Hydrogeological Impact Assessment

State Significant Development: Proposed Seniors Housing Development, 87-89 Tweed Coast Road, Hastings Point, NSW

Final Report

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Prepared for TriCare (Hastings) Limited

environmental science & engineering

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1 Introduction

1.1 Overview

Martens & Associates Pty Ltd (**MA**) have been engaged by TriCare (Hastings) Limited (the **Client**) to undertake a Hydrogeological Impact Assessment (**HIA**) at 87-89 Tweed Coast Road, Hastings Point, NSW (the **Site**).

This HIA has been prepared to support a state significant development application (**SSDA**) to the NSW Department of Planning and Environment (**NSW DPE**) for a proposed seniors living development. This report addresses part of Item 13 of the Secretary's Environmental Assessment Requirements (**SEARs**) for the development proposal (Ref. SSD-41110128, dated 20 April 2022).

1.2 Proposed Development

The proposed development comprises both independent living units (**ILU**) and a residential aged care (**RAC**) home, which will be supported by a range of other services.

Specifically, the proposal includes:

- A 47 place RAC (Building D) comprising:
    - Individual private rooms with ensuite facilities;
    - Shared dining, lunge and sitting rooms;
    - Café;
    - Kitchen;
    - Serveries;
    - Nurses' stations;
    - Offices;
    - Staff room and facilities;
    - Waste room; and
    - Loading bay.
- 51 ILUs split across 3 buildings, including:
    - 24 ILUs in Building E
    - 18 ILUs in Building F
    - 9 ILUs in Building G

All buildings are to include one level of basement parking, with finished floor levels (**FFL**) of 0.85 mAHD, 1.0 mAHD, 1.5 mAHD and 2.32 mAHD for Buildings D, E, F and G, respectively. We understand from the Civil Engineering Report prepared by Cozens Regan Group (ref. 220450, dated February 2025) that basement excavations will result in the order of 12,000 m^3 of material to be won on site.

Complimenting the ILUs and RAC, the development is to include a range of communal facilities for entertainment, health and recreation, including:

- Bowling green and pavilion with bowls store, amenities, kitchen and covered seating area;
- Indoor swimming pool and spa;
- Perimeter walking trail; and
- Landscaped Gardens

No changes to the existing Stage 1 development are proposed.

Relevant architectural drawings are provided in Appendix A.

1.3 Reporting Scope

Our reporting scope for this HIA is summarised as follows:

1. Review and analysis of existing hydrogeological data for the Site and surrounding area.
2. Analysis of results from field investigations.
3. Preparation of numerical groundwater models for the following groundwater conditions at the Site:
    a. **Existing** – The groundwater system as it currently exists calibrated to Site groundwater monitoring data.
    b. **Proposed** – The future groundwater system as it is expected to exist following proposed development.
4. Assessment of the predicted construction dewatering volumes and drawdown impacts in surrounding land, particularly in relation to nearby coastal wetlands mapped pursuant to *State Environmental Planning Policy (Resilience and Hazards)* 2021.
5. Analysis of groundwater modelling results to determine long-term effects of the proposed development on the local groundwater system and where necessary, provide recommendations to mitigate potential environmental impacts.
6. Assessment of any groundwater impacts in relation to the NSW Aquifer Interference Policy.

2 Hydrogeological Data

2.1 Overview

2.1.1 Field Investigation Data

The following field investigation data was collected for the purposes of this HIA:

1. Nine boreholes (BH102 – BH110) and corresponding monitoring wells (MW02 – MW10) installed for the purposes of groundwater monitoring. Detailed monitoring well construction logs are provided in Appendix C.
2. One surface water monitoring point (MW01) installed in Cudgera Creek located adjacent to the north western site boundary.
3. 15-minute interval groundwater level observations at MW01 – MW10 recorded between 1 November 2022 and 30 May 2024.
4. Falling / rising head slug tests completed at MW03, MW04, MW06, MW08 and MW10 to determine sub-surface hydraulic conductivity.
5. Collection and laboratory analysis of water samples from MW01 – MW10.

2.1.2 Regional Data

This assessment reviewed and incorporated a range of available regional data from the following sources:

1. Public domain bore data (Australian Government Bureau of Meteorology Groundwater Explorer, 2023.
2. NSW seamless geology (Department of Regional NSW).
3. Soil and Land Resources of Central and Eastern NSW (NSW Department of Planning and Environment, 2016).

2.2 Site Setting

The study area is situated within an outer barrier dune system forming the southern portion of Hastings Point, bounded by Cudgera Creek to the west, and Cudgera Beach to the east. The Site, located in the central western portion of the study area, comprises an existing high density residential development in the east, and grassed open space in the west.

The topography of the surrounding landscape is characterised by slopes <3% and local relief between <5 – 10 m. Site elevation ranges between approximately 1 – 7 mAHD, with slopes declining to the west towards Cudgera Creek.

Refer to the Site Setting map and Study Area Relief map, provided in Appendix B Map 02 and Map 03 respectively.

2.3 Regional Geology and Soils

The subsurface profile within the study area is largely comprised of deep quaternary deposits overlying sandstone bedrock.

The following relevant geologies described by the NSW Seamless Geology Rock Unit Map (Appendix B Map 04) are present within the study area:

1. **Coastal deposits – beach facies (Q_bb)** – Marine-deposited quartz-lithic fine- to medium-grained sand, shell and shell material, polymictic gravel.

2. **Coastal deposits – dune facies (QH_bd)** – Marine-deposited and aeolian-reworked coastal sand dunes; partially consolidated.

3. **Coastal deposits – beach ridge (QP_br)** – Fine- to coarse-grained quartz-lithic-carbonate sand (marine-deposited), shell and shell-fragment-rich beds, polymictic gravel.

4. **Estuarine in-channel bar and beach deposits (QH_eci) & Estuarine channel deposits (subaqueous) (QH_ecw)** – Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell, gravel.

5. **Estuarine interbarrier creek deposits (QH_ei)** – Fine- to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, organic mud, peat, gravel, shell material.

The Soil and Land Resources of Central and Eastern NSW data set (Appendix B Map 05) identifies the following soil profiles within the study area:

1. **Angels Beach (9541ab)** – Holocene beach and dune sands. Beaches consist predominantly of coarse-grained quartz sand and some shell fragments, deposited by wave action. Dunes consist of fine- to coarse-grained aeolian quartz sands.

2. **Bogangar (9541bo)** – Holocene dunes consisting of marine quartz sands forming the outer barrier system.

3. **Cobaki variant a (9541cba)** – Quaternary estuarine alluvium consisting of Holocene and Pleistocene in-fill materials—clay, silt, sand and gravel occur, but organic materials dominate the surface.

2.4 Licensed Groundwater Users

According to the Bureau of Meteorology's (BoM) 'Australian Groundwater Explorer' (2023) website, there are five registered groundwater monitoring bores within the study area, all located at the service station to the southeast of the Site. Registered bore locations are shown in Appendix B Map 07 and available data is summarised in Table 1.

Table 1: Registered bores within study area.

Well I.D.	Bore Depth (m)	Purpose	Status
GW306499	4.5	Monitoring	Functional
GW307634	6.0	Monitoring	Functional
GW307635	6.0	Monitoring	Functional
GW307637	6.0	Monitoring	Functional
GW307638	6.0	Monitoring	Functional

2.5 Climate Data

2.5.1 Rainfall and Evapotranspiration

Local rainfall data recorded from 1969 to 2023 was obtained from the Kingscliff weather station (BoM Station No. 58137) located approximately 12.5 km to the north of the Site. Mean annual evapotranspiration of 846 mm has been estimated from BoM average monthly pan evapotranspiration data. A summary of mean monthly rainfall, evapotranspiration data and calculated surplus is shown below in Table 2.

Table 2: Mean monthly rainfall data summary for Kingscliff (BOM Station 58137).

Month	Rainfall (mm) [1]	Evapotranspiration (mm)	Rainfall Surplus Rainfall – Evap. (mm)
January	196	110	72
February	213	99	110
March	244	97	152
April	164	63	109
May	159	39	128
June	119	27	93
July	84	26	60
August	70	28	47
September	56	49	13
October	119	88	40
November	147	102	47
December	157	118	34
Annual	**1779**	**846**	**956**

Notes:

1. Rainfall data from Kingscliff weather station (BoM station no. 58137).

2.5.2 Cumulative Residual Rain

Cumulative residual rainfall is the running total of recorded rainfall minus average rainfall and indicates whether conditions over preceding months / years have been average, drier than average or wetter than average.

A plot showing annual rainfall and cumulative residual rainfall from 1969 to 2023 is provided in Appendix D Figure 1. A plot showing monthly rainfall and cumulative residual

rainfall since January 2019 up to and including the monitoring period is provided in Appendix D Figure 2.

A rising trend in cumulative rainfall can be observed from January 2020 to November 2022, indicative of wetter than average conditions at the start of the monitoring period.

2.6 Sea Level Data

A tidal gauge station operated by the Manly Hydraulics Laboratory (**MHL**, NSW Government) is located at Cudgen Creek in Kingscliff approximately 11 km to the north of the study area. The MHL harmonic analysis of tidal data from 2001 – 2020 (MHL, 2023) shows that the mean sea level at this station is -0.001 mAHD.

2.7 Groundwater Levels

2.7.1 Monitoring Methodology

Groundwater monitoring at MW01 – MW10 commenced on 1 November 2022, using data loggers recording at 15 minute intervals.

Monitoring well construction details are presented in Table 3, with locations shown in Appendix B Map 06, and borehole logs are provided in Appendix C.

Table 3: Summary of monitoring well construction details.

Location	Surface Level (mAHD) [1]	Depth of Top of Screen (mAHD / mbgl)	Depth of Bottom of Screen (mAHD / mbgl)	Length of Open Screen (m)
MW02(BH102)	2.81	1.81 / 1.00	-1.69 / 4.50	3.5
MW03 (BH103)	3.33	2.33 / 1.00	-1.17 / 4.50	3.5
MW04 (BH104)	4.21	2.21 / 1.70	-1.09 / 5.00	3.3
MW05 (BH105)	3.91	3.21 / 1.00	-0.29 / 4.50	3.5
MW06 (BH106	4.47	2.67 / 1.80	-0.53 / 5.00	3.2
MW07 (BH107)	5.02	3.02 / 2.00	-0.28 / 5.30	3.3
MW08 (BH108)	5.59	3.49 / 2.10	0.09 / 5.50	3.4
MW09 (BH109)	5.69	3.19 / 2.50	-0.31 / 6.00	3.5
MW10 (BH110)	6.45	2.45 / 4.00	-1.65 / 8.10	4.1

Notes:

1. Surface levels from well survey (UC, 2022).

2.7.2 Groundwater Level Observations

Average groundwater depths over the monitoring period were observed in the order of 1.5 – 2.5 mAHD (approximately 1 – 4 mbgl), with generally deeper groundwater observed at higher elevations, becoming shallower approaching Cudgera Creek in the west. All locations appeared to show a rapid response to rainfall.

A statistical summary of recorded groundwater levels over the monitoring period (1/11/2022 to 30/05/2024) is provided in Table 4, and time series plots of groundwater levels for monitored bores and daily rainfall are provided in Appendix D Figure 3.

Table 4: Summary of groundwater monitoring statistics (1/11/2022 to 30/05/2024).

ID.	Ground Level (mAHD)	Min. (mAHD)	25 %-ile (mAHD)	Median (mAHD)	Mean (mAHD)	75 %-ile (mAHD)	Max (mAHD)	Range (Max – Min, m)
MW01[1]	-	0.32	0.48	0.60	0.67	0.82	1.71	1.39
MW02	2.81	1.32	1.63	1.76	1.77	1.90	2.59	1.28
MW03	3.33	1.22	1.54	1.68	1.71	1.85	2.69	1.47
MW04	4.21	1.26	1.55	1.68	1.72	1.85	2.63	1.37
MW05	3.91	1.75	2.11	2.28	2.31	2.46	3.27	1.52
MW06	4.47	1.73	2.06	2.22	2.25	2.39	3.11	1.37
MW07	5.02	1.60	1.91	2.07	2.10	2.24	2.94	1.34
MW08	5.59	1.73	2.01	2.13	2.17	2.27	2.89	1.16
MW09	5.69	1.94	2.30	2.54	2.57	2.77	3.55	1.61
MW10	6.45	1.76	2.05	2.27	2.29	2.44	3.14	1.38

Notes:

1. Surface water monitoring point installed in Cudgera Creek at the western site boundary.

2.8 Hydraulic Conductivity

Saturated hydraulic conductivity ($\mathbf{K_{sat}}$) testing was undertaken at MW03, MW04, MW06, MW08 and MW10 on 1 November 2022, with duplicate testing completed to provide consistency.

K_{sat} results for each well are provided in Table 5 below and calculation sheets are provided in Appendix E.

Table 5: Saturated hydraulic conductivity test data.

Well I.D.	Test 1 (m/day)	Test 2 (m/day)
MW03	0.84	0.75
MW04	1.60	1.94
MW06	2.63	4.19
MW08	0.36	0.23
MW10	0.85	0.73

2.9 Water Sharing Plans

Three water sharing plans (**WSP**) cover the study area of the proposed development. These are:

1. Tweed River Area Unregulated and Alluvial Water Sources 2023.
2. North Coast Coastal Sands Groundwater Sources 2016.
3. North Coast Fractured and Porous Rock Groundwater Sources 2016.

2.10 Groundwater Sensitive Environments

WSPs identify a groundwater dependent ecosystem (**GDE**) located at the western boundary of the study area, along Cudgera Creek.

Additionally, the *State Environmental Planning Policy (Resilience and Hazards) 2021* identifies a coastal wetland area along the western study area boundary largely coinciding with the GDE, as well as a littoral rainforest environment in the central northern portion of the study area.

Coastal wetland and littoral rainforest areas are shown in Appendix B Map 08.

2.11 Groundwater Dependent Culturally Significant Sites

No groundwater dependent culturally significant sites are identified in the WSP for Tweed River Area Unregulated and Alluvial Water Sources 2023, North Coast Coastal Sands Groundwater Sources 2016 or North Coast Fractured and Porous Rock Groundwater Sources 2016.

2.12 Groundwater Quality

2.12.1 Testing Methodology

One round of groundwater quality sampling has been completed at the Site, on 13 January 2023.

All wells were purged using a foot valve pump and sampled using laboratory supplied bottles with appropriate preservatives and no headspace.

Sample bottles were labelled with a unique identification number and stored on ice immediately following collection. Samples were dispatched to a NATA accredited laboratory (Envirolab Pty Ltd) under chain of custody (**COC**) documentation and within appropriate holding times.

Samples were tested for pH, electrical conductivity (**EC**), ionic balance, and a range of dissolved heavy metals.

2.12.2 Testing Results

Laboratory results indicate that surface water at Cudgera Creek is saline and slightly basic, while Site groundwater is fresh and moderately acidic.

Laboratory heavy metal analysis identified elevated concentrations of zinc in all samples (including MW01), and copper in MW09 and MW10, exceeding the ANZG (2018) 95% default guideline values for marine water.

Given that beneficial groundwater use is not proposed for the development, and that basements will be fully tanked, ongoing risk to sensitive receptors posed by groundwater is expected to be low. However, some form of groundwater management will be required during temporary dewatering as part of the construction phase of the development.

Dewatering management requirements have been addressed in Section 5.4 of this report.

2.13 Groundwater System Productivity

The NSW Department of Primary Industries Office of Water NSW Aquifer Interference Policy (2012) (**AIP**) defines groundwater systems as 'highly productive' or 'less productive', with highly productive groundwater systems characterised by:

1. Groundwater quality – total dissolved solids (**TDS**) < 1500 mg/L; and

2. Groundwater supply – yield > 5 L/s.

Based on measured hydraulic conductivities, 5 L/s abstraction from the aquifer is readily achievable.

EC results indicate moderate levels of salinity across the Site, with an average of 912 µS/cm reported across the nine monitoring wells. This corresponds to TDS levels in the order of 584 mg/L, using a scaling factor of 0.64 (Dahaan *et al*, 2016).

We therefore assess this aquifer as being a 'highly productive alluvial groundwater source' in accordance with the AIP.

3 Existing Conditions Groundwater Model

3.1 Groundwater Model Conceptualisation

3.1.1 Flow Directions and Water Table Elevation

Observed groundwater levels indicate that groundwater at the Site flows in a westerly to north westerly direction towards Cudgera Creek. The mean water level over the monitoring period was observed to be in the order of 1.0 to 2.5 mAHD across the Site.

3.1.2 Sources and Sinks

Recharge to the groundwater system is primarily from rainfall infiltration reflective of a predominately unconfined system.

Vegetation coverage across the model domain can be generally zoned into grassland, trees, mangroves and low / high density residential areas. Differing recharge rates are expected in these areas based on impervious areas, root zone depth and vegetation cover. Fully impermeable areas including existing basement footprints and roads were assigned a recharge rate of zero.

Groundwater discharge occurs at Cudgera Creek in the west and Cudgera Beach in the east, as well as through evapotranspirative losses.

3.1.3 Hydraulic Conductivity and Confinement

Hydraulic conductivity values adopted for modelling are specified in Section 2.8.

For all units, vertical conductivity was assumed to be a third of the magnitude of the horizontal conductivity due to layering of strata and the presence of lower permeability interbeds.

3.2 Software

The MODFLOW NWT Solver was utilised within the GMS 10.4.7 (2019) graphical user interface for this model.

3.3 Settings and Water Balance Error Criteria

The NWT solver options were kept at the recommended settings as per the *USGS Online Guide to MODFLOW-NWT* (2022).

A model water balance error threshold of 1% was used which represents the typically adopted industry threshold value provided in the Australian *Groundwater Modelling Guidelines* (2012). This water balance error is the percentage difference between the total water entering and leaving the model and is a measure of the reliability of the groundwater model. An error of greater than 1% would require a reduction in the model's convergence criteria (closure criterion) to ensure the model water balance error fell below 1%.

3.4 Model Extents and Grid Configuration

A model domain of 770 m east to west by 1,010 m north to south, with a 2 m grid resolution, was used for the assessment of groundwater conditions and impacts. Of this domain, approximately 55% comprised the active model area with the remaining portion remaining inactive.

3.5 Layer Configuration

Model geology was represented using eight layers, comprising seven layers (layers 1 – 7) of alluvium / beach sand, and one underlying layer (layer 8) representing inferred bedrock (sandstone).

Existing topography was represented by the top of layer 1 and was defined using LIDAR data (NSW DFSI, 2013). The interface between layers 7 and 8 (bottom of sand, top of bedrock) was inferred to be at 30 m below the existing ground surface. The bottom of layer 8 was set at a nominal constant value of -40 mAHD.

3.6 Boundary Conditions

Constant head boundaries were assigned to all layers of the model as follows:

1. A constant head of 0.67 mAHD was assigned to Cudgera Creek in the west based on mean water level data recorded at MW01 over the monitoring period (Section 2.7.2).

2. A constant head value of -0.001 mAHD was assigned to Cudgera Beach in the east based on sea level data reviewed in Section 2.6.

Constant head boundaries are shown in Appendix B Map 09

3.7 Pre-Calibration Model Parameters

3.7.1 Hydraulic Conductivity

Hydraulic conductivity for alluvium was assigned based on the median of results of k_{sat} testing provided in Section 2.8, and hydraulic conductivity for beach sand and underlying sandstone was assigned with reference to representative values provided in Bair (2006).

Assigned values are summarised in Table 6.

Table 6: Horizontal hydraulic conductivity values.

Hydraulic Conductivity Zone	Assigned Value (m/day)
Alluvium	0.7
Sandstone	0.01
Beach Sand	20

A vertical anisotropy ratio (K_h / K_v) of 3.0 was used for all hydraulic conductivity zones.

3.7.2 Recharge and Evapotranspiration

Recharge and evapotranspiration zones for the existing conditions groundwater regime are shown in Appendix B Map 10.

Recharge rates in % of annual rainfall (Section 2.5) were adjusted within the upper and lower bounds in Table 7 to achieve calibration. Note that existing basement footprints and impervious areas such as roads were assigned a recharge rate of zero.

Table 7: Recharge rate calibration ranges.

Recharge zoning	Calibration range (% of rainfall)
Beach	70 – 100
Dirt Road	10 – 30
Dunes	50 – 80
Grass	90 – 100
Residential (Low Density)	20 – 50
Residential (High Density)	5 – 20
Mangroves	60 – 90
Trees	40 – 70

Evapotranspiration rates were obtained using evapotranspiration data from BoM (see Section 2.5.1). Evapotranspiration rates were applied in full to vegetated areas and halved for residential areas.

Evapotranspiration extinction depths were adjusted within the upper and lower bounds in Table 8 to achieve calibration.

Table 8: Evapotranspiration depth calibration ranges.

Evapotranspiration Zoning	Calibration Range (m)
Beach	0.1 – 0.3
Dirt Road	0.1 – 0.3
Dunes	0.1 – 0.3
Grass	0.2 – 0.5
Residential (Low Density)	1.0 – 2.0
Residential (High Density)	1.0 – 2.0
Mangroves	0.4 – 1.0
Trees	1.5 – 3.0

3.8 Calibration

3.8.1 Calibration Procedure

Trial-and-error was used to calibrate the model to the mean groundwater levels recorded over the monitoring period. Recharge rates and evapotranspiration extinction depth values were adjusted within the ranges identified in Section 3.7 to achieve calibration.

At the completion of calibration, the model parameters were as presented in Table 9.

Table 9: Calibrated existing conditions model parameters.

Calibration Parameter	Units	Calibrated Value
Recharge Rates		
Beach	% of rainfall	100
Dirt Road	% of rainfall	15
Dunes	% of rainfall	60
Grass	% of rainfall	100
Residential (Low Density)	% of rainfall	30
Residential (High Density)	% of rainfall	5
Mangroves	% of rainfall	80
Trees	% of rainfall	60
Evapotranspiration Depths		
Beach	mbgl	0.2
Dirt Road	mbgl	0.2
Dunes	mbgl	0.2
Grass	mbgl	1.5
Residential (Low Density)	mbgl	1.5
Residential (High Density)	mbgl	1.5
Mangroves	mbgl	0.4
Trees	mbgl	3.0

3.8.2 Calibration Results

A calibration scatter plot of modelled and observed heads along with key calibration statistics is provided in Appendix D Figure 4. As the constant head boundary condition at Cudgera Creek was assigned based directly on water levels observed in MW01, this point was excluded from the calculation of calibration statistics.

The model's normalised root mean square (NRMS) was 8.69%, below the typical threshold value of 10% recommended by the Australian Groundwater Modelling Guidelines (2012). The absolute residual mean was 0.058 m, and the residual mean was 0.27 m, indicating a very slight bias towards marginal over-prediction of head. The mass balance discrepancy was -0.0473 % and therefore acceptable, being well below the adopted threshold of 1.0 %.

Overall, the calibrated existing conditions model is closely representative of observed groundwater level data and the conceptual model, and the model is considered satisfactory for predictive purposes.

3.9 Results

The calibrated heads for the existing groundwater regime are provided in Appendix B Map 11. A section view showing the modelled water table is provided in Figure 5 Appendix D.

3.10 Model Confidence Level Classification

In accordance with the *Australian Groundwater Modelling Guidelines* (2012), the model is considered to generally represent a 'Class 2' model confidence level classification, suitable for impact assessment.

A 'Class 2' classification is justified based on the following:

- Calibration statistics are acceptable and within recommended criteria.
- Mass balance error is less than 1.0% of total.
- Groundwater head observations and geotechnical data coverage are reasonable in the vicinity of the proposed development.
- Model parameters are generally consistent with conceptualisation.

3.11 Modelling Uncertainty

There are inherent uncertainties in any numerical model arising from assumptions made while simplifying a complex natural regime to several fundamental computational parameters. The following issues contribute to uncertainty within the model:

1. Groundwater monitoring well investigations were completed within Site boundaries with limited offsite groundwater level data available.
2. Evapotranspiration and evaporation rates were based on limited data from BoM.
3. Potential for variable horizontal and vertical hydraulic conductivity.

Notwithstanding the above, the model has been calibrated to an NRMS of 8.69% using one and a half years of monitoring data collected during average climatic conditions at the site. We therefore consider the overall uncertainty of the model is low.

3.12 Model Sensitivity

Model sensitivity is the extent to which model results change due to changes to model inputs. The model is sensitive to parameters including:

- Hydraulic conductivity
- Recharge rates
- Evapotranspiration rates and extinction depths

The potential variance of these parameters has been considered as part of the calibration process with the final parameters used producing the most accurate reproduction of the monitored groundwater levels.

The model outcomes are ultimately concerned with the level and extent of drawdown caused by the proposed development. Since any changes to model parameters would occur across existing, temporary dewatering, and proposed conditions modelling scenarios, the sensitivity of the drawdown to model parameters would be due only to relative changes to the parameters modified between scenarios. We therefore consider that a further formal sensitivity analysis is not warranted for this assessment.

4 Post Development Assessment

4.1 Overview

A post development groundwater model was developed to assess likely changes to the hydrogeological regime based on expected development footprints.

4.2 Post Development Conditions Without Mitigation

4.2.1 Modifications to Calibrated Groundwater Model

To represent expected groundwater conditions arising from the post development scenario, recharge and evapotranspiration zones were updated to reflect the proposed development (Arqus Design, 2023), including new basements and impervious areas.

Modified recharge and evapotranspiration zones are shown in Appendix B Map 12.

4.2.2 Groundwater Levels

Groundwater heads for the post development scenario are shown in Appendix B Map 13.

Mass balance discrepancy in the post development model was -0.0466 % and therefore acceptable being below the adopted threshold of 1.0 %.

4.2.3 Drawdown

Modelled drawdown contours arising from the proposed development are shown in Appendix B Map 14, noting that positive drawdown values represent a lowering of the groundwater table.

Modelling demonstrates that the proposed development is expected to cause a drawdown of up to 0.15 m within the coastal wetland in the western portion of the development. Negligible drawdown impacts are predicted in the littoral rainforest area to the northeast of the Site.

5 Groundwater Dewatering Management

5.1 Overview

Based on observed groundwater levels at the site, temporary groundwater dewatering will be required during excavation and construction of the proposed basements for buildings D – G. MA understands that basement construction will involve the installation of impermeable shoring walls and the implementation of permeation grouting which will limit groundwater inflow into the open excavation.

We anticipate that a dewatering timeframe of 3 – 6 months will be required after the installation of the shoring walls to allow for completion of the excavation, construction, and tanking of the basement slabs.

As a conservative measure, the model assumes that dewatering for all basements will occur simultaneously, which likely represents the "worst case" drawdown scenario with the greatest potential groundwater inflow.

5.2 Temporary Dewatering Model Configuration

A transient (time varying) groundwater model based on the calibrated existing conditions model was developed to estimate the rate of inflow, and the extent of local groundwater drawdown resulting from temporary groundwater dewatering. The following additions were made to the existing conditions model:

- Groundwater inflow into proposed basement excavations was represented by drains with base levels 0.5 m below respective basement FFLs.
- Permeation grouting was represented by a 1.5 m thick layer of impermeable material applied across each basement footprint, from 2 m to 3.5 m below respective basement FFLs.
- Impermeable shoring walls were modelled as horizontal flow barriers at basement perimeters, from the ground surface to the base of permeation grouting slabs (3.5 m below FFL).

5.3 Temporary Dewatering Model Results

Temporary dewatering impacts were assessed over one, three and six-month periods, with groundwater take summarised in Table 10. Map 15 in Appendix B shows modelled groundwater drawdown after the maximum expected dewatering timeframe of 6 months.

Table 10: Expected dewatering volumes.

Elapsed Time	Total Dewatered Volume (ML)
1 month	1.54
3 months	2.74
6 months	4.54

Modelling indicates that drawdown impacts arising from temporary dewatering will largely be limited to the site, with drawdown of no greater than 0.1 m predicted outside site boundaries.

After six months of dewatering, groundwater impacts in the coastal wetland area to the east are expected to be no greater than 0.05 m, and no impacts are expected in the littoral rainforest to the northwest.

5.4 Dewatering Management

Due to the acidity and elevated concentrations of heavy metal and ammonia found during groundwater quality analysis (Section 2.12), dewatered groundwater will need to be managed prior to release into the environment in accordance with one or more of the management options summarised in Table 11.

Table 11: Summary of groundwater management options.

Management Option	Consideration	Comments
On-site treatment and discharge to nearby water body.	Preferred	• Treatment likely to include removal of suspended solids, alum dosing and pH balancing. • Discharge would satisfy NSW DPIE (2021) and ANZG (2018).
Disposal to sewer under a Trade Waste Agreement.	Acceptable subject to further negotiation and costs	• Requires negotiation with sewer service provider and establishment of water quality prior to disposal. • Water quality screening levels will depend on the specific Trade Waste Agreement with sewer service provider.
pH balance and irrigate to landscaped areas	Acceptable subject to available irrigation area	• Treatment would be limited to pH balancing. • Dewatering and irrigation would be paused during rainfall to limit runoff to nearby water bodies. • Large irrigation area likely required due to the volume of estimated groundwater take.
Tanker off-site for disposal at an aqueous treatment plant by a suitably licenced contractor.	Not expected to be required Likely costly	• Suitable for any heavily contaminated groundwater where on-site treatment / disposal is not practicable or where trade waste agreement not available. • Water quality screening levels will depend on specific requirements of the contractor. • Not expected to be required based on current groundwater quality monitoring data but included for contingency purposes.

5.5 Dewatering Management Plan

A dewatering management plan should be prepared as part of the detailed design process and construction certificate documentation to guide dewatering during the basement construction phase. We recommend that this includes:

1. Monitoring of groundwater levels outside the basement excavation areas using existing monitoring wells.
2. The establishment of trigger values for groundwater level and water quality based on monitoring of existing groundwater conditions.
3. Routine monitoring of groundwater quality during the groundwater extraction process to inform any treatment requirements.
4. Monitoring of groundwater extraction (pumping) rates.
5. A description of treatment and disposal methods.
6. A trigger, action and response plan (**TARP**) to manage situations where trigger values are exceeded.

5.6 Licensing Requirements

As groundwater take is expected to be greater than 3 ML / year, dewatering activities for the proposed development will not satisfy WaterNSW requirements for water access licensing exemptions. As such, a water supply works approval and a Water Access License from WaterNSW will be required prior to commencement of basement excavation works.

6 Aquifer Interference Policy

The Aquifer Interference Policy (**AIP**) details the role and requirements of the Minister administering the *Water Management Act 2000* regarding water licencing and assessment processes for aquifer interference activities under the Act.

The AIP applies to all activities that penetrate, interfere with, obstruct, abstract water from, or dispose of water to, an aquifer. The AIP requires that proponents demonstrate that the minimal impact considerations specified under the AIP can be met.

An assessment of the proposal's compliance with the AIP is provided in Table 12 and is based on the groundwater modelling reported in Sections 3 and 4, noting that the groundwater source category at the Site is defined as being a 'highly productive alluvial groundwater source' (see Section 2.13).

Table 12: NSW Aquifer Interference Policy Assessment.

Minimal Impact Consideration	Martens' Assessment
Water Table	
1. Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site listed in the schedule of the relevant water sharing plan; or A maximum of a 2m decline cumulatively at any water supply work.	Complies. No high-priority GDEs listed in the water sharing plan suffers a 10% cumulative variation in the water table as a result of the proposal. No high-priority culturally significant sites listed in the water sharing plan are within the affected area. No water supply work within the affected area suffers a decline in head of more than 2m caused by the proposal.
2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2m decline cumulatively at any water supply work, then make good provisions should apply.	N/A
Water Pressure	
1. A cumulative pressure head decline of not more than 40% of the "post-water sharing plan" pressure head above the base of the water source to a maximum of a 2m decline, at any water supply work.	Complies. No water supply work within the affected area suffers a decline in head of more than 40% caused by the proposal.
2. If the predicted pressure head decline is greater than requirement 1. Above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-	N/A

Minimal Impact Consideration	Martens' Assessment
term viability of the affected water supply works unless make good provisions apply.	
Water Quality	
1. (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity. (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity	Complies. The proposal will not significantly reduce groundwater quality since it incorporates suitable stormwater treatment devices and does not cause drawdown greater than what would otherwise occur due to seasonal and climatic variations.
2. If condition 1(a) is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works. If condition 1(b) is not met, then appropriate studies are required to demonstrate the Minister's satisfaction that the River Condition Index category of the highly connected surface water source will not be reduced at the nearest point to the activity.	N/A

The assessment has found that groundwater drawdown caused by the proposal will comply with the minimal groundwater impact considerations set out by the AIP for a 'highly productive alluvial groundwater source'.

7 Summary and Conclusions

7.1 Study Scope

This study has assessed hydrogeological conditions and potential impacts associated with the proposed seniors housing development at 87 – 89 Tweed Coast Road, Hastings Point, NSW. The following works were completed as part of this study:

1. Review of existing hydrogeological investigation data and regional information for the Site and surrounding area.
2. Construction of groundwater monitoring wells and monitoring of existing groundwater levels and groundwater quality at the Site.
3. Development of a calibrated groundwater model representing existing Site conditions.
4. Development of a groundwater model representing post development Site conditions to assess the potential impact of the proposed development.
5. Development of a temporary dewatering groundwater model to assess likely inflow volumes and drawdown impacts arising from temporary basement dewatering.

7.2 Long-term Groundwater Impacts

This assessment found that expected groundwater drawdown caused by the proposed development will be no greater than 0.15 m in nearby coastal wetland areas to the west of the Site. No long-term groundwater related impacts are expected on nearby properties, productive groundwater bores or littoral rainforests.

Additionally, the assessment has found that expected groundwater drawdown caused by the proposed development will comply with the minimal groundwater impact considerations set out by the NSW Aquifer Interference Policy for a 'highly productive alluvial groundwater source'.

7.3 Temporary Construction Dewatering Impacts

The assessment found that temporary dewatering works required for the excavation and construction of the proposed basement are expected to take approximately 2.74 – 4.54 ML of groundwater over an anticipated dewatering timeframe of 3 - 6 months. As such, a water supply works approval and a Water Access License from WaterNSW will be required prior to commencement of excavation works.

Various options are available to manage and dispose of extracted groundwater including, treatment and discharge to waterways, landscape irrigation and off-site disposal. Modelled drawdown impacts arising from dewatering are minimal and generally limited to within Site boundaries. No drawdown greater than 0.05 m is expected within any coastal wetland or littoral rainforest areas.

8 References

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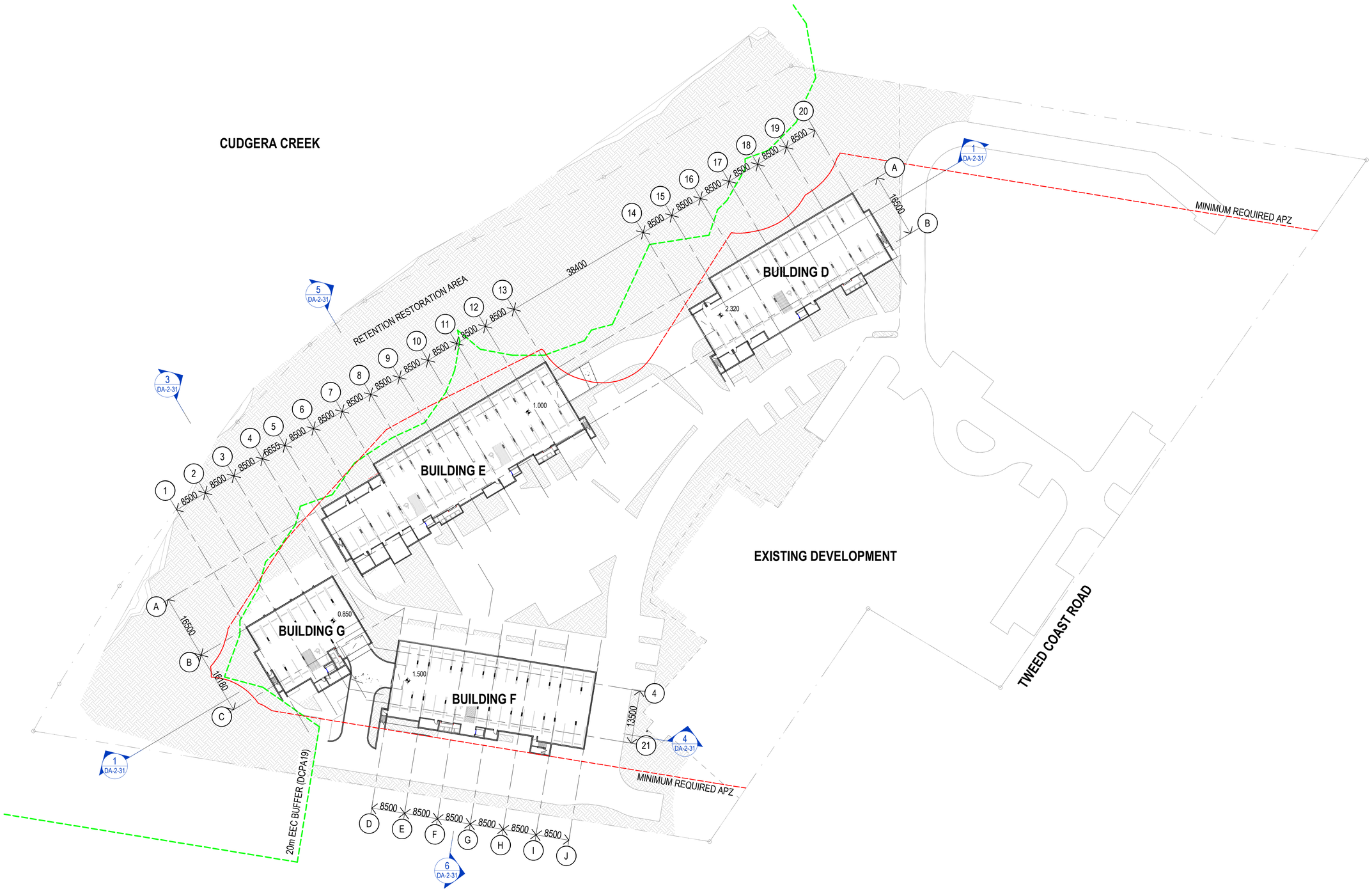
Appendix A – Architectural Drawings



1 OVERALL SITE - BASEMENT
1 : 500

Arqus DESIGN

Integrated perspective

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24.01.22	DRAFT DA PACKAGE	C
24.03.08	FOR INFORMATION	D
24.03.13	FOR INFORMATION	E

CLIENT

TriCare
Retirement Living. Home Care. Aged Care.

PROJECT

TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

SITE PLAN - BASEMENT LEVEL

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
1 : 500 @A1 1 : 1000 @A3	29/06/23	

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1 OVERALL SITE - GROUND LEVEL
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TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

SITE PLAN - GROUND FLOOR

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
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DRAWING NUMBER **DA-2-02** ISSUE **F**

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1 OVERALL SITE - LEVEL ONE
1 : 500

Arqus DESIGN

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24.03.13	FOR INFORMATION	E

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TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

SITE PLAN - LEVEL 01

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	ZC	SP

SCALE	DATE CREATED	NORTH
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1 OVERALL SITE - LEVEL TWO
1 : 500

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DRAWING

SITE PLAN - LEVEL 02

JOB NUMBER	DESIGN	DRAWN	CHECKED
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SCALE	DATE CREATED	NORTH
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DRAWING NUMBER	ISSUE
DA-2-04	**C**

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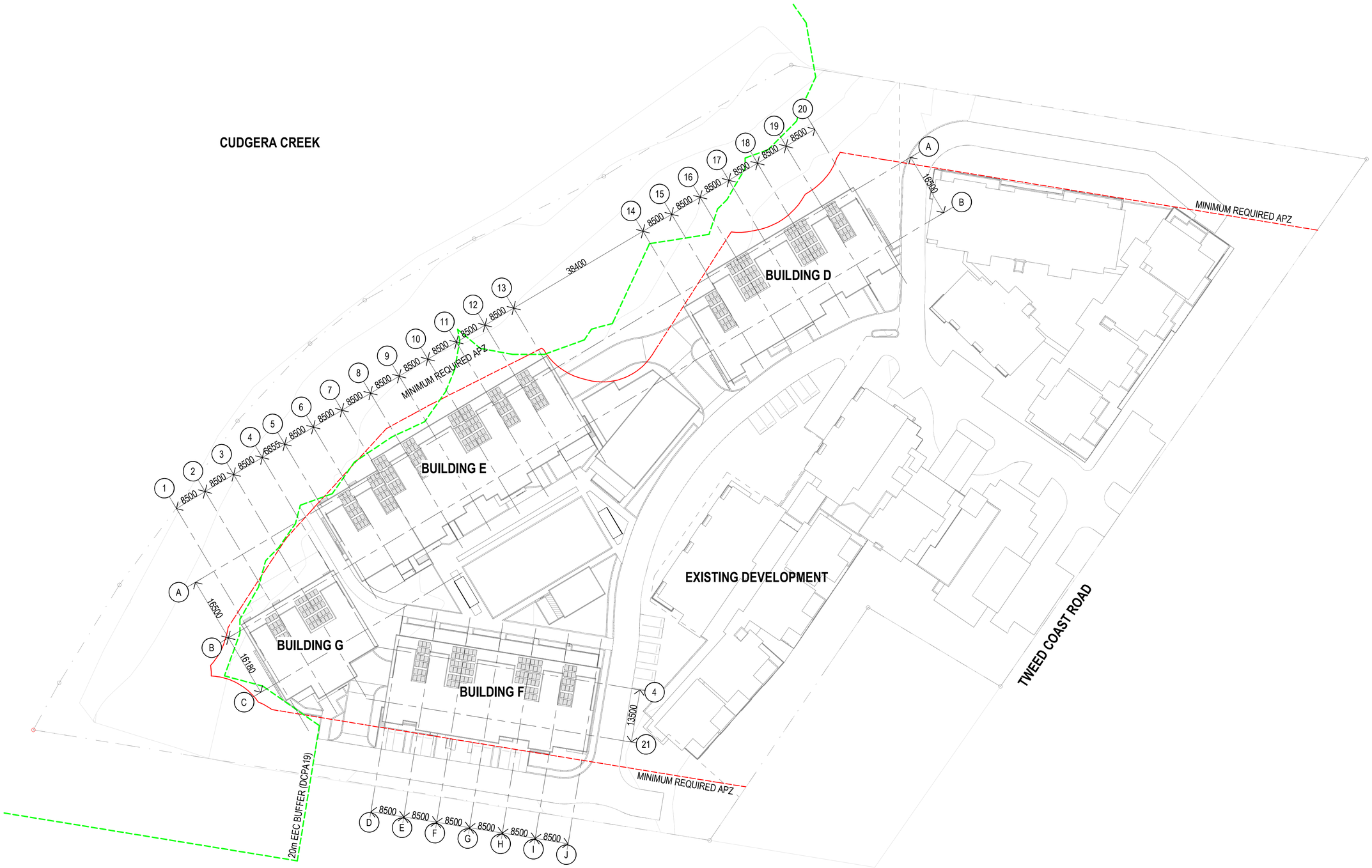

1 OVERALL SITE - ROOF
1 : 500

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24.03.13	FOR INFORMATION	E

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TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

SITE PLAN - ROOF

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
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DRAWING NUMBER **DA-2-05** ISSUE **E**

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1 OVERALL SITE AREA PLAN - LANDSCAPING AREAS (GROUND LEVEL)
1 : 500

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LANDSCAPING AREAS

ENDANGERED ECOLOGICAL COMMUNITY ZONE	7597.33m²
DEEP PLANTING	5536.81m²
LAWN	1184.54m²
PLANTER	63.03m²
GROUND LEVEL TOTAL LANDSCAPE AREA	6784.38m²

LANDSCAPING LEGEND

- ENDANGERED ECOLOGICAL COMMUNITY ZONE
- DEEP PLANTING
- LAWN
- PLANTER

REFER TO LANDSCAPE ARCHITECT'S DOCUMENTATION FOR ALL LANDSCAPE AREAS

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TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

OVERALL AREA PLAN - LANDSCAPING AREAS (GROUND LEVEL)

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
1 : 500 @A1 @A3	01/12/23	

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1 OVERALL SITE AREA PLAN - IMPERVIOUS AREAS
1 : 500

IMPERVIOUS/PERVIOUS AREAS

IMPERVIOUS AREA	8857.34m²
PERVIOUS AREA	14321.36m²

LEGEND

- IMPERVIOUS AREA
- PERVIOUS AREA

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TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

DRAWING

OVERALL AREA PLAN - IMPERVIOUS AREAS

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
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DA-2-19	**B**

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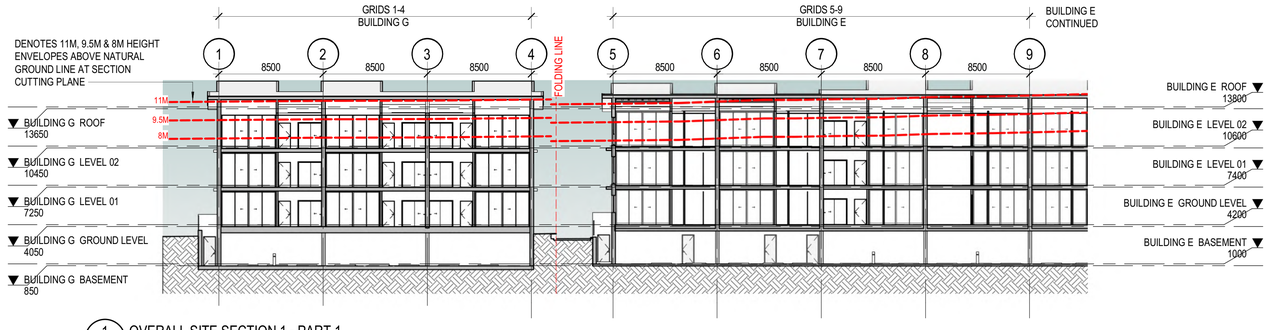

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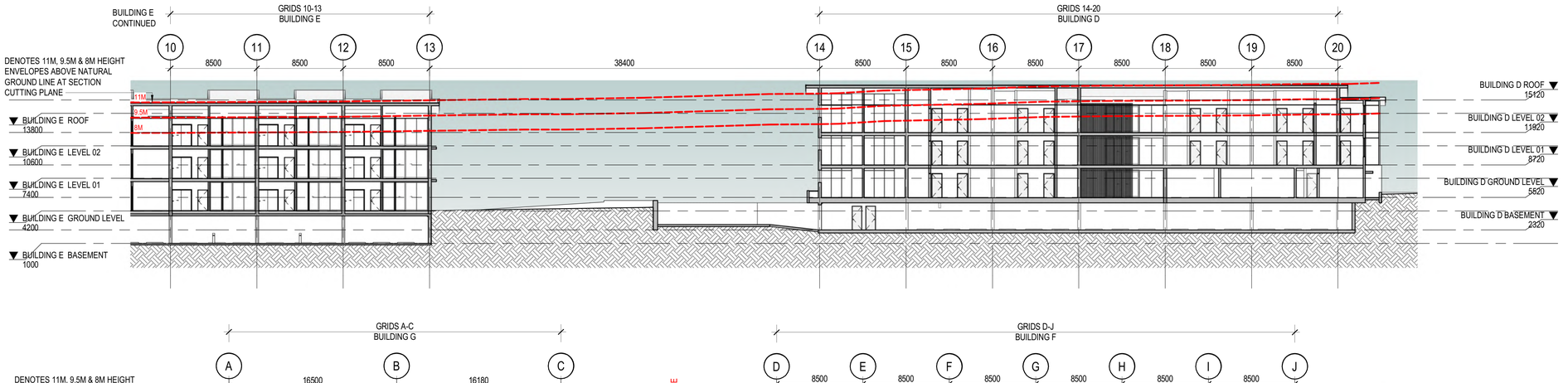

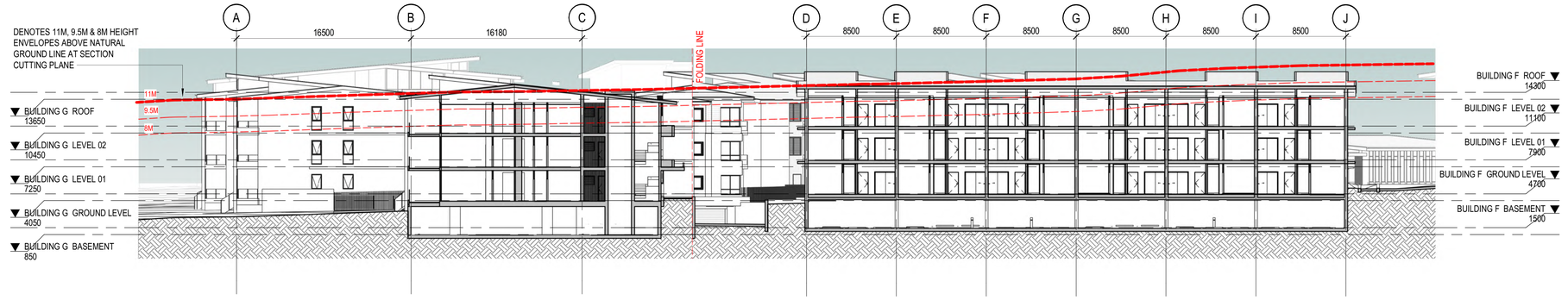

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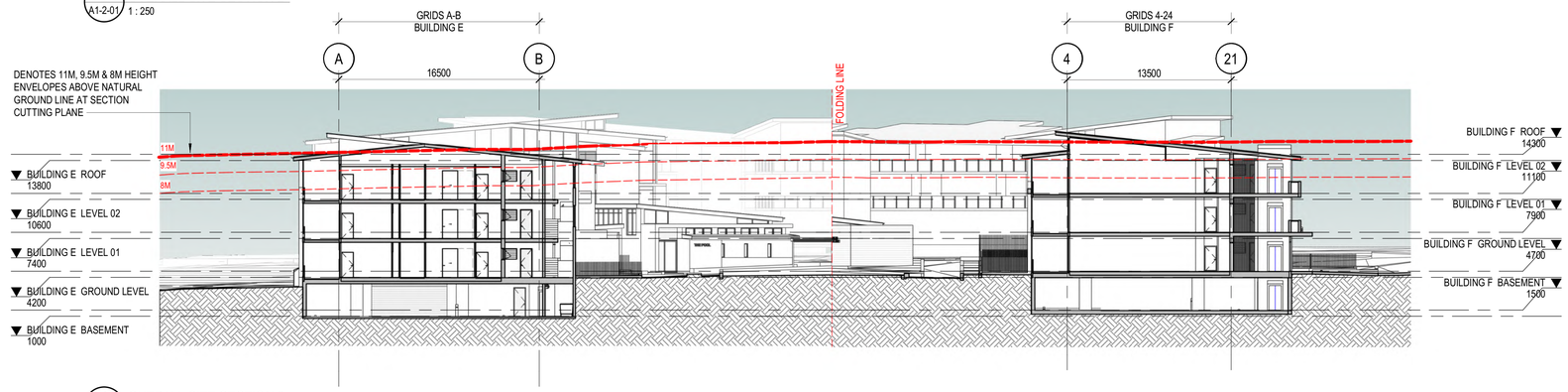

4 A1-2-01 OVERALL SITE SECTION 3
1 : 250

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24.08.16	DRAFT DA PACKAGE	C
24.10.09	DA PACKAGE	D

CLIENT

TriCare
Retirement Living. Home Care. Aged Care.

PROJECT

TRICARE HASTINGS POINT

87 TWEED COAST RD, HASTINGS POINT 2489, NSW

COUNTRY: BUNDJALUNG

DRAWING

OVERALL SITE SECTIONS

JOB NUMBER	DESIGN	DRAWN	CHECKED
23-0025	SP	KF	SP

SCALE	DATE CREATED	NORTH
1 : 250 @A1 @A3	18/09/2023	

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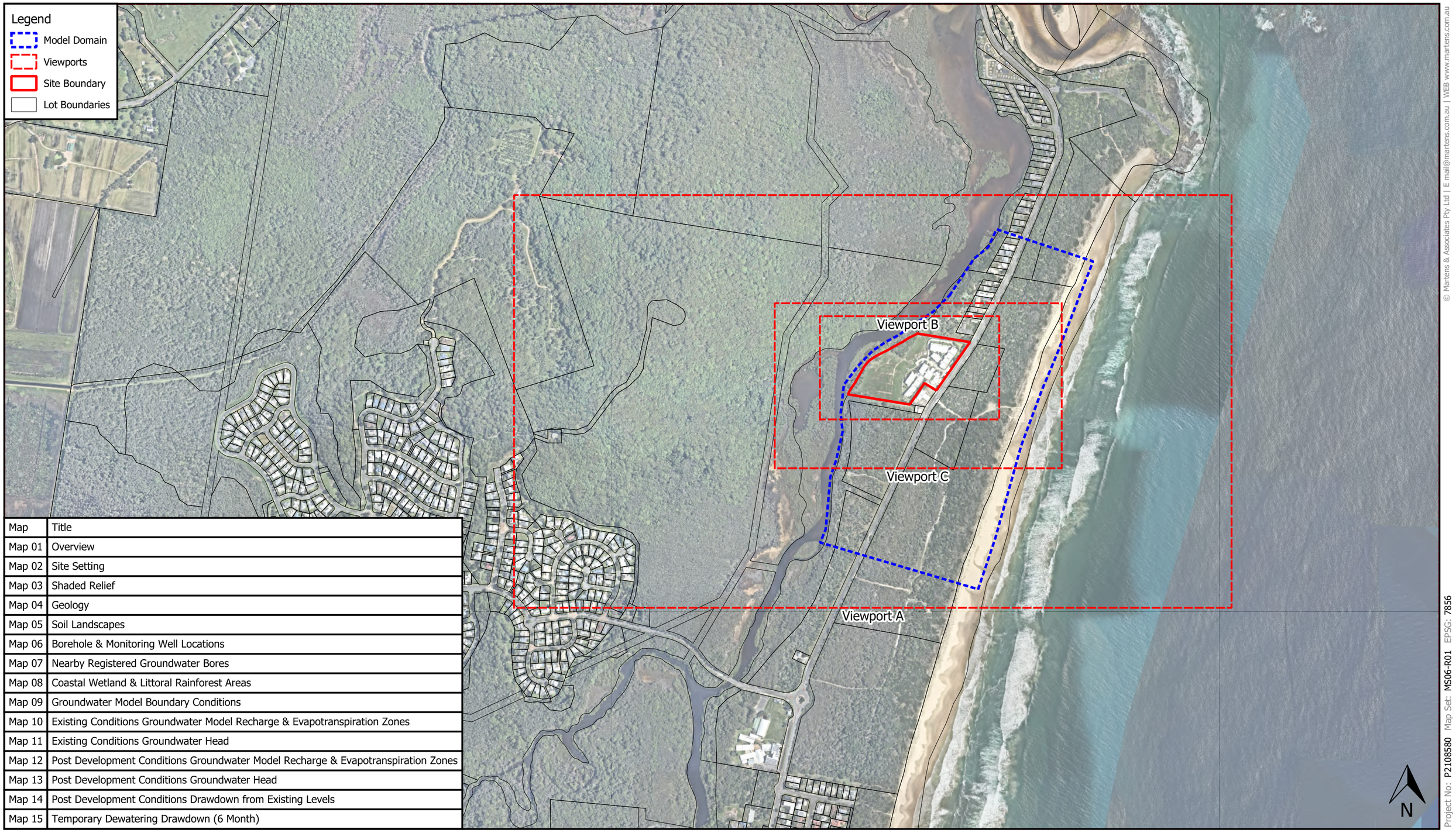
DEVELOPMENT APPLICATION

Appendix B – Site Maps



Map	Title
Map 01	Overview
Map 02	Site Setting
Map 03	Shaded Relief
Map 04	Geology
Map 05	Soil Landscapes
Map 06	Borehole & Monitoring Well Locations
Map 07	Nearby Registered Groundwater Bores
Map 08	Coastal Wetland & Littoral Rainforest Areas
Map 09	Groundwater Model Boundary Conditions
Map 10	Existing Conditions Groundwater Model Recharge & Evapotranspiration Zones
Map 11	Existing Conditions Groundwater Head
Map 12	Post Development Conditions Groundwater Model Recharge & Evapotranspiration Zones
Map 13	Post Development Conditions Groundwater Head
Map 14	Post Development Conditions Drawdown from Existing Levels
Map 15	Temporary Dewatering Drawdown (6 Month)

0 100 200 300 400 500 m

1:10000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2024).
- Cadastre from NSW DFSI (2023).

martens
Environment | Water | Geotechnics | Civil | Projects

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Map Title / Figure:
Overview

Map 01	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

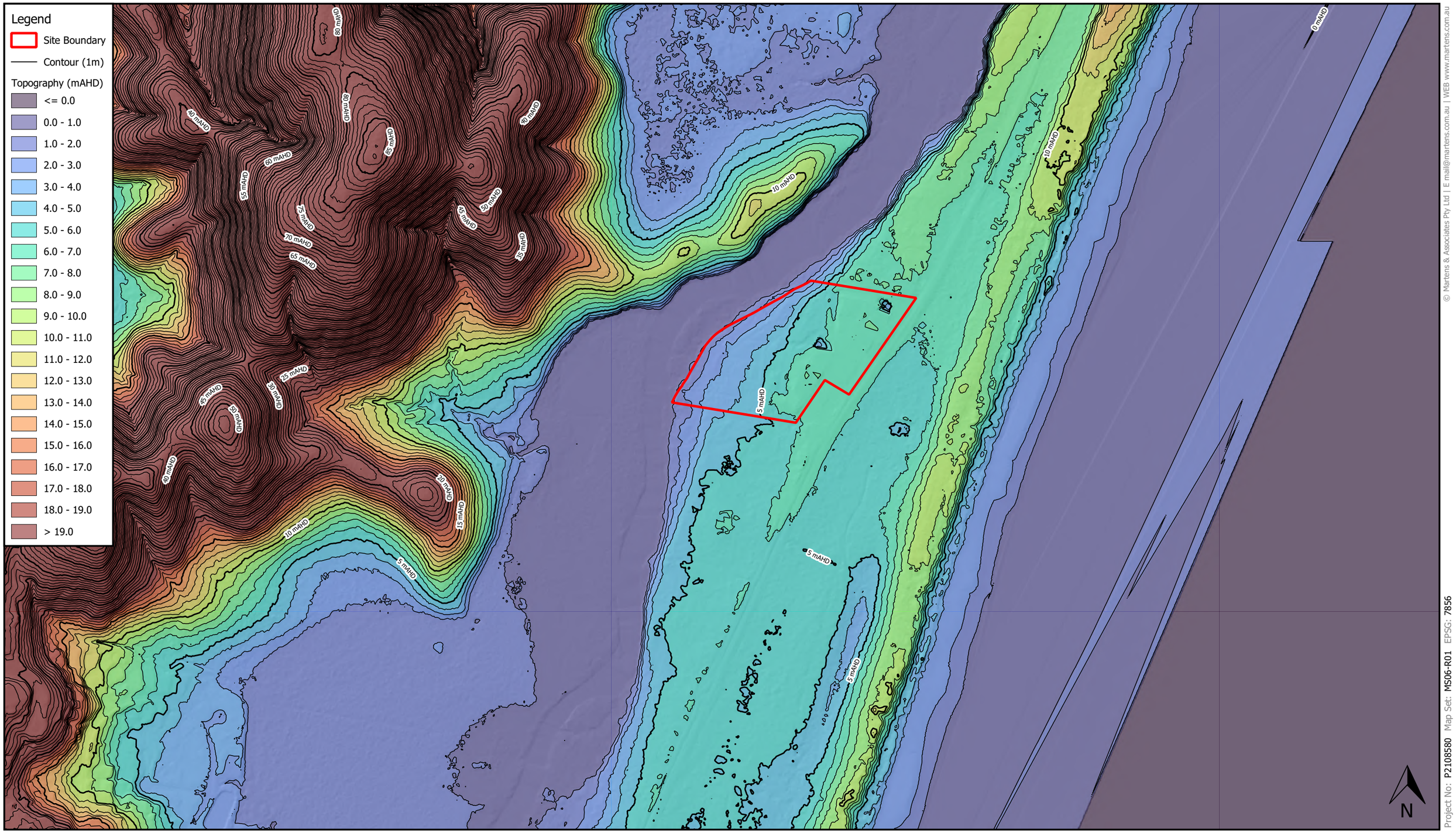
Notes:
- Aerial from Nearmap (2024).
- Cadastre from NSW DFSI (2023).

martens
Environment | Water | Geotechnics | Civil | Projects

Map Title / Figure:
Site Setting

Map 02	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856



Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Topography based on LiDAR data from NSW DFSI (2013).

Map Title / Figure:

Shaded Relief

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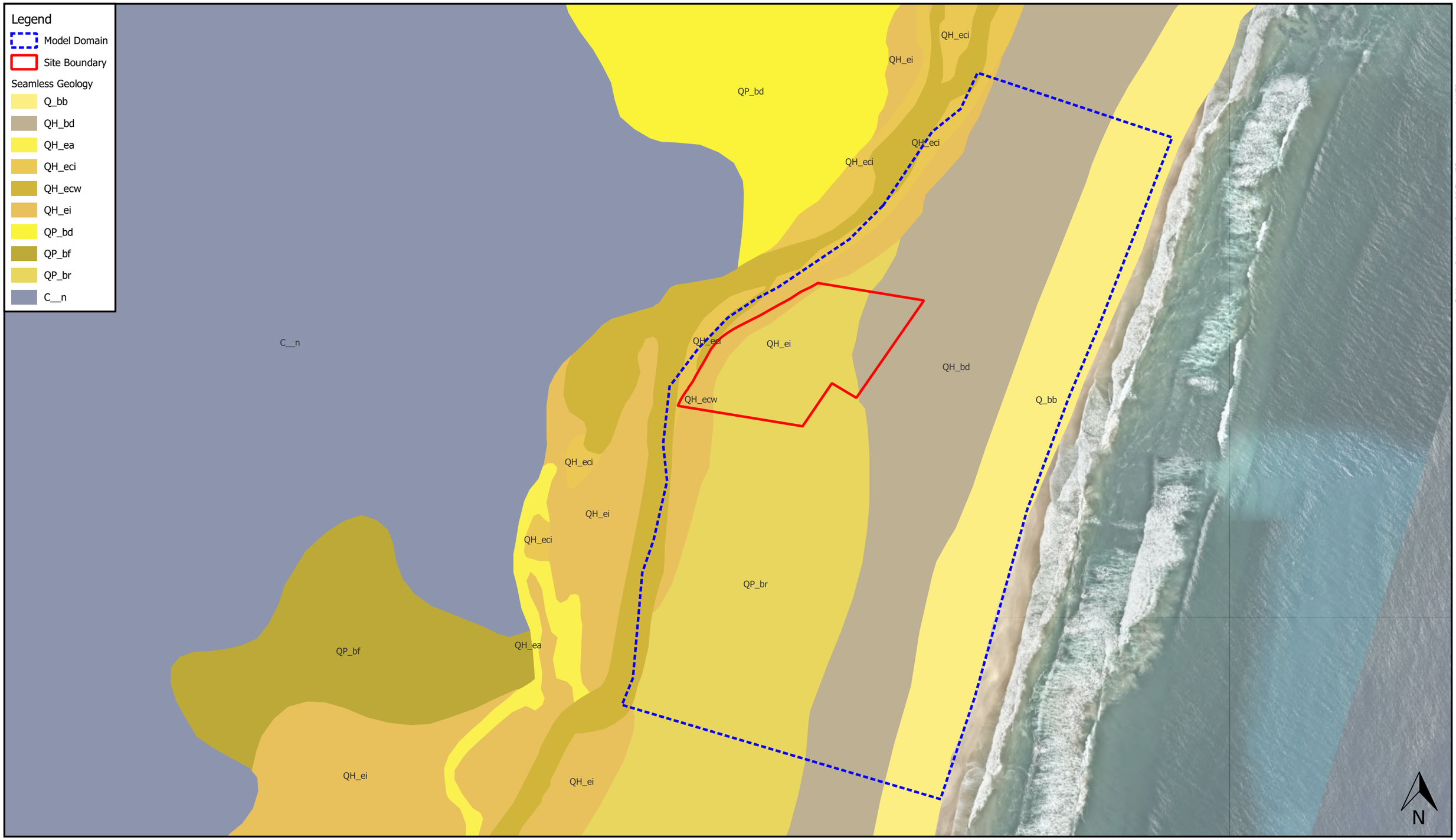
Map 03	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date



0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Surface Geology from NSW Seamless Geology, NSW Department of Regional NSW (2024).

Map Title / Figure:
Geology

Map 04	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

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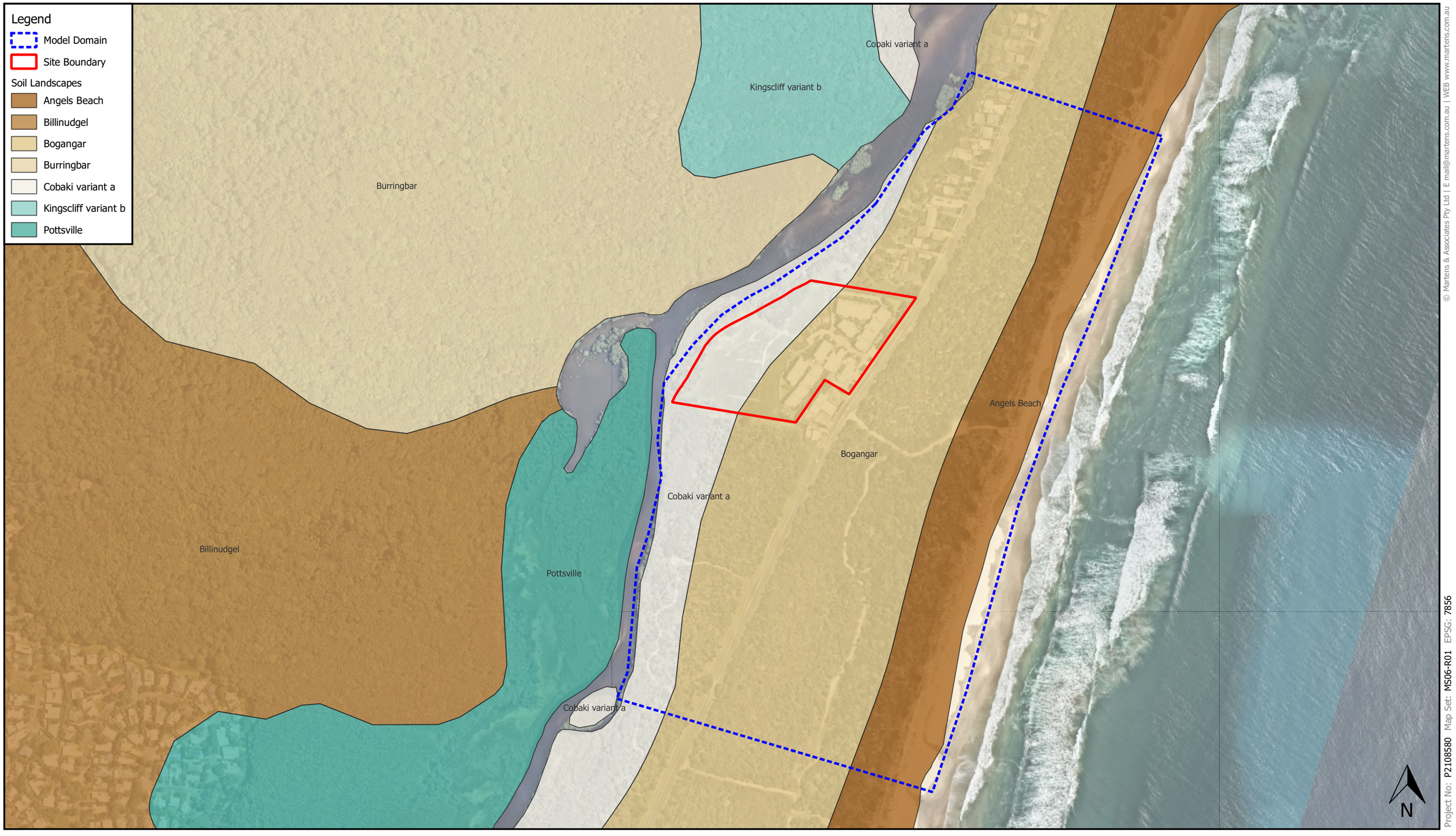
Project No: P2108580 Map Set: MS06-R01 EPSG: 7856



Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Soil Landscapes from NSW eSPADE (2024).

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Map Title / Figure:
Soil Landscapes

Map 05	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

0 10 20 30 40 50 m

1:1250 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2024).
- Topography based on LiDAR data from NSW DFSI (2013).

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Map Title / Figure:

Borehole & Monitoring Well Locations

Map 06	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Legend
- Model Domain
- Site Boundary

BoM Registered Bores
- Monitoring

GW307637.1.1
GW306499.1.1
GW307638.1.1
GW307634.1.1
GW307635.1.1

N

0 10 20 30 40 50 m

1:1250 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2024).
- Registered bore locations from Australian Government BoM's Groundwater Explorer (2024).

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Map Title / Figure:
Nearby Registered Groundwater Bores

Map 07	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2024).
- Coastal wetland and littoral rainforest areas from NSW State Environmental Planning Policy (Resilience and Hazards) 2021.

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Map Title / Figure:

Coastal Wetland & Littoral Rainforest Areas

Map 08	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

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0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2024).

Map Title / Figure:

Groundwater Model Boundary Conditions

Map 09	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

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Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2024).

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Map Title / Figure:

Existing Conditions Groundwater Model Recharge & Evapotranspiration Zones

Map 10	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Legend

- Site Boundary
- Groundwater Head (mAHD) - Existing Conditions

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2024).

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Map Title / Figure:

Existing Conditions Groundwater Head

Map 11	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

0 10 20 30 40 50 m

1:1250 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2024).

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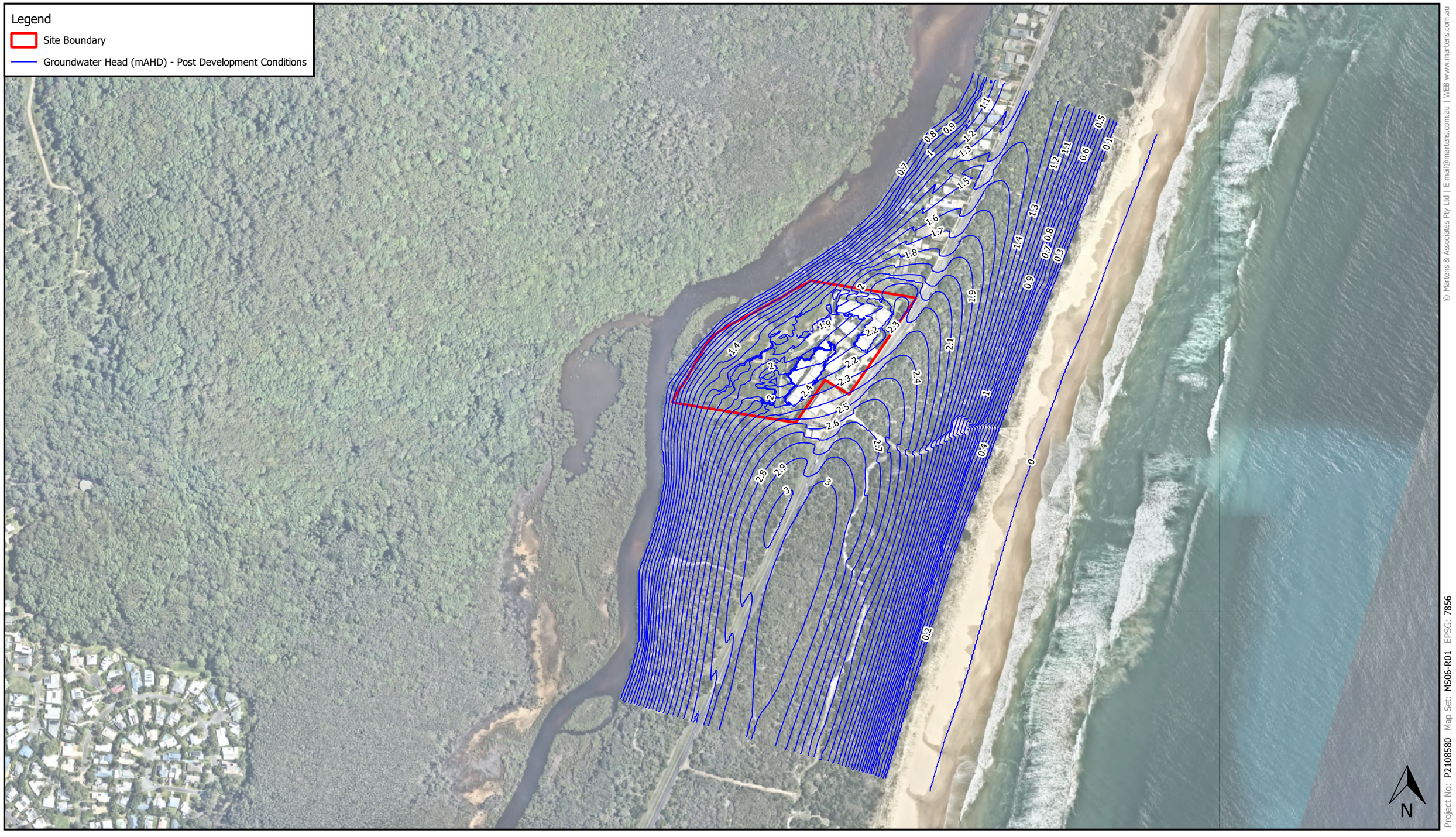
Map Title / Figure:

Post Development Conditions Groundwater Model Recharge & Evapotranspiration Zones

Map 12	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Legend

- Site Boundary
- Groundwater Head (mAHD) - Post Development Conditions



0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Notes:
- Aerial from Nearmap (2024).

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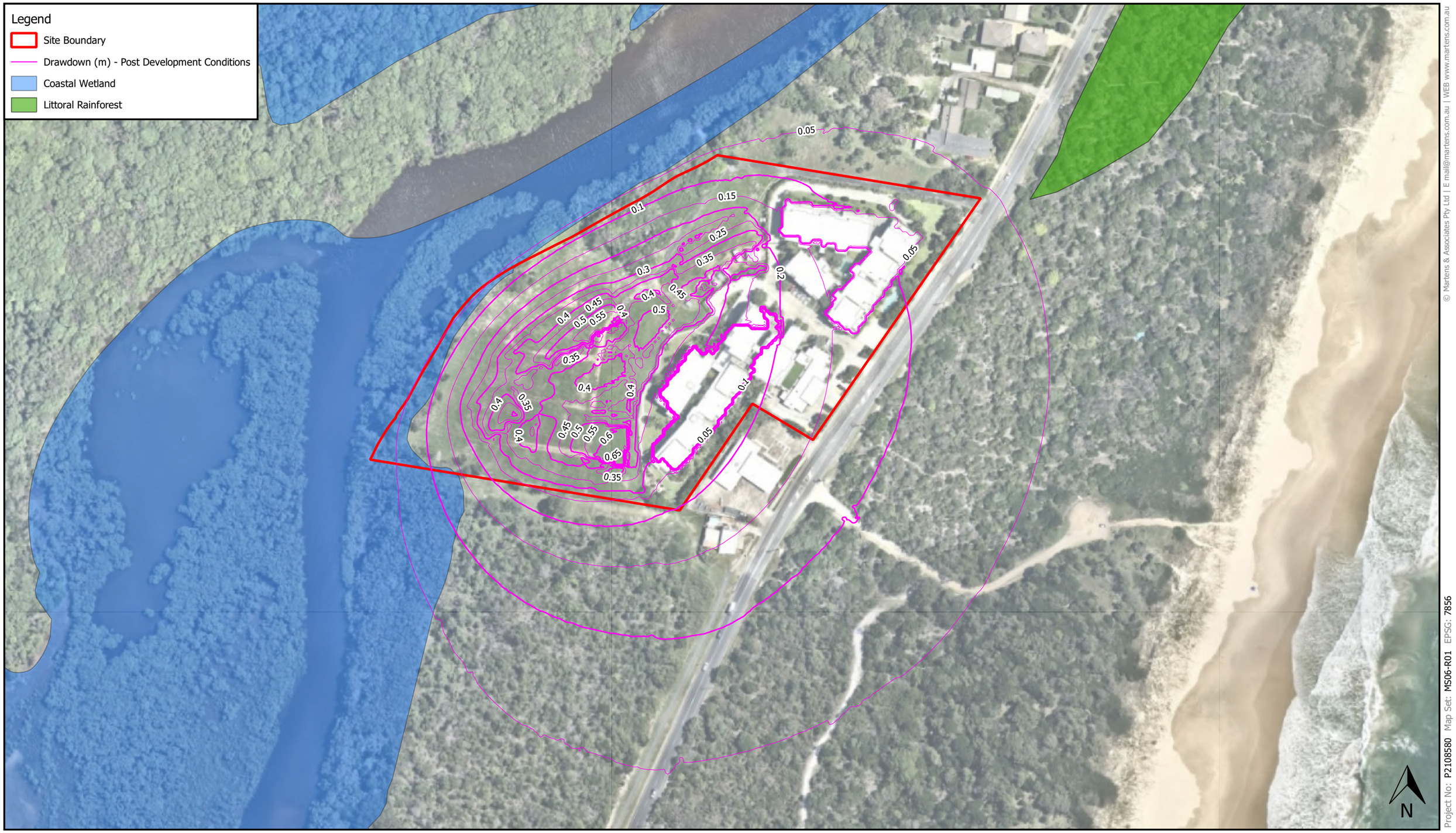
Map Title / Figure:

Post Development Conditions Groundwater Head

Map 13	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856



0 20 40 60 80 100 m

1:2000 @ A3

Viewport C

Notes:
- Aerial from Nearmap (2024).
- Coastal wetland and littoral rainforest areas from NSW State Environmental Planning Policy (Resilience and Hazards) 2021.

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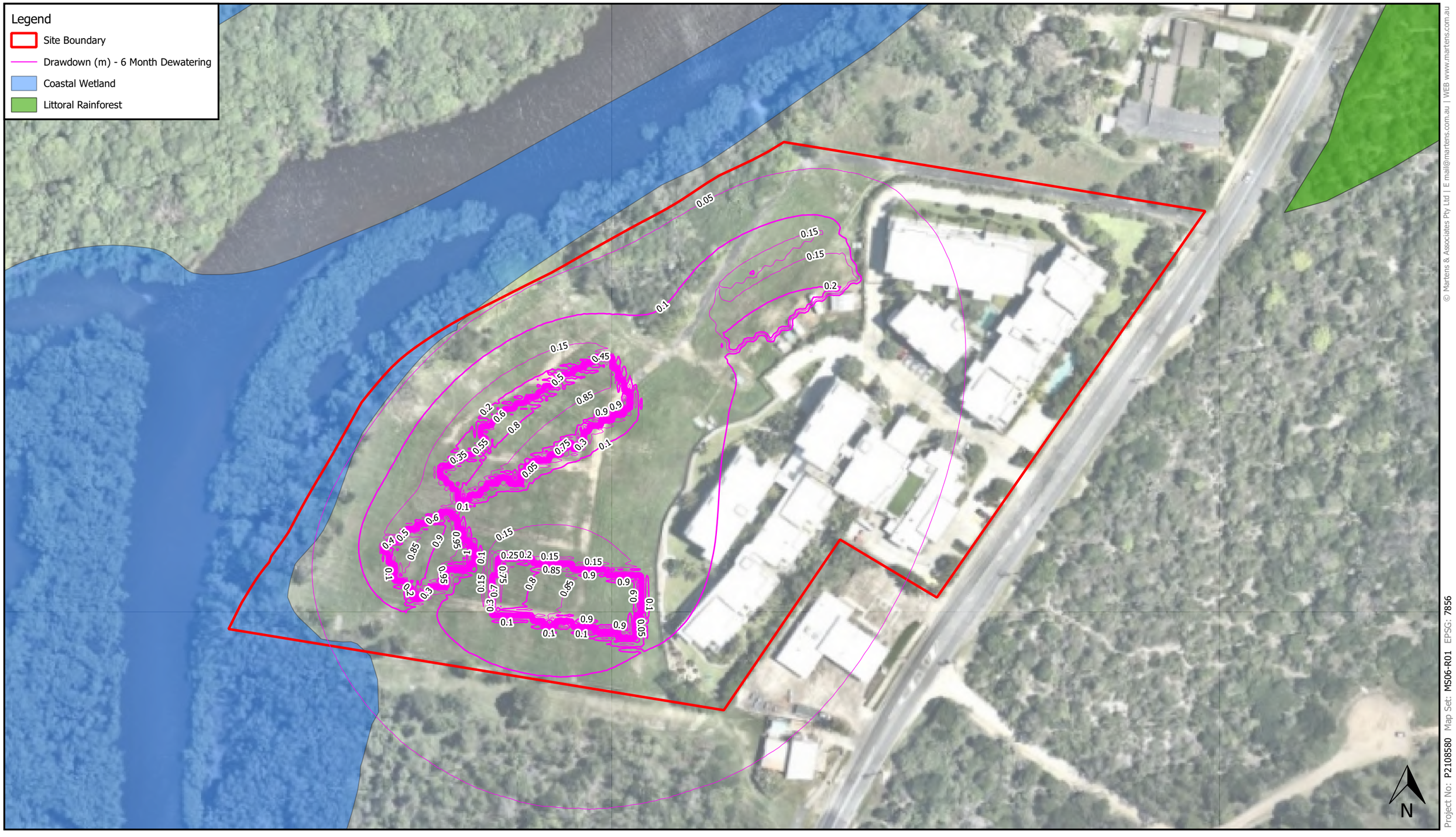
Map Title / Figure:

Post Development Conditions Drawdown from Existing Levels

Map 14	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856



0 10 20 30 40 50 m

1:1250 @ A3

Viewport B

Notes:
- Aerial from Nearmap (2024).
- Coastal wetland and littoral rainforest areas from NSW State Environmental Planning Policy (Resilience and Hazards) 2021.

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Map Title / Figure:

Temporary Dewatering Drawdown (6 Month)

Map 15	Map
87 - 89 Tweed Coast Road, Hastings Point, NSW	Site
Proposed Seniors Housing Development	Project
Hydrogeological Impact Assessment	Sub-Project
TriCare (Hastings) Limited	Client
10/09/2024	Date

Project No: P2108580 Map Set: MS06-R01 EPSG: 7856

Appendix C – Borehole and Monitoring Well Logs

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH102/MW02**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.5711	RL SURFACE	2.81 m	DATUM AHD
EXCAVATION DIMENSIONS		4.50 m depth	LATITUDE	-28.36862	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW02 Static Water Level
AD/V			0.0	2.81				S	SAND: fine grained; pale grey / pale brown; trace silt			Concrete
				0.25 2.56				S	SAND: fine grained; white / pale grey			Cuttings
			0.5									Bentonite
			1.0									Casing
			1.5	*1.50* 1.31				SM	Silty SAND: fine grained; brown with traces of organics			
WB			2.0	*2.00* 0.81				S	Indurated SAND: fine grained; brown			Sand
			2.5									Screen
			3.0									
			3.5									
			4.0									
			4.5	*4.50*					Hole Terminated at 4.50 m			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH103/MW03**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57159	RL SURFACE	3.33 m	DATUM AHD
EXCAVATION DIMENSIONS		4.50 m depth	LATITUDE	-28.36819	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW03 Static Water Level
AD/V			0	3.33				S	SAND: fine grained; brown / grey; with silt	D - M		MW03
				0.30 3.03				S	SAND: fine grained; pale grey / pale brown	M (<PL)		Cuttings
			0.5									Bentonite
			1.0									Casing
			1.5									
			2.0	*2.25* 1.08				SM	Silty SAND: fine grained; brown; trace of organics			
WB			2.5	*2.50* 0.83				S	Indurated SAND: fine grained; brown			Sand
			3.0									Screen
			3.5									
			4.0									
			4.5	*4.50*					Hole Terminated at 4.50 m			

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Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH104/MW04**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57231	RL SURFACE	4.21 m	DATUM AHD
EXCAVATION DIMENSIONS		5.00 m depth	LATITUDE	-28.36781	ASPECT	<2%	SLOPE NW

Drilling | **Sampling** | **Field Material Description**

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
AT	L-M		0.0	4.21				S	Gravelly SAND: fine grained; pale brown / yelow; igneous gravels; 10-50mm	M		ID MW04 Static Water Level
				0.20 4.01				S	SAND: fine grained; pale grey / white; trace of silt to 0.8m.			
	L		0.5								L	Concrete
			1.0									Cuttings
			1.5									Casing
			2.0									Bentonite
			2.5									
			3.0									
			3.5									Sand
			4.0									Screen
			4.5									
			5.0	*5.00*					Hole Terminated at 5.00 m			

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Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH105/MW05**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57133	RL SURFACE	3.91 m	DATUM AHD
EXCAVATION DIMENSIONS		4.50 m depth	LATITUDE	-28.3671	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW05 Static Water Level
AD/V			0.0	3.91				S	SAND: fine grained; pale grey / pale brown; trace silt			Concrete
				0.25 3.66				S	SAND: fine grained; white / pale grey			Cuttings
			0.5									Bentonite
			1.0									Casing
			1.5	*1.50* 2.41				SM	Silty SAND: fine grained; brown, trace of organics			
WB			2.0	*2.00* 1.91				S	Indurated SAND: fine grained; brown			Sand
			2.5									Screen
			3.0									
			3.5									
			4.0									
			4.5	*4.50*					Hole Terminated at 4.50 m			

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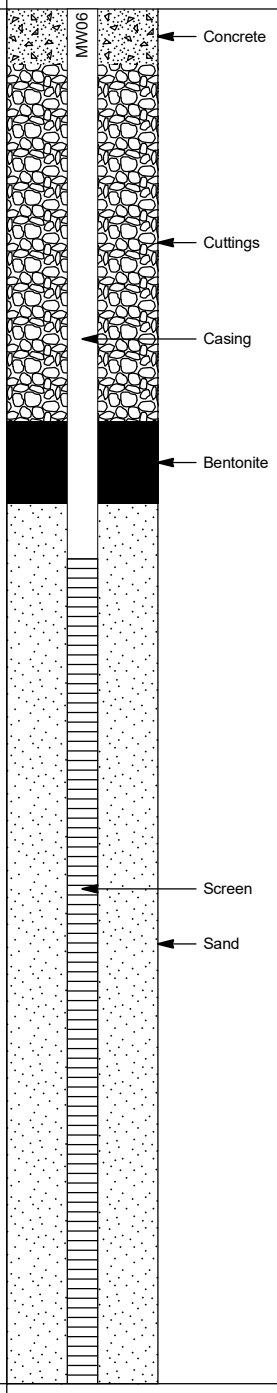
Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH106/MW06**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57176	RL SURFACE	4.47 m	DATUM AHD
EXCAVATION DIMENSIONS		5.00 m depth	LATITUDE	-28.3685	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
			0.5	4.47				S	SAND: fine grained; grey / brown; with silt			ID MW06 Static Water Level
				0.40 4.07				S	SAND: fine grained; white / pale grey			
			1.0									
			1.5									
			2.0									
			2.5	*2.50* 1.97				S	SAND: fine grained; grey / brown			
			3.0									
			3.5	*3.50* 0.97				S	Indurated SAND: fine grained; brown			
			4.0									
			4.5									
			5.0	*5.00*					Hole Terminated at 5.00 m			



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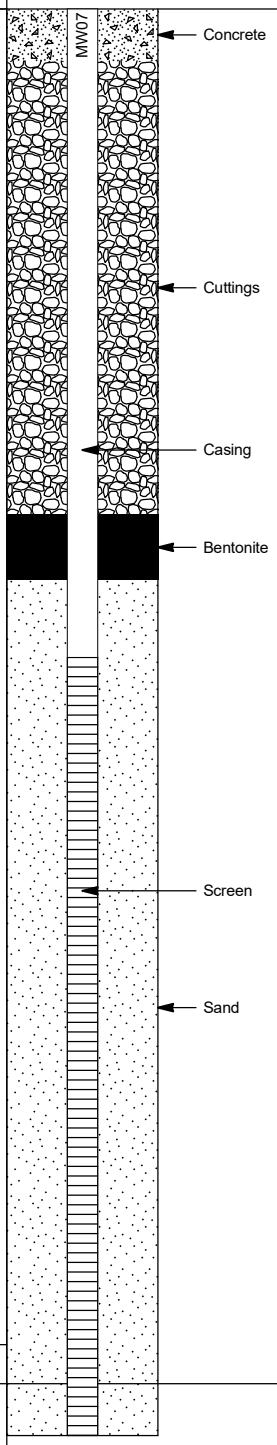
Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH107/MW07**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57212	RL SURFACE	5.02 m	DATUM AHD
EXCAVATION DIMENSIONS		5.30 m depth	LATITUDE	-28.3682	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW07
	L-M			5.02				S	Gravelly SAND: fine grained; pale brown / yelow; igneous gravels; 10-50mm	M		
				0.20								
				4.82				S	SAND: fine grained; pale grey / white; trace of silt to 0.8m.			
AT	L		0.5								L	
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									
				5.15								
	H-M			-0.13				S	Indurated SAND: fine grained; brown / orange			
				5.30								
									Hole Terminated at 5.30 m			
			5.5									



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Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH108/MW08**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57252	RL SURFACE	5.59 m	DATUM AHD
EXCAVATION DIMENSIONS		6.00 m depth	LATITUDE	-28.36811	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
			1	5.59				S	SAND: fine grained; white / pale grey; trace of silt.			ID MW08 Static Water Level
				0.30 5.29				S	SAND: fine grained; pale grey			Concrete
			2									Cuttings
												Casing
			3	*3.20* 2.39				S	Indurated SAND: fine grained; brown			Bentonite
			4	*4.20* 1.39					Igneous gravel / boulder from 4.2 - 4.6			Sand
			5									Screen
			6	*6.00*					Hole Terminated at 6.00 m			

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Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH109/MW09**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57191	RL SURFACE	5.69 m	DATUM AHD
EXCAVATION DIMENSIONS		6.00 m depth	LATITUDE	-28.36926	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW09
				5.69				S	SAND: fine grained; brown / grey; with silt			Concrete
				0.15								
				5.54				S	SAND: fine grained; white / pale grey			Cuttings
			1									Casing
			2									Bentonite
			3									
			4									Screen
												Sand
			5	***5.00***				S	Indurated SAND			
				0.69								
			6	***6.00***					Hole Terminated at 6.00 m			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - TEST

CLIENT	TriCare (Hastings) Limited		COMMENCED	18/10/2022	COMPLETED	18/10/2022	**REF BH110/MW10**
PROJECT	Monitoring Well Installation		LOGGED	RM	CHECKED		Sheet 1 OF 1
SITE	87 -89 Tweed Coast Road, Hastings Point		GEOLOGY	Quaternary	VEGETATION	Grass	PROJECT NO. P2108580
EQUIPMENT		4WD truck-mounted hydraulic drill rig	LONGITUDE	153.57312	RL SURFACE	6.45 m	DATUM AHD
EXCAVATION DIMENSIONS		8.10 m depth	LATITUDE	-28.36868	ASPECT	<2%	SLOPE NW

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW10
AT			0	6.45				S	SAND: fine grained; grey / brown; with silt	M	L	Concrete
				0.25								
				6.20				S	SAND: fine grained; pale grey; trace of silt		L	
			1									
				1.70								
				4.75				S	SAND: fine grained; white		L	Casing
			2									Cuttings
				3.00								
			3	3.45				S	SAND: fine grained; pale brown / pale grey			
												Bentonite
			4									
WB											MD	
			5									
												Sand
			6									
				6.40								
				0.05				S	Indurated sands-fine grained, brown/orange, interbedded, varying strength		MD	
			7									Screen
			8	*8.10*								
									Hole Terminated at 8.10 m			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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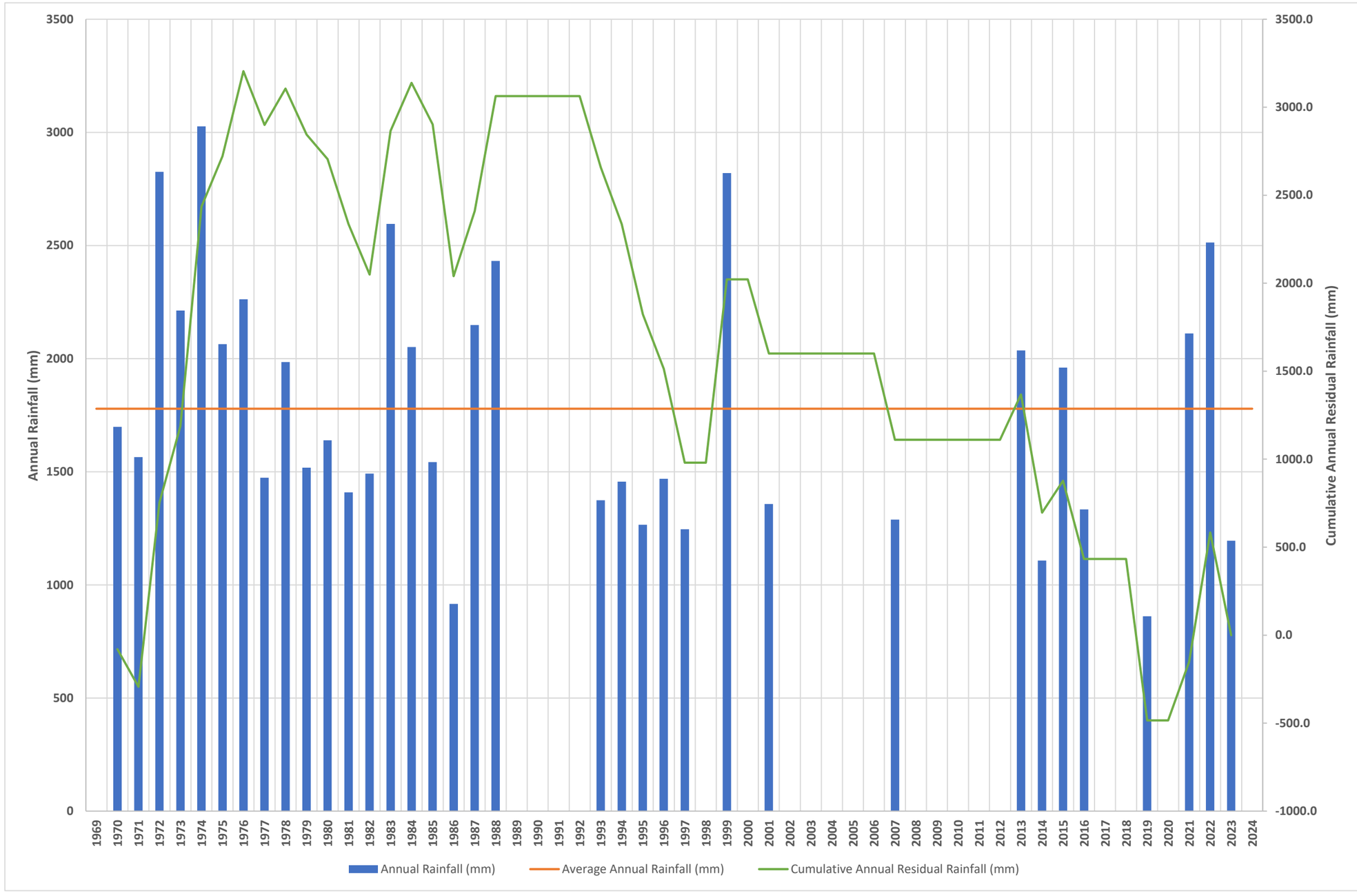
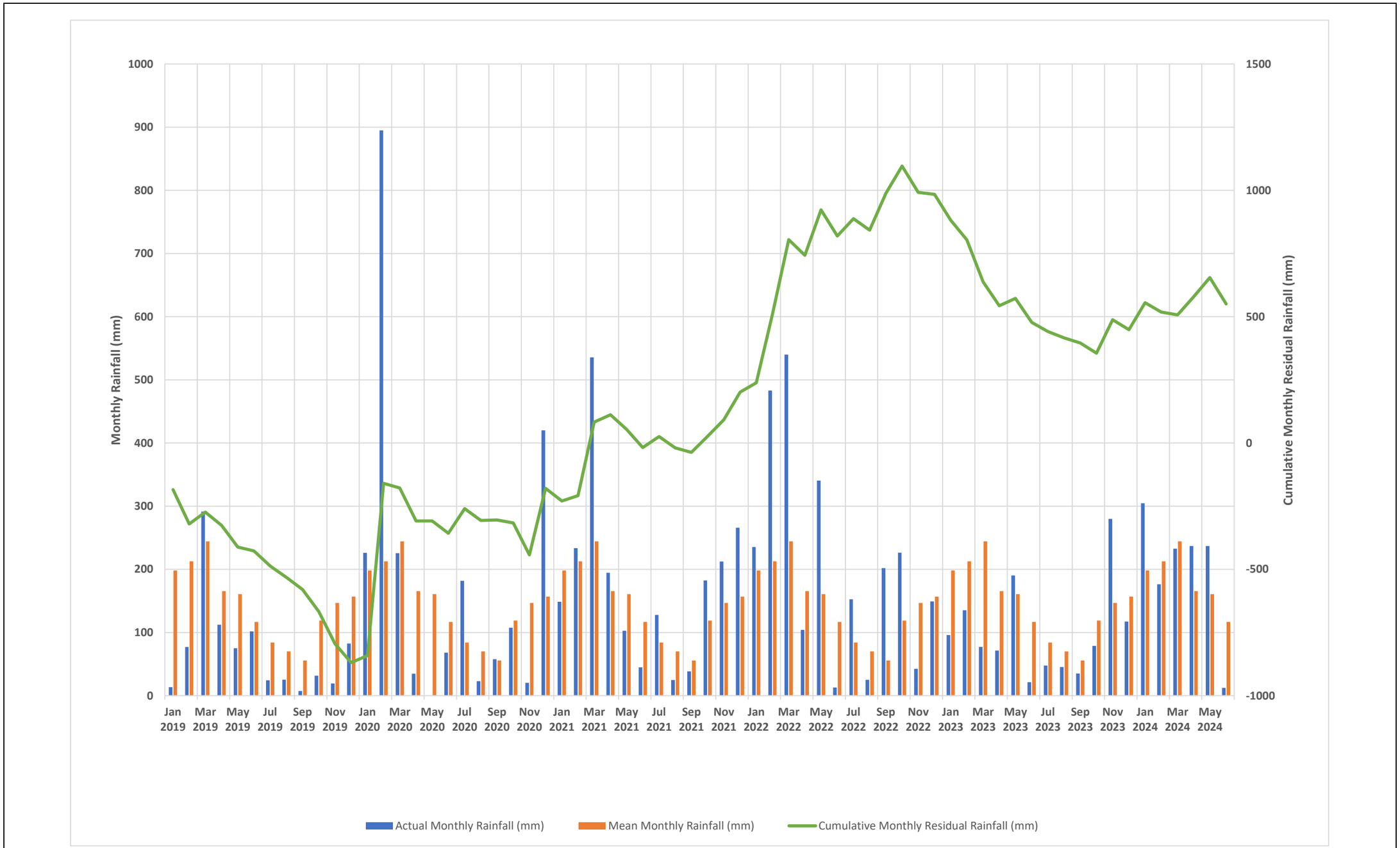
Engineering Log - TEST

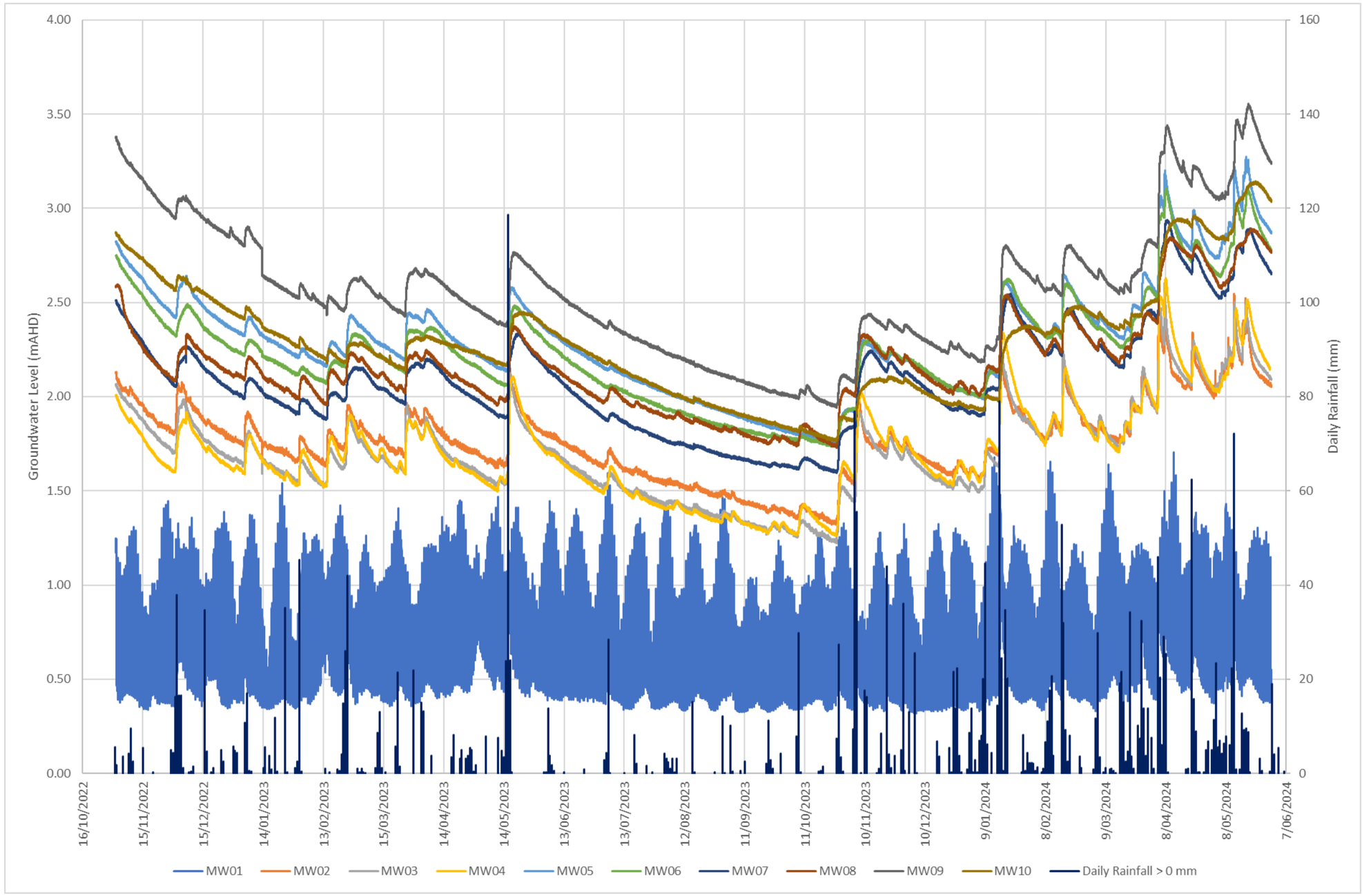
Appendix D – Figures



NOTES: ○ Cumulative annual residual rainfall is the running total of recorded annual rainfall minus average annual rainfall.	**Martens & Associates Pty Ltd**		**Environment | Water | Wastewater | Geotechnical | Civil | Management**
	Drawn:	DS	**Figure 1:** Historical annual rainfall and cumulative annual residual rainfall. Report:
	Approved:	JCF	
	Date:	13/05/2025	Page 65

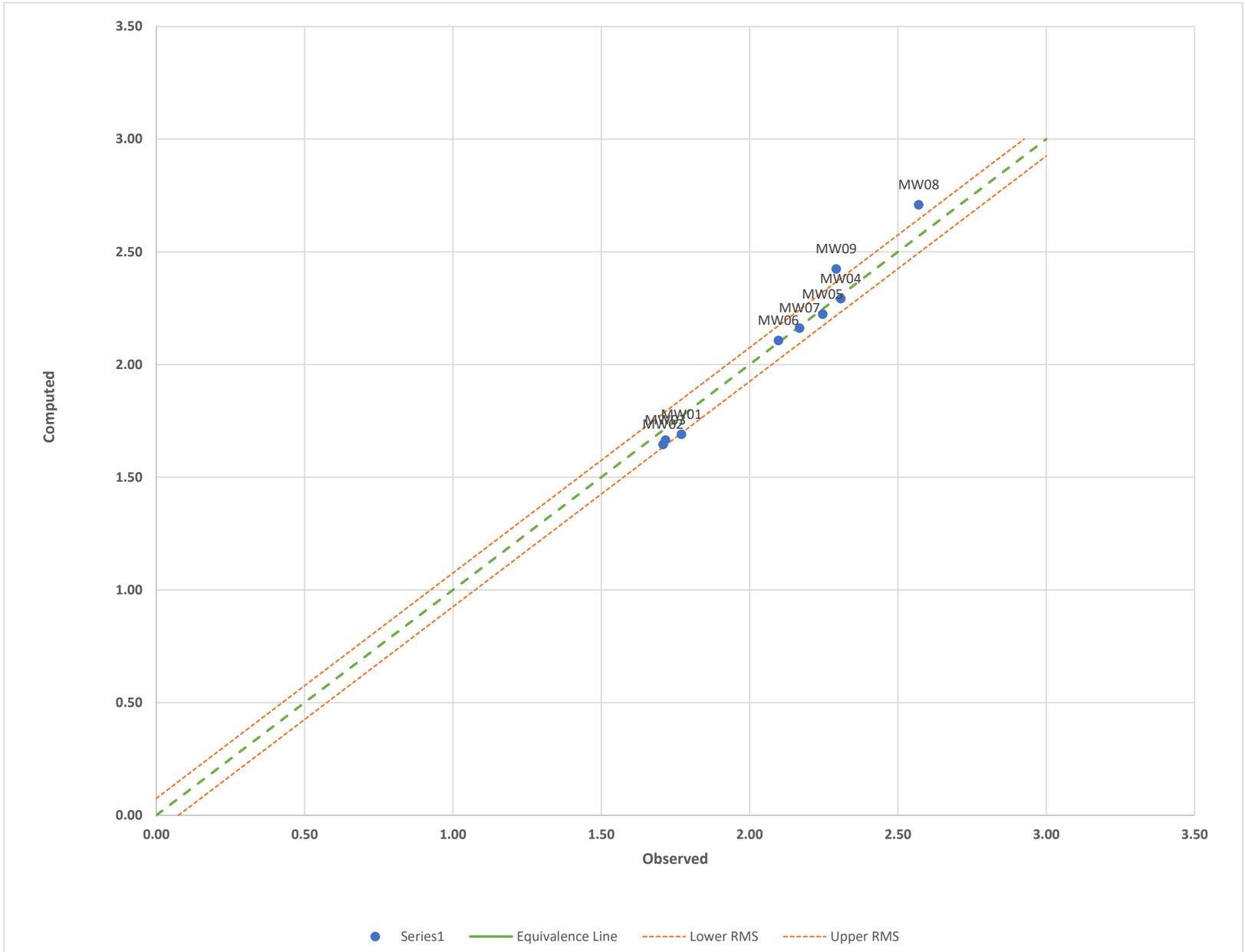


NOTES: ○ Cumulative monthly residual rainfall is the running total of recorded monthly rainfall minus average monthly rainfall.	**Martens & Associates Pty Ltd**		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
	Drawn:	DS	**Figure 2:** Recorded and average monthly rainfall, and cumulative monthly residual rainfall for the 2 years preceding groundwater monitoring.	Report:
	Approved:	JCF		
	Date:	13/05/2025		Page 66

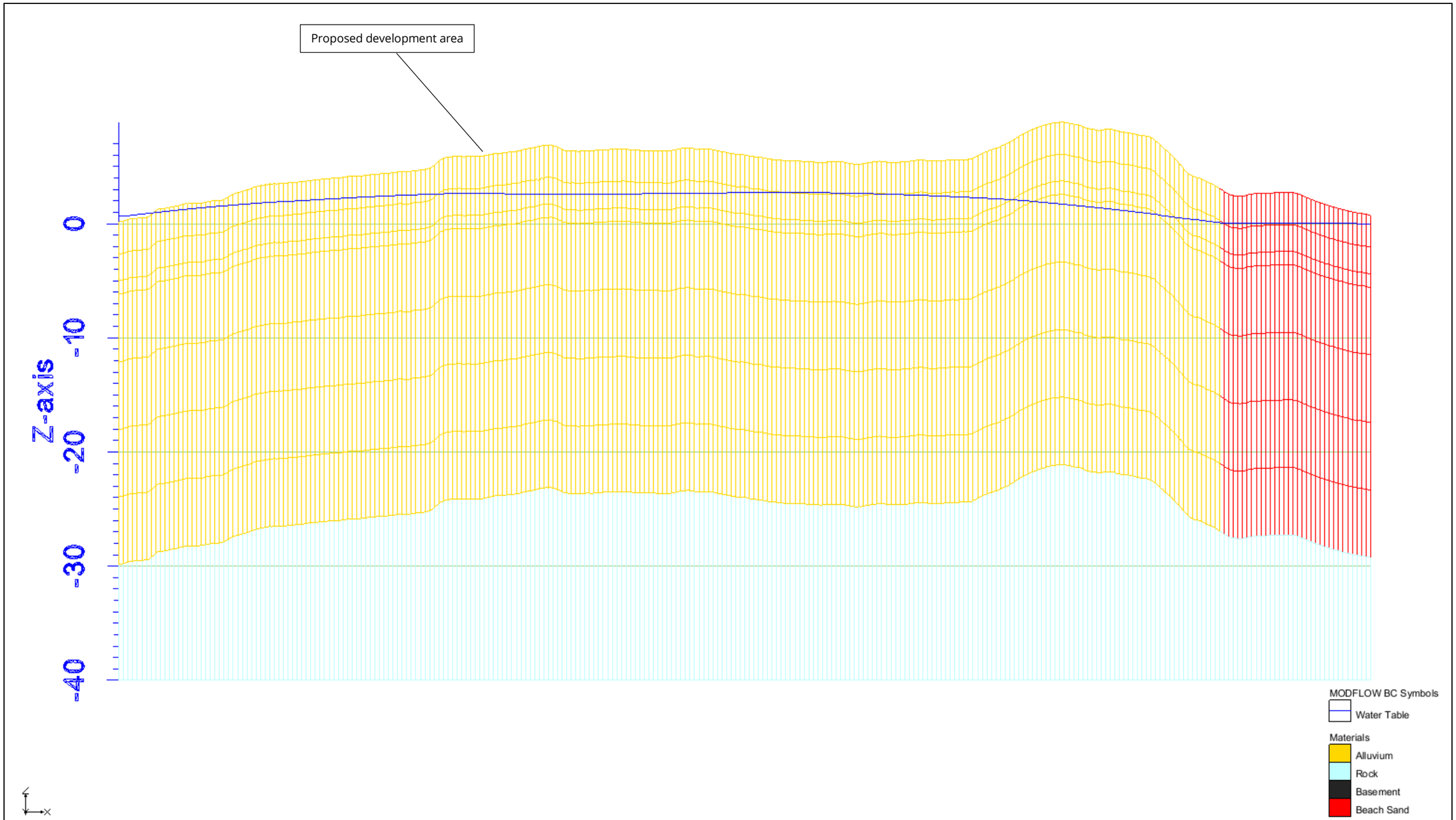


	Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
	Drawn:	DS	**Figure 3:** All monitored groundwater levels and daily rainfall from 1/11/2022 to 30/05/2024.	Report:
	Approved:	JCF		
	Date:	13/05/2025		Page 67

No. of Data Points	9
Mean Residual	0.027
Mean Absolute Residual	0.058
Root Mean Squared Residual	0.075
Normalised RMS	8.69%



	Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
	Drawn:	DS	**Figure 4:** Existing conditions model calibration results.	Report:
	Approved:	JCF		
	Date:	13/05/2025		Page 68



	Martens & Associates Pty Ltd		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
	Drawn:	DS	**Figure 5:** Hydrogeological section.	Report:
	Approved:	JCF		
	Date:	13/05/2025		Page 69

Appendix E – Slug Test Results

Single Bore Slug Test (Falling Head)

Method ST-13 Revised 7.3.2007

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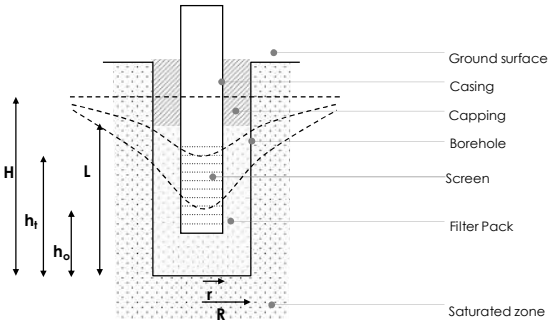
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW03	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.998	m
h_o - Water level reading at time = 0 (depth)	3.160	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.50	m
T_o - Length of characteristic time	1.23	minutes
K_{sat} - Saturated hydraulic conductivity	0.8426	m/d



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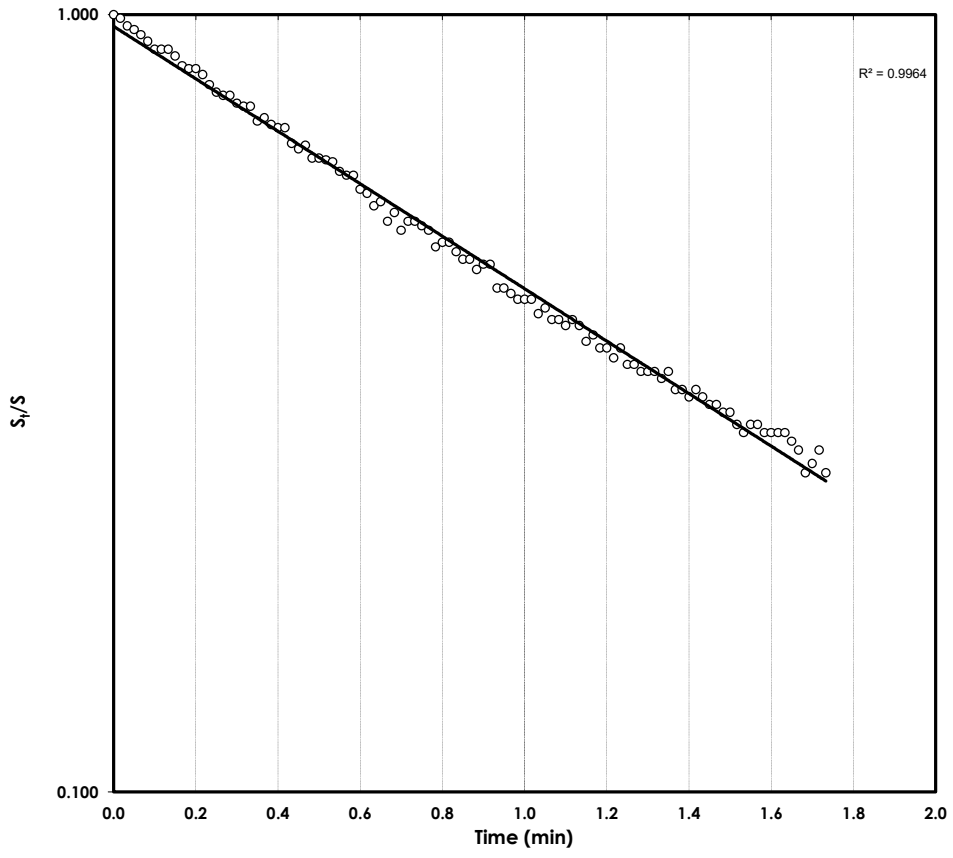

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Single Bore Slug Test (Falling Head)

Method ST-13 Revised 7.3.2007

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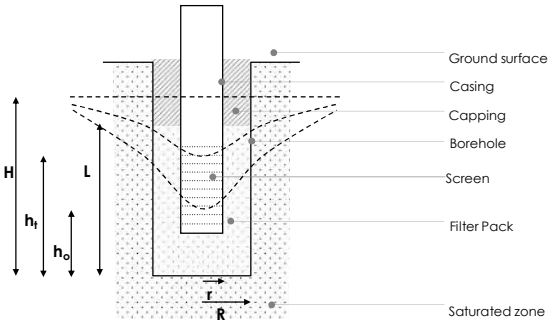
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW03	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.993	m
h_o - Water level reading at time = 0 (depth)	3.273	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.50	m
T_o - Length of characteristic time	1.39	minutes
K_{sat} - Saturated hydraulic conductivity	0.7457	m/d



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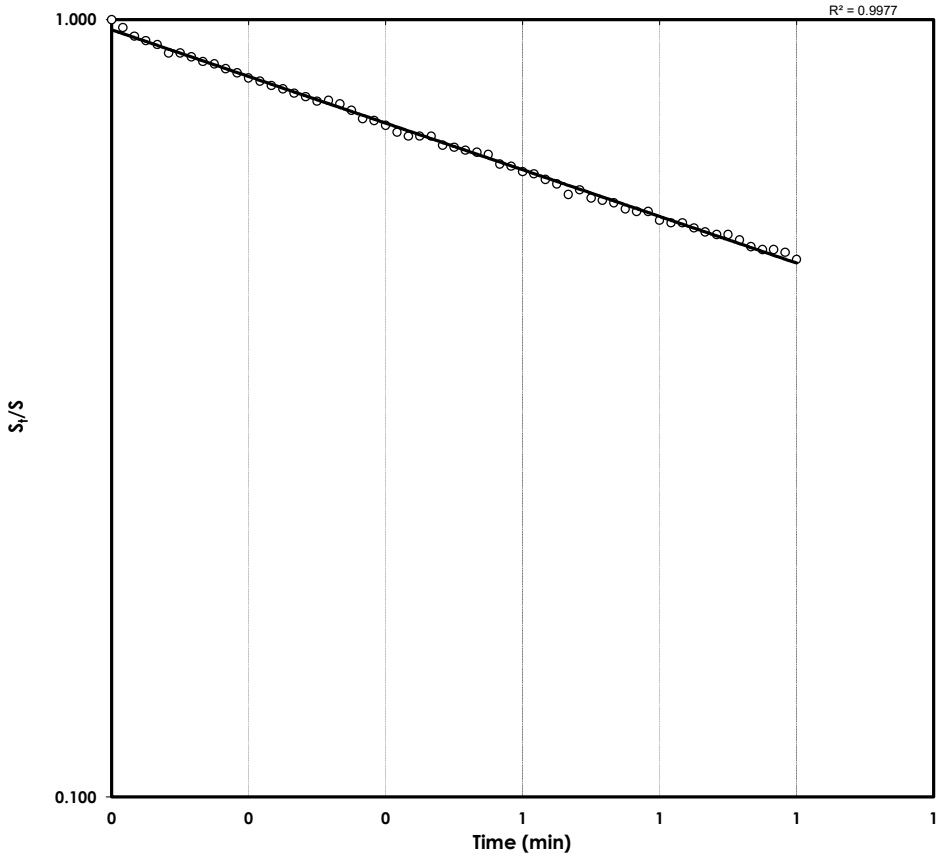

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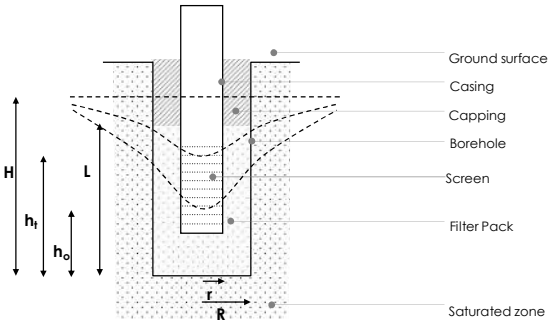
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW04	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.610	m
h_o - Water level reading at time = 0 (depth)	2.693	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.30	m
T_o - Length of characteristic time	0.68	minutes
K_{sat} - Saturated hydraulic conductivity	1.6028	m/d



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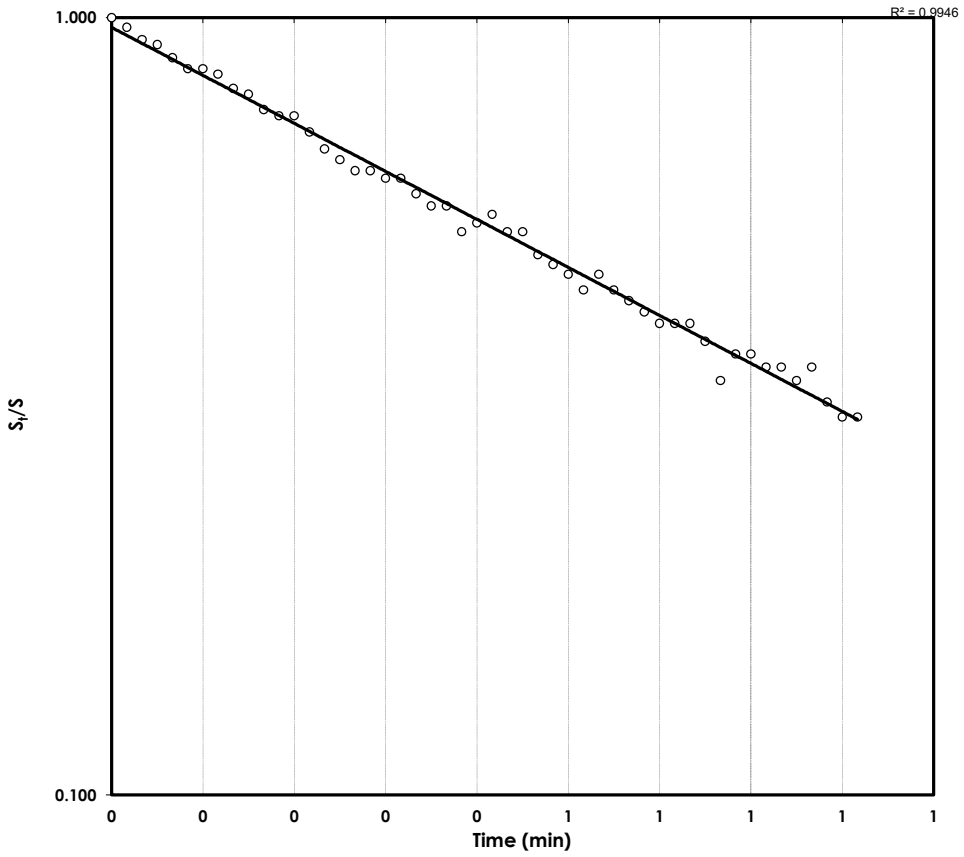

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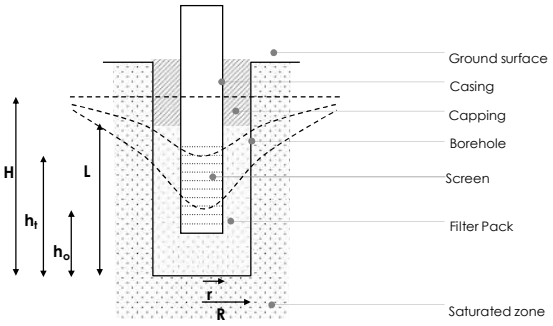
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW04	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.610	m
h_o - Water level reading at time = 0 (depth)	2.700	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.30	m
T_o - Length of characteristic time	0.56	minutes
K_{sat} - Saturated hydraulic conductivity	1.9363	m/d



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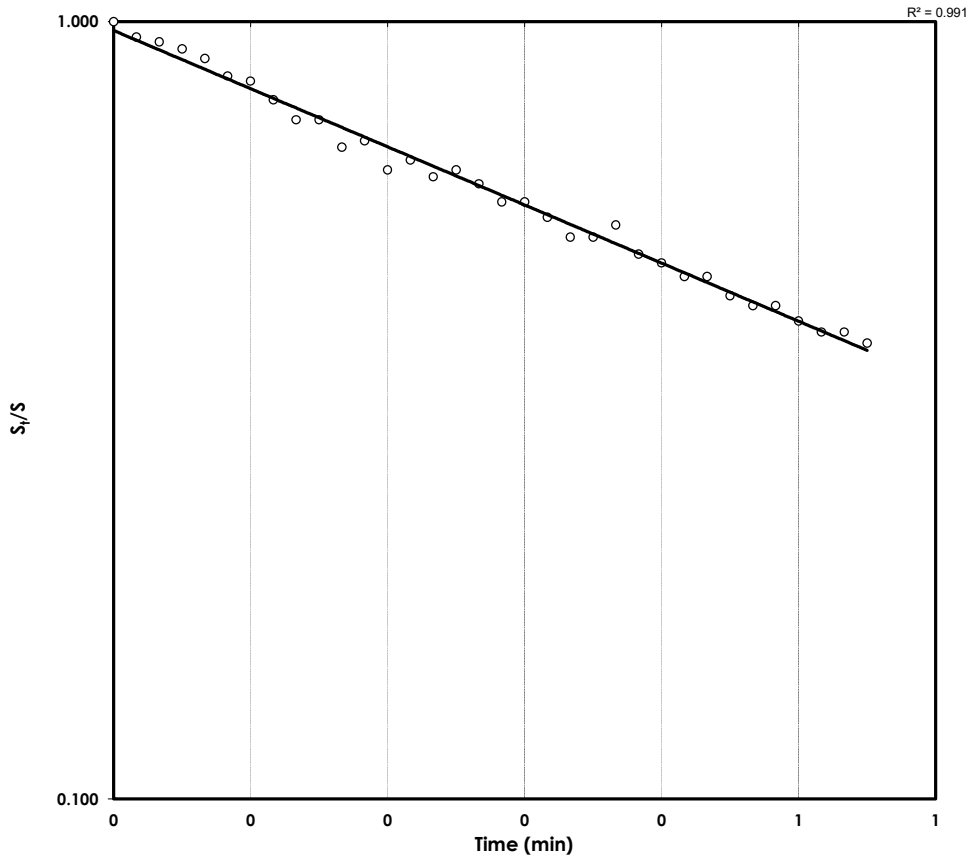

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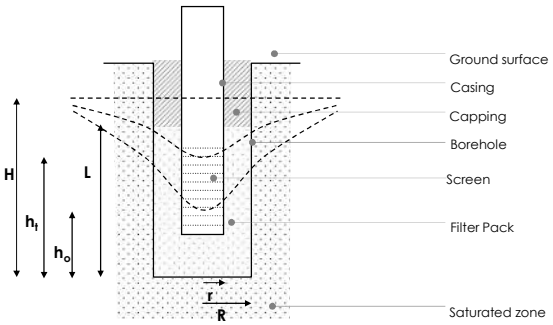
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW06	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.881	m
h_o - Water level reading at time = 0 (depth)	2.940	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.20	m
T_o - Length of characteristic time	0.42	minutes
K_{sat} - Saturated hydraulic conductivity	2.6324	m/d



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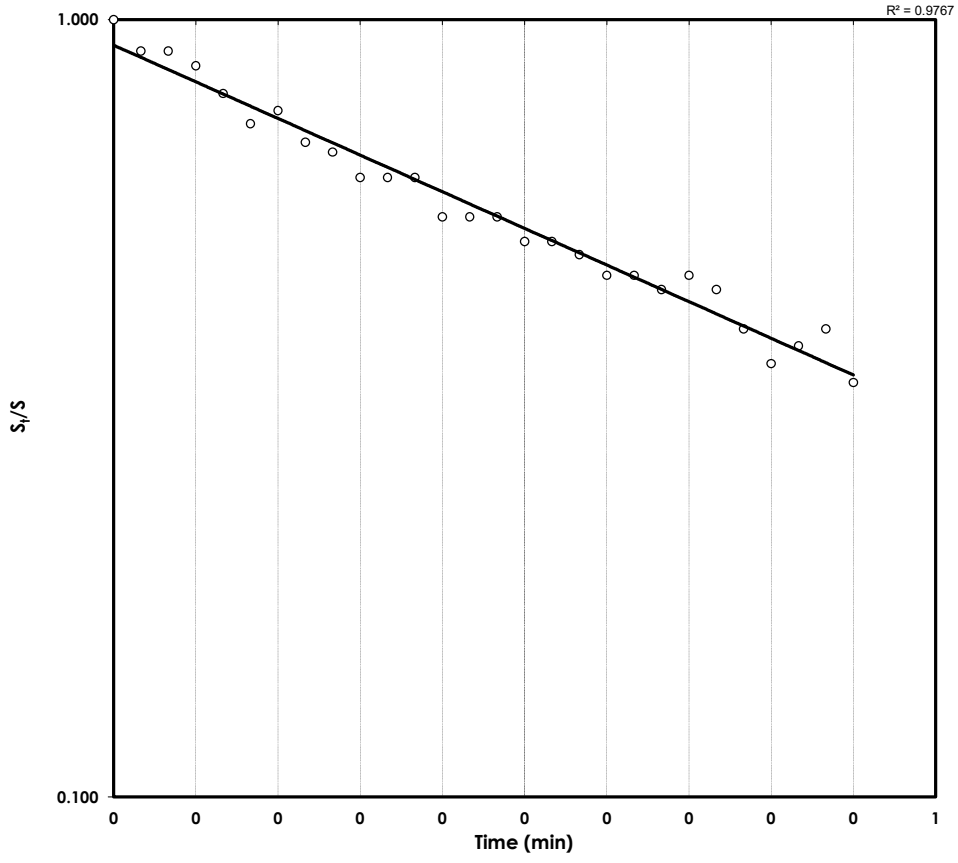

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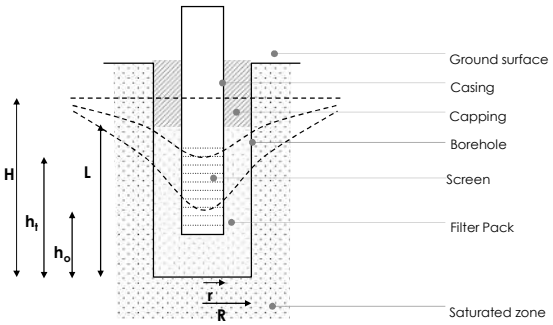
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW06	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	2.881	m
h_o - Water level reading at time = 0 (depth)	2.930	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.20	m
T_o - Length of characteristic time	0.27	minutes
K_{sat} - Saturated hydraulic conductivity	4.1894	m/d



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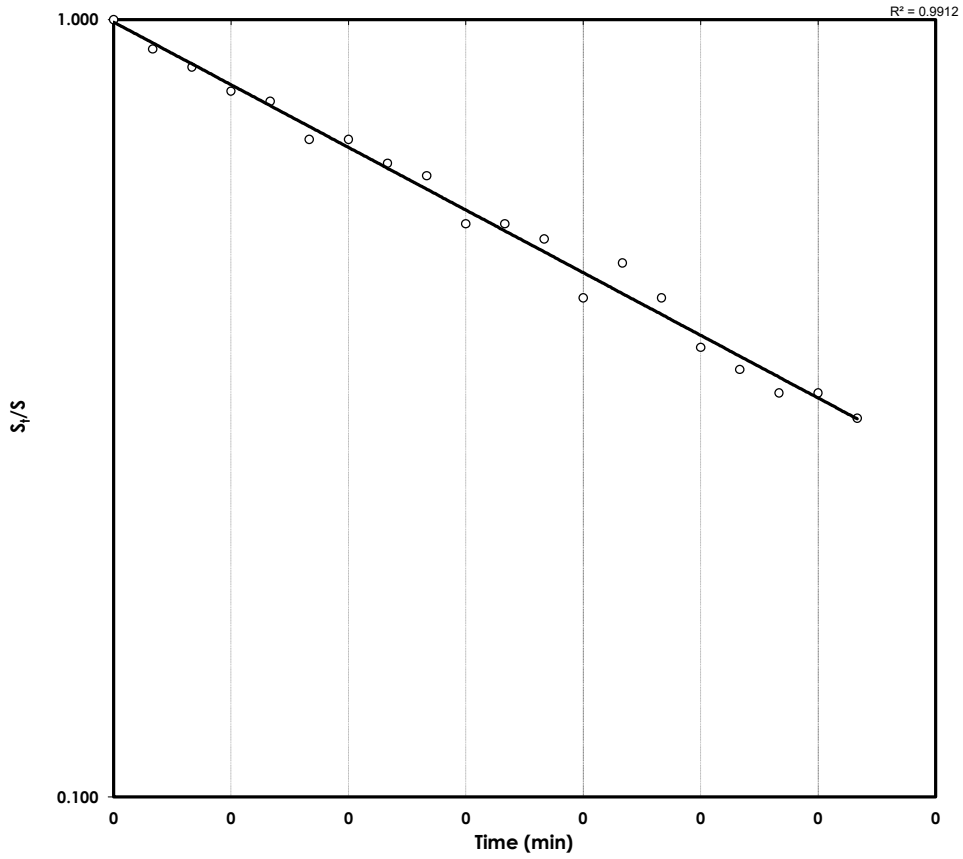

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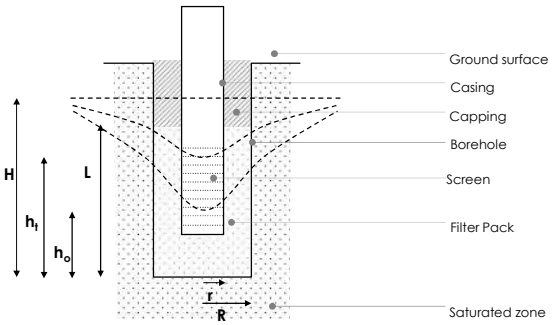
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW08	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	1.480	m
h_o - Water level reading at time = 0 (depth)	2.167	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.40	m
T_o - Length of characteristic time	2.93	minutes
K_{sat} - Saturated hydraulic conductivity	0.3634	m/d



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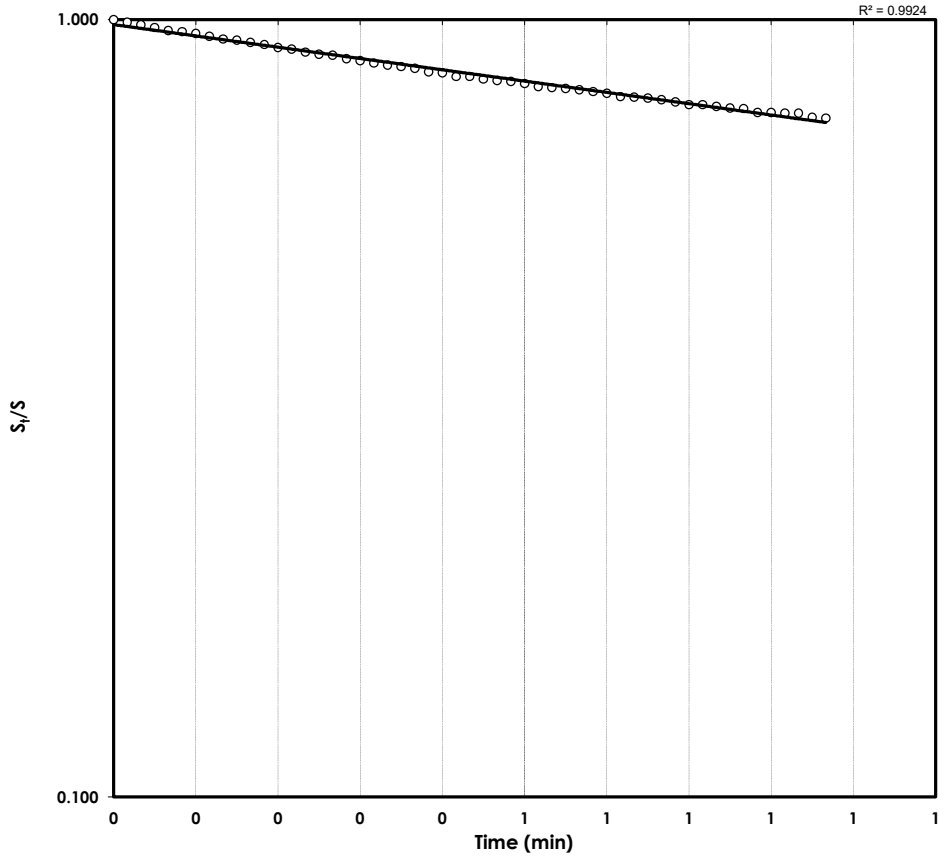

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PROJECT DETAILS

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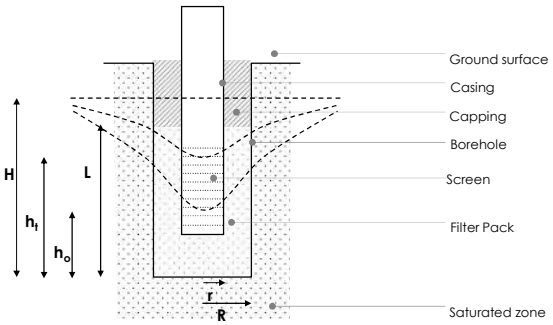
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW08	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	1.547	m
h_o - Water level reading at time = 0 (depth)	2.129	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	3.40	m
T_o - Length of characteristic time	4.70	minutes
K_{sat} - Saturated hydraulic conductivity	0.2262	m/d



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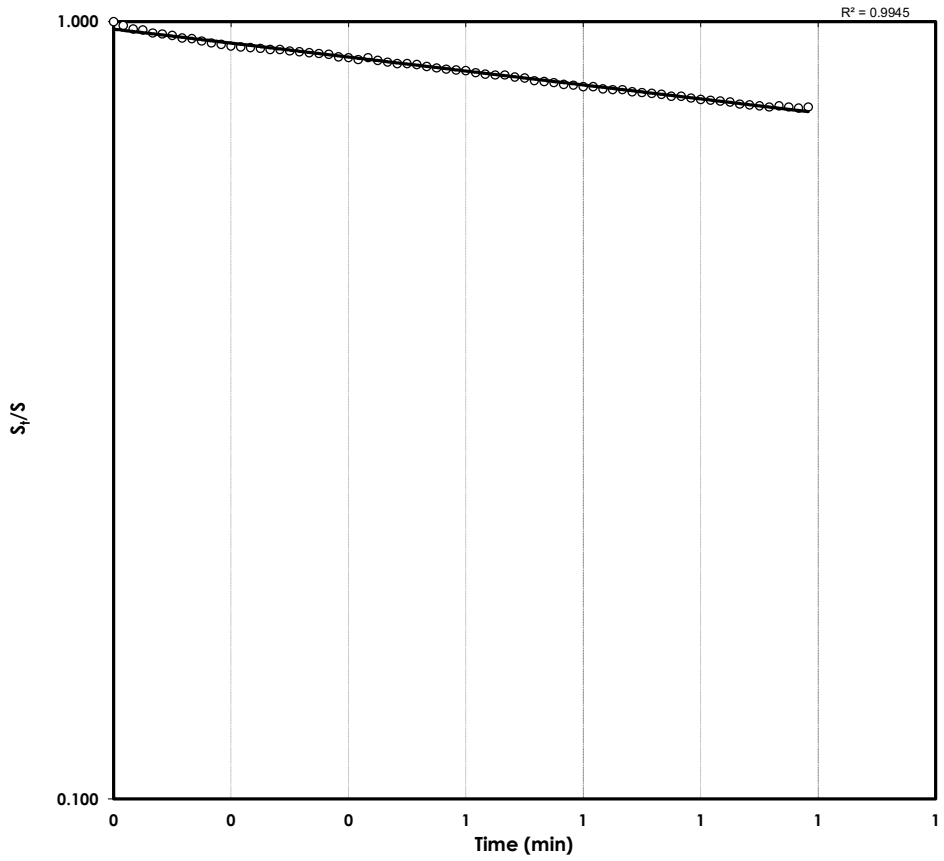

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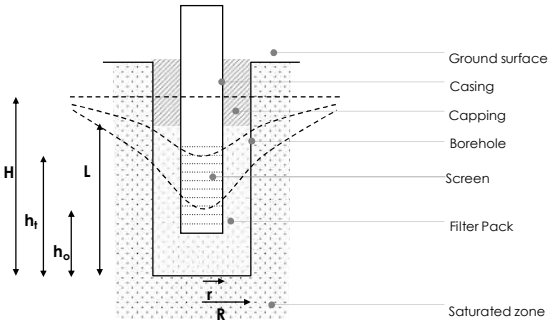
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW10	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	4.045	m
h_o - Water level reading at time = 0 (depth)	6.154	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	4.10	m
T_o - Length of characteristic time	1.08	minutes
K_{sat} - Saturated hydraulic conductivity	0.8530	m/d



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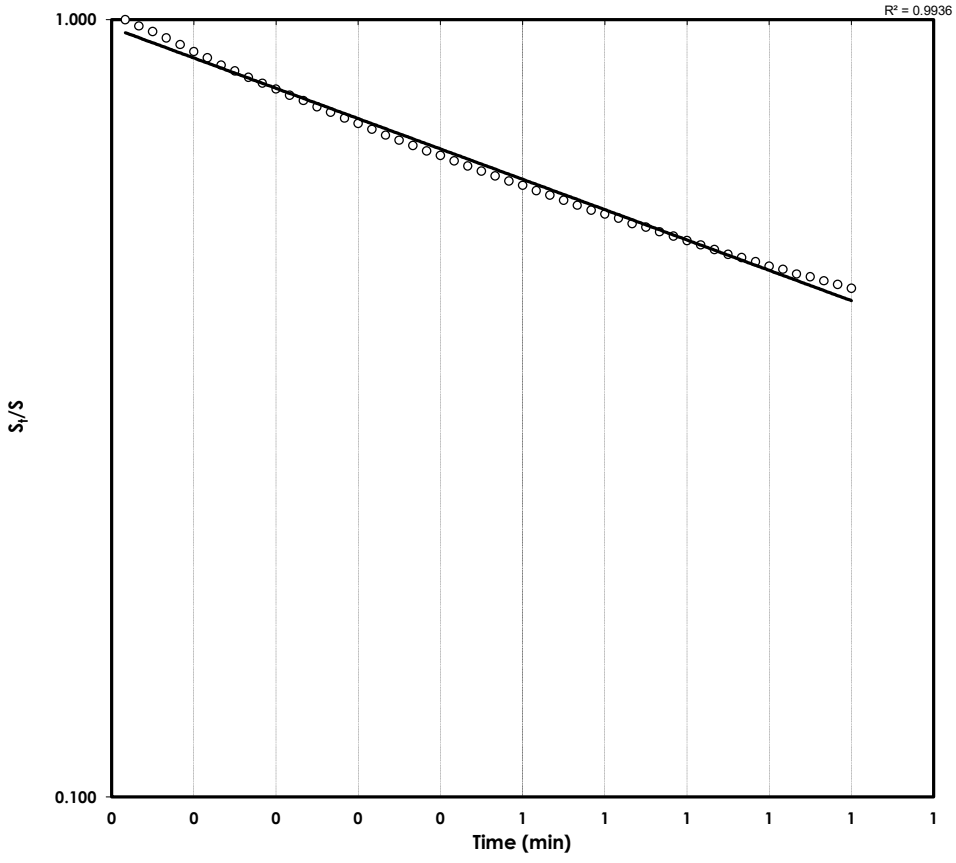

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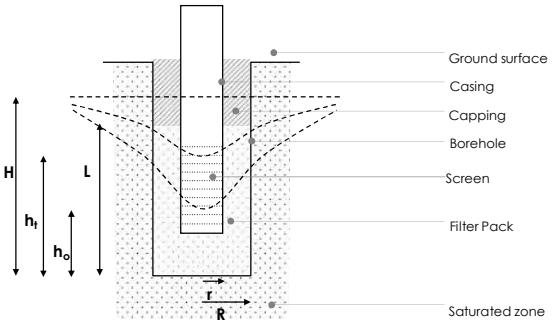
PROJECT DETAILS

Project	87-89 Tweed Coast Road, Hastings Point, NSW	Test Date	1/11/2022
Project Ref	P2108580	Field Testing	RM
Borehole Ref	MW10	Data Analysis	DS
Method	Hvorslev (1981)	Reviewed	JF

FIELD TEST DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	4.065	m
h_o - Water level reading at time = 0 (depth)	6.608	m
r - Casing radius	0.035	m
R - Bore radius	0.050	m
L - Length of open screen	4.10	m
T_o - Length of characteristic time	1.27	minutes
K_{sat} - Saturated hydraulic conductivity	0.7271	m/d



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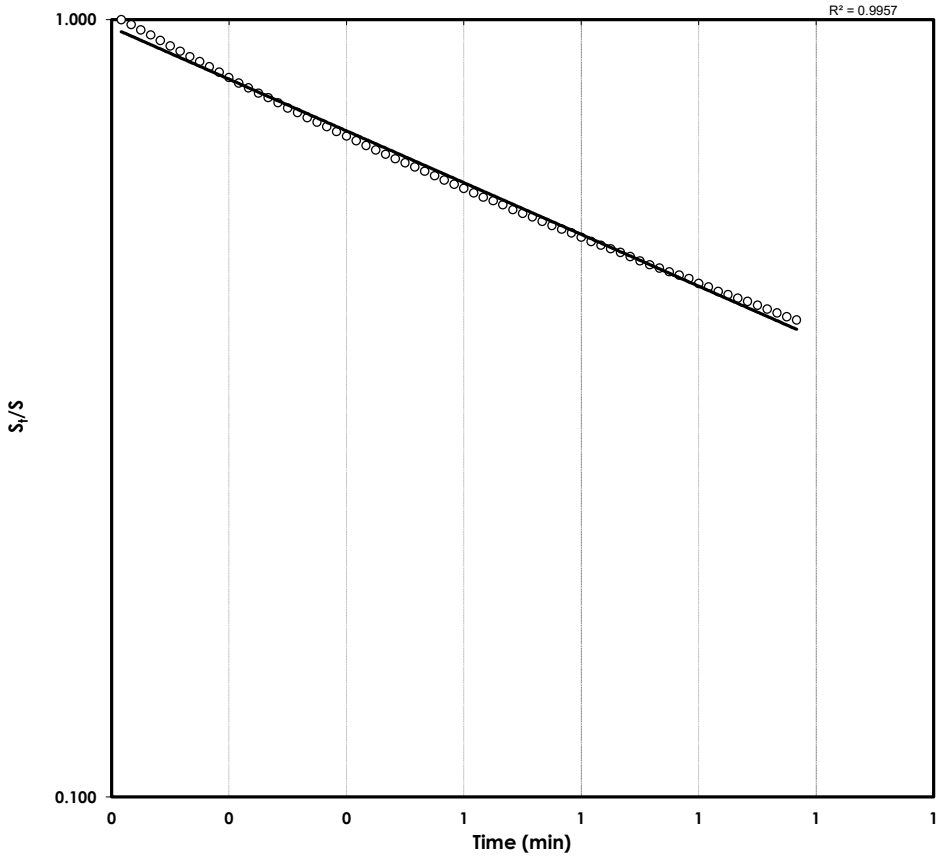

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Appendix F – Laboratory Documentation

COC 18/1 14:06.

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SOIL ANALYSIS CHAIN OF CUSTODY FORM

Additional Testing												
Name	P2108580: 87-89 Tweed Coast Road, Hastings Point, NSW											
Martens Contact Officer	Robert Mehaffey				**Contact Email**	rmehaffey@martens.com.au						
Sampling and Shipping	**Sample Date**	13/1/2023	**Dispatch Date**	18/1/2023	**Turnaround Time**	Standard						
	Our Reference	P2108580COC01V01			**Shipping Method (X)**	**Hand**		**Post**		**Courier**	X	
	On Ice (X)	X	**No Ice (X)**		**Other (X)**							
Laboratory												
Name	EnviroLab											
Sample Delivery Address	12 Ashley Street, Chatswood											
Delivery Contact	**Name**	Sample Receipt	**Phone**	9910 6200	**Fax**		**Email**	samplereceipt@envirolabservices.com.au				
Please Send Report By (X)	**Post**		**Fax**		**Email**	X	**Reporting Email Address**	rmehaffey@martens.com.au mshahrokian@martens.com.au martens@esdat.com.au				

Sample ID	pH	EC	Ionic Balance	17 HM	Hold
1 MW01/230113	X	X	X	X	
2 MW02/230113	X	X	X	X	
3 MW03/230113	X	X	X	X	
4 MW04/230113	X	X	X	X	
5 MW05/230113	X	X	X	X	
6 MW06/230113	X	X	X	X	
7 MW07/230113	X	X	X	X	
8 MW08/230113	X	X	X	X	
9 MW09/230113	X	X	X	X	
10 MW10/230113	X	X			X
11 DUP01					

ENVIROLAB GROUP

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 314712
Date Received: 18/1/23
Time Received: 1715
Received By:
Temp: Cool/Ambient 12 14.c
Cooling: Ice/Icepack
Security: Intact/Broken/None

Head Office
Suite 201, Level 2, 20 George Street
Hornsby NSW 2077, Australia
Ph 02 9476 9999 **Fax** 02 9476 8767

> mail@martens.com.au
> www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details

Client	Martens & Associates Pty Ltd
Attention	Robert Mehaffey

Sample Login Details

Your reference	P2108580: 87-89 Tweed Coast Rd, Hasting Point, NSW
Envirolab Reference	314712
Date Sample Received	18/01/2023
Date Instructions Received	18/01/2023
Date Results Expected to be Reported	25/01/2023

Sample Condition

Samples received in appropriate condition for analysis	Holding time exceedance
No. of Samples Provided	11 Water
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	14
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Metal bottles "filtered" ticked but sediment visible

Please contact the laboratory within 24 hours if you wish to cancel the aforementioned testing. Otherwise testing will proceed as per the COC and hence invoiced accordingly.

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

Sample ID	pH	Electrical Conductivity	Calcium - Dissolved	Potassium - Dissolved	Sodium - Dissolved	Magnesium - Dissolved	Hardness	Hydroxide Alkalinity (OH-) as CaCO3	Bicarbonate Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Sulphate, SO4	Chloride, Cl	Ionic Balance	All metals in water - total	On Hold
MW01/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW02/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW03/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW04/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW05/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW06/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW07/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW08/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW09/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MW10/230113	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DUP01																✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.
Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.
TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

Envirolab Services Pty Ltd
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12 Ashley St Chatswood NSW 2067
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customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 314712

Client Details

Client	Martens & Associates Pty Ltd
Attention	Robert Mehaffey
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2108580: 87-89 Tweed Coast Rd, Hasting Point, NSW**
Number of Samples	11 Water
Date samples received	18/01/2023
Date completed instructions received	18/01/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	25/01/2023
Date of Issue	25/01/2023

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Inorganics Supervisor
Loren Bardwell, Development Chemist
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Miscellaneous Inorganics						
Our Reference		314712-1	314712-2	314712-3	314712-4	314712-5
Your Reference	UNITS	MW01/230113	MW02/230113	MW03/230113	MW04/230113	MW05/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
pH	pH Units	7.6	6.3	4.7	4.6	6.2
Electrical Conductivity	µS/cm	53,000	250	1,500	3,400	98

Miscellaneous Inorganics						
Our Reference		314712-6	314712-7	314712-8	314712-9	314712-10
Your Reference	UNITS	MW06/230113	MW07/230113	MW08/230113	MW09/230113	MW10/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
pH	pH Units	6.4	6.7	5.2	6.1	6.4
Electrical Conductivity	µS/cm	220	460	1,900	120	260

Ion Balance						
Our Reference		314712-1	314712-2	314712-3	314712-4	314712-5
Your Reference	UNITS	MW01/230113	MW02/230113	MW03/230113	MW04/230113	MW05/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Calcium - Dissolved	mg/L	300	3	10	27	2
Potassium - Dissolved	mg/L	400	5	11	20	1
Sodium - Dissolved	mg/L	10,000	83	230	440	11
Magnesium - Dissolved	mg/L	1,200	7.9	20	58	2
Hardness	mgCaCO 3 /L	5,700	39	110	300	11
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	120	45	5	<5	20
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	120	45	5	<5	20
Sulphate, SO4	mg/L	2,900	9	110	140	2
Chloride, Cl	mg/L	20,000	42	350	940	17
Ionic Balance	%	-6.0	33	1.0	-6.0	-12

Ion Balance						
Our Reference		314712-6	314712-7	314712-8	314712-9	314712-10
Your Reference	UNITS	MW06/230113	MW07/230113	MW08/230113	MW09/230113	MW10/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Calcium - Dissolved	mg/L	15	28	13	6.1	13
Potassium - Dissolved	mg/L	4	4	11	0.8	3
Sodium - Dissolved	mg/L	18	41	320	9.8	25
Magnesium - Dissolved	mg/L	2	4	23	2	2
Hardness	mgCaCO 3 /L	45	84	130	24	40
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	47	90	11	16	57
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	47	90	11	16	57
Sulphate, SO4	mg/L	13	34	82	4	10
Chloride, Cl	mg/L	26	60	500	26	39
Ionic Balance	%	-5.0	-8.0	2.0	-10	-11

All metals in water-dissolved						
Our Reference		314712-1	314712-2	314712-3	314712-4	314712-5
Your Reference	UNITS	MW01/230113	MW02/230113	MW03/230113	MW04/230113	MW05/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Arsenic-Dissolved	µg/L	1	1	<1	<1	9
Boron-Dissolved	µg/L	5,400	100	200	420	20
Barium-Dissolved	µg/L	6	10	140	75	4
Beryllium-Dissolved	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt-Dissolved	µg/L	<1	<1	<1	<1	<1
Chromium-Dissolved	µg/L	<1	1	<1	<1	2
Copper-Dissolved	µg/L	<1	<1	<1	<1	1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese-Dissolved	µg/L	7	15	39	89	10
Molybdenum-Dissolved	µg/L	11	2	<1	1	1
Nickel-Dissolved	µg/L	<1	1	1	2	1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Antimony-Dissolved	µg/L	<1	<1	<1	<1	<1
Selenium-Dissolved	µg/L	<1	<1	<1	<1	<1
Tin-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	37	35	270	150	84

All metals in water-dissolved						
Our Reference		314712-6	314712-7	314712-8	314712-9	314712-10
Your Reference	UNITS	MW06/230113	MW07/230113	MW08/230113	MW09/230113	MW10/230113
Date Sampled		13/01/2023	13/01/2023	13/01/2023	13/01/2023	13/01/2023
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Date analysed	-	19/01/2023	19/01/2023	19/01/2023	19/01/2023	19/01/2023
Arsenic-Dissolved	µg/L	<1	<1	<1	1	2
Boron-Dissolved	µg/L	50	80	200	<20	40
Barium-Dissolved	µg/L	12	50	24	12	35
Beryllium-Dissolved	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt-Dissolved	µg/L	<1	<1	1	<1	<1
Chromium-Dissolved	µg/L	1	<1	<1	<1	1
Copper-Dissolved	µg/L	1	1	1	2	3
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese-Dissolved	µg/L	16	33	38	6	28
Molybdenum-Dissolved	µg/L	2	1	1	1	2
Nickel-Dissolved	µg/L	1	<1	3	<1	1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Antimony-Dissolved	µg/L	<1	<1	<1	<1	<1
Selenium-Dissolved	µg/L	<1	<1	<1	<1	<1
Tin-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	68	26	160	48	96

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 15% ie total anions = total cations +/-15%.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			19/01/2023	[NT]	[NT]	[NT]	[NT]	19/01/2023	[NT]
Date analysed	-			19/01/2023	[NT]	[NT]	[NT]	[NT]	19/01/2023	[NT]
pH	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
Electrical Conductivity	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]

QUALITY CONTROL: Ion Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	314712-2
Date prepared	-			19/01/2023	1	19/01/2023	19/01/2023		19/01/2023	19/01/2023
Date analysed	-			19/01/2023	1	19/01/2023	19/01/2023		19/01/2023	19/01/2023
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	300	[NT]		96	[NT]
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	400	[NT]		93	[NT]
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	10000	[NT]		96	[NT]
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1200	[NT]		95	[NT]
Hardness	mgCaCO 3 /L	3	Metals-020	[NT]	1	5700	[NT]		[NT]	[NT]
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	[NT]		[NT]	[NT]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	120	[NT]		[NT]	[NT]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	[NT]		[NT]	[NT]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	120	[NT]		98	[NT]
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	2900	2900	0	108	106
Chloride, Cl	mg/L	1	Inorg-081	<1	1	20000	20000	0	106	94
Ionic Balance	%		Inorg-040	[NT]	1	-6.0	[NT]		[NT]	[NT]

QUALITY CONTROL: Ion Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	3	19/01/2023	19/01/2023		[NT]	[NT]
Date analysed	-			[NT]	3	19/01/2023	19/01/2023		[NT]	[NT]
Calcium - Dissolved	mg/L	0.5	Metals-020	[NT]	3	10	10	0	[NT]	[NT]
Potassium - Dissolved	mg/L	0.5	Metals-020	[NT]	3	11	11	0	[NT]	[NT]
Sodium - Dissolved	mg/L	0.5	Metals-020	[NT]	3	230	230	0	[NT]	[NT]
Magnesium - Dissolved	mg/L	0.5	Metals-020	[NT]	3	20	20	0	[NT]	[NT]
Hardness	mgCaCO 3 /L	3	Metals-020	[NT]	3	110	110	0	[NT]	[NT]
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	[NT]	3	<5	[NT]		[NT]	[NT]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	[NT]	3	5	[NT]		[NT]	[NT]
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	[NT]	3	<5	[NT]		[NT]	[NT]
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	[NT]	3	5	[NT]		[NT]	[NT]
Sulphate, SO4	mg/L	1	Inorg-081	[NT]	3	110	[NT]		[NT]	[NT]
Chloride, Cl	mg/L	1	Inorg-081	[NT]	3	350	[NT]		[NT]	[NT]
Ionic Balance	%		Inorg-040	[NT]	3	1.0	[NT]		[NT]	[NT]

QUALITY CONTROL: All metals in water-dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	314712-2
Date prepared	-			19/01/2023	1	19/01/2023	19/01/2023		19/01/2023	19/01/2023
Date analysed	-			19/01/2023	1	19/01/2023	19/01/2023		19/01/2023	19/01/2023
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	1	1	0	93	[NT]
Boron-Dissolved	µg/L	20	Metals-022	<20	1	5400	5400	0	108	[NT]
Barium-Dissolved	µg/L	1	Metals-022	<1	1	6	6	0	87	[NT]
Beryllium-Dissolved	µg/L	0.5	Metals-022	<0.5	1	<0.5	<0.5	0	92	[NT]
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	94	[NT]
Cobalt-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	[NT]
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	89	[NT]
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	92	[NT]
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	80	80
Manganese-Dissolved	µg/L	5	Metals-022	<5	1	7	6	15	86	[NT]
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	1	11	11	0	89	[NT]
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	89	[NT]
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	[NT]
Antimony-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	95	[NT]
Selenium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	96	[NT]
Tin-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	94	[NT]
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	37	35	6	92	[NT]

QUALITY CONTROL: All metals in water-dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	314712-3
Date prepared	-			[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	19/01/2023
Date analysed	-			[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	19/01/2023
Arsenic-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	92
Boron-Dissolved	µg/L	20	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	#
Barium-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	70
Beryllium-Dissolved	µg/L	0.5	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	95
Cadmium-Dissolved	µg/L	0.1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	96
Cobalt-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	87
Chromium-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	86
Copper-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	87
Manganese-Dissolved	µg/L	5	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	84
Molybdenum-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	87
Nickel-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	86
Lead-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	86
Antimony-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	83
Selenium-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	91
Tin-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	96
Zinc-Dissolved	µg/L	1	Metals-022	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	#

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

pH
Samples were out of the recommended holding time for this analysis.

Dissolved Metals: For the determination of dissolved metals in samples #2-10, the unpreserved sample was filtered through 0.45um filter at the lab due to the appearance
of colloids and/or sediment in the supplied HNO3 bottle (it appears the sample has not been field filtered). Note: there is a possibility some elements may be underestimated.

All metals in water-dissolved - # Percent recovery is not applicable due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

The mass inbalance may be caused by other ions that have not been measured.