BARALABA
SOUTH

Baralaba South Project

Environmental Impact Statement

CHAPTER 5

Groundwater

arc
ENVIRONMENTAL SOLUTIONS

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5 Groundwater

This chapter describes the assessment of potential impacts on existing water resource values associated with the activities of the proposed Baralaba South Project (the Project).

The following related studies have been undertaken and have provided input in evaluating the potential impacts of the Project on groundwater:

- Surface Water Impact Assessment (Appendix A);
- Groundwater Modelling and Assessment (Appendix B);
- Terrestrial Ecology Assessment (Appendix F);
- Aquatic Ecology Assessment (Appendix G);
- Groundwater Dependent Ecosystem Assessment (Appendix H); and
- Stygofauna Assessment (Appendix I).

The Groundwater Modelling and Assessment (Appendix B) has been peer reviewed by the suitably qualified expert Andrew Durick, from AGE Consultants. The report of the peer reviewer is provided in Attachment 7.

The information requirements of the Independent Expert Scientific Committee (IESC) relating to groundwater are included in this chapter, and addressed in Chapter 9, Matters of National Environmental Significance. EIS Attachment 4 provides a reconciliation table for the Independent Expert Scientific Committee Guidelines.

5.1 Environmental objectives and performance outcomes

The Proponent has prepared this chapter to assist in the assessment of the following relevant environmental objectives as stated in the Project TOR and Schedule 8, Part 3, Division 1 of the EP Regulation; specifically, that the construction and operation of the Project will meet the following objectives:

- the equitable, sustainable and efficient use of water resources;
- the maintenance of environmental flows, water quality, instream habitat diversity, and naturally occurring inputs from riparian zones (including groundwater-dependent ecosystems) to support the long-term maintenance of the ecology of aquatic biotic communities (including stygofauna);
- that the condition and natural functions of water bodies (e.g. lakes, springs, watercourses and wetlands) are maintained – including the stability of beds and banks of watercourses;
- the Project will be operated in a way that protects the environmental values of waters;
- the Project will be operated in a way that protects the environmental values of wetlands (including soaks and springs) and GDEs; and
- the Project will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

The detailed assessment presented in this chapter and in the relevant appendices demonstrate that the Project will achieve a performance outcome for each water environmental objective relevant to groundwater, as outlined in Schedule 8 of the EP Regulation.

Specifically, the Project will achieve item 2 of the performance outcome for each water environmental objective in satisfaction of section 2(4) of Schedule 8 to the EP Regulation, as follows:

- the water performance outcomes will be achieved because the Project will be operated in a way that achieves all of the following:

  - the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks;
  - acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered;
  - any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland; and
  - the activity will be managed so that adverse effects on environmental values are prevented or minimised;
- the Project will achieve item 2 of the **wetlands** performance outcomes because it will be managed in a way that prevents or minimises adverse effects on wetlands; and
- the Project will achieve item 2 of the **groundwater** performance outcomes because it will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

As well as addressing the abovementioned objectives, the TOR also requires that section 126A of the EP Act is addressed. Section 126A relates to applications for an EA involving the exercise of underground water rights and requires a description of the proposed exercise of underground water rights, the areas in which underground water rights are to be exercised, the affected aquifers, anticipated impacts on environmental values of groundwater, and mitigation measures to manage the anticipated impacts.

5.2 Description of environmental values

5.2.1 Environmental values and water quality objectives

Environmental values associated with Queensland waters are protected under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity)). The EPP (Water and Wetland Biodiversity) achieves the objectives of the EP Act to protect Queensland's waters while supporting ecologically sustainable development. Queensland waters include water in rivers, streams, wetlands, lakes, groundwater aquifers, estuaries and coastal areas. The Project is located within:

- Surface Water: Lower Dawson River Sub-basin – WQ1309 (Figure 5.1); and
- Groundwater: Fitzroy Basin Groundwater Zones / Lower Dawson Groundwaters – WQ1310 (Figure 5.2)

The Project lies within Groundwater Chemistry Zone 34 of the Dawson River sub-basin, for which Water Quality Objectives (WQOs) have been set (DEHP, 2011). This zone is described as “Saline: [high] Na, Cl” on the map accompanying DEHP (2011) (Figure 5.2).

Environmental values (EVs) and water quality objectives (WQOs) for waters are prescribed in Schedule 1 of the EPP (Water and Wetland Biodiversity). WQOs are long-term goals for water quality management that protect environmental values. Schedule 1 refers to the Dawson River Sub-basin Environmental Values and Water Quality Objectives, published by the Department in September 2011. WQOs are typically based on national water quality guidelines.

The Queensland Government has published consultation materials (including revised environmental values, WQOs and aquatic ecosystem protection mapping) for the Fitzroy Region groundwaters and surface waters, in 2020.

A summary of the environmental values applying to the Project is presented in Table 5.1.

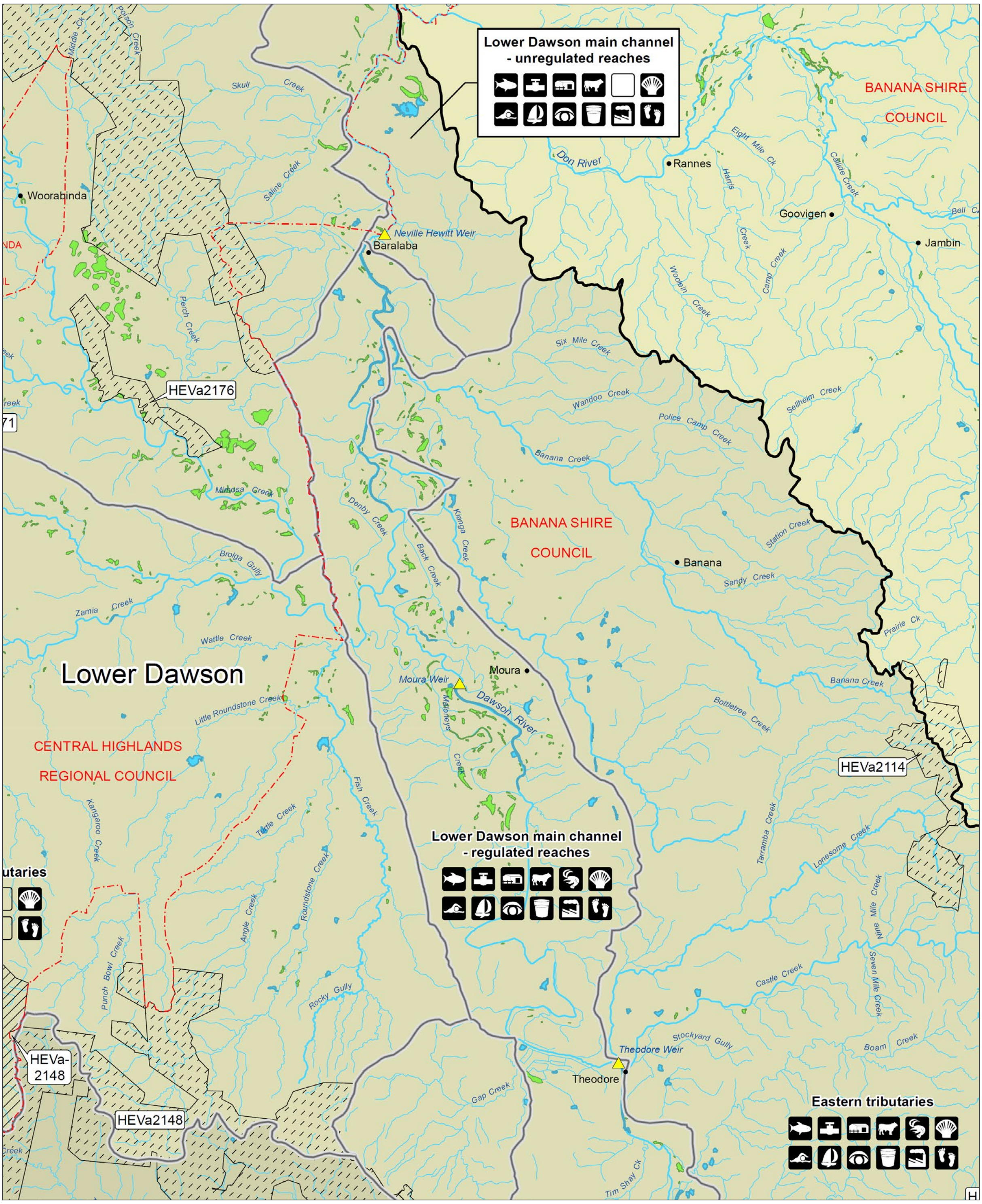


Figure 5.1: Environmental values—Lower Dawson River Sub-basin—WQ1309

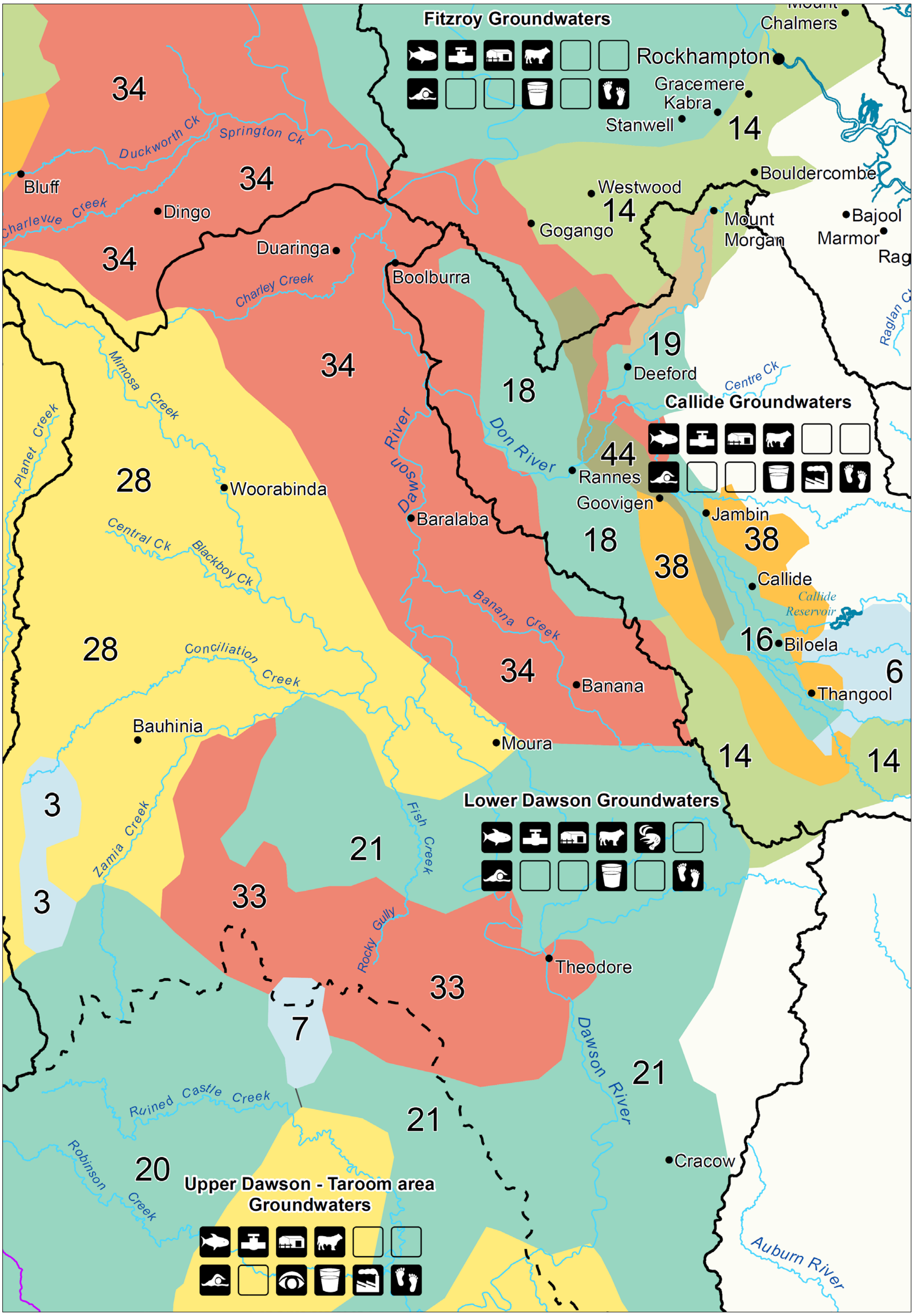


Figure 5.2: Environmental values—Fitzroy Basin Groundwater Zones—WQ1310

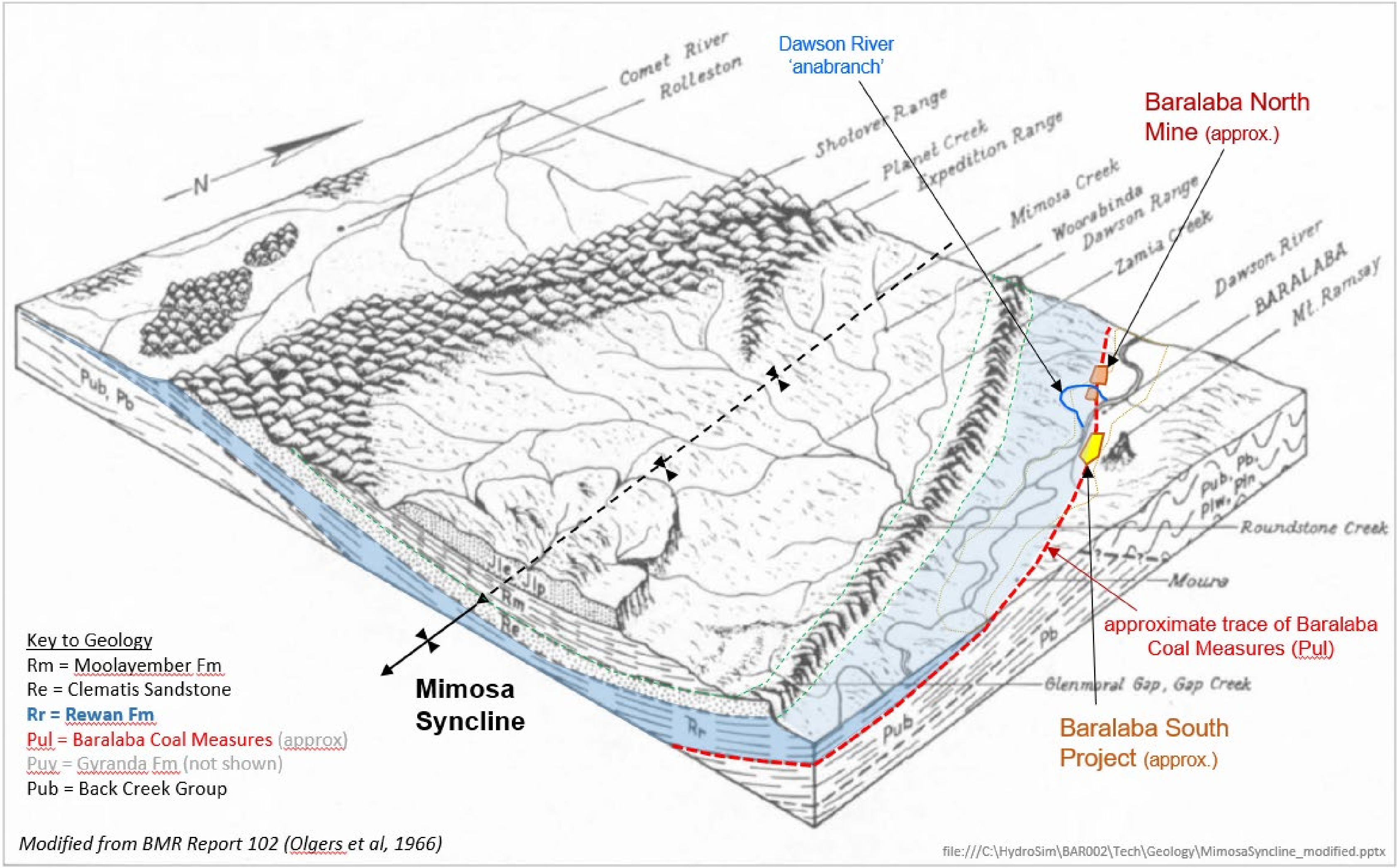
Table 5.1: Environmental values—surface waters and groundwaters relevant to the Project

Environment value	**EPP (Water and Wetland Biodiversity) [Schedule 1]**
	Groundwaters
	Fitzroy Basin groundwater zones/Lower Dawson groundwaters—WQ1310
	Lower Dawson groundwaters – groundwater chemistry Zone 34
Aquatic ecosystem	✓
Irrigation	✓
Farm supply/use	✓
Stock watering	✓
Aquaculture	✓
Human consumers of aquatic foods	
Primary recreation	✓
Secondary recreation	
Visual recreation	
Drinking water supply	✓
Industrial use	
Cultural and Spiritual Values	✓

5.2.2 Geology

The Project lies within the southern part of the Permo–Triassic aged Bowen Basin. In this part of the Bowen Basin the Mimosa Syncline, of which Baralaba lies on the eastern flank, is the significant structural feature. The Mimosa Syncline is characterised by a complex pattern of northerly trending folds and thrust (reverse) faults. The Project is situated in a structurally complex zone on the eastern limb of the Mimosa Syncline (Figure 5.3). Figure 5.3 illustrates how the Permian strata, including the coal measures, dip to the west toward the axis of the Mimosa Syncline, which is some 30-40 km west of Baralaba. The regional dip is relatively gentle, even flat, in the axis of the syncline. However, the strata steepen toward Baralaba and this structure brings the Permian Baralaba Coal Measures toward the surface there.

The economic coal seams lie in the Permian-age Baralaba Coal Measures. The coal measures are overlain by the Triassic-age Rewan Formation, comprising massive sandstone strata that are interbedded with successions of laminated mudstone, siltstone and sandstone.



Modified from BMR Report 102 (Olgers et al, 1966)

file:///C:\HydroSim\BAR002\Tech\Geology\MimosaSyncline_modified.pptx

Figure 5.3: Structural geology setting

Mt Ramsay is an isolated igneous extrusive body trachyte which occurs east of MLA 700057. Based on the regional mapping, the western edge of this feature runs along the eastern edge of the ML boundary, and is >500 m from the eastern edge of the proposed open cut pit.

Distinct local faults have been interpreted to the west of MLA 700057. The local faults are generally north-west striking thrust faults dipping to the south-west at 60-80 degrees. The groundwater assessment considers these faults, both in the government mapping and the local geological (resource) mapping, in terms of their potential to act as hydraulic barriers or conduits.

The subsections below describe the hydrogeological properties of the geological units and structures associated with the Project. Further information regarding the geology of the Project area is described in Chapter 2, Project Description.

5.2.2.1 Outcrop geology

The Permian Baralaba Coal Measures subcrop along a narrow (up to 3.5 km in width) corridor that trends north-north-west, and within MLA 700057 is buried under a veneer of Quaternary alluvium and some Tertiary-Quaternary colluvium.

At the base of the Baralaba Coal Measures is the basal sub-unit Kaloola Member containing minor coal horizons, which in turn is underlain by the Gyranda Formation. The Kaloola Member strata are dominantly fine-sandstones and siltstones with subordinate carbonaceous shale, tuffs and banded coal with some coking and thermal properties.

Overlying the Baralaba Coal Measures is the Rewan Formation of Triassic age. It comprises mainly siltstones and mudstones, as well as unconsolidated sediments (including clays), and a lateritic weathering profile obscuring the coal measures.

The base of the Great Artesian Basin (GAB) is defined by the Lower Triassic Dunda Beds and Rewan Formation, a thick aquitard unit that lies beneath the Clematis Sandstone, the most easterly outcropping aquifer in the GAB. The Clematis Sandstone is part of the GAB recharge beds known as the Eastern Recharge Zone and lies more than 10 km to the west of MLA 700057.

5.2.2.2 Surficial geology

The Quaternary sediments consist of alluvial and colluvial sands and gravel, soil and clay. Available information indicates that the alluvium is heterogeneously distributed, but often comprises distinct layers of surficial clays, thick sands/gravels and basal sandy clays.

The sediments thicken beneath and immediately adjacent the Dawson River, and are typically about 15 m thick (HydroSimulations, 2014). The thickness of Quaternary sediments along Banana Creek are expected to be less than the Dawson River with an even lesser veneer of alluvium/colluvium across parts of MLA 700057.

The weathered rock (regolith) profile has an average depth of weathering of approximately 28 m (HydroSimulations, 2014).

5.2.3 Hydrogeological conceptual model

The conceptual model of the groundwater regime at the Project incorporates two main hydrogeological units in the Project area:

- Quaternary alluvial and colluvial sediments associated with the Dawson River and tributaries; and
- Permian strata, specifically the Baralaba Coal Measures, as well as the overlying Rewan Formation (regional aquitard) and underlying Gyranda Formation (a poorly productive aquifer).

Based on the review of groundwater datasets and dependent assets, the limited groundwater users in the vicinity, the typically dry nature of the alluvial sediments (away from the Dawson River), the brackish-saline nature of the groundwater, and the fact that the Project is not in a defined groundwater management area in the Fitzroy Basin confirm that the identified groundwater systems are not significant aquifers. That is, despite being the main hydrogeological units in the Project area, the groundwater systems at the Project are of limited anthropogenic potential. Nevertheless, from an industrial use perspective, associated groundwaters that would be accessed by the Project would provide a beneficial industrial use through its use in the mine site water inventory.

5.2.3.1 Alluvial and colluvial strata

Along with the Permian coal measures, the alluvium present along the Dawson River (and Banana Creek confluence) is the main groundwater bearing unit near the Project.

Recharge of the surficial sediments is from direct rainfall and infiltration (loss) from streams, particularly where surficial clays are absent. This has been demonstrated by the isotope sampling results which indicate the alluvial bore closer to the Dawson River (i.e. A-OB2) is more readily recharged by rainfall, while bores sampled away from the river (i.e. A-OB4 and A-OB8) have more distinct signatures.

Further, the Neville Hewitt Weir (which has a full storage level at approximately 79 mAHD) maintains the Dawson River stage at this higher elevation than the majority of the groundwater levels observed around Baralaba. This recharge mechanism was identified by the results (i.e. relatively swift recovery) of the pumping tests conducted on site.

A number of alluvial bores have been recorded as dry within MLA 700057 and the isotope analysis by SLR of the groundwater at P-OB1 (Permian bore) indicated it was more readily recharged by rainfall.

Because of its position away from the Dawson River, the colluvium is typically dry, being recharged only by direct rainfall.

There are 12 groundwater monitoring bores screened in alluvium present within the immediate vicinity of the Project area. The alluvial monitoring bores with the highest recorded groundwater elevations are those nearest to the Dawson River (A-OB12, A-OB11, A-OB1, A-OB2 and A-OB3). At an increasing distance from the Dawson River, alluvium screened monitoring bores indicate that the recharge mechanism is from the Dawson River to the alluvium (i.e. losing conditions). All alluvium bores in the southern transect (furthest from the Dawson River and its confluence with Banana Creek) were recorded as dry (A-OB6, A-OB7, A-PB2 and A-OB8).

5.2.3.2 Triassic and Permian strata

In the Permian Coal Measures, groundwater is typically stored and transmitted in the coal seams, while the sandstone/siltstone (interburden) units are of lower permeability. The Gyranda Formation underling the Baralaba Coal Measures is a poorly productive aquifer or an aquitard.

Recharge to these Permian strata is likely to be from rainfall recharge where it occurs at outcrop, noting that infiltration recharge rates in this area are quite low (typically on the order of 1% of average rainfall or less), as well as from downward leakage from the overlying alluvium, if and where saturated.

SKM (2014) conducted detailed analyses of the measured vertical head gradients at each of the VWPs in the Permian coal measures presented in Appendix B, Groundwater Modelling and Assessment, and demonstrated good correlation of sensor depths (mbg) vs head on sensor (m) at the Project area (i.e. a natural decline in potentiometric head with depth).

The Triassic-aged Rewan Formation, which directly overlies the Coal Measures, is a known aquitard, being of tens to hundreds of metres thick and having relatively low permeability.

There is a total of six groundwater monitoring bores screened in the Permian Baralaba Coal Measures within the vicinity of the Project area Two of these bores have been constructed in the interburden, three in coal seams and one in the Gyranda Formation (Figure 5.4). The groundwater elevations recorded in the coal seam bores show that groundwater flow is topographically controlled. Coal seam groundwater levels are approximately 77.5–78 m AHD, with the exception of bores located among rising topography in the south-east. The groundwater elevations in the interburden are similar to that recorded in the coal seams at approximately 74–75 m AHD.

By comparison to the other bores in the Permian Baralaba Coal Measures, the recorded groundwater elevations are highest further east near Mount Ramsay. This is reflective of the rising topography and also supports the overall general hydraulic gradient from east to west within the Project area. Recharge to the Permian Baralaba Coal Measures is likely to be from rainfall recharge, where it occurs at outcrop as well as from downward leakage from the overlying alluvium, if and where saturated (Appendix B, Groundwater Modelling and Assessment).

5.2.3.3 Existing (pre-mining) conditions

With reference to the conceptual groundwater model cross-section (Figure 5.4), existing hydrogeological conditions key points are:

- Recharge rates are low, generally <1% of rainfall (higher to the west, on the GAB aquifers – see below), where average annual rainfall is around 700 mm/year. Minimal groundwater flux or recharge occurs through the Rewan Formation (aquitard) present across much of the study area.
- Evaporation rates are high, with potential evaporation being over 2,000 mm/year, with actual evapotranspiration between 600 and 700 mm/year for the Baralaba region.
- Surficial units (alluvium and colluvium) are generally relatively more permeable compared to Triassic and Permian rock units present in the area. Thickness varies from absent or a few metres to around 20 metres.
- Of the Permo-Triassic strata in the Baralaba region, only the Clematis Sandstone (part of the GAB) and potentially the Duaringa Formation are thought of as significant aquifers, in the sense of producing useable quantities of groundwater. However, the Clematis Sandstone is distant (more than 10 km) from the Project., and there is only a single registered bores (RN 128844) penetrating the Duaringa Formation. This bore is 9 km north-east of the Baralaba North Mine, and 22 km north of the Project.
- The Rewan Formation (overlying the Coal Measures) and Gyranda Formation and other older units (underlying the Coal Measures) are known regional aquitards. The Rewan Formation in particular is thick (i.e. tens to hundreds of metres) and intervenes between the Baralaba Coal Measures and the Clematis Sandstone (GAB) aquifer.
- The Baralaba Coal Measures consist of coal seams with interburden consisting primarily of siltstones, sandstones and mudstones.
- The coal seams are more permeable than the surrounding interburden, although they are not highly transmissive, particularly because the coal seams are not usually more than a few metres thick.
- Local faults may act as permeable or conductive features, but more likely as barriers to flow. For the purposes of the assessment at Project and for conservatism, faulting is not assumed to be a barrier to flow.
- There is minimal anthropogenic groundwater use in the area, due to poorer groundwater quality associated with the Permian coal measures and low-yielding formations. Irrigated paddocks near the Project are located in areas immediately adjacent to the Dawson River and, given the lack of registered

bores associated with these properties, these agricultural operations are considered to be reliant on regulated surface water extractions.

- The Dawson River is a losing watercourse, particularly upstream of Baralaba township, where it is regulated by the Neville Hewitt Weir.
- Similarly, backwaters from the Dawson River to Banana Creek upstream of the confluence are also a losing system.
- Runoff is likely to be the primary source of flow to local drainage lines across the Project area, particularly when considering the depth to the groundwater table is typically 12-15 mbg or greater.
- Wetlands in the area are unlikely to be dependent on or connected to regional groundwater systems. The wetland systems are considered to exist due to the presence of clays in the shallow subsurface, which allow perched water tables to develop and persist after rain or flood events. This is based on the review by 3D Environmental (refer Appendix H), and inspection of groundwater levels in this study.

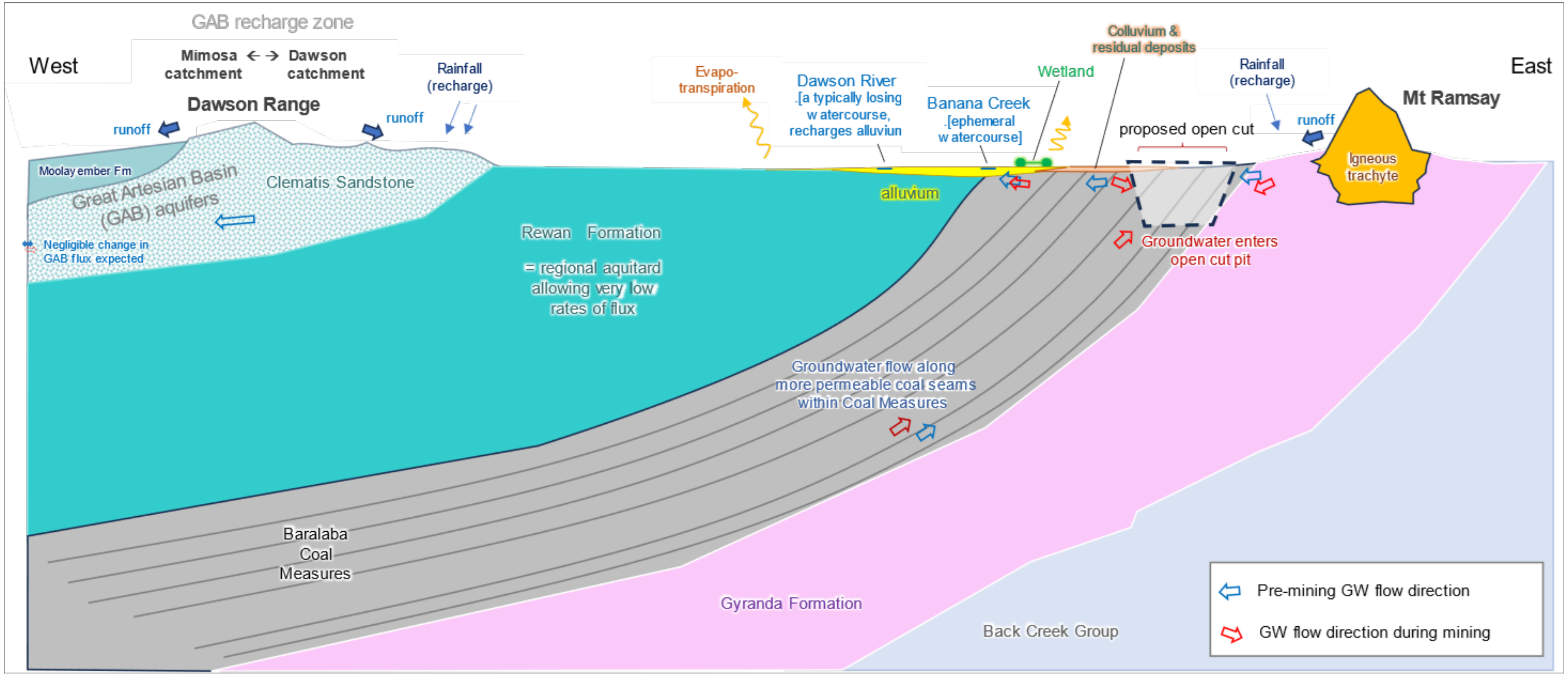


Figure 5.4: Conceptual model of conditions during mining

5.2.4 Baseline groundwater characteristics

5.2.4.1 Groundwater level

Using the groundwater datasets presented in Appendix B, Groundwater Modelling and Assessment, contour maps of measured and inferred water levels are presented on Figure 5.5. This also allows for the depth to water table / interpreted unsaturated depth in the vicinity of the Project site and surrounds to be estimated and this is presented as Figure 5.6.

For conservative assessment purposes, where multiple records exist at the one location, the maximum water levels (elevation) were used to assist with identifying areas of ‘potential’ interaction between vegetation and the water table.

Interpolation of the water table elevation was conducted using the ArcGIS 10 ‘Topo To Raster’ tool, which is based on a spline interpolation method, and has the advanced functionality of allowing interpolation from multiple datasets, including points (e.g. observations at bores) and polyline contours (e.g. hand-drawn contours).

Flow directions can be inferred from a groundwater elevation contour map, as flow occurs from areas of high head to those of low head. From Figure 5.5, the inferred groundwater flow directions in the vicinity of the Project are predominantly topographically controlled:

- Convergent along Banana Creek (and alluvium) toward the confluence of and then northward along the Dawson River.
- Westward from Mount Ramsay and east of the Dawson Range through the Project site toward Dawson River.

It is likely that the regulation of the Dawson River behind the Neville Hewitt Weir, which has raised the Dawson River stage above the natural levels upstream of the weir, has led to slightly elevated groundwater levels in this area, including to the west of the Project.

Figure 5.6 shows the depth to groundwater is typically 10-15 mbgl in the north of MLA 700057, 15-20 mbgl in the west of MLA 700057 and greater than 20 mbgl in the east of MLA 700057.

Further details regarding assessment methodology are provided in Appendix B, Groundwater Modelling and Assessment, along with groundwater level data.

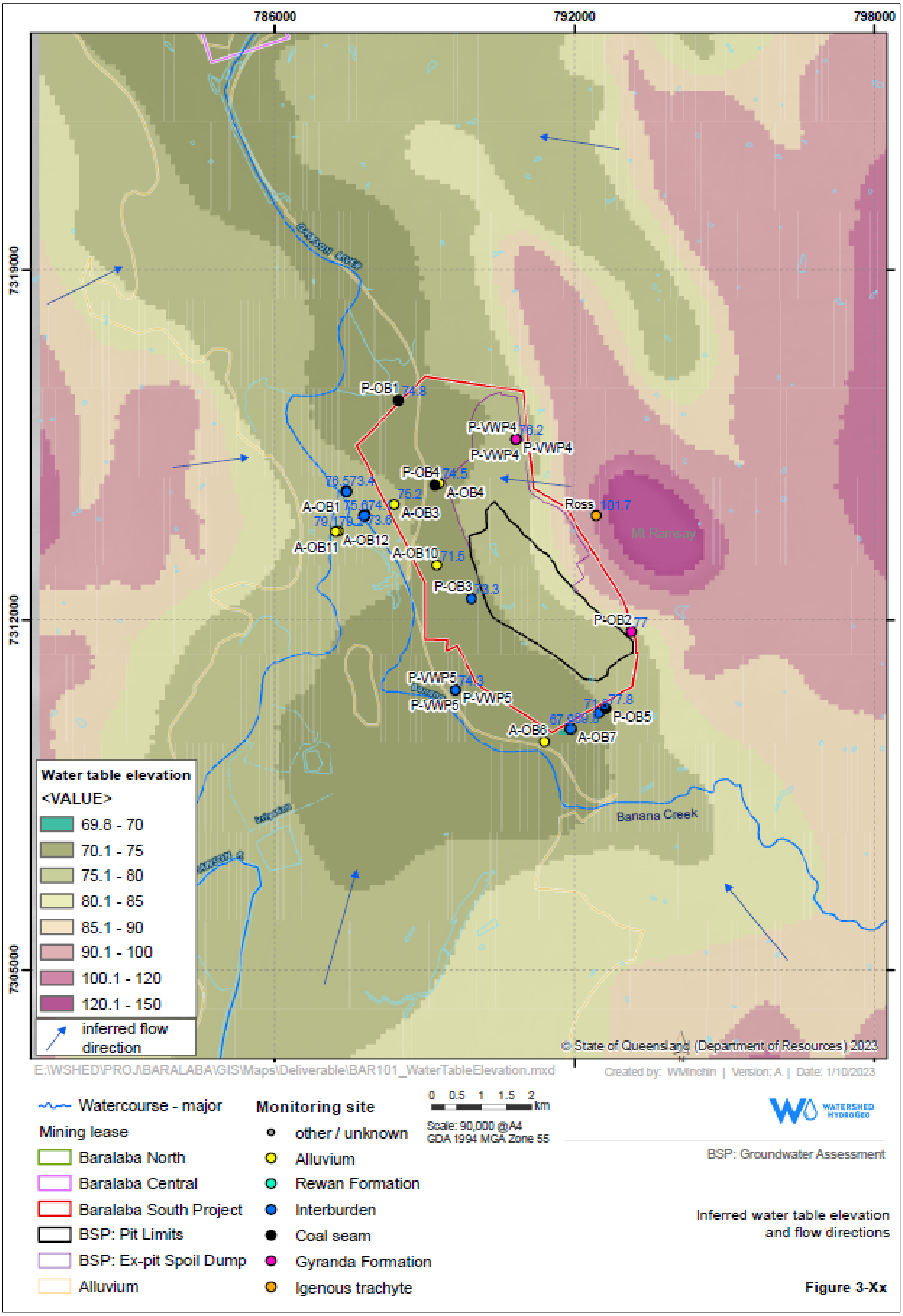


Figure 5.5: Inferred water table elevation and flow direction

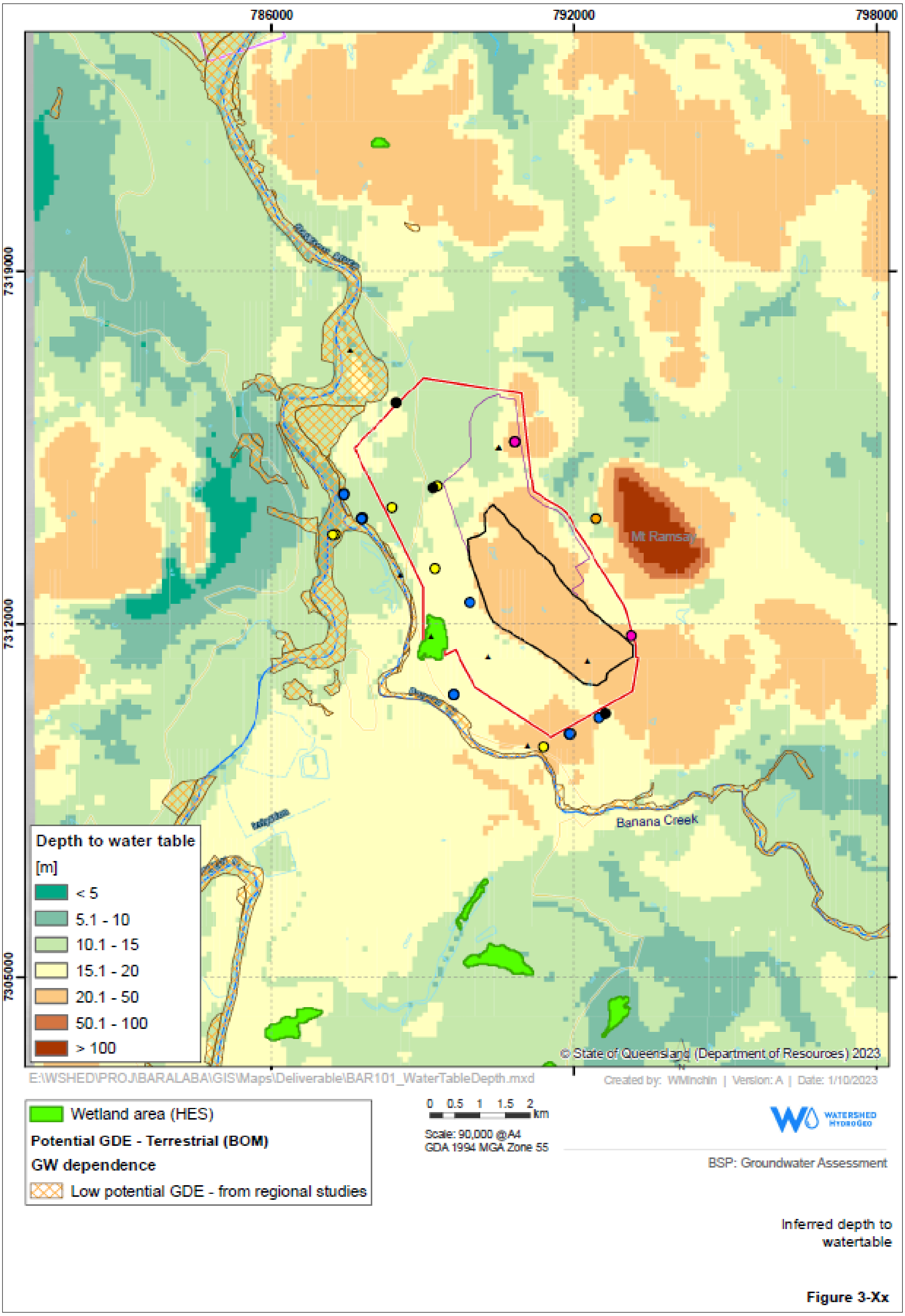


Figure 5.6: Depth to observed groundwater table / interpreted unsaturated depth

5.2.4.2 Groundwater quality

An assessment of baseline groundwater quality has been undertaken using data collected from groundwater quality sampling programs and is presented in detail in the Groundwater Modelling and Assessment Report (Appendix B). The groundwater sampling program involves the collection of data for physio-chemical parameters, major ion hydrochemistry and isotope sampling at a range of bore types (shallow groundwater, deep groundwater and igneous trachyte). For the following sub-sections, it is assumed that this can be read as 'shallow' = alluvium and colluvium, 'deep' = Permo-Triassic strata.

2012 Groundwater Quality

A groundwater quality sampling program was initiated in the Project area in July–August and December 2012 (SKM, 2014). A summary of the physico-chemical parameters and major ion hydrochemistry data recorded in 2012 from the alluvium and Permian coal measures (i.e. Baralaba Coal Measures [interburden/ coal] and Gyranda Formation) is presented Table 5.2 and Table 5.3, respectively.

Table 5.2: Physico-chemical parameters and major ion hydrochemistry (2012)—alluvium

Bore ID	**pH**	**EC (µS/cm)**	**TDS (mg/L)**	**Major ions (mg/L)**						
				Na	**Mg**	**Ca**	**K**	**Cl**	**SO4**	**HCO_3 [$CaCO_3$]**
A-PB1	6.7	484	333	79	6	12	3	84	11.5	97.5
A-OB1	7.3	570.5	407	45	17.5	40	3.5	35	11	199
A-OB2	6.8	836	488	115	13	21	4.5	152	6.5	146
A-OB3	7.3	696	401	101	5	8.5	2	54	25	171
A-OB4	6.7	21,039	18,100	2,850	845	925	29	7,720	731	301
A-OB8+	7.3	4,400	2,310	835	42	45	11	1,000	328	—
A-OB10	6.6	28,558	1,895	2,640	1,245	1,895	29	10,035	855	294
A-OB11	7.1	664	452	64	27	42	5	4	119	242
A-OB12	7.5	421	421	54	24	43	6	89	5	212

Table 5.3: Physico-chemical parameters and major ion hydrochemistry (2012)—Permian coal measures

Bore ID	**pH**	**EC (µS/cm)**	**TDS (mg/L)**	**Major Ions (mg/L)**						
				Na	**Mg**	**Ca**	**K**	**Cl**	**SO_4**	**HCO_3 [$CaCO_3$]**
Baralaba Coal Measures (interburden)										
P-PB1	7.4	15,641	12,990	2,430	20.5	832.5	3	5,365	<1	37
P-OB3	6.5	31,765	28,350	3,910	1,115	1,475	29.5	10,550	1,205	270

Baralaba Coal Measures (coal seams)										
P-OB1	6.4	27,339	22,200	3,225	1,090	1,245	30	9,075	1,560	375
P-OB4	6.6	35,432	35,800	3,880	1,270	1,700	1,270	10,600	1,520	210
P-OB5	8.3	11,200	16,700	3,650	307	266	307	6,800	568	78
Gyranda Formation										
P-OB2	6.8	17,398	12,500	2,900	267.5	378	17	5,750	165	553

The results of these sampling rounds, as well as that conducted in 2017-2023 are discussed in the following sub-sections, noting that tables in this chapter typically include a (representative) selection of data, while a summary of the full historic dataset is presented in Appendix B, Groundwater Modelling and Assessment (specifically in Appendix C of this report).

2017 – 2023 Groundwater quality

To augment these datasets, a targeted baseline groundwater quality sampling program of alluvium and Permian coal measure bores within the Project area and surrounds was conducted by SLR Consulting during 2017–2018 and by 4T Consultants from 2019 to 2023 at the sites shown in Table 5.1. Consistent with the findings of the 2012 baseline groundwater quality sampling program (SKM, 2014), the field data shows that alluvium groundwater quality varies depending on the influence / proximity to the Dawson River, with those nearest (A-PB1, A-OB1, A-OB2, A-OB11 and A-OB12) with fresher water quality.

The results of the 2017–2023 groundwater monitoring program are presented in Table 5.4 to Table 5.9

Table 5.4: Groundwater quality sampling results—alluvium (pH, EC and TDS)

Bore ID	**Dec 17**	**Mar 18**	**Jun 18**	**Oct 18**	**Feb 19**	**May 19**	**Aug 19**	**Nov 19**	**Mar 20**	**Sep 20**	**Oct 20**	**Nov 20**	**Dec 20**	**Jan 21**	**Feb 21**	**Mar 21**	**Apr 21**	**May 21**	**Jun 21**	**Mar 22**	**Aug 22**	**Oct 22**	**Jan 23**	**Apr 23**	**Jul 23**
pH (pH units) (field)																									
A-PB1	-	6.07	6.12	6.19	6.41	6.35	6.48	6.49	I	6.46	6.5	6.49	6.48	6.56	6.54	6.57	7.56	7.44	6.5	6.63	6.6	-	-	-	-
A-OB1	6.42	6.49	6.26	6.16	6.26	6.33	6.52	6.53	I	6.46	6.45	6.45	6.38	6.39	6.37	6.44	6.44	6.83	6.41	6.62	6.58	6.4	6.72	6.95	-
A-OB2	6.41	6.48	7.00	6.27	6.48	6.6	6.75	6.75	I	6.55	6.52	6.51	6.48	6.55	6.5	6.52	8.21	6.88	6.52	6.62	6.63	6.79	6.81	7.04	7.29
A-OB3	-	6.75	6.55	6.54	B	B	B	B	I	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
A-OB4	6.31	6.29	6.3	6.43	7.40	6.32	6.4	6.36	I	6.39	6.43	6.36	6.35	6.37	6.33	6.35	6.35	6.58	6.4	6.47	6.42	6.23	6.69	7.42	7.33
A-OB7	6.62	6.95	6.64	6.92	6.64	6.65	6.73	6.7	I	6.68	6.7	6.66	6.65	6.68	6.63	6.64	6.68	6.53	6.72	6.77	6.73	6.71	6.7	6.83	-
A-OB8	6.89	6.94	6.57	6.47	6.50	6.42	6.61	6.59	6.53	6.57	6.52	6.48	6.5	6.48	6.44	6.48	6.47	6.36	6.49	6.57	6.52	6.34	6.66	6.68	-
A-OB10	6.42	6.2	6.15	6.36	7.11	6.3	6.39	6.39	6.49	6.44	6.37	6.37	6.38	—	6.39	6.38	6.42	6.63	6.44	6.5	6.46	6.3	6.56	6.81	7.29
A-OB11	6.08	6.14	6.37	6.23	6.25	6.3	6.46	6.35	I	6.53	6.49	6.51	6.49	6.52	6.42	6.4	6.46	6.29	6.46	6.46	6.17	6.39	6.91	6.6	-
A-OB12	6.17	6.25	6.25	6.28	6.48	6.56	6.64	6.53	I	6.49	6.43	6.43	6.41	6.48	6.35	6.38	6.44	6.18	6.4	6.79	6.46	6.32	6.72	6.7	-
EC (µS/cm) (field)																									
A-PB1	-	646	630	610	720	711	615	648	I	630	685	766	830	877	861	868	906	857	1011	710	588	-	-	-	-
A-OB1	570	466	486	493	586	700	606	644	I	675	598	622	645	524	654	645	563	559	564	695	714	629	897	693	-
A-OB2	657	617	686	565	583	831	843	911	I	612	621	649	658	686	665	679	960	649	628	509	524	824	831	508	524
A-OB3	-	561	593	489	B	B	B	B	I	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
A-OB4	37,011	35,920	37,557	40,022	37,150	36,385	36,423	31,759	I	37,592	37,445	37,703	37,581	37,415	37,197	37,461	37,120	36,990	37,258	37,936	37,027	19,314	37,328	32,341	44,800
A-OB7	15,681	16,809	16,637	18,390	20,122	19,487	19,657	18,058	I	20,717	20,547	20,584	20,597	20,508	20,436	20,578	20,358	20,611	20,548	20,807	20,402	19,314	20,417	19,539	-
A-OB8	26,260	25,877	26,914	27,752	28,071	28,197	27,752	25,754	28,536	29,366	29,951	29,668	29,744	29,553	29,457	29,469	29,439	29,496	29,648	30,580	29,951	28,287	27,533	27,945	-
A-OB10	31,708	36,433	38,097	38,786	37,303	35,894	34,430	29,887	32,507	33,117	33,025	33,242	32,847	—	32,584	32,833	32,450	32,673	32,850	33,746	31,792	30,885	32,405	32,668	40,600
A-OB11	425	405	434	377	440	481	452	351	I	360	335	362.7	397	346	336	452	370	427	438	515	399	370	449	489	-
A-OB12	381	354	328	323	430	526	456	306	I	392	392	417	343	393	388	378	477	393	395	375	360	308	399	325	-
TDS (mg/L) (lab)																									
A-PB1	648	-	320	340	-	390	444	393	I	372	404	451	462	496	472	484	516	485	554	383	299	-	-	-	-
A-OB1	644	260	260	230	310	440	407	432	I	432	409	432	407	368	654	645	563	559	564	695	714	629	897	693	-
A-OB2	911	370	300	380	350	442	475	588	I	363	357	382	375	391	378	527	622	356	308	319	402	447	338	323	378
A-OB3	B	-	390	360	350	B	B	B	I	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
A-OB4	31,759	30,000	34,000	23,000	38,000	28,800	23,300	30,200	I	B	31,000	31,600	31,700	28,100	29,800	31,000	30,400	26,600	31,400	33,400	25,800	29,200	33,800	28,200	30,200
A-OB7	18,058	13,000	13,000	16,000	16,000	13,200	12,600	15,600	I	14,900	15,100	14,500	15,400	15,000	15,900	16,200	15,400	13,600	16,100	17,300	13,700	14,500	16,700	14,500	-
A-OB8	25,754	14,000	18,000	19,000	27,000	19,900	17,900	21,200	19,200	21,000	21,600	22,700	22,100	21,800	22,500	22,000	22,100	19,700	23,700	24,200	18,400	21,400	20,400	20,800	-

Bore ID	Dec 17	Mar 18	Jun 18	Oct 18	Feb 19	May 19	Aug 19	Nov 19	Mar 20	Sep 20	Oct 20	Nov 20	Dec 20	Jan 21	Feb 21	Mar 21	Apr 21	May 21	Jun 21	Mar 22	Aug 22	Oct 22	Jan 23	Apr 23	Jul 23
A-OB10	29,887	32,000	37,000	33,000	38,000	27,800	19,500	28,200	23,400	27,800	26,900	28,400	26,900	-	26,000	28,800	26,800	23,400	28,800	30,400	24,400	25,500	31,300	26,000	28,300
A-OB11	351	210	210	220	240	258	298	262	I	228	213	252	213	243	300	279	308	248	320	314	276	254	254	339	-
A-OB12	306	180	160	140	190	259	287	219	I	251	243	258	211	243	230	239	289	230	228	230	204	197	231	208	-

(-) Bore Dry, not sampled. (B) Bore is blocked, not sampled. (I) Bore Inaccessible due to weather conditions, not sampled.
No results are presented for A-PB2 and A-OB6 as bores were dry.

Table 5.5: Groundwater quality sampling results—Permian coal measures (pH, EC and TDS)

Bore ID	Dec 17	Mar 18	Jun 18	Oct 18	Feb 19	May 19	Aug 19	Nov 19	Mar 20	Sep 20	Oct 20	Nov 20	Dec 20	Jan 21	Feb 21	Mar 21	Apr 21	May 21	Jun 21	Mar 22	Aug 22	Oct 22	Jan 23	Apr 23	Jul 23
pH (pH units) (field)																									
Baralaba Coal Measures (interburden)																									
P-PB1	—	7.3	6.9	7.1	7.0	6.72	6.8	6.8	I	6.89	7.05	6.98	6.91	7.02	6.93	6.57	7.21	7.08	6.90	6.76	6.96	6.74	6.82	7.10	7.16
P-OB3	6.1	6.2	6.2	6.2	6.3	6.33	6.5	6.4	6.5	6.41	6.41	6.42	6.37	6.42	6.38	6.39	6.37	6.31	6.41	6.49	6.42	6.33	6.45	6.57	7.27
Baralaba Coal Measures [coal seams]																									
P-OB1	6.2	6.3	6.2	6.2	6.3	6.06	6.4	6.3	I	6.32	6.30	6.28	6.31	6.31	6.16	6.20	6.34	6.52	6.33	6.30	6.01	6.22	6.35	6.46	-
P-OB4	6.5	6.1	6.2	6.3	6.4	6.31	6.5	6.5	I	6.51	6.48	6.45	6.47	6.45	6.40	6.41	6.44	6.50	6.46	6.46	6.55	6.40	6.67	6.78	7.43
P-OB5	7.3	7.2	6.8	6.5	6.5	6.44	6.6	6.5	I	6.59	6.55	6.54	6.53	6.56	6.51	6.52	6.49	6.41	6.56	6.59	6.60	6.60	6.83	6.85	-
Gyranda Formation																									
P-OB2	—	6.1	6.1	6.3	6.4	6.19	6.4	6.3	6.4	6.42	6.42	6.37	6.35	6.35	6.32	6.38	6.38	6.29	6.40	6.47	6.43	6.30	6.73	6.51	7.32
EC (µS/cm) (Field)																									
Baralaba Coal Measures (interburden)																									
P-PB1	—	15,950	16,296	18,453	15,763	15,574	15,303	13,721	I	15,839	16,031	15,955	15,902	15,813	15,861	15,906	16,115	15,776	15,884	16,156	15,697	15,260	15,763	15,177	19,200
P-OB3	34,107	33,141	34,154	37,120	33042	32,548	32,169	28,835	32,386	32,661	33,460	33,292	33,074	33,012	32,906	33,050	32,502	32,427	32,605	33,534	32,405	31,220	32,811	30,890	40,900
Baralaba Coal Measures [coal seams]																									
P-OB1	29,785	30,324	31,390	33,260	34,270	34,234	33,794	30,700	I	34,370	34,711	34,510	34,547	34,400	34,437	34,360	34,392	34,214	34,488	34,801	34,257	32,274	31,888	32,999	-
P-OB4	37,088	36,356	37,492	40,297	36,546	36,131	35,942	31,702	I	36,644	37,035	37,051	36,818	36,415	36,511	36,698	36,164	36,311	36,677	37,223	35,792	33,348	36,299	32,669	45,400
P-OB5	24,664	27,225	23,666	34,100	29,073	28,889	28,641	25,455	I	29,147	29,529	29,324	29,143	29,062	28,955	29,035	28,866	29,044	29,100	29,602	28,682	26,602	28,127	27,201	-
Gyranda Formation																									
P-OB2	—	19,480	19,503	21,075	19,085	19,000	18,964	16,669	18,797	19,560	19,435	19,371	19,242	19,196	19,126	19,351	18,750	19,252	19,316	19,970	19,514	18,182	19,372	17,180	26,500
TDS (mg/L) (Lab)																									
Baralaba Coal Measures (interburden)																									
P-PB1	-	11,000	12,000	12,000	-	9,750	8,880	11,000	I	10,800	11,000	11,100	11,000	11,000	10,800	10,700	11,000	9,780	10,600	13,000	10,800	11,100	12,000	10,500	11,100
P-OB3	30,000	31,000	19,000	27,000	-	24,600	18,200	26,700	22,900	26,400	27,500	27,700	25,800	27,600	25,500	28,000	26,800	27,400	26,900	31,400	22,400	24,800	30,400	26,700	27,200
Baralaba Coal Measures (coal seams)																									
P-OB1	25,000	28,000	21,000	29,000	-	26,100	23,600	28,500	I	27,300	28,500	29,000	26,400	27,700	27,800	29,500	29,200	249,000	27,200	29,600	25,600	26,700	31,000	23,000	-
P-OB4	27,000	31,000	25,000	35,000	-	28,700	20,200	31,100	I	34,100	28,300	31,800	28,800	31,300	30,200	29,800	30,600	30,000	30,800	35,200	28,300	28,400	33,800	28,900	30,200
P-OB5	13,000	12,000	12,000	24,000	-	19,200	17,200	20,800	I	20,100	20,200	17,800	18,200	20,700	19,600	20,100	20,600	19,800	21,000	22,200	21,700	19,100	21,400	19,700	-
Gyranda Formation																									
P-OB2	-	13,000	14,000	13,000	-	12,600	11,700	13,600	12,600	13,400	13,700	14,200	13,800	14,100	13,800	13,900	13,500	15,600	14,200	16,200	12,800	13,200	15,000	12,800	13,800

Note: TDS not sampled in February., (-) Bore dry, not sampled. (I) Bore inaccessible due to weather conditions, not sampled.

Table 5.6: Statistical analysis of groundwater quality sampling results—alluvium (metals concentrations)

Alluvium metals concentrations (mg/L)—total and filtered

Bore ID	Parameter	Al	Al (f)	As	As (f)	B	B (f)	Cd	Cd (f)	Cr	Cr (f)	Co	Co (f)	Cu	Cu (f)
A-PB1	Sample count	20	20	20	20	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.05	< 0.05	< 0.001	< 0.001	< 0.05	< 0.05	< 0.0002	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	20th percentile	0.172	0.01	0.001	0.001	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.0014	0.001
	Median	0.54	0.01	0.002	0.001	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.002	0.001
	95th percentile	3.262	0.05	0.003	0.003	0.05	0.05	0.0002	0.0002	0.0082	0.001	0.0064	0.001	0.0065	0.001
	Maximum	9.57	<0.05	0.003	0.003	< 0.05	< 0.05	< 0.0002	< 0.0002	0.009	<0.001	0.007	< 0.001	0.007	0.001
A-OB1	Sample count	24	24	24	24	4	4	4	4	4	4	4	4	4	4
	Minimum	0.46	<0.01	0.001	<0.001	< 0.05	< 0.05	<0.0002	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001
	20th percentile	6.298	0.01	0.002	0.001	0.056	0.05	0.0002	0.0002	0.004	0.001	0.001	0.001	0.0042	0.001
	Median	10.27	0.01	0.002	0.001	0.065	0.055	0.0006	0.0002	0.015	0.001	0.0505	0.001	0.0345	0.001
	95th percentile	31.2000	0.0500	0.0099	0.0020	0.0700	0.0600	0.0018	0.0002	0.0487	0.0010	0.1935	0.0027	0.1371	0.0027
	Maximum	78	< 0.05	0.013	0.002	0.07	0.06	0.0019	<0.0002	0.053	< 0.001	0.21	0.003	0.15	0.003
A-OB2	Sample count	23	23	23	23	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.05	<0.01	<0.001	<0.001	< 0.05	< 0.05	< 0.0002	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	20th percentile	0.674	0.01	0.001	0.001	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.001	0.001
	Median	2.22	0.01	0.001	0.001	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.001	0.001
	95th percentile	12.1800	0.0500	0.0040	0.0029	0.0500	0.0680	0.0002	0.0002	0.0136	0.0010	0.0136	0.0019	0.0424	0.0010
	Maximum	14.9	< 0.05	0.004	0.004	< 0.05	0.07	< 0.0002	< 0.0002	0.015	< 0.001	0.015	0.002	0.047	0.001
A-OB3	Sample count	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.05	< 0.05	0.003	0.003	< 0.05	< 0.05	< 0.0002	< 0.0002	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001
	20th percentile	0.082	0.05	0.0038	0.0034	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.0014	0.001
	Median	0.13	0.05	0.005	0.004	0.05	0.05	0.0002	0.0002	0.001	0.001	0.001	0.001	0.002	0.001
	95th percentile	1.6330	0.0500	0.0050	0.0049	0.0500	0.0590	0.0002	0.0002	0.0028	0.0010	0.0046	0.0019	0.0038	0.0037
	Maximum	1.8	< 0.05	0.005	0.005	0.05	0.06	< 0.0002	< 0.0002	0.003	< 0.001	0.005	0.002	0.004	0.004
A-OB4	Sample count	24	24	24	24	4	4	4	4	4	4	4	4	4	4
	Minimum	< 0.05	<0.01	0.002	0.002	0.1	0.11	0.0009	< 0.0002	< 0.001	< 0.001	0.036	0.028	0.026	< 0.001
	20th percentile	2.584	0.05	0.005	0.0046	0.106	0.116	0.0012	0.00056	0.0058	0.001	0.0432	0.0346	0.0284	0.001
	Median	3.54	0.05	0.005	0.005	0.115	0.12	0.00155	0.0011	0.009	0.0055	0.0565	0.0415	0.0525	0.002
	95th percentile	16.8600	0.0925	0.0095	0.0094	0.1285	0.1285	0.0028	0.0034	0.0430	0.1035	0.1118	0.0619	0.9463	0.0430
	Maximum	18.1	51	0.016	0.017	0.13	0.13	0.003	0.0038	0.049	0.12	0.12	0.065	1.1	< 0.05
A-OB7	Sample count	23	23	23	23	4	4	4	4	4	4	4	4	4	4

Alluvium metals concentrations (mg/L)—total and filtered

	Minimum	5.26	< 0.01	0.002	< 0.001	0.18	0.21	0.0018	0.0005	0.037	< 0.001	0.094	0.006	0.081	0.001
	20th percentile	13.48	0.01	0.0034	0.001	0.198	0.21	0.00198	0.0005	0.0694	0.001	0.1096	0.0066	0.1764	0.0022
	Median	17.4	0.01	0.004	0.001	0.215	0.22	0.0023	0.00055	0.1155	0.001	0.145	0.0075	0.34	0.004
	95th percentile	201	0.05	0.0233	0.0046	0.3645	0.2385	0.0052	0.0006	0.6500	0.0070	0.7140	0.0080	1.4260	0.0093
	Maximum	920	0.1	0.06	0.01	0.39	0.24	0.0057	0.0006	0.74	0.008	0.81	0.008	1.6	0.01
A-OB8	Sample count	24	24	24	24	4	4	4	4	4	4	4	4	4	4
	Minimum	0.7	< 0.01	0.003	0.001	0.13	0.05	0.0003	0.0003	0.017	< 0.001	0.003	0.003	0.052	0.021
	20th percentile	4.94	0.05	0.005	0.002	0.16	0.134	0.0006	0.0003	0.0188	0.0016	0.0066	0.003	0.1768	0.0228
	Median	8.305	0.05	0.006	0.005	0.19	0.255	0.00095	0.00035	0.056	0.002	0.0255	0.0035	0.32	0.0315
	95th percentile	44.9300	0.0925	0.0355	0.0050	0.3020	0.3625	0.0018	0.0007	0.2688	0.0207	0.1338	0.0040	0.4480	0.2014
	Maximum	140	0.1	0.068	0.01	0.32	0.37	0.0019	0.0007	0.3	0.024	0.15	0.004	0.46	0.23
A-OB10	Sample count	24	24	24	24	4	4	4	4	4	4	4	4	4	4
	Minimum	1	0.01	0.005	0.001	0.11	0.11	0.0014	< 0.0002	0.026	0.001	0.025	0.005	0.046	0.001
	20th percentile	3.9	0.05	0.005	0.0016	0.116	0.11	0.00176	0.00092	0.026	0.001	0.0292	0.0116	0.0628	0.0268
	Median	6.87	0.05	0.005	0.005	0.12	0.115	0.00245	0.0015	0.0295	0.001	0.0335	0.0165	0.177	0.0655
	95th percentile	31.6550	0.0500	0.0100	0.0050	0.1285	0.1200	0.0050	0.0025	0.0390	0.0104	0.1158	0.0179	0.3225	0.1746
	Maximum	38	0.1	0.011	0.01	0.13	0.12	0.0054	0.0027	0.04	0.012	0.13	0.018	0.33	0.19
A-OB11	Sample count	23	23	23	23	4	4	4	4	4	4	4	4	4	4
	Minimum	0.25	< 0.01	0.004	0.002	< 0.05	< 0.05	< 0.0002	< 0.0002	< 0.001	< 0.001	0.005	0.006	< 0.001	< 0.001
	20th percentile	2.5	0.01	0.0084	0.006	0.05	0.05	0.0002	0.0002	0.0034	0.001	0.0062	0.006	0.0022	0.001
	Median	8.68	0.01	0.009	0.007	0.05	0.05	0.0002	0.0002	0.005	0.001	0.008	0.006	0.004	0.001
	95th percentile	33.6200	0.0500	0.0231	0.0080	0.0500	0.0500	0.0004	0.0002	0.0305	0.0010	0.0609	0.0077	0.0254	0.0010
	Maximum	49.2	0.07	0.149	0.009	0.05	0.05	0.0004	< 0.0002	0.035	< 0.001	0.07	0.008	0.029	< 0.001
A-OB12	Sample count	23	23	23	23	4	4	4	4	4	4	4	4	4	4
	Minimum	0.41	< 0.01	0.008	0.007	< 0.05	< 0.05	< 0.0002	< 0.0002	< 0.001	< 0.001	0.002	0.002	< 0.001	< 0.001
	20th percentile	2.082	0.01	0.009	0.008	0.05	0.05	0.0002	0.0002	0.0028	0.001	0.0032	0.0026	0.0028	0.001
	Median	5.92	0.01	0.01	0.009	0.05	0.05	0.0002	0.0002	0.0055	0.001	0.0045	0.003	0.0055	0.001
	95th percentile	12.6600	0.0500	0.0120	0.0109	0.0585	0.0500	0.0004	0.0002	0.0368	0.0010	0.0144	0.0030	0.0410	0.0010
	Maximum	28	< 0.05	0.013	0.011	0.06	< 0.05	0.0004	< 0.0002	0.042	< 0.001	0.016	0.003	0.047	< 0.001

(f) Filtered, Data analysis is based on the sampling conducted by SLR Consulting in December 2017, March, June and October 2018 and sampling conducted by 4T Consultants in February, May, August and November 2019, March, September, October, November and December 2020 and January 2021. Sample count refers to the number of sampling results for the bore. To calculate the 20th percentile, median and 95th percentile data, less than symbols have been removed from the results.

Table 5.7: Statistical analysis of groundwater quality sampling results—alluvium (metal concentrations)

Alluvium metals concentrations (mg/L)—total and filtered															
Bore ID	Parameter	Pb	Pb (f)	Hg	Hg (f)	Mo	Mo (f)	Ni	Ni (f)	Se	Se (f)	U	U (f)	Zn	Zn (f)
A-PB1	Sample count	3	3	20	20	20	20	3	3	20	20	20	20	20	19
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.005	< 0.005	0.005	<0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.001	0.001	0.001	0.0014	0.01	0.01	0.001	0.001	0.0176	0.008
	Median	0.001	0.001	0.0001	0.0001	0.001	0.001	0.001	0.002	0.01	0.01	0.001	0.001	0.0345	0.02
	95th percentile	0.0028	0.001	0.0001	0.0001	0.005	0.0052	0.0073	0.002	0.01	0.01	0.005	0.005	0.17115	0.1859
	Maximum	0.003	< 0.001	< 0.0001	< 0.0001	< 0.005	0.009	0.008	0.002	0.01	0.01	< 0.005	< 0.005	1.2	0.95
A-OB1	Sample count	4	4	24	24	24	24	4	4	24	24	24	24	24	23
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.009	<0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.001	0.001	0.0026	0.001	0.01	0.01	0.001	0.001	0.046	0.009
	Median	0.016	0.001	0.0001	0.0001	0.001	0.001	0.0405	0.0015	0.01	0.01	0.001	0.001	0.07	0.015
	95th percentile	0.0599	0.0010	0.0002	0.0001	0.0050	0.0050	0.1137	0.0029	0.0100	0.0100	0.0050	0.0050	0.2561	0.0976
	Maximum	0.065	< 0.001	0.0004	< 0.0001	< 0.005	0.008	0.12	0.003	< 0.01	< 0.01	0.008	< 0.005	0.36	0.101
A-OB2	Sample count	3	3	23	23	23	23	3	3	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.006	<0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.001	0.001	0.0018	0.0014	0.01	0.01	0.001	0.001	0.0254	0.0074
	Median	0.001	0.001	0.0001	0.0001	0.001	0.001	0.003	0.002	0.01	0.01	0.001	0.001	0.039	0.0185
	95th percentile	0.0145	0.0010	0.0001	0.0001	0.0050	0.0050	0.0165	0.0029	0.0100	0.0100	0.0050	0.0050	0.1250	0.0889
	Maximum	0.016	0.001	0.0005	0.0002	< 0.005	0.008	0.018	0.003	<0.01	0.01	< 0.005	< 0.005	0.141	0.124
A-OB3	Sample count	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.005	< 0.005	0.001	0.001	< 0.001	< 0.001	< 0.005	< 0.005	0.006	< 0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.005	0.005	0.0014	0.0014	0.001	0.001	0.005	0.005	0.0124	0.005
	Median	0.001	0.001	0.0001	0.0001	0.005	0.005	0.002	0.002	0.001	0.001	0.005	0.005	0.022	0.005
	95th percentile	0.0028	0.0010	0.0001	0.0002	0.0050	0.0086	0.0065	0.0020	0.0010	0.0019	0.0050	0.0050	0.3352	0.0167
	Maximum	0.003	< 0.001	< 0.0001	0.0002	< 0.005	0.009	0.007	0.002	0.001	0.002	< 0.005	< 0.005	0.37	0.018
A-OB4	Sample count	4	4	24	24	24	24	4	4	24	24	24	24	24	22
	Minimum	0.005	< 0.001	< 0.0001	< 0.0001	< 0.005	0.002	0.032	0.01	< 0.001	< 0.001	0.008	0.008	0.045	0.02
	20th percentile	0.0092	0.001	0.0001	0.0001	0.005	0.005	0.0344	0.0154	0.05	0.0106	0.0106	0.01	0.066	0.032
	Median	0.019	0.001	0.0001	0.0001	0.005	0.005	0.0595	0.0225	0.05	0.05	0.012	0.01	0.0875	0.0555
	95th percentile	0.0847	0.8417	0.0009	0.0001	0.005	0.0092	0.1485	0.0303	0.0925	0.0925	0.0149	0.0139	0.2189	0.1651
	Maximum	0.095	0.99	0.0042	< 0.005	0.012	0.02	0.16	0.031	0.1	0.1	0.02	0.014	0.36	0.169
A-OB7	Sample count	4	4	23	23	23	23	4	4	23	23	23	23	23	22

Alluvium metals concentrations (mg/L)—total and filtered

	Minimum	0.034	< 0.001	0.0001	< 0.0001	0.002	0.002	0.11	0.008	< 0.001	< 0.001	< 0.005	< 0.005	0.059	0.008
	20th percentile	0.0682	0.001	0.0001	0.0001	0.002	0.002	0.128	0.0092	0.01	0.01	0.008	0.007	0.086	0.0188
	Median	0.1255	0.001	0.0001	0.0001	0.002	0.002	0.175	0.01	0.01	0.01	0.009	0.007	0.121	0.0395
	95th percentile	0.6785	0.0087	0.0005	0.0003	0.0460	0.0100	0.8815	0.0100	0.0500	0.0500	0.0146	0.0089	0.7290	0.1580
	Maximum	0.77	< 0.01	0.0016	0.0003	1.92	0.011	1	0.01	0.1	0.1	0.055	0.01	4.3	0.18
A-OB8	Sample count	4	4	24	24	24	24	4	4	24	24	24	24	24	23
	Minimum	0.005	< 0.001	< 0.0001	< 0.0001	0.008	0.009	0.032	0.027	< 0.001	< 0.001	0.032	0.012	0.025	0.02
	20th percentile	0.0158	0.001	0.0001	0.0001	0.011	0.01	0.0968	0.0288	0.0106	0.01	0.0506	0.0424	0.1282	0.0478
	Median	0.1315	0.001	0.0001	0.0001	0.012	0.011	0.15	0.037	0.05	0.05	0.0595	0.049	0.178	0.107
	95th percentile	0.3165	0.0019	0.0008	0.0006	0.0234	0.0227	0.3385	0.1341	0.0585	0.0925	0.1155	0.0764	0.5375	0.2291
	Maximum	0.33	0.002	0.0014	0.0007	0.025	0.034	0.37	0.15	0.1	0.1	0.14	0.081	0.66	0.278
A-OB10	Sample count	4	4	24	24	24	24	4	4	24	24	24	24	24	23
	Minimum	0.006	< 0.001	< 0.0001	< 0.0001	< 0.005	< 0.001	0.034	0.007	0.003	< 0.001	< 0.005	0.003	0.055	0.021
	20th percentile	0.0144	0.001	0.0001	0.0001	0.005	0.005	0.0442	0.0148	0.05	0.01	0.005	0.005	0.075	0.047
	Median	0.0315	0.001	0.0001	0.0001	0.0065	0.005	0.052	0.02	0.05	0.05	0.005	0.005	0.1045	0.067
	95th percentile	0.049	0.001	0.0011	0.0009	0.0243	0.01	0.11	0.02	0.05	0.05	0.007	0.006	0.2327	0.1567
	Maximum	0.05	0.001	0.0014	0.0013	0.026	0.011	0.12	0.02	0.1	0.1	0.01	0.01	0.36	0.205
A-OB11	Sample count	4	4	23	23	23	23	4	4	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	0.004	< 0.001	0.007	0.005
	20th percentile	0.0016	0.001	0.0001	0.0001	0.001	0.001	0.0032	0.002	0.01	0.01	0.001	0.001	0.0434	0.0108
	Median	0.002	0.001	0.0001	0.0001	0.001	0.001	0.004	0.002	0.01	0.01	0.002	0.001	0.113	0.017
	95th percentile	0.0224	0.0010	0.0001	0.0001	0.0050	0.0050	0.0533	0.0020	0.0100	0.0100	0.0050	0.0050	0.2280	0.0356
	Maximum	0.026	< 0.001	< 0.0001	< 0.0001	< 0.005	0.008	0.062	0.002	< 0.01	< 0.01	0.007	< 0.005	0.61	0.042
A-OB12	Sample count	4	4	23	23	23	23	4	4	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.007	< 0.005
	20th percentile	0.0016	0.001	0.0001	0.0001	0.001	0.001	0.0028	0.001	0.01	0.01	0.001	0.001	0.0448	0.0144
	Median	0.0025	0.001	0.0001	0.0001	0.001	0.001	0.005	0.0015	0.01	0.01	0.001	0.001	0.072	0.026
	95th percentile	0.0277	0.0010	0.0003	0.0001	0.0050	0.0050	0.0239	0.0020	0.0100	0.0100	0.0050	0.005	0.1962	0.1270
	Maximum	0.032	< 0.001	0.0004	0.0002	< 0.005	0.01	0.027	0.002	< 0.01	< 0.01	0.005	< 0.005	0.227	0.203

(f) Filtered. Data analysis is based on the sampling conducted by SLR Consulting in December 2017, March, June and October 2018 and sampling conducted by 4T Consultants in February, May, August and November 2019, March, September, October, November and December 2020 and January 2021. Sample count refers to the number of sampling results for the bore. To calculate the 20th percentile, median and 95th percentile data, less than symbols have been removed from the results.

Table 5.8: Statistical analysis of groundwater quality sampling results—Permian (metals concentrations)

Permian metals concentrations (mg/L)—total and filtered															
Bore ID	**Parameter**	**Al**	**Al (f)**	**As**	**As (f)**	**B**	**B (f)**	**Cd**	**Cd(f)**	**Cr**	**Cr(f)**	**Co**	**Co (f)**	**Cu**	**Cu (f)**
Baralaba Coal Measures (interburden)															
P-PB1	Sample count	23	23	23	23	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.01	< 0.01	0.009	0.008	0.12	0.11	< 0.0002	< 0.0002	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001
	20th percentile	0.024	0.01	0.0084	0.0062	0.128	0.118	0.0002	0.0002	0.001	0.001	0.001	0.001	0.001	0.001
	Median	0.05	0.01	0.012	0.011	0.14	0.13	0.0002	0.0002	0.001	0.001	0.001	0.001	0.001	0.001
	95th percentile	0.242	0.05	0.0149	0.0139	0.176	0.175	0.0002	0.0002	0.0028	0.001	0.001	0.001	0.001	0.001
	Maximum	0.28	< 0.05	0.016	0.016	0.18	0.18	< 0.0002	< 0.0002	0.003	< 0.001	0.001	0.001	0.001	< 0.001
P-OB3	Sample count	25	25	25	25	4	4	4	4	4	4	4	4	4	4
	Minimum	< 0.05	< 0.01	0.001	0.001	0.18	0.16	< 0.0002	< 0.0002	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001
	20th percentile	1.244	0.05	0.0038	0.002	0.212	0.196	0.0002	0.0002	0.0016	0.001	0.0016	0.0016	0.001	0.001
	Median	3.495	0.05	0.005	0.005	0.22	0.22	0.0002	0.0002	0.002	0.001	0.002	0.002	0.001	0.001
	95th percentile	14.818	0.09	0.01	0.009	0.458	0.458	0.00173	0.00173	0.0088	0.00865	0.0088	0.0088	0.0537	0.0537
	Maximum	18	< 0.5	3.17	< 0.01	< 0.5	< 0.5	< 0.002	< 0.002	< 0.01	< 0.01	< 0.01	< 0.01	0.063	0.063
Baralaba Coal Measures (coal seams)															
P-OB1	Sample count	23	23	23	23	4	4	4	4	4	4	4	4	4	4
	Minimum	< 0.05	<0.01	0.002	0.001	0.18	0.17	< 0.0002	< 0.0002	< 0.001	< 0.001	0.003	0.003	< 0.001	< 0.001
	20th percentile	0.9	0.026	0.005	0.004	0.186	0.176	0.0002	0.0002	0.001	0.001	0.0036	0.0036	0.001	0.001
	Median	2.9	0.05	0.005	0.005	0.2	0.195	0.0002	0.0002	0.001	0.001	0.005	0.005	0.001	0.001
	95th percentile	6.385	0.05	0.0099	0.0069	0.21	0.21	0.0002	0.0002	0.00525	0.001	0.00855	0.0077	0.001	0.001
	Maximum	25.6	0.1	0.01	0.01	0.21	0.21	< 0.0002	< 0.0002	0.006	< 0.001	0.009	0.008	< 0.001	< 0.001
P-OB4	Sample count	24	24	24	24	4	4	4	4	4	4	4	4	4	4
	Minimum	< 0.05	< 0.01	< 0.001	< 0.001	0.22	0.23	< 0.0002	< 0.0002	0.002	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001
	20th percentile	0.05	0.05	0.005	0.002	0.226	0.242	0.0002	0.0002	0.0026	0.0016	0.013	0.0136	0.0028	0.001
	Median	0.1	0.05	0.005	0.005	0.23	0.265	0.0002	0.0002	0.004	0.0025	0.016	0.0165	0.0065	0.001
	95th percentile	0.5	0.0925	0.00925	0.00925	0.4595	0.467	0.00173	0.00173	0.00925	0.00895	0.017	0.017	0.00985	0.00865
	Maximum	3.43	0.5	< 0.01	< 0.01	0.5	0.5	< 0.002	< 0.002	< 0.01	< 0.01	0.017	0.017	< 0.01	< 0.01
P-OB5	Sample count	23	23	23	23	4	4	4	4	4	4	4	4	4	4
	Minimum	< 0.05	< 0.01	0.002	0.001	0.78	0.78	< 0.0002	< 0.0002	0.002	< 0.001	< 0.001	< 0.001	0.005	< 0.001
	20th percentile	0.054	0.05	0.005	0.004	0.78	0.78	0.0002	0.0002	0.0026	0.0016	0.001	0.001	0.005	0.001
	Median	0.1	0.05	0.005	0.005	0.835	0.82	0.0002	0.0002	0.003	0.0025	0.001	0.001	0.0075	0.001
	95th percentile	0.247	0.098	0.0098	0.0096	1.3235	1.319	0.00173	0.00173	0.0098	0.00895	0.00865	0.00865	0.0185	0.00865
	Maximum	< 0.5	< 0.5	< 0.01	< 0.01	1.4	1.4	< 0.002	< 0.002	0.011	< 0.01	< 0.01	< 0.01	0.02	< 0.01

Permian metals concentrations (mg/L)—total and filtered

Gyranda Formation

P-OB2	Sample count	24	24	24	24	3	3	3	3	3	3	3	3	3	3
	Minimum	< 0.05	< 0.01	< 0.001	< 0.001	1.6	1.6	< 0.0002	< 0.0002	< 0.001	< 0.001	0.001	0.001	0.019	0.009
	20th percentile	0.224	0.01	0.001	0.001	1.68	1.68	0.0002	0.0002	0.0014	0.001	0.0014	0.0014	0.0258	0.0126
	Median	1.285	0.01	0.002	0.001	1.8	1.8	0.0002	0.0002	0.002	0.001	0.002	0.002	0.036	0.018
	95th percentile	3.2685	0.05	0.00755	0.00455	1.89	1.89	0.0002	0.0002	0.0155	0.0019	0.002	0.002	0.1026	0.0918
	Maximum	4.43	0.1	0.01	0.01	1.9	1.9	< 0.0002	< 0.0002	0.017	0.002	0.002	0.002	0.11	0.1

(f) Filtered Data analysis is based on the sampling conducted by SLR Consulting in December 2017, March, June and October 2018 and sampling conducted by 4T Consultants in February, May, August and November 2019, March, September, October, November and December 2020 and January 2021. Sample count refers to the number of sampling results for the bore. Calculate the 20th percentile, median and 95th percentile data, less than symbols have been removed from the results.

Table 5.9: Statistical analysis of groundwater quality sampling results—Permian (metals concentrations)

Permian metals concentrations (mg/L)—total and filtered															
Bore ID	**Parameter**	**Pb**	**Pb (f)**	**Hg**	**Hg (f)**	**Mo**	**Mo (f)**	**Ni**	**Ni (f)**	**Se**	**Se (f)**	**U**	**U (f)**	**Zn**	**Zn (f)**
Baralaba Coal Measures (interburden)															
P-PB1	Sample count	3	3	23	23	23	23	3	3	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	0.001	0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.009	0.009
	20th percentile	0.001	0.001	0.0001	0.0001	0.001	0.001	0.001	0.001	0.01	0.01	0.001	0.001	0.0348	0.038
	Median	0.001	0.001	0.0001	0.0001	0.002	0.001	0.001	0.001	0.01	0.01	0.001	0.001	0.054	0.044
	95th percentile	0.001	0.001	0.00019	0.0001	0.005	0.005	0.0019	0.0019	0.05	0.046	0.005	0.005	0.1274	0.1089
	Maximum	< 0.001	< 0.001	0.0003	< 0.0001	0.009	0.006	0.002	0.002	0.05	0.05	< 0.005	< 0.005	0.19	0.121
P-OB3	Sample count	4	4	25	25	25	25	4	4	25	25	24	25	25	24
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.005	< 0.001	0.002	0.001	< 0.001	< 0.001	<0.005	< 0.001	0.005	<0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.005	0.005	0.002	0.0016	0.0064	0.0064	0.005	0.005	0.0414	0.0148
	Median	0.001	0.001	0.0001	0.0001	0.005	0.005	0.0025	0.002	0.05	0.05	0.005	0.005	0.078	0.05
	95th percentile	0.00865	0.00865	0.00054	0.0001	0.009	0.01	0.00895	0.0088	0.05	0.05	0.00925	0.009	0.2004	0.1597
	Maximum	< 0.01	< 0.01	< 0.001	< 0.001	< 0.05	< 0.05	< 0.01	< 0.01	0.1	0.1	< 0.05	< 0.05	0.238	0.185
Baralaba Coal Measures (coal seams)															
P-OB1	Sample count	4	4	23	23	23	23	4	4	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	<0.005	< 0.001	0.003	0.003	< 0.001	< 0.001	< 0.005	< 0.001	0.021	0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.005	0.0026	0.0036	0.0036	0.0266	0.01	0.005	0.005	0.1148	0.0526
	Median	0.001	0.001	0.0001	0.0001	0.005	0.005	0.0055	0.0045	0.05	0.05	0.005	0.005	0.196	0.0935
	95th percentile	0.001	0.001	0.0006	0.0001	0.005	0.005	0.00785	0.00585	0.05	0.05	0.005	0.0095	0.5215	0.2351
	Maximum	< 0.001	< 0.001	< 0.0001	< 0.0001	0.01	0.01	0.008	0.006	0.1	0.1	0.01	0.01	1.23	0.256
P-OB4	Sample count	4	4	24	24	24	24	4	4	24	24	24	24	24	23
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.005	0.003	< 0.01	< 0.01	< 0.001	< 0.001	< 0.005	0.002	0.006	< 0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.005	0.005	0.0142	0.0136	0.05	0.01	0.005	0.005	0.05	0.028
	Median	0.001	0.001	0.0001	0.0001	0.005	0.005	0.024	0.023	0.05	0.05	0.005	0.005	0.091	0.06
	95th percentile	0.00865	0.00865	0.000555	0.000185	0.0097	0.01255	0.0327	0.03765	0.05	0.05	0.00925	0.01	0.2236	0.1548
	Maximum	< 0.01	< 0.01	< 0.001	< 0.001	< 0.05	< 0.05	0.033	0.039	0.1	0.1	< 0.05	< 0.05	0.238	0.167
P-OB5	Sample count	4	4	23	23	23	23	4	4	23	23	23	23	23	22
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.005	< 0.005	0.003	0.002	< 0.001	< 0.001	0.002	< 0.001	0.013	< 0.005
	20th percentile	0.001	0.001	0.0001	0.0001	0.006	0.005	0.0072	0.005	0.01	0.01	0.005	0.005	0.053	0.0252
	Median	0.001	0.001	0.0001	0.0001	0.008	0.006	0.012	0.0085	0.05	0.05	0.005	0.005	0.087	0.084
	95th percentile	0.00865	0.00865	0.00076	0.0001	0.0202	0.047	0.01485	0.01085	0.05	0.05	0.0095	0.0095	0.2907	0.1928

Permian metals concentrations (mg/L)—total and filtered															
	Maximum	< 0.01	< 0.01	< 0.001	< 0.001	< 0.05	0.08	0.015	0.011	0.1	0.1	<0.05	<0.05	0.31	0.21
Gyranda Formation															
P-OB2	Sample count	3	3	24	24	24	24	3	3	24	24	24	24	24	23
	Minimum	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.001	< 0.001	0.003	0.003	< 0.001	< 0.001	0.002	0.001	0.008	0.008
	20th percentile	0.001	0.001	0.0001	0.0001	0.001	0.001	0.003	0.003	0.01	0.01	0.002	0.002	0.064	0.0436
	Median	0.001	0.001	0.0001	0.0001	0.001	0.001	0.003	0.003	0.01	0.01	0.002	0.002	0.104	0.092
	95th percentile	0.001	0.001	0.000285	0.0001	0.005	0.005	0.012	0.0048	0.05	0.044	0.005	0.005	0.25595	0.2566
	Maximum	< 0.001	< 0.001	0.0004	0.0002	0.01	0.01	0.013	0.005	0.1	0.1	0.01	0.01	0.38	0.38

(f) Filtered Data analysis is based on the sampling conducted by SLR Consulting in December 2017, March, June and October 2018 and sampling conducted by 4T Consultants in February, May, August and November 2019, March, September, October, November and December 2020 and January 2021. Sample count refers to the number of sampling results for the bore. To calculate the 20th percentile, median and 95th percentile data, less than symbols have been removed from the results.

5.2.4.3 Hydraulic properties of groundwater

Alluvium

The hydraulic properties of alluvium are typically variable due to the heterogeneous distribution of sediments (i.e. fine clays to coarse gravels). Hydraulic testing (slug and falling head tests) of the alluvial bores at the Project were conducted by SKM (2014), with a reported average hydraulic conductivity of 2.1 m/day, and localised readings ranging between 0.0001 m/day to 13 m/day, demonstrating such a natural heterogeneous distribution. In March 2018, additional pumping tests (multi-rate step test and 24-hour constant rate test) were conducted by Australian Groundwater Services at the alluvial production bore (A-PB1). Key observations include:

- the identification of possible recharge boundary effects;
- the adjacent alluvial monitoring bore (A-OB2) recording minor (6cm) water level response despite being only 17.5 m away, indicating limited connectivity; and
- other nearby bores screened in the Permian coal measures (P-PB1 and P-VWP2 [Sensor 2]) showed no visible response for the duration of the test, indicating limited connectivity.

The results of all permeability test work support the conclusion that alluvium is made up of a series of sand/gravel lenses that are limited in both horizontal and vertical extent and separated from other lenses by significantly less permeable clays.

Baralaba Coal Measures—interburden

In 2014, a 72-hour constant rate pumping test (followed by 72-hour recovery) was conducted at P-PB1 to estimate the local aquifer transmissivity and storativity properties and reported in SKM (2014). Key observations include:

- similar types and magnitudes of pressure response to pumping at P-PB1 in the VWP sensors located in the Baralaba Coal Measures, confirming the pumping induced vertical flow within the Permian coal measures during the test;
- negligible vertical leakage (and very low/negligible aquitard K_v values) through the aquitard units during the test;
- limited connectivity of the pumped Permian coal measures to the Dawson River (based on no recharge boundary effects being observed despite being within 500 m of the Dawson River);
- the adjacent shallow alluvial monitoring bores did not show any response to pumping in the Permian coal measures; and
- the VWP sensor in the Rewan Formation (P-VWP2 [Sensor 1]) was not influenced over the period of pumping (72 hours) and subsequent recovery (72 hours).

A series of slug tests were conducted over four days in 2014 at the two standpipe groundwater monitoring bores at the Project area (P-PB1 and P-OB3) to provide estimates of local hydraulic conductivity in the interburden of the Baralaba Coal Measures. P-PB1 ranged in hydraulic conductivity from 0.026 to 3.2 m/day. P- OB3 ranged from 0.00025 to 0.0042 m/day.

In 2014, GES also conducted laboratory permeability test work on interburden core samples from the Baralaba Coal Measures at the Baralaba North Mine. All core samples were taken from the interburden sequences and the results indicating that there is limited matrix permeability in the interburden of the Baralaba Coal Measures, both in the horizontal and vertical directions (HydroSimulations, 2014).

Baralaba Coal Measures—coal seams

A series of slug and falling head tests were also completed over 6 days on bores in the coal seams (P-OB1, P- OB4 and P-OB5) by SKM in 2014. The estimates for coal seam hydraulic conductivity are within the estimates presented in coal seams elsewhere (e.g. upper Hunter Valley in NSW) by Mackie (2009). P-OB1 ranged from 0.0055 to 0.5 m/day. P-OB4 ranged from 0.17 to 0.18 m/day. P-OB5 ranged from 0.0025 to 0.0027 m/day. It is noted that the hydraulic properties of the coal measures can be influenced locally by weathering (e.g. at the subcrop) and as is typically observed in coal seams, however the results demonstrated strong consistency from the repeated tests.

5.2.5 Water dependent assets

5.2.5.1 Agricultural groundwater users

Groundwater within and surrounding the Project area is generally considered unsuitable for stock watering, farm supply and irrigation. Groundwater appears to have had limited use as stock water supply historically. Water supply for agriculture is generally sourced directly from Dawson River allocations in the region.

A review of Queensland Government's Groundwater Database (Queensland Globe) and Australian Groundwater Explorer (BoM) was conducted to identify the location and source aquifers of existing groundwater bores in the Project area (Appendix B, Groundwater Modelling and Assessment).

Three private landholder bore locations were confirmed by field inspection to exist within 5 km of the Project:

- Ross bore—located approximately 500 m east of the Project on Lot 26 of FN153, with a total drilled depth of 52.67 m and intersecting mapped Cretaceous Intrusives (Igneous Trachyte) associated with Mount Ramsay. The recorded groundwater elevation is at approximately 102–103 m AHD and is much higher than the surrounding Permian Baralaba Coal Measures. It is understood the private landholder bore is currently equipped for use.
- Riverland 1 and 2—consists of paired bores approximately 3 m apart located approximately 1.5 km west of the Project on Lot 4 of FN514 between the Dawson River and Banana Creek, and immediately south of their confluence adjacent the Dawson River. The bores have been recorded as being 18 m AHD and 22 m AHD deep, respectively, intersecting the sands and gravels of the Quaternary alluvium. Aerial imagery shows two centre-pivot irrigation areas existing nearby on the property; however, it is understood that the supply of irrigation water is sourced from the Dawson River, not the groundwater bores. Neither bore is equipped.
- Webb bore—located approximately 3.5 km south of the Project on Lot 35 on FN141 on the southern side of Banana Creek. It is recorded as a 'deep bore' (approximately 78 m AHD) and as 'not equipped'.

5.2.5.2 Springs

No springs have been identified within or surrounding the Project site.

5.2.5.3 Groundwater-dependent ecosystems

This assessment shows ‘Low Potential’ for groundwater dependence for all the potential ‘Terrestrial’ GDEs associated with riparian vegetation and watercourses in this area. The low potential for groundwater dependence is consistent with the unsaturated depth inferred on Figure 5.6.

Two hydrogeological cross-sections have been developed to illustrate the local site geology and observed and predicted groundwater conditions in the vicinity of the potential GDEs. Cross section A-A’ intersects the Dawson River and cross section B-B’ is through the HES wetland.

Figure 5.7 presents cross-section A-A’ and shows groundwater flow within the alluvial sediments associated with the local drainages of Banana Creek and the Dawson River is towards the west of the Project. Groundwater levels are generally hydraulically disconnected with (i.e., deeper than) surface waters.

The depth of the water table is approximately 15 m below the HSE wetland (Figure 5.6) with negligible predicted groundwater level change at the end of the Project mining (Figure 5.8). The HES wetland is considered to be a ‘perched’ system, i.e., separate from the regional groundwater system, with the presence of underlying clays.

Based on the available evidence (i.e., groundwater level monitoring, vegetation mapping and site survey and reconnaissance by Eco Solutions & Management (2023), Ecological Service Professionals (2023) and 3D Environmental (2023)), the wetlands are considered reliant on direct rainfall, runoff and floodwaters, which are held near the surface by the shallow clays.

Details of the GDE assessment for the Project are addressed further in Appendix H, Groundwater Dependant Ecosystems Assessment.

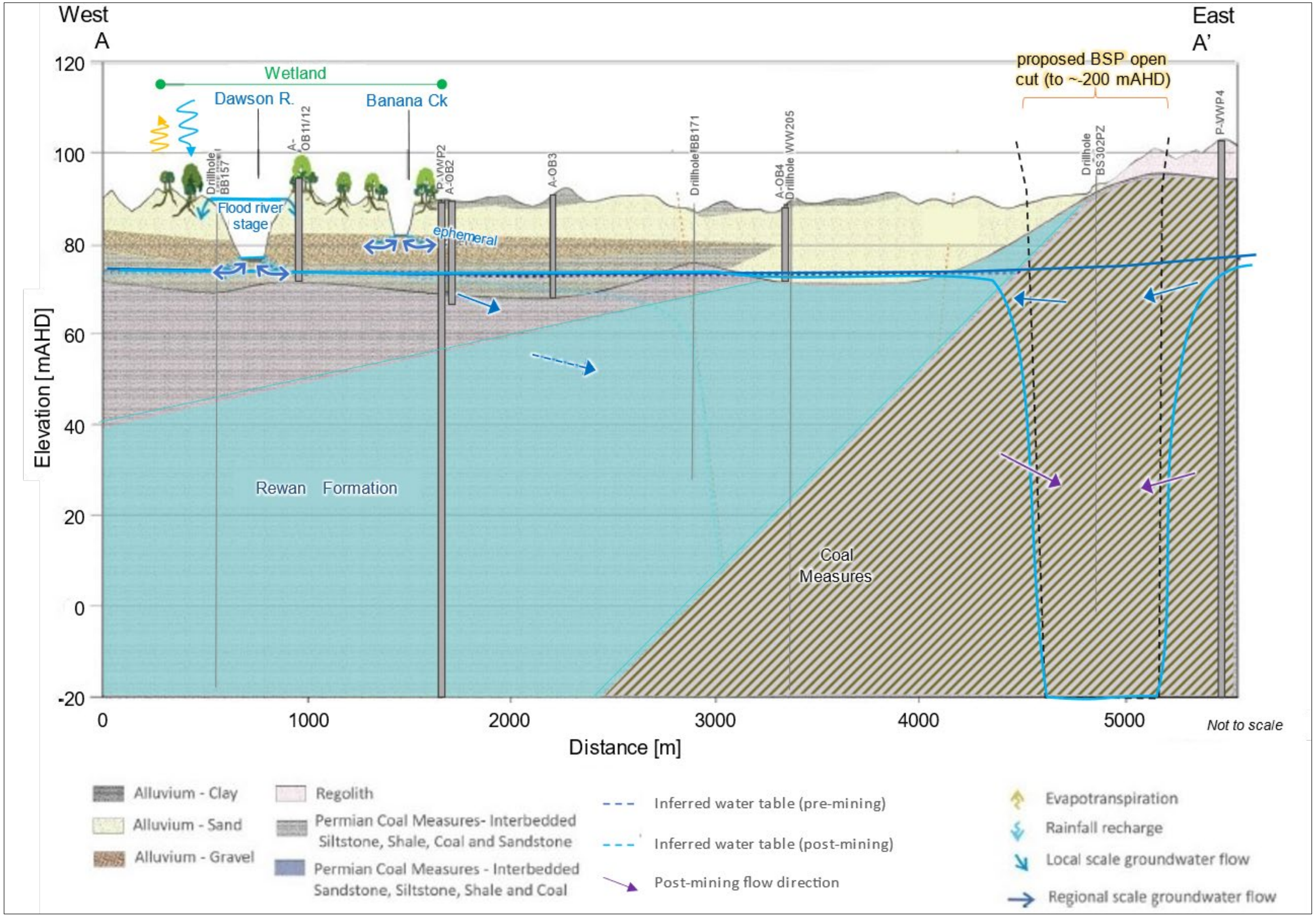


Figure 5.7: Section A-A: groundwater levels and likely groundwater interaction at wetlands

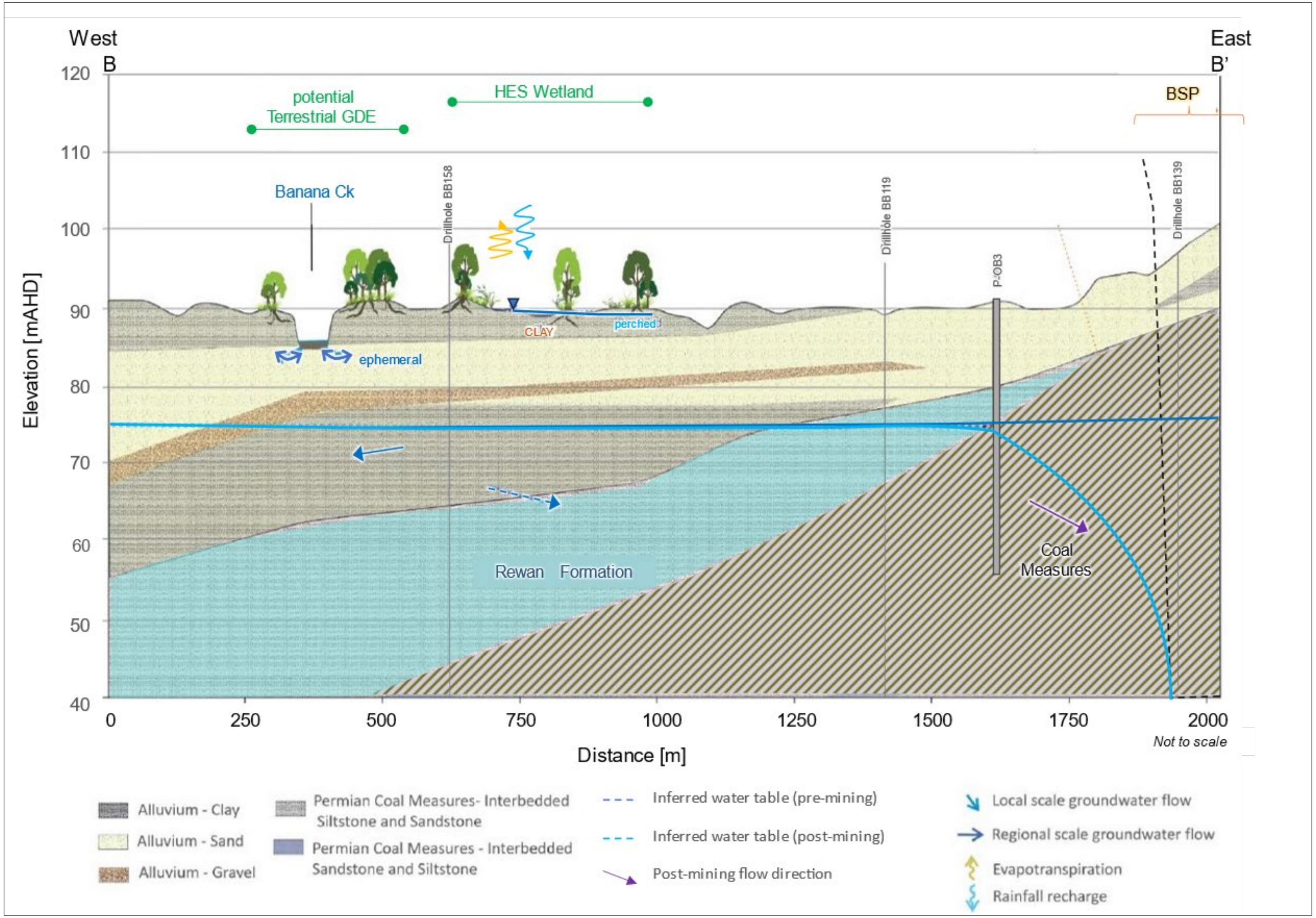


Figure 5.8: Section B-B: groundwater levels and likely groundwater interaction at wetlands

Targeted GDE assessment has been undertaken by 3D Environmental (2023) (Appendix H, Groundwater Dependent Ecosystems Assessment) to assess the groundwater dependence of the vegetation in the Project area and surrounds and assess the potential impacts of the Project, including groundwater drawdown, on GDEs.

The assessment identified that groundwater dependency within the MLA and adjacent areas associated with the Dawson River flood plain is controlled by small discontinuous lenses of sand that are distributed sporadically throughout the heavy clay soils that otherwise characterise the flood plain sediments. GDEs identified, which include those at GDE Area 1, GDE Area 6 and GDE Area 9 are all associated with overland flow paths of the main Dawson River channel, which would act to increase infiltration into the soil profile due to prolonged ponding of surface water. The sandy lenses support shallow, fresh and seasonal groundwater resources that are perched above and disconnected from the regional groundwater table. Recharge of the sandy lenses occurs during surface water infiltration, which is associated with overbank flow and intense rainfall events, and seasonality will depend on climatic factors including transpiration rates and flood interval.

While it is not possible to precisely define the extent of groundwater dependent vegetation due to the sporadic nature of the sandy lenses, this assessment indicates that they are discrete, restricted in extent, generally discontinuous and more likely to coincide with overland flow paths and flood channels. Because of these factors, there are no identified causal pathways for impact which have capacity to alter GDE function and cause ecological harm.

A causal pathways model of the Dawson River floodplain at the confluence of Banana Creek, which illustrates the ecohydrological function of vegetation in relation to sandy lenses, seasonal bank and aquifer recharge during dry and wet season scenarios is shown in Figure 5.9, Figure 5.10 and Figure 5.11.

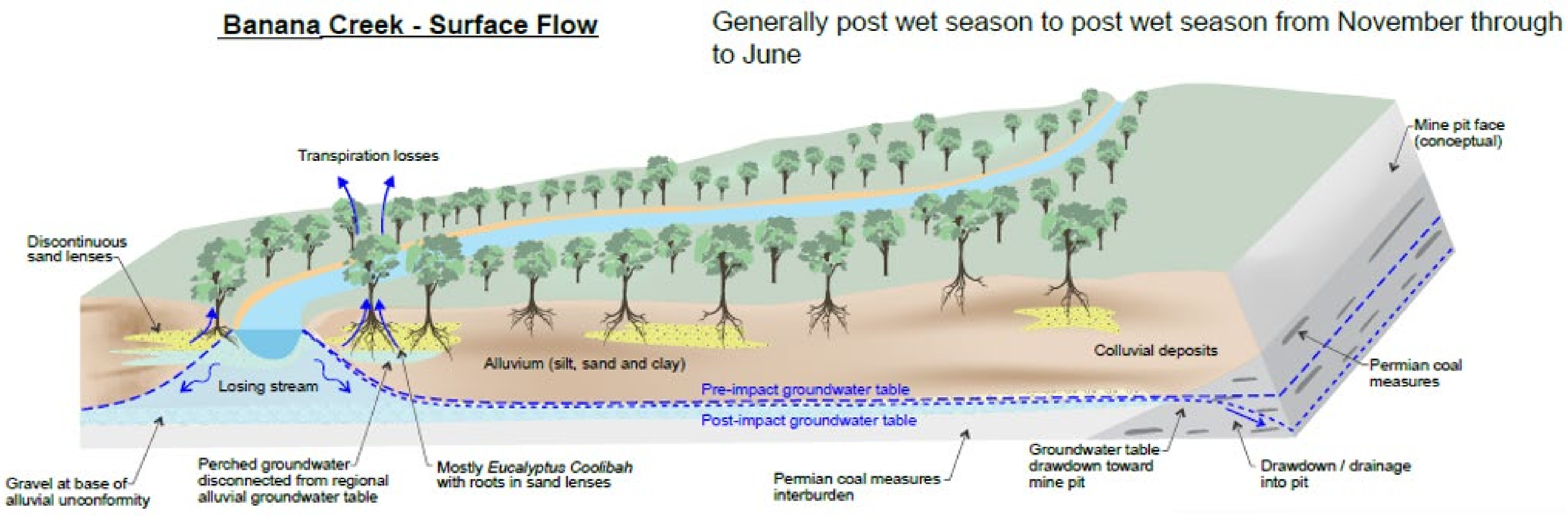


Figure 5.9: Ecohydrogeological model of the Dawson River flood plain at its confluence with Banana Creek – surface flow conditions

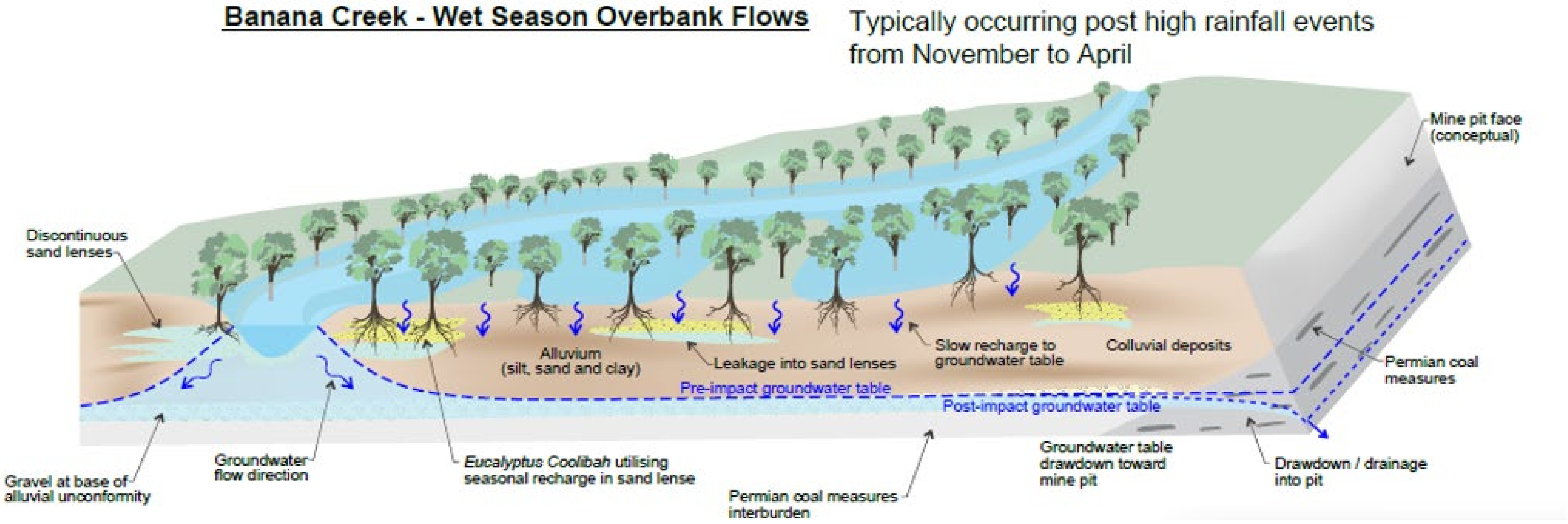


Figure 5.10: Ecohydrogeological model of the Dawson River flood plain at the confluence of Banana Creek - bank overflow conditions

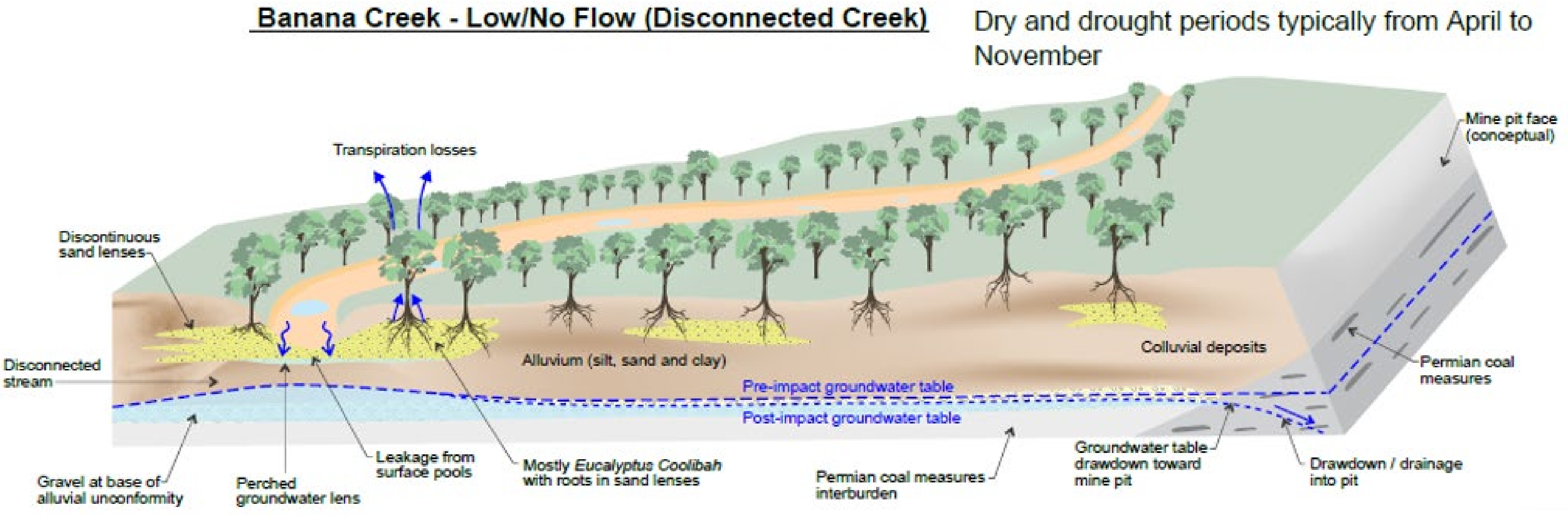


Figure 5.11: Ecohydrogeological model of the Dawson River flood plain at the confluence of Banana Creek – low/no flow conditions

5.2.5.4 Wetlands

A wetland of high ecological significance is mapped in the west of MLA 700057. Two wetlands of general ecological significance (GES) are also located within MLA 700057. Other wetlands of GES also occur in the wider surrounds.

Further description and assessment of impacts to these wetlands is provided in Chapter 7, Flora and Fauna.

5.2.5.5 Stygofauna

Field sampling was undertaken by Stygoecologica (Appendix I, Stygofauna Assessment) over 5 rounds during 2017-2019 to identify the presence of stygofauna within the Project disturbance area and surrounds. Field sampling identified a limited stygofauna community associated with the alluvial aquifer adjacent the Dawson River.

A total of 3 taxa (Oligchaeta, Polydesmida and Diplura) and 24 individuals were collected during the surveys. The stygofauna community was assessed as having low ecological value due to the depauperate, sporadic and localised nature of the community recorded.

Further information regarding Stygofauna is described in Chapter 7, Flora and Fauna, and Appendix I, Stygofauna Assessment.

5.2.5.6 Drinking water

With EC generally ranging from 15,000 µS/cm to 38,000 µS/cm, the groundwater in the Project area is not considered suitable for human consumption.

5.2.5.7 Industrial users

The Project would use groundwaters that drain directly to the open cut pit. The groundwaters would be pumped to holding dams, where water collected would be incorporated into the site water balance.

No WQOs are provided for industrial use as water quality requirements for industry vary within and between industries. Similarly, ANZECC & ARMCANZ (2000) does not provide guidelines for industry and indicates that industrial water quality requirements need to be considered on a case-by-case basis. Based on this approach, associated groundwaters accessed by the Project would provide a beneficial industrial use.

5.2.5.8 Cultural values

There are no known environmental values in relation to cultural and spiritual values of groundwater within MLA 700057 or surrounds. No WQOs are currently provided for cultural and spiritual values.

5.3 Potential impacts

Potential impacts of the Project on groundwater resources include:

- changes to the hydraulic properties of the backfilled mine extents due to replacement with heterogeneously layered, higher permeability waste rock;
- the operational pit and final void acting as a localised hydraulic sink, drawing down groundwater with potential to impact on surrounding users or dependant ecosystems;
- potential for seepage from mining activities to impact on groundwater surrounding the mine; and
- possible leakage from the Dawson River and Banana Creek.

Modelling of groundwater drawdown and the assessment of Project impacts on groundwater values and dependent assets is described in the following sub-sections.

5.3.1 Model methodology

5.3.1.1 Conceptual groundwater model during and post mining

A conceptual hydrogeological model was developed for the Project and is described in Section 0. The model describes two main hydrogeological units in the Project area, including:

- Quaternary alluvial sediments associated with the Dawson River and its tributaries; and
- Permian strata that host the Baralaba Coal Measures.

Mine operation conditions

The targeted coal seams are toward the base of the Baralaba Coal Measures. During mining it is anticipated that:

- The water table would be lowered in the immediate vicinity of active open cut pit. Some localised dewatering of the veneer of alluvial sediments and colluvium (albeit negligible/dry) where excavated within the pit extent could occur initially (resulting in short-term higher groundwater inflows). Gradual reduction in groundwater upflow via the permeable coal measures would also be expected over time.
- Significant drawdowns within the coal measures would occur immediately around the excavated pit, although seepage faces would be present along the walls of the pit (as has been observed at Baralaba North Mine [HydroSimulations, 2014]).
- Where the Rewan Formation is present, drawdowns (if any were to extend as far) would be impeded due to its low permeability (aquitard) properties.
- Drawdown would tend to spread along the strike of the base of the Baralaba Coal Measures (i.e. essentially north-south), rather than:
    - to the east (where the coal measures are absent and the Gyranda Formation outcrops) or
    - to the west, where the Rewan Formation becomes thicker and a more effective aquitard. Also, the increasing depth of cover to the west (with intervening siltstones, sandstones and mudstones) would be expected to result in reduced permeability (and propagation) in the deeper Baralaba Coal Measures.
- Excavated spoil is likely to exhibit more permeable characteristics than the native rock strata, hence there could be some increased recharge through areas of in-pit backfilled spoil, although the hydraulic properties of the waste are not well understood. Some localised mounding of the groundwater table may therefore also occur beneath out-of-pit WRE.
- Groundwater sourced from the coal measures and via enhanced recharge of WREs would report to the open cut pit as groundwater inflows. However, it is noted that the actual volume of groundwater inflow observed or requiring direct management may be significantly less where high evaporation rates were to occur at the pit walls and floor (as has been observed at Baralaba North Mine [HydroSimulations, 2014], and supported by observations by Engeny and operators regarding the evidence for low inflow rates).

Post mine conditions

Post-mining, it is expected that:

- Water collected within the final void would evaporate from the lake surface and continue to draw in groundwater from the surrounding geological units (predominantly the Baralaba Coal Measures).
- Evaporation from the lake surface would concentrate salts in the lake slowly over time.

5.3.1.2 Numerical groundwater model

Model workflow been designed to facilitate history-matching or calibration of the groundwater model leading to predictive modelling that incorporates quantitative uncertainty analysis. The workflow adopts the industry-standard parameter estimation and uncertainty analysis software, PEST and PESTPP (Watermark Numerical Computing, 2018; White et al., 2020) as a central element, coupled with a MODFLOW groundwater model. Much of the pre-processing was done in Groundwater Vistas 8, as well as other custom python scripts.

Sensitivity Analysis

PESTPP-IES has been used and done so in combination with pilot points for hydraulic conductivity and storage parameters to develop a large number of alternative model realisations. This highly parameterised method is focussed on simulating the key predictions or "Quantities of Interest" multiple times with a range of parameter values to provide a quantified estimate of uncertainty.

This therefore precludes the need for a formal sensitivity analysis which is typically done to assess the scale of changes to model outputs as a result of changing input parameters, Doherty (2022) states: *With the availability of regularised, highly parameterised inversion, sensitivity analysis, undertaken for this reason, is no longer required*".

Model confidence classification

The Australian Groundwater Modelling Guidelines (AGMG) (Barnett et al., 2012a) recommend adoption of "confidence level" classification terminology with further guidance on the application of the classification provided by Middlemis and Peeters (2018). The confidence level classification comprises Class 1, Class 2 and Class 3, in order of increasing confidence. Confidence typically depends on the available knowledge and data, consistency between the calibration conditions and predictive analysis scenario, and the level or severity of stresses being simulated (relative to baseline conditions).

Using this approach, the current project groundwater model is considered to satisfy some attributes of the different confidence classes. Overall, it is considered to be a 'Class 2' (medium confidence) model but is currently limited by temporally and spatially sparse datasets (e.g., groundwater levels, permeability testing, geological characterisation), and especially so by a lack of flux data or targets (e.g., baseflow) and mine inflow (although inflow rates are estimated by engineers/field staff, they are not measured per se).

Modelling software

The numerical groundwater model for Baralaba Coal operations has evolved over the past decade, but remains in the MODFLOW family of model software. MODFLOW (McDonald and Harbaugh, 1988), originally developed by the United States Geological Survey (USGS) is the most widely used code for groundwater modelling and has long been considered an industry standard.

The current Project numerical groundwater model was developed by HydroSimulations/SLR in 2020-21 and is based on the earlier BNCOP model. The model was updated by Watershed HydroGeo in 2023 with the main changes being:

- an extension to the south to cover the Project area; and
- a change to use the MODFLOW-USG-Transport software (sometimes referred to as "MODFLOW-USG-T").

Further details of the MODFLOW-USG model design and construction (including geometry, mesh, boundary conditions, etc.) used for the Project numerical groundwater model is provided in Appendix B, Groundwater Modelling and Assessment.

A summary of the key components of the numerical groundwater model are outlined below. A detailed description of the numerical groundwater model including calibration characteristics is presented in Appendix B, Groundwater Modelling and Assessment.

Model structure

The Project numerical groundwater model covers an area of approximately 2,000 km2 and extending roughly 38 km from west to east (actually WSW to ENE) and 53 km from south to north (actually SSE to NNW). The model is centred on the Dawson River valley, but by comparison to the BNCOP model, has been extended approximately 10 km to the south to better cover the Project area. A rectangular model grid has been retained for the Project numerical model. Each cell in the model grid is a regular 200 m by 200 m. Over the 17 model layers the Project numerical groundwater model has a total of 855,950 cells, with 640,428 of these being active.

Geological model

The regional 3D geological model was built covering 120 km x 120 km, an area significantly larger than the numerical groundwater model domain. The larger model area took advantage of substantial geological datasets and information from a variety of local and regional sources.

The key points for the geological and stratigraphic framework for the Project numerical groundwater model are:

- Coal seams which were grouped together, typically in pairs, e.g. Layer 4, were constructed using the combined coal seam thickness of the relevant coal seams.
- CSG bores provided useful data for extrapolating the stratigraphic layers away from the local-scale geological models. However, they usually only provided the top and sometimes the base of the Baralaba Coal Measures, and rarely provide information on the thickness or elevation of the component overburden or coal seams.
- In the area between the Project and the Baralaba North Mine, the coal seam and interburden elevations were interpolated.
- Away from the local-scale geological models, and toward the northern, southern and western edges of the model coal seam thickness was extrapolated using the nearest edge of the local-scale geological models, and the interburden layers thickened or thinned according to the Baralaba Coal Measures top and bottom elevations at the nearest exploration bore.

Model layers and faulting

Layer geometry and corresponding aquifer parameters are attributed using the MODFLOW BAS and BCF packages. The top surface of Layer 1 in the model relies on topographical data (DEM – Digital Elevation Model) which is the 3-second resolution data from the SRTM dataset.

Geological faults have been incorporated into the numerical groundwater model in two ways:

1) Those from regional and local scale geological have been incorporated into the geological model surfaces. That is, flow barrier boundary conditions and/or zones of enhanced permeability have not been used to simulate these structures. As coal continuity is assumed across these structures, estimates for distant environmental effects would be conservative.
2) The faults identified in the Transient Electromagnetic (TEM) survey data at the Baralaba North Mine have been simulated using flow barriers (MODFLOW HFB package). They have been specified in model Layers 2-16 (i.e. not in Layer 1, which is the alluvium and colluvium). In Layers 3-16 the HFBs have been set with a horizontal hydraulic conductivity equal to that of the least permeable Permian stratum in the groundwater model, while in Layer 2 the hydraulic conductivity is specified as an order of magnitude lower than the surrounding weathered material.

Besides the elevated topography associated the igneous trachyte at Mt Ramsay, the structure has been conservatively represented as a continuation of the Gyranda Formation in the model, and not a barrier to groundwater flow.

Model stresses

The transient historic groundwater model was run for the period 1970 to present day. This historical period is discretised into a total of 45 stress periods. The subsequent predictive period is set as 2024 to 2500, represented as a further 45 stress periods (a total of 90 for the historical and predictive period). Stress periods are set at an annual resolution for the duration of Project mining, extending to decades and then centuries to represent very long-term post-closure conditions (Appendix B, Groundwater Modelling and Assessment for further detail). This allows simulation of the progressive changes to the groundwater system in response to mining and dewatering.

Boundary conditions

Regional flow

MODFLOW's GHB package was used to apply general head conditions at the upstream and downstream extents of the model associated with the alluvium and weathered Permian units in Layer 1. General head conditions were also applied at the western extent of the model, consistent with the approach adopted for the Baralaba North Continued Operations Project EIS (BNCOP) numerical groundwater model.

Inactive areas

Inactive areas lie to the west of the Dawson Range and to the east of the Dawson River valley. Inactive areas were included as a stress in the numerical groundwater model.

Watercourses

River cells (using the MODFLOW RIV package) were applied along the Dawson River, Banana Creek and other watercourses and/or drainage features. In addition, a pre-Neville Hewitt Weir stage based on topography for all watercourses in the first model stress period, which was then altered for all River cells upstream of Baralaba to be 78 m AHD (or above, if topographic data indicated this), based on the storage level of the weir.

A user-specified head was applied to all river cells of 6 m above the riverbed for a single model stress period in early 2011 to represent the occurrence of significant flooding along the Dawson River. After that period, river stages returned to the previously specified level.

Rainfall recharge

Rainfall recharge was applied to each active model cell as a percentage of actual rainfall using the MODFLOW RCH package. Four zones of differing recharge rates were set-up in the model based on the outcrop geology as follows:

- alluvium;
- Permian regolith;
- Clematis Sandstone and Duaringa Formation; and
- colluvium.

Initial recharge rates were allowed to vary in the calibration process, with consideration of the recharge analysis provided elsewhere in the Bowen Basin.

Flood recharge has only been represented by increasing the stage on River cells (using the MODFLOW RIV package) for a selected stress period (in 2011). Due to the flooding period in 2011 that was a result of high rainfall, the rainfall recharge has been increased at this time and the river stage has been increased above the surface to create high recharge to groundwater.

Evapotranspiration

Evapotranspiration was simulated using the MODFLOW EVT package. Two conceptual zones were set based on vegetation cover (trees versus grasses). A simple analysis of trees versus grassland/bare areas was completed in GIS based on aerial photography. Results of this analysis were then used to assign zones for the MODFLOW EVT package. Evapotranspiration rates have been set using 'Actual ET' data from the BOM.

Prior mining and dewatering

The numerical groundwater model incorporated dewatering activities associated with the Baralaba North Mine using drain cells (MODFLOW DRN package).

No prior mining or associated dewatering activities have occurred within the Project. No prior dewatering by neighbouring properties have been undertaken.

Parameterisation – hydraulic properties

Aquifer hydraulic properties, hydraulic conductivity (horizontal: Kh; and vertical: Kv), specific yield (Sy) and specific storage (Ss), were assigned to the groundwater model using a combination of pilot points and parameter zones.

To allow PEST to adjust hydraulic conductivity and storage parameters in the groundwater model, the pre-processing software PLPROC (Watermark Numerical Computing) is used with pilot points. A maximum possible 242 points per model layer was used.

Further description of hydraulic properties, including the initial value and ranges of hydraulic conductivity and aquifer storage are described in Appendix B.

Observation data

History-matching or calibration has considered three types of observation:

- Groundwater levels or heads (as absolute elevation);
- Transient change in groundwater levels (from the groundwater levels); and
- Estimated groundwater inflow to the Baralaba North Mine pits.

This is consistent with the suggested history-matching datasets in Tomlin *et al* (2023), noting that baseflow or leakage observations are not available at this site. The total number of observations (7,958) are summarised by observation type:

- groundwater levels: 4,053;
- groundwater level change: 3,903; and
- inflow (Baralaba North estimates): 2.

Approach to calibration

Model history-matching is the process of replicating hydrogeological targets by varying key model parameters such as hydraulic conductivity and storage within the range of reasonable values and some of the boundary condition parameters.

The modelling relies on many available values of hydraulic conductivities and storage parameters Some trial-and-error calibration and testing of the model was carried out to adjust boundary conditions and hydraulic conductivity (horizontal and vertical), and storage parameters of model layers or zones to test model stability and plausible representation to groundwater levels.

Along with trial-and-error methods, PESTPP-IES (White et al., 2020) has been used to carry out automated calibration. PESTPP-IES does not focus solely on 'calibration' per se. White et al (2020) state: that the exploration and regularisation of parameters "implemented by PESTPP-IES thus attempts to ensure that parameters comprising each realisation are changed from their initial values by the smallest amount required for model outputs to reproduce field observations "acceptably well". So, while performing 'calibration', PESTPP-IES also generates a set of plausible alternative model realisations that fit the observations or targets to this "acceptable" degree.

Modelled mine inflow

The target mine inflow for Baralaba North Mine underpinned the PEST modelling of inflow between 0.6 and 2.0 ML/d. PESTPP-IES generally improved the representation of inflow to the Baralaba North Mine, with iteration 1 having a slightly narrower range in inflow, and iteration 2 reducing the inflow to more appropriate volumes, albeit still slightly higher than the upper estimate (2 ML/d).

Modelled water balance

A tabulated water balance for the whole model domain in Table 5.10. This presents the average water balance for the (transient) historical period, 2005-2023.

In general, the largest simulated influx and outflux components being river leakage (35.1 ML/d) is expected, as well as this being primarily balanced by evapotranspiration (32.8 ML/d). Recharge is low, as is baseflow to watercourses, and this is consistent with the conceptual model. Net groundwater storage change is relatively small for this period, representing a slight increase in modelled groundwater levels across the model for the selected period.

At the end of the calibration period (late 2023, stress period 45), the modelled mass balance error was less than 0.04%, which is within 1-2% error.

Table 5.10: Simulated water balance average 2005 - 2023

Modelled component	**Catchment process**	**Simulated flux (ML/d)**	
		In	Out
Recharge	Infiltration recharge	7.6	0
River leakage	Groundwater interaction w/ watercourses and springs (leakage/baseflow)	35.1	13.6
Evapotranspiration	Evapo-transpiration from water table	0	32.8
Head dep bounds	Regional groundwater flow	26.4	16.2
Drains	Inflow to Baralaba North Mine	0	0.6
Storage	Groundwater storage	6.9	12.8
Total (ML/d)		76	76

5.3.1.3 Simulated (posterior) parameters

This section presents a summary of resultant modelled parameters at the end of the PESTPP-IES history matching process, i.e. the ‘posterior’ parameters:

- Modelled hydraulic conductivity parameters are displayed in Figure 5.12
- Modelled storage parameters are displayed in Figure 5.13.
- Modelled recharge and drain conductance are displayed in Figure 5.14.

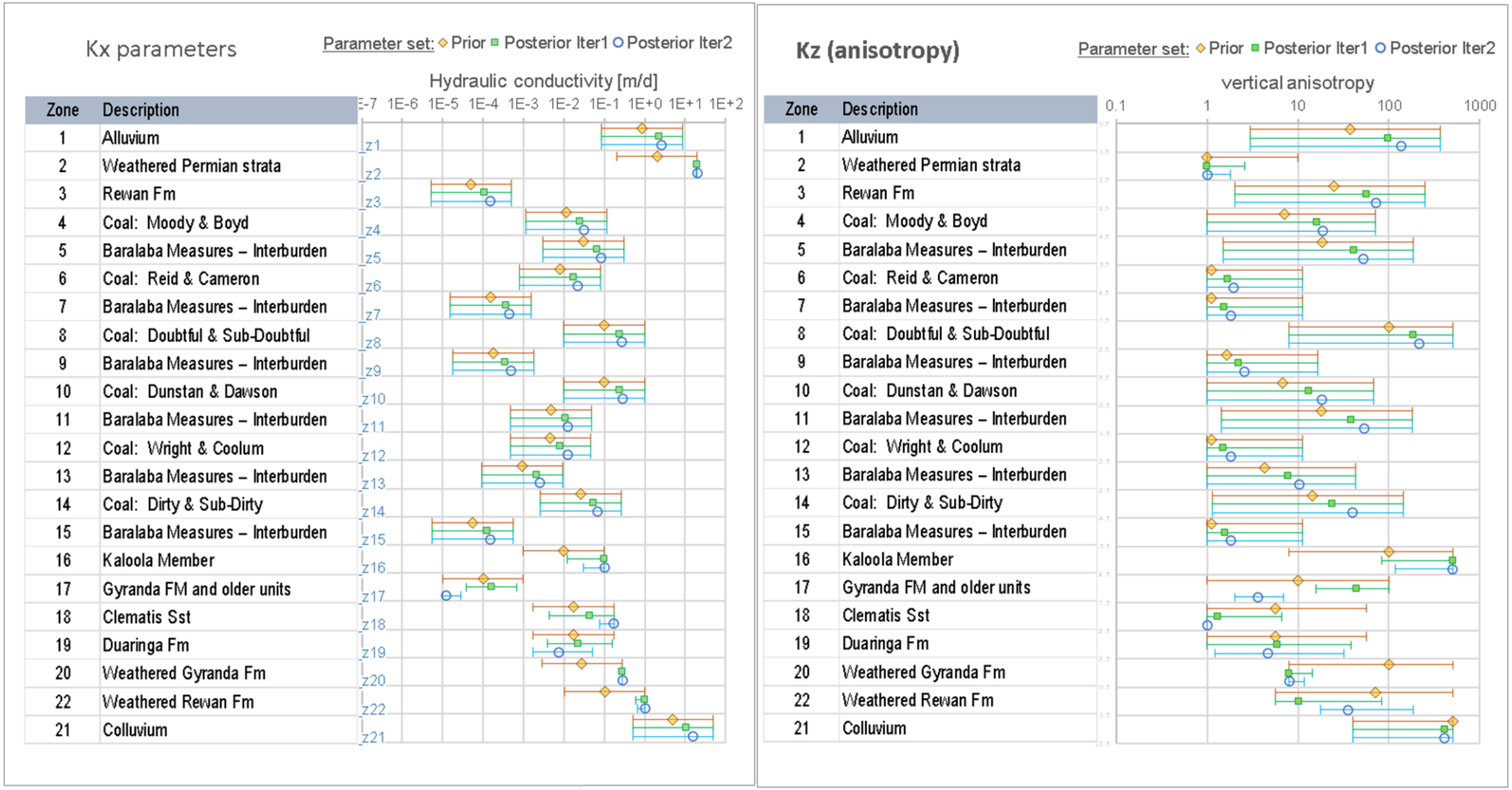


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Figure 5.12: Modelled hydraulic conductivity parameters

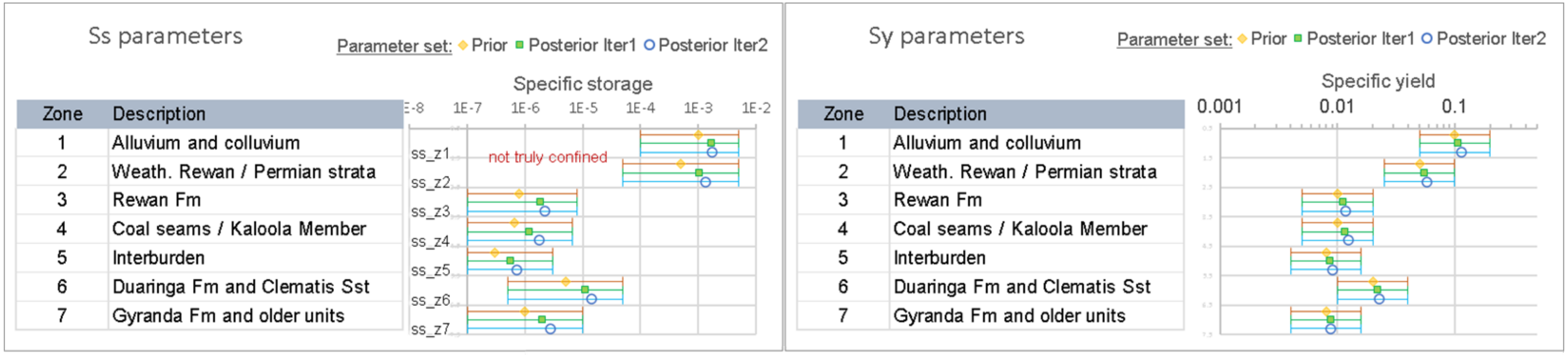

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Figure 5.13: Modelled storage parameters

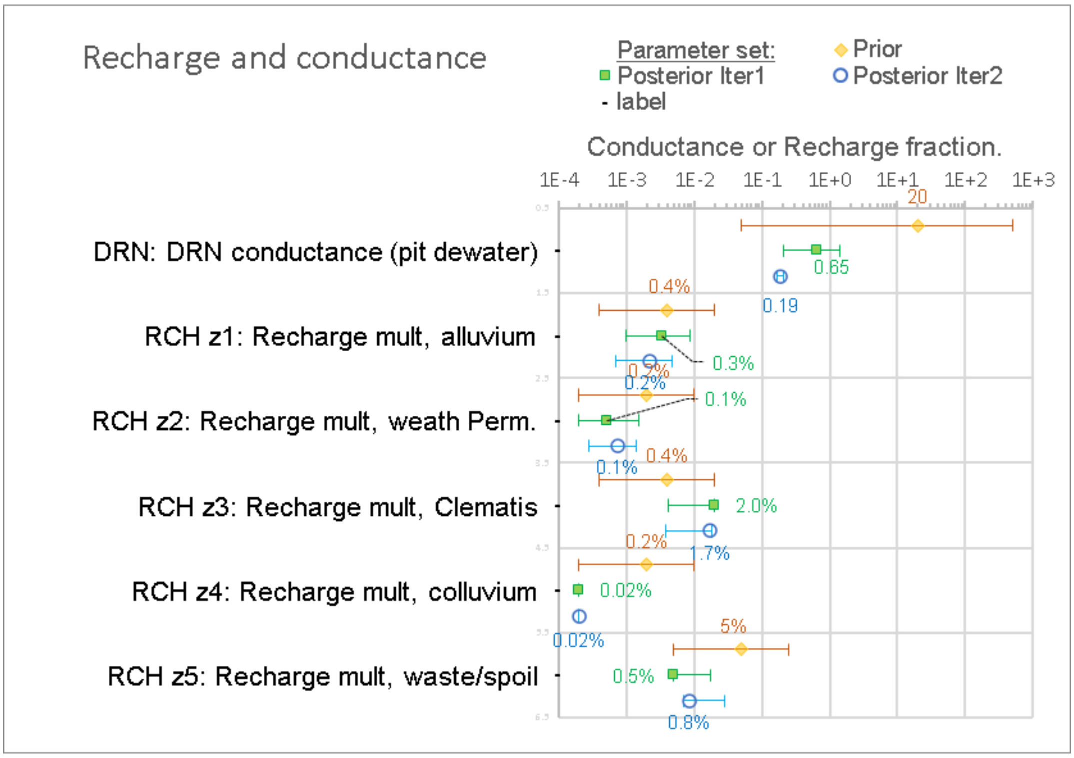

Figure 5.14: Modelled recharge and drain conductance

5.3.1.4 Climate change sensitivity

The potential impacts of climate change on the groundwater model outcomes were assessed using data on annual rainfall and evaporation in the Project area from the 'Climate Change in Australia (CCiA) Model East Coast Climate Futures Projections' (2017). Impacts associated under the predicted climate in 2030 and 2090 have been selected to represent the median year of the Project and longer-term projections, respectively.

Interpretation of these results is that there is more likely to be:

- A slight increase in annual rainfall, probably in the range 5-15%, but closer to 5%.
- A slight increase in potential evaporation, probably in the range of 1-5%, but closer to 5%.

The more likely changes in rainfall (approximately 7%) are predicted to result in changes in rainfall recharge in the order of 20% in the future. However, some rainfall projections indicate that higher rainfall would be derived from larger, more frequent high rainfall events, which could lead to more runoff and lower recharge. As such, the approach taken for this assessment has been to conduct a transient simulation for the prediction period perturbing rainfall recharge by -20% and +20% to represent postulated climate change scenarios, noting that in the short-term, climate variability, rather than climate change, will govern whether rainfall is similar to the long-term average or not. Potential evaporation from groundwater was not modified.

Further details regarding climate change assessment methodology and model inputs are outlined in Appendix B, Groundwater Modelling and Assessment.

5.3.1.5 Model limitations/uncertainty minimisation

There are four sources of scientific uncertainty affecting groundwater model simulations:

1) Structural/Conceptual - geological structure and hydrogeological conceptualisation assumptions applied to derive a simplified view of a complex hydrogeological reality (any system aspect that cannot be changed in an automated way in a model).
2) Parameterisation - hydrogeological property values and assumptions applied to represent complex reality in space and time (any system aspect that can be changed in an automated way in a model via parameterisation).
3) Measurement Error - combination of uncertainties associated with the measurement of complex system states (heads, discharges), parameters and variability (3D spatial and temporal) with those induced by upscaling or downscaling (site-specific data, climate data).
4) Scenario Uncertainties - guessing future stresses, dynamics and boundary condition changes (e.g. mining, climate variability, land and water use change).

Each of the above has been considered during the development of the Project numerical model and the qualitative uncertainties are described in Appendix B, Groundwater Modelling and Assessment.

It is also noted that the overall target model confidence level classification for the Project numerical groundwater model is Class 2, and has been largely achieved and exceeded for several key criteria (based on the criteria in Barnett et al., 2012), most notably (Sections 6.2.1 and 6.15):

- Groundwater head observations and bore logs are available and with a reasonable spatial coverage around the Project area and regionally.
- Aquifer-testing data is available to define key parameters.
- Calibration statistics (average residual, mass balance closure error) are acceptable and is calibrated to heads.
- The length of the forward predictive model is not excessive compared to length of the mining simulated within the transient calibration period (from 2005 to 2023).

While there is a reasonable amount of groundwater level and pressure data for the Project area, being a ‘new’ mining area where groundwater systems are of limited potential, the area is naturally limited by a lack of flow/flux (i.e. mine inflow and stream baseflow) data, to calibrate against, primarily as: (1) no mining has occurred to date within MLA 700057; and (2) with the exception of the Dawson River, other drainage features are ephemeral.

5.3.2 Predicted groundwater inflows

Groundwater inflows to the Project open cut mining operations have been extracted from the predictive model. The model predicted groundwater take/inflows estimates, presented as a daily average for an average annual period, for the Project are presented in Figure 5.15. The total inflow is presented with and without the inclusion of the inflow at cross passages, and is summarised as the 5th, 50th and 95th percentile estimates from the model ensemble.

It is noted that the predicted groundwater inflow estimates include any moisture in ROM coal and are before evaporative losses from pit floor or walls and does not account for direct rainfall or surface water ingress.

The model ensemble predicts groundwater inflows to range up to 1.5 ML/day (peaking in Year 23), with an average of 0.3 (5th percentile) to 0.75 ML/day (95th percentile) for the operational life of the mine. The predicted total volume of the Project open cut inflow is 2,250 to 6,900 ML for the proposed life of the mine (median estimate 3,700 ML).

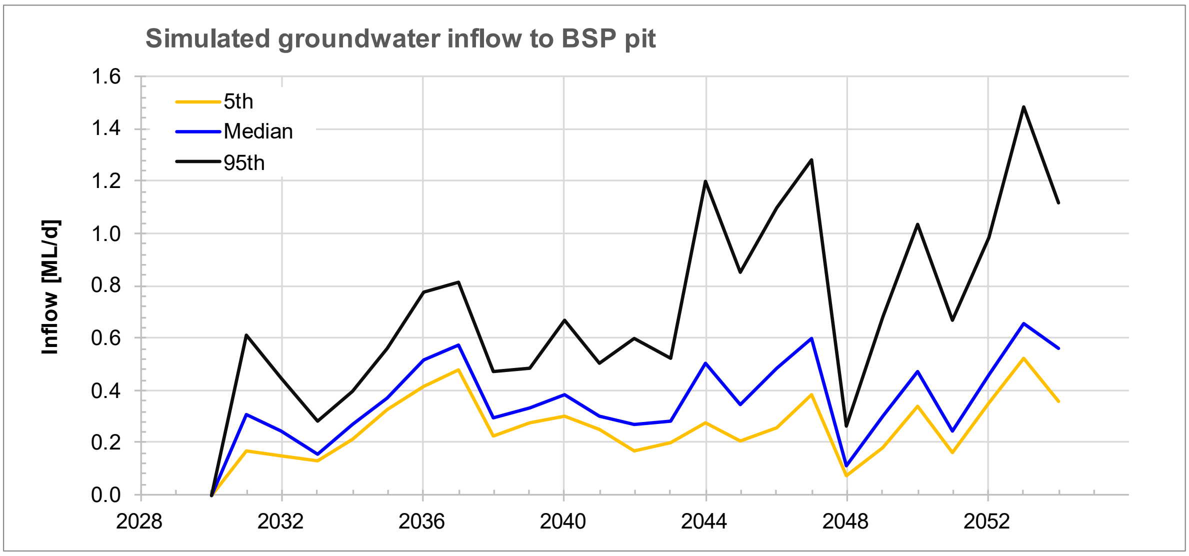

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Figure 5.15: Estimated groundwater inflow to the project

The effects of the climate change are uncertain, as briefly described in Section 7.10. Based on the two climate change groundwater model scenarios for the Project, groundwater take/inflow estimates could vary as follows (from the base realisation):

- -20% rainfall recharge: average take/inflows reduced to a range of 0.25 ML/d to 0.7 ML/d (median estimate of 0.4 ML/d), being -5% to essentially no change.
- +20% rainfall recharge: average take/inflows increased to a range of 0.35 ML/d to 0.8 ML/d (median estimate of 0.4 ML/d), again representing a relatively small change.

The small changes are likely related to the low rainfall recharge in this area. Literature indicates that shallow aquifers and surface water system are more sensitive to climate change, rather than 'deep' aquifer systems.

5.3.3 Associated water take

This section summaries the estimates of 'take' or groundwater captured or lost from the hydrogeological system. Table 5.11 presents indicative ranges for associated water take derived from model-predicted groundwater inflow.

Table 5.11: Associated water take (ML/year)

Water Source / Management Zone	**Estimated Take^ (ML/yr)**	
	Median	Upper
Groundwater: un-declared area within the Water Plan (Fitzroy Basin) 2011.		
Year 1	115	224
Year 2	97	164
Year 3	59	103
Year 4	99	146
Year 5	143	204
Year 6	192	283

Water Source / Management Zone	**Estimated Take^ (ML/yr)**	
	Median	Upper
Year 7	215	296
Year 8	108	171
Year 9	124	176
Year 10	150	244
Year 11	114	183
Year 12	103	220
Year 13	109	191
Year 14	180	438
Year 15	140	311
Year 16	180	402
Year 17	244	468
Year 18	47	96
Year 19	114	249
Year 20	195	379
Year 21	95	245
Year 22	175	359
Year 23	273	541

5.3.4 Predicted groundwater drawdown

The potential impact of the Project activities on groundwater drawdown have been extracted from the numerical groundwater model runs and hydrographs of drawdown through time have been prepared. The maximum drawdown predicted in every model cell in a number of selected 'stratigraphic' layers, as well as the drawdown in the simulated water table has been calculated during construction (2024-2030), and in the long-term for the following stratigraphic units or layers:

- the lower Coal Measures and Permian strata (model layer 16); and
- the water table (calculated here as the modelled water level in the uppermost saturated model layer, i.e. uppermost saturated or partially saturated stratigraphic unit).

The maximum modelled drawdown predicted to occur between 2030 and 2054 is presented in Figure 5.16 and Figure 5.17; the latter for the water table. The median or 50th percentile estimate of the maximum drawdown from the ensemble is the main focus on these maps, but the key drawdown contours from the 95th percentile ('realistic worst case') are also shown to illustrate uncertainty in the predictions. For the water table drawdown, the 5th percentile estimate ('realistic best case') is also shown.

Figure 5.16 shows the relatively extensive cone of depression in the Permian strata. The cone of depression is large because of the high hydraulic conductivity, the lack of direct rainfall or river recharge, and the confined nature of the coal measures. This outcome is not considered a problem because it does not manifest as measurable drawdown in the water table (where the environmental values are), and because there are so few anthropogenic bore users in the coal measures. However, it is shown on Figure 5.16 that the contours do intersect the location of the Ross bore to the east of the Project.

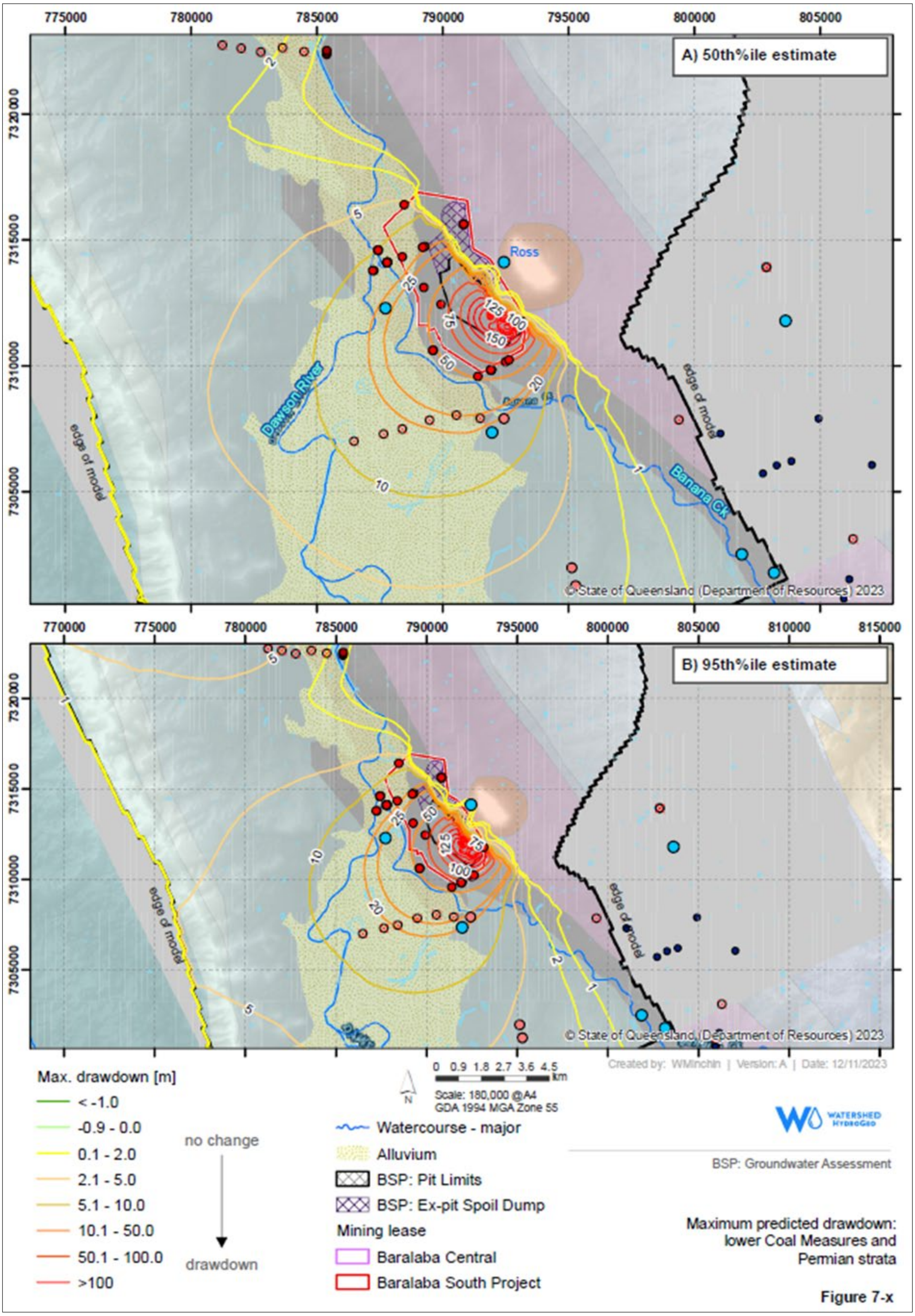

Figure 5.16: Maximum predicted drawdown in Permian strata during mining (2030-2054)

The water table drawdown (Figure 5.17) is focussed on the Project open cut, and it can be seen that the 1 m contour of the cone of depression is essentially contained within the northern and eastern boundaries of the MLA, and extends beyond the MLA boundary to the west (by up to 800 m [50th percentile] to 1,200 m [95th percentile]), and extends further to the south (by 3.5-4.5 km) along the strike of the coal seams. The 5th percentile estimate of drawdown is almost completely contained within the MLA boundary.

To the west, the cone of depression in the water table is mitigated by the presence of the higher permeability and porosity alluvium and the presence of the watercourses.

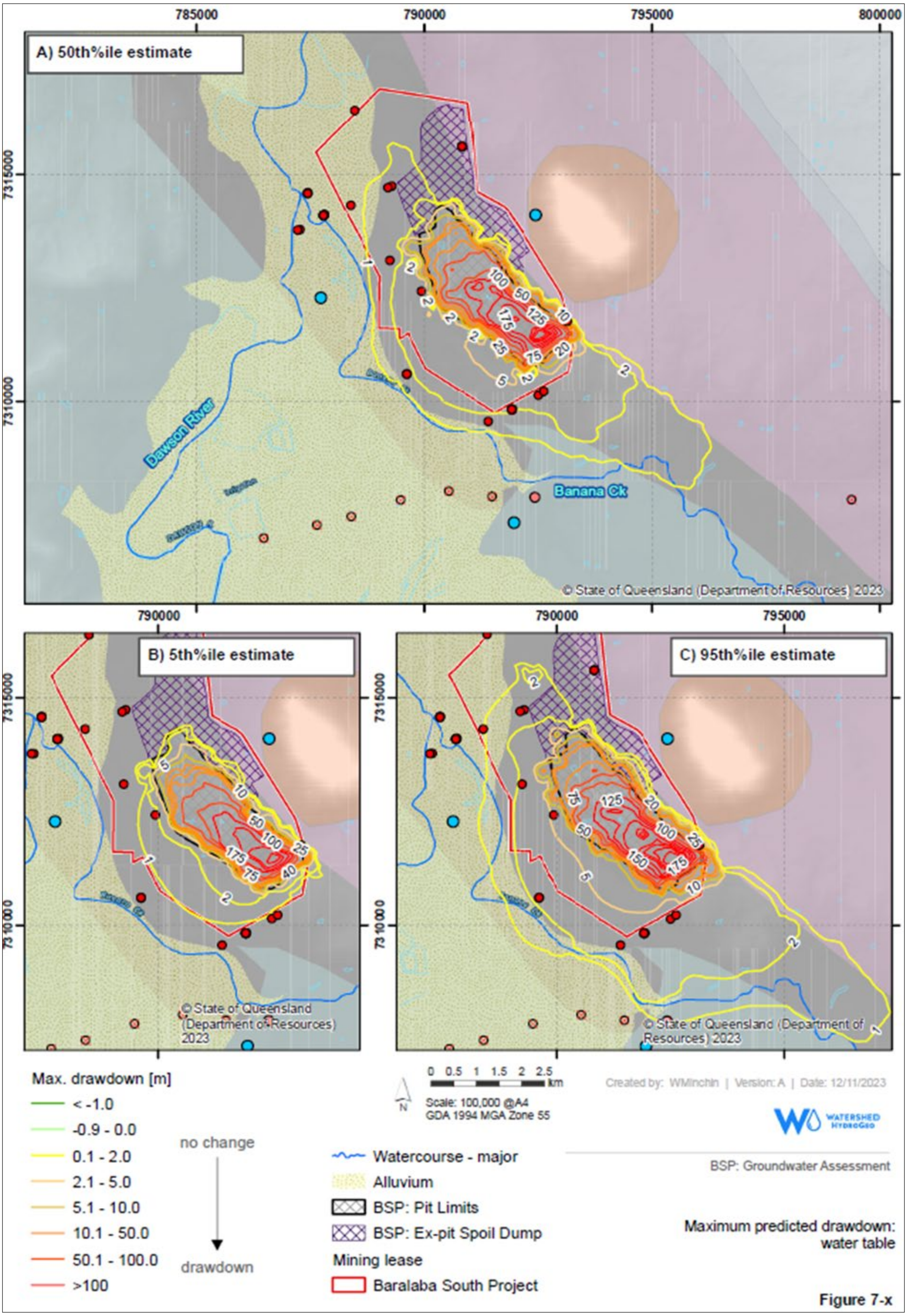

Figure 5.17: Maximum predicted drawdown in the water table during mining (2030-2054)

In order to understand the potential drawdown within the alluvial and colluvial deposits around the Project, Figure 5.18 shows the maximum predicted saturated groundwater drawdown in alluvium and colluvium deposits due to the Project, i.e. the 50th percentile maximum drawdown is limited to the inferred saturated thickness of these deposits (model layer 1), based on the inferred groundwater levels.

The figure includes the drawdown across all surficial deposits, and restricted to the mapped alluvium only, showing contours down to 0.5 m. Figure 5.18 indicates that there is up to 8 m predicted drawdown within the colluvium just to the west or south-west of the open cut pit, and this cone of depression extends to the west toward Banana Creek. Other small cones of depression are evident to the south-east (near Banana Creek) and north-west of the pit.

Figure 5.18 also shows this drawdown restricted further to the alluvium shown by the Queensland government mapping. This means that the maximum drawdown is approximately 1 m within this mapped alluvium, mainly around the reach of Banana Creek where it flows on the Dawson River alluvium (and outside of the MLA boundary), as well as a small cone of depression (also approximately 1 m drawdown) to the north-west of the open cut (within the MLA boundary).

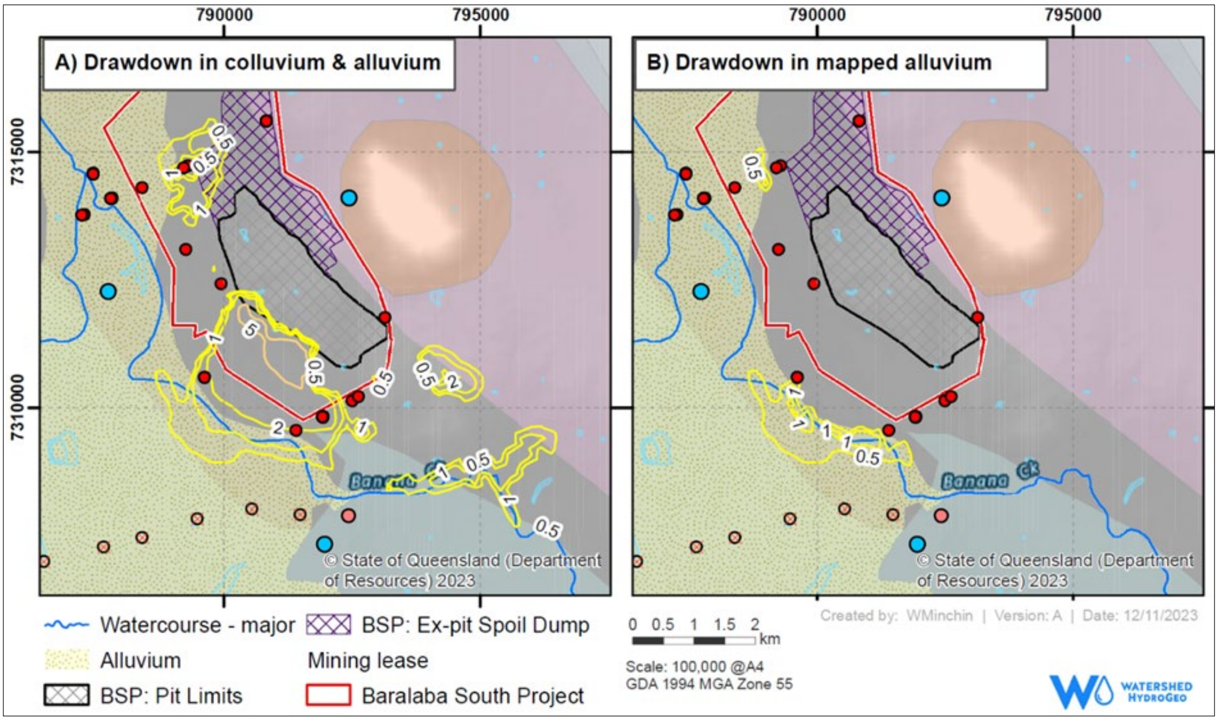

Figure 5.18: Modelled drawdown in surficial deposits

5.3.4.1 Drawdown impacts at private landholder bores

The maximum groundwater drawdown predicted as a result of mining at the Project on the private landholder bores are described in Table 5.12.

The results indicate the Project would have a negligible impact on groundwater levels or groundwater yield at the Riverland and Webb landholder bores. The maximum predicted drawdown of 0.15-0.7 m at the Ross Bore during mining would be similar to natural variation in the recorded groundwater table.

Table 5.12: Predicted maximum drawdown at private landholder bores due to the Project

Bore	Hydrogeological unit	Maximum drawdown during mining	Maximum drawdown after mining	Relative location	Other comments
Ross Bore	Cretaceous Intrusive (Igneous Trachyte)	0.15 (5th %ile) 0.4 (50th %ile) 0.7 (95th %ile)	1.5 (5th %ile) 2.25 (50th %ile) 4.2 (95th %ile	Located 500 m east of MLA 700057	Bore in use (stock watering)
Riverland 1 & 2	Quaternary Sediments (Alluvium)*	0.01 (5th %ile) 0.11 (50th %ile) 0.13 (95th %ile)	0.02 (5th %ile) 0.15 (50th %ile) 0.17 (95th %ile)	Located 1.5 km west of MLA 700057	Bore(s) not in use
Webb Bore	Triassic and Permian Coal Measures*	0 (5th %ile) 0 (50th %ile) 0 (95th %ile)	0 (5th %ile) 0 (50th %ile) 0 (95th %ile)	Located 3.5 km south of MLA 700057	Bore not in use

5.3.4.2 Drawdown impacts at wetlands and groundwater dependent ecosystems

3D Environmental (2023) has assessed the dependence of vegetation in the Project area and surrounds on groundwater through the measurement of leaf water potential, soil moisture potential, stable isotopes and physical observation. The assessment concluded that groundwater dependence within the MLA and adjacent areas associated with the Dawson River floodplain is controlled by small discontinuous lenses of sand that are distributed sporadically throughout the heavy clay soils that otherwise characterise the floodplain sediments (Appendix H, Groundwater Dependent Ecosystems Assessment). The sandy lenses support fresh groundwater resources on a seasonal basis that are perched above and disconnected from the regional groundwater table. Recharge of the sandy lenses occurs during surface water infiltration associated with overbank flow and intense rainfall events.

Groundwater modelling completed for the Baralaba South Project indicates Groundwater drawdown associated with mining void development is not predicted to impact the ecological function of GDEs both inside and outside the MLA which utilise and rely upon the perched seasonal groundwater resources. Drawdown will interact with the saline basal colluvial groundwater system with depressurisation and drainage of the system toward the mining void. There may also be some increased leakage from Banana Creek to the underlying sediments, which Watershed HydroGeo (2023) considers negligible due to a conservative model stimulation based on a fixed head / consistent source of water, noting that Banana Creek flows only irregularly.

Groundwater drawdown will only be propagated beneath Banana Creek during periods when the alluvium or colluvium, is saturated and would only induce leakage of surface flow from this watercourse when the watercourse is flowing, and a saturated connection exists between the alluvial groundwater table and surface water in the creek. In this instance, the impact of drawdown and the induced leakage would likely be negligible in comparison to the rate of groundwater recharge. There will be no interaction between the perched discontinuous sandy lenses which seasonally support vegetation groundwater dependence and the drawdown in the deeper colluvial groundwater unit due to the physical separation of these units, and the lack of hydraulic connection. Because of these factors, there are no identified causal pathways for impact which have capacity to alter GDE function and cause ecological harm.

With implementation of management and monitoring controls, it is considered that the risk to GDE’s posed by mine development is insignificant. The assessment of potential impacts to GDEs is addressed in Appendix H, Groundwater Dependant Ecosystem Assessment.

5.3.4.3 Drawdown impacts on stygofauna

Within the open cut pit extent and spatial extent of drawdown at the Project stygofauna, were they to be present, have the potential to be locally impacted by groundwater drawdown. The Project is not predicted to significantly impact stygofauna due to the alluvium largely being unsaturated within the pit extent and the limited groundwater level drawdown predicted in the shallow groundwater systems. Groundwater level drawdown is largely contained within the Permian coal measures, wherein no stygofauna of significance had been recorded during either the 2012 or 2017–2019 sampling programs.

Further assessment of the Project risks to Stygofauna are provided in Chapter 7, Flora and Fauna and Appendix I, Stygofauna Assessment.

5.3.5 Effects of groundwater-surface water interaction

Drawdown effects on the baseflow / leakage for the Dawson River and Banana Creek in the vicinity of the Project have been modelled with results suggesting that two types of watercourses are present in the vicinity of the Project:

1) the Dawson River and its anabranches which are regulated at Neville Hewitt Weir—the relatively permeable alluvium, low recharge rates and high evapotranspiration and impoundment at the weir lead to consistently losing (surface water) river conditions; and
2) Banana Creek (and other minor tributaries of the Dawson River), being ‘losing’ creeks with water flows occurring from the watercourse into the alluvium.

The drawdown effects on the baseflow/leakage at the watercourses and drainage features defined near the Project have been assessed in Appendix B, Groundwater Modelling and Assessment, with the results of the analysis presented in Table 5.13 which includes a comparative analysis of the predicted groundwater–surface water interactions with and without the Project.

While the predicted groundwater drawdown due to the Project in the Permian strata would be limited in the shallow groundwater systems, it would incidentally transfer indirectly to some, albeit immeasurable, leakage from the Dawson River (upstream of Neville Hewitt Weir) to the surficial geology by a peak of up to approximately 0.2 ML/day, although more likely 0.16 ML/d, which when compared to the average surface water flows in the Dawson River for the past 5 years (approximately 1,469 ML/d for Beckers - 2018-22) is a 0.01% reduction in flow.

Similarly, the modelled leakage predicted from Banana Creek is considered negligible as it only flows on occasions following rainfall events (while in the model it is conservatively simulated as a fixed head or consistent source of water, which is conservative with respect to river-aquifer interaction, but perhaps not with respect to the potential extent of drawdown).

These small to negligible changes are primarily due to a combination of the relatively low permeability of the Triassic (e.g. the Rewan Formation) and steeply dipping Permian stratigraphy that largely prevents drawdown in the Coal Measures from propagating up into the shallow groundwater system.

The numerical groundwater model verifies the conceptual model that there is poor connection between the groundwater system and ephemeral drainage features. This is largely due to the 12-15 m depth to groundwater which in turn limits the ability of drawdown to capture any localised baseflows that may occur at or near the invert of the watercourses and drainage features.

Table 5.13: Groundwater predicted baseflow/enhanced leakage

Watercourse reach	**Modelled groundwater-surface water flux (average 2030-2054) (ML/d)**		**Predicted Change due to the Project (Predictive Model Run Minus 'Null' Run)**	
	Model without mining (Null)	Model with Baralaba North Mine and Baralaba South Project	Effect During Mining at Baralaba South Project (ML/d)	
Dawson River (d/s Neville Hewitt Weir) [Zone C]	Mean +3.79 Range +2.48 to +5.22 (consistent leakage)	Mean +3.80 Range +2.49 to +5.23	0.01	Negligible
Dawson River (u/s Neville Hewitt Weir) [Zone D]	Mean +1.94 Range +1.20 to +2.63 (consistent leakage)	Mean +2.04 Range +1.26 to +2.73	0.06 to 0.1 (average 0.09)	Peak effect of <0.01% of average flow^
Dawson River (Upstream) [Zone E]	Mean +1.41 Range +1.18 to +1.56 (consistent leakage)	Mean +1.40 Range +1.17 to +1.55	0.01	Negligible
Banana Creek *	Mean +0.06 Range +0.01 - +0.11 (consistent leakage)	Mean +0.16 Range +0.11 to +0.22	0.1 additional loss[#]	Negligible as Banana Creek only flows on occasions following rainfall events
			# this is filtered to include only model realisations where Banana Creek is predominantly losing, as per the conceptual model. Modelled loss up to 0.15 ML/d if including realisations where baseflow dominates, but this is not considered likely.	

5.3.6 Great Artesian Basin impacts

The Project numerical groundwater model demonstrates that the Project would not cause a change in flow direction of groundwater in the hydrogeological units that constitute the GAB.

Capture of groundwater from the GAB units was assessed using ZoneBudget mass balance functionality, and comparing the results from the models run both with and without the Project. The modelled incidental reduction in GAB groundwater resources caused by the Project operation were up to:

- Incremental Project effect: median estimate <0.1 m^3/d (<0.008 ML/yr) and 95th percentile estimate of 0.4m^3/d or 0.026 ML/yr.

- Cumulative Baralaba North Mine and Project effects (2030-onward): median estimate 0.2 m^3/d (<0.07 ML/yr) and 95th percentile estimate of 2 m^3/d or 0.76 ML/yr. (noting that the peak mining effect of approximately 6 m^3/d is simulated as occurring prior to the commencement of the Project).

Over such a broad model domain, these modelled rates of groundwater capture are minor, and immeasurable, and the model supports the conclusion that there would be effectively no decline in groundwater levels in the hydrogeological units that constitute the Great Artesian Basin (GAB) as a result of the Project. The difference between simulated Baralaba North Mine and Project effects is likely due to their relative position compared to the other major hydraulic source/sink in this area, which is the Dawson River, with the Baralaba North Mine being to the west of the river.

5.3.7 Groundwater quality

There is not expected to be any measurable change in the quality of groundwater as a consequence of mining, either in Permo-Triassic strata (within which groundwater level drawdown would be largely contained) or in younger units, such as alluvium or colluvium.

Based on the geochemical characterisation of overburden, runoff and potentially enhanced infiltration / recharge across or within the backfill spoil and out-of-pit WREs are likely to be less saline than the naturally occurring groundwaters associated with the Permo-Triassic sediments in the area, and therefore not considered a risk to local groundwater exceeding the WQOs.

The localised hydraulic sink that will form as mining develops will minimise the potential migration of saline or poorer quality groundwater from within the open cut pit to other areas. Consequently, there will be negligible impacts on groundwater quality in aquifers or surface water quality in downstream waters due to interaction with groundwater (Appendix B, Groundwater Modelling and Assessment).

5.3.8 Cumulative impacts

The results of the predictive model run presented in the above sections included the cumulative impacts of the approved Baralaba North Mine. Consistent with the cumulative modelling and assessments conducted for the BNCOP numerical groundwater model (HydroSimulations 2014), the results demonstrate there is unlikely to be any interference between the Project and the Baralaba North Mine operations in the north. Thus, the predicted cumulative drawdown impacts at private landholder bores, springs, wetlands, groundwater dependent ecosystems and on stygofauna are equivalent to the Project alone.

Further, it is demonstrated that the predicted baseflow impacts / leakage in the Dawson River downstream of the Neville Hewitt Weir (relevant to the Baralaba North Mine) is negligible. Similarly, the Project would have no cumulative effect on the predicted impacts previously presented for the approved BNCOP in HydroSimulations (2014).

5.3.9 Post mining void recovery

5.3.9.1 Post-mining groundwater levels

Recognising that there are several factors which effect the final void equilibrium lake levels (including void surface catchment area, varying evaporation rates, rainfall scenarios and potential for inundation due to flooding [i.e. final landforms]), the post-mining equilibrium levels were determined in an integrated manner with Engeny. The groundwater model initially provided modelled stage groundwater inflow estimates to the void (at the end of mining within the Project, and then a further post-mining period). This was done by setting constant head boundary conditions to a range of stage levels to get the modelled long-term inflow in response to these. The resulting stage groundwater inflows Table 5.14.

Table 5.14: Initial stage groundwater inflows to the final void

Lake stage (mAHD)	Estimated inflow (ML/d)
-150	1.29
-100	0.64
-75	0.64
-50	0.41
-25	0.40
0	0.35
20	0.21
30	0.19
40	0.18
50	0.21
60	0.17
70	0.14
80	0.01

Simulation of the recovery of void lake water levels were based on transient lake recovery levels-provided by Engeny (2023). Engeny have indicated that:

- The final equilibrium lake level would be approximately 32 mAHD, likely ranging between 28 and 37.5 mAHD according to variability in rainfall and evaporation; and
- It would take approximately 325 years for this to be achieved (i.e. approximately year 2375).

To establish the post-mining equilibrium target groundwater levels in the Project numerical groundwater model the time- variant constant head package (CHD) was used, with the final void lake stage level target set at 32 mAHD.

The post-mining recovery model was then run and groundwater levels for year 2500 are presented on Figure 5.19. The results of this are summarised as follows:

- In the Project final void, lake water levels are predicted to recover to approximately 40 m below pre-mining standing water levels (based on observed data, this is typically 68-80 mAHD – and the modelling is consistent with this; Figure 5.19) and therefore remain as a sink.
- The continued residual capture of water from the Permian strata means that there remains a residual long-term drawdown. At this equilibrium level the 1 m water table drawdown contours extended 2 km to the north of the pit limit (but effectively within the MLA boundary) and 3 km to the south (south-east) of Project footprint (Figure 5.19).
- There is predicted to be some recovery of groundwater levels at the backfilled (northern end) of the Project, nearest the Dawson River / Banana Creek confluence, yet the relative permeability of those sediments and uncertainty about the infiltration into those means that some drawdown will persist within them.
- Groundwater levels are predicted to rise to approximately 10 m residual drawdown within the limits of the Project pit, and up to 5 m residual drawdown at the northernmost extent of the backfilled pit, when compared to the pre-mine standing groundwater level (Figure 5.19). Recovery is relatively quick (in the

order of a decade) due to the likely enhanced recharge rates through the backfill spoil at the northern end of the Project .

It is noted that the final void lake recovery analysis (i.e. timeframes and final levels) undertaken by Engeny Water Management (2023) incorporates the stage versus groundwater inflow from the (interim) modelling, and also includes a number of other processes which are either not simulated (i.e. rainfall runoff from the direct surface water catchment) or are better simulated in a surface water model than in a groundwater model (e.g. the void lake volume-surface area-level relationships which governs evaporation and direct rainfall).

Based on the final void configuration, the predicted additional leakage due to the Project from the Dawson River (Zone D - upstream of Neville Hewitt Weir) would be approximately 0.07 ML/d post-mining, which is only slightly lower than the rate during mining, and so is also noted to be approximately equivalent to 0.01% of flow in the Dawson. Similarly, the model predicts the long-term reduction in flow in Banana Creek (by way of increased leakage) would be 0.06 ML/d; this is slightly reduced from the operational rate.

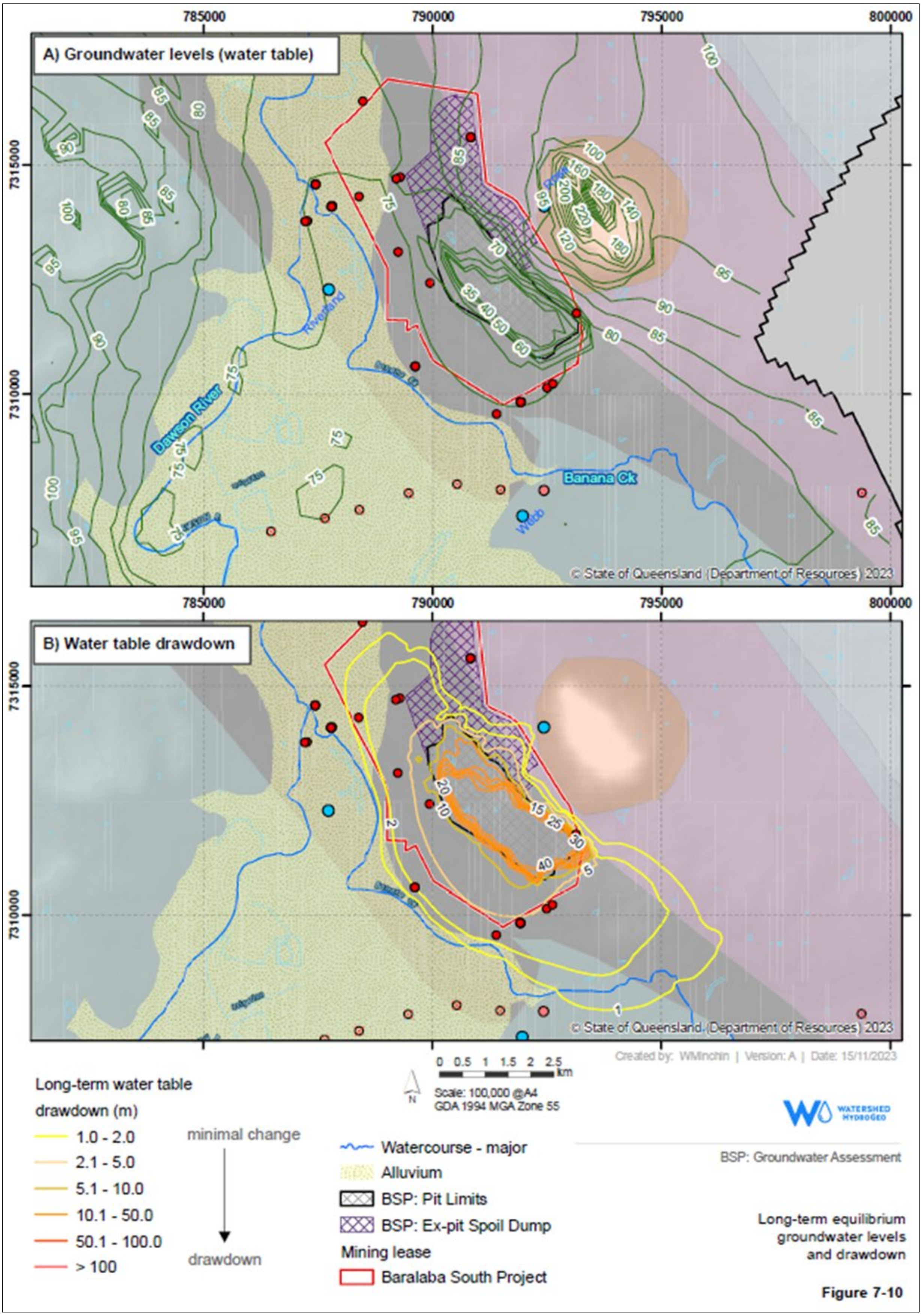

Figure 5.19: Post-mining equilibrium water table elevation and drawdown (in 2500)

5.4 Monitoring, mitigation and management measures

A suite of mitigation, management and monitoring measures will be implemented to ensure the water resource values of ground waters are maintained and the performance objectives outlined in the TOR for the Project are met.

5.4.1.1 Groundwater monitoring program

The existing groundwater monitoring program will continue to be monitored throughout the life of the Project. Exceptions to this will include existing bores within the disturbance footprint (i.e. P-WVWP4 and POB2) where monitoring will be maintained for pre-mining baseline data only. Additional shallow alluvial bores have also been proposed:

- one paired with the existing bore P-OB1;
- one near the HES wetland; and
- one to the south or south-east the Project site near to Banana Creek.

A summary of the proposed monitoring network is provided in Table 5.15.

Sample methodology

Groundwater monitoring will be undertaken by a competent person and will be undertaken in accordance with the latest edition of the administering authorities Water Quality Sampling Manual. Groundwater level monitoring will be undertaken quarterly at the monitoring bores detailed in Table 5.15. Water levels will be measured either manually or through the use of data loggers. Groundwater level samples will be undertaken prior to the collection of groundwater quality samples.

Groundwater quality sampling will be carried out ensuring:

- bores are purged prior to the collection of a representative sample;
- monitoring equipment requiring calibration is calibrated and maintained in accordance with manufacturer’s instructions;
- the use of appropriate sample containers which have been provided by the laboratory;
- samples will be labelled clearly with the sample number, site and date sampled;
- all samples will be kept cold and forwarded to the laboratory in a secure and appropriately cooled container;
- samples are to be collected and handled within appropriate holding times for the analysis of concern, this information can be obtained and confirmed from the laboratory responsible for the analysis of samples;
- water samples will be analysed by a NATA accredited laboratory for analysis;
- all sample batches to be sent to a NATA accredited laboratory are to be accompanied by a chain of custody form; and
- trip blanks (analyte-free solutions) and triplicate samples are collected and analysed for quality assurance purposes.

Groundwater quality monitoring will continue to be undertaken on a quarterly basis, as outlined in Table 5.15. Each quarterly event will include sampling and field analysis of EC and pH. Water samples will also be collected and submitted to a NATA accredited laboratory annually for analysis of:

- physio-chemical indicators (pH, EC and TDS);
- major ions (calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate);

- total alkalinity as $CaCO_3$, HCO_3, CO_3; and
- total and dissolved metals (aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt copper, iron, lead, manganese, molybdenum, nickel, selenium, uranium, vanadium, zinc and mercury).

Groundwater monitoring criteria will be established to monitor predicted impacts on both environmental values and predicted changes in groundwater quality. Impact assessment criteria for the site will be documented in the Receiving Environment Monitoring Program (REMP).

Monitoring of the physical condition of the bores will also be undertaken, prior to or post water sampling. Monitoring will include a physical inspection of the bore for evidence of interference or damage. Results of the physical condition of the bore will be recorded on field data sheets.

Bore construction, maintenance and decommissioning

The drilling and installation of additional groundwater bores will be undertaken by a licenced contractor. Bores will be cased and constructed to prevent any hydraulic connection between various strata through the bore annulus. Maintenance of bores will be undertaken as soon as practicable where corrective actions will be dependent on the identified issue and cause. If the issue cannot be corrected in-situ, the bore will either be re-drilled and re-installed in the same location (over drill the existing bore and install a new bore) or a new bore will be installed adjacent the faulty bore as a replacement.

At the cessation of groundwater monitoring for the mine the bores will be retained subject to a landholder agreement or decommissioned. Decommissioning activities will be undertaken in accordance with standard industry practices at the time of decommissioning, ensuring that no cavity remains and that there is no bore connection between various strata.

Groundwater triggers

Preliminary groundwater quality and drawdown triggers have been developed for the Project and are included in Chapter 19, Proposed Environmental Authority Conditions. These triggers will be revised prior to commencement of operations, following the collection of additional baseline groundwater quality and level data.

Drawdown triggers were developed with reference to the Water Act and IESC Information Guidelines Explanatory Note: Uncertainty analysis—Guidance for groundwater modelling within a risk management framework (Middlemis H and Peeters LJM, 2018), using the following criteria:

- Default drawdown limits from the Water Act of 2 m for unconsolidated aquifers and 5 m for consolidated aquifers were applied as a baseline, and adopted for bores where modelling predicted a drawdown of less than this default values.
- Drawdown triggers are based on the difference between the predicted water level without the Project (zero drawdown) and the minimum (lowest) predicted water level at any time during the life of the Project.
- Where modelling predicted a drawdown greater than the default triggers, and with negligible impact on landholder bores, groundwater level drawdown trigger values were assigned equal to the maximum 90th percentile model drawdown prediction at each bore over the life of the Project as derived from the model uncertainty analysis.

For groundwater quality, trigger levels were developed using the following approach:

- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) guideline values for 95% species protection were applied where suitable.

  When the ANZG (2018) guideline values were not suitable, the WQO values from groundwater chemistry zone 34 (WQ 1310 Fitzroy Basin) were applied.

- When both ANZG (2018) guideline values and WQO values from groundwater chemistry zone 34 were unsuitable, triggers were derived by grouping the bores and using the 80th percentile of the combined bores.
- If the value determined using the grouping of bores was also not suitable, and if the bore had at least eight observations that did not exhibit a statistically significant increasing trend, then bore-specific interim limits are proposed.

Monitoring program review

A comparative analysis of the results from the groundwater monitoring program and groundwater quality triggers will be undertaken as soon as practicable upon receipt of the groundwater monitoring results. Groundwater quality trigger levels will be reviewed in line with the Department of Science, Information Technology and Innovation (DSITI) guideline, ‘Using monitoring data to assess groundwater quality and potential environmental impacts’ (DSITI, 2017). Consistent with the DSITI (2017) guidelines, the triggers will be established in consideration of the Water Plan (Fitzroy Basin) 2011 WQOs, ANZECC (2000[2018]) criteria and site-specific conditions. Trigger criteria will be established for each groundwater unit potentially impacted by the Project, being alluvium and the Permian coal measures.

Table 5.15: Proposed bore monitoring network

Bore ID	Easting	Northing	Ground level (m AHD)	Screened interval (mbgl)	Stratigraphy	Water level monitoring	Water quality	Purpose
A-PB1	787806	7314088	88.4	11.5–23.5	Alluvium	Q†	—	Monitor change in water levels and quality in alluvium for early detection of potential impacts from site activities beyond those predicted, and monitor interaction between alluvium and coal measures
A-PB2	791931	7309808	91.5	11.5–23.5	Alluvium	Q†	—	
A-OB1	787440	7314586	88.9	10–22	Alluvium	D	Q/A	
A-OB2	787802	7314105	88.3	11.5–17.5	Alluvium	D	Q/A	
A-OB3	788393	7314309	87.9	12–30	Alluvium	Q	Q/A	
A-OB4*	789290	7314733	87.5	8–17	Alluvium	Q*	—	
A-OB6	791402	7309557	91.4	9–18	Alluvium	D	Q/A	
A-OB7	791935	7309829	91.7	11–26	Alluvium	D	Q/A	
A-OB8	792501	7310136	91.4	10–22	Alluvium	D	Q/A	
A-OB10*	789247	7313094	87.5	8–20	Alluvium	D*	—	
A-OB11	787270	7313771	86.2	9–15	Alluvium	D	Q/A	Determine background information on groundwater trends in alluvium at the Dawson River
A-OB12	787220	7313767	87.2	9.6–15.6	Alluvium	D	Q/A	
P-PB1	787805	7314101	88.3	38	BG (interburden)	Q	Q/A	Monitor change in water levels and quality in coal measures for early detection of potential impacts from site activities beyond those predicted
P-OB1	788477	7316388	87.4	105	BG (coal seam)	Q	Q/A	
P-OB2	793140	7311758	105.3	147	BG (interburden)	Q	Q/A	
P-OB3*	789939	7312422	89.6	29	BG (interburden)	Q*	—	

Bore ID	Easting	Northing	Ground level (m AHD)	Screened interval (mbgl)	Stratigraphy	Water level monitoring	Water quality	Purpose
P-OB4*	789205	7314695	87.1	76	BG (coal seam)	Q*	—	
P-OB5	792626	7310218	91.4	184	BG (coal seam)	Q	Q/A	
P-VWP1	787442	7314568	89.0	38	Interburden	D	—	Monitor depressurisation of Permian Baralaba Coal Measures and Rewan Formation in response to mining to verify against predicted changes
				105	Interburden	D	—	
				147	Interburden	D	—	
P-VWP2	787789	7314089	88.51	29	Overburden	D	—	
				76	Rewan Formation	D	—	
				184	Interburden	D	—	
				234	Interburden	D	—	
P-VWP3	791922	7309816	91.6	55	Interburden	D	—	
				121	Interburden	D	—	
				155	Interburden	D	—	
				175	Interburden	D	—	
P-VWP4	790829	7315606	101.0	25	Interburden	D	—	
				80	Interburden	D	—	
				150	Interburden	D	—	
				200	Interburden	D	—	

Bore ID	**Easting**	**Northing**	**Ground level (m AHD)**	**Screened interval (mbgl)**	**Stratigraphy**	**Water level monitoring**	**Water quality**	**Purpose**
P-VWP5	789621	7310598	90.4	66	Interburden	D	—	
				138	Interburden	D	—	
				185	Interburden	D	—	
Proposed A1	788477	7316388	87.4	~15	Alluvium	Q	Q/A	Paired bore with P-OB1 and between the Dawson River and out-of-pit waste rock dump Monitor change in water levels and quality for early detection of potential impacts from site activities beyond those predicted
Proposed A2	789319	7312065	TBC	~15	Alluvium	Q	Q/A	Baseline data on alluvium near HES wetland and proposed out-of-pit waste rock dump Monitor change in water levels and quality for early detection of potential impacts from site activities beyond those predicted
Proposed A3	794800	7309250	~94	~5-20	Alluvium	D	-	Alluvium bore to monito baseline and change in water levels for detection of effects from Project activities.
Proposed A4	793100	310622	~100	TBC	Permian Coal Measures	D	-	Drilled to 200 m depth to understand geology (faulting) and permeability (via packer testing). Monitoring bore to be installed to depth based on this testing/analysis.
Note: Coordinates in MGA94 Zone 55 * within disturbance footprint, to monitor for baseline data only, no triggers to be applied D: Daily – bore equipped with level logger/VWP Q/A: Quarterly field water quality and annual full suite of water quality						BG: Blackwater Group † - Near other existing bores therefore water level monitoring proposed only Q: Quarterly		

5.4.1.2 Groundwater pit inflow monitoring program

Groundwater pit inflow will be monitored during the open cut mining operational phase. The partition of groundwater inflow/seepage rates will be estimated through annual review of the following:

- pit dewatering/pumping records;
- the operational site water balance model;
- catchment (rainfall runoff);
- coal moisture; and
- evaporation considerations to partition groundwater inflow/seepage rates.

Any observations of unexpected or significantly increased groundwater inflows directly to the open cut pit will be recorded and monitored during the operation of the Project.

5.4.1.3 Private landholder bores

Periodic (e.g. seasonal/quarterly, or less frequently if otherwise agreed) water level monitoring will be conducted at private landholder bores in the vicinity of the Project during the operational life of the mine to validate predictions of no significant impact.

Mitigation measures will be implemented in the unlikely event that monitoring and/or subsequent investigation from monitoring confirms that drawdown impacts on an existing groundwater supply user are due to the Project.

If required, make good measures may include the following measures:

- deepening the affected groundwater supply bore; or
- constructing a new groundwater supply bore; or
- providing a new alternative water supply source, provided that any such attributed impacts are demonstrated to be due to mining at the Project and not due to natural variations, such as rainfall deficit or other factors.

The Proponent will ensure that as a minimum the proposed mitigation measures are acceptable to the affected groundwater user.

5.4.1.4 Groundwater model validation

An ‘annual monitoring report’, consistent with contemporary EA reporting requirements for relevant groundwater datasets, will be prepared and submitted each year to the Queensland Government for the annual return period.

The numerical groundwater model will be reviewed and, if necessary, updated in accordance with the guideline ‘Underground Water Impact Reports and Final Reports’ (DES, 2017). Any details of verification of the numerical groundwater model predictions or updates to the numerical groundwater model (e.g. recalibration, additional sensitivity analysis or revised forward predictions) will be accounted for in these reports.

5.4.1.5 Annual review

An annual review of the Water Management Plan will be undertaken. The annual review will consider the results of groundwater monitoring and management measures and the development of mining activities. The review will assess the change in groundwater quality over time compared to historical trends and impact assessment predictions. The Water Management Plan will be updated pending the outcomes of the review or updates/changes in legislative requirements.