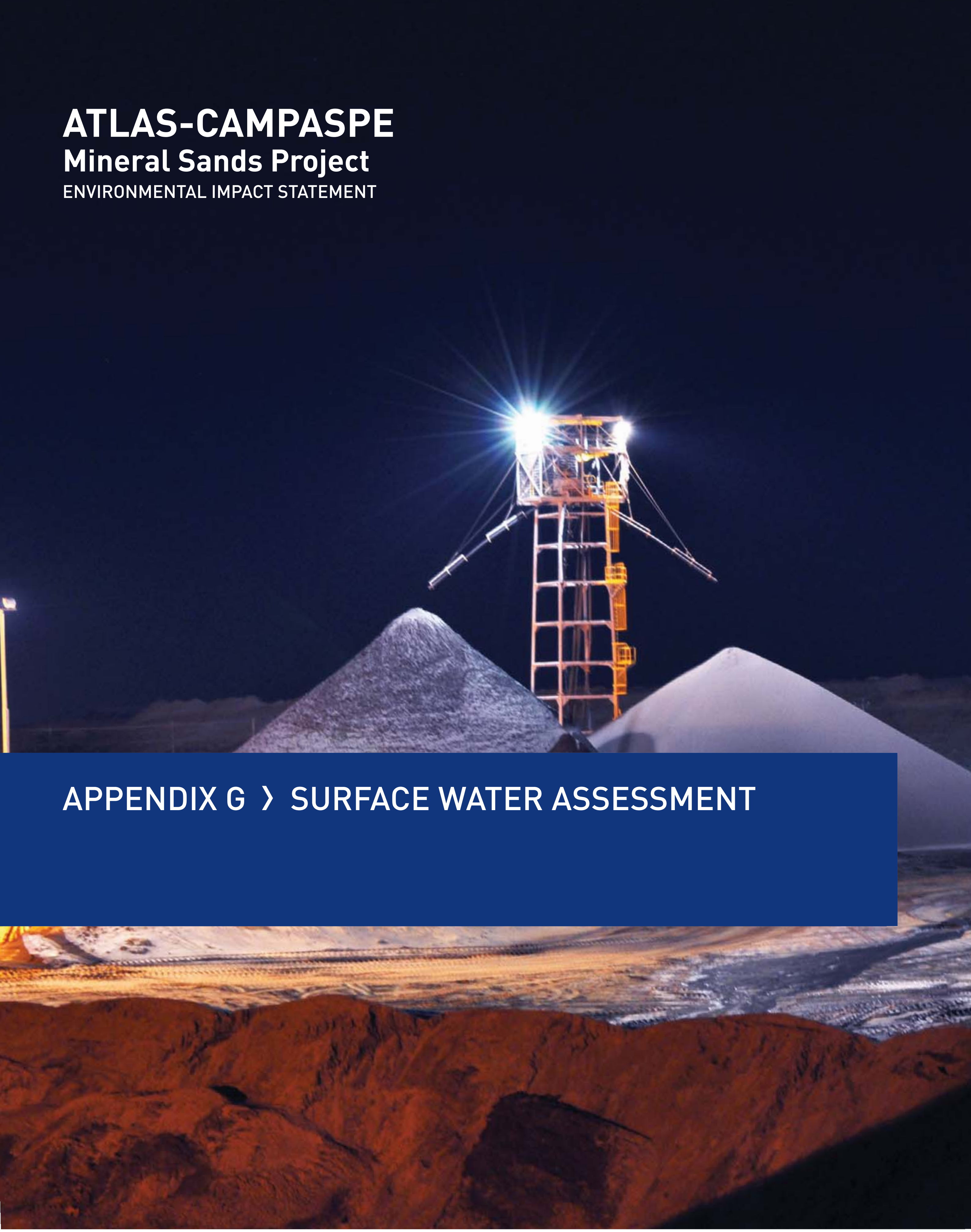
ATLAS-CAMPASPE
Mineral Sands Project
ENVIRONMENTAL IMPACT STATEMENT



APPENDIX G 〉 SURFACE WATER ASSESSMENT

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Resource Strategies

Cristal Mining Australia Limited

Atlas-Campaspe Mineral Sands Project

Surface Water Assessment

November 2012

Version Control

Revision	Date Issued	Author	Reviewed By	Comments
1.0	26/8/2012	SP	SP	For Resource Strategies review
2.0	26/9/2012	DH/SP	SP	For Cristal Mining Australia Limited review
3.0	12/11/2012	DH/SP	SP	Final

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1 Introduction

1.1 The Project Setting

The Atlas-Campaspe Mineral Sands Project (the Project) involves the construction and operation of a mineral sands mine (herein referred to as the Atlas-Campaspe Mine) located approximately 80 kilometres (km) north of Balranald, New South Wales (NSW) and 270 km south-east of Broken Hill, NSW (**Figure 1.1**). The Project is also proposed to involve the construction and operation of a rail facility at Ivanhoe (the Ivanhoe Rail Facility) approximately 135 km north-east of the Project and approximately 290 km south-east of Broken Hill (**Figure 1.1**).

Product (Mineral Concentrate) generated as a result of operations at the proposed Atlas-Campaspe Mine would be trucked to the Ivanhoe Rail Facility for transfer to rail carriages, which would then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (**Figure 1.1**).

To facilitate road transportation to the Ivanhoe Rail Facility, roadworks would also be undertaken along a 37 km section along the proposed mineral concentrate transport route during construction of the Project.

This report describes the surface water setting and assesses the surface water impacts associated with the Project.

The proposed Atlas-Campaspe Mine involves the extraction of mineral sands from two deposits that are located approximately 7 km and 14 km respectively south of Boree Plains Station in western NSW. At their closest, the mine footprints are located about 5 km east of the boundary of Mungo National Park and about 10 km east of the Willandra Lakes Region World Heritage Area.

The proposed mining would involve sequential development and operation of two separate mineral sands ore extraction areas orientated in south-east to north-west direction. A 12 km section of the Atlas deposit (typically less than 100 metres [m] wide), and a 14 km section of the Campaspe deposit (typically less than 300 m wide) is proposed to be mined by the Project.

The Atlas-Campaspe Mine site is located in a semi-arid area with variable annual rainfall of between 100 millimetres (mm) and 730 mm, with an average of 293 mm. Rainfall is highly episodic and runoff is sporadic. Land use is predominantly grazing with water for domestic stock provided by in-ground excavated tanks that are fed by extensive contour banks to direct runoff into the tank.

The Atlas-Campaspe Mine is located within the Benanee basin of the lower Murray River system in NSW. The Benanee basin borders the upstream effluent creeks of the Lachlan River basin, Darling and Murrumbidgee River basins and the downstream Murray River basin. The Benanee basin is made up of a number of ill-defined creeks, streams and ephemeral lakes that contribute negligible inflows to the Murray River (New South Wales Office of Water, 2012).

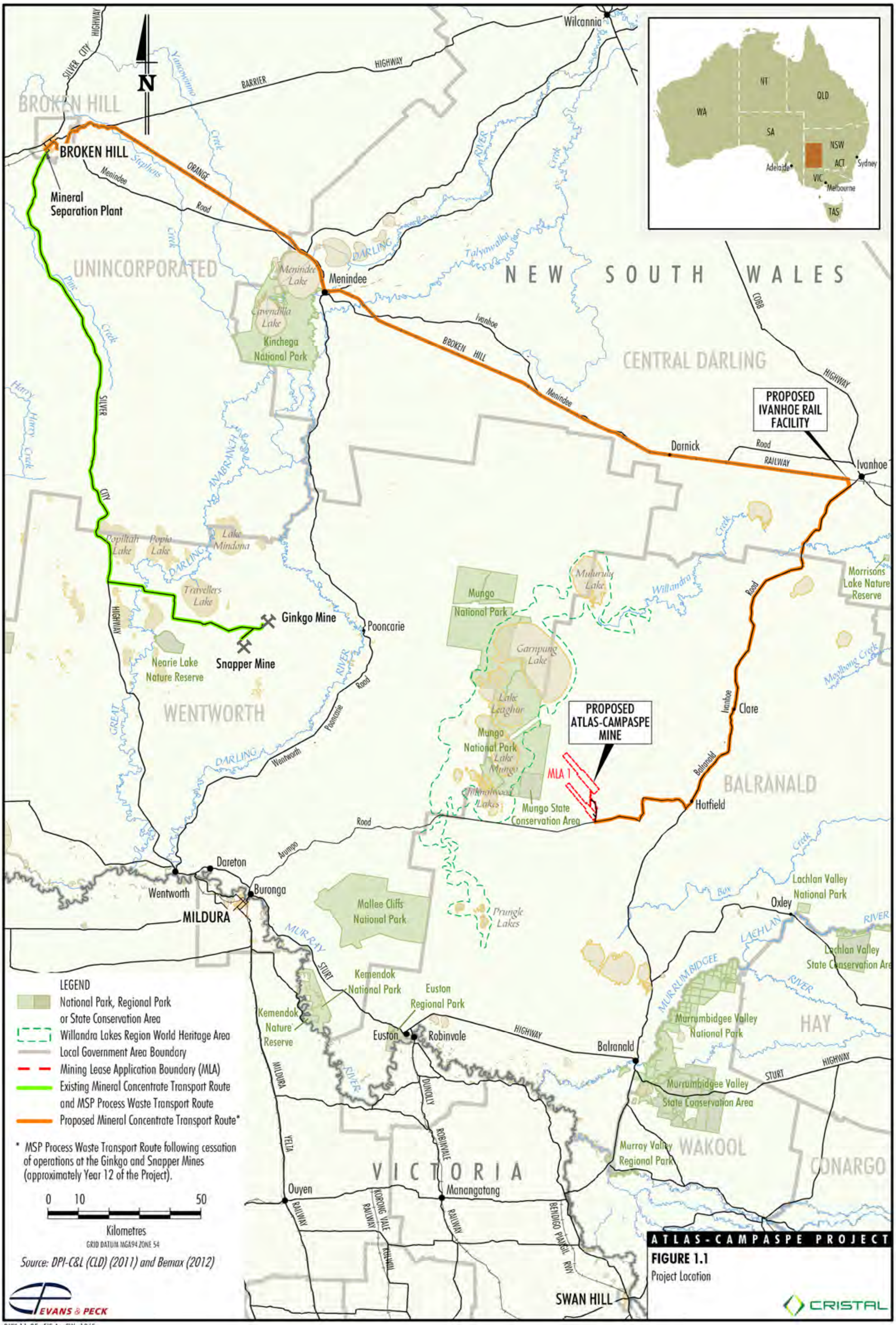

FIGURE 1.1
Project Location

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The Atlas-Campaspe Mine site is located approximately mid-way between two ill-defined drainage systems (**Figure 1.1**):

- **The Willandra Creek and Willandra Lakes system** (to the north and west of the Atlas-Campaspe Mine site) - this system contains numerous dry lakes (Mulurulu, Garnpung, Leaghur, Mungo and Chibnalwood) which drain from north-east to south-west; and
- **The Arumpo Creek and Prungle Lakes system** (to the east and south of the Atlas-Campaspe Mine site) - this system also drains from north-east to south-west.

The regional surface drainage in the vicinity of the Atlas-Campaspe Mine occurs by overland flow from north-east towards the south-west. The Atlas-Campaspe Mine site contains no defined water courses other than a few minor drainage lines that drain from the south-eastern end of the Campaspe deposit towards a relic lake depression.

1.2 Director-General's Requirements

This report addresses the following aspects of the Director-General's Environmental Assessment Requirements that relate to this surface water assessment:

> *"The EIS must address the following specific issues:*
>
> *...*
>
> - *Water Resources - including:*
>   - *detailed assessment of potential impacts on the quality and quantity of existing surface water ... resources, including:*
>
> *...*
>
>   - *impacts on riparian, ecological, geomorphological and hydrological values of watercourses, including environmental flows;*
>
> *...*
>
>   - *an assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives; - identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;*
>
> *...*
>
>   - *a detailed description of ... other measures to mitigate surface ... impacts;"*

As part of the assessment process an Environmental Risk Assessment (ERA) (Appendix O of the Environmental Impact Statement [EIS]) was undertaken. This included a facilitated, risk based workshop involving experts across a range of disciplines and experienced Cristal Mining Australia Limited (Cristal Mining) personnel. The objective of the assessment was to identify key potential environmental issues for further assessment in the EIS. The key potential surface water related issue identified in the ERA (Appendix O of the EIS) was:

- Changes to surface water flow regimes at the Atlas-Campaspe Mine and surrounding areas and as a consequence potential impacts on the Black Box Woodland and wetland.

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2 Project Overview

The Project would involve two main development components (**Figure 1.1**):

1. Construction and development of infrastructure for mining operations at the proposed Atlas-Campaspe Mine.
2. Construction and operation of the Ivanhoe Rail Facility.

The proposed life of the Project is approximately 20 years, commencing approximately 1 July 2013, or upon the grant of all required approvals.

The Project general arrangements are shown on **Figure 2.1** and **Figure 2.2**. A detailed description of the Project is provided in Section 2 in the Main Report of the EIS. The activities associated with the two main development components of the Project are summarised below.

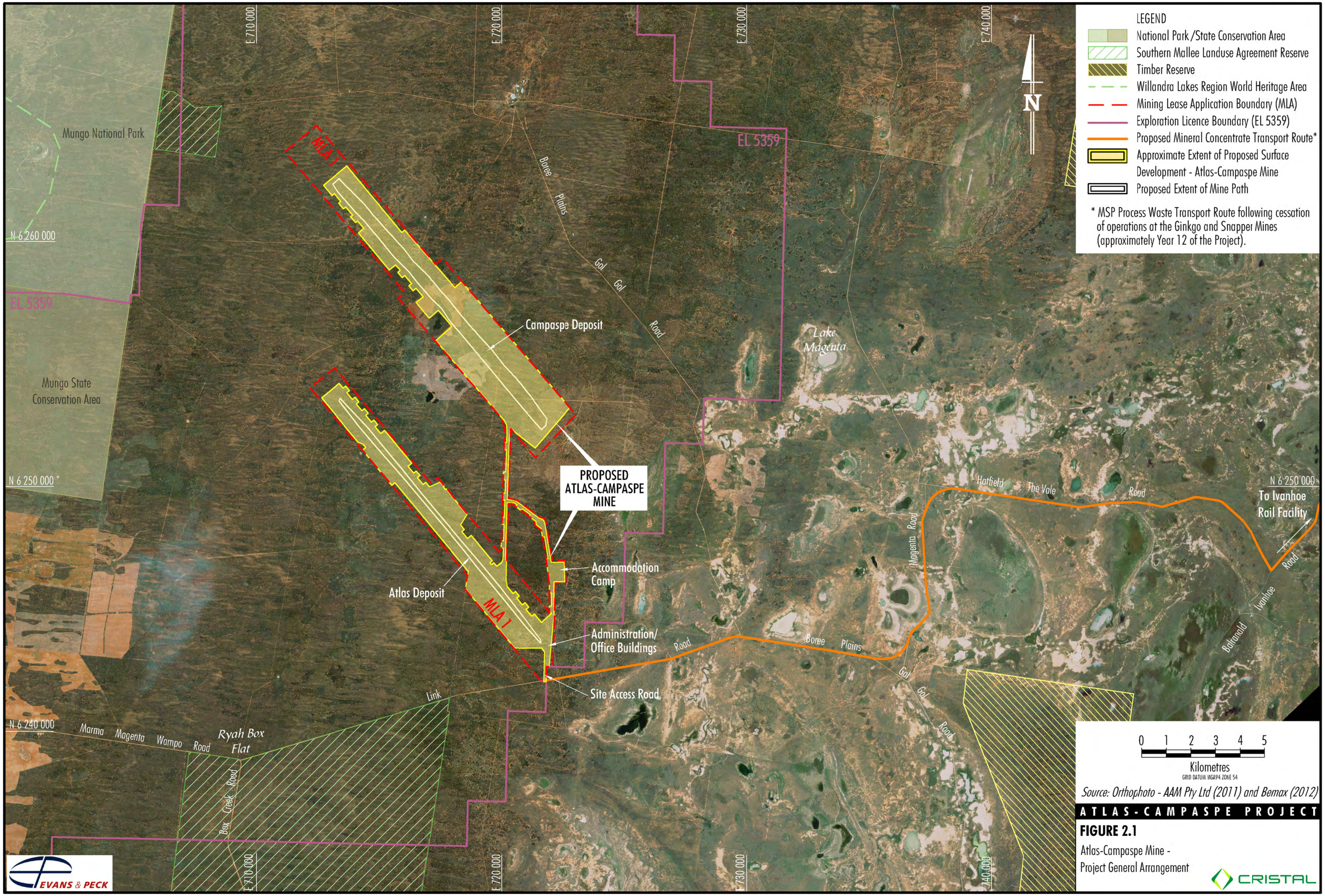
2.1 Atlas-Campaspe Mine

The main activities associated with the development of the Atlas-Campaspe Mine would include:

- ongoing exploration activities;
- sequential development and operation of two separate mineral sands ore extraction areas within the Mining Lease Application 1 area;
- use of conventional mobile equipment to mine and place mineral sands ore into dry mining units[1] at a maximum ore production rate of up to 7.2 million tonnes per annum;
- mineral processing infrastructure including the primary gravity concentration unit, salt washing facility and a wet high intensity magnetic separation circuit;
- mineral concentrate stockpiles and materials handling infrastructure (e.g. towers and stackers);
- progressive backfilling of mine voids with overburden behind the advancing ore extraction areas or in overburden emplacements adjacent to the mine path;
- placement of sand residues and coarse rejects (and MSP process wastes[2]) following mineral processing to either the active mining area (behind the advancing ore extraction area) or in sand residue dams;
- development of a groundwater borefield at the Atlas deposit and localised dewatering systems (bores, spearfields and trenches) at both the Atlas and Campaspe deposits, including associated pump and pipeline systems;
- reverse osmosis plant to supply the salt washing facility and potable water;
- progressive development of water storage dams, sediment basins, pumps, pipelines and other water management equipment and structures;
- administration/office buildings, car parking facilities, workshop and stores;
- on-site accommodation camp;
- sewage treatment plant;
- diesel powered generators, electricity distribution station and associated internal electricity transmission lines;

[1] Mining would use conventional open pit methods and would not involve dredge mining.

[2] Following cessation of operations at the Ginkgo and Snapper Mines (approximately Year 12 of the Project).



Source: Orthophoto - AAM Pty Ltd (2011) and Bemax (2012)

ATLAS-CAMPASPE PROJECT

FIGURE 2.1

Atlas-Campaspe Mine - Project General Arrangement

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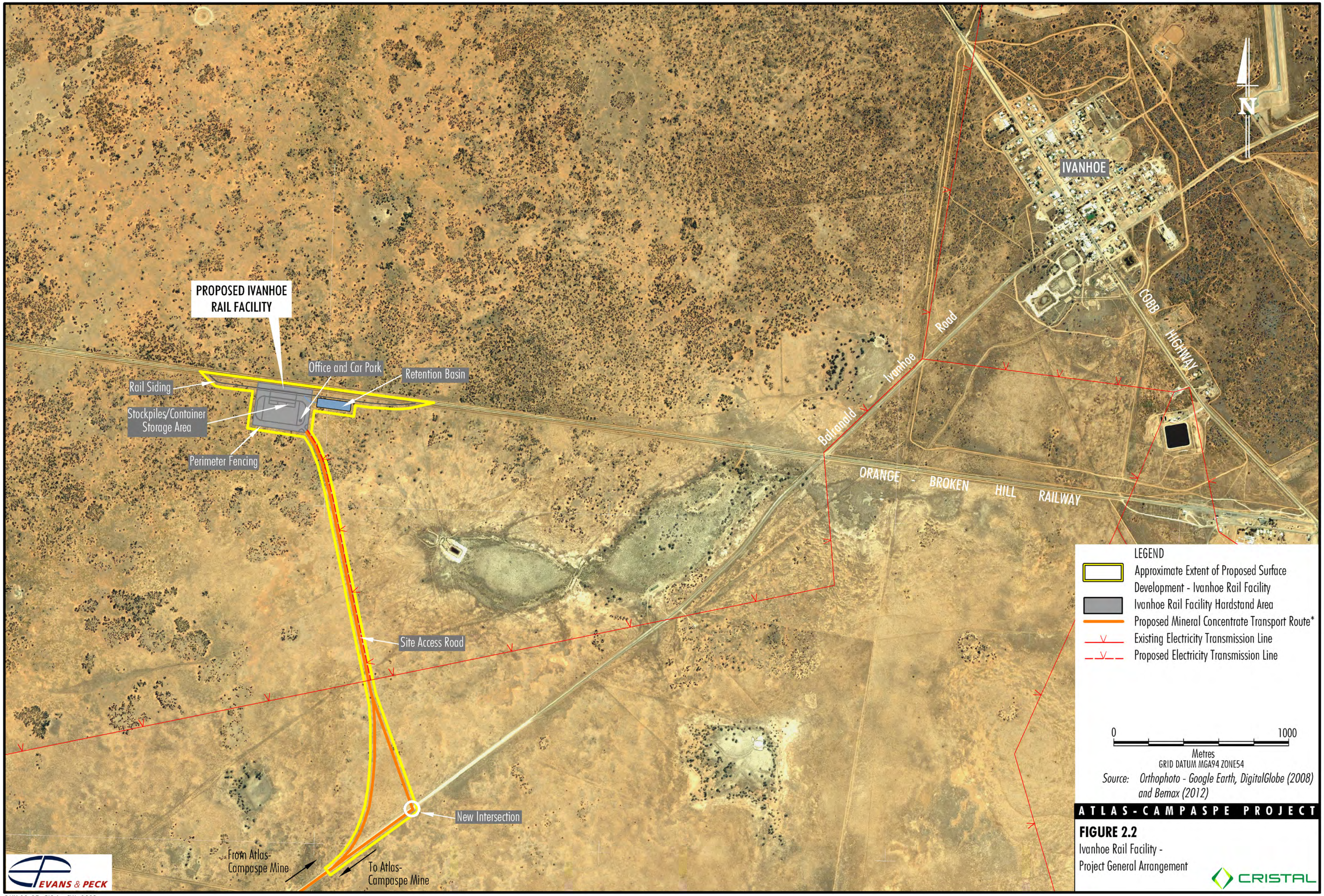

FIGURE 2.2
Ivanhoe Rail Facility - Project General Arrangement

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- site access road, internal access roads and haul roads;
- roadworks along the proposed mineral concentrate transport route to the Ivanhoe Rail Facility;
- transport of mineral concentrates along the mineral concentrate transport route to the Ivanhoe Rail Facility;
- road transport of MSP process waste[3] in sealed storage containers from the Ivanhoe Rail Facility to the Atlas-Campaspe Mine for subsequent unloading, stockpiling and placement behind the advancing ore extraction areas;
- development of soil stockpiles and laydown areas;
- monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

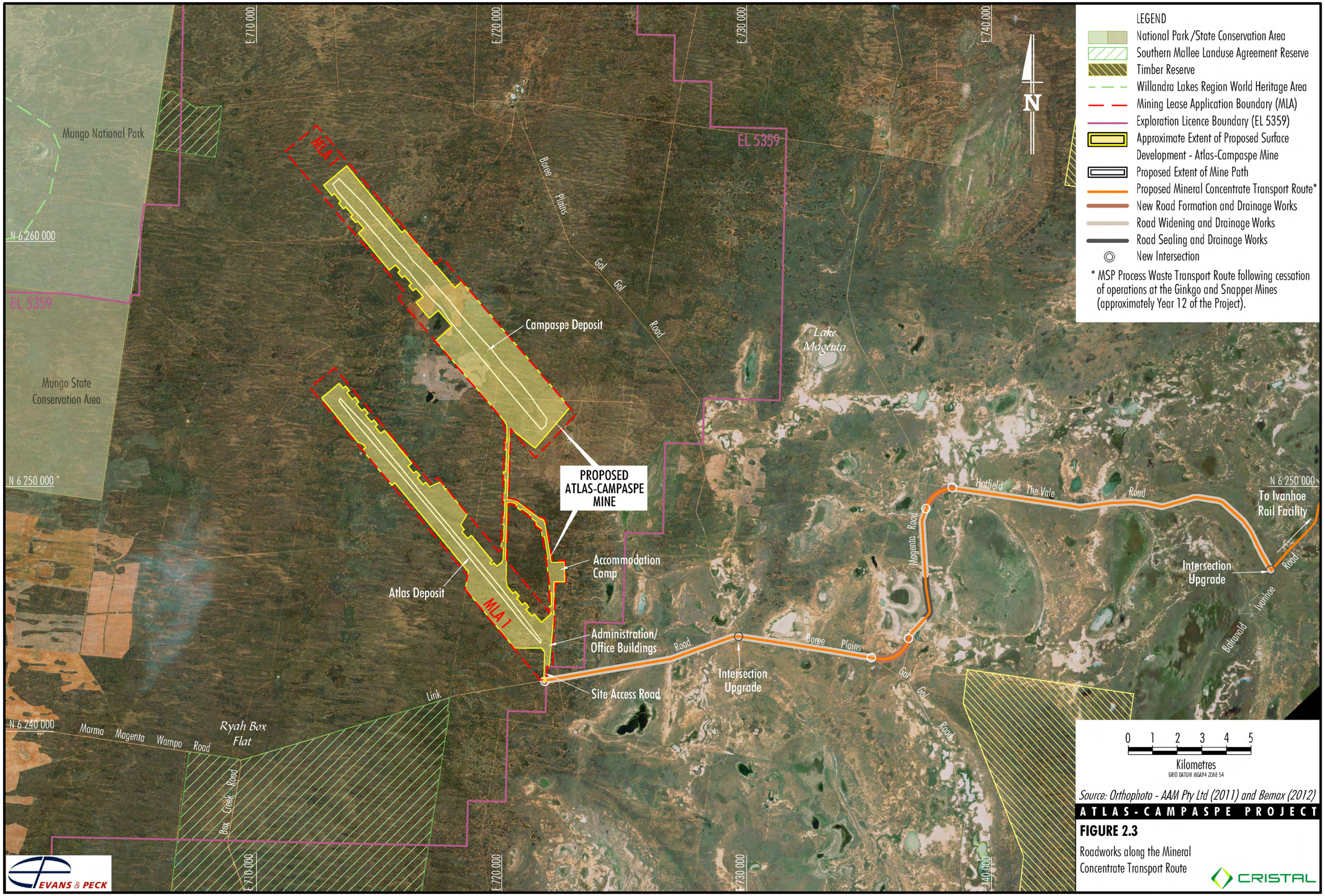
2.2 Roadworks along the Mineral Concentrate Transport Route

With the exception of approximately 37 km of existing unsealed roads between the Atlas-Campaspe Mine site access road and the intersection with the sealed Balranald-Ivanhoe Road (**Figure 2.3**), the remaining section of the approximate 175 km long proposed mineral concentrate transport route is approved to accommodate road trains.

Roadworks along the 37 km section would therefore be required during construction of the Project and, as shown on **Figure 2.3** would include:

- upgrade of the intersection at Hatfield-The Vale Road and Balranald-Ivanhoe Road;
- road widening and associated drainage works (up to approximately 23 m total width) along a 14.5 km section of Hatfield-The Vale Road to accommodate an unsealed two-lane road;
- new intersections at Hatfield-The Vale Road and Magenta Road;
- a new unsealed two-lane road formation (approximately 2 km long and up to approximately 23 m total width) between the new intersections at Hatfield-The Vale Road and Magenta Road;
- road widening and associated drainage works (up to approximately 23 m total width) along two sections (approximately 2 km and 1 km, respectively) of Magenta Road to accommodate an unsealed two-lane road;
- sealing and associated drainage works (up to approximately 21 m total width) along a 2 km section of Magenta Road to accommodate a two-lane road;
- new intersections at Magenta Road and Boree Plains-Gol Gol Road;
- a new unsealed two-lane road formation (approximately 2 km and up to approximately 23 m total width) between the new intersections at Magenta Road and Boree Plains-Gol Gol Road;
- road widening and associated drainage works (up to approximately 23 m total width) along a 5.5 km section of Boree Plains-Gol Gol Road to accommodate an unsealed two-lane road;
- road widening and associated drainage works (up to approximately 23 m total width) along a 8 km section of Link Road to accommodate an unsealed two-lane road; and
- a new intersection at Link Road and the Atlas-Campaspe Mine site access road.

[3] Following cessation of operations at the Ginkgo and Snapper Mines (approximately Year 12 of the Project).



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2.3 Ivanhoe Rail Facility

The main activities associated with the construction and operation of the Ivanhoe Rail Facility located approximately 4.5 km south-west of Ivanhoe (see **Figure 2.2**), would include:

- development of a rail siding for:
  - loading of train wagons with mineral concentrate for rail transport to the MSP via the Orange – Broken Hill railway; and
  - unloading of MSP process waste in sealed storage containers (transported via the Orange – Broken Hill railway) from train wagons[4];
- site access road and internal haul roads/pavements;
- hardstand areas for mineral concentrate and MSP process waste[4] unloading, stockpiling/sealed container storage and loading;
- a retention basin, drains, pumps, pipelines and other water management equipment and structures;
- site office and car parking facilities;
- extension to existing 11 kilovolt powerline;
- monitoring, landscaping and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

4 Following cessation of operations at the Ginkgo and Snapper Mines (approximately Year 12 of the Project).

3 Existing Surface Water Environment

3.1 Climate

The Project is located in a region with a semi-arid climate with low and sporadic rainfall and high evaporation. The Bureau of Meteorology (BoM) operates a number of daily rainfall gauges within the region, the key features of those closest to the site are summarised in **Table 3.1**.

Table 3.1: Key Features of Bureau of Meteorology Rainfall Stations in the Vicinity of the Project

Station	Station No	Distance from Project	Period of Record	Average Annual Rainfall (mm)
Euston (Turlee)	49111	28 km SW	1960 - 2012	300
Hatfield (The Vale)	49047	45 km W	1924 - 2012	286
Pooncarie (Top Hut)	47018	42 km WNW	1920 – 2012	268
Pooncarie (Mulurulu)	47024	55 km N	1882 - 2012	282
Hatfield (Clare)	49008	73 km NE	1873 - 2012	292

Note: N = North, S = South, E = East, W = West

As can be seen from **Table 3.1** there are only minor differences in the average annual rainfall for most stations. For purposes of this assessment, the long term daily rainfall record for Hatfield (Clare), which has 140 years of complete record, was adopted because it has average annual rainfall comparable to that at the closest station Euston (Turlee) (292 mm compared to 300 mm) but it has more than double the length of record (140 years compared to 53 years).

Other features of the climate of the area have been derived from the following sources:

- daily pan evaporation from Menindee DWR Depot (Station 47058) which commenced in 1968;
- monthly potential evapotranspiration derived from the electronic spatial data on the BoM dataset "*Climatic Atlas of Australia – Evapotranspiration*"; and
- rainfall intensity-frequency-duration data for the site derived from the BoM CDIRS website.

Table 3.2 summarises the monthly and annual rainfall statistics for the long term rainfall station at Hatfield (Clare) which illustrates a number of important features of the climate of the area:

- Annual rainfall is both low (average 292.9 mm) as well as highly variable (minimum 110.7 mm and maximum 734.4 mm).
- Rainfall can be expected to be less than about 170 mm in 10% of years and greater than 440 mm in 10% of years.
- All months of the year expect to have less than 5 mm of rainfall at least 10% of the time.

Table 3.2: Historical Rainfall Data – Hatfield (Clare) Station 49008

Statistic (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	25.5	26.3	27.4	21.4	28.8	26.1	22.5	23.9	22.7	26.5	23.1	21.5	292.9
Std Dev	34.1	33.3	35.5	25.4	25.9	21.7	17.7	17.5	22.0	24.3	25.0	24.2	112.7
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.7
10%	0.0	0.0	0.0	0.7	2.4	3.4	3.8	4.0	2.9	2.6	1.2	0.0	171.8
20%	2.1	0.5	1.2	2.1	7.0	8.0	6.1	7.9	7.3	7.9	3.1	2.2	205.0
50%	12.2	10.9	15.5	13.8	24.8	20.8	18.8	21.4	16.8	18.9	12.9	13.2	280.5
80%	43.7	50.1	40.7	36.4	44.1	41.6	37.7	41.3	33.0	44.6	36.6	36.0	377.7
90%	68.2	77.2	77.7	54.1	59.5	52.7	47.8	49.9	48.7	58.4	61.0	51.4	439.1
Max	179.0	144.5	166.2	152.9	133.9	129.5	82.7	71.6	134.2	137.6	130.3	119.2	734.4

Std Dev – Standard Deviation

Table 3.3 illustrates the fact that, on average, rainfall only occurs on less than 50 days per year and that the 65% of rain days (32.7) have rainfall less than 5 mm. The table also shows that about 60% of the total depth of rainfall occurs on days when there is more than 10 mm of rain.

Table 3.3: Average Number of Rainfall Days per Year and Percentage of Total Rainfall (Hatfield [Clare])

Rainfall	Days/Year	% of Total Rainfall
<1	12.3	2.5%
1 - 2	8.7	4.5%
2 - 5	11.7	13.1%
5 - 10	8.3	19.5%
10 - 20	5.6	26.6%
20 - 50	2.8	27.7%
>50	0.3	6.1%
TOTAL	**49.7**	**100%**

Figure 3.1 is a graph of the cumulative departure of rainfall from the long term mean. A trend downwards to the right indicates rainfall less than the long term mean and, conversely, an upward trend indicates greater than the long term mean. The graph shows that long term droughts are a feature of the climate of the area. In particular:

- An extended drought occurred between about 1880 and 1900.
- A further extended drought occurred between about 1930 and 1950.

- Since 1950, rainfall has generally been above the long term average with the exception of droughts in the late 1960's and from 2000 to the end of 2009.
- Rainfall has been significantly above average since 2010 with 650 mm of rainfall in that year and 440 mm in 2011, which is evident by water ponding in low-lying areas surrounding the Atlas-Campaspe Mine site.

The above is also supported by the fact that the nearest BoM meteorological station to the Project site (Euston [Turlee]) recorded its highest daily total in 53 years of record on 14 January 2011 (110 mm) (BoM, 2012).

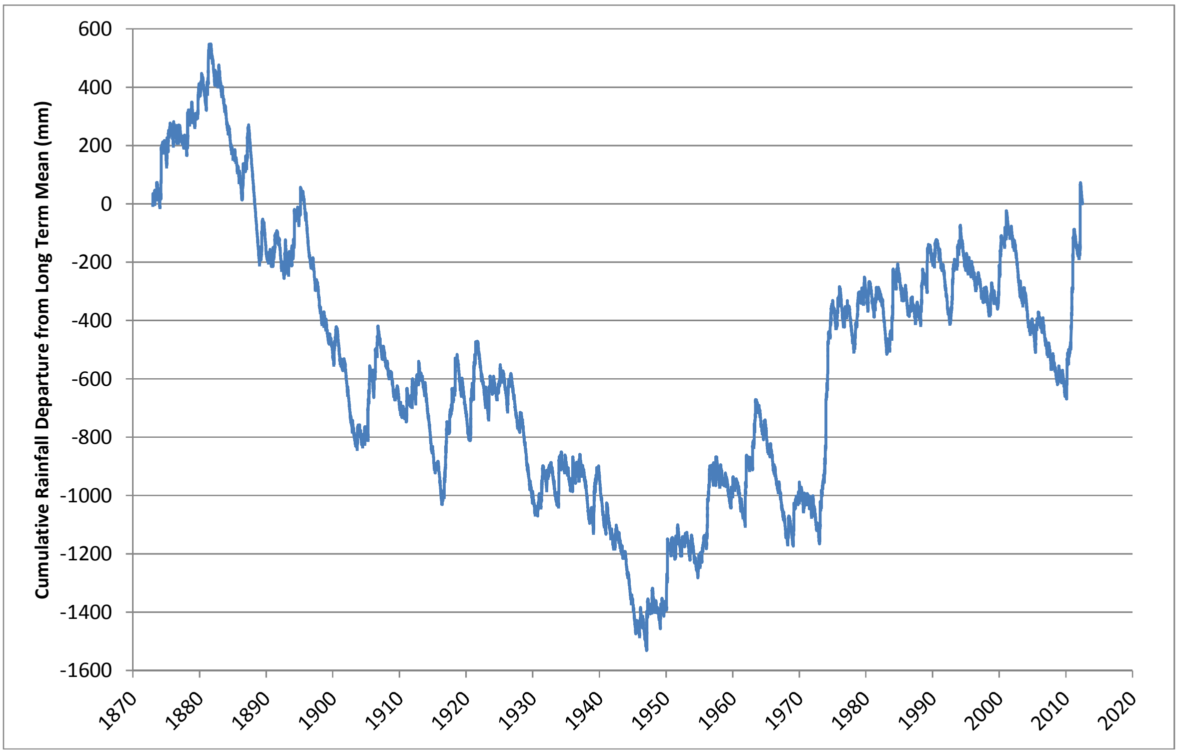


Figure 3.1: Cumulative Rainfall Departure from Long Term Mean (Hatfield [Clare])

Table 3.4 summarises the monthly open water and potential evapotranspiration for the Project area which shows that:

- Net open water evaporation in excess of 1.5 m per year can be expected. Accordingly, any runoff collected in the shallow depressions that characterise the landscape can be expected to evaporate rapidly.
- Potential evapotranspiration from vegetation exceeds the average rainfall in each month. Under these conditions, vegetation is under continual water stress and actual evapotranspiration will be governed by the ability of vegetation to access moisture deep in the soil profile.

Table 3.4: Evaporation, Evapotranspiration and Rainfall Deficit by Month

	Rainfall (mm)	Open Water Evaporation (mm)	Open Water Rainfall Deficit (mm)	Potential Evapotranspiration (mm)	Potential Evapotranspiration Rainfall Deficit (mm)
Annual	**297**	**1,575**	**1,278**	**1,163**	**866**
January	26	236	210	183	157
February	26	191	165	138	112
March	27	160	133	115	88
April	21	102	81	70	49
May	29	61	32	43	14
June	26	41	15	28	2
July	23	46	23	32	9
August	24	71	47	47	23
September	23	104	81	75	52
October	27	151	124	121	94
November	23	185	162	149	126
December	22	227	205	162	140

Table 3.5 summarises the rainfall intensity data for the Project site and shows that moderate intensity rainfall can be expected for short durations during the life of the Project which have the potential to cause localised soil erosion, particularly on sandy soils unless they are well protected.

Table 3.5: Intensity-Frequency-Duration (IFD) Rainfall Data for the Atlas-Campaspe Mine Site

Rainfall Duration	Probability of Occurrence (1 in X Years)						
	1 Year	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years
5 minutes	54	71	97	112	132	159	180
10 minutes	41	53	72	84	99	119	135
30 minutes	24	31	47	49	57	69	77
1 hour	15	20	27	32	37	44	50
2 hours	9.3	12	17	19	23	27	31
6 hours	4.0	5.2	7.2	8.4	9.9	12	14
12 hours	2.3	3.1	4.2	5.0	5.9	7.1	8.1
24 hours	1.4	1.8	2.5	3.0	3.5	4.3	4.9
48 hours	0.82	1.1	1.5	1.7	2.1	2.5	2.8
72 hours	0.58	0.76	1.0	1.2	1.4	1.8	2.0

Table 3.6 summarises the rainfall intensity data for the Ivanhoe Rail Facility.

Table 3.6: Intensity-Frequency-Duration (IFD) Rainfall Data for the Ivanhoe Rail Facility

Rainfall Duration	Probability of Occurrence (1 in X Years)						
	1 Year	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years
5 minutes	56	74	100	117	138	167	189
10 minutes	42	55	75	88	104	125	142
30 minutes	25	32	44	51	60	73	83
1 hour	16	21	29	33	39	47	54
2 hours	9.6	13	17	20	24	29	33
6 hours	4.0	5.3	7.4	8.7	10	13	14
12 hours	2.4	3.1	4.3	5.1	6.1	7.4	8.5
24 hours	1.4	1.9	2.6	3.1	3.6	4.5	5.1
48 hours	0.84	1.1	1.5	1.8	2.1	2.6	3.0
72 hours	0.59	0.78	1.1	1.3	1.5	1.8	2.1

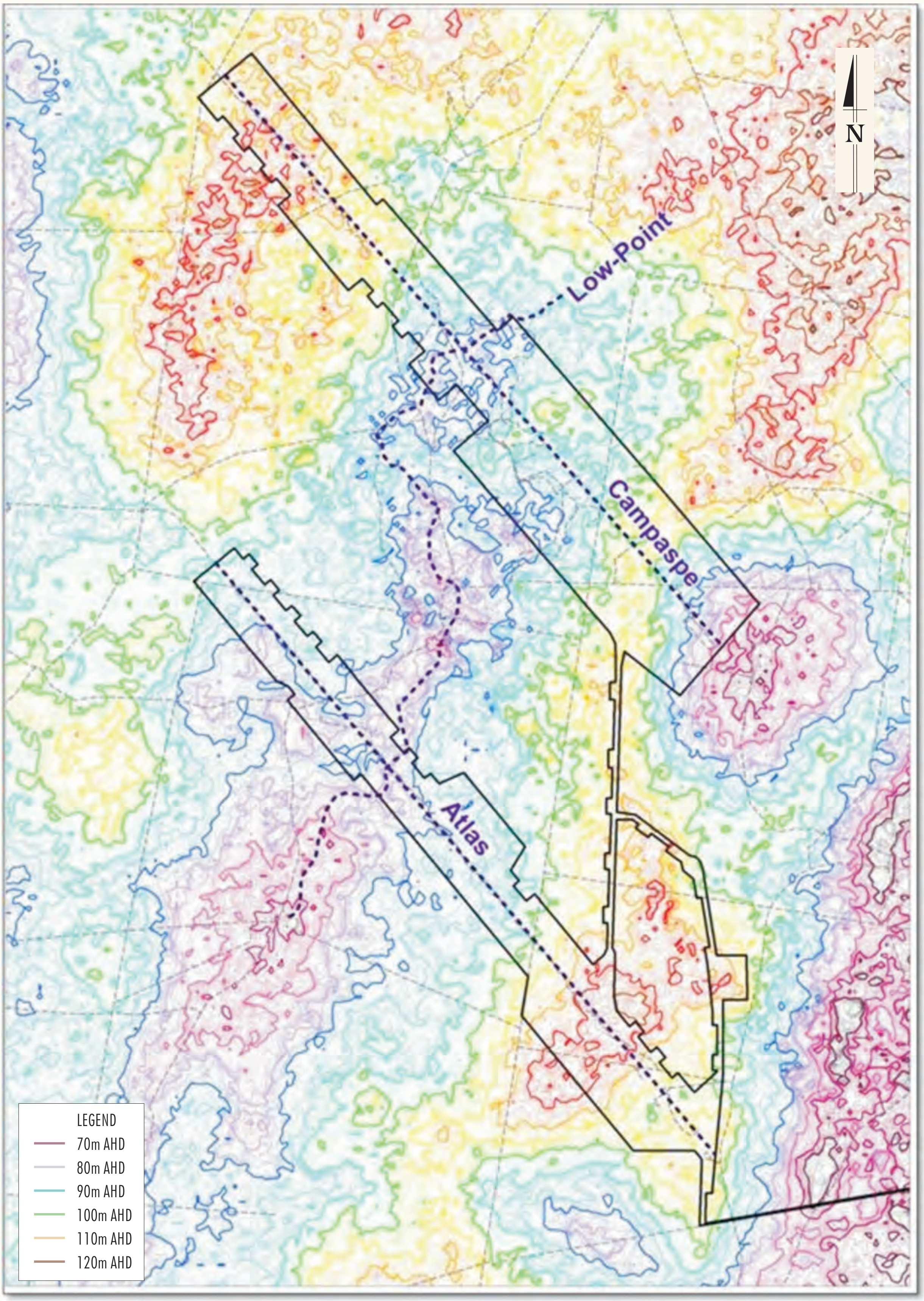
3.2 Mine Site Landform, Topography and Drainage

Topographic information for the Atlas-Campaspe Mine site (in the form 1 m contours) has been derived from Lidar data provided by Cristal Mining. For purposes of highlighting minor differences in the landform, this data has been colour coded (see **Figure 3.2**) to show areas of higher elevation (brown grading to red) and lower lying areas (blue grading to purple/pink). As shown in **Figure 3.2**, the landform in the vicinity is highly complex with numerous closed minor depressions.

For purposes of illustrating the topography in the Project area, ground surface profiles have been prepared for the centreline of each footprint, and for a natural low-point that runs in a north-south flow direction commencing to the north of the Campaspe footprint, continuing between the mining areas and extending to the south**. Figure 3.2** shows the locations of the two centreline profiles and the longitudinal profile along the low-point.

The Campaspe footprint (the northern of the two deposits) runs in a rectangular strip from north-west to south-east and is characterised by flat slopes and localised depressions. **Figure 3.3** shows the ground surface profile along the centreline of the Campaspe footprint. While the profile does not pick up all minimum and maximum elevations within the footprint area, it is largely reflective of the topography along the Campaspe footprint.

Ridges near each end of the deposits run across (perpendicular to) the footprints, with the ground then falling away towards low-points at the boundaries at both ends. The ridge at the north-west end has a top elevation of approximately 118 m Australian Height Datum (AHD), with the elevation at the north-west boundary being approximately 110 m AHD. Slopes between the ridge and the boundary are flat at around 0.5 %. The elevation of the ridge at the south-east end is approximately 107 m AHD, with the elevation dropping down to the south-east boundary at approximately 71 m AHD at a slope of around 1.7 %. Between these two ridges the land drops to two low-lying depressions in the centre of the mine footprint separated by a small ridge with an elevation of around 100 m AHD. Both the depressions have a minimum elevation of approximately 80 m AHD. The slope from the ridges down into the depressions is around 1.4%. The maximum slope across the mine footprint from north to south is approximately 0.7 %, however in a number of areas there is no discernible change in elevation.



Source: Bemax (2012)

ATLAS - CAMPASPE PROJECT

FIGURE 3.2
Ground Surface Profile Locations

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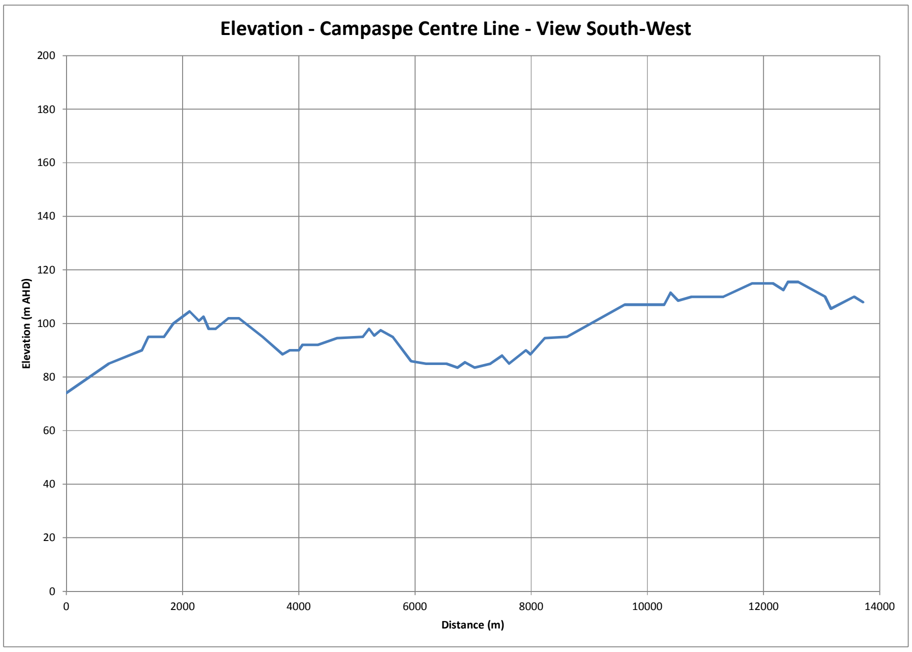


Figure 3.3: Centreline Profile for the Campaspe Footprint (looking south-west)

Figure 3.4 shows the ground surface profile along the centreline of the Atlas footprint. A clear and wide ridge runs across the mine area at the south-east end with a maximum elevation of approximately 119 m AHD. Around 3 km of the Atlas footprint area drains to the south-east at this end, flowing into a major depression area with its low-point outside the Atlas footprint area with a minimum elevation of 59 m AHD. There is a large depression covering the central and north-west portion of the mine disturbance area corresponding to the low point defined on **Figure 3.2**. On the centre line of the mine path, this low point has an elevation of around 77 m AHD. The ground surface slope from the ridge to the central depression is approximately 0.6 %. The depression is made up of a number of smaller depressions, with two main low-lying areas between distances 8,000 m to 11,000 m where runoff could exit the mine area.

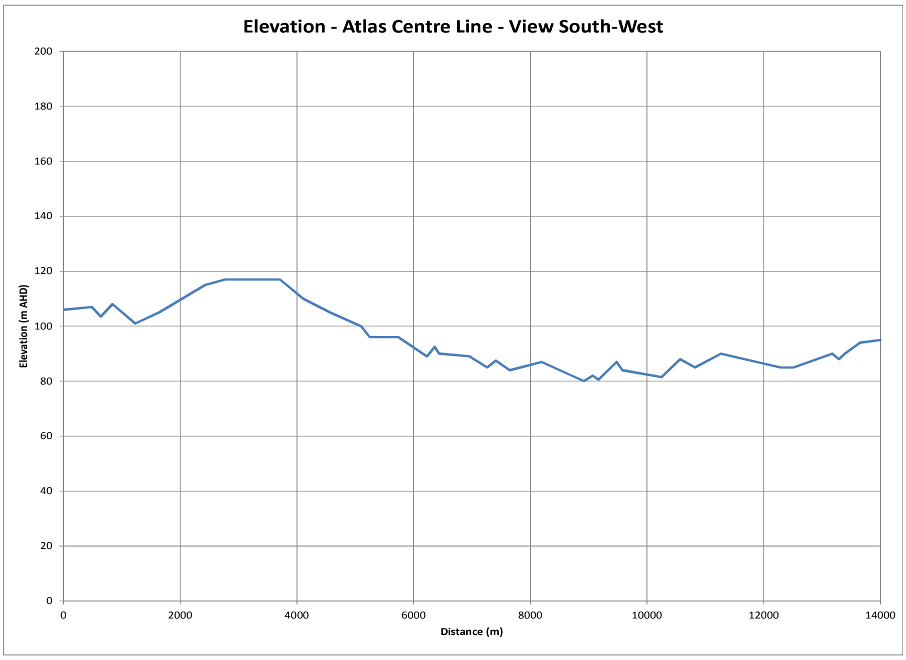


Figure 3.4: Centreline Profile for the Atlas Footprint (looking south-west)

Figure 3.2 shows the location of a broad depression that runs from the north-east to the south-west across the Atlas-Campaspe Mine site. The depression is bounded by a low horseshoe shaped ridge that extends crosses the north-western and south-eastern ends Campaspe footprint and extends to about 6 km north-east of the Campaspe deposit. This depression extends to the south of the Atlas footprint where is contributes runoff to the 'Yankie Tank' which is shown on the 1:100,000 'Turlee' map sheet.

Figure 3.5 shows the ground surface profile along this depression that crosses the two mine paths, (designated as 'low point' on **Figure 3.2**). The extent of the Atlas-Campaspe disturbance areas are shown as red bars on **Figure 3.5**. The profile is characterised by a series of basin-like depressions separated by crests, with each 'basin' needing to fill before 'overflowing' to the downstream 'basin'. These smaller depressions sit within two major depressions which have their downslope crests at distances 11,000 m and 3,000 m on **Figure 3.5.** The upstream major depression would need to fill with runoff to a depth of approximately 7 m over a length of 4 km before it would 'overflow', while the downstream depression would need to fill to a maximum depth of approximately 13 m over a length of approximately 7 km before it would 'overflow'. The volume of runoff required to cause these large depressions to fill and overflow would be very significant. It is unlikely that runoff from the mine areas would ever be sufficient to fill and overflow these depressions.

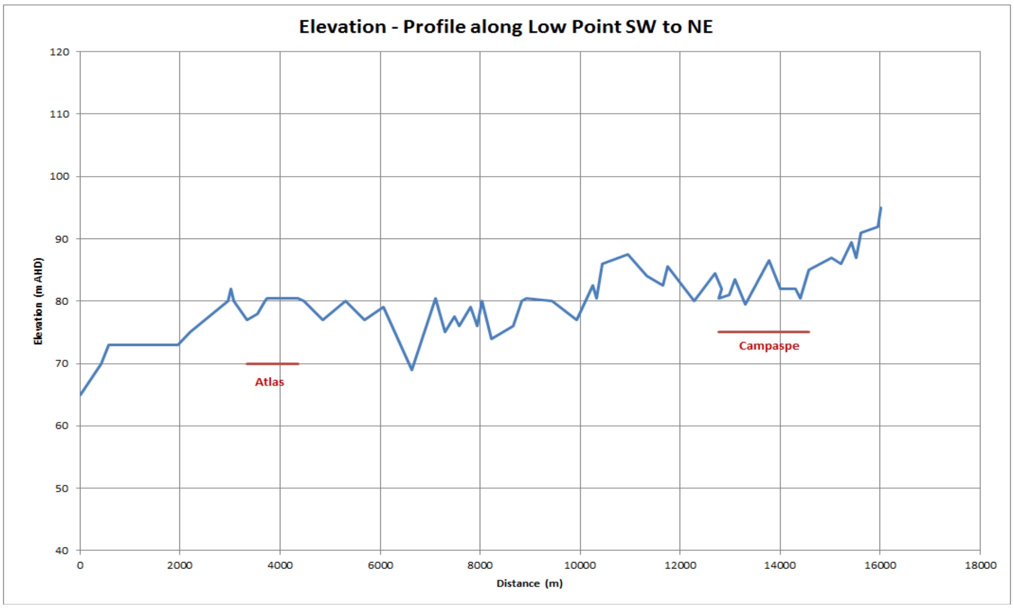


Figure 3.5: Profile along Depression Running from South-west to North-east through the Atlas-Campaspe Mine Site

As can be seen from **Figure 3.2** to **Figure 3.5** the landform in the Atlas-Campaspe Mine site area is very complex and contains many minor depressions and clay pans within the overall landform that has overall slopes of less than 1%. Notwithstanding that there are a number of lower lying areas over the majority of the Atlas-Campaspe Mine site, there are no defined drainage lines and runoff occurs as overland flow. In many locations, particularly along the line of the 'low point' shown on **Figure 3.2**, the overland flow drains to shallow closed depressions where it is held for short periods after heavy rainfall. **Figure 3.6** to **Figure 3.9** show typical examples of this landform. Only following prolonged heavy rainfall would runoff spill from these small closed depressions and drain as overland flow to the major depressions such as that shown in **Figure 3.10** and **Figure 3.11**.

Figure 3.6: Typical Landform Variation

Figure 3.7: Typical Small Closed Bare 'Clay Pan' Depression

Figure 3.8: Example of Small Closed Depression – Indicated by Light Green Vegetation

Figure 3.9: Aerial View of Typical Closed Depressions

Figure 3.10: Water in a Large Depression Outside the Disturbance Area for the Campaspe Footprint (following above average rainfall in 2010-11)

Figure 3.11: Aerial View of the Large Depression Shown in Figure 3.10

(Source: GoogleEarth - photography 1 July 2010)

This landform and runoff pattern occurs throughout a swathe of land approximately 25 km wide between the regional scale drainage systems to east and west (**Section 3.3**).

The importance of the drainage depressions such as those shown above has been recognised in the development of the mine plan. The area around the depression shown in **Figure 3.9** has been excised from the disturbance area for the Campaspe footprint, while the depression shown in **Figure 3.10** and **Figure 3.11** is located between the disturbance areas for the Atlas and Campaspe deposits.

The absence of defined flow paths in the majority of the Atlas-Campaspe Mine site indicates the need to avoid discharge of concentrated flow from the disturbance areas or from the final landform. At the same time, the pathways for overland flow within and across the mine paths would need to be restored in order to maintain existing broad-scale drainage patterns.

The absence of defined drainage lines has led landholders to construct extensive catch drain systems to direct overland flow into excavated tanks to provide water for domestic stock. In the vicinity of the Project, the topographic maps show the existence of a number of such tanks:

- ‘First Mildura Tank’ is located about 850 m north-east of the Campaspe footprint. The catchment draining to this tank is located to the north and west and would not be affected by the Project.
- An un-named tank system is located about 500 m south of the Campaspe footprint. The catchment for this tank is located predominantly to the south and west. The Campaspe footprint would encroach onto a small portion of the northern section of the catchment and has the potential to have a minor effect on runoff to the tank.
- ‘Yankie Tank’ is located about 3 km south-west of the Atlas footprint on the major depression shown on **Figure 3.2** and **Figure 3.5**. While both the Atlas and Campaspe footprints would cross this depression, as shown on **Figure 3.5**, there are intervening ridges that would impede runoff from the mine paths reaching this tank.

The only location where any clearly defined drainage lines have been observed on within the Atlas-Campaspe Mine site is at the south-eastern end of the Campaspe footprint where longer steeper slopes run down to a major closed depression which has a low point at about 59 m AHD approximately 1 km south-east of the end of the Campaspe footprint. **Figure 3.12** shows an example. The presence of longer and steeper slopes in this area indicates that land rehabilitation would require special care to minimise the potential for discharge as concentrated flow.

Figure 3.12: Example of Defined Drainage Line near the South-eastern end of the Campaspe Footprint

3.3 Regional Setting and Drainage System

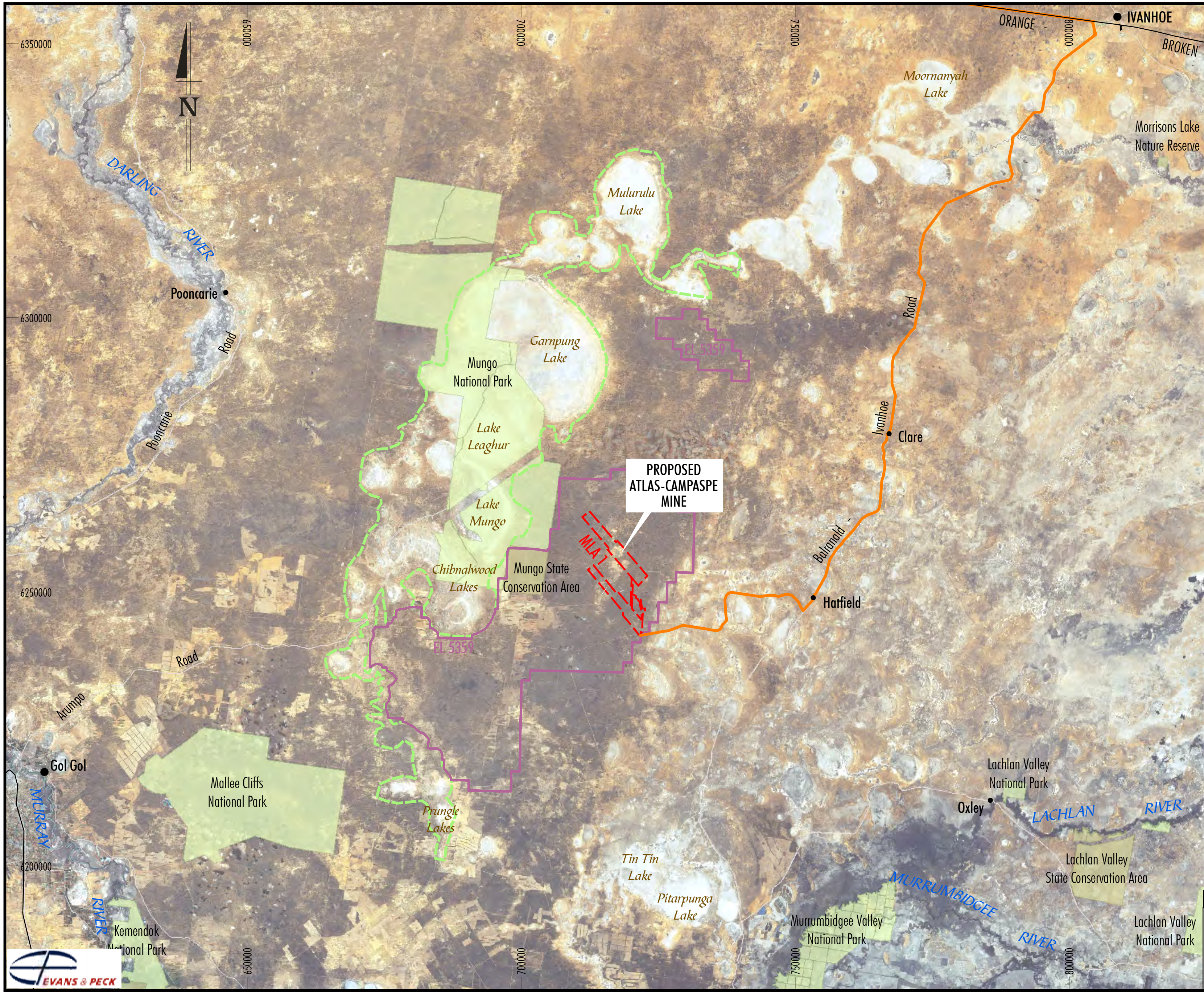
As shown on **Figure 3.2**, the Atlas and Campaspe Mine areas comprise parallel rectangular strips approximately 14 km in length oriented in a north-west to south-east direction. **Figure 3.13** is a copy of a regional map that shows the boundary of the Willandra Lakes Region World Heritage Area and key locations in the vicinity. The Campaspe footprint is located approximately 7 km south of Boree Plains, with the Atlas footprint being another 7 km further south.

As outlined in **Section 1.1**, the Atlas-Campaspe Mine site is located approximately mid-way between the Willandra Lakes system to the west (**Figure 3.13**) and the Arumpo Creek system to the east. Although both these systems comprise large numbers of predominantly dry lake beds, at a river basin scale they represent ancestral distributary delta from the Lachlan River which breaks into a number of channels to the north of Hillston.

The broad scale landform and drainage from the Atlas-Campaspe Mine site has been assessed to determine the potential for runoff from the mine areas to drain to the Willandra Lakes Region World Heritage Area. Several 1:100,000 topographic maps containing 20 m contours and spot levels were assessed (Turlee, Hatfield, Bidura) in addition to the 1 m Geographic Information System (GIS) compatible contour layer (**Figure 3.2**) which extends to around 10 km south of Ryah Box Flat (**Figure 2.1**).

Any runoff from the Atlas-Campaspe Mine areas that filled the local depressions would flow predominantly in a south-south-easterly direction, following a series of large basin-like depressions that can be over 20 m in depth. Ryah Box Flat is located in the middle of the deepest of these depressions, which covers a roughly circular region with a diameter of 5 km. Runoff draining to this area would need to pond to a depth of approximately 23 m in order to flow further south, which would require a very significant volume of water.

Should this depression overflow and runoff continue flowing south, it would follow a flow path that spreads out and convey the runoff to the large tank area immediately north-east of Benenong in the west, or to Upson Downs in the east, or any area in-between.



ATLAS - CAMPASPE PROJECT

FIGURE 3.13
Willandra Lakes Region World Heritage Area

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It appears from the Bidura 1:100,000 topographic map that ground elevations are sufficient in the area east of Prungle Lakes that runoff from the Atlas-Campaspe Mine site would not enter the Willandra Lakes Region World Heritage Area at this location, but would continue to flow south to Benenong Lake, which is outside the Willandra Lakes Region World Heritage Area, from where runoff would flow south-east in Arumpo Creek and at no time enter the Willandra Lakes Region World Heritage Area.

It should be noted that while the vast majority of the Atlas-Campaspe Mine site drains in this southerly direction, there are areas at the extremities of the Atlas-Campaspe Mine areas that drain in other directions. Of relevance to the Willandra Lakes Region World Heritage Area is the north-west end of the Campaspe footprint. An area about 1 km in length at the end of the footprint drains to the north-west, from where it could potentially flow into Lake Mungo or Lake Leaghur which lie within the Willandra Lakes Region World Heritage Area approximately 15 to 20 km to the west of the Atlas-Campaspe Mine site. However, as shown on **Figure 3.2** the landform to the west is similar to that within the Atlas-Campaspe Mine site itself and contains numerous small depressions that would impede drainage to the west. The possibility of any runoff from the Atlas-Campaspe Mine site reaching, or having any impact on, the Willandra Lakes Region World Heritage Area could only occur under rainfall conditions that are unlikely to have been experienced in the region for thousands of years.

3.4 Soils of the Atlas-Campaspe Mine Site

For purposes of this report the key aspect of the soil characteristics of the Atlas-Campaspe Mine site have been derived from *Land Systems of Western NSW* (Soil Conservation Service of NSW, 1991). Further details of the soils are contained in *Atlas-Campaspe Mineral Sands Project – Soils, Rehabilitation Capability and Agricultural Resources Assessment* (Ogyris Ecological Research, 2012).

The Land Systems of Western NSW GIS layer (as downloaded from the Office of Environment and Heritage [OEH] website) shows five unique and 12 total land systems across the Atlas-Campaspe Mine site. The distribution of these land systems is shown on **Figure 3.14** and the key landform, geomorphic, soils, vegetation and erosion characteristics are summarised in **Table 3.7**.

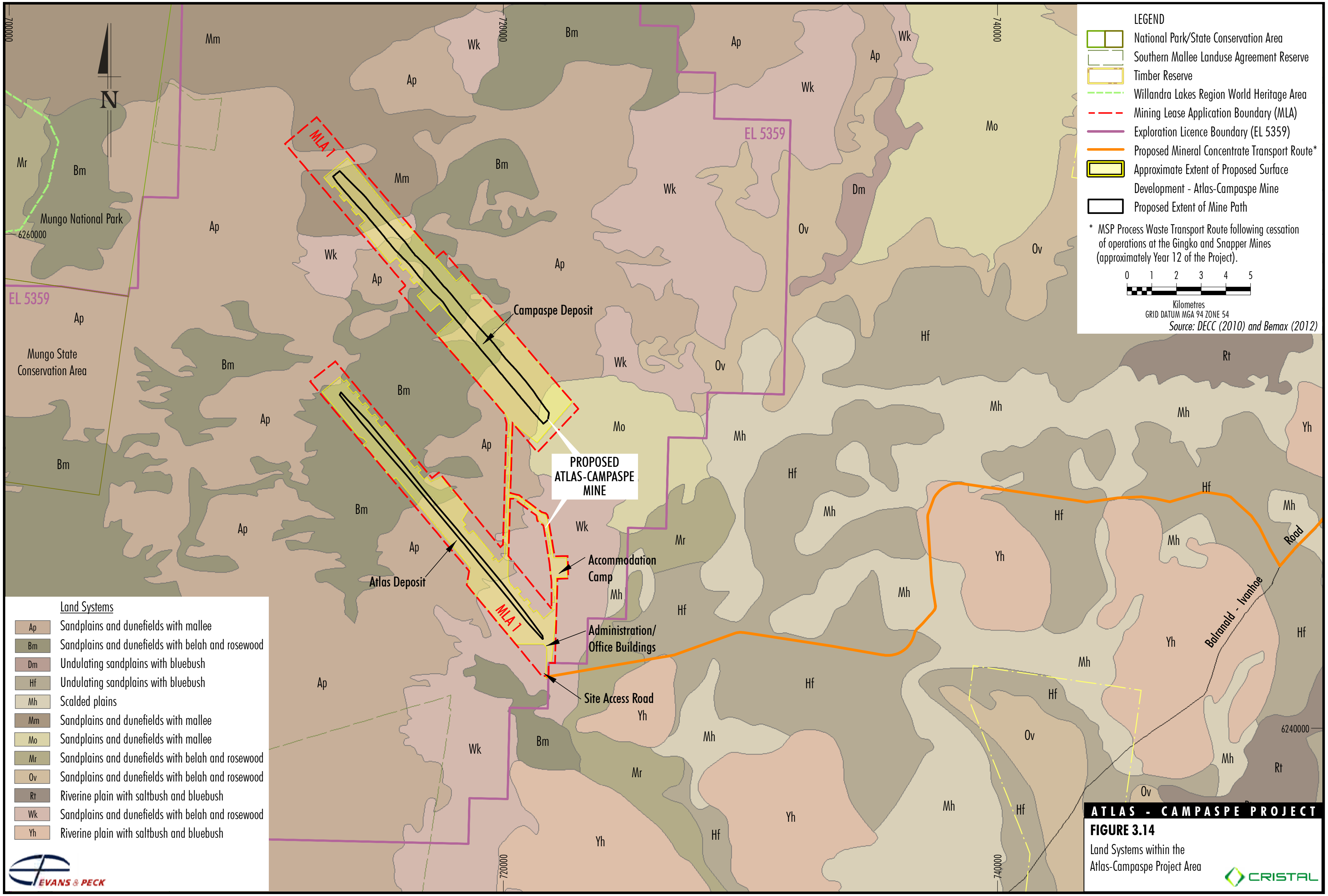

FIGURE 3.14
Land Systems within the Atlas-Campaspe Project Area

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Table 3.7: Land Systems within the Atlas-Campaspe Mine Site

	Landform	Geomorphology	Soils & Vegetation	Erosion
Arumpo (Ap)	Parallel dunes and sandplain with narrow calcareous swales.	Long linear, east-west trending dunes of reworked Quaternary aeolian material with narrow swales and flats merging to level sandplains; dune relief to 7 m.	Dunes of deep brownish sands and calcareous sands; swales of highly calcareous solonized brown soils and texture-contrast soils; sandplains of solonized brown soils and calcareous red earths; dunes with dense mallee and variable porcupine grass; swales with belah, rosewood and inedible shrubs; variable speargrass, cannon-ball and forbs.	Minor to moderate windsheeting.
Bulgamurra (Bm)	Extensive undulating sandplain with dunes and open flats.	Slightly undulating sandplain of Quaternary Aeolian material and areas of east-west trending dunes and rises; relief to 6 m; open calcareous flats and scattered swamps and depressions to 500 m diameter.	Sandplain of solonized brown soils with clumps of belah, rosewood, scattered wilga and nelia; dunes of deep brownish sands with white cypress pine or mallee and porcupine grass; areas of edible and inedible shrubs, variable speargrass, copperburrs and forbs; depressions of grey cracking clays with fringing black box.	Minor to moderate windsheeting and drift.
Mandleman (Mm)	Parabolic and unaligned dunes merging into sandplains.	Strongly reworked Quaternary aeolian parabolic and sub-parabolic dunes; relief to 7 m; scattered linear east-west trending dunes with narrow, level swales.	Dunes of deep siliceous and brownish sands and earthy sands; plain and swales of solonized brown soils and red texture-contrast soils; dense mallee and porcupine grass; moderately dense inedible shrubs; grasses, copperburrs and forbs.	Minor to severe drift on dunes.
Marona (Mo)	Small relict lakes merging into dunefields, east of Pooncarie.	Relict lakes and pans to 8 km long with well-developed crescentic lunettes to 10 km long, relief to 10 m; extensive sandplain merging into strongly reworked aeolian dunefield or east-west trending dunes.	Lakes of saline, gypseous or calcareous clays with scattered dillon bush and tobacco tree; lunettes and dunes of deep earthy sands with dense mallee and porcupine grass and scattered shrubs; sandplain and isolated swales of solonized brown soils with dense to scattered bluebushes, variable speargrass, copperburrs and forbs.	Minor windsheeting and drift.
Wilkurra (Wk)	Level sandplains with belah.	Sandplain of Quaternary aeolian material with isolated dunes and rises trending east-west, relief to 5 m; small level swales and flats.	Plains and flats with highly calcareous solonized brown soils; dunes with deep brownish sands; uniformly dense stands of belah and rosewood, scattered mulga, wilga and inedible shrubs; white cypress pine on sandy rises; variable speargrass, copperburrs and forbs.	Minor windsheeting and drift.

Source: Walker (1991).

From a surface water perspective, the notable aspects of the soils in the Atlas-Campaspe Mine site are:

- The majority of the ridges have deep (up to approximately 1 m) fine wind-blown sandy loam topsoils that are vulnerable to both wind and water erosion once vegetation is removed.
- Similarly, the sandy clay loam and light sandy clay loam soils on the lower dune slopes and sand-plains have relatively fine texture and can be expected to be susceptible to erosion, particularly from concentrated flow.
- Depression areas tend to have a higher proportion of clay in the topsoil which will make them slightly more cohesive and less vulnerable to erosion.
- The *Soils, Rehabilitation Capability and Agricultural Resources Assessment* (Appendix HA of the EIS) indicates that all topsoils in the Atlas-Campaspe Mine site have a low dispersion index (generally less than 7, which indicates very low exchangeable percentage and high stability).

Although there is no published data on the erodibility of these soils, the finer wind-blown soils are likely to have erodibility factor in excess of 0.05, indicating they are susceptible to erosion in sheet concentrated flow.

Where sandy layers occur the upper layer (sand) drains fast down to lower layer (clay). Water collects on the clay and persists after rain on numerous clay-based run-on depressions and gilgai. A series of such depressions occurs in an approximately north-south direction to the south-east of the Campaspe footprint.

3.5 Acid-Generating Potential of Mine Overburden

An assessment of the geochemical characteristics of the overburden material associated with the development of the Project is provided in the Atlas-Campaspe Mineral Sands Project Assessment of Overburden Acid-Generating Potential (Attachment A prepared by Cristal Mining [2012]). A summary of the assessment is provided below.

Test-work was conducted on 29 overburden samples from 21 drill holes distributed across the Atlas-Campaspe Mine footprint. The test-work included analysis of pH, electrical conductivity and sulphur. The test-work results showed:

- Overburden materials would typically be alkaline, however, would range from weakly acidic to strongly alkaline.
- Overburden materials would typically be non-saline to moderately-saline.
- Total sulphur content of the overburden materials is very low and the sulphate sulphur content averaged approximately 50% of the total sulphur.

Based on the test-work results, the acid-generating potential of overburden materials was considered to be very low.

3.6 Mineral Concentrate Transport Route

Mineral concentrates from the Atlas-Campaspe Mine would be transported to Ivanhoe for loading onto train wagons for subsequent transport via rail to Broken Hill for further processing. The proposed transport route (**Figure 2.3**) generally follows existing unsealed roads from near the southern corner of the Atlas-Campaspe Mine to the Balranald – Ivanhoe Road, which is sealed.

Section 2.2 outlines the works to be undertaken on the mineral concentrate transport route.

As shown on **Figure 2.3**, the route for the upgraded road traverses an area containing numerous clay pan depressions and dry lakes that form part of the complex system that extends from northward from the Arumpo Creek drainage system. Surface drainage in this area is dominated by the local slope towards the nearest depression rather than any significant north-south slope.

Inspection of the existing road system identified a total of 18 cross drainage culverts, the majority of which comprised 300 mm or 450 mm concrete pipes, a few with twin pipes (see **Figure 3.15** for typical example) with a few box culverts (see **Figure 3.16** for typical example). The hydraulic capacity of many of the culverts has been compromised by silt deposition (see **Figure 3.17** for typical example) while other exhibit downstream scour (see **Figure 3.18**). While the gradient downstream of some culverts is inadequate to allow water to drain away (see **Figure 3.19**), recent upgrade works in other areas have significantly improved the ability of water to drain away from the road (see **Figure 3.20**).

Figure 3.15: Example of Twin Circular Pipe Culvert

Figure 3.16: Example of Box Culvert

Figure 3.17: Example of Silted Culvert Inlet

Figure 3.18: Example of Scour Downstream of a Culvert

Figure 3.19: **Ponding Downstream of a Culvert**

Figure 3.20: **Example of Newly Constructed Outlet Drain**

Notwithstanding the deficiencies of some of the existing culverts, there were no signs of the road being overtopped as a result of culvert blockage. At one location (approximately 31.3 km from the southern corner of the Atlas-Campaspe Mine footprint) visual inspection indicated that an additional culvert would be desirable. As part of the road widening, most culverts would require an additional length of pipe. While this work is being undertaken, the opportunity could be taken reconfigure those culverts which exhibit the worst upstream siltation or downstream scour. The construction of 'level spreaders' outlets or evaporation basins could be considered as options to minimise downstream scour.

Only a few table drains convey water away from the side of the road, the majority of which are located on the steeper grade sections, particularly immediately west of the location where the mine access road would join.

3.7 Existing Water Quality

No water quality baseline data has been collected from any of the ephemeral or constructed permanent waterbodies in the vicinity of the Atlas-Campaspe Mine site. Some limited data is available on water quality in the Darling and Murray Rivers, but this is not of relevance to the Atlas-Campaspe Mine site.

3.8 Relevant Legislation, Regulations and Guidelines

From a river basin water regulatory perspective, the Atlas-Campaspe Mine site is located:

- to the west of the Lachlan River and its distributary delta (principally Willandra, Muggabah, Merrimajeel, and Merrowie Creeks);
- within the Benanee catchment for purposes of the *Lower Murray-Darling Catchment Action Plan* (Lower Murray Darling Catchment Management Authority [CMA], 2008); and
- on the eastern boundary of the *Water Sharing Plan for the Lower Murray-Darling Unregulated Water Source*.

Similarly the Ivanhoe Rail Facility is located near the far north-western edge of the area covered by:

- the *Lachlan Catchment Action Plan* (Lachlan CMA, 2006); and
- the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources* 2012.

3.8.1 Water Quality and River Flow Objectives for the Barwon-Darling and far Western Catchments

The *Water Quality and River Flow Objectives for the Barwon-Darling and Far Western Catchments* (NSW Office of Environment and Heritage, 2012) identifies the Project area as being located in Benanee Catchment, but does not identify any specific flow and water quality objective\s for this catchment.

The most relevant objectives quoted for the Benanee Catchment are those quoted for "*Uncontrolled Streams*". Whilst the documentation clearly specifies that the flow and water quality objectives apply only to <u>defined drainage systems</u>, the underlying principles are applicable to a number of objectives for constructed or ephemeral waterbodies within the Project area.

Water Quality

Table 3.8 lists the proposed trigger values for further assessment (taken from Australian and New Zealand Environment and Conservation Council, 2000) that are relevant to the conditions in the constructed (permanent) and ephemeral waterbodies in the Project area.

Table 3.8: Proposed Provisional Water Quality Trigger Values for the Project Area

Parameter	Proposed Trigger Value	Protection
pH	6.5 - 8	Ecosystems - Lakes and reservoirs
Turbidity	20 NTU	Ecosystems - Lakes and reservoirs
Total Phosphorus	10 µg/L	Ecosystems - Lakes and reservoirs
Total Nitrogen	350 µg/L	Ecosystems - Lakes and reservoirs
Chlorophyll-a	5 µg/L.	Ecosystems - Lakes and reservoirs
Salinity	2,200 µS/cm	Ecosystems - Lakes and reservoirs
Total Dissolved Solids	4,000 mg/L (± 6,400 µS/cm)	Stock water - Sheep and cattle

NTU = Nephelometric Turbidity Units.
µg/L = micrograms per litre.
µS/cm = microSiemens per centimetre.
mg/L = milligrams per litre.

As there has been no water quality monitoring in any of the constructed (permanent) or ephemeral waterbodies in the vicinity of the Project area, the proposed trigger values listed in **Table 3.8** are provisional pending future monitoring of water quality in natural and constructed waterbodies located in the vicinity of the Atlas-Campaspe Mine site:

- First Mildura Tank (reference water body not affected by the Project);
- an un-named tank located about 500 m south of the Campaspe footprint;
- the natural depression located between the Atlas and Campaspe footprints (shown in **Figure 3.10** and **Figure 3.11**); and
- Yankie Tank located about 3 km south of the Atlas footprint.

Flow

The relevant flow objective applicable to the Project area is the '*maintenance of wetland and floodplain inundation*'. For the Atlas-Campaspe Mine site, this objective would be achieved as long as surface drainage patterns from, and across, the mine footprints were maintained as far as possible during mining and, at the end of mining, restored to conditions comparable to pre-mining conditions.

3.8.2 Lower Murray Darling Catchment Action Plan

The *Lower Murray Darling Catchment Action Plan* (Lower Murray Darling CMA, 2008) identifies five equally important Catchment Objectives:

- community Values;
- water Quality and Quantity;
- salinity;
- soils and Vegetation; and
- biodiversity.

Of these objectives, those relating to Water Quality and Quantity focus on water in the river systems:

> *"To endeavour to ensure that the quality and quantity of water supply available to the region satisfies the region's environmental, social, and economic requirements and to ensure that all water leaving the Lower Murray Darling Catchment is of the highest possible quality."*

The related Catchment Target is specified as:

> *"An identifiable net improvement in riverine health across the Lower Murray Darling Catchment by 2015. This will be determined by:*
>
> - *an improvement in the native to introduced fish ratio (55% improvement in species ratio, 25% improvement in abundance ratio, 25% improvement in biomass ratio);*
> - *a 20% reduction in the number of days subject to blue green algal alerts; and*
> - *the reinstatement of more natural flow patterns as modelled in each of five river management zones."*

None of these objectives are relevant to the Atlas-Campaspe Mine site.

3.8.3 Lachlan Catchment Action Plan

The *Lachlan Catchment Action Plan* (Lachlan CMA, 2006), contains four catchment targets and ten management targets relating to water and aquatic ecosystems. The only Management Target that has any potential relevance to Ivanhoe Rail Facility is:

> "***Management Target 14: Sustainable Surface Water Management***
>
> *MT14 By 2016 3 surface water sources are being managed in accordance with the Water Sharing Plans.*
>
> *….*

> *This target promotes surface water sharing arrangements to ensure environmental protection and equitable outcomes for the water users and community. This target covers all surface water sources in the Lachlan Catchment. The three water sharing plans include:*
>
> *…..*
>
> - *Macro Water Sharing Plan for the Unregulated Water Sources of the Lachlan*

The Macro Water Sharing referred to above has now been gazetted as the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources* 2012 (**Section 3.8.5**).

3.8.4 Water Sharing Plan for the Lower Murray-Darling Unregulated and Alluvial Water Sources 2011

The Atlas-Campaspe Mine site is located within the area to which the *Water Sharing Plan for the Lower Murray-Darling Unregulated and Alluvial Water Sources 2011* applies. The plan commenced on 30 January 2012. The unregulated water source, to which the plan applies, includes all water occurring naturally on the surface of the ground shown on the Registered Map (which includes the Atlas-Campaspe Mine site), and in rivers, lakes, estuaries and wetlands in these water sources, with the exception of:

- water contained between the banks of rivers declared to be regulated within the NSW Murray and Lower Darling Regulated Rivers Water Sources as defined in the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2003*; and
- water taken under a floodplain harvesting access licence with a share component that does not specify one of these water sources.

The main provisions of the Plan that potentially affect the Atlas-Campaspe Mine site are those under Part 5, Division 2, clause 19 that relate to harvestable rights:

> *"The requirement for water under harvestable rights in these water sources is the total amount of water that owners or occupiers of landholdings are entitled to capture and store pursuant to a harvestable rights order made under Part 1 of Chapter 3 of the Act [Water Management Act 2000 (NSW)]."*

In accordance with the '*Harvestable Rights – Western Division'* Order made by the Minister (under Part 1 of Chapter 3 of the *Water Management Act 2000*) in the NSW Government Gazette No 110 (pp 5515 – 5519, 2004), Paragraph 3 states that for all lands in the Western Division of NSW:

> *"A landholder has the right to capture all rain water runoff on land to which this Order applies by means of a dam or dams which are located on "minor streams". This water may be used for any purpose, except as provided in paragraph 4."*

Paragraph 4 concerns waters taken from a river or lake and for domestic and stock purposes, which does not specifically relate to this Project. With regards to defining "minor streams", Paragraph 2 indicates that the streams of water referred to in relation to the definition of "river" in the NSW Government Gazette No 57 (p 1480, March 2001), are declared to be "minor streams" for these purposes. Paragraph 1 of Schedule 1 of this gazette states that:

> *"The following streams of water are not "rivers" for the purposes of Part 2 of the Act [Water Act 1912 (NSW)]:*
>
> *(a) Any stream or part of a stream:*

> *(i) The location of which is represented on any of the topographic maps listed in Schedule 3 [1:100,000 Land Information Centre maps], and*
>
> *(ii) Is a first or second order stream, or part of such a stream, determined in accordance with the system set out in Schedule 4 [Strahler System], and*
>
> *(iii) Which does not maintain a permanent flow of water, being visible flow which occurs on a continuous basis, or which would so occur if there were no artificial abstractions of water or obstruction of flows upstream, and*
>
> *(iv) Which does not at any time carry flows emanating from a third, fourth or higher order stream system as determined in accordance with the system set out in Schedule 4, and*
>
> *(b) Any stream or part of a stream the location of which is not represented on any of the topographic maps listed in Schedule 3."*

The relevant 1:100,000 topographic map ('Turlee') does not have any continuous blue lines that could be designated as anything other than "minor streams" for the purposes of the Water Sharing Plan. Consequently, any dam will not be on a stream other than a "minor stream".

On the basis of the analysis set out above, there would appear to be no restriction on the retention and use of surface runoff for the Project.

3.8.5 Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012

The Ivanhoe Rail Facility is located within the area to which the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2011* applies. The plan commenced on 14 September 2012. The unregulated water source, to which the plan applies, includes all water occurring naturally on the surface of the ground shown on the Registered Map (which includes the Ivanhoe Rail Facility), and in rivers, lakes, estuaries and wetlands in these water sources, with the exception of:

- water contained in any fractured rock or porous rock;
- water contained in the Lachlan Regulated River Water Source; the Lower Lachlan Groundwater Source; NSW Murray-Darling Basin Fractured Rock Groundwater Sources; the Lower Murrumbidgee Alluvium; the Belubula River from the upper limits of Carcoar Dam storage at full supply level to its confluence with the Regulated Lachlan River; or the Mandagery Creek Water Source; and
- water taken under a floodplain harvesting access licence with a share component that does not specify one of these water sources.

The main provisions of the Plan that potentially affect the Ivanhoe Rail Facility are those under Part 5, Division 2, clause 21 that relate to harvestable rights:

> *"The requirement for water under harvestable rights in these water sources is equal to the total amount of water that owners or occupiers of landholdings are entitled to capture and store, pursuant to a harvestable rights order made under Part 1 of Chapter 3 of the Act [Water Management Act 2000 (NSW)]."*

The relevant provisions under Part 1 of Chapter 3 of the Act are set out in **Section 3.8.4** above. The relevant 1:100,000 topographic map ('Ivanhoe'), has a short blue line which designates a drain leading to the '2 Mile Tank' located to the south of the Orange – Broken Hill Railway. This blue line does not cross the site of the proposed Ivanhoe Rail Facility. The Ivanhoe Rail Facility does not contain any defined drainage lines that could be designated as anything other than "minor streams" for the purposes of the Water Sharing Plan.

Accordingly, there would appear to be no restriction on the retention and use of surface runoff for the Project.

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4 Proposed Surface Water Management

4.1 Proposed Mining Operations

Mining at the Atlas-Campaspe Mine would involve progressive mining from south-east to north-west along the Atlas deposit followed by the Campaspe deposit. The general sequence of mining operations is illustrated in **Figure 4.1** to **Figure 4.5** while **Figure 4.6** shows a typical general layout of the mine operations. The mining process would involve:

- Vegetation clearance followed by soil stripping. Where stripped soils cannot be used directly for progressive rehabilitation behind the mining operations, the soil would be stockpiled separately and seeded with grasses to maintain soil viability.
- Overburden removal ahead of ore extraction. Where overburden cannot be used directly for progressive backfilling behind the mining operations, particularly at the start of mining, the overburden would be placed adjacent to the mine path and rehabilitated.
- Extraction of mineral sands ore for pre-processing before being transported by road to Ivanhoe where it would be loaded onto rail for transport to Broken Hill for further processing.
- Progressive backfilling of mine voids behind the advancing ore extraction areas.
- Placement of process wastes (i.e. sand residues, coarse rejects etc) following mineral processing either below finished ground level behind the advancing ore extraction area or into sand residue dams located adjacent to each mine path (see **Figure 4.1** to **Figure 4.5**).
- Overburden and soil replacement including profiling of the final landform in preparation for rehabilitation activities.
- Progressive rehabilitation behind the advancing mining operation.

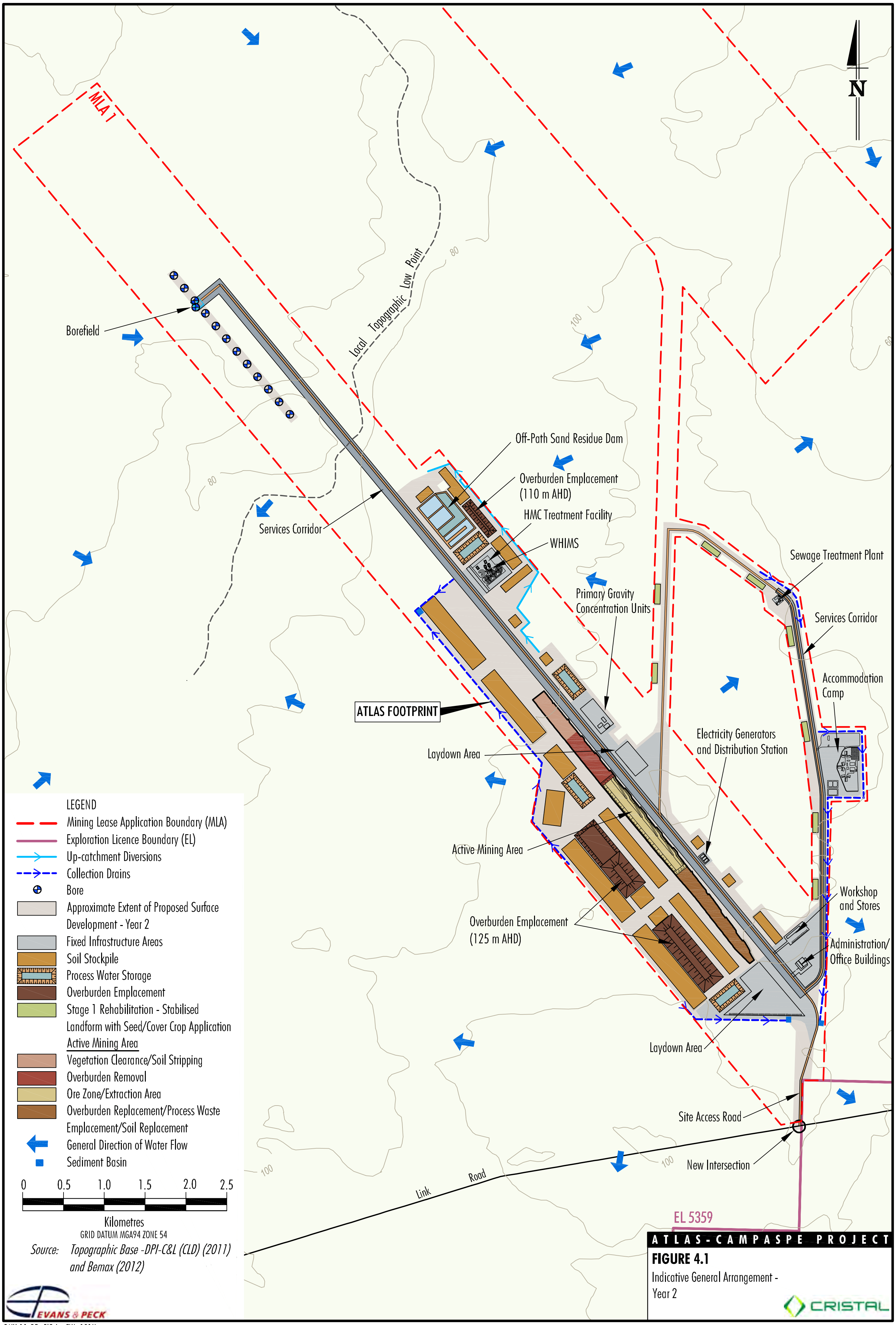
4.2 Proposed Mine Water Management

The objectives of on-site water management throughout the Project life would be to:

- separate runoff from areas undisturbed by mining from water generated within active mining areas;
- collect and preferentially re-use any surface runoff from disturbed areas for dust suppression or make-up of the water supply for on-site processing of the mineral sands;
- capture and contain on-site any potentially contaminated Atlas-Campaspe Mine site water; and
- provide a reliable source of water to meet Project requirements.

In order to meet these objectives, mine water management would involve two predominantly separate systems:

1. **Mine operations water management system** which would be fed from groundwater and would involve a high degree of water recycling to meet the requirements for sand processing and water supply for the mine staff. Apart from disposal of effluent from the office/amenities and the accommodation camp, and evaporation/seepage losses from water storage dams, this water system would involve a high degree of water recycling and not involve any off-site discharge. Further details of this system and the site water balance are provided in the *Hydrogeological and Water Supply Assessment* (GEO-ENG, 2013).



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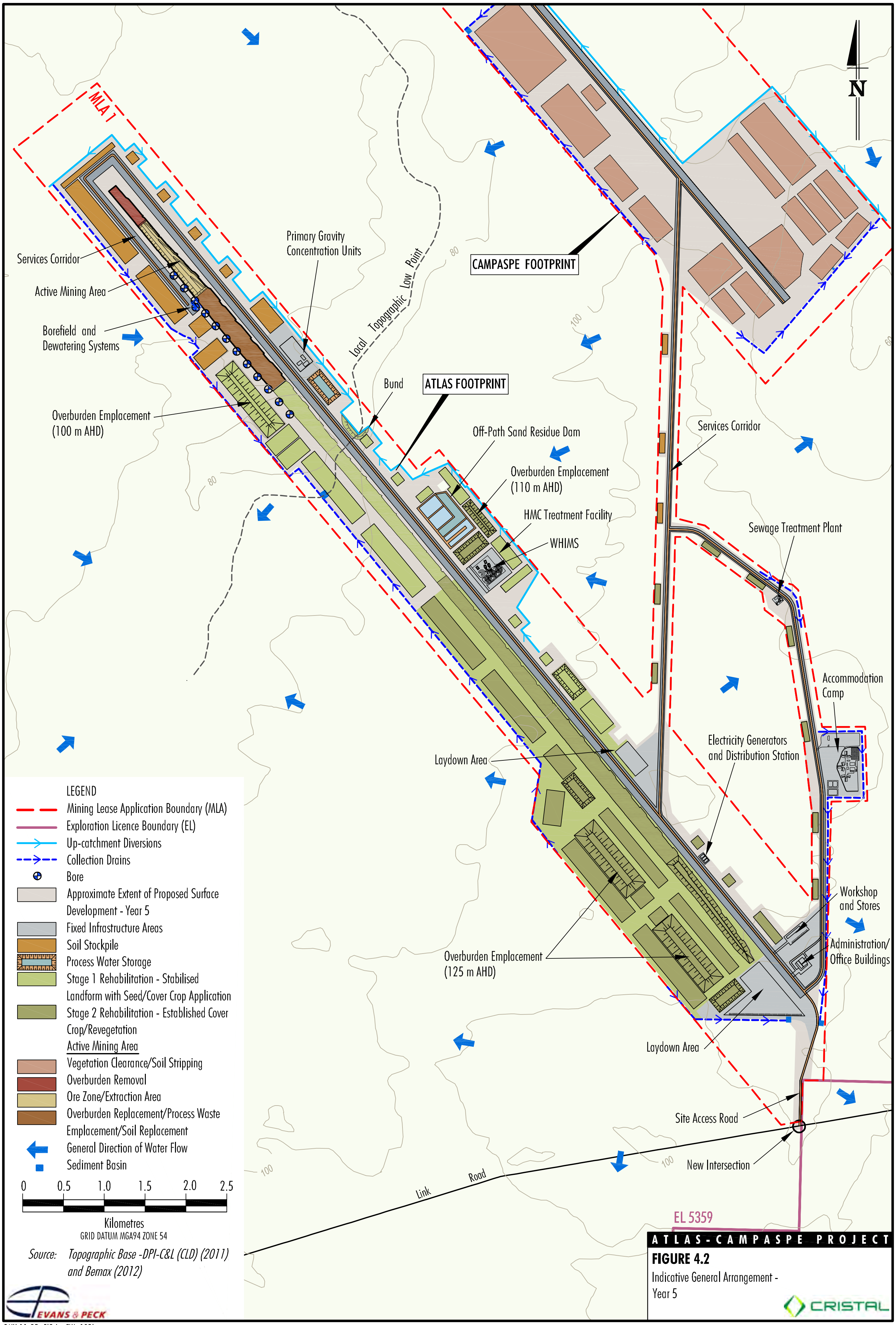

ATLAS-CAMPASPE PROJECT

FIGURE 4.2

Indicative General Arrangement - Year 5

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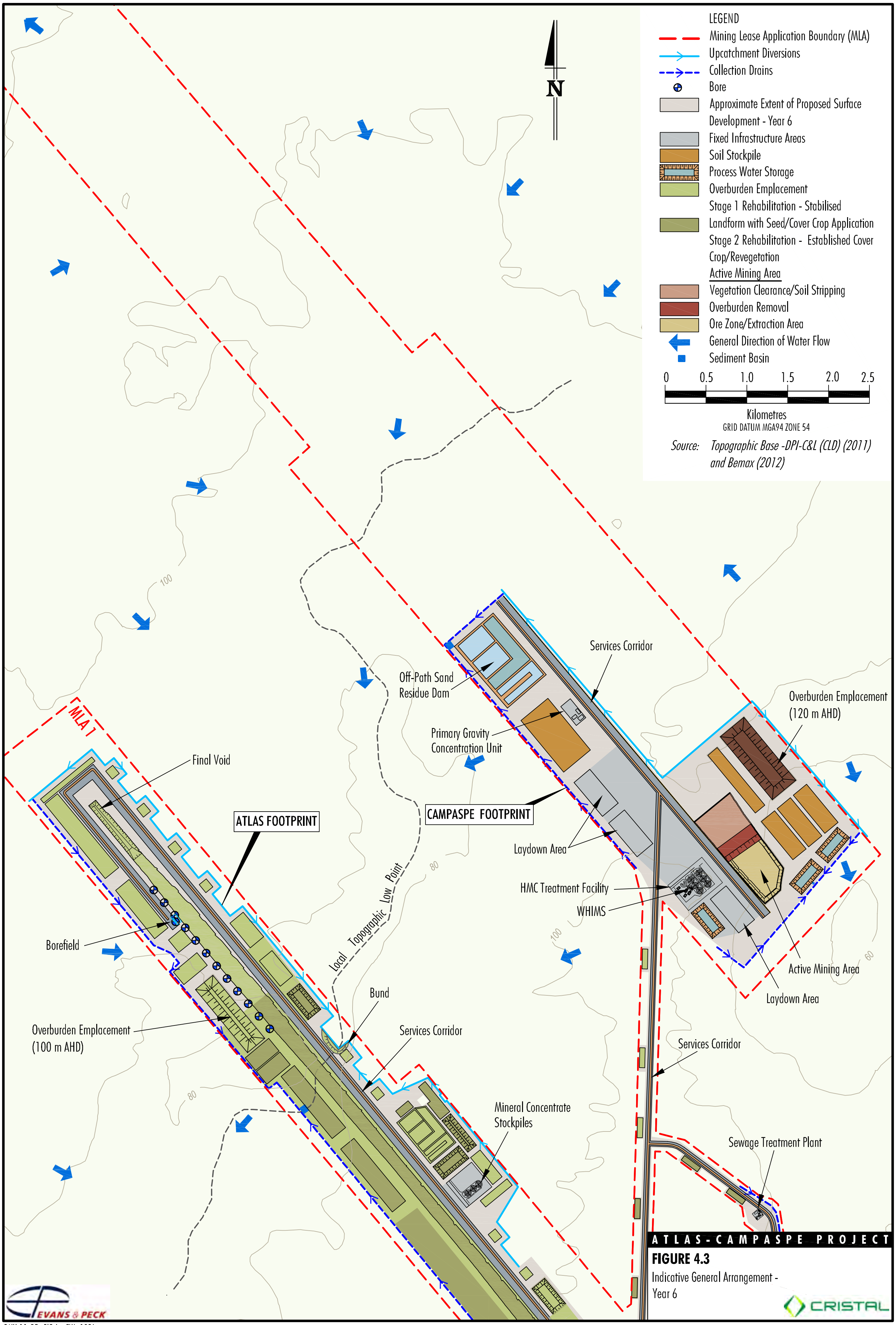

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FIGURE 4.3

Indicative General Arrangement - Year 6

BMX-11-25_EIS AppSW_103J

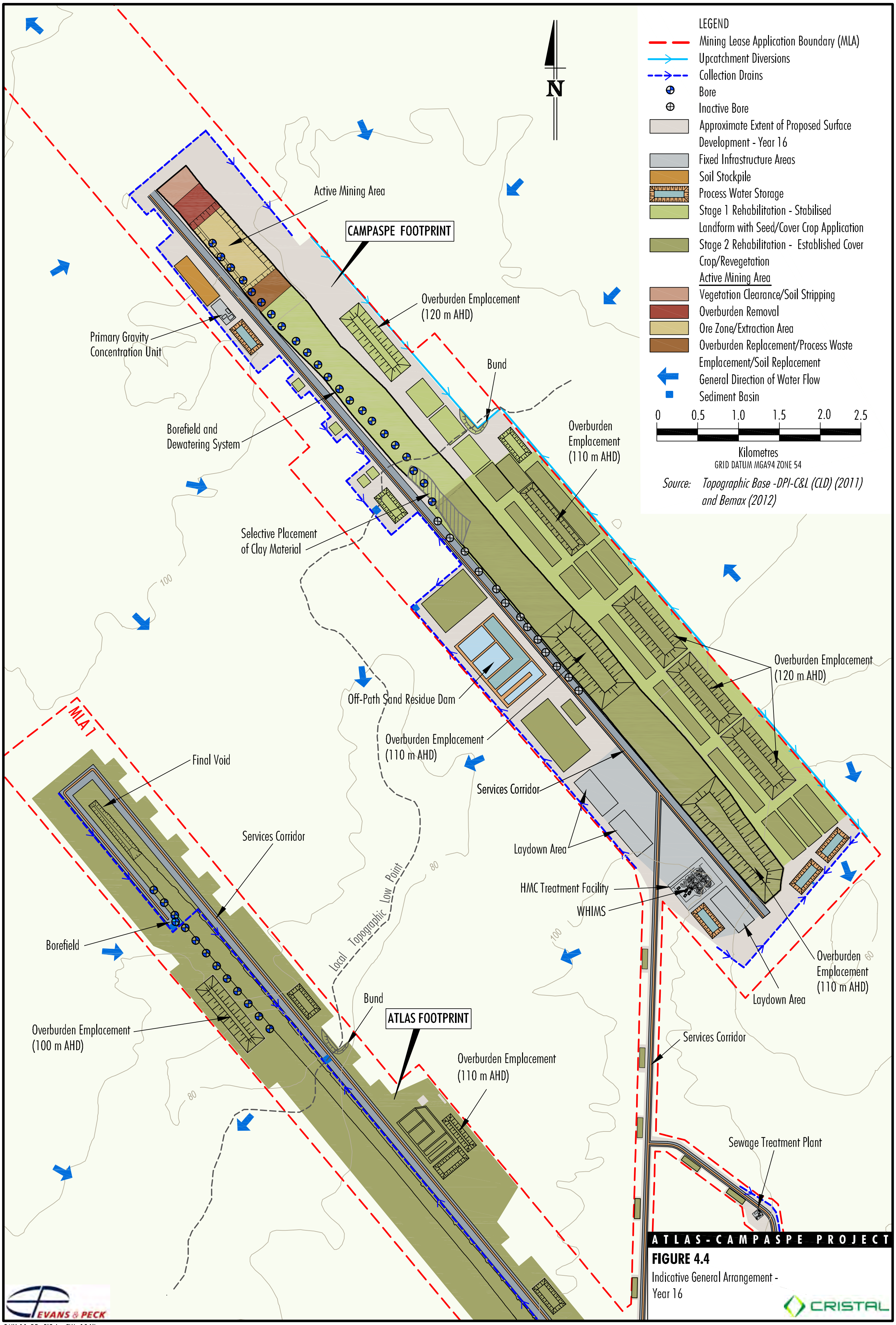

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FIGURE 4.4

Indicative General Arrangement - Year 16

BMX-11-25_EIS AppSW_104K

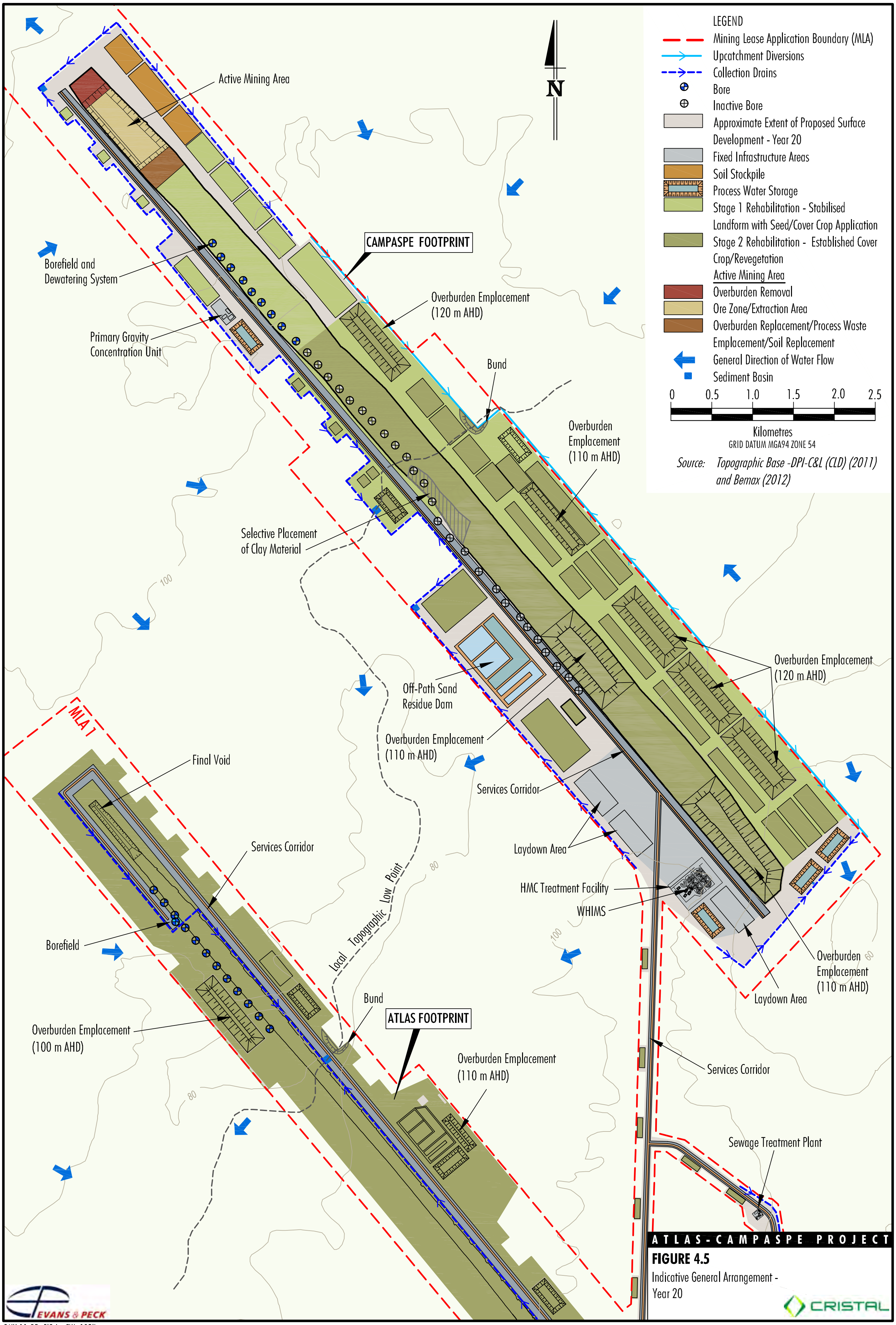

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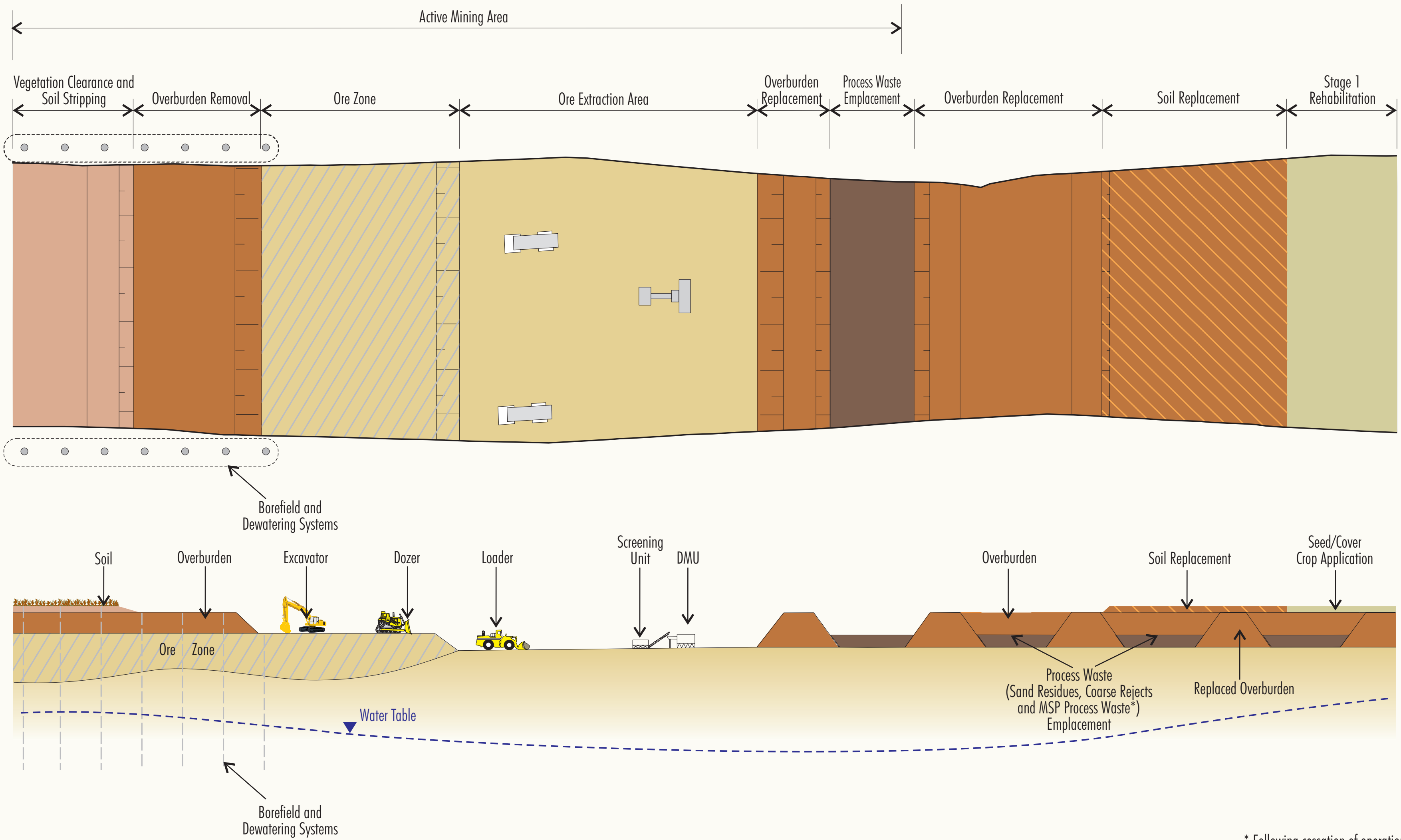
FIGURE 4.5

Indicative General Arrangement - Year 20

BMX-11-25_EIS AppSW_105K



* Following cessation of operations at the Ginkgo and Snapper Mines (approximately Year 12 of the Project)

Not to Scale

Source: Bemax (2012)

ATLAS - CAMPASPE PROJECT

FIGURE 4.6

Mining Operations Conceptual Plan and Section

CRISTAL

EVANS & PECK

BMX-11-25 EIS AppSW_001D

2. Surface water management system which would provide for:

- orderly conveyance across the mine path of runoff emanating from outside the mine path;
- sediment control of runoff emanating from within the mine path, particularly runoff from off-path overburden and soil stockpiles, and from the batters of water storage dams and the off-path sand residue dams. When available water collected for sediment control purposes would be used preferentially for dust suppression or processing water make-up requirements; and
- discharge of any runoff from the site as shallow overland flow in a manner which is consistent with the overland flow characteristics of the existing landscape.

Because of the linear progression of mine operations, the surface water management system would develop progressively, except for locations where there are semi-permanent facilities such as the treatment facilities and off-path sand residue dam shown on **Figure 4.1** to **Figure 4.5**.

4.3 Landform Development and Rehabilitation

As noted in **Section 3.2** the existing landform is characterised by low slopes, overland flow into minor depressions and, with a few exceptions, the absence of concentrated flow. The activities associated with mining have the potential to significantly alter this landform and create areas of steeper slopes (on the batters of overburden emplacements and water storages) as well as concentrating runoff into confined flow paths.

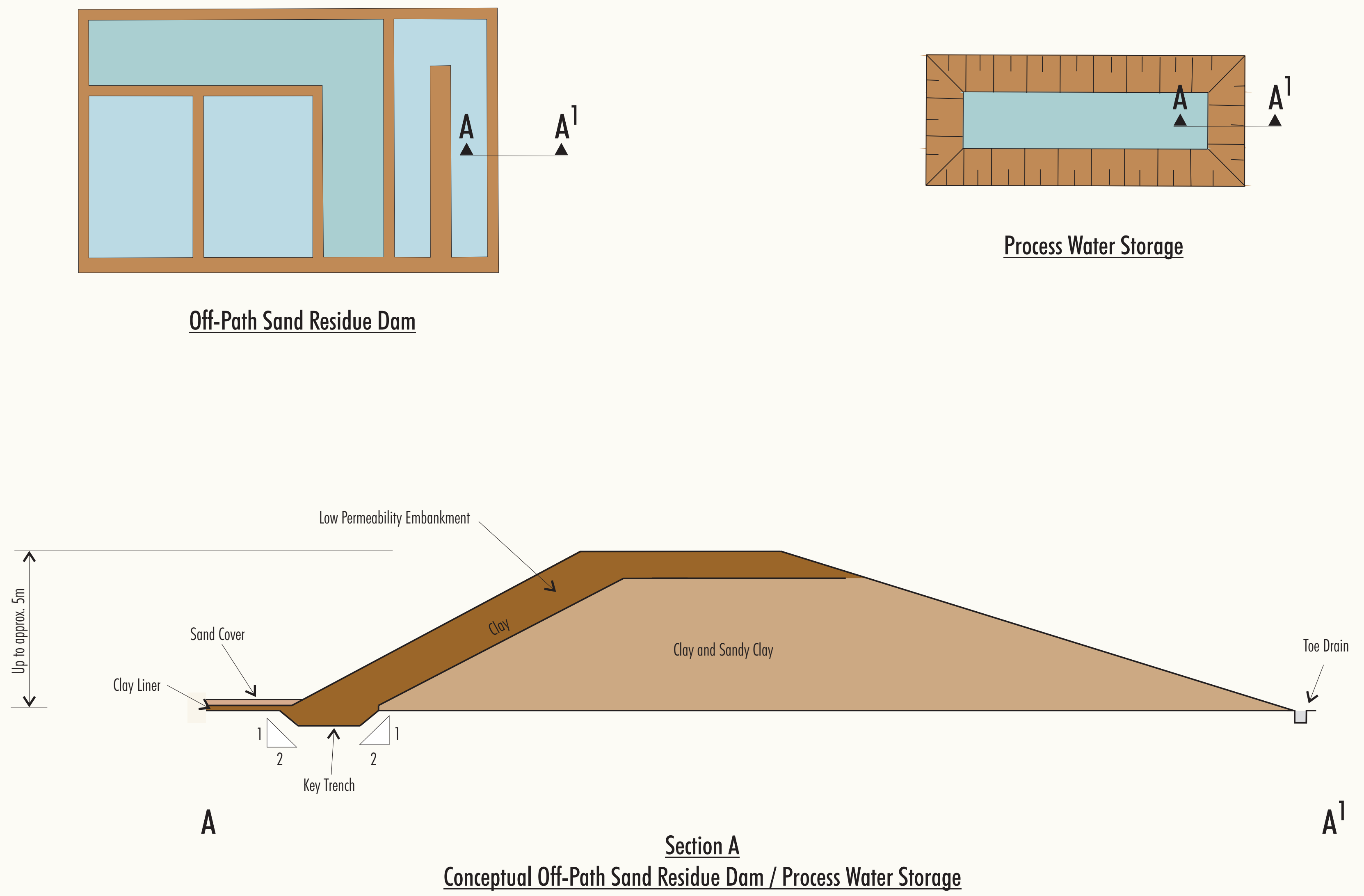
Whilst rainfall runoff is a rare event in this climate, the earthworks would, nevertheless, be undertaken and rehabilitated in a manner which seeks to minimise the risk of off-site impacts.

Figure 4.7 shows conceptual design of sand residue and water storage structures. The main feature of relevance to this report is the outside batter of the embankments which has a slope of about 1:6.5 vertical:horizontal (V:H). Although not specifically shown on **Figure 4.1** to **Figure 4.5**, similar batter slopes are proposed for the overburden emplacements.

The batter slopes of the overburden emplacements which could have slope lengths of 130 m would be particularly vulnerable to soil erosion in the event of heavy rainfall prior to vegetation establishment. Whilst rainfall events that have sufficient rainfall intensity to cause erosion are rare, planting with a sterile ‘cover crop’ should take place immediately after completion of construction in order to provide temporary protection against erosion while more permanent vegetation cover has an opportunity to establish.

In order to eliminate additional runoff from the upper surface of the overburden emplacements, it is proposed to adopt the technique that has been successfully employed at Cristal Mining’s Ginkgo and Snapper mines. This involves creating a level surface on the top of the emplacement and constructing a bund around the perimeter to create an artificial closed depression from which there would be no discharge onto the batters. The diligence and expertise of Cristal Mining in applying such rehabilitation planning and practices at the Ginkgo Mine have been recognised through the receipt of a highly commended award at the 2012 NSW Minerals Council Excellence Awards.

As shown on **Figure 4.7** it is proposed to construct a drain at the toe of the embankments in order to collect runoff which would be directed into small sediment retention basins. Proposed design criteria for drains, water diversion banks and sediment basins are set out in **Section 4.4** below.



Not to Scale

Source: Bemax (2012)

ATLAS - CAMPASPE PROJECT

FIGURE 4.7

Conceptual Design of Off-Path Sand Residue Dams and Process Water Storage Embankments

CRISTAL

EVANS & PECK

BMX-11-25 EIS AppSW_003B

Once mining is complete, the land levels along the main flow paths would be restored to levels that allow cross drainage to occur (Section 5.1.3).

4.4 Mine Site Runoff and Sediment Control

Drainage from disturbance areas within the Atlas-Campaspe mine footprint would be directed to the sediment basins from where water would be preferentially taken for dust suppression and top-up of the water supply for the mine operations.

For purposes of establishing the design criteria for drainage systems and sediment basins, the environment surrounding the site is 'standard' according to the criteria in table 6.1 in *Managing Urban Stormwater: Soils and Construction – Volume 2E: Mines and Quarries* (NSW Department of Environment and Climate Change [DECC], 2008a). In view of the presence of clay and sandy clay soils at the Atlas-Campaspe Mine site, the soils are assumed to be 'Type F' and, therefore, require any sediment basin to be designed to capture and retain runoff from a specified design storm. The relevant minimum criteria are:

- for temporary sediment basins (disturbance between 1 and 3 years):
  - runoff capture capacity based on runoff from 80th percentile 5 day storm (14.4 mm);
  - embankment and spillway designed to be stable in a 50 year average recurrence interval (ARI) storm (see **Table 3.5**); and
- for permanent sediment basins (disturbance greater than 3 years):
  - runoff capture capacity based on runoff from 90th percentile 5 day storm (23.9 mm); and
  - embankment and spillway designed to be stable in a 50 year ARI storm (see **Table 3.5**).

Note that the 5 day rainfall depths quoted above have been derived by correlation of the rainfall characteristics of the Atlas-Campaspe Mine site against those for centres in western NSW for which the relevant rainfall depths are quoted in table 6.3 in *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004), namely Broken Hill, Griffith, Nyngan and Bourke.

4.4.1 Diversion Banks and Drains

Where possible, concentration of surface runoff into defined drains should be avoided. Where this is not possible because of the layout of site facilities, drains and diversion banks should be designed with shallow trapezoidal cross section at a minimum grade consistent with the grade necessary to direct water to the required direction. As noted in **Section 3.2**, although the prevailing general slopes in the landscape are moderate (<1%) some local slopes exceed 1.5%. Where practical, longitudinal slopes for drains and diversion banks aligned across the prevailing slope in order to achieve grades of less than 1%, and preferably less than 0.5%.

Where diversion banks are constructed to redirect off-site runoff around or away from the disturbance area, the drainage outlets should be constructed in the same manner as roadside table drains that run parallel to the contour in order to provide a 'level spreader' outlet to promote shallow overland flow onto the undisturbed landscape. Where possible, 'level spreader' outlets should be located in areas with well-established ground cover immediately down slope.

4.4.2 Sediment Basins

The operational requirements for the proposed sediment basins are that the capture capacity of the basin be restored within the same period of time after the design rainfall event (e.g. restore the capture capacity within 5 days where the basin has been designed on the basis of a 5 day rainfall event). *Managing Urban Stormwater: Soils and Construction– Volume 2E: Mines and Quarries* also provides alternative design criteria for 10 and 20 day rainfall events for circumstances in which emptying the basin within 5 days is not practical. For basins sized on the basis of 10 and 20 day rainfall, the time required for restoration of the capture capacity is 10 and 20 days in each case. **Table 4.1** summarises the alternative design rainfall depths for different durations and the corresponding basins sizes expressed as cubic metres per hectare (m^3/ha) of contributing catchment (note that the quoted volume includes an additional 50% allowance for sediment accumulation).

Table 4.1: Alternative Design Rainfall and Sediment Basin Volumes

Design Storm (days)	Temporary Basin (80th percentile)		Permanent Basin (90th percentile)	
	Rainfall (mm)	Basin Volume (m^3/ha)	Rainfall (mm)	Basin Volume (m^3/ha)
5	14.4	110	23.9	180
10	20.6	155	32.8	245
20	32.1	240	47.1	355

Appropriate criteria from **Table 4.1** would be adopted for the sizing of sediment basins which would be fully excavated. Where feasible, sediment basins would be located on the edge of the disturbance area and sited so as to allow any overflow to be directed onto area of well-established ground cover vegetation.

For purposes of design of overflow spillways for sediment basins to meet the requirement for design capacity of 50 years ARI (see above), **Figure 4.8** shows the estimated 50 year ARI peak discharge as a function of contributing catchment area based on the rainfall characteristics of the Atlas-Campaspe Mine area as set out in **Table 3.5**.

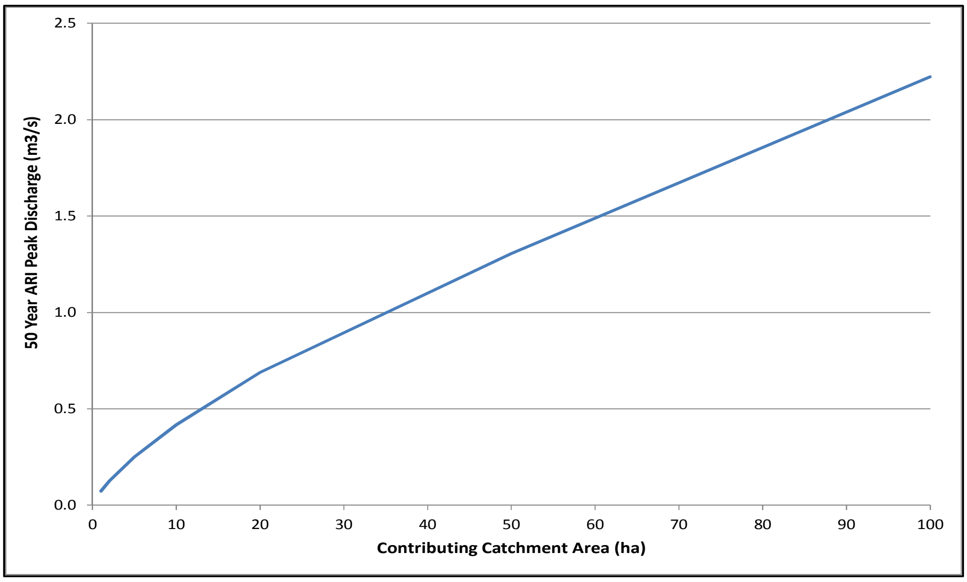


Figure 4.8: Estimated 50 Year ARI Design Discharge Rate

Figure 4.9 sets out the required length of 'level spreader' required to provide down-slope flow velocity of less than 0.5 metres per second, which is indicative of non-scouring velocity on sparsely vegetated land.

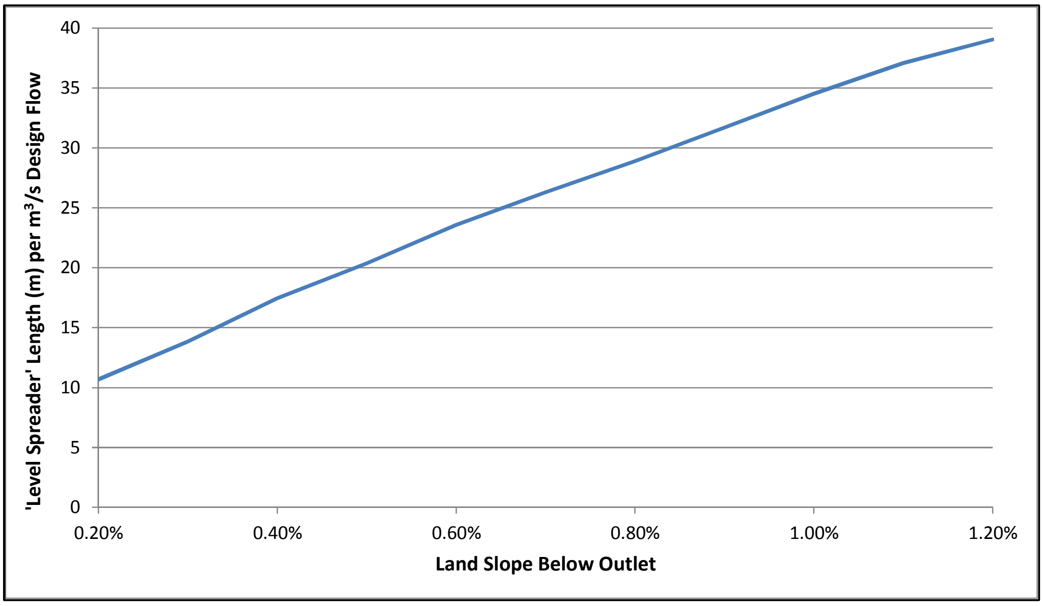


Figure 4.9: Required 'Level Spreader' Outlet Length for Discharge

4.5 Diversion and Conveyance of Off-site Runoff

Both temporary and permanent up-slope diversion bunds/drains would be constructed to divert runoff from undisturbed areas around the mine path, overburden emplacements, soil stockpiles, off-path sand residue dams, process water storages and other fixed infrastructure areas.

The design capacity of up-catchment diversion works would depend on the size of the catchment, the design life of the diversion and the potential consequences of a breach. In compliance with the requirements set out in table 6.1 of in *Managing Urban Stormwater: Soils and Construction – Volume 2E: Mines and Quarries* the following design criteria are proposed:

- temporary diversions (less than 3 years life) 10 Year ARI storm; and
- permanent diversions (greater than 3 years life) 20 Year ARI storm.

Figure 4.10 provides estimated design discharges corresponding to these design recurrence intervals.

Diversions banks should be designed to be stable (non-eroding) at the relevant design flow. Stabilisation would be achieved by design of appropriate channel cross-sections and gradients and the use of channel lining with grass or rock stabilisation if required.

Discharge back to the existing land surface at the end of the diversion banks would be designed on the same basis as the 'level spreaders' for overflow from the sediment dams.

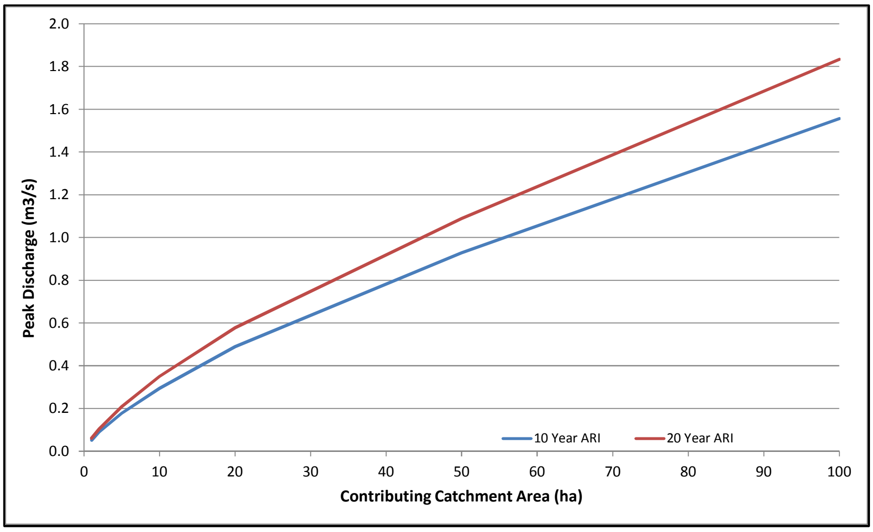


Figure 4.10: Estimated 10 and 20 Year ARI Design Discharge Rates

4.6 Upgrading of the Mineral Concentrate Transport Route

As outlined in **Section 3.6**, the mineral concentrate would be taken by truck to Ivanhoe for trans-shipment to rail and transport to Broken Hill for further processing. The proposed truck transport route follows unsealed section of public road from the mine to the Balranald – Ivanhoe Road and then via the existing sealed road to Ivanhoe.

As part of the Project it is proposed to carry out various roadworks along the unsealed section of road as outlined in **Section 2.2**.

Table drains and culvert extensions would be installed as part of the roadworks along the existing unsealed road, with the details to be determined as part of the detailed road design. Apart from the two new sections of road, the upgraded road would follow the existing road alignment which has been described in **Section 2.2**. The route traverses an area containing numerous clay pan depressions and dry lakes in which surface drainage is dominated by the local slope towards the nearest depression rather than any significant north-south slope. The existing road system has a total of 18 cross drainage culverts, the majority of which comprised 300 mm or 450 mm concrete pipes, a few with twin pipes and a few box culverts. There are a few existing table drains on the steeper grade sections of the road, particularly near the proposed mine access intersection.

Apart from one location where additional cross drainage could be considered (approximately 31.3 km from the mine access intersection – as measured along the existing route), the absence of any observable damage due to water running across the road suggests that the existing cross drainage systems are appropriately located and function adequately, notwithstanding severe siltation at some culverts.

As part of the road widening, most culverts would require an additional length of pipe. While this work is being undertaken, the opportunity could be taken reconfigure those culverts that have the worst upstream siltation or downstream scour. The construction of ‘level spreaders’ outlets or evaporation basins would be considered as options to minimise downstream scour.

During roadworks along the unsealed road, temporary sedimentation controls (such as silt fencing and sediment/evaporation basins) would be installed as required in accordance with the guidelines in *Managing Urban Stormwater: Soils & Construction – Volume 2C: Unsealed Roads* (DECC, 2008b).

4.7 Ivanhoe Rail Facility

The Ivanhoe Rail Facility is proposed to be constructed approximately 4.5 km south-west of Ivanhoe, on the southern side of the Orange – Broken Hill Railway. Mineral concentrates from the Atlas-Campaspe Mine would be stockpiled for loading onto train wagons for transport via rail to Broken Hill for further processing.

The main facilities at the Ivanhoe Rail Facility that are of relevance to this report are shown on **Figure 2.2** and outlined in **Section 2.3** and include:

- a fenced area, measuring about 6 ha, that would include a bunded hardstand area for stockpiles of mineral concentrates and container storage;
- a retention basin to collect runoff from the hardstand area and provide a source of water for dust suppression, drains; and
- pumps, pipelines for transfer of water from the retention basin to the hardstand area, and sprays for dust control.

Sediment control for construction works would be provided by the construction of an in-ground basin which would initially serve as a sediment basin and subsequently as a water retention basin and sediment trap for the operational phase.

Several factors have been considered in determining an indicative size for the basin (to be confirmed during detailed design):

- For the construction phase, the minimum requirement would be for a basin to retain runoff from a 80^{th} percentile 5 day rainfall of 14.8 mm. Given that, in later stages of construction the lower permeability hardstand would be laid down, the basin has been sized on the conservative assumption of 80% runoff. The required basin size would be 1,000 m^3 including 50% additional capacity for sediment storage.
- Once the facility is operating the main source of sediment is expected to be the mineral concentrate (with particle size in the range of 125 – 150 [micrometres] µm). For capture of sediments of this size, the relevant design requirements for 'Type C' sediments as set out in *Managing Urban Stormwater: Soils & Construction* are for a 'flow through' basin with sufficient water surface area to allow particles to settle out as the water flows through the basin. Based on the runoff from a 1 year ARI storm (as specified in table 6.1 of *Managing Urban Stormwater: Soils & Construction – Volume 2E: Mines and Quarries*) the design flow is 0.66 m^3/s and the required basin surface area is 110 square metres. One option to be considered during detailed site design would be to provide this area as a small sediment basin to capture the coarser sediment before water drains into the main retention basin. A basin 5 m wide, 20 m long and 1-1.5 m deep would be sufficient for this purpose.

- The retention basin would be required to store water for dust suppression purposes. There are no defined guidelines for the sizing of such basins. A common ‘rule of thumb’ employed by landholders in the Western Division has been to construct water holding tanks that have sufficient depth to allow for evaporation loss over at least 12 months (say 2 m) and to have sufficient capacity to retain all the runoff in an average rainfall year. For the Ivanhoe Rail Facility the total runoff as a proportion of rainfall is uncertain. However, as shown by the rainfall data in **Table 3.3**, about 40% of the total rainfall occurs as 10 mm per day or less, most of which is likely to be lost to evaporation. Accordingly, in this climate the maximum volume of runoff as a proportion of total annual rainfall from a hardstand area is likely to be less than 50%. For purposes of an initial estimate of the annual runoff volume 40% has been assumed. On this basis the average annual runoff volume from the hardstand area (5.5 ha) would be about 6.6 ML which would require a retention basin of the following approximate dimensions:
  - Depth 2.5 m;
  - Length 110 m;
  - Width 33 m; and
  - Batters 1:3 (V:H).

  The proposed retention basin shown on **Figure 2.2** is significantly larger than this (about 200 m x 50 m) and can, therefore be expected to provide ample water storage for retention of site runoff in periods of unusually prolonged wet weather.

Figure 2.2 shows that the Ivanhoe Rail Facility is located about 1 km north-west of a constructed stock water tank (the “2 Mile Tank”) and appears to lie within the catchment of the tank. Two potential impacts of the proposed facility on the tank have been considered:

- Because the Ivanhoe Rail Facility will retain all runoff for operational purposes, it has the potential to reduce runoff to the tank. However, although the available mapping and aerial photography does not contain sufficient detail to define the catchment boundary, the loss of about 6 ha of catchment is unlikely to have a significant impact on the runoff reaching the tank.
- Any overflow from the retention basin in extended wet weather is likely to drain towards the tank. Because of the size of the proposed retention basin, overflow is unlikely to occur except in very rare prolonged wet weather. In addition, the option of providing a sediment capture basin (such as that outlined above) would ensure that there was a very low risk of any mineral sands being conveyed to the tank.

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5 Surface Water Assessment

5.1 Atlas-Campaspe Mine Site

5.1.1 Potential Impacts

The proposed Atlas-Campaspe Mine site is located in an area of complex landform with gentle slopes and numerous closed depressions which pond with surface runoff after significant rainfall. The climate of the area is semi-arid (average annual rainfall <300 mm) and surface runoff is highly ephemeral. The acid-generating potential of overburden materials was considered to be low (Attachment A). The complex landform, semi-arid climate and inert overburden characteristics combine to provide conditions in which the risk of off-site surface water impacts is minimal.

There are no blue lines on the relevant 1:100,000 topographic maps that cover the proposed mine disturbance areas or the surrounding land. In the course of site inspection, defined drainage lines attributable to concentrated flow were only observed in the south-east section of the Campaspe footprint, which drains to a closed depression located further south-east of the Campaspe footprint.

Because of these landform characteristics, there are no "rivers" as defined in the *Water Act 1912, Water Management Act, 2000* or the *Water Sharing Plan for the Lower Murray-Darling Unregulated and Alluvial Water Sources, 2011*. Accordingly, there are no riparian zones or fluvial geomorphic features that require consideration for purposes of this assessment.

The main surface water features that could be impacted by the Project are a series of depressions that are strung along a line that runs from north of the Campaspe footprint and continues in a southerly direction traversing both deposits. These depressions, which vary in size, hold water after significant rainfall. Some depressions are very shallow and any water collected in them evaporates or seeps away after a few days, while larger depressions may hold water for more than a few months.

A temporary water-body is located about mid-way between the two mine footprints. The boundary of the Campaspe footprint is located about 2.5 km 'upstream' of this water-body. The supply of runoff ('environmental flow') and maintenance of water quality draining to these depressions has been considered in developing the proposed discharge and water quality mitigation measures set out in **Section 4** and summarised in **Section 5.1.3** below.

5.1.2 Site Discharge

There are no water quality and flow objectives that are directly applicable to the Atlas-Campaspe Mine site. Nevertheless, the Project intends to:

- control the water quality of any discharge from the site so as maintain the ecological values of the ephemeral waterbodies located in the vicinity;
- only retain water on site that is necessary for pollution control and operational purposes; and
- provide for conveyance of off-site runoff across the mine path in order to maintain the opportunity for runoff to reach the main depression areas.

5.1.3 Mitigation

The proposed mine water management system includes a range of measures to minimise any potential impacts on the ephemeral waterbodies located immediately adjacent to, or ‘downstream’ of the Atlas-Campaspe Mine site. These include:

- Construction of temporary diversions banks to divert any off-site runoff around the active mine path in order to maintain the opportunity for runoff to reach the relevant ephemeral waterbodies. Once mining is complete, the land levels along the main flow paths would be restored to levels that allow cross drainage to occur.
- Runoff from areas undisturbed by mining would be separated from water generated within active mining areas.
- Surface runoff from disturbed areas would be collected and preferentially re-used for any dust suppression or make-up of the water supply for on-site processing of the mineral sands. Sediment basins would be constructed and operated in accordance with the relevant requirements of *Managing Urban Stormwater: Soils & Construction*.
- Potentially contaminated mine site water, principally associated with sand processing, would be retained within a ‘closed’ mine water management system. There would be no provision for surface water discharge from this system, with the exception of disposal of excess water to water disposal dams within the mine path (i.e. to the deep underlying saline groundwater system) (GEO-ENG, 2013).

5.1.4 Licensing and Approvals

As no water is proposed to be extracted from a regulated water source in the Benanee basin (i.e. Murray River), the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2003* would not apply to the Project.

The Atlas-Campaspe Mine is located within the Lower Murray-Darling Unregulated Water Source as defined in the *Water Sharing Plan for the Lower Murray Darling Unregulated and Alluvial Water Sources, 2011* under the *Water Management Act, 2000*. No water is proposed to be directly extracted from any rivers, lakes, estuaries or wetlands in the Lower Murray-Darling Unregulated Water Source.

No access water licences would be required for the water containments (e.g. evaporation/ sediment sumps, process water storages, off-path sand residue dams and water disposal dams). This conclusion has been made on the basis that runoff water contained within the site would either be within harvestable rights (i.e. all rain water runoff on landholdings) (in consideration of the exempt classes under the harvestable rights order for the Western Division made under Section 54 of the *Water Management Act, 2000* and published on 31 March 2006 in the Government Gazette) and/or would be relevant excluded works under Schedule 1 (clauses 1 to 3) of the *Water Management (General) Regulation, 2011*.

An Environment Protection Licence (EPL) would be obtained to cover the relevant conditions in which discharge might occur from the Atlas-Campaspe Mine site.

5.1.5 Surface Water Monitoring Program

The proposed surface water monitoring program would involve sampling of water from a number of natural and constructed waterbodies in the vicinity of the Atlas-Campaspe Mine site:

- First Mildura Tank (reference water body not affected by the Project);
- an un-named tank located about 500 m south of the Campaspe footprint;
- the natural depression located between the Atlas and Campaspe footprints; and
- Yankie Tank located about 3 km south of the Atlas footprint.

In order to establish existing baseline conditions, monitoring should be undertaken on a monthly basis (while ever there is water at the nominated locations) for a 12 month period. Water samples would be analysed for the parameters listed in **Table 5.1**.

The results of monitoring should be used to develop specific local 'trigger values' that would warrant further investigation if exceeded. These would supersede the proposed provisional trigger values in **Table 5.1**, which would only apply until such time as sufficient data had been collected to justify specific local 'trigger values'.

In view of the highly episodic and rare occurrence of surface runoff in the area, following the initial monthly sampling for 12 months, ongoing sampling should only be undertaken every six months or whenever there had been significant rainfall leading to:

- inflow from natural catchments to the monitoring points; or
- discharge from the sediment basins within the Atlas-Campaspe Mine site.

Table 5.1: Proposed Provisional Water Quality Trigger Values for the Atlas-Campaspe Mine Site

Parameter	Proposed Trigger Value	Protection
pH	6.5 - 8	Ecosystems - Lakes and reservoirs
Turbidity	20 NTU	Ecosystems - Lakes and reservoirs
Total Phosphorus	10 µg/L	Ecosystems - Lakes and reservoirs
Total Nitrogen	350 µg/L	Ecosystems - Lakes and reservoirs
Chlorophyll-a	5 µg/L	Ecosystems - Lakes and reservoirs
Salinity	2,200 µS/cm	Ecosystems - Lakes and reservoirs
Total Dissolved Solids	4,000 mg/L (± 6,400 µS/cm)	Stock water - Sheep and cattle

As there has been no water quality monitoring in any of the permanent or ephemeral waterbodies in the vicinity of the Atlas-Campaspe Mine site, the proposed trigger values listed in **Table 3.8** are provisional pending future monitoring of water quality in waterbodies located in the vicinity of the Atlas-Campaspe Mine site:

- First Mildura Tank (reference water body not affected by the Project);
- an un-named tank located about 500 m south of the Campaspe footprint;
- the natural depression located between the Atlas and Campaspe footprints; and
- Yankie Tank located about 3 km south of the Atlas footprint.

5.2 Roadworks along the Mineral Concentrate Transport Route

5.2.1 Potential Impacts and Mitigation Measures

The unsealed section of the existing public road between the Atlas-Campaspe Mine and the Balranald-Ivanhoe Road would be upgraded as described in **Section 2.1**.

The route traverses an area containing numerous clay pan depressions and dry lakes in which surface drainage is dominated by the local slope towards the nearest depression rather than any significant north-south slope.

The main potential surface water impacts associated with these earthworks would be mobilisation of sediments in the event of heavy rainfall during the construction period. Temporary sedimentation controls (such as silt fencing and sediment/evaporation basins) should be installed as required to address this issue.

5.2.2 Site Discharge

Other than temporary sedimentation controls, no surface water discharge controls are proposed for the roadworks or operation of the mineral concentrate transport route.

5.2.3 Licensing and Approvals

No specific surface water related licensing or approvals are required for the roadworks or operation of the mineral concentrate transport route.

5.2.4 Surface Water Monitoring

No specific surface water monitoring is proposed in relation to the roadworks or operation of the mineral concentrate transport route.

5.3 Ivanhoe Rail Facility

5.3.1 Potential Impacts and Mitigation Measures

The main potential surface water impacts associated with the Ivanhoe Rail Facility relate to:

- mobilisation of sediment during construction; and
- surface runoff containing sediments from the stockpile area during operations.

Both these issues should be addressed by the implementation of standard sediment control measures, including:

- implementation of standard sediment controls along the access road and hardstand areas during construction; and
- early construction of a retention basin, with a 'pre-treatment' sediment sump to capture any sediment washed off the hardstand areas during construction. The retention basin would therefore provide a source of water for dust suppression as well as performing as a sediment basin to contain sediment laden runoff.

5.3.2 Site Discharge

Site discharge is unlikely to occur because of the requirement to retain water for dust suppression purposes. Any discharge that does occur would be via an approved (e.g. licensed by the EPA) discharge location.

5.3.3 Licensing and Approvals

As no water is proposed to be extracted from a regulated water source in the Lachlan River basin (i.e. Willandra Creek upstream of the Willandra Homestead Weir), the *Water Sharing Plan for the Lachlan Regulated River Water Source, 2003* would not apply to the Project.

The Ivanhoe Rail Facility is located within the Unregulated Effluent Creeks Water Source as defined in the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources, 2011* under the *Water Management Act, 2000*.

No access water licences would be required for the capture and use of water from the retention basin at the Ivanhoe Rail Facility. This conclusion has been made on the basis that runoff water retained on site would be within harvestable rights (i.e. all rain water runoff on landholdings) (in consideration of the exempt classes under the harvestable rights order for the Western Division made under Section 54 of the *Water Management Act, 2000* and published on 31 March 2006 in the Government Gazette) and/or would be relevant excluded works under Schedule 1 (clauses 1 to 3) of the *Water Management (General) Regulation, 2011.*

An EPL would be obtained to cover the relevant conditions in which discharge might occur from the Ivanhoe Rail Facility site.

5.4 Conclusions

The semi-arid climate combined with relatively mild slopes provide an environment in which the inherent risk of surface water impacts from any of the aspects of the Project is very low.

The proposed mining activities would include separate water management systems:

- Mine processing water, which would have elevated salinity levels. With the exception of disposal of excess water to water disposal dams within the mine path (i.e. to the deep underlying saline groundwater system) (GEO-ENG, 2013), no discharge would occur from this water management system.
- Surface runoff from the disturbed areas including overburden emplacements, soil stockpiles and the batters of water dams and sand residue dam storages.

Provision should be made for off-site runoff to be diverted and conveyed across the site for discharge to the down-slope side of the disturbance area (e.g. use of up-catchment runoff controls). Temporary and permanent sediment basins should be constructed progressively as required and de-commissioned once they are no longer required. Any discharge from diversions banks/channels or overflow from sediment dams should be discharged via ‘level spreader’ banks in order to ensure flow occurs as shallow overland flow consistent with existing surface runoff conditions.

Standard road construction erosion and sediment control practices as set out in *Managing Urban Stormwater: Soils & Construction – Volume 2C: Unsealed Roads* (DECC, 2008b) should be employed during roadworks along the mineral concentrate transport route between the Atlas-Campaspe Mine site and the Balranald-Ivanhoe Road.

Similarly, standard erosion sediment control practices should be employed during the construction of the Ivanhoe Rail Facility. During operation, the chance of any surface water discharge would be low because of the need to retain water for on-site dust suppression. Because of the size of the proposed water retention basin any discharge that does occur can be expected to have very low concentration of sediment.

For all features of the Project, the risk of surface water impact is inherently low and would be further reduced by the proposed range of mitigation measures.

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ATTACHMENT A

ATLAS-CAMPASPE MINERAL SANDS PROJECT ASSESSMENT OF OVERBURDEN ACID-GENERATING POTENTIAL (CRISTAL MINING AUSTRALIA LIMITED, 2012)

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ATLAS-CAMPASPE MINERAL SANDS PROJECT

ASSSESSMENT OF OVERBURDEN ACID-GENERATING POTENTIAL

OCTOBER 2012
Project No. BMX-11-25

1 INTRODUCTION

This Assessment of Overburden Acid-Generating Potential for the Atlas-Campaspe Mineral Sands Project (the Project) has been prepared with reference to the waste components of the Director-General's Requirements for the Project, which require:

> ***Waste** - including:*
>
> *accurate estimates of the quantity and nature of the potential waste streams of the development and their acid-generating potential; and*

Additional information on the quantities and management of overburden at the Project is provided in Section 2 of the Main Report of the Environmental Impact Statement.

2 TEST PROGRAMME

2.1 SAMPLES ANALYSED

The geochemical analysis was conducted on 29 samples of overburden (eight from the Woorinen Formation; eight from the Shepparton Formation; seven from the Upper Loxton-Parilla Sands unit and six from the Lower Loxton-Parilla Sands unit) from 21 drill holes (Figure 1) distributed across the Atlas and Campaspe deposits.

2.2 ANALYTICAL PROGRAMME

The following tests were conducted on all overburden samples:

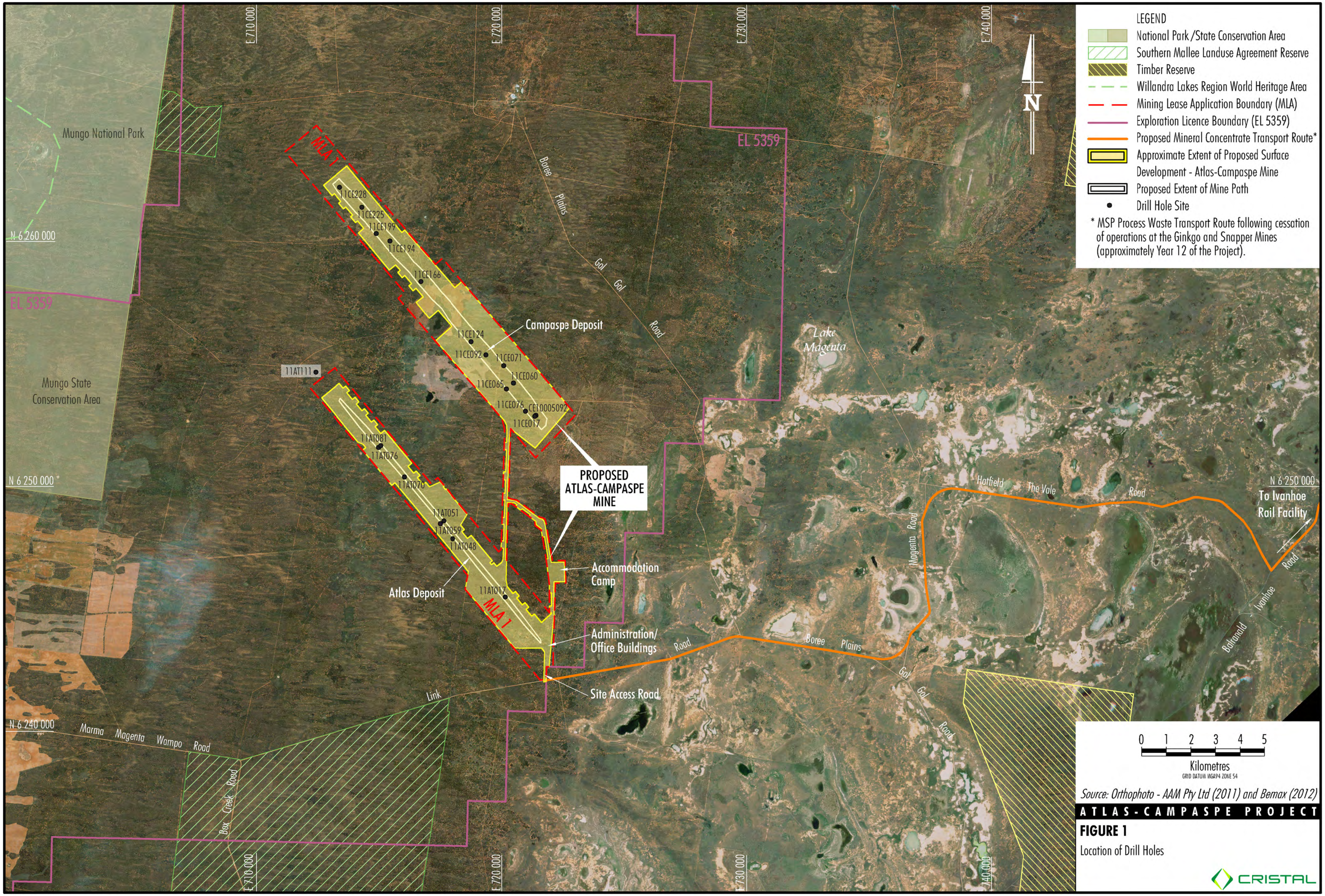
- electrical conductivity (EC) (1:5 aqueous extract);
- pH;
- sulphate; and
- total sulphur.

3 RESULTS AND DISCUSSION

Table 1 provides the results of the analytical programme.

The EC of the overburden samples materials range from non-saline (0.03 deciSiemens/metre [dS/m]) to moderately-saline (2.1 dS/m). The overburden samples are generally alkaline however range from weakly acidic (pH 5.1) to strongly alkaline (pH 9.9).

The total sulphur content of the overburden samples analysed is very low, averaging 0.03 percent (%) and ranging from 0.01 to 0.32%. Of the total sulphur an average of approximately 50% is sulphate sulphur. Therefore the acid-generating potential of these samples is considered to be very low.



BMX-11-25_EIS AppGeochem_101E

Table 1
Analytical Programme Results

Drill Hole[1]	Sample Code	Formation	EC (dS/m)	pH	Sulphate (%)	Total Sulphur (%)
Campaspe Deposit						
11CE166	S347511	Woorinen	1.10	9.1	0.022	0.044
11CE194	S350559	Woorinen	0.56	9.2	0.006	0.016
11CE225	S351463	Woorinen	0.18	9.8	0.002	<0.010
CE10005092	S238022	Woorinen	2.10	8.7	0.060	0.320
11CE166	S347513	Shepparton	0.61	7.1	0.013	0.037
11CE194	S350562	Shepparton	1.30	8.1	0.021	0.032
11CE071	S344010	Shepparton	1.10	8.5	0.028	0.033
11CE060	S343668	Shepparton	0.76	9.9	0.012	0.014
11CE228	S351586	Upper Loxton-Parilla Sands	0.03	8.6	<0.001	<0.010
11CE017	S352847	Upper Loxton-Parilla Sands	0.08	8.6	0.003	<0.010
11CE092	S334804	Upper Loxton-Parilla Sands	0.33	7.3	0.009	<0.012
11CE124	S345996	Upper Loxton-Parilla Sands	0.27	9.6	0.003	<0.010
11CE065	S343824	Lower Loxton-Parilla Sands	0.16	7.0	0.002	<0.010
11CE076	S344289	Lower Loxton-Parilla Sands	0.12	8.7	0.002	<0.010
11CE199	S350747	Lower Loxton-Parilla Sands	0.21	9.2	0.003	<0.010
Atlas Deposit						
11AT111	S349828	Woorinen	0.20	9.9	0.003	<0.010
11AT070	S348896	Woorinen	0.53	9.9	0.008	0.011
11AT017	S347665	Woorinen	0.19	9.9	0.002	0.011
11AT059	S348615	Woorinen	0.18	9.2	0.002	<0.010
11AT076	S349067	Shepparton	1.50	6.9	0.020	0.035
11AT111	S349839	Shepparton	0.39	5.5	0.012	0.013
11AT070	S348901	Shepparton	0.93	6.7	0.024	0.030
11AT017	S347671	Shepparton	0.67	6.7	0.020	0.027
11AT076	S349088	Upper Loxton-Parilla Sands	1.40	7.6	0.015	0.015
11AT017	S347688	Upper Loxton-Parilla Sands	0.20	6.1	0.005	<0.010
11AT059	S348631	Upper Loxton-Parilla Sands	0.50	7.2	0.005	<0.010
11AT081	S349177	Lower Loxton-Parilla Sands	1.30	8.3	0.012	0.012
11AT051	S348484	Lower Loxton-Parilla Sands	0.15	7.1	0.003	<0.010
11AT048	S348390	Lower Loxton-Parilla Sands	0.42	5.1	0.006	<0.010

1 Refer to Figure 1

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