Iron Valley Project - Above Water Table Mining

Soils and Landforms Preliminary Study

7 AUGUST 2012

Prepared for

Iron Ore Holdings

42908158

URS

Project Manager:

....
Mike Jones
Environmental Scientist

Principal-In-Charge:

....
Ashley Bird
Principal-In-Charge

Author:

....
Mike Jones
Environmental Scientist

Reviewer:

....
David Gemmell
Associate Geo-environmental Scientist

URS Australia Pty Ltd

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

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

Date:	**7 August 2012**
Reference:	42908158/xxx/1
Status:	Draft

Document delivery

URS Australia provides this document in either printed format, electronic format or both. URS considers the printed version to be binding. The electronic format is provided for the client's convenience and URS requests that the client ensures the integrity of this electronic information is maintained. Storage of this electronic information should at a minimum comply with the requirements of the Commonwealth Electronic Transactions Act (ETA) 2000.

Where an electronic only version is provided to the client, a signed hard copy of this document is held on file by URS and a copy will be provided if requested.

Table of Contents

Table of Contents

Tables

Figures

Plates

Table of Contents

Abbreviations

Abbreviation	Description
API	Assessment on Proponent Information
AHD	Australian Height Datum
BIF	Banded Iron Formation
BHPBIO	BHP Billiton Iron Ore
EPA	Environmental Protection Authority
FMG	Fortescue Mining Group
GSWA	Geological Survey of Australia
Ha	Hectares
LIDAR	Light Detection And Ranging
Mt	Million tonnes
the Project Area	Iron Valley Project site
PSD	Particle Size Distribution
RTIO	Rio Tinto
URS	URS Australia Pty Ltd

Executive Summary

The main objective of this soils and landforms study was to describe landforms and characterise the soils and soil profile across the site through literature review and a visual assessment of the surface soil and landforms.

As part of the scope of work, the following was undertaken:

- Literature review, including information provided by Iron Ore Holdings, aerial photography and publicly available information; and
- Site inspection.

The following conclusions were drawn about the rehabilitation of soils encountered;

- Three primary soil types were observed in the Project Area;
  - Red loamy earths;
  - Stony soils; and
  - River bed soils (limited coverage in drainage channels).
- The areas with stony soils have large amounts of aggregates and are poorly developed and apedal (poorly structured). It is unlikely that these soils will be suitable for capping material;
- The limited soil observations undertaken during the inspection have suggested the red loamy earths, which cover the majority of the proposed infrastructure areas, have a small proportion of aggregates, and this soil type may have a degree of pedality (structure);
- River bed soils are not present in significant quantities and confined to drainage channels, as such will do not comprise a reliable resource for capping material;
- It is likely that the carbon percentage of soils is low. Careful supplementation of organic nutrient media may increase capacity for the soil to revegetate.
- Stony soils are described in literature (Van Vreeswyk et al) as having variable slaking at surface, indicating a low clay content and therefore prone to dispersion. The red loamy earth has been described as having partial to complete soil slaking, indicating variable dispersion. Therefore careful management of slopes and erosion barriers will be required; and
- Soils from the red loamy earth soil unit may produce a sufficient volume of soils with a clay content suitable for construction of engineering surface.

Plants do better in well-compacted, uniform, sandy soils with relatively low porosity (high density) or in well graded sands where sufficient fine (silts and clays) are present to provide moisture retention. The stony soils do not appear to provide these conditions, however, the red loamy soils may provide better conditions.

The soils located within the project area are likely to be soils with limited hard-setting surfaces and with relatively medium to coarse topsoil textures exhibiting low moisture retention. When vegetation cover and gravelly or stony mantle are removed and the surface materials are disturbed by earth moving operations, the earthy fabric of the soils will be destroyed and the single grained fabric of these materials will then predispose them to accelerated wind and water erosion.

In addition, the finished shape of the project infrastructure will likely result in much larger surface area than the original footprint of the infrastructure. Therefore, insufficient topsoil may be recovered from disturbed areas and retained for rehabilitation to cover the final landforms to allow suitable depth for re-vegetation. Additional topsoil may be obtainable from elsewhere on site and it is possible that some of the vegetation species in the area can grow reasonably well on thin soil mantles overlying the harder bedrock. Careful design of micro-relief features on the capping and topsoil will provide more

advantageous conditions to the indigenous vegetation (such as increased water retention) and is likely to result in more successful rehabilitation.

While this desktop study provides general guidance as to the suitability of soils on site for rehabilitation, prior to Project construction it is likely that a site investigation will be required in order to confirm the conclusions of this report and provide additional information on soil profile and chemistry

Introduction

1.1 Overview

URS Australia Pty Ltd (URS) was commissioned by Iron Ore Holdings (IOH) to undertake a soils and landforms preliminary study at the Iron Valley Project site (the Project Area).

The EPA has provided a Prepared Scoping Guideline for the proposal and has set the assessment as category A. Further to this, the Scoping Guidelines have identified Rehabilitation and Mine Closures as a key environmental factor. This includes final landforms and revegetation, which will require an assessment of the baseline soils and landforms over the project area. The study is required for inclusion in the Assessment on Proponent Information (API) to be submitted to the Environmental Protection Authority (EPA), in order to assess the suitability of topsoils and soil units to facilitate appropriate rehabilitation at the site upon cessation of operations. Rehabilitation procedures are outside the scope of this particular study, however it is considered that the findings of this study can be used to aid in the development of rehabilitation criteria.

This report is based on a literature review and site inspection survey. The site inspection survey was undertaken on the 16 July 2012. No intrusive investigation, soil sampling or analysis was undertaken as part of this assessment

1.2 Project Description

The project is located in the Eastern Pilbara Region of Western Australia approximately 90 km north-west of Newman and 150 km east of Tom Price. The Project is within close proximity of a number of operating iron ore mines including the Rio Tinto (RTIO) Yandicoogina and Hope Downs operations, BHPBIO Yandi operation and FMG Cloudbreak operation. Figure 1 shows the project location.

The project area occurs within Mining Lease M47/1439 and Exploration Licence E47/1385. The project area is located within the Marillana (pastoral) Station and the site has historically been used for pastoral use and more recently mineral exploration.

The Project Area is currently accessed via the BHPBIO rail access road and RTIO access road. IOH has authorisation from BHPBIO and RTIO to access the site for exploration activities and an access agreement would be sought from BHPBIO and RTIO to access the site for the operation of the Project via the existing access road.

The project will comprise an expected iron ore resource of 200 million tonnes (Mt) with a mine life of 7 years (with an additional 2 years construction and 10 years decommissioning/closure). It is expected that up to 5 Mt will be mined per annum with a strip ratio of waste to ore of 1.8:1. Crushing and screening of the ore will be undertaken and it is expected that the process plant will have a throughput of 5 Mt per annum. All pit excavations will be undertaken in dry conditions above the water table.

The total area of direct ground disturbance for the Project is expected to be up to 674 ha, distributed as follows:

- Up to 249 ha for mining pit;
- Up to 137 ha for the WRL;
- Up to 13 ha for the topsoil storage areas;
- Up to 18 ha for the campsite (within exploration lease E 4701385); and
- Up to 257 ha for processing, and ancillary works.

It should be noted that the area of disturbance required for any future transport corridors is not considered as part of this Project as the Project is viable in its own right. An access agreement would be sought from BHPBIO and RTIO to access the site via an existing access road for operation of the Project.

Figure 2 shows the layout of the project infrastructure.

1.3 Objective

The main objective of this preliminary soils and landforms study was to identify and describe landforms across the site through desktop assessment and visual assessment of the land surface. No intrusive investigation, soil sampling or analysis was undertaken as part of these works.

1.4 Scope of Work

The following scope of work was conducted to meet the objective detailed above.

1.4.1 Literature Review

As part of the literature review, URS undertook the following:

- A review of literature made available by the client;
- A review of further broad-scale soils and landforms information that were used to define the range of soils and landforms potentially present at the site; and
- A review of aerial photography to aid in landform delineation by describing surface morphology.

The following sources of information were used to provide broad-scale soils and landforms information for the site:

- Van Vreeswyk, A.M.E., Payne A.L., Leighton K.A., Hennig P. (2004). *An inventory and condition survey of the Pilbara region, Western Australia*. Department of Agriculture Technical Bulletin No. 92, Perth;
- URS Groundwater Water Report; and
- Astron Environmental Services. (2012). *Iron Valley Project – Flora and Vegetation Survey.*

1.4.2 Site Inspection

A landform site inspection of the Project Area was undertaken on the 16 July to further identify the landforms and soils described in the desktop review and to assess lesser landforms not identified on aerial photography.

Background Information

The following section provides information on geology, topography and anticipated soil types for the site based on a review of publicly available information and documentation provided by IOH.

A summary of the information gathered is presented below and interpretation of the soil suitability for rehabilitation and/or reuse is discussed in Section 5.

2.1 Regional Geology

The site is shown on the Geological Survey of Australia (GSWA), 1:100,000 Geological Map series Weeli Wolli Sheet (Sheet 2752). The Iron Valley Project is located in the Precambrian iron formations of the Hamersley Ranges. The Project Area consists of younger valley-fill material and detritals in the lower topographic areas, overlying Banded Iron Formation (BIF), shales, mineralised shales and mineralised BIFs and dolerites sequences.

The geology of the area is dominated by the following geological units:

- Recent transported unconsolidated sediments and valley fill material;
- Mineralised Brockman; and
- Weeli Wolli formation geology.

2.2 Local Geology

The following provides a description of the local geology:

2.2.1 Quaternary Formation

The Quaternary alluvium mainly consists of soil and coarse BIF fragments with minor iron minerals. This unit is unsorted and not layered. The depth of this unit varies across the Project Area and can be expected to vary between 5 and 35 m thickness.

2.2.2 Tertiary Formation

The Tertiary Formation may vary between 5 and 75m in thickness and is subdivided into three units in the following sequence:

- Tertiary Alluvium: Tertiary Alluvium comprises red clay with trace to minor percentage of iron minerals. The fragments within this unit are very small in size and well sorted;
- Tertiary Detritals: comprise coarse to medium size fragments of Hematite, Goethite Hematite and Magnetite, with minor to major percentages of chert fragments and partially cemented within the red clay matrix; and
- Tertiary Canga: consists of major Hematite, Goethite Hematite and Magnetite fragments cemented with or without traces of silica and clay. Generally the fragments are sub-rounded to sub-angular in shape.

2.2.3 Weeli Wolli Formation

The Weeli Wolli Formation is approximately 300 m in thickness and consists of chert and shale with minor BIF bands, intruded by dolerite sills.

2.2.4 Brockman Iron Formation

The Brockman Iron Formation is divided into four members (Yandicoogina Shale, Joffre, Mt Whaleback and Dales Gorge) and is the host of the iron ore in the Iron Valley Project Area. The Brockman Iron Formation ranges in thickness between 500 m at Paraburdoo to 620 m at Tom Price, and comprises alternating beds of BIF, chert and shale.

2.2.4.1 Yandicoogina Shale Member

The Yandicoogina Shale Member (~60 m) consists of interbedded chert and shale, locally intruded by dolerite sills.

2.2.4.2 Joffre Member

The Joffre Member is approximately 360 m in thickness and contains predominantly BIF units with minor thin shale bands. It has been sub-divided informally into six units (strands) named from the base upwards as J1 - J6. Strands J1, J3 and J5 contain more shale than J2, J4 and J6.

2.2.4.3 Whaleback Shale Member

The Whaleback Shale Member is approximately 50 m in thickness, and consists of alternating bands of shale.

2.2.4.4 Dales Gorge Member

The Dales Gorge Member is approximately 150 m in thickness and is an alternating assemblage of 17 BIF macro-bands and 16 shale macro-bands.

2.3 Structural Setting

The regional structure of the Project is an anticline (fold) of the Brockman Iron Formation which plunges in a southerly direction. There are a series of folding structures outcropping on the hills, with fold axes trending in the northeast to southwest direction, and major structures trending a northeast/southwest direction.

The Iron Valley deposit is bisected by a dolerite dyke (Dyke), which trends in a northeast to southwest direction splitting the main orebody. A north-south trending fault also intersects the tenement, and is located through the middle of the orebody.

2.4 Local Hydrogeology

A Phase 1 Pre-Feasibility Groundwater Assessment has been undertaken for the site by URS. This describes the local hydrology, which is summarised below.

The general hydrogeological setting indicates that one of the important regional aquifers in the area is the valley fill/detritals, covering a large area of the model and is located in the lower lying areas and associated with creek beds. The valley fills and detritals are connected with weathered rock formations just below the topographic datum. The orebody straddles a younger east-west striking dolerite intrusive dyke. This Dyke creates a local compartment with a large 40 m head difference across it in a north-south direction.

2.5 Surface Hydrology

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.

2.6 Topography

The following information has been ascertained from LIDAR data supplied by IOH. Below provides a description of the topography, and a figure showing the topography is included as Figure 4.

The western edge of the site is dominated by an escarpment, striking north-east to south-west. The escarpment drops in height from approximately 590 m AHD in the north-east to 535m AHD in the south west of the project area. The slope angle of the eastern slope of the escarpment is approximately 10 degrees, with a drop of 70m in height over 400m. There are a number of gulleys in the escarpment, and a larger valley in the approximate location of the Dyke (see Section 2.2 Local Geology). To the east of the escarpment, in the centre of the project area is a valley with an elevation of approximately 480m AHD in the centre of the valley. There is a ridge in the centre east of the project area, which rises to approximately 500m AHD.

There is a hill in the north-west corner of the site, which rises to 510m AHD, with a slope angle of approximately 6 degrees. The south eastern part of the site is generally flat and level.

2.7 Land Systems and Soils

The information on landform and soils presented in this section is based on work undertaken by Vreeswyk et al., (2004) for the Pilbara region. Land systems are comprised of repeating patterns of topography, soils, and vegetation (i.e. a series of landform units that occur on characteristic physiographic types within the land systems). It should be noted that a landform system might be 10-100,000 km² in area while a landform unit is in the order of 1-10 km² in area. As such it should be noted that the footprint of the proposed disturbance area would be expected to contain only a few landform units.

Surveys of the rangelands within the Pilbara Region (van Vreeswyk et al. 2004) were undertaken on behalf of the (now) Department of Agriculture and Food, Western Australia. The land system mapping and survey provided a description of biophysical properties and resources within the region, as well as an evaluation of the soil and vegetation condition.

The project area is located on two land systems: the Boolgeeda and Newman. These land systems are described in detail below, and are shown on Figure 3.

2.7.1 Boolgeeda Land System

The Boolgeeda Land System is characterised by the following, and the associated landform units are summarised in Table 2-1:

- Geology: Quaternary colluvium;

- Geomorphology: Predominantly depositional surfaces; very gently inclined stony slopes and plains below hill systems becoming almost level further downslope; closely spaced, dendritic and sub-parallel drainage lines;
- Relief up to about 20 m;
- Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands;
- Land management: Hard spinifex grasslands are not preferred by livestock but soft spinifex is moderately preferred for a few years following fire. Vegetation is generally not prone to degradation and the system is not susceptible to erosion. The system is subject to fairly frequent burning;

Table 2-1 Boolgeeda Land System Landform Units

Unit No.	Landform	Soil
1	**Low hills and rises -** isolated hills and low rises usually <500 m in extent, surface mantles of very abundant pebbles and cobbles of ironstone, basalt and other rocks; relief up to 20 m.	Stony soils and red shallow loams.
2	**Stony slopes and upper plains –** very gently inclined slopes and upper interfluves immediately downslope from adjacent hill systems, dissected up to 5 m by dendric or sub-parallel small creeklines, surface mantles of common to very abundant pebbles of chert ironstone, quartz and other rocks	Red shallow loams or re loamy earths.
3	**Stony lower plains –** almost level plains downslope from Unit No. 3, surface mantles vary from few to very abundant ironstone and other pebbles; subject to sheet and channelised flow.	Red loamy earths
4	**Groves –** small (up to 20 m long) arcuate drainage foci occurring infrequently on Units 2 and 3.	Red loamy earths
5	**Narrow drainage floors and channels –** dendritic and parallel flow zones and creeklines on slopes and plains (Units 2 and 3), only 5 to 10 m wide in upper parts becoming wider on lower plains, larger channels may be braided and incised up to 3 m.	Red loamy earths and minor self-mulching cracking clays. Channels with river bed soils.

2.7.2 Soils within the Boolgeeda Land System

2.7.2.1 Stony soils

The majority of stony soils occur within the extensive areas of hills, ranges and upper stony plains and are very shallow to shallow (<25-50 cm) and skeletal or poorly developed. The soils vary depending on the nature of the parent rock. The parent material is mostly basalt, granite or sedimentary rocks such as sandstone and shale and, less frequently, metamorphic rocks. The soils formed on basalt, shale or metamorphic rocks tend to have texture ranges from fine sandy loam to loam or clay loam. Soil colour is dark reddish brown to dark red and soil reaction is generally acidic to neutral. Some soils are alkaline and may contain calcium carbonate derived from weathered rock.

Soils developed on granite rocks tend to have lighter textures ranging from loamy coarse sand to sandy loam. Soil colour is mostly dark red and soil reaction is acidic to weakly acidic. A heavy stony mantle mostly protects the stony soils. Stone or rock may comprise 20-80% of the soil profile. Outcropping rock is a feature of this soil group and some soils may contain ironstone gravel.

2.7.2.2 Red Shallow Loams

These soils are shallow loams often overlying weathered rock. The thin (1-10 cm) topsoils range from sandy loam to clay loam and overlie thin to medium (10-30 cm) subsoils of sandy clay loam or clay loam. Some soils have uniform textures throughout the soil profile. The main type of underlying rock is basalt, shale or schist and less commonly the soils may overlie hardpan or gravel. Many soils have acid to neutral soil reaction trends. Soils occurring on or with dolerite, some shales and basalts tend to be alkaline. The alkaline soils tend to contain carbonates either partly or completely through the soil profile. Soil properties can be variable depending on parent material. The soils are mostly dark reddish brown in colour and non-saline.

Shallow loams on basalt or shale occur on the hillslope, lower footslope, low rise and stony plain land units. Shallow loams on gravel occur on the lateritic plain, lower footslope and stony plain land units. Shallow loams occur on a wide variety of other units, although generally are not dominant.

2.7.2.3 Red Loamy Earths

Red loamy earths soils exhibit thin to medium (10-30 cm) loam to clay loam topsoils overlying thick (30-60 cm) lay loam to light clay subsoils. The soils are deep but occasionally have substrates of red-brown hardpan, granite or banded ironstone at moderate depth (80-100 cm). The soils are dark reddish brown in colour, non-calcareous, non-saline with neutral to slightly alkaline soil reaction trends. The soils have either common to abundant (10->50%) cryptogam crusts or common to abundant (10->50%) stony mantles. Many soils occurring on footslopes, hillslopes, stony plains and laterite plains, are deep with common to abundant (10- >50%) stones or gravels through all or most of the soil profile. Red loamy earth soils occurring in broad drainage zones, groves or open plains tend to be stone free apart from occasional surface mantles.

2.7.2.4 Self-Mulching Cracking Clays

Self-mulching cracking clay soils are deep (>100cm) with thin to medium (10-30 cm) light, silty or medium clay topsoils. Occasionally the topsoils may include a thin (1-10 cm) layer of clay loam. The thick to very thick (>60 cm) subsoils have textures of medium to heavy clay or, less frequently, light clay. The uppermost layers of these soils exhibit large surface cracks or have crumbly (self-mulching) surfaces when dry and often show rough mounded (gilgai) surfaces. Large areas of cracking clays tend to show zonations of varying amounts of surface cracking. Soil colour is mainly dark reddish brown to red, soil reaction is alkaline and many soils contain some carbonates within at least part of the profile. Surface mantles of fine ironstone pebbles are common to abundant. The soil surfaces are generally non-saline with deep sub soils being partially saline. On upland areas large boulders of basalt occur on the soil surface and throughout the soil profile. Cracking clay soils often occur with or adjacent to, deep red/brown non-cracking clay soils and are susceptible to gullying where found on undulating plains.

2.7.2.5 Channels with River Bed Soils

Most of the soils within this group are either poorly developed or occur as a minor component in relation to the complete survey area. The poorly developed soils are juvenile or recent alluvial deposits associated with active drainage channels, levees, or flood plains of major and minor creek or river systems. These soils exhibit sediment layers of coarse loose sand, clayey sand, silty sand and silty clay. Layers containing water-worn rocks, boulders and pebbles often occur through the profile. Soil depth is mostly variable and dependent on the location within the landscape catena. Where soil depth is less than one metre the soil is often underlain by rock, calcrete or occasionally red-brown hardpan. These soils may also occur in drainage foci or other low-lying areas receiving major run-on.

The juvenile soils are mostly weakly acidic to neutral (pH 6.0-7.5) and non-saline although saline juvenile soils may occur as localised areas within or adjacent to some drainage foci and the coast. Soil colour varies from dark red to strong brown.

2.7.2.6 Red Shallow Sands

These soils are uniform textured coarse sands or medium textured sands overlying weathered granite, sandstone or red brown hardpan at shallow (25-50 cm) depth. Some soils occur over substrates such as conglomerate or quartz and are incorporated into this group. The soils are red to dark red in colour and non-calcareous with a weakly acidic to neutral soil reaction trend. The soils are mostly found within or adjacent to the parent rock resulting in gritty sands. The lower subsoil mostly overlies partially weathered granite rock and coarse fragments of quartz and granite are common throughout the profile. These soils often have a common to abundant (10- >50%) stony mantle. Slightly saline soils may infrequently occur at the base of occasional large granite domes or outcrops. Domes and tors of bare rock are included in this soil group.

2.7.3 Newman Land System

The Newman Land System is characterised by the following, and the associated landform units are summarised in Table 2-2 and shown in Figure 4;

- Geology: Lower Proterozoic jaspilite, chert, siltstone, shale, dolomite and minor acid volcanics;
- Geomorphology: Erosional surfaces; plateaux and mountains - extensive high plateaux, mountains and strike ridges with vertical escarpments and steep scree slopes and more gently inclined lower slopes; moderately spaced dendritic and rectangular tributary drainage patterns of narrow valleys and gorges with narrow drainage floors and channels;
- Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands;
- Relief up to 450 m; and
- Land management: Much of the system is inaccessible or poorly accessible and is unsuitable for pastoral purposes. The system contains iron ore deposits which are currently being mined and deposits which are likely to be mined in the future. Spinifex is the dominant vegetation and the system is burnt fairly frequently.

Table 2-2 Newman Land System Landform Units

Landform	Soil
Plateaux, ridges, mountains and hills - mountain tracts, plateaux and strike ridges, relief up to 400 m; level or rounded plateaux summits and mountain crests, ridges and indented escarpments with vertical upper cliff faces and moderately inclined to very steep upper scree slopes; surface mantles of abundant to very abundant pebbles, cobbles and stones of ironstone, jaspilite, chert and other rocks. Also outcrop of parent rock.	Stony soils, red shallow loams and some red shallow sands
Lower slopes - gently inclined concave slopes mostly less than 400 m in extent with mantles of very abundant pebbles and cobbles of ironstone and other rocks.	Stony soils on upper margins with red loamy earths on lower margins.
Stony plains - gently undulating lower plains and interfluves up to 500 m in extent with mantles of abundant to very abundant pebbles of ironstone.	Stony soils, red shallow loams and some red shallow sands
Narrow drainage floors with channels - almost level floors up to 400 m wide but usually much less in valleys, mantles of abundant pebbles of ironstone and other rocks; channels up to 200 m wide with cobble bedloads.	Stony soils on upper margins with red loamy earths on lower margins.

2.7.3.1 Newman Land System Soil Types

The following soil types are present in the Newman Land System (Vreeswyk et al., 2004):

- Stony Soils (described above);
- Red Loamy earths (described above); and
- Red shallow sands (described above).

Field Methodology

The following section summarises the site inspections completed as part the Preliminary Study.

3.1 Health, Safety and Environment Plan

Prior to commencing fieldwork a site-specific URS Health, Safety and Environment Plan (HSEP) was prepared. The plan detailed potential hazards associated with the site inspection, the methods used to minimise identified hazards, and plans for implementation of emergency procedures in case of an incident or accident.

3.2 Site Layout

The most recent aerial image of the site, superimposed with the proposed site infrastructure, is illustrated in Figure 2.

3.3 Landform Description

A site inspection for the purpose of describing landforms and surface soils was undertaken by URS field staff on 13 July 2012. Landform patterns and features were inspected and recorded with the aim of ground-truthing the topographical features and landforms recorded as part of the literature review summarised in Section 2. Slope angles were estimated using a topographical map (Figure 4). Landform units have been described in Section 4 based on their gross physical features such as elevation and/or relief, drainage, and to a certain extent, soil type.

The landform descriptions were undertaken from a number of key viewpoints across the site. To aid in description a number of photographs were taken which are included in Plates 1 to 20 (see Plates section).

Field Observations

The following section summarises field observations completed as part of the soils and landforms site inspection.

4.1 Field Observations

4.1.1 Landforms of the Site

A landform site inspection of the Project Area was conducted on 13 July 2012 in order to identify the landforms identified in the desktop review and to assess lesser landforms not identified on aerial photography.

Locations were selected based on the following criteria:

- Accessibility;
- Topography – high elevation allowing good viewing; and
- View of different landforms particularly where proposed infrastructures will be located.

Six locations were selected and from which observations of landforms were made towards the north, south, east and west. The observation locations are shown on Figure 4.

4.1.1.1 Observation Location 1

This location is on a rocky rise in the north east corner of the Project Area; at coordinates 50 K 0739846E/ 7485460N (see Plate 5). The rise slope angles are approximately 9 degrees leading to the summit of the rise.

West

At the base of the rise is a flat valley leading to a steep escarpment. The ore body and proposed main pit is located within the valley. The steep escarpment is higher than the observation location and has a number of gulleys (see Plate 1 and Plate 4).

North

A steep slope towards the valley floor, then largely flat towards the tenement boundary and Weeli Wolli Creek (see Plate 2). One of the satellite pits is located within this area.

East

A steep slope towards a flat valley, denoting the tenement boundary, leading to Weeli Wolli Creek. This leads to a high escarpment in the far distance (see Plate 3).

South

A shallow slope leading to a gulley, then rising to a second rock rise (see Plate 6).

4.1.1.2 Observation Location 2

This location is on a rocky rise directly south of observation location 1; at coordinates 50 K 0739733E/ 7485346N (see Plate 9).

4 Field Observations

South West

Looking south west across a slightly undulating valley floor, towards a steep escarpment. The escarpment reduces in height to the south (see Plate 7). This view looks towards one of the proposed waste dumps.

4.1.1.3 Observation Location 3

This location is located in the centre of the northern part of the Project Area, at coordinates 50 K 0737666E/ 7485528N. The location is flat, with sparse vegetation. A small hand dug pit indicated that the soil is reddish brown sandy gravel with rare rootlets, becoming more sandy at depth (see Plate 11).

East

To the east is a flat valley, containing the orebody, towards a rocky rise. (see Plate 10).

North-west

To the north-west is flat valley with a rocky escarpment in the near distance (Plate 12 and Plate 13).

4.1.1.4 Observation Location 4

This location is situated on lower slope of an escarpment in the north western part of the Project Area, at coordinates 50 K 0737662E/ 7485528N. The location is gravelly with sparse vegetation. The slope at this point has a shallow slope angle of approximately 6.5 degrees.

North-east

The landscape is flat towards a rocky escarpment in the far distance. The proposed main pit will be located within the valley (Plate 14).

North

Looking upslope towards the summit of the escarpment. There are a number of gulley's and erosion channels in the escarpment. The slope angle increases towards the summit to approximately 7 degrees (Plate 15).

South-east

A flat valley leading to a slight rise (Plate 16).

South

The ridge line continues south (Plate 17).

4.1.1.5 Observation Location 5

The location is situated on the lower slope of an escarpment which will be removed as part of the pit excavation, at coordinates 50 K 0737899E/ 7485030N. The soil in this area appears to be of poor quality with sparse vegetation (Plate 18).

4 Field Observations

4.1.1.6 Observation Location 6

The location is situated in the southern corner of the Project Area, at coordinates 50 K 0736093E/ 7480515N. The location is on the top of a small rise, with a shallow slope angle.

Looking north across the Project Area the landscape is flat with a rocky escarpment in the near distance (Plate 19). A number of drainage systems can be seen where the vegetation is more dense.

The southern and eastern view from Observation Location 6 is outside of the tenement boundary.

4.1.1.7 General Observation

The project area encompasses rises, plains and drainage tracks with elevations ranging from 470m to 575m AHD. Higher elevation is found on the western side of the project area, with a high point in the north eastern corner. More rocky outcrops were observed on rises than on plains.

The project area has a number of tributary drainage channels in the southern part of the project area, running from west to east towards Weeli Wolli Creek (as shown in Plate 20). Soils were inspected in one of the drainage lines and consisted of coarse loose sand with some fines content.

5 Discussion of Results

All results obtained from field observations have been interpreted to identify the following.

5.1 Impacted Landform Units

The landform units most likely to be impacted by the proposed infrastructure are detailed in Table 5-1

The estimated amount of each land system which may be impacted is given below, along with the dominant landform and primary soil type. This will give an indication of the expect soils which may be excavated as part of the mining works.

Table 5-1 Impacted Landform Units

Mining Infrastructure	Area (ha)	Land System with Area Impacted	Dominant Landform	Primary Soil Type
Stage 1 Pit	22	Newman	Lower Slopes	Stony soils
Stage 2 pit	109	Newman (35 ha)	Lower Slopes	Stony soils
		Boolgeeda (74 ha)	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)
Stage 3 Pit (Large)	90	Newman (7 ha)	Lower Slopes	Stony soils
		Boolgeeda (83 ha)	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)
Stage 3 Pit (Small 1)	16	Boolgeeda (15 ha)	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)
		Newman (1 ha)	Lower Slopes	Stony soils

5 Discussion of Results

Stage 3 Pit (Small 2)	9	Boolgeeda (6 ha)	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)
		Newman (3 ha)	Lower Slopes	Stony soils
WRL Stockpiles	137	Newman (100 ha)	Lower Slopes	Stony soils
		Boolgeeda (37 ha)	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)
Topsoil Storage	13	Newman	Lower Slopes	Stony soils
Camp Area	18	Newman	Lower Slopes	Stony soils
Ancillary Infrastructure	257	Boolgeeda	Stony lower plains	Red loamy earths
			Narrow drainage floors and channels (limited to drainage channels)	River bed soils (channels)

5.2 Soil Structure and Stability

Soil structure describes the arrangement of solid particles and void space in soil. It is an important factor influencing the ability of soil to support plant growth. Soil pedality (soil macro structure and shape of soil aggregates) is an important factor in allowing root penetration and changes to soil properties due to moisture fluctuation.

The ideal soil structure has a large proportion of aggregates from 0.5 to 2 mm which are not easily broken down. It has high porosity for water entry and gas exchange, low strength, is stable when wet or mechanically disturbed, and aggregates can reform if subjected to adverse management (Moore, 2001).

Soil stability is influenced by soil structure and soil chemistry. Chemical properties of organic materials encountered and clay materials present influence the binding characteristics of soil aggregates and soil pedality (if present).

The soil structures for each potentially impacted soil type are given in Table 5-2 below (van Vreeswyk et al. 2004).

Table 5-2 Soil Structure

Soil Type	Description
Red loamy earths	Loam to clayey loam with abundant (10 to >50%) stones or gravel (2 to 60 mm). Non-calcareous, non-saline. Apedal topsoils with occasional pedal subsoils. Earthy topsoils with earthy or pedal subsoils. Massive topsoils and massive or moderate to strongly pedal subsoils. Nil to complete topsoil slaking. Mostly non-saline.
Stony soils	Fine sandy loam to loam of clay loam. Stone or rock may comprise 20 to 80% of the soil profile. Skeletal or poorly developed. May contain ironstone gravel. Apedal, earth and massive to weakly structured. Variable topsoil slaking. Non-saline.
River bed soils (channels)	Layers of coarse loose sand, clayey sand, silty sand and silty clay. Layers containing water-worn rocks, boulders and pebbles often occur through the profile. Poorly developed or occur as a minor component in relation to the complete survey area. The juvenile soils are mostly weakly acidic to neutral and non-saline although saline juvenile soils may occur as localised areas.

The limited soil observations undertaken during the inspection have suggested the red loamy earths, which cover the majority of the proposed infrastructure areas, have a small proportion of aggregates, and this soil type may have a degree of pedality. This suggests that the soil may have some fine content, and be suitable for rehabilitation works. However, depending on the fines content, the soil may structurally decline if reworked and used as a capping.

The limited soil observations have suggested the stony soils, which cover the minority of the proposed infrastructure areas, have large amounts of aggregates and are poorly developed and apedal. It is unlikely that these soils will be suitable for capping material.

For the red loam soils and stony soils, pH values may range between 6 and 9. The ideal pH range for plant growth of most agricultural species is considered between 5.0 and 7.5 (Moore, 2001), however native species have generally adapted to, and are able to tolerate a soil pH outside of this range.

River bed soils are unlikely to be present in significant quantities and confined to drainage channels, as such will do not comprise a reliable resource for capping material.

5.3 Soil Compaction

It is generally recommended that minimal soil compaction is conducted during earthworks so as not to impede growth and development of native plants. Soil must retain enough interconnected void space to allow storage and passage of air and water in the soil. Some degree of compaction is needed after planting or insertion of cuttings to close large voids and to provide suitable soil density for appropriate plant growth. Too much void space can lead to poor contact and desiccation of a seed or cutting from the surrounding soil.

Optimal conditions occur when there are enough large pores to transmit water readily, but also enough small pores to retain and store water. Therefore, plants do better in well-compacted, uniform, sandy soils with relatively low porosity (high relative density) or in well-graded sands where sufficient fines (silts and clays) are present to provide moisture retention.

The ideal soil for rehabilitation use should be well graded as this material will have good moisture retention capabilities with a PSD range that will give good infiltration values while minimising erodibility to both wind and water. The surface soils observed on site, namely the read loam and stony soils, showed a small resistance to penetration, and as such may be described as loose to medium dense.

The stony soils are well graded, however, appear to have a low fines content, making them unsuitable for rehabilitation. The red loamy earths appear to have some degree of fines present, so may represent good rehabilitation material. Careful management of the rehabilitation process is likely to aid this process.

5.4 Nutrient Availability

No nutrient information was available in published literature; however, assuming a worse-case scenario, soils of this nature generally have nutrients in low concentrations. However, this would be typical of weathered ancient soils and generally native species have adapted to these conditions.

5.5 Land Susceptibility

Landform units within land systems have properties which influence the type and intensity of use that can be applied to the unit. Soil chemical and physical characterisation together with other factors need to be taken into consideration when determining land capability for various land uses.

Factors such as erosion hazard and flood risks should be used in conjunction with the recommended physical and chemical testing (as detailed in Section 5.7 for the determination of land capabilities, with specific bias toward rehabilitation.

5.5.1 Soil, Land Attributes and Land Capability

Table 5-3 provides some guidance for management issues for land units located within the site, by providing indication on susceptibility to erosion in the form of a risk assessment. This table should be used in conjunction with other physical and chemical characteristics identified for these soils. The erosion hazard ratings were extracted from *An Inventory and Condition Survey of the Pilbara region, Western Australia: Technical Bulletin No. 92* (*Vreeswyk et al, 2004*).

5 Discussion of Results

Table 5-3 Erosion Susceptibility and Pastoral Value Ratings

Landform	Main Soil Types	Pastoral Value	Erosion Hazard	
			Water	Wind
Stony Lower Plains	Red loamy earths	Low	Low to moderate	Low
Lower slopes	Stony soils	Low	Low (due to stony mantle and rock outcrop)	Low (due to stony mantle and rock outcrop)
Narrow drainage floors and channels	River bed soils (channels)	n/a (limited extent)	H	H

Based on these classifications, the soils located within the site have very low erosion risks with low pastoral value. Many of the land surfaces of the site are protected from erosion in a number of ways such as (*Vreeswky et al, 2004*):

- Common gravelly and stony mantles;
- Rock outcrops;
- On the valley floor, there are generally low to gently inclined slopes which promote low velocity diffuse sheet flow.; and
- Vegetation cover on the valley floor.

The soils surface tends to have moderate to abundant gravelly to stoney mantles on relatively level or sloping land surfaces and more abundant rocky outcrops on rises and low rises. When the vegetation cover and gravelly mantle is removed by earth moving operations, the soil will then be prone to accelerated wind and water erosion.

The flood risk factor for the red loamy earths is moderate, indicating moderate flooding frequency. The flood risk factor for stony soils is nil. The flood risk factor is land form dependant and these soils may potentially erode as a result of sheet flooding in a 1:5 year rainfall event. This is with the exception of drainage channel soils, which are at a higher risk of flooding, which may be present within the mine pit areas. Red loamy earths in stony lower plains may exhibit slower drainage in relation to catchment runoff, whereby soils may be waterlogged for greater than one day.

5.6 Conclusion

In regards to rehabilitation of the project area at the cessation of mining activities, the following conclusions may be drawn about the usefulness of the soils observed within the footprint of the proposed work:

- Three primary soil types were observed in the Project Area;
  - Red loamy earths;
  - Stony soils; and

- River bed soils (channels).

- The areas with stony soils have large amounts of aggregates and are poorly developed and apedal. It is unlikely that these soils will be suitable for capping material;
- River bed soils are not present in significant quantities and confined to drainage channels, as such will do not comprise a reliable resource for capping material;
- The limited soil observations undertaken during the inspection have suggested the red loamy earths, which cover the majority of the proposed infrastructure areas, have a small proportion of aggregates, and this soil type may have a degree of pedality (structure);
- It is likely that the carbon percentage of soils is low. Careful supplementation of organic nutrient media may increase capacity for the soil to revegetate;
- Stony soils are described in literature as having variable slaking at surface, indicating a low clay content and therefore prone to dispersion. The red loamy earth has been described as having partial to complete soil slaking, indicating variable dispersion. Therefore careful management of slopes and erosion barriers will be required; and
- Soils from the red loamy earth soil unit may produce a sufficient volume of soils with a clay content suitable for construction of engineering surface.

Plants do better in well-compacted, uniform, sandy soils with relatively low porosity (high density) or in well graded sands where sufficient fine (silts and clays) are present to provide moisture retention. The stony soils do not appear to provide these conditions, however, the red loamy soils may provide better conditions.

The soils located within the project area are likely to be soils with limited hard-setting surfaces and with relatively medium to coarse topsoil textures exhibiting low moisture retention. When vegetation cover and gravelly or stony mantle are removed and the surface materials are disturbed by earth moving operations, the earthy fabric of the soils will be destroyed and the single grained fabric of these materials will then predispose them to accelerated wind and water erosion.

In addition, the finished shape of the project infrastructure will likely result in much larger surface area than the original footprint of the infrastructure. Therefore, insufficient topsoil may be recovered from disturbed areas and retained for rehabilitation to cover the final landforms to allow suitable depth for re-vegetation (dependant on outcomes of further site investigation as detailed in Section 5.7). Additional topsoil may be obtainable from elsewhere on site and it is possible that some of the vegetation species in the area can grow reasonably well on thin soil mantles overlying the harder bedrock. Careful design of micro-relief features on the capping and topsoil will provide more advantageous conditions to the indigenous vegetation (such as increased water retention) and is likely to result in more successful rehabilitation.

5.7 Recommendations for Further Work

While this desktop study provides general guidance as to the suitability of soils on site for rehabilitation, prior to Project construction it is likely that a site investigation will be required in order to confirm the conclusions of this report and provide additional information on soil profile and chemistry. The following provides an indication of the works which may be required to confirm the conclusions of this report.

5 Discussion of Results

Tongway et al (updated 2005 "*Procedures for Monitoring and Assessing Landscapes, with Special Reference to Minesites and Rangeland, CSIRO"*) provides general guidance as to site investigations for soils and landforms. URS has also undertaken extensive consultation with the DMP with regards to the requirements for site investigations for soils and landforms assessments. From this guidance, it is recommended that any future site investigation may include the following:

- Undertake sampling from 5 sampling locations per land form identified, therefore approximately 15 sampling locations. Sampling will target areas which will be disturbed by mining operations e.g. proposed pit areas, waste dump area, accommodation area and process area.
- The completion of soil profiling in accordance with McDonald et al (1998), to include horizonation due to colour change and texture change, the presence of pans, ferricrete zones or non-ferricrete gravels, the nature of the horizon boundaries, texture, structure, colour and fabric;
- Completion of a number of in-situ field tests/observations from ground surface to 0.05 m, 0.10 m to 0.20 m and 0.5 m bgl to aid in soil classification. Field tests/observations would include roots (size, depth of penetration and abundance), field dispersion and slaking tests, field pH/EC, depth to free water and water repellence;
- Collection of topsoil and subsoil layers for analytical testing at the proposed depths from ground surface to 0.05 m, 0.10 m to 0.20 m and 0.5 m bgl. Based on soil logs, representative samples of the topsoil and subsoil will be submitted for a range of analytical tests;
- Soil samples would be tested for the following;
  - Selected metals;
  - Selected nutrients;
  - Selected cations and anions;
  - pH;
  - Salinity; and
  - Total organic carbon.

Following the site investigation, this report would be updated to take account of the further work.

References

Astron Environmental Services. (2012). Iron Valley Project – Flora and Vegetation Survey.

Bruce, R.C. and Rayment, G.E. (1982). Analytical Methods and Interpretations Used by the Agricultural Chemistry Branch for Soil and Land Use Surveys. Queensland Department of Primary Industries Bulletin No. QB2004, Brisbane.

Department of Mines and Petroleum (2006). Guidelines for Mining Proposals in Western Australia. Department of Mines and Petroleum, February 2006, Perth.

Geological Survey of Australia (GSWA), (1979). 1:100 000 Geological Map series Weeli Wolli Sheet (Sheet 2752)

INAP, 2012. Global Acid Rock Drainage Guide. The International Network for Acid Prevention. Online. www.gardguide.com. Accessed May 2012.

King, P.M (1981). Comparison of methods for measuring severity of water repellency of sandy soils and assessment of some factors that affect its measurement. Australian Journal of Soil Research 19, 275-285.

McMullen, B (2000). Soilpak for Vegetable Growers. New South Wales Department of Primary Industries. Online document available: http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/vegetable. Accessed 22 April 2012.

Moore, G. (2001). Soil Guide: A Handbook for Understanding and Managing Agricultural Soils. Department of Agriculture, Bulletin 4343, Perth.

National Committee on Soil and Terrain (2009). Australian Soil and Land Survey Field Handbook (3rd Edition). CSIRO Publishing, Collingwood, Victoria.

D J Tongway and N L Hindley (updated 2005). Procedures for Monitoring and Assessing Landscapes, with Special Reference to Minesites and Rangeland, CSIRO

URS. 2012. Iron Valley Project. Phase 2 Surface Water Study.

Van Vreeswyk, A.M.E., Payne A.L., Leighton K.A., Hennig P. (2004). An inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture Technical Bulletin No. 92, Perth;

Limitations

URS has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of IOH and only those third parties who have been authorised in writing by URS to rely on this 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 Proposal Number 3114333 dated 24 July.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared in July 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.

Except as required by law, no third party may use or rely on this Report unless otherwise agreed by URS in writing. Where such agreement is provided, URS will provide a letter of reliance to the agreed third party in the form required by URS.

To the extent permitted by law, URS expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. URS does not admit that any action, liability or claim may exist or be available to any third party.

Except as specifically stated in this section, URS does not authorise the use of this Report by any third party.

It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Plates

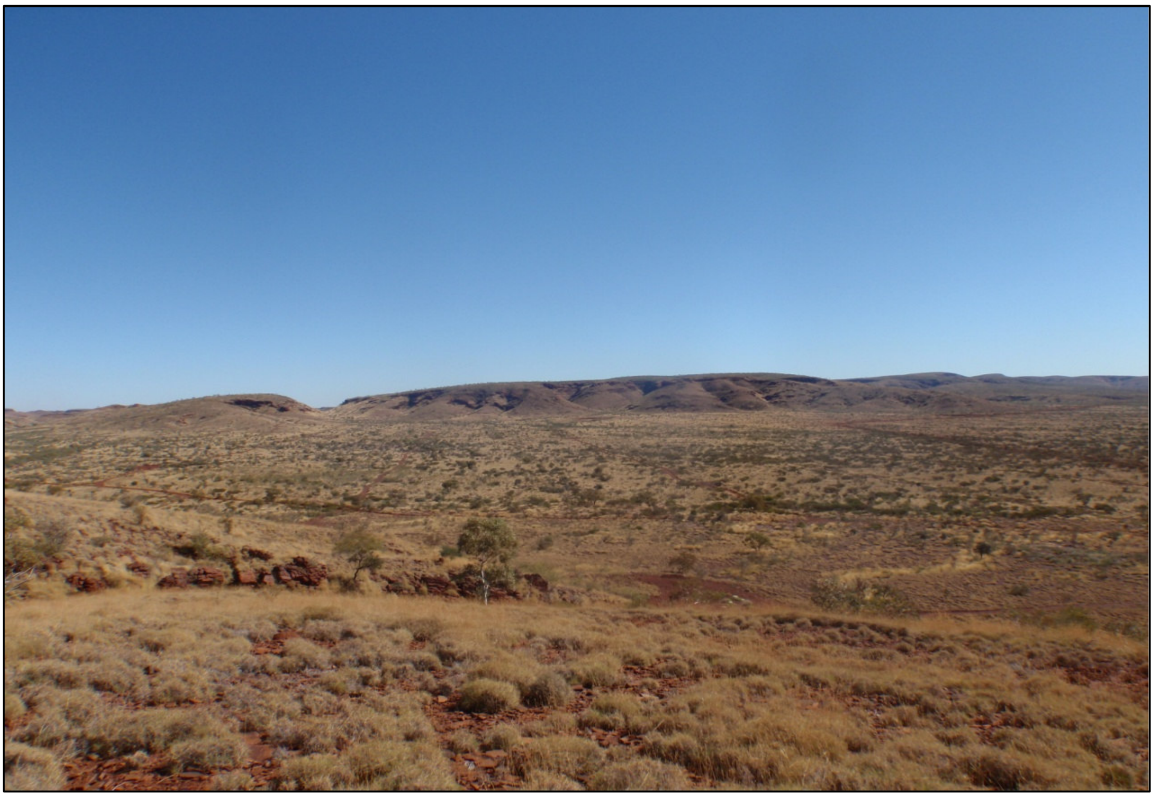


PLATE 1 Observation Location 1 - Looking west across valley towards escarpment

PLATE 2 Observation Location 1 - View north towards Weeli Wolli Creek and tenement boundary

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 1 & 2	Rev. A
	Job No.	File No.			A4

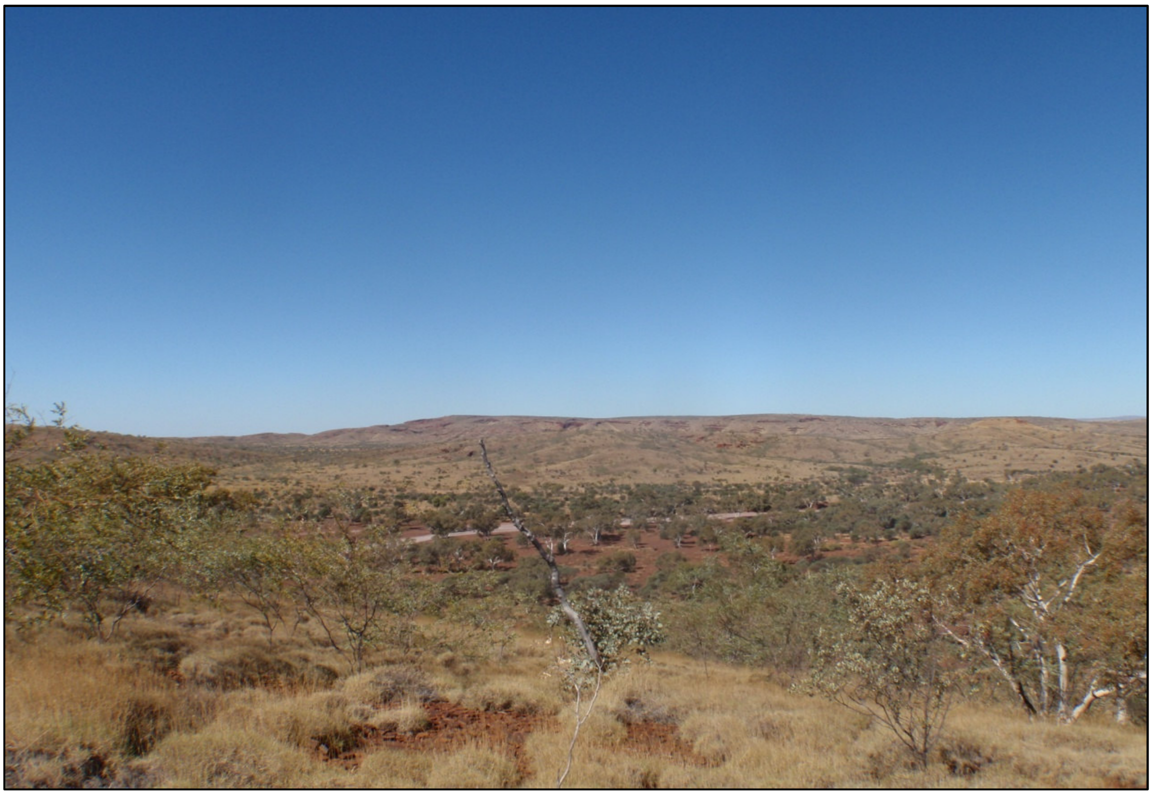


PLATE 3 Observation Location 1 - Looking east towards Weeli Wolli Creek

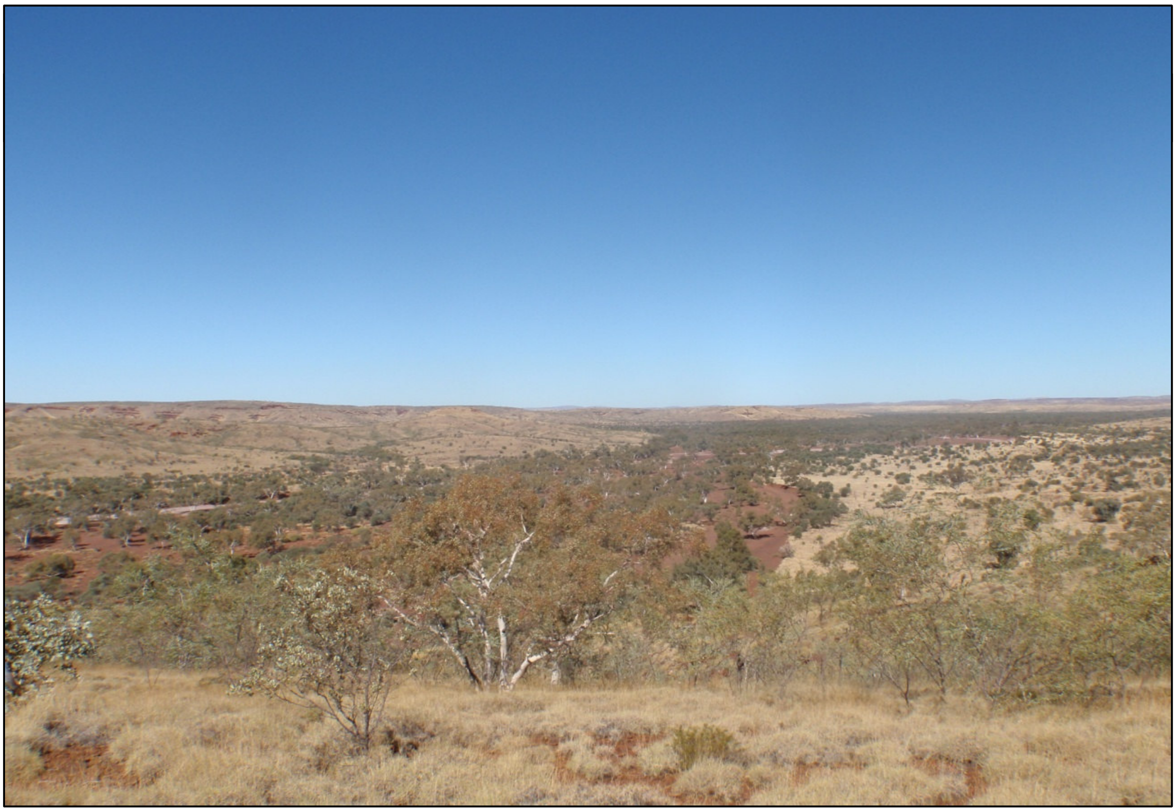


PLATE 4 Observation Location 1 - Looking south west across Weeli Wolli Creek flood plain

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 3 & 4	Rev. A
	Job No.	File No.			A4

PLATE 5 Observation Location 1 - Summit of rocky rise

PLATE 6 Observation Location 1 - Looking south towards Observation Location 2

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 5 & 6	Rev. A
	Job No.	File No.			A4

PLATE 7 Observation Location 2 - Looking south-west over the project area towards the former camp site

PLATE 8 Outcropping looking east from mid-slope towards Observation Location 1

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 7 & 8	Rev. A
	Job No. 42907964	File No.			A4

PLATE 9 Observation Location 2 - Looking east from mid-slope towards Observation location 2

PLATE 10 Observation Location 3 - Vegetation and soil cover, looking east across valley

Client:	Project:			Title:	
Iron Ore Holdings	Iron Valley Project			PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 9 & 10	Rev. A
	Job No. 42907964	File No.			A4

PLATE 11 Observation Location 3 - Subsurface soils

PLATE 12 Observation Location 3 - looking north west

Client:	Project:			Title:	
Iron Ore Holdings	Iron Valley Project			PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 11 & 12	Rev. A
	Job No. 42907964	File No.			A4

PLATE 13 Observation Location 3 - Looking west

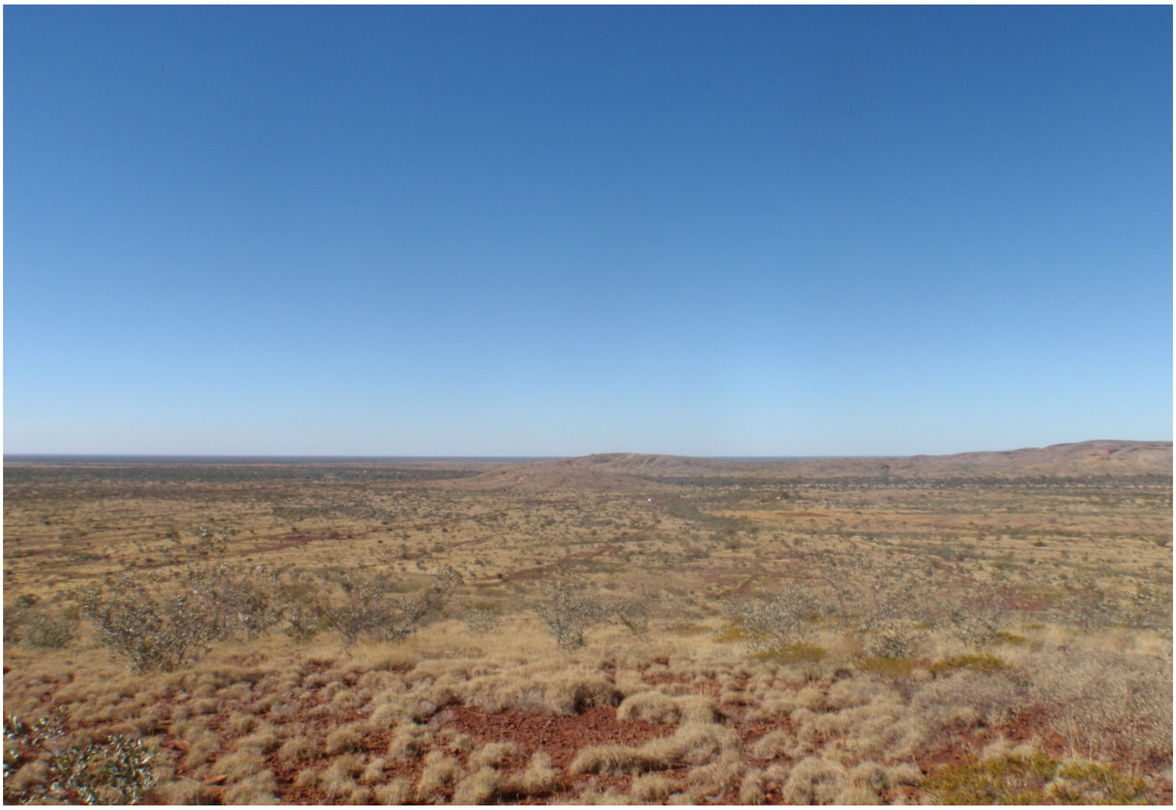


PLATE 14 Observation Location 4 -Looking north east towards Observation Location 1 in distance

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 13 & 14 / Rev. A
	Job No. 42907964	File No.		A4

PLATE 15 Observation Location 4 - Looking north towards higher escarpment

PLATE 16 Observation Location 4 - Looking south-east across valley

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 15 & 16	Rev. A
	Job No. 42907964	File No.			A4

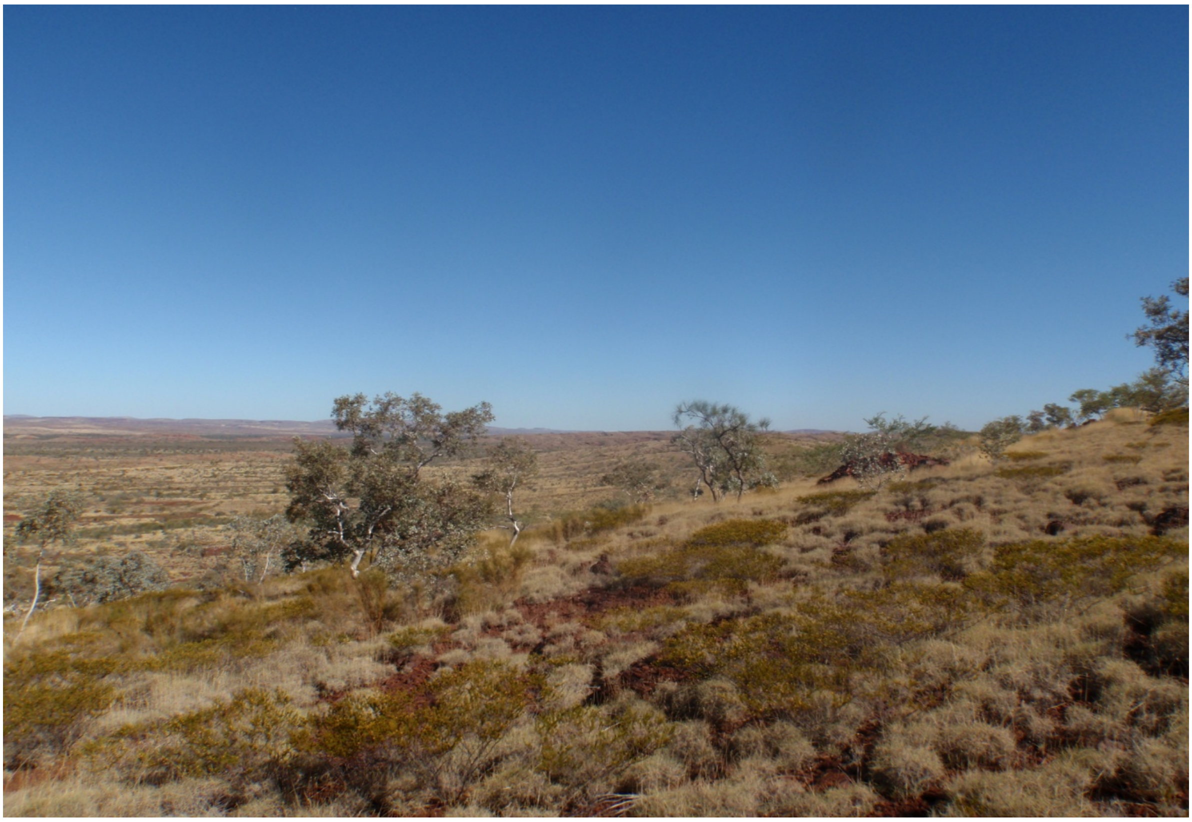


PLATE 17 Observation Location 4-Looking south along the ridge line

PLATE 18 Observation Location 5 - Looking north west

Client: Iron Ore Holdings	Project: Iron Valley Project			Title: PLATES	
URS	Drawn: MJ	Approved: DWG	17/07/2012	Plate: 17 & 18	Rev. A
	Job No. 42907964	File No.			A4

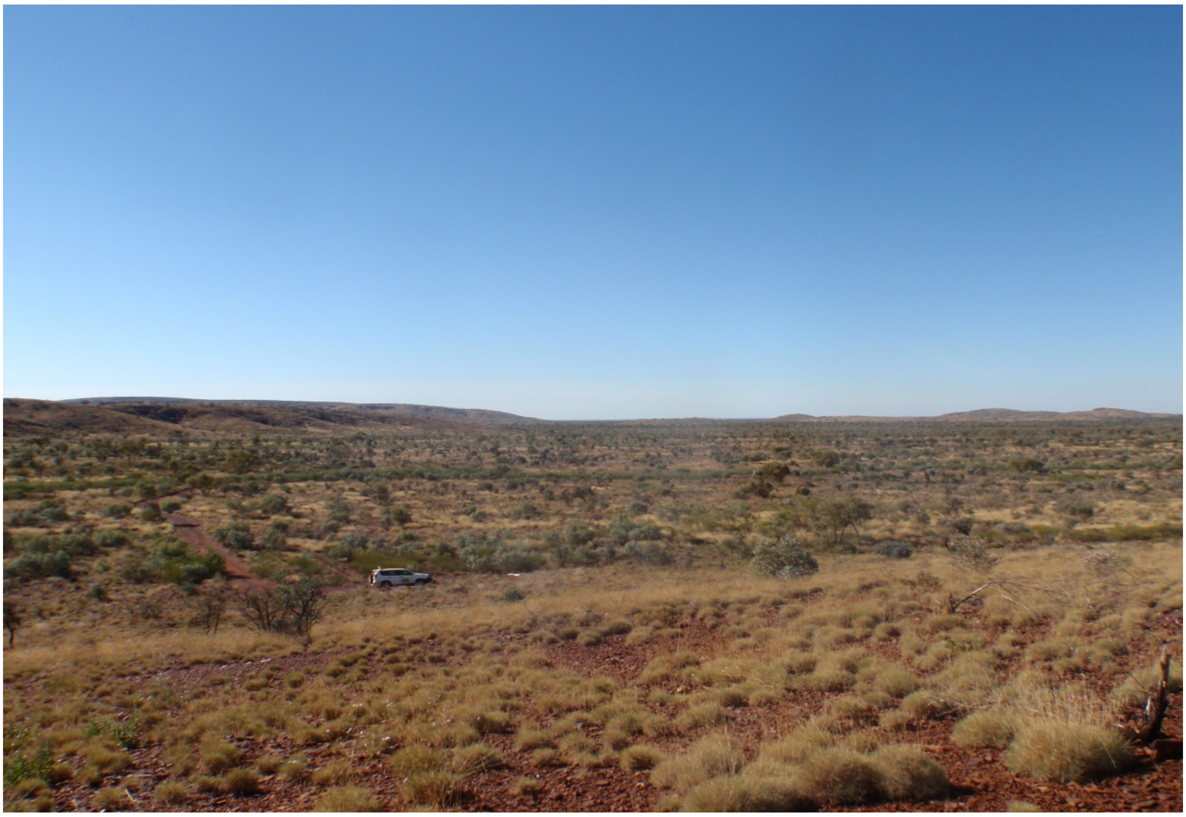
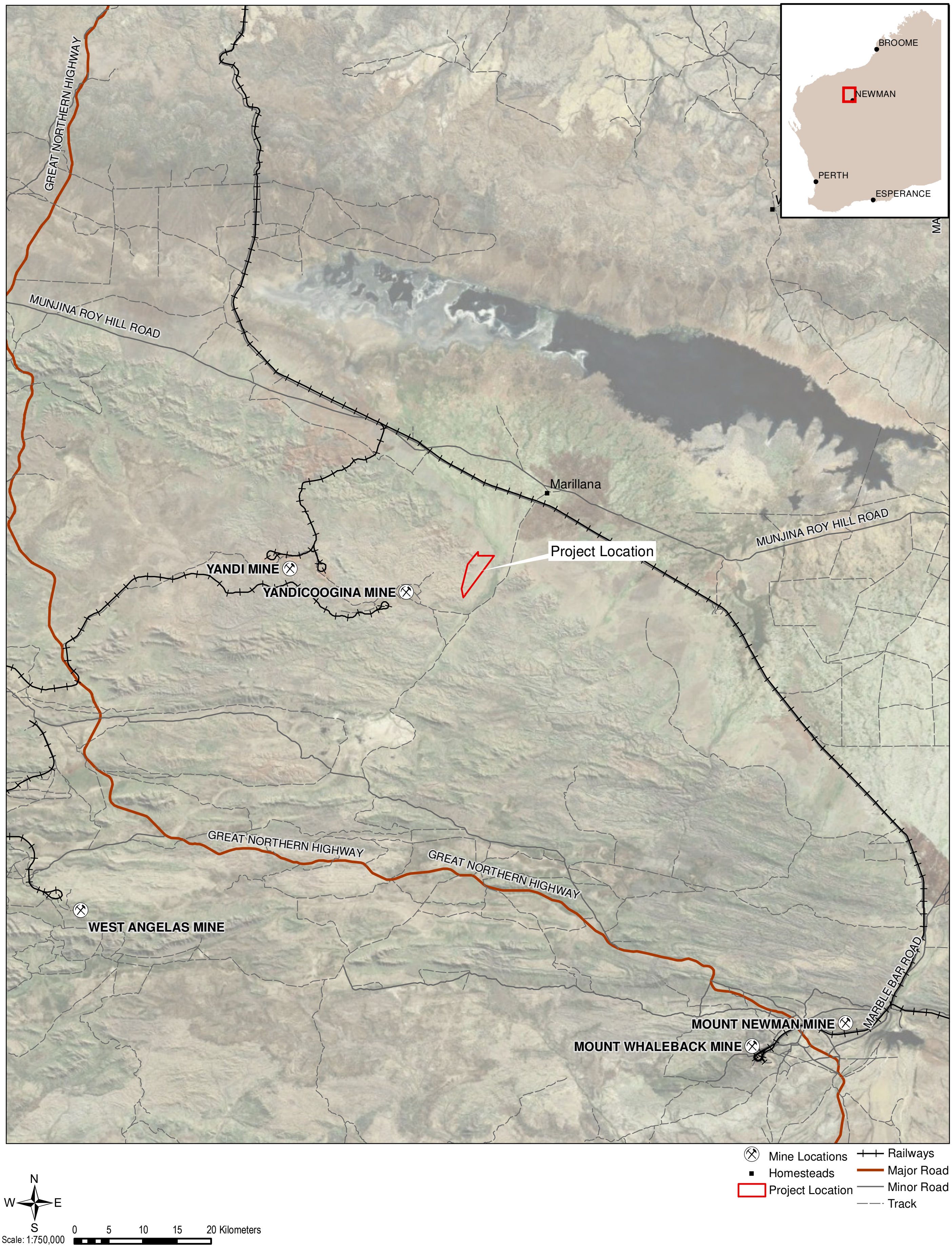


PLATE 19 Observation Location 6 - Looking north across valley

PLATE 20 Drainage channel in southern area of site looking east

Client: Iron Ore Holdings	Project: Iron Valley Project	Title: PLATES
URS	Drawn: MJ / Approved: DWG	Plate: 19 & 20 / Rev. A
	Job No. 42907964 / File No.	A4

Figures



Coordinate System: GCS GDA 1994

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

IRON ORE HOLDINGS LIMITED

PROJECT TITLE

Draft

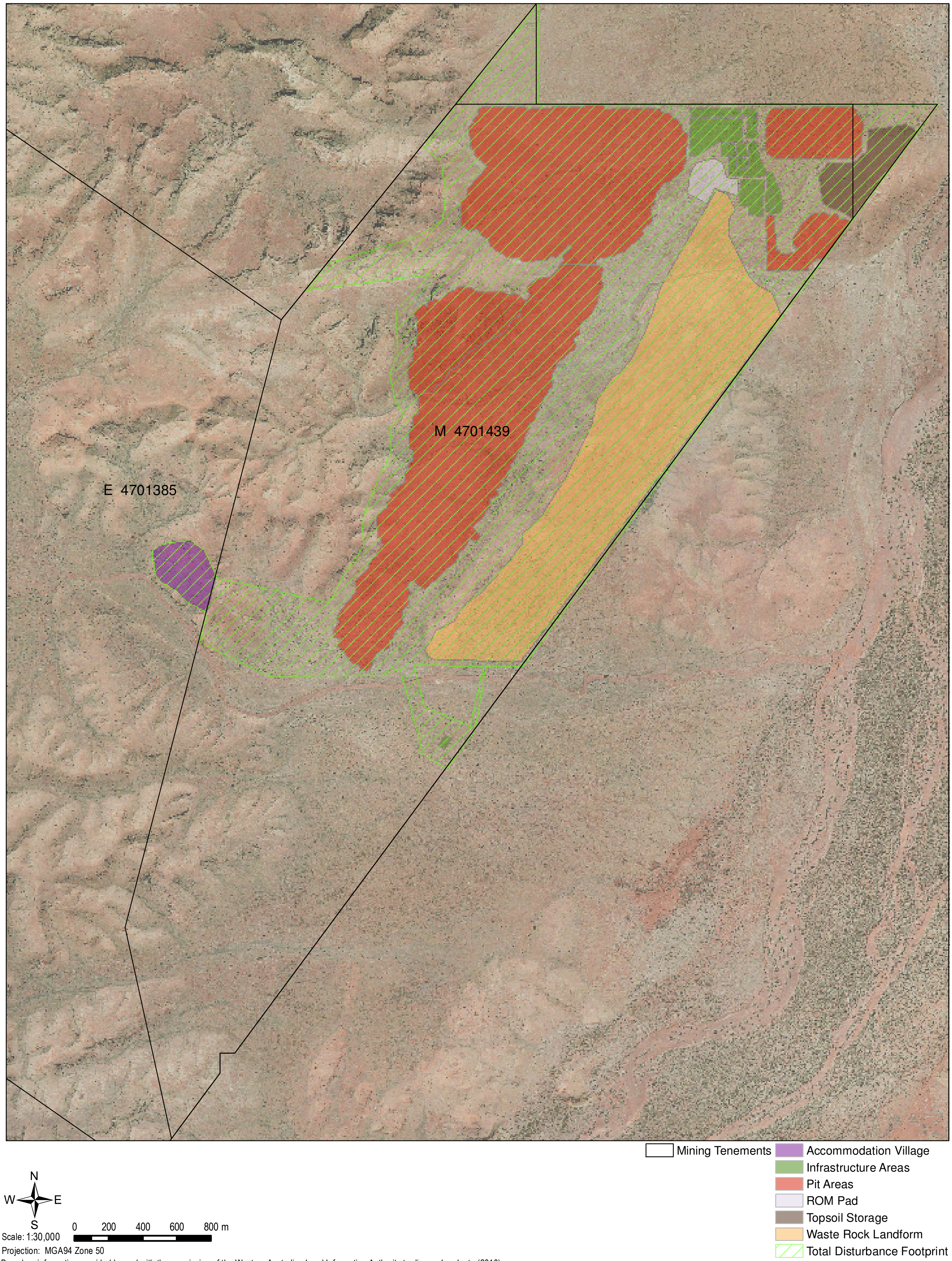
PROJECT LOCATION

URS

PROJECT/CHAPTER TITLE

Figure: **1**

File No: **42907936-ES-004.mxd** Drawn: **RNM** Approved: **MJ** Date: **27/07/2012** Rev. **A** A4



Projection: MGA94 Zone 50

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

Whilst every care is taken by URS to ensure the accuracy of the digital data, URS makes no representation or warranties about its accuracy, reliability, completeness, suitability for any particular purpose and disclaims all responsibility and liability (including without limitation, liability in negligence) for any expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred as a result of data being inaccurate in any way for any reason. Electronic files are provided for information only. The data in these files is not controlled or subject to automatic updates for users outside of URS.

IRON ORE HOLDINGS LIMITED

IRON VALLEY PROJECT
SOILS AND LANDFORMS PRELIMINARY STUDY

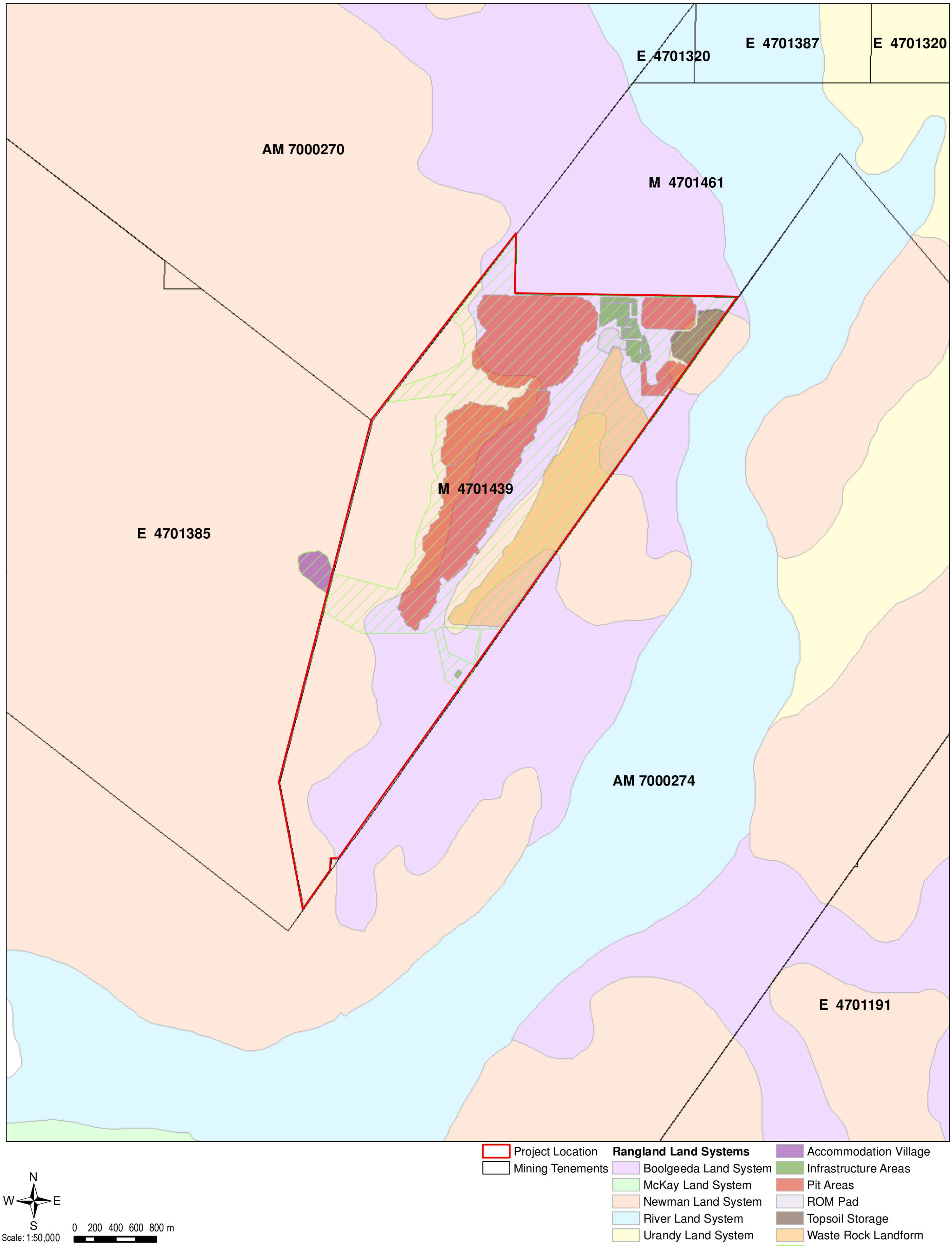
Draft

PROPOSED SITE INFRASTRUCTURE

URS

Figure: **2**

File No: **42907936-ES-005_RB.mxd** Drawn: **RNM** Approved: **MJ** Date: **23/08/2012** Rev. **A** A4



Projection: MGA94 Zone 50

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

IRON ORE HOLDINGS LIMITED

IRON VALLEY PROJECT
SOILS AND LANDFORMS PRELIMINARY STUDY

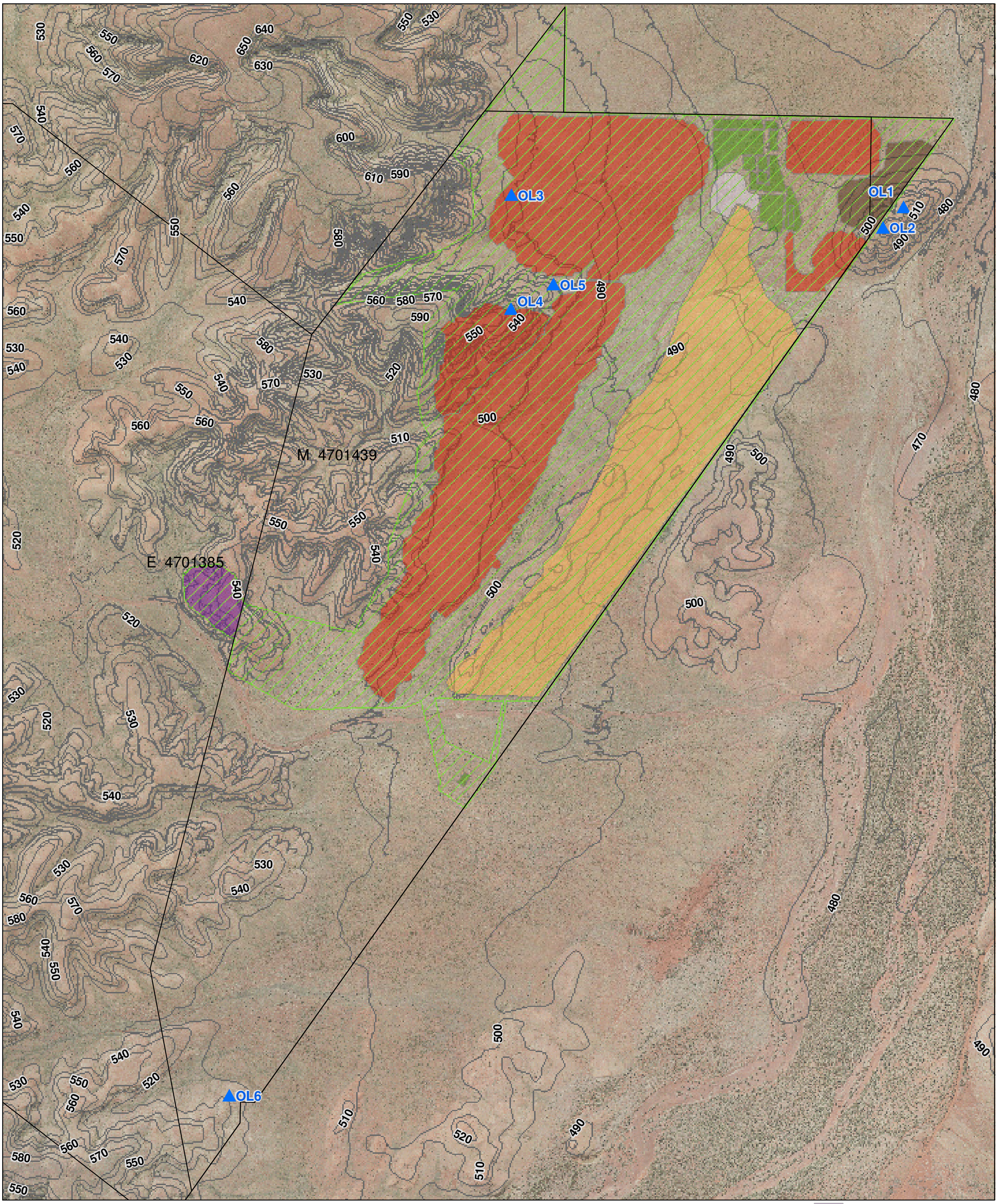
Draft

LAND SYSTEMS

URS

Figure: 3

File No: **42907936-ES-023.mxd** Drawn: **RNM** Approved: **MM** Date: **23/08/2012** Rev. **A** A4



- ▲ Observation Locations
- — 10m Topographic Contours
- ▭ Mining Tenements
- Accommodation Village
- Infrastructure Areas
- Pit Areas
- ROM Pad
- Topsoil Storage
- Waste Rock Landform
- Total Disturbance Footprint

N / W / E / S

0 200 400 600 800 m

Scale: 1:30,000

Projection: MGA94 Zone 50

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

IRON ORE HOLDINGS LIMITED

IRON VALLEY PROJECT
SOILS AND LANDFORMS PRELIMINARY STUDY

Draft

TOPOGRAPHY AND OBSERVATION LOCATIONS

URS

Figure: 4

File No: **42907936-ES-006_RB.mxd** Drawn: **RNM** Approved: **MJ** Date: **23/08/2012** Rev. **A** A4

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

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

www.ap.urscorp.com