Memorandum

Date: 18 September 2012

To: Iron Ore Holdings

From: Ian Brunner

Subject: Iron Valley Groundwater Assessment

1. INTRODUCTION

Iron Ore Holdings (IOH) proposes to develop an iron ore mine on its Iron Valley tenement in the Eastern Pilbara Region of Western Australia. The Iron Valley Project is located in proximity to and west of Weeli Wolli Creek, to the north of the confluence with Marillana Creek, approximately 90 km north-west of Newman. The Project area is in close proximity to a number of operating iron ore mines including the Rio Tinto Iron Ore (RTIO) Yandicoogina operation and the BHP Billiton Iron Ore (BHPBIO) Yandi operation within the lower catchment areas of Marillana Creek. The iron ore occurs in mineralised successions of the local Brockman Iron Formation.

The purpose of this memorandum was to provide relevant hydrogeological data on the local groundwater environment to support the preparation of an Assessment on Proponent Information (API) document (also known as an Environmental Review) for the Iron Valley Project. The API document incorporated a revision of the Iron Valley Project description to only address mining above the water table. It was intended that the API document be submitted to the Office of the Environmental Protection Authority (OEPA) to inform regulatory approvals.

Groundwater data were compiled from the mineral resource exploration programmes, geotechnical drilling programme and several groundwater exploration investigations. The groundwater exploration investigations were conducted during three general phases of work including the Water Scoping Study, Phase 1 and Phase 2 Pre-Feasibility Groundwater Assessments. These investigations have provided a reasonable database from which to conceptualise the local hydrogeology, interpret the baseline groundwater environment and develop a preliminary groundwater flow model. These aspects were initially applied to develop an understanding of the Project water balance, surplus groundwater disposal options and risk assessment under development scenarios that involved mining below the water table and iron ore beneficiation by washing to separate fines.

This memorandum outlines the interpreted baseline groundwater environment based on a number of site investigations and assesses the potential changes linked to meeting of water supply demands for potable and dust suppression activities by abstraction of groundwater from the Project iron ores of the Brockman Iron Formation.

2. SITE INVESTIGATIONS

Site Investigations associated with the Iron Valley Project had included both desk-top and field-based intrusive works, including:

- Water Scoping Study.
- Phase 1 Pre-Feasibility Groundwater Assessments.
- Phase 2 Pre-Feasibility Groundwater Assessments.

These investigations and associated findings are summarised below.

2.1 WATER SCOPING STUDY

IOH commissioned a Water Scoping Study for the Iron Valley Project in 2010. The main objectives of the Water Scoping Study included:

1. Determine the extent of surplus water that would result from abstraction for the mine dewatering operations.
2. Assess the impacts of the intended mining operations on the water resources.

The scope of the Water Scoping Study included a desktop data review in the IOH data room in February 2010 and development of a preliminary conceptual hydrogeological model for the Project. Key aspects of the conceptual model were as follows:

- Regional groundwater quantity and quality.
- Site water balance.
- Potential issues associated with disposal of surplus groundwater.

Preliminary findings of the water balance were discussed with IOH at a Risk Assessment Workshop in April 2010. Several groundwater and surface water risks were identified, predominantly related to the potential propagation of drawdown, due to pit dewatering abstractions, to beneath Weeli Wolli Creek and surplus groundwater disposal. Results of the Water Scoping Study are presented in detail in the Preliminary Water Balance Assessment Report (URS, 2010). Key risks that were identified are summarised broadly as follows:

- Uncertainties in the water balance related to the rate and volume of pit dewatering abstractions, surplus water disposal options and site water deficit.
- Water quality for potable supply and dust suppression.
- Potential environmental impacts to groundwater dependent ecosystems and environmentally sensitive surface water environments as a result of groundwater abstraction for dewatering and disposal of surplus groundwater.
- Timeframes for regulatory approvals.

2.2 PHASE 1 PRE-FEASIBILITY GROUNDWATER ASSESSMENTS

Following the Water Scoping Study, IOH undertook a Phase 1 Pre-Feasibility Groundwater Assessment (Phase 1) for the Project (URS, 2011a). The pre-feasibility assessments were sub-divided into two key components:

- Preliminary groundwater flow model.
- Disposal options for surplus groundwater.

These aspects are discussed below.

2.2.1 Preliminary Groundwater Flow Model

The first component involved the development of a preliminary groundwater flow model. The model was constructed and calibrated against the data compiled during the Water Scoping Study, with updates based on recent data where appropriate.

The purpose of the Phase 1 model was to simulate the preliminary water balance with an emphasis on the groundwater fluxes and also to predict operational dewatering requirements for the initial mine plan. The groundwater flow model form and parameterisation was based on the available geological and hydrogeological data. A number of the model parameters were assumed and based on a recent groundwater flow model for a nearby Pilbara project located in a similar hydrogeological setting. The Phase 1 model was used to assess groundwater abstraction for mining below the water table and associated drawdown impacts on Weeli Wolli Creek, Marillana Creek and the Fortescue Marsh.

The developed groundwater flow model provided a preliminary understanding of the hydrogeological setting within the Iron Valley Project area. Results of the predictive modelling are presented in the Phase 1 Pre-Feasibility Groundwater Assessment Report (URS, 2011a).

2.2.2 Options for Surplus Groundwater Disposal

This evaluation utilised the results of the Water Balance Assessment and the Preliminary Groundwater Flow Model to evaluate water disposal options for possible surplus groundwater generated by abstraction for pit dewatering at the Iron Valley Project. Disposal options were broadly separated into three categories:

- Onsite - Groundwater disposal at facilities on the mine-site or inside the tenement. Typical disposal options were the final mining voids, evaporation and storage dams.
- Return to the Environment – Aquifer reinjection or release to surface water.
- Supply to Other Users – Provide the surplus groundwater to other users that would remove the surplus water from the IOH property altogether.

Conclusions and recommendations from the disposal options study are presented in the Phase 1 Pre-Feasibility Surplus Groundwater Disposal Options Report (URS, 2011b).

2.3 PHASE 2 PRE-FEASIBILITY GROUNDWATER ASSESSMENTS

Outcomes of the Water Scoping Study and the Phase 1 assessment provided a framework for developing scopes of work for further studies, including site investigations, to commence during the Phase 2 Pre-Feasibility Groundwater Assessment (Phase 2).

Activities that were performed for the Phase 2 assessment generally include as follows:

- Licencing (26D) for groundwater drilling and bore construction.
- Groundwater drilling and bore construction.
- Water level measurement.
- Packer testing and slug testing.
- Groundwater quality field screening.
- Development of technical specifications for additional groundwater quality sampling and aquifer testing.

A groundwater exploration drilling programme was completed from November 2011 to February 2012 to provide data for refinement of the conceptual hydrogeological model and preliminary groundwater flow model. This programme resulted in the drilling and construction of 12 groundwater exploration bores, including:

- Two test production bores (PB01 and PB02) drilled within the Brockman Iron Formation ore-body to depths of 142 and 170 m, respectively, and constructed using 255 mm (id) diameter slotted casing.
- Ten monitoring bores, drilled to depths ranging from 86 to 170 m and constructed using 50 mm (id) diameter slotted casing.

Bore construction information are summarised in Table 1-1.

The test production bores and monitoring bores were developed by air lifting methods. Technical specifications were developed for aquifer testing (step-drawdown and constant-rate) to provide reliable estimates of potential groundwater yields. The aquifer testing in PB01 and PB02 has yet to be completed.

Further to these aspects, an opportunity was identified to perform packer testing and slug testing in conjunction with geotechnical drilling. Subsequently, packer testing and slug testing was performed in two geotechnical bores (GT05 and GT06) to estimate aquifer properties (hydraulic conductivity and transmissivity) for selected stratigraphic zones within the Brockman Iron Formation and hanging-wall successions of the Weeli Wolli Formation. The packer tests were performed at numerous depth intervals in GT05 and GT06. In total, approximately 50 tests were performed in the two bores. The test results inform the conceptual hydrogeological model and the preliminary groundwater flow model.

Table 1-1 Bore construction information

Bore	Type	Easting (m)	Northing (m)	Completion Date	Total Depth (mbgs)	Top of Screen (mbgs)	Bottom of Screen (mbgs)
MBA	Monitoring bore	739780.392	7485810.512	24-Feb-12	86	49	86
MBC-a	Monitoring bore	738371.000	7485400.000	5-Dec-11	162	54	162
MBC[a]	Abandoned	738387.325	7485400.621	1-Dec-11	170	*n/a*	*n/a*
MBD	Monitoring bore	738398.529	7485251.231	29-Nov-11	146	54	144
MBE	Monitoring bore	738045.000	7484794.000	10-Nov-11	136.5	39	136
MBF-a	Monitoring bore	737627.000	7484196.000	9-Dec-11	130	40	124
MBF[a]	Abandoned	737615.714	7484191.235	7-Dec-11	130	*n/a*	*n/a*
MBG	Monitoring bore	737899.977	7484191.235	11-Dec-11	128	44	122
MBH	Monitoring bore	738617.946	7485601.365	24-Feb-12	104	34	104
MBJ	Monitoring bore	736443.981	7481199.218	26-Feb-12	140	10	64
MBK	Monitoring bore	739240.607	7484895.366	9-Feb-12	128	90	128
MBL	Monitoring bore	737326.000	7482593.000	24-Feb-12	113	53	113
PB01	Production bore	738127.483	7485006.600	25-Nov-11	142.5	58	142.5
PB02	Production bore	737704.000	7484194.000	29-Jan-12	170	58.5	154.5

Notes:

[a] Hole collapsed and bore abandoned.

3. HYDROGEOLOGICAL SETTING

The Iron Valley Project is hosted in the Precambrian iron formations of the Hamersley Ranges. The Project area consists of detritals in the lower topographic areas, overlying Banded Iron Formation (BIF), shale, mineralised shale and mineralised BIF of the Brockman Iron Formation. Within the northern Project area a sub-vertical dolerite intrudes the Precambrian succession.

The majority of the iron ore mineralisation is within the eastern limb of a sub-regional anticline fold structure, predominantly within the Joffre Member of the Brockman Iron Formation but with subordinate occurrence within the Dales Gorge Member. Fold axes trend to the northeast. Sympathetic with the fold axes is an interpreted fault structure (Ore0body Fault) that propagates along the length of the iron ore mineralisation.

In the north, the dolerite dyke forms a regional scale intrusive, evident on a east-northeast strike over a length of about 150 km.

3.1 AQUIFER UNITS

Groundwater resources in the Project area are hosted within aquifers comprised of the following types:

- Young erosion products alluvium, colluvium and Tertiary detritals.
- Weathered and fractured bedrock of the Brockman Iron Formation and Weeli Wolli Formation.
- Mineralised zones that comprise the ore-body within the Brockman Iron Formation.
- Geological structures including regional shears and the Ore-body Fault that traverses the proposed pit.

The general hydrogeological setting indicates that the valley-fill successions are one of the important regional aquifers in the area. The main valley-fill succession is comprised of the alluvium and Tertiary detritals beneath the Weeli Wolli Creek. Other valley-fill successions are located beneath within minor drainages on the flanks of the ranges to the west of the tenement. Exploration drilling logs indicate that the thickness of these units varies from 10 to 42 m. Groundwater within these units is likely to be in hydraulic connection with the weathered and fractured bedrock of the Brockman Iron Formation and Weeli Wolli Formation.

The mineralised zones that are usually associated with fracturing in the Brockman Iron Formation also form an important local aquifer. The mineralised zones are likely to have higher hydraulic conductivities, due to fault-related fracturing and brecciation. Perimeter zones typically characterised by comparatively massive and barren shales and BIF within the Brockman Iron Formation and Weeli Wolli Formation are likely to have moderate to low hydraulic conductivity.

The interpreted Ore-Body Fault forms a potential zone of enhanced transmissivity and preferred groundwater flow path.

The dolerite dyke beneath the northern Project area transects the mineralised Brockman Iron Formation; the strike of the dyke may by superimposed on structure defects in the Precambrian bedrocks. The dyke was interpreted to form a low-transmissivity barrier to groundwater flow. It was interpreted that the dolerite dyke was a later (younger) feature than the Ore-Body Fault, thus displacing the southern and northern footprints of the fault.

Aquifer hydraulic parameters that were used in the calibrated preliminary groundwater flow model are summarised in Table 2-1. Preliminary analysis of the packer testing and slug testing results indicates that the aquifer properties are variable throughout the ore-body. Transmissivity was interpreted to be enhanced within the weathered and fractured iron-ore mineralised zones. The high-transmissivity zones have greater potential to yield larger volumes of groundwater from abstraction in pumping bores for dewatering and water supply purposes. Aquifer tests in PB01 and PB02 would enhance the reliability of estimates of the production bore yields and the effective characteristics of the aquifer system formed by the mineralised successions of the Brockman Iron Formation.

Table 2-1 Aquifer Hydraulic Parameters

Aquifer Unit	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)	Specific Yield (dimensionless)	Storage Coefficient (dimensionless)
Alluvium	20	2	0.01	1×10^{-5}
Orebody Fault	20	20	0.05	1×10^{-5}
Country Rock (in Inactive Zone)	2	0.2	0.01	1×10^{-5}
Mineralised Zones (Orebody)	1.6	0.16	0.05	1×10^{-5}
Weathered Brockman Formation	0.15	0.015	0.001	1×10^{-5}
Fresh Weeli Wolli Formation	0.05	0.005	0.001	1×10^{-5}
Weathered Weeli Wolli Formation	0.03	0.003	0.001	1×10^{-5}
Minor Valley Fill	0.03	0.003	0.001	1×10^{-5}
Fresh Brockman Formation	0.001	0.0001	0.001	1×10^{-5}
Dolerite Dyke	1.00E-05	1.00E-05	0.0001	1×10^{-5}

3.2 GROUNDWATER LEVELS AND GROUNDWATER FLOW DIRECTIONS

Several monitoring bores have been established in the catchments of Marillana Creek and lower Weeli Wolli Creek by the Department of Water (DoW). This network extends from Flat Rocks (in the upper reaches of the Marillana Creek Catchment) to the confluence of Weeli Wolli Creek with the Fortescue Marsh. These monitoring bores provide data on the regional baseline water table environment and enable interpretation of the drawdown impacts of nearby pit dewatering abstractions from the Yandicoogina and Yandi mines.

Groundwater levels are typically controlled by topographic elevation with the lowest levels locally occurring in the lower lying areas adjacent to surface water features (Weeli Wolli Creek, Marillana Creek and Fortescue Marsh). Depth to water table settings in July 2010 and September 2012 are shown on Figure 3-1 and Figure 3-2, respectively. Static water levels were measured at depths ranging from 6 to 18 metres below ground level (m bgl, typically in the range 474 to 477 m AHD) in the monitoring bores located south of the dyke and at depths ranging from 30 to 35 m bgl (428 to 430 m AHD) in monitoring bores located north of the dyke. Locally, the interpreted water table elevations reflect west to east groundwater flow, towards Weeli Wolli Creek. The available groundwater level data supports interpretations that the dolerite dyke forms a local barrier to groundwater flow, with compartmentalisation of the southern iron ore aquifer system from that in the north. These data reflect occurrence of steep hydraulic gradients across the dyke. There is also the possible occurrence of preferred groundwater flow paths fractured margins of the dolerite dyke.

3.3 RECHARGE AND DISCHARGE

The Central Pilbara is characterised by its semi-arid climate, consisting of hot summers and mild winters. The summer periods traditionally occur between the months October and April, with the cooler winter conditions occurring between May and September.

Historical records show that the majority of rainfall occurs between the months of December and March (Newman Aero BOM Station No. 007176). Annual rainfall received in the area is on average 310 mm, with January and February experiencing monthly averages of 50 and 80 mm, respectively. High evaporation rates of 3,200 to 3,600 mm/annum combined with the variability in annual cyclonic activity are the driving factors behind maintaining the semi-arid climate of the Central Pilbara.

The main aquifers are recharged by infiltration of rainfall and surface water flows during cyclonic events. Significant rainfall recharge may occur within the fractured ore-body. However, regional rainfall recharge is estimated to be minor and have a limited effect on long-term groundwater levels, as the depth to the groundwater is generally more than 5 m bgl.

Experience with groundwater models in similar areas of the Pilbara indicates that recharge is approximately 0.5 to 1.5 percent of annual rainfall (URS, 2011a). A nominal rate of 1 mm/annum net recharge was used in the preliminary groundwater flow model for the Project.

Regionally, groundwater in the Project area flows to the north and discharges to the Fortescue Marsh located to the north and east of the Project area.

3.4 GROUNDWATER YIELDS

Groundwater in the Project area originates directly from rainfall infiltration and surface water flows. Groundwater occurs throughout the Pilbara but it is most easily located and accessed in close proximity to surface water drainage lines (alluvial channels) and geological structures (fractures and faults).

To the south of the dolerite dyke, test production bore yields of up to 80 L/s were measured during air lifting; air-lift yields in the monitoring bores ranged from 6 to 120 L/s during air lifting. The measured air-lift yields were considered rough order-of-magnitude estimates.

3.5 GROUNDWATER QUALITY

Groundwater quality in the region is considered to be generally potable (Gardiner, 2003), being typically weakly acidic to slightly alkaline and calcium–magnesium–bicarbonate types. Groundwater quality data from monitoring bores in the Marillana Creek Catchment typically indicate fresh groundwater resources with Total Dissolved Solids (TDS) concentrations less than 700 mg/L. The salinity of groundwater is recognised to show seasonal variation dependent on occurrence or not of rainfall recharge events and the overall water balance within the local catchment.

IOH collected three groundwater samples from the Camp Bore at the Iron Valley Project in January 2010 and submitted the samples to ALS Labs for analytical testing. The quality results indicate that groundwater at the site is fresh, with TDS ranging between 485 and 515 mg/L. The groundwater is slightly alkaline with a pH about 8.2. Baseline groundwater quality data were also collected using field screening methods during drilling and bore development for the Phase 1 assessment. Field measurements of TDS ranged from 410 to 600 mg/L and pH ranged from 7.5 to 8.3.

Groundwater quality work undertaken for nearby mining projects indicates that a wedge of saline groundwater (high TDS) may exist to the north of the Project area. The wedge of saline groundwater is interpreted to be associated with salt accumulation in the Fortescue Marsh to the north. The southern extent of the saline wedge is interpreted to be located in the valley-fill and fractured rock aquifers beneath Weeli Wolli Creek to the northeast of the Project area.

4. DUST SUPPRESSION AND POTABLE SUPPLY

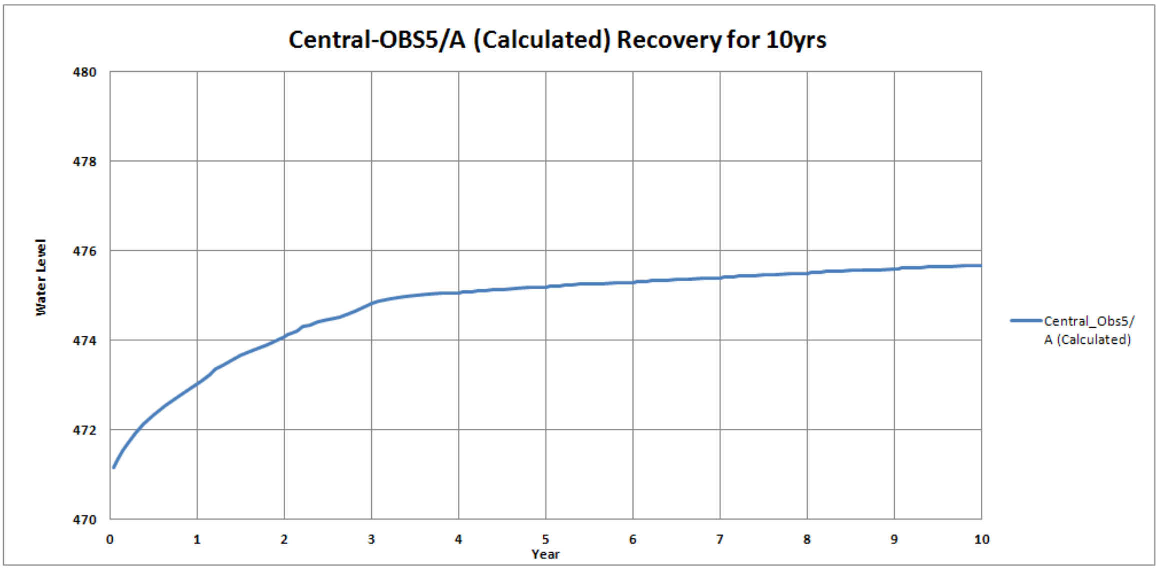
The new mine plan indicates that 5 Mt of ore will be mined annually for up to seven years. No mining is planned below the water table and, therefore, no abstraction for pit dewatering is required. Groundwater is, however, proposed to be abstracted to meet dust suppressions and potable supply demands.

The water demand for dust suppression and potable supply is estimated at 0.36 GL/annum. Source areas to meet these supply demands have been assumed to be the aquifer system associated with the iron ores of the Brockman Iron Formation. It is recognised that a source area for potable supply within an active mining environment is not ideal. This assumption, however, was anticipated to provide a reasonable worst-case scenario for the estimation of drawdown impacts for abstraction of 0.36 GL/annum. Collection of groundwater samples during aquifer tests would provide additional quality data to support beneficial use assessments.

The preliminary groundwater flow model of the Project area was used to simulate abstraction of 0.36 GL/annum for a period of seven years. Simulated abstraction was focussed within the iron ores of the Brockman Iron Formation, with pumping of 1,000 kL/day from a virtual production bore located approximately mid-way between PB01 and PB02, south of the dolerite dyke.

Predictive results from the modelling indicate (Figure 4-1) that the drawdown preferentially propagates along the Ore-Body Fault and throughout the mineralised Brockman Iron Formation to the south of the dolerite dyke (Figure 4-1). Within the iron ores, the predicted drawdown ranges up to about 2 to 8 m south of the dolerite dyke. The compartmentalisation influence of the dolerite dyke was reinforced, with predicted local steepening of hydraulic gradients along the strike length of the dyke and comparatively small-scale (less than 2 m) drawdown impacts propagating to the north. Further to these aspects, the predictions show limited propagation of drawdown to the east (within the Weeli Wolli Formation); there is no predicted drawdown beneath Weeli Wolli Creek. The interpreted low-transmissivity of the Weeli Wolli Formation is a key influence on the predicted drawdown. Subsequently, after cessation of abstraction, comparatively rapid water table recovery over three years to a residual drawdown of up to 4 m. There was ongoing steady recovery at a rate or rise of about 0.5 m over six years. Full recovery to the baseline water table elevation was predicted to occur after about 30 years. The groundwater recovery is shown in Graph 1.

Graph 1. Groundwater Recovery over time



The model findings are intended to be only indicative. Aquifer tests in PB01 and PB02 would enhance the interpretations of the conceptual hydrogeological model and both form and parameterisation of the groundwater flow model. In particular, these data would inform:

- The hydraulics of the iron ores of the Brockman Formation.
- Characteristics of the Ore-Body Fault.
- Structural setting of the dolerite dyke, inclusive of potentials for occurrence of structural beaches in the dyke and perimeter zones of high-transmissivity.
- Transmissivity of the Weeli Wolli Formation and barren successions of the Brockman Iron Formation.

Tables

Figures

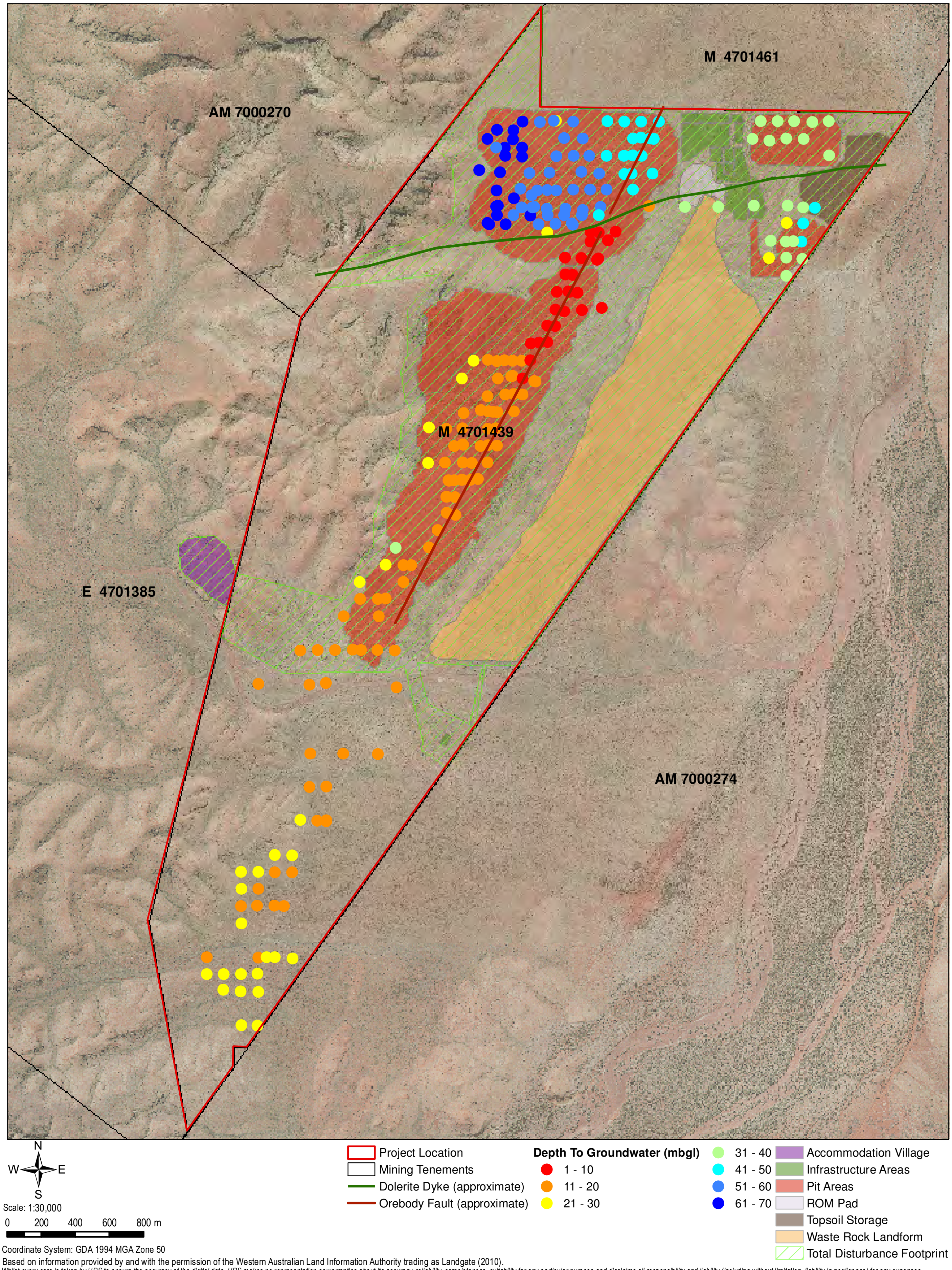
References

Gardiner, S.J., 2003, Impacts of Mining and Mine Closure on Water Quality and the Nature of Shallow Aquifer, Yandi Iron Ore Mine. Published Master Degree Thesis, Curtin University.

URS, 2010, Preliminary Water Balance Report, Iron Valley, Prepared for Iron Ore Holdings Ltd., 26 August 2010, Report No. 42907456/TESG0148/0.

URS, 2011a. Phase 1 Pre-Feasibility Groundwater Assessment (Modelling), Iron Valley Ore Project, Prepared for Iron Ore Holdings Ltd., 10 August 2011, Report No. 42907456/W0532.762/0.

URS, 2011b, Phase 1 Pre-Feasibility Surplus Groundwater Disposal Options Report, Iron Valley Project, Prepared for Iron Ore Holdings Ltd., 11 August 2011, Report No. 42907456/W0535.762/0.



Coordinate System: GDA 1994 MGA Zone 50

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ASSESSMENT ON PROPONENT INFORMATION
IRON VALLEY PROJECT –
ABOVE WATER TABLE MINING.

GROUNDWATER LEVEL DATA JULY 2010

URS

Figure: 3-1

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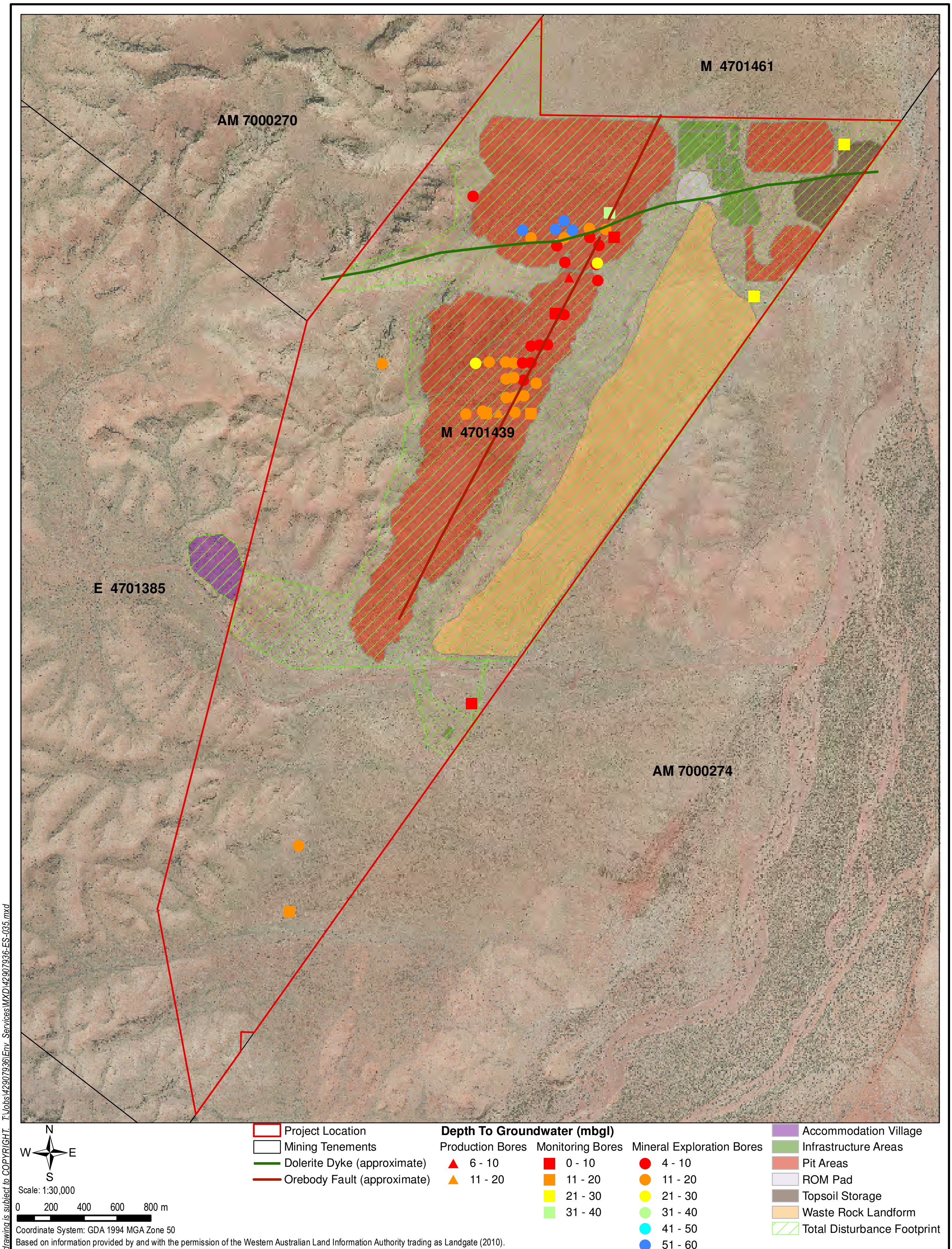

IRON ORE HOLDINGS LIMITED

ASSESSMENT ON PROPONENT INFORMATION
IRON VALLEY PROJECT –
ABOVE WATER TABLE MINING.

GROUNDWATER LEVEL DATA FEBRUARY 2012

URS

Figure: 3-2

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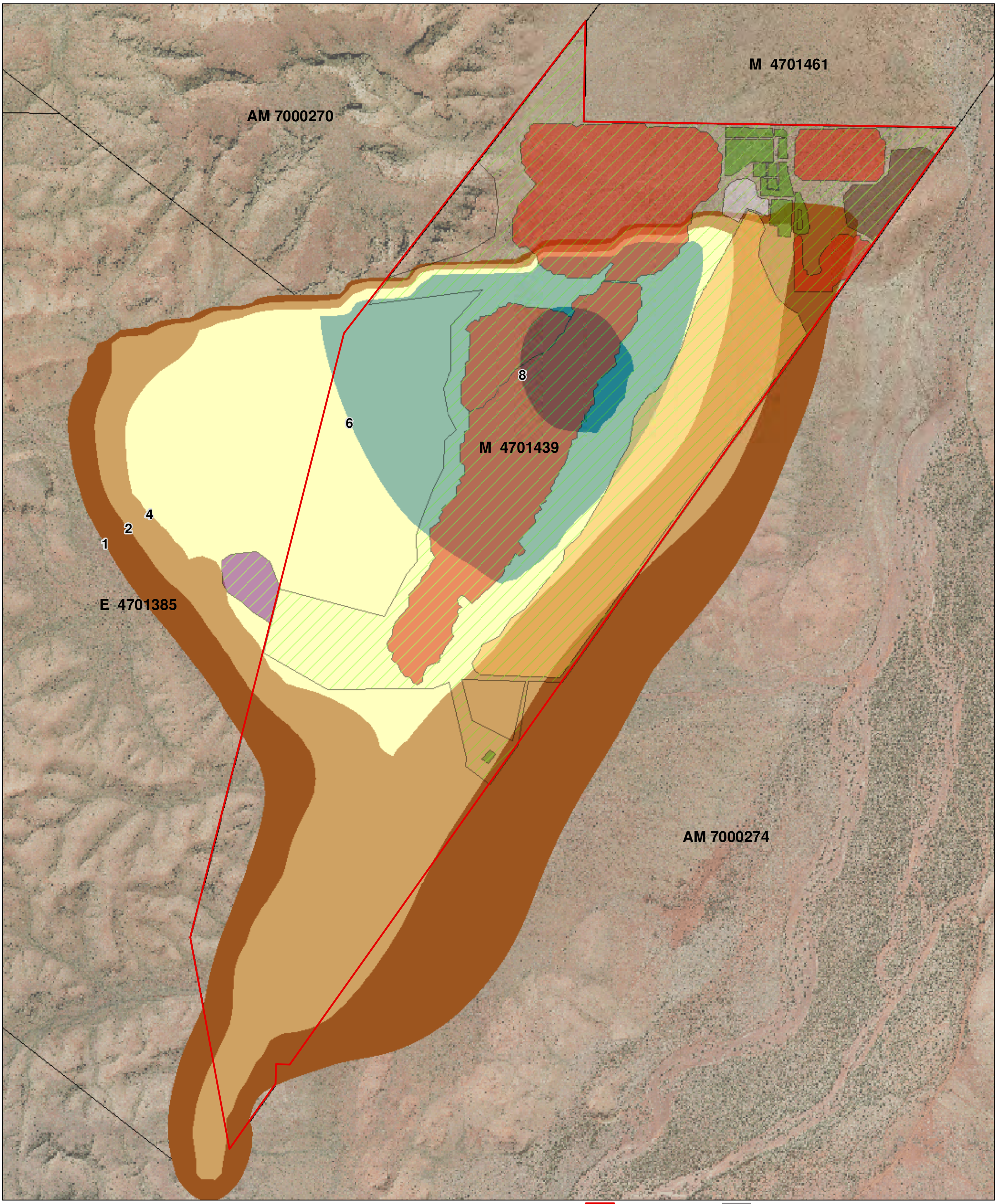

Legend		Drawdown (m)
Project Location	Accommodation Village	1 - 2
Mining Tenements	Infrastructure Areas	2.1 - 4
	Pit Areas	4.1 - 6
	ROM Pad	6.1 - 8
	Topsoil Storage	8
	Waste Rock Landform	
	Total Disturbance Footprint	

N W E S

Scale: 1:31,500 — 0 200 400 600 800 m

Projection: MGA94 Zone 50

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PREDICTED AQUIFER DRAWDOWN

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Figure: 4-1

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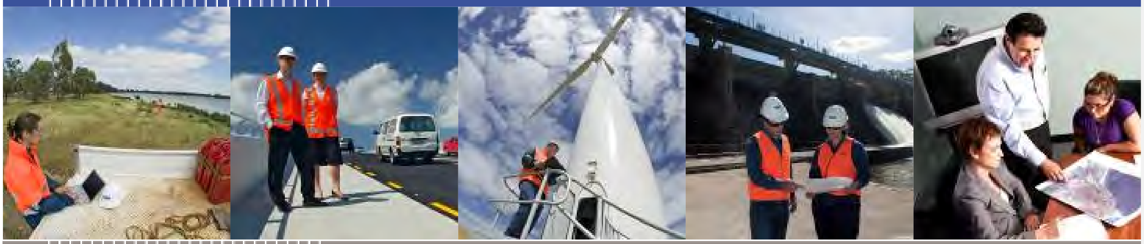

Report

Iron Valley Project

Surface Water Study

13 AUGUST 2012

Prepared for

Iron Ore Holdings Ltd

Level 1, 1 Altona Street
West Perth WA 6005

42907456

URS

Project Manager:

....
Michael Jones
Project Environmental Scientist

Principal-In-Charge:

....
Ian Brunner
Senior Principal

Author:

....
Ainis Vincevicius
Senior Hydrologist

Reviewer:

....
Bas Wijers
Senior Principal

URS Australia Pty Ltd

Level 4, 226 Adelaide Terrace
Perth WA 6000
PO Box 6004, East Perth, 6892
Australia

T: 61 8 9326 0100
F: 61 8 9326 0296

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Abbreviations

Abbreviation	Description
AHD	Australian Height Datum
AR&R	Australian Rainfall and Runoff
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval
BHPBIO	BHP Billiton Iron Ore
BoM	Bureau of Meteorology
CL	Continuing Loss
DoE	Department of Environment and Conservation
DoW	Department of Water
EC	Electrical Conductivity
FMG	Fortescue Metals Group
IL	Initial Loss
IOH	Iron Ore Holdings Ltd
LIDAR	Laser Imaging Detection and Ranging
RTIO	Rio Tinto
TDS	Total Dissolved Salts
TSS	Total Suspended Solids
WA	West Australia

Executive Summary

Overview

Iron Ore Holdings Ltd (IOH) proposes to develop an iron ore mine on its Iron Valley tenement in the Eastern Pilbara Region of Western Australia. The Project Area is located approximately 90km north-west of Newman and 150 km east of Tom Price. The Project is located in proximity to a number of operating iron ore mines including RTIO Yandicoogina operation, BHPBIO Yandi operation and Fortescue Metals Group (FMG) Cloudbreak operation.

URS were commissioned by IOH to undertake a Surface Water Assessment Study, as part of the environmental baseline and impact mitigation studies for the Iron Valley Project under the scope of work and objectives agreed by IOH. This Pre-Feasibility Study Report includes:

- Hydrology study update based on the most up to date data;
- Hydraulic model refinements using higher resolution surface elevation model, improving model resolution and increasing number of inflow points to represent smaller sub-catchments
- Developed case modelling with the bunds and channel diversions option to protect mine infrastructure from surface water flooding (50 and 100 year ARI events).

Potential Surface Water Impacts

An impact assessment was undertaken for this study and suggests that the Iron Valley Project will have a relatively limited impact on the existing baseline hydrological regime of the local Iron Valley Catchment. When placed into context with other existing mining operations within the Weeli Wolli Creek Catchment, such as BHP Billiton Iron Ore's (BHPBIO) Yandi and RTIO's Yandicoogina mine sites, the Project is likely to have negligible bearing on cumulative surface water impacts from Weeli Wolli Creek. However, potential local impacts have been identified from the small sub-catchments and a number of channel diversions have been proposed.

The primary risk to the natural hydrological regime has been identified as a potential increase in sediment load carried by surface waters generated on-site. The following methods are suggested to be implemented to reduce this risk, including:

- Catch drains and sediment ponds constructed around stockpile areas, or areas of ground disturbance;
- Appropriate design of creek crossings; and
- Periodic monitoring of surface water quality.

Identification of Surface Water Risks

The key surface water risks to mining infrastructure at the Project Site have been identified as potential inundation of the pit and creek crossings. The following mitigation measures will be required to be implemented to reduce the risk of inundation.

- Flows generated upstream of the mine area which currently flow through the Project Site, will require diversion around main pit using a cut-off bunds and diversion channels in sub-catchments C14_G and C16_A (see Figure 3-4).
- A flow generated from the sub-catchment C15_A has no sensible diversion option due to topography. It was suggested to build a small dam and let water to pond U/S or let the water flow into the pit and pump it out.

Introduction

1.1 Background

Iron Ore Holdings Ltd (IOH) proposes to develop an iron ore mine on its Iron Valley tenement in the Eastern Pilbara Region of Western Australia, hereafter referred to as the Iron Valley Project (the Project).

The Project Area is located approximately 90km north-west of Newman and 150 km east of Tom Price (Figure 1-1). The Project is located in proximity to a number of operating iron ore mines including RTIO Yandicoogina operation, BHPBIO Yandi operation and Fortescue Metals Group (FMG) Cloudbreak operation.

The Project will comprise the following components:

- Stage 1 Pit, which will be approximately 0.4 km wide, 0.8 km long, and target a surficial ore outcropping;
- Stage 2 Pit, which will be approximately 1 km wide, 2.7 km long, and to a maximum depth of 20 m deep (depending depth of water table);
- Stage 3 Pit (large), which will be approximately 1 km wide, 1.2 km long, and to a maximum of 70 m deep (depending depth to water table);
- Waste Rock Landform, for the storage of approximately 40 million loose cubic metres (LCM) of waste rock. This landform will be approximately 0.7 km wide, 3 km long and to a maximum height of 30 m;
- Accommodation village (situated within exploration licence E 47/01385);
- ROM pad and dry crushing and screening plant;
- Buildings including offices, workshops, explosives magazine and other storage infrastructure;
- Internal haul roads and maintenance access roads servicing the infrastructure and mine;
- Access to the Project will be via an existing road;
- Water supply borefield for potable and non-potable water;
- Electricity supply consisting of a series of on-site diesel generators; and
- Associated infrastructure including potable water treatment, sewage treatment and waste management facilities.

The proposed area to be disturbed is up to 676 ha.

This area does not include the disturbance required by any transport corridors, which are not considered as part of this Project.

IOH proposes to commence construction in Quarter 3, 2014, with operations commencing in Quarter 1, 2014. The life of the Project is expected to be approximately seven years. Decommissioning is expected to occur between years 2021 and 2023, and remaining closure activities, including rehabilitation, would continue for a further 10 years until 2033. The life of the Project is expected to be seven years.

1.2 Scope of the Work

URS were commissioned by IOH to undertake a Surface Water Assessment Study, as part of the environmental baseline and impact mitigation studies for the Iron Valley Project under the scope of work and objectives agreed by IOH. The scope of work includes interpretation of the local hydrology; assessment of potential surface water risks to the Iron valley Project and the likely impacts on the existing surface water flow regime. The key tasks for the Study comprise:

- Literature Review and Desktop Study;
- Baseline Surface Water Hydrology Characterisation;

- Identification of Potential Surface Water Impacts and Risks; and
- Summary of Potential Surface Water Management Options.

1.3 Literature Review

A literature review was undertaken to establish the existing surface water environment and the current level of understanding of regional and local surface water issues. The following documents were reviewed for the purposes of this study:

- BHP Billiton (2006). Marillana Creek (Yandi) Mine: Surface Water and Groundwater Management Plan. Published Report, June 2006.
- Beard, J. S. (1975). Pilbara. *Explanatory Notes and Map Sheet 5, 1:1 000 000 series Vegetation Survey of Western Australia*. University of Western Australia Press, Nedlands.
- BHP Utah Minerals International (1987). *Yandicoogina (Marillana) Project Public Environmental Review*. Published Report.
- CSIRO (2007). *Climate Change in Australia: Technical Report 2007.* Climate Change in Australia.
- Gardiner S.J. (2003). Impacts of Mining and Mine Closure on Water Quality and the Nature of Shallow Aquifer, Yandi Iron Ore Mine. Published Masters Thesis, Curtin University Perth.
- Water and Rivers Commission (2000). *Surface Water Hydrology of the Pilbara Region*. Report Number SWH 32.

Background information obtained from the above sources is presented in Section 3.

Physical Settings

2.1 Climate

The Central Pilbara is characterised by its semi-arid climate, consisting of hot summers and mild winters. The summer periods are between the months October and April, with the cooler winter conditions occupying the months from May to September. During the summer months daily maximum temperatures can fluctuate between 35˚C to 45˚C, with daily average maximum temperatures of 25˚C experienced during the winter periods. Rainfall of the region is infrequent due to the areas influence from tropical cyclones; however, when thunderstorms and cyclones pass through the Central Pilbara, rainfall is usually intense over short durations and can cause flooding.

2.1.1 Rainfall and Evaporation

Historical records show that the majority of rainfall occurs between the months of December and March (Newman Aero BOM Station # 007176). Annual rainfall received in the area is on average 310 mm, with January and February experiencing a monthly average of 50 mm and 80 mm respectively. High evaporation rates of 3,200 to 3,600 millimetres per year (mm/yr) combined with the variability in cyclonic activity annually are the driving factors behind maintaining the semi-arid climate of the Central Pilbara. Average seasonal climate statistics are given in Table 2-1 and Figure 2-1.

Table 2-1 Historical Climate Data from Newman Aero Station 007176 (BOM, 2011)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
Mean maximum temperature (°C)	39.0	37.2	35.8	31.6	26.0	22.4	22.3	24.8	29.2	33.6	36.6	38.3	31.4
Mean minimum temperature (°C)	25.3	24.4	22.4	18.4	13.0	9.6	8.1	10.1	13.7	17.9	21.4	23.9	17.3
Rainfall													
Mean rainfall (mm)	51.4	80.1	38.6	25.3	23.2	25.0	12.6	10.5	4.1	3.9	9.8	27.0	310.2
Decile 5 (median) rainfall (mm)	34.3	57.5	23.9	12.0	12.5	9.8	4.1	2.6	0	0.7	5	16.1	307.8
Mean number of days of rain ≥ 1 mm	4.5	5	3.3	2.6	2.6	2.3	1.7	1.4	0.6	0.8	1.5	3.2	29.5

2.1.2 Climate Change

The Central Pilbara has undergone slight climate change since rainfall and temperature data was first recorded in 1900. Analysis of total rainfall trend maps indicate that the south of WA has been becoming drier and the North Western region of WA has received more rainfall. It is predicted that Australia will also undergo a small temperature increase of up to 1˚C by 2030 and 2-5˚C by 2050, meaning evaporation rates in the Pilbara are likely to exceed their current levels. It is currently under debate as to the affect that global warming will have on the occurrence of cyclones, with many studies leaning towards an increase whilst a number of studies predict decreases in cyclonic activity.

2.2 Topography and Land Systems

The Project Site lies within the physiographic unit known as the Hamersley Plateau. The Hamersley Plateau fronts on to the Fortescue Valley and rises from 550 to 700 m AHD, with hills locally rising to 1,150 m AHD.

The Fortescue Valley occupies a trough between the Chichester and Hamersley Plateaus (Beard, 1975). Drainage in the east occurs internally to the Fortescue Marsh and in the west via a young valley cut through the Chichester Plateau. Gorges have been eroded into the plateau in areas close to the escarpment. The basic topographic units are dominated by sand plains, outwash plains, valley plains and flood-out zones. Most of the extensive valley plains comprise earthy clays together with cracking clays, shallow loams and hard red soils.

The Project site is located toward the mid-eastern area of the Hammersley Ranges, the area is typical of the Central Pilbara with rocky hills, small gorges, ephemeral watercourses and gravely loam valleys. In the Project area the elevation ranges from approximately 500 m AHD to 600.

2.3 Regional Hydrology

The Iron Valley catchment, a small tributary of Weeli Wolli Creek, is located just upstream of the Fortescue Marsh, which is a national designated wetland system and the final receptor of all surface water flows generated in the Upper Fortescue Basin. The Weeli Wolli Creek system drains the Hamersley and Hancock Ranges with the majority of waters flowing northwards to the creek's discharge point at the Fortescue Marsh. The Hamersley Plateau is crossed by the Mouse Creek, Marillana Creek and Yandicoogina Creek, which are all major tributaries of Weeli Wolli Creek. Weeli Wolli Creek has a catchment area of approximately 4,000 km^2 with an approximate main stream length of 112 km from the upper catchment to the outfall at the Fortescue Marsh System. The creek is the second largest contributor to the Fortescue Marsh and it is estimated that, on average, it contributes approximately 11% of total inflows to the marsh. The Marillana Creek is a large tributary of the Weeli Wolli Creek accounting for almost 50% of its catchment area (see Figure 2-2).

Stream flow in the Central Pilbara is typically ephemeral, being directly related to intense rainfall events usually associated with cyclonic activity or localised thunderstorms. Flows decay rapidly once rainfall has ceased. The drainage system upstream of the Fortescue Marsh has negligible baseflow; stream flow infiltrates the watercourses and recharges the alluvial aquifers during flow events.

Natural perennial flows in the Weeli Wolli Creek only occur at Weeli Wolli Spring. Artificial perennial flows occur at various locations within the Marillana and Weeli Wolli Catchments as a result of excess groundwater from mine dewatering operations being disposed of in local watercourses.

The Weeli Wolli Creek is currently gauged by the Department of Water (DoW) at two locations (Waterloo Bore and Tarina), as presented in Figure 2-3. The creek has also been gauged at Weeli Wolli Spring, 4kms upstream of the Tarina station, during 1997 and 2008. Marillana Creek has one DoW gauging station located at Flat Rocks (Table 2-2).

Table 2-2 Flow Gauging Stations Weeli Wolli Creek Catchment

Site No	Site Type	Name	River	Period of Record	Time Step	MGA Zone	Easting	Northing
708001	Flow	Flat Rocks	Marillana Creek	1967 to present	15 minutes and daily	50	702640	7485954
708013	Flow	Waterloo Bore	Weeli Wolli Creek	1984 to present	15 minutes and daily	50	740180	7484344
708014	Flow	Tarina	Weeli Wolli Creek	1985 to present	15 minutes and daily	50	729240	7467654
708016	Flow	Weeli Wolli Spring	Weeli Wolli Creek	1997 to 2008	15 minutes and daily	50	726831	7464086

2.3.1 Regional Water Quality

The Department of Water (DoW) has sampled water at the Tarina Gauging Station. Two grab samples and in-situ sampling has taken place at random periods with multiple samples obtained in some years and sporadic samples taken over several years. Tables 2-3 and 2-4 summarise the surface water quality data collected at the Tarina Gauging Station (DoW, 2008). This data should be treated with caution given small sample record and sporadic nature of sampling events and should only be used as an indication of the water quality conditions of the Weeli Wolli Creek.

Table 2-3 Average Concentrations of Major Cations and Anions, Tarina Gauging Station (DoW, 2008)

Watercourse	Location	Cations				Anions		
		K (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	P (mg/L)	SO_4 (mg/L)
Weeli Wolli Creek	Tarina	5.03	33.9	26.5	18.9	37.3	0.007	13.2

Table 2-4 Average Concentrations of Selected Parameters; Tarina Gauging Station (URS, 2008)

Watercourse	Location	Cond (uS/m)	TDSalts (mg/L)	TDSolids (mg/L)	TSS (mg/L)	Turbidity (NTU)	pH
Weeli Wolli Creek	Tarina	94200	N/A	N/A	2	0.6	7.7

2.4 Local Hydrology

The project area has a local catchment area of approximately 64 km^2 and has a maximum stream length of approximately 8 km. Figure 2-4 shows the location of the proposed minesite infrastructure and the main drainage lines that transect the local catchment area.

There are no gauged flow records or water quality data available for the local catchment.

Baseline Characterisation

3.1 Hydrology

3.1.1 Catchment Characterisation

For the purpose of hydrological modelling, the 3953 km^2 Weeli Wolli Creek catchment was broken into regional sub-catchments, ranging in size from 11 km^2 to 848 km^2 (Figure 3-1) and local mine site sub-catchments, ranging in size from 0.6 km^2 to 12 km^2 (Figure 3-2). Table 3-1 presents the individual sub-catchment sizes.

Table 3-1 Regional and Local Sub-catchment Sizes (km^2)

Sub-catchment	Area (km^2)
Regional Sub-catchments	
C1	810.7
C3	543.3
C4	400.5
C5	425.7
C6	583.0
C7	848.0
C8	64.7
C9	119.9
C10	65.4
C11	10.7
C12	17.5
Local Sub-catchments	
C14_D1	1.7
C14_D2	1.5
C14_E1	0.6
C14_E2	1.3
C13	8.3
C14_A	11.7
C14_B	4.5
C14_C1	1.6
C14_C2	1.5
C14_C3	1.0
C14_E3	1.5
C14_F	5.5
C14_G	1.4
C14_H	7.8
C15_A	1.1
C15_B	4.2
C16_A	2.0
C16_B	6.4
Total:	3,953

3.1.1.1 Catchment Losses

In order to represent rainfall infiltration (or loss) to catchment soils, an initial and continuing loss model was utilised during hydrological modelling. The Initial Loss (IL) is the depth of rainfall (in mm) lost to the soil before runoff commences and the Continuing Loss (CL) is the rate at which rainfall loss to the soil occurs (in mm/hr) after the IL has been reached. The Australian Rainfall and Runoff (AR&R) IL and CL values for the Pilbara region are based on research conducted by the Western Australian Main Roads Department on six gauged catchments within the Pilbara. These estimated values have been used to represent soil losses in the Weeli Wolli hydrological model (see Section 3.1.2).

3.1.1.2 Catchment Roughness (Manning's n)

Manning's *n* values were used to characterise the varying roughness of land systems within the Weeli Wolli catchment. The initial value has been based on photographic evidence, aerial images and Department of Agriculture Land Systems classification map shown in Figure 3-3. Later on the value has been calibrated in hydrological model (XPRafts). The calibrated Manning's n value for hydrological model is 0.038. This value has been applies for all the sub-catchment and 0.03 for all the link units in hydrology model.

3.1.2 Hydrological Model Parameterisation

Rainfall runoff modelling was conducted to determine the watershed characteristics of the Weeli Wolli Creek catchment and the local Iron Valley sub-catchment. Predicted stream flows generated from this modelling were used to assess any potential impact on the proposed infrastructure at Iron Valley using a hydraulic modelling package. This is discussed further in Section 3.2 and Section 4.

The hydrological model was developed to determine the sub-catchment runoff hydrographs for design rainfall events for varying Average Recurrence Intervals (ARIs). The model employs the Laurenson non-linear runoff routing procedure to predict a sub-catchment stormwater runoff hydrograph for an actual event (recorded rainfall time series) or design storm. The standard method of rainfall-runoff characterisation as described in Australian Rainfall and Runoff (AR&R) (Engineers Australia, 1987) was used to characterize the hydrology of the project area. The model uses the Intensity-Frequency-Duration (IFD) data, together with dimensionless storm temporal patterns and other AR&R data to produce design runoff hydrographs. The hydrological model utilises loss models to generate excess rainfall and estimates hydrographs based on rainfall, catchment, channel and flood plain characteristics.

3.1.2.1 Sub Catchment Parameterisation

Sub-catchments within the hydrological model are assigned the following key parameters:

- Area;
- Slope;
- Roughness (Manning's n); and
- Losses.

Sub-catchment areas range from 0.6 km2 to 848 km2. Mean sub-catchment slopes range from 0.3 % to 13 %.

Initial loss (IL) values (Table 3-2) are dependent on ARI and have been taken from AR&R up to a 1:50 year ARI event. The IL value for the 1:100 year ARI has been calibrated using December 1999 event.

Table 3-2 Initial Loss Values for the Pilbara Region

ARI (years)	2	5	10	20	50	100
Mean IL (mm)	22	40	52	47	32	10

For the purpose of hydrological modelling the IL values are assumed to be the same for each sub-catchment in the hydrological model for a given ARI.

The continuing loss value is a constant (5 mm/hr) and does not change with ARI (AR&R, 1987).

Roughness values (Manning's *n*) for the sub-catchments have been determined by calibrating the model with observed flow gauge data at Tarina Gauge. The calibration showed that a Manning's n value of 0.038 gave the best fit calibration.

3.1.2.2 Channel Parameterisation

Channels within the hydrological model are assigned the following key parameters:

- Length;
- Cross-section geometry;
- Slope; and
- Roughness (Manning's *n*).

Main channel lengths range from 1 km to 35 km and mean channel slopes from 0.002 % to 0.02 %.

The Manning's *n* of the channels within the Weeli Wolli Creek catchment was estimated to be 0.03.

Design Rainfall

The CRC-FORGE method was used to derive design storm depths for 1:50 and 1:100 year design storms as recommended in Book IV of AR&R (DoE, 2004). The CRC-FORGE rainfall depths were distributed over the AR&R temporal pattern for various rainfall durations.

A critical storm analysis, the comparison of peak discharges generated from varying storm durations, found that the critical storm was of 24 hrs duration for the entire Weeli Wolli Creek as well as the individual sub-catchments. Total rainfall depths for the critical 1:50 and 1:100 year ARI design storms are 128.4 mm and 165.8 mm, respectively.

3.1.3 Hydrological Model Validation

Weeli Wolli Creek is gauged at Weeli Wolli Spring (Bureau of Meteorology Station No 708016), Tarina (Bureau of Meteorology Station No. 708014) and Waterloo Bore (Bureau of Meteorology Station No. 708013). Daily discharge and rainfall records are available at Tarina since 1985.

The baseline hydrological model incorporated standard Australian Rainfall & Runoff (1987) Intensity-Frequency-Duration (IFD) data to produce design rainfall temporal patterns. Subsequently, loss estimates were used to generate excess rainfall and runoff hydrographs based on rainfall, catchment, channel and flood plain characteristics.

The validation of the baseline hydrological model was based on a 1999 rainfall event recorded as tropical cyclone John, which passed over Weeli Wolli Creek Catchment. The surface water flows generated by this event were recorded at the Tarina gauging station. Validation of the model was undertaken by using the observed 1999 rainfall and adjusting the losses and roughness coefficients to match the recorded peak flow for this event, peaking at 2,100 m^3/s at Tarina station. (DoW, 2011) It is important to note that the peak flow for this event has been estimated using the recorded water level and an extended rating curve and therefore represents a best estimate.

The validated model was used to estimate peak flow discharge rates for a range of rainfall events using design rainfall intensities for the Weeli Wolli Spring Catchment, based on regional parameters identified in Australian Rainfall & Runoff (Engineers Australia, 1987).

3.1.4 Simulated Flow Hydrographs

The results presented in this section are for the critical storm (24 hours duration). The hydrographs from local and regional catchments presented formed the inputs to the hydraulic model discussed in Section 3.2.

3.1.4.1 Regional Catchments

Peak flows and flow hydrographs are presented for the following regional catchments (see Figure 3-1):

- C10 – a tributary of Weeli Wolli Creek joining the system downstream of the confluence of Weeli Wolli and Marillana Creeks (local sub-catchment flow only);
- Weeli Wolli Creek catchment – comprising total flow from sub-catchments C3, C4, C5, C7, C12, C6, C1, C8, C9 and C11.

Simulated peak flows for the regional catchments are presented in Table 3-3 and flow hydrographs are presented in Charts 3-1 and 3-2.

Table 3-3 Simulated Peak Flows - Regional Hydrographs

Sub-catchment	Simulated Peak Flow [m^3/s]	
	50 year event	100 year event
C10	121	212
C11	3,107	5,684

Chart 3-1 Flow Hydrographs – C11

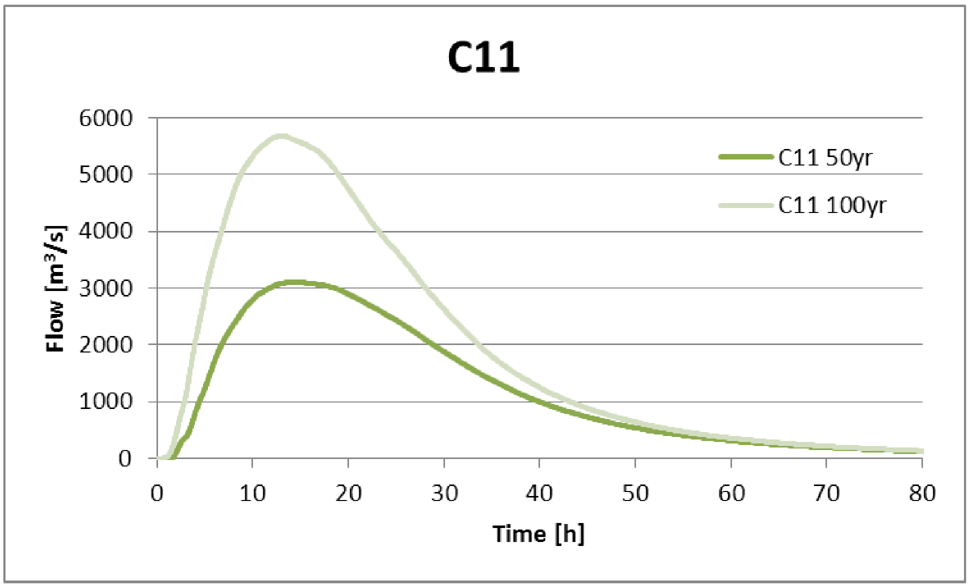
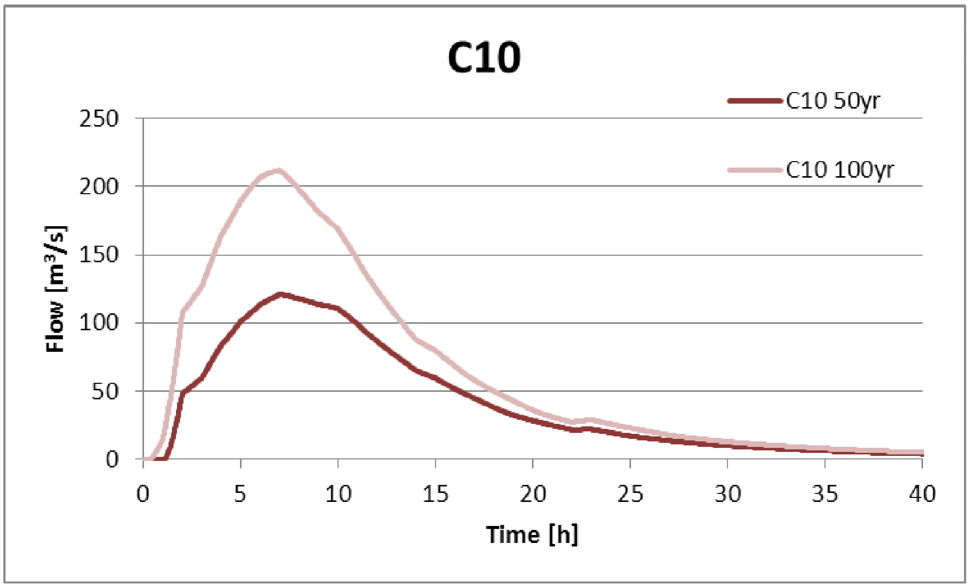


Chart 3-2 Flow Hydrographs – C10



3.1.4.2 Local Mine Site Sub-Catchments

Peak flows and local flow hydrographs are presented for 6 local mine site sub-catchments (sub-catchments used in hydrological model represented in Figure 3-4. Hydraulic model inflow hydrographs combine several local sub-catchments and are presented in Figure 3-2:

- C13 (local flow only);
- C14_H (local flow only);
- C14_G (total flow of all C14 local sub catchments upstream (C14_A to C14_G));
- C15_A (local flow only);
- C16_A (local flow only); and

- C16_B (local flow only).

Simulated peak local and total flows for the mine site sub-catchments are presented in Table 3-4 and flow hydrographs are presented in Charts 3-3 and 3-4.

Table 3-4 Peak Local Flows (m^3/s) – Mine Site Sub-catchments

Sub-catchment	Simulated Peak Flow [m^3/s]	
	50 year ARI event	100 year ARI event
C13	30.4	50.2
C14_G	168.0	306.1
C14_H	24.8	41.6
C15_A	7.6	14.2
C16_A	18.7	29.4
C16_B	27.2	47.6

Chart 3-3 Local Mine Site Sub-catchments – 50 yr ARI Flows

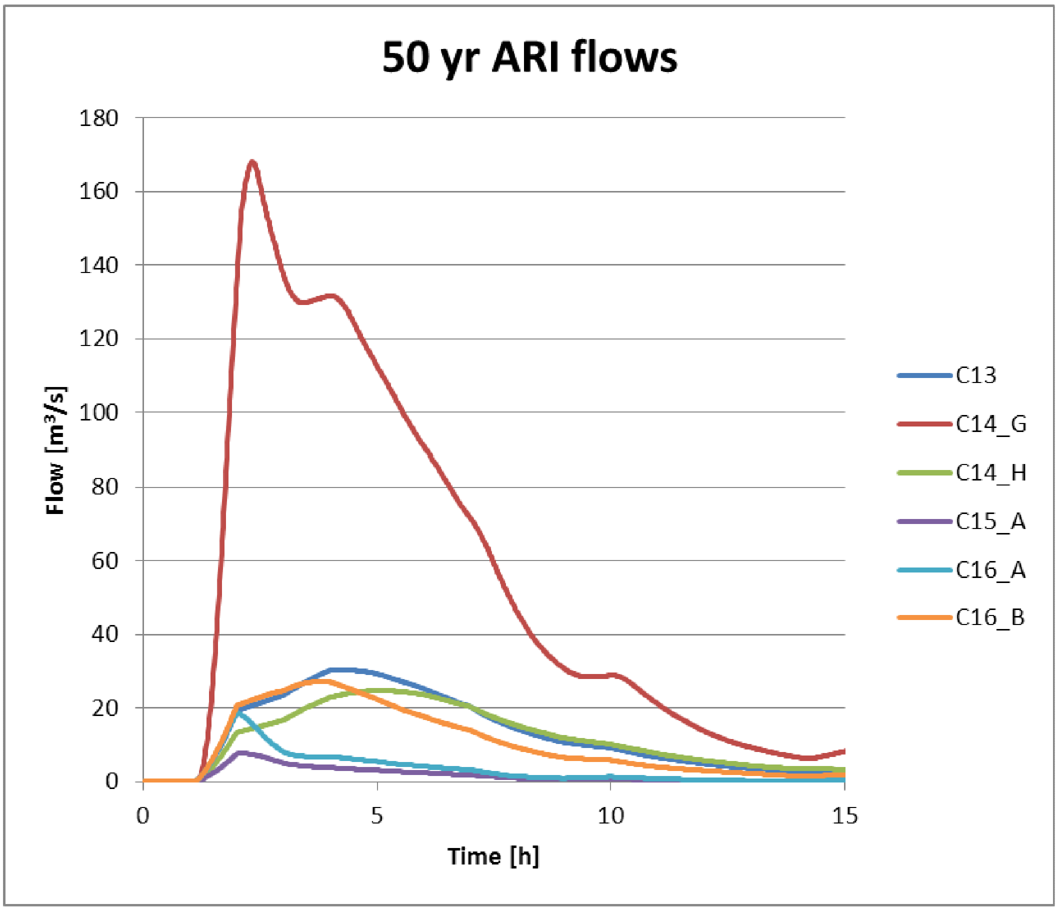
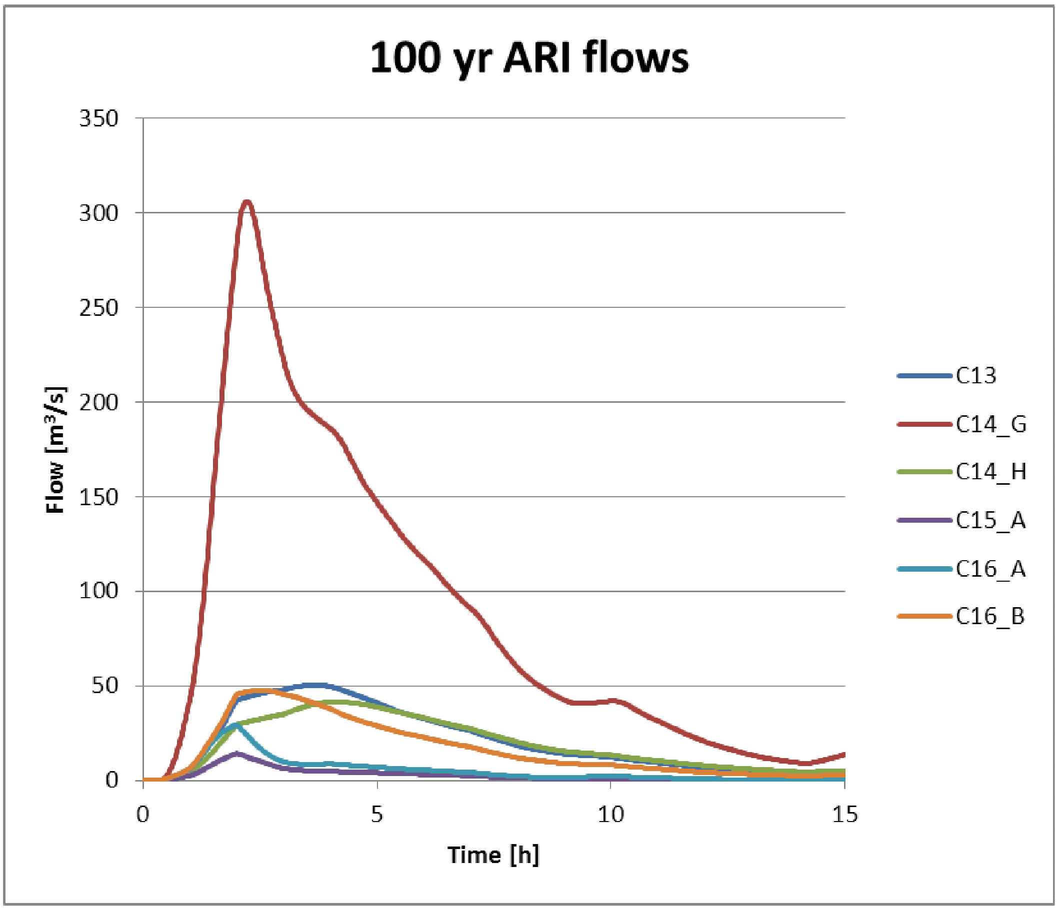


Chart 3-4 Local Mine Site Sub-catchments – 100 yr ARI Flows



3.2 Hydraulic (Flood) Modelling

The baseline hydraulic flood model characterises the surface water flow along the main flow paths of the Weeli Wolli Catchment and local flows in the vicinity of the minesite. The model incorporates the predominant flow paths of the Weeli Wolli Catchment and routes the runoff generated from the defined sub-catchments to simulate the catchment flood characteristics, including:

- Extents of flooding for selected ARI events;
- Depths of flood water for selected ARI events;
- Natural attenuation of flood waters; and
- Flow velocities.

A 2-dimensional hydro dynamic flow model was developed, utilising TUFLOW modelling software (TUFLOW version: 2011-09-AF-iDP-w64), to produce a baseline and developed case flood map for the 1:50 year and 1:100 year ARI critical duration rainfall events.

The TUFLOW modelling platform is widely used for the simulation of surface water levels and flows. The model simulates unsteady two dimensional flows in one vertically homogeneous fluid layer using an Alternating Direction Implicit technique to integrate the conservation of mass and momentum equations, and resolves the equations matrices that results for each direction and each individual grid line. The grid size utilised in the hydraulic modelling was 10 m x 10 m (based on 20 m LiDAR topography).

3.2.1 Hydraulic Model Parameterisation

3.2.1.1 Hydraulic Roughness

Surface roughness values represent the likely resistance to surface water flows in the model domain. The hydraulic roughness values used are the Manning's *n* values. A composite Manning's *n* value of 0.04 was selected to represent roughness in the channels and floodplains of the Weeli Wolli catchment.

3.2.1.2 Hydrographs / Model Inflows

The catchment hydrographs generated by the hydrological model have been applied to the model domain for the 1:50 year and 1:100 year ARI flood events with applied scaling factor to represent the Sub-catchment affecting the site or split the flow into two separate model inflows (each representing part of the catchment). Model Inflows with scaling factors and model schematic represented in Figure 3-4. The following model inflow points have been used:

- Marillana and Weeli Wolli Creek total inflow hydrograph applied as a QT (flow vs time) boundary indicated as C11 in Figure 3-4;
- Sub-catchment on the east of Weeli Wolli Creek – C10;
- C13 – local sub-catchment;
- C14_H Sub-catchment local flow was split into two inflow points as 10 and 90% of the flow based on catchment area. NOTE: Chart 3-3 and 3-4 represents unscaled flows;
- C14_G Sub-catchment total flow has been split into two equally scaled inflow points. NOTE: Chart 3-3 and 3-4 represents unscaled flows;
- C15_A Sub-catchment has 80% of the local flow, as part of the catchment falls within the pit area;
- C16_A Sub-catchment local flow has been split into two equally scaled inflow points; and
- C16_B Sub-catchment local flow scaled to 50% to represent only a half of it, this inflow point doesn't do much influence to the extents anyway as it is outside the area of interest.

3.2.1.3 Downstream Boundaries

The hydraulic model has two downstream boundaries where the water flows out of the system. These boundaries are so called "free flow" boundaries where discharge is calculated based on the average slope and water level. The boundaries are located some 5 km downstream of the project site and therefore do not affect water levels at the areas of interest.

3.2.2 Baseline Flood Simulations

The simulated baseline flood extents and maximum water depths for 1:50 and 1:100 year ARI flood events are shown on Figures 3-5 and 3-6 respectively. Baseline scenario simulations indicate the existing flow paths and the flood levels under present day conditions. It is important to note that the 20 m resolution topography (LiDAR) does not allow for the representation of small drains and the definition of flow channels in the shallow areas. The grey colour areas indicate water depths less than 0.05 m (sheet flow). The area indicated may change if higher resolution topography with well-defined channels would be used.

3.3 Baseline Surface Water Quality

Available surface water quality data for the Tarina Gauging Station is presented in Tables 2-3 and 2-4. The data should be treated as indicative given the small sample record and sporadic nature of sampling events and should not be used to represent the baseline water quality conditions of the Weeli Wolli Creek.

Potential Surface Water Impact and Risk Assessment

During the three phases of the life of mine (construction, operation and closure) there is potential for the existing surface water regime to be impacted.

Development of the Project will require clearing of vegetation to accommodate the pit, mine infrastructure, stockpiles, processing plant, site access roads and the accommodation village, resulting in potential impacts on the surface water flow regime and surface water quality within the Project Site.

4.1 Potential Risks

The main potential surface water risks to the development of the Project have been identified as mine access road and camp road inundation at creek crossings.

4.1.1 Pit Inundation

The main pit is at risk from inundation by surface flows in the main creek lines in sub-catchments C15_A and C16_A (Figure 4-1), unless adequate diversions are provided.

Direct rainfall into the pit may also pose a risk to operations and personnel during high intensity rainfall events, and some operational downtime is likely to occur as a result of potential localised in pit flooding. This should be taken into account for mine operations, and will most likely occur during the summer months (December-March).

4.1.1.1 Creek Crossings

The areas where the proposed roads within the Project Site are likely to intersect drainage lines are identified in Figure 4-1. It should be noted that final design for site roads has not been finalised, and these are representative locations. Inundation of these crossings during peak flow events may pose a risk to operations by reducing access to the Project Site, damaging roads and pose potential risk to minesite personnel using the roads during the Project's operational life. Restricted access and operational downtime as a result of flooding of creek crossings should be factored into the mine operations. Alternatively increased capital costs provisions should be allowed for suitable structures at these crossing locations.

The location of the explosives storage facility, across the creek line from the pit, presents some operational risk. Access to the facility may be restricted during and after significant storm events, with the requirement of the construction of a creek crossing at this location.

4.1.2 Risk to Existing Downstream Operations

The Project is expected to have no significant impact on existing downstream mining operations, primarily due to the likely insignificant impact on the existing hydrological regime.

4.2 Impacts on Baseline Surface Water Flow Regime

4.2.1 Potential Local Impacts

4.2.1.1 Reduction in Surface Runoff

The combined area of the proposed mine and associated infrastructure is likely to be small compared with the area of the Iron Valley catchment. It is anticipated that the disturbed area of the project will cover less than 0.5% of the Weeli Wolli Creek Catchment (10.5 % of the Iron Valley Catchment) and therefore the potential reduction in surface water runoff generated by the Iron Valley will be small.

4.2.2 Potential Regional Impacts

The potential impact of the Project on the natural flow characteristics of Weeli Wolli Creek are likely to be insignificant and will not contribute greatly to existing cumulative impacts, particularly when placed in context with larger, existing mining operations, such as RTIO's Yandicoogina and BHPBIO's Yandi operations. These operations occupy much larger areas of the Weeli Wolli catchment, altering the natural runoff regime through changes in surface permeability, interception of rainfall and runoff and disposal of excess groundwater, generated from mine dewatering operations, to creeks in the Weeli Wolli catchment.

4.3 Impacts on Surface Water Quality

Clearing activities during the construction phase of the Project will result in a possible increase in runoff containing sediment, from the disturbed areas, thereby increasing the sediment load in surface waters. The turbidity levels and sediment load in the Pilbara watercourses are noted as being low for average flow events and extremely high during flood events (Water and Rivers Commission, 2000).

Potential peak 1:100 year ARI flow from the Iron Valley catchment area is 306 m^3/s. This compares to a peak flow of approximately 5,684 m^3/s generated by the entire Weeli Wolli Catchment for the same ARI event. This would suggest that Total Suspended Solids and sediment loads generated from the disturbed area of the Project Site would be negligible compared to those generated from the whole of the Weeli Wolli Catchment during a high intensity rainfall event.

The potential for sediment to be transported into drainage lines from stockpiles, waste rock dumps and other infrastructure will require appropriate management controls during mine operations.

Management Measures

To mitigate the surface water impacts and risks identified in the above section of this report, water management measures have been identified to mitigate the risk of flooding, manage stormwater and potential surface water quality impacts.

5.1 Flood Risk Mitigation

5.1.1 Stream Flow Diversions

Flows generated upstream of the mine area which currently flow through the Project Site, will require diversion around mine infrastructure using a cut-off bunds and diversion channels. The Diversion options are described further below in more details (Section 5.3). Figure 5-1 shows the locations of required diversion points. Figures 5-2 and 5-3 represent flood extents and depths for the developed case for the 50 year and 100 year ARI events respectively.

To mitigate the risk of surface water flowing into the pit a perimeter bund and local drainage diversion channels may be applied to prevent surface water ingress into the pits. The areas requiring flood risk mitigation are shown in Figure 5-1 and indicated as areas A to F. The mitigation measures for each of these areas are described below.

Mitigation measures, such as sediment traps, will be applied to reduce any potential transportation of sediment off-site during all phases of the Project.

5.1.1.1 Area A (Figure 5-1) – Explosives Storage Facility

This area would require a flood protection bund surrounding the Explosives Storage facility, or elevating the storage building itself to prevent it from flooding. Hydraulic simulations for the 100 yr ARI event show that the flood protection would require a 900 m long, 0.4 m high bund (without freeboard). However, this option would make access more difficult. Elevating storage building by a minimum of 0.4 m above the ground would be a more viable alternative (the flood water elevation for a 100 year ARI event at this location is 487.8 m AHD).

5.1.1.2 Area B – Southern Pit Edge and Waste Rock Dump

To protect the southern edge of the pit and erosion of the proposed waste rock dump, this area would require a 2.0 km long bund of up to 1.6 m high (without freeboard). Approximately half of this bund could be formed as part of access roads. The bund would prevent surface water runoff to flow into the main pit and waste dump sites.

5.1.1.3 Area C - Camp Site

This area would require a small bund on the lowest portion along the camp site. The required bund would be about 100 m long and about 0.5 m high (without freeboard). The stormwater generated from the catchment upstream of the proposed Camp site would require to be diverted around the Camp site and drain into the creek upstream of the proposed flood bund.

5.1.1.4 Area D- Western Pit Edge

The mitigation of flood risk in this area may be achieved through several different options:

1. The modelled scenario includes a bund along the pit edge by forming a dam where water could be stored during a flood event and pumped out. This option would require about 120 m length bund and more than 9 m in height (at the deepest part) to store the 100 year ARI 24 hr duration flood.

The water could be pumped out by placing a long pipe on the surface to either side along the pit. The pipe could work as a syphon as the lower end of the pipe would be placed lower than the dam bottom. This option could cause safety as well as environmental issues and needs to be investigated in more detail.

2. The construction of a diversion channel in either northerly or south-westerly direction to drain the water into adjoining stream lines. Both diversion option alignments are across some hills. It is estimates that the channels require a cutting of more than 30 m deep.
3. The more favourable option would be to let the water flow into the pit in a controlled manner, collect it in a sump and pump it out. The expected volume of water from this small sub-catchment is 124,000 m^3 for 100 year ARI 24 hr storm (11.3 m^3/s peak flow) and 80,000 m^3 for 50 year ARI events. The sub-catchment upstream has a surface area about half size of the pit surface. It would be also beneficial to form a small V-shape ridges along the drains so water would pond in the small pools and evaporate after the storm. These ridges would reduce the amount of water flowing into the pit.

5.1.1.5 Area E - -North-western Pit Edge

The mitigation of flood risk in this location requires the diversion of two watercourses and a flood protection bund along the pit (estimated to be required to be 3.6km long and a minimum of 0.3 m high). The flood bund would extend along the northern mining lease boundary to protect the pit, infrastructure and topsoil storage areas (Figure 5-1). The diversion channel would be about 1.2 km long and about 3-5 m in cut.

Northern diversion would require V shape bunds (160m length and 0.4m high) to funnel water into the new diversion.

5.1.1.6 Area F – Eastern Sub-Pit

The mitigation of flood risk of Weeli Wolli Creek flood waters into the Eastern Sub-pit would require a flood bund of about 200 m long and 1.3 m high (without freeboard).

5.2 Stormwater Management System

A stormwater management system will be required to manage runoff generated from hardstand areas and stockpiles within the minesite. The stockpiles are likely to shed runoff to surrounding with a higher-sediment load than runoff generated in undisturbed areas. Therefore, catch drains will be required to be constructed around the perimeters of the stockpile areas (and other hardstand areas) to collect surface runoff and reduce the sediment load via sediment pond(s) before it is discharged back into the natural drainage system.

A separate drainage system will be required to manage runoff generated from the upstream of the minesite. This ‘clean’ runoff will be diverted around the minesite and discharged back in to the natural drainage system via the diversions used to manage flows from sub-catchments C15 and C16.

Direct rainfall into the pit will be required to be managed using sump-and-pump facilities. This would consist of a sump to collect surface water and a pump and delivery pipeline to lift this water to a higher elevation, for disposal into a sediment pond before reuse on site.

5.3 Stormwater Management System

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Direct rainfall into the pit will be required to be managed using sump-and-pump facilities. This would consist of a sump to collect surface water and a pump and delivery pipeline to lift this water to a higher elevation, for disposal into a sediment pond before reuse on site.

5.4 Surface Water Quality

5.4.1 Transport of Sediment Off-Site

The risk of an increase in the transportation of sediment off site as a result of mining activities during both the construction and operations phases can be mitigated by implementing the following suggested measures:

- The installation of catch drains and sediment traps to collect runoff from stockpiles and other hardstand areas;
- Schedule the majority of construction work to take place during the dry season to limit the transportation of runoff containing sediments;
- Creek crossings to be designed so that flow velocities are not significantly altered as to increase scour of creek channels and banks; and
- Potential sources of pollution such as hydrocarbons and solvents to be stored in appropriate facilities so that the risk of any pollutant incidents spills is greatly reduced. Appropriate pollution spill procedures are required to be in place to limit potential impacts from pollutant spills.

5.4.2 Monitoring

A surface water monitoring program will help identify any increases in sediment load from runoff generated from the Project Site and highlight any changes to management practices that would improve the quality of runoff generated on-site. This will require a baseline surface water condition to be measured prior to the commencement of any ground-disturbing activities at the Project Site.

Periodic monitoring will then be required to be carried out at specific intervals throughout the period of mining and subsequently after mine closure as required by regulatory requirements. Monitoring will be required to be undertaken upstream of the Project Site and at the outlet of the Iron Valley Sub-catchments C14, C15 and C16. In order to measure sediment being transported off-site, Total Dissolved Salts (TDS) and Electrical Conductivity (EC) would be monitored.

Conclusions

6.1 Summary

This study constitutes the Pre-feasibility Surface Water Study for the Iron Valley Project; any finding in the report are preliminary and should be backed up with further work to be carried out in next stage.

Initial studies indicate that the Project will have a limited impact on the existing baseline hydrological regime of the local catchment, primarily due to the size, location and the relatively short lifespan of the Project. However, some surface water impacts have been identified and appropriate management techniques have been proposed to reduce these impacts and risks.

6.1.1 Existing Hydrological Regime

The primary risk to the natural hydrological regime is likely to be an increase in sediment load carried by surface waters generated on-site. This risk can be mitigated through:

- Construction being undertaken during the dry season;
- Catch ponds and sediment traps/ponds around stockpiles and other disturbed areas;
- Appropriate design of creek crossing; and
- Establishment of baseline surface water quality via a baseline monitoring program and subsequent monitoring of surface water quality during all phases of the Project.

6.1.2 Proposed Options

The primary risks to mining infrastructure from flooding have been identified and following mitigation options have been proposed:

- The Explosive Storage (Area A) would require a bund around the facility, or the elevation of the building itself above the simulated flood water level, which for a 100 yr ARI event is simulated to be around 0.4 m above existing ground level.
- The southern pit edge and waste rock dump (Area B) would require a flood protection bund. A portion of this bund could be formed along the proposed Camp access road.
- The Camp site (Area C) require a flood and scour protection bund and surface water runoff diversion channels around the bund.
- At the western pit edge (Area D) alternative flood mitigation measures are considered. The modelled option includes a flood protection bund upstream of the pit edge, which in the event of stream flow would form an upstream pond. As prolonged ponding upstream of the pit is not preferred, this water would have to be drained, either by means of controlled discharge into the pit or pumped into an adjacent local creek line draining around the proposed mine infrastructure.. The upstream sub-catchment area generates an estimated 11.3 m^3/s peak flow during 100 year ARI storm event. The construction of flood flow retardation bunds across the creek channels upstream could reduce the peak flow during a flood event.
- The north-western corner of the proposed pit area (Area E) would require a bund and channel diversion option to protect surface water flowing into the pit and protect the proposed infrastructure site from flooding.
- The eastern sub-pit (Area F) would require a flood protection bund to mitigate the flood risk from Weeli Wolli Creek.

6.2 Recommendations for Further Study

This report is a pre-feasibility level study of surface water issues related to the proposed development. It is recommended that further more detailed planning studies are undertaken in the following areas:

- An update of the mine infrastructure layout incorporating designed levels (road levels and any other changed surfaces);
- To prepare a detail design of the flood mitigation and stormwater management options; and
- Development of a mine site Closure Plan as part of the Mining Proposal. Closure plan (mine infrastructure changes) would require additional model set up to represent the changes of the surface. Comments on closure planning with respect to surface water flows and quality would be required.

References

- Beard, J. S. (1975). Pilbara. Explanatory Notes and Map Sheet 5, 1:1 000 000 series Vegetation Survey of Western Australia. University of Western Australia Press, Nedlands.

- BHP Billiton (2006). Marillana Creek (Yandi) Mine: Surface Water and Groundwater Management Plan. Published Report, June 2006.

- BHP Utah Minerals International (1987). Yandicoogina (Marillana) Project Public Environmental Review. Published Report.

- Bureau of Meteorology (2011). Climate Statistics for Western Australia. Data prepared by the Commonwealth Government of Australia. http://www.bom.gov.au/climate/. Accessed 5 May 2011.

- CSIRO (2007). Climate Change in Australia: Technical Report 2007. Climate Change in Australia.

- Department of Environment (2004). Estimation of Rare Design Rainfalls for Western Australia, Application of the CRC-FORGE Method. Surface Water Hydrology Report Series, Report No. HY17. December 2004.

- Engineers Australia (1987). Australian Rainfall & Runoff

- Institution of Engineers Australia, The (1987). Australian Rainfall and Runoff. Volume 1, A guide to Flood Estimation. National Committee on Water Engineering.

- Iron Valley ProjectPhase 2 Surface Water Study (2011). URS

- Gardiner S.J. (2003). Impacts of Mining and Mine Closure on Water Quality and the Nature of Shallow Aquifer, Yandi Iron Ore Mine. Published Master’s Thesis, Curtin University Perth.
- Water and Rivers Commission (2000). Surface Water Hydrology of the Pilbara Region. Report Number SWH 32.

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Iron Ore Holdings Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal # 3090420 dated 8th Feb 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between July 2012 and August 2012 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners

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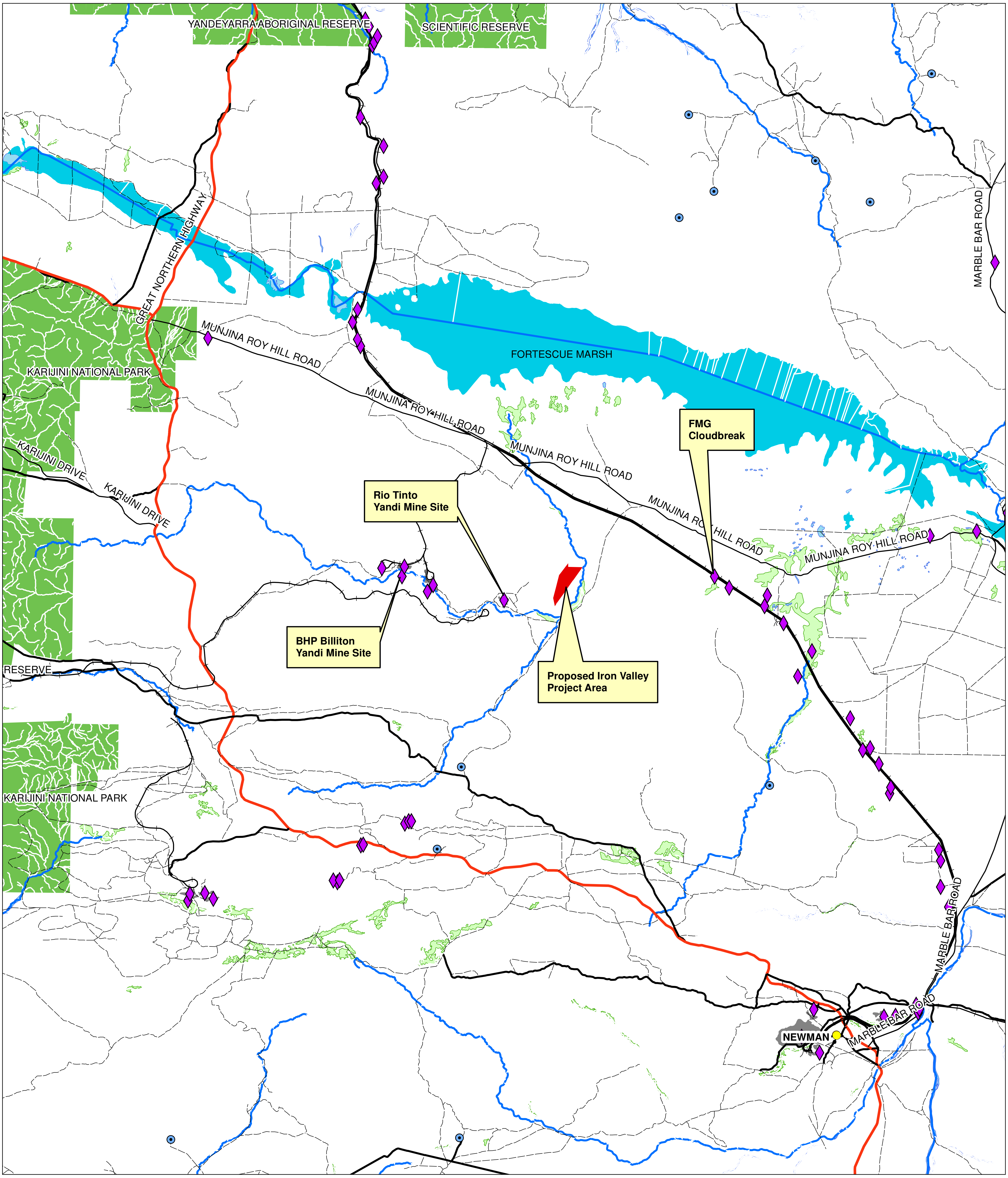
Appendix A Figures

URS



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Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

LEGEND

- Iron Valley Mining Tenament
- Towns
- Springs
- Mine Locations
- Railways
- Flats
- Lakes
- Mine Areas

Native Vegetation Areas

FEATURETYPE

- Forest Or Shrub
- Mangrove
- Rainforest

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IRON VALLEY PROJECT
SURFACE WATER STUDY

LOCALITY MAP

URS

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Figure: 1 - 1

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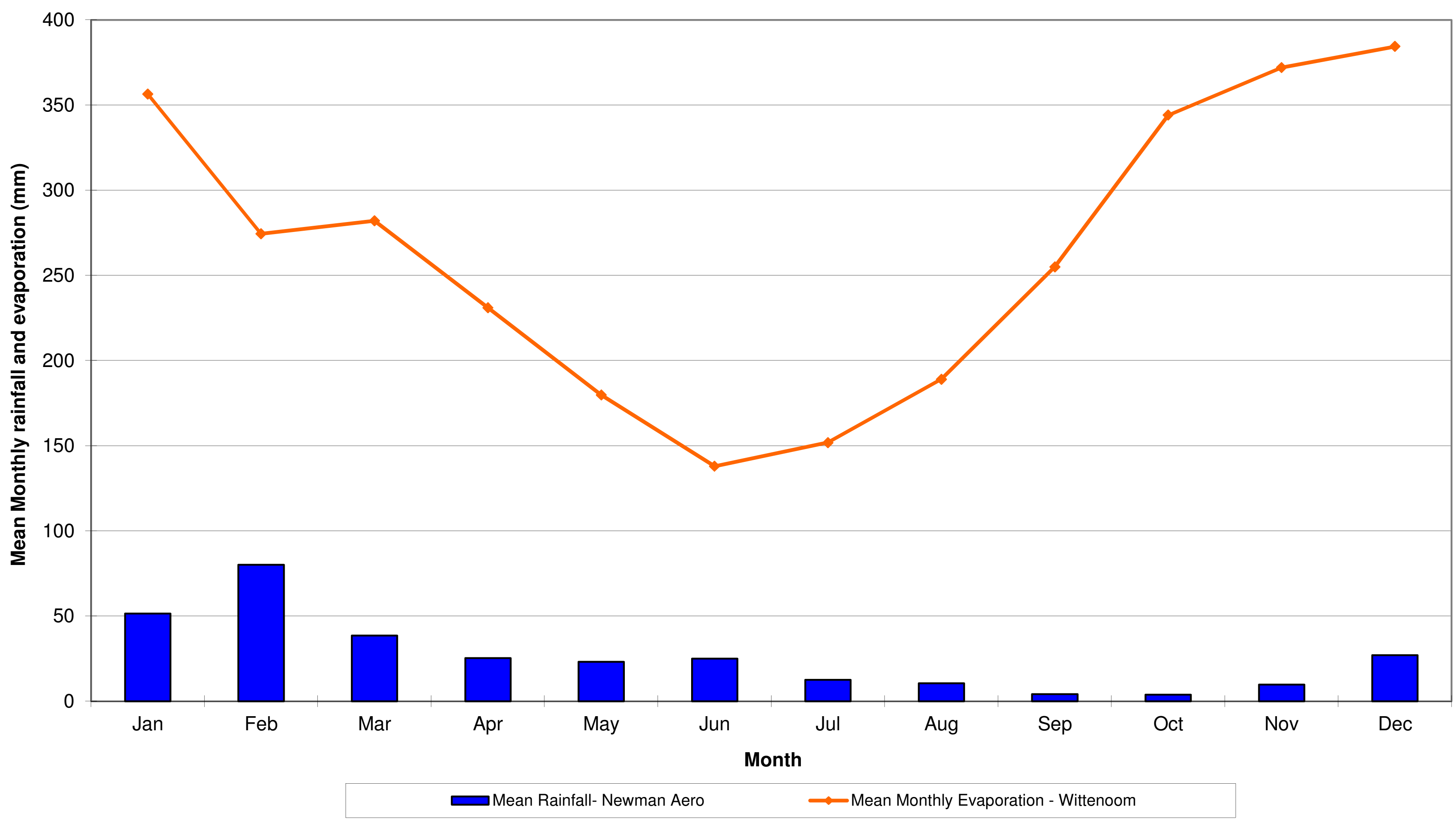

Iron Ore Holdings Ltd	Iron Valley Project Surface Water Study			Mean Monthly Rainfall and Mean Monthly Evaporation	
URS	Drawn: AV	Approved: MJ	Date 10/08/2012	Figure 2-1	Rev.A
	Job No: 42907937				A4

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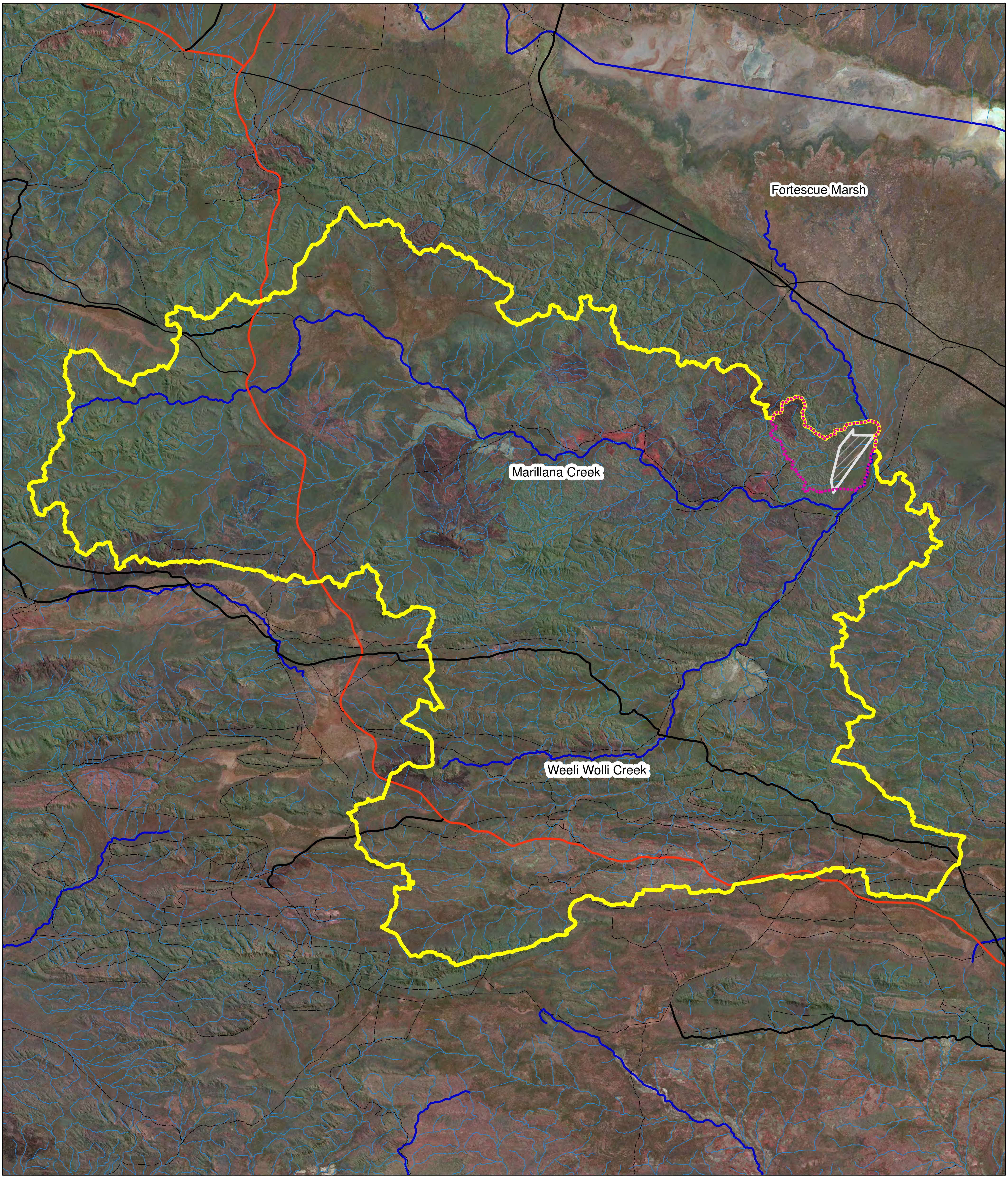

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0 5,000 10,000 Meters
Projection: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

LEGEND

- Local Catchment Boundary
- Weeli Wolli and Marillana Creek Catchment Boundary
- Iron Valley Tenament Boundary

Roads and Tracks

- Principal Road
- Minor Road
- Track

Watercourses

- Major
- Minor

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IRON VALLEY PROJECT
SURFACE WATER STUDY

REGIONAL HYDROLOGY

URS

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Figure: **2 - 2**

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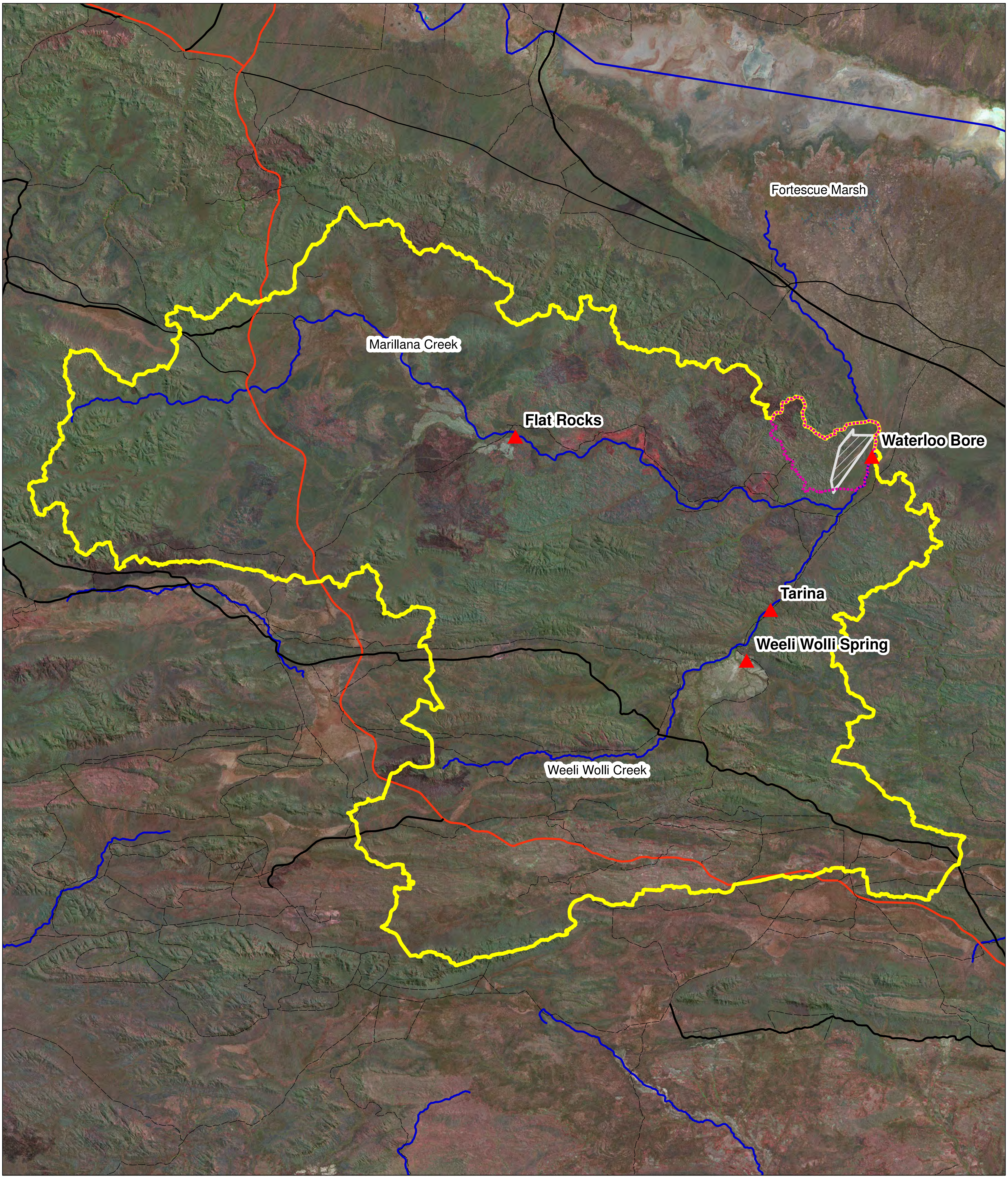

LEGEND

- Local Catchment Boundary
- Weeli Wolli Creek Catchment Boundary
- Iron Valley Tenament Boundary
- DoW Paired Gauging and Rainfall Stations

Roads and Tracks

- Principal Road
- Minor Road
- Secondary Road
- Track

Watercourses

- Major

N W E S

Scale: 1:375,000
0 5,000 10,000 Meters
Projection: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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IRON VALLEY PROJECT
SURFACE WATER STUDY

GAUGING STATION LOCATIONS

URS | IRON ORE HOLDINGS LTD | Figure: 2 - 3

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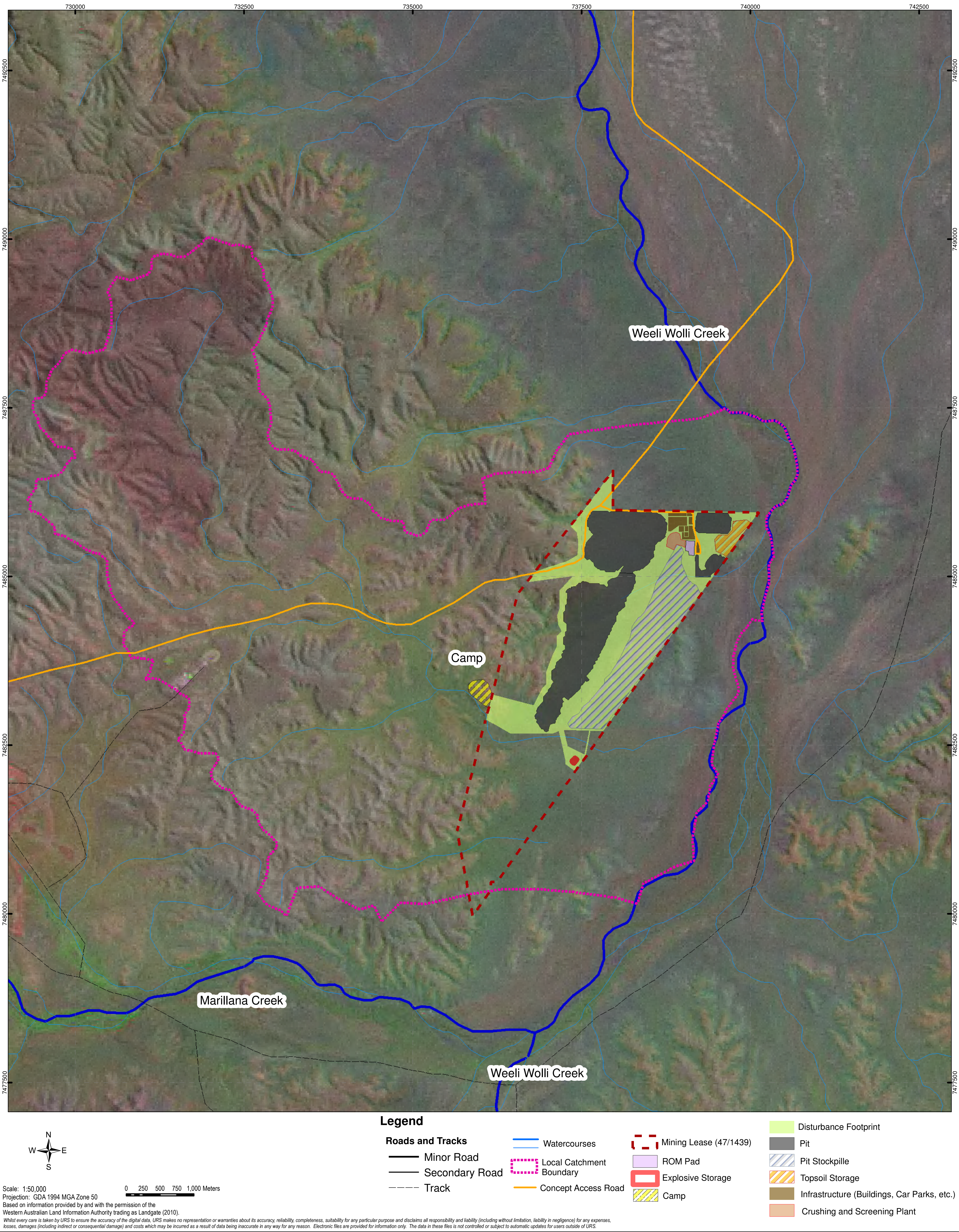

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Projection: GDA 1994 MGA Zone 50
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IRON VALLEY PROJECT
SURFACE WATER STUDY

LOCAL HYDROLOGY WITH PROPOSED MINE INFRASTRUCTURE

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Figure: **2 - 4**

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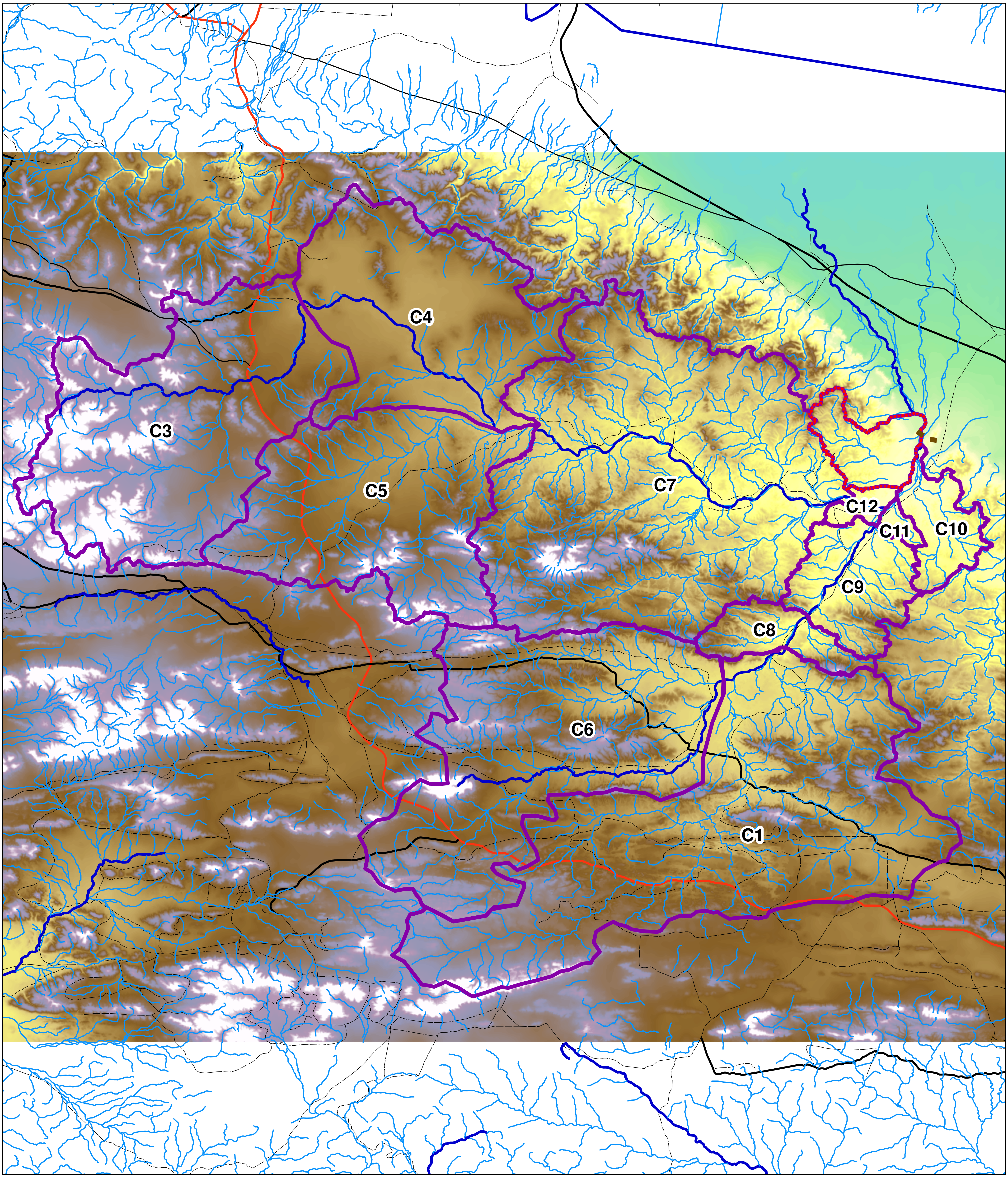

LEGEND

Local Catchment Boundary
Regional Subcatchments

Watercourses

Major
Minor

Roads and Tracks

Principal Road
Minor Road
Secondary Road
Track

Scale: 1:350,000
0 2,500 5,000 7,500 10,000 Meters
Projection: GDA 1994 MGA Zone 50
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IRON VALLEY PROJECT
SURFACE WATER STUDY

REGIONAL SUBCATCHMENTS

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Figure: **3 - 1**

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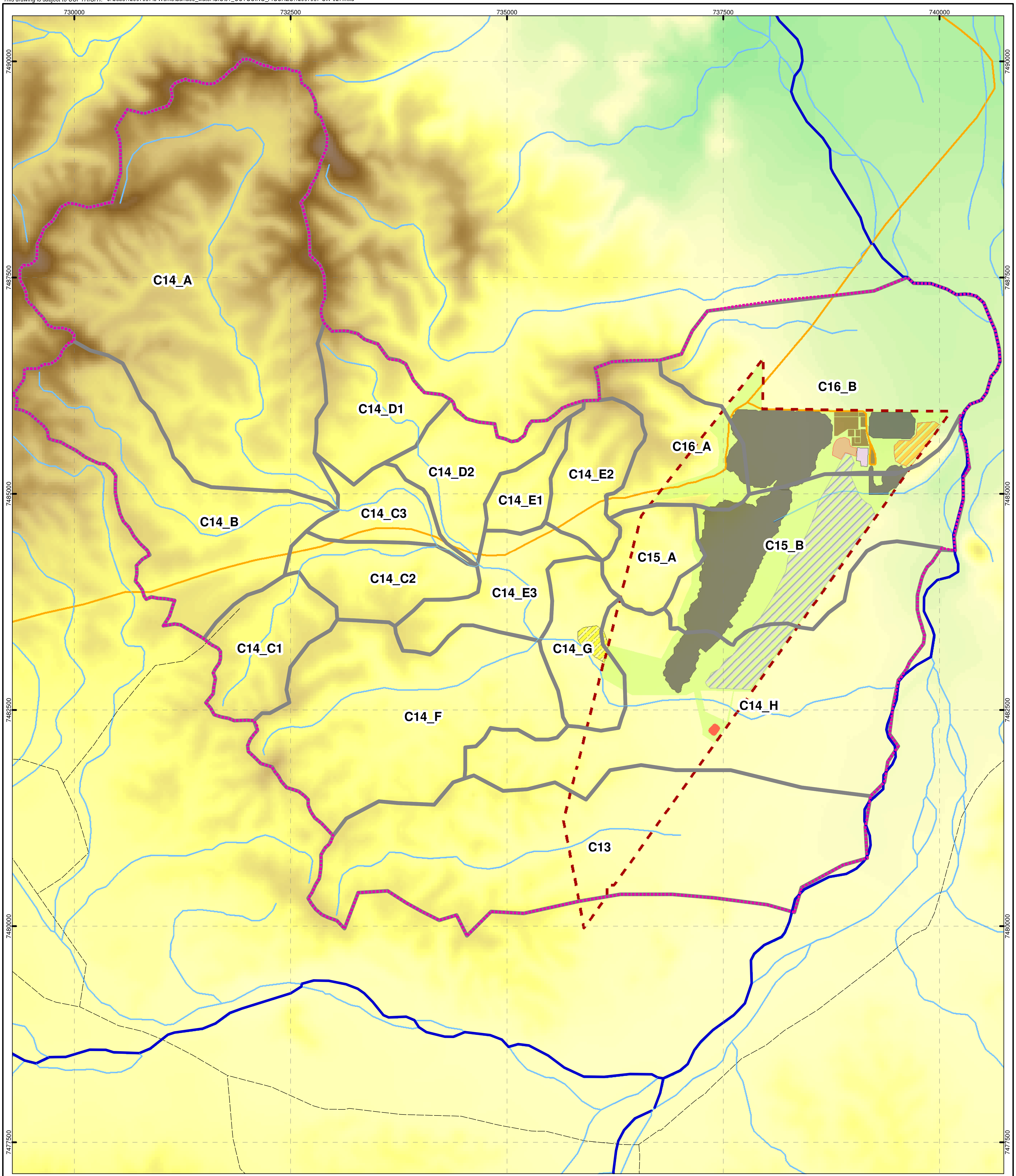

Legend

- Local Catchment Boundary
- Local Sub-catchments
- Watercourses
- Concept Access Road
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpille
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

Roads and Tracks

- Principal Road
- Minor Road
- Secondary Road
- Track

N W E S

Scale: 1:41,001 — 0 250 500 750 1,000 Meters

Projection: GDA 1994 MGA Zone 50

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IRON VALLEY PROJECT
SURFACE WATER STUDY

LOCAL SUBCATCHMENTS

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Figure: **3 - 2**

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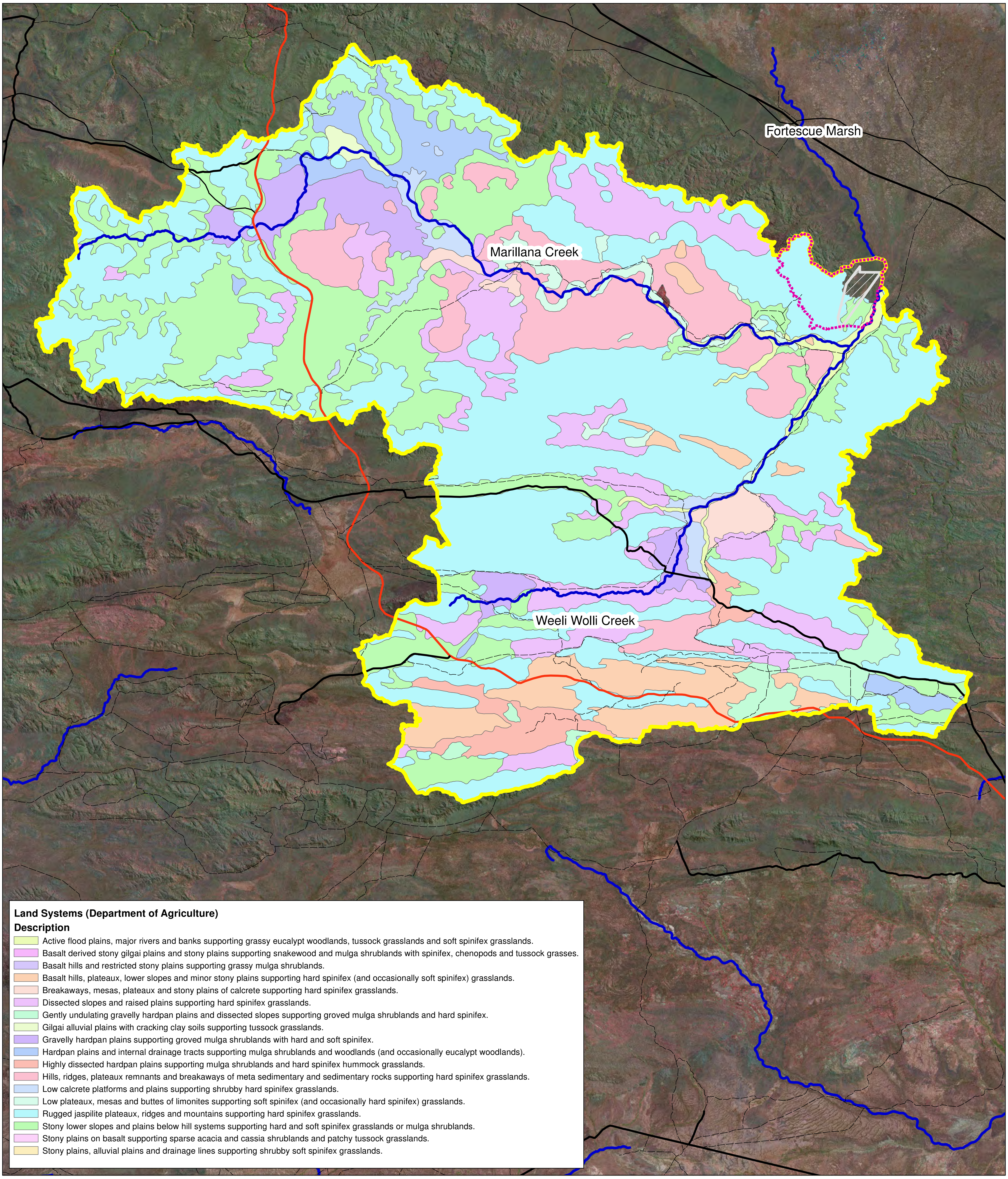

LEGEND

N W E S

Scale: 1:375,000 — 0 5,000 10,000 Meters

Projection: GDA 1994 MGA Zone 50

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Local Catchment Boundary
Weeli Wolli Creek Catchment Boundary
Iron Valley Tenament Boundary

Roads and Tracks
- Principal Road
- Minor Road
- Secondary Road
- Track

Watercourses
- Major

IRON VALLEY PROJECT
SURFACE WATER STUDY

LAND SYSTEMS MAP

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Figure: **3 - 3**

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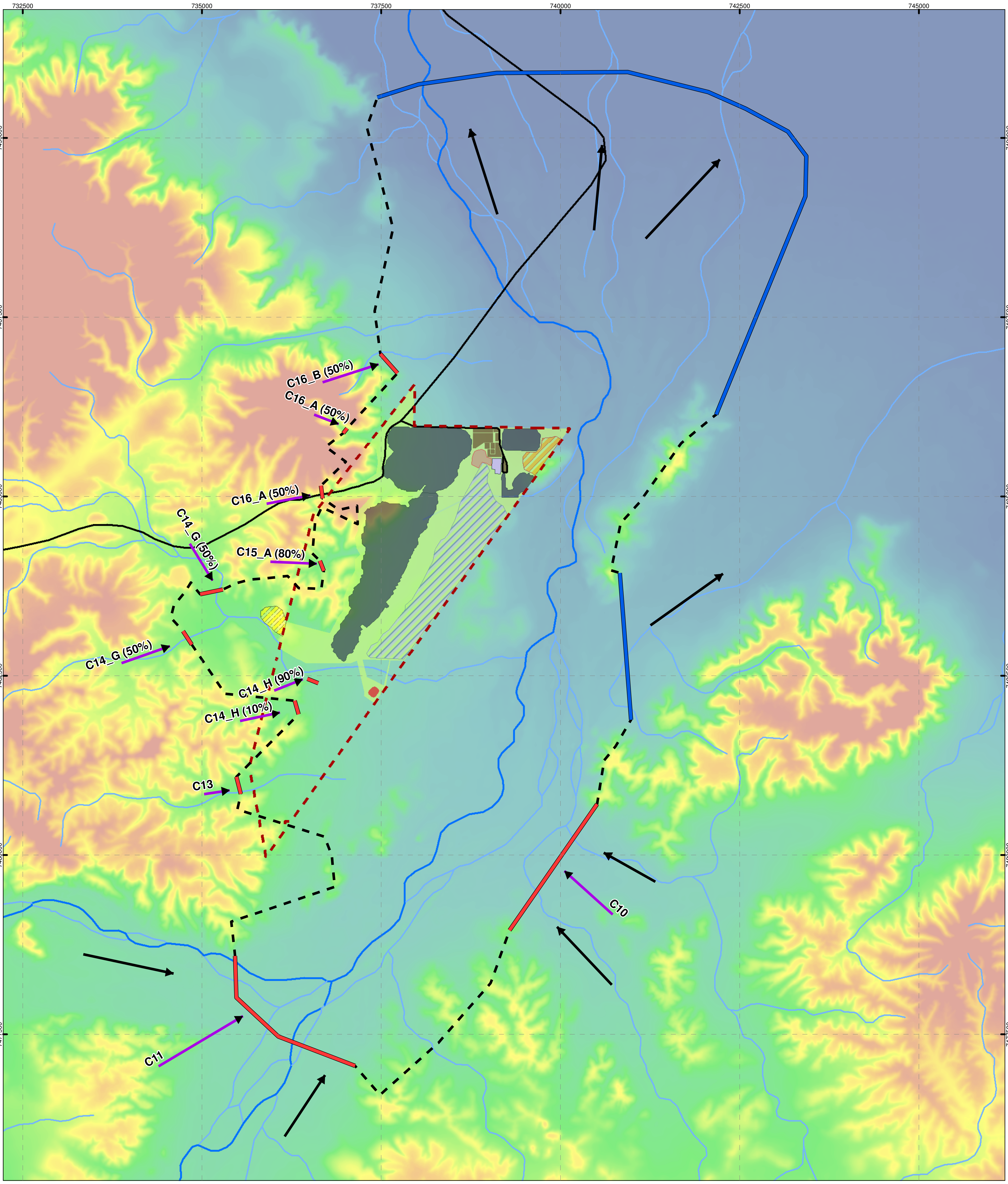

Legend

- Watercourses
- Outflow Model Boundary
- Inflow Model Boundary
- Inflow Hydrograph and percentage of the flow
- Flow Direction
- Model Boundary
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpile
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

N W E S

Scale: 1:50,000 — 0 250 500 750 1,000 Meters
Projection: MGA94 Zone 52
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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SURFACE WATER STUDY

HYDRAULIC MODEL PARAMETERS

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Figure: **3 - 4**

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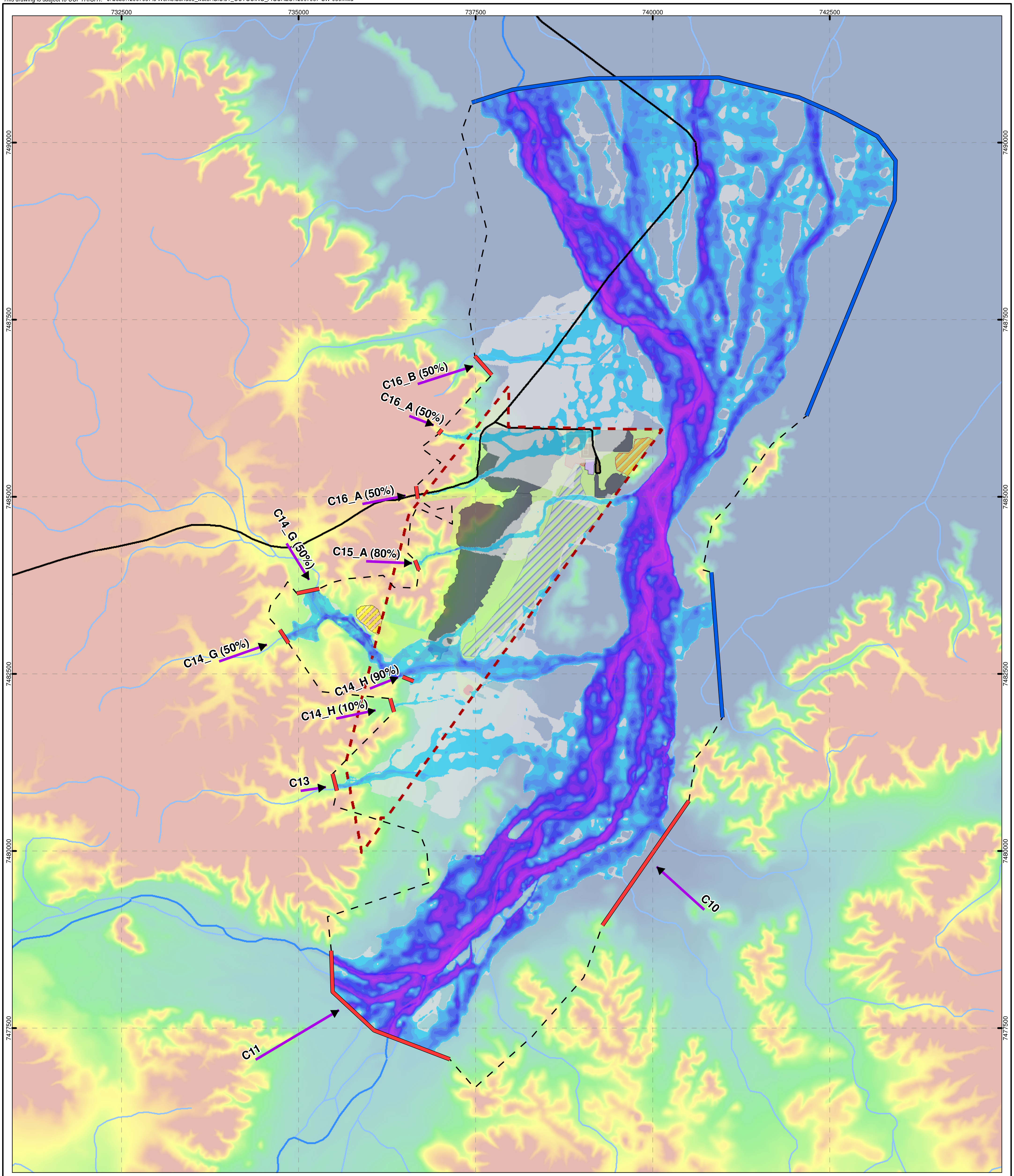

Legend

Water Depth [m]

- 0 - 0.05
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.25
- 1.26 - 1.5
- 1.51 - 1.75
- 1.76 - 2
- 2.01 - 2.5
- 2.51 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 7

- Inflow Hydrograph and percentage of the flow
- Watercourses
- Concept Access Road
- Outflow Model Boundary
- Inflow Model Boundary
- Modelled Area
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpile
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

N W E S

Scale: 1:50,000 0 250 500 750 1,000 Meters
Projection: MGA94 Zone 52
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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IRON VALLEY PROJECT
SURFACE WATER STUDY

BASELINE FLOOD EXTENTS AND DEPTHS - 50 YR ARI

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Figure: 3 - 5

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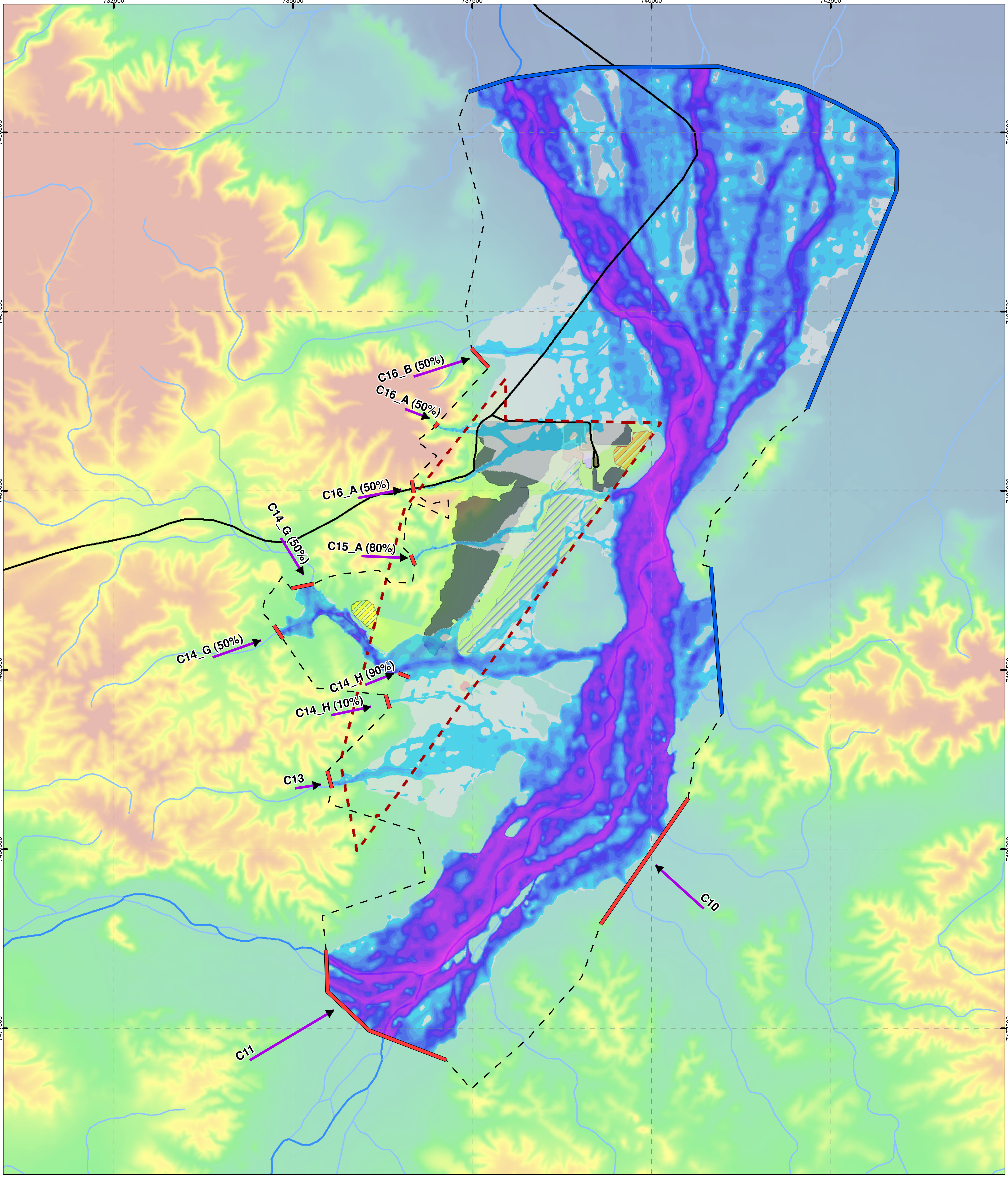

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N / W / E / S

Scale: 1:50,000 — 0 250 500 750 1,000 Meters

Projection: MGA94 Zone 52

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Water Depth [m]

- 0 - 0.05
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.25
- 1.26 - 1.5
- 1.51 - 1.75
- 1.76 - 2
- 2.01 - 2.5
- 2.51 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 7

- Inflow Hydrograph and percentage of the flow
- Watercourses
- Concept Access Road
- Outflow Model Boundary
- Inflow Model Boundary
- Modelled Area
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpille
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

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IRON VALLEY PROJECT
SURFACE WATER STUDY

BASELINE FLOOD EXTENTS AND DEPTHS - 100 YR ARI

URS

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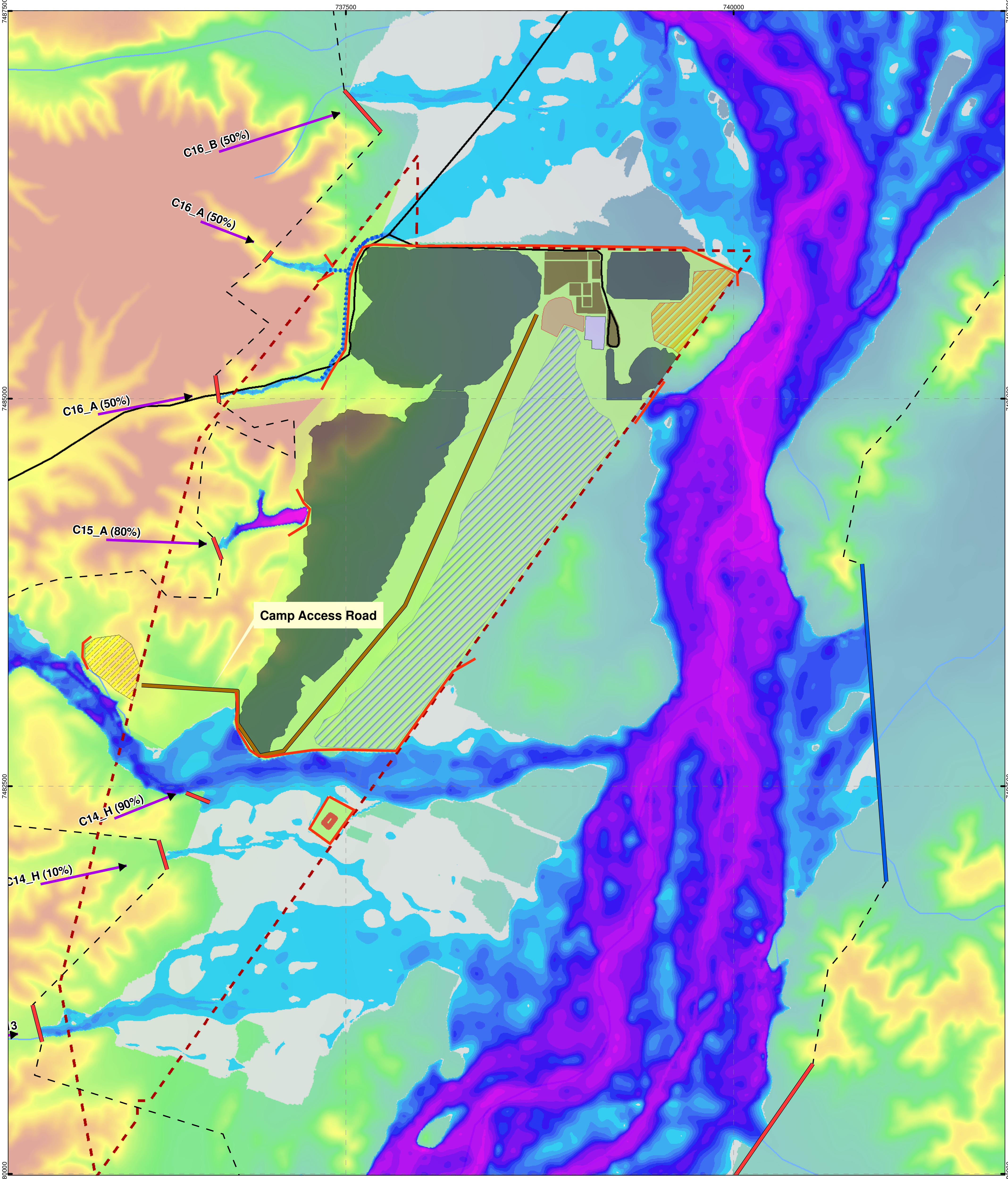

Legend

- Camp Access Road
- Bund
- Channel Diversion
- Inflow Hydrograph and percentage of the flow
- Watercourses
- Concept Access Road
- Outflow Model Boundary
- Inflow Model Boundary
- Modelled Area
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpile
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

Water Depth [m]

0 - 0.05	1.01 - 1.25	2.51 - 3
0.06 - 0.25	1.26 - 1.5	3.01 - 4
0.26 - 0.5	1.51 - 1.75	4.01 - 5
0.51 - 0.75	1.76 - 2	5.01 - 7
0.76 - 1	2.01 - 2.5	

N W E S

Scale: 1:23,000
0 250 500 750 1,000 Meters
Projection: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

IRON VALLEY PROJECT
SURFACE WATER STUDY

POTENTIAL SURFACE WATER IMPACTS AND OPERATIONAL RISKS (100YEAR ARI OUTLINES)

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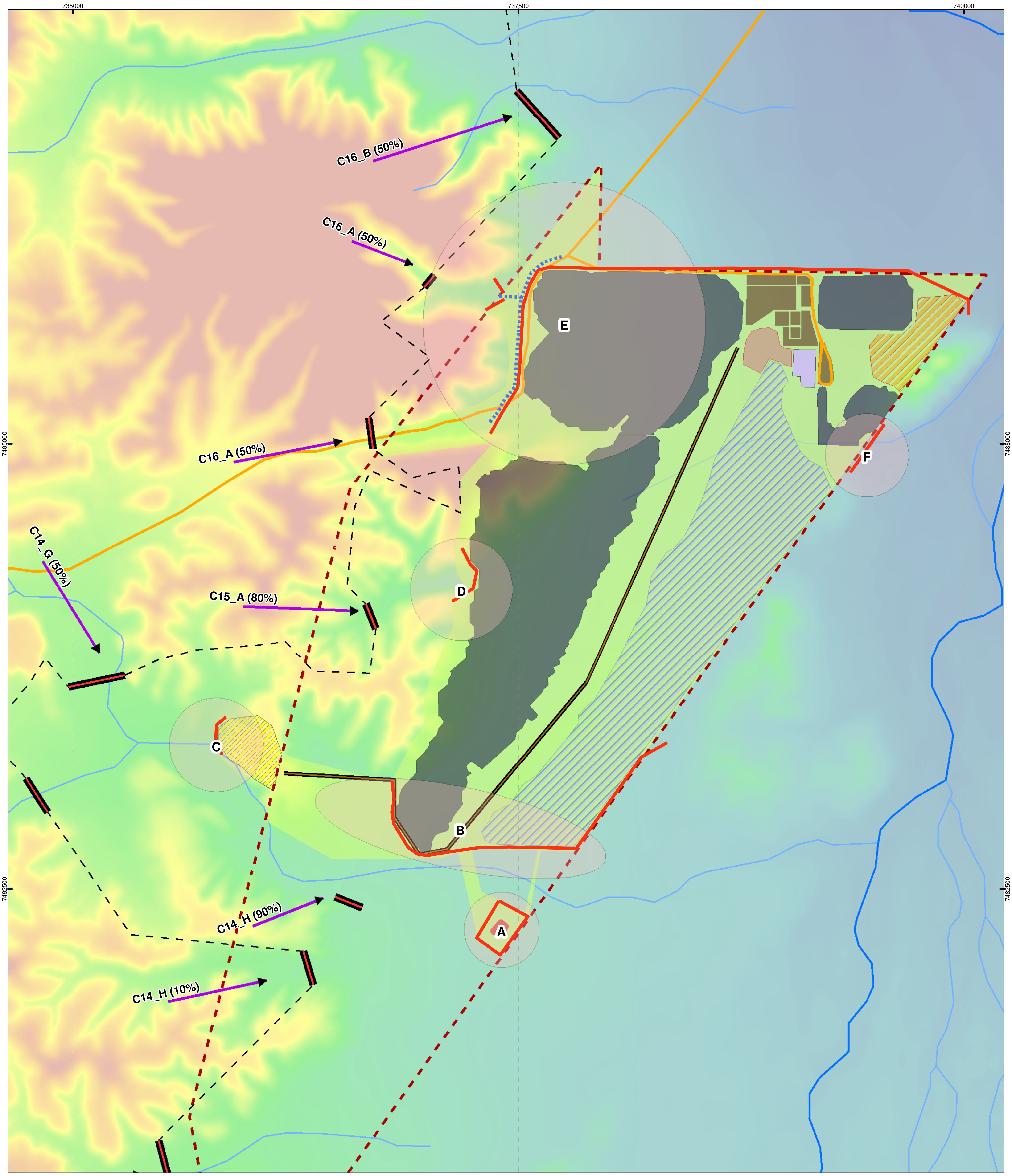
Figure: 4-1

File No: 42907937-SW-025.mxd Drawn: AV Approved: MJ Date: 04/9/2012 Rev. A A3



Legend

- Camp Access Road
- Protected Area
- Bund
- Inflow Model Boundary
- Inflow Hydrograph and percentage of the flow
- Watercourses
- Concept Access Road
- Channel Diversion
- Modelled Area
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpille
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

N W E S

Scale: 1:20,000 — 0 250 500 750 1,000 Meters

Projection: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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IRON VALLEY PROJECT
SURFACE WATER STUDY

LOCATION OF STREAMFLOW DIVERSION INFRASTRUCTURE

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Figure: 5-1

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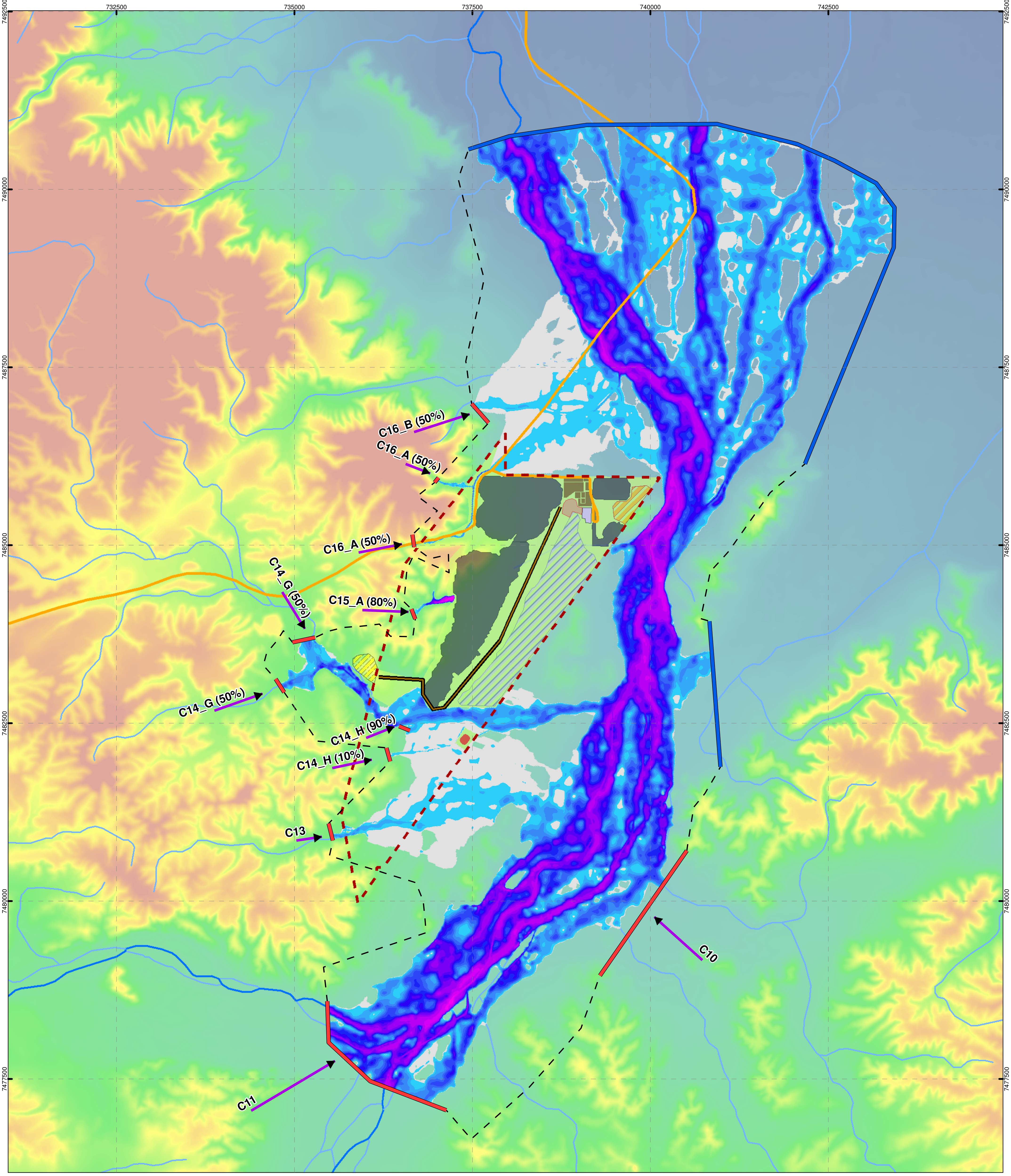

Legend

N
W E
S

Scale: 1:50,000
0 250 500 750 1,000 Meters
Projection: MGA94 Zone 52
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Water Depth [m]

- 0 - 0.05
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.25
- 1.26 - 1.5
- 1.51 - 1.75
- 1.76 - 2
- 2.01 - 2.5
- 2.51 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 7

- Inflow Hydrograph and percentage of the flow
- Camp Access Road
- Watercourses
- Concept Access Road
- Outflow Model Boundary
- Inflow Model Boundary
- Modelled Area
- Mining Lease (47/1439)
- ROM Pad
- Explosive Storage
- Camp
- Disturbance Footprint
- Pit
- Pit Stockpille
- Topsoil Storage
- Infrastructure (Buildings, Car Parks, etc.)
- Crushing and Screening Plant

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SURFACE WATER STUDY

POST DEVELOPMENT MITIGATED FLOOD EXTENTS AND DEPTHS - 50 YR ARI

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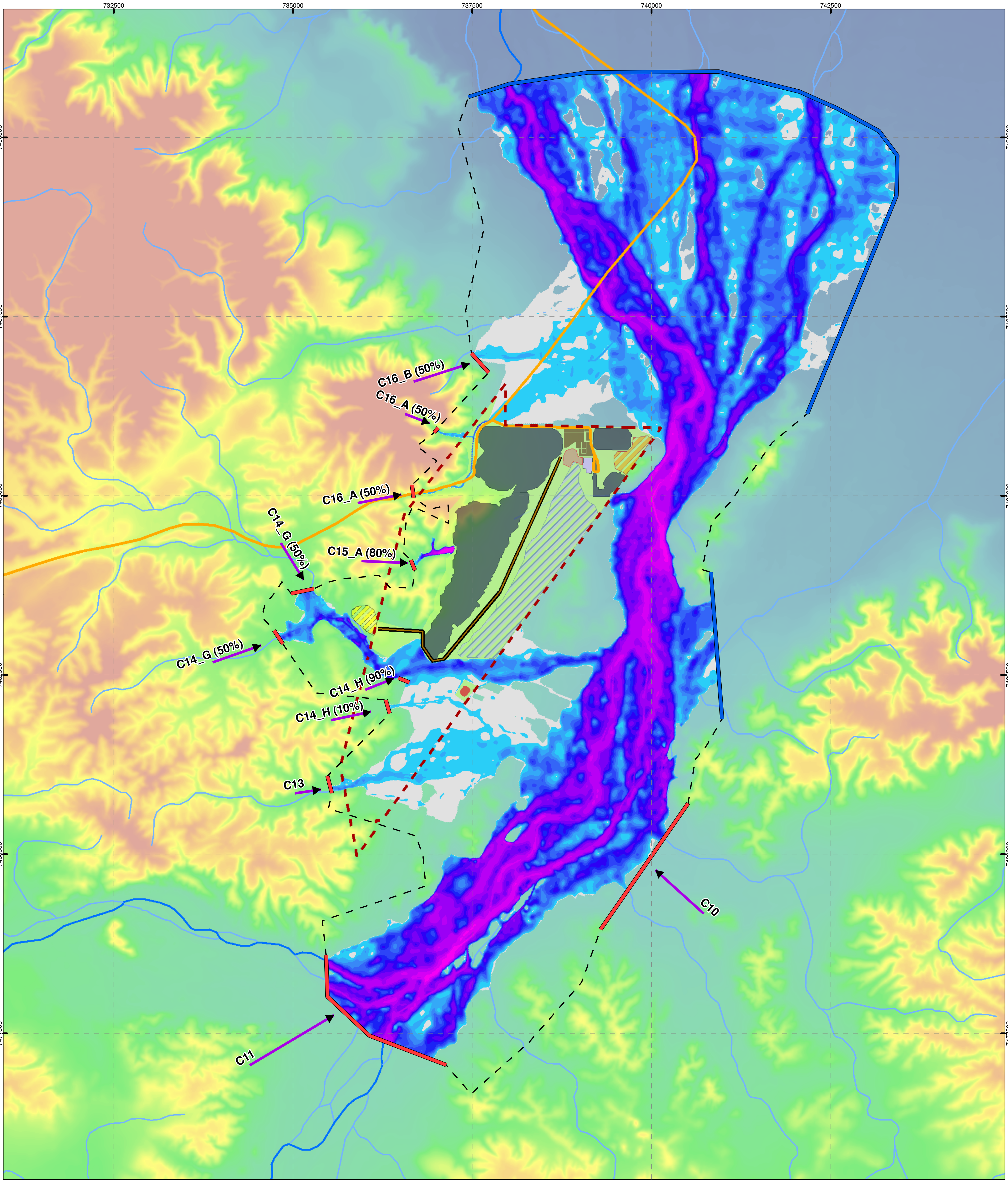
Figure: **5 - 2**

Rev. **A** A3



Legend

N W E S

Scale: 1:50,000
0 250 500 750 1,000 Meters
Projection: MGA94 Zone 52
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Water Depth [m]

0 - 0.05	1.01 - 1.25	2.51 - 3	Inflow Hydrograph and percentage of the flow	Inflow Model Boundary
0.06 - 0.25	1.26 - 1.5	3.01 - 4	Camp Access Road	Modelled Area
0.26 - 0.5	1.51 - 1.75	4.01 - 5	Watercourses	Mining Lease (47/1439)
0.51 - 0.75	1.76 - 2	5.01 - 7	Concept Access Road	ROM Pad
0.76 - 1	2.01 - 2.5		Outflow Model Boundary	Explosive Storage
				Camp

Disturbance Footprint
Pit
Pit Stockpile
Topsoil Storage
Infrastructure (Buildings, Car Parks, etc.)
Crushing and Screening Plant

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IRON VALLEY PROJECT
SURFACE WATER STUDY

POST DEVELOPMENT MITIGATED FLOOD EXTENTS AND DEPTHS - 100 YR ARI

URS

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File No: 42907937-SW-023.mxd Drawn: AV Approved: MJ Date: 04/9/2012

Figure: 5 - 3

Rev. A A3

URS

Memorandum

Date: 10 August 2012

To: Iron Ore Holdings

From: Emmanuelle Svartz / Andrew Mussell (URS)

Subject: **Iron Valley Project - Surface Water Monitoring Plan**

This document presents the surface water monitoring plan for the Iron Valley Project. It is proposed to undertake this monitoring to inform the baseline flow regime and water quality in Weeli Wolli Creek and in the Project Area. It also details a monitoring plan to be implemented during the construction and operational phases.

1. Literature Review and Gap Analysis

Currently no surface water monitoring has been undertaken within the project area. Regionally, the Department of Water (DoW) has surface water gauging stations located within the Weeli Wolli Creek Catchment. Waterloo Bore DoW gauging station is the closest to the Iron Valley site, located on Weeli Wolli Creek approximately 2 km east of the Iron Valley Project Area, This station is considered relevant to the study as it is situated adjacent to the project area and gauges surface water flows that may inundate the project area (Figure 1-1). This station has been recording water levels since 1984, with limited water quality samples taken sporadically between 1985 and 2000. The average monthly discharge reported by this station between the months of December and April is 3 m^3/s, and the maximum recorded discharge is 58 m^3/s (December 1999 – cyclone John).

Tables 1-1 and 1-2 summarise the surface water quality at Waterloo bore, as an average over time (1985-2000).

Table 1-1 Average Concentrations of Major Cations and Anions, Waterloo Bore

Major Ion Concentrations[1] (mg/L)						
Cations				Anions		
Potassium	Calcium	Magnesium	Sodium	Chlorine	Phosphorus	Sulphur
3.17	11	4.8	7.5	9	0.01	1.2

Notes: [1] Sourced from DoW (2008).

Table 1-2 Average Concentrations of Selected Parameters, Waterloo Bore[1]

Electrical Conductivity (EC) (µS/m)	Turbidity (NTU)	pH
24,684	177.3	7.6

Notes: [1] Sourced from DoW (2008).

The key data gaps that currently exist to characterise the baseline hydrological environment of the Iron Valley Project Area are as follows:

- Local surface water quality data;

- Local surface water flow characteristics; and
- Local rainfall intensities.

The proposed surface water monitoring plan aims to fill identified data gaps and increase the resolution of surface water data in the vicinity of the proposed Iron Valley Project Area. This will be achieved by developing a surface water monitoring network that will look to characterise the local surface water flow regime and local surface water quality trends.

2. Baseline Surface Water Monitoring

The Project Area is located in a remote area that experiences ephemeral surface water flows usually generated by cyclonic activity or thunderstorms. Therefore the most practical method of collecting surface water data will be to install a surface water monitoring network that will allow for the continuous recording of surface water events. To supplement this, opportunistic sampling of surface waters is also proposed i.e. when flows are present in the Project Area whilst personnel are present.

2.1 Local Surface Water Flow and Quality Monitoring

2.1.1 In situ Monitoring

Figure 1 shows proposed locations to establish gauging stations to monitor both surface water flows and key surface water quality parameters. These locations are based on baseline flood footprints for the 50 and 1:100 year ARI events. Two gauging stations will be located on Weeli Wolli Creek:

- SW05 positioned upstream of the Project Area, to capture the surface water conditions entering the Iron Valley Sub-catchment; and
- SW01 positioned downstream of the Project Area, to capture any changes potentially brought by the Iron Valley development, by comparing those to the upstream conditions.

These will provide an indication of the water quality and flows upstream and downstream of the proposed Project Area.

It is proposed to set up 3 gauging stations within the Iron Valley sub-catchment:

- SW02 positioned upstream of the main pit area;
- SW03 located on the main Iron Valley Sub-Catchment creek, upstream of the Project Area; and
- SW04 located on the main Iron Valley Sub-Catchment creek, downstream of the Project Area, and before the confluence with Weeli Wolli Creek.

The gauges will be set up to measure the following parameters:

- Turbidity - This will give an indication of sediment loads within surface waters;
- Electrical conductivity - This will give an indication of the salinity of the baseline surface waters;
- pH – This will give an indication of the surface water acidity; and
- Flow depth – this will allow for the estimation of flow volumes.

Surface water monitoring stations will be developed at the 5 locations presented in the section above. Plate 1 below shows a diagram of the typical proposed set up of the monitoring station.

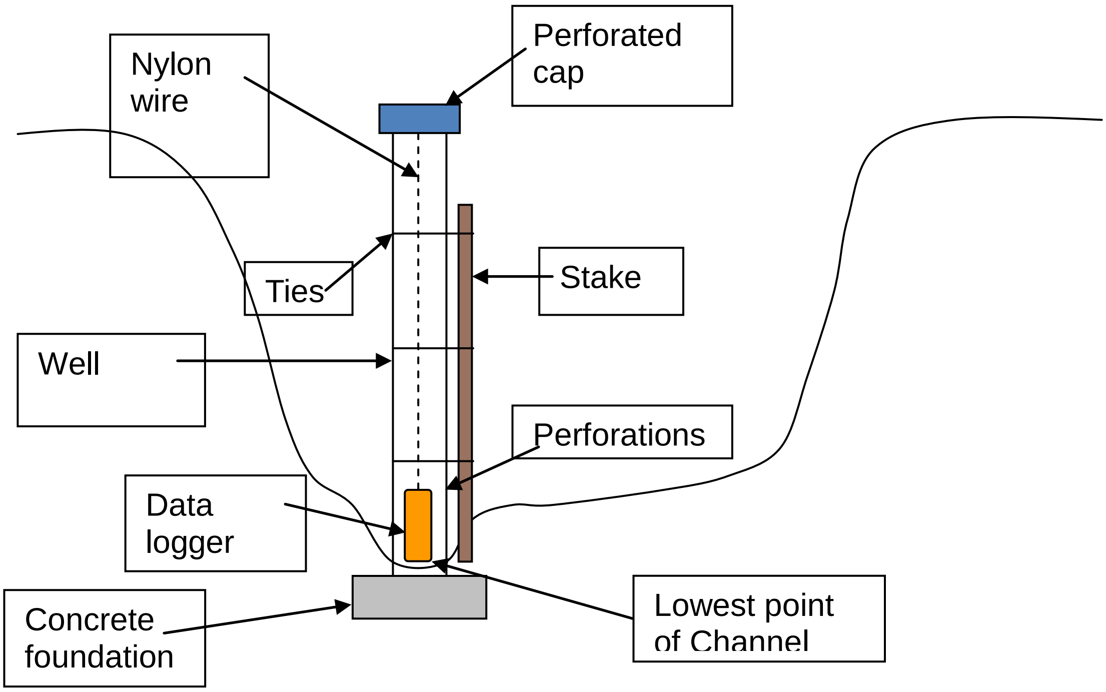


Plate 1: General set up of in-situ surface water monitoring station

Such a logger would be the Insitu Aqua Troll 9500. This would be set up to measure in hourly intervals and would be downloaded every 8 to 12 weeks.

With the gauge in place, the bottom of the gauge will be referenced with the Differential Global Positioning System (DGPS) (set to GDA94) and a cross section upstream and downstream of the gauge undertaken using the DGPS. This will allow for the estimation of flows associated with the flow event, A Barometric gauge will also be required to calibrate the depth recordings taken by the loggers. An in-situ Baro troll will be used for this purpose and will hang in the general vicinity of the gauging stations. The estimated flow volumes and observed flow depth will help develop existing hydrological and hydraulic models used to predict the hydrological regime of the Project Area and surrounds.

2.1.2 Opportunistic sampling

Opportunistic surface water samples will be taken where possible. This will allow other key surface water quality parameters to be recorded such as heavy metals and hydrocarbons. The sampling protocol will be based on those outlined in Surface water sampling methods and analysis — technical appendices (Department of Water, 2009). The parameters tested for will be as follows:

- The full spectrum of petroleum hydrocarbons (C6 through C33) in order to better characterise the potential presence of naturally occurring hydrocarbons and VOC's (including BTEX and naphthalene), plus any additional analysis for hydrocarbons considered necessary (all in µg/L);
- Major cations and anions: Cl, Ca, Mg, Na, K, Sulfate (SO4-2), Sulphur (as S);
- Heavy metals: As, Cd, Cr, Cu, Ni, Pb, Zn, Hg, (all in mg/L); to better characterise the water quality and support the development of trigger values. This will include heavy metals as suggested in Water Quality Monitoring Program Design guideline (DOW, 2009) for mine sites;
- Hydroxide Alkalinity, Carbonate Alkalinity, Bicarbonate Alkalinity, and Total Alkalinity as CaCO3 (mg/L);
- EC (µS/cm@25° C);
- TDS (mg/L); and
- pH (Value).

2.1.3 Local Rainfall Intensities

The installation of a rain gauge within the site boundary is proposed to record localised rainfall. This will help calibrate and develop existing hydrological and hydraulic models. A RG20 rain gauge is suggested for installation.

3. Surface Water Monitoring During Construction and Operation Phases

3.1 Local Surface Water Flow and Quality Monitoring

3.1.1 In-situ Monitoring

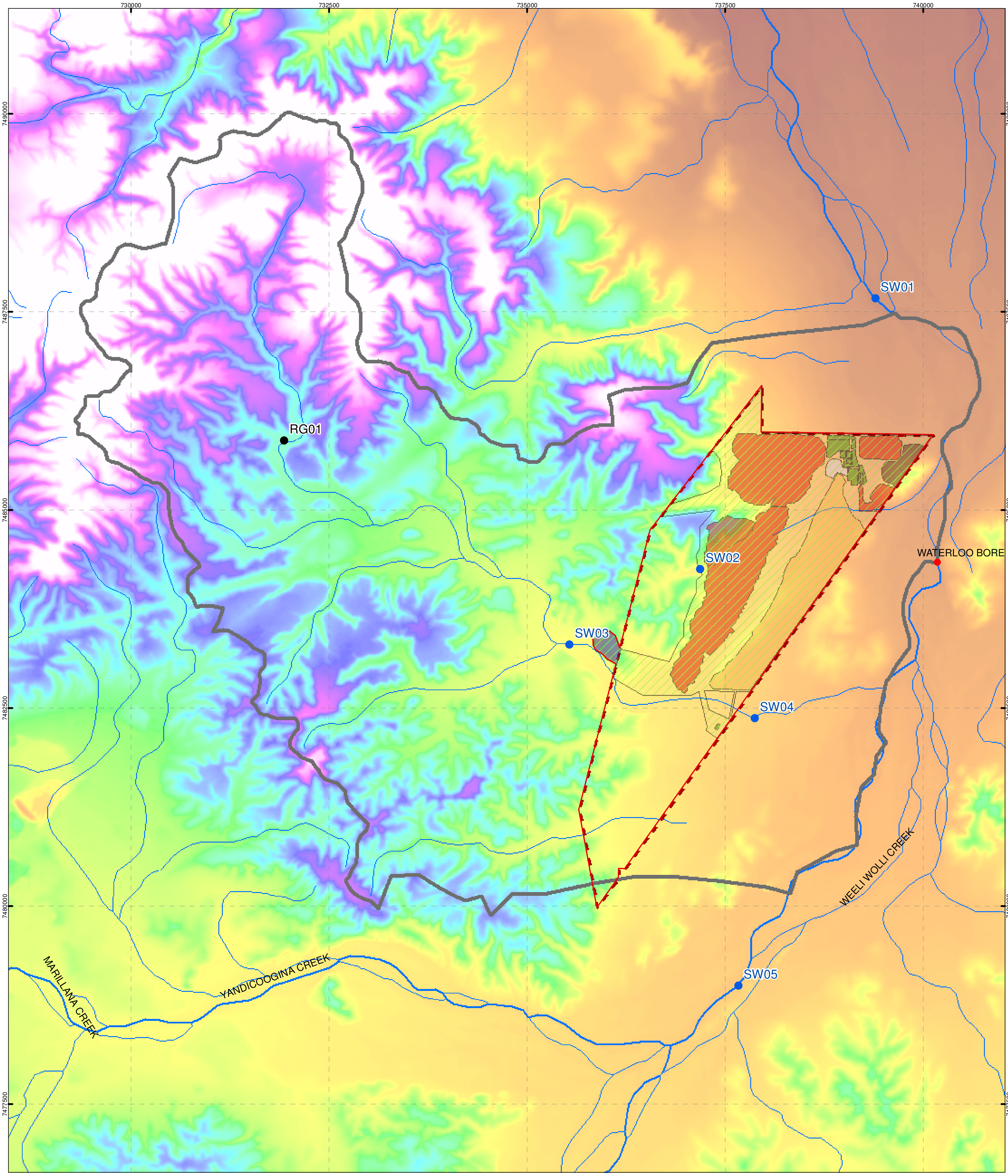
The same monitoring network used to establish baseline surface water characteristics will be used to monitor surface water parameters during construction and operation phases. The section below describes the role of each monitoring station during the construction and operation phases.

- SW05 positioned upstream of the site on Weeli Wolli Creek, to capture the surface water conditions entering the Iron Valley Sub-catchment;
- SW01 positioned downstream of the site, to capture any changes potentially brought by the Iron Valley development, by comparing those to the upstream conditions (SW05);
- SW02 positioned upstream of the main pit area; to estimate the inflow to the site for future diversion requirement, and as a water quality reference point
- SW03 located on the main Iron Valley Sub-Catchment creek, upstream of the disturbance area; and
- SW04 located on the main Iron Valley Sub-Catchment creek, downstream of the disturbance area, to capture any changes potentially brought by the Iron Valley development, by comparing those to the upstream conditions (SW03).

3.1.2 Sampling Programme

A sampling programme based on the water quality parameters measured for baseline conditions should be established. This programme should be based on samples being collected when surface water flows occur. Locations for sampling should be based on the locations of the insitu monitoring stations to allow for comparison between sites upstream and downstream of potential construction works and operations.

Automatic samplers may be considered at locations such as main drains at the site once construction is complete.



- Project Area
- Iron Valley Catchment Outline
- Surface Water Monitoring Locations
- Proposed Raingauge Location
- Major Watercourse
- Minor Watercourse
- Accommodation Village
- Infrastructure Areas
- Pit Areas
- ROM Pad
- Topsoil Storage
- Waste Rock Landform
- Total Disturbance Footprint

Scale: 1:45,000 — 0 250 500 750 1,000 Meters
Projection: MGA94 Zone 52
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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IRON VALLEY PROJECT
PHASE 2 SURFACE WATER STUDY

PROPOSED SURFACE WATER MONITORING LOCATIONS

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Figure: **1 - 1**

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