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Groundwater Assessment Report

Middle Road Subdivision

CDL LAND NEW ZEALAND LTD.

WWLA1869 | Rev. 2

28 August 2026



Middle Road Subdivision

Project no:	WWLA1869
Revision:	1
Date:	28 August 2026
Client name:	CDL Land New Zealand Ltd.
Project manager:	Jon Williamson
Author(s):	Asanka Thilakerathne
File name:	G:\Shared drives\Projects\CDL Land New Zealand Limited\WWLA1869_Middle Road Subdivision - Groundwater\Deliverables\Reports\GW Assessment-Rev2\WWLA Rep_CDL_Groundwater Assessment_280826_Rev2.docx

Williamson Water & Land Advisory

P.O. Box 314
Kumeu
New Zealand
www.wwla.kiwi

Document history and status

Rev	Date	Description	By	Review	Approved
1	20 August 2026	Draft for internal review	Asanka Thilakerathne	Chris Simpson/ Jaide Derbyshire	Chris Simpson / Jon Williamson
2.	28 August 2026	Address client's comments	Asanka Thilakerathne	Jaide Derbyshire	Chris Simpson / Jon Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
1	24 August 2026	CDL Land New Zealand Ltd.	Draft for client's comments
2.	28 August 2026	CDL Land New Zealand Ltd.	Updated draft for client's comments

Executive Summary

Project Objectives	This Groundwater Assessment has been prepared to assess the potential groundwater inflows to the proposed dry basins (DBs) and the potential of basin flooding due to elevated groundwater levels, as part of the Middle Road subdivision project. The assessment also outlines a proposed groundwater monitoring programme to verify the groundwater model predictions.
Methods	Groundwater conditions were assessed using a calibrated, low-complexity, single-layer groundwater model representing both pre-construction and post-construction conditions. The model was developed to simulate groundwater levels and groundwater flows associated with the proposed development. Due to the absence of continuous site-specific groundwater level monitoring data, the model was calibrated using groundwater level data and seasonal groundwater level fluctuations simulated by the Soil Moisture Water Balance Model (SMWBM). An average hydraulic conductivity of 3×10^{-6} m/s was adopted for the silts, clays, and organic materials. Groundwater recharge was set at 40% of mean annual rainfall (730 mm/year) to represent a conservative, high recharge condition.
Summary of Results	The simulated groundwater flow patterns indicate that most of the groundwater inflow to the proposed DBs is conveyed through the low-flow channels. The combined average groundwater flow into the Northern DBs (DB1 to DB3) is approximately 212 m^3/day (2.5 L/s), while the combined average flow into the Southern DBs (DB4 to DB6) is approximately 77 m^3/day (0.9 L/s). The model predicts a maximum total groundwater inflow to the Northern DBs of approximately 9 L/s, comprising flow through the low flow channels and direct groundwater seepage from the DB catchments. The corresponding maximum groundwater inflow to the Southern DBs is approximately 2.5 L/s.
Key Conclusions	The assessment indicates that the proposed development is not at significant risk of groundwater flooding due to overtopping of elevated groundwater levels. Under the modelled conditions, groundwater pressure heads do not exceed the crest elevations of the proposed DBs, and therefore groundwater driven flooding or overflow of the DBs is not predicted. However, site specific groundwater level data are very limited at the time of this assessment. A comprehensive groundwater monitoring programme is therefore recommended to commence as soon as practicable. Continuous monitoring through a range of climatic conditions, including wet weather periods, will provide site specific data to verify the groundwater model predictions and, if required, provide a basis for refining the model and assessment. That information will help inform the need for any additional drainage requirements that can be included during detailed design.

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1. Statement of Qualifications & Experience

Report Author

Asanka Thilakerathne is an Intermediate Hydrogeologist. He has been employed at WWLA since February 2024 and has 13 years of professional experience as a Hydrogeologist. His expertise includes groundwater management, groundwater modelling, geophysical exploration, groundwater recharge, borehole construction and test pumping.

Asanka's qualifications include a Bachelor of Science in Geology from University of Peradeniya, Sri Lanka, completed in 2007 and a Master of Science in Hydrogeology and Environmental Management from the Technical University of Darmstadt in Germany completed in 2013. He also holds a certificate in Numerical Groundwater Modelling from IHE Delft Institute for Water Education in Netherlands, completed in 2019.

Report Reviewer

Jaide Derbyshire is an Intermediate Hydrologist at WWLA. Jaide holds a BSc (Hons) in Environmental Earth Science from Aberystwyth University in the UK, and a MSc (Hons) in Exploration and Environmental Geoscience from Luleå University of Technology in Sweden. Jaide has over 5 years of professional experience in hydrology, hydraulic modelling, structural geology, and flood risk management. Her recent focus has been in ground-surface water interactions, CAD design drawings, groundwater and surface water takes, flood assessments, system capacity analysis, and catchment delineation.

Chris Simpson is a Principal Hydrogeologist at WWLA. Chris holds an MSc (Hons) in economic geology from the University of Auckland and has over 30 years of experience as a consultant and in the private sector. After an initial career in resource exploration and mining, he joined the environmental consulting industry working on projects related to geological engineering, contaminated land, stormwater and groundwater. Stemming from that early experience, he has built a technical profile working on groundwater supply and wastewater disposal projects for domestic, commercial, and municipal clients. Aside from his technical expertise, Chris spent four years teaching hydrogeology at undergraduate and post-graduate levels at the University of Auckland and has been a Certified Environmental Practitioner (CEnvP) for over 10 years.

Technical Director

Jon Williamson is an Earth Scientist with expert skills in hydrology and hydrogeology, and associated sub-disciplines such as soils, wetlands, and fluid hydraulics. Over the last 30 years Jon has been a professional consultant and has achieved great deal of experience in research and assessment of environmental impacts from a vast array of different development and land use types. This experience has also included numerous appearances at Council, Environment Court, Board of Inquiry and EPA Fasttrack Legislation Hearings and involvement in joint witness processes.

Code of Conduct

The qualifications and experience of the author, reviewer and technical director of this report are summarised above. We confirm that we have read the Code of Conduct for Expert Witnesses contained in the Environment Court of New Zealand Practice Note 2023 and we agree to comply with it. We confirm that the issues addressed in this report are within our area of expertise, except where we state that we are relying on the evidence or advice of another person. We have not omitted to consider material facts known to us that might alter or detract from the opinions expressed in this report.

2. Introduction

This Groundwater Assessment Report has been prepared by Williamson Water and Land Advisory (WWLA) on behalf of CDL Land New Zealand Limited (CDL |the Applicant) in support of a Substantive Application for the Middle Road Project under the Fast-track Approvals Act 2024 (FTAA) to be lodged with the Environmental Protection Agency (EPA). The site location is shown on **Figure 1**.

The Project comprises a comprehensively planned residential development of approximately 317 lots, supported by integrated transport, three waters infrastructure and open space, including stormwater management designed in accordance with best-practice treatment and attenuation principles.

WWLA has developed a low complexity 3D numerical groundwater model of the shallow, unconfined aquifer underlying the proposed Middle Road development site. The model domain is shown on **Figure 2**. The model has been developed to simulate groundwater flow into the six proposed dry basins (DB 1 to 6) and the subsequent discharge from the dry basins to the nearby Herehere Stream and Karamū Stream via the proposed outlet structures.

2.1 Description of Application Site

The application site is located at 92, 108, 148 Middle Road and 139 Te Aute Road in Havelock North (site). The site is held in five separate titles and consists of a combined area of approximately 30.6ha. The site is relatively flat and currently used for rural residential and grazing purposes with four existing dwellings. **Figure 1** shows the site extent within the context of Havelock North.



Figure 1. Middle Road site location.

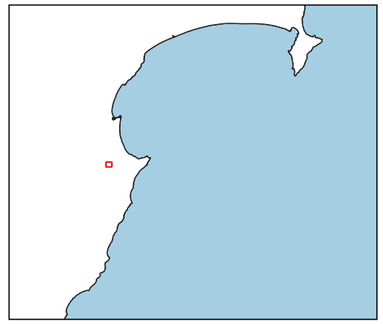
The site is on the southwest side of Havelock North, approximately 900m south of the town centre, which contains a range of retail and commercial uses. The wider land uses to the north, east and west of the site are predominantly suburban residential in character, with a retirement village to the northwest and larger rural landholdings to the southwest.

The Planning Report and other technical assessments prepared to support the substantive application under the FTAA provides a comprehensive description of the site and its context.

Map Title:
Model Area

Project:
Middle Road Subdivision

Client:
CDL Land New Zealand Limited



Legend

- Piezometers
- Low-flow Channels
- Internal Drain Network
- Dry Basins
- Catchments of the Dry Basins
- Project Area
- Model Area

Top Level Basemap Data

- Road
- River/Stream
- Lake/Pond

Data Provenance
Aerial Imagery from Land Information New Zealand

Drawn by: Asanka Thilakerathne
18/08/2026

Layout & Project File
Surface Water

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Figure 2

2.2 Description of the Proposal

The Middle Road project will provide for the residential subdivision of the site to enable the development of approximately 317 residential dwellings. The intended subdivision layout will provide for a range of lot sizes to enable conventional residential development along with medium density development opportunities. A masterplan has been prepared to inform the substantive application and is provided as

Figure 3. The development is supported by a suite of technical assessments addressing key environmental matters, including infrastructure, stormwater, geotechnical, groundwater, landscape, transport, ecology, contamination, productive land, noise, archaeology and urban design.

A full description of the Middle Road Project is provided in the Planning Report submitted in support of the Substantive Application.



Figure 3.. Master plan of the Site

3. Existing Groundwater Environment

3.1 Catchment

The site is located within the Karamū Stream catchment, which covers approximately 468.69 km^2. The catchment extends across much of the Heretaunga Plains, encompassing a diverse range of land uses, including pastoral farming, horticulture, viticulture, cropping, and urban areas such as Hastings and Havelock North. The Karamū Stream serves as the primary drainage network for the southern Heretaunga Plains, receiving runoff, stormwater, and groundwater contributions from numerous tributaries before discharging into the Clive River. The catchment has been extensively modified through flood protection and drainage works, making it a highly managed hydrological system.

3.2 Regional Hydrogeology

The site falls within the southeastern margin of the Heretaunga Plains, an alluvial groundwater system with multiple hydraulically connected and highly permeable gravel aquifer layers. Groundwater supplying Havelock North is abstracted from the Te Mata aquifer, a shallow alluvial aquifer that forms part of the broader Heretaunga Plains groundwater system.

The shallow aquifer system at depths less than 50 m is heavily used for groundwater abstraction, which is a testament of the excellent hydraulic conductivity or ability of the aquifer to transmit water. The Heretaunga aquifer extends considerably deeper and monitoring bores reach 220 m. Some of the highest yields for the Heretaunga Plains aquifer are obtained from Hastings City bores at Frimley Park with aquifer transmissivities greater than 30,000 m^2/day, while in Havelock North yields are poor, with measured transmissivities of 200 to 2,000 m^2/day and a storage coefficient of $2x10^{-3}$.

3.2.1 Shallow Aquifer

As indicated above, the shallow aquifer consists mainly of unconfined to semi-confined Quaternary fluvial gravels and sands deposited by successive channels of the Ngaruroro River. Unlike the highly productive central plains, Havelock North lies near the edge of the main aquifer system, where the aquifer becomes thinner and more heterogeneous with the inclusion of greater proportions of silts, clays and organic material (CDL, 2026a).

The shallow aquifer is primarily recharged by seepage from the Ngaruroro River, particularly along the reach between Roys Hill and Fernhill, which forms the principal recharge zone for the Heretaunga Plains aquifer system. Local rainfall provides additional recharge where the aquifer is unconfined, although this contribution is generally secondary.

Aquifer transmissivity near Havelock North is relatively low, typically ranging from 200 to 2,000 m^2/day, reflecting its location along the margin of the Heretaunga Plains aquifer system. In contrast, bores near Karamū Stream that intercept the approximately 50 m deep gravel aquifer exhibit transmissivities of 10,000–25,000 m^2/day, indicating the presence of locally extensive and highly permeable gravel channels.

3.3 Site Specific Hydrogeology

3.3.1 Groundwater Monitoring, Dry Basins and Catchments

Three piezometers (MH01, MH02, and MH03) were installed at the site (**Figure 2**), and groundwater levels were measured twice at each location during June and July 2026. We note that at the time of undertaking this assessment there is limited groundwater monitoring data available over time and, due to that limitation, simulated water levels have been developed. Ongoing groundwater level monitoring is therefore recommended to support this site-specific assessment and reliably show the groundwater response to weather events and seasonal/inter-annual climate variation.

Table 1. Measured groundwater levels (GWL) within the on-site piezometers (mAMSL).

Bores	MH01	MH02	MH03
Depth (m)	6	6	6
Ground Elevation	8.20	8.60	8.50
GWL on 2 June	5.90	7.50	7.10
GWL on 14 July	6.1	8.15	7.4
Median GWL	6.00	7.82	7.25

All the proposed dry basins are planned to be interconnected at the base, with low flow channels provided along the lowest areas of the basins to convey flows from one basin to the next (**Figure 2**). The dry basins will be approximately 1.5 m deep. DB 1 is the largest proposed basin, which has capacity of approximately 37,156 m^3 (**Table 2**).

Table 2. Summary of dry basins and catchments.

Basin ID	Area (m^2)	Approximate Capacity (m^3)	Basin Cluster
DB 1	24,771	37,156.5	Northern Dry Basins
DB 2	4,318	6,477.0	
DB 3	3,192	4,788.0	
DB 4	4,676	7,014.0	Southern Dry Basins
DB 5	8,587	12,880.5	
DB 6	2,533	3,799.5	

Seven catchments have been delineated by CDL (CDL, 2026c), as shown in **Figure 2** and listed below. It has been assumed that Catchments A, B, C, and E drain to DB 1 to 3 (North DBs), while Catchments D, F, and G drain to DB 4 and 5 (South DBs).

Table 3. Summary of catchments.

Catchment ID	Area (m^2)
Catchment A	19,260
Catchment B	58,025
Catchment C	25,114
Catchment D	37,853
Catchment E	141,300
Catchment F	11,235
Catchment G	27,506

4. Conceptual Groundwater Model

A conceptual hydrogeological model was developed based on the current understanding of the groundwater system, informed by data provided by CDL, preliminary findings from drilling (CDL,2026a) and groundwater measurements, and a review of relevant literature. Site specific continuous monitoring data was not available and is recommended to support further analysis.

A high-level description of the key inputs and assumptions incorporated into the low complexity model development is provided below.

- ***Geological framework*** - The model area is represented by a single principal lithological unit comprising silty to sandy soils with varying amounts of organic material, forming the shallow heterogeneous overburden across the site.
- ***Groundwater recharge*** - Groundwater recharge within the model area is assumed to occur through the infiltration and percolation of rainfall through the soil profile. Based on the available site information and current understanding of the local groundwater system, recharge to the site may be as high as 40% of rainfall when accounting for gains from stream seepage (refer **Section 3.2.1**). In the interest of generating a conservative assessment, high recharge has been assumed.

Groundwater generally flows towards the Karamū Stream, with localised convergence towards the Herehere Stream and several farm drains. Elevated mountainous terrain is present to the south of the site, while the site itself is relatively flat.

Based on this conceptual hydrogeological model, a model was developed to simulate groundwater flow as a means of assessing the hydrological effects of the proposed development, as described in the following sections.

5. Numerical Model Development

The model has been developed in AquaVeo's Groundwater Modelling System (GMS) using the MODFLOW Unstructured Grid (MODFLOW-USG) code, developed by the United States Geological Survey (USGS). The model comprises a single layer with lateral boundary defined by Karamū Stream, Herehere Stream, Unnamed Stream and two no-flow boundaries.

Groundwater levels recorded during site investigations (**Table 1**) represent conditions at the time of measurement and may be influenced by several factors, including seasonal fluctuations, post drilling recovery, perched groundwater, and localised subsoil drainage effects in shallow boreholes. To account for these sources of variability and to establish representative regional groundwater conditions, a low complexity, single layer groundwater model was developed.

5.1 Modelling Methodology

Two versions of the model were developed – a transient model for the predictive simulation (pre-construction) and effects assessment (post- construction). The following sections describe the development of the model grid, boundary conditions assigned to represent the features within the model area that interact with groundwater, and hydraulic parameters used to assign the hydrogeologic materials being represented by the numerical model.

5.2 Grid Layout

5.2.1 Horizontal Discretisation

The model was developed with a base grid spacing of 64 m applied to cells through southern mountainous area, with enhanced resolution 16 m cells aligned within the site (Project Area), 2 m cells within dry basins and streams/drains, as shown in **Figure 4**. The spatial variation in grid size allows for high resolution in potentially sensitive areas, while larger grid cells allow more efficient model run times yet still provide information to assess groundwater conditions at a larger scale.

5.2.2 Vertical Discretisation

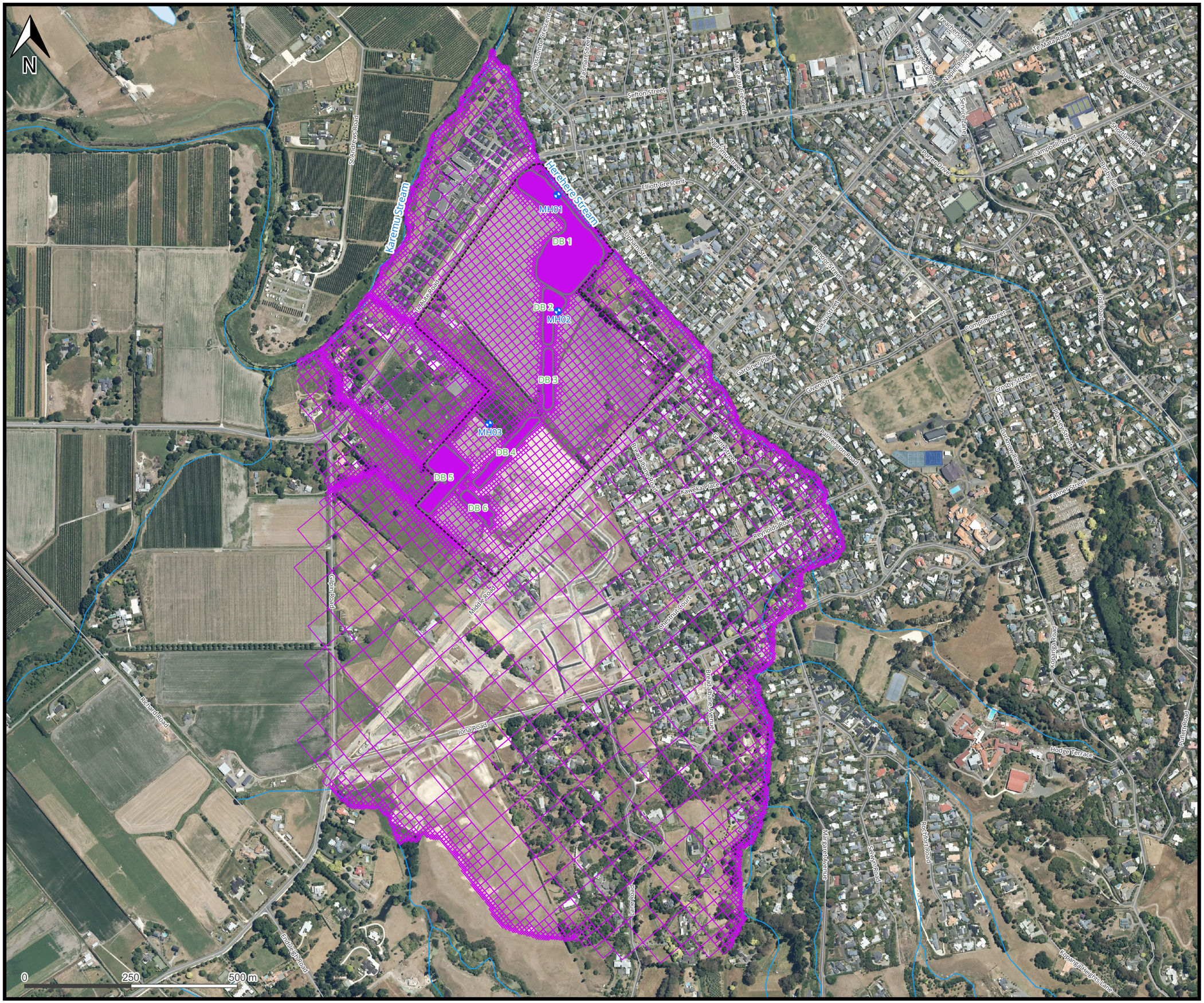
5.2.2.1 Pre Construction Model

The pre-construction model represents existing ground conditions based on 1 m resolution LiDAR data obtained from LINZ for the Hawke's Bay region. The model base elevation was set uniformly at -10 m AMSL across the entire model domain.

5.2.2.2 Post Construction Model

The post-construction model incorporates the proposed finished ground levels derived from the design surface DEM (CDL, 2026b). These design elevations were interpolated onto the 1 m resolution LiDAR dataset to generate the proposed post-construction ground surface.

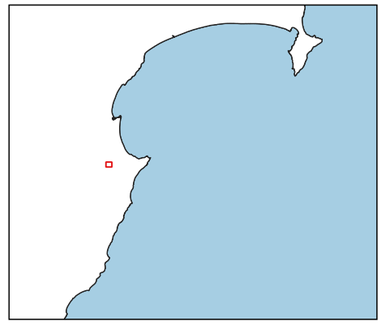
This simplified modelling approach reduces the number of parameters required and computational complexity, while retaining the key characteristics of the underlying geological materials and the principal hydrological features within the model domain.



Map Title:
Groundwate Model Grid

Project:
Middle Road Subdivision

Client:
CDL Land New Zealand Limited



Legend

- Piezometers
- The Site
- Model Grid
- Dry Basins

Top Level Basemap Data

- Road
- River/Stream
- Lake/Pond

Data Provenance
Aerial Imagery from Land Information New Zealand

Drawn by: Asanka Thilakerathne
19/08/2026

Layout & Project File
Surface Water

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Figure 4

5.3 Boundary Conditions

5.3.1 Streams, Farm Drains and Low Flow Channels

Drain boundary conditions were applied to all stream channels, farm drains, and low flow channels, with different configurations adopted for the pre- and post-construction models to account for changes to the internal drainage network between the two scenarios.

Drain elevations were assigned based on the lowest elevation within each model grid cell intersected by a stream, farm drain, or low flow channel (i.e., a drain cell). For the pre-construction model, drain elevations were derived from the LiDAR dataset. For the post-construction model, drain elevations were derived from the combined LiDAR and post-construction design surface DEM datasets. This approach ensures that the drain within a stream, farm drain, or low flow channel cell becomes active (i.e., groundwater discharge is simulated) when the water table reaches the lowest elevation within the cell.

A high drain conductance was adopted to minimise the hydraulic resistance between the drain and the underlying groundwater system. Consequently, the rate of groundwater discharge to the drains is primarily governed by the hydraulic gradient between the drain bed and the aquifer, together with the hydraulic conductivity of the intervening geological materials.

5.3.2 Catchments

The seven catchments (**Table 3**) within the model domain were represented as seepage boundaries, with the seepage elevation set at 0.25 m below ground level for the post-construction model. This configuration ensures that the seepage boundary becomes active (i.e., groundwater discharge is simulated) when the water table reaches 0.25 m below the ground surface.

As a conservative approach, it was assumed that all groundwater seepage from these catchments ultimately discharges to the low flow channels associated with the dry basins.

5.3.3 Groundwater Recharge

The groundwater model adopted a daily land surface recharge approach based on WWLA's Soil Moisture Water Balance Model (SMWBM), which is described in further detail in **Appendix A**. The SMWBM was developed to simulate historical groundwater levels across the site over the 54-year period from 1972 to 2026.

The SMWBM analysis estimated an average groundwater recharge of approximately 61 mm/year, equivalent to 8.35% of annual rainfall. However, as discussed above, the transient recharge applied to the groundwater model was increased by a factor of five, to approximately 42% of annual rainfall, to account for additional recharge associated with streams.

5.4 Model Calibration

5.4.1 SMWBM Calibration

The model was calibrated against groundwater level trends from bores 16611 and 16203, as shown in **Figure 5**. These bores are located approximately 4.5 km and 6 km from the site. They were selected from the four local bores because they provide the longest continuous groundwater level records, enabling more robust calibration across seasonal and climatic conditions. Both bores are also downgradient of the proposed development area and are therefore representative of the groundwater regime likely to influence the site. Calibration results were shown in **Figure 6** and **Figure 7.**

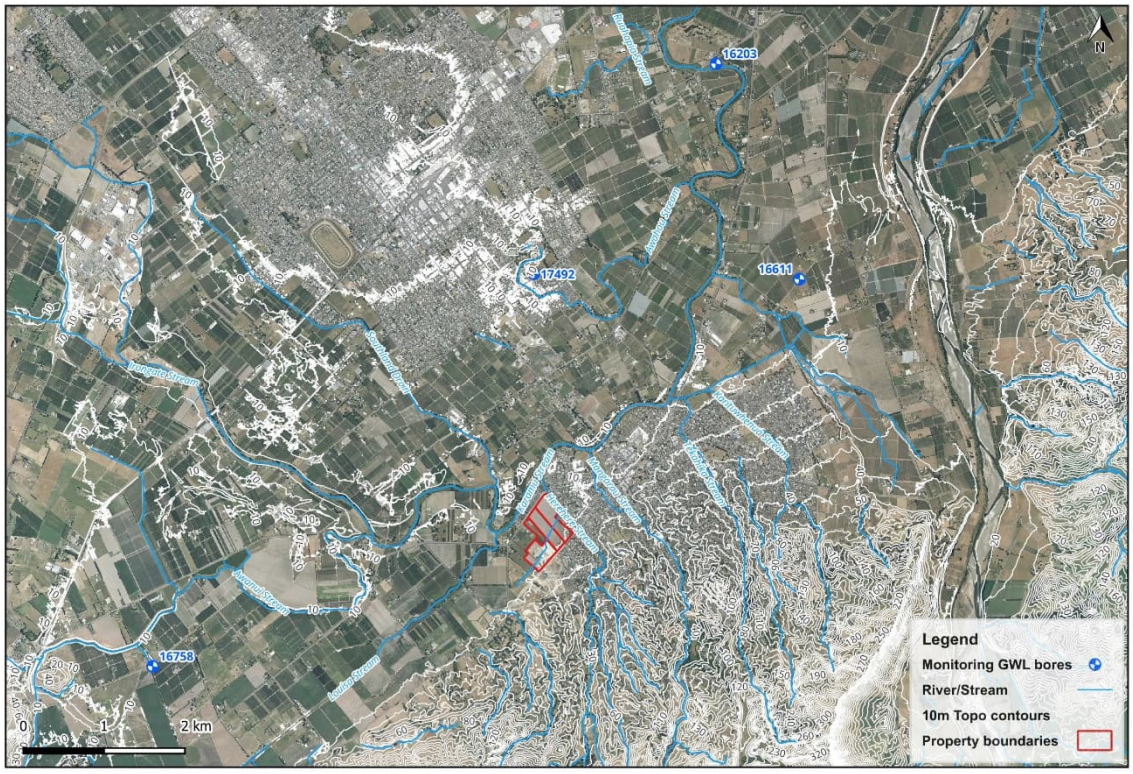


Figure 5. Location of HBRC bores.

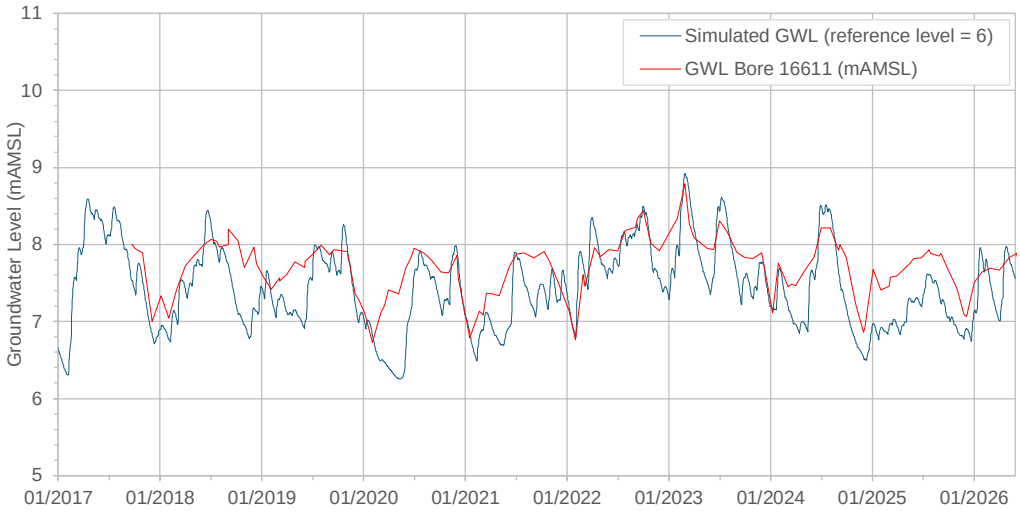


Figure 6. Observed versus simulated groundwater level calibration comparison for bore 16611.

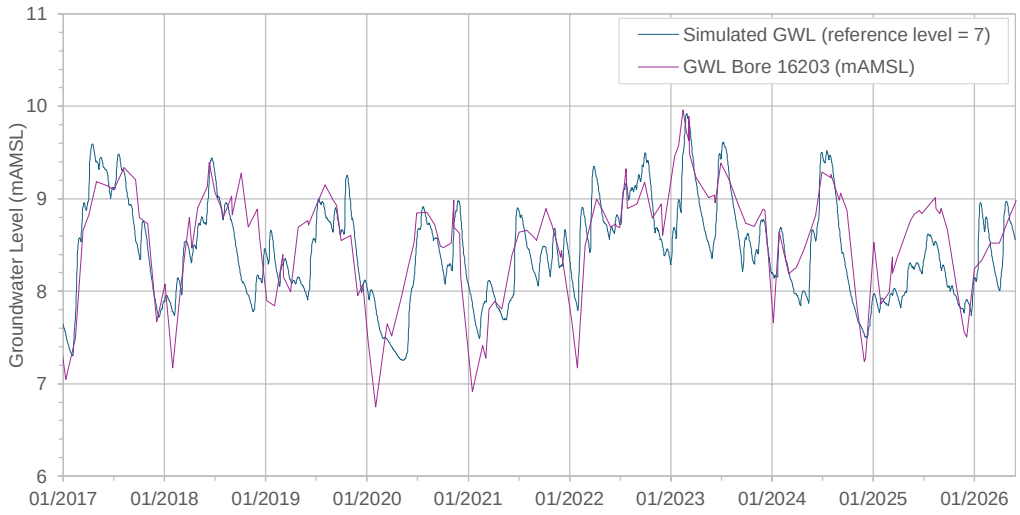


Figure 7. Observed versus simulated groundwater level calibration comparison for bore 16203.

5.4.2 Calibration of Groundwater Model

Calibration of the numerical groundwater model involved adjusting the hydraulic parameters assigned to the model cells to achieve the best possible agreement between simulated and measured groundwater levels.

A steady-state groundwater model was initially developed to represent average climatic conditions and the corresponding long term groundwater recharge regime. The calibration results are presented in **Figure 8**, which compares the simulated groundwater levels at each monitoring location with available data against the corresponding measured groundwater levels.

The model was calibrated by adjusting key hydraulic parameters to achieve an appropriate fit between the simulated and observed groundwater levels. The calibrated hydraulic conductivity was 0.26 m/day (3×10^{-6} m/s), with an associated recharge rate of 9.6×10^{-4} m/day, equivalent to approximately 41.7% of annual rainfall.

Overall, the calibration results indicate a reasonable agreement between simulated and measured groundwater levels. The model provides a good representation of groundwater levels at MH_01 and MH_02, while the simulated groundwater level at MH_03 shows a slightly poorer fit. The discrepancy at MH_03 is considered localised and does not materially affect the overall representation of the groundwater system.

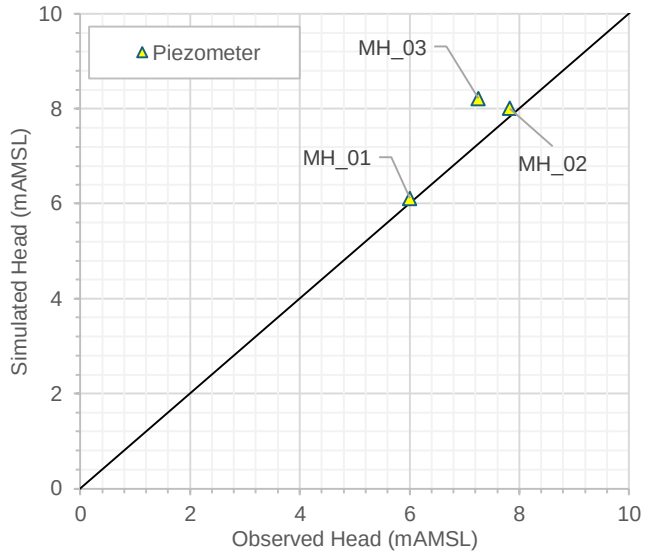


Figure 8. Simulated versus observed groundwater levels.

Following calibration, the steady-state model was converted to a transient groundwater model covering a 53-year period from 1972 to 2025, using monthly stress periods. The transient model was driven by historical rainfall data, with groundwater recharge varying temporally in response to climatic conditions.

The transient model was calibrated against the available measured groundwater levels and anticipated groundwater-level trends at each monitoring bore, as presented in **Figure 9**. In the absence of long-term monitoring data at all locations, the anticipated groundwater levels were developed by closely matching the estimated seasonal groundwater-level fluctuations predicted by the SMWBM.

The analysis indicated that groundwater levels typically fluctuate by approximately 2 m on an annual basis, with greater variability during wetter and drier years. The magnitude of these fluctuations was informed by groundwater level data from the nearest available monitoring sites with similar screened depths and geological materials (**Figure 6** and **Figure 7**).

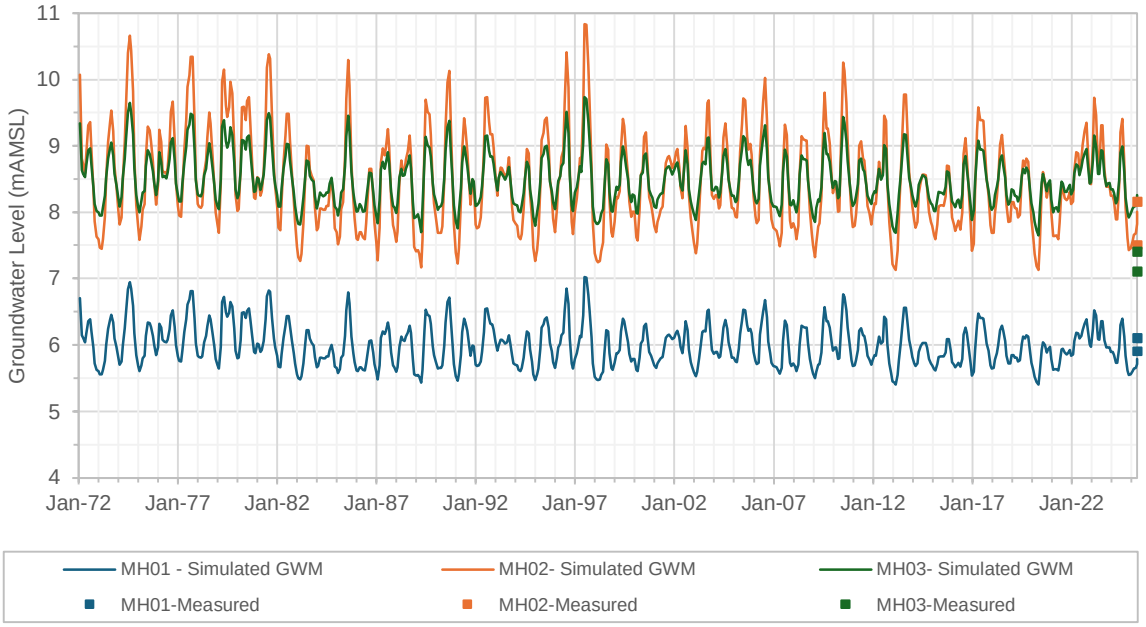


Figure 9. Simulated hydrographs at monitoring piezometer locations.

6. Assessment of Potential Impact

6.1 Flow Analysis into Dry Basins

As noted above, DB1 through DB3 are hydraulically connected and are collectively referred to as the North DBs, while DB4 through DB6 are hydraulically connected and are collectively referred to as the South DBs. CDL has advised that the North and South DBs are also hydraulically interconnected to manage rain fall events exceeding the 10-year ARI, thereby providing additional capacity to manage surface water flooding, despite the two groups being hydraulically graded in different directions.The flow analysis presented here assumes that the drainage from catchments for each dry basins group can be combined to determine the total discharge to the receiving environment. **Table 4** summarises the estimated groundwater flow into each catchment. It has been assumed that Catchment A, B, C and E flows into the North DBs and Catchment D, F and G flows into the South DBs. It should be noted that discharge into the dry basins represents total flow into the basin of the dry basin and the adjacent low flow channels, and these areas are assessed separately from the catchments.

Table 4 shows that Catchment E captures the majority of the modelled groundwater flow. This is because it is the largest catchment area, approximately 14 ha, extending beyond the project area into the neighbouring residential area.

Table 4. Simulated monthly average groundwater inflows (m^3/d).

Month	All flows (m^3/day)							
	Catchment A	Catchment B	Catchment C	Catchment D	Catchment E	Catchment F	Catchment G	Total Flow
Jan.	0.3	0.5	0.0	0.6	48.3	1.4	1.3	52.5
Feb.	0.2	0.3	0.0	0.5	56.6	1.8	1.7	61.0
Mar.	0.4	0.9	0.0	1.1	80.3	2.8	2.7	88.3
April	0.6	1.1	0.0	1.8	111.0	4.0	3.8	122.2
May	0.8	2.2	0.0	3.5	145.4	5.5	5.4	162.8
June	3.6	6.7	0.1	7.5	208.7	8.0	8.4	243.0
July	5.3	9.0	0.2	9.7	240.2	9.1	9.9	283.4
Aug.	3.5	9.0	0.0	7.4	212.4	8.0	8.3	248.7
Sept.	1.4	2.7	0.0	3.7	155.1	5.6	5.5	174.0
Oct.	0.1	0.3	0.0	1.1	96.6	3.1	2.9	104.1
Nov.	0.0	0.0	0.0	0.1	59.4	1.5	1.4	62.5
Dec.	0.0	0.0	0.0	0.0	42.7	1.0	0.9	44.6
AVG	1.3	2.7	0.0	3.1	121.4	4.3	4.4	**137.3**

Groundwater flow from the catchments has been assumed to ultimately discharge to the relevant DB shown in **Table 5**, which presents the monthly average groundwater flows into the six proposed DBs and the discharge from the two DB clusters to their respective outflow streams. The results show a seasonal pattern, with higher groundwater inflows during the winter months and lower flows during summer, reflecting seasonal variations in rainfall and groundwater recharge.

The simulated flow patterns indicate that the majority of the flow is conveyed to the DBs via the low flow channels. The combined average groundwater flow into the Northern DBs is approximately 212 m^3/day (2.5 L/s), while the combined average flow into the South DBs is approximately 77 m^3/day (0.9 L/s). The results indicate that the proposed drainage system will convey a relatively small but continuous groundwater contribution, discharging to both Herehere and Karamū Streams, with flows increasing during the winter months and in response to heavy rain events.

Table 5 Simulated monthly average groundwater flows to Northern and Southern DB groups (m^3/day).

Month	Northern DBs					Southern DBs				
	Low flow Channel Drainage			Catchment Drainage	Total	Low flow Channel Drainage			Catchment Drainage	Total
	DB 1	DB 2	DB 3			DB 4	DB 5	DB 6		
Jan.	12.1	13.9	20.9	49.1	96.0	18.3	11.1	16.5	3.3	49.3
Feb.	14.7	16.2	23.3	57.0	111.3	20.5	11.9	17.7	3.9	53.9
Mar.	21.1	20.4	27.2	81.6	150.3	24.3	13.1	19.4	6.7	63.5
April	27.9	24.6	30.9	112.6	195.9	28.0	14.3	21.1	9.6	73.0
May	37.6	29.8	35.7	148.3	251.5	33.1	16.0	23.4	14.5	87.0
June	51.5	36.4	41.9	219.1	348.9	40.2	18.3	26.6	23.9	109.1
July	58.1	39.3	44.5	254.7	396.6	43.3	19.3	28.0	28.7	119.4
Aug.	52.1	36.8	42.1	224.9	355.9	40.2	18.3	26.7	23.8	108.9
Sept.	38.5	30.6	36.3	159.2	264.7	33.5	16.1	23.7	14.9	88.1
Oct.	24.3	23.0	29.4	97.0	173.6	26.0	13.6	20.3	7.1	67.0
Nov.	14.6	16.9	23.8	59.4	114.7	20.6	11.9	17.7	3.1	53.3
Dec.	10.4	13.5	20.7	42.7	87.3	17.8	10.9	16.5	2.0	47.1
AVG	30.3	25.1	31.4	**125.5**	**212.2**	28.8	14.6	21.5	**11.8**	**76.6**

Figure 10 presents the simulated groundwater flow into the two DB clusters over the simulation period (the sum of direct discharge in low flow channels and drainage through the catchments areas). It is assumed the flow from the wider catchments, which predominantly occurs during high flow events, accumulates in the bottom of the dry basins. It should be noted that the flow rates shown **Figure 10** are monthly averages. Daily flow rates are more variable, and the basins are frequently dry (i.e. they can be used for other purposes).

The results show the seasonal and interannual variability in groundwater inflows. The maximum groundwater flow into the North DBs is approximately792 m^3/day (9 L/s) in total (the sum of the low flow channels and dry basin catchment flows), while the maximum flow into the South DBs totals approximately 213 m^3/day (2.5 L/s).

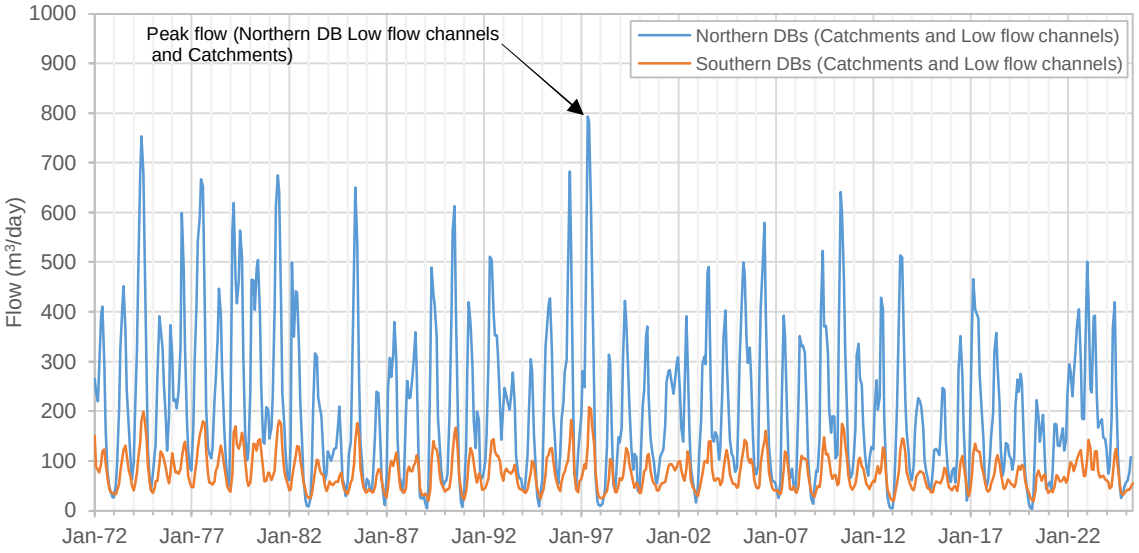


Figure 10. Flow into dry basins over simulation period.

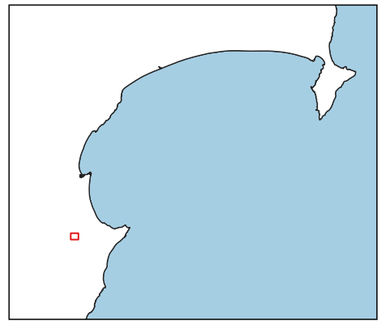
6.2 Groundwater Interaction

Figure 11 presents the simulated groundwater levels during peak flow conditions across the site. **Figure 12** illustrates the spatial extend of shallow groundwater interaction (saturation/exfiltration potential) under both average and peak climatic conditions.

Map Title:
Groundwater Contour Map - Peak Flow

Project:
Middle Road Subdivision

Client:
CDL Land New Zealand Limited



Legend

- Piezometers
- Groundwater Contours (mAMSL)
- Internal Drains
- Low Flow Channels
- Dry Basins
- Model Area
- The Site

Top Level Basemap Data

- Road
- River/Stream
- Lake/Pond

- Catchments of the Ponds

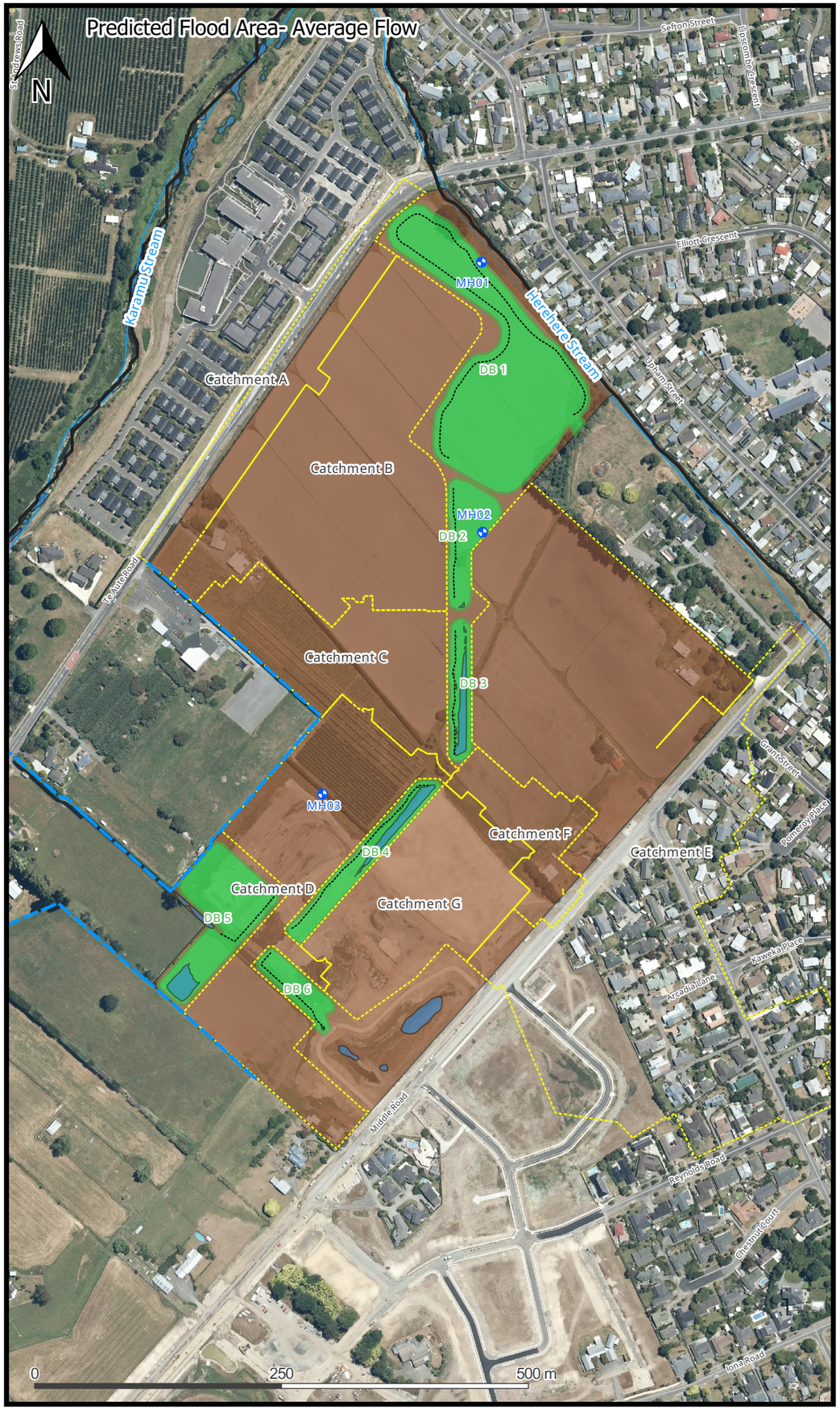
Data Provenance
Aerial Imagery from Land Information New Zealand

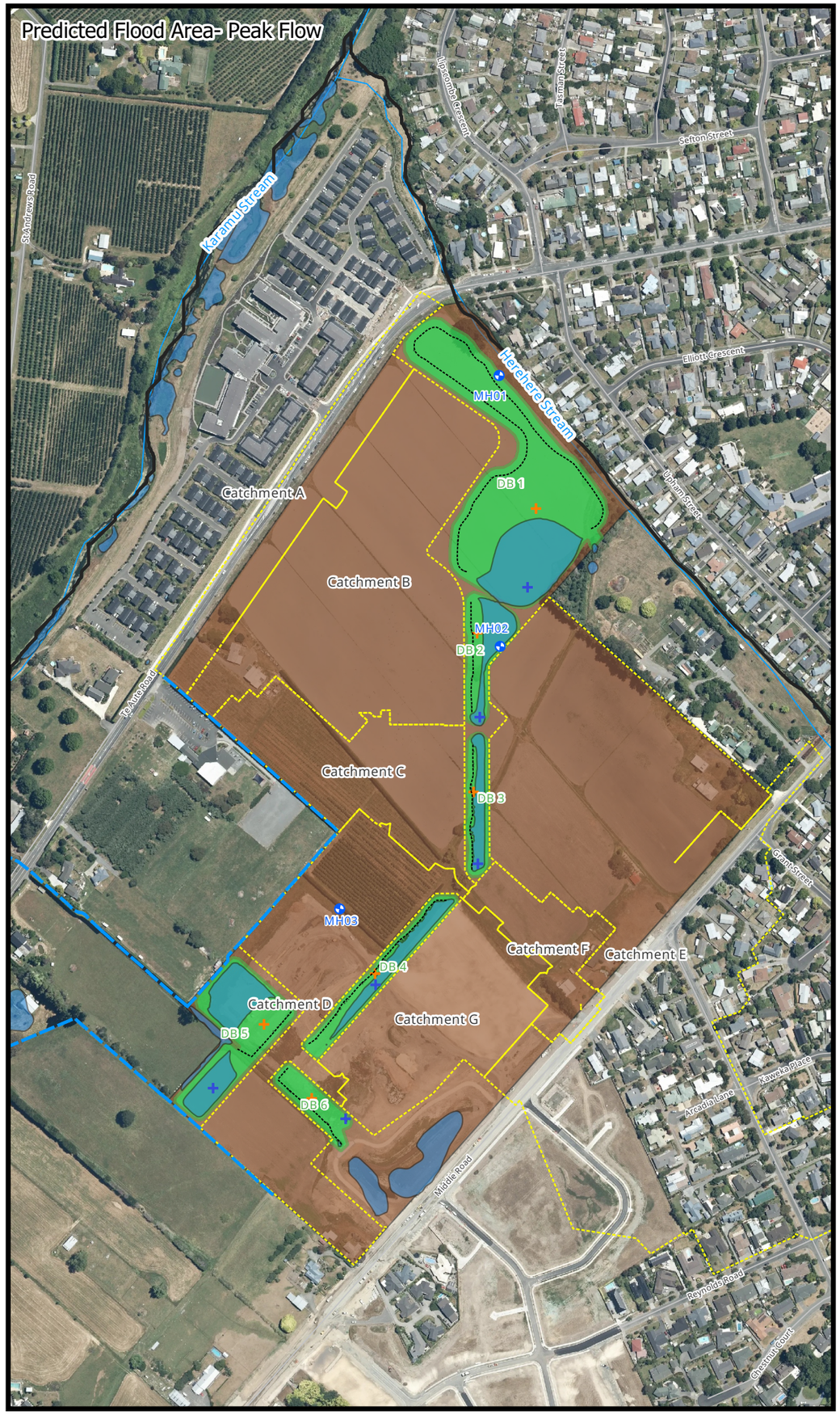
Drawn by: Asanka Thilakerathne
19/08/2026

Layout & Project File
Surface Water

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Figure 11

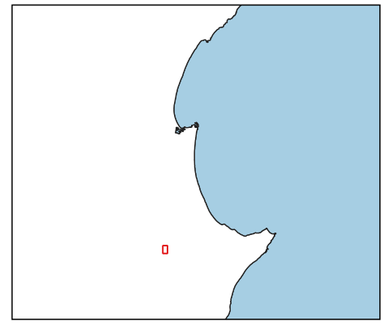




Map Title:
Predicted Flooding Area During Average and Peak Flow

Project:
Middle Road Subdivision

Client:
CDL Land New Zealand Limited



Legend

- Piezometers
- Internal Drain Netwok
- Low Flow Channels
- Predicted Flood Area
- Dry Basins
- Model Area
- The Site

Top Level Basemap Data

- Road
- River/Stream
- Catchments of the Ponds

Groundwater Level Capture Points

- Wet Area
- Dry Area

Data Provenance
Aerial Imagery from Land Information New Zealand

Drawn by: Asanka Thilakerathne
24/08/2026

Layout & Project File
Surface Water

WILLIAMSON WATER & LAND ADVISORY

Figure 12

The groundwater model demonstrates that the proposed development is not at risk of groundwater-driven flooding or structural basin overtopping. Across the entire 53-year simulation period, simulated hydraulic pressure heads remain strictly below the crest elevations of all six DBs.

When evaluating basin performance, a clear distinction must be made between hydraulic pressure head (soil saturation/exfiltration) and unmanaged surface flooding (overtopping):

- ***Hydraulic Pressure Head / Saturation*** – Represents conditions where the water table rises above a basin's floor invert. This creates localised soil saturation and drives upward groundwater exfiltration directly through the basin bed. The integrated low-flow channels intercept and convey this baseline flow directly to the Herehere Stream and the Karamu Stream, preventing deep surface water accumulation.
- ***Structural Overtopping / Flooding*** – Occurs only if groundwater pressure heads exceed the top crest elevation of a basin (approximately +1.5 m above the invert level). No basin exhibits overtopping under the modelled scenario.

Under average climatic conditions, DB 1, DB 2, and DB 6 remain completely dry, while localised baseline saturation occurs across parts of DB 3, DB 4, and DB 5. During peak winter conditions, high water tables induce varying degrees of floor saturation across DBs 1-5, while DB 6 remains dry almost entirely year-round.

To evaluate potential groundwater interaction with the dry basin network, saturated surface areas, under average and peak flow conditions are summarised in **Table 6.**

It should be noted that these results pertain to groundwater, and do not include surface runoff from storm events.

Table 6. Groundwater Interaction under average and peak flow conditions.

Basin ID	Total Basin Area (m²)	Average Flow Conditions		Peak Flow Conditions	
		Interaction Area (m²)	Interaction Area (%)	Interaction Area (m²)	Interaction Area (%)
DB 1	24,771	0	0	5,924	24
DB 2	4,318	11	0	1,924	45
DB 3	3,192	690	22	1,431	45
DB 4	4,676	811	17	1,878	40
DB 5	8,587	626	7	4,166	49
DB 6	2,533	8	0	26	1

DB 1 serves as a representative example of how groundwater pressure heads interact with the physical basin structure (**Figure 13**):

- ***Basin Parameters*** – Floor invert of 7.5 mAMSL, and a crest elevation of 9.0 mAMSL.
- ***Average Climatic Conditions*** – The simulated water table remains below the floor invert of 7.5 mAMSL across 100% of the basin footprint, allowing DB 1 to remain completely dry.
- ***Peak Winter Conditions*** – During severe wet weather periods, the simulated hydraulic pressure head rises above the 7.5 mAMSL flood level across approximately 5,924 m^2 (24%) of the basin area. This head difference drives active groundwater seepage upward into the basin bed.
- ***Channel Drainage and Overtopping Protection*** – Rather than pooling into deep standing water, this exfiltrated groundwater is captured by the low-flow channel and discharged to the nearby stream. At no point during the transient simulation does the groundwater pressure head approach the 9.0 mAMSL crest elevation level, confirming that there is no groundwater-driven overtopping.

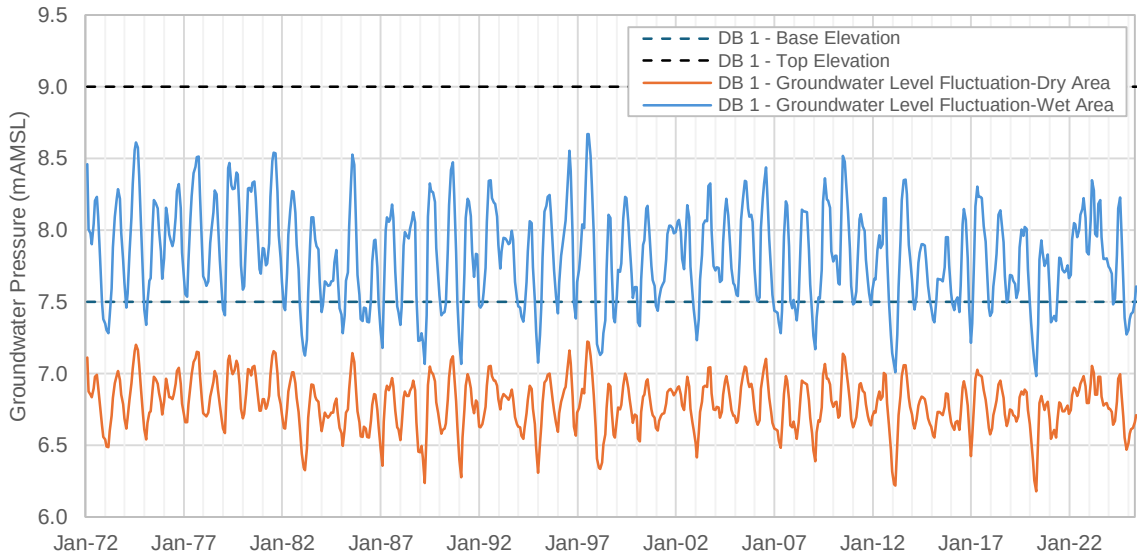


Figure 13. Simulated water level – DB 1

Further detail on the groundwater interaction between each basin is provided in **Appendix B**.

To prevent continuous groundwater exfiltration from waterlogging the basin beds, additional civil drainage infrastructure, such as subsurface underdrains or a wider low-flow channel network, could be integrated into the design. These subsoil drains would cleanly collect baseline groundwater seepage and convey it directly to the stream outlets, keeping the surrounding ground dry and preserving the true dry basin functionality between storm events. Consideration of additional drainage (if required) is proposed to be undertaken at a detailed design phase and subject to condition of consent.

7. Proposed Monitoring Plan

7.1 Groundwater Monitoring

The existing groundwater monitoring piezometers (MH_01, MH_02, and MH_03) should be equipped with automatic water level loggers as soon as practicable to continuously monitor groundwater level fluctuations. Prior to installation of the loggers, the piezometers should be appropriately developed by purging them several times to remove any blockages or accumulated sediment within the screened intervals and to establish adequate hydraulic connectivity between the aquifer and the borehole.

Groundwater-level monitoring should commence one year prior to construction, where practicable, to establish baseline conditions, and should continue throughout the construction period to at least completion of Stage 3 (Woods, 2026). This monitoring will provide a robust dataset for assessing groundwater level responses to construction activities and any longer-term changes associated with the completed development. The results can also be used to validate the accuracy of the predictions made in this assessment.

The proposed monitoring programme is intended to verify that the actual effects of the Project remain consistent with the predictions presented in this report and to provide an early indication of any unexpected groundwater-level changes that may require further investigation or management.

8. Conclusion

WWLA has developed a numerical groundwater model to provide a quantitative representation of groundwater conditions within and surrounding the proposed development area. The model was used to assess groundwater behaviour within the proposed dry basins (DBs), including the potential accumulation of groundwater within the basins and volumetric flow out from the basins.

A single-layer groundwater model was developed to represent the native geological materials underlying and surrounding the site. The model was calibrated against groundwater level information from the three existing monitoring piezometers, with long term groundwater level fluctuations informed by the SMWBM. The calibrated model was subsequently used to assess groundwater conditions under both pre-construction and post-construction scenarios.

The model results show that under high water table conditions groundwater pressures are below the ground level at the down gradient and low flow channel observation locations within the detention basins and are infrequently raised above ground level. In some basins (DBs 3, 4, 5), however, the groundwater pressure heads can be above the ground level in the up hydraulic gradient parts of the basin relatively frequently.

It should be noted that while groundwater pressures are above ground level at the up gradient locations, it does not mean the retention basins are inundated or flooded with water. Rather it means there is upward seepage through the land surface, with that water able to exit the detention basin via swales. During such conditions parts of the detention basin have a saturated surface, that may limit the recreation use in those areas for periods of time.

It should also be noted that the model results represent monthly averages and, in reality, daily changes in soil moisture uptake and evaporation will take place, meaning fully saturated conditions related to groundwater are not likely in the upper 0.3 m of the soil profile for extended periods.

It is acknowledged, however, that site-specific groundwater monitoring data are limited at the time of this assessment. Consequently, there is some uncertainty associated with the representation of long-term groundwater level fluctuations and the assessment of groundwater responses to wet and dry climatic conditions. Due to the limited monitoring data available at this time, our assessment can only be treated as preliminary, with the residual uncertainty addressed through the recommendation described below.

To reduce the uncertainty in this assessment, it is recommended that continuous groundwater level monitoring be initiated at the existing monitoring piezometers as soon as practicable. A period of continuous monitoring that captures a range of climatic conditions, including significant wet weather events, will provide valuable site-specific information to verify the model assumptions and predictions. The monitoring results can be used to confirm the conclusions of this assessment and, if necessary, to refine and update the groundwater model as additional site-specific data become available.

8.1 Recommendations

As stated above, the results of this assessment should be treated as preliminary due to the lack of long-term groundwater level monitoring information. To close out that uncertainty we provide the following recommendations that could form conditions of consent:

I) Continue the collection of automated groundwater level data.
II) Update the numerical modelling during detailed design to confirm the drain configuration to maintain levels such that inundation is infrequent and primarily surface water driven. That may include additional drains to manage higher groundwater levels locally.

9. References

CDL, 2026A. Middle Road Bore Logs (PDF), 25 May 2026.

CDL, 2026B. Middle Road 3D Design Surface (DEM), 28 July 2026.

CDL, 2026C. Catchment Management Plan (AutoCAD files), 05 August 2026.

Woods, 2026. Infrastructure Report (Middle Road – Fast-Track Substantive Application), 28 August 2026.

Appendix A. Soil Moisture Water Balance Model

The Soil Moisture Water Balance Model (SMWBM) is a semi-deterministic rainfall-runoff model. Model functionality includes an infiltration function, surface ponding function, evaporation functions for differing land cover.

The model simulates a partitioning of rainfall between surface runoff, evapotranspiration, interception, soil storage, and deep percolation (i.e. groundwater recharge) on a daily basis. Daily climate data (rainfall and PET) are input into the model while parameters representing soil infiltration rates, soil storage capacity, deep percolation rates, vegetation cover, and slope are varied within realistic bounds based on the topography, land cover, soil type, and geology for a given area.

Daily rainfall and evaporation data from NIWA's data catalogue were used as input data to the model from the period of 1972 to 2026. This data was obtained as indicated below:

- Havelock North EWS station (3026) from 1/01/1972 to 31/08/1983.
- Whakatu EWS station (3031) from 1/09/1983 to 13/08/1998.
- Whakatu EWS station (15876) from 14/08/1998 to 4/06/2026.

The key model parameters for differing land component are detailed in **Table 7** and described further in **Table 8**.

Table 7. Parameters utilised in the SMWBM.

Parameter	Catchment
ST (mm)	150
FT (mm/day)	1
Zmax (mm/hr)	1
PI (mm)	2
AI (0-1)	0.07
Zmin (mm/hr)	0
R (0, 1)	0
DIV (0-1)	0.5
TL (days)	1
GL (days)	1
LAG (days)	0
QOBS (m^3/day)	468690
POW (1-2)	1
SL (mm)	0
AA	0.22
BB	0.22

Table 8. SMWBM parameters.

Parameter	Name	Description
ST (mm)	Maximum soil water content	ST defines the size of the soil moisture store in terms of a depth of water
SL (mm)	Soil moisture content where drainage ceases.	Soil moisture storage capacity below which sub-soil drainage ceases due to soil moisture retention.

FT (mm/day)	Sub-soil drainage rate from soil moisture storage at full capacity	Together with POW, FT (mm/day) controls the rate of percolation to the underlying aquifer system from the soil moisture storage zone. FT is the maximum rate of percolation through the soil zone.
ZMAX (mm/hr)	Maximum infiltration rate	ZMAX and ZMIN are nominal maximum and minimum infiltration rates in mm/hr used by the model to calculate the actual infiltration rate ZACT. ZMAX and ZMIN regulate the volume of water entering soil moisture storage and the resulting surface runoff. ZACT may be greater than ZMAX at the start of a rainfall event. ZACT is usually nearest to ZMAX when soil moisture is nearing maximum capacity.
ZMIN (mm/hr)	Minimum infiltration rate	
POW (>0)	Power of the soil moisture-percolation equation	POW determines the rate at which sub-soil drainage diminishes as the soil moisture content is decreased. POW therefore has significant effect on the seasonal distribution and reliability of drainage and hence baseflow, as well as the total yield from a catchment.
PI (mm)	Interception storage capacity	PI defines the storage capacity of rainfall that is intercepted by the overhead canopy or vegetation and does not reach the soil zone.
AI (-)	Impervious portion of catchment	AI represents the proportion of the catchment that is impervious and directly linked to drainage pathways.
R (0,1)	Evaporation – soil moisture relationship	Together with the soil moisture storage parameters ST and SL, R governs the evaporative process within the model. Two different relationships are available. The rate of evapotranspiration is estimated using either a linear (0) or power-curve (1) relationship relating evaporation to the soil moisture status of the soil. As the soil moisture capacity approaches, full, evaporation occurs at a near maximum rate based on the mean monthly pan evaporation rate, and as the soil moisture capacity decreases, evaporation decreases according to the predefined function.
DIV (-)	Fraction of excess rainfall allocated directly to basin storage	DIV has values between 0 and 1 and defines the proportion of excess rainfall ponded at the surface due to saturation of the soil zone or rainfall exceeding the soils infiltration capacity to eventually infiltrate the soil, with the remainder (and typically majority) as direct runoff.
TL (days)	Routing coefficient for surface runoff	TL defines the lag of surface water runoff.
GL (days)	Groundwater recession parameter	GL governs the lag in groundwater discharge or baseflow from a catchment.
QOBS (m^3/day)	Initial observed streamflow	QOBS defines the initial volume of water in the stream at the model start period and is used to precondition the soil moisture status.
AA, BB	Coefficients for rainfall disaggregation.	Used to determine the rainfall event duration and pattern. Default values usually suffice.

A conceptual diagram of the key components of SMWBM_VZ model structure and functionality is shown in **Figure 14**.

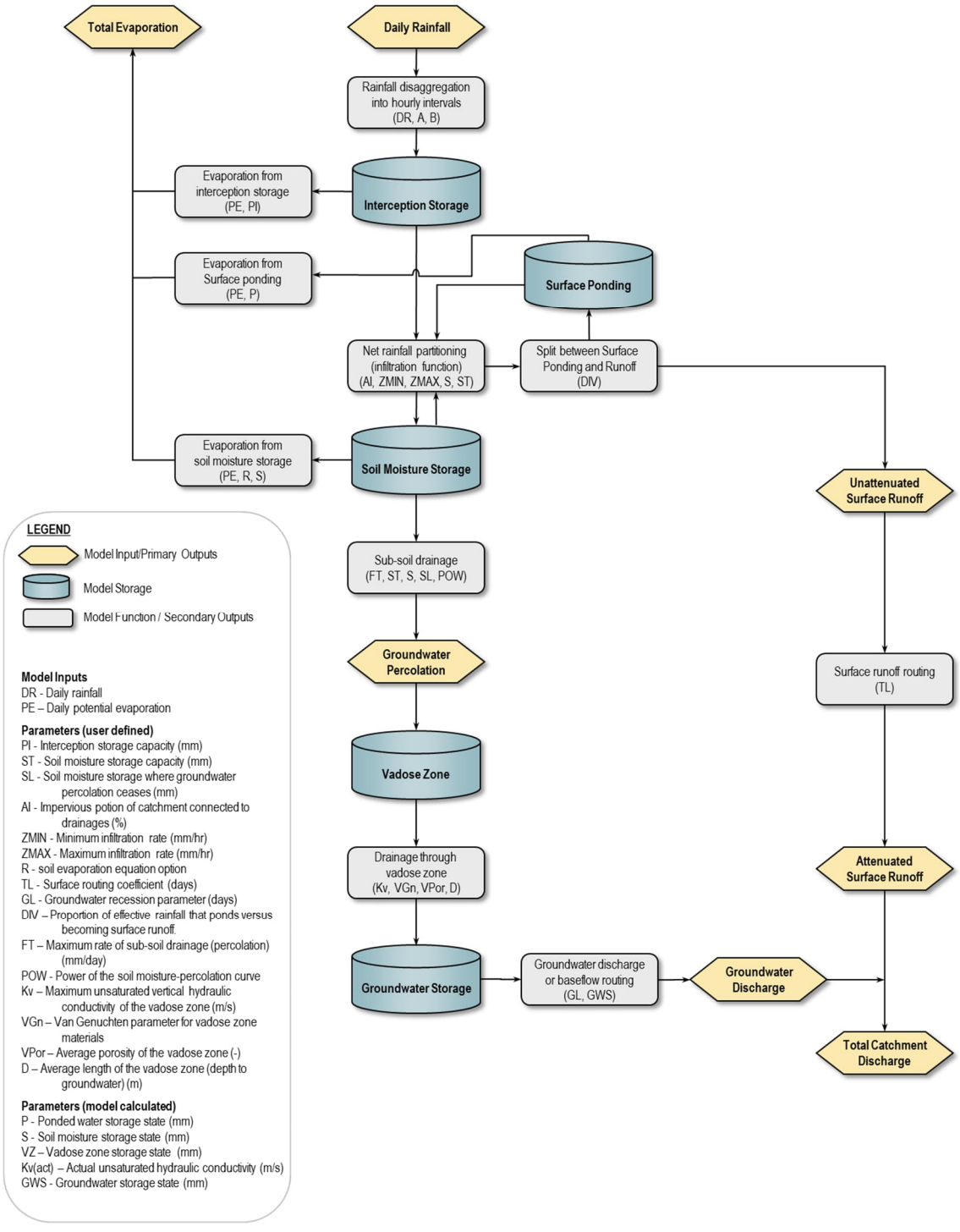


Figure 14. Flow diagram of the SMWBM structure and parameters.

Appendix B. Groundwater Modelling Results

To evaluate the long-term interaction between shallow groundwater and the proposed dry basin network, transient 53-year simulations (1972-2025) were extracted at representative 'wet' and 'dry' area capture points within each basin (as shown in **Figure 12**).

The hydrographs in figures **Figure 15** through **Figure 20** compare simulated hydraulic pressure heads against the key structural levels of each dry basin:

- ***Simulated Groundwater Pressure, Wet Areas (Solid Blue Line)*** – Modelled piezometric head/water table elevation (in mAMSL) in an area where saturation is modelled.
- ***Simulated Groundwater Pressed, Dry Areas (Solid Orange Line)*** – Modelled piezometric head/water table elevation (in mAMSL) where no saturation is modelled.
- ***Basin Floor Invert (Dashed Blue Line)*** – Physical base elevation of the basin floor.
- ***Basin Crest Elevation (Dashed Black Line)*** – Upper crest elevation of the basin (approximately +1.5 m above the basin flood invert).

To understand the groundwater exfiltration and inflow, a short explanation of the data presented is provided below:

- ***Dry Conditions*** - When the simulated groundwater level is below the blue dashed line, groundwater is below the basin floor meaning no groundwater exfiltrates into the basin.
- ***Active exfiltration/Seepage Conditions*** - When the simulated groundwater level is between the two dashed lines, the water table intersects the basin base, forcing groundwater to seep upward into the basin floor. Under these conditions, water exfiltrates into the low-flow channels and drains via the outlet structures without accumulating into deep standing water.
- ***Basin Overflow Conditions*** - When the simulated groundwater level exceeds the black dashed line, groundwater pressures exceed the basin crest, causing groundwater-driven flooding.
- Influx into the DBs will occur when the groundwater pressure (solid blue line) is above the base of the DB (dashed blue line).
- It is assumed that the discharge will be conveyed into the low flow channels under most circumstances.
- It should be noted that the data presented is based on a monthly average analysis and it is possible that short-term events may exceed the water levels that are shown.

Table 9 lists the capture point coordinates for the basin floor and crest elevations assigned to each proposed DB in the post-construction model.

Table 9. Basin flood level location for each DB.

Basin ID	Location of Basin Floor Elevation (m)		Basin Floor Elevation (mAMSL)
	X	Y	
DB 1	1931723	5601265	7.50
DB 2	1931664	5601139	7.63
DB 3	1931660	5600979	7.83
DB 4	1931561	5600796	7.80
DB 5	1931449	5600745	7.56
DB 6	1931497	5600670	7.72

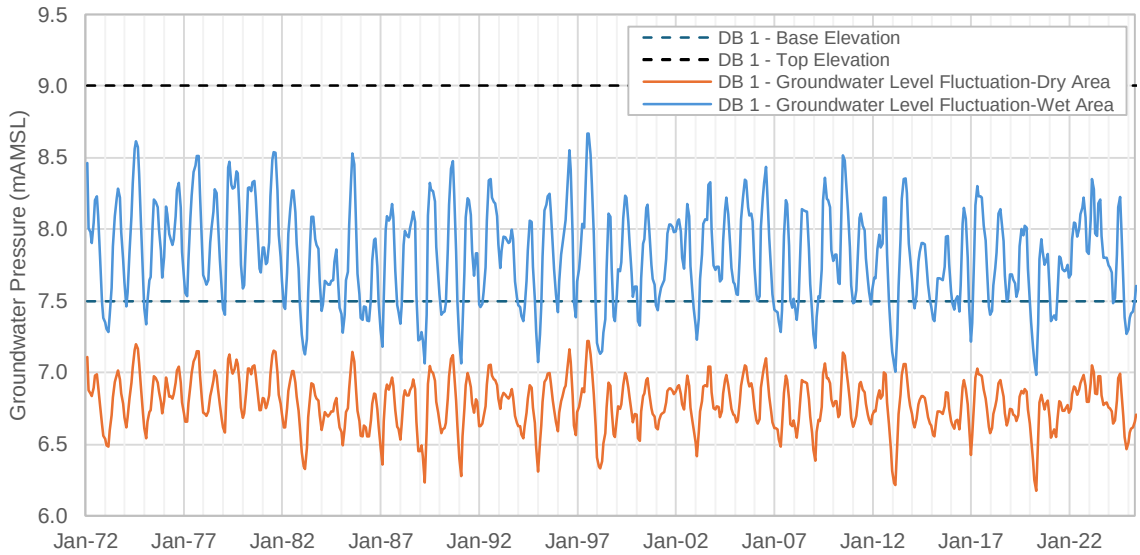


Figure 15. Simulated Water Level – DB 1

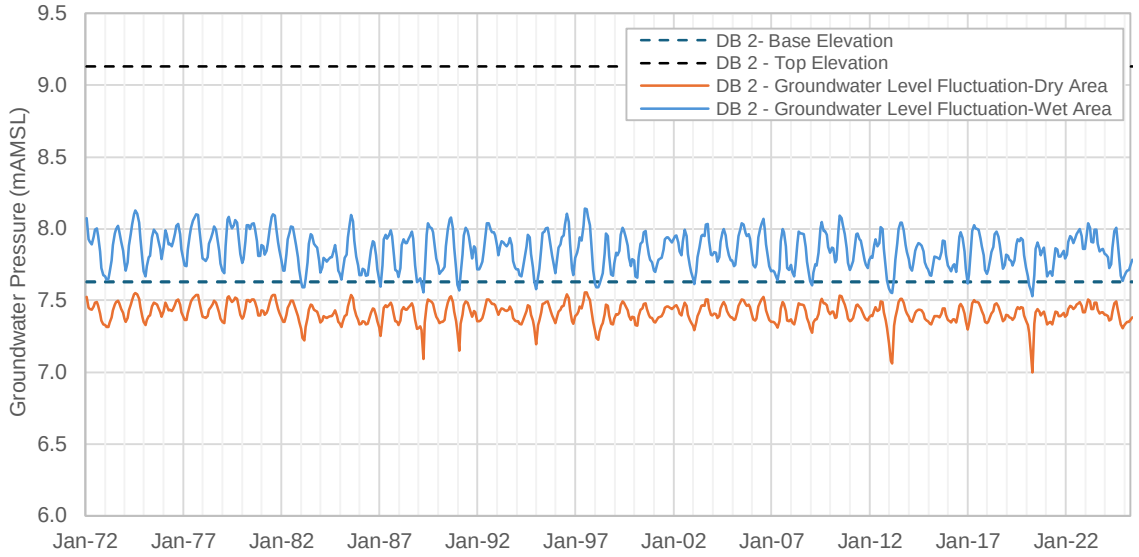


Figure 16. Simulated Water Levels – DB 2

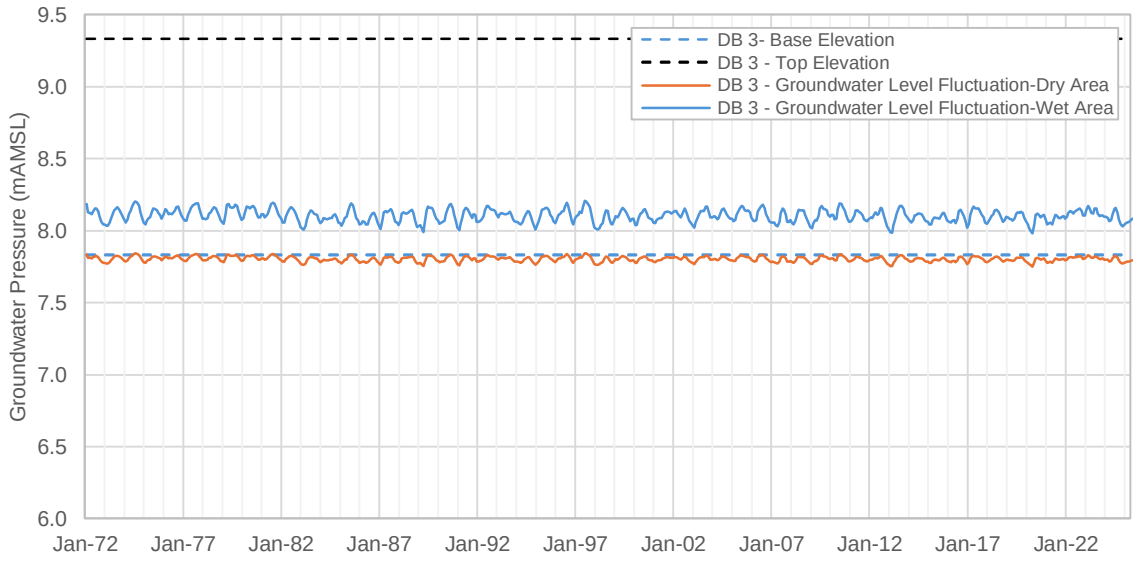


Figure 17. Simulated Water Levels – DB 3

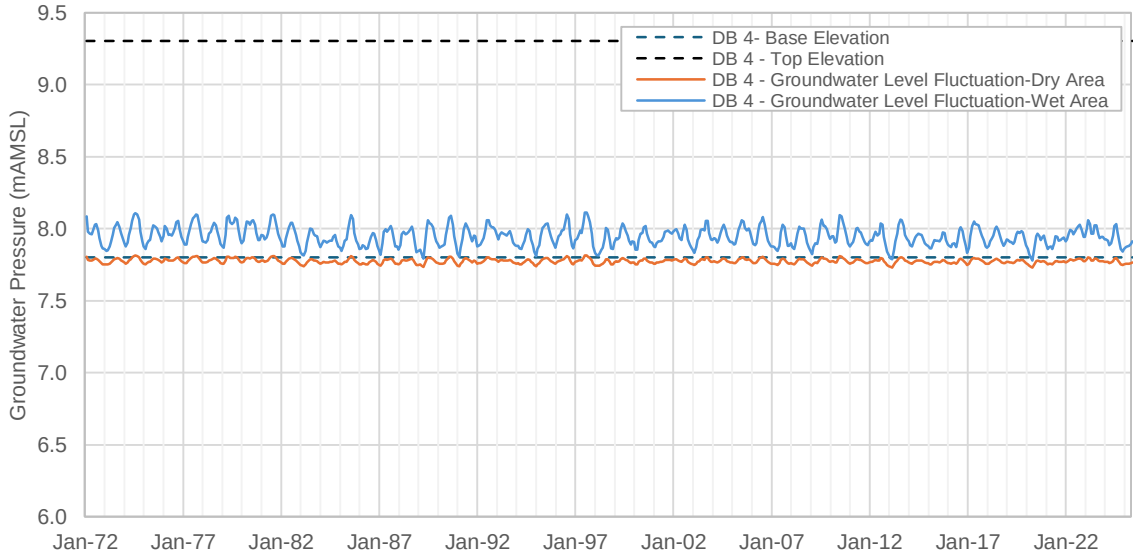


Figure 18. Simulated Water Levels – DB 4

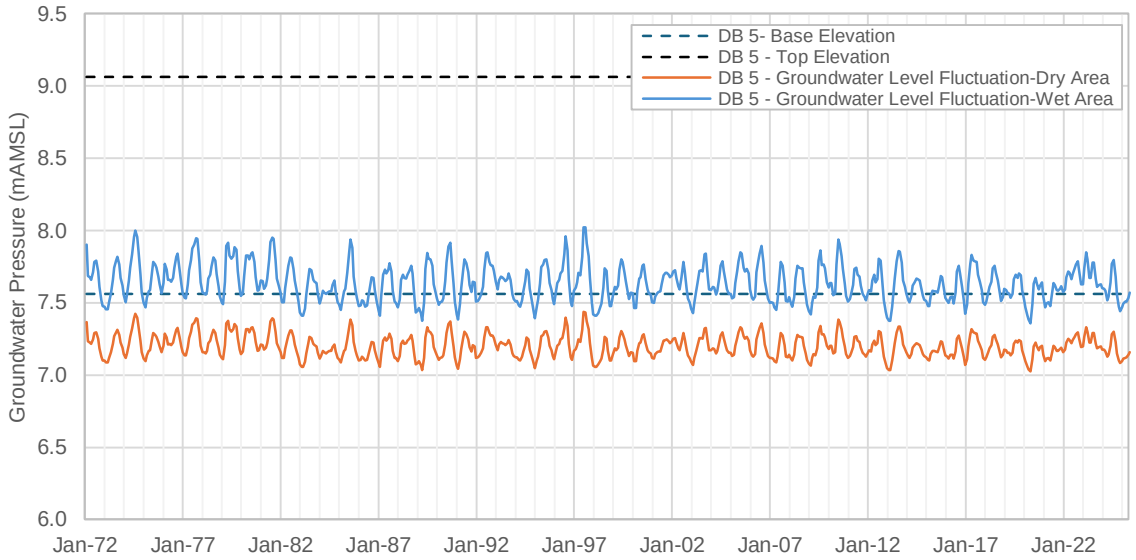


Figure 19. Simulated Water Levels – DB 5

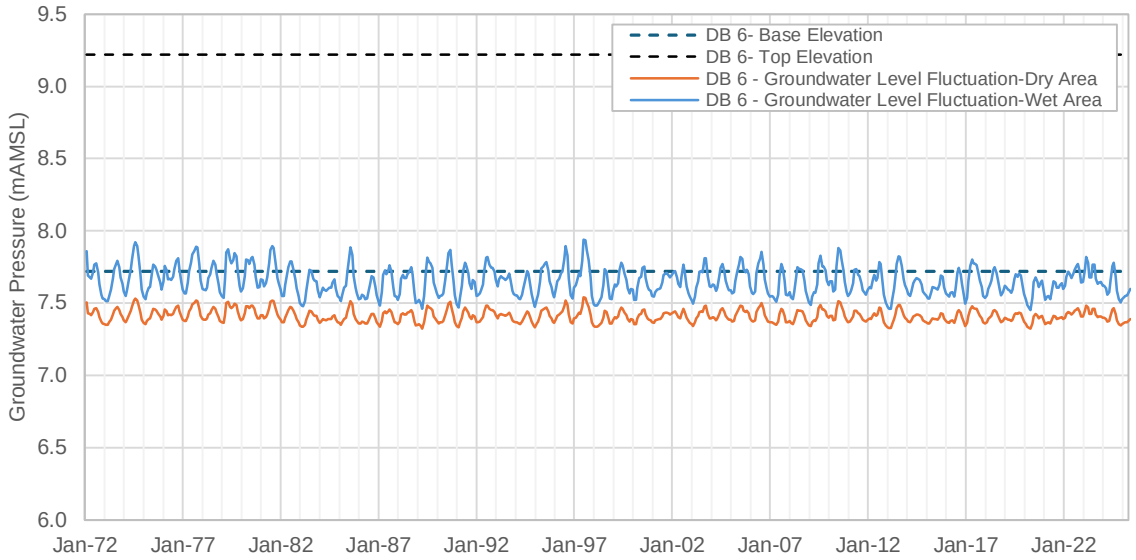


Figure 20. Simulated Water Levels – DB 6

Across all six DBs, the simulated groundwater pressure never reaches the crest elevation. This confirms that groundwater exfiltration alone will not cause basin overtopping or inundation above the design capacity. Note that these levels reflect monthly averages, and brief transient spikes during heavy storm events may briefly exceed these simulated baselines.

However, the hydrographs highlight distinct baseline behaviours across the network.

In DBs 1, 2, and 6, the water table remains below the base invert elevation during average climatic conditions, maintaining dry bed conditions for the majority of the year. In DBs 3, 4, and 5, the water table continuously

intersects the flood in the ‘wet area’ zones, driving persistent trickle exfiltration of around 212 m^3/day (2.5 L/s) in the north and around 77 m^3/day (0.9 L/s). This baseline flow is collected by the low-flow channels and conveyed off site. Under peak conditions, DB 1 through 5 all experience varying degrees of basin floor saturation, leaving DB 6 as the only consistently dry feature year-round.