4.0 HYDROLOGICAL AND HYDROGEOLOGICAL SETTING

4.1 Hydrology

4.1.1 Climate

The mine (and processing facility) is located in the central southern region of the Macquarie-Bogan Catchment with an average annual rainfall of approximately 500 mm (Figure 11).

Pan evaporation in the Macquarie-Bogan catchment has a strong east-westerly gradient and varies from 900 mm/year in the south-east to 2 200 mm/year in the north-east (refer to Figure 12). The Project location is in the region of 1 800 mm/year pan evaporation.

The closest rainfall gauging station maintained by the Bureau of Meteorology is located at Murrumbogie (#050028), approximately 17 km south-east of the mine site. This station has 134 years of near complete rainfall records between the years 1883 and 2017 with few data gaps (Figure 13).

The nearest pan evaporation station is located at the Condobolin Agricultural Research Station (#050052), 40 km to the south-west of the mine site with evaporation data from 1975 to present.

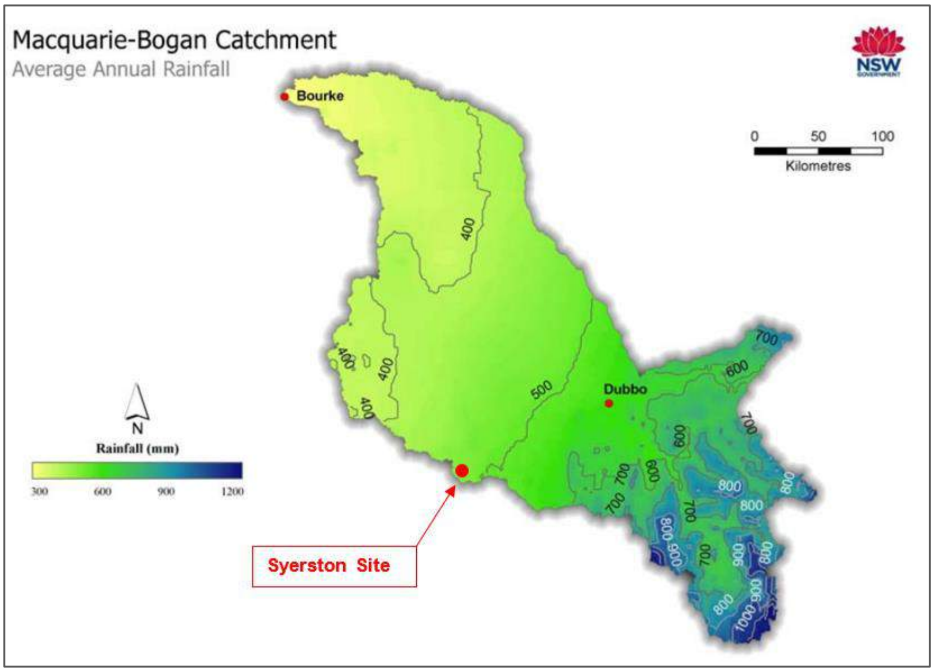


Figure 11: Average annual rainfall distribution in the Macquarie-Bogan catchment (Source: Hutchinson and Kesteven, 1998; via Green et al., 2011[6])

[6] Green D., Petrovic J., Moss P., Burrell M. (2011) Water resources and management overview: Macquarie-Bogan catchment, NSW Office of Water, Sydney

Hutchinson M and Kesteven J. 1998. Monthly mean climate surfaces for Australia. Australian National University. December.

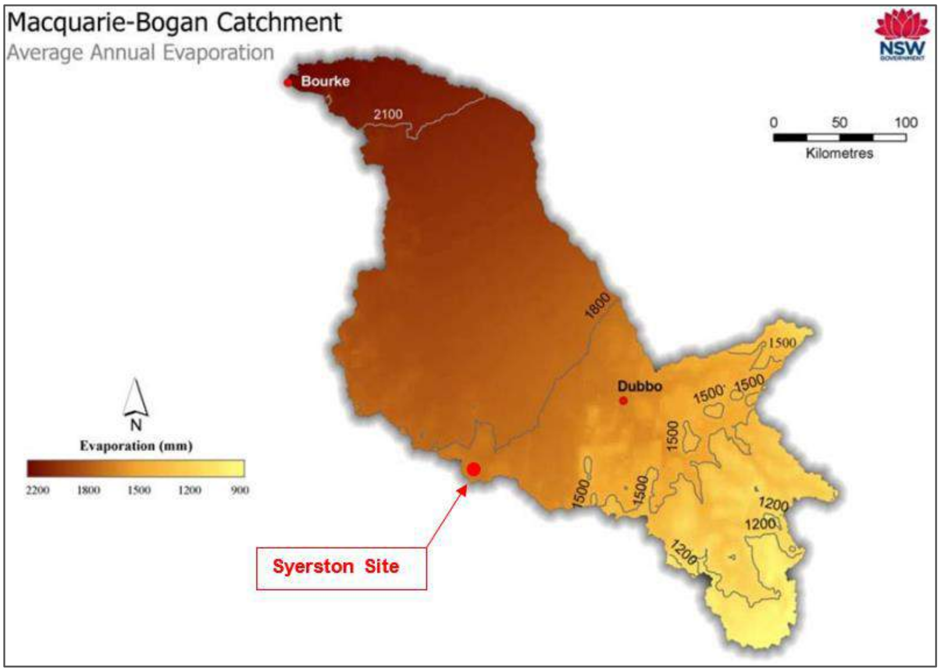


Figure 12: Average annual pan evaporation in the Macquarie-Bogan catchment (Source: Hutchinson and Kesteven, 1998; via Green et al., 2011)

A rainfall and evaporation data record for was obtained from the Department of Science, Information Technology and Innovation's (DSITI) SILO Data Drill (SILO) for the Project location (32.5° S, 147.5° E). SILO accesses grids of data interpolated from point observations by the Australian Bureau of Meteorology (BoM). SILO data formats are available for any location in Australia and are suitable for statistical and modelling applications as data records are long (from 1889 to current) and continuous (without data gaps).

The Project SILO rainfall and class A pan evaporation records have been compared to the gauged sites at Murrumbogie and the Carnarvon Agricultural Research Centre respectively (Figure 13 and Figure 14). In both cases the SILO datasets show exhibit minimal variation from gauged datasets which suggests the SILO dataset is reliable for site climate analysis.

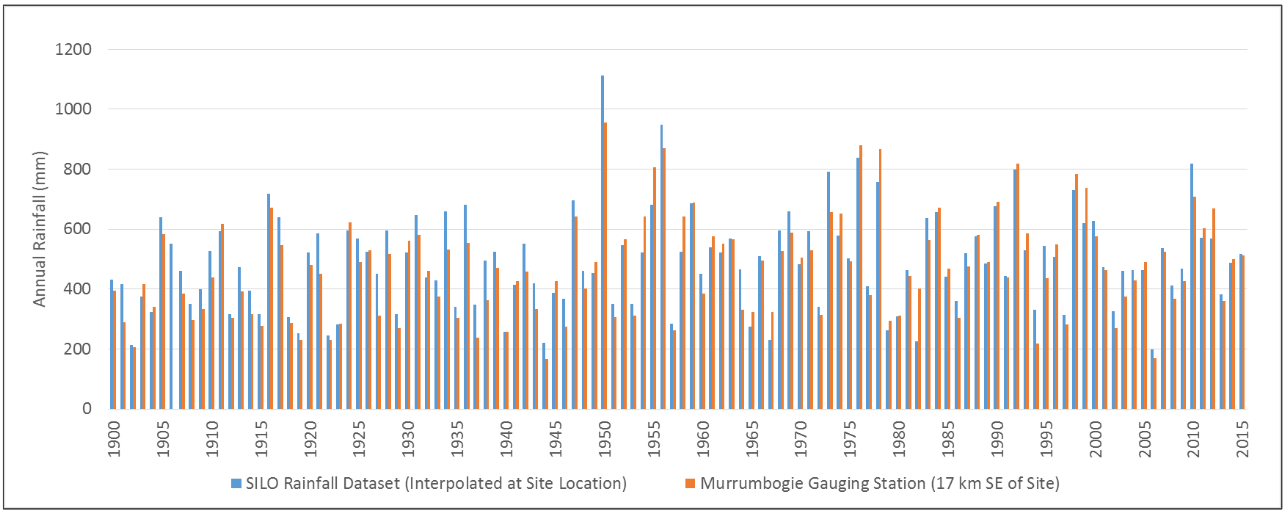


Figure 13: Comparison of Project SILO rainfall and Murrumbogie rainfall gauging station

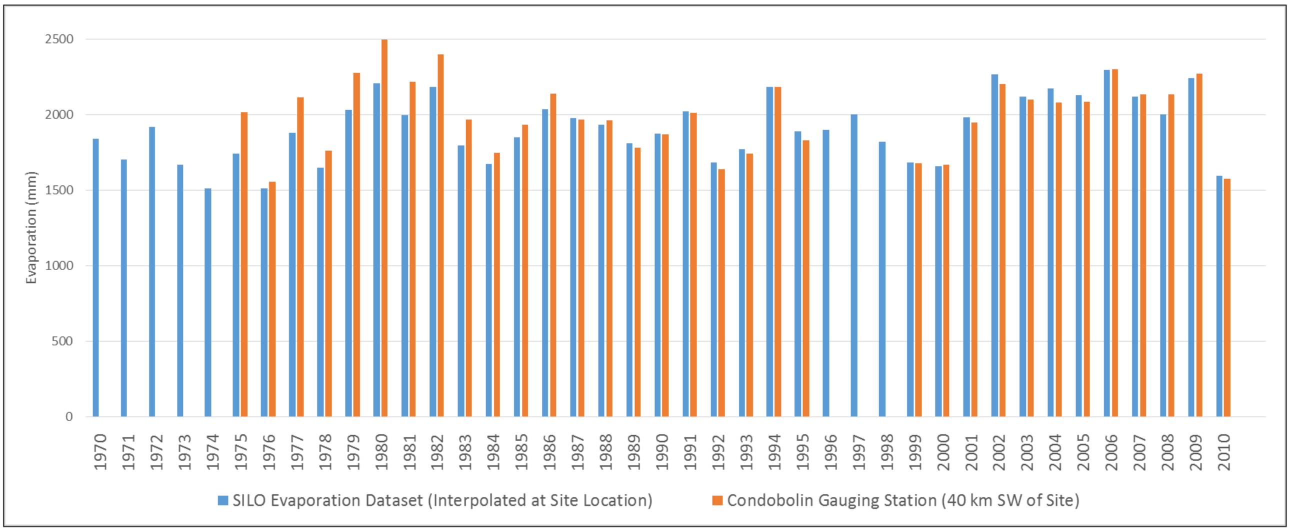


Figure 14: Class A Pan Evaporation: Syerston SILO and Condobolin Agricultural Research Centre

Rainfall records are indicative of a dry (borderline semi-arid) climate which is confirmed by the location of the Project on the Köppen climate classification system as borderline semi-arid with a hot summer (classification: BSh).

Seasonal rainfall and evaporation variation throughout the year is displayed in Table 8 and Table 9 respectively. This variation can be visualised in Figure 15, which outlines monthly statistical totals including a boxplot indicating the 10th, 25th, 50th (median), 75th, and 90th percentiles. The average monthly rainfall indicates rainfall is distributed evenly throughout the year with a slight summer maximum and higher rainfall variability between the months of December and February.

Pan evaporation is seasonally dependent, with average annual variations from 48 mm/month in the winter months to 295 mm/month in summer months.

The Project location has an average annual rainfall of 488 mm/year, annual evaporation of 1 978 mm/year and therefore an annual excess of evaporation over rainfall of 1 490 mm/year.

Table 8: Syerston SILO rainfall (mm) statistics (1900 – 2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	293	244	184	405	151	139	102	152	120	198	215	200	**1 111**
Median	36	27	27	23	31	33	32	34	25	36	33	32	**482**
Min	1	0	0	0	0	0	0	0	0	0	0	0	**93**

Table 9: Syerston SILO pan evaporation (mm) statistics (1975 – 2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Median	295	236	204	125	74	46	50	77	116	179	228	295	**1 908**

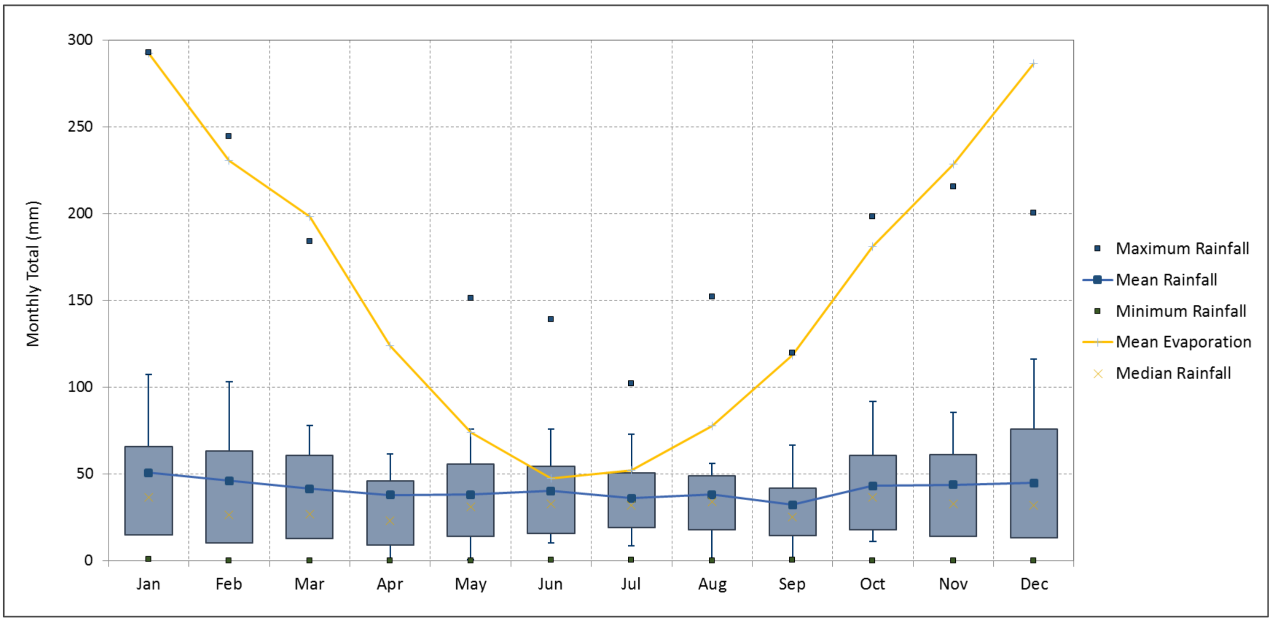


Figure 15: Syerston monthly rainfall and evaporation statistics (SILO)

4.1.2 Topography

Elevations across the Macquarie-Bogan catchment varies from 1 300 mRL in the south-east in the Great Dividing Range down to less than 100 mRL in the north-west of the catchment (Figure 16). The area downstream of Dubbo is predominantly flat alluvial plains with elevations generally less than 300 m.

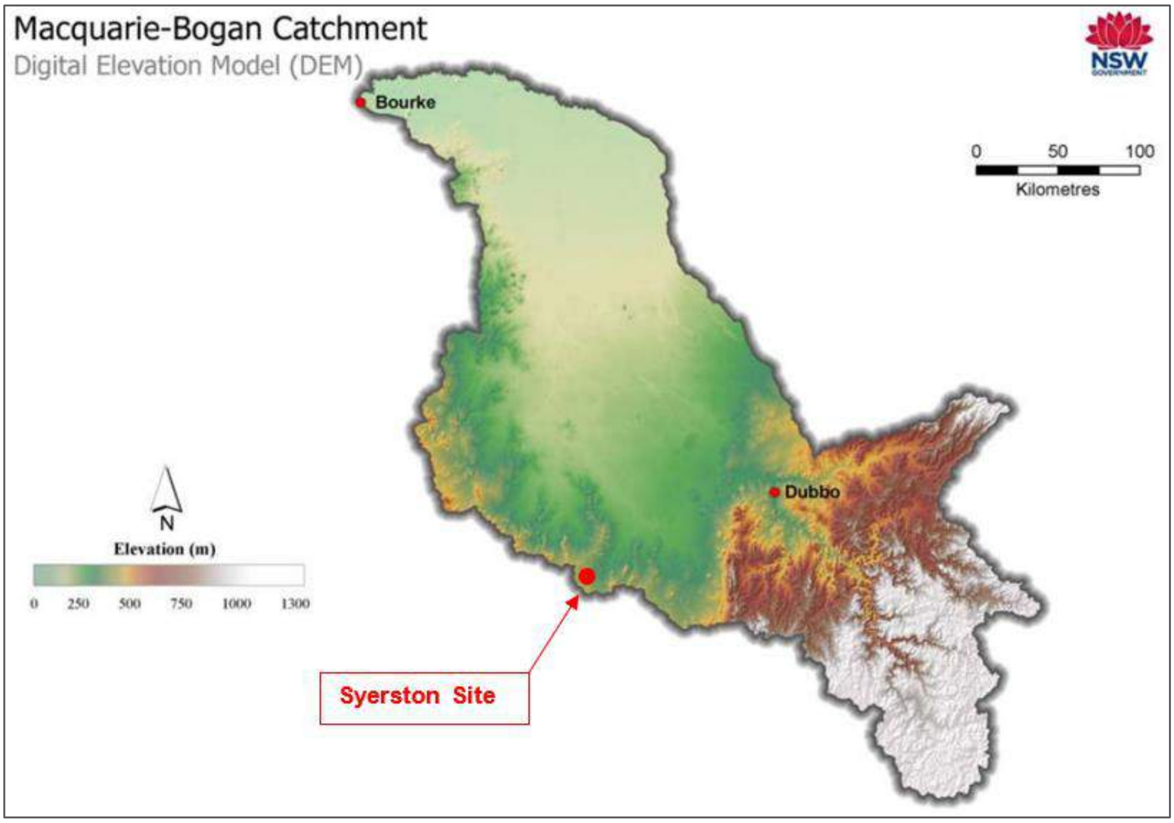


Figure 16: Topography and elevation of the Macquarie-Bogan catchment (Source: Hutchinson and Kesteven, 1998; via Green et al., 2011)

The mine (and processing facility) is situated to the northern side of low lying ridgeline which separates the Macquarie-Bogan catchment from the Lachlan catchment to the south. The topography of the proposed mining lease area consists of gentle to moderate sloping grazing and farming land which generally slopes towards the north-east. Elevations across the mine (and processing facility) area vary from 326 mRL in the south to 274 mRL to the north-east.

Remnant magnesite mining features are present in the north-east corner of the mine site, altering the natural topography with spoil piles and shallow pits.

4.1.3 Streamflow

4.1.3.1 Macquarie-Bogan catchment

The mine (and processing facility) is located within the Macquarie-Bogan catchment which covers an area of approximately 74 800 km^2 within the Murray-Darling Basin. Regional north-west-flowing rivers (Bogan, Macquarie, Castlereagh, Namoi and Barwon) drain an extensive floodplain north of the site. The mine is situated in the upper headwaters of Bullock Creek in proximity to the township of Tullamore to the north-east and the headwaters of the Lachlan catchment to the south.

The NSW Office of Water operates 91 river flow gauging stations within the Macquarie-Bogan catchment recording flows on a continuous basis, with 6 stations located along the Bogan River. Flows along the Bogan River generally increase with distance downstream as a result of regulated water supplies entering from Albert Priest Canal, Gunningbar Creek and Duck Creek.

There are no gauging stations in close proximity to the Project. Peak Hill gauging station is located on the Bogan River 60 km upstream of the confluence of Bullock Creek and Dandaloo gauging station located on the Bogan River 20 km downstream of the confluence of Bullock Creek. Mean daily flow records for gauging stations along the Bogan River are provided as an indication of regional measured river flow relative to catchment area (refer to Table 10).

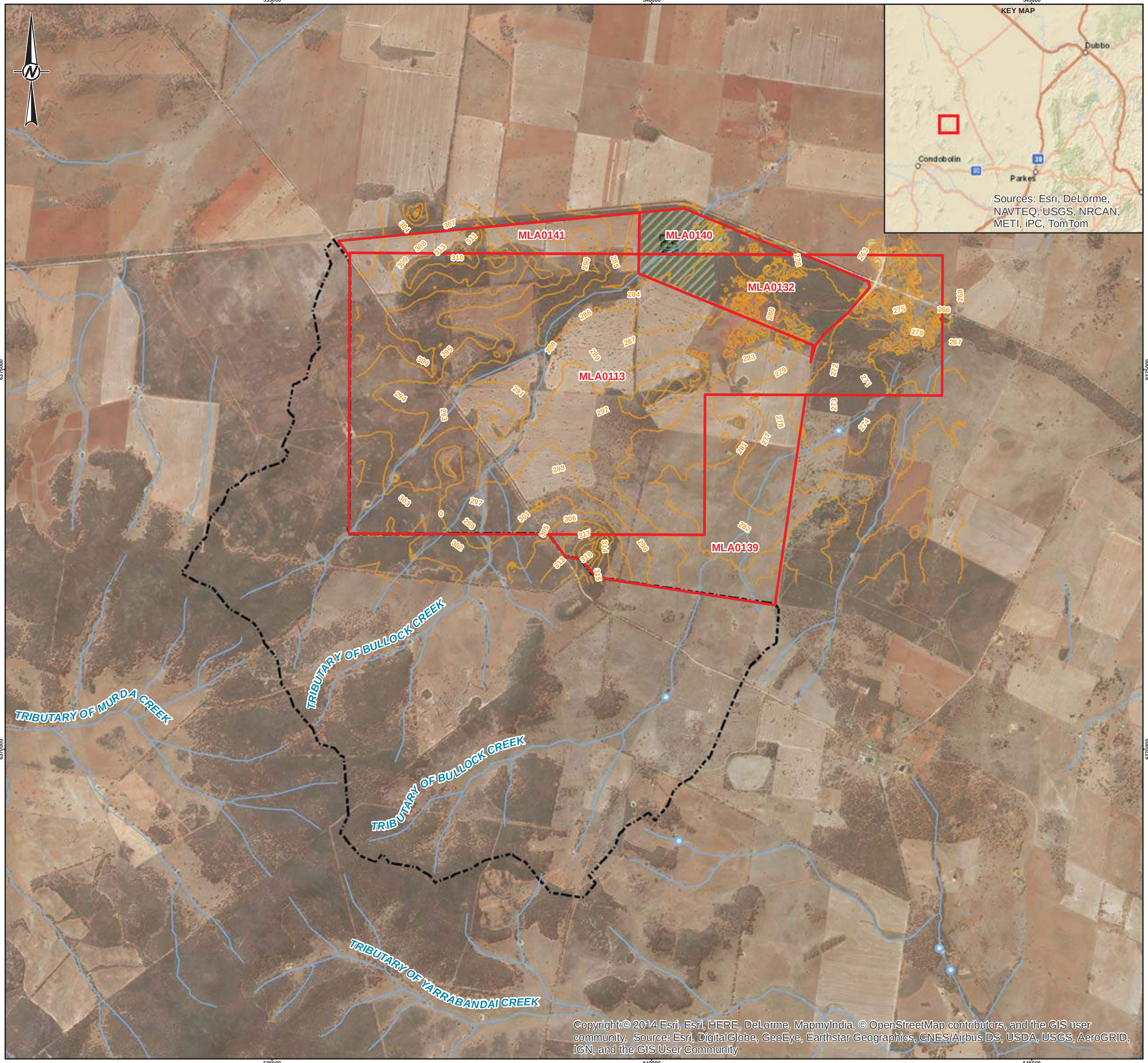
Table 10: Mean daily flow for selected Bogan River gauges

Gauging Station	Catchment Area (km^2)	Mean Daily Flow (ML)	Distance from Bullock Creek Confluence (km)	Period of Record
Upstream of Bullock Creek Confluence				
Peak Hill	1 036	57	60	1967 - 2017
Downstream of Bullock Creek Confluence				
Dandaloo	5 440	174	20	1971 - 2017
Neurie Plain	14 760	221	100	1959 - 2017
Gongolgon	27 970	532	280	1945 - 2017

Two small catchment areas (approximately 2 700 ha and 1 950 ha, respectively) to the south-west, contribute to two ephemeral watercourses which cross the mine area as shown in Figure 17.

The northern watercourse discharges into Bullock Creek to the north-east which flows north-easterly and then discharges to the Bogan River (Figure 1). The southern watercourse loses definition north-east of the site due to a combination of flat terrain and interruption by remnant mining operations in the area.

Watercourses in the location of the mine (and process facility) are shallow broad vegetated ephemeral channels and as such are not suitable for flow monitoring. There are also no gauging stations maintained on Bullock Creek.



LEGEND

- Mining Lease Application Boundary
- Syerston catchment upgradient of mining lease boundary
- Fifield State Forest
- Waterhole
- Mapped Stream
- Major Elevation Conour

0 1,000 2,000

Meters

1:50,000 METRES

NOTE(S)

REFERENCE(S)

CLIENT

SYERSTON NICKEL COBALT PROJECT
SCANDIUM OXIDE MODIFICATION

PROJECT

PHASE 5000 MOD EA AMMENDMENT

TITLE

TOPOGRAPHY AND HYDROLOGY

CONSULTANT

Golder Associates

YYYY-MM-DD	1/08/2017
DESIGNED	TR
PREPARED	KS
REVIEWED	MH
APPROVED	MH

PROJECT NO.	CONTROL	REV.	FIGURE
1524361	039	2	17

4.1.3.2 Lachlan River catchment

The proposed water supply intake is to be located at approximately 33.27°S and 147.53°E consisting of a combined southern borefield and Lachlan River surface water intake; drawing water from the Lachlan Formation groundwater system and Lachlan River.

The Lachlan River catchment occupies an area of around 90 000 km^2 within the Murray-Darling Basin and flows from the Great Dividing Range in the east and terminating at the Great Cumbung Swamp in the west. Water in the catchment is regulated by Wyangala Dam located in the upper headwaters of the Lachlan River (approximately 150 km upstream from the proposed water supply offtake). The Lachlan River flows north-west from Wyangala Dam towards the town of Forbes where it reaches its maximum capacity due to several tributaries entering the Lachlan River within this reach. The proposed bore intake is located approximately 50 km west of Forbes. Downstream of Forbes, the river divides into a number of meandering creeks across a flood plain, reforming as a single continuous river channel downstream of Condobolin.

The NSW Office of Water operates around 100 flow gauging stations within the Lachlan River catchment which record flows on a continuous basis. Due to the complex stream system along the reach between Forbes and Condobolin (downstream of the proposed water supply offtake), there is a lack of continuous and real-time flow gauging station data. Mean daily flow records for selected gauging stations along the Lachlan River are provided in Table 11.

Table 11: Mean daily flow for selected Lachlan River gauges

Gauging Station	Catchment Area (km^2)	Mean Daily Flow (ML)	Distance from Water Supply Intake (km)	Period of Record
Upstream of Intake				
Forbes Cottons Weir	19 000	3 176	40	1892 - 2017
Jemalong Weir	19 400	2 915	20	1941 - 2017
Downstream of Intake				
Condobolin Bridge	25 200	1 640	50	1896 - 2017
Lake Cargelligo Weir	45 800	2 041	130	1910 - 2017

4.1.4 Surface water quality

4.1.4.1 Macquarie-Bogan catchment

The mine site is located within the Upper Bogan River Water Region that is administered by the Macquarie Bogan Unregulated and Alluvial Water Sources WSP. Environmental flows and water quality targets in this river system are regulated. Cease to pump rules apply when the river flow falls below a designated level.

Water Quality Objectives (WQOs) have been developed for NSW rivers and estuaries which provide guideline levels to assist water quality planning and management (NSW Government, 2006). WQOs with accompanying trigger values apply to the following objectives: aquatic ecosystems, visual amenity, recreation, livestock and irrigation, drinking water, and aquatic foods.

Surface water quality data is available for the three proximate NSW Office of Water gauging stations downstream of the mine (and processing facility) site along the Bogan River. The most complete (1970 to present) and regular (monthly) monitoring occurs at Gongolgon gauging station (421023), with only limited data available for remaining sites.

Regularly recorded parameters include: anions and cations, acidity and alkalinity, nutrients, total suspended solids (TSS) and total dissolved solids (TDS). Background TSS levels are shown in Figure 18 and do not exceed 100 mg/L at this location for the sampling events.

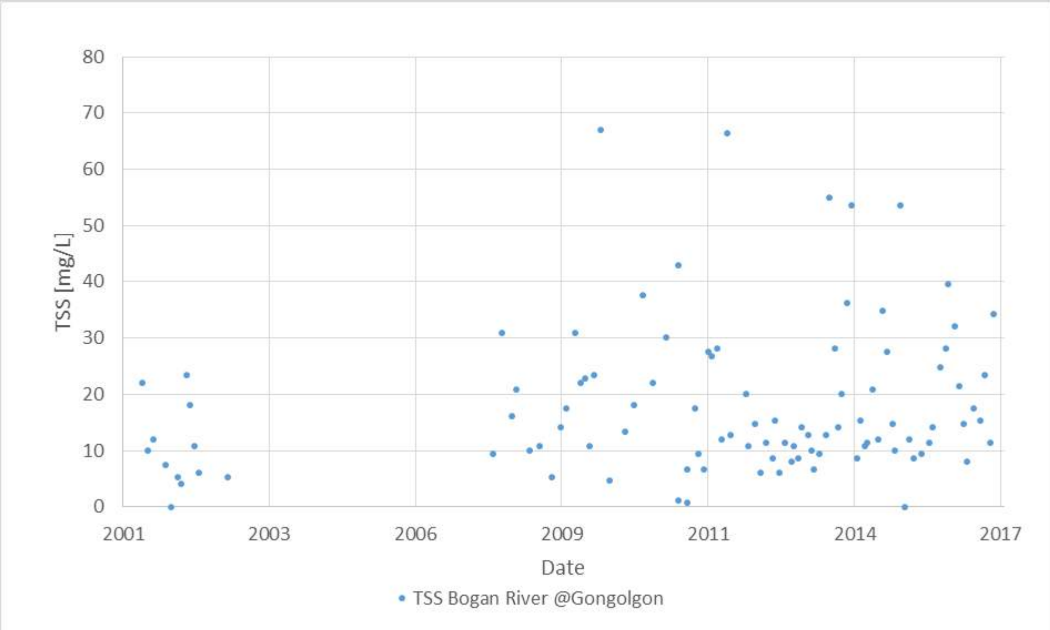


Figure 18: Background total suspended solids (at 105°C) at Gongolgon

Figure 19 shows historical TDS levels at Gongolgon gauging station alongside the Australian Drinking Water Guidelines (ADWG) relevant guideline recommended TDS for ‘good palatability’. No specific health guideline value is provided for TDS under the ADWG, as there are no health effects directly attributable to TDS. For rural industries, ANZECC/ARMCANZ guidelines recommend TDS concentration tolerance levels for livestock ranging from 2 000-5 000 mg/L, and NSW Government recommendations state that salinity levels greater than 670 mg/L can cause problems for the irrigation of some crops and can damage aquatic ecosystems at higher concentrations. Recorded TDS levels generally fall below all relevant recommended levels.

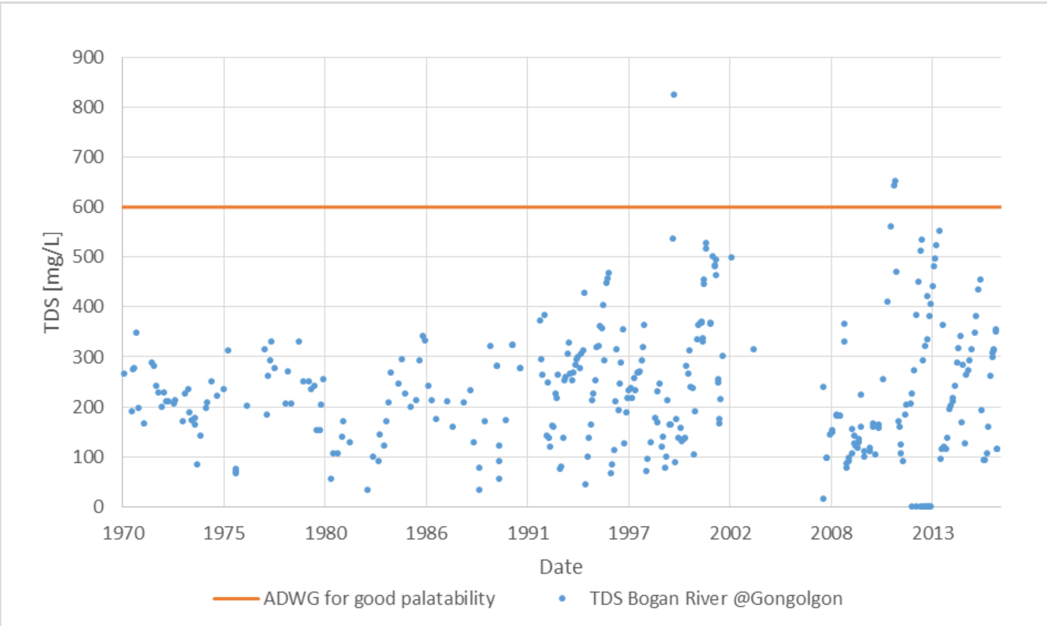


Figure 19: Historical total dissolved solids at Gongolgon versus relevant guidelines

Surface water quality data is not available in the vicinity of Bullock Creek or in close proximity to the mine site (that is the ephemeral watercourses). Accordingly, the Project will reference the low-risk default trigger values applicable to slightly disturbed upland river ecosystems in NSW from the ANZECC/ARMCANZ guidelines, as shown in Table 12 and Table 13. These values are derived from using the 80th and/or 20th percentile of the reference data.

Table 12: ANZECC/ARMCANZ default trigger levels for slightly disturbed aquatic ecosystems in NSW

Ecosystem type	Chlorophyll a	Total Phosphorus	FRP	Total Nitrogen	NOx	Ammonium	Dissolved Oxygen		pH	
							% saturation			
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Upland River	N/A	20	15	250	15	13	90	110	6.5	7.5

Trigger values for toxicants at alternative levels of protection are also specified in the ANZECC/ARMCANZ guidelines. Using the 95% level of protection to derive trigger levels for these toxicants is considered to be a conservative approach. Table 13 lists the default trigger values for chemical toxicants at the 95% level of protection in slightly to moderately disturbed ecosystems.

Table 13: ANZECC/ARMCANZ default trigger levels for toxicants at alternative levels of protection

Chemical	Trigger values for freshwater (µg/L)
	95% Level of protection
Aluminium	55
Arsenic (III)	24
Arsenic (V)	13
Boron	370
Cadmium	0.2
Chromium (III)	3.3
Chromium (VI)	1.0
Cobalt	1.4
Copper	1.4
Iron	300
Lead	3.4
Manganese	1 900
Mercury (inorganic)	0.06[1]
Nickel	11.0
Silver	0.05
Vanadium	6.0
Zinc	8.0

[1] This values is derived from the 99% level of protection which correlates to slightly to moderately disturbed ecosystems.

4.1.4.2 Lachlan River catchment

Surface water sampling was undertaken by Coffey Geosciences Pty Ltd (Coffey) on 27 November 1999 and 15 August 2017 (see Appendix B) at sampling locations indicated in Table 14. Samples were tested at NATA accredited laboratories and results presented in reports Coffey (2000 and 2017).

Table 14: Surface water sample coordinates

Date of Sample	Surface Water ID	Latitude	Longitude	Distance from Intake
27 November 1999	RIVER	33.33 S	147.58 E	8 km upstream
15 August 2017	LR1	33.27 S	147.53 E	0 m (at proposed intake)

Reported concentrations are compared to Australian drinking water guidelines (2011) and trigger values for 95% protection of freshwater ecosystems (ANZECC, 2000). The following analytes were found to exceed defined trigger values:

- 1999: Copper, gold, manganese and total phosphorus.
- 2017: EC, aluminium, copper, iron and total phosphorus.

4.1.5 Surface water users

4.1.5.1 Macquarie-Bogan catchment

The extraction of surface and groundwater within the Macquarie-Bogan catchment is controlled by the Water Sharing Plan for the Macquarie-Bogan Unregulated and Alluvial Water Sources, as discussed in Section 3.3.1.1. The Syerston site falls within the Upper Bogan River water source of the catchment. The total extraction entitlements for surface water users within the Upper Bogan water source under various access licence types is provided in Table 15.

Table 15: Upper Bogan water extraction entitlements (WSP July 2016)

Access licence type	Total Upper Bogan share component	Total Macquarie-Bogan share component
Domestic and stock	155 ML/year	1 952 ML/year
Local water utility	32 ML/year	40 327 ML/year
Unregulated river	1 553 unit shares	113 358 unit shares
Unregulated river (special additional high flow)	1 082 unit shares	44 501 unit shares

Local surface water user data was sourced from the NSW Office of Water (September, 2017). At the time of this information request, there are no licenced surface water users within 10 km radius of the mine area. As noted in Section 3.3.4, landholders in most NSW rural areas are allowed to collect a proportion of the rainfall runoff on their property without requiring a licence. There are a number of small farm dams to the north of the Project site.

4.1.5.2 Lachlan River catchment

The extraction of surface water within the Lachlan River catchment is controlled by the Water Sharing Plan for the Lachlan Regulated River Water Source, as discussed in Section 3.3.1.4. The Project proposes to extract water from the Lachlan River. The total extraction entitlements for surface water users within the Lachlan Regulated River water source under various access licence types is provided in Table 16.

Table 16: Lachlan River water extraction entitlement (WSP, July 2016)

Access licence type	Total Lachlan Regulated River Water Source share component
Domestic and stock	12 502 ML/year
Local water utility	15 545 ML/year
Regulated river (high security)	27 680 unit shares
Regulated river (general security)	592 801 unit shares
Regulated river (conveyance)	17 911 unit shares
Supplementary	N/A

4.2 Hydrogeology

4.2.1 Local geology

Previous hydrogeological investigations have encountered the following geological formations within the Project site: Laterite, Ultrabasic intrusive rocks (pyroxenite, gabbro, diorite), and residual soils/alluvial (Golder, 2000a). Figure 20 shows a typical hydrogeological cross section AA' (refer to Figure 21 for location).

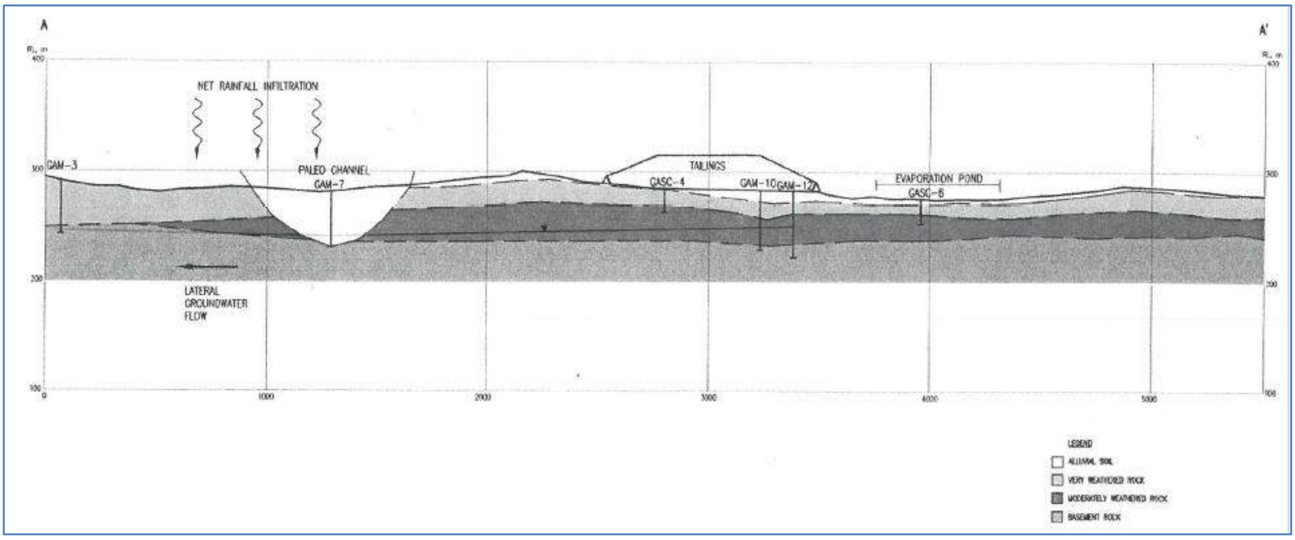


Figure 20: Representative hydrogeological cross section (EIS, 2000, Volume 2)

The mine site comprises generally the Cowra Formation which disconformably overlies the Lachlan Formation. Cowra formation comprises clay, silt and gravel. The Lachlan Formation consists of sand, fine to medium gravel, with minor silt and clay unit (Coffey, 2016).

The Girilambone group forms the basement rock of the mine site and surroundings. The bedrock is mostly dominated by fine quartz sandstone, siltstones and shale, mostly metamorphoses to quartzite, phyllite and schist (EIS, 2000, Volume 1).

The mine site is formed predominantly of an oblate Dunite core intrusion approximately 2 km north-south by 3 km east-west which is surrounded by ultramafic and mafic rocks (gabbro, diorite and olivine pyroxenite) and laterite (EIS, 2000, Volume 1). Residual soil/alluvials covers up to 2 m of low lying area of the Project site (Golder, 2000g). The paleochannel passes through the mine site in a north-easterly direction, encountered in boreholes GAM7, GAM9, GAM13 and GAM16 (refer to Figure 20 and Figure 21). The paleochannel is up to 1 500 m wide and 35 m below ground level and comprises silts, clays, gravels, quartz and rock fragments (Golder, 2000g). The channel materials appear to have hydraulic parameters similar to the surrounding subsurface and can therefore be represented by the same materials – surface alluvium, highly weathered rock, and slightly weathered rock.

Syerston is a Type C nickel laterite deposit classified as oxide deposits dominated by iron-hydroxides. The deposit contains resource grade nickel and cobalt mineralisation within the Laterite profile overlying the Dunite core intrusion (EIS, 2000, Volume 1).

4.2.2 Local hydrogeology

Three aquifers have been encountered on the Syerston site (Golder, 2000a):

- In the more fractured basement rocks
- Where saturated gravel/sand was encountered in the paleochannel (one monitoring bore only)
- In the siliceous cap-rock over the dunite intrusion.

Two recent surveys of the monitoring bores on site have been conducted (December 2016 and June 2017) to measure groundwater levels at the groundwater monitoring bores on site (Table 17) and to install groundwater level data loggers in those bores. Site monitoring bore locations are displayed in Figure 21.

Both periods showed similar interpreted groundwater contours and groundwater flow directions as shown in Figure 22 and Figure 23. Generally, groundwater levels are 30 to 60 m below ground level and follow surface topography, being highest in the western area of the site. It is inferred that groundwater flow enters the site from the west and then flows either south-east towards the paleochannel or north-east following the drop in topography. A groundwater divide is interpreted to exist beneath the topographical ridge in the (centre) eastern area of the site.

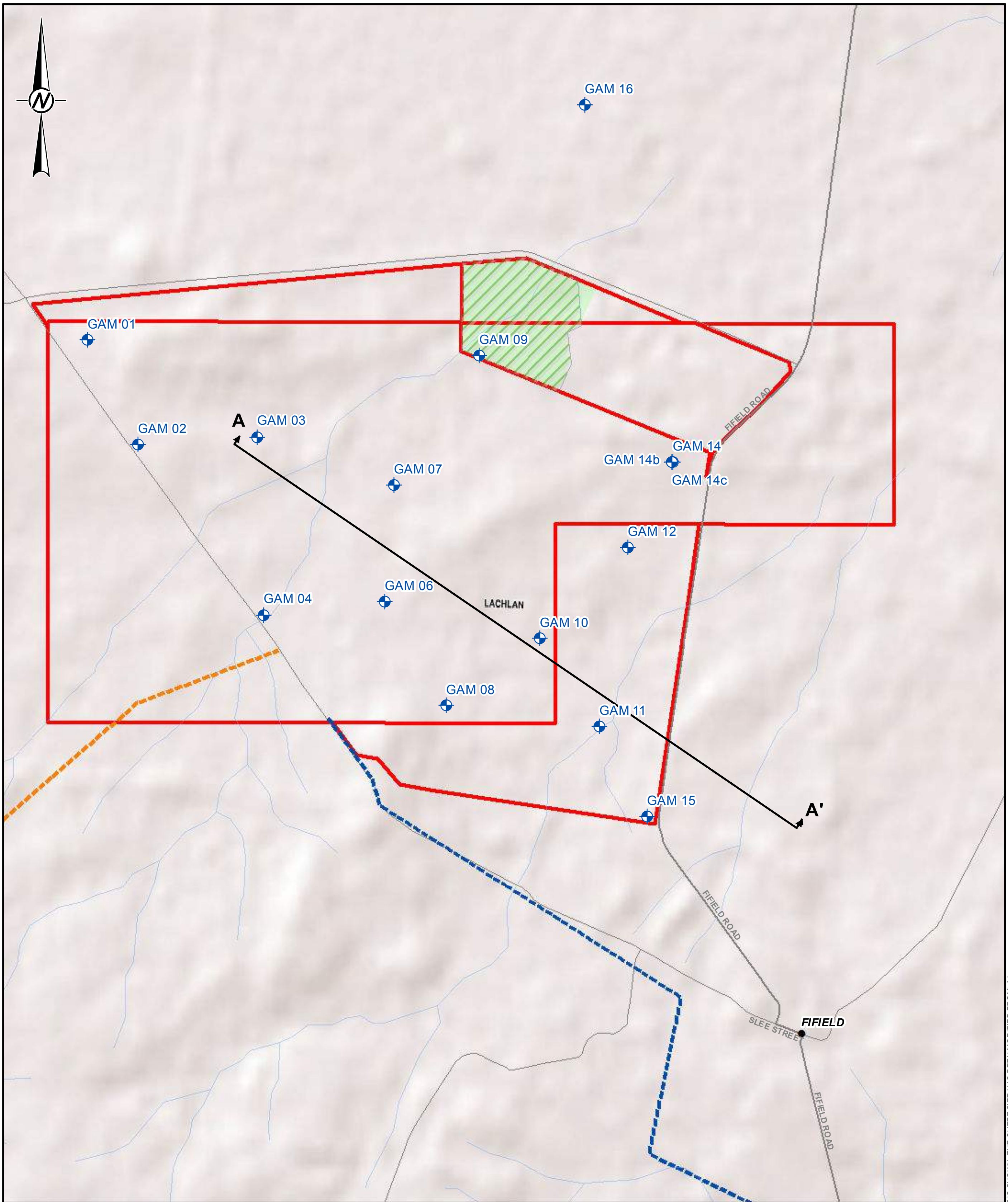
Water samples were not collected during the recent surveys. As such, the understanding of groundwater salinity across the site is based on the water quality data analysis from Golder (2000a) which shows that groundwater is fresh in the north-west area of the site, brackish in and near the centre of the site and saline in the south-east area of the site. Anderson's Pit is located outside the north-east corner of the site and contains fresh water due to surface water runoff.

Table 17: Standing water levels - December 2016 and June 2017

Bore ID	Easting (m) GDA 94	Northing (m) GDA 94	SWL-Dec 2016 (m AHD*)	SWL-Dec 2016 (m BGL**)	SWL-Jun 2017 (m AHD)	SWL-Jun 2017 (m BGL)	SWL Change (m)
GAM 01	536 383	6 376 352	272.87	27.70	276.38	24.19	3.51
GAM 02	536 851	6 375 388	268.64	31.02	268.97	30.69	0.33
GAM 03	537 953	6 375 460	247.28	45.39	247.73	44.94	0.45
GAM 04	538 007	6 373 817	263.73	28.34	264.13	27.94	0.40
GAM 06	539 132	6 373 939	249.14	44.90	249.67	44.37	0.53
GAM 07	539 211	6 375 016	-	-	242.55	46.02	N/A
GAM 08	539 695	6 372 982	244.38	48.68	248.58	44.48	4.20
GAM 09	540 003	6 376 210	237.98	40.97	238.69	40.26	0.71
GAM 10	540 563	6 373 602	249.53	32.93	249.82	32.64	0.29
GAM 11	541 109	6 372 792	241.86	39.30	242.32	38.84	0.46
GAM 12	541 376	6 374 443	250.31	29.46	251.99	27.78	1.68
GAM 14	541 787	6 375 224	243.8	38.38	244.59	37.59	0.79
GAM 14b	541 782	6 375 225	231.28	51.01	232.3	49.99	1.02
GAM 14c	541 776	6 375 225	250.88	31.60	250.63	31.85	-0.25
GAM 15	541 551	6 371 961	239.12	54.45	239.68	53.89	0.56
GAM 16	540 976	6 378 523	216.19	55.96	216.79	55.36	0.60

*Note: * m AHD refers to metres Australian Height Datum*

*** mBGL refers to metres below ground level*



LEGEND

- GAM Monitoring Bores
- Mining Lease Application Boundary
- Hydrogeological Cross Section
- Approved Gas Supply Pipeline
- Approved Water Supply Pipeline
- Limestone Quarry

REFERENCE

Basemaps sourced from Esri Online Basemaps.
Road & Property © New South Wales, Spatial Services, 2015.
Water © Commonwealth of Australia, Bureau of Meteorology, 2014.

0 250 500 1,000 1,500 2,000 Metres

REFERENCE SCALE: 1:50,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
SYERSTON NICKEL COBALT PROJECT
SCANDIUM OXIDE MODIFICATION

PROJECT
PHASE 5000 MOD EA AMENDMENT

TITLE
MPF MONITORING BORE LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-28
PREPARED	KS / AFE
DESIGN	-
REVIEW	MH
APPROVED	MH

PROJECT	CONTROL	REV.	FIGURE
1524361	039-R	2	21

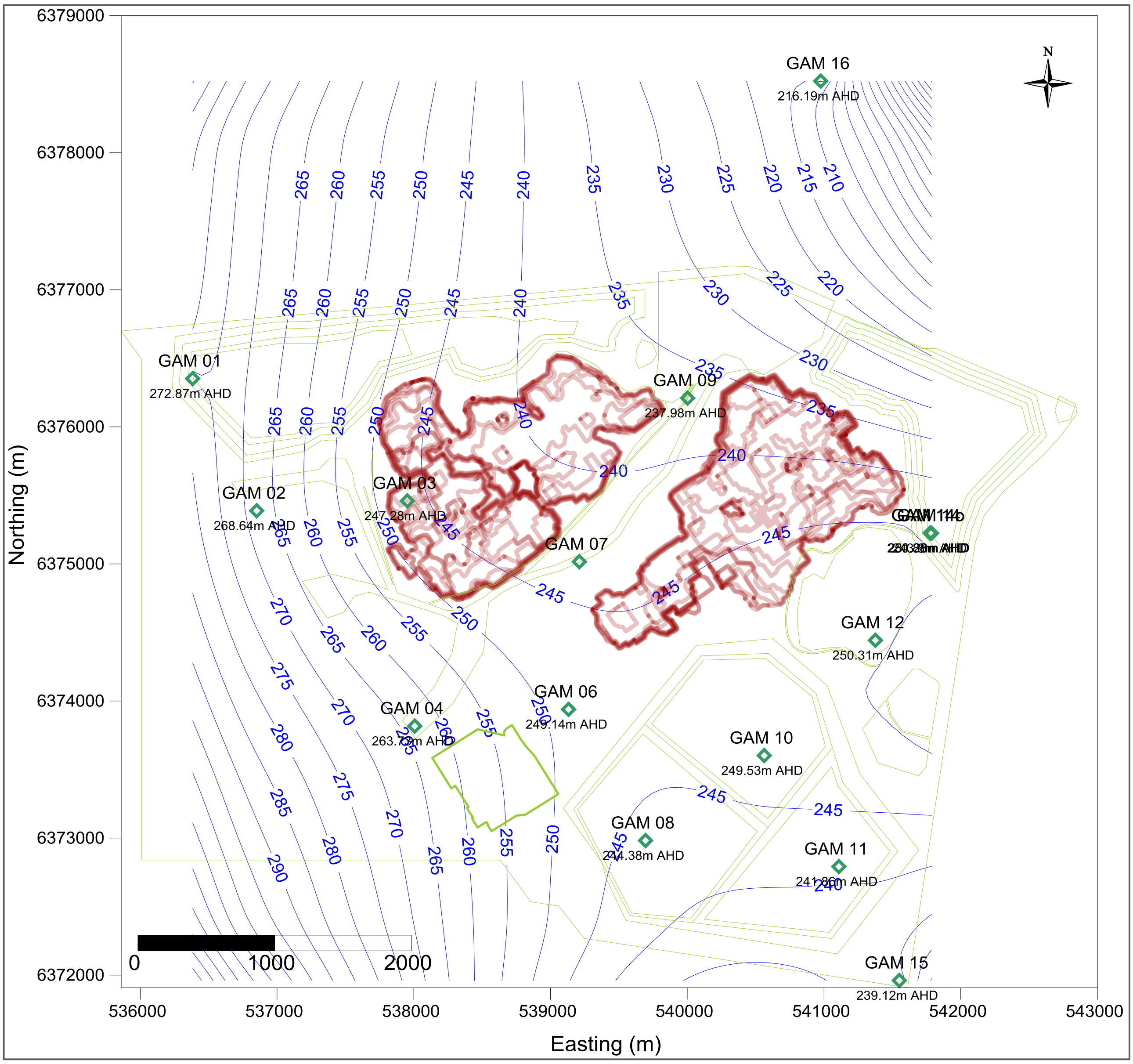


Figure 22: Groundwater level contours December 2016

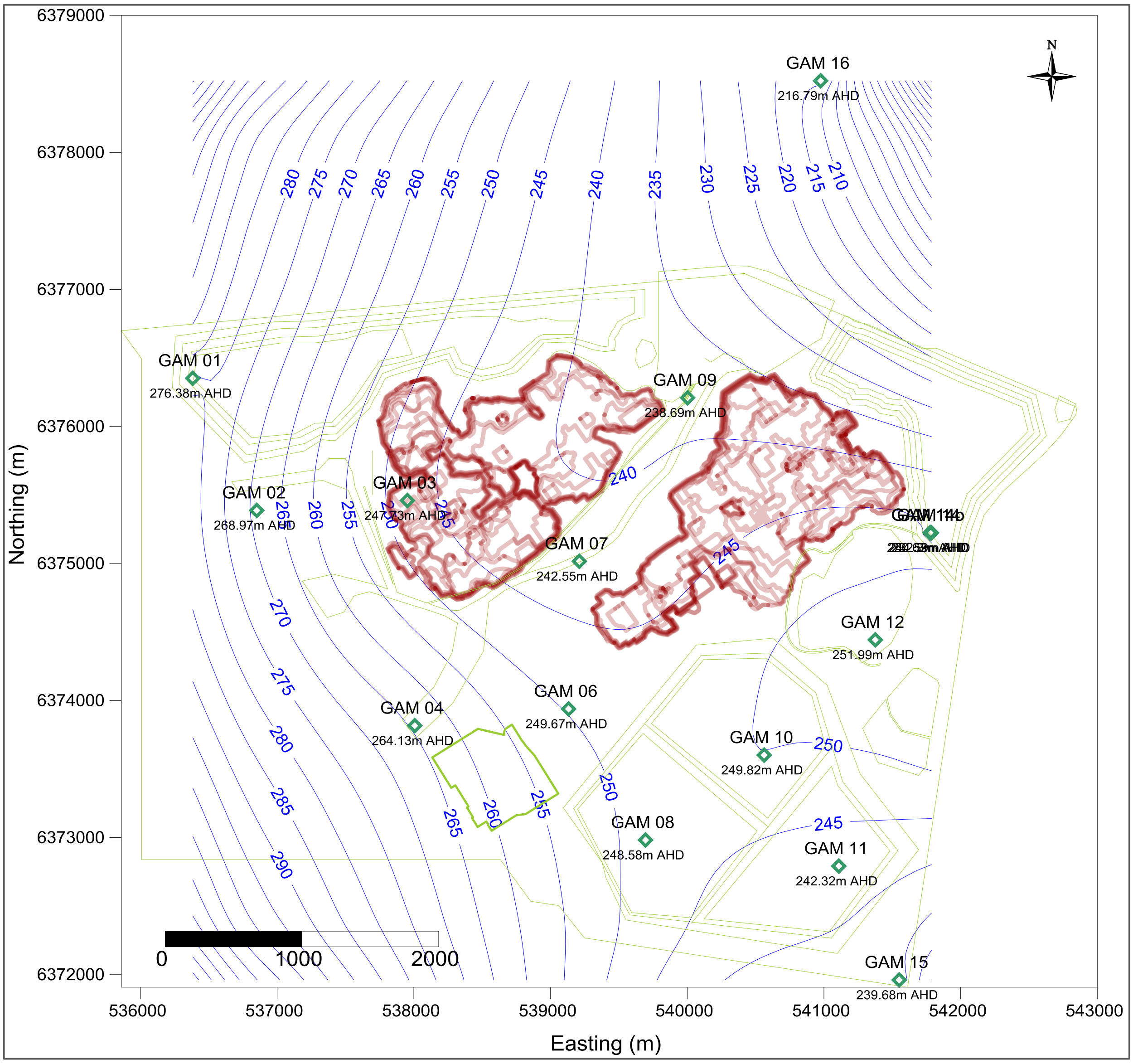


Figure 23: Groundwater level contours June 2017

The installation of automated data loggers (insitu, Rugged TROLL 100 series) for long-term groundwater monitoring was conducted in sixteen bores in June, 2017. A summary of logger installation is provided in Table 18.

Table 18: Summary of automated data logger installation – June, 2017

Bore ID	Installation Date	Data Logger Serial Number	SWL (mBTOC[1])	Approximate Logger Installation Depth (mBTOC)
GAM01	15/06/2017	S/N 449457	24.82	30.20
GAM02	15/06/2017	S/N 538811	31.33	36.00
GAM03	15/06/2017	S/N 518769	45.57	47.50
GAM04	14/06/2017	S/N 519089	28.57	33.00
GAM06	14/06/2017	S/N 518517	44.93	50.00
GAM07	15/06/2017	S/N 516190	46.65	51.00
GAM08	13/06/2017	S/N 518772	45.12	50.00
GAM09[1]	13/06/2017	S/N 518774	40.91	47.00
GAM10	13/06/2017	S/N 518511	33.28	38.00
GAM11	13/06/2017	S/N 516183	39.48	44.00
GAM12	13/06/2017	S/N 518509	28.41	33.50
GAM14A	13/06/2017	S/N 516182	38.21	43.00
GAM14B	13/06/2017	S/N 518528	50.60	55.50
GAM14C	13/06/2017	S/N 518762	32.47	37.00
GAM15	13/06/2017	S/N 515821	54.52	56.50
GAM16	13/06/2017	S/N 518756	56.01	61.00

Note: - 1 –mBTOC- meters below top of casing,
Baro troll (S/N 519712) was installed at GAM09

Hydraulic testing (falling head) was undertaken to estimate the hydraulic conductivity of the subsurface profile at six existing monitoring bores (GAM06, GAM07, GAM09, GAM11, GAM12 and GAM15) from 13th June 2017 to 15th June 2017. Data obtained through the falling head tests was analysed using AQTESOLV. Saturated hydraulic conductivities were calculated from the falling head test data for each bore (Table 19).

Table 19: Summary of estimated saturated hydraulic conductivity from falling head tests

Bore ID	Estimated K (m/s) & Solution Method				Average K (m/s)	Test Interval (mbGL)	Aquifer Thickness (m)	Formation Tested
	Bouwer-Rice	Hvorslev	KGS	Barker-Black				
GAM06	$1.8x10^{-6}$	$2.3x10^{-6}$	$2.2x10^{-6}$	$1.4x10^{-6}$	$1.9x10^{-6}$	51.4 to 57.4	13.14	Pyroxenite, fesh rock, some veining
GAM07	$5.6x10^{-7}$	$7.4x10^{-7}$	$9.6x10^{-7}$	$3.6x10^{-7}$	$6.6x10^{-7}$	51.0 to 57.0	10.27	Pyroxenite, slightly weathered
GAM09	Not analysable (high K)							Pyroxenite, extremely to slightly weathered
GAM11	$2.4x10^{-7}$	$2.9x10^{-7}$	$2.7x10^{-7}$	$1.5x10^{-7}$	$2.4x10^{-7}$	54.0 to 60.0	22.10	Pyroxenite, slightly weathered
GAM12	$9.8x10^{-9}$	$1.1x10^{-8}$	$1.1x10^{-8}$	$5.5x10^{-9}$	$9.3x10^{-9}$	50.8 to 56.8	29.59	Gabbro fresh rock
GAM15	$1.6x10^{-6}$	$1.8x10^{-6}$	$1.8x10^{-6}$	$5.2x10^{-7}$	$1.4x10^{-6}$	64.7 to 70.7	16.85	Pyroxenite, slightly weathered

4.2.3 Groundwater resources

Previous hydrogeological desktop studies identified potential local groundwater resources available within the Syerston site and the area within approximately 3 km of the Syerston site, and regional groundwater resources within 20 km of the Syerston site (Golder, 2015).

With the exceptions of GAM01 and possibly GAM09, hydraulic testing of groundwater monitoring bores suggested that hydraulic conductivities are very low and the potential yield of the fractured rock aquifer may be minimum (on the order of 0.1 L/s or less). GAM1 had a reported airlift yield of 1.3 L/s (Golder, 2000g). Yield testing of GAM9 is being undertaken in late 2017.

Regionally, nine bores are reported (NSW Groundwater Database) within the region yield exceeding about 1 L/s, with most from 1-2 L/s. The relatively high-yield bores are located approximately 10 to 20 km from the mine site, with groundwater being sourced primarily from fractured rock aquifers.

4.2.4 Groundwater users near the mine site

The following land use has been identified between the mine (including processing facility) and the borefield location (Australian Government National Map, 2016):

- Production Forestry
- Cropping
- Grazing modified pasture
- Other minimal use
- Land in transition.

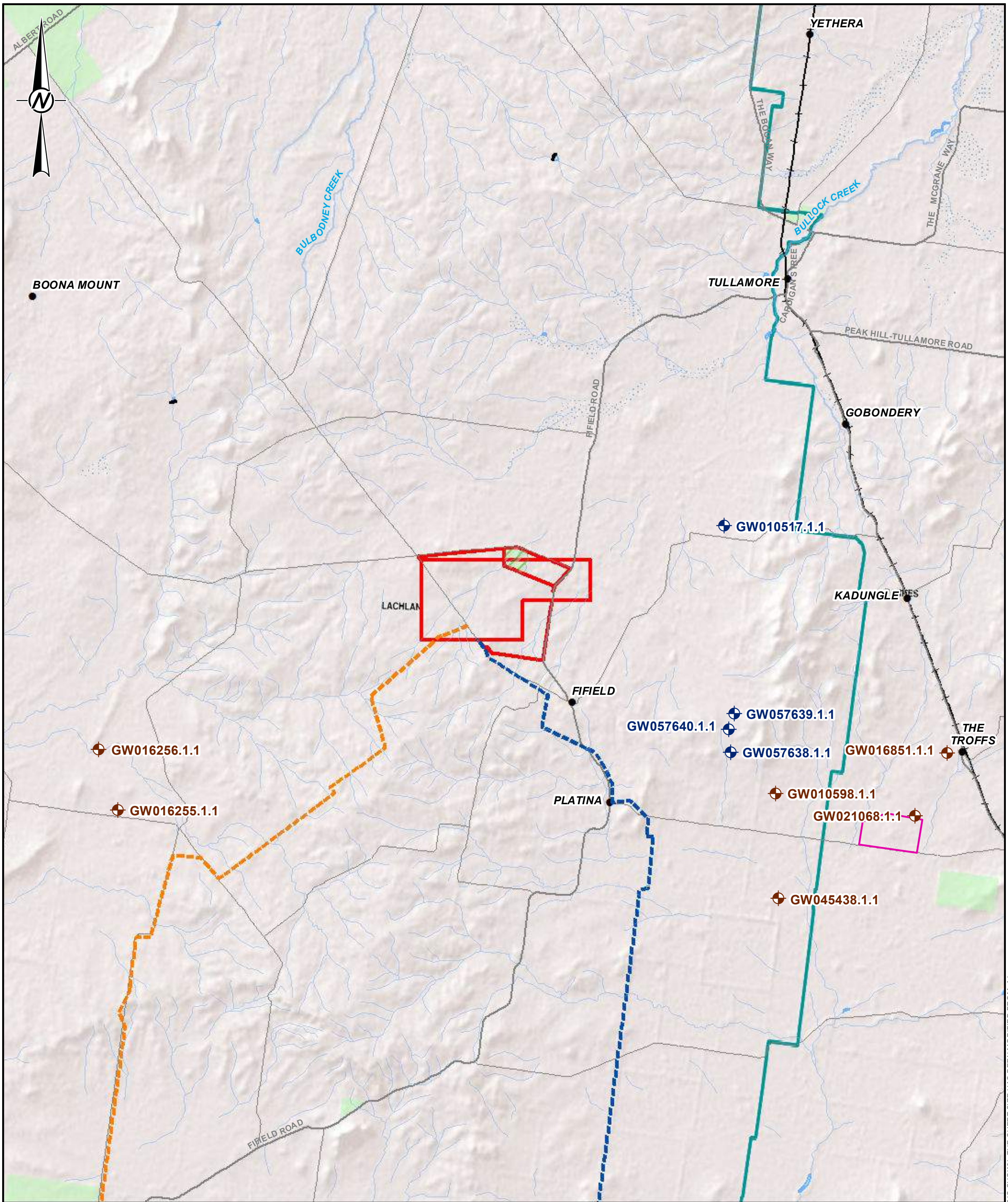
Farmers are likely to use some groundwater for irrigation and/or water supply purpose for their agricultural activities; mainly cropping and grazing. The registered bores usage is outlined in Section 4.2.5.

4.2.5 Registered groundwater bores near the Syerston site

Details of registered groundwater bores, including coordinates, purpose, usage, geology, water levels and salinity measurements, were extracted from the BoM groundwater database. There are 16 registered groundwater bores around the mine (including processing facility) and 177 registered groundwater bores around the borefield, with purpose and usage information including:

- Monitoring
- Stock and domestic
- Water supply
- Irrigation.

Monitoring bores which have recorded information concerning water levels and salinity are shown on Figure 24 (within 20 km of the mine (including processing facility)) and Figure 25 (within 20 km of the borefield). The registered bore closest to the mine (including processing facility), GW010517.1.1, is located approximately 7 km east of site and there are a further three bores within 10 km. There are 32 monitoring bores with recorded information within 10 km of the borefield.



LEGEND

Registered Bores with Water Level or Salinity Information

- Within 10 km of MPF
- Within 20 km of MPF
- Approved Gas Supply Pipeline
- Approved Water Supply Pipeline
- Limestone Quarry
- Mining Lease Application Boundary

REFERENCE

Basemaps sourced from Esri Online Basemaps.
Road & Property © New South Wales, Spatial Services, 2015.
Water © Commonwealth of Australia, Bureau of Meteorology, 2014.

0 1 2 4 6 8 10 Km

REFERENCE SCALE: 1:250,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
SYERSTON NICKEL COBALT PROJECT
SCANDIUM OXIDE MODIFICATION

PROJECT
PHASE 5000 MOD EA AMENDMENT

TITLE
REGISTERED BORES WITH WATER LEVELS AND SALINITY INFORMATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-09-28
PREPARED	KS / AFE
DESIGN	-
REVIEW	MH
APPROVED	MH

PROJECT	CONTROL	REV.	FIGURE
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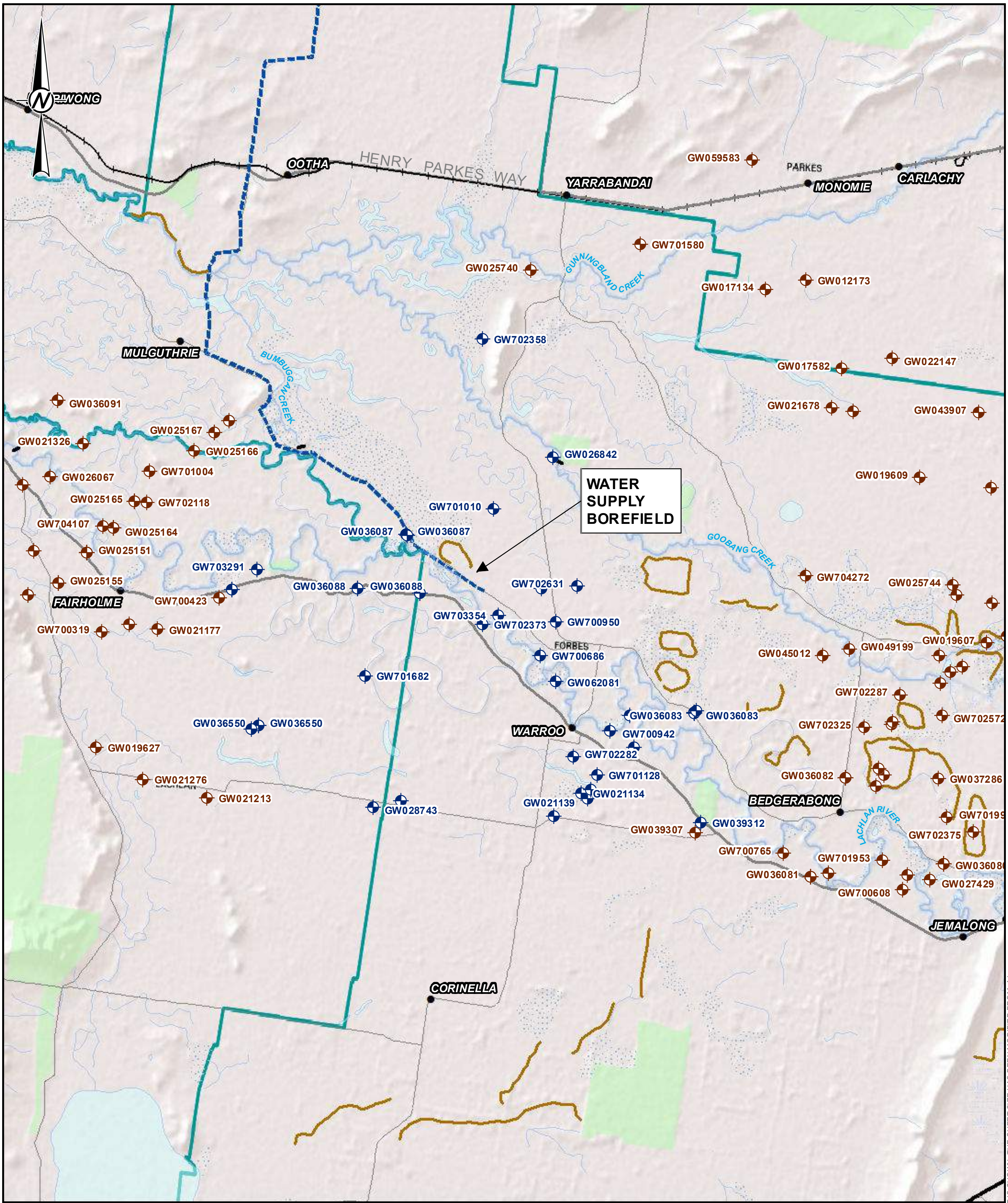

LEGEND

Registered Bores with Water Level or Salinity Information

- Within 10 km of Borefield
- Within 20 km of Borefield
- DamWall
- Levee
- Approved Water Supply Pipeline

REFERENCE

Basemaps sourced from Esri Online Basemaps.
Road & Property © New South Wales, Spatial Services, 2015.
Water © Commonwealth of Australia, Bureau of Meteorology, 2014.

0 1 2 4 6 8 10 Km

REFERENCE SCALE: 1:225,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
SYERSTON NICKEL COBALT PROJECT
SCANDIUM OXIDE MODIFICATION

PROJECT
PHASE 5000 MOD EA AMENDMENT

TITLE
REGISTERED BORES WITH WATER LEVELS AND SALINITY INFORMATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-28
PREPARED	KS / AFE
DESIGN	-
REVIEW	MH
APPROVED	MH

PROJECT	CONTROL	REV.	FIGURE
1524361	039-R	2	25

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5.0 OVERVIEW OF THE APPROVED WATER MANAGEMENT SYSTEM

The purpose of the mine water management system is to control water generated within the Syerston site development and operational areas, as well as divert ephemeral streamflow around these areas. The water management system consists of both temporary structures which will operate during mining operations only and permanent features which will continue to operate post-closure. An overview of the approved management system is provided in Figure 26.

The summary details of the components of the approved water management system are provided in Table 20.

Table 20: Approved water management system components

FACILITY	DETAILS			
Storage facilities	**No. Cells**	**Capacity**	**Unit**	**Area (ha)**
Tailings storage facility	2	46.4	Mm^3	217
Evaporation pond	7	2 420	ML	121
Surge dam	1	1 500	ML	56
Surface water diversions	**Catchment Area (ha)**	**Depth (m)**	**Width (m)**	**Length (m)**
Northern diversion	2 700	1.5 to 1.7	10 to 15	3 500
Southern diversion	1 950	1.5	10	2 450

5.1 Summary of the Approved Water Management System

5.1.1 Tailings storage facility

All mine tailings generated as a result of ore processing were to be stored in a Tailings Storage Facility (TSF) located east of the process plant. The TSF comprised of two cells, a northern and southern cell of total area 217 ha. Tailings were to be pumped to the TSF as a slurry with a solids concentration of approximately 48%. Slurry was to be deposited through a series of spigots located at the perimeter of the cells and a decant pond was to be maintained in the centre of each cell. The TSF design employed an underdrain system which would collect seepage and control the phreatic surface within the cells. Decant water would be piped to sumps outside the perimeter of the TSF embankment which would be pumped back to the TSF or to the evaporation ponds for evaporative disposal.

5.1.2 Evaporation pond

The evaporation pond design consisted of seven contour pond cells contained by 2.5 m high earth embankments located to the immediately east of the TSF. The evaporation pond cells had a combined surface area of 121 ha. Decant water from the TSF cells would be pumped to a sump at the evaporation ponds, from where it would then be distributed to the various evaporation pond cells. When the evaporation pond cells have reached capacity, excess water would be redirected to the surge dam. When the evaporation ponds have spare capacity, stored surge dam water would be pumped back into the evaporation pond cells from the surge dam.

5.1.3 Surge dam

The surge dam was to be located to the immediate north of the TSF with the operational objective to keep the water level as low as possible to ensure available surge capacity for runoff generated from large rainfall events. The base of the surge dam was to be terraced to form four evaporation ponds confined within an 8 m high embankment on the downslope of the dam. The surge dam would provide an approximate storage capacity of 1 500 ML with a 1 m freeboard and a combined surface area of 56 ha. The evaporation pond cells and the surge dam were designed to operate with sufficient freeboard to account for a runoff generated from a 72 hour 0.01% AEP rainfall event.

5.1.4 Surface water diversions

5.1.4.1 Drainage path diversions

Three ephemeral drainage lines which cross the Syerston mine lease area, described in Section 4.1.3, were to be permanently diverted through the site around planned Syerston infrastructure.

The two western drainage lines (on MLA0113 in Figure 17) were to be captured and diverted around the southern and eastern perimeter of the western open cut pit by the Northern Diversion channel, as shown in Figure 26. This diversion was planned to connect back into the natural drainage path downstream of the open cut pit.

The eastern drainage line (on MLA0139 in Figure 17) was to be captured and diverted around the eastern perimeter of the evaporation ponds by the Southern Diversion channel, as shown in Figure 26, and connect back into the existing drainage path before exiting the eastern site boundary.

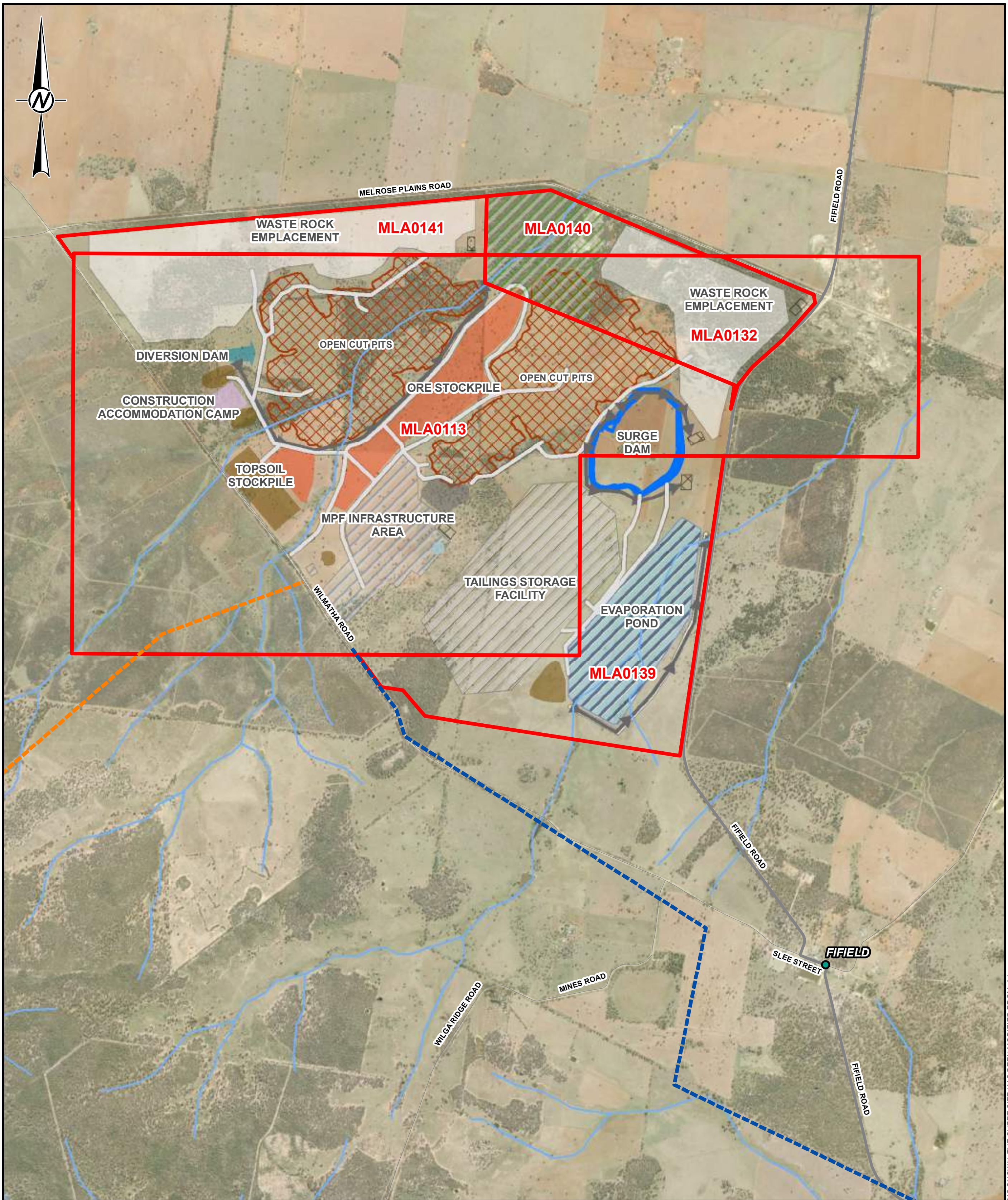
5.1.4.2 Surge dam diversion

The surge dam diversion was located in the east of the Syerston site and was designed to divert water originating within the site upstream of the surge dam around its perimeter to minimise the upslope inflows, as shown in Figure 26.

5.2 Water supply

The main water demand (usage) for the mine (including processing facility) will be associated with the process plant. Other water demand requirements include dust suppression, cooling water and potable and non-potable uses in the mine infrastructure area.

At full production (that is 2.5 Mtpa autoclave feed rate), the total raw water demand for the processing facility was originally estimated and approved to be up to approximately 17.5 ML/d, or an annualised basis, up to 6 387 ML/year. An optimisation study has since been completed by Clean TeQ resulting in the opportunity to increase the efficiency of mining and processing operations, as well as increasing the recycling of water on-site and therefore reducing the water demand from external water supply sources (as discussed in Section 6.2.



LEGEND

- Approved Gas Supply Pipeline
- Approved Water Supply Pipeline
- Diversion Structure
- Key Site Water Pipeline
- MPF Infrastructure Area
- Diversion Dam
- Raw Water
- Evaporation Ponds
- Topsoil Stockpile
- Tailings Storage Facility
- Waste Rock Emplacement
- Ore Stockpile
- ROM Pad
- SD
- Construction Accommodation Camp
- Mining Lease Application Boundary

REFERENCE

Basemaps sourced from Esri Online Basemaps.
Road & Property © New South Wales, Spatial Services, 2015.
Water © Commonwealth of Australia, Bureau of Meteorology, 2014.

0 250 500 1,000 1,500 2,000 Metres

REFERENCE SCALE: 1:50,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
SYERSTON NICKEL COBALT PROJECT
SCANDIUM OXIDE MODIFICATION

PROJECT
PHASE 5000 MOD EA AMENDMENT

TITLE
APPROVED MINE LAYOUT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-01
PREPARED	KS / AFE
DESIGN	-
REVIEW	MH
APPROVED	MH

PROJECT	CONTROL	REV.	FIGURE
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6.0 MODIFICATION 4 WATER MANAGEMENT SYSTEM

6.1 Summary Modification 4 water management system

The Modification 4 Water Management System is shown in Figure 6.

The components of the approved water management system are provided in Table 21.

Table 21: Water management system components

FACILITY	**DETAILS**			
Storage facilities	**No. Cells**	**Capacity**	**Unit**	**Area (ha)**
Tailings Storage Facility	3	62.7	Mm^3	310
Evaporation pond	2	185	ML	27
Water storage dam	1	1 720	ML	58
Surface water diversions	**Catchment Area (ha)**	**Depth (m)**	**Width (m)**	**Length (m)**
Northern diversion	2 700	1.0 to 2.4	12 to 16	3 600
Southern diversion	1 950	2.0 to 2.7	15	3 000

6.1.1 Tailings storage facility

All tailings generated in the process plant will be pumped to and stored in the TSF located north east of the process plant. The TSF comprised of three cells, northern, southern and eastern, with total footprint area of 380 ha. Tailings will be pumped to the TSF as a slurry with a solids concentration of approximately 42%. The tailings slurry will be deposited through a series of spigots located at the perimeter of the cells and a decant pond will be maintained in the centre of each cell. Decant water will be piped to the water storage dam (WSD) for reuse in the process plant.

The tailings are at a pH of above 6, and consist of Gypsum from the neutralisation process (calcium, manganese and sulphate ions) and goethite (precipitated iron oxide).

The NSW Dams Safety committee (DSC) sets out the requirements relating to the safety management of dams in NSW. The DSC has adopted, with qualifications, the Australian National Committee on Large Dams (ANCOLD) Guidelines on Assessment of the Consequences of Dam Failure. The operational flood criteria and overall flood capacity of the TSF will be based on an assessment of the facilities consequence category. The TSF is designed to operate with sufficient flood storage capacity to meet the DSC and ANCOLD requirements.

6.1.2 Water storage dam

The water storage dam (WSD) is located to the immediate north of the TSF with the operational objective to store excess water contained in the TSF for reuse in the process plant. This is located at the site that was previously to be used for the surge pond. The water storage dam will be lined with a High Density Polyethylene (HDPE) liner to limit seepage losses.

As is the case for the TSF, the WSD is designed to operate with sufficient flood storage capacity to account for the required rainfall event. A spillway will be provided and sized consistent with the requirements of the DSC and ANCOLD.

6.1.3 Evaporation pond

An evaporation pond has been retained in the Modification 4 water management system to manage a minor stream of high chloride process water. To prevent chloride build-up in process water, this outflow from the process plant is separated from the TSF and WSD system and retained and evaporated in an evaporation pond.

The evaporation pond has been reduced to 2 contour pond cells contained by 2.5 m high earth embankments located immediately north east of the TSF. The cells will be lined with a low permeability clay to minimise seepage. The high chloride process water will be pumped from the plant to a sump at the evaporation pond, from where it would then be distributed to the two evaporation pond cells.

6.1.4 Surface water diversions

There is no substantial change to the surface water diversions for the ephemeral drainage lines from the approved project general arrangement. The drain depth and width have been adjusted slightly as the design has been updated. The existing drainage paths described in Section 4.1.3, were designed to be permanently diverted through the site around planned site infrastructure as shown in Figure 6.

The diversions that were around the surge dam have been eliminated as the current water storage dam is designed to collect and store water, rather than evaporate it.

Relevant proposed modifications to the water management system are provided in Section 2.0.

6.2 Water supply

6.2.1 Demand

The processing facility raw water demand is 2,960 ML/yr.

The raw water for the processing facility would be supplied from the borefield adjacent the Lachlan River, and would be supplemented by licenced surface water extraction from the Lachlan River. The raw water demand would be minimised by utilising recycled and treated process water and other water collected on site (e.g. internal runoff collection at the mine site [including harvestable rights] and mine dewatering [in-pit and advance]).

6.2.2 Recycled water supply

A water balance model was developed using GoldSim model software to size critical components of water infrastructure and better define the available recycled water supply from the WSD. The WSD receives supernatant decant from the TSF, direct rainfall to the WSD and rainfall runoff from active and newly rehabilitated cells of the TSF. The water process flow for the GoldSim model simulations is shown in Figure 27.

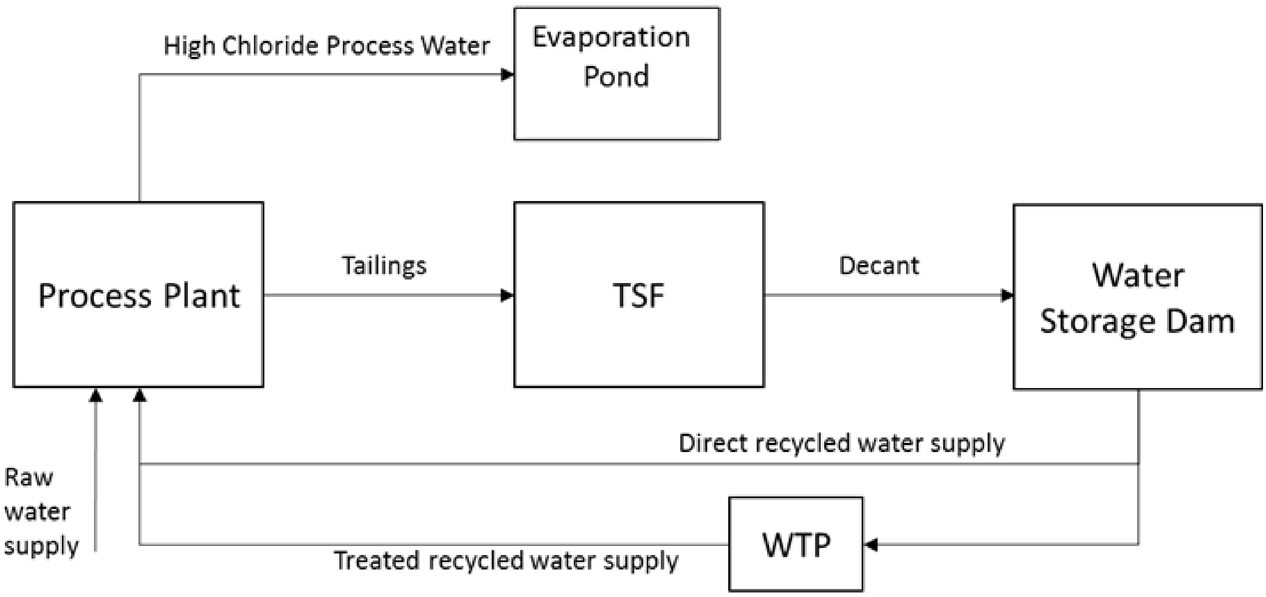


Figure 27: Modelled water flow diagram

The model was simulated for a period of 20 years using daily timesteps. Three scenarios were simulated using SILO rainfall data (discussed in Section 4.1.1):

- Scenario 1 - the driest sequential 20 years.
- Scenario 2 - the average sequential 20 years.
- Scenario 3 - the wettest sequential 20 years.

The model simulated return water from the WSD, including direct recycled water supply, and treated recycled water supply treated through the Water Treatment Plant (WTP).

For this assessment the slurry density was set at 42% and initial tailings dry density at 0.8 t/m^3, resulting in a supernatant flow of 161.7 m^3/hr.

The water balance results for the three rainfall scenarios are summarised in Table 22. The majority of recycled supply is supernatant water from the TSF. The remainder is direct rainfall to the WSD or runoff from active and rehabilitated TSF.

As expected, evaporation exceeds direct rainfall. Overflow is possible from the WSD spillway during extreme rainfall events, however, no overflow occurred during dry or average conditions.

In all scenarios (dry, average and wet climate conditions) and with the exception of a short start up period, 90 m^3/hr (789 ML/yr) and 76 m^3/hr (662 ML/yr) was able to be reliably supplied via direct recycled water supply and treated recycled water supply respectively.

Table 22: WSD balance (at end of 20 year simulation)

	Dry Climate Volume (ML)	Average Climate Volume (ML)	Wet Climate Volume (ML)
Inflow to WSD			
Direct Rainfall to WSD Pond	3 989	4 298	4 853
Decant	32 784	32 995	33 739
Active Cell Overflow	101	0	77
Runoff from the Rehabilitated Cell	1 923	1 830	2 750
Outflow from WSD			
Evaporation	9 243	9 519	10 650
Direct Supply to Process	15 753	15 746	15 749
Supply to WTP	13 302	13 297	13 299
Overflow	0	0	895
Remaining in Storage WSD	**499**	**562**	**826**

6.2.3 Raw water supply

In 2006, the Project was issued a licence under the Water Management Act, 2000 for an extraction rate of 3 154 ML/yr from the water supply borefield located near the Lachlan River, about 65 km south southeast of the Project area (Coffey, 2016).

A long term trial of a pumping rate equivalent to 6 308 ML/yr undertaken by Coffey (Coffey, 2000) has assessed that pumping at this rate in alternating six month cycles between the eastern and western borefields has a limited impact on the aquifer. Groundwater drawdowns recover rapidly following the end of the extraction program. Within the first year following cessation of groundwater extraction, drawdowns are less than 10% of the peak drawdowns with full recovery within 10 years (Coffey, 2000).

This modification proposes to diversify supply sources by including extraction of surface water from the Lachlan River as an alternative to borefield extraction.

A pump station would be constructed near the Lachlan River to extract surface water and pump it to the approved water pipeline.

For the purposes of assessment, Clean TeQ is seeking approval for up to approximately 350 ML/annum surface water extraction from the Lachlan River. When compared to the total share components of general security access licences traded since 1 July 2016, this is less than 1% based on an AWD of 1. As noted in Section 3.3.1.5, if the volume per unit of access licence share component was as low as 0.02 (based on previous AWD orders), then this volume would be approximately half of the total volumetric allocation of general security access licences traded since 1 July 2016, and consequently groundwater use in accordance with the existing (and/or future) WAL would be preferentially utilised for make-up raw water supply during such times.

It is however noted, that if opportunities were to arise (e.g. during wet climate scenarios) to obtain additional access licences for surface water extraction beyond 350 ML/annum, Clean TeQ would obtain the necessary water licences in accordance with Condition 26, Schedule 3 of the Development Consent.

6.3 Evaporation pond

A GoldSim water balance model was developed to simulate the fluctuation of storage in response to high chloride process water inflow, incidental rainfall and evaporation. The evaporation pond has been sized to contain all water from the waste inflow and rainfall during a 20 year simulation using the cumulative wettest sequential 20 years of rainfall data from the SILO rainfall data record.

A minimum evaporation pond area of 7.8 ha (185 ML) with a depth of 2.5 m (not including freeboard) was determined from the water model simulation.

7.0 ASSESSMENT OF POTENTIAL SURFACE WATER IMPACTS

7.1 Potential surface water quantity impacts

The TSF, water storage dam and evaporation pond are designed to contain and manage process water. All of these structures are without external catchments and as such do not collect rainfall runoff.

Water collected in mining pits and runoff from waste dumps will be temporarily contained in sediment basins and recycled, evaporated or assessed to meet surface water discharge requirements prior to discharge to the environment. Sediment basins will be sized according to the guidance provided in the NSW Government document Soils and Construction (Volume 1) (NSW, 2004) and the International Erosion and Sediment Control Guideline, Best Practice Erosion and Sediment Control (IECA, 2008).

None of the storages on-site are used to harvest runoff from land and all storages are used to contain potential contaminated drainage, mine water or effluent in accordance with best management practice or are used to control soil erosion. It is concluded therefore that all of these storages should be excluded from consideration as a component of the harvestable right calculation.

The ephemeral watercourses that enter the mine lease areas at the southern boundary of the mine site are diverted around mining infrastructure, discharging to the northern and eastern boundary of the mine lease area. There is no change to the diversion channel concept design in the Modification 4 water management network.

The pump station at the Lachlan River and all associated infrastructure would be constructed to be at an elevation higher than the 1:25 year flood (Golder, 2017). Water from the river will be filtered prior to transfer to site. A small amount of filter back wash will be generated and would be disposed of to an evaporation pond. As the flow in the Lachlan River is managed by the Wyangala Dam, the impact of the pump station on the quantity of water in the Lachlan River is expected to be minimal.

7.2 Potential surface water quality impacts

There are no changes to potential surface water quality impacts as a result of the Modification 4.

As discussed in Section 6.1, the TSF, water storage dam and evaporation pond have been designed to retain process water without release to the environment. The capacity of these storage facilities have been modelled to assess the water management system during both extended dry and extended wet periods using site based historical climate records.

Extraction of water by the Lachlan River pump station will not alter the quality of the river water.

8.0 ASSESSMENT OF POTENTIAL GROUNDWATER IMPACTS

8.1 Potential groundwater quantity impacts

8.1.1 Groundwater model

Two-dimensional (2D) finite element cross-sectional groundwater models were developed to estimate groundwater inflows to mine pits, seepages from the TSF and water storage dam, and potential groundwater drawdown. The 2D modelling was conducted using industry standard software Seep/W version 8.16, developed by Geo Slope International Ltd. The 2D modelling results are conservative (i.e., likely to over-estimate changes in groundwater levels and flow directions) as it represents maximum disturbance, that is, the mine pits are modelled as being instantaneously excavated to maximum depth, and the TSF is modelled as being instantaneously filled to capacity prior to transient simulation commencing. This approach will maximise mine pit inflows and seepage estimates.

Three (3) 2D cross-sectional models were developed across the project area as follows:

- Model section AB – Runs north-east to south-west direction through deepest final mine pit level. The model will estimate groundwater inflows into final pit void and potential groundwater drawdown
- Model section CD – Runs north-east to south-west direction across the proposed tailing storage facility and water storage dam. Model estimate potential seepage from the proposed TSF and water storage dam
- Model section EF - Runs north-west to south-east direction through proposed TSF and mine pits. The model estimates potential seepages from TSF.

The alignments of the cross-sections modelled are shown in Figure 28.

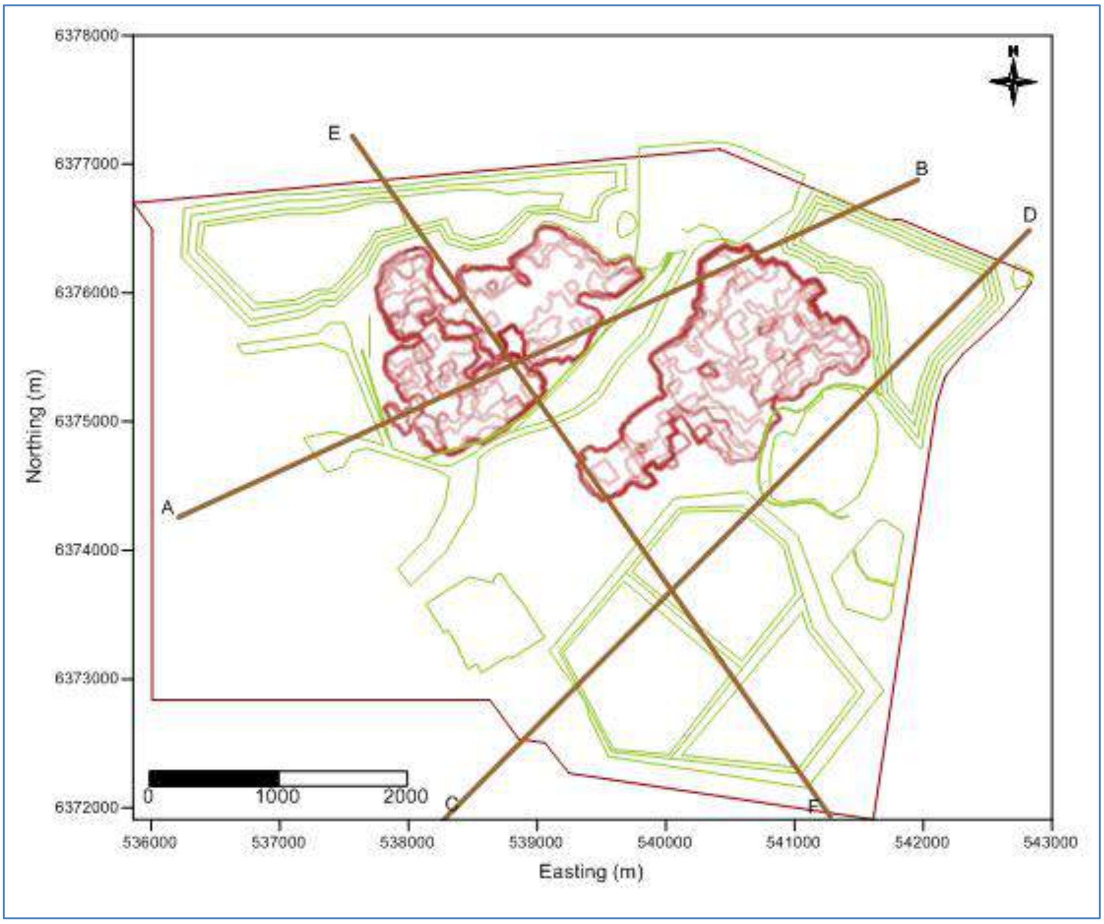


Figure 28: Alignments of cross-sectional groundwater models

8.1.1.1 Hydrogeological conceptual model and calibration

The layering of the models is based on the subsurface conditions interpreted from the results of site investigations (Golder, 2000a, 2000g) and recent hydraulic testing (Golder, 2016, 2017). Four distinct hydrogeological formations were identified across the project area and summary of conceptual hydrogeological units are shown in Table 23. The values for hydraulic conductivity are based on field data obtained from hydraulic testing and calibration to observed groundwater levels. The TSF and water storage dam are modelled as having a low permeability liner.

Table 23: Summary of model hydrogeological units

Layer	Description	Approximate Thickness (m)	Saturated Hydraulic Conductivity K (m/s)[1]
Layer 1	Alluvial soil, mainly sand	3	3.2×10^{-06}
Layer 2	Highly weathered rock	11	1.0×10^{-06}
Layer 3	Slightly weathered rock	13	1.0×10^{-07}
Layer 4	Basement fresh rock	>100	9.0×10^{-09}

The model hydraulic conductivities adopted for tailings is 1×10^{-7} m/s and for the liners (for the base of the TSF and base of the WSD) is 1×10^{-9} m/s.

8.1.1.2 Model boundary conditions

Boundary conditions applied in the models are:

- Constant head boundaries at the right and left hand extremities of the model
- The constant head values defined for these boundaries are based on groundwater contours generated by groundwater level measurements from Dec-2016 and June-2017 and are assumed to be sufficiently distant as to not significantly influence groundwater behaviour near key features (mine pits, TSF and water storage dam)
- A constant head boundary at the final elevation of the water storage dam
- Minimal rainfall recharge (0.01%) applied along the ground surface of the model
- The tailings in the TSF are initially fully saturated.

The hydrogeology, extent and boundary conditions of the three cross-sectional models are presented in Figure 29, Figure 30 and Figure 31.

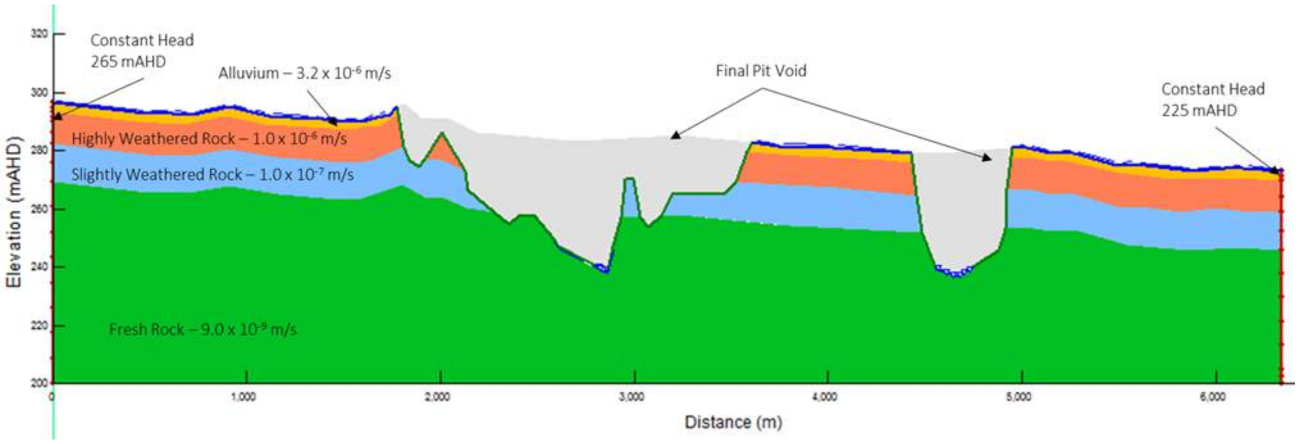


Figure 29: Section AB - Conceptual model showing associated hydraulic conductivity values

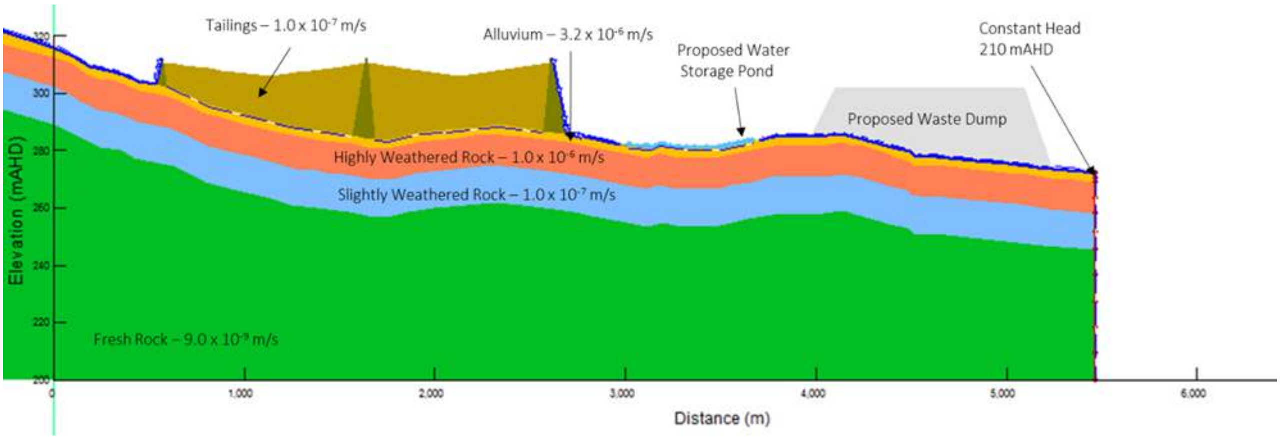


Figure 30: Section CD - Conceptual model showing associated hydraulic conductivity values

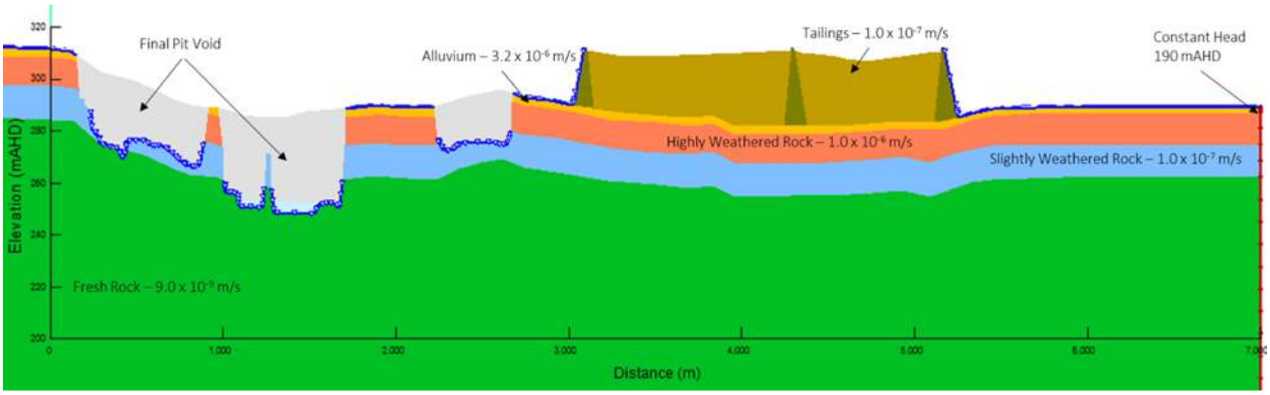


Figure 31: Section EF - Conceptual model showing associated hydraulic conductivity values

8.1.1.3 Groundwater flow simulation scenarios

Each cross-sectional model has been used to simulate groundwater flow behaviour for two scenarios:

- Base Case – each model is run using the calibrated hydraulic conductivities (Table 23)
- Sensitivity Case – each model is run with increased hydraulic conductivity (half order of magnitude).

8.1.2 Groundwater inflows to mine pits (aquifer take)

The mine pit through which the AB cross-sectional model is aligned has the potential to intersect groundwater at the maximum proposed depth of this pit (all other mine pits are not predicted to intersect groundwater). Groundwater entering this pit will be removed from the pit and therefore represents water taken from the aquifer. Estimates of potential groundwater inflows for the Base Case and Sensitivity Case are presented in Table 24. Long-term groundwater inflow to the pit is estimated to be less than 0.002 L/s (for both Base and Sensitivity Cases).

Table 24: Predicted groundwater inflows to mine pits - Section AB

Year	Annual Inflow - Base Case ML/Year	Annual Inflow - Sensitivity Case ML/Year
1	0.071	0.153
2	0.058	0.113
3	0.052	0.098
4 (onwards)	0.046	0.084

8.1.3 Drawdown

Interception of groundwater by the deepest area of the mine pit means there is the potential for a drawdown in the groundwater levels to occur in the vicinity of the interception. The extent of drawdown is estimated using cross-section model AB. The estimated maximum extent of groundwater drawdown of 1 m after 20 years (assuming no backfilling of pits occurs) is shown in Figure 32 and is estimated not to extend beyond the mine site boundaries.

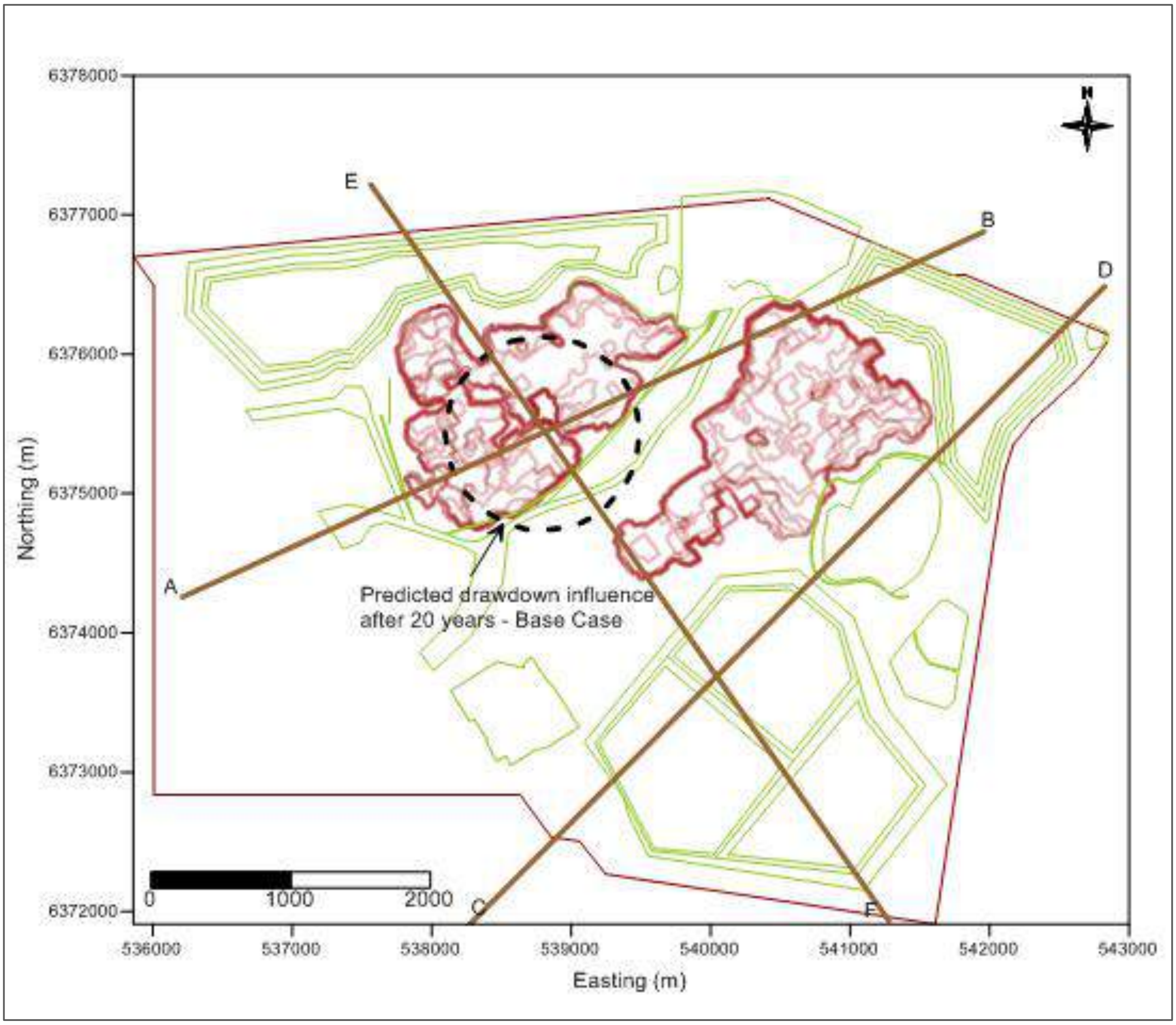


Figure 32: Estimated 1 m drawdown extent after 20 years - Base Case

8.1.4 Seepage

Potential seepage rates (flows) from the storage dam and the TSF into the underlying groundwater system were estimated using cross-sectional models CD and EF respectively.

The TSF and the WSD are modelled as including a lined base with a hydraulic conductivity of 1×10^{-9} m/s. This will be a clay liner for the TSF and a HDPE liner for the WSD. The estimated seepage rates from the WSD for Base and Sensitivity Cases are presented in Table 25. The estimated seepage rates from the TSF for Base and Sensitivity Cases are presented in Table 26.

Long-term seepage rates are estimated to be less than 2.4 L/s (Base Case) for the TSF and less than 0.1 L/s (Base Case) for the water storage dam. Initial instantaneous seepage rates appear high due to the simplification of tailings deposition rates used in the model, as described in Section 8.1.1.

Groundwater mounding can be expected to develop below the TSF and water storage dam due to the low permeability of the underlying ground, with slow migration away from the footprints of the TSF and water storage dam. The cross-sectional model EF (Base Case) estimates that no change in groundwater flow rates across the site boundaries occurs during the first 20 years. The cross-sectional model CD (Base Case) estimates that groundwater flow rates across the site boundaries may increase by <1% during the first 20 years.

Table 25: Estimated Water Storage Dam seepage rates - Section CD

Time (Years)	Total Seepage Storage Dam Base Case		Total Seepage Storage Dam Sensitivity Case 1	
	m^3/day	L/s	m^3/day	L/s
0.7	1.5	0.01	1.9	0.02
1.8	1.6	0.02	23.2	0.3
3.9	12.9	0.2	316.3	3.7
6.3	304.8	3.5	74.0	0.9
7.6	110.8	1.3	47.7	0.6
12.3	30.5	0.4	40.2	0.5
20.0	12.8	0.1	20.0	0.2

Table 26: Estimated TSF seepage rates - Section EF

Time (Years)	Total Seepage TSF - Base Case		Total Seepage TSF - Sensitivity Case 1	
	m^3/day	L/s	m^3/day	L/s
0.2	4 436	51	88 504	1 024
0.3	19 015	220	21 982	254
0.7	2 857	33	1 570	18
1.8	493	5.7	910	11
4.7	288	3.3	742	8.6
7.6	269	3.1	622	7.2
12.3	243	2.8	508	5.9
20.0	207	2.4	397	4.6

8.1.5 Mitigation measures

The proposed control measures for the TSF include the installation of underdrainage and a seepage interception drain at the downstream toe. These drains would intercept any seepage flowing horizontally through the upper layers of the underlying soils. Existing monitoring wells are to be used as sentinel wells.

8.2 Potential groundwater quality impacts

8.2.1 Groundwater Dependent Ecosystems (GDE)

Groundwater Dependent Ecosystems (GDE) are defined as ecosystems whose ecological processes and biodiversity are wholly, or partially, reliant on groundwater. Information on potential groundwater dependent ecosystems at the mine site has been extracted from the National Atlas of Groundwater Dependent Ecosystems (Bureau of Meteorology). Based on information from this atlas, there are no identified aquatic GDEs at the mine site, and only a low potential vegetation (terrestrial) GDE in the vicinity of the mine site (Figure 33).

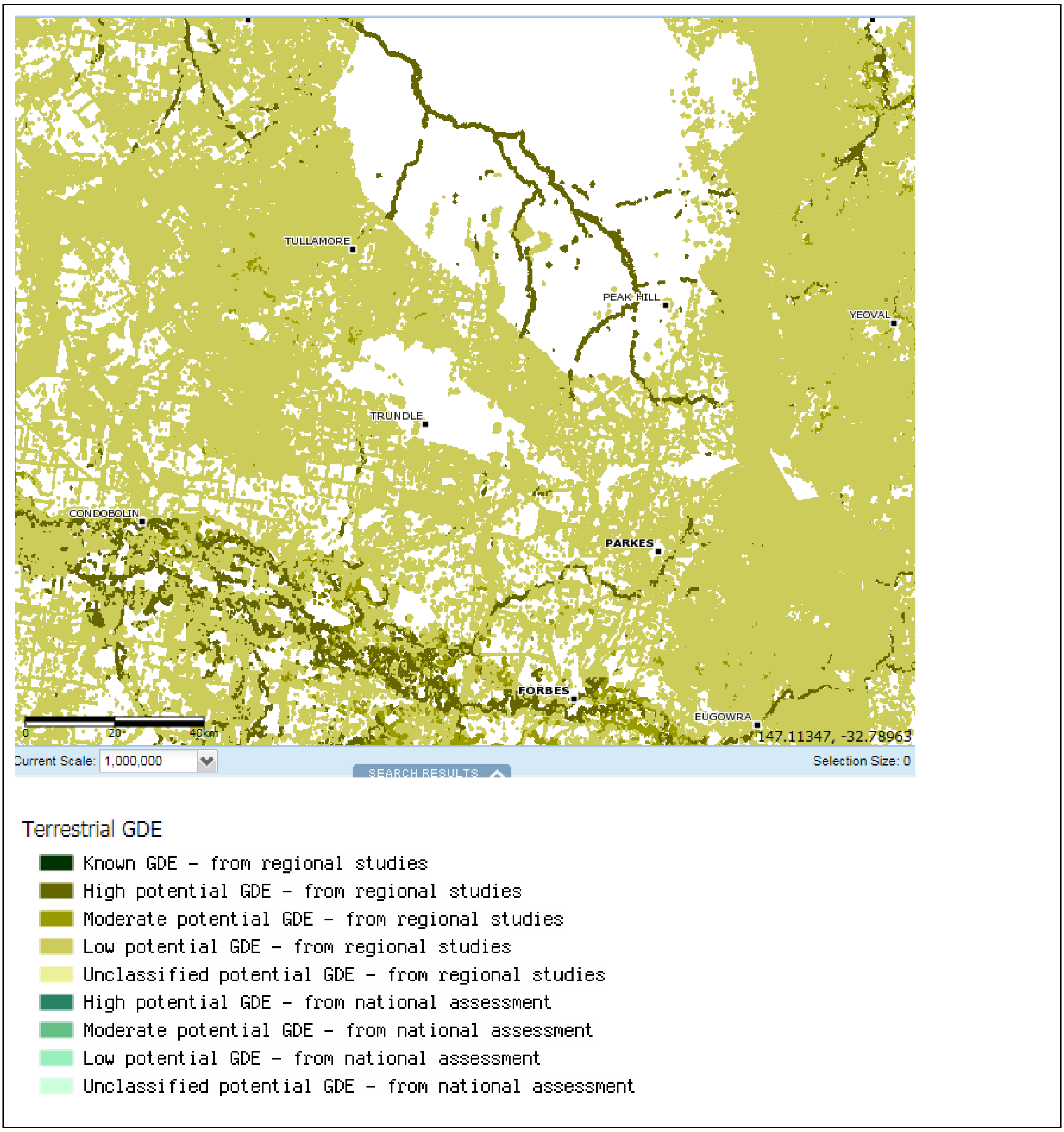


Figure 33: Terrestrial GDE (BOM)

The potential for seepage from the TSF and water storage dam is constrained by the low permeability of the underlying and adjacent soil and rock, with estimated total groundwater flow velocities across the model boundary (Base Case) being of the order of 0.1 m/year. These low flow velocities retard the migration of seepage and are estimated to have no significant water quality impact on the low potential GDE.

8.2.2 Other groundwater quality impacts

The estimated distance of saline migration beyond the site boundary is based on long term seepage rates and changes in horizontal flow velocities estimated by the numerical model. After commencing operations, saline migration is estimated to extend up to 400 m from the site boundaries (following general groundwater flow directions across the site). Extent of the seepage front may increase where the rock permeability is higher or where fractures occur. As groundwater quality is brackish in the vicinity of the TSF, and seepage is constrained by the low permeability of the underlying and adjacent soil and rock, the impact to groundwater quality is estimated to be very low. As the nearest downgradient registered groundwater user is approximately 2.8 km from the site, modelling results estimate that there would be no groundwater quality impacts on groundwater users.

Monitoring of groundwater quality downgradient of the TSF is recommended (as discussed in Section 10.2).

8.2.3 Mitigation measures

The proposed control measures for the TSF include the installation of underdrainage and a seepage interception drain at the downstream toe. These drains would intercept any seepage flowing horizontally through the upper layers of the underlying soils. Existing monitoring wells will be used as sentinel wells.

9.0 POST CLOSURE WATER MANAGEMENT CONCEPTS

The objective of mine closure management will be to ensure, where possible, that rehabilitation achieves a safe, stable and functioning landform which is consistent with the surrounding landscape and post-closure mining activities.

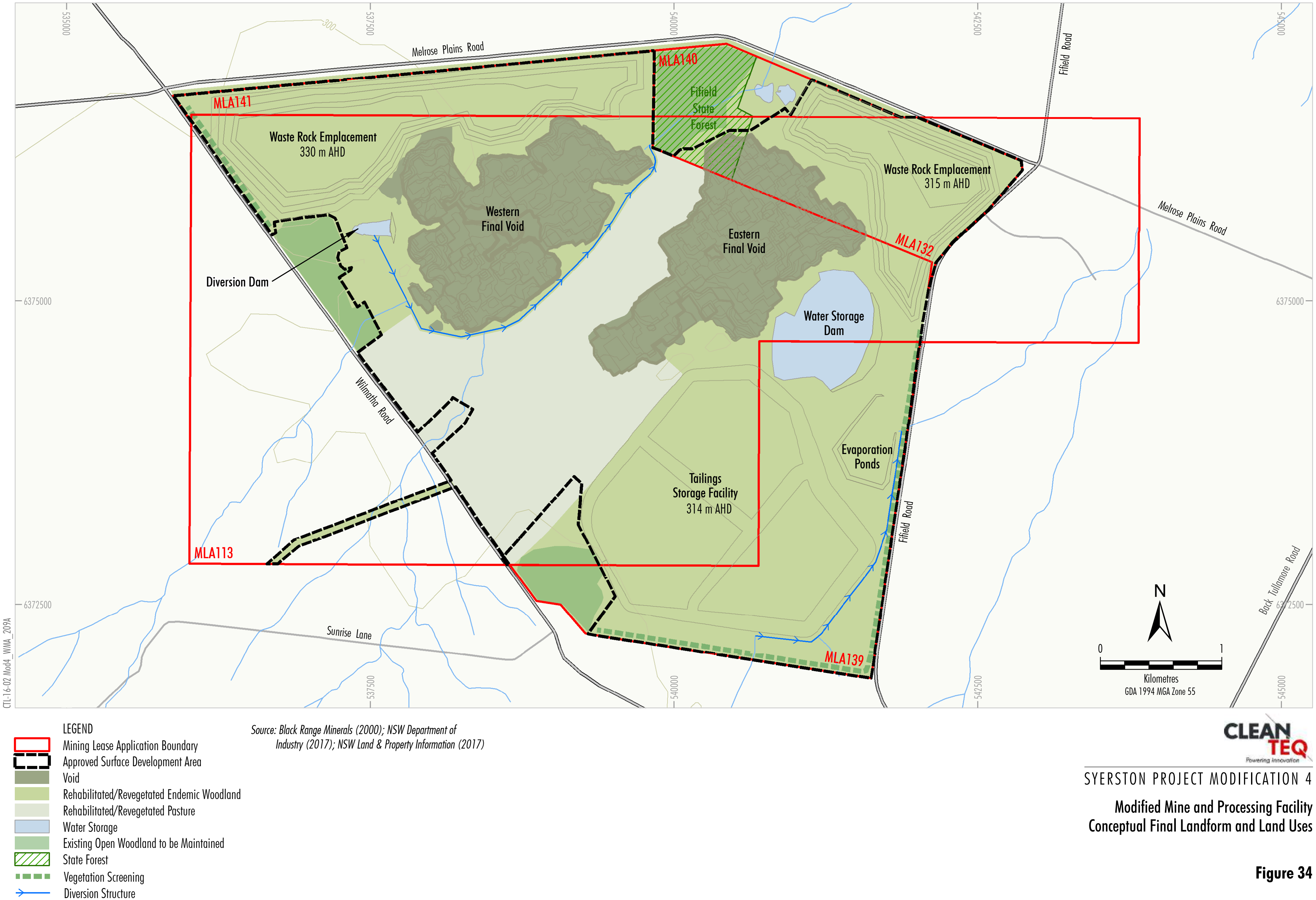
The following concepts have been developed for the water management infrastructure at closure and are illustrated in Figure 34.

The TSF will be progressively rehabilitated during operations with final rehabilitation completed at closure. The TSF surface will be profiled, covered, topsoiled and vegetated to provide a stable land surface that sheds runoff and maintains a vegetated cover. The WSD will remain in place as a water storage resource for post-mining activities.

Evaporation and sediment ponds will be removed and the landform re-profiled and revegetated. Where possible the final landform will be consistent with pre-mining landform and aim to maintain watershed boundaries consistent with the pre-mining watershed.

The clean water diversion channel will be left in place and riparian zone revegetated.

The Modification would not significantly change the rehabilitation strategy for infrastructure, waste rock emplacements, final voids or mine water infrastructure.



Source: Black Range Minerals (2000); NSW Department of Industry (2017); NSW Land & Property Information (2017)

CLEAN TEQ
Powering innovation

SYERSTON PROJECT MODIFICATION 4

Modified Mine and Processing Facility
Conceptual Final Landform and Land Uses

Figure 34

10.0 SURFACE WATER AND GROUNDWATER MONITORING PLAN

10.1 Surface water

The environmental management and monitoring program proposed for the mine (including processing facility) is provided in the Syerston Nickel Cobalt Project EIS (Resource Strategies, 2000). Changes in the water management system as a result of the Modification 4 will not change the surface water monitoring requirement.

In summary, upon completion of construction and commissioning of water management infrastructure, Clean TeQ will monitor the following aspects of the water management system:

- Mine water storage and raw water dam levels and volumes (stored and freeboard), including development of storage curves
- Mine pit inflows/dewatering (where measurable from pumping records)
- Metered water quantity from the borefield and/or surface water extraction
- Potable water supply
- Dust suppression water demands
- Processing water inputs and outputs including:
  - feed tonnage and moisture contents
  - product tonnages and moisture contents
  - tailings tonnages and solid:water ratios
  - deposited tailings *in situ* moisture contents (including determining TSF return water efficiencies)
- Any discharges (volume, rate and quality) licensed by an EPL.

The appropriate monitoring frequencies and methods will be determined by Clean TeQ as required.

10.2 Groundwater

The groundwater monitoring bores listed in Table 17 form a groundwater monitoring network that can be utilised throughout the life and after closure of Syerston as an active mining operation to monitor potential impacts of the TSF, water storage dam and mine pits. Some existing monitoring bores may be destroyed due to mining activities and additional monitoring bores will be installed to meet any changes in operational monitoring requirements.

Baseline groundwater level and quality data has already been collected.

Groundwater levels would be monitored continuously using automatic data loggers with the data to be downloaded and reviewed on a quarterly basis.

Groundwater samples would be collected quarterly for the first two years of operation and analysed for a suite of parameters (EC, pH, major cations, major anions, selected metals and total dissolved solids). Thereafter, and depending on measured variability, sampling would be reduced to annually.

Groundwater inflow rates into the open pits would also be monitored.

Groundwater monitoring at the borefields would be conducted in accordance with the requirements of the WAL and relevant management plan.

11.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix C of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

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Report Signature Page

GOLDER ASSOCIATES PTY LTD

Marian Hart
Senior Hydrologist

Amanda Barrett
Associate

MH/AB

A.B.N. 64 006 107 857

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APPENDIX A

Maximum Harvestable Right Dam Calculator Result

Department of Primary Industries
Office of Water

Maximum Harvestable Right Dam Capacity

Information provided by the user

1. The location of the proposed dam is:
   - Latitude: **-32.754679**
   - Longitude: **147.409186**
2. Total property area to use for calculating the size of the dam is **1901.02 Hectares**

Result

The maximum Harvestable right dam capacity for your property is **104.5561** ML (Megalitres)

Date

18/10/2017

Name

Sarah Duarte

Limitations of the calculator

a) Where to site a dam

You can only construct a harvestable rights dam where the Harvestable Rights Orders apply, refer to NSW Government Gazette 40 dated 31 March 2006 (pages 1628 to 1631).

b) First and Second order streams

The maximum harvestable right calculator does not verify that the location of the proposed dam sits on a first or second order stream. A factsheet : "Where can they be built without a licence?" is available on the DPI Water website to help you work out the stream orders.

You will need to use the legislated topographic map for your area to identify the stream order. This map is the gazetted map as per NSW Government Gazette 57 dated 23 March 2001 (pages 1481-1489).

c) Size of property and dam

The calculator does not take into account other dams already on your property. If you have existing harvestable rights dams on your property, you must take the capacity of these dams into account when constructing a new dam. In the Eastern and Central Divisions other dams must also be taken into account, as described in the NSW Government Gazette 40 dated 31 March 2006 (pages 1628 to 1631).

d) Protected wetlands

The Harvestable Rights Orders specify that you are not allowed to build a dam on or within 3 km of a RAMSAR wetland site. There are 12 RAMSAR wetlands in NSW. Further information on the location of those 12 RAMSAR sites in NSW can be found on the NSW Environment and Heritage government website.

APPENDIX B

Lachlan River Water Quality

Table A1 - Syerston Water Quality - Groundwater and Surface Water Data - November 1999 and August 2017

Analytes	Units	Laboratory Limit of Reporting (LOR)	Drinking Water Guideline [A] (Health)	Aesthetic Water Guideline [A]	ANZECC 95% Protection for Freshwater Ecosystems [B]	Syerston Bore Groundwater	Surface Water Lachlan River	Surface Water Lachlan River
						15/08/2017	15/08/2017	27/11/1999
						ISPB01	LR1	RIVER
Physiochemical Parameters								
pH (field)	pH unit	0.01		6.5 to 8.5	6.5 to 8.0[1]	7.1	7.2	8
Turbidity (field)	NTU	0.1				4.2	53	22
Electrical Conductivity (field)	µS/cm	1			30 to 350[2]	1238	469	
Electrical Conductivity (lab)	µS/cm	1			30 to 350[2]	1350	484	
Total Dissolved Solids (lab)	mg/L	10	*	600		669	262	200
Total Suspended Solids (lab)	mg/L	1				8	94	35
Chemical Oxygen Demand	mg/L	10				<10	22	19
Biochemical Oxygen Demand	mg/L	2				<2	3	<2
Specific Gravity		0.01				1	1	
Reactive Silica	mg/L	0.05		80		13.3	8.04	
Total Hardness as CaCO3	mg/L	1				146	130	
Major Cations								
Calcium	mg/L	1				24	24	25
Magnesium	mg/L	1				21	17	19
Potassium	mg/L	1				3	2	2.8
Sodium	mg/L	1	*	180		188	35	23
Major Anions								
Hydroxide Alkalinity as CaCO3	mg/L	1				<1	<1	
Carbonate Alkalinity as CaCO3	mg/L	1				<1	<1	
Bicarbonate Alkalinity as CaCO3	mg/L	1				193	93	120
Total Alkalinity as CaCO3	mg/L	1				193	93	
Chloride	mg/L	1	*	250		235	61	54
Sulphate as SO4	mg/L	1	500	250		52	26	14
Fluoride	mg/L	0.1	1.5			0.5	0.2	0.14
Metals								
Aluminium	mg/L	0.01		0.2	0.055	0.03	1.25	
Arsenic	mg/L	0.001	0.01		0.013	<0.001	0.001	<0.01
Barium	mg/L	0.001	2			0.034	0.044	<0.1
Bismuth	mg/L	0.001			0.7[4]	<0.001	<0.001	
Boron	mg/L	0.05	4		0.37	0.07	<0.05	
Cadmium	mg/L	0.0001	0.002		0.0002[3]	<0.0001	<0.0001	
Chromium	mg/L	0.001			0.0033[4,5]	<0.001	0.002	
Cobalt	mg/L	0.001			0.0014	<0.001	<0.001	
Copper	mg/L	0.001	2	1	0.0014[3]	<0.001	0.003	0.002
Gold	mg/L	0.001				<0.001	<0.001	
Iron	mg/L	0.05		0.3	0.3[4]	0.92	1.92	0.47
Iron Ferric	mg/L	0.05				<0.05	<0.05	
Iron Ferrous	mg/L	0.05				1	0.23	0.43
Lead	mg/L	0.001	0.01		0.0034[3]	<0.001	0.001	<0.001
Lithium	mg/L	0.001				0.006	0.001	
Manganese	mg/L	0.001	0.5	0.1	1.9	0.051	0.07	0.11
Mercury	mg/L	0.0001	0.001		0.0006	<0.0001	<0.0001	
Molybdenum	mg/L	0.001	0.05		0.034 [4]	<0.001	<0.001	
Nickel	mg/L	0.001	0.02		0.011	<0.001	0.002	
Selenium	mg/L	0.01	0.01		0.011	<0.01	<0.01	<0.01
Silver	mg/L	0.001	0.1		0.00005	<0.001	<0.001	
Strontium	mg/L	0.001				0.543	0.17	0.18
Titanium	mg/L	0.01				<0.01	<0.01	
Vanadium	mg/L	0.01				<0.01	<0.01	
Yttrium	mg/L	0.001				<0.001	<0.001	
Zinc	mg/L	0.005		3	0.008[3]	<0.005	<0.005	0.005
Zirconium	mg/L	0.005				<0.005	<0.005	
Nutrients								
Ammonia as N	mg/L	0.01		0.5	0.9[6]	0.06	0.04	<0.01
Nitrite as N	mg/L	0.01	3			<0.01	<0.01	
Nitrate as N	mg/L	0.01	50		0.7	<0.01	0.42	0.49
Nitrite + Nitrate as N	mg/L	0.01				<0.01	0.42	
Total Phosphorus as P	mg/L	0.01			0.02[2]	0.06	0.06	0.15

A. National Water Quality Management Strategy. 2011 Australian Drinking Water Guidelines. Version 3.3 updated November 2016.

B. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. 2000.
Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Management Council of Australia and New Zealand (ARMCANZ)

* No health-based value considered necessary

1. Range of values are for NSW upland rivers
2. Default trigger values for upland streams in southeastern Australia (NSW upland rivers EC generally near the high end of this range).
3. Dependent on water hardness
4. Indicative Interim Working Level (IIWL) - low reliability trigger value based on limited data
5. Chromium trigger level listed is for Cr III
6. Ammonia trigger level is pH dependent. Value for pH 8.0 listed.

APPENDIX C

Important Information about this Report

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
147 Coronation Drive
Milton, Queensland 4064
Australia
T: +61 7 3721 5400

Golder Associates