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ANKETELL ROAD UPGRADE PROJECT

PRELIMINARY GROUNDWATER ASSESSMENT

Main Roads Western Australia

REPORT NO. 12106RAL02A

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1. Introduction

Main Roads Western Australia (Main Roads) is proposing to upgrade Anketell Road to an Expressway Standard between Leath Road and Kwinana Freeway (the Proposal). The Proposal also includes roadworks on a small section of Anketell Road between the freeway and Treeby Road to connect the Proposal to the existing Anketell Road. Figure 1 shows the Proposal Development Envelope (DE), covering approximately 8.5 km of road alignment.

FSG Geotechnics and Foundations (FSG) has been engaged by Main Roads to prepare a groundwater assessment for the Proposal to support environmental approvals. The purpose of this study is to assess the potential groundwater impacts due to dewatering requirements during construction and groundwater abstraction required to supply construction water. This assessment will support State and Commonwealth environmental approvals.

To avoid confusion, figures embedded in the report text are numbered alphabetically and figures attached to the end of the report text are numbered numerically.

2. Scope of Work

The scope of work for the desktop groundwater assessment is as follows:

- Develop a 3D numerical groundwater flow model that includes the whole of the DE area.
- Run numerous groundwater model scenarios to determine construction dewatering rates and local groundwater impacts from the construction water supply abstraction:
    - Construction dewatering for the proposed underpass at Treeby Road.
    - Groundwater abstraction from multiple locations within the DE area.

3. Concept Design

This study considers an approximately 8.5 km section of the proposed Anketell Road upgrade. The project is predominantly located within the City of Kwinana.

The concept design includes the following main structures (refer to Figure 1):

- **Structure 1**: Three bridges over three railway lines.
- **Structure 2**: Rockingham Road bridge over the new Anketell Road upgrade alignment.
- **Structure 3**: Armstrong Road Motorplex Entrance bridge over new Anketell Road upgrade.
- **Structure 4**: Abercrombie Road bridge over new Anketell Road upgrade.
- **Structure 5**: Bridge over new Anketell Road upgrade connecting Alcoa sites.
- **Structure 6**: Clementi Road underpass.
- **Structure 7**: Mandogalup Road bridge over new Anketell Road upgrade.
- **Structure 8**: Kwinana Fwy over new Anketell Road upgrade.
- **Structure 9:** Dive Structure beneath Narran Street and Treeby Road.

Surface roads will be constructed to maintain full connectivity to the intersecting roads.

The proposed road alignment results in approximately 390,000 m^3 of cut and 2,040,00 m^3 of fill, indicating a total fill requirement of around 1,650,000 m^3 (Ref [11]).

4. Site Conditions

4.1 Site Location

The DE covering this study includes:

- An 8.5 km long road alignment in a west to east direction, which runs from approximately 400 m east of the Indian Ocean to approximately 200 m east of Treeby Road.
- Approximately 2 km long section of Rockingham Road running in a south to north direction, crossing the Anketell Road alignment.
- Approximately 1.4 km long section of Abercrombie Road running in a south to north direction, crossing Anketell Road.
- Approximately 1.3 km long section of Kwinana Freeway running in a south to north direction, crossing Anketell Road.
- Smaller side roads at distances up to 450 m and a proposed new entrance road (500 m) to Perth Motorplex.

Some of the key locations around the DE relevant to this study are (refer to Figure 1):

- The industrial area located west of Rockingham Road where the proposed new Westport is proposed to be located.
- Historical Alcoa tailings facilities (or residue areas) located on the southern side of Anketell Road.
- Operating tailings facilities located on the northern side of Anketell Road.
- Kwinana Wastewater Treatment Plant (KWWTP) located on the southern side of Anketell Road.
- The Spectacles North, which is the largest conservation wetland in the area. Other wetlands and a Tumulus spring also exist in the area (Section 4.5).
- The Peel Main Drain crosses Anketell Road, which forms part of the Jandakot drainage system.
- P1 and P2 Public Drinking Water Source (PDWS) Areas (i.e. Jandakot Underground Water Pollution Control Area) are located approximately 300 m east of the eastern DE boundary.

4.2 Topography

The existing vertical alignment is generally undulating, with surface elevations typically between about RL 5 m AHD and RL 24 m AHD.

4.3 Geology

Figure 2 shows an extract of the Fremantle sheet of the 1:50,000 Environmental Geology Map Series while Appendix B shows a geological long section along the Anketell Road upgrade alignment. The cross-section was created by combining the two geological sections presented in references [10] and [20] and then adjusted to the new alignment with the existing and design surfaces. The only difference to the generated geological sections is a re-interpretation of the bore logs from reference [20] and the introduction of the Becher Sand 2 layer, which based on our experience in the area has different hydrogeological properties and can act as an aquitard (refer to note on Appendix B).

Figure 2 and Appendix B indicates:

- **West of Rockingham Road** – Safety Bay Sand (S_{13}) overlying Becher Sand, Tamala Limestone (LS_1) and then Osborne Formation (Kardinya Shale member).
- **Rockingham Road to the Spectacles** – Tamala Sand (S_7) and Tamala Limestone (LS_1). Guildford Formation and Bassendean Sand (S_8) may be present at depth east of Hendy Road (just west of Abercrombie Road).
- **The Spectacles to Treeby Road** – Transition zone between Bassendean Sand (S_8) and Tamala Sand (S_7) at the surface underlain by Bassendean Sand (S_8) and Guildford Formation at depth. It is

noted that different reports present the surface geology slightly differently in this area (e.g. reference [8] depicts it as being fully covered by Tamala Sand while reference [10] depicts it as Bassendean Sand (and Gnangara Dune Sand)) with the report text also describing this area to possibly consist of thin Bassendean Sand over Guildford Formation (S_{10}).

Near the existing wetlands (e.g. The Spectacles and Mandogalup) the surface geology is described as Swamp Deposits (sandy silt)(MS_5).

Though the Osborne Formation (Kardinya Shale member) was not encountered in the geotechnical boreholes at their target depths, available public information (e.g. reference [3]) indicate that the whole alignment is underlain by Osborne Formation (Kardinya Shale member) between about RL -25 m AHD near Rockingham Road and RL -20 m AHD inland.

The geology has been described in detail in references [10] and [20].

4.4 Acid Sulfate Soils

The DWER Acid Sulfate Soil (ASS) risk map for the soil within 3 m of the ground surface indicates (refer to Figure 2 for geological extents):

- **No Known ASS disturbance risk** in areas covered by Safety Bay Sand (S_{13}), Tamala Sand (S_7) and Tamala Limestone (LS_1)
- **Low to Moderate ASS disturbance risk** in areas covered by Bassendean Sand (S_8) or thin Bassendean Sand over Guildford Formation (S_{10}).
- **Moderate to High ASS disturbance risk** in areas covered by swamp deposits (wetlands) which are known to often contain peaty material.

It is noted that both Bassendean Sand and Guildford Formation geological units are known to either be acidic soils or contain ASS. Preliminary ASS testing reported in reference [10] did not indicate the presence of Actual ASS (AASS) and Potential ASS (PASS) in the boreholes drilled beneath the alignment covered by the DE, though it is noted that the majority of these samples were collected above the groundwater table. It is therefore considered possible the soil present in excavations in Bassendean Sand and Guildford Formation below the groundwater table may consist of PASS.

4.5 Surface Water and Wetlands

Figure 3 shows surface water features and geomorphic wetlands where the Swan Coastal Plain wetlands have been evaluated and assigned an appropriate management category, providing guidance on the nature of the management and protection the wetland should be afforded i.e. Conservation, Resource Enhancement, or Multiple Use category.

The closest wetlands located within 500 m of the DE are:

- **Conway Dampland,** which is classified as Resource Enhancement (second highest classification), is located about 30 m from the DE (east of Rockingham Road and north of Anketell Road).
- **Hendy Road Dampland**, which is classified as Multiple Use (third highest classicisation), is located about 225 m north of the DE (west of Abercrombie Road).
- **Abercrombie Road Dampland,** which is classified as Resource Enhancement, is located about 275 m from the DE (west of Abercrombie Road).
- **The Spectacles North Sumpland,** which is classified as Conservation (highest classification), is located within 125 m of the DE.
- **Mandogalup Road Dampland,** which is classified as Multiple Use, is located within and north of the DE, (north of Anketell Road and between Clementi Road and Mandogalup Road). It is noted that this dampland is now being controlled by an open drain that forms part of the Peel Main Drain system.
- **Mandogalup South and Mid-South Sumpland,** which is classified as Multiple Use to Classification (different classification across the area), is located within and north of the DE (north of Anketell Road and on both sides of Kwinana Fwy). The area located within the DE is classified as Multiple Use while conservation classification is located just outside of the DE. It is noted that:

- A Tumulus Spring is reported within the Multiple Use Sumpland, about 600 m north of Treeby Road.
- Open drainage channels that form part of the Peel Main Drain System, are located within the Multiple Use Sumpland.

As mentioned in Section 4.1 the Peel Main Drain crosses Anketell Road just east of Clementi Road flowing from north to south and into the Spectacles North.

Four infiltration ponds covering a total area of around 1.5 Ha, associated with the Kwinana Wastewater Treatment Plant (KWWTP), are located approximately 540 m south Anketell Road (west of the Spectacle North). Reference [3] indicates that the KWWTP started operating in 1975 and secondary treated wastewater from the plant gets infiltrated into the groundwater aquifer using those infiltration ponds. The disposal was reported to be 4.7 ML/d, corresponding to around 54 L/s or 1.7 GL/yr, which is reported to have resulted in a groundwater mound beneath the infiltration ponds with radial groundwater flow away from the ponds.

Several other man-made ponds exist in the area, but they are all expected to be lined.

4.6 Contaminated Sites

Figure 4 shows the results of a DWER Contaminated Sites Database enquiry and indicates that there are numerous sites located along the alignment:

- **West of Rockingham Road** - Numerous sites located near the alignment within the industrial area has been classified as "Contaminated – Restricted Use"
- **East of Rockingham Road** - The sites with the Alcoa tailings facilities are classified as "Contaminated – Remediation Required".

Reference [2] states that in 2020 an alkali plume extended approximately 900 m to the northwest of the historical Alcoa tailings facilities located south of the alignment (just south of Anketell Road and east of Rockingham Road). Alcoa has numerous groundwater recovery bores (several are located on the south-eastern corner of Rockingham Road and Anketell Road) to capture/contain mobilisation of off-site plumes from the tailings facilities.

4.7 Groundwater

4.7.1 Aquifers

The main regional aquifer of relevance for this study is the Superficial Aquifer comprising Safety Bay Sand, Becher Sand 1, Tamala Sand, Bassendean Sand, Guildford Formation and Tamala Limestone, which is an unconfined aquifer overlying the Osborne Formation, which in this area is considered an aquitard. The saturated thickness of the Superficial Aquifer beneath the alignment ranges between approximately 20 m to 40 m.

West of Rockingham Road the Becher Sand 2 is known to act as an aquitard, separating the Superficial Aquifer into an Upper Aquifer (above the Becher Sand 2) and a Lower Aquifer (below the Becher Sand 2). There is typically a downward hydraulic gradient between the two aquifers.

4.7.2 Groundwater Levels

Figures 5A to 5C present collated groundwater level information (contours and well locations), which was obtained from the following sources:

- Groundwater level contours from the 1997, 2004 and 2019 Groundwater level Atlases (publicly available information).
- DWER Water Information Reporting (WIR) database, from which monitoring wells from 39 locations in the area with relevant groundwater level information from the Superficial Aquifer were selected and downloaded. Of the 39 well locations, 20 well locations are located around the KWWTP.
- 18 project monitoring wells installed in the area of and along the project alignment in 2021 (8 wells) and 2023 (10 wells) during geotechnical investigations (references [10] and [20]). Groundwater level

monitoring using automated groundwater level loggers was undertaken in all monitoring wells in 2023 with groundwater level hydrographs available to present date (monitoring is still ongoing).

- 10 monitoring wells were installed in 2023 west of Rockingham Road as part of the Westport investigations. Of the 10 wells, 6 wells are screened in the Upper Aquifer, 2 in the Lower Aquifer and 2 in the Kardinya Shale (aquitard). However, it is noted that the geotechnical boreholes were all drilled to depths between 40 m and 45 m and that the boreholes where then backfilled with filter pack without installing a bentonite plug in the Becher Sand 2 aquitard, which questions the validity of the monitoring wells being representative of the screened sub-aquifer (i.e. it is likely to represent a combination of the two sub-aquifers). Based on this, the groundwater levels in these monitoring should be used with caution until it is established if two sub-aquifers exist in the Superficial Aquifer and what the head difference is between the aquifers.
- 8 monitoring wells were installed in 2021 along Anketell Road (GBH09 is located 400 m east of the eastern DE boundary). All wells are installed in the Superficial Aquifer.

Appendix C presents a summary table with construction details of the collated monitoring wells.

Groundwater Atlases

The 1997 Perth Groundwater Atlas presents the inferred historical maximum groundwater level contours, which range between approximately RL 1 m AHD and RL 20 m AHD across the DE with similar flow directions. It is noted that the Atlas may consider old wetlands or drains that have been installed/removed, and may therefore not be presentative of the current site conditions. The hydraulic gradient (i.e. distances between the 1m contours) changes significantly along the alignment. Where the hydraulic gradients are steeper (i.e. where contours are more closely spaced) the aquifer transmissivity is smaller. Such changes can normally be found at geological changes. The very flat gradient in the western part of the alignment indicates that the Tamala Sand/Limestone has the highest aquifer transmissivity.

The 2004 Perth Groundwater Atlas presents the inferred May 2003 (dry season) groundwater level contours, which range between approximately RL <1 m AHD and RL 18 m AHD across the DE with similar east to west flow directions. It is noted that the Atlas may not always represent the measured May 2003 groundwater level observations that well due to the adopted interpolation methodology, and this Atlas should therefore be used with caution in this context.

The 2019 Perth Groundwater Map contours represent regionally modelled seasonal maximum groundwater levels, which range between approximately RL <1 m AHD and RL 19 m AHD across the DE with similar east to west flow directions. It is noted that these groundwater contours represent a regional developed groundwater model and do not consider all localised conditions (e.g. it does not appear the Peel Main Drains or the Spectacles have been considered in this area).

Groundwater Level Hydrographs

Figure 6 shows all the collated hydrographs for the full monitoring period. Figures 6A to 6C separate the hydrographs into west, central and eastern sections along the alignment.

Figure 7 shows all the collated hydrographs for the last 5 years (2019 to 2024). Figures 7A to 7C separate the hydrographs into west, central and eastern sections along the alignment.

The groundwater level hydrographs can generally be summarised as follows:

- **Western Section (west of the RL 3 m AHD Groundwater Level Contour):**
  - The long-term groundwater level hydrographs from wells located in the western part of the alignment (Tamala Sand/Limestone) generally shows an overall steady groundwater level trend (slight decreasing trend from the 1970s to 2010s followed by a slight increasing trend until present date).
  - The project wells generally have a similar trend and seasonal variation as the DWER wells.
  - The seasonal variation in these wells is generally around 0.5 m to 1.0 m, indicating a transmissive aquifer and in some wells tidal influence/control.
  - The project monitoring wells located near the ocean all show daily tidal influence with amplitudes ranging between 0.2 m and 0.5 m. The greatest amplitude is observed in wells screened in the

Tamala Limestone (Lower Aquifer). SCID_04, which is located 600 m from the ocean also shows daily tidal influence. This well is screened in the highly transmissive Tamala Limestone, suggesting the tidal influence extends further inland in the Lower Sub-Aquifer than the Upper Sub-Aquifer.

- **Central Section (western section to Mandogalup Road):**
  - The wells located at or in close vicinity to the KWWTP are showing a steady increase in groundwater levels from the 1980s to around 2009, after which they stabilise and slightly start decreasing. The rise is likely to be related to the infiltration from the KWWTP infiltration ponds, while the stabilising and decrease is currently unknown but could be due to several factors such as decrease in infiltration volume or increase in groundwater abstraction.
  - The groundwater level hydrographs from wells located further away from the KWWTP (generally in the Bassendean Sand) generally show an overall decreasing groundwater level trend from the 1970s to around 2010, after which the groundwater levels start showing an increasing trend over the last 15 years. The trends may be related to groundwater abstraction and changes in land use.
  - The project wells have a similar seasonal variation as the DWER wells (refer e.g. to GBH05 and 61410084 in Figure 7B).
  - The seasonal variation in these wells is generally around 1.0 m to 1.2 m.
  - The groundwater level in several wells indicate direct impact from groundwater abstraction with larger and erratic seasonal variations (ID. 61419863 and 61410418), Both of these wells are located in close proximity to pumping wells.
- **Eastern Section (east of Mandogalup Road):**
  - The long-term groundwater level hydrographs from wells located in the eastern part of the alignment (Bassendean Sand and Thin Bassendean San over Guildford Formation) generally show an overall decreasing groundwater level trend from the 1970s to the 2010s followed by increasing trends until present date. The trends may be related to groundwater abstraction and changes in land use.
  - The project wells have a similar seasonal variation as the DWER wells.
  - The seasonal variation in these wells is generally around 1.0 m to 2.0 m with an increase in amplitude toward the east (inland) where the geology becomes Thin Bassendean Sand over Guildford Formation, which has a lower permeability.
- The seasonal maximum in all wells is found to occur around August/September/October with the seasonal minimum occurring around April/May.

Perched Groundwater

During a recent desktop study (Ref [17]) of a potential access road to the Perth Motorplex, it was discovered that a perched groundwater table exists within the decommissioned Alcoa residual storage area (RSA) south of Anketell Road. The perched groundwater levels within the RSA were measured to be only a few metres below the existing ground level corresponding to a groundwater level elevation of around RL 20 m AHD, which is approximately 19 m higher than the regional Superficial Aquifer groundwater level of around RL 1 m AHD. This perched groundwater is considered important for any potential access road through the decommissioned RSA or in areas where Anketell Road requires widening which could result in excavation into the RSA embankment.

Though currently unknown, it is expected that a similar perched groundwater level exists within the currently operating Alcoa RSA north of Anketell Road.

4.7.3 Hydraulic Properties

The desktop assessment did not find any site-specific information from hydraulic tests. Reference [3] provides the following range of hydraulic properties for the different geological units (yellow highlighted are units present beneath the project area).

Table 4-1 Hydrogeological Properties for Different Geological Units (Excerpt of Table 3.1 from Ref [3])

AGE	GROUNDWATER	STRATIGRAPHIC UNITS	THICKNESS RANGE IN THE STUDY AREA (m)	LITHOLOGY	AVERAGE SPECIFIC YIELD FOR UNCONFINED UNITS; STORATIVITY (S) WHERE INDICATED	HORIZONTAL HYDRAULIC CONDUCTIVITY (m/d)
Late Tertiary - Quaternary	Superficial Aquifer	Superficial formations	30-65	Sand, silt, clay, limestone		
		Safety Bay Sand	0-20	Sand and shell fragments	0.2	15 (avg)
		Becher Sand	0-20	Sand, silt, clay and shell fragments	0.2	8 (avg)
		Tamala Limestone	0-65	Calcareous eolianite (limestone)	0.2-0.3	100-1000
		Bassendean Sand	0-50	Sand and minor silt and clay	0.2	10-50 (avg 15)
		Gnangara Sand	0-30	Sand, gravel and minor silt and clay	0.2	20
	Local confining bed	Guildford Clay	0-25	Clay with minor sand and gravel	0.05	0.1-1 (basal sandy units-up to 10)
	Superficial Aquifer	Ascot Formation	0-20	Limestone, sand, shells and clay	0.2	8
	Rockingham Aquifer	Rockingham Sand	0-70	Sand, silt and minor clay	0.2	20
Cretaceous	Aquitard	Kardinya Shale Member of the Osborne Formation	0-100	Shale, siltstone, minor sandstone		$10^{-4} – 10^{-6}$
	Leederville Aquifer	Henley Sandstone Member of the Osborne Formation	0-40	Sandstone and minor siltstone	S: $10^{-3} – 10^{-4}$	2-3
		Leederville Formation	150-320	Sandstone, siltstone and shale		
		Pinjar Member	0-70	Sandstone, siltstone and shale	S: $10^{-3} – 10^{-4}$	1
		Wanneroo	100-150	Sandstone, siltstone and	S: $10^{-3} – 10^{-4}$	1-10

Given the sedimentary nature of the geological units, which have been deposited in fluvial environments, it would be expected that the ratio between the vertical and horizontal hydraulic conductivity (k_v/k_h) would be less than 1 (i.e. the vertical hydraulic conductivity is smaller than the horizontal hydraulic conductivity), particularly in the Guildford Formation where intermittent clay layers are present. The general literature suggests that k_v could be several orders of magnitude smaller than k_h and it is not uncommon to assume a k_v/k_h ratio of 0.1. FSG's experience is that for Bassendean Sand and Tamala Sand the ratio is more likely to be around 0.3 or higher.

4.8 Groundwater Abstraction Licenses

FSG has undertaken a search of the DWER Water Register for existing 5C groundwater licenses and the allocated water abstraction volumes. The DE is located within two groundwater areas:

- **West of Main Peel Drain crossing:** Cockburn Groundwater Area (Valley Sub-Area). The DWER Register indicates that the Superficial Aquifer is fully allocated.
- **East of Main Peel Drain crossing, South of Anketell Road:** Serpentine Groundwater Area (Jandakot Mound 1 Sub-Area). The DWER Register indicates that the Superficial Aquifer has allocation available.
- **East of Main Peel Drain crossing , North of Anketell Road:** Jandakot Groundwater Area (Mandogalup Sub-Area). The DWER Register indicates that the Superficial Aquifer has allocation available.

Figure 8 shows an extract from the DWER register with the existing lots that has a current 5C groundwater licence in the Superficial Aquifer together with the groundwater area boundaries.

It is noted that the DWER Water Register in some cases provide the groundwater abstraction locations. However, where more than one abstraction location is present within the lot, the distribution of groundwater abstraction is not known. Further, it is not known if the full water allocation is being abstracted by the 5C License holders and when it is abstracted (e.g. seasonally). There is therefore currently a significant unknown as to the location, amount, and distribution of water abstraction from the 5C lots. This unknown could be reduced if DWER or the 5C License holders could provide access to the annual compliance reporting required for a 5C License holder.

Table 4-2 summarises the 5C License water allocations obtained from the DWER Register. The green columns are factual data from the DWER Register, while the other columns are estimates of the number of wells (based on location points in the register) and the average daily pumping rate per well if the wells were operated continuously.

Table 4-2 5C License Holders and Water Allocations

Figure 8 Well ID	5C License ID	Annual Water Allocation (kL)	Potential Number of Wells	Pumping Rate per Well (kL/d)	Pumping Rate per Well (L/s)
1	163607	40,000	1	110	1.3
2	73597	12,000	1	33	0.4
3	159072	60,850	1	167	1.9
4	78096	300,000	1	822	9.5
5	181288	1,500	1	4	0.0
6	175930	129,100	1	354	4.1
7	Recovery Bores	788,400	5	432	5.0
8	158359	3,000	1	8	0.1
9	50465	97,000	3	89	1.0
10	54280	15,000	1	41	0.5
11	109942	150,000	2	205	2.4
12	159085	5,404,000	9	1,645	19.0
13	175643	75,000	1	205	2.4
14	171301	9,750	1	27	0.3
15	202605	226,285	10	62	0.7
16	166922	724,935	5	397	4.6
17	169930	119,650	1	328	3.8
18	177515	270,800	3	247	2.9
19	205255	18,650	1	51	0.6
20	202118	1,875	1	5	0.1
21	101078	10,350	2	14	0.2
22	48228	19,950	1	55	0.6
23	160839	8,000	1	22	0.3
24	58529	9,200	2	13	0.1
25	179454	61,150	2	84	1.0
26	208076	16,800	1	46	0.5
27	203006	15,375	1	42	0.5
28	210876	20,000	1	55	0.6
29	156470	18,650	1	51	0.6
30	208184	37,500	2	51	0.6
31	57056	27,650	1	76	0.9
32	106782	6,750	1	18	0.2
33	150481	17,900	1	49	0.6
34	205662	51,650	1	142	1.6
35	155800	37,125	1	102	1.2
36	181321	300,000	2	411	4.8
	TOTAL	**9,105,845**	**71**		

5. Construction Water Demand

Metis (Ref [11]) has estimated that the construction water demand during the earthworks to be around 430,000 kL, consisting of 308,000 kL for moisture conditioning during the placement of fill and 122,000 kL for dust suppression during the earthworks period. The water demand estimations were based on the following assumptions:

- Moisture Conditioning: 150 L/m^3 for placement of Fill material
- Dust Suppression: 5% of the total earthworks (cut and fill).
- Construction period of 2 years with a total of 423 earthworks days.

In addition to the construction water demand during the earthworks period, dust suppression construction water is likely to also be required outside of the earthworks period (particularly during the dry season). The additional volume of water was estimated to be approximately 270,000 kL, based on the following assumptions:

- The area within the DE envelope that could require dust suppression was estimated to be around 600,000 m^2.
- Assumed water requirement of 2.5 mm/d of water for dust suppression.
- Dust suppression would be required for around 7 months per year (outside the earthworks period).

Table 5-1 summarises the construction dewatering demand divided into different work areas (refer to Figure 8), while Appendix E provides a breakdown of the calculations.

Table 5-1 Summary of Estimated Construction Water Demand

Work Area	Earthworks				Additional Water Demand	
	Assumed Work Fronts *	Duration (days)	Water Demand			
			Moisture Conditioning (kL)	Dust Suppression (kL)	Duration (days) **	Water Demand (kL)
Area 4	1	<7	<1,000	<500	420	15,500
Area 5	2	36	22,000	9,500	420	72,000
Area 6	2	61	37,000	20,000	420	121,000
Area 7	2	413	248,000	92,000	210	61,500
TOTAL			**308,000**	**122,000**		**270,000**
			700,000			

* The number of days depends on the number of work fronts for the earthworks

** Reflects on 1 or 2 summers depending on the earthworks requirements in the work area.

It is noted that the annual total construction water demand of 350,000 kL is less than 4% of the annual total allocated 5C License volumes around the DE.

6. Construction Water Supply from Groundwater Abstraction

6.1 Modelled Timeframe and Duration

A 3D numerical groundwater model was developed for the area, which was used to model the groundwater level drawdown from pumping bores to assess the potential impact of supplying construction water from groundwater abstraction could have on the environment. Appendix D provides a description of the groundwater model setup and adopted hydraulic properties.

The selected timeframe of the required groundwater abstraction over the two year (730 days) construction period (i.e. adopted in the groundwater model) was as follows:

- The earthworks period ranges from Day 0 to Day 413.
- Since the required timeframes are different for the four work areas, with most earthworks and thereby longest earthwork duration required in Area 7, it was assumed that all earthworks would stop at the same time (on Day 413 which is duration required for Area 7). This assumed schedule results in all four works areas require water supply at the same time towards the end of the earthworks period (i.e. groundwater abstraction will be required for each of the work areas at the same time and thereby all production bores will be pumping at the end of this period, resulting in the most stress on the aquifer).
- The additional dust suppression period ranges from Day 413 to Day 623 (210 days during the dry period). Again, by assuming that the additional dust suppression period starts right after the end of the earthwork period, this results in the longest pumping duration of each bore and the greatest overlap of pumping between the bores.

This selected model timeframe is considered to result in the worst case groundwater abstraction scenario where each production bore is pumped for the required longest duration and all productions bores are pumped simultaneously for the longest period of time. Since the water demand, and thereby the pumping rate, is greatest for the earthworks period, the greatest extent of groundwater level drawdown (i.e. greatest risk of environmental impact) would be on Day 413 of the model run.

Table 6-1 summarises the model durations where groundwater is abstracted from the production bores to supply the working areas.

Table 6-1 Modelled Timeframe with Groundwater Abstraction

Work Areas	Purpose	Model Start (days)	Model Stop (days)
Area 4	Earthworks	399	413
	Additional Dust Suppression	413	623
Area 5	Earthworks	377	413
	Additional Dust Suppression	413	623
Area 6	Earthworks	351	413
	Additional Dust Suppression	413	623
Area 7	Earthworks	0	413
	Additional Dust Suppression	413	623

6.2 Model Scenarios

The following three groundwater abstraction for construction water supply scenarios were modelled:

- **Scenario 1:** 100% of the earthworks construction water demand (430,000 kL) and 100% of the additional water demand for dust suppression (270,000 kL) was obtained from 5 production bores located within the DE boundary (refer to Figure 9 for locations).
- **Scenario 2:** 100% of the earthworks construction water demand (430,000 kL) and 100% of the additional water demand for dust suppression (270,000 kL) was obtained from 3 production bores located within the DE boundary (refer to Figure 10 for locations).
- **Scenario 3:** 50% of the earthworks construction water demand (215,000 kL) and 100% of the additional water demand for dust suppression (270,000 kL) was obtained from 3 production bores located within the DE boundary (refer to Figure 11 for locations).

Table 6-2 summarises the number of production bores and pumped volumes for each of the model scenarios

Table 6-2 Number of Production Bores and Pumped Volumes for each Model Scenario

Model Scenarios	Number of Pumping Bores	Earthworks		Additional Dust Suppression		Total	
		Pumped Volume (kL)	% of Required Water Demand	Pumped Volume (kL)	% of Required Water Demand	Pumped Volume (kL)	% of Required Water Demand
1	5	430,000	100%	270,000	100%	700,000	100%
2	3	430,000	100%	270,000	100%	700,000	100%
3	3	215,000	50%	270,000	100%	485,000	69%

Appendix E presents the breakdown of the water demand and pumping rate for each of the production bores, which was proportioned based on the bore locations and work areas they supply. The required pumping rate from the bores to supply 100% of the earthworks water demand range between 4 L/s and 12 L/s while the pumping rate reduces to range between 0.2 L/s and 2 L/s to supply the additional dust suppression water demand in the second year of construction.

6.3 Extent of Groundwater Level Drawdown

Figures 9 to 11 shows the modelled maximum groundwater level drawdown (at Day 413) together with the modelled groundwater flow directions, which provides an understanding of the groundwater capture zones of the production bores (i.e. the zone where the groundwater flow direction is toward production bores).

Table 6-3 summarises the modelled groundwater level drawdown extent for Scenario 1 while Table 6-4 summarises the modelled groundwater level drawdown extent for Scenarios 2 and 3.

Table 6-3 Modelled Maximum Groundwater Level Drawdown and Extent for Scenario 1

Production Bore	Total Pumping Duration (Days)	Maximum Aquifer GWL Drawdown (m)	Extent of 0.1 m GWL Drawdown Contour
A	38	0.4	240
B	97	0.7	400
C	413	0.3	325
D	413	0.5	375
E	61	0.3	160

Table 6-4 Modelled Maximum Groundwater Level Drawdown and Extent for Scenarios 2 and 3

Production Bore	Scenario 2		Scenario 3	
	Maximum Aquifer GWL Drawdown (m)	Extent of 0.1 m GWL Drawdown Contour	Maximum Aquifer GWL Drawdown (m)	Extent of 0.1 m GWL Drawdown Contour
1	0.7	375	0.3	230
2	0.5	560	0.3	125
3	0.7	625	0.15	175

Figure 12 shows the groundwater model drawdown and extent at Day 623 for Scenario 3 (i.e. after at the end of the additional dust suppression pumping period). The comparison of the groundwater level drawdown extents between Figure 11 and Figure 12 show that the 0.1 m groundwater level drawdown will not increase (i.e. extend any further) after the end of the earthworks pumping period (Day 413). The reason for this is that the required pumping rate from the production bores during the additional dust suppression is lower than during the earthworks (i.e. the groundwater cone of depression reduces rather than expands).

6.4 Preliminary Construction Groundwater Supply Risk Classification

Figure 13 shows a preliminary construction groundwater supply risk classification map covering the DE, based on the groundwater modelling results from all modelled scenarios. The purpose of the map is to provide some indication of the risk of obtaining suitable construction groundwater supply for the project. The map is therefore based on the following main assumptions:

- A total required construction water demand of 700,000 kL over a 2 year period.
- The groundwater abstraction will be split over minimum 3 pumping bores.
- DWER registered contaminated lots represents the existing contamination in the area.
- DWER conservation and resource enhancement wetlands and the Tumulus Spring are the only groundwater dependent ecosystems.
- KWWTP will continue infiltrating secondary treated wastewater at the current capacity through the infiltration ponds.

The DE area has been given one of the following three criteria:

- **Low Risk** = Areas considered suitable for groundwater abstraction with low risk of deterioration in abstracted groundwater quality. No to minimal additional investigations likely to be required.
- **Moderate Risk** = Areas considered possibly suitable for groundwater abstraction with moderate risk of deterioration in abstracted groundwater quality. Some additional investigations likely to be required.
- **High Risk** = Areas currently considered unsuitable for groundwater abstraction with high risk of deterioration in abstracted groundwater quality. Significant additional investigations likely to be required.

It is considered that any area where a construction water supply bore is proposed to be installed will require further localised investigation (i.e. drilling, hydraulic testing and installation of monitoring network). However, the level of investigation required is expected to be different. It is noted that in the end DWER will decide what type of investigation is required as part of a 26D and 5C License application.

If the risk map was purely based on hydrogeological conditions (i.e. the aquifers capability to provide the required construction water demand), then the whole DE area would have classified as a low risk due to the highly transmissive aquifer and the modelled very low drawdown.

The reason for the risk classifications are as follows:

- The moderate risk area near the coast is due to potential risk of saline water intrusion or upconing.
- The high risk area along Rockingham Road and Anketell Road is due to the known groundwater contamination seeping into the aquifer from the decommissioned Alcoa residue storage facilities south of Anketell Road.
- The high risk area along Abercrombie Road and Anketell Road is due to potential contamination risk from the operating Alcoa residual areas. North of the KWWTP the risk is increased as there is a further potential of encountered E-coli in the abstracted groundwater.
- The moderate risk area north of the Spectacles North is mainly because it is located close to the Spectacles conservation wetland and there is an increased risk of encountered E-coli in the abstracted groundwater.

7. Preliminary Dewatering Assessment

7.1 Dewatering Requirements

Dewatering will be required wherever the groundwater level is higher than the base of the excavation level. Furthermore, it may be necessary to draw the groundwater level down to about 1 m below the excavation level to allow for removal and replacement of unsuitable founding materials, placement of bedding material, compaction of soils and/or site trafficability during construction.

Based on the concept plans & profiles and the estimated current seasonal maximum groundwater levels, **the risk of construction dewatering requirements for this project is considered very low**. One of the key outcomes of this groundwater level assessment is that it is considered unlikely that construction dewatering would be required for the proposed large dive structure itself (Structure 9).

It is though still possible that some localised dewatering could be required at the dive structure at the deepest part of the structure where a small stormwater collection tank and sump pump pit would typically be required to allow for any stormwater runoff flowing into the dive structure to be capture and pumped out. The current concept design does not provide design information on the potential area and depth of the collection tank and pump. MRWA therefore requested that modelling be undertaken for the scenario where it is assumed that the pump station box could measure 5 m by 5 m with an invert level 2 m below the current seasonal maximum groundwater level and that construction dewatering would be required for 3 months.

The dewatering requirement for such a scenario would be to lower the groundwater level by 3 m during the wet season (1 m below the excavation level for the box) and around 1.9 m during the dry season (based on an estimated seasonal groundwater fluctuation of 1.1 m in this area). To allow for construction activities within this area the plan area for the dewatering based on an open excavation set at 15m by 15m.

Lastly, there may also be other localised areas (e.g. near the coast or along Kwinana Fwy) where the groundwater levels are closer to the ground surface that could require dewatering (e.g. for underground service installation or relocations), but this can only be determined during the detailed design phase.

7.2 High-Level Dewatering Rates and Volumes Estimations

The following groundwater modelling runs were undertaken for the pump station box at using the developed 3D numerical groundwater model:

- **Model Run 1:** Construction dewatering during <u>the wet season without infiltration</u> of the abstracted groundwater back into the aquifer.
- **Model Run 2:** Construction dewatering during <u>the wet season with infiltration</u> of some of the abstracted groundwater back into the aquifer.

- **Model Run 3:** Construction dewatering during the dry season without infiltration of the abstracted groundwater back into the aquifer.
- **Model Run 4:** Construction dewatering during the dry season with infiltration of some of the abstracted groundwater back into the aquifer.

The modelled infiltration trench was located between the dewatering area and the known Tumulus Spring, which is understood to be Threatened Ecological Community (TEC), located approximately 675 m north of the dewatering area (refer to Figure 15).

Table 7-1 presents the modelled high-level dewatering rates and volumes for the different model runs and indicates that the average dewatering rates during the wet season would be around 35 to 40 L/s and between 23 L/s and 27 L/s during the dry season. The model runs also indicates that around 60% of the dewatering volume would need to be infiltrated between the dewatering area and the TEC to not impact the groundwater levels at the TEC.

Table 7-1 High-Level Dewatering Rates and Volume Estimations

Model Run	Season	Infiltration	Dewatering Rate (L/s)		Dewatering Volume (kL) **	Infiltration Rate (L/s)	% of Dewatering Rate
			Initial *	Average			
1	Wet	No	49	35	270,000	-	-
2	Wet	Yes	50	40	310,000	23	59%
3	Dry	No	32	23	180,000	-	-
4	Dry	Yes	33	27	210,000	16	58%

* Average rate in the first week of dewatering. ** For a 3 month dewatering duration

It is noted that the dewatering volumes, if undertaken in the dry season, are similar to approximately 50% of the earthworks construction for Scenario 3.

7.3 Extent of Groundwater Level Drawdown

Figures 14 and 15 show the extent of the groundwater level drawdown after 3 months of dewatering for the model runs without and with infiltration of some of the abstracted groundwater, respectively.

Table 7-2 presents the modelled high-level off-site groundwater level drawdown after 3 months of dewatering.

Table 7-2 Extent of Groundwater Level Drawdown from the Dewatering Area after 3 Months of Dewatering.

Model Run	Season	Infiltration	Maximum Extent of 0.5 m GWL Drawdown Contour (m)	Extent of 0.5 m GWL Drawdown Contour toward the TEC (m)	Maximum Extent of 0.1 m GWL Drawdown Contour (m)	Extent of 0.1 m GWL Drawdown Contour toward the TEC (m)
1	Wet	No	460	420	1,060	**785**
2	Wet	Yes	300	130	960	175
3	Dry	No	340	285	930	**675**
4	Dry	Yes	190	100	840	175

Note: **Red bold** is when the groundwater level drawdown reaches the TEC

The groundwater modelling indicates:

- Wet Season (No Infiltration):
  - A groundwater level drawdown of around 0.1 m is modelled to occur at the TEC. It is noted that this is well within the typical natural seasonal fluctuations (around 1 m) at the TEC (i.e. it is only the top 0.1 m of the peak groundwater levels that is being “removed”).
  - The groundwater flow direction at the TEC does not change.

- Based on this the construction dewatering would not be expected to result in any significant detrimental impact on the TEC given the short period of dewatering and that the groundwater level drawdown is well within typical natural seasonal fluctuations.

- Dry Season (No Infiltration):
  - A groundwater level drawdown of <0.1 m during the dry season (seasonal low groundwater level) is modelled to occur at the TEC.
  - The groundwater flow direction at the TEC does not change.
  - A 0.1 m groundwater level drawdown at the TEC below the current seasonal low would likely still be within the historical natural groundwater level fluctuations that the TEC has experienced (i.e. the 0.1 m will not result in the groundwater level declining below the historical minimum groundwater level at the TEC, which over the last 20 years occurred in 2016 and 2011).
  - Based on this the construction dewatering is therefore also unlikely to result in detrimental impact on the TEC. That said, it is considered that the risk of impact is likely to be greater than compared to if the dewatering was undertaken during the wet season.
- Both during the wet and dry dewatering scenarios, it should be possible to infiltrate part of the abstracted groundwater (must be in between the dewatering area and the TEC) so that no groundwater level drawdown would occur at the TEC from the dewatering activity.

7.4 Dewatering Discharge Disposal Options

Dewatering discharge should be disposed of so as not to cause harm to the environment or allow flooding. The dewatering disposal options will depend on the dewatering rates and the abstracted discharge water quality. Based on the DWER guidelines (Ref [21] and [22]), the following potential dewatering disposal options have been identified:

- Reuse of water for construction or reticulation.
- Infiltration/Recharge (infiltration basins or recharge wells).
- Discharge into the stormwater system or surface water features.

It is noted that the regulators typically consider discharge to the stormwater system or surface water as the least preferred option as it is likely to carry the greatest environmental impact risk. Given the size of the project, it is recommended that early discussion be held with regulators during the planning and design process.

The dewatering disposal options should be further assessed and finalised as part of the dewatering design and preparation of a site-specific Dewatering Management Plan (DMP). The DMP would outline treatment, monitoring, and management requirements of the dewatering discharge for the chosen option(s).

7.5 Dewatering License Requirements

A 5C License(s) to Abstract Water and a 26D License(s) to Construct a Well would be required from the DWER for each of the Groundwater Sub-Areas where groundwater abstraction is required from prior to commencement of the construction dewatering.

A Dewatering Management Plan (DMP) is typically required as a supporting document to the DWER license application. The DMP will outline the dewatering requirements, estimated effect of the dewatering, monitoring requirements/program and contingency options.

It should be noted that the 5C license is only for the abstraction of the water and does not include all permissions for disposal of the water. Permission for disposal of water depends on the specific disposal option.

Given that the estimated dewatering volume is greater than 100,000 kL, it would be necessary to advertise the planned dewatering operation in the local newspaper for public comment as part of the application process.

8. Identified Hydrogeological Risks

The following preliminary hydrogeological risks have been identified for the project with regards to groundwater abstraction (either for construction water or dewatering):

- Insufficient well capacity at the proposed bore locations (greatest risk would be at the eastern end of the alignment).
- Other groundwater users in the area could be affected in two ways:
  - Reduction in groundwater level which may affect the capacity of existing groundwater pumping wells.
  - Change in groundwater quality which may affect the suitability of the groundwater use.
- Potential Disturbance of ASS.
- Potential groundwater level drawdown at Groundwater Dependent Ecosystems or TEC's.
- Mobilisation of existing contamination plumes.
- Change in surface water quality during construction dewatering (if abstracted groundwater is discharged into the surface water environment).

The identified hydrogeological risks are currently all considered to be low to very low and it is considered that appropriate management measures can be introduced that would further reduce the risk classification (e.g. groundwater level control/management during dewatering via infiltration/recharge).

9. Conclusion

The conclusion from this groundwater assessment are as follows:

- The total construction water demand over a two year construction period has been estimated to around 700,000 kL, comprised of around 430,000 kL during earthworks and 270,000 kL for possible additional dust suppression.
- The groundwater modelling indicates that all the groundwater (700,000 kL) can be obtained from groundwater abstraction using a minimum of 3 bores.
- The greater the number of pumping bores, the smaller the pumping rate per bore and thereby the smaller the groundwater level drawdown impact will be from each individual bore, which reduces the risk of saline intrusion/upconing and mobilisation of potential contaminants. However, the close the bores are located together, the greater the risk that some interference drawdown between the wells could occur (this was seen for Bores C and D in Model Scenario 1).
- From the three model scenarios the groundwater level drawdown extent is small, which reduces the risk of environmental impact. For all modelled scenarios, the risk of impact is considered to be very low to low at the modelled bore locations, with Scenario 3 having the lowest risk (only 69% of the water demand was pumped for this scenario.
- Construction dewatering may be required for the installation of the pump station at the proposed dive structure beneath Narran Street and Treeby Road, irrespective of the time of the year (wet or dry season) the construction is undertaken. The dive structure itself is currently not expected to require dewatering.
- The estimated average dewatering rate for the pump station is modelled to be around 23 L/s and 35 L/s for the dry and wet season, respectively, if none of the abstracted groundwater is reinfiltrated back into the aquifer. The modelled groundwater level drawdown at the nearby TEC (Tumulus Spring) would be around 0.1 m.
- The groundwater modelling indicates that it should be possible to re-infiltrate part of the abstracted groundwater between the dewatering area and the TEC so that no groundwater level drawdown would occur at the TEC from the dewatering activity. Therefore, it should be possible through groundwater management to undertake the construction dewatering without impacting the groundwater at the nearby Tumulus Spring.

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11. Closure

Finally, we draw your attention to the attached Important Information about your FSG report.

Please contact the undersigned if any further information or clarification is required.

Regards,

Allan Lundorf
Senior Principal Groundwater Engineer

Important Information About Your FSG Report

Deep foundation and geotechnical engineering problems are a principal cause of construction delays, cost overruns, claims and disputes. The following information is provided to help you to understand this report and its limitations and manage your risks.

Scope and Applicability of this Report

This report has been prepared for a specific purpose and scope and its applicability is limited. FSG Geotechnics & Foundations (FSG) cannot accept any responsibility for the use of this report outside of the stated scope and purpose. If a service has not been explicitly included in the scope, it must be assumed that it has not been provided. Assessment of soil or groundwater contamination does not form part of this geotechnical report and any reference to any potential site contamination is for information only. If you are uncertain about the applicability of the results for any particular purpose, you should consult FSG to avoid any misunderstanding or miss-application.

This report has been prepared for the nominated Client and project only and should not be relied upon by other parties, or for other purposes, without consulting FSG. Any party relying on this report beyond its specific purpose and scope does so entirely at their own risk and responsibility. FSG does not take responsibility for the use of this document by any other person or party than the Client.

Project Details and Information Provided

This report has been based on project details as provided to us at the time of the commission. We have assumed that the information supplied to FSG by the client or other external sources on behalf of the client, is correct unless explicitly stated so. FSG does not accept any responsibility for incomplete or inaccurate data provided by others.

If any project details change during the course of the project or observed conditions are considered to differ from those expected or assumed, FSG should be notified in order to investigate if and how changes in project details affect the conclusions and recommendations in our report. If FSG is not consulted when changes are made to the initial project details, we cannot accept any responsibility for problems arising from these changes.

Geotechnical Information and Interpretation

Site investigations only sample discrete parts of the ground, and that extrapolation and interpolation of collected information can be used with varying degrees of risk and uncertainty depending on the extent and quality of the site investigation, the variability of the subsurface conditions and the consequences to the proposed works.

The analyses and recommendations in this report rely on the results of site investigation information, and other reported geotechnical information that is relevant to the works. This may include the results of pile load testing, other geotechnical testing, and inspections and observations from studies that have been performed as part of the works or in the vicinity of the works previously.

We have endeavoured to incorporate the available information into an appropriate geotechnical model based on our interpretation of the likely subsurface conditions. This process, and the geotechnical analysis and interpretation based on that model, is an inexact science, as a model is but a simplification of reality to derive a geotechnical solution. While we endeavour to incorporate realistic model parameters, our models, interpretations and the outcomes or our work generally may differ from reality for a range of reasons including:

- <u>Spatial Variability:</u> Geotechnical and geological variability across the site which may not have been captured in the site investigation works that have been used in our works. Geotechnical site investigations are very limited in the extent of physical investigation compared to the size of the entire site. No site investigation, no matter how comprehensive, can reveal all subsurface details and anomalies and conditions that differ from those observed in the site investigation will occur;
- <u>Temporal Variability:</u> Subsurface conditions can change with time due to man-made events such as cutting or filling or any construction works on or adjacent to the site which can also affect the site drainage and hence underlying properties; or by natural events such as floods or groundwater fluctuations.
- <u>Variability in Mechanical Properties:</u> Normal geotechnical variability in the inferred properties of materials represented in the boreholes, the performance of foundations or other elements that are tested or observed, and the performance of structures that are in contact with the ground in general. The data collected is only directly relevant to the exact location where the investigation was undertaken. The subsurface conditions between test locations have been inferred based on judgement and experience with the facts available at that time and related to the relative position of the proposed works;
- <u>Testing Limitations:</u> Uncertainty associated with geotechnical testing, design correlations associated with those tests or material descriptions, and case histories from which geotechnical parameters may have been inferred or in design and/or analysis methods that have been adopted;

- Construction Effects: Variability in the performance of construction equipment, such as hammers, cushions, guides and associated equipment for piling, construction effects that may influence the way structures interact with the ground, as well as inaccuracies in data measurement and testing methods that may have been used to record construction processes.

The results provided should be considered as indicative of the best estimate of likely outcomes (or range thereof), and should not be considered to be definitive or absolute, or represent the full range of possible outcomes at this site. Caution and prudence should be exercised when making decisions with significant implications for your project. The limitations of this report as outlined herein should be incorporated in decision making, and appropriate contingencies should be put in place to accommodate unexpected variability in relation to the works

Geotechnical Modelling

Model parameters that are used may vary in nature depending on the purpose of the analysis. Where it is necessary to make a realistic evaluation of the soil model, we would normally describe this as a 'best estimate' (BE). Depending on the particular application, it may be important to understand the sensitivity of the solution to soil model changes. We may then also define an 'upper-bound' (UB) soil model and a 'lower-bound' soil model, being estimates of the likely, strongest and weakest soil conditions which are anticipated based on the available geotechnical information and inferred geotechnical parameters. In certain circumstances, such as cases where the ground conditions appear to extremely uncertain or variable, we may also define 'extreme upper bound' (XUB) and 'extreme lower bound' (XLB) parameters which are intended to represent the likely extremes of the site conditions. In all cases, these models are inferred using engineering judgement from the available information and actual conditions and associated outcomes may differ from those assumed or given in our report, due to the inherent unpredictability of the ground, as outlined in the preceding section.

It should be noted that depending on the particular application either upper-bound or lower-bound analyses could be deemed conservative.

Disclaimer

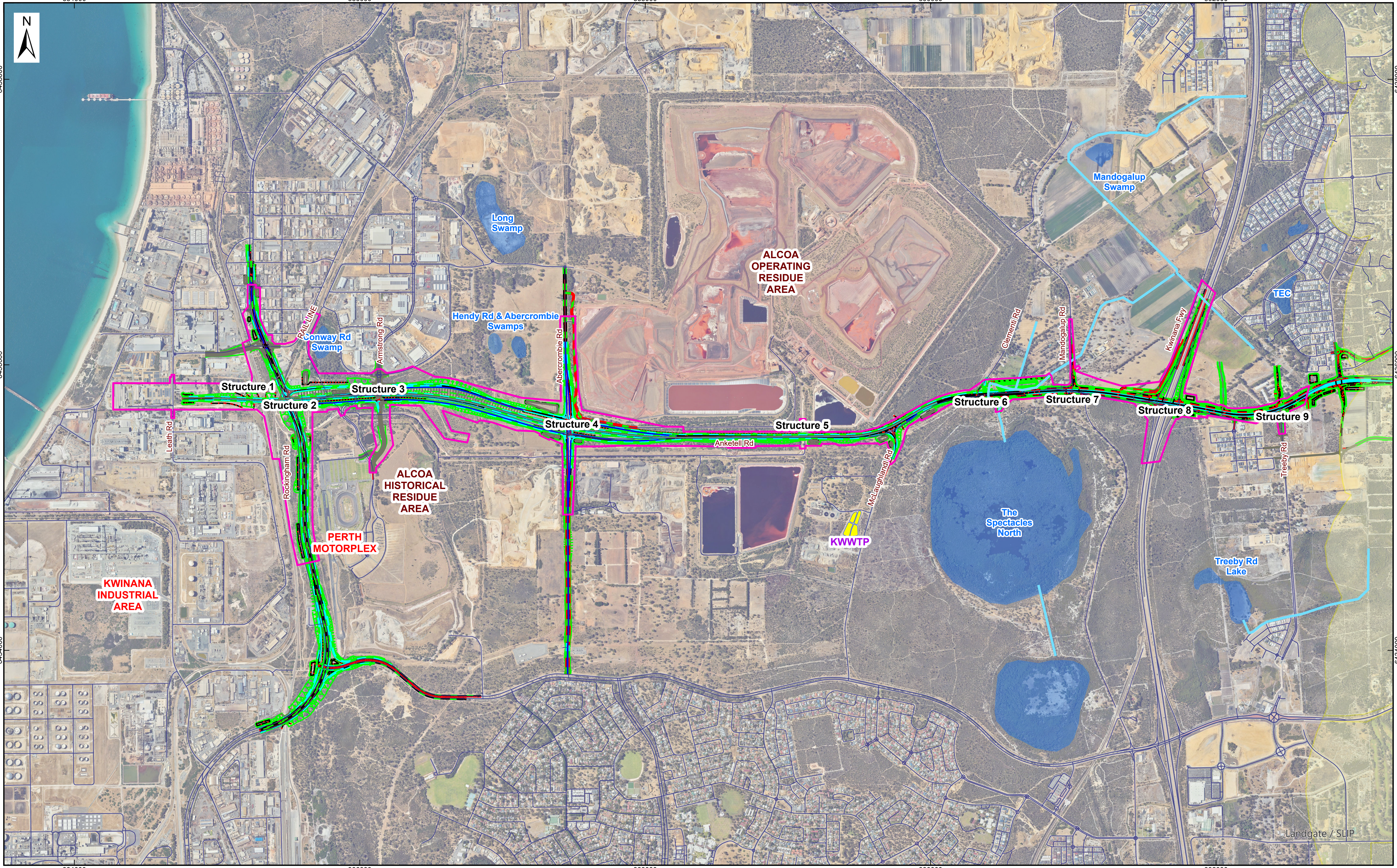
The results, opinions, conclusions and any recommendations in this report are based on assumptions made by FSG in order to carry out the work. FSG specifically disclaims responsibility: arising from, or in connection with, any change to the site conditions or the nature of the proposed works including change in position of the structure or proposed works relative to the available data; to update this report if the site conditions or project details change or if the report is used after a protracted delay; and for liability arising from any of the assumptions that have been made or information provided being incorrect, incomplete or inaccurate.

Subject to the terms of an Agreement for Professional Services between FSG and the client, and to the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by FSG and this report are excluded.

Closure

Unless otherwise documented by way of a signed agreement for the services provided, all services in preparing this report have been provided under FSG's standard Terms and Conditions which are referenced in our fee proposal. The report is specific to the brief provided with its associated time and cost constraints.

Should you require any further information or clarification in relation to this report, please contact FSG.



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LEGEND

- EPA REFERRAL BOUNDARIES
- PEEL MAIN DRAIN
- KWWTP INFILTRATION BASINS
- WETLANDS

REFERENCES:

1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

NOTE:

1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000

SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	1
TITLE	SITE PLAN
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

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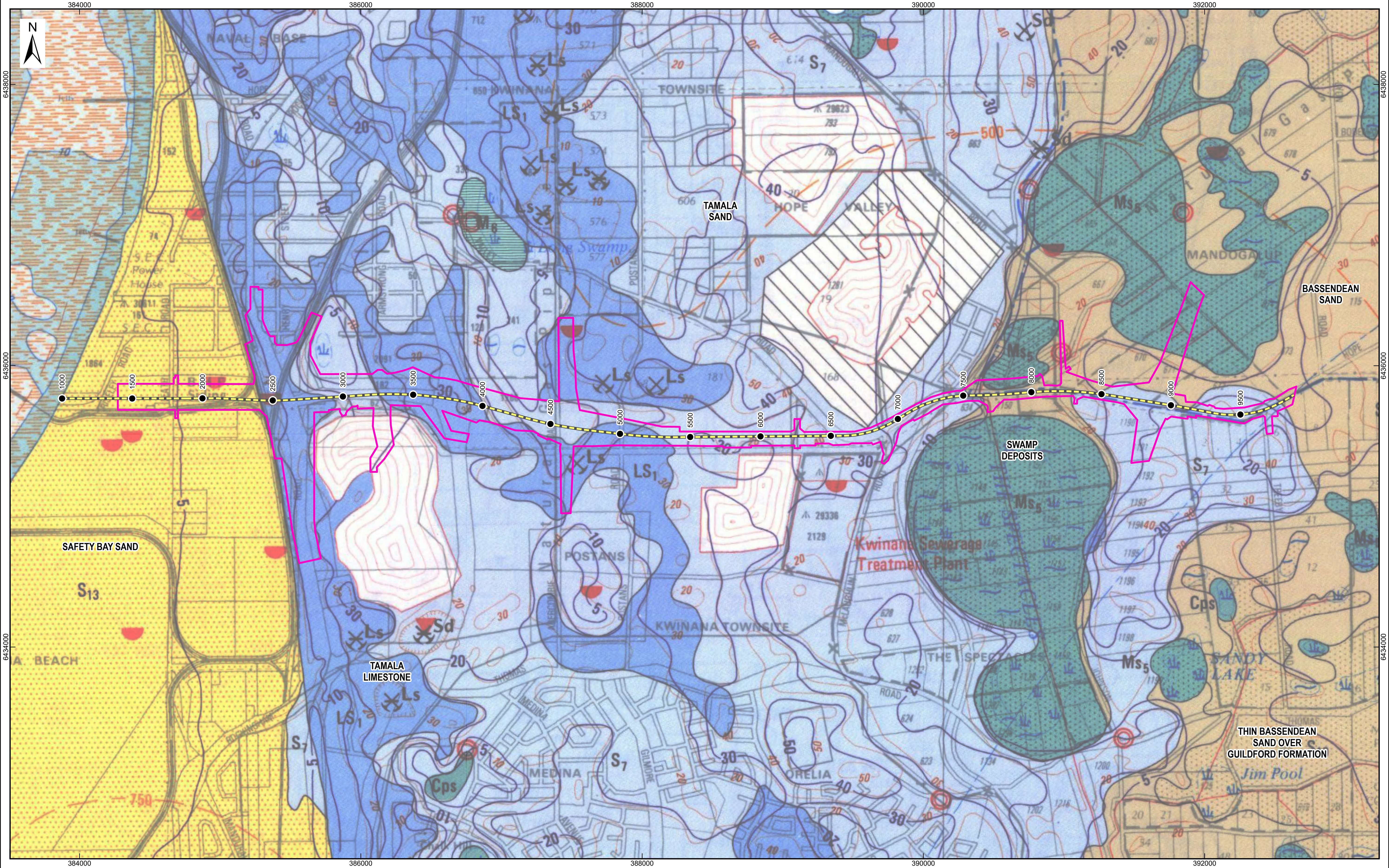

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LEGEND

- CURRENT MCE ALIGNMENT
- EPA REFERRAL BOUNDARIES

REFERENCE:
PERTH METROPOLITAN REGION
1:50 000 ENVIRONMENTAL GEOLOGY SERIES
FREMANTLE
PART SHEETS 2033 I & 2033 IV
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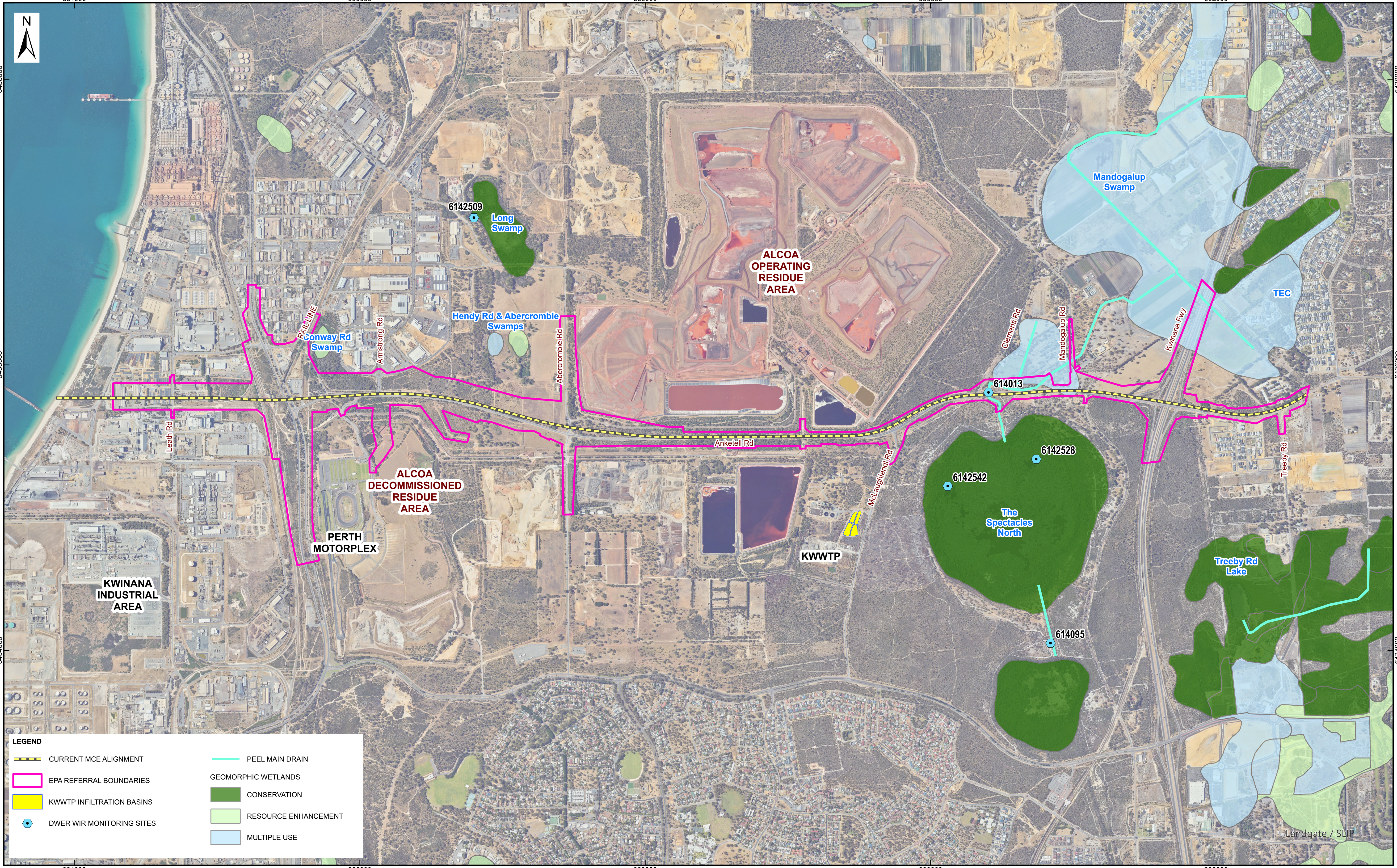
NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000
SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	2
TITLE	GEOLOGICAL MAP
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\00 GIS\PRO\12106-02-R-RevA_NEW.aprx

REFERENCES:

1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

NOTE:

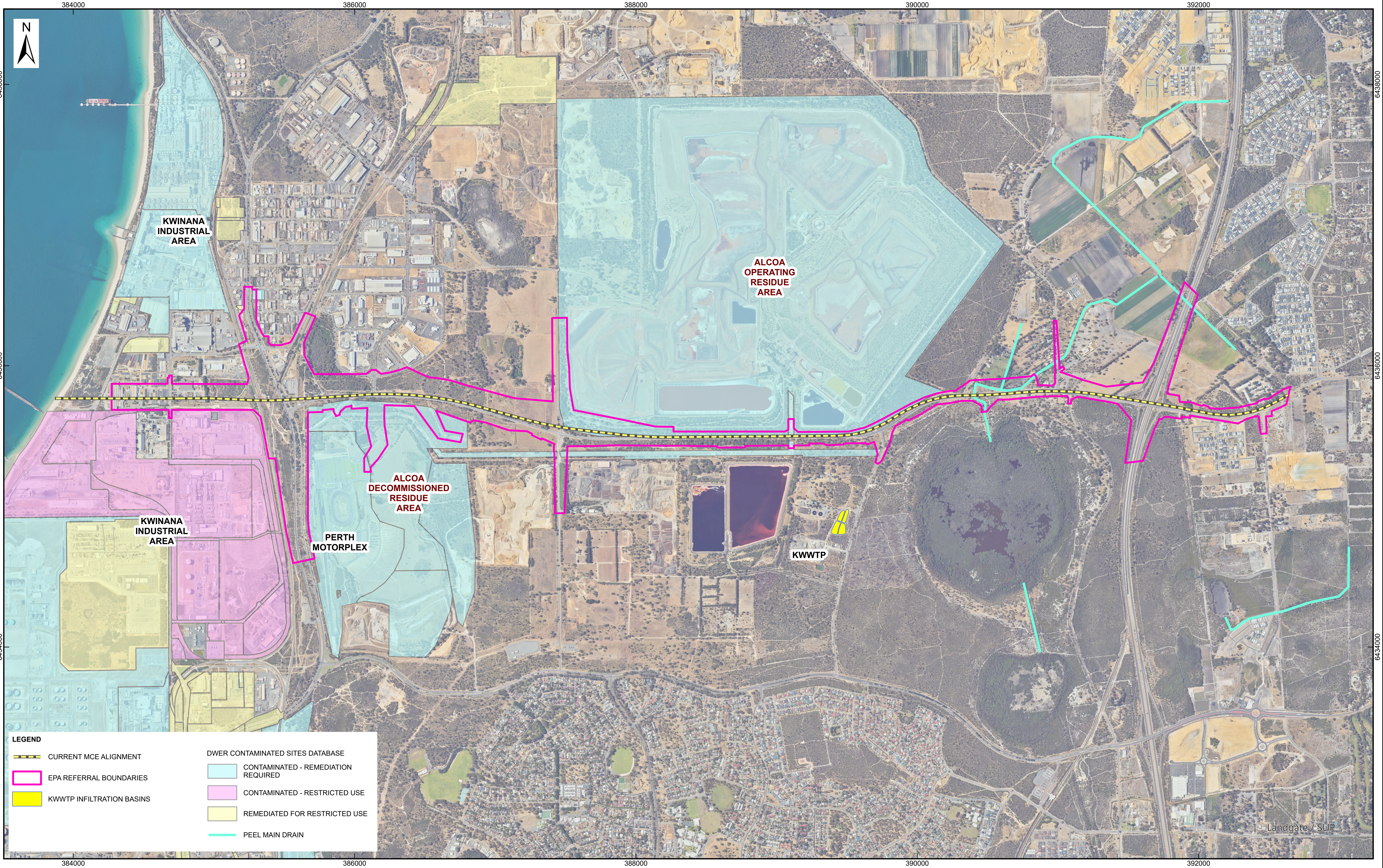
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000

SCALE: 1:25,000 METRES

CLIENT: MAIN ROADS WA	TITLE: SURFACE WATER AND WETLANDS
PROJECT: ANKETELL ROAD GROUNDWATER ASSESSMENT	DATE: 23-02-2025
	DRAWN: J.R. PETILLA
	DESIGNED: A. LUNDORF
	REVIEWED:
PROJECT NO. 12106 · DOC 02 · REV. A · FIGURE 3	APPROVED:

FSG GEOTECHNICS +FOUNDATIONS



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REFERENCES:

1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

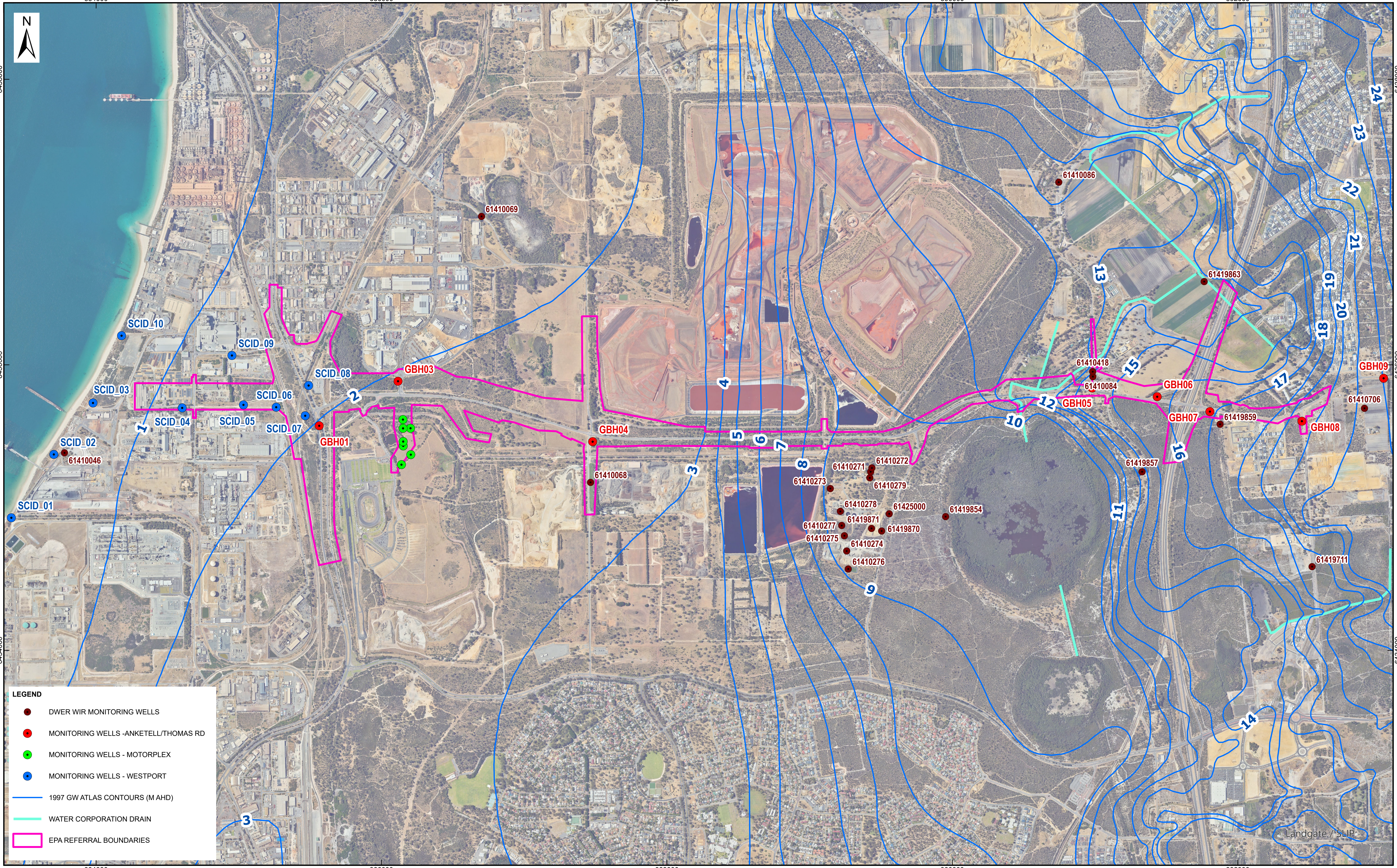
NOTE:

1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000

SCALE: 1:25,000 METRES

CLIENT MAIN ROADS WA	TITLE DWER CONTAMINATED SITES REGISTER
PROJECT ANKETELL ROAD GROUNDWATER ASSESSMENT	DATE: 23-02-2025 DRAWN: J.R. PETILLA DESIGNED: A. LUNDORF REVIEWED: APPROVED:
PROJECT NO. 12106 / DOC 02 / REV. A / FIGURE 4	FSG GEOTECHNICS +FOUNDATIONS



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REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

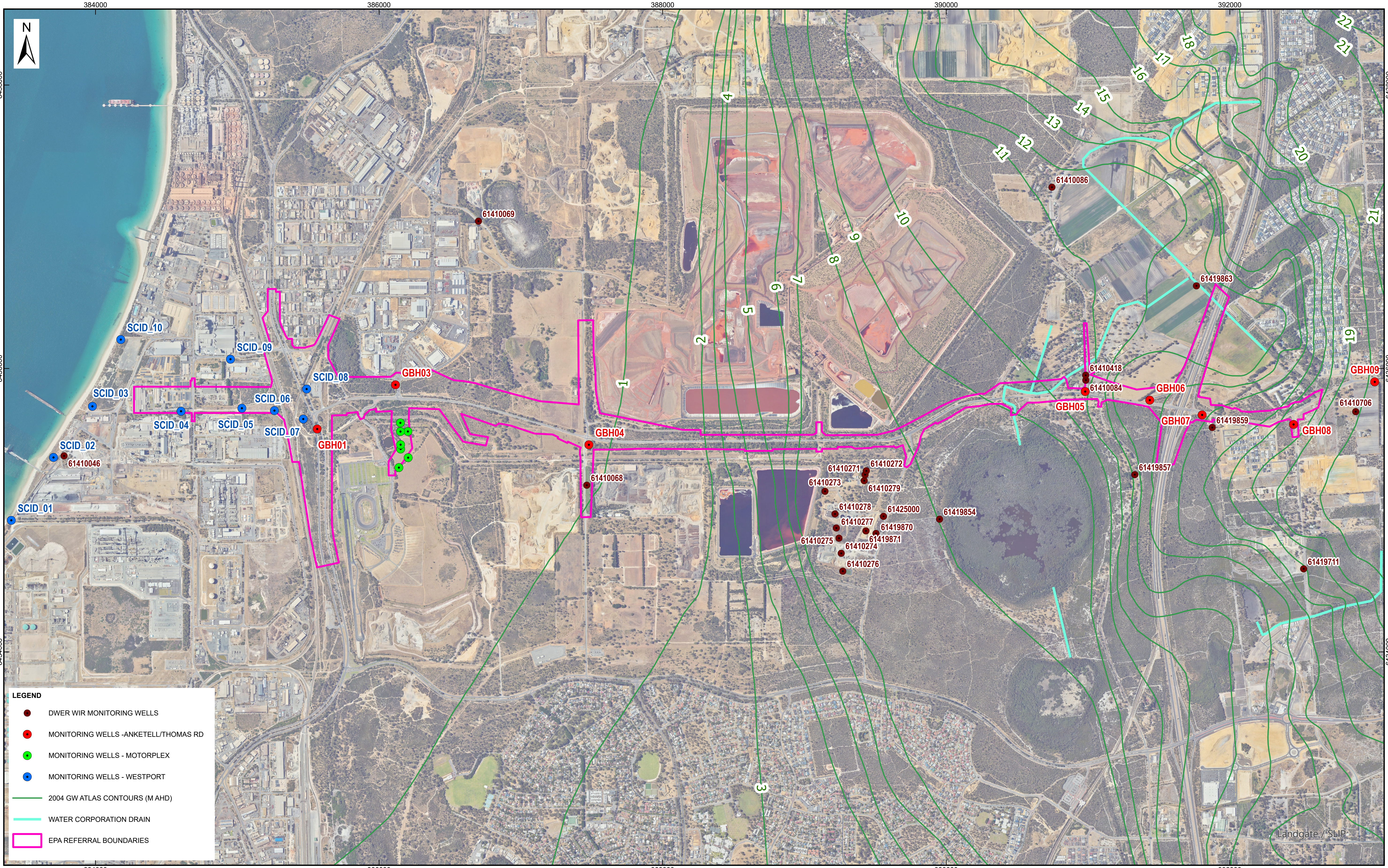
NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000

SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	5A
TITLE	1997 GW ATLAS CONTOURS
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



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REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

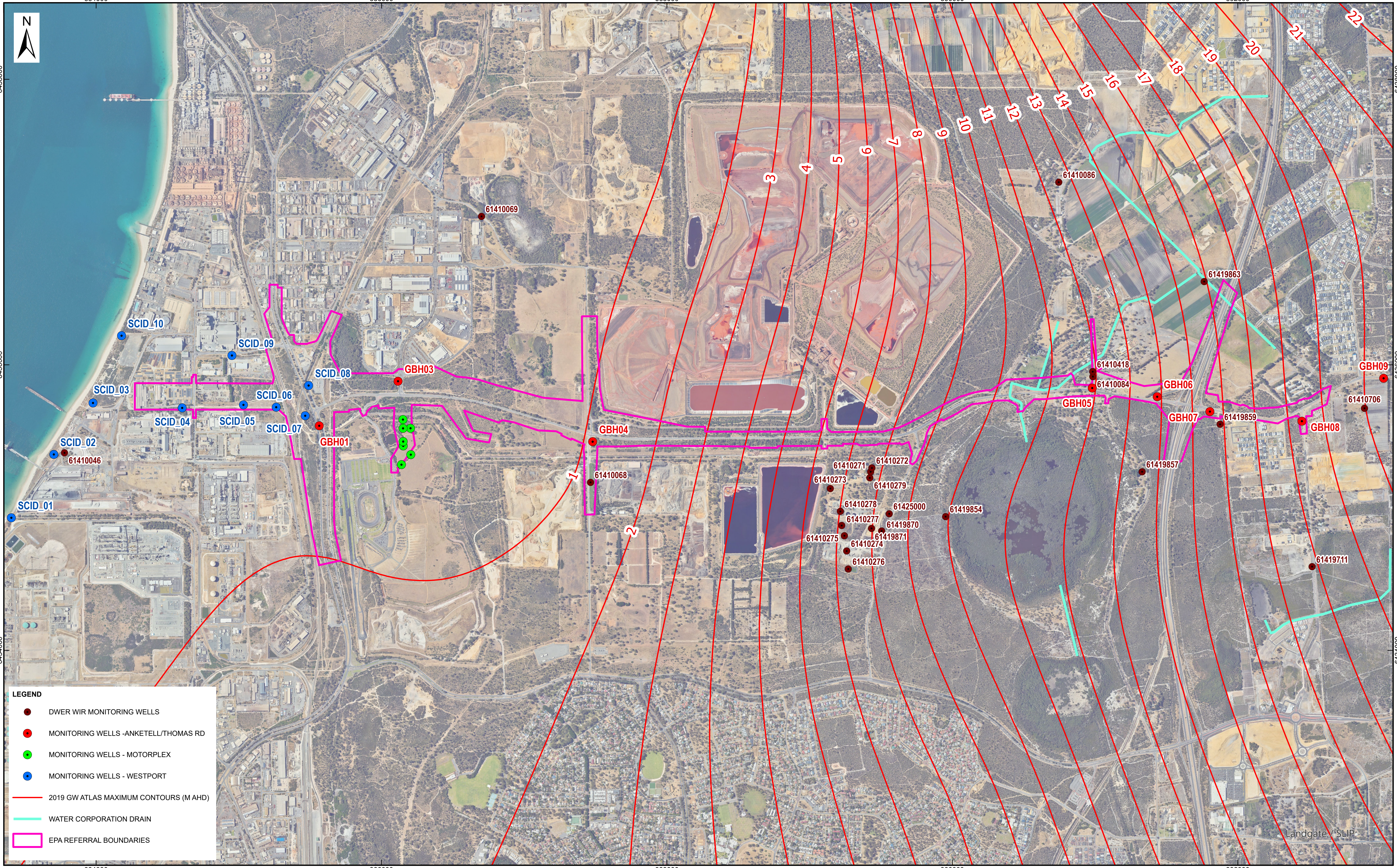
NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000

SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	5B
TITLE	2004 GW ATLAS CONTOURS
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS + FOUNDATIONS



LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\00 GIS\PRO\12106-02-R-RevA_NEW.aprx

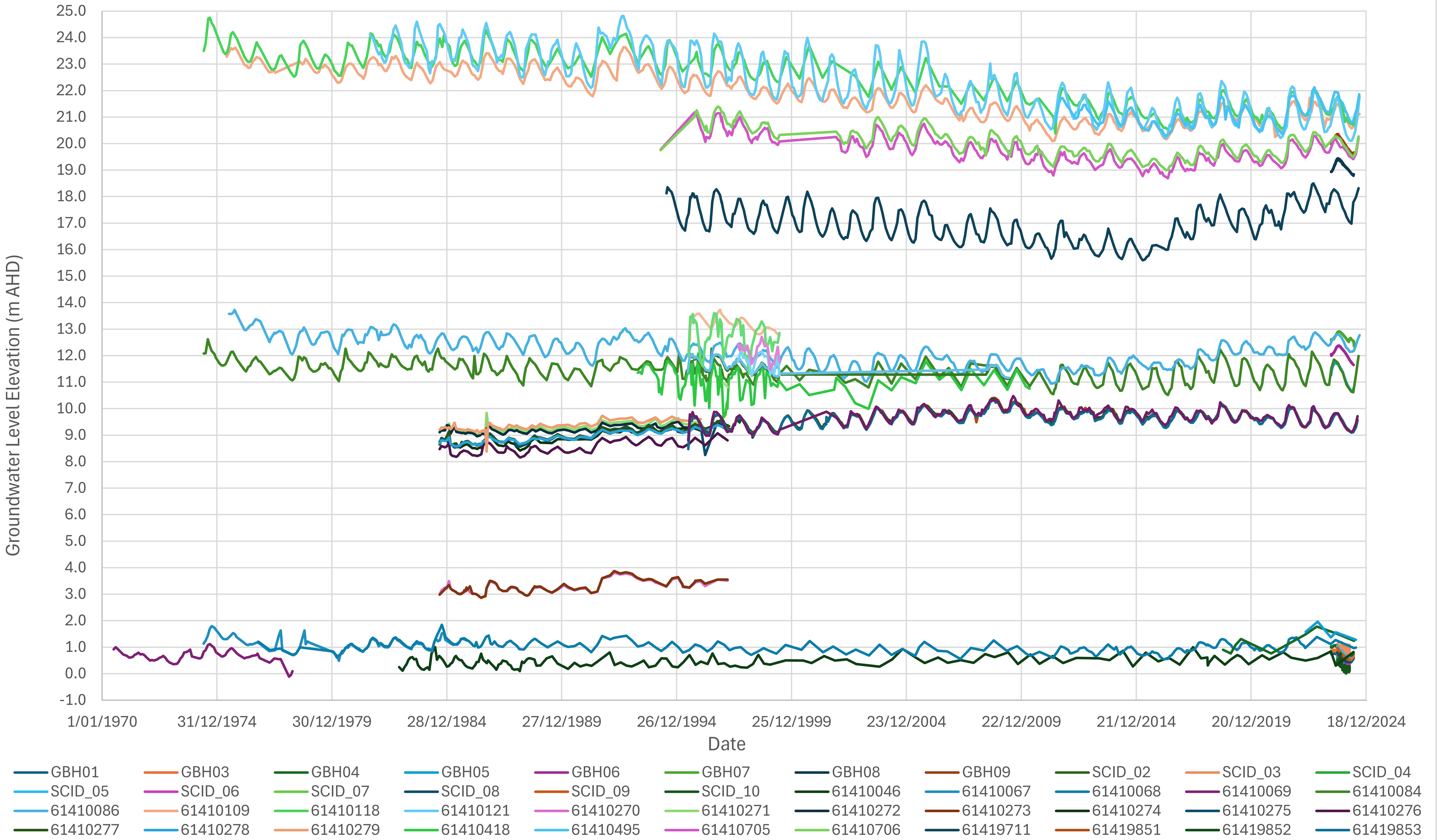
REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 200 400 600 800 1,000
SCALE: 1:25,000 METRES

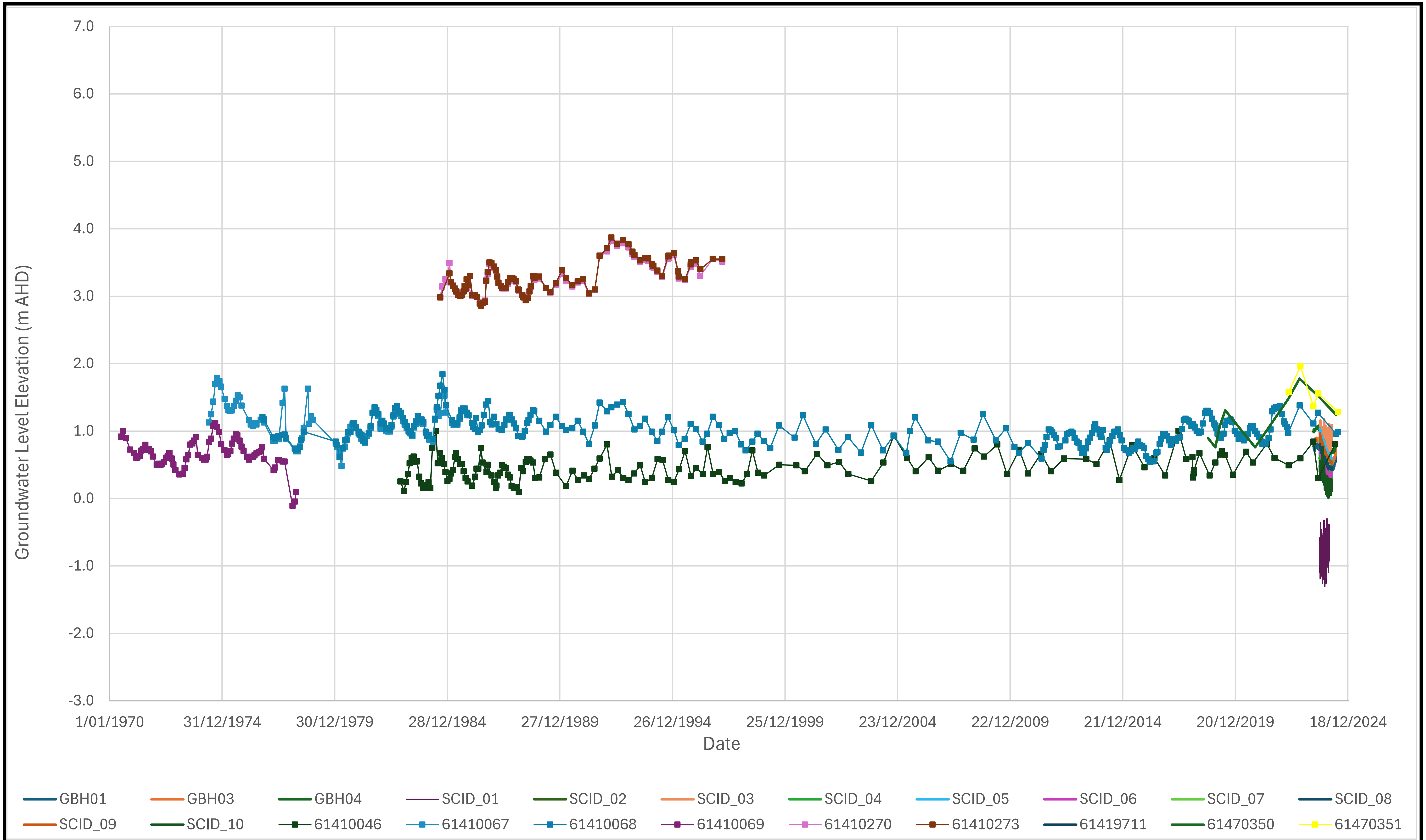
CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	5C
TITLE	2019 GW ATLAS CONTOURS
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



FSG GEOTECHNICS + FOUNDATIONS

CLIENT	Main Roads WA	PROJECT	Anketell Rd GWL Assessment
DRAWN AL	DATE 17-Dec-24	TITLE	ALL HYDROGRAPHS - ALL YEARS
CHECK DK	DATE 17-Dec-24		
SCALE Not To Scale	A3	PROJECT No. 12106	FIGURE No. 6



CLIENT	Main Roads WA			PROJECT	Anketell Rd GWL Assessment
DRAWN	AL	DATE	17-Dec-24	TITLE	**ALL HYDROGRAPHS - ALL YEARS WESTERN SECTION**
CHECK	DK	DATE	17-Dec-24		
SCALE	Not To Scale		A3	PROJECT No. 12106	FIGURE No. 6A

FSG GEOTECHNICS + FOUNDATIONS

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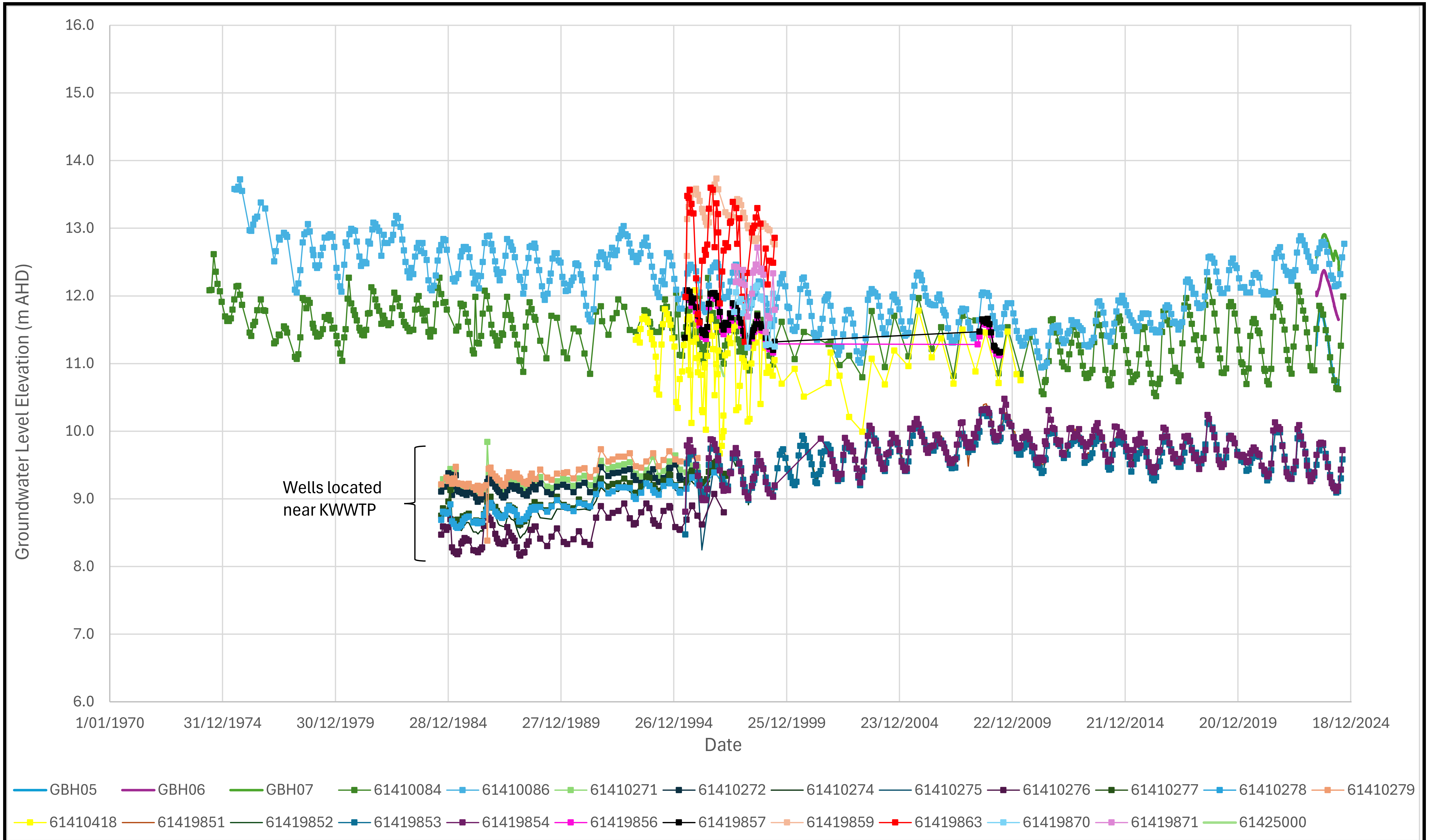

CLIENT	Main Roads WA			PROJECT	Anketell Rd GWL Assessment
DRAWN	AL	DATE	17-Dec-24	TITLE	**ALL HYDROGRAPHS - ALL YEARS CENTRAL SECTION**
CHECK	DK	DATE	17-Dec-24		
SCALE	Not To Scale		A3	PROJECT No. **12106**	FIGURE No. **6B**

FSG GEOTECHNICS + FOUNDATIONS

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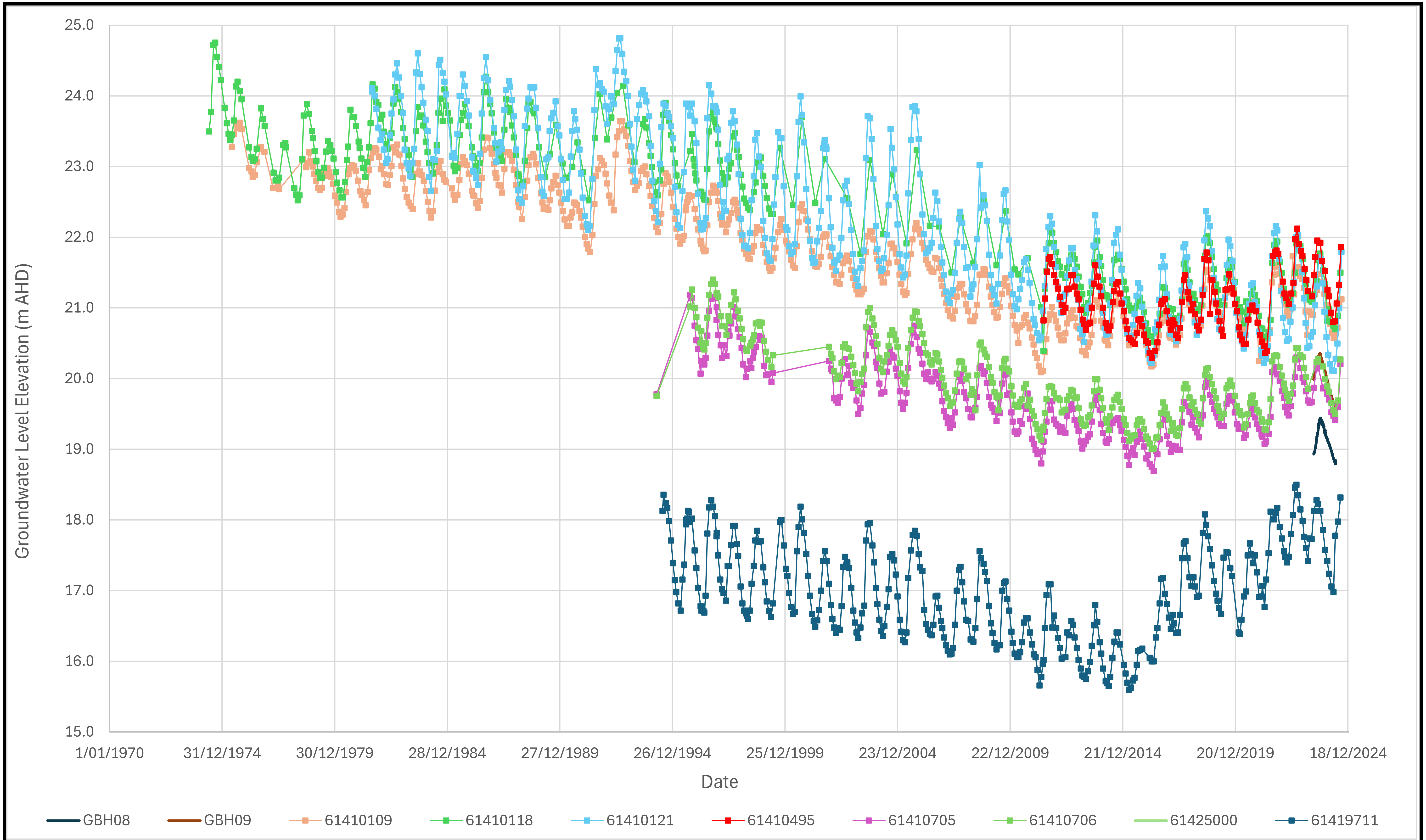
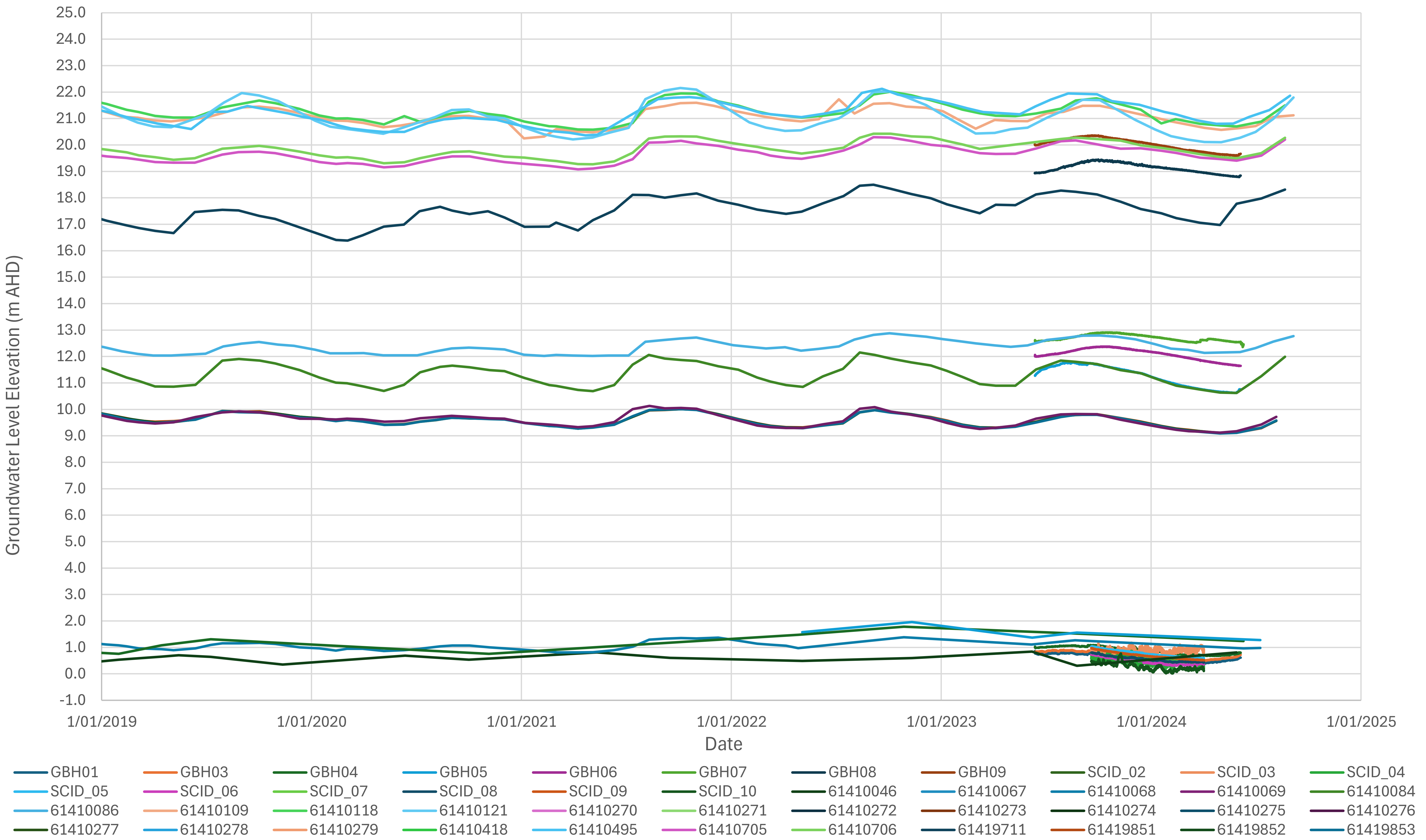


FSG GEOTECHNICS + FOUNDATIONS

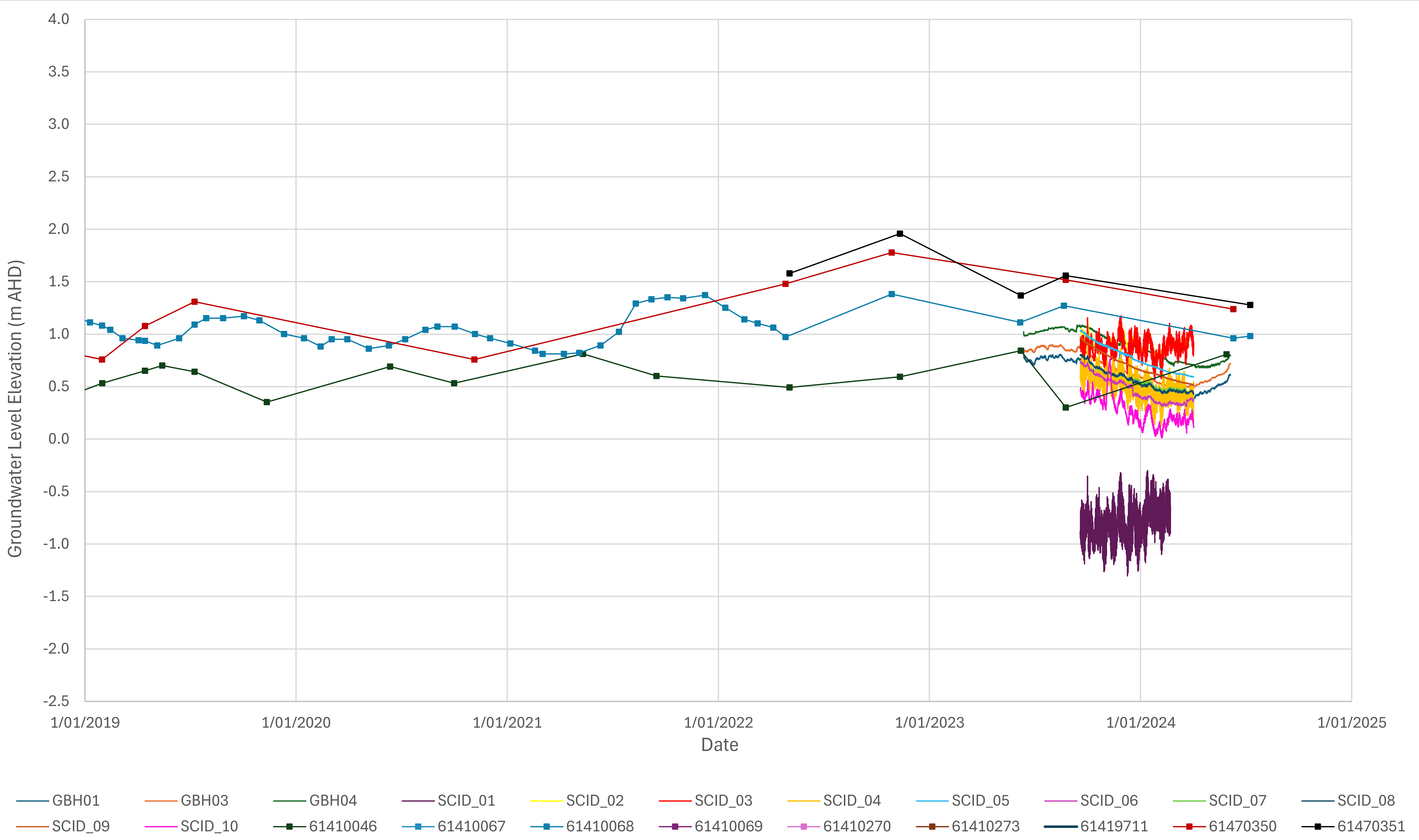
CLIENT	Main Roads WA			PROJECT	Anketell Rd GWL Assessment
DRAWN	AL	DATE	17-Dec-24	TITLE	**ALL HYDROGRAPHS - ALL YEARS EASTERN SECTION**
CHECK	DK	DATE	17-Dec-24		
SCALE	Not To Scale		A3	PROJECT No. 12106	FIGURE No. 6C

C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\GWL_MASTER_Rev4.xlsb



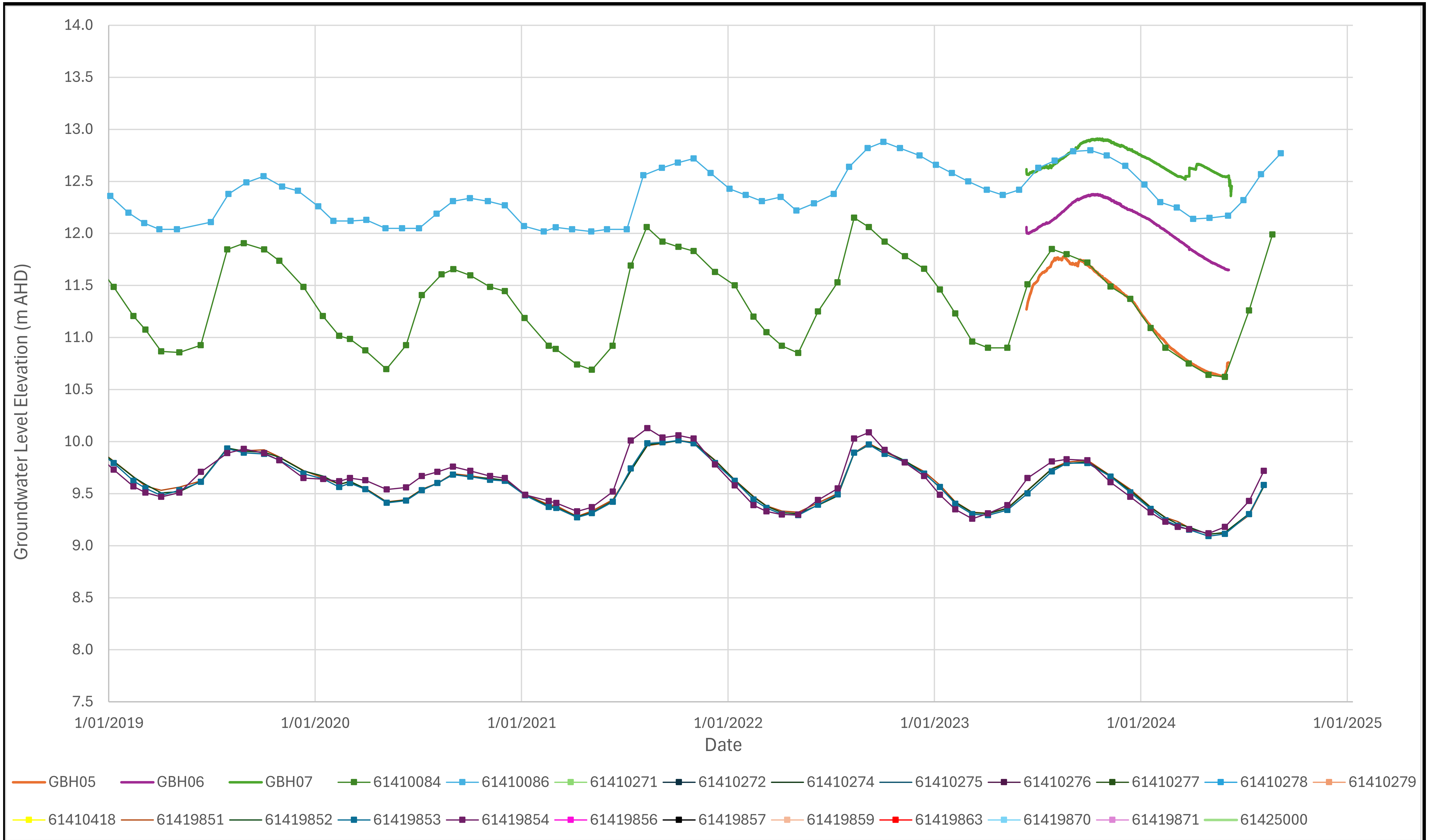
FSG GEOTECHNICS + FOUNDATIONS	CLIENT	Main Roads WA		PROJECT	Anketell Rd GWL Assessment
	DRAWN	AL	DATE 17-Dec-24	TITLE	**ALL HYDROGRAPHS - 2019 TO 2024**
	CHECK	DK	DATE 17-Dec-24		
	SCALE	Not To Scale	A3	PROJECT No. 12106	FIGURE No. 7

C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\GWL_MASTER_Rev4.xlsx



FSG GEOTECHNICS +FOUNDATIONS

CLIENT	Main Roads WA	PROJECT	Anketell Rd GWL Assessment
DRAWN AL	DATE 17-Dec-24	TITLE	**ALL HYDROGRAPHS - 2019 TO 2024 WESTERN SECTION**
CHECK DK	DATE 17-Dec-24		
SCALE Not To Scale	A3	PROJECT No. 12106	FIGURE No. 7A



CLIENT	Main Roads WA		PROJECT	Anketell Rd GWL Assessment
DRAWN	AL	DATE 17-Dec-24	TITLE	**ALL HYDROGRAPHS - 2019 TO 2024 CENTRAL SECTION**
CHECK	DK	DATE 17-Dec-24		
SCALE	Not To Scale	A3	PROJECT No. **12106**	FIGURE No. **7B**

FSG GEOTECHNICS + FOUNDATIONS

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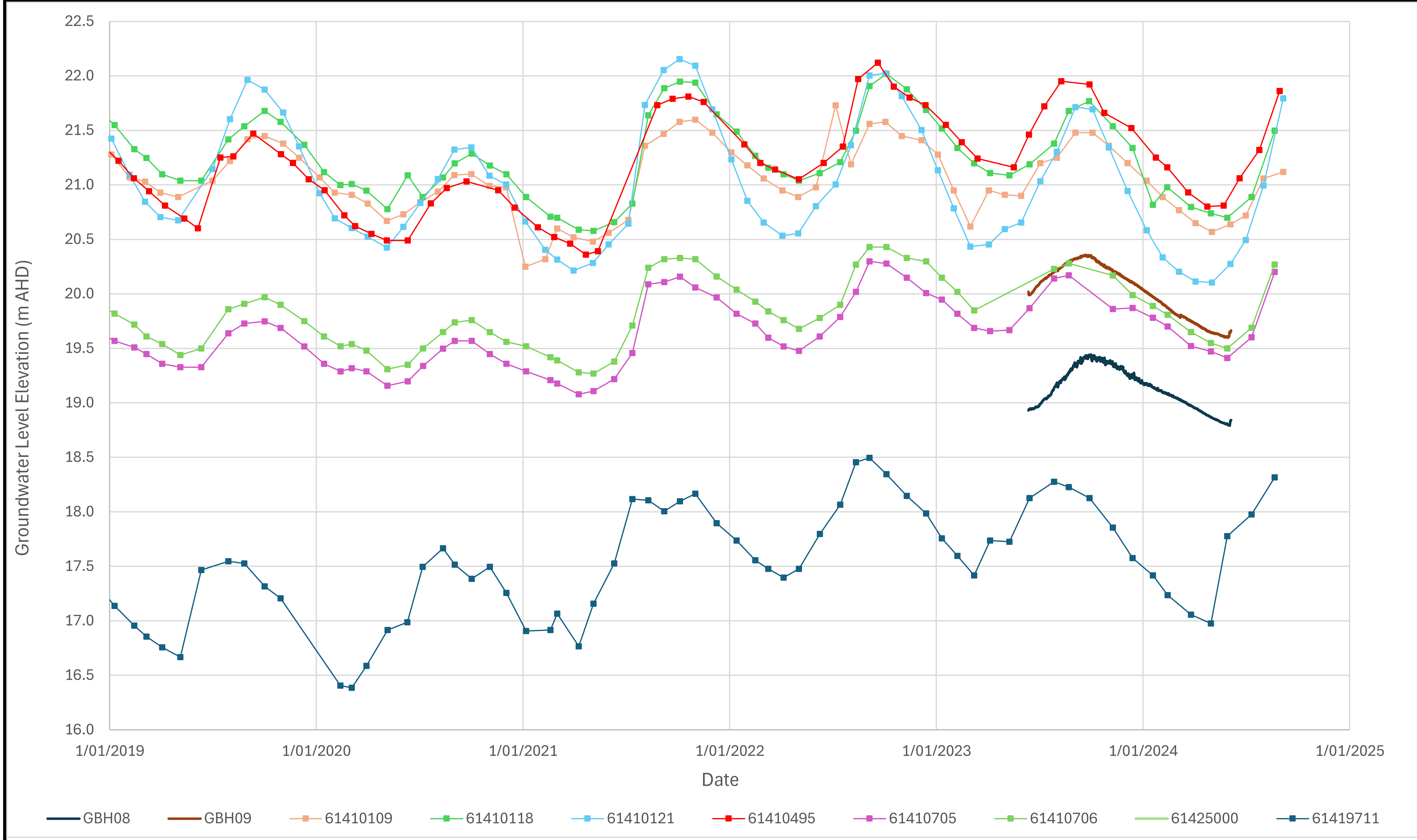

CLIENT	Main Roads WA		PROJECT	Anketell Rd GWL Assessment
DRAWN	AL	DATE 17-Dec-24	TITLE	**ALL HYDROGRAPHS - 2019 TO 2024 EASTERN SECTION**
CHECK	DK	DATE 17-Dec-24		
SCALE	Not To Scale	A3	PROJECT No. 12106	FIGURE No. 7C

FSG GEOTECHNICS + FOUNDATIONS

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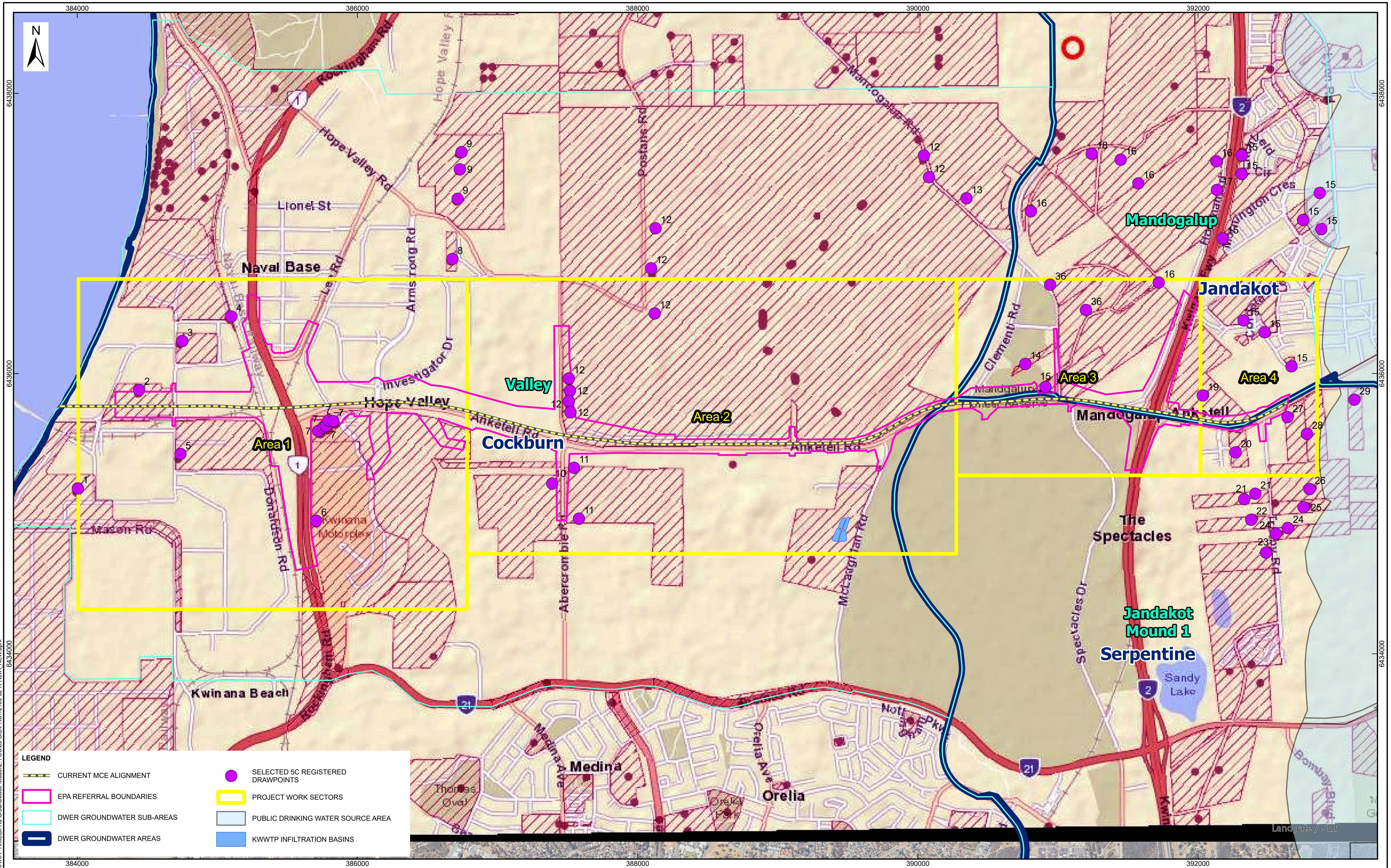


LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\00 GIS\PRO\12106-02-R-RevA_NEW.aprx

REFERENCES:

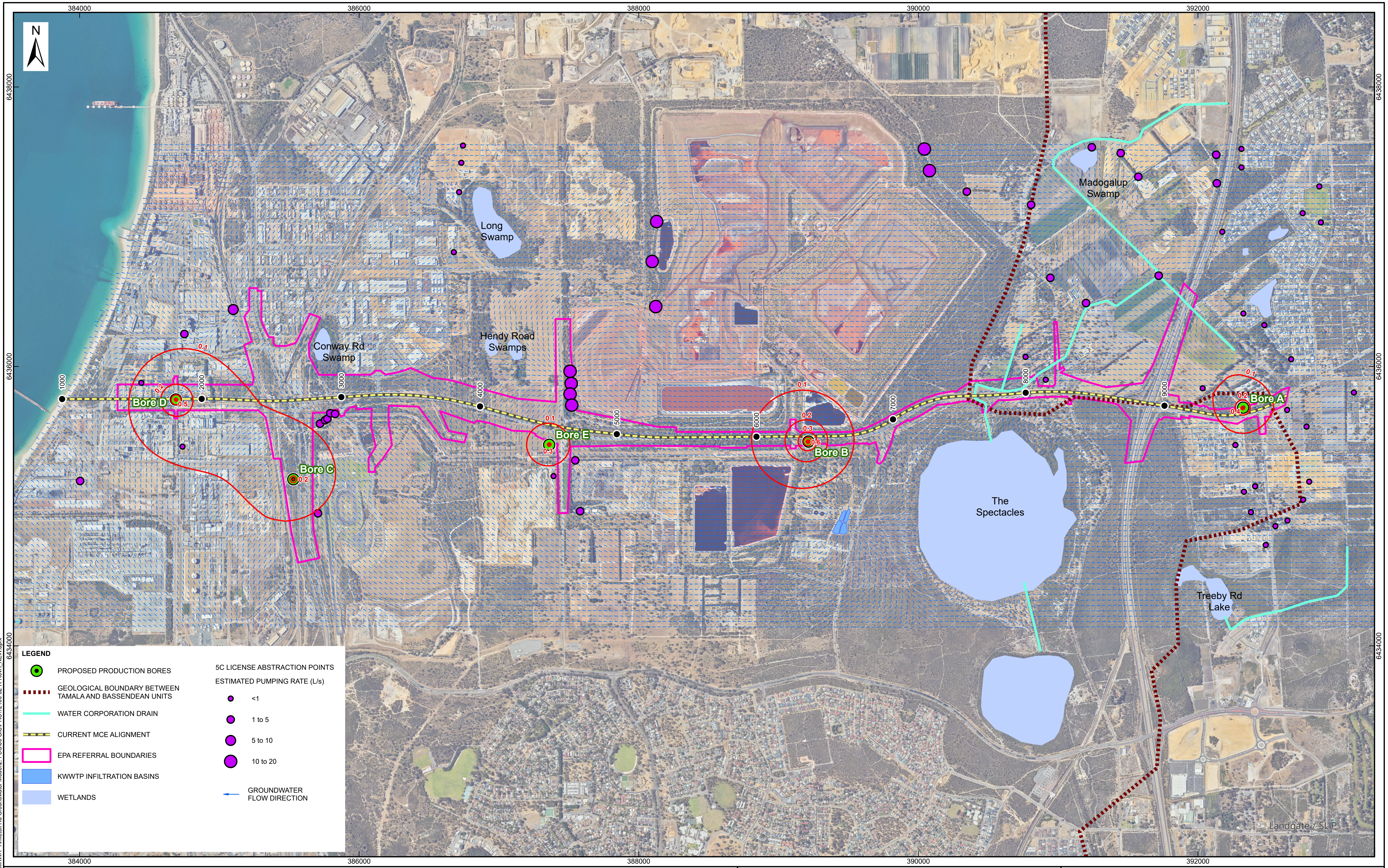
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

NOTE:

1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	8
TITLE	DWER REGISTERED 5C LICENSE HOLDERS IN SUPERFICIAL AQUIFER
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS + FOUNDATIONS



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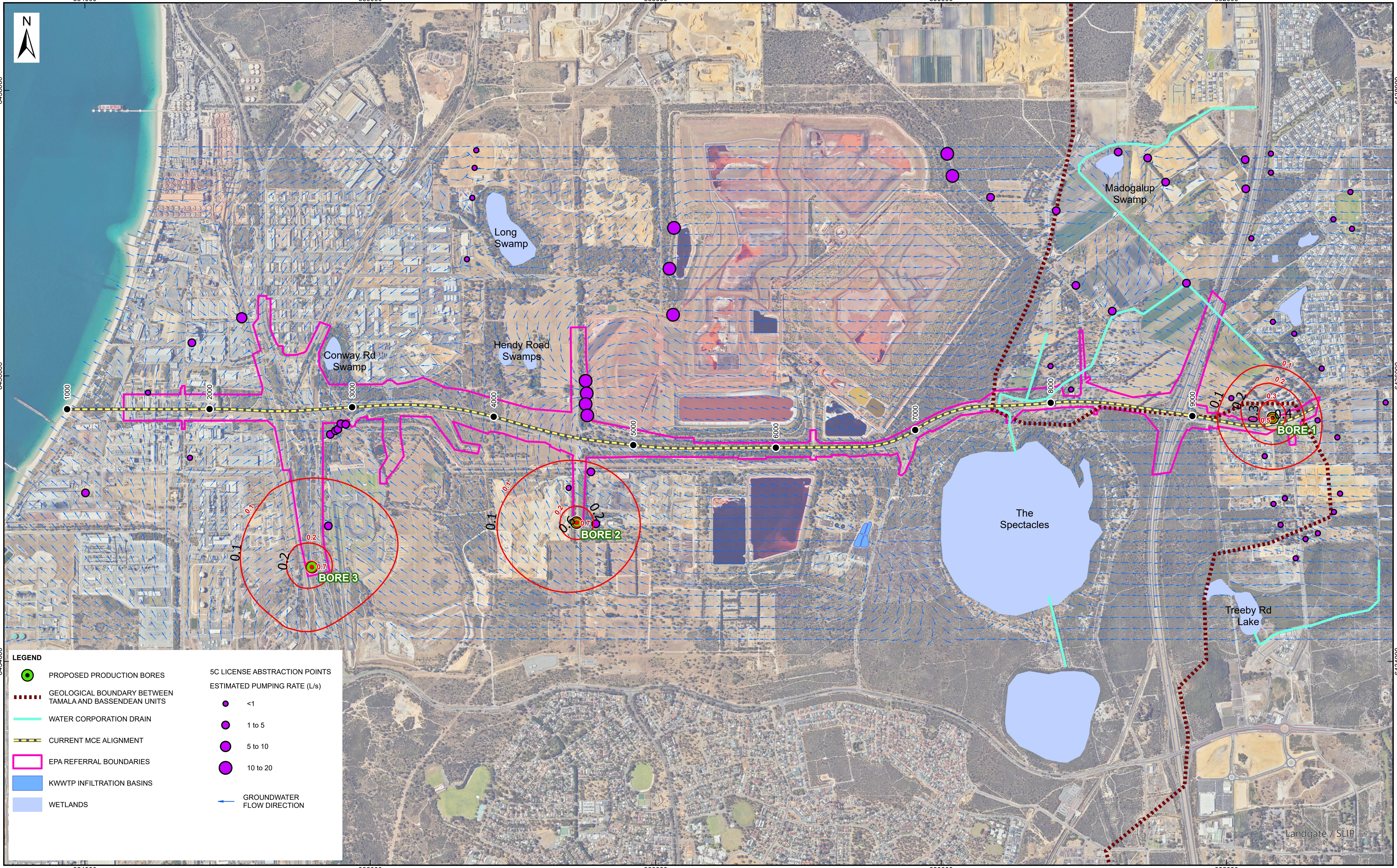
REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 250 500 750 1,000 1,250
SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
TITLE	GROUNDWATER LEVEL DRAWDOWN CONTOURS - SCENARIO 1, DAY 413
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	9

FSG GEOTECHNICS +FOUNDATIONS



LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\00 GIS\PRO\12106-02-R-RevA_NEW.aprx

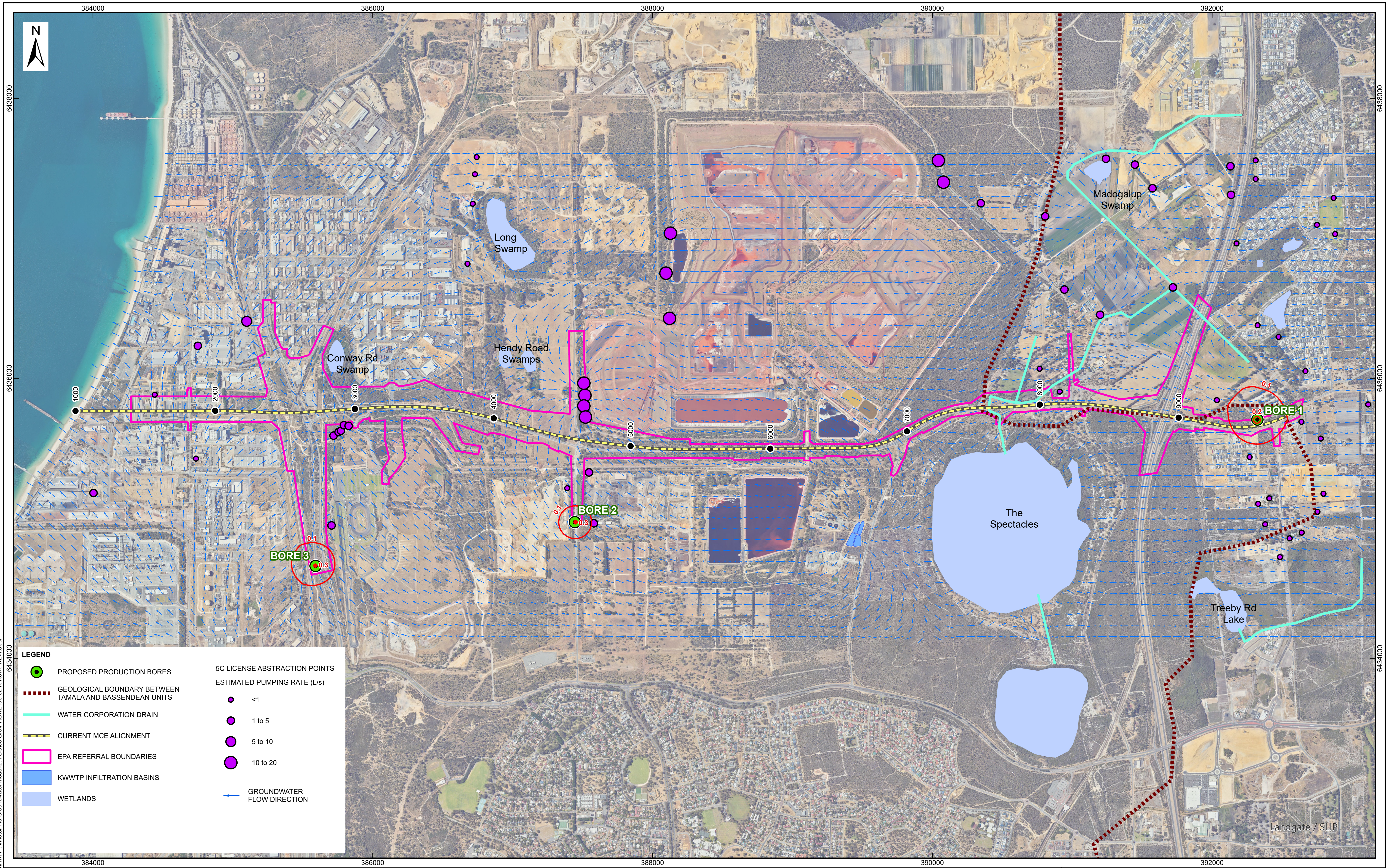
REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 250 500 750 1,000 1,250
SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	10
TITLE	GROUNDWATER LEVEL DRAWDOWN CONTOURS - SCENARIO 2, 413 DAYS
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS + FOUNDATIONS



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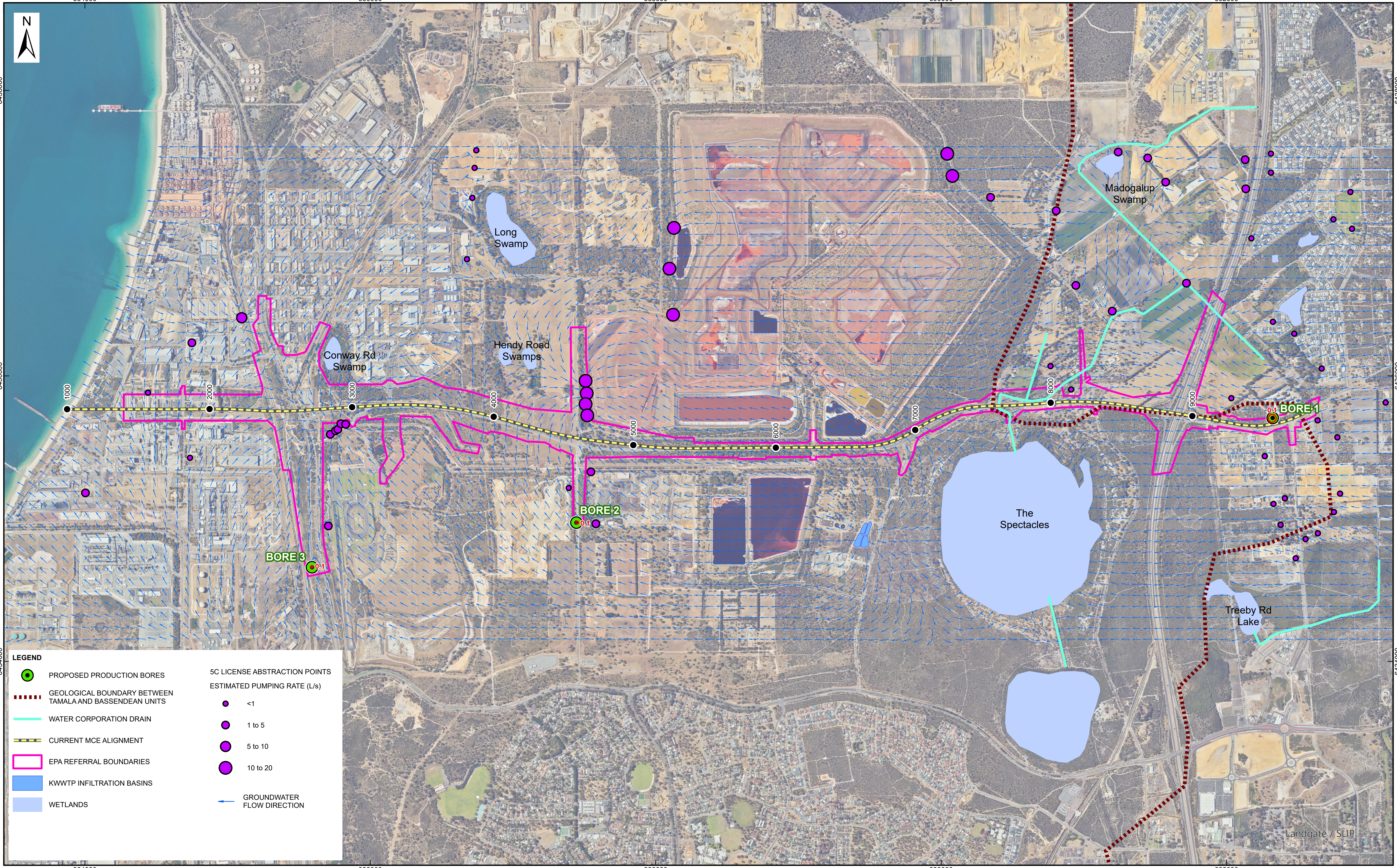
REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 250 500 750 1,000 1,250
SCALE: 1:25,000 METRES

CLIENT	MAIN ROADS WA
PROJECT	ANKETELL ROAD GROUNDWATER ASSESSMENT
PROJECT NO.	12106
DOC	02
REV.	A
FIGURE	11
TITLE	GROUNDWATER LEVEL DRAWDOWN CONTOURS - SCENARIO 3, 413 DAYS
DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



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REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

0 250 500 750 1,000 1,250
SCALE: 1:25,000 METRES

CLIENT
MAIN ROADS WA

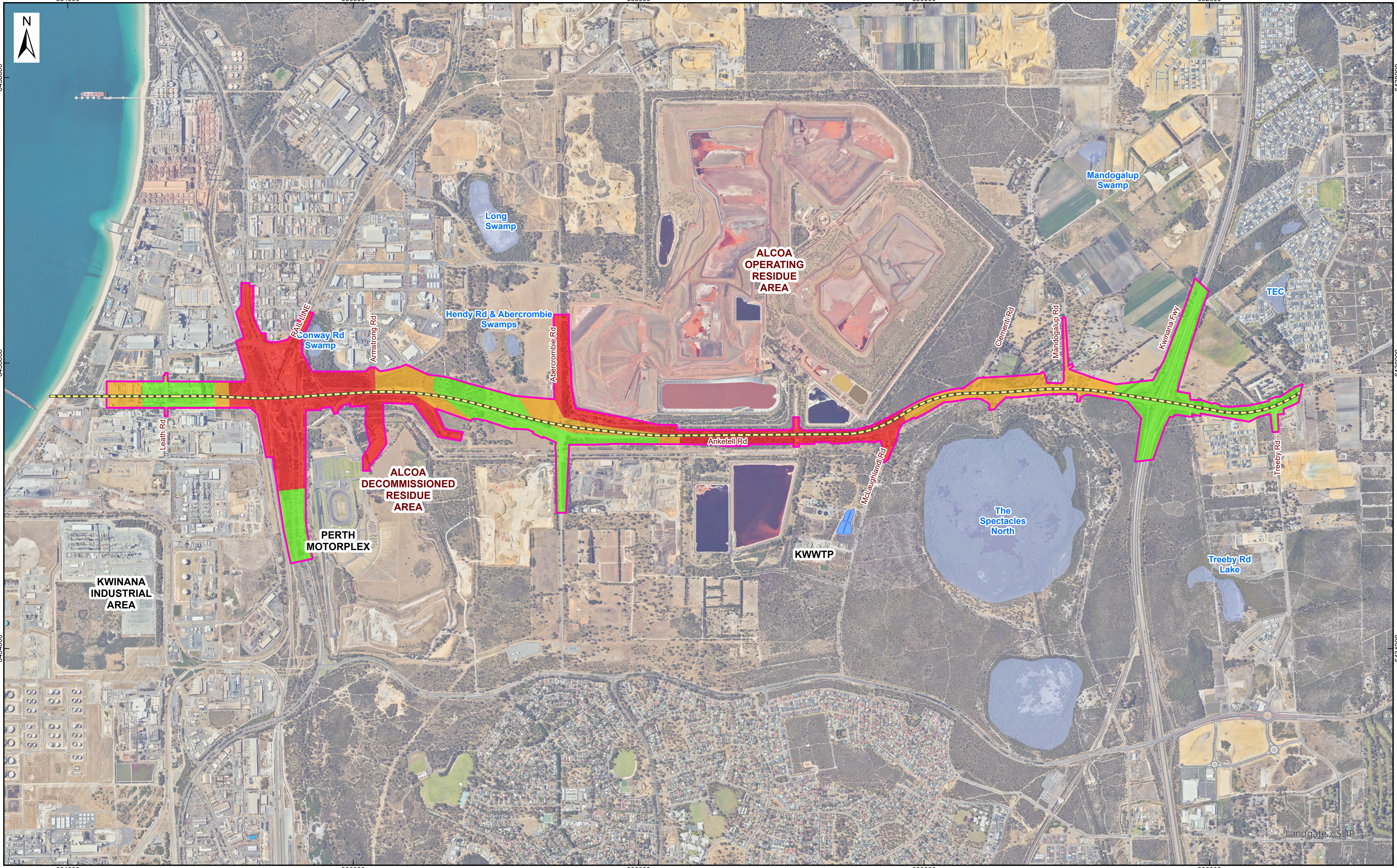
TITLE
GROUNDWATER LEVEL DRAWDOWN CONTOURS - SCENARIO 4 - DAY 623

PROJECT
ANKETELL ROAD GROUNDWATER ASSESSMENT

PROJECT NO.	DOC	REV.	FIGURE
12106	02	A	12

DATE	17-12-2024
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\00 GIS\PRO\12106-02-R-RevA_NEW.aprx

LEGEND

- CURRENT MCE ALIGNMENT
- EPA REFERRAL BOUNDARIES
- KWWTP INFILTRATION BASINS
- WETLANDS

PUMPING RISK:

- LOW
- MODERATE
- HIGH

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

0 250 500 750 1,000 1,250

SCALE: 1:25,000 METRES

CLIENT
MAIN ROADS WA

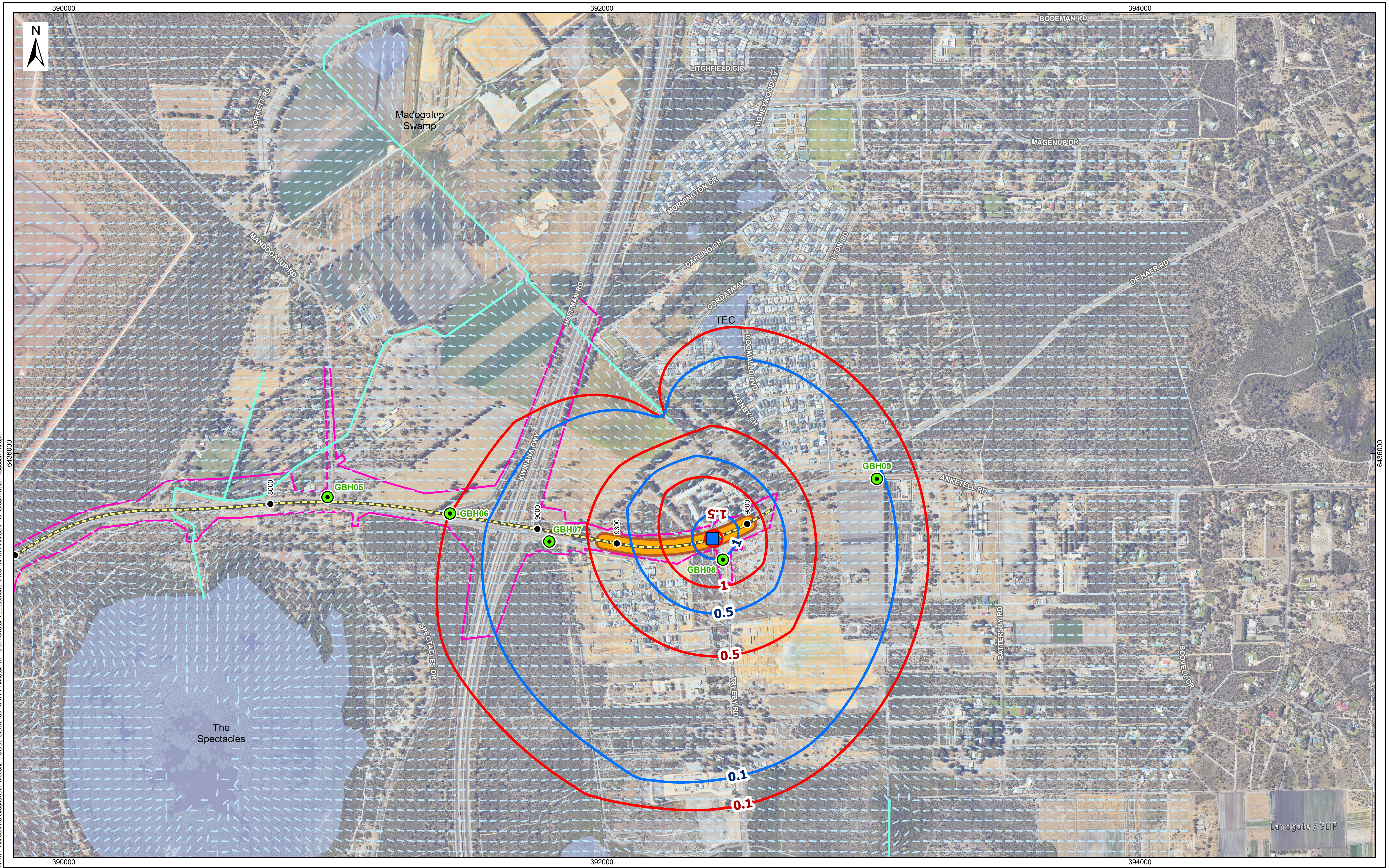
PROJECT
ANKETELL ROAD GROUNDWATER ASSESSMENT

PROJECT NO.	DOC	REV.	FIGURE
12106	02	A	13

TITLE
CONSTRUCTION WATER SUPPLY PUMPING RISK CLASSIFICATION WITHIN PROJECT BOUNDARY

DATE	23-02-2025
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS +FOUNDATIONS



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LEGEND

- EPA Referral Boundary
- CURRENT MCE ALIGNMENT
- Current_Chainage
- Dive Structure
- Dewatering Area
- DWER Well with Hydrograph
- Monitoring Well
- Groundwater Level Drawdown (m) during Dry Season
- Groundwater Level Drawdown (m) during Wet Season
- Groundwater Flow Direction
- Water Corporation Main Drain
- Wetland & TEC

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

0 130 260 390 520 650
SCALE: 1:13,000 METRES

CLIENT: MAIN ROADS WA

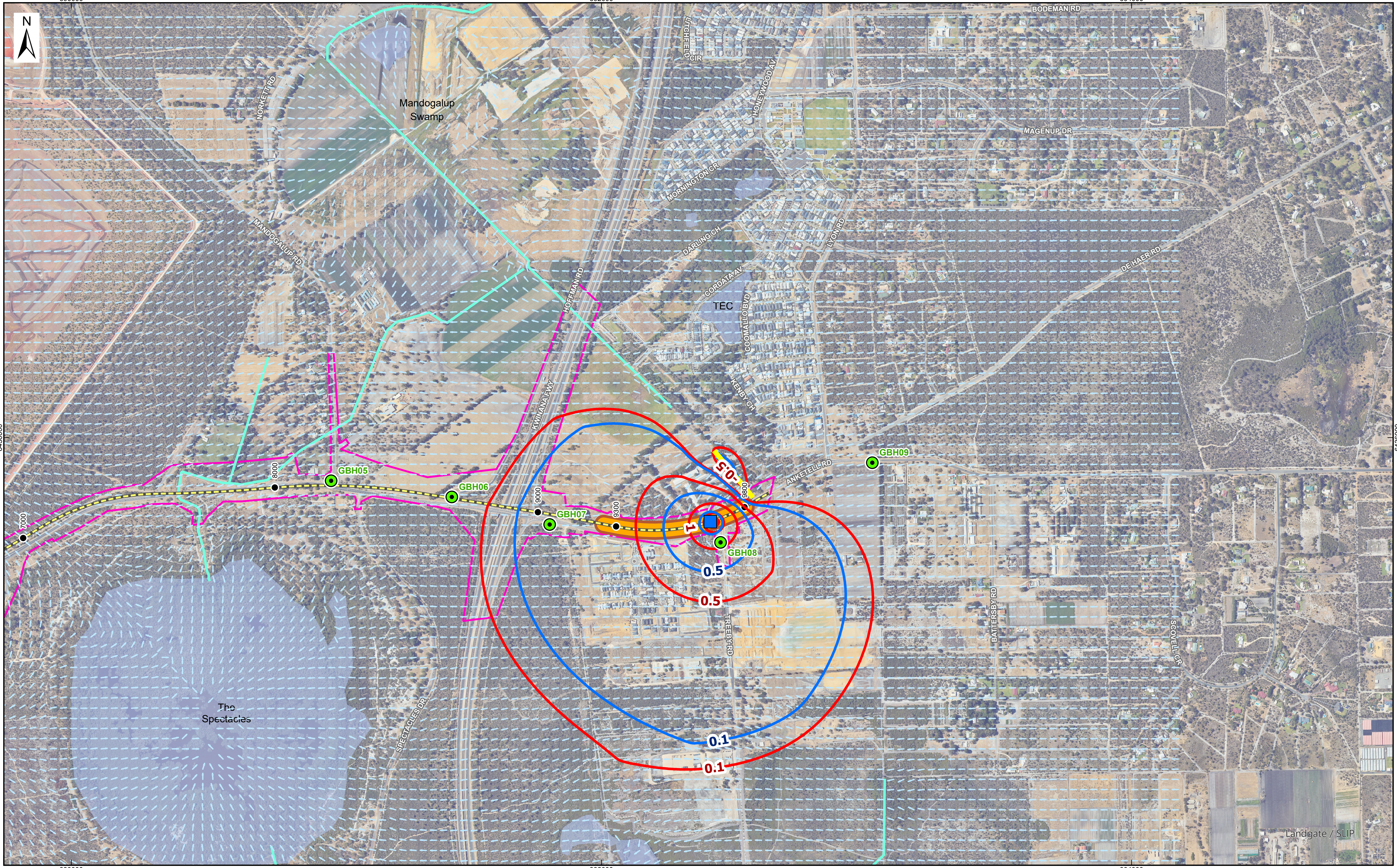
TITLE: MODELLED GROUNDWATER LEVEL DRAWDOWN WITHOUT RE-INFILTRATION

PROJECT: ANKETELL ROAD GROUNDWATER ASSESSMENT

PROJECT NO.	DOC	REV.	FIGURE
12106	02	A	14

DATE: 15-11-2024
DRAWN: J.R. PETILLA
DESIGNED: A. LUNDORF
REVIEWED:
APPROVED:

FSG GEOTECHNICS + FOUNDATIONS



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LEGEND

- EPA Referral Boundary
- CURRENT MCE ALIGNMENT
- Current_Chainage
- Dive Structure
- Dewatering Area
- Monitoring Well
- DWER Well with Hydrograph
- Groundwater Level Drawdown (m) during Wet Season
- Groundwater Level Drawdown (m) during Dry Season
- Infiltration Trench
- Groundwater Flow Direction
- Water Corporation Main Drain
- Wetland & TEC

NOTE:
1. SPATIAL REFERENCE: GDA2020 MGA Zone 50

REFERENCES:
1. BASED ON INFORMATION PROVIDED BY AND WITH THE PERMISSION OF THE WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2024).
2. 5C DRAWPOINTS AND ALLOCATION OBTAINED FROM THE DWER WATER REGISTER.

0 130 260 390 520 650

SCALE: 1:13,460 METRES

CLIENT	TITLE
MAIN ROADS WA	MODELLED GROUNDWATER LEVEL DRAWDOWN WITH RE-INFILTRATION

PROJECT			
ANKETELL ROAD GROUNDWATER ASSESSMENT			
PROJECT NO.	DOC	REV.	FIGURE
12106	02	A	15

DATE	15-11-2024
DRAWN	J.R. PETILLA
DESIGNED	A. LUNDORF
REVIEWED	
APPROVED	

FSG GEOTECHNICS + FOUNDATIONS

Appendix A
Geological Long-Section

LEGEND

- FILL
- BASSENDEAN SAND (GNANGARA DUNE)
- BASSENDEAN SAND
- TAMALA SAND
- TAMALA LIMESTONE
- GUILDFORD FORMATION
- OSBORNE FORMATION
- SAFETY BAY SAND
- BECHER SAND 1 & BRIDPORT CALCILUTITE
- BECHER SAND 2 (CLAY / SILT / SAND)
- EXISTING SURFACE LEVEL
- DESIGN SURFACE LEVEL
- TARGET DEWATERING LEVEL
- 40 YR DESIGN GROUNDWATER LEVEL (DGWL)
- CURRENT SEASONAL MAXIMUM GROUNDWATER LEVEL
- CURRENT SEASONAL MINIMUM GROUNDWATER LEVEL

NOTE

THE GEOLOGICAL SECTION AND BOUNDARIES HAVE BEEN RE-CREATED BY "STITCHING" TOGETHER:
* FIGURE 2: TERRESTRIAL SECTION PROFILE FROM REPORT WP-S3-DL-SCID-405522-P4-PS-WS6-GL-RPT-0001_1
* FIGURE 6: GEOLOGICAL MODEL FROM REPORT 21493850-001-R-Rev0
* ALIGNING THOSE SECTIONS TO THE NEW ALIGNMENT WITH THE EXISTING SURFACE AND DESIGN SURFACES OBTAINED FROM DRAWING SK-C00090-C

FOLLOWING THIS, FSG ADDED BECHER SAND 2 BASED ON THE INTERPRETATION OF THE BORE LOGS PROVIDED IN WP-S3-DL-SCID-405522-P4-PS-WS6-GL-RPT-0001_1 AND OUR EXPERIENCE IN THE AREA THAT THIS IS A LOW PERMEABILITY LAYER THAT SEPARATES THE SUPERFICIAL AQUIFIER INTO TWO SUB-AQUIFERS WHERE THIS LAYER IS PRESENT.

0 5 10 15 20
SCALE: 1:400 V METRES
0 150 300 450 600
SCALE: 1:12,000 H METRES

CLIENT MAIN ROADS WA	TITLE GEOLOGICAL LONG SECTION
PROJECT ANKETELL ROAD GROUNDWATER ASSESSMENT	DATE 12-11-2024 DRAWN J.R. PETILLA DESIGNED A. LUNDORF REVIEWED APPROVED
PROJECT NO. 12106 DOC REV. FIGURE	FSG GEOTECHNICS +FOUNDATIONS

LOCATION: C:\FSG Dropbox\Jobs\WA\12106 - MRWA - Anketell Rd Groundwater Model\2. FSG\05 CAD\FIGURES\01\Rev\A\12106-01-RevA-F001.dwg

Appendix B
Summary of Construction Details for Selected Monitoring Wells

APPENDIX C - SUMMARY OF CONSTRUCTION DSETAILS OF SELECTED MONITORING WELLS

Well ID	Source	Easting	Northing	Ground Elevation (m AHD)	Top Of Casing (m AHD)	Borehole Depth	Well Depth (m bgl)	Screen From (mbGL)	Screen To (mbGL)	Screened Geology	GWL Period Start	GWL Period End	Duration (Years)	Minimum Groundwater Level (m AHD)	Date of Min	Maximum Groundwater Level (m AHD)	Date of Max	Average Seasonal Change (m)	Current Seasonal Maximum Groundwater Level (m AHD)	Current Seasonal Minimum Groundwater Level (m AHD)	Difference between MIN and MAX GWL (m)
GBH01	MRWA	385564	6435573	17.18	17.12	29.8	29.8	26.8	29.8	Limestone	13/06/2023	5/06/2024	1	0.36	13/03/2024	0.81	15/08/2023	0.40	0.90	0.36	0.54
GBH03	MRWA	386116	6435885	10.79	10.71	30.0	30.0	27.0	30.0	Limestone	13/06/2023	5/06/2024	1	0.49	24/03/2024	0.90	5/06/2024	0.40	1.00	0.49	0.51
GBH04	MRWA	387479	6435461	9.15	9.04	19.8	19.8	16.8	19.8	Limestone	13/06/2023	5/06/2024	1	0.68	8/04/2024	1.09	14/09/2023	0.40	1.15	0.68	0.47
GBH05	MRWA	390980	6435837	16.48	16.39	9.0	9.0	6.0	9.0	Bassendean Sand	13/06/2023	5/06/2024	1	10.62	25/05/2024	11.78	18/08/2023	1.20	12.20	10.40	1.80
GBH06	MRWA	391435	6435776	22.96	22.83	15.0	15.0	12.0	15.0	Bassendean Sand	13/06/2023	5/06/2024	1	11.65	5/06/2024	12.38	17/10/2023	0.70	12.50	11.60	0.90
GBH07	MRWA	391805	6435672	25.02	24.93	15.0	15.0	12.0	15.0	Bassendean Sand	13/06/2023	5/06/2024	1	12.36	9/06/2024	12.91	17/10/2023	0.4	13.00	12.40	0.60
GBH08	MRWA	392449	6435605	32.87	32.77	18.0	18.0	15.0	19.0	Bassendean Sand	13/06/2023	5/06/2024	1	18.79	1/06/2024	19.44	2/10/2023	0.70	19.50	18.80	0.70
GBH09	MRWA	393022	6435905	29.27	29.19	12.9	12.9	9.9	12.9	Bassendean Sand	13/06/2023	5/06/2024	1	19.60	24/05/2024	20.36	22/09/2023	0.70	20.50	19.60	0.90
SCID01	MRWA	383406	6434928	2.92	3.52	44.5	28.4	25.0	28.0	Limestone	19/09/2023	2/04/2024	1	-1.30	10/12/2023	-0.30	13/01/2024	-	Tide		
SCID02	MRWA	383704	6435372	3.75	4.31	44.2	13.8	10.0	13.0	Sand	19/09/2023	2/04/2024	1	0.76	7/02/2024	1.11	2/10/2023	-	Tide		
SCID03	MRWA	383978	6435733	4.71	4.61	44.5	44.4	41.0	44.0	Kardinya Shale	19/09/2023	2/04/2024	1	0.57	26/01/2024	1.17	27/11/2023		Tide		
SCID04	MRWA	384603	6435698	3.85	3.77	42.5	25.2	22.0	25.0	Limestone	19/09/2023	2/04/2024	1	0.12	6/02/2024	0.91	1/10/2023	0.40	1.00	0.15	0.85
SCID05	MRWA	385033	6435719	7.02	7.60	45.5	10.8	7.0	10.0	Silty Sand	19/09/2023	2/04/2024	1	0.59	30/03/2024	1.04	21/09/2023	0.40	1.10	0.55	0.55
SCID06	MRWA	385262	6435703	5.14	5.79	44.0	15.0	11.0	14.0	Limestone	19/09/2023	2/04/2024	1	0.31	8/02/2024	0.74	21/09/2023	0.55	0.90	0.20	0.70
SCID07	MRWA	385465	6435643	11.14	11.79	39.5	21.0	17.0	20.0	Limestone	19/09/2023	21/03/2024	1	0.45	8/02/2024	0.80	21/09/2023	0.55	0.90	0.20	0.70
SCID08	MRWA	385489	6435855	18.28	18.91	47.5	48.3	45.0	48.0	Kardinya Shale	19/09/2023	2/04/2024	1	0.43	9/02/2024	0.81	20/09/2023	0.55	0.90	0.20	0.70
SCID09	MRWA	384952	6436065	6.02	6.90	44.5	10.7	7.0	10.0	Sand	19/09/2023	2/04/2024	1	0.51	2/04/2024	0.97	19/09/2023	0.55	1.05	0.40	0.65
SCID10	MRWA	384178	6436204	5.10	5.00	44.5	10.0	7.0	10.0	Sand	19/09/2023	2/04/2024	1	0.01	7/02/2024	0.76	9/11/2023	-	Tide		
61410046	DWER	383779	6435384	4.00	-	-	38.0	-	-	-	1/12/1982	29/05/2024	42	0.09	26/06/1984	1.00	2/03/1988	-	Tide		
61410068	DWER	387465	6435177	14.69	-	35.0	35.0	26.0	32.0	-	14/10/1976	9/07/2024	48	0.54	10/10/1974	1.84	18/04/1980	0.6	1.40	0.80	0.60
61410069	DWER	386701	6437040	-	-	-	-	-	-	-	3/07/1970	14/04/1978	8	-0.11	11/10/1984	1.12	1/03/2016	0.7	1.10	0.27	0.83
61410084	DWER	390985	6435916	16.68	-	45.0	40.0	0.0	40.0	Sand & Limestone	4/06/1974	21/08/2024	50	10.52	10/09/1974	12.62	16/02/1978	1.3	12.2	10.4	1.80
61410086	DWER	390746	6437279	20.23	-	13.0	13.0	-0.5	13.0	-	11/07/1975	5/09/2024	49	10.94	9/08/1974	13.72	6/05/2016	0.7	12.9	12.0	0.90
61410109	DWER	393326	6437620	25.80	-	16.7	16.7	4.6	16.6	-	6/06/1975	5/09/2024	49	20.09	9/10/1975	23.64	4/04/2011	0.9	21.6	20.5	1.10
61410118	DWER	395255	6435693	30.40	-	51.0	47.0	0.0	47.0	Sand	4/06/1974	21/08/2024	50	20.39	2/09/1992	24.75	3/05/2011	1.0	22.0	20.5	1.50
61410121	DWER	395320	6437661	26.12	-	13.7	13.7	-0.5	13.7	-	28/08/1981	5/09/2024	43	20.10	10/09/1974	24.82	16/06/2011	1.6	22.10	20.10	2.00
61410271	DWER	389428	6435251	-	26.02	21.8	20.8	15.8	20.8	-	5/09/1984	12/01/1996	11	9.04	10/04/1992	9.84	30/06/1986	1.1	10.05	8.65	1.40
61410272	DWER	389437	6435278	-	25.67	20.8	19.8	14.8	19.8	-	5/09/1984	13/03/1997	13	8.96	23/09/1986	9.51	21/04/1986	1.1	9.95	8.55	1.40
61410274	DWER	389260	6434696	-	17.31	12.8	11.8	6.8	11.8	-	5/09/1984	13/03/1997	13	8.42	10/04/1992	9.41	30/06/1986	0.7	9.6	8.8	0.80
61410275	DWER	389244	6434803	-	21.85	19.0	18.0	13.0	18.0	-	5/09/1984	13/03/1997	13	8.25	8/03/1988	9.53	8/10/1996	1.1	9.8	8.4	1.40
61410276	DWER	389271	6434570	-	12.92	9.7	8.7	3.7	8.7	-	5/09/1984	13/03/1997	13	8.16	8/10/1996	9.07	24/03/1996	1.3	9.5	7.7	1.80
61410277	DWER	389225	6434875	22.55	22.55	20.4	19.4	14.4	19.4	-	5/09/1984	8/04/1997	13	8.59	8/10/1996	9.55	8/03/1988	0.9	9.8	8.6	1.20
61410278	DWER	389216	6434974	-	20.09	16.5	15.5	10.5	15.5	-	5/09/1984	13/03/1997	13	8.57	15/11/1996	9.39	20/06/1985	0.7	9.6	8.8	0.80
61410279	DWER	389422	6435209	26.42	26.42	21.5	20.5	15.5	20.5	-	5/09/1984	12/01/1996	11	8.38	8/10/1996	9.73	27/05/1985	1.1	10.23	8.83	1.40
61410418	DWER	390984	6435953	-	15.57	29.0	28.0	22.0	28.0	-	20/04/1993	5/05/2010	17	9.67	3/10/1991	12.08	23/09/1986		Affected by pumping		
61410495	DWER	395310	6433900	-	25.20	0.0	4.5	-	-	-	17/06/2011	30/08/2024	13	20.29	4/12/1995	22.12	9/01/1997	1.1	22.20	20.40	1.80
61410706	DWER	392888	6435696	23.75	24.44	9.0	9.0	4.0	9.0	Sand	15/04/1994	21/08/2024	30	19.00	9/10/1995	21.40	6/05/2016	0.8	20.40	19.30	1.10
61419711	DWER	392521	6434586		19.92	6.0	6.0	3.0	6.0	Coffee rock & Sand	18/07/1994	21/08/2024	30	15.60	16/10/1996	18.50	4/04/2016	1.2	18.50	16.40	2.10
61419854	DWER	389955	6434936	10.81	11.39	7.0	7.0	3.0	7.0	-	30/06/1995	6/08/2024	29	8.81	12/09/2008	10.48	30/06/1995	0.8	10.10	9.10	1.00
61419857	DWER	391330	6435251	14.38	14.90	5.0	5.0	3.0	5.0	-	20/06/1995	8/06/2009	14	11.16	26/07/1995	12.08	26/05/2009	0.9	12.30	11.10	1.20
61419859	DWER	391876	6435584	26.59	27.13	21.0	21.0	15.0	21.0	-	25/07/1995	15/06/1999	4	12.59	27/07/1995	13.73	26/05/2009	1.0	13.80	12.60	1.20
61419863	DWER	391765	6436584	13.98	14.60	8.0	8.0	3.0	8.0	-	4/07/1995	15/06/1999	4	11.32	15/11/1996	13.60	25/07/1995	1.3	13.80	12.30	1.50
61419870	DWER	389505	6434836	-	18.88	7.5	7.5	1.5	7.5	-	27/08/1997	15/06/1999	2	11.23	13/08/1996	12.22	17/02/1998	-	11.90	10.90	1.00
61419871	DWER	389434	6434854	-	19.33	9.6	9.6	6.6	9.6	-	27/08/1997	15/06/1999	2	11.46	17/10/1997	12.71	1/04/1998	-	13.20	12.20	1.00
61425000	DWER	389558	6434957	-	21.31	16.3	16.3	10.3	16.3	-	13/01/1997	13/03/1997	0	10.81	8/09/1998	10.96	22/01/1999	-	11.10	10.10	1.00
61470350	DWER	384736	6435329	6.26	-	30.0	30.0	13.0	28.0	Sand & Limestone	1/10/2018	10/06/2024	6	0.76	8/10/1996	1.78	13/03/1997	1	1.80	0.80	1.00

Appendix C
Groundwater Model Description

1 Model Setup

The numerical groundwater model was developed using the software Visual MODFLOW, which is a 3D finite difference groundwater flow model used extensively throughout the world.

The model setup and main input parameters are outlined below.

1.1 Extent and Grid Sizing

Figure A shows the extent of the model, which is 11.5 km long and 3.5 km wide, which was selected so that:

- The Indian Ocean the western boundary of the model.
- The eastern boundary follows a groundwater level contour.
- Boundaries were set at distances judged to be far enough outside the anticipated influence of groundwater drawdown caused by dewatering at the site.

The grid sizing within the model is 10 m by 10 m across the whole model domain. The model consists of a total of 350 rows and 1150 columns.

The model has been setup using the GDA2020 Zone 50 coordinate system with no model rotation.

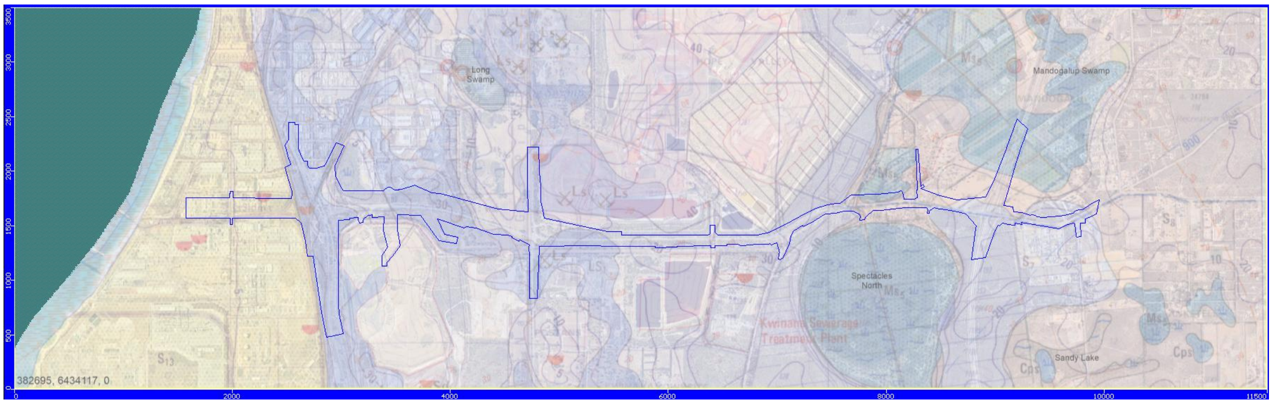

Figure A: Model Extent

1.2 Model Layers

Figure B shows schematic long-sections in the model along the alignment in a west-east direction. The model is divided into six layers to represent the hydrogeological units of the Superficial Aquifer.

The surface elevation is based on the publicly available 1m LIDAR surface elevation, while the remaining layers are flat (i.e. constant elevation). The bottom of the model represents the contact with the Osborne Formation, which is here considered an impermeable aquitard.

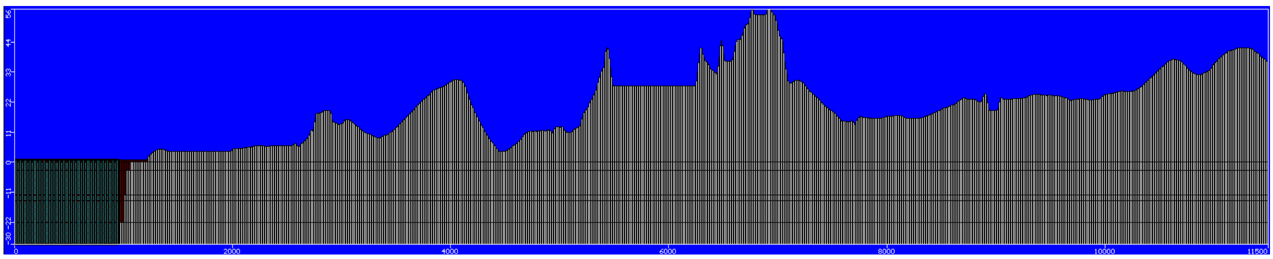

Figure B: Groundwater Model Long-Section with Model Grid and Layers

1.3 Boundary Conditions

Boundary conditions are assigned at the edges of the model to assess how water will flow into and out of the model. It is preferable that natural boundaries are used where they exist, otherwise boundaries should be set far enough away that they do not influence what is occurring within the model.

Figure C shows boundary conditions applied to the model.

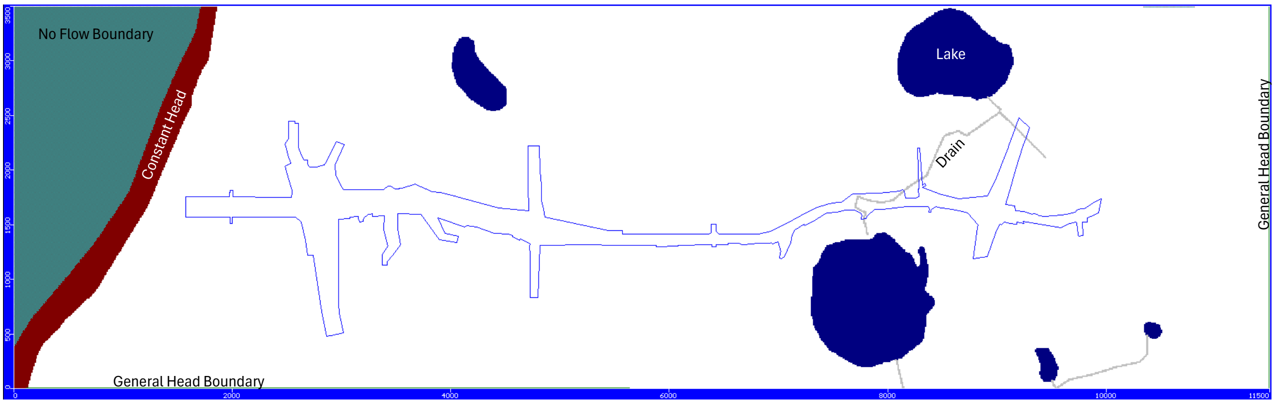

Figure C: Boundary Conditions

1.3.1 Constant Head

The ocean surrounding acts as a natural boundary. Constant Head boundaries were assigned to the western boundary of the model where the model extends all the way to the ocean. Assigning a constant head means that the groundwater level will be fixed to the assigned head and that the cells can receive or give an infinite amount of water.

For the 40 Yr DGWL model scenario the constant head was set to rise by 0.3 m over the 40 year period, which was based on the Department of Transport recommended sea level rise predictions to use for infrastructure planning near coastal areas.

1.3.2 General Head

General Head boundaries were applied to the eastern and southern model boundaries to simulate groundwater flow through these sections. Assigning a constant head means that cell and receive or give a finite amount of water. The amount of water that it can receive/give depends on the applied conductance of the cells, which are determined based on the hydraulic conductivity of the aquifer. The advantage of a General Head is that the groundwater level drawdown can extend to the model boundary with the groundwater level drawdown able to be modelled beyond the model boundary.

1.3.3 Drain

A drain function was applied to the Peel Main Drain. The drain level was set to be 0.5 m above the invert level of the Peel Main Drain. The drain function can only receive water, which allows the drain to control the groundwater level in the vicinity of the drain as long as the groundwater level is above the drain level. When the groundwater level falls below the drain level, the drain will dry out until such a time that the groundwater level rises above the drain level again.

1.3.4 Lake

A Lake function was applied to the wetlands. The drain level was set based on wetland water level measurements. The lake function can both give and receive a finite amount of water. The amount of water that it can receive/give depends on the applied conductance of the cells, which are determined based on an assumed permeability of the base of the wetland.

1.3.5 Recharge

A spatially and temporally uniform recharge value was applied across the whole model. For the current wet season the recharge rate was set at 100 mm/yr (around 30% of the wet season rainfall), while for the dry season model the recharge rate was set to be 0 mm. During the 40 Yr DGWL the rainfall recharge rate was increased to 175 mm/yr to account for a 40 Yr wet year.

1.3.6 Wells

Groundwater abstraction from existing 5C License holders were represented in the model using the well function. The well function requires the modelled screened length (wells were assumed to have been drilled to the base of the Superficial Aquifer and screened across the whole aquifer) and then a pumping rate was applied over a set period/duration. The pumping rate was calculated based on the 5C water allocation and distributed evenly across the draw points shown in the DWER Water Register.

1.3.7 Transient Model (Non-Steady-State) – Groundwater Abstraction and Dewatering

For the groundwater abstraction model runs a well function was added to the proposed location of the pumping well. The wells were assumed to be drilled to the base of the Superficial Aquifer and screened across the whole aquifer, and then a pumping rate was applied over a set period/duration based on the estimated construction water demand requirements from the particular well.

For the construction dewatering model runs the drain function was used to lower the groundwater level to the target dewatering level over the excavation area. The drain elevations were set to be 1 m below the required excavations levels and the total drained water from the cells is then representative of the dewatering rate.

1.4 Model Assumptions

The following is a list of assumptions used in the development of the model:

- Each hydrogeological unit is homogenous.
- Ocean tidal fluctuations were not included in the model.

1.5 Adopted Hydraulic Properties

Table 1 presents the adopted hydraulic input parameters that provided the best overall calibration of the steady-state models. The hydraulic conductivities used in the model were generally found to be similar to the hydraulic conductivities provided by publicly available data, except for Tamala Limestone which was set to be less permeable than the literature suggests.

Table 1 Applied Hydraulic Properties

Conductivity				Storage		
Zone	Kx [m/d]	Ky [m/d]	Kz [m/d]	Zone	Ss [1/m]	Sy []
1	10	10	10	1	1E-5	0.2
2	0.1	0.1	0.01	2	1E-5	0.2
3	100	100	100	3	1E-5	0.3
4	8	8	3	4	1E-5	0.2
5	5	5	1.5	5	1E-5	0.1
6	15	15	5	6	1E-5	0.2
7	0.1	0.1	0.01	7	1E-5	0.05
8	5	5	1.5	8	1E-5	0.2
9	50	50	50	9	1E-5	0.2
10	50	50	5	10	1E-5	0.2

Figure D presents a plan view of the hydraulic properties for Layer 1 in the model and a long-sectional view through the centre of the model across the alignment.

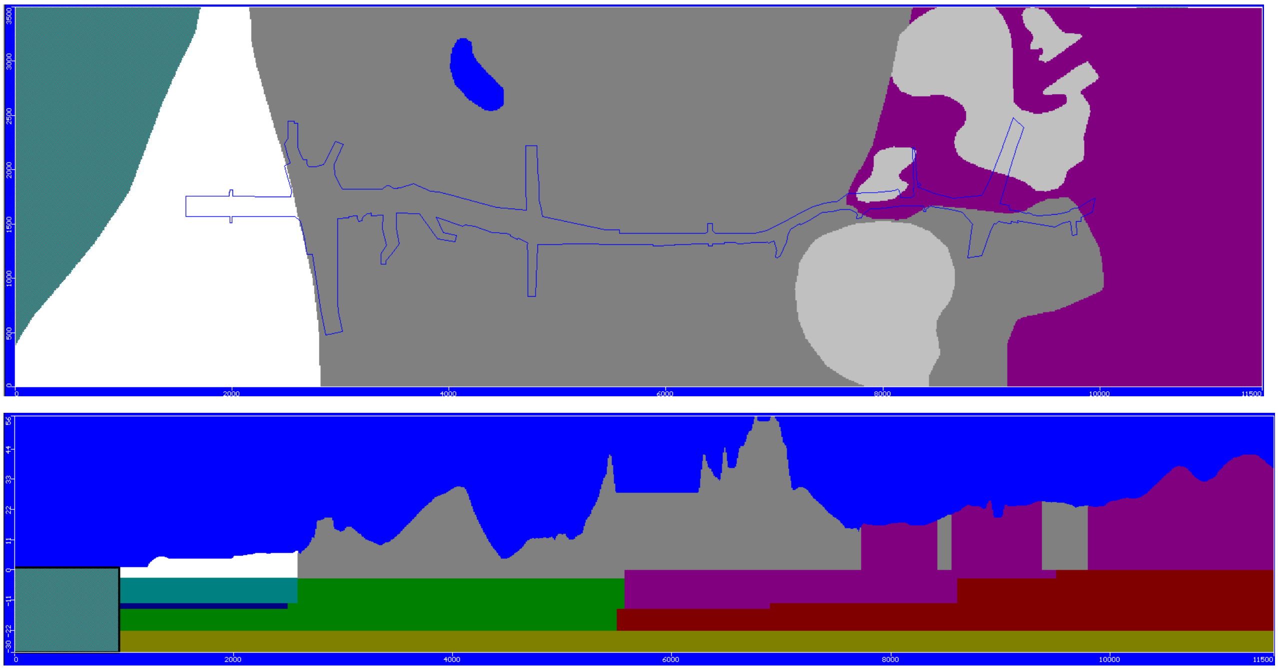

Figure D: Applied Hydraulic Properties

2 Model Results

Figure E shows a long-sectional view of the modelled groundwater levels for the 40 Yr Design Groundwater Levels model scenario along the project alignment. The section provides a good appreciation of the changes in the hydraulic gradient across the alignment as well as different hydraulic heads at depth (head contours are not vertical) in the western part of the model where the Becher Sand 2 hypothesised to act as an aquitard separating the Superficial Aquifer into a two sub-aquifer system (Upper Aquifer above the aquitard and Lower Aquifer below).

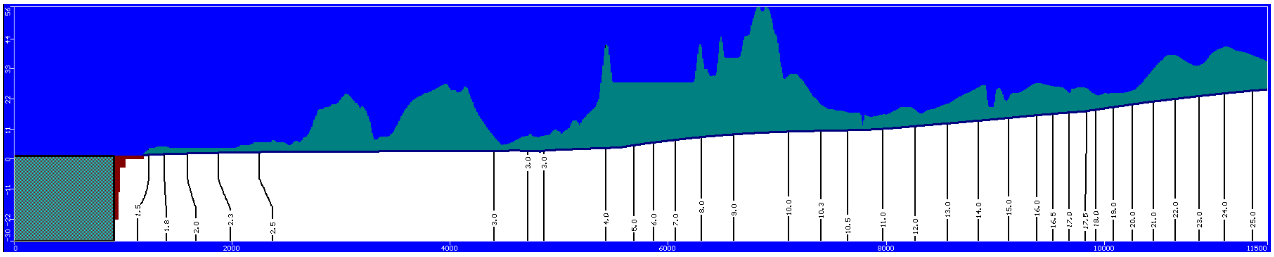

Figure E: Modelled 40 Yr Design Groundwater Levels along the Project Alignment

Appendix D

Construction Water Demand and Estimated Production Bore Pumping Rates

SCENARIO 1: 5 BORES, 100% EARTHWORKS WATER DEMAND AND 100% ADDITIONAL DUST SUPPRESSION WATER DEMAND SUPPLIED BY BORES

Work Areas	Duration (days)	Earthworks					Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Cut (m3)	Fill(m3)	Cut to Fill	Fill activities	Work Fronts	Required Duration (days)	Water(kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	2	1,202	3,195	1,993	1,202	1	2	479	220	699	350	18	2	Bore A	1	350	4.4	8.1
Area 5 - Project Case	71	43,685	141,697	98,012	43,685	2	36	21,255	9,269	30,524	860	43	4	Bore A & B	2	430	5.4	10.0
Area 6 - Project Case	121	158,251	242,264	84,013	158,251	2	61	36,340	20,026	56,366	932	47	4	Bore B & E	2	466	5.9	10.8
Area 7 - Project Case	826	185,753	1,652,999	1,467,246	185,753	2	413	247,950	91,938	339,888	823	42	4	Bore C & D	2	411	5.2	9.5
Total - Project Case	**1,020**	**388,891**	**2,040,155**	**1,651,264**	**388,891**			**306,024**	**121,453**	**427,477**								

* Based on a 20 kL water truck

Minimum Fill Rate per truck (0.5 hr) 11 L/s

** This requires Turkeys nests to be built for water storage over night

Work Areas	Additional Dust Suppression Days (days)	Dust Suppression					Additional Dust Suppression Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Total EPA Area (m2)	Total Work Area (m2)	% of Total Work Area	Area Requiring Dust Suppression (m2)	Work Fronts	Required Duration (days)	Water (kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	210	68,752	59,875	5%	29,938	1	420	-	15,717	15,717	37	1	1	Bore 1	1	19	0.2	0.4
Area 5 - Project Case	210	428,750	275,660	22%	137,830	1	420	-	72,361	72,361	172	5	1	Bore 1	2	43	0.5	1.0
Area 6 - Project Case	210	659,793	461,578	36%	230,789	1	420	-	121,164	121,164	288	8	1	Bore 2	2	72	0.9	1.7
Area 7 - Project Case	210	1,052,558	468,474	37%	234,237	1	210	-	61,487	61,487	293	8	1	Bore 3	2	73	0.9	1.7
Total - Project Case	**-**	**2,209,853**	**1,265,587**	**100%**	**632,794**				**270,729**	**270,729**								

Total - Project Case								**306,024**	**392,182**	**698,206**								

* Based on a 20 kL water truck

** This requires Turkeys nests to be built for water storage over night

*** It is assumed that only half of the water demand will be provided by the pumping bores

3 years of construction

2.5 mm/d for dust suppression

0.5 of the work area will require dust suppression

SCENARIO 2: 3 BORES, 100% EARTHWORKS WATER DEMAND AND 100% ADDITIONAL DUST SUPPRESSION WATER DEMAND SUPPLIED BY BORES

Work Areas	Duration (days)	Earthworks					Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Cut (m3)	Fill(m3)	Cut to Fill	Fill activities	Work Fronts	Required Duration (days)	Water(kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	2	1,202	3,195	1,993	1,202	1	2	479	220	699	350	18	2	Bore 1	1	350	4.4	8.1
Area 5 - Project Case	71	43,685	141,697	98,012	43,685	2	36	21,255	9,269	30,524	860	43	4	Bore 1	1	860	10.9	19.9
Area 6 - Project Case	121	158,251	242,264	84,013	158,251	2	61	36,340	20,026	56,366	932	47	4	Bore 2	1	932	11.8	21.6
Area 7 - Project Case	826	185,753	1,652,999	1,467,246	185,753	2	413	247,950	91,938	339,888	823	42	4	Bore 3	1	823	10.4	19.1
Total - Project Case	**1,020**	**388,891**	**2,040,155**	**1,651,264**	**388,891**			**306,024**	**121,453**	**427,477**								

* Based on a 20 kL water truck

Minimum Fill Rate per truck (0.5 hr) 11 L/s

** This requires Turkeys nests to be built for water storage over night

Work Areas	Additional Dust Suppression Days (days)	Dust Suppression					Additional Dust Suppression Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Total EPA Area (m2)	Total Work Area (m2)	% of Total Work Area	Area Requiring Dust Suppression (m2)	Work Fronts	Required Duration (days)	Water (kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	210	68,752	59,875	5%	29,938	1	420	-	15,717	15,717	37	1	1	Bore 1	1	19	0.2	0.4
Area 5 - Project Case	210	428,750	275,660	22%	137,830	1	420	-	72,361	72,361	172	5	1	Bore 1	1	86	1.1	2.0
Area 6 - Project Case	210	659,793	461,578	36%	230,789	1	420	-	121,164	121,164	288	8	1	Bore 2	1	144	1.8	3.3
Area 7 - Project Case	210	1,052,558	468,474	37%	234,237	1	210	-	61,487	61,487	293	8	1	Bore 3	1	146	1.8	3.4
Total - Project Case	**-**	**2,209,853**	**1,265,587**	**100%**	**632,794**				**270,729**	**270,729**								

Total - Project Case								**306,024**	**392,182**	**698,206**								

* Based on a 20 kL water truck

** This requires Turkeys nests to be built for water storage over night

*** It is assumed that only half of the water demand will be provided by the pumping bores

3 years of construction

2.5 mm/d for dust suppression

0.5 of the work area will require dust suppression

SCENARIO 3: 3 BORES, 50% EARTHWORKS WATER DEMAND AND 100% ADDITIONAL DUST SUPPRESSION WATER DEMAND SUPPLIED BY BORES

HALF WATER DEMAND SUPPLIED BY WELLS

Work Areas	Duration (days)	Earthworks					Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Cut (m3)	Fill(m3)	Cut to Fill	Fill activities	Work Fronts	Required Duration (days)	Water(kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	2	1,202	3,195	1,993	1,202	1	2	479	220	699	350	9	1	Bore 1	1	175	2.2	4.0
Area 5 - Project Case	71	43,685	141,697	98,012	43,685	2	36	21,255	9,269	30,524	860	22	2	Bore 1	1	430	5.4	10.0
Area 6 - Project Case	121	158,251	242,264	84,013	158,251	2	61	36,340	20,026	56,366	932	24	2	Bore 2	1	466	5.9	10.8
Area 7 - Project Case	826	185,753	1,652,999	1,467,246	185,753	2	413	247,950	91,938	339,888	823	21	2	Bore 3	1	411	5.2	9.5
Total - Project Case	**1,020**	**388,891**	**2,040,155**	**1,651,264**	**388,891**			**306,024**	**121,453**	**427,477**								

* Based on a 20 kL water truck

Minimum Fill Rate per truck (0.5 hr) 11 L/s

** This requires Turkeys nests to be built for water storage over night

Work Areas	Additional Dust Suppression Days (days)	Dust Suppression					Additional Dust Suppression Water Demand					Water Trucks Required per day *	Water Trucks Required per Working hour	Bores	No. of Bores	Daily Demand per Bore (kL/d)	Required Flow Rate per Bore for 22 hour pumping per day ** (L/s)	Required Flow Rate per Bore for 12 hour pumping per day (L/s)
		Total EPA Area (m2)	Total Work Area (m2)	% of Total Work Area	Area Requiring Dust Suppression (m2)	Work Fronts	Required Duration (days)	Water (kL)	Dust (kL)	Total (kL)	Rate (kL/d)							
Area 4 - Project Case	210	68,752	59,875	5%	29,938	1	420	-	15,717	15,717	37	1	1	Bore 1	1	19	0.2	0.4
Area 5 - Project Case	210	428,750	275,660	22%	137,830	1	420	-	72,361	72,361	172	5	1	Bore 1	1	86	1.1	2.0
Area 6 - Project Case	210	659,793	461,578	36%	230,789	1	420	-	121,164	121,164	288	8	1	Bore 2	1	144	1.8	3.3
Area 7 - Project Case	210	1,052,558	468,474	37%	234,237	1	210	-	61,487	61,487	293	8	1	Bore 3	1	146	1.8	3.4
Total - Project Case	**-**	**2,209,853**	**1,265,587**	**100%**	**632,794**				**270,729**	**270,729**								
Total - Project Case								**306,024**	**392,182**	**698,206**								

* Based on a 20 kL water truck

** This requires Turkeys nests to be built for water storage over night

*** It is assumed that only half of the water demand will be provided by the pumping bores

3 years of construction

2.5 mm/d for dust suppression

0.5 of the work area will require dust suppression