6 CONCEPTUAL HYDROGEOLOGICAL MODEL

6.1 Regional Geology

The Dawson Mining Complex is located within the Bowen Basin, an Early-Permian to Middle-Triassic foreland basin containing thick successions of shallow marine and non-marine sediments, volcanics, and productive Permian Coal Measures (Table 6.1, Figure 6.1 and Figure 6.2). Dawson South is overlain by Quaternary Alluvium associated with the Dawson River and associated creeks (JBT 2018).

General stratigraphy of the Dawson Mining Complex is presented Table 6.1. Permian coal-bearing strata generally strike north-south and dip 5° to 16° west. They are exposed to the east of the mining complex where isolated Tertiary or Quaternary watercourse sediments occur. Tertiary cover is relatively thin, thickening west where the unit becomes increasingly pervasive (JBT 2018). A series of minor roughly west-to-east striking faults are inferred to the east of the open pits that are part of the Project. The most prominent of these are located between pits and act to separate Pit 25 from Pit 26 and Pit 27 from Pit 28. These occur most in the deeper Permian units and are not indicated to extend to surface.

Information in this section comprises previously known geological information, augmented by geological data from bores drilled since 2004.

Table 6.1 Regional Stratigraphy at The Dawson Mining Complex

Age		Formation	Hydrostratigraphic Description (OGIA 2019b)	Relevance to Project area
Cenozoic	Quaternary	Alluvium	Aquifer	Associated with watercourses
		Tertiary Sediments (includes residual Tertiary aged cover, Colluvium (Qr) and Duaringa Formation)	-	Deposits across the Project area
Jurassic	Early	Boxvale Sandstone Member / Evergreen Formation	-	Outcrops 25 km south of the Project area
		Precipice Sandstone	Aquifer	
Triassic	Middle	Moolayember Formation	Tight Aquitard	Predominantly located to the west of the Project area. However, the Rewan Group is also present within the Project area
		Clematis Group	Major Aquifer	
	Early	Rewan Group	Tight Aquitard	
Permian	Late	Baralaba Coal Measure	Interbedded Aquitard	Target CSG formation
	Middle	Back Creek Group	-	Located east of the Project area
Pre-Permian Basement		Basement Rocks	-	

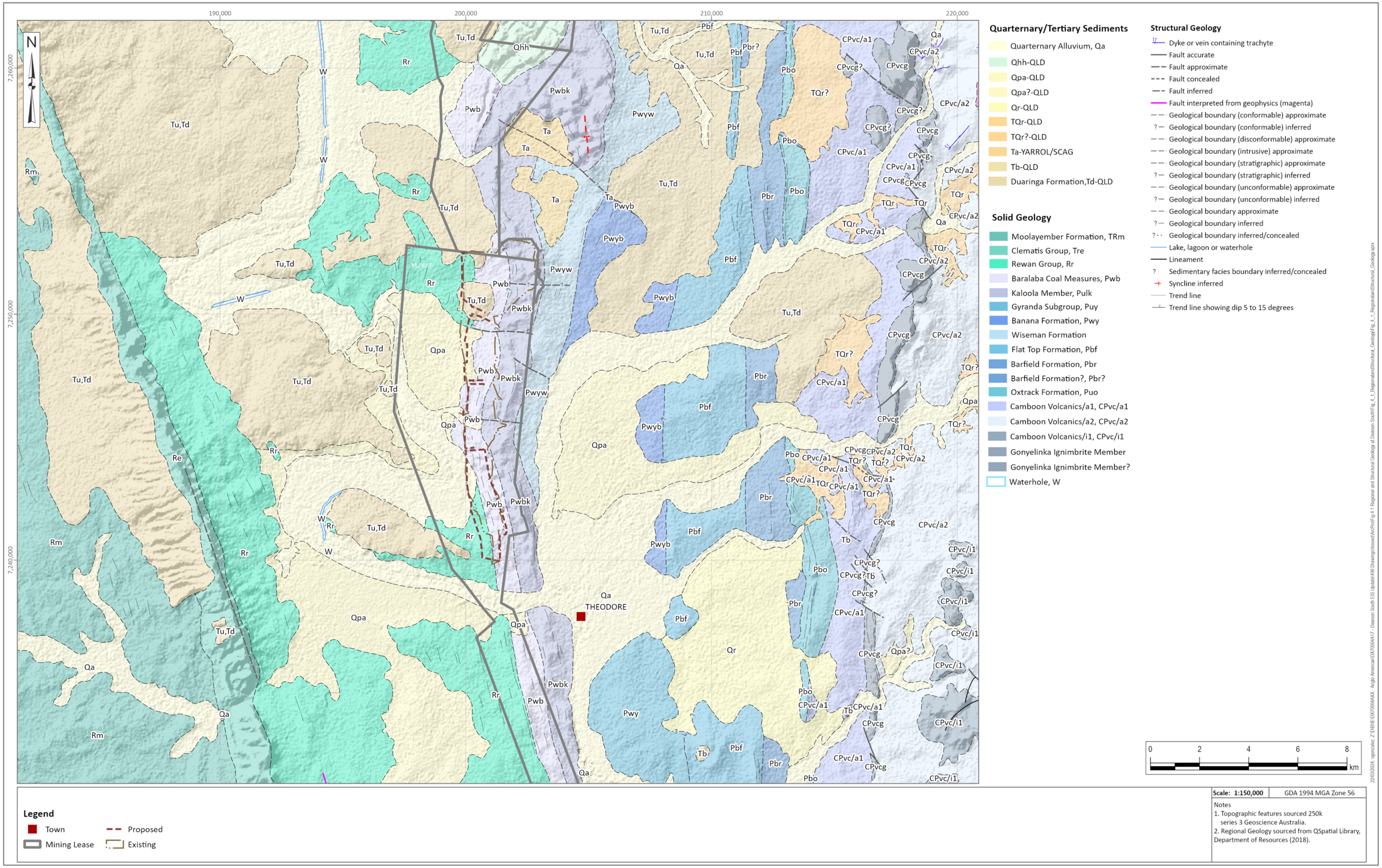

Figure 6.1 Regional and Structural Geology at Dawson South

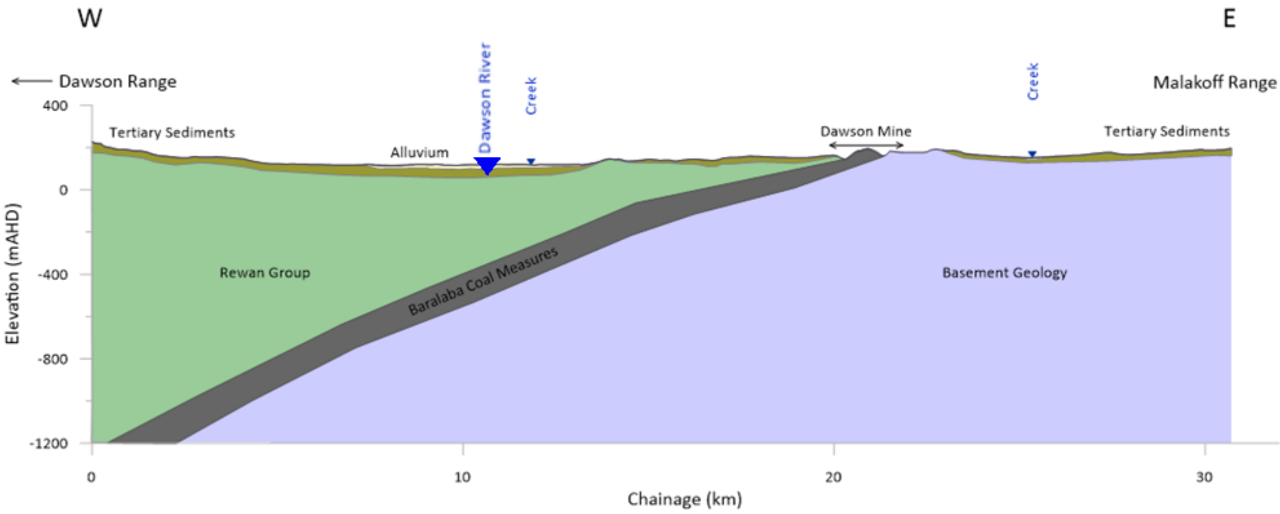

Figure 6.2 Schematic Geological Cross-section for the Dawson Mining Complex

6.2 Geological Units

6.2.1 Alluvium (Recent)

Regional Quaternary deposits comprise a sequence of unconsolidated alluvium deposited by the Dawson River and associated creeks. Primary alluvial deposits associated with the Dawson River occur within the Project area. Lesser alluvial deposits associated with Kianga Creek and Lonesome Creek occur in the north and east. Alluvium is composed of fine to coarse grained gravels and channel sands interbedded with silt and clay lenses. The formation overlies Tertiary deposits and Triassic to Permian units. Alluvium thickness ranges from 17 – 21 m and distribution are variable.

6.2.2 Tertiary Sediments

Tertiary Sediments (clay, silt, sands, and gravel) occur beneath Quaternary Alluvium in some areas (DNRME 2018). The unit is not exposed within the Project area; however, it is exposed beyond the Dawson Ranges. Exposures of limited extent also occur west of the Project area.

The Duaringa Formation unconformably overlies Permian units of the Bowen Basin and is the most exposed geological unit in the area. The unit is composed of mudstone, sandstone, conglomerate, siltstone, shale, lignite and basalt (Murray and Cranfield 1989).

Geological contacts between Tertiary-Quaternary colluvium and the Duaringa Formation are often indistinguishable due to lithological similarities between the two units. The units are therefore considered to be a single unit, hereafter referred to as the ‘Tertiary Sediments’.

6.2.3 Rewan Formation (Triassic)

The Rewan Group comprises reddish-brown to greenish-grey siltstones and mudstones, and thick-bedded, fine to medium-grained, micaceous and feldspathic sandstones. Thin, medium-coarse grained, poorly sorted sandstones occur near the top of the unit (Olgers et. al. 1966).

6.2.4 Baralaba Coal Measures (Permian)

The Late-Permian Baralaba Coal Measures underlies the Rewan Group and forms the upper parts of a larger group known as the Blackwater Group. The Baralaba Coal Measures comprises economical coal seams interbedded with calcareous mudstone, siltstone, and shale overburden/interburden (CDM Smith 2016). The Baralaba Coal Measures were deposited in predominantly paludal and lacustrine environments. The lower section comprises carbonaceous shale, limestones, coal, and sandstone deposited during base level fluctuation sedimentation.

Baralaba Coal Measures strike north south and dip 5^{o} to 16^{o} west (AGE 2011); the lower range is likely more representative within the Project area. Upper coal seams of the target Baralaba Coal Measures occur ~40 m below ground level in the eastern area of PL 94, to >1,500 m below ground level in the western section.

6.2.5 Kaloola Member (Permian)

The Kaloola Member (equivalent to the Burngrove Formation) comprises mudstone, siltstone, sandstone, conglomerate, and minor coal (Geoscience Australia 2022) and is the basal sub-unit of the Baralaba Coal Measures.

The Kaloola Member outcrops to the east of the Project area, immediately east of the Dawson Mine. The unit is recognised as an interbedded aquitard.

6.2.6 Gyranda Formation (Permian)

The Late-Permian Gyranda Formation is part of the Blackwater Group and comprises siltstone and shale with minor tuff, sandstone, and coal (rare).

6.3 Structural Features

The Bowen Basin contains a variety of thrust faults, volcanics, extensional fault systems, and reactivated faults resulting in a structurally complex basin (OGIA 2021).

The main structural feature (located in the southern part of the Bowen Basin) is the Mimosa Syncline, located ~45 km west of the Dawson Mining Complex. The syncline axis follows the Taroom Trough and basin development occurred during the Triassic (Dickins and Malone 1973).

Discontinuous northwest-southeast trending faults occur to the northeast of the Dawson Mining Complex. Multiple phases of deformation resulted in reactivation of older structures. A compressional event during the Middle Cretaceous caused uplift and erosion of the Bowen and Surat Basins and their associated volcanic arcs (Green 1997).

Regional faulting is summarised below (JBT 2018):

- Reverse faults occur throughout the Moura area;
- Reverse faults generally strike north-west and dip 30° to 70° northeast;
- Fault displacement is variable along strike, and it is assumed that larger faults (with vertical displacements >2 to 3 m) will disrupt all coal seams;
- Structural movement occurs along faults following weaker zones in strata, which may occur within the seam or along lithological boundaries;

- Some faults are less than 1 m wide, however, others may comprise fractured zones which can be 20 - 30 m wide; and
- Dominant joint set trend is north south to northwest/southeast with 2 to 4 m joint spacing (Figure 6.1). Iron oxide staining is present in some fracture surfaces, indicating water movement along joints.

6.4 Existing Hydrogeology

6.4.1 Groundwater Bores

The groundwater monitoring network at Dawson South includes 25 monitoring bores and 15 VWPs, screened or installed in four hydrostratigraphic units (Alluvium, Rewan, Permian Coal Measures, and a Fault Zone) at varying depths (Figure 4.1). All monitoring bores with available data were installed post-2004.

6.5 Hydrostratigraphy

Three main aquifer types occur at Dawson South: a shallow alluvial aquifer; a weathered basement aquifer; and a sequence of deeper sedimentary rock aquifers(schematically on Figure 6.2).

The alluvial aquifer occurs within unconsolidated sediments deposited on land by rivers, creeks, and flood events. Alluvial aquifers generally follow surface water drainage systems and are thickest next to rivers and creeks, thinning laterally with distance. Alluvial aquifers directly overlie weathered basement and competent rock aquifers. Bore logs indicate alluvial thickness at Dawson is between 17 and 21 m.

Weathered basement aquifers occur directly beneath alluvium or outcrop at the surface and consist of a weathered zone of basement rock typically 2 m to 25 m thick (AGE 2004). Monitoring bores DSMB06 and DSMB13 (drilled during 2022) indicate a weathered zone of 1.5 m to 15 m thick (Hydrogeologist.com.au 2022). Primary porosity occurs within intergranular space and secondary porosity within fractures. These aquifers may have moderate to high hydraulic conductivity and storage capacity.

Competent rock aquifers underlie weathered basement aquifers and consist of competent, un-weathered rock. Groundwater storage in these aquifers may be within intergranular space where rock porosity and permeability are high (e.g., sandstone), or in fractures where rock porosity and permeability are low (e.g., mudstone). These units are described in detail in the subsection that follow, and indicative idealisation of the units across the region and closer to Dawson South are shown on Figure 6.3 to Figure 6.5.

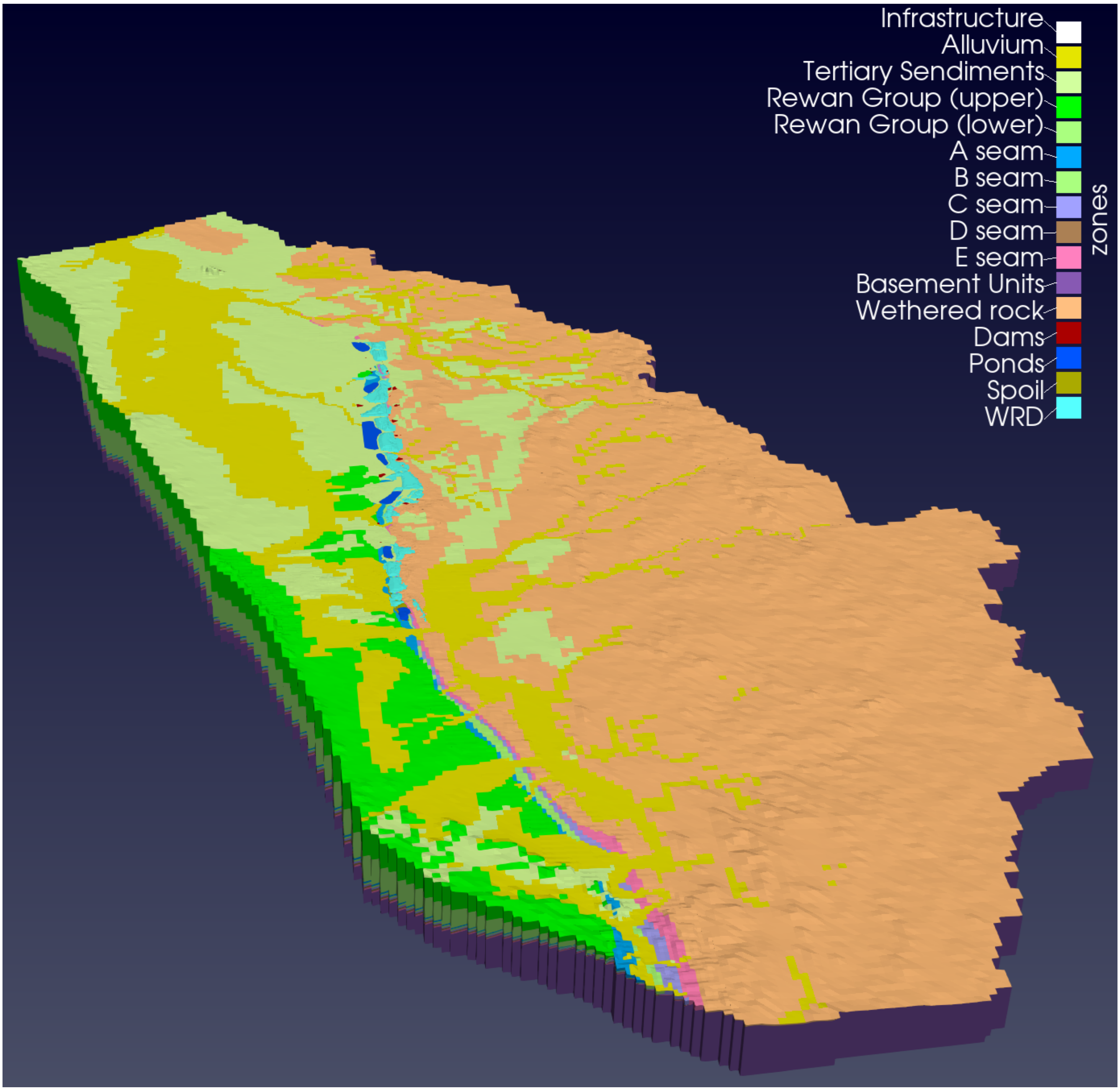

Figure 6.3 Hydrostratigraphic variation across the region as represented by the numerical model domain

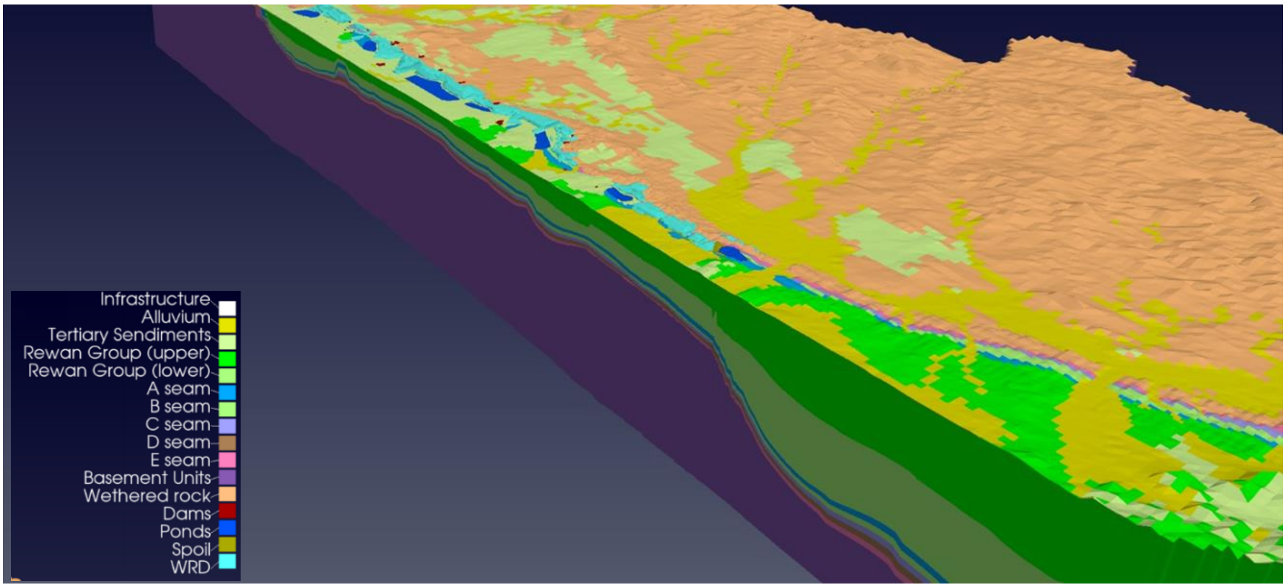

Figure 6.4 North -South Cut through the Dawson Area showing hydrostratigraphic variation

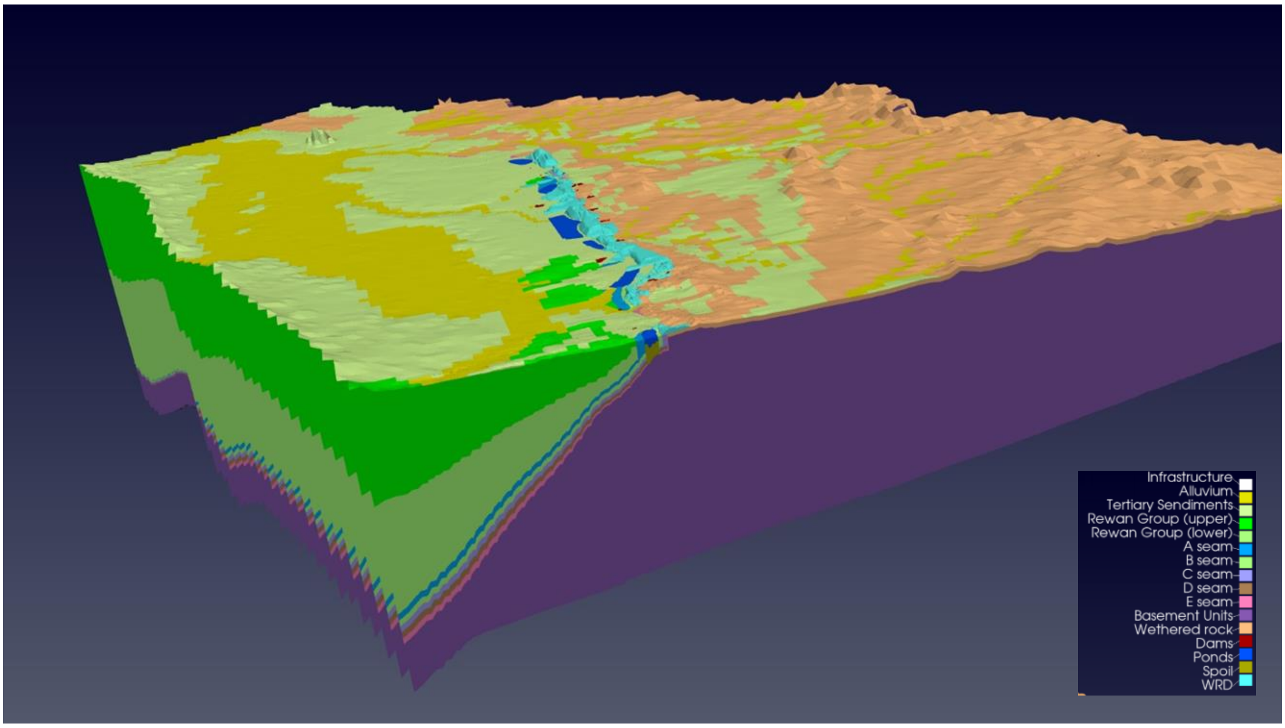

Figure 6.5 West -East Cut approximately along Dawson Central/Dawson South boundary showing hydrostratigraphic variation

Additional detail on the hydrogeological properties of each aquifer type is provided below:

6.5.1 Alluvium/Tertiary Sediments *Aquifer*

Quaternary Alluvium comprises unconsolidated sediments with relatively high hydraulic conductivity and storage which form a complex sequence of productive confined and semi-confined aquifers (of variable thickness and lateral extent) and interbedded aquitards. Stratigraphic complexity occurs where grain size and cementation are variable: interbedded mud/clay lenses and sands/gravels.

Tertiary Sediments comprise a sequence of weathered, weakly consolidated or unconsolidated sands, silts, and clays.

6.5.2 Rewan Formation *Tight Aquitard*

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone, and minor fine-grained sandstone that overlies the Permian Coal Measures. It is recognised as a regional aquitard and forms a confining unit which overlies the Permian Coal Measures. This unit is characterised by low primary porosity; therefore, groundwater movement is controlled by secondary porosity (local fracture sets). This unit exhibits slightly higher permeability where fractures intersect; where fracture intersections are absent lower permeability (associated with primary porosity) occurs (KCB 2022).

6.5.3 Baralaba Coal Measures *Interbedded Aquitard*

The Baralaba Coal Measures outcrops to the east of the Project area (CDM Smith 2019) and are recognised regionally as an interbedded aquitard (OGIA 2021). The unit’s coal seams are the primary regional-scale conduits for groundwater flow within Permian units.

Interbedded fine-grained shales and siltstones exhibit low permeability and form local aquitards; however, target coal seams often exhibit higher permeability and form confined aquifers.

6.5.4 Transmissive Fault Zones

Faults and fractures influence both regional and local groundwater movement by providing preferential flow paths or creating compartmentalisation across the hanging wall and foot wall of faults. Initially high yields in those zones decrease over relatively short timeframes (weeks or months), indicating that faulted rock zones represent high-yielding aquifer systems with low storage.

When faulted rock units are drained of groundwater, recharge will occur from adjacent groundwater storage units (spoils, surface water-recharged dilated zones close to mined voids) along fractures.

6.6 Hydraulic Conductivity

Hydraulic conductivity values for Dawson aquifers are summarised in Table 6.2.

Hydraulic conductivity values from six pumping tests in the alluvium range from 1.27 to 12.7 m/day (KCB 2022). The Rewan Formation is characterised by generally low hydraulic con ductivity (ECG 2012). Hydraulic conductivity within the coal seams is generally low despite them being the main conduits for groundwater flow in that unit.

Table 6.2 Hydraulic conductivity values for Dawson South

Source	Hydraulic Conductivity, K (m/day)		
	Alluvium and Tertiary Sediments	Rewan Formation	Permian Coal Measures
KCB 2022	1.27 to 12.7		
Hydrogeologist.com.au 2022		5.8×10^{-5} to 1.3×10^{-3}	1.1×10^{-4} to 9.8×10^{-2}
JBT 2018			2.0×10^{-3} to 9.4×10^{-3}
ECG 2012		1.2×10^{-3} to 6.1×10^{-4}	2.4×10^{-6} to 1.1×10^{-2}
AGE 2004			8.6×10^{-3} to 1.7×10^{-2} (*Moura North*) 4.3 to 1.7×10^{-2} (*Dawson South Stage 1*) 4.3×10^{-4} to 1.1×10^{-2} (*Dawson South Stage 2*)

6.7 Groundwater Levels, Flow, Recharge and Discharge

Baseline groundwater flow (pre-mining) is from east to west with a hydraulic gradient of 0.01 in the Dawson South Stage 2 area (PB, 2004). Mining at Dawson South (Pit 25) commenced in August 2003.

Groundwater levels in the Permian Coal Measures show a steady decline until 2011. Groundwater levels then show a notable recovery during 2011 following a major recharge event, indicating a resilient groundwater system which is responsive to recharge (Figure 6.6). Those bores have not been monitored since 2012. Groundwater monitoring for DSM bores commenced in 2022 with elevations ranging from 135 to 140 mAHD.

Figure 6.6 presents groundwater levels recorded during September 2013 (the period with most data available from multiple bores) and 2023. In 2013 the bores showed dewatering influence from nearby mining areas and a slight northwest declining gradient and are located in the northern part of Dawson South (aligned with mining areas). The bores (DSMB08 and DSMB10) are located nearer to Pits 27 and 28 at the southern part of Dawson South and show the same northwest gradient decline toward the Dawson River. Groundwater levels range from 58 to 140 mAHD.

Groundwater level monitoring in alluvium commenced in 2023, with elevations from four bores ranging from 113 to 120 mAHD. Available data is limited but does not show decreases in groundwater levels in the alluvial aquifer.

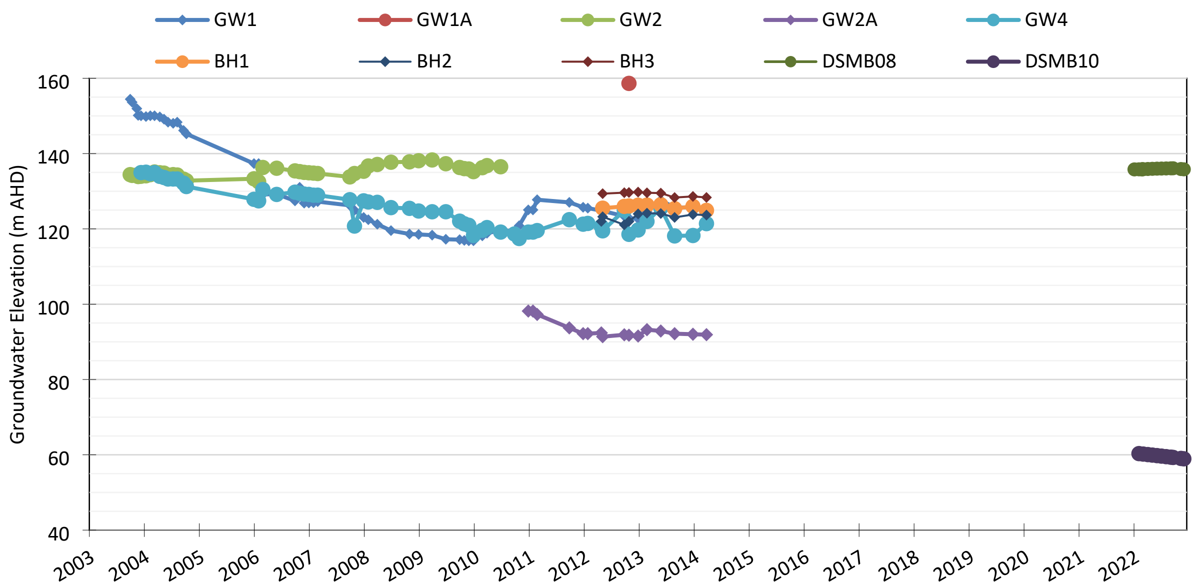

Figure 6.6 Groundwater Elevations, Permian Coal Measures

6.8 Groundwater Chemistry

Groundwater quality records were analysed for Alluvium and the Permian Coal Measures within Dawson South.

This section provides groundwater monitoring results from data collected in 2022 for the Alluvium, from 2004 to 2012 and 2022 for the Permian Coal Measures.

Timeseries plots for key parameters (pH, EC, sulfate, chloride) are presented in subsequent sections. Those parameters were selected as representative water quality indicators because changes in those parameters provide indication of changing groundwater quality or hydrogeochemical conditions (Table 6.3).

Table 6.3 Water Quality Summary Data for Dawson South

Parameter		Alluvium	Permian Coal Measures
pH (pH units)	Min.	8.0	6.3
	Max.	8.3	9.2
	Mean.	8.1	7.5
Electrical Conductivity (µS/cm)	Min.	3660	210
	Max.	8460	11830
	Mean.	5013	4049
Sulfate (mg/L)	Min.	108	2.1
	Max.	687	886
	Mean.	442	93
Chloride (mg/L)	Min.	892	1320
	Max.	1010	1320
	Mean.	933	1320

It should be noted that higher EC is expected in the Permian Coal Measures (which is more saline) relative to the alluvium (which may have variable but generally lower salinity) as a consequence of depositional setting. Anomalous minimum and mean EC in alluvium is a function of a smaller sample size (n = 4) relative to the Permian Coal Measures (n = 140).

6.8.1 Alluvium

Water quality data were not available for bores screened in alluvium pre-2022. A summary of 2022 data is provided below:

- pH values range from 8.01 to 8.27, indicating slightly alkaline groundwater.
- Electrical Conductivity (EC) values range from 3660 to 8460 uS/cm. Highest EC was observed in DSMB05.
- Chloride concentrations range from 892 to 2240 mg/L. Highest chloride concentration observed in DSMB05.
- Sulfate concentrations range from 108 to 687 mg/L.

6.8.2 Permian Coal Measures

Figure 6.7 to Figure 6.9 present timeseries plots for pH, EC, and sulfate for bores screened within the Permian Coal Measures. Data are summarised below:

- pH values generally range from 6.0 to 9.0. Three sampling periods in 2009 and 2010 recorded alkaline pH at 8.5 to 9.0. Most bores during these periods fluctuated in a similar pattern, indicating possible response to a common groundwater influence.
- Electrical Conductivity for most bores screened within the Permian Coal Measures declined from the start of the monitoring in 2004 and remained stable until 2012. GW2 exhibited declining EC levels before slightly increasing from 2009 to 2010.
- Stable sulfate concentrations were observed for all bores screened within the Permian Coal Measures. Maximum sulfate concentrations were recorded at the start of the monitoring period in 2004 and have since declined and remained stable at less than 250 mg/L until 2012. DSMB08 recorded 521 mg/L in January 2022.
- No pre-2022 data were available for chloride.

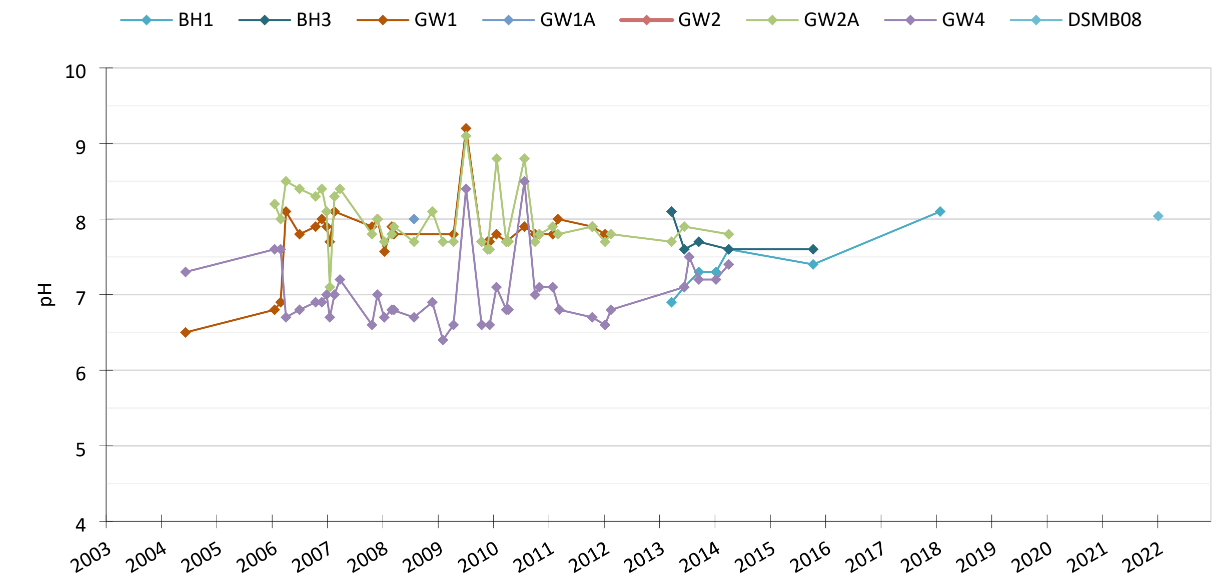

Figure 6.7 pH of Groundwater in the Permian Coal Measures

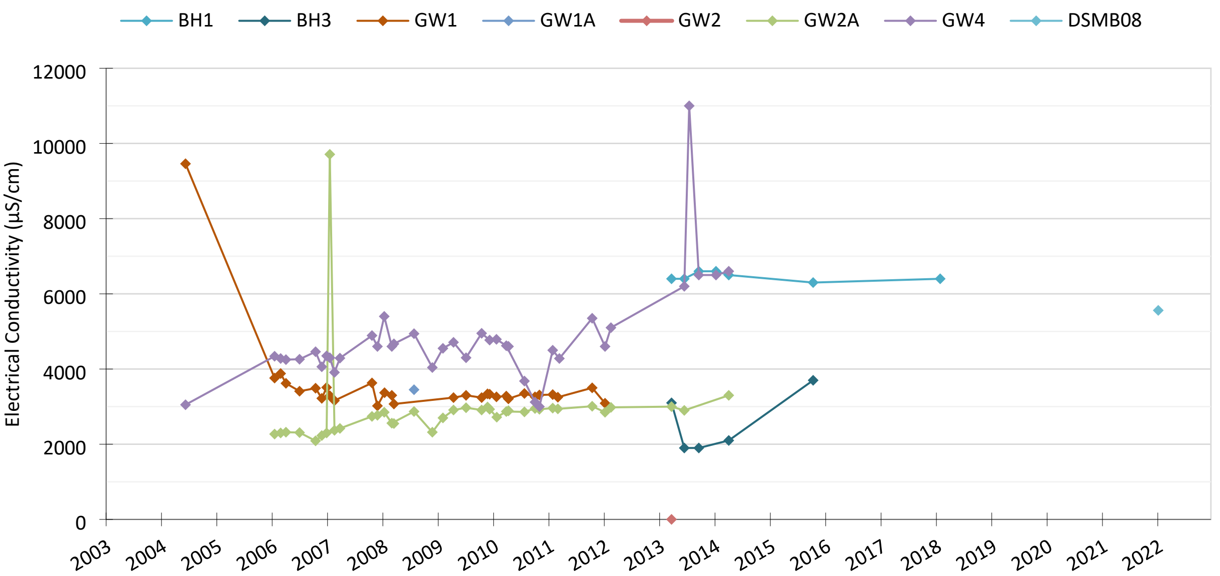

Figure 6.8 EC of Groundwater in the Permian Coal Measures

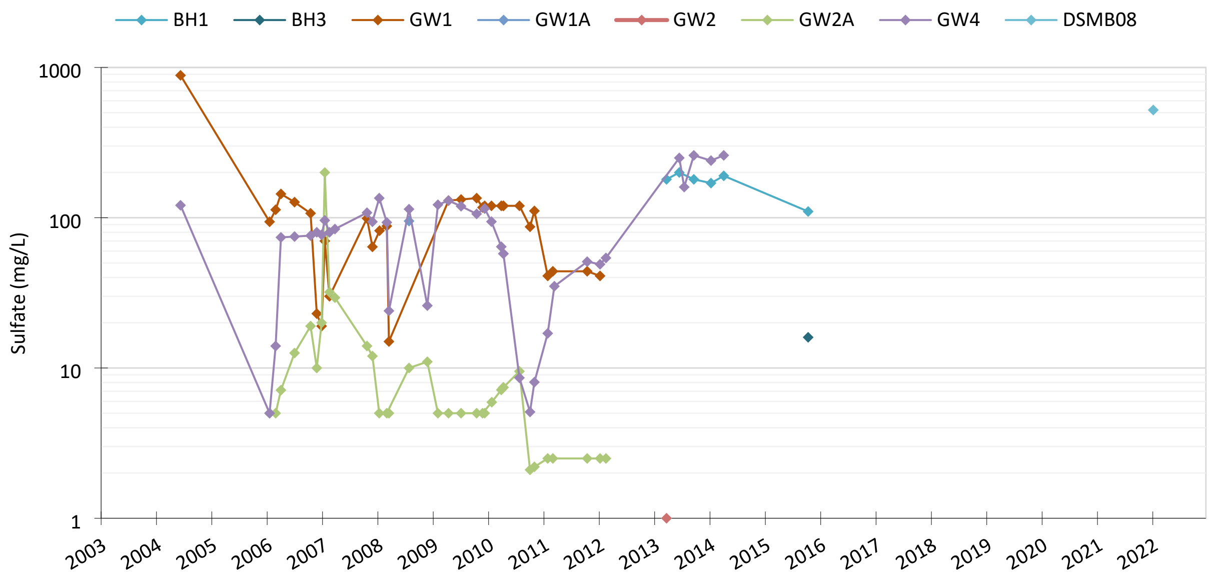

Figure 6.9 Sulfate of Groundwater in the Permian Coal Measures

6.9 Groundwater-Surface Water Interactions

Groundwater-surface water interaction within the Project area may occur from two key processes, where surface water systems are either gaining or losing, or both along the length of the drainage systems:

- Discharge of groundwater to watercourses as baseflow; and
- Recharge to aquifers as leakage from watercourses.

Recharge to groundwater systems from watercourses (like the Dawson River) may occur across the Project area.

6.10 Springs and Groundwater Dependent Ecosystems

GDEs are defined as 'Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements to maintain their communities of plants and animals, ecological processes and ecosystem services' (Richardson et al. 2011). There are three categories of GDEs:

- Aquatic GDEs, which are ecological communities dependent on the surface expression of groundwater, including springs other than EPBC-listed springs, river baseflow systems (watercourse springs), riparian ecosystems and wetlands.
- Terrestrial GDEs, which are surface ecosystems dependent on the subsurface presence of water (i.e., terrestrial vegetation accessing the water table below ground), including ecosystems that are intermittently and permanently dependent on groundwater; and
- Subterranean GDEs, which are subterranean ecosystems dependent on the permanent presence of subsurface water.

6.10.1 Potential Aquatic GDE's

Public domain information of mapped springs and wetlands (DNRME 2018), indicate that there are no known springs within 5 km of the Project area. Based on the GDE mapping, there are no potential surface GDEs located within 5 km of the Project site.

6.10.2 Potential Terrestrial GDEs

GDE mapping of the Fitzroy basin indicates that there is low confidence terrestrial GDEs located adjacent to the Dawson River which is within 5 km of the Project area. There is also a vegetation managed wetlands located near the town of Theodore which is within 5 km of the Project site (DNRME 2018). Potential GDE Wetlands and potential terrestrial GDEs within the vicinity of the project are presented on Figure 6.10. These are mapped with variable confidence regionally and the moderate and low potential ratings have not been field-verified.

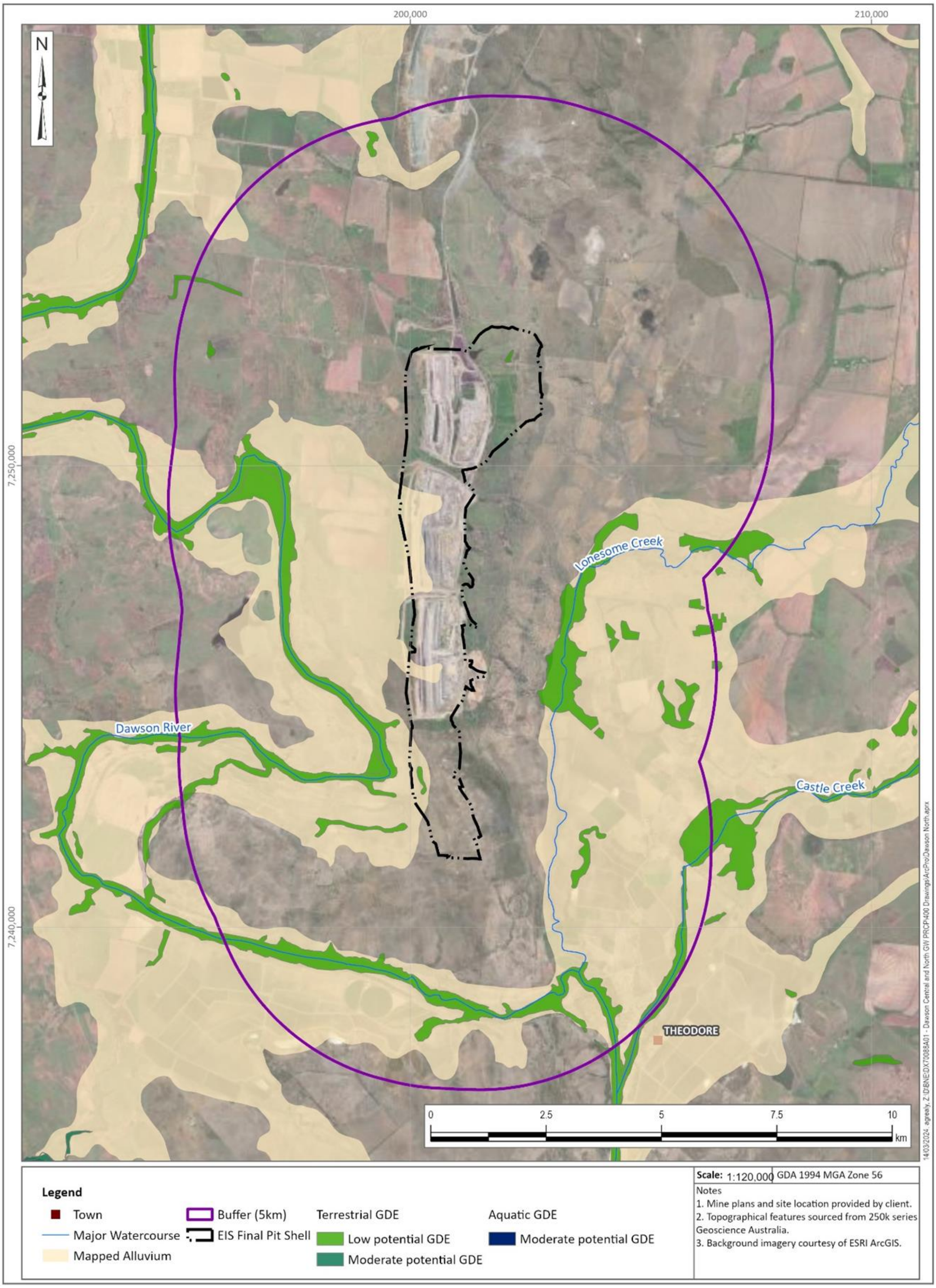

Figure 6.10 Potential Terrestrial and Aquatic GDEs from Desktop Review

6.11 Third-Party Groundwater Users

Table 6.4 summarises the current registered bores from the DRDMW groundwater bore database that occur within a 5 km buffer of the Project area. A total of 49 registered bores are located within the 5 km buffer of the Project area. Figure 6.11 presents the location of these registered bores; which comprise:

- 36 bores screened in the Quaternary Alluvium;
- 7 bores screened in the Baralaba Coal Measures;
- 1 bore screened in the Gyandra Subgroup; and
- 5 bores where the screened lithology is not stated.

There 83 listed abandoned bores which include past exploration bores and groundwater monitoring bores within 5 km of the Project area. These bores comprise:

- 15 petroleum gas exploration bores screened in the Baralaba Coal Measures; and
- 68 water monitoring and investigation bores screened in the Dawson River Alluvium.

The majority of the bores screened in the Quaternary Alluvium are for water supply purposes. Seven bores screened in the Quaternary Alluvium are listed as monitoring bores. All of the bores screened in the Baralaba Coal Measures are mine monitoring bores. This information has been used to inform the conceptual understanding of the groundwater regime and the numerical groundwater model discussed in Sections 7 and 8, respectively.

Table 6.4 Summary of Registered Groundwater bores within 5 km of Project Area

Bore	Screened Lithology (Bore Card)	Screened Interval	Recorded Use
38975	Dawson River Alluvium	18.6-21.4	Water Supply
47549	Dawson River Alluvium	10.7-13.7	Water Supply
62918	Castle Creek Alluvium	16.7-19.2	Water Supply
68103	Lonesome Creek Alluvium	16.4-19.0	Water Supply
68104	Lonesome Creek Alluvium	17.8-21.4	Water Supply
68105	Lonesome Creek Alluvium	15.5-21.8	Water Supply
68337	Lonesome Creek Alluvium	16.6-19.4	Water Supply
68338	Lonesome Creek Alluvium	17.5-20.2	Water Supply
89508	Castle Creek Alluvium	15.5-17.5	Water Supply
89546	Dawson River Alluvium	19.3-21.0	Water Supply
89563	Castle Creek Alluvium	21.0-23.2	Water Supply
89591	Lonesome Creek Alluvium	14.1-16.2	Water Supply
89619	-	-	Water Supply
111712	-	6.00-24.0	Water Supply
128096	-	-	Water Supply
128151	Castle Creek Alluvium	17.5-19.00	Water Supply
128192	Gyranda Subgroup	23.4-25.8	Water Supply
128193	Cattle Creek Alluvium	20.5-23.5	Water Supply
128298	Dawson River Alluvium	16.0-22.0	Water Supply
128647	-	25.5-37.5	Water Supply
128831	Castle Creek Alluvium	14.0-20.0	Water Supply
128957	Quaternary Alluvium	18.4-20.6	Water Supply

Bore	Screened Lithology (Bore Card)	Screened Interval	Recorded Use
128958	Lonesome Creek Alluvium	16.31-18.14	Water Supply
128965	Castle Creek Alluvium	20.34-23.59	Water Supply
170009	Quaternary Alluvium	16.15-18.59	Water Supply
170221	Dawson River Alluvium	19.20-21.34	Water Supply
170259	Castle Creek Alluvium	21.64-23.47	Water Supply
170358	Dawson River Alluvium	7.0-10.0	Monitoring Bore
170367	Baralaba Coal Measures	26-29	Monitoring Bore
170368	Baralaba Coal Measures	69.0-78.0	Monitoring Bore
170369	Baralaba Coal Measures	50.0-56.0	Monitoring Bore
170406	Quaternary Alluvium	17.36-19.34	Water Supply
170423	Quaternary Alluvium	14.5-18.5	Monitoring Bore
170446	Castle Creek Alluvium	16.64-18.14	
170447	Dawson River Alluvium	19.49-21.49	
170448	Dawson River Alluvium	17.66-19.96	
170449	Quaternary Alluvium		
170464	Quaternary Alluvium	11.0-14.0	
170465	Quaternary Alluvium		Monitoring Bore
170466	Quaternary Alluvium	10.5-13.5	Monitoring Bore
170467	Quaternary Alluvium	27.31-39.31	
170470	Quaternary Alluvium	10.5-13.5	Monitoring Bore
170471	Quaternary Alluvium	11.0-14.0	Monitoring Bore
170472	Quaternary Alluvium		Monitoring Bore
170495	-		Water Supply
196314	Quaternary Alluvium	16.5-19.5	Monitoring Bore
196315	Baralaba Coal Measures	17.0-20.0	Monitoring Bore
196316	Baralaba Coal Measures	-	Monitoring Bore
196317	Baralaba Coal Measures	15.5-18.5	Monitoring Bore
196484	Baralaba Coal Measures	-	Monitoring Bore

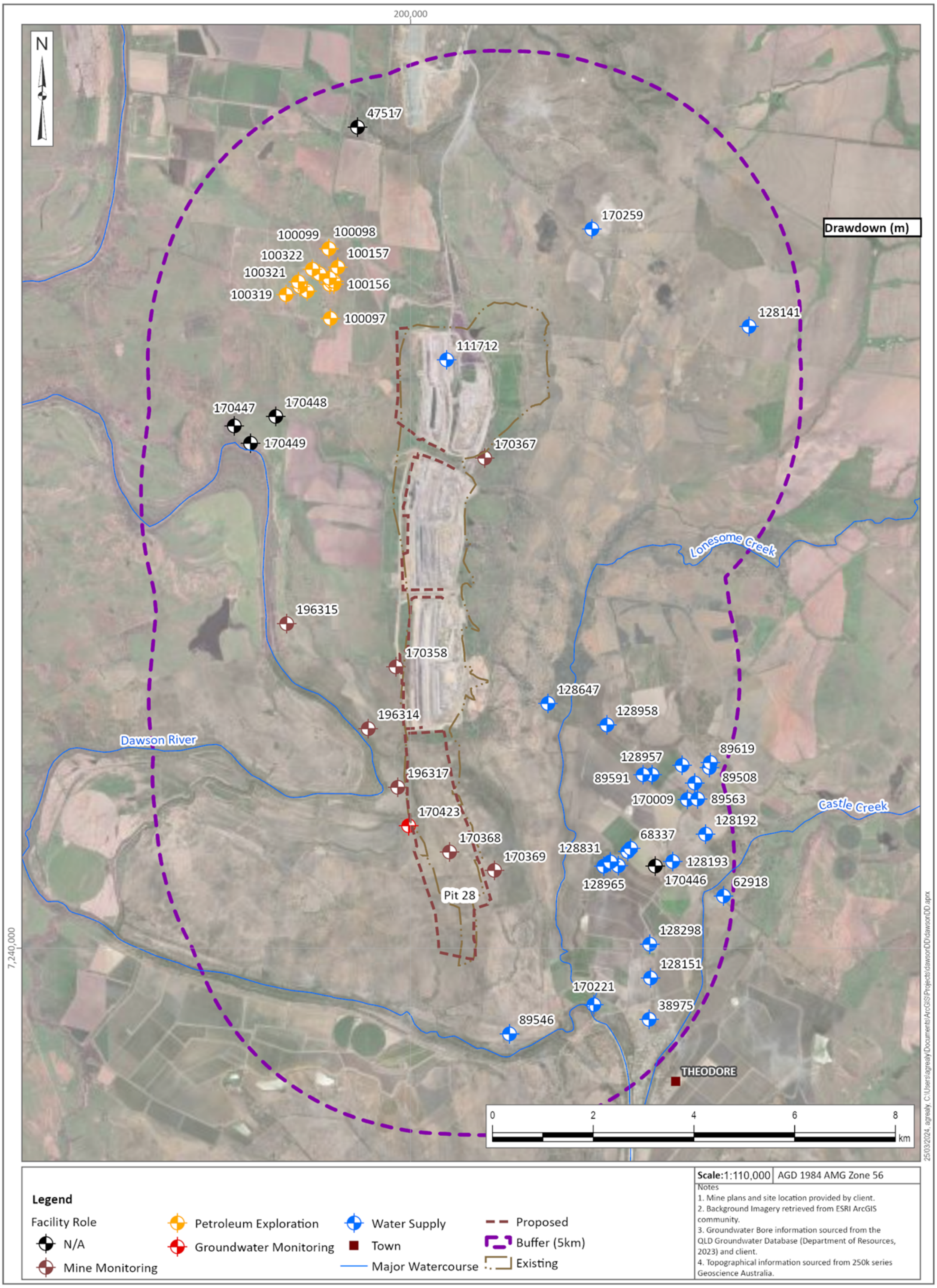

Figure 6.11 Location of Registered Groundwater Bores within 5 km of the Project Area