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Appendix F1

Water Management Plan

Sherwin Iron (NT) Pty Ltd

Sherwin Creek Iron Ore Project

Environmental Impact Statement



2013

Water Management Plan: Sherwin Creek Iron Ore Project

Prepared for: Sherwin Iron (NT) Pty Ltd

Prepared by: EcOz Environmental Services



2013

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Document Control Record

Document Code:	EZ13503-C0302-EIA-Ms-004
Catalogue Number:	32965
Project Manager:	Ray Hall
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Approved by:	
	Ray Hall
Approval date:	5 November 2013

DOCUMENT HISTORY

Version	Issue Date	Brief Description	Reviewer/Approver
1.A - E	4 November 2013	Report preparation by authors	M Welch
1.F	5 November 2013	EcOz review	R Hall
1.0	5 November 2013	Issue document to client	R Hall

Recipients are responsible for eliminating all superseded documents in their possession.

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1 Current conditions

1.1 Surface water

1.1.1 Regional catchments context

The Sherwin Creek Iron Ore Project Area (Project Area) is located within the middle reaches of the Roper River catchment, which is 81 794 km^2 in extent and the largest river entering the Gulf of Carpentaria. From its headwaters, the Roper River catchment drains in an easterly direction for a total length of approximately 500 km, where it enters the Gulf of Carpentaria. The tidal limit of the river is Roper Bar, a natural rock bar extending across the river, approximately 200 km east of Mataranka and 20 km downstream of the proposed mine site (Figure 1-2).

The Roper River is a losing system, with flows decreasing with distance downstream, except for areas of groundwater interaction (Knapton 2009). Only the upper reaches of the Roper River maintain flows greater than 0.1 m^3/s (100 l/s) by the end of the dry season, due to groundwater input. The middle and lower reaches of the river usually have flows less than 0.1 m^3/s by the end of the Dry season, and flow records show that cease to flow conditions can often occur at Roper Bar. In some very dry periods, such as the 1950s and 1960s, cease to flow events occurred up to 65 km upstream of Roper Bar at Judy Crossing.

Under the *NT Water Act (2004)*, the entire Roper River catchment falls within the Daly Roper Water Control District, in which there is considered a need for close management of water resources in order to avoid stressing groundwater reserves, river flows or wetlands. Legislation in Water Control Districts covers all aspects of sustainable water resource management including the investigation, use, control, protection and allocation.

There are no listed significant wetlands in the vicinity of the Project Area. Although not considered to be within the potential zone of impact, it is noted that the lower estuarine reaches of the Roper River, together with its associated tidal flats and coastal dunes, are contained within the Limmen Bight and associated coastal floodplains Site of Conservation Significance (NT). Covering an area of 185,000 ha, this area is also listed in the Directory of Important Wetlands in Australia as the Limmen Bight (Port Roper) Tidal Wetlands System (Environment Australia, 2001). The area is significant because it is the second largest area of saline coastal flats in the NT. The Mataranka thermal pools in the upper Roper River catchment are also outside of the potential zone of impact and listed as a Site of Conservation Significance (NT).

Several cattle stations and communities (e.g. Ngukurr) extract water from the Roper River at points downstream of the Project Area, and the river is widely used for stock watering purposes. The Roper River is a very popular destination for local and visiting anglers.

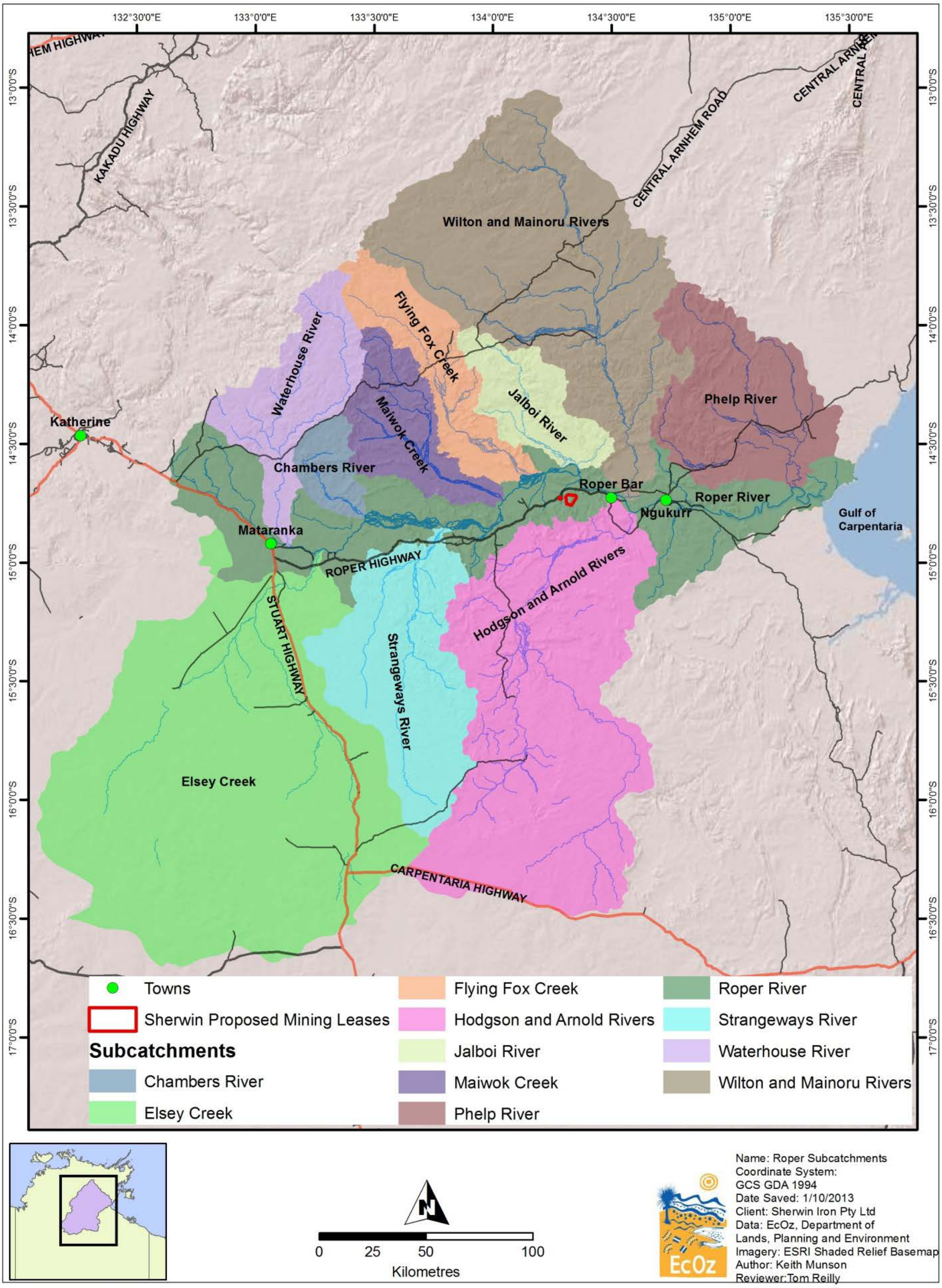

Figure 1-1. Map showing Sherwin Creek Iron Ore Project and river catchments

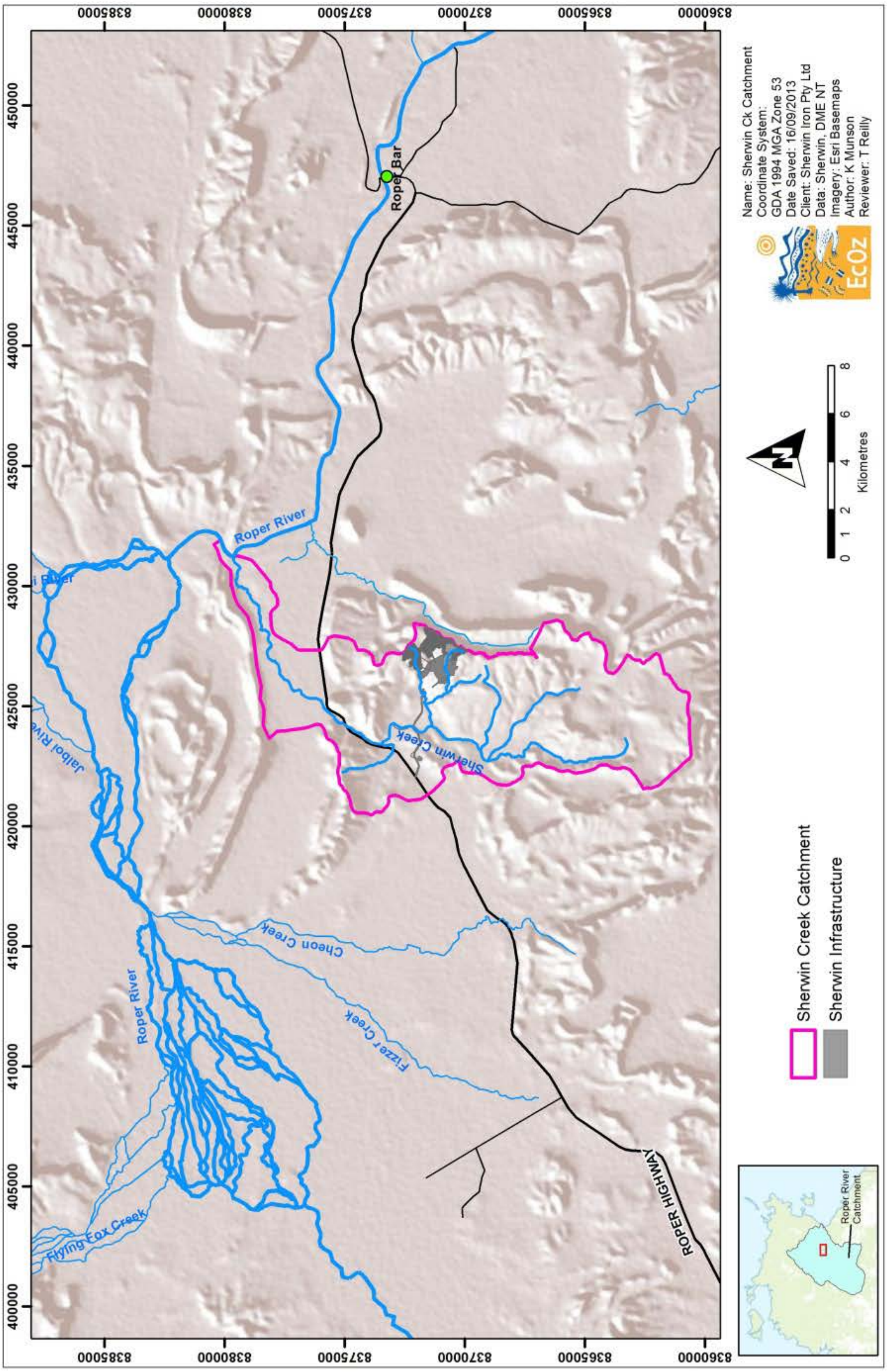

Figure 1-2. Map showing Sherwin Creek catchment.

Figure 1-3. Image showing typical character of Sherwin Creek
(taken from monitoring site SISW04)

1.1.2 Local catchments

The Project Area is located in the middle reaches of Sherwin Creek, a small intermittent 1st order tributary of the Roper River, whose catchment is approximately 100 km^2 in area (Figure 1-3). Over its 30 km length, the total fall in elevation of Sherwin Creek is approximately 140 m. In the vicinity of the proposed mine site, Sherwin Creek has a rocky bed with average channel dimensions of 25m (wide) x 3m (deep) (Figure 1-4). The mine site drains predominantly to the west whilst Sherwin Creek drains from south to north into the Roper River some 8km north-east of the mine. The Access/Haul Road crosses Sherwin Creek some 2 km downstream of the mine site.

Although there is no measured hydrological data available, given the relatively small size of the catchment it is assumed that stream flows are highly responsive to rainfall events and anecdotal observations suggest that the stream ceases to flow in the early dry season (i.e. May/June), with some permanent/semi-permanent pools located downstream of the proposed mine site.

Adjacent minor catchments include Cheon and Fizzer Creeks to the west and a small un-named tributary to the east of the Sherwin Creek catchment (Figure 1-3).

1.1.3 Sherwin Creek hydrology

Sherwin Creek displays a slight sinuous and meandering form with a well-defined active channel. The floodplain is relatively small along most of the channel. Most of the unnamed tributaries draining the mine site are relatively straight with steep hydraulic gradients. Critical parameters necessary for hydraulic estimations (Manning's n) were visually assessed and based on photographs, observations made and professional hydrological judgment, it was concluded that an n-value of 0.035 (dimensionless) for the channel and overbanks should be adopted.

The Rational Method (Australian Rainfall and Runoff, AR&R, Institution of Engineers Australia 1998) has been employed for flood estimation, which provides recommended run-off coefficients for the entire Northern Territory (Table 1-1). Since Sherwin Creek is relatively steep the higher coefficients were used. Whilst there is only limited design information available in the Northern Territory, which translates to a greater uncertainty than for other regions in Australia, the Rational Method provides useful order-of-magnitude design flood estimates. The method was used to estimate flood peak discharges from the main catchments for the 5, 10 and 100 year average recurrence interval (ARI) rainfall events. The Rational Method is based on following formula, as follows:

$Q_p = 0.278 \times C \times i \times A$

where:

Q_p = peak flow (m^3/s)

C = coefficient of runoff

i = intensity of rainfall in time t_c (mm/hr)

A = area of catchment (km^2)

For the purposes of this assessment, only the portion of the Sherwin Creek catchment upstream of the Access/Haul Road (i.e. 12.5 km long and some 64 km^2 in extent) was considered.

Table 1-1. Runoff coefficients for Northern Territory (AR&R).

ARI	Runoff Coefficient
1:2 year	0.5 - 0.7
1:5 year	0.6 - 0.8
1:10 year	0.7 - 0.9
1:100 year (adopted value)	0.9

The final step in the hydrological estimation is to determine the time of concentration (t_c). This is the time required for rain falling at the farthest point of the catchment to flow to the catchment outlet. After time t_c, the whole catchment area is contributing to the flow in the river (Shaw 1994). The Bransby-Williams formula was adopted to estimate t_c (Institution of Engineers Australia 1998), as follows:

$t_c = 58 \times L /(A^{0.1} \times S_e^{0.2})$

where:

t_c = time of concentration (min)

L = mainstream length (km)

A = area of catchment (km^2)

S_e = average slope of catchment (m/km)

The mainstream length and the average slope of the catchment were calculated using a contour data (2 m) of the area. Rainfall at t_c was determined using the online computer program (BoM, 2013) which calculates IFD curves (Intensity-Frequency-Duration). For this assessment, rainfall intensity values were determined for the three rainfall events (5, 10 and 100 year ARIs) using the time of concentration as the rainfall duration. The IFDs for Sherwin Creek are presented in Figure 1-1.

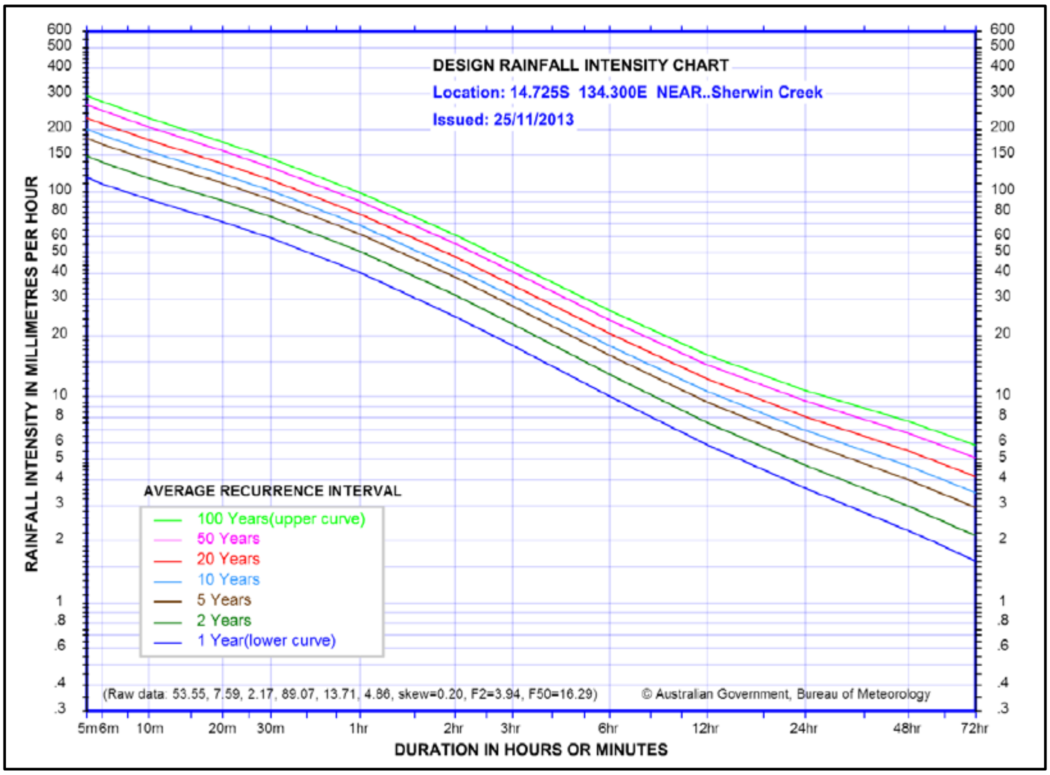

Figure 1-4. Adopted IFDs for the Sherwin Iron ore Project.

Estimated rainfall intensity values (i), flow (Q) and depths for the times of concentration and ARI rainfall events and the estimated peak flood discharges are provided in Table 1-2.

Table 1-2. Estimated rainfall intensities and flood peak discharges.

ARI	5 year	10 year	100 year
i (mm/hr)	16	18	26
Q (m^3/s)	228	288	416
Estimated Flow Depth (m)	4.3	4.8	5.5

This preliminary assessment indicates that the main active channel of Sherwin Creek may accommodate only smaller flows and larger flood events will overtop the stream banks, with flood water inundating the floodplain.

Depths of water across the floodplain could be approximately 2.5 m for the 100-yr ARI flood event at the crossing of the site access road on Sherwin Creek. Estimated flow velocities, both within the channel and in the overbank regions, are relatively low, which this is to be expected given the gradient along the course of the Sherwin Creek.

The mean annual runoff from the catchment above the Access/Haul Road is estimated at 34.5 ML/a.

1.1.4 Surface water quality

There is limited available baseline surface water quality data for Sherwin Creek, which includes two samples at adjacent (1 km apart) sites within the Project Area and one sample from a site on the lower reaches of Sherwin Creek, about 2 km upstream of the Roper River confluence (Table 1-3, Figure 1-5).

Available water quality data indicate that the upper to middle reaches of Sherwin Creek is rainfall-dominated, being characterised by circum-neutral pH, moderate electrical conductivity (EC) and low ionic composition. In contrast, it appears that the lower reaches of Sherwin Creek are groundwater-fed, as indicated by relatively high pH, EC, alkalinity and ionic composition. Concentrations of dissolved heavy metals are generally below laboratory detection limits, with the exception of manganese and iron. Nutrient concentrations are slightly elevated in comparison to default ANZECC (2000) guidelines for 95 % protection of aquatic ecosystem health (Table 1-3).

Table 1-3. Baseline water quality data for Sherwin Creek

Site	Date	In-situ pH	In-situ DO	In-situ EC	In-situ Turbidity	Total Dissolved Solids	Total Suspended Solids	Hydroxide $CaCO_3$	Carbonate $CaCO_3$	Bicarbonate $CaCO_3$	Total Alkalinity $CaCO_3$	Total hardness CaCO3	SO_4^{2-}	Cl	Ca	Mg	Na	K
		units	%	uS/cm	FTU	g/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 95%		*6 - 8*		*250*	*2 - 15*													
SISW05	17/05/2012	6.65	1.1		12		6	<1	<1	21	21		<1	29	2	6	14	1
SISW04	17/05/2012	6.55	73	147	5.8	0.094	<5	<1	<1	11	11		3	22	1	5	12	1
G9035112	20/06/1986	8.5		925		0.545			6	259	222	280	82	120	48	39	89	10

Site	Date	As	Cd	Cr	Cu	Mn	Ni	Pb	Zn	Fe	Ammonia	Nitrite	Nitrate	Nitrite + Nitrate	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 95%		*0.024*	*0.0002*	*0.001*	*0.0014*	*1.9*	*0.011*	*0.0034*	*0.008*		*0.01*		*0.16*	*0.005*		*0.3*	*0.01*
SISW05	17/05/2012	<0.001	<0.0001	<0.001	0.001	0.036	<0.001	<0.001	<0.005	0.13	0.02	<0.01	0.01	0.01	2.8	2.8	0.02
SISW04	17/05/2012	<0.001	<0.0001	<0.001	<0.001	0.03	<0.001	<0.001	<0.005	<0.05	0.01	<0.01	<0.01	<0.01	0.1	0.1	0.02
G9035112	20/06/1986												1				

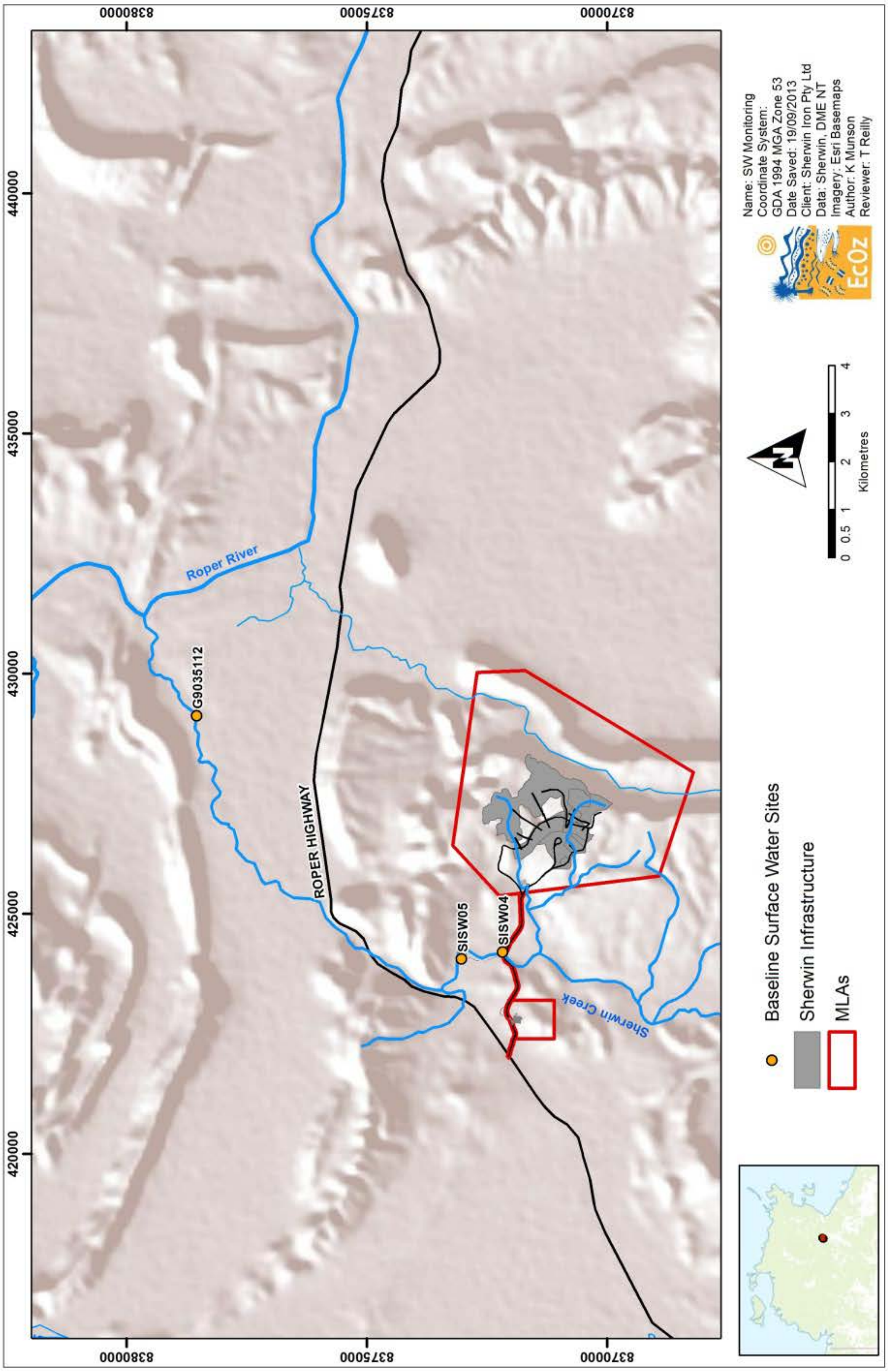

Figure 1-5. Map showing location of baseline surface water monitoring sites

1.2 Groundwater

1.2.1 Regional groundwater resources

The project area is located within the Daly-Roper Water Control District (WCD), where a water extraction licence is generally required for any extraction. Exceptions apply to mining operations, domestic purposes, drinking water, grazing stock and irrigation of a domestic garden not exceeding 0.5 ha.

The Daly-Roper WCD comprises the combined Daly and Roper River catchments, each with major river systems including the Katherine, Flora, Douglas, and tributaries of the Daly and Roper Rivers (i.e. Waterhouse, Mainoru, Wilton and Phelp). The Oolloo, Jinduckin and Tindall aquifers are also included in the WCD as these aquifers discharge into the rivers. The WCD also includes the Katherine, Oolloo and Mataranka Water Allocation Plan (WAP) areas.

Under section 57 of the NT *Water Act,* any bore drilled within the WCD requires a bore construction permit, except for mining operations. A bore located outside a WCD does not require a construction permit, noting that under the same Act, a Northern Territory licensed driller must be used to drill the bore.

1.2.2 Local groundwater resources

The project area terrain is predominantly flat to undulating and blanketed with thin Quaternary soils. The cyclic sandstone and mudstone shallow marine sequence is up to 2,000 m thick in the area and has been intruded by dolerite sills, up to 50 m thick, prior to regional deformation (Alarcon-Leon 2013a – EIS Appendix F2).

MLA29584 (Deposit C) contains the Maiwok Sub Group, comprising a sequence of mud/siltstones at the bottom, sandstone with silt/mudstones and at the top, interbedded fine grained sandstone, siltstone and mudstone, with distinct pisolitic ironstone units at several stratigraphic horizons near the surface. The Upper, Middle and Lower Ironstone beds are well represented at Sherwin Creek. Dolerite sills, up to 50 m or more in thickness, have intruded between the Lower Ironstone and the overlying basal oolitic hematite of the Middle Ironstone.

The local aquifers may be described as weathered strata overlying hard fractured bed rock and comprise:

- A permeable and ephemeral shallow system. The pedological column, particularly at the north-western end of Deposit C, contains some lenses of fresh ground water trapped locally in silty-clays, overlying extremely weathered sandstone (~6 m thick). These conditions do not extend across the footprint of the proposed open pit and are highly localised, within the alluvial-debris fans located at the outlets of numerous small creek channels and gullies.

- The shallow system is underlain by a sequence of interlayered weathered and fractured siltstones, sandstones, shales and localised mudstones, in which groundwater is encountered between about 20 m below surface (lower lying terrain) and 70 m below surface (across higher lying terrain and the open pit). Below this, there is a thick sequence of siltstones overlying a very hard bluish dolerite that acts as the lower boundary of the confining system.

Groundwater strikes were generally small and resultant groundwater levels below the depth of mining (Table 1-4). The hydraulic parameters of the aquifers are low, indicative of the relative impermeability of the terrain. Baseline EIS groundwater investigations (Alarcon-Leon 2013a) indicated that mining to about 40 m below surface would not interfere with the deeper fractured aquifers and groundwater influx will not take place.

Current groundwater sources are detailed in Table 1-4 and Figure 1-6.

Table 1-4. Groundwater sources (source: Alarcon-Leon 2013a - EIS Appendix F2)

Bore ID	Depth	Water Strikes	GWL	Airlift Yield	Medium Term Sustain ability	Long Term Sustainable Yield	Aquifer
	mbgl	mbgl	mbgl	L/s	(L/s)	(L/s)	
SEMB1	50	47	50.1	<0.01	-	not calculated	Shale underlying clay.
SEMB2	50	37	36.6	0.20	0.10	not calculated	Fracture zone in siltstones.
SEMB3	55	16, 23	4.3	1.33	0.90	0.81	Sherwin Ironstones.
SEMB4	40	23	22.9	0.01	-	not calculated	
SEMB5	50	43	45.8	<0.01	-	not calculated	Clay.
SEMB6	55	25	16.3	0.10	0.10	not calculated	Weathered sandstone.
SPB01	27	13 to 18	9.6	0.45	0.40	not calculated	Alluvial conglomerates, grey siltstone and quartz.
SPB02	100	26, 34, 37, 51	2.3	0.50	0.10	not calculated	Fractured iron rich sandstones, siltstones and shales.
SPB03	75	34, 48, 51, 67	0.5	<0.01	-	not calculated	
SPB06	75	25, 26, 40, 43, 53, 61, 67	3.5	0.22	0.20	not calculated	
SPB07	75	9, 15	6.5	1.0	0.65	0.11	Alluvial conglomerates overlying highly weathered and fractured sandstones. Bore is the same system as per SPB01.

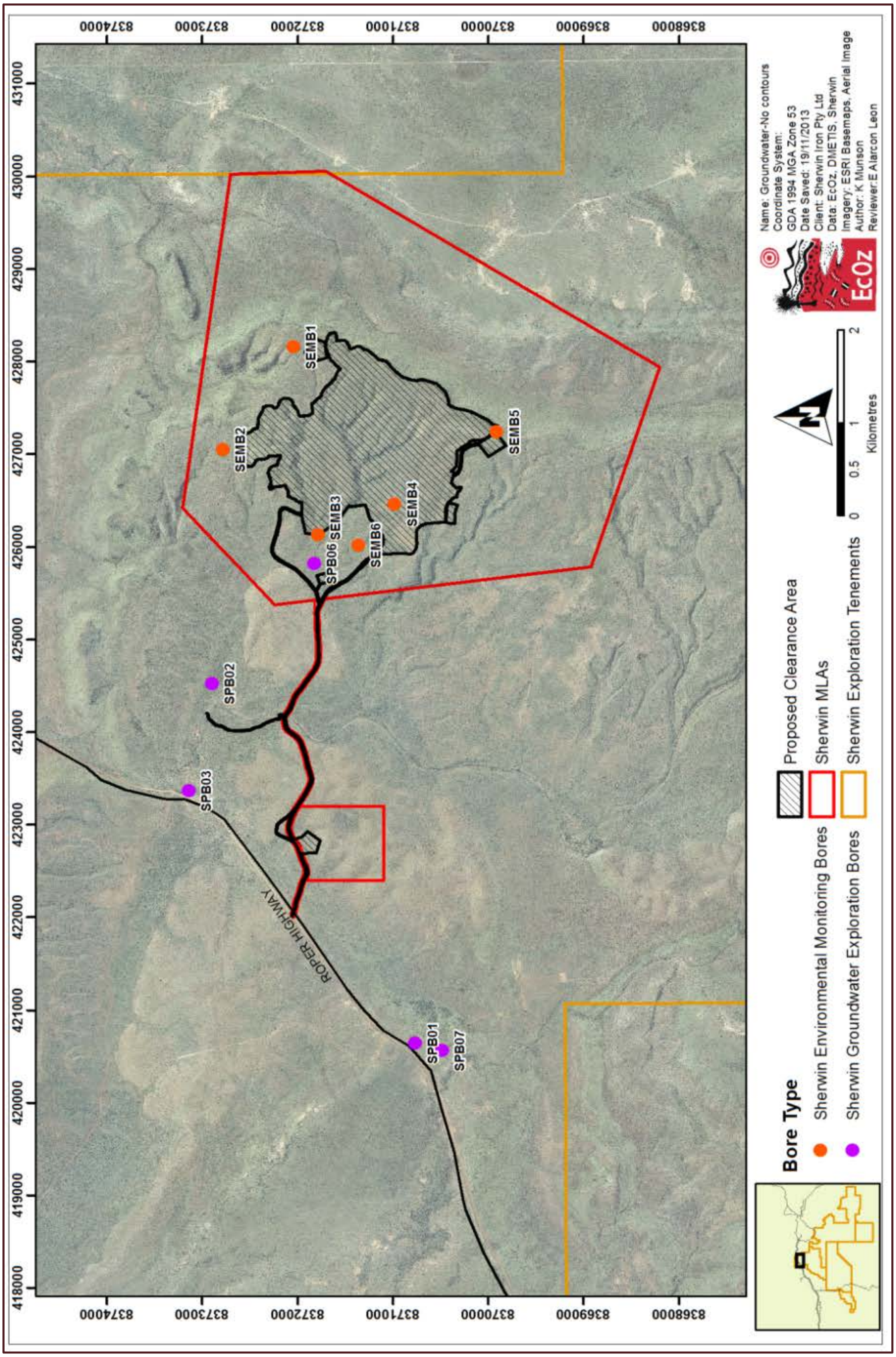

Figure 1-6. Map showing groundwater extraction and monitoring bore locations

1.2.3 Groundwater quality

Groundwater qualities (Table 1-5) are deemed suitable for most uses/users:

- Circum-neutral to slightly alkaline pH, ranging from 5.84 to 8.99.
- Electrical conductivities (EC) range from 98 to 1,110 µS/cm, averaging 464 µS/cm.
- Most groundwaters have relatively small concentrations of major ions, with only one sample (bore SPB03) having elevated chloride (108 mg/L) and sodium (178 mg/L).
- The trace elements are generally well below their assessment levels.
- Hydro-geochemical assessments indicate the presence of three types of ground water: the first is a $Ca(HCO_3)_2$ type, indicating recently recharged waters which occur across the low lying ground to the west and south-west of the proposed open pit. The second is a $NaHCO_3$ type which indicates ion-exchange waters to the north and north-west of the proposed open pit (i.e. between bores SPB02 and SPB03). The third group is a NaCl type, which indicates end-point (saline/brackish) waters across high lying ground and below the proposed mine pit. These waters have lower pH values than elsewhere and slight salinity, indicating slow and little recharge, if any.

Table 1-5. Groundwater quality

Sherwin Mine Ground Water Quality			Assessment Levels		Sample Type: Ground Water										
			NHMRC/NRMMC	ANZECC	Sampling Date: Year 2013										
			(2011)[1]	(2000)[2]	6-Sep	30-Aug	27-Oct	27-Oct	27-Oct	12-Sep	9-Nov	15-Oct	7-Nov	12-Oct	25-Oct
Analyte	**Unit**	**LOR**		**95%**[3]	SEMB02	SEMB03a	SEMB03b	SEMB03c	SEMB03d	SEMB06	SPB01	SPB02	SPB03	SPB06	SPB07
Field Measurement															
pH Value	pH Unit				5.84	7.39				6.74	8.25	8.99	8.58	8.32	6.5
Electrical Conductivity	µS/cm				98	311.2				220.6		446	1880	339.1	
Total Dissolved Solids	mg/L				63.8	202.3				141.8					
Salinity	ppt				0.1	0.1				0.1	0.54	0.2	0.94	0.23	0.3
Dissolved Oxygen	%				98.5	87				65		72.9		76.1	
Temperature	°C				27.8	30.2				30.2		33.5		30.5	
Laboratory Measurement															
pH Value	pH Unit	0.01		6.0-8.5	5.84	7.39	7.02	6.97	7.01	6.74	8.27	8.02	9.12	8.1	7.66
Electrical Conductivity @ 25°C	µS/cm	1		10000	98	311.2	387	342	347	220.6	1110	336	896	339	714
Total Dissolved Solids (Calc.)	mg/L	1		100	638	223	252	222	226	141.8	722	218	582	220	464
Total Hardness as $CaCO_3$	mg/L	1			4	133	115	114	113	87	386	50	<1	105	204
Alkalinity															
Hydroxide Alkalinity as $CaCO_3$	mg/L	1			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1			<1	<1	<1	<1	<1	<1	<1	<1	57	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1			1	105	142	116	117	85	459	107	173	112	298
Total Alkalinity as $CaCO_3$	mg/L	1			1	105	142	116	117	85	459	107	230	112	298
Aions															
Acidity as $CaCO_3$	mg/L	1					79	52	54		11	5	<1	<1	31
Sulfate as SO_4 - Turbidimetric	mg/L	1		400	4	7	5	6	6	3	4	9	7	3	3
Chloride	mg/L	1	250	400	21	24	27	28	28	13	52	24	108	29	38

Sherwin Mine Ground Water Quality			Assessment Levels		Sample Type: Ground Water										
			NHMRC/NRMMC	ANZECC	Sampling Date: Year 2013										
			(2011)[1]	(2000)[2]	6-Sep	30-Aug	27-Oct	27-Oct	27-Oct	12-Sep	9-Nov	15-Oct	7-Nov	12-Oct	25-Oct
Analyte	**Unit**	**LOR**		**95%[3]**	SEMB02	SEMB03a	SEMB03b	SEMB03c	SEMB03d	SEMB06	SPB01	SPB02	SPB03	SPB06	SPB07
Cations															
Calcium	mg/L	1			<1	2	5	3	4	2	54	5	<1	4	34
Magnesium	mg/L	1			1	31	25	26	25	20	61	9	<1	23	29
Sodium	mg/L	1		300	16	15	14	15	15	10	82	49	178	17	64
Potassium	mg/L	1			2	2	1	1	1	7	4	6	3	4	3
Dissolved Metals															
Arsenic	mg/L	0.001			<0.001	0.001	0.002	0.001	0.002	0.002	<0.001	<0.001	0.001	<0.001	<0.001
Boron	mg/L	0.05			<0.05	0.09	0.11	0.11	0.11	<0.05	0.13	0.12	0.5	0.09	0.09
Barium	mg/L	0.001			0.004	0.006	0.01	0.008	0.008	0.018	0.012	0.007	0.002	0.008	0.013
Beryllium	mg/L	0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001			<0.0001	<0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Cobalt	mg/L	0.001			0.003	0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.006	<0.001	0.002	<0.001
Manganese	mg/L	0.001			0.18	0.099	0.153	0.129	0.135	0.457	0.137	0.099	0.013	0.089	0.462
Nickel	mg/L	0.001			0.001	<0.001	0.001	<0.001	<0.001	0.002	0.007	0.004	<0.001	0.002	<0.001
Lead	mg/L	0.001			<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005			<0.005	<0.005	10.5	0.475	1.34	<0.005	0.009	<0.005	0.005	<0.005	0.252
Total Metals[4]															
Arsenic	mg/L	0.001	0.01	0.024	0.001	0.002	0.003	0.002	0.002	0.027	0.002	0.021	0.005	0.009	<0.001
Boron	mg/L	0.05	4	0.37	<0.05	0.08	0.1	0.12	0.1	0.05	0.16	0.13	0.59	0.1	0.1

Sherwin Mine Ground Water Quality			Assessment Levels		Sample Type: Ground Water										
			NHMRC/NRMMC	ANZECC	Sampling Date: Year 2013										
			(2011)[1]	(2000)[2]	6-Sep	30-Aug	27-Oct	27-Oct	27-Oct	12-Sep	9-Nov	15-Oct	7-Nov	12-Oct	25-Oct
Analyte	**Unit**	**LOR**		**95%[3]**	SEMB02	SEMB03a	SEMB03b	SEMB03c	SEMB03d	SEMB06	SPB01	SPB02	SPB03	SPB06	SPB07
Barium	mg/L	0.001	2	-	0.017	0.01	0.018	0.009	0.013	0.131	0.061	0.133	0.07	0.162	0.017
Beryllium	mg/L	0.001	0.06	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.002	<0.001	0.003	<0.001
Cadmium	mg/L	0.0001	0.002	0.0002	<0.0001	<0.0001	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006
Cobalt	mg/L	0.001	-	-	0.005	0.003	<0.001	<0.001	<0.001	0.048	0.014	0.033	0.005	0.024	<0.001
Chromium	mg/L	0.001	0.05	0.001	0.001	<0.001	0.012	<0.001	<0.001	0.02	0.008	0.027	0.007	0.031	0.001
Copper	mg/L	0.001	2	0.0014	<0.001	<0.001	0.014	0.001	0.003	0.009	0.019	0.274	0.006	0.037	0.008
Manganese	mg/L	0.001	0.1	1.9	0.346	0.156	0.197	0.142	0.146	3.7	2.28	2.43	1.12	0.809	0.412
Nickel	mg/L	0.001	0.02	0.011	0.002	<0.001	0.004	<0.001	<0.001	0.012	0.014	0.079	0.007	0.035	0.002
Lead	mg/L	0.001	0.01	0.0034	<0.001	<0.001	0.01	<0.001	0.002	0.006	0.008	0.014	0.005	0.009	0.016
Selenium	mg/L	0.01	0.01	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.01	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.11	0.04	0.01	0.03	0.02
Zinc	mg/L	0.005	3	0.008	<0.005	0.01	13.5	1.39	1.37	0.045	1.65	0.69	0.127	0.103	3.52
Dissolved Mercury	mg/L	0.0001					<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Recoverable Mercury	mg/L	0.0001	0.001				<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Others															
Fluoride	mg/L	0.1					0.2	0.2	0.2		1.4	1.2	0.5	0.3	0.6
Ammonia as N	mg/L	0.01					0.03	0.04	0.04		0.04	0.4	0.23	0.16	0.36
Nitrite as N	mg/L	0.01					<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01					<0.01	<0.01	<0.01		0.12	0.08	0.02	<0.01	0.4
Nitrite + Nitrate as N	mg/L	0.01		11	0.24	<0.01	<0.01	<0.01	<0.01	0.01	0.12	0.08	0.02	<0.01	0.42
Total Kjeldahl Nitrogen as N	mg/L	0.1			<0.1	<0.1	0.1	0.1	0.1	0.7	0.1	1.1	0.2	0.4	0.7
Total Nitrogen as N	mg/L	0.1			0.2	<0.1	0.1	0.1	0.1	0.7	0.2	1.2	0.2	0.4	1.1
Total Phosphorus as P	mg/L	0.01			<0.01	0.02	0.01	0.02	0.03	0.07	0.08	0.33	0.03	0.05	0.01

Sherwin Mine Ground Water Quality			Assessment Levels		Sample Type: Ground Water										
			NHMRC/NRMMC	ANZECC	Sampling Date: Year 2013										
			(2011)[1]	(2000)[2]	6-Sep	30-Aug	27-Oct	27-Oct	27-Oct	12-Sep	9-Nov	15-Oct	7-Nov	12-Oct	25-Oct
Analyte	**Unit**	**LOR**		**95%[3]**	SEMB02	SEMB03a	SEMB03b	SEMB03c	SEMB03d	SEMB06	SPB01	SPB02	SPB03	SPB06	SPB07
Reactive Phosphorus as P	mg/L	0.01					<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01
Ionic Balance															
Total Anions	meq/L	0.01			0.7	2.92	3.7	3.23	3.25	2.13	10.7	3.15	7.79	3.12	7.09
Total Cations	meq/L	0.01			0.83	3.35	3.82	3.34	3.36	2.36	11.4	3.28	7.82	2.95	6.94
Ionic Balance	%	0.01					1.57	1.55	1.63		2.98	1.92	0.15		1.05

Note:

1. NHMRC and ARMCANZ (2011). Australian Drinking Water Guidelines.
2. ANZECC and ARMCANZ (2000). Australian Water Quality Guidelines for Fresh and Marine Water Quality.
3. Values are 'triggers' for slightly moderately disturbed ecosystems. Values applicable to high conservation/ecological value systems and highly disturbed ecosystems are available in ANZECC and ARMCANZ (2000).
4. All values above the Australian Drinking Water Guidelines are highlighted in yellow colour.

2 Water management system

2.1 Water use

An estimate of the water demand for potable use and mining operations is provided in Table 2-1 below.

Table 2-1. Potable and mining operational water requirements

Water Demand/Requirement DSO Mining 3Mt/a	ML/a	L/s
Camp Site (100 occupants)	11	0.7
Mine Offices/Workshop/Site (65 personnel)	4	0.2
Total Potable Water Requirement	**15**	**0.9**
Mine Water Requirement (non-potable)		
Crushing and Screening (dust suppression)	3	0.2
Workshop/Wash Bays	15	0.9
Haul Road/Open Pit Mining/ROM (dust suppression)	17	1.0
Total Mine Operational Water Requirement	**35**	**2.1**

The potable and mine water demand will be met from groundwater sources within or close to the project area, with the primary use will being for dust suppression at the screening plant and along the haul roads. The estimates for water requirements for dust suppression are based on using several water saving strategies, including:

- Water-saving devices and worker awareness training at the camp and mine ablutions.
- The latest technology in crushing and screening.
- Polymers on all roads requiring dust suppression.

The commercially-available polymer 'ISB9000' (or similar) is to be sprayed with the correct amounts of product and water for sealing purposes and dust control of road and hardstand pavements. The polymer proposed is not classified as a dangerous good under the Australian Dangerous Goods Code.

2.2 Water management infrastructure and operation

The water management system for the Sherwin Creek Iron Ore Project is illustrated in Figure 2-1

Fire water storage tanks will be located at the plant and accommodation camp for use in the case of an emergency. The camp will have a dedicated pressurised fire water system. The fire water storage tank reserve capacity in each location will be located in the lower portion of the respective raw water tanks, with all other water consumption being drawn from above the fire water reserve capacity. The fire water pumps will be a conventional system, utilising an electric duty and standby pump, with a diesel back-up pump.

Water required for human consumption (drinking or washing) will be treated via ultra-violet treatment and reverse osmosis prior to use. Raw water will be stored at the mine camp in three 45 kL and two 35 kL tanks prior to treatment.

A modular 'OSMOMBR' wastewater treatment plant (max. capacity 500 kL/day) will be installed at the mine camp. The wastewater effluent after treatment will be reticulated onto landscaped areas and the surplus will be stored in a turkey's nest dam for use in dust suppression. All products resulting from the wastewater treatment plant will be managed in accordance with relevant legislation and guidance material for minimum quality of water to be used in irrigation.

Erosion control measures are detailed in the Erosion and Sediment Control Plan (ADG 2013 - EIS Appendix E), which involves the re-routing of clean, upstream catchment run-off around disturbed areas through a system of diversion channels and level spreaders. Uncontaminated run-off from disturbed areas will be collected in catch drains and channelled into sediment basins. Sediment basins will be constructed using the IECA Best Practice Erosion and Sediment Control guidelines with a minimum storage depth of 0.6 m. Implementation of these measures will ensure the integrity of receiving waters.

As outlined in the baseline Acidic/metalliferous Drainage (AMD) Assessment Report (Alarcon-Leon 2013b – EIS Appendix G), the risk of AMD is considered to be low and coupled with the absence of groundwater influx into the open pit, there is unlikely to be a requirement to manage contaminated water on site. The ore extraction process is also benign (i.e. no chemicals added), so there is no risk of contamination associated with chemical extraction. Although the risks are considered minimal, sedimentation ponds located downstream of potential sources of contamination from mined materials (i.e. waste dumps, stockpiles) and stored hazardous materials (i.e. workshops, fuel storages etc.) will be monitored to confirm that water quality is suitable for discharge and if an issue is identified, specific changes in management and/or infrastructure may need to be made.

The groundwater investigation (Alarcon-Leon 2013a – EIS Appendix F2) confirmed the absence of groundwater within the depth of mining. Thus, there will be no flux of groundwater into the open pit. Rain falling directly into the open pit will be collected in sumps, fitted with submersible pumps; at the downstream end (western side) of the open pit mining will take place in a sequence to facilitate pit mine water management in such a fashion that higher elevations are mined during the wet season. This pit rain and runoff water will be the primary source for dust suppression water.

Groundwater sources will be pumped and piped to several turkey's nests (nominally designed to be 75 x 75 m and at least 3 m deep (Figure 2-2):

- North of the magazine area but more than 500 m away near the new haul road access (to be supplied by bores located between the magazine and sub-grade stockpile area).
- Along the existing access road (to be supplied by bores located near Sherwin Creek, south of the Restricted Work Area).
- West of the proposed camp (to be supplied by bores located further west of the proposed camp).

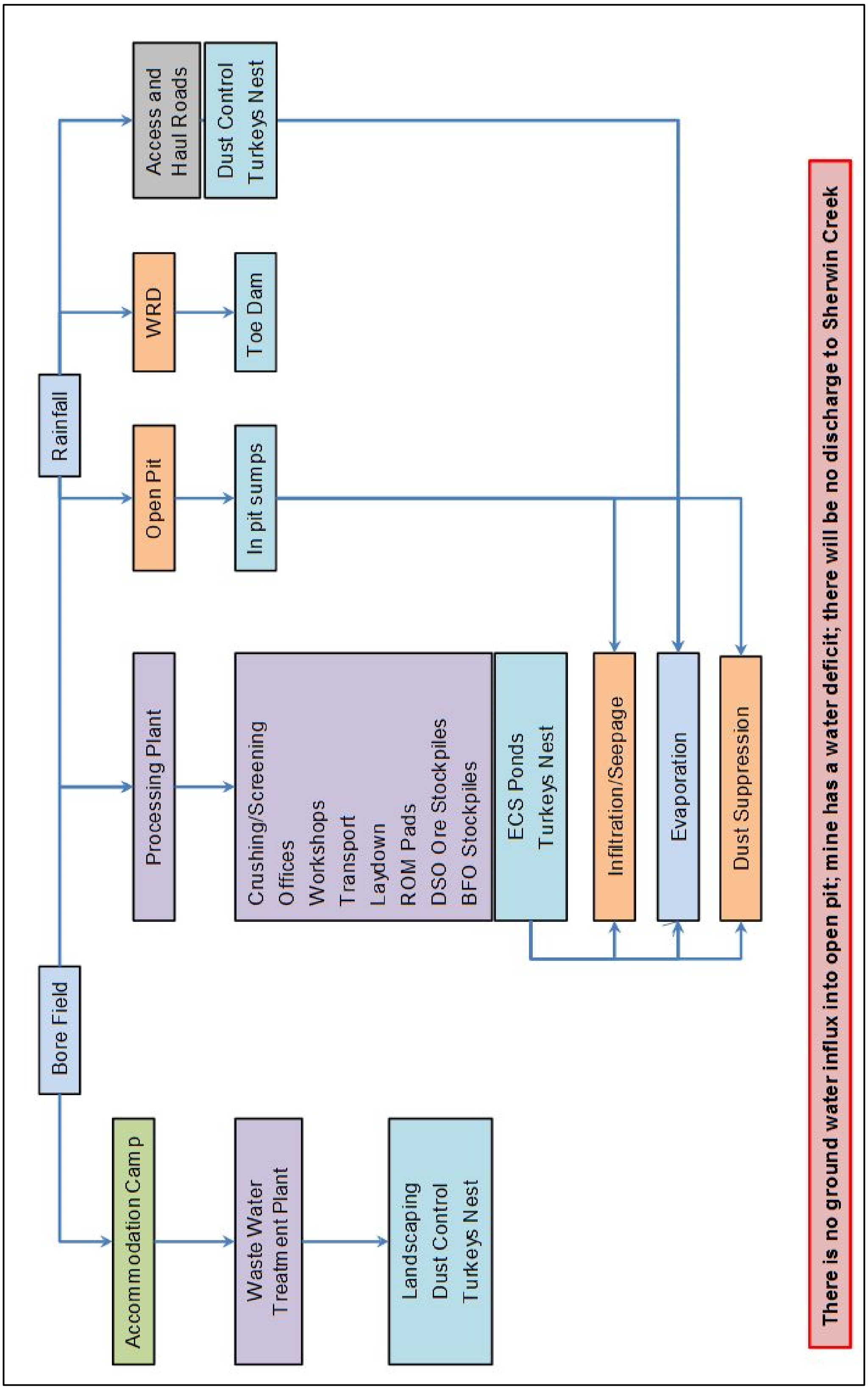

Figure 2-1. Diagram showing water management system for year 1 operations

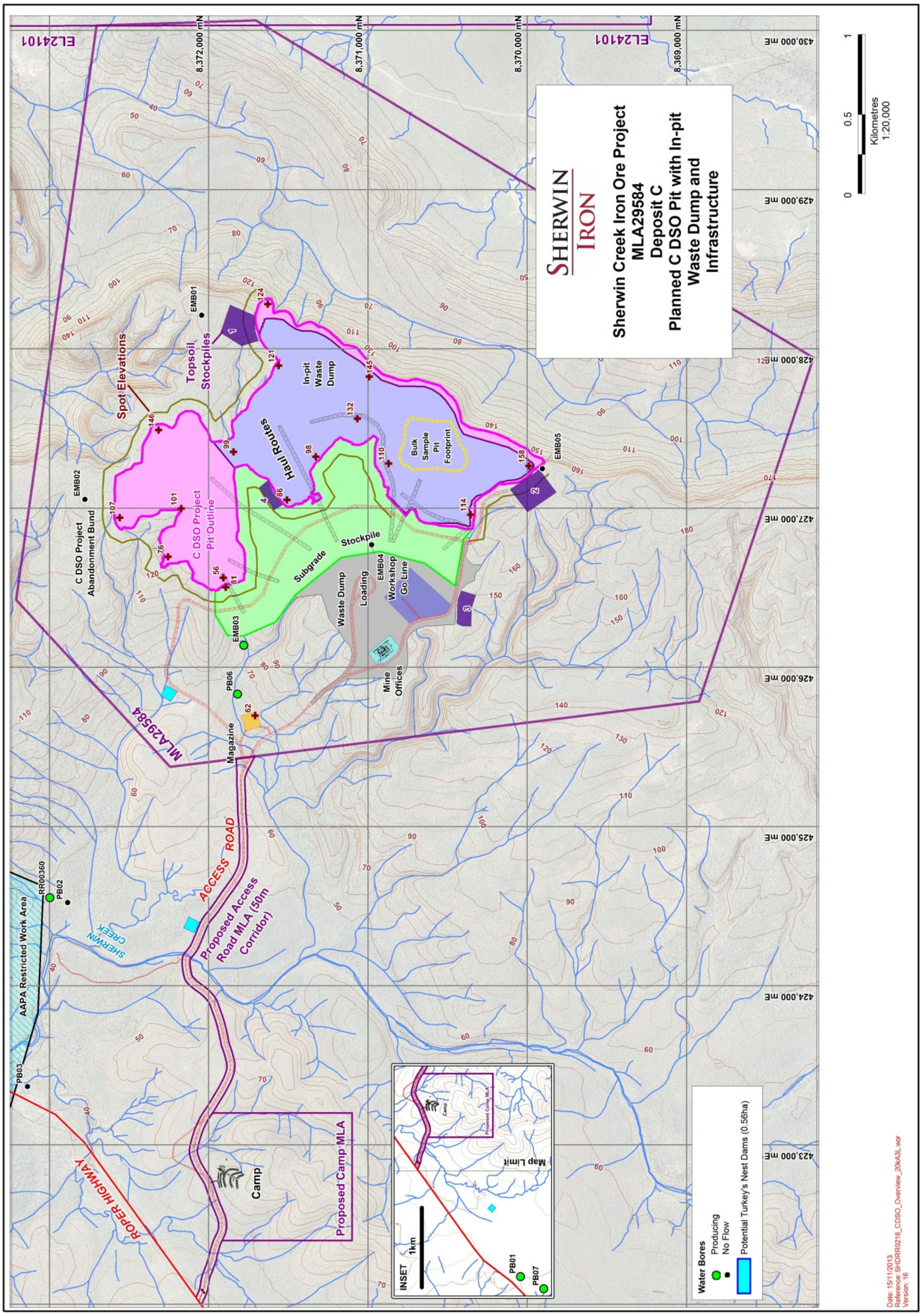

Figure 2-2. Map showing mine layout and locations of turkey's nest dams.

2.3 Water account

Based on a detailed water balance for the project, the water account for an average rainfall year (Appendix 1) indicates a water deficit, due to large evaporation and in the absence of mine influx (groundwater level is below depth of mining). However, positive flows will be experienced during the wet season (i.e. between December and April), when rainfall exceeds evaporation. The stored excess rainfall accumulated in the pit will be the primary source for dust suppression water. Deficits during the dry season will be made up from bores.

3 Knowledge gaps

3.1 Identification of knowledge gaps

A key knowledge gap is the deficiency in the amount of available baseline water quality data. It is generally considered that at least two years of baseline data covering a range of seasonal conditions is an ideal baseline, upon which the potential impacts of mining operations can be assessed.

3.2 Filling knowledge gaps

As substantial disturbance associated with the bulk sample mining activities have already commenced within the Project Area, it is not possible to address the issue of inadequate baseline water quality data. However, the proposed water quality monitoring program (Section 5.1) includes a surface water monitoring site on Sherwin Creek that is upstream of mining operations, which can be used as a reference site to assess potential future impacts.

4 Risk management

4.1 Assessment methods

Risk is defined as the chance of something happening that will have an impact on objectives. The first step in the risk assessment process involved identifying the hazards associated with hydrology and water quality. Each hazard was analysed for likelihood and consequence and a risk ranking was developed for the inherent value. Mitigation measures were considered for each hazard and a new likelihood, consequence and risk ranking (now the residual risk) was defined.

The ranking for event consequence is shown in Table 4-1. The likelihood of an event occurring provides a measure of the known or anticipated frequency of occurrences (see Table 4-2). Combining likelihood with consequence (see Table 4-3) provides guidance on risk levels of each aspect and enables ranking of priorities.

Identified hazards, associated risks, mitigation measures and residual risks to hydrology and water quality associated with the project are summarised in Table 4-4 and discussed in further detail in Section 4.2 below.

Table 4-1. Consequence ranking

Consequence		
1	Insignificant	No measurable impact on the environment. No injuries. Low-nil financial loss.
2	Minor	Minor, temporary environmental impact. No publicity likely and no stakeholder concerns. First aid treatment required. Medium-low financial loss.
3	Moderate	Substantial temporary or permanent minor, localised environmental damage. Stakeholder enquires (this may include government, unions or public). Medical attention required. High-medium financial loss.
4	Major	Substantial or permanent environmental damage. Prosecution possible. Loss of company credibility and high stakeholder interest. Permanent injuries. High financial loss.
5	Catastrophic	Widespread severe and permanent environmental damage. Major stakeholder and media interest. Prosecution likely. Permanent injury or death. Extreme financial loss.

Table 4-2. Qualitative measures of likelihood

Probability/likelihood			Likelihood criteria
A	Rare:	Practically impossible, will only occur in exceptional circumstances. Has never occurred in the industry.	0-1%
B	Unlikely:	Could occur at some time but highly unlikely. Has occurred in the industry previously.	1-10%
C	Moderate:	Might occur at some time. Has occurred in associated companies previously.	11-50%
D	Likely:	Known to occur or will probably occur in most circumstances. Has occurred several times/year in associated companies.	51-90%
E	Almost certain:	Common or repeating occurrence. Is expected to occur several times/year in any associated business.	91-100%

Table 4-3. Risk rankings used by combining consequence with likelihood levels for each aspect identified

		Consequence				
Likelihood		**1**	**2**	**3**	**4**	**5**
	A	1	3	6	10	15
	B	2	5	9	14	19
	C	4	8	13	18	22
	D	7	12	17	21	24
	E	11	16	20	23	25

Where;

Red =	extreme risk	intolerable
Purple =	high risk	intolerable or tolerable
Yellow =	medium risk	tolerable or acceptable
Green =	low risk	acceptable

4.2 Actions and strategies in response to identified risks

4.2.1 Surface water hydrology

The main potential risks to surface water hydrology are the alteration to surface water flows associated with:

i. Road crossing of Sherwin Creek

ii. Modification of natural drainage flow paths associated with mining infrastructure.

Hydrology inherent risk profile

The proposed road between the mine site and Roper Highway crosses Sherwin Creek and in the absence of appropriate design and construction, stream crossings (e.g. bridges, culverts, causeways) could lead to a localised alteration of stream hydrology (e.g. increased velocities associated with constriction of flows); which may affect upstream movement of aquatic fauna (e.g. fish) and lead to increased localised erosion. While there are no recorded or expected threatened species within the local waterbodies, this may have an effect on accessible wet season habitat for some species. This is considered to be of minor consequence with a moderate likelihood, resulting in a medium inherent risk.

There will be some modification and removal of the upper sections of several drainage lines in the catchment of a minor tributary of Sherwin Creek associated with construction of the mine site, with potential impacts on flows to downstream areas. However, as these drainage lines are located at the top of their respective catchments, this is considered to be a minor consequence (i.e. minor, temporary environmental impact) and in the absence of any mitigation measures is moderately (i.e. might occur at some time) likely to occur. This results in a low inherent risk of impact to downstream aquatic environments.

Hydrology risk mitigation

To minimise the potential risks of alteration to surface water flows associated with the road crossing of Sherwin Creek and other minor drainage lines, their design and construction will incorporate appropriate engineering principles and natural flows will be maintained at all times. Construction will be cognisant of fish passage principles (e.g. Fairfull and Witheridge 2003).

Natural surface water flows will be maintained within the mine site area as far as practicable and where minor drainage diversions are required (e.g. around waste dumps/stockpiles), consideration will be given to ensuring that water flows resume their natural flow paths as close as possible downstream of disturbed areas.

Hydrology residual risk

The above mitigation measures reduce the risk of hydrological impacts associated with both the construction of haul road stream crossings and modification of natural drainage flow paths to a low level.

4.2.2 Surface water quality

Surface water systems are particularly susceptible to changes in water quality associated with mining activities that may lead to inputs of contaminants from:

- Acid/metalliferous drainage (AMD) from ore and/or waste rock
- Suspended solids and turbidity in run-off from disturbed areas
- Spills/leaks of hazardous chemicals
- Sewage and other wastes

Surface water quality inherent risk profile

The transfer of rock materials from underground to the ground surface may result in the mobilisation of solutes (e.g. metals, salts), which may in turn lead to degradation in quality of downstream surface and/or groundwaters. The risk of contaminant mobilisation is increased significantly with the occurrence of potentially acid forming (PAF) materials and as outlined in the AMD/PAF Report (Alarcon-Leon 2013b – EIS Appendix G). Detailed investigations indicate that there are small quantities of PAF materials located in the north-western section of the proposed pit shell. In the absence of appropriate management, acid/metalliferous drainage has the potential to impact water quality and subsequently, aquatic ecosystem health for a considerable distance downstream. Given the relatively small quantities of PAF likely to be encountered in this project, the fact that these small quantities are ore and will be shipped off site and the absence of groundwater influx to the mine pit (Alarcon-Leon 2013a – EIS Appendix F2), in the absence of appropriate management and/or mitigation measures, both the consequence and likelihood of this impact are considered to be moderate, resulting in a high inherent risk of impact to downstream surface water quality.

Within the project area, there are some soil types that pose an inherently high risk of erosion and clearing for mining and ancillary activities (e.g. pits, stockpiles, waste dumps, roads, processing areas, etc.) involves the removal of vegetation and in many cases, the soil surface cover. This may lead to erosion of soils/subsoils and subsequent transport of sediments into downstream aquatic environments in surface run-off. Increased sedimentation and turbidity can affect the functioning of aquatic environments in a number of ways, such as smothering of habitats, inhibition of photosynthetic activity and ecological effects (e.g. changes in visibility affecting predatory species). In the absence of appropriate mitigation measures, there are likely to be major consequences (i.e. substantial or permanent environmental damage) with a moderate likelihood (i.e. might occur at some time), resulting in a high risk of impact to downstream aquatic environments.

There are to be no chemicals used in the ore extraction process, with the storage and handling of hazardous materials being primarily associated with hydrocarbons (i.e. fuel for mining equipment). Potential impacts associated with spills or leaks of hazardous materials include contamination of downstream surface quality. In the absence of appropriate mitigation measures, there are likely to be ‘major’ consequences (i.e. substantial or permanent environmental damage) with a ‘moderate’ likelihood (i.e. might occur at some time), resulting in a ‘high’ risk of impact to downstream aquatic environments.

Treated sewage water will be used for dust suppression. If the disposal location has a connection to a drainage line, there is a risk of impacts on downstream surface water quality associated with elevated nutrient concentrations, which may in turn cause nuisance/toxic algal blooms. Irrigation of water in a small area could also lead to waterlogging of the soil and potentially a localised effect on vegetation (e.g. change in species composition). If not located or managed appropriately, domestic waste disposal may also pose a risk to surface water quality. Remaining non-hazardous (inert and putrescible) solid wastes will be disposed of in an on-site, trench type landfill. If the disposal trench location has a connection to a drainage line, there is a moderate consequence (i.e. substantial temporary or permanent minor environmental damage) and moderate likelihood (i.e. might occur at some time), resulting in a medium risk of impacts on downstream surface water quality associated with elevated nutrient concentrations.

Surface water quality risk mitigation

Proposed measures to manage any PAF materials that are encountered are summarised below and details provided in the AMD/PAF Report (Alarcon-Leon 2013b – EIS Appendix G):

- Demarcation, progressive excavation and immediate implementation of measures such as burial, sealing and compaction to contain/encapsulate/cover and prevent oxidisation of any PAF materials.
- Benching were possible will be excavated in lengths that permit easy extraction, remediation and closure.
- Where PAF is exposed, sealing and compaction of the sides and base of the excavation will be undertaken before backfilling.

- Implementation of construction methods to prevent long-term PAF exposure to oxygen (e.g. sheet piling) will be considered.
- Any generated AMD will be monitored, managed and treated using appropriate methodologies.

To mitigate potential impacts of increased turbidity and suspended solids associated with construction and mining works, monitoring and management of runoff will be undertaken in accordance with the Erosion and Sediment Control Plan (ADG 2013 – EIS Appendix E) and this WMP. This will include the construction of sediment basins in key areas, to enable adequate settling of suspended materials prior to use or discharge. Wherever possible, any discharge points will be located so that water flows into relatively flat, vegetated areas rather than directly into drainage lines.

Hazardous materials and wastes will be stored in appropriately labelled containers within purpose-built dangerous goods and chemical storage containers. These will be self-bunded, ventilated and compliant with AS1940-2004 Storage and Handling of Flammable and Combustible Liquids. These containers are suitable for the storage of paint, thinners, oils, diesel, chemicals, Class 3 flammables substances (as classified in the *UN Recommendations for the Transport of Dangerous Goods – Model Regulations*) and other potentially dangerous liquids. In the event that a spill or leak is detected, steps will be undertaken immediately to contain the leak/spill and if required, remediation measures will be implemented (e.g. recovery and appropriate disposal of contaminated soil).

All sewage wastewater generated from the mine site and camp will be treated to a high quality and recycled. The recycled water will be used for irrigation within the camp area and dust suppression around the mine site. Irrigation of recycled water will be in accordance with the *Guidelines for Management of Recycled Water Systems* (Department of Health 2011a) and *Environmental Health Factsheet No. 513 Recycled Water Irrigation: Information Guide for Applicants* (Department of Health 2011b). The trench landfill will be located at least 150 m away from any surface water pathways.

A comprehensive surface water monitoring program will be undertaken at the mine site, which will include sampling of both potential sources of contamination (e.g. sediment basins) and natural surface waterbodies upstream and downstream of mining infrastructure. Details of the proposed monitoring program are provided in Section 5.1. Data will be stored in an appropriate database and reviewed at regular intervals (i.e. as data become available), to assess whether mining activities are impacting on surface water quality or if there are any trends in water quality that provide early warning of potential impacts.

Surface water quality residual risk

The mitigation measures outlined above will reduce high risks to surface water quality to moderate or low risks.

4.2.3 Groundwater levels

The main potential risk to groundwater levels is from abstraction for potable and operational mine water supplies (i.e. primarily dust suppression), in the absence of other users.

Groundwater levels inherent risk profile

It was concluded in the baseline groundwater assessment (Alarcon-Leon 2013a – EIS Appendix F2) that influx of groundwater to the mine pit and hydraulic connectivity of ground water to surface water resources in the vicinity of the mine (including GDEs) are not considered risks and will not be impacted by mining and processing. Dewatering to facilitate open pit mining will not be required and therefore no safeguards or management measures in relation to groundwater levels are required. However, the groundwater resources identified to date in the vicinity of the mine site (i.e. long-term sustainable yield = 12 ML/a) are inadequate to meet the total operational requirements of the mine (i.e. 50 ML/a).

Although the operational risk associated with depletion of local groundwater resources is relatively high, there is considered to be a 'minor' environmental consequence (i.e. minor, temporary environmental impact) and 'unlikely' likelihood (i.e. could occur at some time but highly unlikely), resulting in a 'low' inherent risk of environmental impacts.

Groundwater levels risk mitigation

To minimise water use and therefore the risk of lowering of groundwater levels, Sherwin will implement of water saving strategies, including (but not limited to) the following:

- Minimise use (e.g. education of workers in camp, use of polymers on roads to reduce requirements for dust suppression)
- Recycling of wastewater for dust suppression (i.e. sewage treatment plant)
- Re-use of rainfall/run-off captured in disturbed areas of the mine site for dust suppression.

In order to identify additional groundwater resources to meet mining operational requirements, Sherwin will undertake geophysical exploration, bore drilling, testing and sampling. Sherwin will assess potential impacts of extraction and sustainable yields from these additional groundwater resources (i.e. potential GDE's, other users, etc).

In order to minimise the operational and environmental risks (if any) associated with depletion of groundwater resources, Sherwin will ascertain/set operational controls for ground water exploitation (i.e. sustainable safe yield, allowable drawdown and distance to zero drawdown) and monitor bore yields, groundwater level behaviour and water quality, in accordance with this WMP.

Groundwater levels residual risk

The above mitigation measures further reduce the 'low' risk of impacts associated with changes to groundwater levels associated with extraction for mining operations.

4.2.4 Groundwater quality

Existing groundwater quality within the project area is variable but relatively good and there are no major regional aquifers in the immediate area (Alarcon-Leon 2013a – EIS Appendix F2). The main potential risks to groundwater quality are localised and associated with inputs of contaminants from:

i. Acid/metaliferous (AMD) drainage from ore and/or waste rock; and
ii. Spills/leaks of hazardous chemicals.

Groundwater quality inherent risk profile

The baseline AMD assessment (Alarcon-Leon 2013b – EIS Appendix G) indicated that potentially acid forming (PAF) bodies are relatively small, isolated and largely confined to the north-west of the proposed open pit. The volumes of PAF requiring disposal will be relatively low, with the primary risk associated with AMD for this project being infiltration of rain water from a partially backfilled open pit during mining and post-closure, which may leach through PAF materials located below or downstream of the pit and therefore impact on downstream groundwater quality. In the absence of appropriate mitigation measures, there is a 'moderate' consequence (i.e. substantial temporary or permanent minor, localised environmental damage) and 'moderate' likelihood (i.e. might occur at some time), resulting in a 'high' inherent risk of impact to groundwater quality.

The storage and handling of hazardous materials is primarily associated with hydrocarbons. Potential impacts associated with spills or leaks of hazardous materials include contamination of downstream groundwater quality and, in the absence of appropriate management/mitigation measures, there is a 'high' risk of this occurring.

Groundwater quality risk mitigation

Proposed measures to manage any PAF materials that are encountered are summarised below and details provided in the AMD/PAF Report (Alarcon-Leon 2013b – EIS Appendix G):

- Demarcation, progressive excavation and immediate implementation of measures such as burial, sealing and compaction to contain/encapsulate/cover and prevent oxidisation of any PAF materials.
- Benching were possible will be excavated in lengths that permit easy extraction, remediation and closure.
- Where PAF is exposed, sealing and compaction of the sides and base of the excavation will be undertaken before backfilling.
- Implementation of construction methods to prevent long-term PAF exposure to oxygen (e.g. sheet piling) will be considered.
- Any generated AMD will be monitored, managed and treated using appropriate methodologies.

In order to mitigate the potential risk of groundwater contamination from spills/leaks of hazardous materials and wastes, these will be stored in appropriately labelled containers within purpose built dangerous goods and chemical storage containers. These are self-bunded, ventilated and are compliant with AS1940-2004 Storage and Handling of Flammable and Combustible Liquids. These containers are suitable for the storage of paint, thinners, oils, diesel, chemicals, Class 3 flammables substances (as classified in the UN Recommendations for the Transport of Dangerous Goods – Model Regulations) and other potentially dangerous liquids. In the event that a spill or leak is detected, steps will be undertaken immediately to contain the leak/spill and if required, remediation measures will be implemented (e.g. recovery of contaminated soil).

Groundwater quality residual risk

The mitigation measures outlined above will reduce high risks to groundwater quality to low risks.

Table 4-4. Risks to surface and groundwater

Risk	Aspect	Potential impact/hazard	Inherent risk (C=Consequence; L=Likelihood; RS=Risk Score)			Management measures	Residual risk (C=Consequence; L=Likelihood; RR=Residual Risk)		
			C	L	RS		C	L	RR
Surface water hydrology	Change in hydrology due road crossings from mine site to Roper Highway.	• Impeded fish migration • Increased erosion	2	C	M 8	• Ensuring that creek crossing design (culverts) will have limited influence on flows.	2	B	L 5
Surface water hydrology	Change in hydrology due to modification of upper parts of catchment.	• Reduced stream flow into Sherwin Creek	2	C	M 8	• Natural surface water flows will be maintained within the mine site area and where minor drainage diversions are required. • Consideration will be given to ensuring that water flows resume their natural flow paths as far as possible.	2	B	L 5
Surface & ground-water quality	Storage of ore and/or waste rock	• Contamination of downstream surface and/or groundwaters associated with acid mine drainage (i.e. acid and/or heavy metal contamination).	3	C	H 13	• Ongoing characterisation of materials and storage and management methods. • Demarcation and progressive excavation and implementation of immediate remediation measures such as burial, sealing and compaction to prevent PAF materials to oxidise. • Where PAF is exposed, sealing and compaction of the sides and base of the excavation will be undertaken before backfilling. • Implementation of construction methods to prevent	2	B	L 5

Risk	Aspect	Potential impact/hazard	Inherent risk (C=Consequence; L=Likelihood; RS=Risk Score)			Management measures	Residual risk (C=Consequence; L=Likelihood; RR=Residual Risk)		
			C	L	RS		C	L	RR
						long-term PAF exposure to oxygen (e.g. sheetpiling) will be considered.			
Surface water quality	Land disturbance	• Erosion leading to transport of sediments in run-off, resulting in impact on downstream surface water quality (e.g. increased suspended solids, turbidity).	4	C	H 18	• Management of runoff in accordance with Erosion and Sediment Control Plan and this WMP.	3	B	M 9
Surface & ground-water quality	Storage & handling of hazardous materials (e.g. hydrocarbons)	• Spill or leak to environment with potential to contaminate downstream surface and/or groundwaters.	4	C	H 18	• Appropriate storage of hazardous materials and monitoring of storage facilities, in accordance with Standard Operating Procedures, Environmental Management Plan and relevant standards/guidelines. • Adequate training (e.g. inductions).	3	B	M 9
Surface & ground-water quality	Disposal of sewage & other waste	• Contamination of downstream surface and/or groundwaters.	3	C	H 13	• Appropriate design, location and operation of waste facilities, in accordance with operational procedures and Environmental Management Plans.	2	B	L 5

Risk	Aspect	Potential impact/hazard	Inherent risk (C=Consequence; L=Likelihood; RS=Risk Score)			Management measures	Residual risk (C=Consequence; L=Likelihood; RR=Residual Risk)		
			C	L	RS		C	L	RR
Ground-water levels	Groundwater abstraction (e.g. water supply, pit dewatering)	• Alteration to local or regional groundwater levels and availability	2	B	L 5	• Implementation of water saving strategies (i.e. minimise use, recycling of wastewater, use of polymers on roads to reduce requirements for dust suppression) • Undertake geophysical exploration, bore drilling, testing and sampling to identify additional nearby groundwater resources. • Assess potential impacts on additional nearby groundwater resources (i.e. potential GDE's, other users, etc). • Ascertain/set operational controls for ground water exploitation (i.e. sustainable safe yield, allowable drawdown and distance to zero drawdown). • Monitor bore yields, ground water level behaviour and water quality in accordance with this WMP.	2	B	L 5

5 Monitoring

5.1 Monitoring program

5.1.1 Surface water monitoring

Details and site locations for the proposed surface water monitoring program are provided in Table 5-1 and Figure 5-1 below. In order to assess potential impacts of mining on water quality, monitoring sites have been selected on Sherwin Creek, both upstream and several locations downstream of mining activities, as well as a reference site at a similar location in an adjacent catchment.

Table 5-1. Proposed surface water monitoring program

Monitoring Sites	Frequency	Measurements/Analytes
Stream Monitoring Sites: SISW01 – SISW07 **Sediment Basins and Turkeys Nest Dams** (specific locations to be determined prior to commencement of mining)	**Monthly** (during periods of flow) or **Quarterly** (during periods of no flow)	**Field measurements:** Rainfall Flows (visual observations, estimations using average flow widths, depths and velocities, and/or calibrated V-Notches). Records should reflect whether flowing or standing water is sampled. Temperature, pH, oxidation-reduction potential (ORP), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO) and turbidity. **Laboratory analyses:** Total suspended solids (TSS), hardness, acidity and alkalinity. Major anions (Cl, SO_4, CO_3/HCO_3, NO_3) and cations (Ca, Mg, Na and K). Dissolved metals*: Al, As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn, Fe. Ammonia and nutrients (NO_2, NO_3, TKN, Total N and Total P).
*** Note: A full metal scan analysis will be undertaken for at least 3 sampling events and then periodically (e.g. annual) to confirm the proposed metal suite is appropriate for ongoing monitoring. Total metals analyses will also be undertaken at key monitoring sites as a quality control measure and to assess the proportion of metals bound in particulate matter.**		

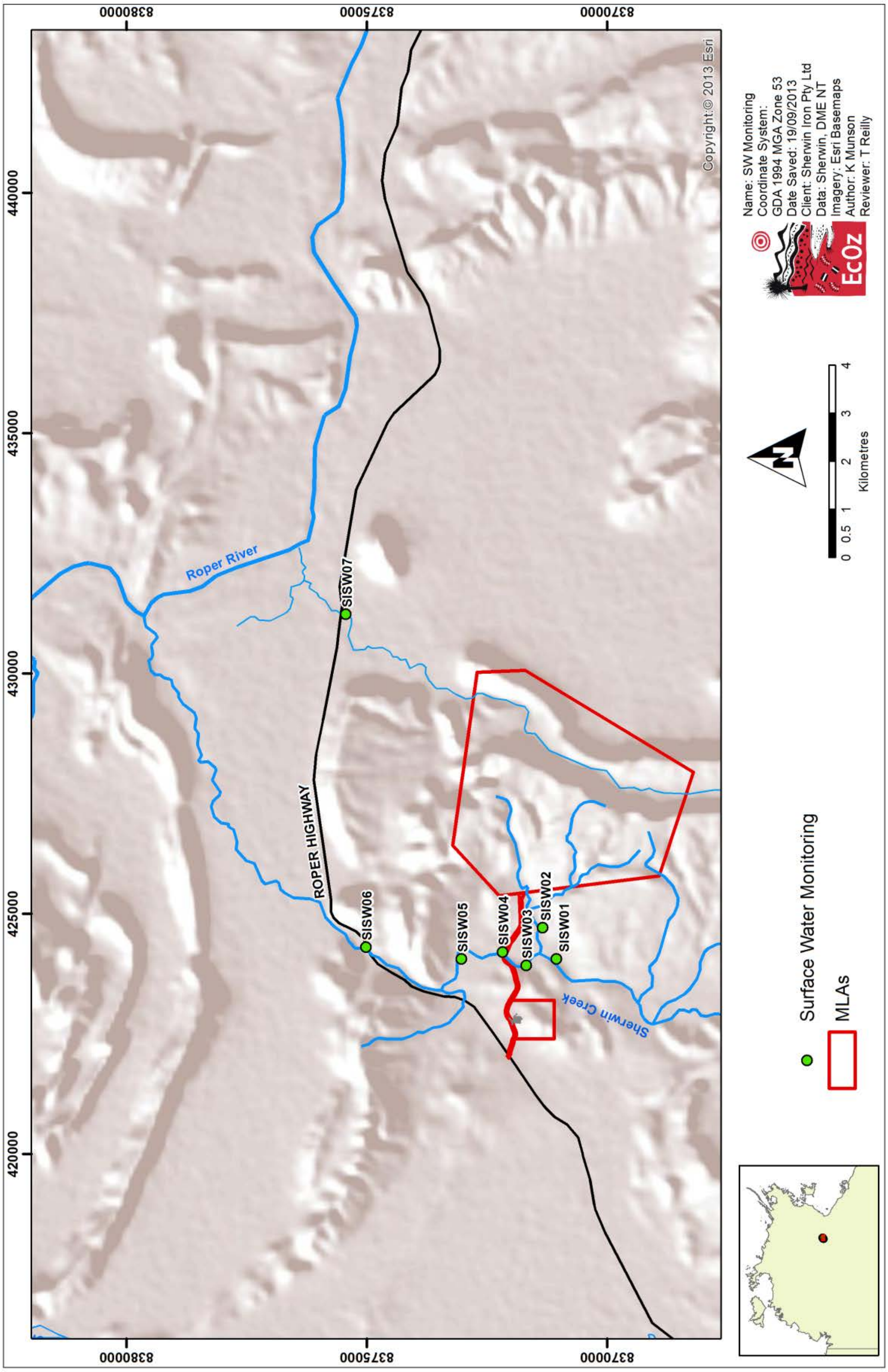

Figure 5-1. Map showing locations of stream surface water monitoring sites

5.1.2 Groundwater monitoring

Details and site locations for the proposed surface water monitoring program are provided in Table 5-2 and Figure 1-6. In order to assess potential impacts of open pit mining on the groundwater regime, six baseline environmental monitoring bores have been installed around mine site infrastructure. It is likely that additional monitoring bores will be required to adequately monitor potential effects of specific infrastructure and locations and these will be determined upon completion of detailed design and provided prior to commencement of mining.

Table 5-2. Proposed groundwater monitoring program

Monitoring Sites	Frequency	Measurements/Analytes
Groundwater Monitoring Sites: Figure 1-6. Open Pit: SEMB01 to SEMB06 Borefields: SPB01 to SPB07	**Quarterly**	**Field measurements:** Rainfall. Depth to ground water level. Abstraction from bores. General field *in situ* (field) water quality measurements: pH, EC, TDS, Salinity, Temperature, Dissolved Oxygen, Oxidation Reduction Potential including observations such as odour, colour, etc.) **For samples collected for lab analysis:** Total Alkalinity (Talk, mg/L). Total Acidity (TAc, mg/L). Major anions (Cl, SO_4, CO_3/HCO_3, NO_3-N; mg/L). Major cations (Ca, Mg, Na and K; mg/L). Dissolved metals (Al, As, B, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn, Fe; µg/L).
*** Note: A full metal scan analysis will be undertaken for at least 3 sampling events and then periodically (e.g. annual) to confirm the proposed metal suite is appropriate for ongoing monitoring. Total metals analyses will also be undertaken at one monitoring site per sampling event as a quality control measure.**		

5.2 Data review and interpretation

Water quality data will be entered into an appropriate database as soon as it is collected and comparisons made with water quality trigger values (see below); in order to immediately identify any potential impacts of mining operations. Further investigation and (if required) remedial action(s) will be undertaken promptly to address any potential water quality issues.

5.2.1 Water quality trigger values

It is proposed that for surface water, the default ANZECC (2000) guidelines for 95 % aquatic ecosystem protection (hardness-modified) will initially be adopted as maximum trigger values for surface water monitoring. It is envisaged that site-specific trigger values will be developed when there is sufficient data available from baseline monitoring and/or upstream reference sites.

It is proposed that for groundwater, the default Ground Water Investigation Levels (GILs) Schedule B1 National Environment Protection (Assessment of Site Contamination) Measure 2011 which combines the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011) and the guidelines for 95 % species protection levels (hardness modified) (ANZECC and ARMCANZ 2000) be adopted as trigger values for ground water quality. Site-specific (and possibly individual monitoring location-specific) trigger values are to be developed when there is sufficient data available from baseline monitoring and reference sites.

In addition to the above, water discharged shall have no visible surface films, oils and greases, Total Petroleum Hydrocarbons, litter or suspended matter.

Monitoring data will be reported on and raw data provided to Regulatory Authorities (e.g. DME, EPA) at required intervals and in agreed formats. At a minimum, this will include trend analysis and comparison with water quality trigger values.

6 Acronyms and references

6.1 Acronyms

AMD	Acid/metalliferous drainage
ANZECC	Australian and New Zealand Environment & Conservation Council
EC	Electrical conductivity
DO	Dissolved oxygen
DSO	Direct shipping ore
GDE	Groundwater dependent ecosystem
Mtpa	Million tonnes per annum
NT	Northern Territory
PAF	Potentially acid-forming
ROM	Run of mine (i.e. ore material)

6.2 References

ADG, 2013, *Sherwin Creek Deposit C Erosion and Sediment Control Plan*, report to EcOz Environmental Services, November 2013.

Alarcon-Leon, E 2013a, *Ground Water Assessment: Implications for Mine Water Management – Deposit C Sherwin Creek Iron Ore Project*, report to Sherwin Iron Ltd (Revision 1), November 2013.

Alarcon-Leon, E 2013b, *Acid Mine/Metalliferous Drainage (AMD): Implications for Mine Waste Management – Deposit C Sherwin Creek Iron Ore Project*, report to Sherwin Iron Ltd (Revision 2), November 2013.

Australian and New Zealand Environment & Conservation Council (ANZECC) 2000, *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment & Conservation Council and Agriculture & Resource Management Council of Australia and New Zealand, October 2000.

Bureau of Meteorology (2013, Climate Data Online, viewed 25 November 2013, <http://www.bom.gov.au/climate/data/>

Department of Health 2011a, *Guidelines for Management of Recycled Water Systems*, September 2011, Northern Territory Government.

Department of Health 2011b, *Environmental Health Factsheet No. 513 Recycled Water Irrigation: Information Guide for Applicants*, Northern Territory Government.

Environment Australia 2001, *A directory of important wetlands in Australia*, *Third Edition*, Environment Australia, Canberra.

Fairfull, S & Witheridge, G. 2003, *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*, NSW Fisheries, Cronulla.

Institution of Engineers Australia, 1998, *Australian Rainfall and Runoff. Volume One - A guide to flood estimation*, Barton, The Institution of Engineers, Australia.

Knapton, A 2009, *Gulf Water Study Integrated Surface Groundwater Model of the Roper River Catchment Part A: Coupled Surface – Groundwater Model*, NT Department of Natural Resources, Environment, The Arts and Sport, Darwin.

Shaw, E M 1994, *Hydrology in Practice (3rd edition),* Oxon: Routledge.

Appendix 1: Water Account

INPUT - OUTPUT STATEMENT DATA ENTRY

Site Details:	Sherwin Creek Iron Ore Project

Reporting Period Details	Date (dd/mm/yyyy)	Storage (ML)
Start	01-July-2014	0
Finish	30-June-2014	0

Quick Reference Guide on Adjacent page

INPUTS-OUTPUTS

Input-Output	Source/Destination	Inputs/Outputs	Water Quality Category 1 (ML)	Category 2 (ML)	Category 3 (ML)	Sub-Element Total (ML)	Accuracy (high, medium, low) Measured	Estimated	Simulated	Notes (1,2..)
Inputs	Surface Water	*Precipitation and Runoff*	317			317		Medium		1
		Rivers and Streams				0				
		External Surface Water Storages				0				
	Groundwater	*Aquifer Interception*				0				2
		Bore Fields		50		50		Medium		
		Entrainment		94		94		Medium		3
	Sea Water	*Estuary*				0				
		Sea/Ocean				0				
	Third Party Water	*Contract/Municipal*				0				
		Waste Water				0				
	TOTAL INPUTS		317	144	0	461				
Outputs	Surface Water	*Discharge*				0				
		Environmental Flows				0				
	Groundwater	*Seepage*		5		5		Medium		
		Reinjection				0				
	Sea Water	*Discharge to Estuary*				0				
		Discharge to Sea/Ocean				0				
	Supply to Third Party					0				
	Other	*Evaporation*		386		386		Medium		
		Entrainment		70		70				
		Other (define)				0				
	TOTAL OUTPUTS		0	461	0	461				

DIVERSIONS*

Input-Output	Source/Destination	Inputs/Outputs	Category 1 (ML)	Category 2 (ML)	Category 3 (ML)	Sub-Element Total (ML)	Measured	Estimated	Simulated	Notes
Inputs	Surface Water	*Precipitation and Runoff*				0				
		Rivers & Streams				0				
	Groundwater	*Aquifer Interception*				0				
	TOTAL DIVERSION INPUTS		0	0	0	0				
Outputs	Surface Water	*Discharge*				0				
	Groundwater	*Reinjection*				0				
	Supply to Third Party					0				
	Other	*Other (define)*				0				
	TOTAL DIVERSION OUTPUTS		0	0	0	0				

* Only commonly used Diversion Source and Destination categories visible. Remaining categories (Sea Water, Third Party inputs and sea water output) rows 'hidden'.

Accuracy Summary - Input (ML)

Confidence	High	Medium	Low
Measured	0	0	0
Estimated	0	461	0
Simulated	0	0	0

Accuracy Summary - Output (ML)

Confidence	High	Medium	Low
Measured	0	0	0
Estimated	0	391	0
Simulated	0	0	0

Diversions Accuracy Summary - Input (ML)

Confidence	High	Medium	Low
Measured	0	0	0
Estimated	0	0	0
Simulated	0	0	0

Diversions Accuracy Summary - Output (ML)

Confidence	High	Medium	Low
Measured	0	0	0
Estimated	0	0	0
Simulated	0	0	0

Notes (user defined):

1 *Average Rainfall at Ngukurr.*
2 *No mine influx - ground water level below floor of open pit.*
3 *Rock moisture.*

Input-Output Data Entry Usage Notes:

Modification of the Input-Output Model

Companies/operations may include new Sub-elements within the input-Output model as required by individual circumstances.
However, the Primary Elements (Sources and Destinations) must remain the same.
The worksheet can be unlocked by right mouse clicking the worksheet tab and clicking unprotect sheet (no password required).

Data Entry

Data is only to be entered into unshaded cells
Only one accuracy parameter is to be entered for each element.

Data Sources

Data Sources may include but not be limited to:
- Direct Measurement (storage and flow)
- Water Allocation
- Water Sharing Plans
- Site Water Balance Models
- Publicly Available Water Information
- Water User Charges

Diversions

Diversions include water that is diverted away from the operational facility, and is not involved in any of the tasks within the operational facility. It is water which is actively managed by the minerals operation, but is not used in a traditional 'consumptive' sense. **Diverted water is not included in the reporting of inputs-outputs for the operational facility.**
Source and Destination Categories for Diversions are consistent with those for the Operational Facility. Note, only commonly used categories are visible in the input-out data entry table. The remaining categories (Sea Water, Third Party inputs and sea water output) can be viewed by right clicking and unhiding the rows along the left side of the worksheet.

Water Quality

Water Quality category can be company defined. For Preliminary Water Quality Categorisation Worksheet (No.5) for full definitions and water quality decision tree

Accuracy (High, Medium, Low)

High, Medium and Low values are a qualitative measure of confidence assigned by site operators. These levels can be based upon the level of available data, assessed reliability of data, past performance of measurement/estimation tools and/or operator experience.