Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Groundwater Study

Proposed Manufactured Housing Estate
40-80 Chapmans Road, Tuncurry

Prepared for
Allam MHE Developments No. 2 Pty Ltd

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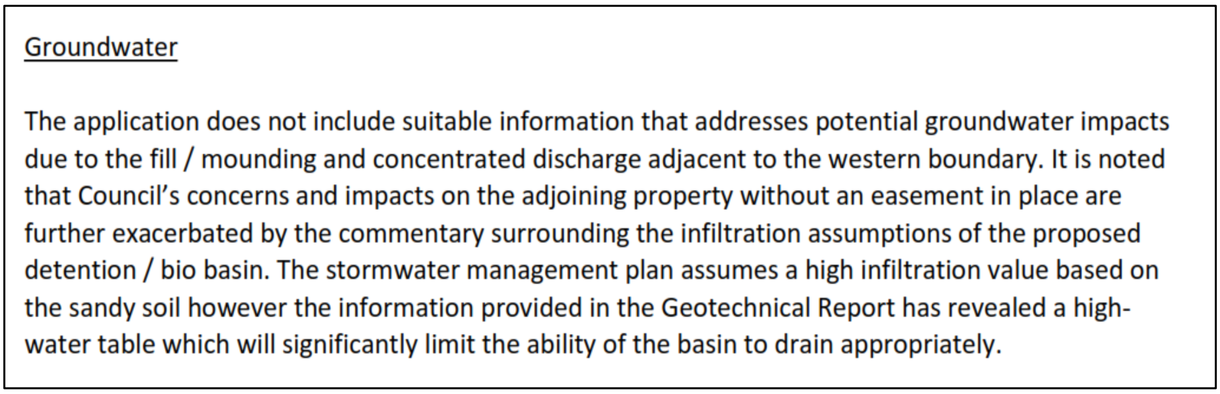
Report on Groundwater Study
Proposed Manufactured Housing Estate
40-80 Chapmans Road, Tuncurry

1. Introduction

This report presents the results of a groundwater study undertaken for the proposed manufactured housing estate at 40-80 Chapmans Road, Tuncurry. The investigation was commissioned by Allam MHE Developments No. 2 Pty Ltd (Allam) on 5 December 2022 and was undertaken with reference to Douglas Partners' (DP) proposal 2195396.00 dated 28 November 2022.

It is understood that the proposed development comprises a manufactured housing estate which will be constructed on up to 3 m of imported fill. In assessing the development application (DA2022/0214), Mid Coast Council (MCC) have raised matters regarding groundwater as follows:



Groundwater

The application does not include suitable information that addresses potential groundwater impacts due to the fill / mounding and concentrated discharge adjacent to the western boundary. It is noted that Council's concerns and impacts on the adjoining property without an easement in place are further exacerbated by the commentary surrounding the infiltration assumptions of the proposed detention / bio basin. The stormwater management plan assumes a high infiltration value based on the sandy soil however the information provided in the Geotechnical Report has revealed a high-water table which will significantly limit the ability of the basin to drain appropriately.

Figure 1: Extract from MCC Council Assessment Report (PPSHCC-217) for DA2022/0214.

This report has been prepared in response to MCC Council Assessment report and a subsequent meeting between Allam, DP and other consultants with MCC on 14 June 2023, to provide an assessment of possible impact to groundwater levels on the site and adjacent areas in response to the MCC request.

2. Scope of Work

The scope of work comprised following:

- Brief review of available existing data comprising geological maps, topographic data, registered groundwater bores and salinity mapping;
- Summary of subsurface conditions from previous investigation;
- Preparation/revision of a conceptual hydrogeological model (CHM);
- Site walkover;

- In-situ screening of surface waters (dams / creeks / rivers) for field parameters (i.e. pH, electrical conductivity, dissolved oxygen), where present;
- Datalogger installation and subsequent download;
- Hydraulic conductivity testing of wells;
- Groundwater modelling of the site under two scenarios (pre-development and post development) using MODFLOW;
- Preparation of this report including comments addressing comments from MCC regarding groundwater (see Figure 1).

For the purposes of this study the following documents were provided:

- ADW Johnson (ADW) Detail and Contour Survey (ADW project 190835-DET-001-A);
- Land Dynamics Australia (LDA) Stormwater Management Plan (LDA, 2023);
- LDA Stormwater Treatment Measures Plan (LDA project 5445 drawing S1001 revision C);
- LDA Road Alignment Concept Plan (LDA project 5445 drawing 1003 revision C);
- Regional Geotechnical Solutions Pty Ltd (RGS) Detailed Site Investigation (RGS, 2022);
- Regional Geotechnical Solutions Pty Ltd (RGS) Addendum to Detailed Site Investigation – Contamination Assessment (RGS, 2023).

3. Proposed Development

Reference to LDA Road Alignment Concept Plan (LDA project 5445 drawing 1003 revision C) it is understood that the proposed development includes:

- Construction of engineered fill platform approximately 3 m high (design RL 2.9 to 4.3 AHD) across majority of the site, comprising dredged sand or other MCC approved fill material;
- Construction of 88 manufactured homes on the fill platform;
- Construction of new road (Collector Road) to provide access to the manufactured homes off Chapmans Road; and
- Construction of two bioretention areas to accept all site stormwater.

Reference to LDA Stormwater Treatment Measures Plan (LDA project 5445 drawing S1001 revision C) it is understood that the bioretention areas are known as Basin West and Basin East and have infiltration areas of 550 m^2 and 160 m^2 respectively. These basins are proposed to comprise filter media with saturated hydraulic conductivity of 140 mm/hour (4 x 10^{-5} m/sec). Basin locations are shown in Figure 2.

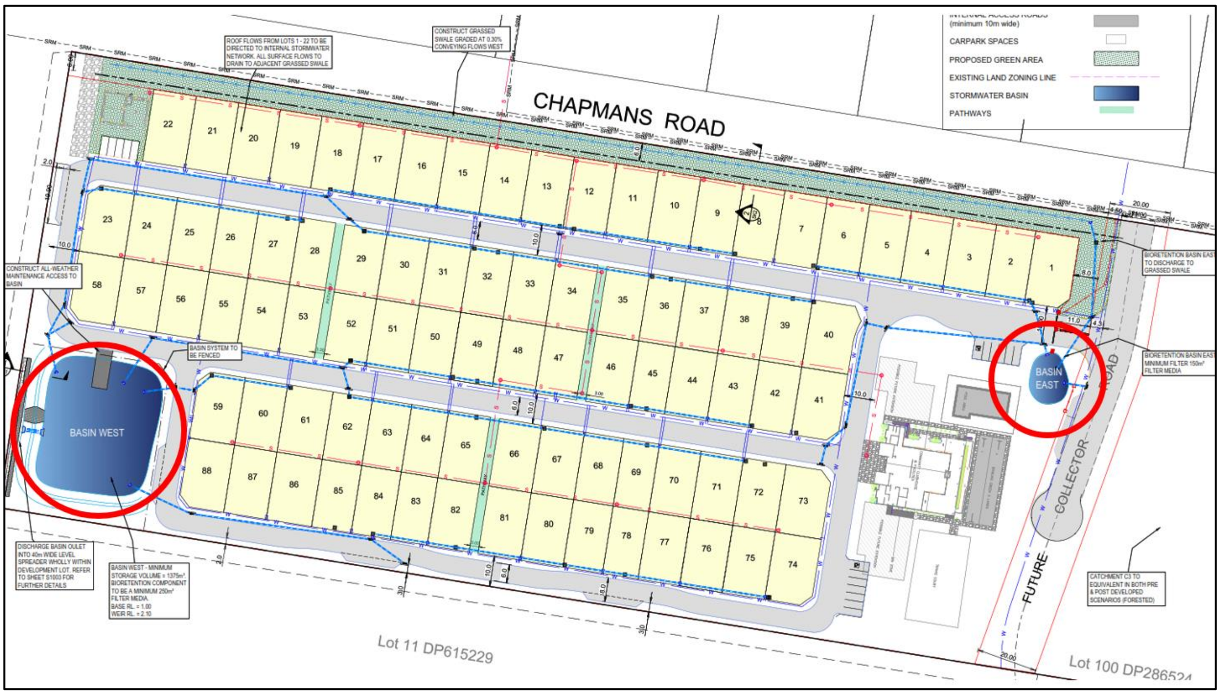


Figure 2: Extract from Stormwater Treatment Measures Plan (LDA, project 5445 drawing S1001, revision C), bioretention areas indicated in red.

4. Site Description

The site is identified as Lot 100, DP 1286524 at 40-80 Chapmans Drive, Tuncurry. The site is rectangular in shape and is approximately 6.1 ha in size.

At the time of field work the lot was undeveloped with a fill platform approximately 1 m thick in the central portion of the site. 'End-dump' stockpiles of soils and stockpiles of materials (pallets, concrete pits, brick, sheet metal, wood) are in the central portion of the site, on top of the fill platform. The eastern and western portions of the site did not appear to be filled and were undeveloped with stockpiles of mulch, probably from recent removal and subsequent mulching of mature vegetation such as trees. Vegetation across the site comprised mainly 'slashed' grass and some denser bushes typically on soil stockpiles.

Site location is shown in Figure 3 with general site condition shown in Figure 4.

Figure 3: The ‘site’ shown in red (base map from Sixmaps)

Figure 4: Typical site condition, south-eastern corner of the site looking north-west

5. Published Information

5.1 Topography

Reference to site survey by ADW (project 190835-DET-001-A) indicates the site levels as of July 2022 are as follows:

- Western and eastern portion of the site – in the order of RL 0.5 (m AHD) to RL 1.5; and
- Central portion of the site – in the order of RL 1.5 to RL 4.5.

Reference to NSW 1 m LIDAR contour mapping indicates the regional topography to be in the order of RL 0 at Wallamba River to the west of the site, grading to RL 7 to the east of the site, with an overall slope dipping to the west/south west.

5.2 Geology

Reference to NSW Seamless Geology map indicates the following (see Figure 5):

- Quaternary aged coastal deposits (Sand), which typically comprises sand, shell and gravel – eastern portion of the site;
- Quaternary aged estuarine tidal-delta flat (QH_et),which typically comprises sand, silt, clay shell and gravel – western portion of the site;
- Quaternary aged alluvial floodplain deposits (Q_afs), which typically comprise silty clay and sand;
- Quaternary aged clastic sediments (QH_af), which typically comprise silt, sand and clay – to the west of the site (in the vicinity of Wallamba River).

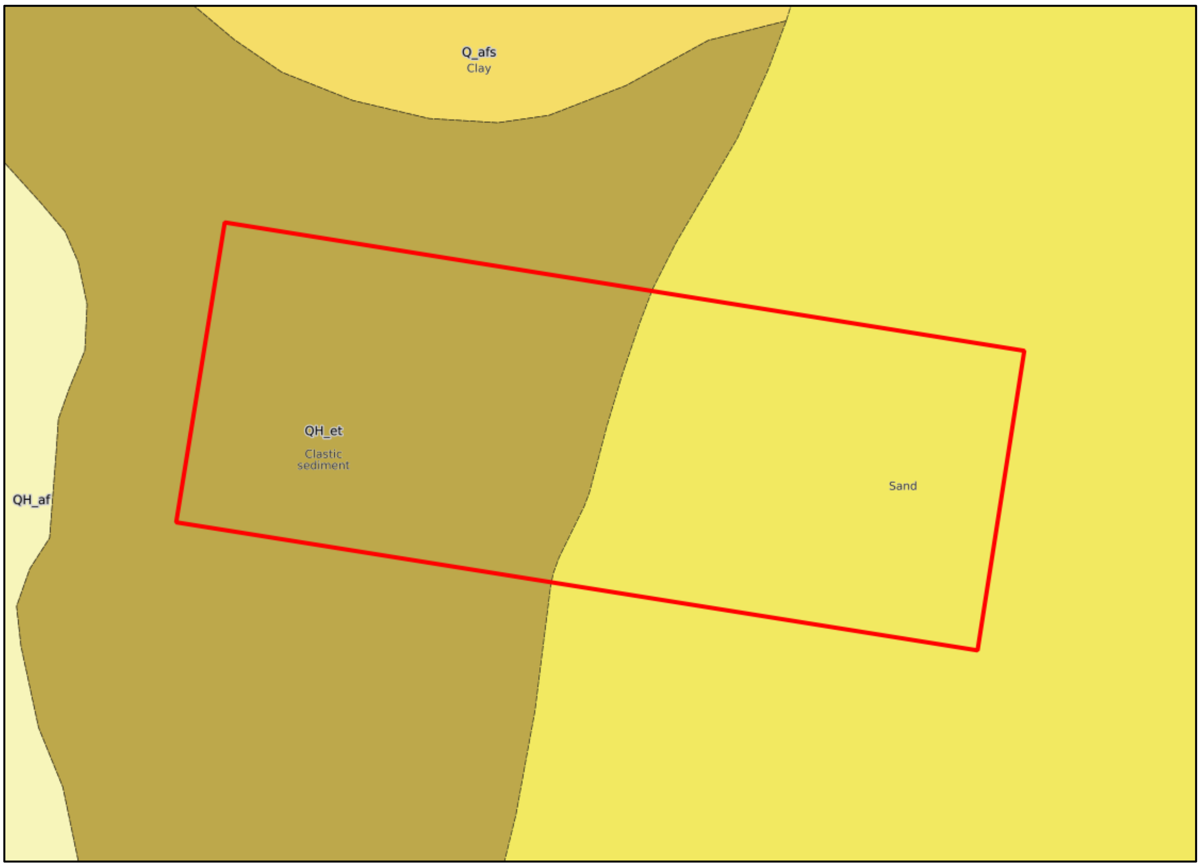


Figure 5: Geology mapping, site shown in red

5.3 Groundwater

An on-line records search of groundwater wells registered with the NSW Office of Water indicated the absence of registered wells on the site (see Figure 6).

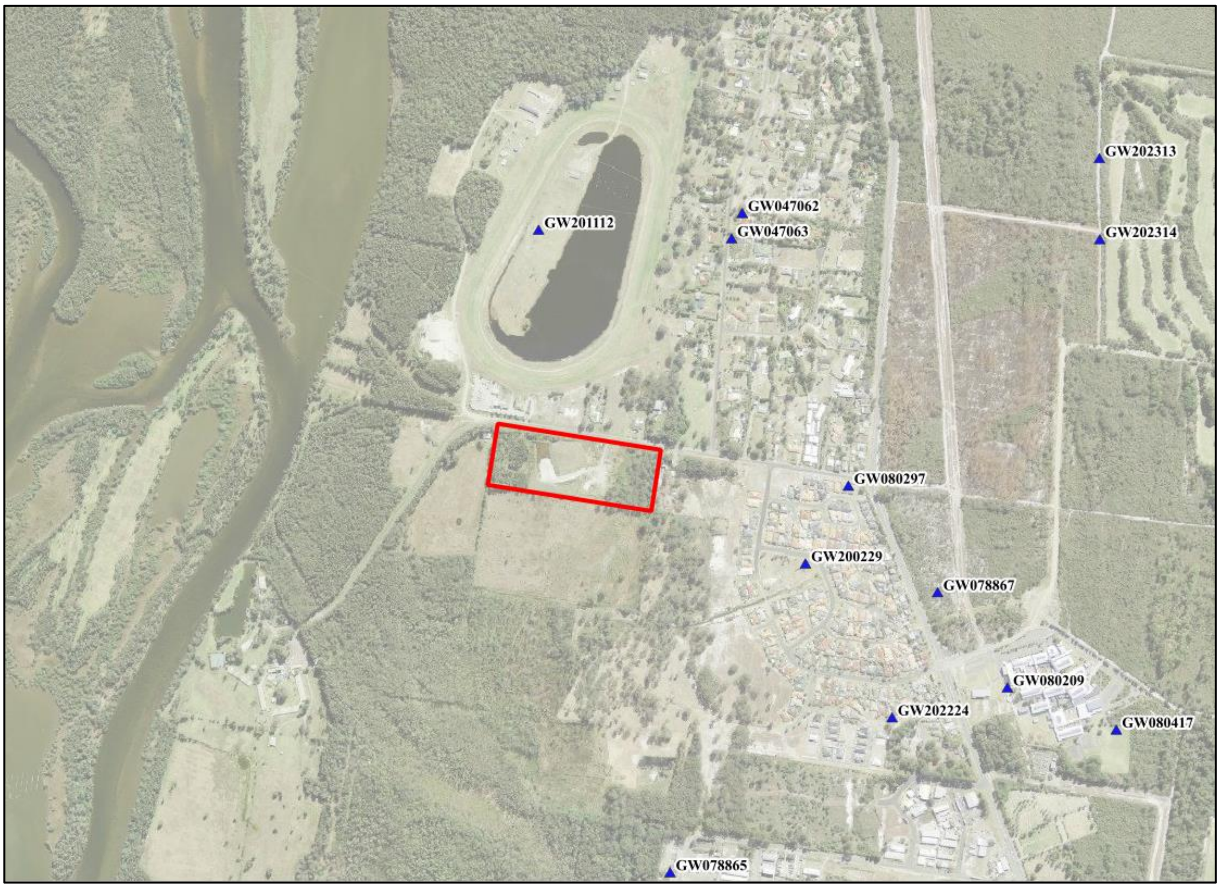


Figure 6: NSW Registered Groundwater Bores, site boundary shown in red.

A number of registered wells were within 500 m of the site, details are summarised below in Table 1.

Table 1: Summary of relevant nearby registered groundwater bores (within 500 m of the site)

Bore ID	Easting, Northing	Bore Depth (m bgl)	Standing Water Level (m bgl)	Soil/Rock Material (m bgl)	Purpose	Distance from site (m)
GW200229	451773, 6441839	9.0	2.7	Sand (0-9.0)	Recreational	400 m south-east
GW080297	451877, 6442028	9.0	2.7	Sand (0-9.0)	Not available	450 m east
GW201112	451123, 6442650	7.0	2.0	Not available	Irrigation	480 m north

Note to Table:
m bgl – metres below ground level

The registered bores within the vicinity of the site generally indicate a sandy subsurface profile with groundwater between 2 m and 2.7 m below ground level.

It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and therefore vary with time.

5.4 Surface Water

The surface water bodies in the vicinity of the site as follows:

- Lake at the racecourse, approximately 150 m north of the site;
- Unnamed channel, approximately 300 m south of the site; and
- Wallamba River, approximately 475 m west of the site.

The local surface flow direction is likely to be to the west (toward Wallamba River).

5.5 Salinity Mapping

With reference to NSW Department of Planning and Environment eSPADE mapping indicates a data node approximately 25 m north-west of the site has “salting evident”. This suggests potentially high salinity conditions in soils within the vicinity of the site.

5.6 Flood Levels

Reference to Land Dynamics Australia (LDA) Stormwater Management Plan (LDA, 2023) indicates that information was sought from MCC in relation to design flood levels. The following flood levels were supplied:

- Flood planning level – RL 2.7; and
- Habitable floor level – RL 3.2.

5.7 Acid Sulfate Soils

Reference to NSW Acid Sulfate Soil Risk map indicates that there is a high probability of acid sulfate soil occurrence between 1 m and 4 m below the ground level at the site (see Figure 7).

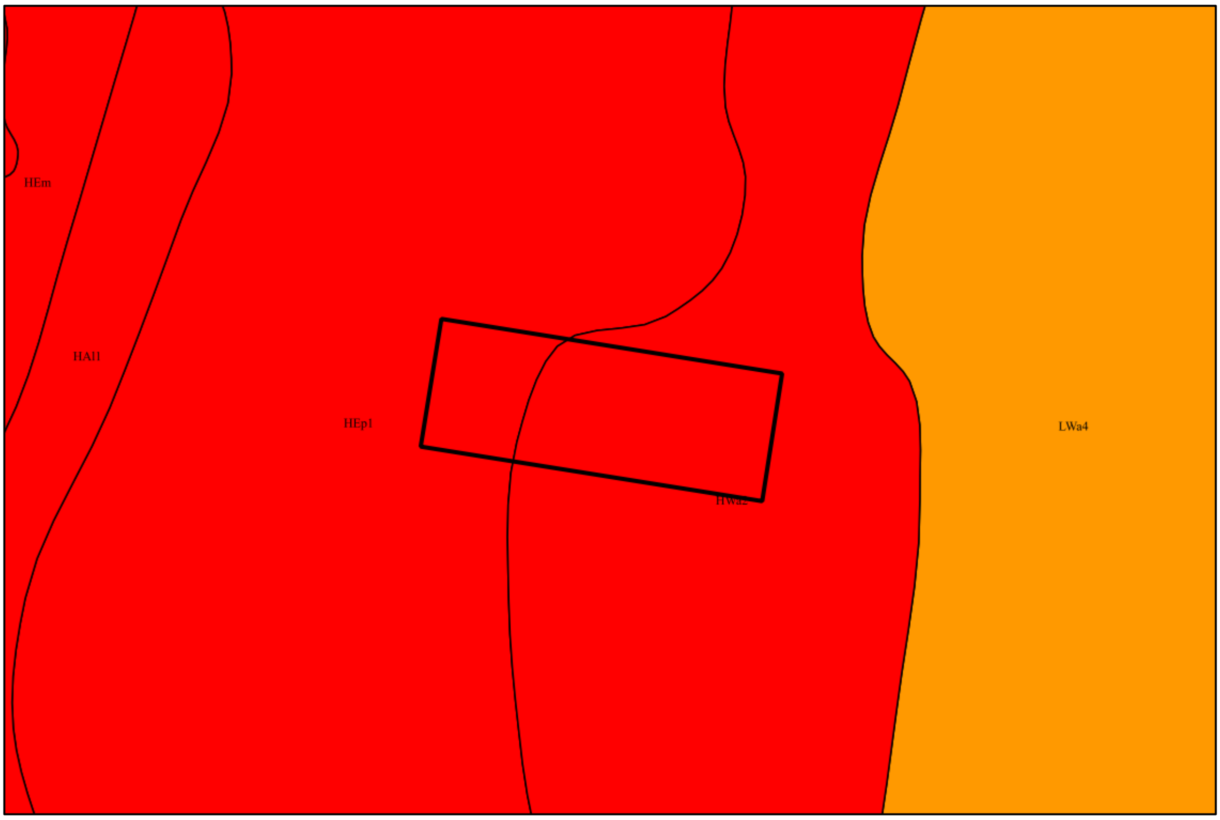


Figure 7: High probability of ASS (in red), low probability of ASS (in orange), site boundary shown in black

5.8 Groundwater Dependant Ecosystems (GDEs)

A review of the Bureau of Meteorology Groundwater Dependant Ecosystems Atlas indicates the following:

- The very eastern portion of site and various areas in the vicinity of the site as high potential for terrestrial GDE (swamp paperbark, swamp mahogany, swamp oak, saw sedge, baumea juncea grasses, banksia) (see red areas on Figure 8); and
- Wallamba River (approximately 300 m west of the site) as high potential for aquatic GDE (see blue areas on Figure 8).

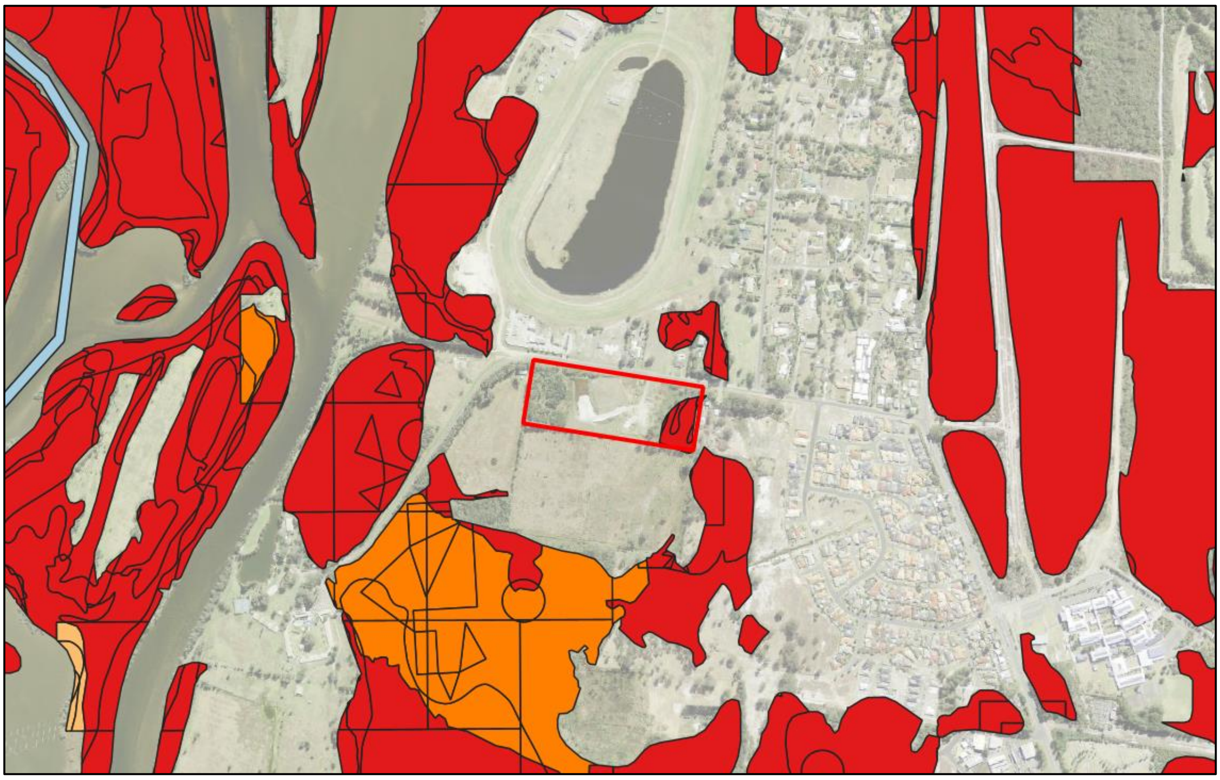


Figure 8: High potential for terrestrial GDE (red), medium potential for terrestrial GDE (orange), high potential for aquatic GDE (blue), site boundary shown in red outline.

6. Previous Investigations - Regional Geotechnical Solutions (RGS, 2022; RGS, 2023)

Regional Geotechnical solutions (RGS) has undertaken a detailed site investigation for contamination at the site in 2022 (RGS, 2022). Following council comments an addendum to the detailed site investigation was also undertaken (RGS, 2023). Scope of work for this previous investigation by RGS included site walkover, excavation of 55 test pits, installation of four wells, soil and water sampling and analysis of collected samples for testing.

During the site walkover on 4 October 2022 the site was described as follows:

- The eastern and western portions of the site are cleared of mature trees with mulching in progress;
- The central portion of the site has been extensively filled above natural grade;
- An asphalt access road, from Chapmans Road to the central portion of the site; and
- Various stockpiles of materials such as aggregate, road base, gravel, vegetation and anthropogenic materials scattered across the site.

Subsurface conditions encountered in test pits generally comprised:

- Fill:
    - In above ground stockpiles, generally in the eastern portion of the site, generally comprising of sandy gravelly CLAY / sandy GRAVEL / clayey gravelly SAND / sandy GRAVEL;
    - In the central portion of the site, generally comprising SAND with some shell; underlain by
- Sand / clayey sand (slightly indurated in areas): grey / pale grey to termination depth with maximum investigation to 2.6 m below ground level.

Groundwater monitoring wells (MW1 to MW4) were installed on 7 September 2022 by RGS. The monitoring wells were installed using a 6T Excavator with 100 mm diameter auger to depths of 2.0 m. Detailed borehole logs are attached in Appendix B. Subsurface conditions encountered in the groundwater monitoring wells generally comprised:

- Fill / topsoil / clayey sand: dark grey / black, some roots to depths of between 0.2 m to 0.7 m; underlain by
- Sand / clayey sand (slightly indurated in areas): pale grey / grey / pale brown / dark brown to the termination depth of 2.0 m;
- A summary of the construction of groundwater monitoring wells is provided in
- Table 2.

Table 2: Groundwater Monitoring Well Installation Summary

Well	Depth (m)	Depth to Groundwater During Drilling (m)	Screen Length (m)	Depth to Bottom of Screen (m)
MW1	2.0	0.5	1.5	2.0
MW2	2.0	0.8	1.5	2.0
MW3	2.0	1.0	1.5	2.0
MW4	2.0	0.5	1.5	2.0

It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

7. Field Work

7.1 Methods

Field work by Douglas Partners comprised the following:

- Site walkover;
- In-situ screening of surface waters (dams / creeks / rivers) for field parameters (i.e. pH, electrical conductivity, dissolved oxygen), where present;
- Rising head hydraulic conductivity tests in monitoring wells (MW1, MW3 and MW4); and

- Installation of groundwater level loggers in groundwater monitoring wells.

Coordinates and surface levels at monitoring well locations were recorded using a differential GPS (dGPS) which has a typical accuracy of ± 0.1 m depending on satellite coverage.

The monitoring well locations are shown on Drawing 1, Appendix C.

7.2 Site Walkover

A site walkover was conducted by a geotechnical engineer from DP on 1 May 2023. Relevant findings from the site walkover are detailed below:

- The site is a vacant, relatively flat parcel of land with filling of approximately 1 m in the central portion of the site (Figure 9);
- Various stockpiles of soils and materials within the central portion of the site (Figure 10 and Figure 11);
- Low-lying area along the eastern boundary of the site approximately 80 m wide (Figure 12);
- Monitoring wells MW1, MW3 and MW4 located in the north-eastern, south-western and north-western portions of the site, respectively;
- Monitoring well MW2 could not be located during site walkover, however, broken PVC pipe indicative of former monitoring well could be found (Figure 13);
- Informal table drain along Chapmans Road (dry during walkover), which slopes to the west (Figure 14). The drain continues to the west along on the southern side of Chapmans Road and eventually crosses Chapmans Road via pipe culvert and feeds into a low-lying area approximately at the entrance of Tuncurry Lakes Resort (Figure 15). It is assumed that this low-lying area then connects directly to Wallamba River; and
- Unnamed water course, adjacent to Grandis Drive footbridge (Figure 16). From aerial imagery this water course is presumed to flow from Grandis Drive along open fields/wetland areas and eventually discharges directly into Wallamba River. This water course is assumed to collect stormwater from the nearby residential area.

During site walkover there did not appear to be any other formalised surface drainage paths on the subject site or adjacent sites to the south. Therefore, it is understood that surface runoff in the vicinity of the site is dominated by sheet flows along the ground surface, which is then collected by the table drain adjacent to Chapmans Road, or the unnamed watercourse to the south. Both the table drain and the unnamed watercourse discharge into Wallamba River then Coolongolook River and finally Pacific Ocean.

Figure 9: Typical site condition, north-eastern corner of the site, looking south-west.

Figure 10: ‘End dump’ stockpiles, central portion of the site, looking north.

Figure 11: Boulder and wood stockpile, central portion of the site, looking south-west.

Figure 12: Low-lying area, western portion of the site, looking west.

Figure 13: Former MW2 location, southern portion of the site.

Figure 14: Table drain, north of the site adjacent to Chapmans Road, looking east.

Figure 15: Low-lying area and pipe culvert, north of Chapmans Road, looking north.

Figure 16: Unnamed water course, adjacent to Grandis Drive foot bridge, looking west.

7.3 Rising Head Hydraulic Conductivity Testing

In-situ hydraulic conductivity testing comprised rising head tests in MW1, MW3 and MW4. The test comprised a inducing a rapid drawdown in water level within the well and measuring the recovery of the groundwater level with respect to time using a datalogger.

Permeability was estimated using the Hvorslev method (Hvorslev, 1951). The hydraulic conductivity values are applicable only to the soil unit corresponding to the well screen interval (Hvorslev, 1951).

Results of rising head tests are attached in Appendix B with results summarised below in Table 3.

Table 3: Summary of Rising Head Tests

Well	Well Construction			Number of Tests	Estimated Hydraulic Conductivity	
	Casing Radius (m)	Gravel Radius (m)	Effective Screen Interval (m bgl)		m/second	m/day
MW1	0.025	0.075	1.5	4	2.4 x 10^{-4} to 3.3 x 10^{-4}	21 to 29
MW3	0.025	0.075	1.5	4	1.1 x 10^{-4} to 1.6 x 10^{-4}	10 to 14
MW4	0.025	0.075	1.5	7	1.0 x 10^{-4} to 1.1 x 10^{-4}	9 to 10

Notes to table:
m bgl – metres below ground level

7.4 Field Screening of Surface Waters

In conjunction with site walkover, DP also undertook in-situ screening of surface waters for field parameters, measured using a hand-held calibrated meter. The locations were screened to give a broader understanding of water quality in nearby surface water bodies. Locations are shown in Figure 17 and summarised in Table 4 below.

Table 4: Summary of Field Screening of Surface Waters (1 May 2023)

Location		Location Description	Easting	Northing	RL (AHD)	Temperature (°C)	pH	EC (mS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)
On site	W1	Low lying area, south eastern portion of the site	451321	6441984	1.4	24.5	7.0	0.27	81	5.8	1
On site	W2	Low lying area, north eastern portion of the site	451367	6442063	1.5	21.3	5.6	0.29	154	4.9	28
On site	W3	Low lying area, northern boundary of the site	451230	6442138	1.1	21.2	6.2	0.60	-3	1.1	>1000
On site	W4	Low lying area, northern boundary of the site	451180	6442152	1.1	22.5	6.3	0.51	-25	2.3	157
Off site	W5	Surface water body, Tuncurry Lakes Resort	450423	6441736	0.1	22.6	6.8	23.00	83	5.4	2
Off site	W6	Wallamba River	450292	6441654	0.1	22.2	7.0	21.20	54	6.4	5
Off site	W7	Table drain, north side of Chapmans Road	450625	6441744	0.5	19.4	7.5	0.97	-19	6.7	3
Off site	W8	Table drain, south side of Chapmans Road	450700	6441820	0.6	20.5	6.8	0.07	3	6.5	42
Off site	W9	Table drain, south side of Chapmans Road	450816	6441987	0.5	20.1	7.4	0.42	21	6.9	43
Off site	W10	Surface water body, racecourse	451320	6442876	0.5	21.4	8.0	0.35	42	10.3	7
Off site	W11	Concrete lined drain adjacent to Viola Circuit	451670	6441747	1.8	19.7	7.7	0.26	56	6.0	54
Off site	W12	Wallamba River	451278	6439501	0.3	21.4	7.4	41.00	115	6.6	6
Off site	W13	Coolongolook River	452842	6439352	0.3	21.5	7.8	49.40	79	6.5	2

Notes to Table:
Co-ordinates of tested locations were measured using a hand-held GPS and therefore coordinates are approximate only.
EC – electrical conductivity
NTU – Nephelometric Turbidity Units
DO – dissolved oxygen
ORP – oxidation reduction potential

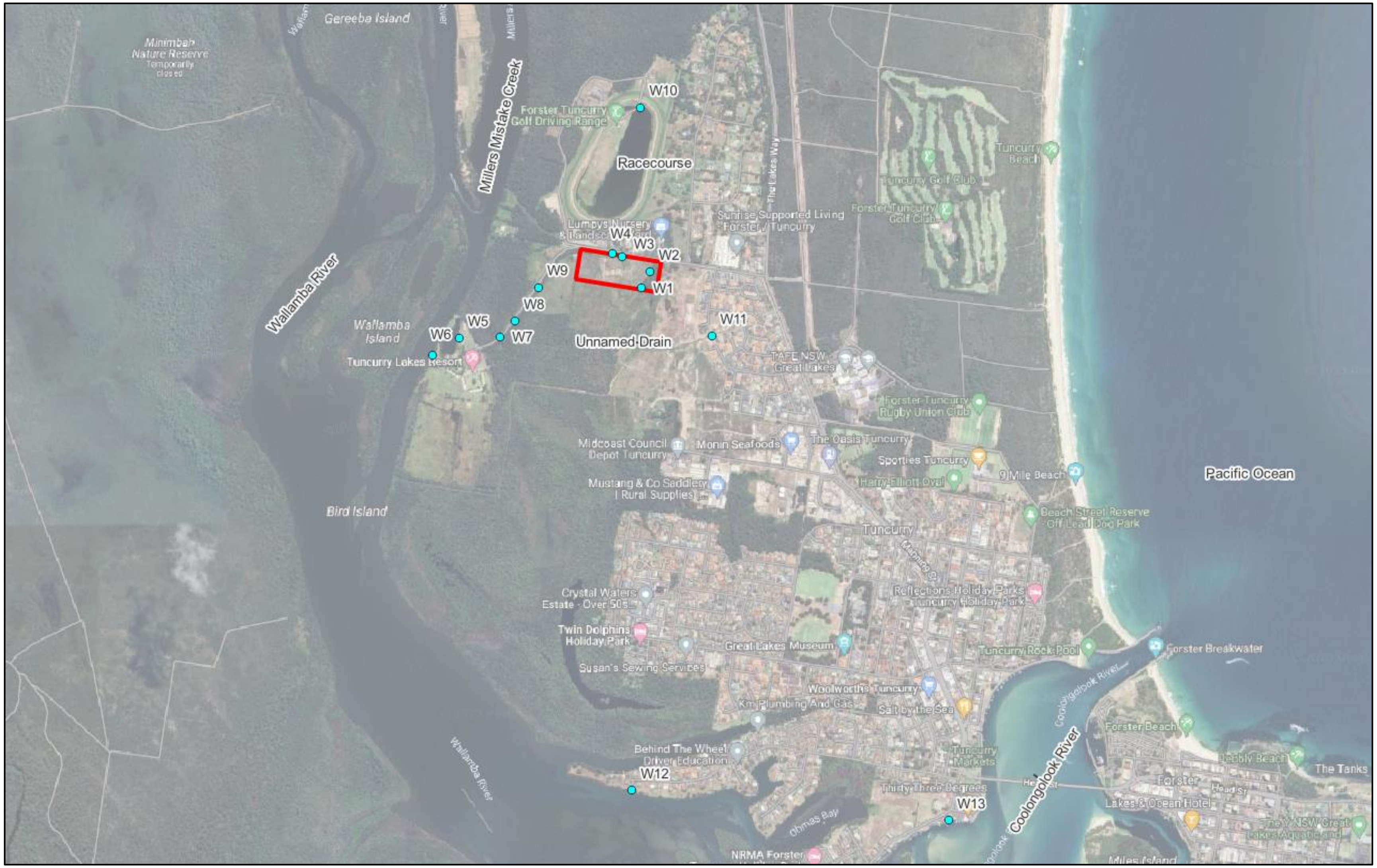


Figure 17: Approximate Surface Water Screening Locations

Generally, surface waters were moderately acidic to neutral (i.e. pH 5.9 and 7.0). Surface waters at all test locations were low in salinity (i.e. EC <1.4 mS/cm). There were no obvious indications of gross contamination at surface water screening locations (i.e. absence of staining, odours, hydrocarbon slick/sheen etc).

7.5 Groundwater Flow

Estimated groundwater contours based on groundwater levels measured at MW1, MW3 and MW4 as well as level at surface water screening locations W1 to W13 on 1 May 2023. It is understood that groundwater level within groundwater monitoring wells are representative of level in the unconfined aquifer and therefore are connected to surface water features. These contours are shown in Figure 18.

Figure 18: Estimated groundwater contours 1 May 2023 in blue, site boundary shown in red.

7.6 Groundwater Level Monitoring

Groundwater level monitoring (groundwater monitoring) was undertaken at existing well locations (MW1, MW3 and MW4) using dataloggers for a period of approximately 1 month between 2 May 2023 and 16 June 2023. The dataloggers were programmed to take groundwater level readings every 20 minutes.

The range of groundwater level observed at groundwater monitoring locations over the monitoring period is summarised in Table 5.

Table 5: Range of Groundwater Level in bores – 2 May 2023 to 16 June 2023

Well	Groundwater Level Range (AHD)	Groundwater Depth Range (m bgl)	Water Level Fluctuation (m)
MW1	1.07 to 1.33	0.17 to 0.43	0.25
MW3	0.76 to 0.90	0.21 to 0.36	0.15
MW4	0.67 to 0.83	0.72 to 0.87	0.16

Notes to Table:

m bgl metres below ground level

The results from the groundwater monitoring are presented in detail in Figure B1 in Appendix B, together with estimated site rainfall. In lieu of a site-specific rainfall gauge, site rainfall was estimated by inverse distance weighted (IDW) interpolation between four active Bureau of Meteorology (BoM) weather stations (Wootton, Bungwahl, Old Bar and Taree Airport AWS). The largest rainfall events during the monitoring period was estimated (by IDW interpolation) to be 10 mm on 18 May 2023 and 12 mm on 27 May 2023. Approximate weather station locations are shown on Figure 19.

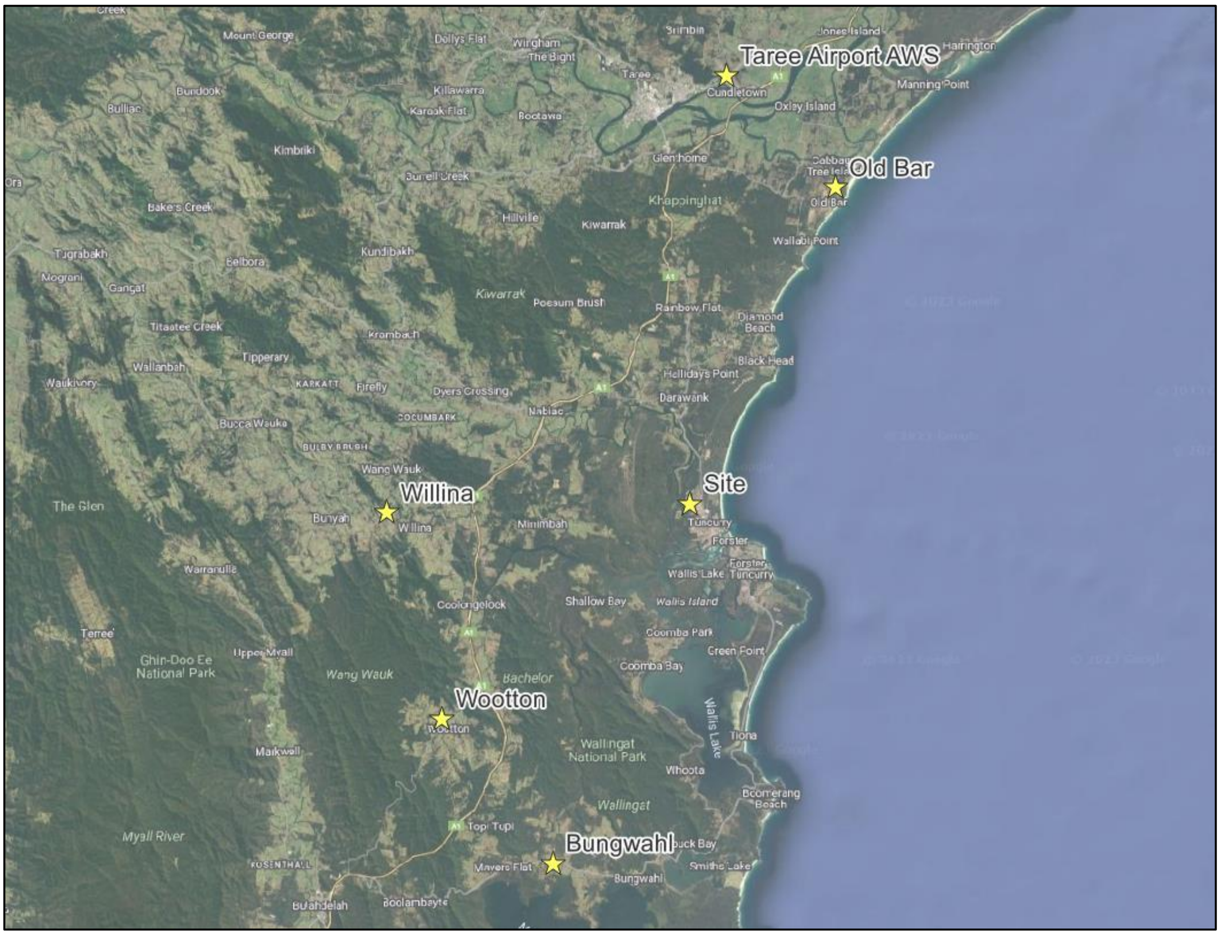


Figure 19: Approximate Bureau of Meteorology (BoM) weather stations used to estimate site rainfall and the site.

8. Conceptual Hydrogeological Model

8.1 Existing Conditions

On the basis of desktop review, previous subsurface investigation, site walkover and field work completed to date, the following conceptual hydrogeological model (CHM) has been prepared.

Investigation to date indicates the sand /clayey sand was present at the site to termination depths of approximately 2.8 m below ground level (see Section 6). Subsurface conditions are primarily sandy and are relatively high permeability (see Section 7.3). Lower permeability layers or lenses, comprising silt or indurated sand may also be present, but these are not expected to be confining layers. Based on previous site investigations in Tuncurry by DP, the base of the unconfined layer is estimated to be at a depth of approximately 10 m.

Investigation to date indicates the site and surrounding flood plain is underlain by an unconfined aquifer which is primarily sandy with a high transmissivity for groundwater flow. Permeability of soils may decrease with clastic sediments to the west of the site (closer to Wallamba River).

From information to date, it is assessed that groundwater flow direction across the site is primarily to the west (see Section 7.5), however flow directions may potentially be dependent on seasonal conditions.

Groundwater recharge will generally be controlled by rainfall. The surface water body at the racecourse to the north of the site may be an additional source of recharge and discharge and may impact groundwater flow directions.

Reference to Figure B1, Appendix B which plots the measured groundwater levels against estimated site rainfall indicated the following:

- Groundwater levels are responsive to rainfall events and the groundwater levels fall relatively quickly after these events, generally returning to previous levels within about a week in the absence of additional rainfall;
- Based on analyses of a selection of isolated rainfall events (8 May 2023 and 27 May 2023), the ratio of the response of groundwater level compared to rainfall amount for each event ranged from about 3 to 5. This is equivalent to a specific yield of between about 0.06 and 0.09 assuming 30% direct recharge.

A residual rainfall mass balance (RRMB) has also been undertaken on the long-term rainfall records from Taree Airport (AWS), which have been collected by BOM continuously since 1997 to present. A RRMB provides a cumulative plot of above or below average rainfall over the length of the rainfall records. A slope upwards on the plot indicates above average rainfall whereas a slope downward indicates below average rainfall (over the length of rainfall records). The RRMB calculated from Taree Airport (AWS) rainfall records is shown in Figure 20.

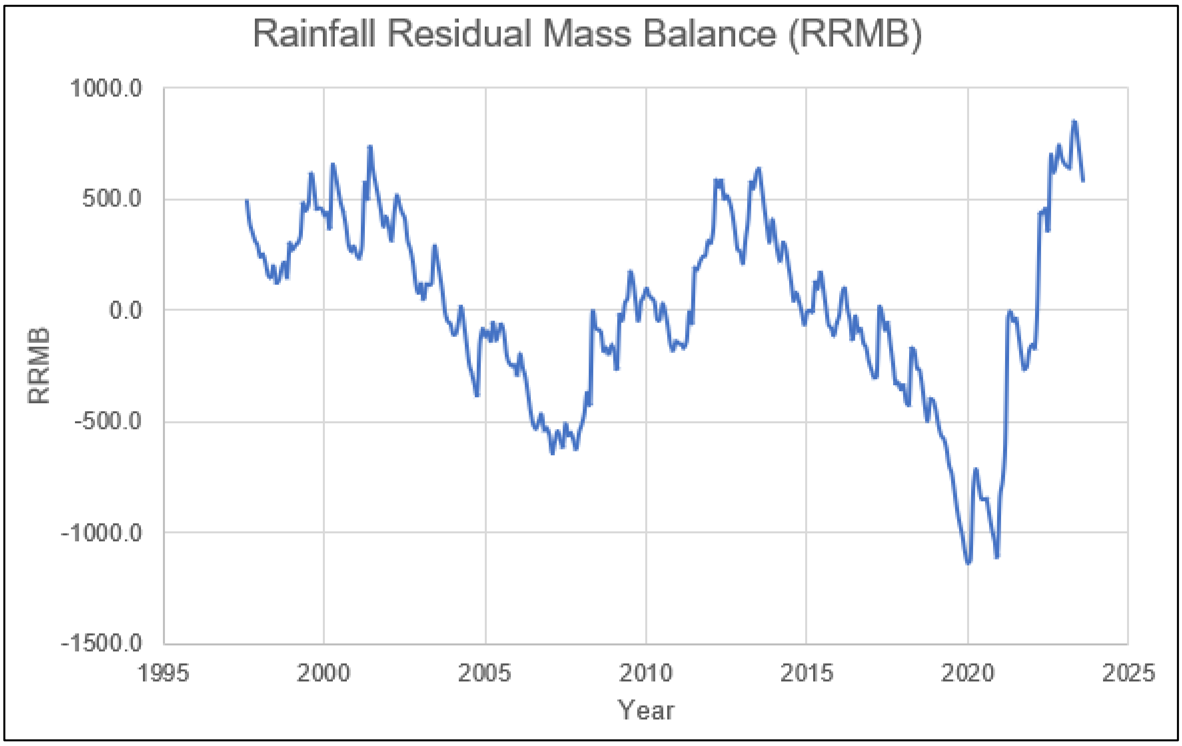


Figure 20: Residual Rainfall Mass Balance (RRMB) from Taree Airport (AWS).

The RRMB plot indicates generally increasing overall trend in rainfall since about 2021. More recently the RRMB plot is on a downward trend which indicates below average rainfall.

Groundwater levels in many aquifers often have similar trends to the RRMB trend line, however in this case the aquifer is highly constrained by boundary conditions and therefore water levels are more related to shorter terms rainfall events. Lower bound water levels are constrained by the relatively close river with groundwater levels after extended periods unlikely to drop below average tide levels.

During and after relatively wet rainfall conditions groundwater levels can be expected to come close to or above the surface and groundwater flows may be locally affected by surface drainage features (if any) or surface topography, and may follow the surface water flow directions as shown by the blue arrows on Drawing 1, Appendix C. Due the high transmissivity of the aquifer, as well as likely high evapotranspiration levels due to shallow groundwater, levels can be expected to fall relatively quickly in periods of drier rainfall conditions.

When groundwater levels fall below the surface then groundwater flow directions are likely to become more regional and controlled by the larger permanent surface water features, with flow approximately to the west as shown by the red arrows on Drawing 1, Appendix C.

8.2 Proposed Development

The groundwater monitoring for the site to date indicates the groundwater at the site reaching a minimum of approximately 0.2 m depth below ground level. Given the relatively dry period over which the recent monitoring was undertaken it is likely that in larger rainfall events groundwater may be at or above the ground surface in lower lying parts of the site. During these events ground surface may limit upper groundwater levels which may otherwise be likely to occur with a higher ground level.

The construction of impervious surfaces such as building roofs, footpaths and roads will increase runoff from the site and reduce both recharge and evapotranspiration from the site. In the absence of re-infiltration of the runoff, this would likely lead to an average decrease in groundwater recharge and levels. Where all the runoff is collected in a basin and then re-infiltrated at the site then average groundwater levels would be expected to rise, particularly in proximity to the infiltration area (groundwater mounding). This is because the potential for evapotranspiration is reduced while recharge is maintained or increased.

When the site is filled to raise ground levels, the groundwater has the potential to rise higher than it can currently, with some mounding within the fill possible and more likely following rainfall events. The propensity for mounding will depend on site preparations and the type of filling used as well as the impact on recharge and evaporation from the presence of additional impervious surfaces.

The type of filling will have a large impact on the likelihood and degree of mounding. Lower permeability soils such as clays will limit the amount of infiltration and reduce the likelihood of mounding. Higher permeability soils such as sand are likely to drain easily and although they will allow relatively high infiltration, water levels would be expected to drain quickly as well provided that any low permeability surface soils are removed prior to placement of the sand. Moderate permeability soils such as a fine grained sand or silty sand are likely to provide the highest potential for mounding as they still allow infiltration, however, provide limited drainage.

The most likely time for mounding to occur within the general fill is during construction before impervious surfaces and surface drainage has been installed however is highly weather dependant.

Mounding in the filling is only expected to be an issue when the water table comes within the depth of influence of building foundations, pavements and other infrastructure.

A number of measures can be used to limit the propensity for mounding in the fill:

- Removal of all low permeability layers from the surface prior to placement of filling at the site. This is especially important if higher permeability filling is to be placed over. The need for removal of such material will depend on its lateral extend and what other measured are proposed to limit water levels as outlined below;
- Placement of higher permeability material in the lower parts of the filling, with any lower permeability material used at higher levels to form a capping layer; and
- Incorporation of subsoil drainage within the filling to control the upper level of groundwater within the fill, in essence replicating the drainage provided by the previous site surface.

The most likely time for mounding to occur in the vicinity of the infiltration areas is post construction and following rainfall events.

9. Numerical Modelling

9.1 Overview

The purpose of developing the model was approximately replicate the existing groundwater flow regime on the site and then use this model to estimate the potential for changed groundwater conditions as a result of the proposed development.

Based on the conceptual groundwater model, steady-state groundwater flow models were developed using the graphical user interface Visual MODFLOW Flex using MODFLOW 2005 numerical engine.

9.2 Model Cases

To estimate the degree of groundwater mounding prior to development and after development using a steady state model, two cases were modelled. The cases are as follows:

- Pre-development - the current site and surrounds; and
- Post-development - after filling of the site and construction of manufactured housing estate.

9.3 Layers

The groundwater system was represented by a single layer of sand which represents the unconfined aquifer. Based on previous site investigations in Tuncurry by DP, the base of the unconfined layer at the site has been assumed to be at a depth of 10 m below ground level (RL -9). It is noted that the unconfined aquifer may be deeper at the site however for this groundwater study the depth of the natural sands are not considered to be a sensitive component of the modelling.

The surface level of the model was based on NSW Spatial Services 1 m Digital Elevation Model for Bulahdelah and Forster. Contours of the surface elevation are shown below in Figure 21.

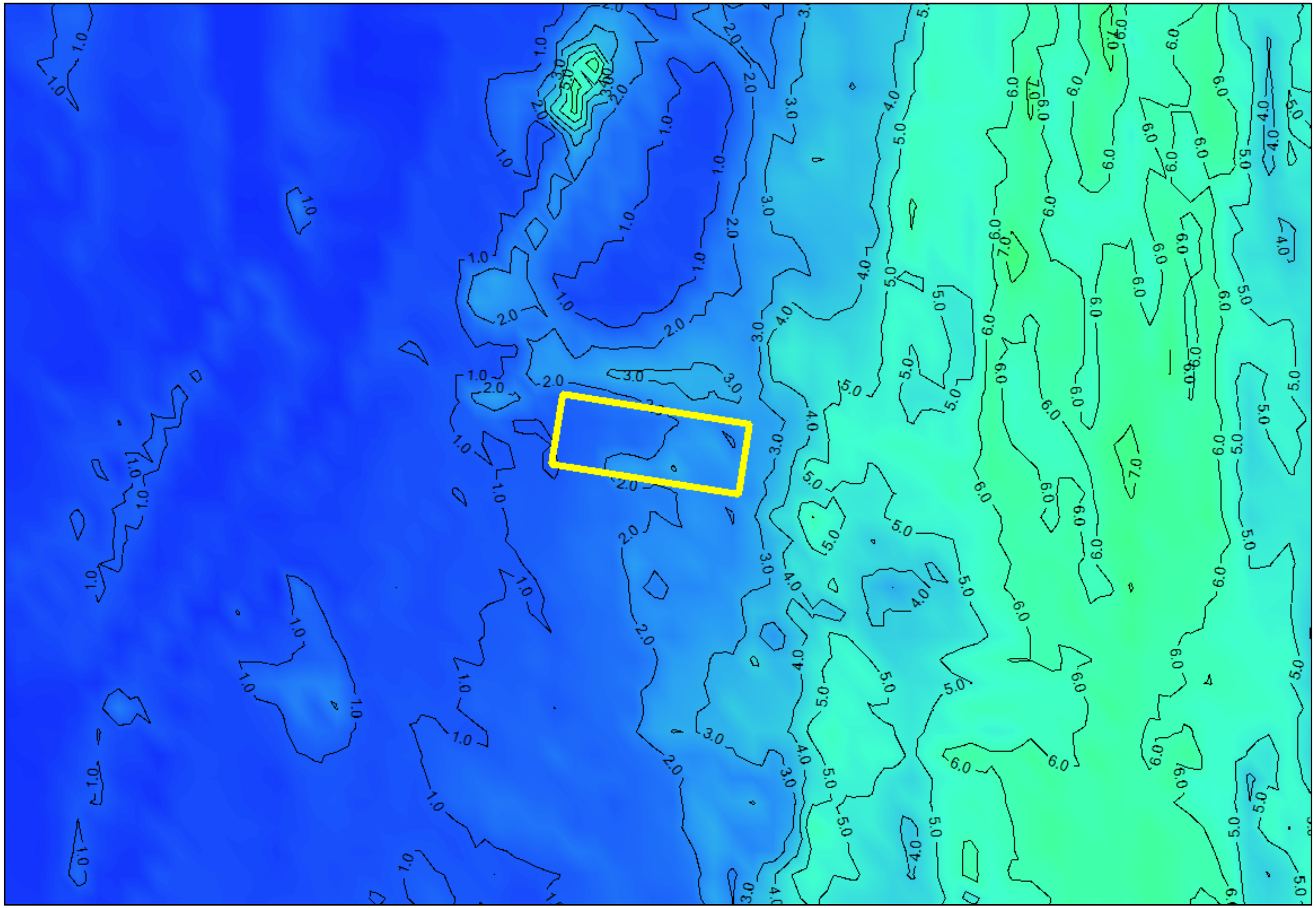


Figure 21: Pre-development surface contours (AHD) imported into MODFLOW, site boundary shown in yellow

9.4 Model Extents and Boundary Conditions

The extent of the model was set to boundaries which could be reasonably defined as follows:

- The western extent of the model was approximately 500 m from site at Wallamba River and set as a constant head boundary condition of RL 0.5;
- The eastern extent of the model was approximately 2000 m from the site at Pacific Ocean and set as a constant head boundary condition of RL 0.5;
- The remaining extents were a minimum of 1500 m from the site. These boundaries are significantly distant from the site to reduce impacts on the model at the subject site.

The overall size of the model was 4000 m from the east to west and 4900 m from the north to south, discretised using a non-uniform grid (focused on the site becoming coarser with distance from the site) of 151 columns and 177 rows, with a minimum cell size of 5 m by 5 m. The size of the grid was selected to allow reasonable representation of the site, site specific features and proposed features (stormwater drains and proposed development). The model grid is shown below in Figure 22 and Figure 23.

Figure 22: Model grid, site shown in yellow.

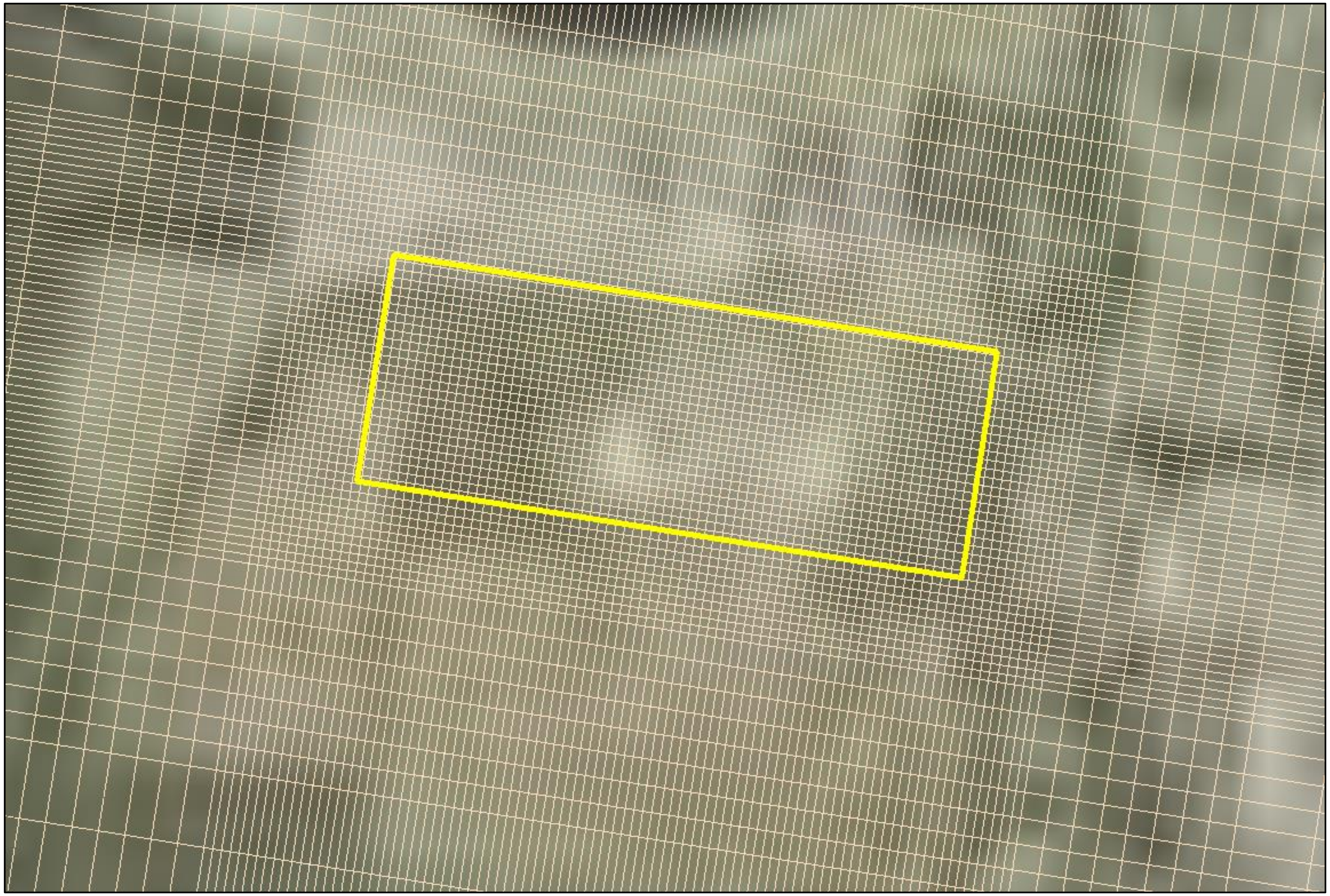


Figure 23: Model grid (zoomed in), site shown in yellow.

9.5 Hydraulic Parameters

Hydraulic parameters required for the model included hydraulic conductivity. Initial estimates were obtained from the particle size distribution and slug tests. The permeability of the sand was found to be in the range of 1.0 x 10^{-4} m/sec to 3.3 x 10^{-4} m/sec. Parameters used in the development of the model were:

- Horizontal Hydraulic conductivity (K_H) = 3 x 10^{-4} m/sec;
- Vertical to horizontal permeability ratio = $K_V / K_H = 0.2$.

9.6 Storage and Porosity

Specific storage (S_s) and specific yield (S_y) are required for the model. Initial estimates of S_s and S_y were made by observing groundwater level response following rainfall events. Given the relatively low amount of observed rainfall responses, estimates of S_s and S_y are approximate only. Parameters used in the development of the model were:

- $S_s = 1 \times 10^{-5}\ m^{-1}$
- $S_y = 0.1$

Total porosity (TP) and effective porosity (EP) are also required for the model. Initial estimates of TP and EP were obtained from literature. Parameters used in the development of the model were:

- TP = 0.3
- EP = 0.3

9.7 Recharge and Evapotranspiration

Rainfall and runoff are the major components of aquifer recharge. As the runoff component is difficult to estimate and assumed to be minor compared to rainfall infiltration. As such, runoff was not included in the groundwater model.

The site is located near to Taree Airport AWS (060141) weather station. According to data from BoM for this weather station, mean annual temperatures vary between 12.6°C to 24.1°C. January and February are the hottest months with mean maximum temperature of 29.0°C. March is generally the wettest month (mean rainfall of 200 mm) and mean annual rainfall (1997-2023) is reported to be 1157 mm/year. Mean annual evapotranspiration (2020-2023) is reported to be 1169 mm/year.

The mean annual rainfall was utilised in the model, then calibrated to adjust the percentage of rainfall entering the model to observed groundwater level in wells. Calibrated recharges percentages are shown in

Table 6.

Table 6: Pre-Development Recharge Parameters

Mean Annual Rainfall (Taree Airport AWS 1997-2023) (mm/year)	Calibrated Recharge (% rainfall)		Ponding (m)
	Undeveloped Areas	Developed Areas	
1157	40	20	2

The mean evapotranspiration at Taree Airport AWS (060141) from 2020 to 2023 was reported to be 1169 mm/year. For the purposes of model calibration, initial evapotranspiration parameters are shown in Table 7.

Table 7: Pre-Development Evapotranspiration Parameters

Mean Evapotranspiration (Taree Airport AWS 2020-2023) (mm/year)	Undeveloped Areas (% ET)	Developed Areas (% ET)	Extinction Depth (m)
1169	100	50	2

9.8 Visual MODFLOW Flex Settings

The following settings were selected in Visual MODFLOW Flex version 7.0 to best simulate conditions expected at the site:

- Flow Type: Saturated (Constant Density); and
- Numeric Engine: USGS MODFLOW 2005.

9.9 Model Calibration (Pre-Development)

Calibration of a flow model refers to the trial and error process by which model parameters are adjusted to produce an acceptable match between simulated and observed groundwater levels (during the monitoring period).

The steady state calibration of three cases was aimed at reproducing the observed groundwater levels in groundwater monitoring wells and expected flow patterns in the geometry of the model. Comparison of observed water level and modelled water level are shown below in Table 8.

Table 8: Calibration of model (pre-development)

Well	Observed Water Level (AHD)	Modelled Water Level (AHD)	Difference (m)
MW1	1.31	1.30	-0.01
MW3	0.89	0.81	-0.08
MW4	0.83	0.90	+0.07

Overall, the model calibration provides an acceptable representation of the groundwater system and is considered suitable for the purposes of assessing the sensitivity of the groundwater system to changed induced by the proposed development.

It is a noted that a steady state calibration is non-unique and that there is a range of possible combinations of hydraulic conductivity vs recharge which would produce a similar calibration. In reality the hydraulic conductivity and therefore calibrated recharge could vary by about 50% to 200%, although for the purposes of assessment potential mounding due to the development each matching pair or recharge/hydraulic permeability would be expected to result in similar results.

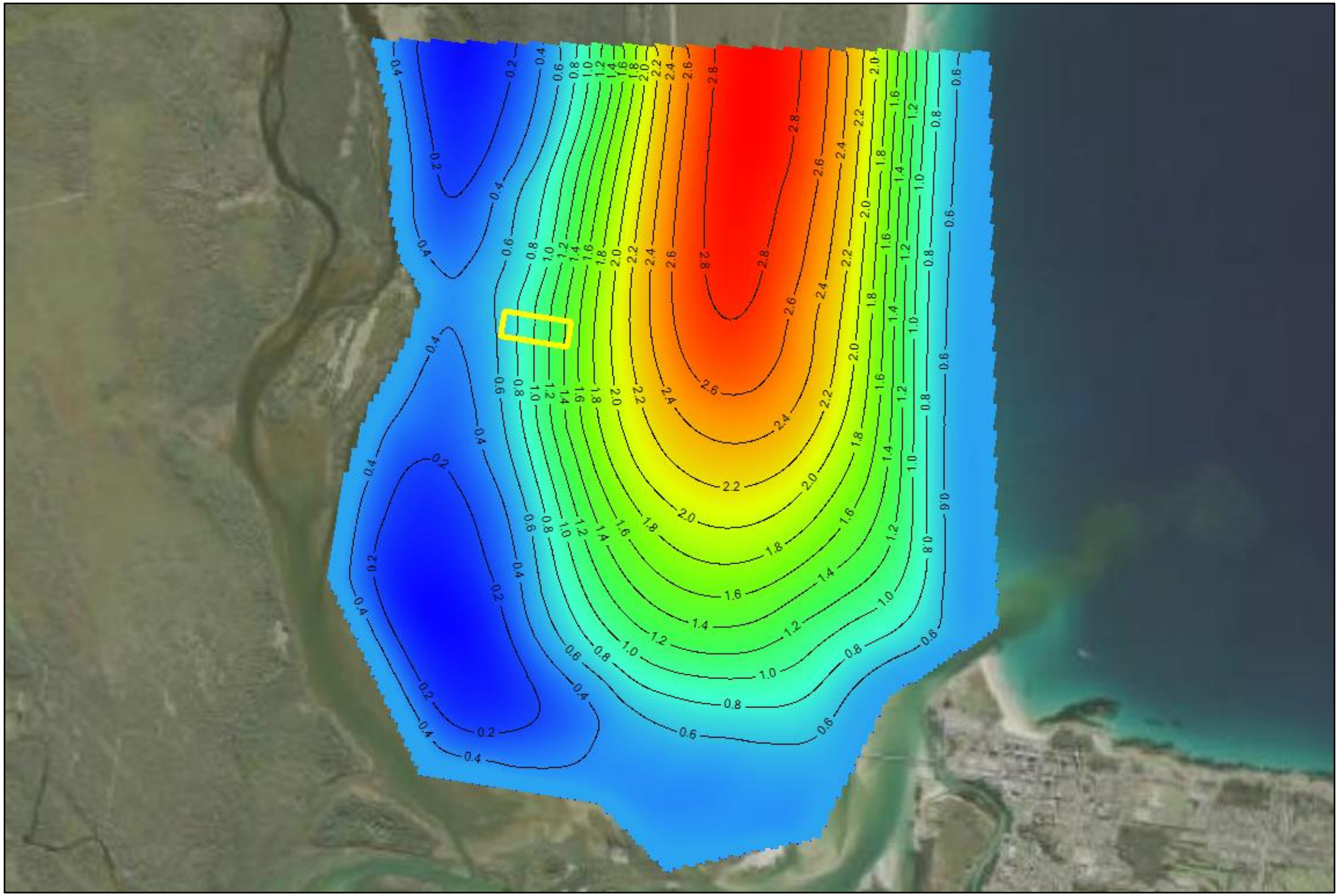


Figure 24 : Pre-Development – Modelled groundwater elevation, 0.2 m contours, site boundary shown in yellow

9.10 Modelling the Proposed Development

Modelling the proposed development is based on pre-development model, with some changes relevant to proposed development. The relevant modified features of the post development models are as follows:

- Surface contour at the site changed to filled levels (to a maximum of RL 4.3);
- ET at the site changed from undeveloped site ET to developed site ET.
- Recharge at the site changed from undeveloped site recharge to developed site recharge; and
- Recharge at basin areas increased to account for rainfall that was previously falling the proposed development area but is now concentrating into basin areas.

Table 9: Pre-Development Recharge Parameters

Mean Annual Rainfall (Taree Airport AWS 1997-2023) (mm/year)	**Recharge (% Rainfall)**			**Recharge (mm/year)**
	Undeveloped Areas	**Developed Areas**	**Site**	**Basins**
1157	40	20	20	14292

Groundwater elevation figures for post-development are shown in Figure 25. With comparison of modelled groundwater level in MW1, MW3, MW4 and four nearby GDE locations are shown in Table 10.

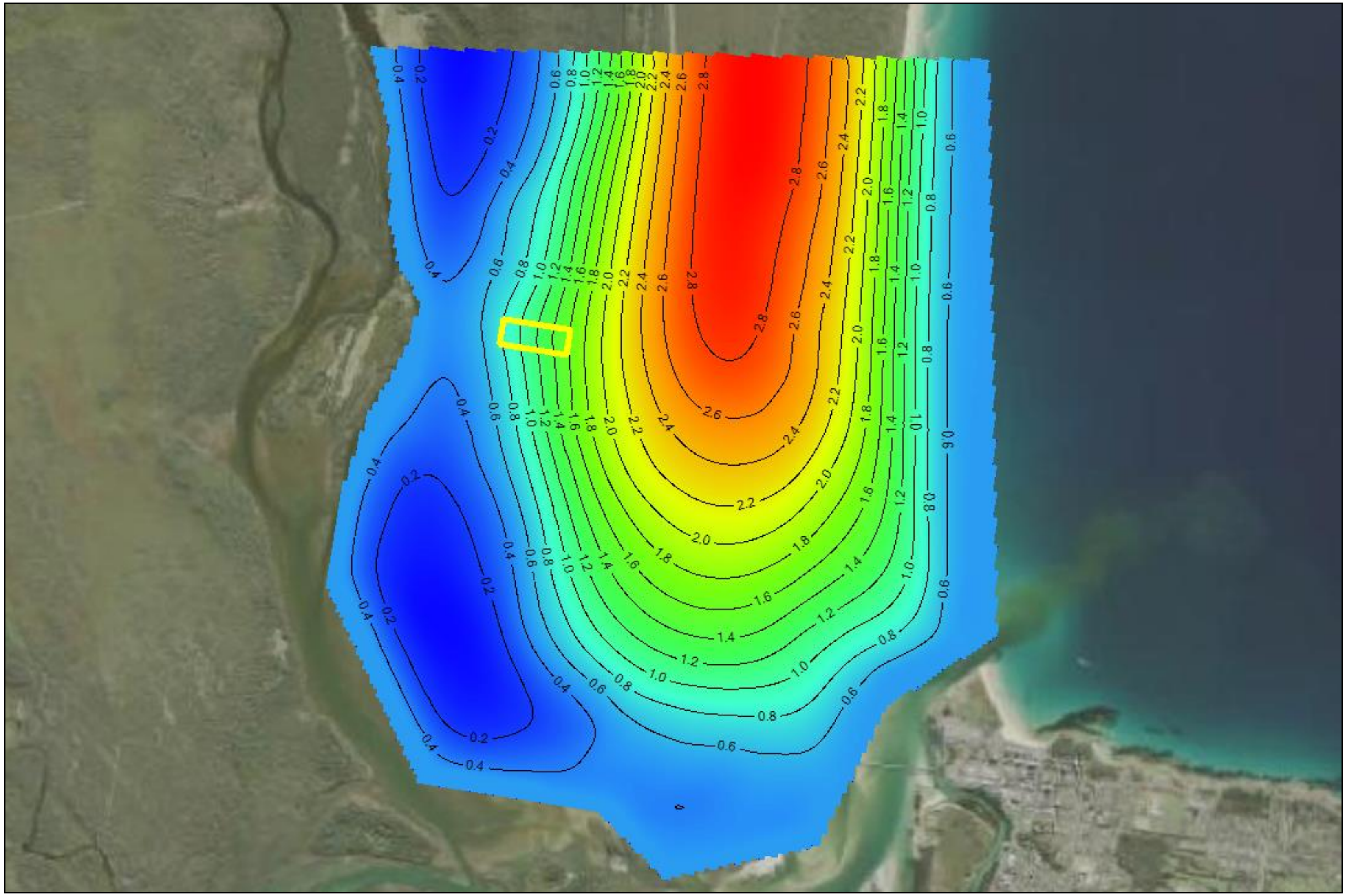


Figure 25: Post-Development – Modelled groundwater elevation, 0.2 m contours, site boundary shown in yellow

Table 10: Comparison of Modelled Groundwater Level Pre and Post Development

Location	Modelled Pre-Development Water Level (AHD)	Modelled Post-Development Water Level (AHD)	Difference (m)
MW1	1.30	1.42	0.12
MW3	0.81	0.97	0.16
MW4	0.90	1.05	0.15
Basin West	0.69	0.93	0.24
Basin East	1.30	1.47	0.17
Terrestrial GDE 40 m north-west of the site	1.50	1.57	0.17
Terrestrial GDE 100 m east of the site	0.56	0.66	0.12
Terrestrial GDE 160 m south-west of the site	0.58	0.66	0.08
Terrestrial GDE 20 m south-east of the site	1.48	1.55	0.07

9.11 Limitations of Modelling

The precision of the results presented in Table 10 are not indicative of the accuracy of the modelling, the precision provided to allow comparison between pre and post development cases, however the accuracy is less than this.

It is considered that the modelling undertaken provides a reasonably representation of the average groundwater flow conditions occurring on the site for the periods of the modelling and provides an indication of the likely average groundwater mounding which may occur below the site and surrounds following development. It is noted that the model does not account for transient effects and mounding that will occur in the shorter term following specific rainfall events, a transient model would be required to assess this. Similarly, localised effects in the immediate vicinity of any infiltration areas may be greater than presented in Table 10.

Furthermore approximately one month of monitoring data was utilised for the development of this model, generally 6 months of monitoring data is preferred to understand groundwater level at the site under various seasonal conditions, rainfall events and to understand average groundwater level at the site.

Changes in longer term climatic conditions will have impacts on overall groundwater levels across the site and surrounds and this would include potential climate change effects. Any future sea level changes would have a commensurate impact on groundwater level changes.

10. Estimated Groundwater Impacts

Based on DP's understanding of the proposed development comprising preliminary plans provided by the client, the anticipated changes in site recharge conditions has been used to predict approximate average groundwater mounding below the site.

10.1 Proposed Development Impacts

The groundwater modelling suggested that under conditions averaged over time mounding of up to about 0.2 m may occur under the majority of the site. These estimates are reliant on the type of fill placed and assume that sand filling will be used, and all low permeability being stripped from the site prior to filling. For low permeability soil the degree of mounding would be expected to be less due to reduced recharge and for intermediate permeability such as a silty sand the mounding could be higher.

These increases in average groundwater level are expected to fall within the natural range of seasonal groundwater variations on the site. Given that some areas to the south and west of the site exhibit natural surface ponding of groundwater from time to time, this ponding can be expected to occur somewhat more often and possibly potentially to some increased extent under seasonally wetter conditions.

Higher mounding of water within the fill can be expected to occur in the following scenarios:

- Short term increases in mounding above average conditions modelled are expected may occur following specific rainfall events and this may lead to mounding within the fill.
- Placement of filling could result in short term elevated water levels within the lower part of the fill for typical rainfall conditions. In the case of more severe rainfall, it is possible groundwater may approach the surface of the filling. These short-term increases are generally expected to peak quickly and dissipate within a week or less.
- Mounding above average conditions modelled can be expected during construction prior to construction of impervious surfaces.

Short term mounding within the filling has some potential to impact on surface infrastructure such as building footings and road pavement and can be managed by appropriate installation of subsurface drainage with the fill.

Higher localised mounding is expected to occur in close proximity to infiltration areas, in particular during and following specific rainfall events.

DP has not specifically modelled the impacts of climate change which may have an overall impact on groundwater levels across the region commensurate with any changes in sea level that may occur in the future. Further work would be required to quantify this.

10.2 Off Site Impacts

The results of modelling suggest that any groundwater mounding will be relatively localised to the immediate site and surrounds. Flows within the surface drainage from the site are expected to occur more often and may lead to more infiltration along the line of the drainage to the river.

Modelling indicates that the changes to average groundwater levels are minor for the areas of terrestrial groundwater dependant ecosystems. Predicted increases are less than 0.2 m and well within the natural variations.

11. Conclusion and Recommendations

The results of the groundwater assessment indicate that there is potential for increases in groundwater levels below the site and groundwater infiltration areas, and that these impacts are likely to be confined to relatively close proximity to the development site.

Groundwater modelling suggests potential increases in average groundwater levels below the site of less than 0.2 m. As the site is being filled there is potential for shorter term increases in groundwater to mound within the filling above the existing groundwater level following rainfall events. These levels could come close to the surface follow severe rainfall and this has the potential to affect surface infrastructure. This level of mounding is well within normal seasonal variations of groundwater level and therefore the impacts to groundwater level from the proposed development is minimal.

The degree of groundwater mounding has been assessed against average groundwater level and average rainfall conditions over one month of groundwater monitoring and is therefore approximate only. Majority of the groundwater recharge is expected following large storm events and will result in a greater degree of mounding for these events due to above average recharge.

The following is recommended to manage groundwater mounding in the filling post construction:

- Stripping of any lower permeability topsoil or clayey layers prior to placement of the fill to ensure high hydraulic conductivity between the proposed development and underlying subsurface and to reduce the likelihood of perching of water above these layers;
- Installation of appropriate subsoil drainage about 1.0 to 1.5 m below the finished ground surface to protect pavements and building footings from saturation under more severe conditions;
- If fill other than sand with minimal fines is used, then careful consideration should be given to the layering of such soils to prevent placing lower permeability soils below permeable soils. Lower permeability soils, if used, will reduce the effectiveness of subsoil drainage and are preferably placed near the upper sections of fill to provide a capping above drainage measures;
- Ongoing monitoring of groundwater level to confirm baseline groundwater conditions under various seasonal and rainfall conditions; and
- Transient groundwater model, to assess the likelihood of groundwater mounding under peak flow conditions.

12. References

Hvorslev, M. (1951). *Time Lag and Soil Permeability in Groundwater Observations.* Bulleton No 36, Vicksburg, Mississippi: Waterways Experiment Station, Corps of Engineers, US Army.

LDA. (2023). *Stormwater Management Plan, Manufactured Home Estate, 40-80 Chapmans Road, Tuncurry.* Document No. 5445 SWMP RevC: Land Dynamics Australia.

RGS. (2022). *Detailed Site Investigation, Proposed Manufactured Home Estate, 40-80 Chapmans Road, Tuncurry.* Document No. RGS03137.1-AC: Regional Geotechnical Solutions Pty Ltd.

RGS. (2023). *Addendum to Detailed Site Investigation - Contamination Assessment, Proposed Manufactured Home Estate, 40-80 Chapmans Road, Tuncurry.* Document No.RGS03137-AD: Regional Geotechnical Solutions Pty Ltd.

13. Limitations

Douglas Partners (DP) has prepared this report for this project at 40-80 Chapmans Road, Tuncurry with reference to DP's proposal 219536.00.P.001.Rev0 dated 28 November 2022 and acceptance received from Allam MHE Developments No. 2 Pty Ltd dated 5 December 2022. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Allam MHE Developments No. 2 Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the groundwater components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

RGS Bore Logs (MW1 to MW4)
Slug Test Analysis Report Sheets
Figure B1 – Groundwater Level vs Rainfall

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - BOREHOLE

BOREHOLE NO: **MW1**
CLIENT: Allam Property Group
PAGE: 1 of 1
PROJECT NAME: Proposed MHE
JOB NO: RGS03137.1
SITE LOCATION: 40-80 Chapmans Road, Tuncurry
LOGGED BY: APH
TEST LOCATION: See Figure 3
DATE: 7/10/22

DRILL TYPE: 6T Kubota Excavator
EASTING:
SURFACE RL:
BOREHOLE DIAMETER: 100 mm
INCLINATION: 90°
NORTHING:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (Not measured)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T				0.20m		SC	**TOPSOIL:** Clayey SAND, fine to medium grained, dark grey/black, clay, low plasticity, some roots	M				TOPSOIL
	▽ 7/10/2022			2.00m		SP	**SAND:** Fine to medium grained, grey/pale grey					AEOLIAN
							Hole Terminated at 2.00 m					

LEGEND:

Water

- ▼ Water Level (Date and time shown)
- ► Water Inflow
- ◄ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - BOREHOLE

CLIENT: Allam Property Group
PROJECT NAME: Proposed MHE
SITE LOCATION: 40-80 Chapmans Road, Tuncurry
TEST LOCATION: See Figure 3

BOREHOLE NO: **MW2**
PAGE: 1 of 1
JOB NO: RGS03137.1
LOGGED BY: APH
DATE: 7/10/22

DRILL TYPE: 6T Kubota Excavator
BOREHOLE DIAMETER: 100 mm
INCLINATION: 90°
EASTING:
NORTHING:
SURFACE RL:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (Not measured)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T				0.2	▨	SC	**TOPSOIL:** Clayey SAND, fine to medium grained, dark grey/black, clay, low plasticity, some roots	M				TOPSOIL
				0.20m 0.4 0.6	░	SC	**Clayey SAND:** Fine to coarse grained, brown/dark brown, clay, low plasticity, trace roots					LIGHTLY INDURATED SAND
	▽ 7/10/2022			0.8 1.0	░							
				1.00m 1.2 1.4 1.6 1.8	░	SP	**SAND:** Fine to medium grained, grey/pale grey/pale brown	W				AEOLIAN
				2.00m			Hole Terminated at 2.00 m					

LEGEND:

Water

▼ Water Level
(Date and time shown)
►— Water Inflow
—◄ Water Outflow

Strata Changes

– – – Gradational or transitional strata
——— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - BOREHOLE

BOREHOLE NO: MW3

CLIENT: Allam Property Group

PAGE: 1 of 1

PROJECT NAME: Proposed MHE

JOB NO: RGS03137.1

SITE LOCATION: 40-80 Chapmans Road, Tuncurry

LOGGED BY: APH

TEST LOCATION: See Figure 3

DATE: 7/10/22

DRILL TYPE: 6T Kubota Excavator

EASTING:

SURFACE RL:

BOREHOLE DIAMETER: 100 mm

INCLINATION: 90°

NORTHING:

DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (Not measured)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T				0.0 – 0.25m	▨	CL	**TOPSOIL:** Silty CLAY, low plasticity, dark grey/black, some sand, fine to medium grained, some roots	M				TOPSOIL
	7/10/2022			0.25m – 2.00m	⁙	SC	**Clayey SAND:** Fine to coarse grained, pale grey/pale brown, clay, low plasticity, some roots					ALLUVIAL SOIL
				2.00m			Hole Terminated at 2.00 m					

0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8

LEGEND:

Water

Water Level (Date and time shown)

Water Inflow

Water Outflow

Strata Changes

— — Gradational or transitional strata

—— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - BOREHOLE

CLIENT: Allam Property Group
PROJECT NAME: Proposed MHE
SITE LOCATION: 40-80 Chapmans Road, Tuncurry
TEST LOCATION: See Figure 3

BOREHOLE NO: MW4
PAGE: 1 of 1
JOB NO: RGS03137.1
LOGGED BY: APH
DATE: 7/10/22

DRILL TYPE: 6T Kubota Excavator
BOREHOLE DIAMETER: 100 mm **INCLINATION:** 90°
EASTING:
NORTHING:
SURFACE RL:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (Not measured)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/T	▽ 7/10/2022			0.2 0.4 0.50m		SC	**FILL:** Clayey SAND, fine to medium grained, dark grey/black, clay, low plasticity, some roots	M				FILL/TOPSOIL
				0.6 0.70m		SC	**TOPSOIL:** Clayey SAND, fine to medium grained, dark grey/black, some roots					TOPSOIL
				0.8 1.0 1.2 1.20m		SC	**Clayey SAND:** Fine to coarse grained, brown/pale brown, clay, low plasticity	W				LIGHTLY INDURATED SAND
				1.4 1.6 1.8 2.00m		SC	**Clayey SAND:** Fine to coarse grained, pale grey/pale brown, clay, low plasticity					ALLUVIAL SOIL
							Hole Terminated at 2.00 m					

LEGEND:

Water

▼	Water Level (Date and time shown)
▶	Water Inflow
◀	Water Outflow

Strata Changes

— — —	Gradational or transitional strata
———	Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

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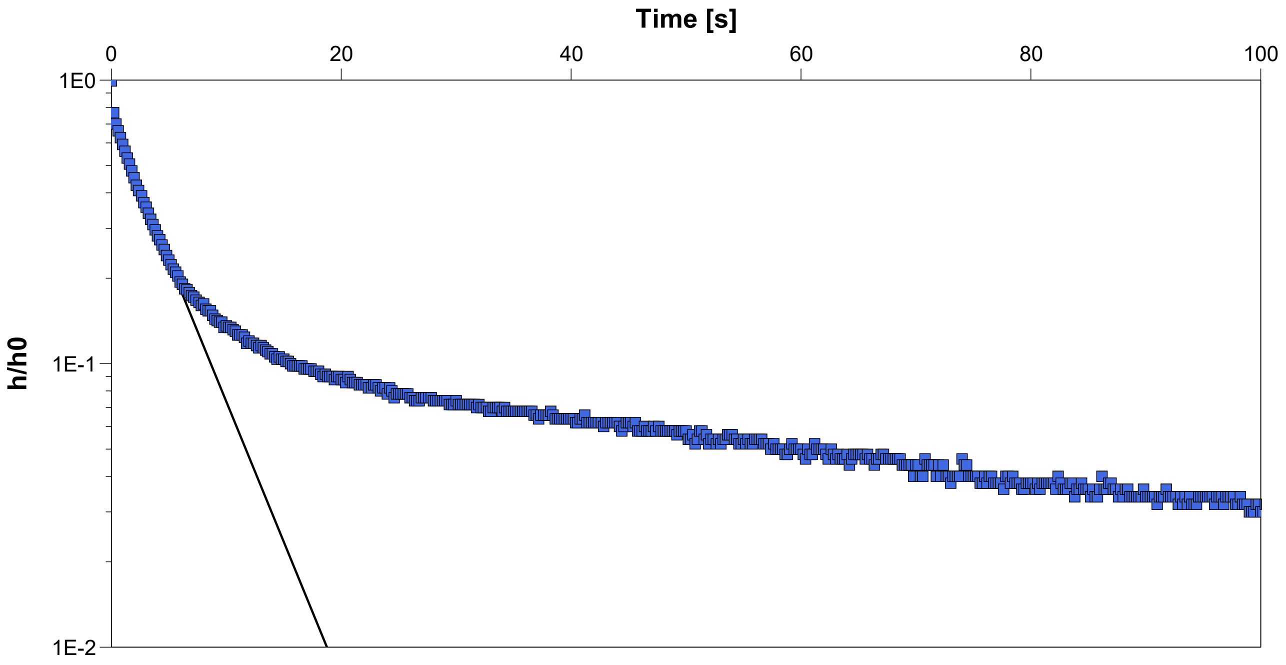
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW1-1	Test Well: MW1
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW1-1	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	2.40×10^{-4}	

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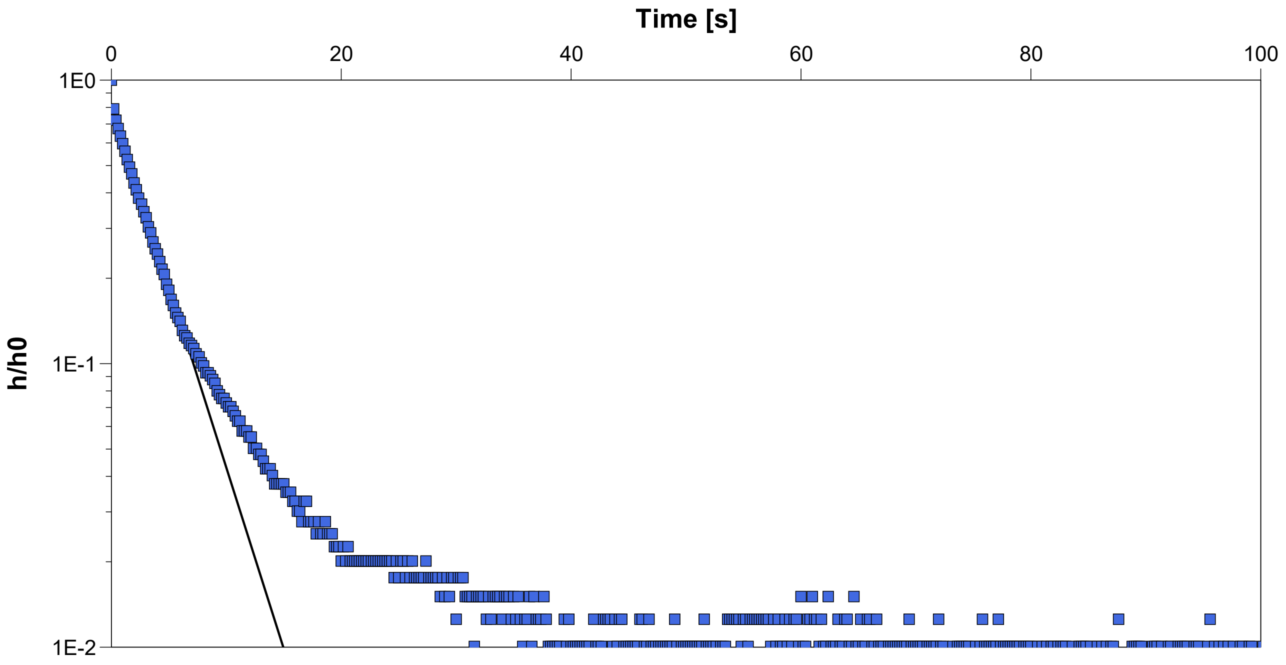
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW1-2	Test Well: MW1
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW1-2	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	3.10×10^{-4}	

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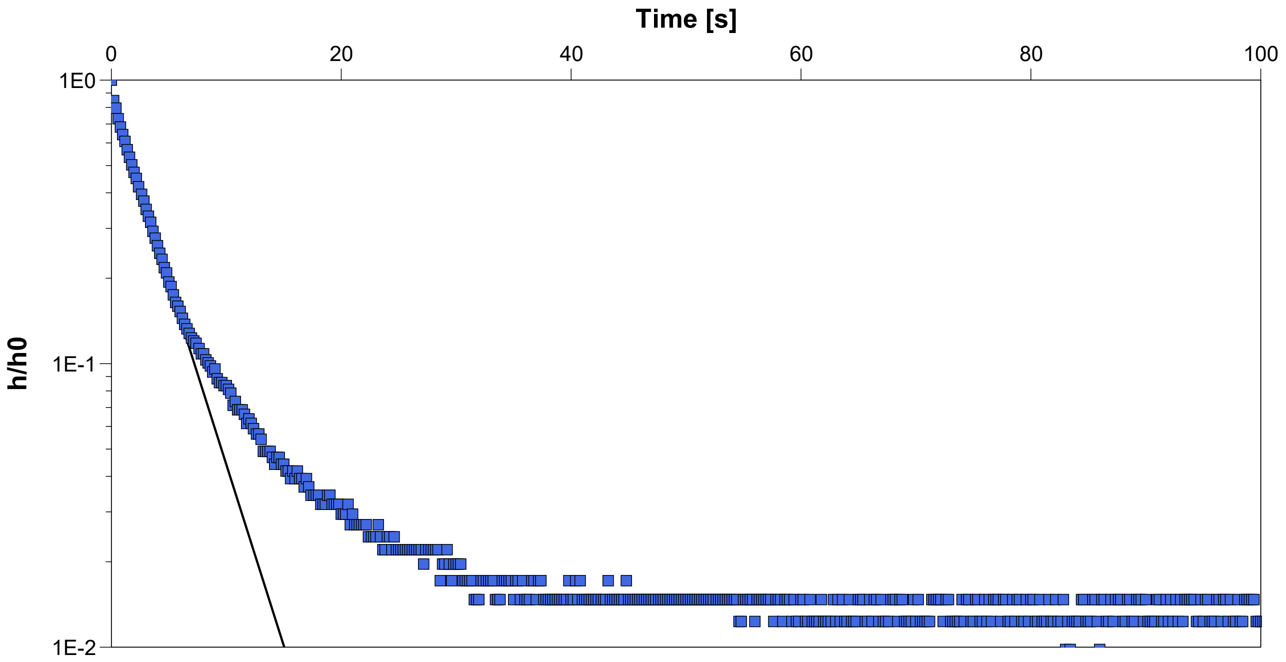
Slug Test Analysis Report
Project: Proposed Manufactured Housing Estate
Number: 219536.00
Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW1-3	Test Well: MW1
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW1-3	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	3.10×10^{-4}	

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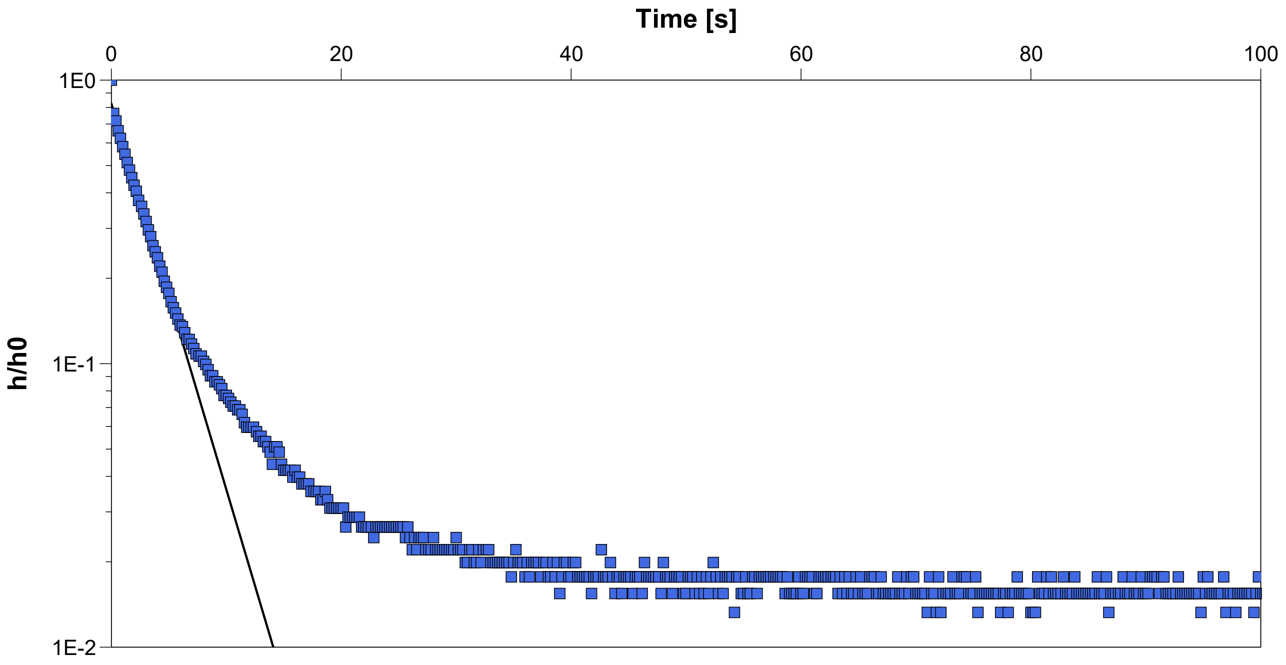
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW1-4	Test Well: MW1
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW1-4	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	3.30×10^{-4}	

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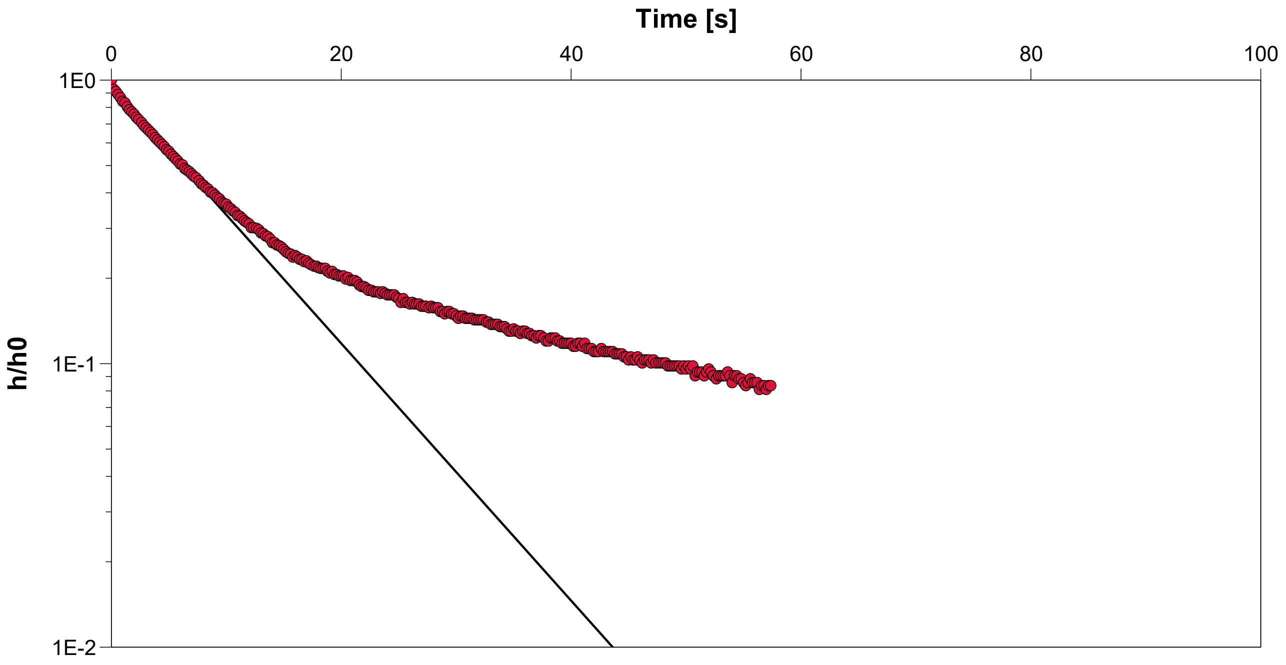
Slug Test Analysis Report	
Project:	Proposed Manufactured Housing Estate
Number:	219536.00
Client:	Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW3-1	Test Well: MW3
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW3-1	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW3	1.10×10^{-4}	

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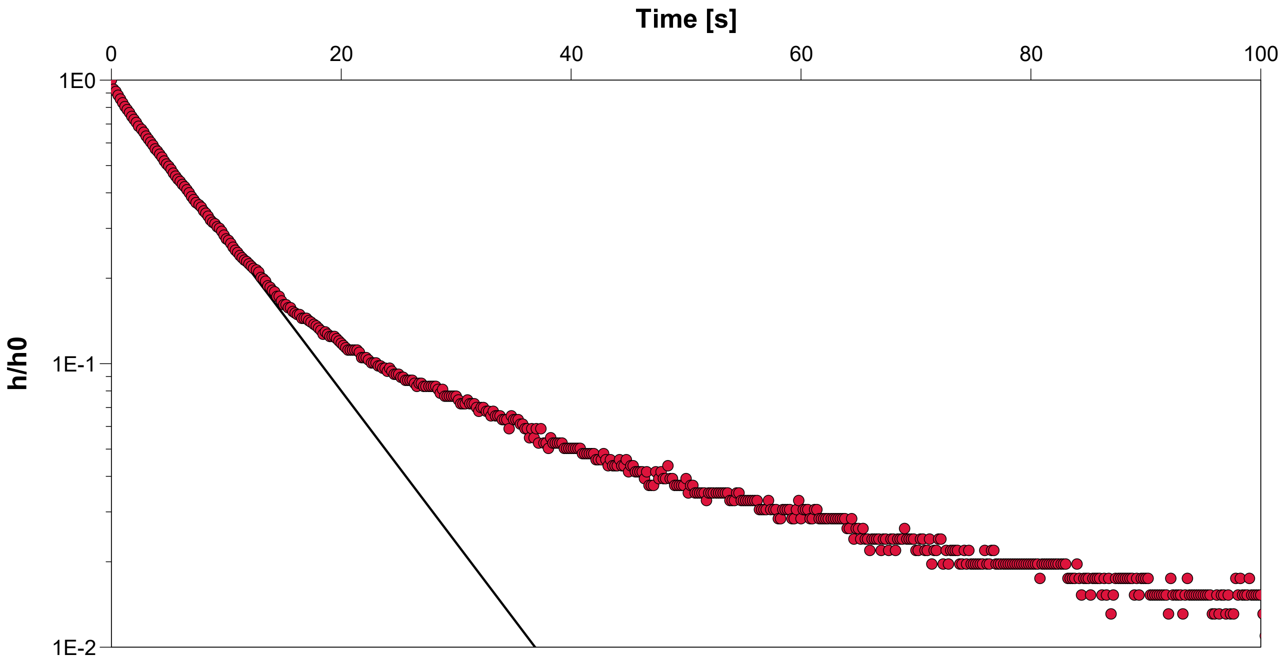
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW3-2	Test Well: MW3
Test Conducted by:		Test Date: 11/05/2023
Analysis Performed by: JCL	MW3-2	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW3	1.30×10^{-4}	

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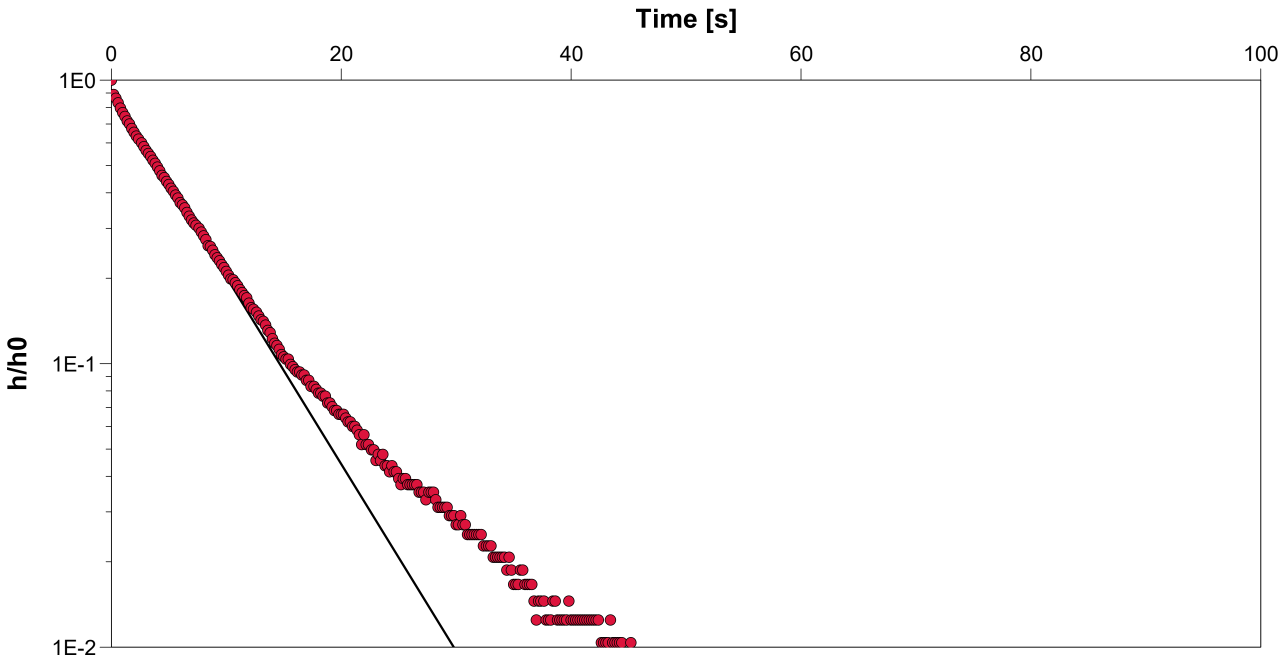
Slug Test Analysis Report
Project: Proposed Manufactured Housing Estate
Number: 219536.00
Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW3-3	Test Well: MW3
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW3-3	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW3	1.60×10^{-4}	

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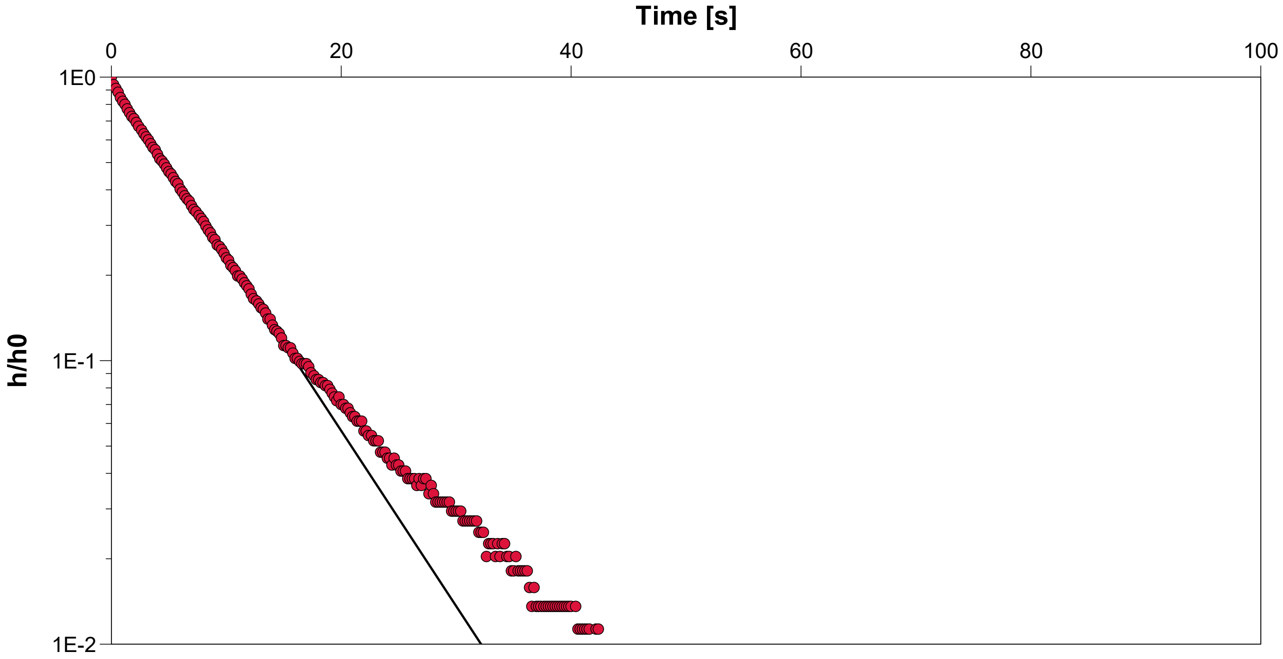
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW3-4	Test Well: MW3
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW3-4	Analysis Date: 11/05/2023
Aquifer Thickness:		

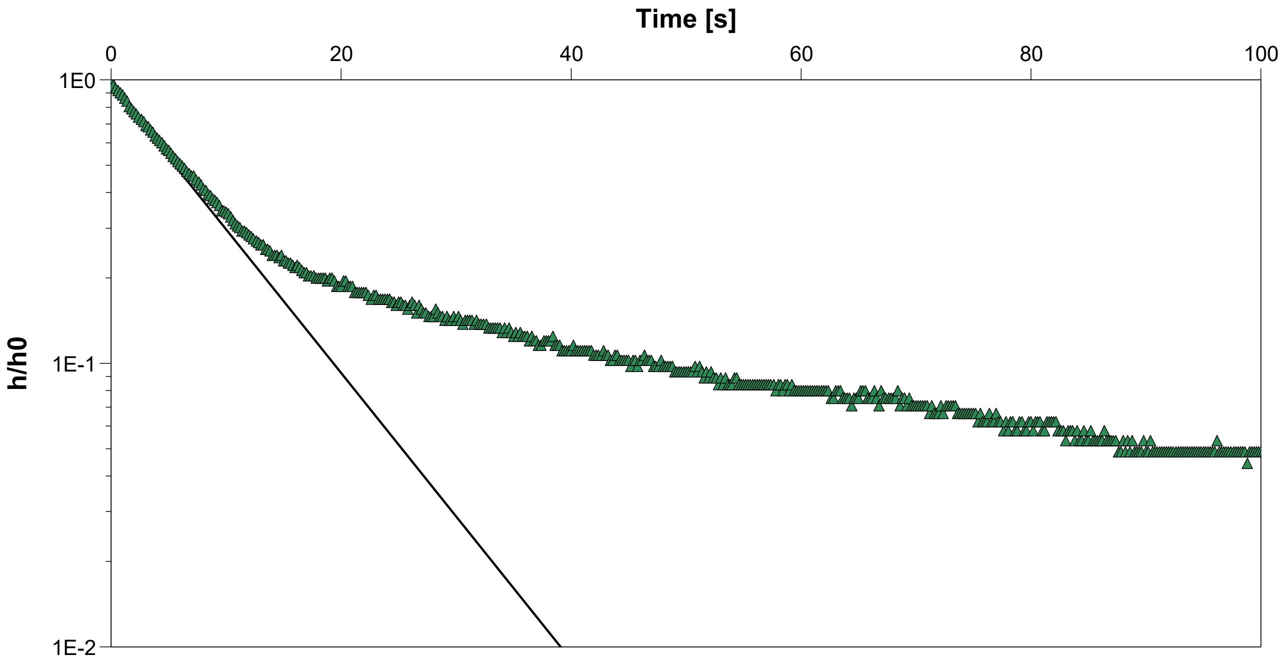


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW3	1.50×10^{-4}	

Douglas Partners Geotechnics / Environment / Groundwater	**Slug Test Analysis Report**
	Project: Proposed Manufactured Housing Estate
	Number: 219536.00
	Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-1	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-1	Analysis Date: 11/05/2023
Aquifer Thickness:		

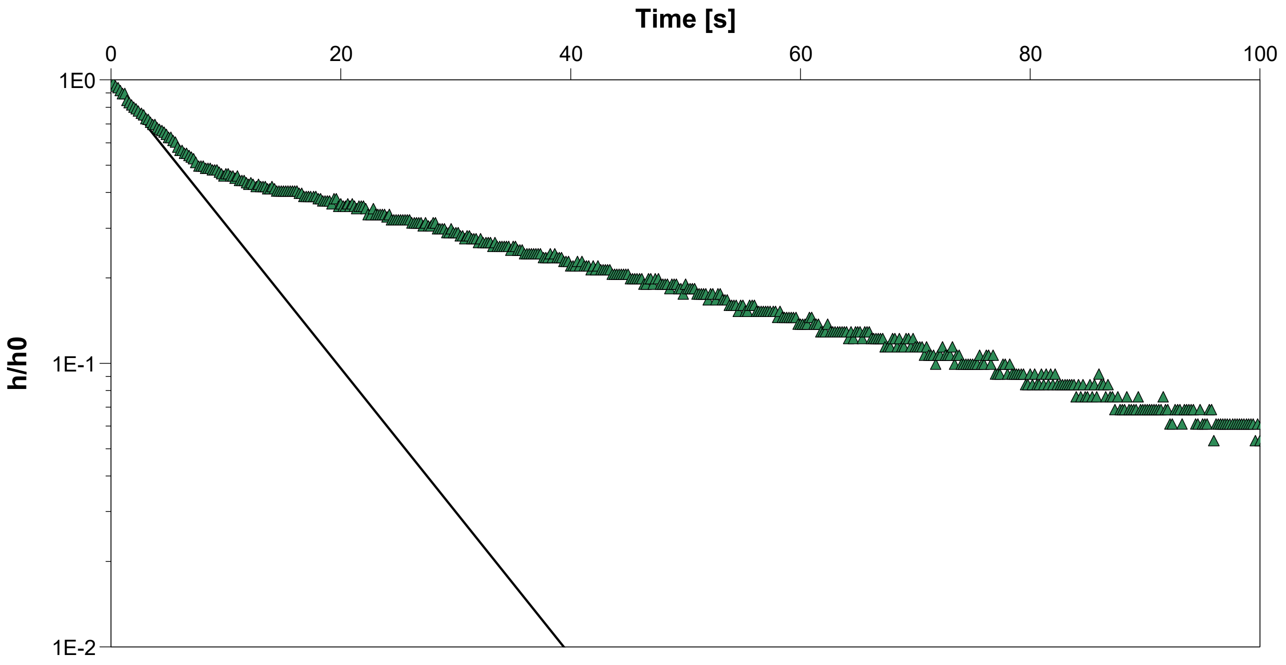


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.00×10^{-4}	

Douglas Partners Geotechnics / Environment / Groundwater	**Slug Test Analysis Report**
	Project: Proposed Manufactured Housing Estate
	Number: 219536.00
	Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-2	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-2	Analysis Date: 2/05/2023
Aquifer Thickness:		

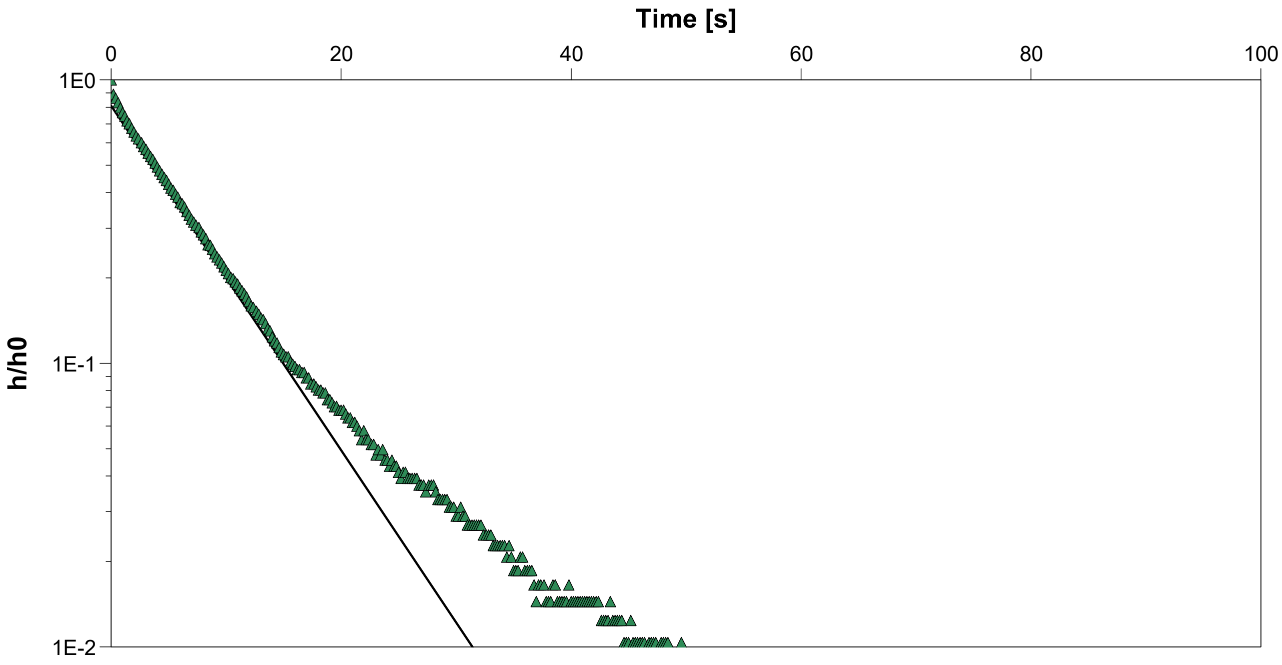


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.00×10^{-4}	

Douglas Partners Geotechnics / Environment / Groundwater	**Slug Test Analysis Report**
	Project: Proposed Manufactured Housing Estate
	Number: 219536.00
	Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-3	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-3	Analysis Date: 11/05/2023
Aquifer Thickness:		

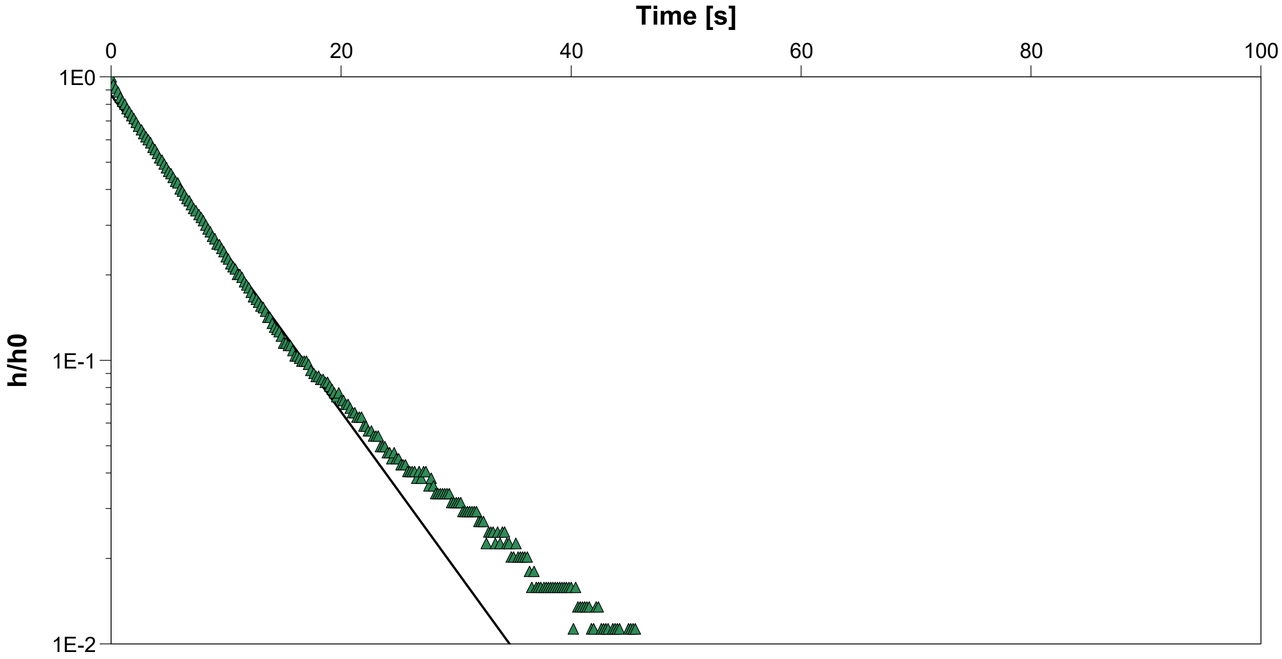


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.20×10^{-4}	

Douglas Partners Geotechnics / Environment / Groundwater	**Slug Test Analysis Report**
	Project: Proposed Manufactured Housing Estate
	Number: 219536.00
	Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-4	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-4	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.10×10^{-4}	

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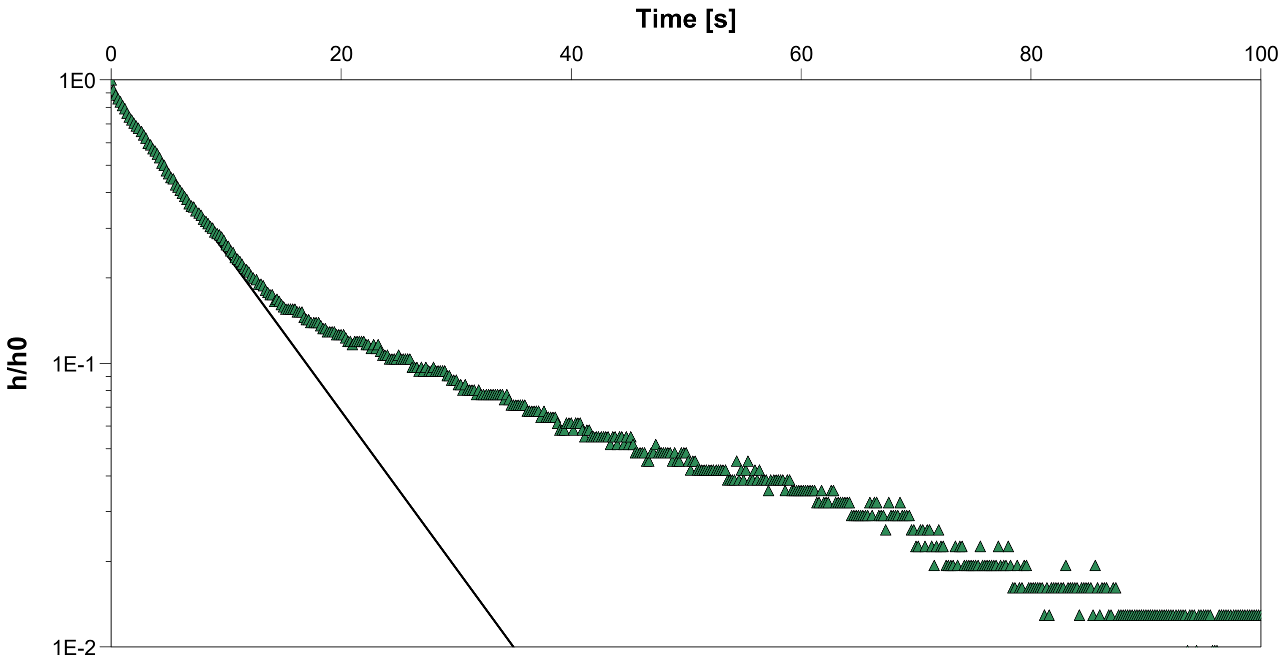
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-6	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-6	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.10×10^{-4}	

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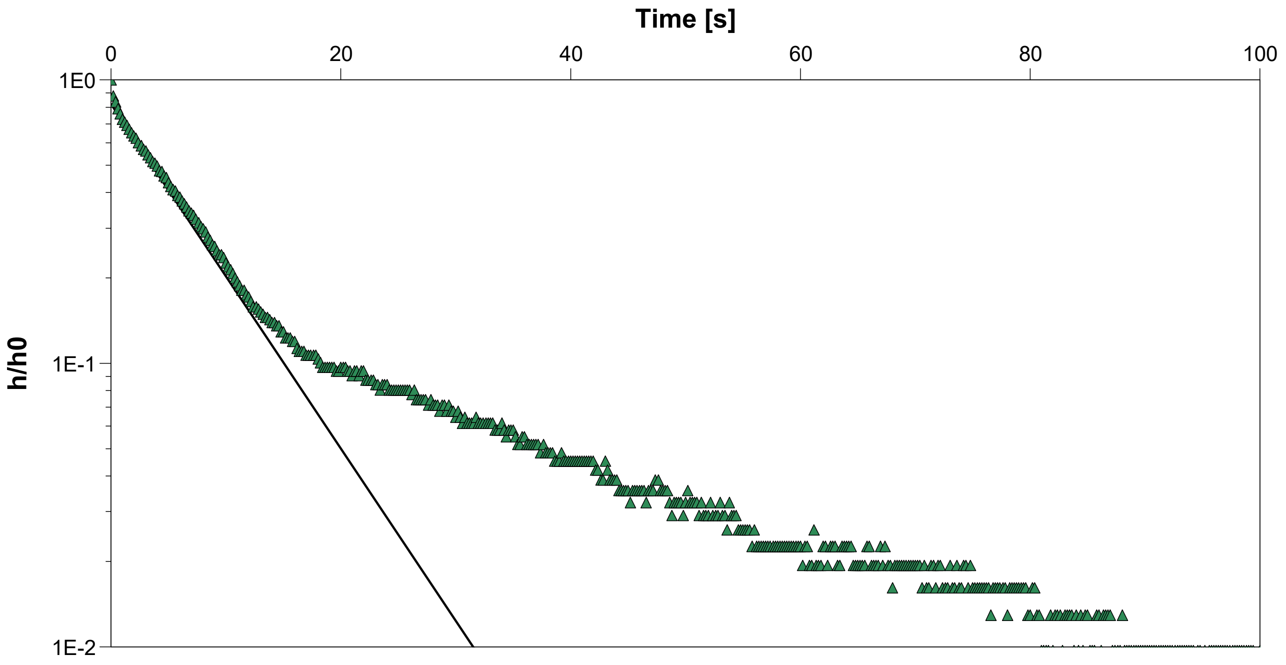
Slug Test Analysis Report

Project: Proposed Manufactured Housing Estate

Number: 219536.00

Client: Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-7	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-6	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.20×10^{-4}	

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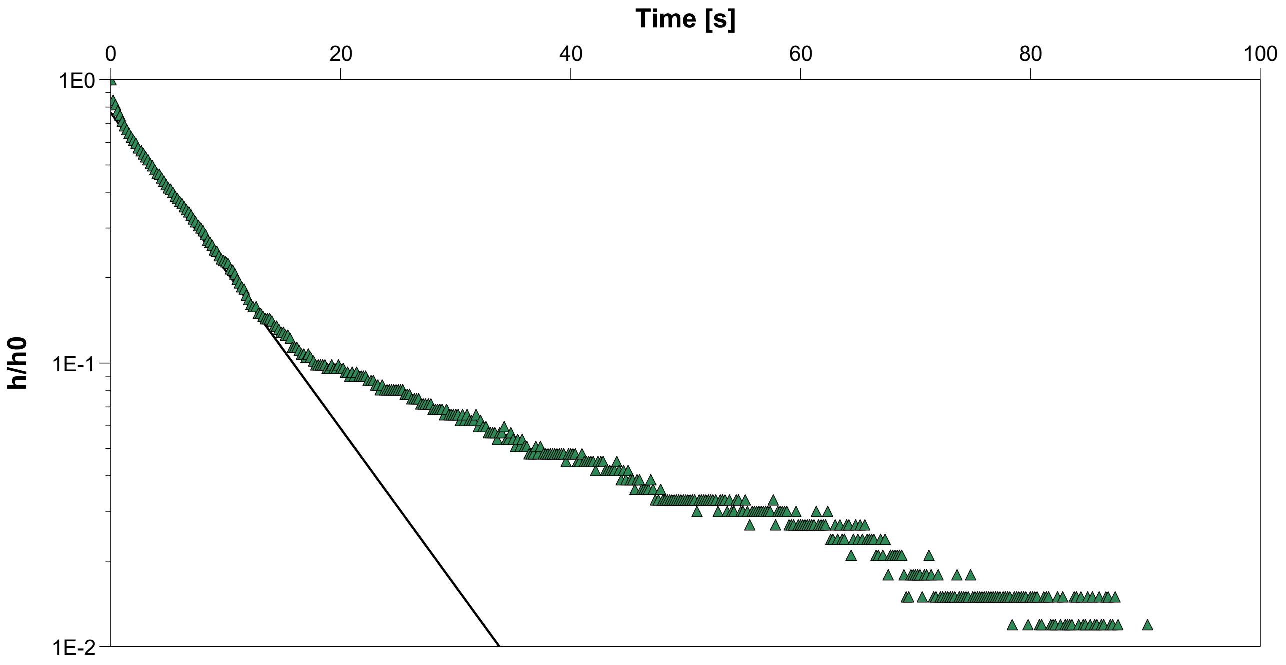
Geotechnics / Environment / Groundwater

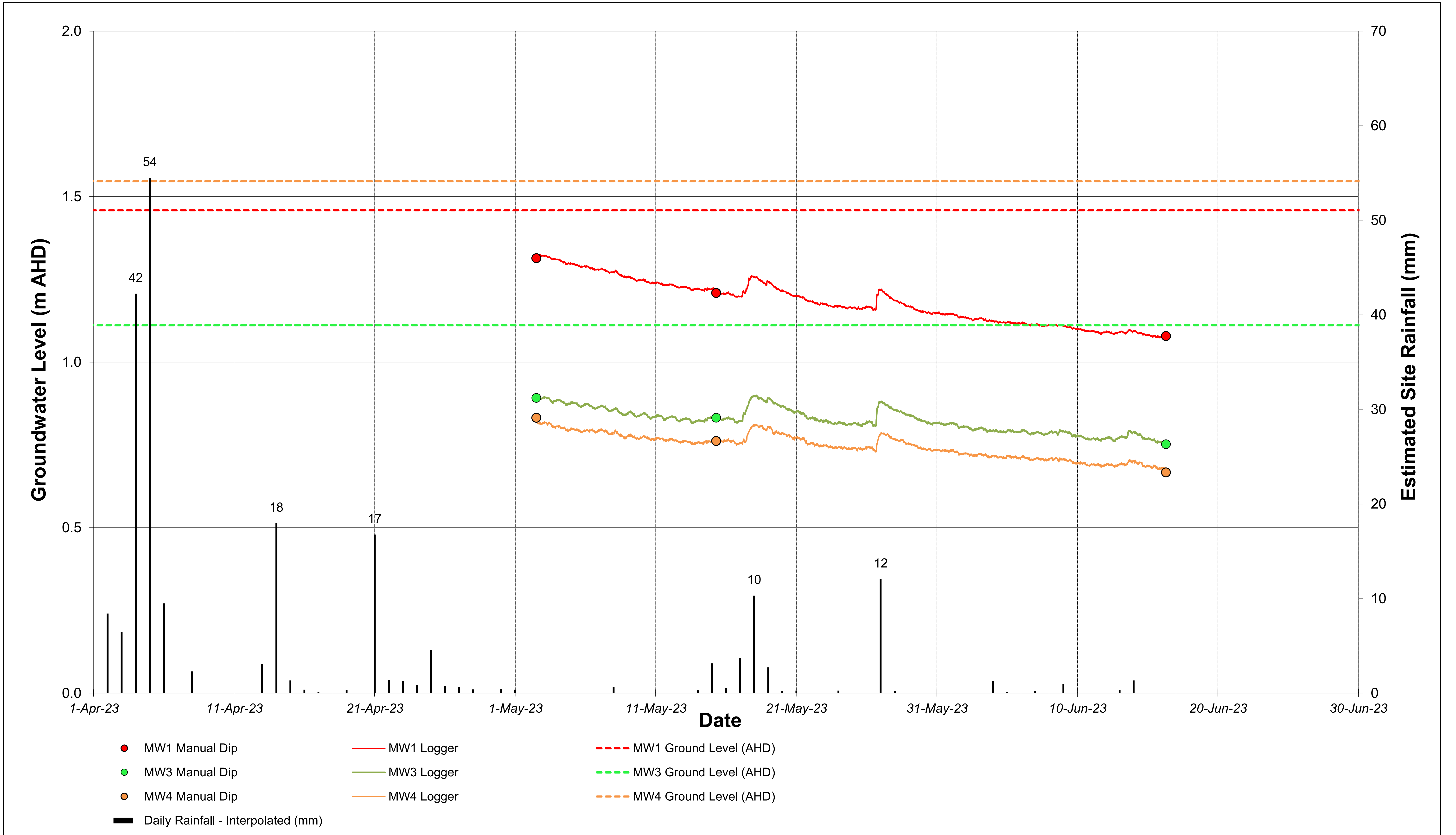
Slug Test Analysis Report	
Project:	Proposed Manufactured Housing Estate
Number:	219536.00
Client:	Allam Property Group

Location: 40-80 Chapmans Road, TUNCURRY	Slug Test: MW4-8	Test Well: MW4
Test Conducted by: JCL		Test Date: 2/05/2023
Analysis Performed by: JCL	MW4-8	Analysis Date: 11/05/2023
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4	1.10×10^{-4}	



Douglas Partners
Geotechnics / Environment / Groundwater

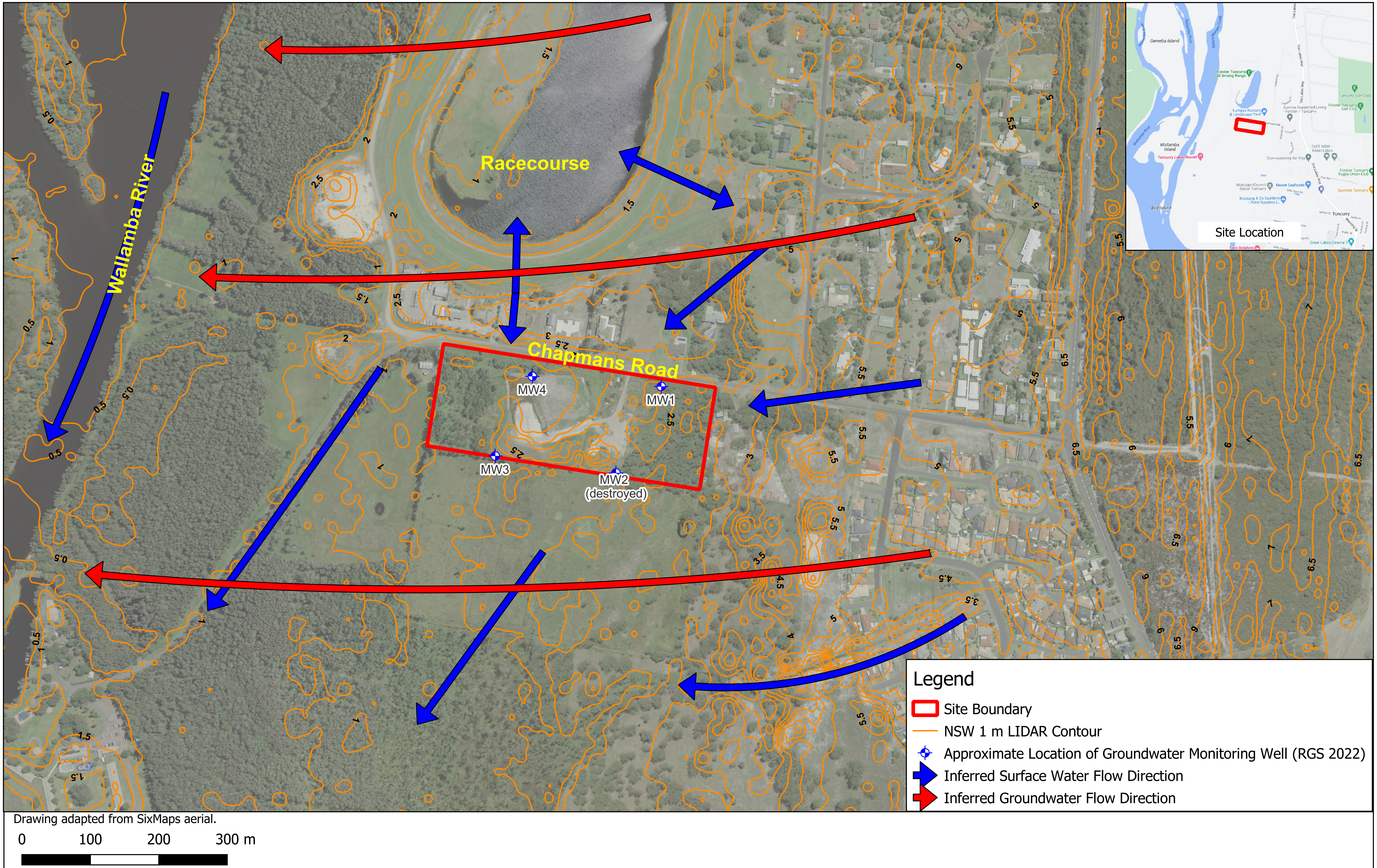
CLIENT: Allam MHE Developments No. 2 Pty Ltd	
OFFICE: Newcastle	DRAWN BY: JCL
SCALE: N/A	DATE: 19 June 2023

Groundwater Level vs Rainfall (May 2023 to June 2023)
Proposed Manufactured Home Estate
40 - 80 Chapmans Road, Tuncurry

PROJECT NO: 219536.00
FIGURE NO: 1
REVISION: 0

Appendix C

Drawing 1 – Site Plan and Inferred Surface Water and Groundwater Flow Direction



Drawing adapted from SixMaps aerial.

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Allam MHE Developments No. 2 Pty Ltd
OFFICE: Newcastle
DRAWN BY: JCL
SCALE: 1:5000 @ A3
DATE: 05.July.2023

TITLE: **Site Plan and Inferred Surface Water and Groundwater Flow Direction**
Groundwater Study
40-80 Chapmans Road, Tuncurry

N

PROJECT: 219536.00
DRAWING No: 1
REVISION: 1