Gravel	Sandy			Clay
K39/0011	8.22	Clay				
K39/0011	9.1	Gravel	Clayey			
K39/0012	0.6	Topsoil				
K39/0012	0.9	Clay				
K39/0012	3.05	Gravel	Clayey			
K39/0012	4.26	Gravel	Sandy			
K39/0012	4.87	Gravel	Clayey, sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0012	5.18	Gravel				
K39/0012	5.48	Gravel	Sandy			
K39/0012	6.4	Clay				
K39/0014	0.3	Topsoil				
K39/0014	1.4	Gravel	Clayey			
K39/0014	3.96	Gravel		Clay		
K39/0014	4.1	Gravel	Clayey			
K39/0014	5.48	Gravel	Sandy	Clay		
K39/0014	8.07	Gravel	Sandy	Clay		
K39/0014	8.68	Sand	Clayey			
K39/0015	0.3	Topsoil				
K39/0015	1.22	Clay				
K39/0015	7.92	Gravel	Sandy			
K39/0015	13.11	Gravel	Clayey			
K39/0015	14.63	Gravel	Sandy			
K39/0015	14.93	Clay	Sandy			
K39/0015	17.37	Gravel	Clayey			
K39/0015	22.54	Gravel	Clayey			
K39/0017	0.91	Topsoil				
K39/0017	8.84	Gravel	Clayey			
K39/0017	9.75	Gravel	Clayey			
K39/0017	14.32	Gravel	Clayey			
K39/0017	16.15	Clay				
K39/0017	24.69	Gravel	Clayey			
K39/0017	28.35	Clay		Gravel		
K39/0017	30.48	Gravel	Clayey			
K39/0021	0.5	Fill				
K39/0021	1.5	Silt	Clayey			
K39/0021	3	Gravel				
K39/0021	4	Gravel	Clayey			
K39/0021	5.5	Gravel	Sandy			Clay
K39/0021	7	Gravel	Clayey			
K39/0021	8	Gravel	Sandy			
K39/0021	10	Gravel	Silty			
K39/0021	12.7	Gravel	Silty			
K39/0057	0.3	Topsoil	Clayey			
K39/0057	3.8	Gravel	Clayey, sandy			
K39/0057	8	Gravel				
K39/0057	13	Gravel	Clayey, sandy			
K39/0057	21	Sand	Clayey, silty			
K39/0057	22.29	Gravel	Clayey, silty			
K39/0057	24	Gravel	Clayey, sandy			
K39/0057	27.2	Gravel	Sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0057	29.6	Clay	Sandy			
K39/0057	33.4	Gravel	Sandy			
K39/0057	41.5	Gravel	Clayey, sandy			
K39/0057	49	Clay				
K39/0057	52.59	Clay				
K39/0057	53.5	Clay				
K39/0057	59.2	Clay				Sand
K39/0057	62.7	Gravel				Clay and sand
K39/0057	65.8	Gravel	Clayey, sandy			
K39/0057	67.5	Sand	Clayey			
K39/0057	76.8	Silt				
K39/0057	78.4	Clay				
K39/0057	80.5	Sand	Silty			
K39/0057	85	Clay		Sand		Wood
K39/0057	86.59	Clay				Wood
K39/0057	90.3	Clay				Gravel
K39/0057	109.6	Sand	Silty			
K39/0057	116.7	Clay				
K39/0057	119.5	Sand				Gravel
K39/0057	124.8	Clay				
K39/0057	128.1	Sand	Silty			
K39/0057	140	Sandstone				
K39/0109	4.9	Gravel				
K39/0109	12.2	Gravel	Sandy			Clay
K39/0109	12.9	Clay				
K39/0109	15.24	Silt	Clayey			
K39/0110	4.5	Gravel				
K39/0110	12	Gravel	Clayey			
K39/0110	12.8	Clay				
K39/0110	13.1	Silt	Clayey			
K39/0110	15.1	Silt	Clayey			
K39/0110	15.5	Silt				
K39/0111	1.5	Gravel	Clayey			
K39/0111	3.96	Gravel	Sandy			
K39/0111	6.1	Gravel	Sandy			Clay
K39/0112	0.9	Gravel	Clayey			
K39/0112	4.6	Gravel				
K39/0112	6.1	Gravel	Clayey			
K39/0112	7	Gravel	Clayey			
K39/0112	9.75	Gravel				
K39/0112	10.05	Gravel	Clayey			
K39/0114	0.2	Topsoil				
K39/0114	14.2	Gravel	Silty, sandy			

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0114	18.9	Silt	Sandy			
K39/0114	20	Gravel				
K39/0116	1	Fill				
K39/0116	1.5	Topsoil	Silty			
K39/0116	9.23	Sand	Silty			
K39/0117	1	Fill				
K39/0117	1.5	Topsoil				
K39/0117	8.22	Gravel	Silty, sandy			
K39/0118	0.2	Fill				
K39/0118	0.7	Topsoil				
K39/0118	10.29	Gravel	Silty, sandy			
K39/0119	0.2	Fill				
K39/0119	0.7	Topsoil	Silty			
K39/0119	9.45	Gravel	Silty, sandy			
K39/0120	1.05	Fill				
K39/0120	9.45	Gravel				
K39/0121	9.45	Gravel	Silty, sandy			
K39/0122	0.7	Silt				
K39/0122	9.45	Gravel	Silty			
K39/0123	8.45	Gravel	Silty			
K39/0124	0.7	Silt				
K39/0124	6.45	Gravel	Silty			
K39/0125	1.1	Fill				
K39/0125	5.5	Gravel	Silty, sandy			
K39/0127	5.13	No Log				
K39/0128	2.15	Silt				
K39/0128	5.2	Gravel	Silty, sandy			
K39/0129	2.4	Silt				
K39/0129	4.4	Gravel	Silty, sandy			
K39/0129	6.69	Silt				
K39/0181	0.05	Silt				
K39/0181	0.65	Silt		Gravel		
K39/0181	0.7	Silt		Gravel		
K39/0181	0.75	Silt				Gravel
K39/0181	1	Silt	Sandy			
K39/0181	1.05	Silt			Sand	
K39/0181	1.15	Sand				Gravel
K39/0181	1.45	Clay	Gravelly			
K39/0181	1.7	Clay	Gravelly			
K39/0181	1.85	Clay	Gravelly			
K39/0181	1.9	Clay	Silty			Sand
K39/0181	1.95	Sand			Gravel	
K39/0181	2.1	Clay	Silty		Peat	Sand

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0181	4.8	Gravel	Sandy			
K39/0182	0.05	Topsoil				
K39/0182	0.2	Gravel	Sandy		Silt	
K39/0182	0.9	Gravel		Sand	Silt	
K39/0182	1	Silt		Gravel		Sand
K39/0182	1.2	Silt		Sand		
K39/0182	1.35	Sand				Silt
K39/0182	1.5	Sand	Silty		Gravel	
K39/0182	1.8	Gravel		Sand		
K39/0182	1.9	Sand			Gravel	
K39/0182	2.9	Gravel			Sand	
K39/0182	4.5	Topsoil	Gravelly			
K39/0182	4.9	Gravel		Sand	Silt	
K39/0182	5	Gravel		Sand		
K39/0183	0.05	Silt			Sand	Gravel
K39/0183	0.25	Silt		Gravel	Sand	Clay
K39/0183	0.75	Gravel	Silty	Sand		
K39/0183	0.85	Silt		Gravel		
K39/0183	1.45	Silt			Gravel	
K39/0183	1.5	Silt	Clayey			
K39/0183	1.7	Silt	Clayey			
K39/0183	1.85	Boulders				
K39/0183	1.9	Silt	Clayey			
K39/0183	2.35	Sand				Silt
K39/0183	2.75	Gravel	Sandy			
K39/0183	4.8	Gravel	Sandy			
K39/0184	0.1	Silt		Peat	Wood	
K39/0184	0.55	Silt				Sand
K39/0184	0.6	Silt				Sand
K39/0184	0.65	Silt				Sand
K39/0184	0.7	Clay	Silty			Sand
K39/0184	1.25	Clay	Silty			Sand
K39/0184	2	Silt	Clayey			
K39/0184	3	Silt	Sandy			Gravel
K39/0184	3.75	Gravel		Sand	Clay	
K39/0184	4.15	Silt		Gravel	Sand	
K39/0184	4.6	Gravel	Sandy	Silt		
K39/0184	5	Gravel	Sandy	Silt		
K39/0185	0.26	Fill				
K39/0185	0.57	Silt		Organic material	Gravel	
K39/0185	1.06	Silt				
K39/0185	2.5	Gravel	Sandy		Silt	
K39/0185	5	Gravel	Sandy		Silt	

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0185	6	Gravel	Sandy		Silt	
K39/0185	6.75	Gravel	Sandy	Silt		
K39/0185	7.45	Gravel	Sandy		Silt	
K39/0185	7.5	Boulders				
K39/0185	9.65	Gravel	Sandy	Silt		
K39/0185	9.75	Gravel	Sandy	Silt		
K39/0185	12	Gravel	Sandy	Silt		
K39/0251	0.3	Fill				
K39/0251	0.9	Silt				
K39/0251	6	Gravel	Sandy	Silt	Boulders	
K39/0252	0.6	Fill				
K39/0252	0.8	Silt				
K39/0252	6	Gravel	Sandy	Silt	Boulders	
K39/0257	0.3	Topsoil				
K39/0257	0.8	Clay				
K39/0257	3.2	Gravel	Silty			
K39/0257	8.1	Gravel	Sandy	Cobbles		
K39/0257	11.6	Gravel	Silty			
K39/0257	18.6	Clay				
K39/0257	21.3	Gravel	Sandy			
K39/0257	21.9	Clay				
K39/0257	25.9	Gravel	Sandy			
K39/0257	26.3	Gravel	Silty			
K39/0257	27.7	Gravel	Sandy			
K39/0257	28.1	Clay				
K39/0257	32.8	Gravel	Silty			
K39/0257	35.6	Gravel	Sandy			
K39/0257	37.4	Clay				
K39/0257	39.1	Gravel	Sandy			
K39/0257	39.5	Clay				
K39/0257	41.3	Gravel	Sandy			
K39/0257	43	Clay				
K39/0258	0.5	Topsoil				
K39/0258	8	Gravel	Sandy			
K39/0258	10	Sand				
K39/0258	12	Gravel				
K39/0258	16	Clay				
K39/0258	24	Gravel	Sandy			
K39/0258	34	Gravel	Sandy			
K39/0258	39	Clay				
K39/0258	42	Gravel				
K39/0258	42.01	Clay				
K39/0272	0.4	Gravel	Sandy			Silt

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0272	0.9	Silt	Sandy	Clay		
K39/0272	1.1	Silt	Sandy	Clay	Gravel	
K39/0272	1.3	Sand	Silty	Gravel		
K39/0272	1.9	Gravel	Sandy	Silt		
K39/0272	2.5	Gravel	Sandy	Silt		
K39/0273	0.3	Topsoil				
K39/0273	0.7	Silt	Sandy	Clay		
K39/0273	0.9	Gravel	Silty	Clay		
K39/0273	2.5	Gravel	Sandy	Silt		
K39/0274	0.2	Topsoil				
K39/0274	2.5	Gravel	Sandy	Silt	Clay	
K39/0275	0.38	Topsoil				
K39/0275	1.7	Silt	Sandy	Clay		
K39/0275	2.5	Gravel	Sandy	Silt		
K39/0276	0.23	Topsoil				
K39/0276	0.33	Silt	Sandy	Clay		
K39/0276	2.5	Gravel	Sandy	Silt		
K39/0277	0.25	Silt			Sand	Clay
K39/0277	0.55	Gravel	Sandy		Silt	
K39/0277	1	Gravel	Sandy		Silt	
K39/0277	2.5	Gravel	Sandy		Silt	
K39/0278	0.3	Topsoil				
K39/0278	1.4	Gravel	Sandy			
K39/0278	2.5	Gravel	Silty	Sand		
K39/0279	0.25	Silt				Clay and sand
K39/0279	2.5	Gravel		Silt		
K39/0304	0.3	Topsoil				
K39/0304	1	Silt				
K39/0304	11.2	Gravel	Sandy			
K39/0304	12.2	Silt				
K39/0304	15	Gravel	Sandy			
K39/0305	0.3	Topsoil	Clayey, silty			
K39/0305	0.6	Gravel	Silty		Sand	
K39/0305	5.65	Gravel	Sandy			
K39/0305	5.75	Clay	Silty			
K39/0305	5.85	Sand	Silty			
K39/0305	8.85	Gravel	Sandy	Silt		
K39/0305	9	Sand		Silt		
K39/0305	10.13	Gravel	Sandy	Silt		
K39/0306	0.3	Topsoil	Clayey, silty			
K39/0306	1.2	No Recovery				
K39/0306	1.5	Clay	Silty		Sand	
K39/0306	2.25	Gravel	Sandy	Silt		

WELL NUMBER	BASE DEPTH (m)	MAJOR FRACTION	SECONDARY FRACTION	SOME FRACTION	MINOR FRACTION	TRACE FRACTION
K39/0306	2.3	Sand	Silty			
K39/0306	9	Gravel	Sandy	Silt		
K39/0306	10.39	Sand	Silty		Gravel	
K39/0307	0.35	Clay	Silty			
K39/0307	1.3	Silt	Sandy	Clay		
K39/0307	8.82	Gravel	Sandy	Silt		
K39/0309	0.2	Topsoil	Silty			
K39/0309	0.5	Silt				
K39/0309	5	Gravel	Silty, sandy			
K39/0309	6.5	Sand				
K39/0309	10.7	Gravel	Silty			
K39/0309	11.1	Silt				
K39/0309	13.6	Silt				
K39/0309	13.7	Peat				
K39/0309	20	Silt				
K39/0311	0.2	Topsoil	Silty			
K39/0311	1	Silt				
K39/0311	7	Gravel	Silty, sandy			
K39/0311	10.5	Gravel	Silty			
K39/0311	12	Silt	Gravelly			
K39/0311	15.3	Silt				
K39/0311	16.9	Silt	Peaty			
K39/0311	20	Gravel	Silty			
K39/0312	0.2	Topsoil	Silty			
K39/0312	0.5	Silt				
K39/0312	5	Gravel	Silty, sandy			
K39/0312	6.5	Sand				
K39/0312	10.7	Gravel	Silty			
K39/0312	11.1	Silt				
K39/0312	13.6	Silt				
K39/0312	13.7	Peat				
K39/0312	20	Silt				

APPENDIX E

NUMERICAL GEOLOGICAL MODEL



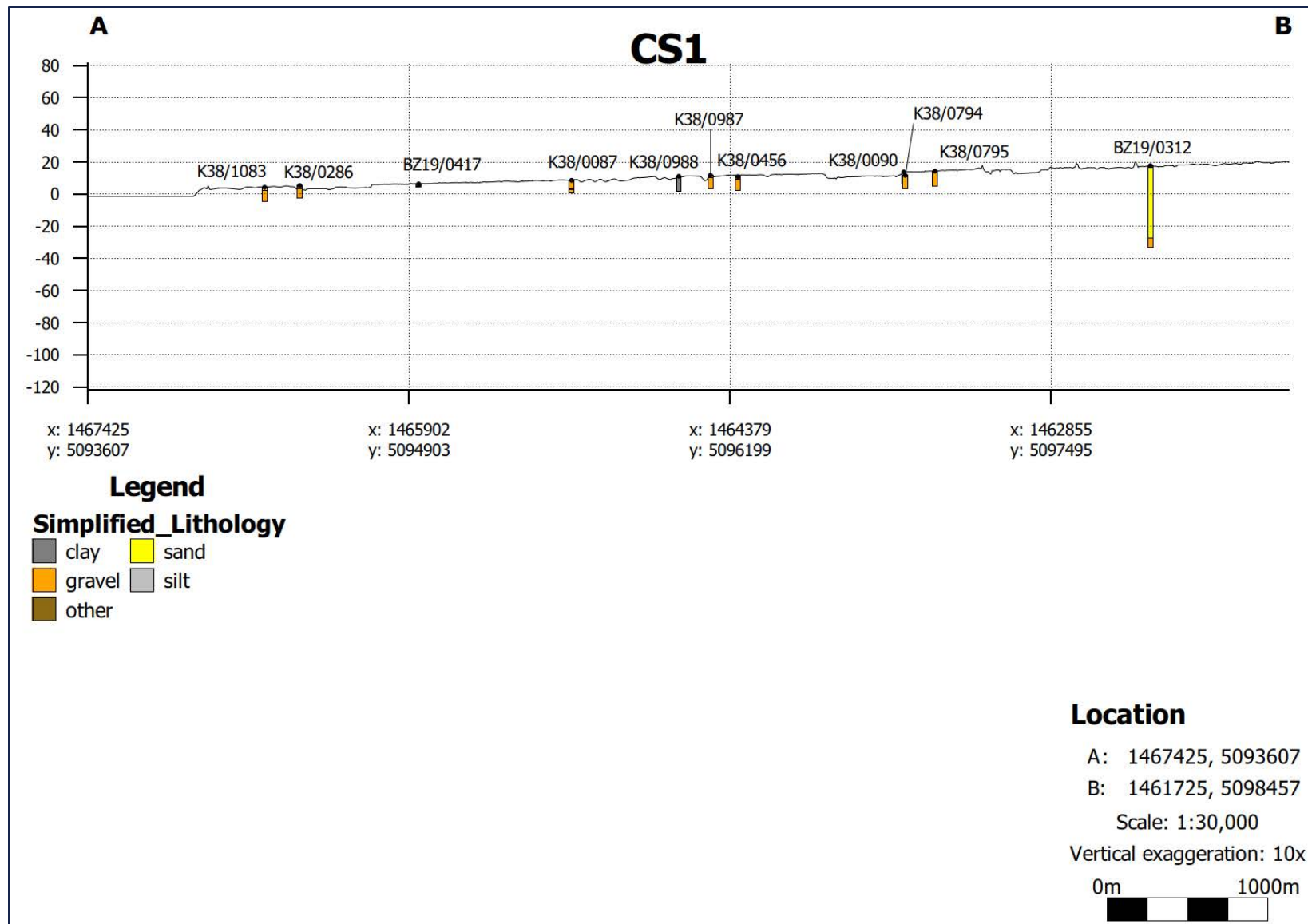


Figure E1: Cross Section 1

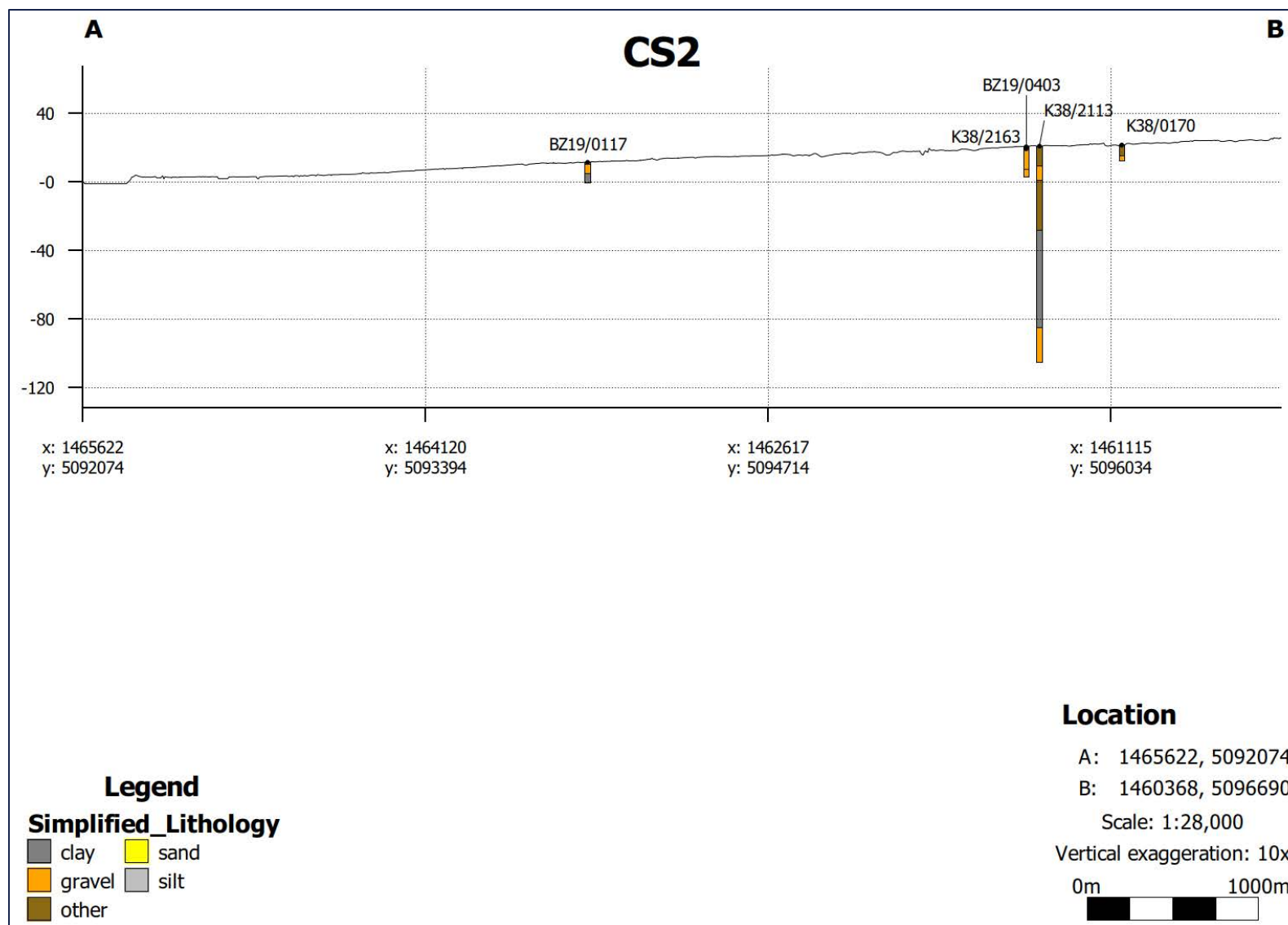


Figure E2: Cross Section 2

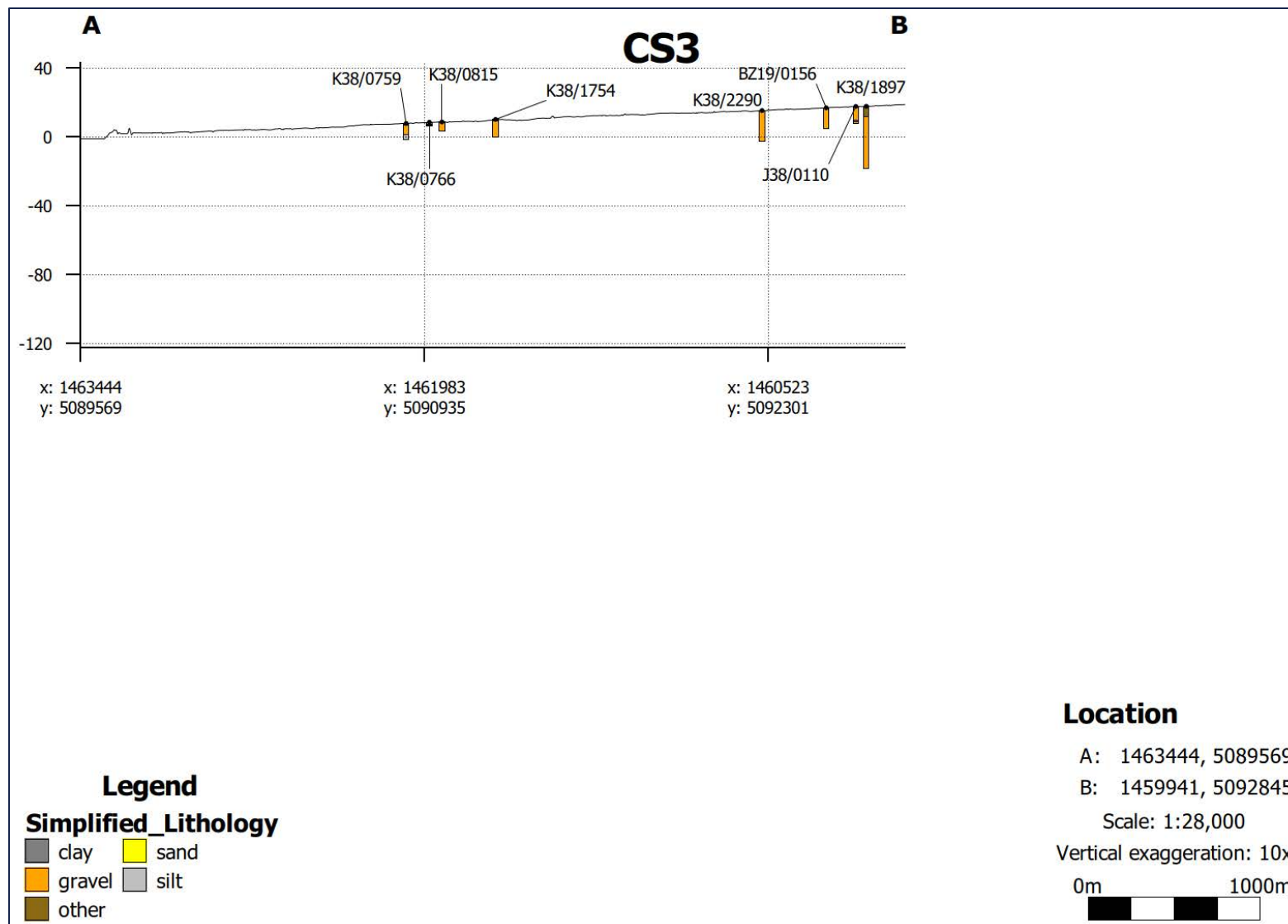


Figure E3: Cross Section 3

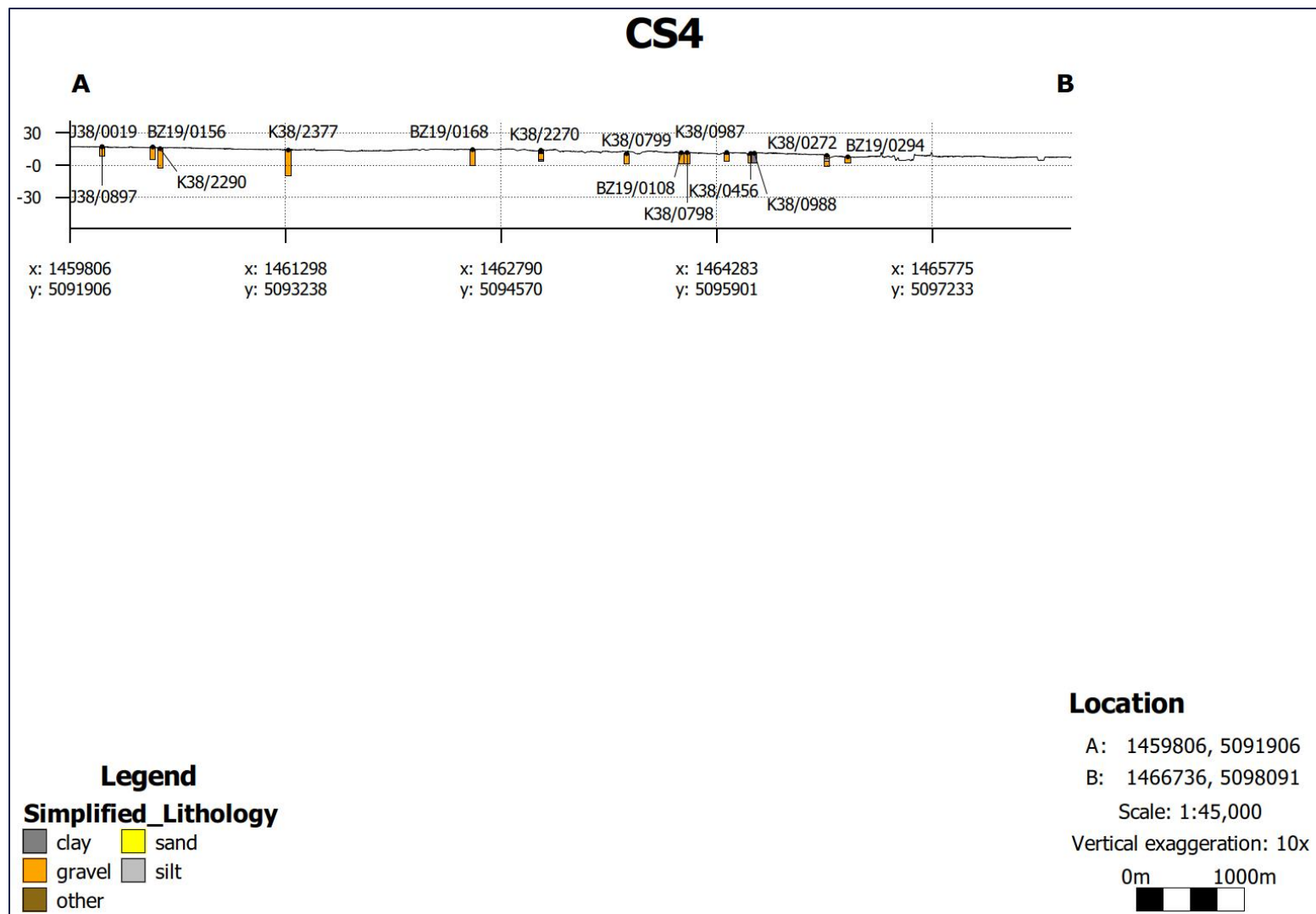


Figure E4: Cross Section 4

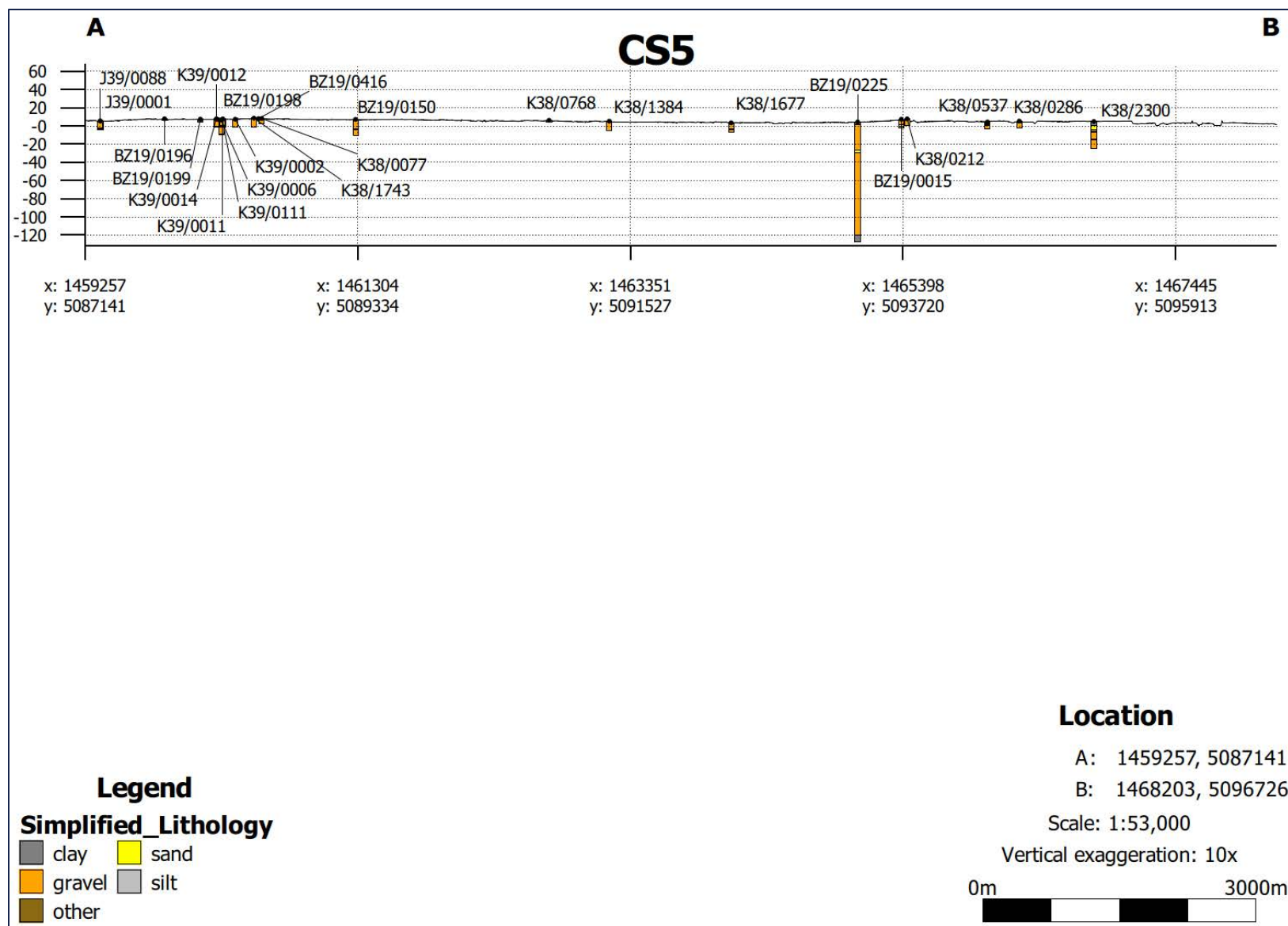


Figure E5: Cross Section 5

APPENDIX F

PUMPING TEST RESULTS



The tables in this appendix summarise the hydraulic parameters derived from stepped rate and constant rate tests performed on wells located within the area of interest. The tables have been divided by approximate depth of well screen, with most wells being screened within the first 10 m below ground level.

The transmissivity and storativity values presented in the following tables has been sourced from the ECan wells database. The hydraulic conductivity values have been calculated by assuming the targeted aquifer is the same thickness as the length of the well screen. Based on that assumption, the hydraulic conductivity has been calculated by transmissivity divided by screen length. As many of the shallow bores (<10 m deep) do not have recorded well screen intervals, assumptions have been made regarding the screen lengths, as provided in the notes to Table B1.

WGA recognises that the assumptions made in calculating aquifer hydraulic conductivity are often not strictly valid. However, this was the best approximation for aquifer characteristics that could be achieved within the project timeframe.

No data is available from the ECan database on the hydraulic characteristics of confining layers, such as leakance. Several aquifer tests reports from the area of interest have been accessed and reviewed. However, these reports do not provide guidance on the characteristics of aquifer confining layers.

WGA notes that most of the storativity values available for the shallow wells (Table B1) indicate unconfined aquifer conditions. The few storativity values available for deeper wells indicate leaky confined to fully confined conditions.

Table D1: Hydraulic Parameters for Wells with Screens Mostly Less than 10 m BGL

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0015	9.20	2,500	417	-
BZ19/0071	6.20	2,500	833	-
BZ19/0136	11.00	587	98	-
BZ19/0173	4.00	806	269	-
BZ19/0418	9.30	11,720	3,907	-
J38/0065	8.50	200	67	-
J38/0071	9.80	1,800	300	-
J38/0098	7.92	3,900	1,279	-
J38/0128	9.80	1,700	283	-
J38/0129	9.80	1,580	263	-
J38/0130	9.40	750	250	-
J38/0131	9.20	1,240	207	-
J38/0132	9.80	110	18	-
J38/0133	10.00	4,900	817	-
J38/0134	10.00	2,045	341	-
J38/0135	10.00	1,950	325	-
J38/0136	9.80	4,620	770	-
J38/0137	10.00	6,500	1,083	-
J38/0730	7.50	2,500	556	-
K38/0088	9.58	2,380	496	0.03
K38/0089	9.21	1,340	642 ⁽³⁾	0.0006
K38/0183	7.20	2,800	933	0.02
K38/0208	8.00	9,000	2,250	-
K38/0270	8.40	4,926	1,642	-
K38/0272	10.00	1,313	199	-
K38/0274	9.29	900	300	-
K38/0275	10.00	8,640	1,440	-
K38/0276	10.00	3,080	513	-
K38/0277	10.00	86	14	-
K38/0279	9.80	3,672	612	-
K38/0287	7.32	2,000	667	-
K38/0341	6.00	1,200	400	-
K38/0424	4.90	1,650	550	-
K38/0453	12.00	18,642	3,107	0.1
K38/0610	9.80	2,220	370	0.01699
K38/0701	7.50	600	200	-
K38/0789	10.00	11,438	1,906	0.06
K38/0821	9.50	1,050	175	-
K38/0824	10.00	1,875	376 ⁽³⁾	-
K38/1085	10.00	8,144	2,715	-
K38/1086	10.00	3,461	1,154	-
K38/1384	10.70	2,249	395	-
K38/2075	12.80	1,140	175	-
K38/2076	12.50	4,500	643	-
K38/2077	11.00	3,900	650	-
K38/2117	9.80	250	81 ⁽³⁾	-
K38/2163	11.00	2,706	564	-
K38/2303	8.00	2,565	855	-
K38/2371	10.30	1,000	152	-
K38/2402	8.85	3,735	1,245	0.032

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen. Where no well screen length has been provided, it has been assumed that all wells with depth of less than 9 m have screens of 3 m length and wells exceeding that depth have screens of 6 m length.

3) The approximated hydraulic conductivity of the aquifer targeted by wells K38/0089, K38/0824 and K38/2117 has been adjusted upward due to a significant fraction of the designated screen interval being opening onto clay horizons.

Table D2: Hydraulic Parameters for Wells with Screens Mostly Between 10 and 20 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0439 ⁽³⁾	17.32	5,260	625	-
BZ19/0440 ⁽³⁾	17.26	2,220	331	-
BZ19/0441 ⁽³⁾	17.29	2,373	298	-
BZ19/0446 ⁽³⁾	17.50	1,177	127	-
BZ19/0447 ⁽³⁾	17.43	687	70	-
J39/0739	14.50	46	10	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

3) These bores are located within 600 m of each other, are owned by the same person and were drilled at about the same time. The screen depths may not have been determined primarily by aquifer hydraulic parameters or lithological sequence intersected.

Table D3: Hydraulic Parameters for Wells with Screens Mostly Between 20 and 40 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
J38/0934	38.00	90	23	-
K38/2300	29.25	6	3	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D4: Hydraulic Parameters for Wells with Screens Mostly Between 40 and 50 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
J38/0309	49.40	50	25	-
J39/0087	48.00	25	8	-
K39/0257	43.00	38	8	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D5: Hydraulic Parameters for Wells with Screens Mostly Between 50 and 60 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0152	64.93	106	18	-
BZ19/0157	52.59	24	12	-
BZ19/0314	61.68	720	90	-
J38/0920	61.00	120	6	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D6: Hydraulic Parameters for Wells with Screens Mostly Between 60 and 100 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0165	65.22	264	132	-
BZ19/0186	81.37	185	46	0.0002
BZ19/0222	80.72	79	20	-
J39/0362	91.00	26	4	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D7: Hydraulic Parameters for Wells with Screens Mostly Between 100 and 150 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0039	150.00	40	1	-
J38/0571	168.32	37	37	-
K38/2113	121.05	30	5	-
K38/2394	185.00	25	2	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D8: Hydraulic Parameters for Wells with Screens Mostly Between 150 and 200 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0090	197.40	35	6	-
BZ19/0180	174.00	14	1	-
CA19/0056	174.50	40	10	-
J39/0494	197.70	7	1	-
J39/0732	190.00	1000	125	-

Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

Table D9: Hydraulic Parameters for Wells with Screens Mostly Exceeding 200 m BGL.

WELL NUMBER ⁽¹⁾	WELL DEPTH (m)	TRANSMISSIVITY (m ² /day)	HYDRAULIC CONDUCTIVITY (m/day) ⁽²⁾	STORATIVITY
BZ19/0089	248.58	265	44	
BZ19/0151	206.97	78	13	0.0001
J38/0977	239.50	500	83	

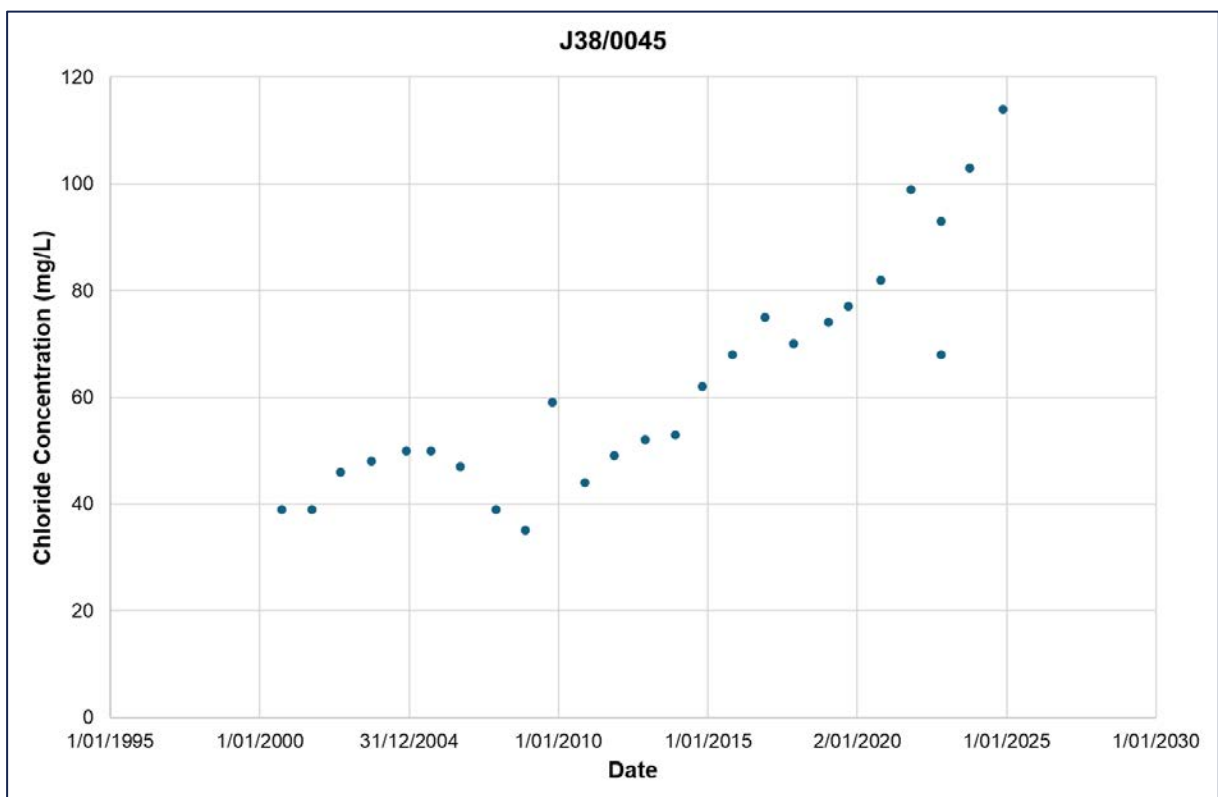
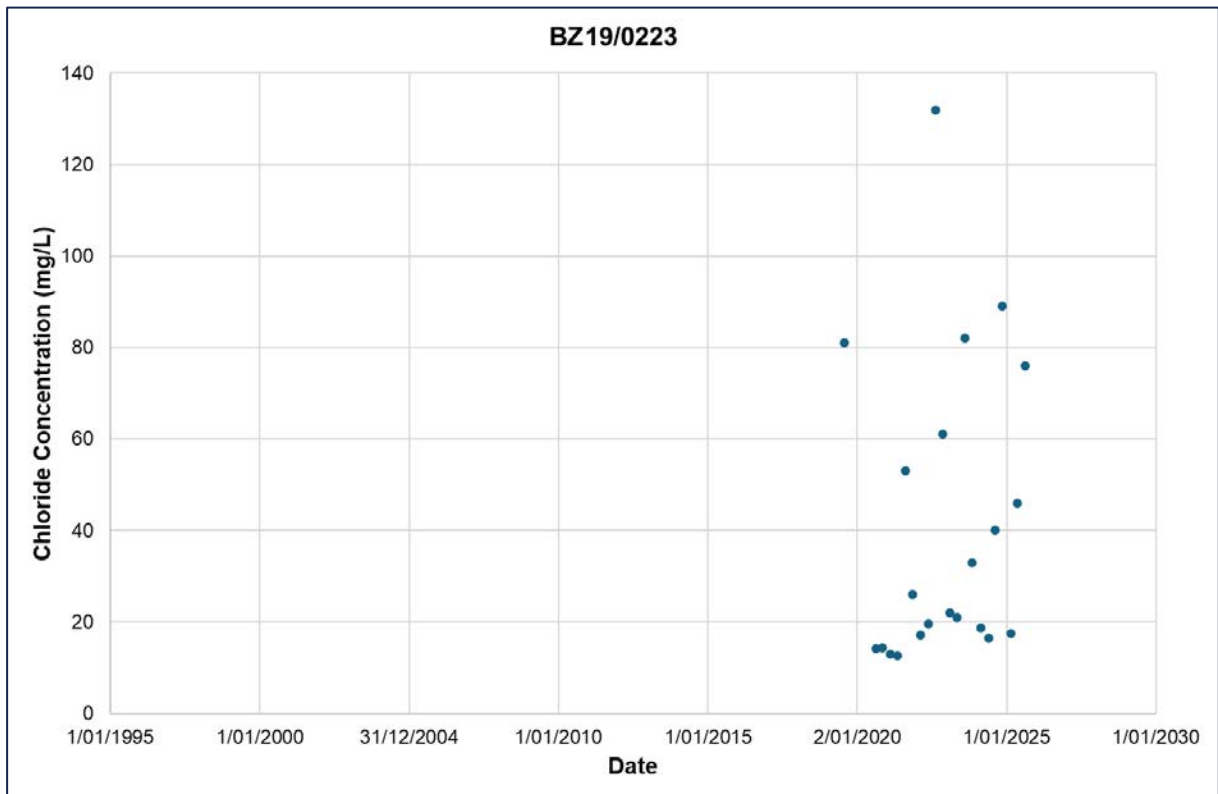
Note: 1) The results of all pumping tests for wells in the area of interest have been accepted as valid, irrespective of the level of confidence indicated in the ECan database.

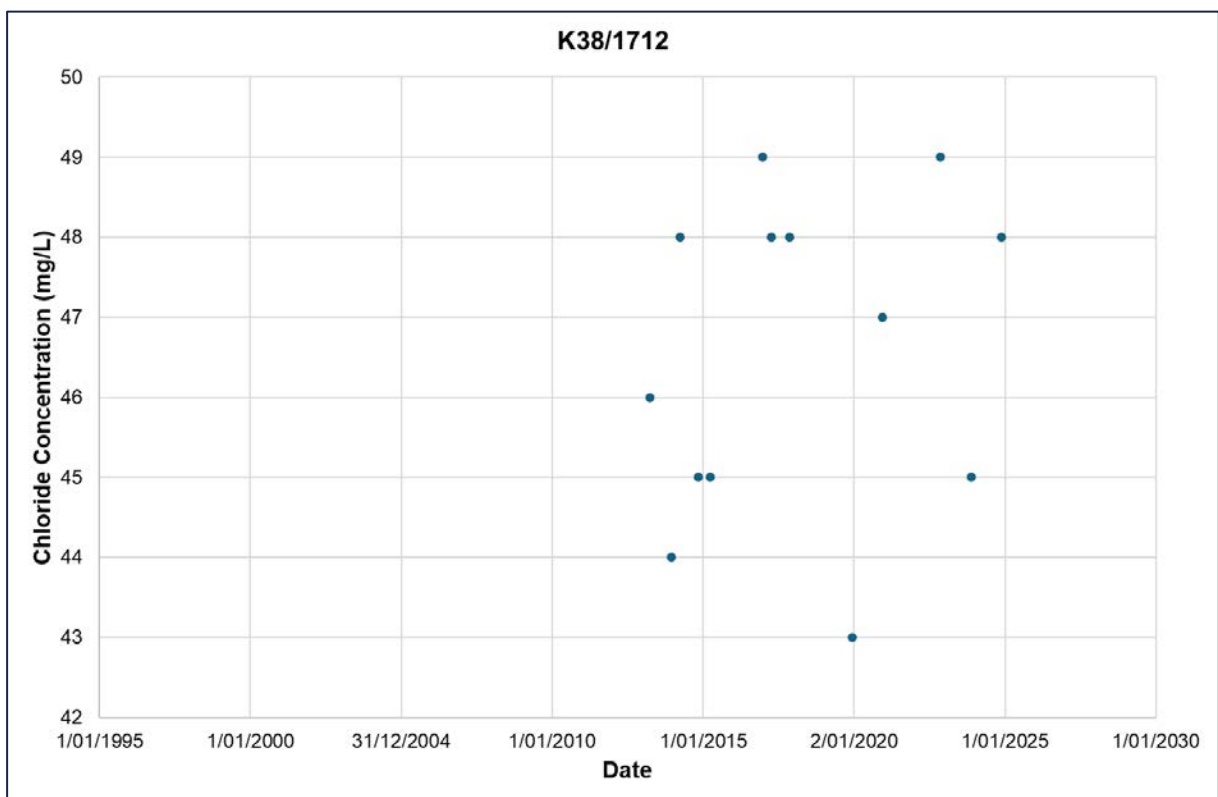
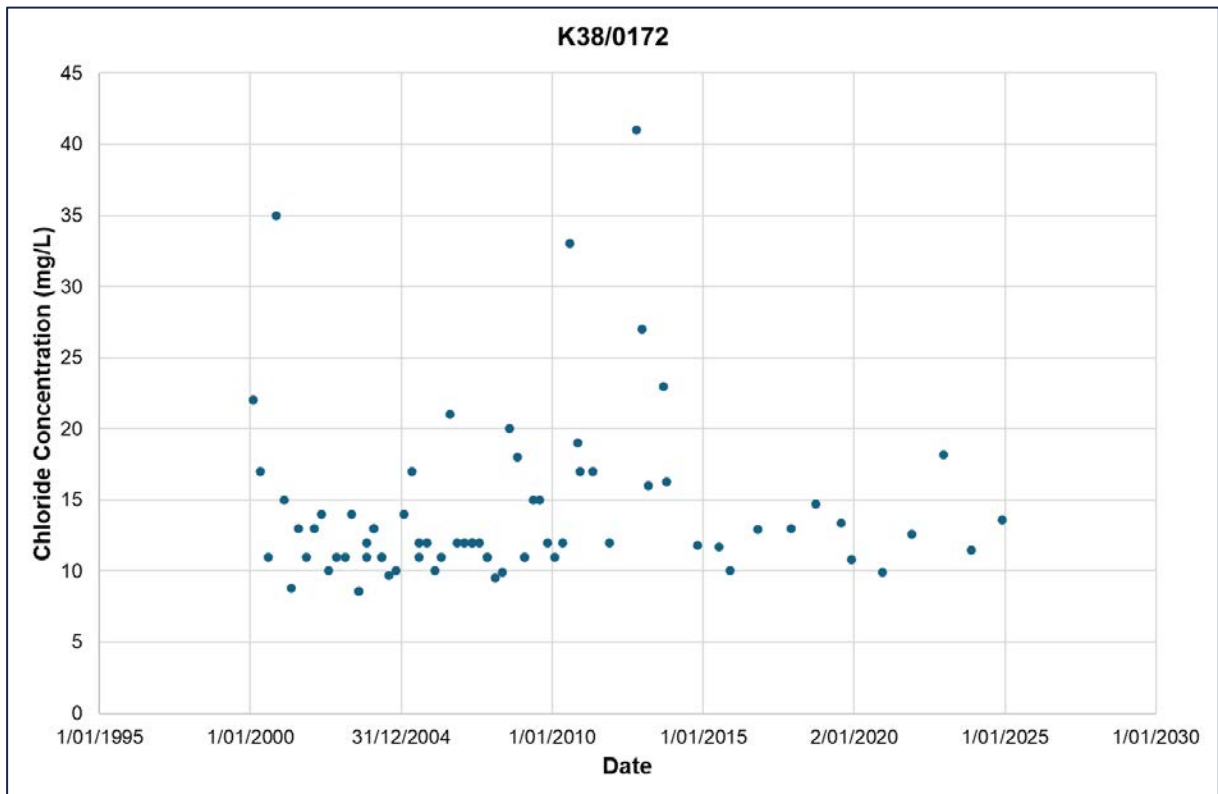
2) Hydraulic conductivity has been approximated by dividing the aquifer transmissivity value provided by ECan by the length of the well screen.

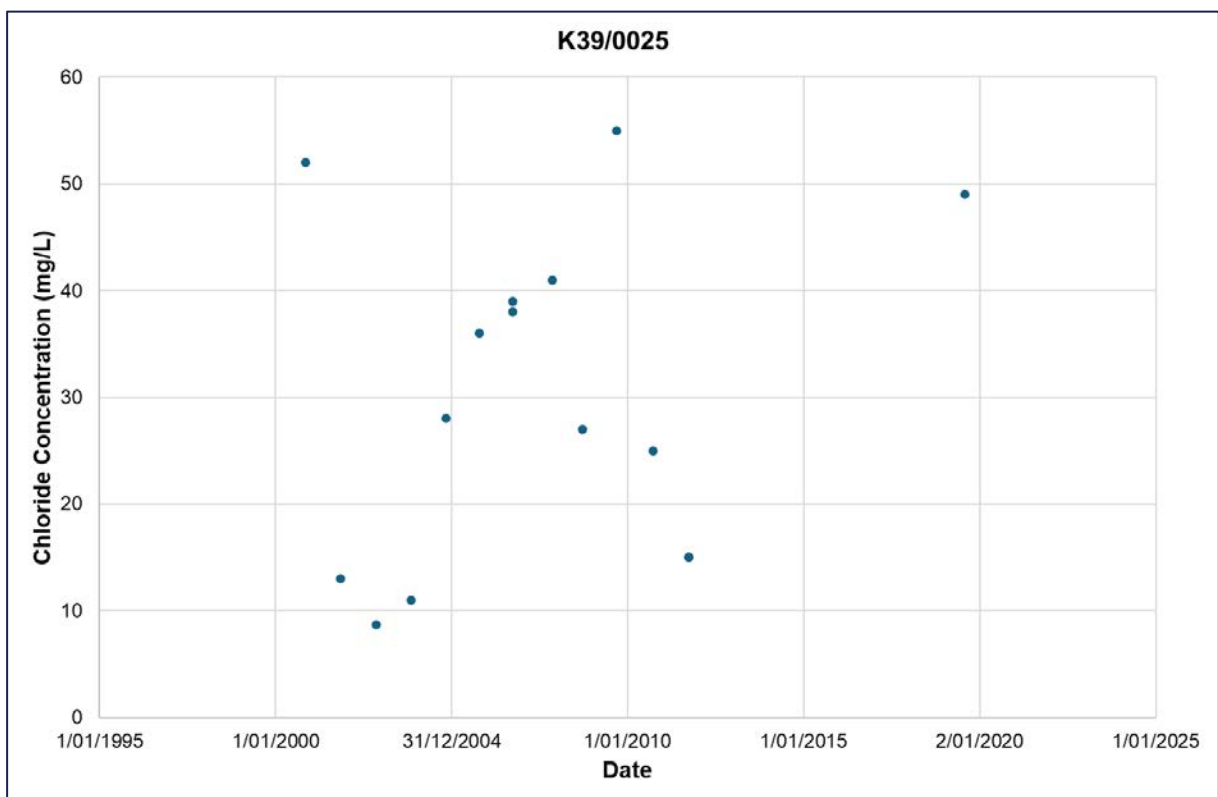
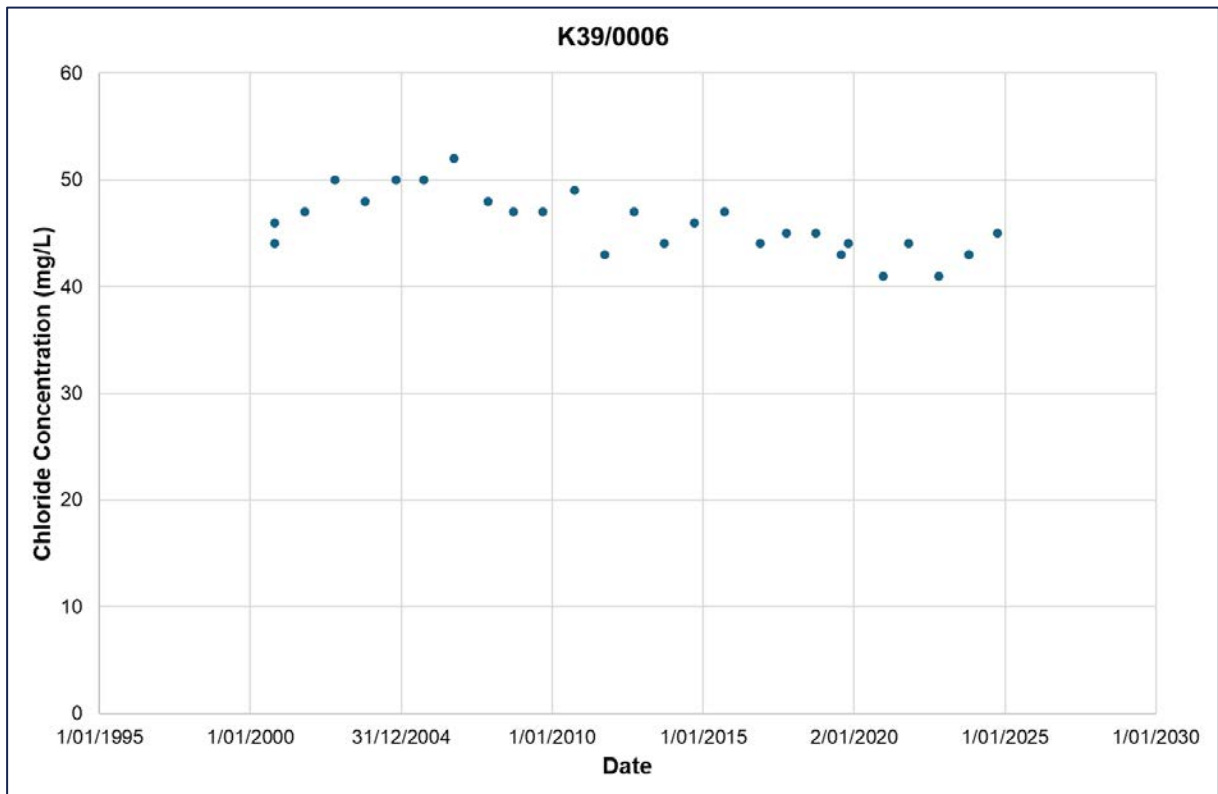
APPENDIX G

GROUNDWATER CHLORIDE MONITORING DATA









APPENDIX H

CONSENTED TAKES



FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
BZ19/0015	146528 8	509379 6	CRC240240	New Consent	Oct-23	Dec-33	4.9	6897.8	27567	27567
BZ19/0029	145875 6	508939 9	CRC133536	Change in Conditions	Jan-13	Mar-36	3	35301	35301	0
BZ19/0117	146338 7	509399 4	CRC241423	Change in Conditions	Dec-23	Nov-40	2	14175	14175	14175
BZ19/0165	145915 9	509077 2	CRC184763	New Consent	May-18	May-33	4.9	37806	37806	37806
BZ19/0186	146008 5	508961 4	CRC185001	New Consent	May-18	May-33	66	553571	553571	553571
J38/0081	146004 7	509088 9	CRC051053	New Consent	Mar-05	Mar-40	3.5	29417	29417	0
J38/0114	145944 8	508878 9	CRC224247	Part Surrender	Apr-22	Apr-30	19.1	30644	30644	0
J38/0134	145867 9	509055 5	CRC181899	Part Transfer	Oct-17	Oct-30	40	518400	518400	0
J38/0135	145938 5	508996 3	CRC253612	Full Transfer	Feb-25	Oct-30	47.6	596636	596636	0
J38/0140	145831 8	508956 8	CRC952014	Renewal	May-95	May-30	1.4	5883	5883	0
J38/0143	145988 0	509004 4	CRC185001	New Consent	May-18	May-33	66	553571	553571	553571
J38/0147	145964 8	508863 7	CRC240205	Full Transfer	Jun-23	Sep-30	5	47068	47068	0
J38/0633	145999 3	508931 6	CRC185001	New Consent	May-18	May-33	66	553571	553571	553571
J38/0934	145848 8	508906 2	CRC251174	Renewal	Sep-24	Jan-40	4.2	54258	54258	54258

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
J39/0556	145992 5	508675 1	CRC215021	Full Transfer	May-21	Mar-42	22	665000	665000	665000
K38/0085	146184 7	509049 0	CRC040516.2	Full Transfer	Oct-06	Oct-38	25	195180	195180	0
K38/0086	146135 8	508896 0	CRC960129	Renewal	Aug-95	Aug-30	49	402188	402188	0
K38/0087	146524 5	509589 0	CRC223562	Part Surrender	Nov-21	Oct-30	60			
K38/0088	146238 4	509289 4	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/0088	146238 0	509289 7	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0089	146225 0	509223 2	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/0089	146224 9	509223 8	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0092	146090 1	508977 9	CRC041364.1	Full Transfer	Sep-06	Jul-36	35	152220	152220	0
K38/0172	146140 8	509345 7	CRC012064	Renewal	Feb-02	Jan-37	7	6196	6196	0
K38/0174	146114 6	509358 9	CRC951600	Renewal	Dec-98	Dec-33	19	235455	235455	0
K38/0182	146154 8	508979 0	CRC951474	New Consent	Apr-95	Apr-30	12	29573	29573	0
K38/0190	146499 5	509622 0	CRC251896	Full Transfer	Sep-24	Sep-34	19	53760	53760	0
K38/0193	146404 5	509569 0	CRC223553	Part Surrender	Nov-21	Oct-34	50	448403	448403	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K38/0199	1463396	5094000	CRC155767	Change in Conditions	Jul-15	May-30	107	988250	988250	988250
K38/0199	1464399	5094039	CRC155767	Change in Conditions	Jul-15	May-30	107	988250	988250	988250
K38/0202	1464405	5094040	CRC155767	Change in Conditions	Jul-15	May-30	107	988250	988250	988250
K38/0208	1463534	5094191	CRC155767	Change in Conditions	Jul-15	May-30	107	988250	988250	988250
K38/0212	1465282	5093889	CRC960266.2	Full Transfer	May-12	Sep-30	38	453972	453972	0
K38/0216	1464265	5094710	CRC223571	Part Surrender	Nov-21	May-36	33	274772	274772	0
K38/0228	1463682	5094474	CRC155767	Change in Conditions	Jul-15	May-30	107	988250	988250	988250
K38/0230	1462147	5089750	CRC251495	Full Transfer	Oct-24	Dec-33	66	87500	350000	350000
K38/0270	1463362	5093455	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0270	1463146	5093440	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/0272	1465144	5096590	CRC195408	Full Transfer	Jun-19	Oct-30	25			
K38/0275	1461447	5091190	CRC155440	Change in Conditions	Mar-15	Mar-39	30	148754	148754	148754
K38/0278	1461946	5093539	CRC156037	Full Transfer	Mar-15	Jul-30	20	197297	197297	0
K38/0279	1460131	5090975	CRC181901	Part Transfer	Oct-17	Oct-30	22.7	260507	260507	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K38/0280	146210 1	509359 6	CRC202277	Full Transfer	Nov-19	Aug-26	19	39434	157735	157735
K38/0282	146604 5	509469 1	CRC223538	Part Surrender	Nov-21	May-30	38	418132	418132	0
K38/0290	146315 7	509564 7	CRC156464	Full Transfer	Apr-15	Jul-30	38	47830	47830	0
K38/0290	146315 7	509564 7	CRC121509.1	Full Transfer	Jul-12	Jul-30	38	233169	233169	0
K38/0301	146147 7	509008 0	CRC181046	Part Surrender	Aug-17	Feb-30	4.9	44100	44100	0
K38/0324	146255 6	509611 5	CRC991813A	Renewal	Mar-02	Oct-30	40			
K38/0325	146509 6	509336 1	CRC231121	Full Transfer	Jun-22	Sep-30	35	413911	413911	0
K38/0327	146126 5	508977 3	CRC232814	Full Transfer	Dec-22	Jul-36	35	141949	141949	0
K38/0328	146659 5	509442 1	CRC951166.2	Full Transfer	May-08	Apr-30	20	226986	226986	0
K38/0332	146424 5	509529 0	CRC050196	New Consent	Oct-05	Oct-30	45.5	252720	252720	252720
K38/0332	146424 5	509529 0	CRC960509	Renewal	Oct-95	Oct-30	27	252720	252720	0
K38/0336	146054 6	509268 9	CRC170285	Part Surrender	Jun-16	Jul-30	4.9	18760	18760	0
K38/0347	146198 8	508929 0	CRC960129	Renewal	Aug-95	Aug-30	49	402188	402188	0
K38/0424	146288 2	509292 9	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K38/0424	146288 2	509292 9	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0439	146124 8	508989 0	CRC181548	Full Transfer	Sep-17	Nov-28	4	11829	11829	0
K38/0452	146294 6	509438 0	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/0453	146268 6	509407 0	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/0536	146752 5	509489 1	CRC952556.2	Full Transfer	May-08	Aug-30	20	191146	191146	0
K38/0600	146240 9	509507 7	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/0601	146338 5	509485 0	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/0701	146164 7	509183 9	CRC211198	Full Transfer	Sep-20	Dec-34	20	106800	106800	106800
K38/0759	146207 7	509088 0	CRC223395	Part Surrender	Jan-22	Jul-30	30	343043	343043	0
K38/0765	146597 6	509511 3	CRC960510.1	Change in Conditions	Nov-05	Oct-30	45	322559	322559	0
K38/0789	146248 5	509586 9	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/0795	146324 9	509684 2	CRC021573A. 4	Change in Conditions	Dec-07	Oct-30	54			
K38/0795	146324 9	509684 2	CRC021573B. 4	Change in Conditions	Dec-07	Oct-30	54			
K38/0798	146423 5	509554 0	CRC223553	Part Surrender	Nov-21	Oct-34	50	448403	448403	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K38/0821	1462428	5091619	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0822	1462634	5091874	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0823	1462476	5092560	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0823	1462476	5092560	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/0824	1462742	5092348	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/0824	1462742	5092348	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/0860	1465589	5095249	CRC251903	Full Transfer	Sep-24	Sep-34	32	143359	143359	0
K38/0863	1463275	5096520	CRC151275	Full Transfer	Jul-14	Oct-30	25			
K38/0988	1464645	5096020	CRC223562	Part Surrender	Nov-21	Oct-30	60			
K38/1083	1466605	5094341	CRC012786.1	Full Transfer	May-08	Jan-37	45	128426.3	513705	0
K38/1085	1463002	5093575	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/1085	1463002	5093575	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/1086	1461639	5092973	CRC202942	Renewal	Nov-24	Nov-31	92.5	906681	906681	906681
K38/1086	1461639	5092973	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K38/1290	1463456	5092264	CRC991999.2	Full Transfer	Mar-07	Mar-36	21.1	99579	119495	0
K38/1384	1463292	5091264	CRC260285	Full Transfer	Jun-25	Feb-34	25	54939	219756	0
K38/1511	1463157	5090630	CRC260281	Full Transfer	Jun-25	Jul-34	24	236581	236581	0
K38/1671	1461737	5092080	CRC951122.2	Full Transfer	Jan-06	Mar-30	28	178500	178500	178500
K38/1684	1461937	5090620	CRC040516.2	Full Transfer	Oct-06	Oct-38	25	195180	195180	0
K38/1899	1461030	5092645	CRC061327	New Consent	Nov-05	Nov-40	15	143450	143450	143450
K38/2270	1462935	5094960	CRC224423	Renewal	Oct-24	Dec-33	146	221180	221180	884720
K38/2300	1466952	5095140	CRC184742	New Consent	May-18	May-33	4.9	32857	32857	32857
K38/2371	1462878	5093798	CRC183228	Full Transfer	Dec-17	Jan-37	14	180602	180602	180602
K38/2371	1462781	5093782	CRC183228	Full Transfer	Dec-17	Jan-37	14	180602	180602	180602
K39/0021	1460029	5086749	CRC215009	Full Transfer	May-21	Apr-30	11	345800	345800	0
K39/0024	1461428	5087690	CRC183605	Part Surrender	Feb-18	Apr-30	4.9	5915	5915	0
K39/0025	1460515	5087599	CRC204012	Full Transfer	Mar-20	Jun-30	35	576576	576576	0
K39/0026	1460449	5087579	CRC204012	Full Transfer	Mar-20	Jun-30	35	576576	576576	0

FEATURE NAME	NZTMX	NZTMY	CONSENT NO	CONSENT SOURCE	FM DATE	TO DATE	MAX RATE (L/s)	EFFECTIVE ANNUAL VOLUME (m³)	FULL EFFECTIVE ANNUAL VOLUME (m³)	CONSENTED ANNUAL VOLUME (m³)
K39/0027	146044 9	508756 9	CRC204012	Full Transfer	Mar-20	Jun-30	35	576576	576576	0
K39/0033	146039 7	508716 0	CRC951131.1	Full Transfer	Dec-09	Feb-30	9.5	186732	186732	0
K39/0257	146151 9	508781 9	CRC176639	Full Transfer	Jun-17	Jan-32	20	315360	315360	315360
K39/0258	146156 9	508787 9	CRC176639	Full Transfer	Jun-17	Jan-32	20	315360	315360	315360
K38/0301	146147 7	509007 9	CRC181046	Part Surrender	Aug-17	Feb-30	4.9	44100	44100	0
K38/2300	146699 9	509502 2	CRC184742	New Consent	May-17	May-33	4.9	32857	32857	32857
J38/0143 J38/0633 BZ19/0186	146001 9	508994 5	CRC185001	New Consent	May-18	May-33	66	553571	553571	553571
K38/1384	146336 0	509083 7	CRC260285	Full Transfer	Jun-25	Feb-34	25	54939	219756	0

APPENDIX I

FIELD IMAGES





Figure I1: Horseshoe Lagoon at Coast



Figure I2: Stopbank at Horseshoe Lagoon (North Facing)



Figure I3: Stopbank at Horseshoe Lagoon (South Facing)



Figure I4: Stopbank at Philips Lagoon, Beach Road (South Facing)



Figure I5: Ditch Running Across Beach Road (Photo from Stopbank)



Figure I6: Philips Lagoon (Westward facing)



Figure I6: Stage Difference between Philips Lagoon (Right Water Body) and Coastal Waters (Left Water Body)



Figure I7: Philips Lagoon At Seadown Main Drain Start



Figure I8: Seadown Main Drain Facing Southward at Philips Lagoon



Figure I9: Coastal-side of Stopbank at Philips Lagoon



Figure I10: Beach Road Drain and Culvert, Connected to Philips Lagoon



Figure I11: Kereta Road and Culvert, Connected to Philips Lagoon



Figure I12: A Drain and Culvert on Kereta Road Drain, Connecting to Seadown Main Drain



Figure I13: An Additional Drain and Culvert on Kereta Road, Connecting to Seadown Main Drain



Figure I14: A Drain on the Coastward side of Kereta Road, Connecting to Seadown Main Drain



Figure I15: Converging Drains at Corner of Kereta Road and Phar Lap Road (Connecting to Seadown Main Drain)



Figure I16: Stage Gauge and Weir at Aorangi Road (Connecting to Seadown Main Drain)



Figure I17: Seadown Main Drain at Aorangi Road (Southward Facing)



Figure I18: Seadown Main Drain at Aorangi Road (Northward Facing)



Figure I19: Aorangi Road Drain Entering Seadown Main Drain at Aorangi Road (Eastward Facing)



Figure I20: Washdyke Lagoon Ring Drain at Outlet (Facing Westward)



Figure I21: Washdyke Lagoon Ring Drain Coastal Outlet

APPENDIX J

SENSITIVITY ANALYSIS



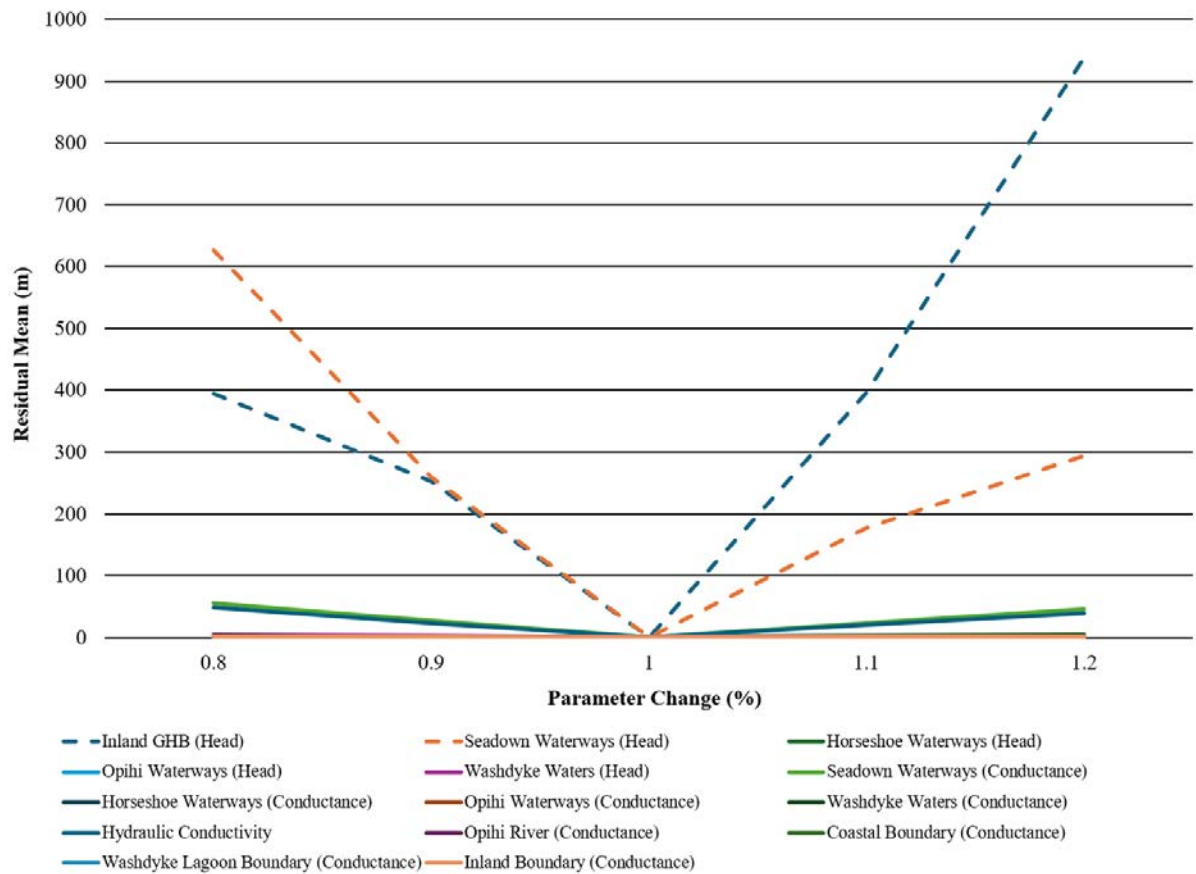


Figure J1: Parameter Sensitivity Based on Percentage Change and Residual Mean

GROUNDWATER VISTAS SENSITIVITY ANALYSIS									
Parameter: GHB Head Reach: 15									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	2.99E+08	394.3546	2576.517	1.113456	69492.44	-218897	1.49E+09	-3E+08
2	0.9	1.23E+08	253.0152	1654.288	0.551741	45831.93	-243600	1.23E+09	-1.2E+08
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	3.02E+08	395.4731	2588.653	-0.53612	-6957.33	-288810	3.02E+09	-3E+08
5	1.2	1.70E+09	938.2331	6143.675	-1.05261	-35722.1	-308006	8.5E+09	-1.7E+09
Parameter: Drain Head Reach: 1									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	7.59E+08	626.6871	4106.618	0.138345	21321.99	-250087	3.8E+09	-7.6E+08
2	0.9	1.30E+08	259.7282	1700.805	0.056726	20753.76	-260012	1.3E+09	-1.3E+08
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	6.02E+07	176.5986	1155.855	-0.03718	20025.34	-272094	6.02E+08	-6E+07
5	1.2	1.67E+08	294.4401	1928.522	-0.06193	19835.22	-275502	8.37E+08	-1.7E+08
Parameter: Drain Head Reach: 2									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	1.76E+03	1.281522	6.250416	0.000382	20327.7	-267184	8782.07	-1756.41
2	0.9	5.62E+02	0.865936	3.536731	0	20319.55	-267218	5612.516	-561.252
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	5612.516	-561.252
5	1.2	5.62E+02	0.865936	3.536731	0	20319.55	-267218	2806.258	-561.252
Parameter: Drain Head Reach: 3									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	1.72E+04	3.313051	19.55998	0.009943	23692.85	-266939	86092.55	-17218.5
2	0.9	3.41E+03	1.656344	8.702843	0.002685	21257.78	-267133	34067.97	-3406.8
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	7.33E+02	0.942864	4.037763	0.00004	20314.35	-267216	7320.086	-732.009
5	1.2	7.01E+02	0.929112	3.94814	0.000031	20312.8	-267219	3499.02	-699.804
Parameter: Drain Head Reach: 4									

GROUNDWATER VISTAS SENSITIVITY ANALYSIS									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	3.62E+04	4.653003	28.34373	0.003811	20323.1	-266946	180806.3	-36161.3
2	0.9	1.34E+04	2.959224	17.24259	0.002037	20322.98	-267066	133803.3	-13380.3
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	7.64E+02	0.956094	4.117074	-0.0013	20322.96	-267291	7627.457	-762.746
5	1.2	1.07E+04	2.67802	15.38939	-0.00308	20322.87	-267412	53321.4	-10664.3
Parameter: Drain Conductance Reach: 1									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	5.77E+06	54.93973	358.1025	-0.01106	20249.97	-268598	28868381	-5773676
2	0.9	1.39E+06	27.11518	175.6436	-0.00506	20288.54	-267850	13889793	-1388979
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	1.01E+06	23.16584	149.7261	0.005409	20357.65	-266559	10093750	-1009375
5	1.2	3.94E+06	45.45868	295.8966	0.010181	20383.61	-265976	19710653	-3942131
Parameter: Drain Conductance Reach: 2									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	5.62E+02	0.865936	3.536731	0	20319.55	-267218	2806.258	-561.252
2	0.9	5.62E+02	0.865936	3.536731	0	20319.55	-267218	5612.516	-561.252
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	5612.516	-561.252
5	1.2	5.62E+02	0.865936	3.536731	0	20319.55	-267218	2806.258	-561.252
Parameter: Drain Conductance Reach: 3									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	9.20E+02	1.017257	4.522993	0.000085	20316.33	-267209	4594.629	-918.926
2	0.9	1.07E+03	1.073324	4.889027	0.000118	20318.1	-267203	10739.55	-1073.96
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	1.06E+03	1.069054	4.861128	0.000119	20323.24	-267200	10617.14	-1061.71
5	1.2	9.12E+02	1.014212	4.503098	0.000088	20324.39	-267203	4554.224	-910.845
Parameter: Drain Conductance Reach: 4									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss

GROUNDWATER VISTAS SENSITIVITY ANALYSIS									
1	0.8	8.58E+03	2.436167	13.80459	-0.00285	20323.04	-267375	42904.87	-8580.97
2	0.9	4.22E+02	0.793615	3.06006	-0.00115	20323.03	-267271	4209.869	-420.987
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	1.07E+04	2.681558	15.42328	0.001762	20323.05	-267092	107051.2	-10705.1
5	1.2	2.48E+04	3.909249	23.46925	0.003024	20323.05	-267013	123958.5	-24791.7
Parameter: Kx Zone: 1									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	4.46E+06	48.31784	314.6441	0.01694	16992.12	-213632	0	-4457169
2	0.9	1.04E+06	23.51848	152.0419	0.007909	18677.36	-240431	0	-1040734
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	7.27E+05	19.70505	127.0474	-0.00638	21930.7	-293914	0	-726732
5	1.2	2.88E+06	38.87321	252.7374	-0.01293	23500.96	-320681	0	-2875901
Parameter: River Conductance Reach: 0									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	8.27E+02	0.981236	4.288048	-8.9E-05	19911.82	-266890	4128.876	-825.775
2	0.9	8.61E+02	0.99473	4.376037	-1E-06	20126.18	-267057	8600.785	-860.078
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	1.79E+03	1.290827	6.310852	0.000404	20496.5	-267321	17905.87	-1790.59
5	1.2	8.30E+02	0.982634	4.297019	0.000197	20647.25	-267472	4146.191	-829.238
Parameter: GHB Conductance Reach: 0									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	3.20E+03	1.614964	8.427475	-0.00159	19873.85	-266301	15990.69	-3198.14
2	0.9	1.38E+01	0.383922	0.556192	-0.00049	20123.9	-266755	128.1465	-12.8147
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	4.68E+03	1.883748	10.1934	0.000848	20499.14	-267568	46747.49	-4674.75
5	1.2	1.14E+04	2.75755	15.92009	0.001576	20659.19	-267852	57031.63	-11406.3
Parameter: GHB Conductance Reach: 1									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	1.95E+03	1.332674	6.584495	0.000273	20321.43	-266767	9747.081	-1949.42

GROUNDWATER VISTAS SENSITIVITY ANALYSIS									
2	0.9	1.81E+03	1.296285	6.346464	0.000258	20321.37	-266993	18108.86	-1810.89
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	5.93E+02	0.880693	3.632773	0.000018	20319.87	-267385	5922.309	-592.231
5	1.2	5.09E+02	0.839501	3.36479	0.000002	20319.8	-267536	2539.296	-507.859
Parameter: GHB Conductance Reach: 15									
Run	Multiplier	Sum of Squares	Residual Mean	Residual Std.	Average Drawdown	River	GHB	Sensitivity	DeltaRss
1	0.8	1.89E+03	1.317763	6.487321	0.001035	20330.09	-267195	9460.829	-1892.17
2	0.9	9.10E+02	1.013391	4.497993	0.000327	20323.18	-267207	9087.634	-908.763
3	1	5.62E+02	0.865936	3.536731	0	20319.55	-267218	0	-561.252
4	1.1	9.15E+02	1.015433	4.510886	-0.00012	20317.79	-267207	9140.153	-914.015
5	1.2	9.08E+02	1.012943	4.494468	-0.00029	20315.72	-267207	4536.859	-907.372

APPENDIX K

PILOT POINT TARGETS



Appendix K1: Pilot Point Targets and Range

WELL NUMBER	NZTMX	NZTMY	TARGET K (m/DAY)	LOWER K (m/DAY)	UPPER K (m/DAY)
BZ19/0015	1465288	5093796	417	139	1251
BZ19/0418	1463184	5090808	3907	1302	11721
J38/0134	1458679	5090555	341	114	1023
J38/0135	1459385	5089963	325	108	975
K38/0088	1462380	5092897	496	165	1488
K38/0089	1462249	5092238	642	214	1925
K38/0183	1462047	5091290	933	311	2799
K38/0208	1463534	5094191	2250	750	6750
K38/0270	1463362	5093455	1642	547	4926
K38/0272	1465035	5096590	199	66	597
K38/0275	1461447	5091189	1440	480	4320
K38/0277	1460197	5090389	14	5	42
K38/0279	1460131	5090975	612	204	1836
K38/0341	1463497	5091430	400	133	1200
K38/0424	1462882	5092929	550	183	1650
K38/0453	1462686	5094070	3107	1036	9321
K38/0701	1461647	5091839	200	67	600
K38/0789	1462485	5095869	1906	635	5718
K38/0821	1462428	5091619	175	58	525
K38/0824	1462742	5092348	376	125	1127
K38/1085	1463002	5093575	2715	905	8145
K38/1086	1461639	5092973	1154	385	3462
K38/1384	1463292	5091264	395	132	1185
K38/2371	1462781	5093782	152	51	456
BZ19/0447	1460928	5093977	70	23	210
Fill Pilot Points	-	-	500	150	1700



FOR FURTHER INFORMATION CONTACT:

William Dench
Senior Hydrogeologist

T [Click here to enter Phone](#)
E wdench@wganz.co.nz

WGA.COM.AU
WGANZ.CO.NZ

