South Flank, East Pilbara

South Flank Project: Landscape and Visual Impact Assessment

Prepared for:

BHP Billiton Iron Ore

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Executive Summary

With world-class deposits and some of the words biggest iron ore players, the Pilbara region of Western Australia will be subjected to further mining developments in the near future. Along with the environmental and socio-cultural impacts of mining developments, the potential alteration to the aesthetics of a landscape requires consideration and management, particularly for developments that are accessible and can be viewed by the public.

GHD/360 Environmental were engaged to perform a Landscape and Visual Impact Assessment (LVIA) for proposed South Flank mining operations. Planning for South Flank is in progress, so the site layouts and dimensions are considered as preliminary. As the site is in close proximity with the Great Northern Highway, and can be viewed from various high and low points in the region, it is intuitive that visibility impacts may result, and that appropriate management may be required to minimise negative impacts on landscape values and visual amenity.

The LVIA for South Flank was conducted through several viewshed analyses performed through a Geographic Information System as well as a visual assessment of the site. The analysis took into account the topography of the site and height of the viewer to identify areas that are visible from any point on the map. Alongside the viewshed analyses, this document also contains information on the soils, landforms, vegetation, surface water features and geology of the site which form part of the 'visual landscape' and 'view experience' at South Flank. Consideration was also given to the impacts of dust from the Project potentially impacting view experiences and landscape values in areas adjacent to the indicative disturbance boundary of the Project.

The South Flank Project has a relatively high visibility due to its close proximity to the Great Northern Highway. The viewshed analysis suggests that visibility will be greatest for the western portion of the site. Based on the results of the field assessment, viewshed analysis and photomontage analysis, three locations on the Great Northern Highway and were found to have very significant views of the Project. In addition to this, the summit of Mt Robinson and the eastern slopes of The Governor were found to have substantial views of the Project. The Viewpoints located on the Great Northern Highway were the most visually impacted, due mostly to their proximity to the Project and the relatively high volume of visitors.

In general, the most appropriate visual impact mitigation measure considered was early revegetation of mine infrastructure, in particular, OSAs. This has several benefits to visual amenity (reduced erosion, conformity with the natural landscape, dust trapping, positive public perception and long term rehabilitation benefits) in addition to the inherent environmental benefits. Early revegetation is also considered to be a leading

rehabilitation practice and is positively perceived by regulators and members of the general public.

Great Northern Highway Viewpoint 3 (Plate 12) – High Priority

An Overburden Storage Area (OSA) will be prominently visible in the foreground at this location. Revegetation of OSA sides as soon as possible is recommended. This viewpoint will likely be heavily affected by dust

Great Northern Highway Viewpoint 4 (Plate 13) – High Priority

OSAs and the pit may be visible in the midground from this location. Revegetation of OSA sides as soon as possible is recommended. This site is also a suitable location for a viewing platform, as it encapsulates a diverse view, including OSA's, the pit and areas of natural vegetation, in addition to providing an opportunity for showcasing rehabilitation trials.

Great Northern Highway Viewpoint 1 (Plate 10) – Medium Priority

OSAs will be visible in the midground. Revegetation of OSA sides at the earliest opportunity is recommended.

Great Northern Highway Viewpoint 5 (Plate 14) – Medium Priority

OSAs and small areas of the pit may be visible from this viewpoint in the midground and background. Early revegetation of OSA sides is recommended.

Mt Robinson Viewpoint 6 (Plate 15) – Medium Priority

There is the potential for significant views of the OSA, pit and processing plant. Unless the access track is upgraded, this viewpoint is classed as having a medium priority for mitigation as access is currently limited. Natural colouring of plant infrastructure and early revegetation of OSAs is recommended.

Great Northern Highway Viewpoint 2 (Plate 11) – Low Priority

The OSA is moderately visible in the midground and background from this location. The low number of visitor traffic puts it at a lower priority for action. Revegetation of OSA sides at the earliest possible opportunity is recommended.

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1 Introduction

1.1 Background

The proposed South Flank Iron Project (the Project) and associated areas are located approximately 80 kilometres (km) to the north-west of the Newman township, within the Central Pilbara region of Western Australia. The indicative disturbance boundary is located approximately parallel and six kilometres south of BHP Billiton Iron Ore's Mining Area C operations, within lease M281SA issued under the *Iron Ore (Mount Goldsworthy) Agreement Authorisation Act 1964* (Figure 1).

The proposed South Flank Iron Ore Project is bounded by the Great Northern Highway to the west, the Jilpaplpur Range to the north and Mt Robinson to the south (Figure 1). At its maximum extents the indicative disturbance area is approximately 25 km long and seven kilometres wide, occupying an area of approximately 120 km^2.

The main process and non-process infrastructure being considered at South Flank includes the open pit, crushers, conveyors, ore-handling plants, train load-out facilities, rail loops, workshops, administration facilities, laydown, stockpile and overburden storage areas, power and water distribution infrastructure, and management facilities for dangerous goods and hazardous materials (Figure 2).

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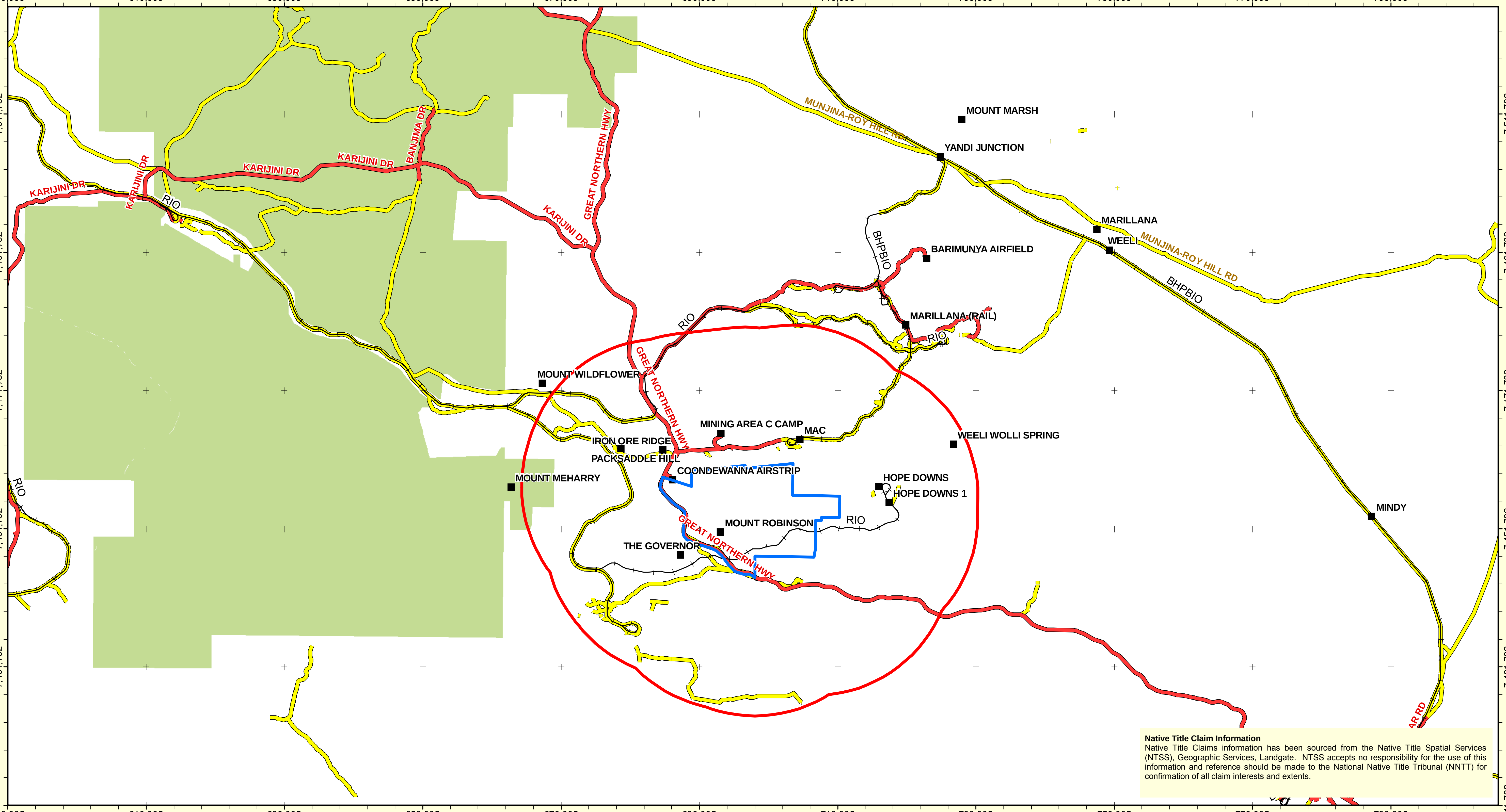

Native Title Claim Information
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South Flank & Marillana Visual Impact Assessment
Study Area

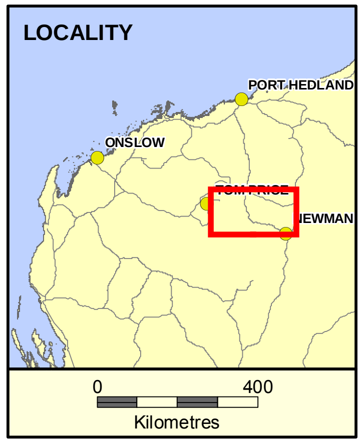
N

0 2.5 5 10 15 20 25
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:555,336	Prepared: T.Donohue	Project No: RES048
Date: 02/07/2012	Checked: J.N.Rao	Figure: 1
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

Data source: Conservation Areas Supplied by DEC 2012
Roads, railways, infrastructure & project areas supplied by BHP

- Extent of Study Area
- South Flank Iron Ore Project
- Infrastructure and Places
- Railways

Roads

- Road - sealed
- Road - unsealed

DEC Managed Areas

- Karijini National Park

360 environmental

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 1 - Study area.mxd

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1.2 Project Scope

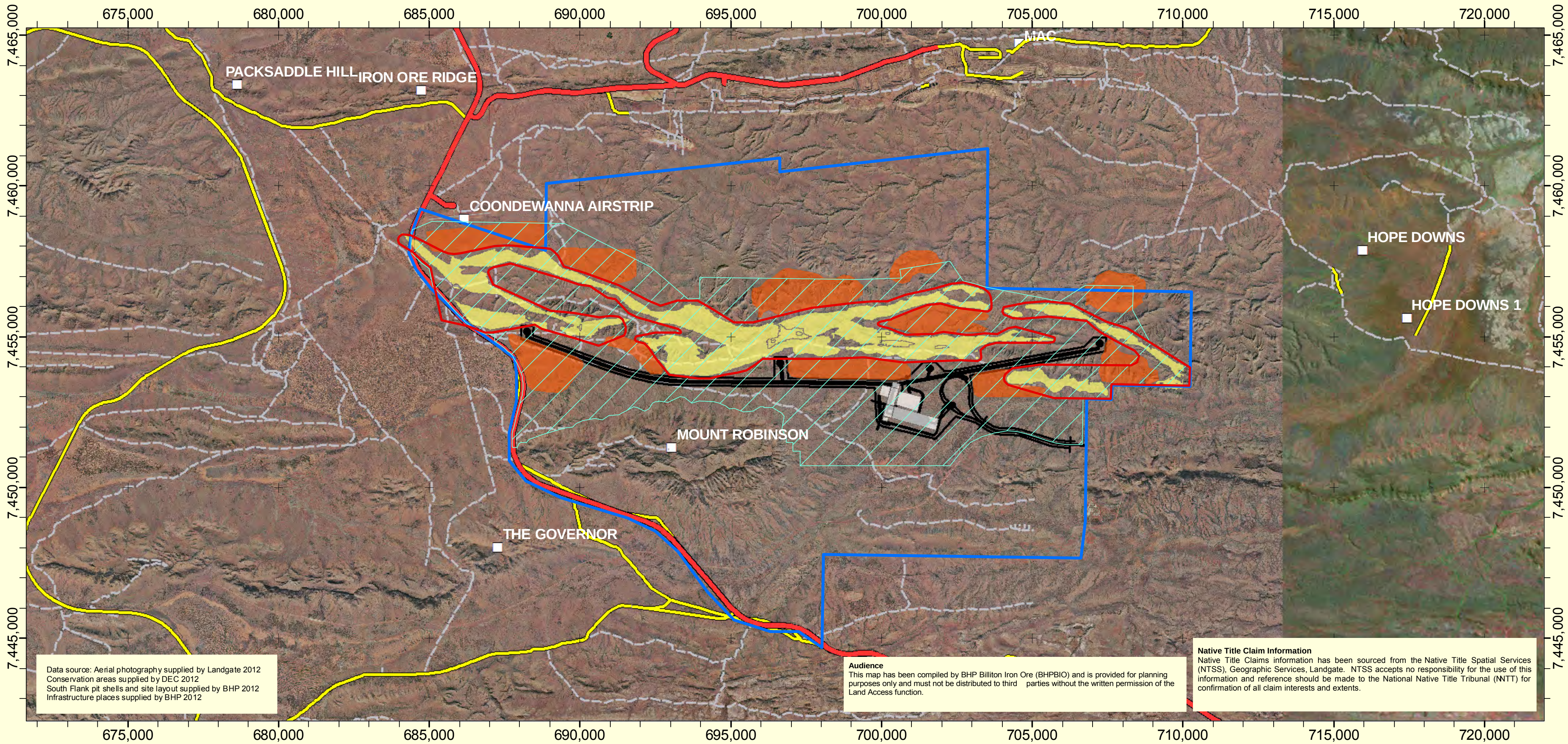
The purpose of this assessment was to identify potential visual impacts associated with mining activities at the proposed South Flank operation area. Mining activities within the site are expected to last for 20 years. The objectives of this study were to:

- Identify and locate key sites valued and accessible by the community and general public;
- Identify key landscape values within and surrounding the proposed mining area;
- Evaluate the significance and acceptability of potential visual impacts corresponding with the proposed mining activities; and
- Propose impact mitigation strategies for the identified key sites.

1.3 Study Area

The area of focus for this study (the study area) is considered to be within 20 km of the Project (Figure 1). The Great Northern Highway runs through the study area, and adjacent to the Project (Figure 1).

The development will include various mining infrastructure, the layouts of which are illustrated in Figure 2. This assessment focused on the CE-1 infrastructure hub option (K. Hollins, pers. comm. 19 June 2012).



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South Flank Visual Impact Assessment

South Flank Site Layout

N

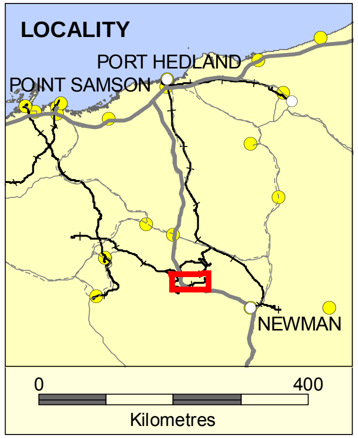
0 2.5 5 10

Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A4: 1:190,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 2
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

- South Flank Iron Ore Project
- Indicative Disturbance Area
- Ore Body
- Proposed Pit (fe57)
- Proposed OSAs
- Proposed Central Plant Area
- Proposed Central Plant Conveyors and Rails

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Infrastructure and Places

Aboriginal Heritage Act

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 2 - SF Site Layout.mxd

1.4 Legislative Context

1.4.1 Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act), has the following objective in relation to landscape planning and visual impact:

> "to ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape to as low as reasonably practicable"

1.4.2 Western Australian State Planning Framework

The Western Australian Planning Commission's (WAPC) *State Planning Policy No. 2: Environment and Natural Resource Policy* for Western Australia (WAPC 2003) states that the objective for planning is to:

> "identify and protect landscapes with high natural resource values (such as ecological, aesthetic or geological)"; and
>
> "consider the need for a landscape or visual impact assessment for development proposals that may impact upon sensitive landscapes".

1.4.3 Pilbara Planning and Infrastructure Framework

The WAPC's Pilbara Planning and Infrastructure Framework (WAPC 2012) highlights the need to:

> "safeguard and enhance significant natural landscape assets and cultural heritage values"; and
>
> "protect and manage the region's cultural heritage, arts including indigenous significant places, and landscapes of significance".

1.5 Definitions of Terms, Acronyms and Abbreviations

The definitions of terms and abbreviations used in the assessment are presented in Table 1.

Table 1: Definition of Terms, Acronyms and Abbreviations

Term	Definition
Background	Five to ten kilometres from the viewer.
Foreground	From the viewer to one kilometre away.
Georeferenced	The attribution of a coordinate system to data which corresponds to real life.
Landscape	A collection of natural and man made features within an area.
Landscape Character Type/ Unit	A geographic area sharing common characteristics such as landforms, vegetation, water forms and cultural land use.
Land system	A geographic area sharing common soil, vegetation and terrain characteristics.
Midground	One to five kilometres away from the viewer.
Valued Landscape Characteristic	The resulting landscape characteristic that results from a combination of natural features. E.g. panoramic, coastal.
View Experience	The appreciation a viewer experiences for a particular view relative to the landscape. E.g. negative, neutral, positive.
Viewshed	The theoretical area of visibility from a given point.
Visual Amenity	The values and services that result from a view.
Visual Impact	The changes to visual amenity as a result of a development. Can be positive, for improvements to visual quality or negative for reductions in visual quality.
Visual Plane	The theoretical straight line of sight from a viewer to an object.
Visual Quality	A society based measure which contributes to the overall appeal of a region. Generally based on frequency and type of view experiences.
Visual Risk	The likelihood of positive and negative visual impact.
Mitigation Strategy	A strategy to minimise visual impact.

Acronym	Definition
AHD	Australian Height Datum (Relative to Sea Level)
AQA	Air Quality Assessment
CAD	Computer-Aided Design
CALM	Department of Conservation and Land Management (now DEC)
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EP Act	Environmental Protection Act
ESRI	Earth Systems Research Institute
DEC	Department of Environment and Conservation, Western Australia
DMP	Department of Mines and Petroleum, Western Australia
DPI	Department of Planning and Infrastructure, Western Australia
GDA	Geodetic Datum of Australia
GIS	Geographic Information Systems
GNH	Great Northern Highway
LiDAR	Light Detection and Ranging
LCT	Landscape Character Type
LCU	Landscape Character Unit
LVIA	Landscape and Visual Impact Assessment
OSA	Overburden Storage Area
SEA	Strategic Environmental Assessment
VMO	Visual Management Objective
WA	Western Australia
WAPC	Western Australian Planning Commission

Abbreviation	Definition
µm	Micrometre
m	Metre
km	Kilometre
km^2	Square kilometre
Mt	Mount
Mtpa	Million tonnes per annum

2 Methods

The methodology applied for the visual impact assessment for South Flank is in accordance to the assessment methodology outlined by the Department of Planning and Infrastructure's (DPI) *Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design* (DPI 2007), and the *Guidelines for Landscape and Visual Impact Assessment* (2002) from the Landscape Institute and Institute of Environmental Management and Assessment (United Kingdom).

Most LVIA methodologies include a desktop and field assessment stage followed by computer based impact simulations prior to the recommendation of mitigation strategies. These are usually a combination of qualitative and quantitative methods (Landscape Institute and Institute for Environmental Management and Assessment 2002).

2.1 Desktop Assessment

The desktop assessments were undertaken to identify areas of the landscape which are potentially 'significant', as legislation urges the protection of these 'significant' landscapes. Determining what is a significant landscape is the main objective of the desktop assessment. In order to do this, the following quantitative information was collated and mapped using ESRI's ArcGIS to minimise the use of unreliable qualitative indicators.

- Land systems;
- Soil landforms;
- Geology;
- Surface water features;
- Vegetation;
- Landscape form (topography); and
- Land use and roads/infrastructure.

It is known that combinations of the above features can produce significant views. The result of these combinations produces 'valued landscape characteristics'.

2.2 Field Assessment

Criteria for the site based landscape and visual assessment were established prior to undertaking the field visit (Table 2). The identified key viewpoints were visited by foot and vehicle between 23 April and 25 April 2012. GPS waypoints, field notes and digital photographs were taken at each site. The digital photographs were later used in the photomontage analysis. Additional photos were provided by BHP Billiton Iron Ore, for sites that were inaccessible to field personnel.

2.2.1 Definitions of Field Terms

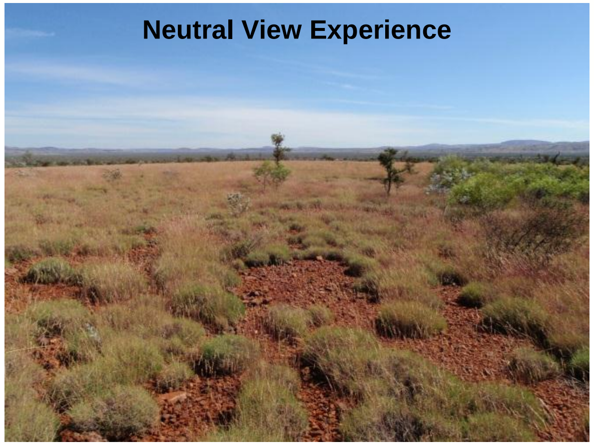
An example of a field visit survey sheet that shows what was typically recorded when the field assessment was being completed is presented in Table 2. Fields range from geographical aspects of the location, the valued landscape characteristics seen from the viewpoint, as well as the potential Visual Management Objective (VMO).

Table 2: Field Assessment Criteria.

Field Term	Definition
Visual Location	Location relative to surrounding features
Viewpoint Elevation	Elevation of viewpoint relative to the AHD
Viewing Distance	Approximate distance from development
Visual Setting	Extent of views, such as foreground and background views
Motion of Viewer	Speed at which a viewer may be travelling
Vegetation Cover	Approximate plant density
Vegetation Type	General vegetation assemblages
Canopy Density	Density of the vegetation canopy
Land Use	Major land use of the viewpoint surroundings
Potential Visual Risk	Potential for visual impact at the viewpoint
Percentage of total Development Area Visible	Approximate area of the development that may be visible from the viewpoint
Valued Landscape Characteristics	Characteristics contributing to the view experience
View Experience	Overall impression of the view
VMO	Generic Visual Management Objective to reduce impact

2.2.2 Defining View Experiences

Understanding view experience is an integral part of the development of strategies to manage visual landscape character. In this context, a 'view experience' can be termed as how a view or landscape is valued by an individual. This is usually the result of a combination of landforms, geology, water features, vegetation and topography producing a relatively positive, neutral or negative view. View experience was qualitatively assessed at each viewpoint during the site visit, with notes taken on the combination of landforms. Greater variety in landforms, topography and vegetation result in a more interesting view and therefore generally positive view experiences.



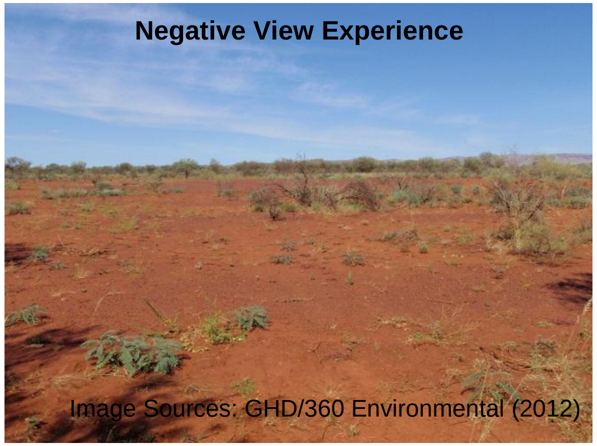


Plate 1: View Experiences from Different Landform Combinations

Different combinations of vegetation, landforms, water features, soils, topography and geology may interact to form different view experiences. The positive view experience example demonstrates a high variety in natural features, including a cliff in the foreground, hills in the background, a water body, different vegetation types as well as soils. Although the neutral experience example does show variety in vegetation types the terrain is relatively plain, with flats in the foreground and midground, and hills in the background. The negative experience on the other hand demonstrates little variation in vegetation type, topography or geology. It is important to understand that these definitions are relative, the negative view experience is not negative by itself, but rather is negative in relation to the neutral and positive view experiences.

2.2.3 Selecting Viewpoints

Based on the desktop assessment, potential viewpoints may be selected. These are areas where the proposed development may be visible. Key viewing locations can also be determined based on areas that are easily accessible by the public, usually confirmed through the field assessment. The project area was assessed according to the type of public use and the volume of people accessing the landscape.

The significance level of access routes increases with (DPI 2007):

- Rarity and significance of a view based on natural beauty and/or cultural significance;
- The background of viewers i.e. tourists or locals;
- The degree of use i.e. the amount of traffic a view location receives;
- The relative importance of a viewpoint to the area, for instance a viewpoint on a major highway as opposed to a viewpoint located on a remote observation platform; and
- The duration and clarity of a view, for instance a sudden glimpse of the operation area through dense vegetation while travelling along a highway from close proximity, as opposed to a sustained view of the operation area from further away.

Three levels of significance were determined for the viewpoints and the potential levels of impact assessed. These were defined as Level 1, Level 2 or Level 3. These are defined in Table 3.

Table 3: Viewpoint Levels of Significance Matrix

	National/State Level Significance	Regional Level Significance	Local Level Significance
High Visitor Traffic/ Accessibility	**Level 1 (High Impact)**	**Level 2 (Moderate Impact)**	**Level 2 (Moderate Impact)**
Moderate Visitor Traffic/ Accessibility	**Level 2 (Moderate Impact)**	**Level 2 (Moderate Impact)**	**Level 3 (Low Impact)**
Low Visitor Traffic/ Accessibility	**Level 2 (Moderate Impact)**	**Level 3 (Low Impact)**	**Level 3 (Low Impact)**

A field visit is the easiest method of determining viewpoints, as it allows the assessor to be exposed to views of the landscape that the general public are also likely to be exposed to.

2.3 Visual Impact Simulations

2.3.1 Viewshed Analysis

A viewshed analysis has often been used as a proxy for determining the zone of visual influence. It is predominantly a GIS based method for determining the theoretical area of visibility from a point, given the known elevation of that point relative to the elevation of the surrounding landscape. The conceptual model in Figure 3 illustrates this concept.

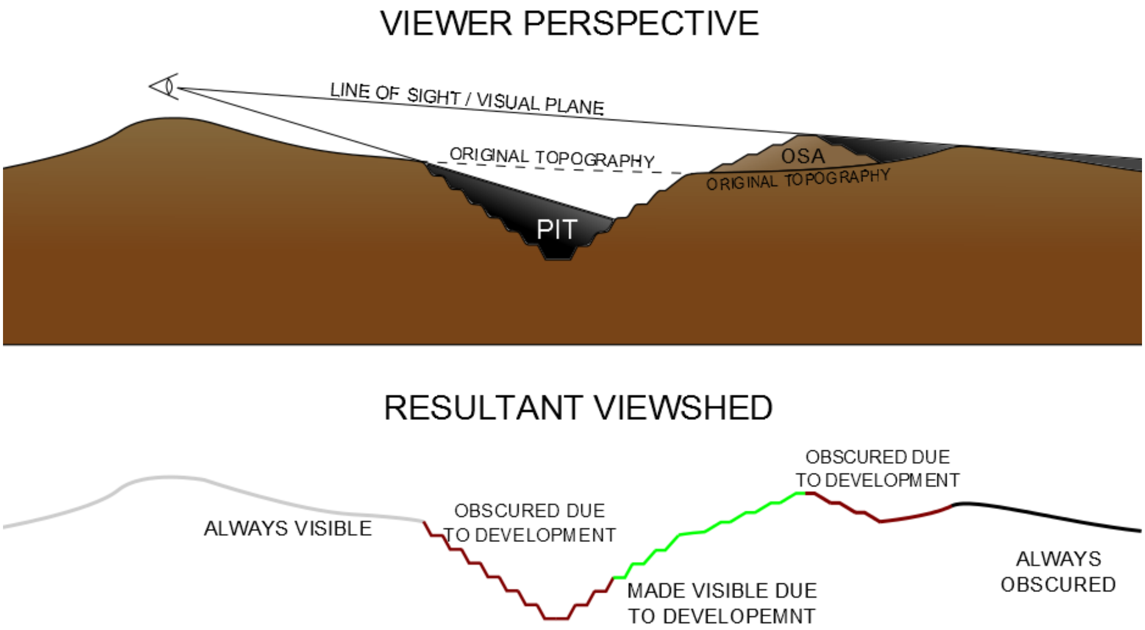


Figure 3: 2D Conceptual Model of a Viewshed Analysis

In this study, the viewer height was fixed at 1.76 m to simulate the height of an average viewer. A 360^{o} field of view was used.

2.3.2 Photomontage Analysis

A photomontage is a simulated view of what the development would look like from a given point. It involves the overlaying of a 2D model of the development with an actual photograph in an image editing software. In this study the photomontages were produced firstly by creating a georeferenced 3D model of the development. As GPS coordinates are taken at each viewpoint, the model can be oriented within software so that the viewer location corresponds with the location of the viewpoint photograph. Finally, a 2D snapshot of the model is combined with the site photograph to produce the photomontage.

The benefits of using 3D, georeferenced site models (where elements in the model have a latitude and longitude coordinate assigned which correspond to real life) is that the size and location of the operation on a 2D snapshot corresponds accurately to real life.

The photomontage analysis relies on the availability of data for the proposed mining development. Photomontage analyses are discussed further in Section 5.2.

2.3.3 Dust Modelling

An Air Quality Assessment (AQA) was conducted by PAEHolmes for BHP Billiton Iron Ore in September 2012 (PAEHolmes 2012). The findings of this AQA were used in the assessment of visual impacts. Dust has a large visual impact and can impair views of an area from large distances. As dust is often seen as a nuisance, the presence of dust at a site can result in negative view experiences.

The AQA included an assessment of existing background air quality as well as an assessment of the potential impacts of the Project. Potential impacts were determined through modelling in four distinct phases. These were:

- Phase 1: Existing and approved emission sources;
- Phase 2: Construction and early works of the Project;
- Phase 3: Mining year 11 of the Project; and
- Phase 4: Mining year 11 of the Project with emissions from surrounding sources.

For the purpose of this assessment, Phase Four was used, as it represented the most realistic approximation of real-world conditions, as Mining Area C has the potential to contribute to air quality at the Study Site.

The AQA also considered several types of emission parameters. These were:

- PM_{10}: Total suspended particulate matter under 10 µm in diameter;
- $PM_{2.5}$: Total suspended particulate matter under 2.5 µm in diameter; and
- TSP: Total Suspended Particulate matter under 30 µm in diameter.

For the purpose of this assessment the PM_{10} parameter was used as larger particles usually settle by gravitation shortly after being emitted, whereas PM_{10} particles can stay suspended for several days. Larger particles can have a large impact on visual amenity at close distances and at a close distance to the ground, although they will settle fairly quickly (PAEHolmes 2012). Due to the positioning of infrastructure, easterly views into the Project area will likely be limited, as well as the impact of these larger particles.

Light scattering is heavily influenced by the chemical composition, shape and molecular weight of dust particles, as well as the distribution of particle sizes in the air (in addition to prevailing environmental conditions) (Cao et al. 2012; Jayaratne et al.

2011; Lee et al. 2012). Hence, there is no fixed relationship between suspended particle concentrations and their effect on light penetration and attenuation. Due to this, the results of the dust modelling could not be used in the viewshed analysis, as a quantifiable value is required to alter the viewshed modelling results. Instead, the dust modelling results were compared to the locations of key viewpoints identified and were also approximated in the photomontage analysis for heavily affected viewpoints (Plates 17 and 18).

2.4 Mitigation Strategy Development and Evaluation

The results of the photomontage analysis will serve to reinforce the findings of the viewshed analysis. As the desktop and field assessments determine valued landscape characteristics, appropriate mitigation strategies can be developed, which take into account the significance of the view as well as the potential level of impact.

There are three main approaches which need to be considered when formulating a visual impact mitigation strategy:

1. Best practice and design: this is the baseline objective and will be completed for the entire study area;
2. Protection and maintenance of visual landscape character; and
3. Restoration of degraded character or enhancement of opportunities.

Strategies for the restoration and enhancement objectives of developments aim to restore and enhance degraded visual landscape character (DPI 2007). It should be applied to areas that have visually degraded features that require improvement; whether that be rehabilitation or otherwise. It should also be used to improve the visual character of the landscape, which may include building lookouts and information panels. The strategies set-out by the DPI (2007) to adhere to this objective are outlined below:

- Create or enhance viewing opportunities by creating additional infrastructure;
- Develop new roads and/or walk-trails;
- Restore and/or enhance established travel routes; and
- Plant roadside vegetation to screen visually degraded views.

Where possible, mitigation strategies were designed with these key points in mind.

3 Desktop Assessment Results

3.1 Landscape Characteristics

3.1.1 Landscape Character Types (LCT)

An LCT is a geographic area sharing common characteristics such as landform, vegetation, water form and cultural land use patterns relevant to human interaction and experience. LCTs display particular aesthetic characteristics which relate to landforms, line, colour, texture, scale, vegetation, water form and land use. According to the Department of Conservation and Land Management (CALM; now the Department of Environment and Conservation), the study area is located within the Hamersley Range landscape unit (CALM 1994). The Range runs through the study area and the Great Northern Highway runs adjacent to the Project (Figure 4).

The Hamersley Range is a LCT characterised by a large distinctive heavily weathered landscape. The entire area is relatively low in elevation, with undulating and folding profiles. Dark orange termite mounds which dot the base of the range blend in with the bright brown-orange gravel and soil (Plate 2). As the landscape is extremely old, heavy weathering has caused a distinctive horizontal banding on hills when viewed from close range. Scattered trees and shrubs also reflect this banding pattern when viewed from afar due to the natural topography; however is viewed as angular and rugged from closer on.

Karijini National Park to the west of the proposed South Flank site represents one of the main recreational sites in the region. Mt Meharry is located approximately 20 km west of South Flank within Karijini National Park. It is accessible to the public and has a lookout to view the landscape. Mt Robinson is the closest recreational site to the Project. It is a mountain that is approximately 2.5 km from the site boundary and is potentially a popular tourist attraction, boasting a public lookout near the summit (inaccessible at the time of the site visit due to bad track conditions). However it is likely that this area will constitute a high visual impact as it overlooks the site.

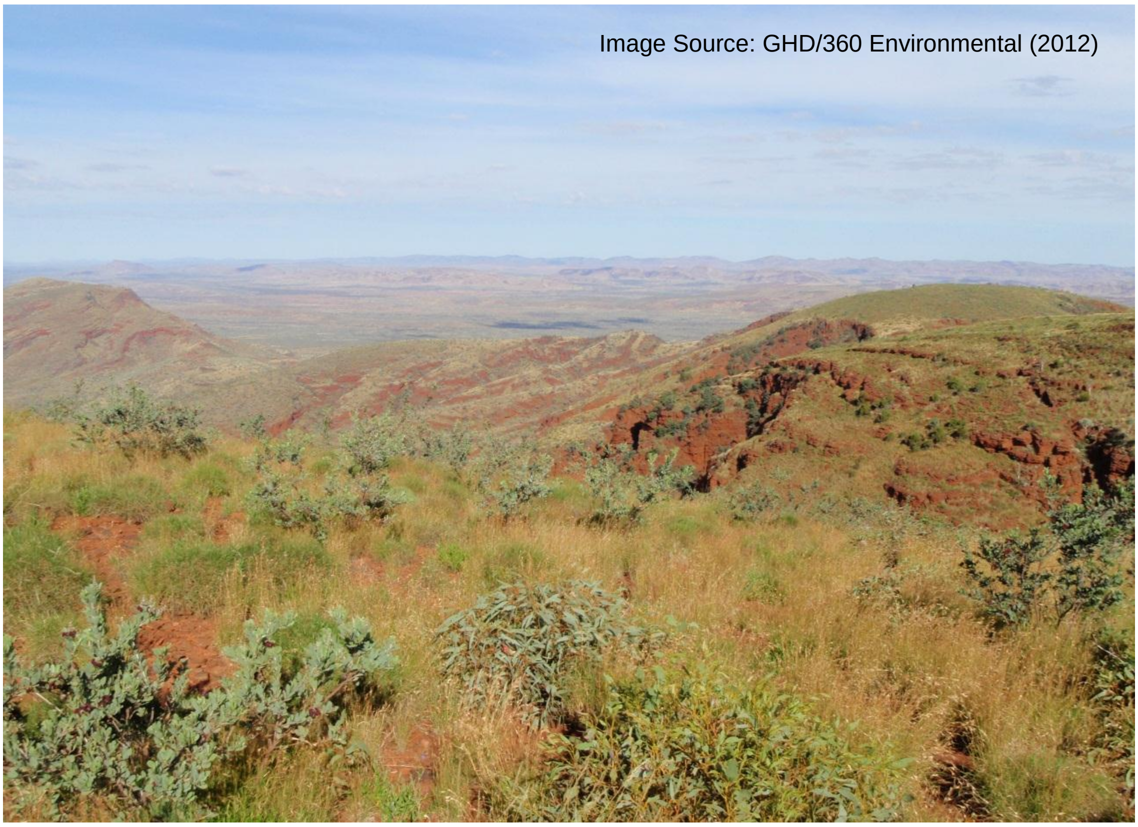


Plate 2: The Bright Orange-red Hues Typical of the Hamersley Range

3.1.2 Land Systems

The landscape is characterised by the Hamersley Range which is generally steep with many dissecting hills and ridges (Plate 3). The highest point within the study area is Mt Meharry, which is the highest mountain within Western Australia at approximately 1,249 m above sea level. Mt Robinson is another mountain that is within close proximity to the site, extending to approximately 1,120 m above sea level.

The most prominent land system within the Hamersley Range is the Newman system. This system is composed of hills and ranges with spinifex grasslands that include rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands. The South Flank site also consists of three other smaller systems:

- Boolgeeda – stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands;
- Pindering – Gravelly hardpan plains supporting grooved shrublands with hard and soft spinifex; and
- Platform – dissected slopes and raised plains supporting hard spinifex grasslands.

Figure 5 illustrates the major land systems across the study area.

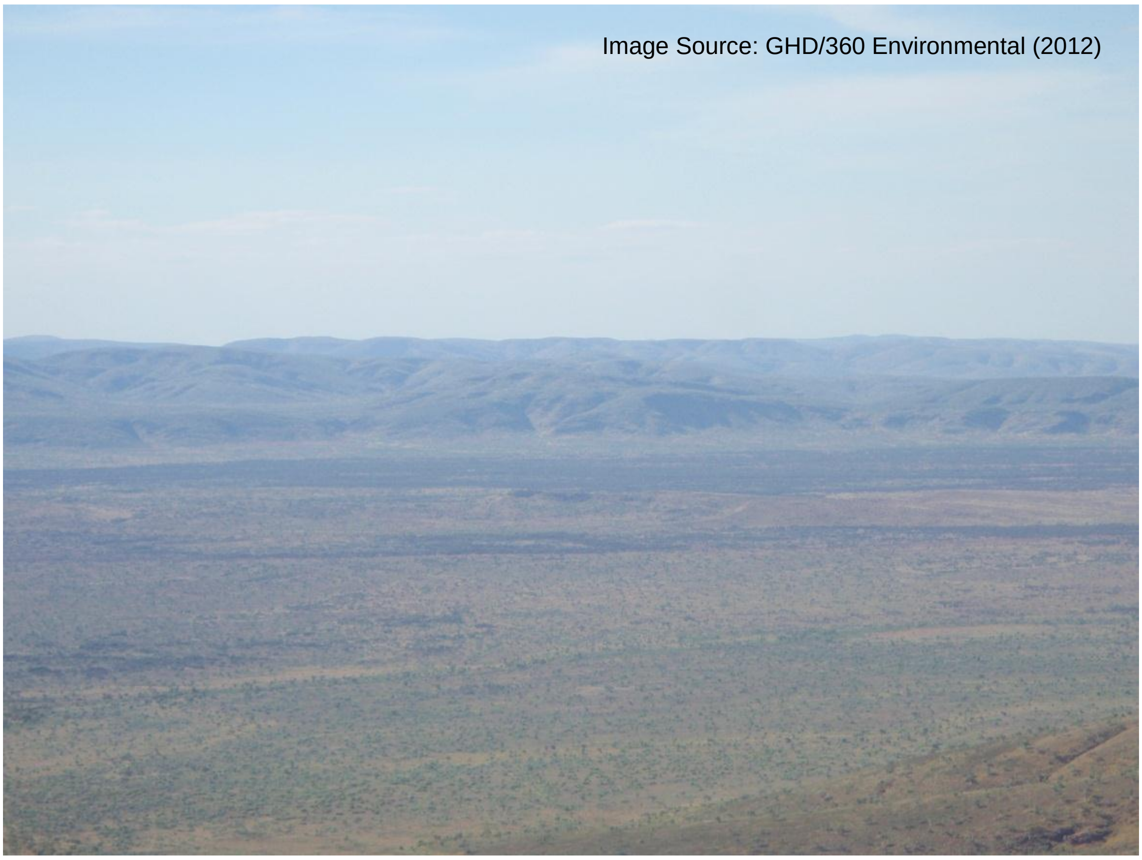


Plate 3: View North from Mt Meharry towards the Hamersley Ranges

3.1.3 Soil Landscapes

Soil landscapes within the study area occur in long distinctive areas with little variation apart for the north-east of the study area where the landscape become more mosaicked in nature. The dominant soil landform within the study area is Fa13 unit which is composed of ranges of banded jaspilite and chert along with shales. The soils within this unit are typically shallow. South Flank is within this soil landscape as well as two other smaller systems outlined below:

- Fb3 – high-level valley plains set in extensive areas of unit Fa13. There are extensive areas of pisolitic limonite deposits; principal soils are deep earthy loams (Um5.52) along with small areas of (Gn2.12) soils. These are soils with predominately physical limitations (shallow soils); and
- Fa14 – Steep hills and steeply dissected pediments on areas of banded jaspilite and chert along with shales. These are soils with predominately physical limitations (shallow soils).

The soil/ landforms of the study area are illustrated in Figure 6.

3.1.4 Geology

Geology around the study area is complex and varies greatly. There is no one major geological feature that stands out as the most prominent; however, there are multiple features which cover large areas; these are:

- Qw – alluvium and colluvium: red – brown sandy and clayey soil on low slopes and sheet wash areas;
- PLHj – Weeli Wolli formation: banded iron – formation (commonly jaspilitic), pelite, and numerous metadolerite sills; and
- PLHb – Brockman Iron Formation: banded iron – formation, chert, and pelite.

South Flank is within the following geological units:

- AHm – Marra Mamba Iron Formation: chert, banded iron – formation and pelite;
- Czc – colluvium – partly consolidated quartz and rock fragments in silt and sand matrix, old valley – fill deposits;
- Qa – alluvium – unconsolidated silt, sand and gravel;
- AFd – Jarrinah formation: pelite, chert and thin – bedded metasandstone; intruded by metadolerite sills in the Hamersley Range;
- Czc – colluvium – partly consolidated valley – fill deposits; and
- Hm – Marra Mamba formation: chert, ferruginous chert and banded iron – formation with minor shale.

Figure 7 displays the regional geology of South Flank and surrounding areas. This is especially significant in the context of the site location as geology can manifest as visually appealing landforms such as banded iron rock formations.

3.1.5 Water Features

The surface water features within the study area are mostly ephemeral minor drainage channels that can be viewed to some extent when travelling on foot and/or by car. Even diffuse drainage features are often clearly discernible within the landscape when viewed from aerial photography and digital elevation models. Scattered throughout the Pilbara landscape are many natural water features such as waterholes, pools and some waterfalls to the north and north-west of the Project (Figure 8). Man-made water features such as waterpumps, water tanks and bores are present within the landscape and close to the indicative disturbance boundary. Both natural and man-made water features can be visually appealing (e.g. gorges and water flows in nearby Karijini Natural Park).

Figure 8 displays the water features for South Flank and the surrounding area. Pebble Mouse Creek, a locally significant waterway flows through the south-eastern section of the indicative disturbance boundary. Views of this water feature are not easily accessible as it is located in excess of 20 km from the Great Northern Highway. It is unlikely that the Project will have adversely impact the landscape value of the creek.

3.1.6 Vegetation

The vegetation surrounding the study area can be classified into two broad vegetation types based on Beard's (1975) classification. These are:

- Spinifex grassland: tree steppe; and
- Eucalyptus woodland with low woodland.

South Flank is located within the dominant spinifex grassland: tree steppe system. Figure 9 illustrates the vegetation of the site and surrounding area.

3.1.7 Landscape Form

Western Australia's highest mountain (Mt Meharry) is located to the west of South Flank within the Karijini National Park. There are other mountains of note within the study area including Mt Robinson, The Governor and Mt Wildflower, as well as high elevated areas to the west within Karijini National Park (Figure 10). As the proposed development area is relatively recessed compared to the surrounding terrain, it is likely that the development will negatively impact view experiences from these high areas.

South Flank is dissected by ridges that are elevated mostly within the centre of the site. There are less elevated areas to the east and west. The slope of the landscape is generally less than 20^{o} apart for small areas corresponding to the highest elevated areas. The landscape form including landform relief and slope of terrain pre and post-development are presented in Figures 10a/b and 11a/b respectively.

3.1.8 Land Use

Land uses of the study area are predominately characterised into three types. These are:

- Natural and cultural conservation reserves;
- Pastoral stations; and
- Mining tenements.

Mining infrastructure is a prominent feature within the landscape, including associated railways, camps, pits and OSAs being a significant feature in the surrounding landscape. Railways are predominantly operated by the iron ore industry to transport ore to port. Most of the roads within the study area are unsealed apart from the Great

Northern Highway (GNH) and two roads which diverge from it (Figure 12). The nearest town to the study area is Newman, located approximately 125 km to the south-east. Newman supports many mining and pastoral activities within the area.

Karijini National Park is Western Australia's second largest National Park and is located 25 km west of South Flank. It is a popular tourist and visitor attraction of the Pilbara region, attracting over 166,000 visitors in 2009, according to the Australian Broadcasting Corporation (ABC 2010). There are other nature reserves in proximity of the study area including the Fortescue Marsh to the north-east of the study area. The Fortescue Marsh, a part of the Fortescue River catchment is a floodway that when flooded, supports many species of bird (some are protected as Threatened or Endangered under State and/or Federal legislation).

Figure 12 illustrates land use within the study area.

Data source: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

Audience
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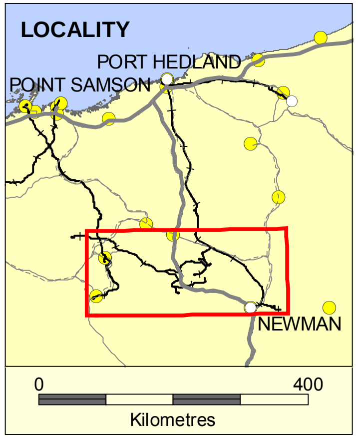
South Flank Visual Impact Assessment

Landscape Character Types

N
0 12.5 25 50
Kilometres
Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A4: 1:1,040,000	Prepared: J.N.Rao	Project No: RES048
Date: 02/07/2012	Checked: F.Donaldson	Figure: 4
	Reviewed: M.Rhodes	

LOCALITY



LEGEND

South Flank Project

Landscape Character Types
- Ashburton
- Augustus
- Chichester Range
- Fortescue Valley
- Hamersley Range

Transport Network
- Road - sealed
- Road - unsealed
- Localities

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 4 - Landscape Character.mxd

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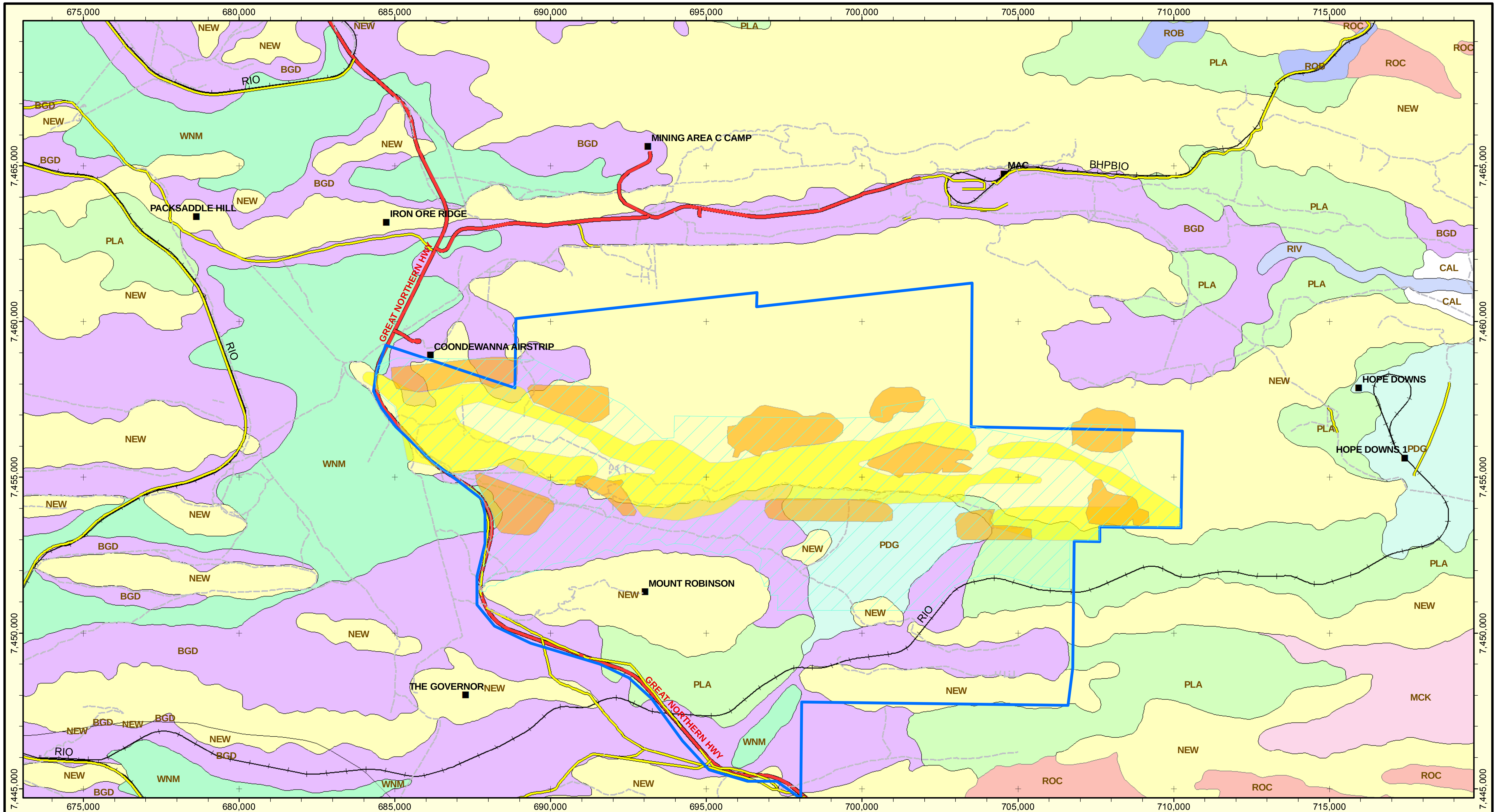

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South Flank Visual Impact Assessment
Land Systems

N
0 1 2 4 6 8
Kilometres
Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 5
	Reviewed: F.Donaldson	

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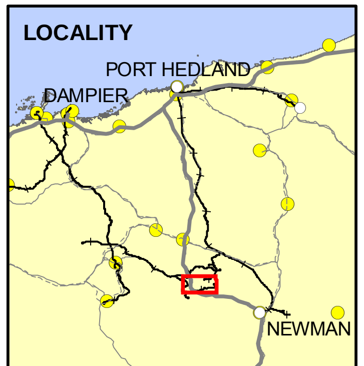

LEGEND

Data source:
All data supplied by BHP 2012 unless otherwise specified

Land Systems
- CAL, Calcrete, Low calcrete platforms and plains supporting shrubby hard spinifex grasslands.
- BGD, Boolgeeda, Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.
- MCK, McKay, Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands.
- RIV, River, Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.
- ROC, Rocklea, Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.
- WNM, Wannamunna, Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands).
- ROB, Robe, Low plateaux, mesas and buttes of limonites supporting soft spinifex (and occasionally hard spinifex) grasslands.
- NEW, Newman, Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
- PDG, Pindering, Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.
- PLA, Platform, Dissected slopes and raised plains supporting hard spinifex grasslands.
- South Flank Project
- Indicative Disturbance Boundary

- Proposed OSAs
- Ore Body

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways
- Infrastructure

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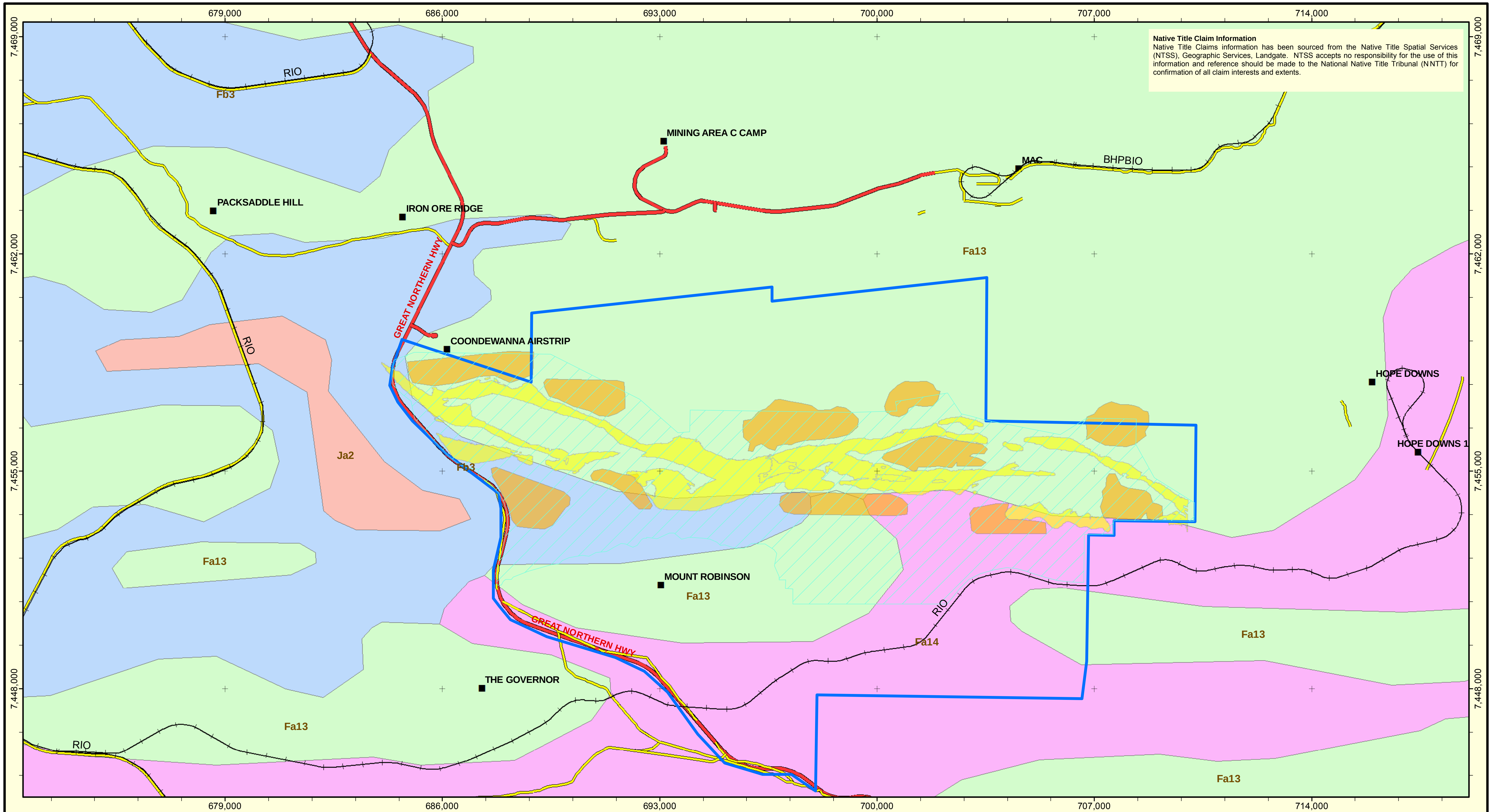
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 5 - Land Systems.mxd



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South Flank Visual Impact Assessment

Soil / Landforms

N

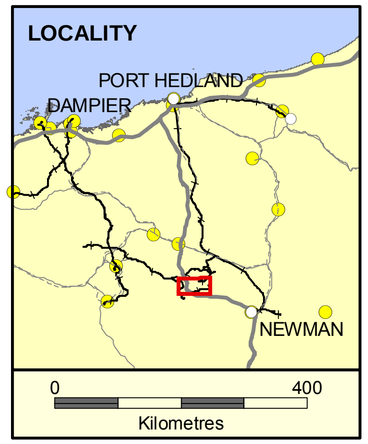
0 1 2 4 6 8

Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 6
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

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South Flank Project

Indicative Disturbance Area

Soil Landscapes

Fb3, Extensive pisolitic limonite deposits: deep earthy loams (Um5.52) with small areas of (Gn2.12) soils

Fa14, Steeply dissected pediments on areas of banded jaspilite and chert along with shales

Ja2, Chiefly earthy clays (Uf6.71). Extensive areas of (Ug5.38) soils

Proposed Pit

Proposed OSAs

Transport Network

Road - sealed

Road - unsealed

Railways

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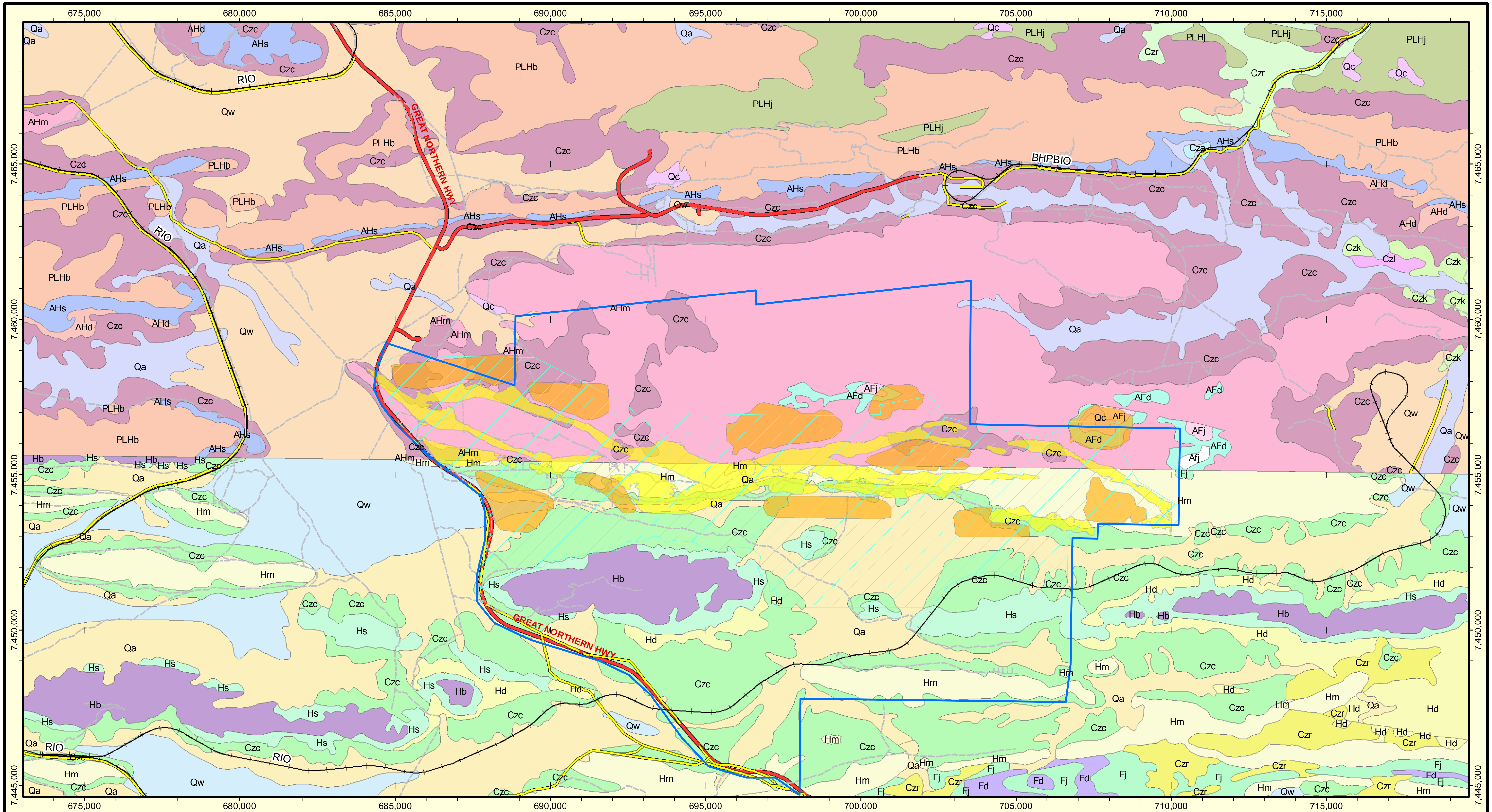
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 6 - Soil Landforms_A3.mxd



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South Flank Visual Impact Assessment
Regional Geology

N

0 1 2 4 6 8
Kilometres
Datum: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 7
	Reviewed: F.Donaldson	

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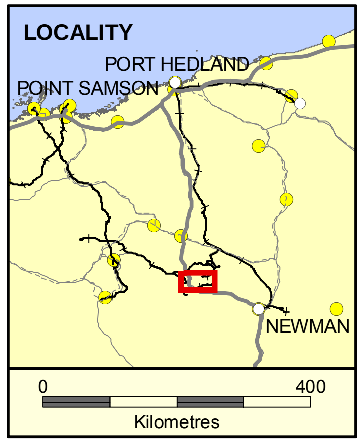

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- South Flank Iron Ore Project
- Indicative Disturbance Area
- Proposed Pit Footprint
- Proposed OSAs

Railways

- Railways
- Road - sealed
- Road - unsealed
- Track

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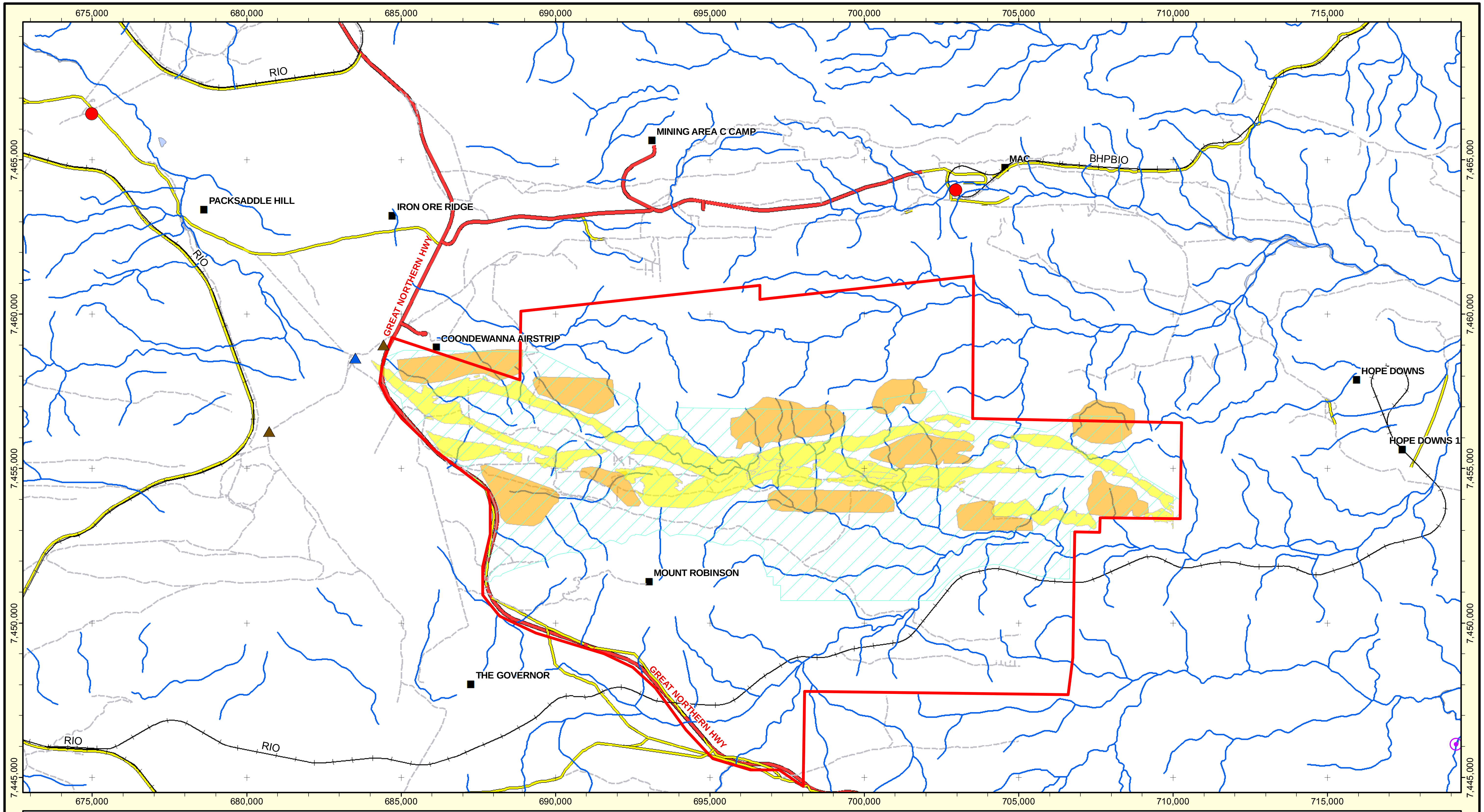
360

K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 7 - Geology.mxd

Figure 7a: Regional Geology Legend

Geology Legend

- AFd, Jeerinah Formation: pelite, chert, and thin-bedded metasandstone; intruded by metadolerite sills in the Hamersley Range
- AFj, Jeerinah Formation: pelite, chert, and thin-bedded metasandstone; intruded by metadolerite sills in the Hamersley Range
- AHd, Wittenoom Formation: thin- to medium-bedded metadolomite, dolomitic pelite, chert, and metamorphosed volcanic sandstone
- AHm, Marra Mamba Iron Formation: chert, banded iron-formation, and pelite
- AHs, Mount McRae Shale and Mount Sylvia Formation: pelite, chert, and banded iron-formation
- Cza, Alluvium-partly consolidated silt, sand, and gravel; old alluvium dissected by present-day drainage
- Czc, Colluvium - partly consolidated valley-fill deposits
- Czc, Colluvium-partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits
- Czk, Calcrete - sheet carbonate usually formed in major drainage lines
- Czk, Calcrete-sheet carbonate; found along major drainage lines
- Czl, Lateritic deposits-massive and pisolitic ferruginous duricrust
- Czr, Hematite-goethite deposits on banded iron-formation and adjacent scree deposits
- Czr, Laterite, includes surficial hematite-goethite deposits on banded iron-formation; forms Hamersley Surface
- Fd, Metadolerite sills intruded into Fortescue Group; medium- to coarse-grained, massive grey-green rock, usually foliated
- Fj, Jeerinah Formation: interbedded mudstone, siltstone and chert with minorfelsic tuff, dolomite and sandstone
- Fjb, Metabasalt; pillows locally well developed
- Hb, Brockman Iron Formation: banded iron-formation, chert and minor shale (2490+-20 Ma, U-Pb)
- Hd, Wittenoom Formation: dolomite; interbedded thin chert, shale and dolomite in upper part
- Hm, Marra Mamba Iron Formation: chert, ferruginous chert and banded iron-formation with minor shale
- Hs, Mount McRae Shale and Mount Sylvia Formation: interbedded shale, chert and banded iron-formation
- PLHb, Brockman Iron Formation: banded iron-formation, chert, and pelite
- PLHj, Weeli Wolli Iron Formation: banded iron-formation (commonly jaspilitic), pelite, and numerous metadolerite sills
- PLHt, Medium- to coarse-grained metadolerite sills intruded into Hamersley Group
- Qa, Alluvium - unconsolidated silt, sand and gravel
- Qa, Alluvium_unconsolidated silt, sand, and gravel; in drainage channels and on adjacent floodplains
- Qc, Colluvium-unconsolidated quartz and rock fragments in soil; locally derived soil, and scree, and talus deposits
- Qw, Alluvium and colluvium - red-brown sandy and clayey soil
- Qw, Alluvium and colluvium-red-brown sandy and clayey soil; on low slopes and sheetwash areas



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South Flank Visual Impact Assessment

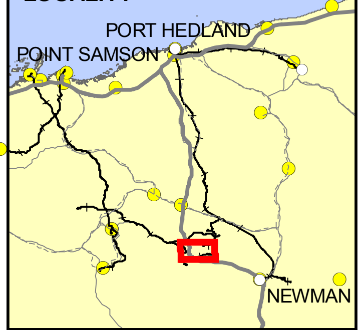
Surface Water Features

N

0 1 2 4 6 8
Kilometres
Datum: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 8
	Reviewed: F.Donaldson	

LOCALITY



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Kilometres

LEGEND

Data source:
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South Flank Iron Ore Project
Indicative Disturbance Area
Proposed Pit
Proposed OSAs

Water Features

Watercourse
Waterbodies
Floodways
Windpumps
Pool
Waterholes
Water Tanks

Transport Network

Road - sealed
Road - unsealed
Track
Railways

Infrastructure and Places

360 environments

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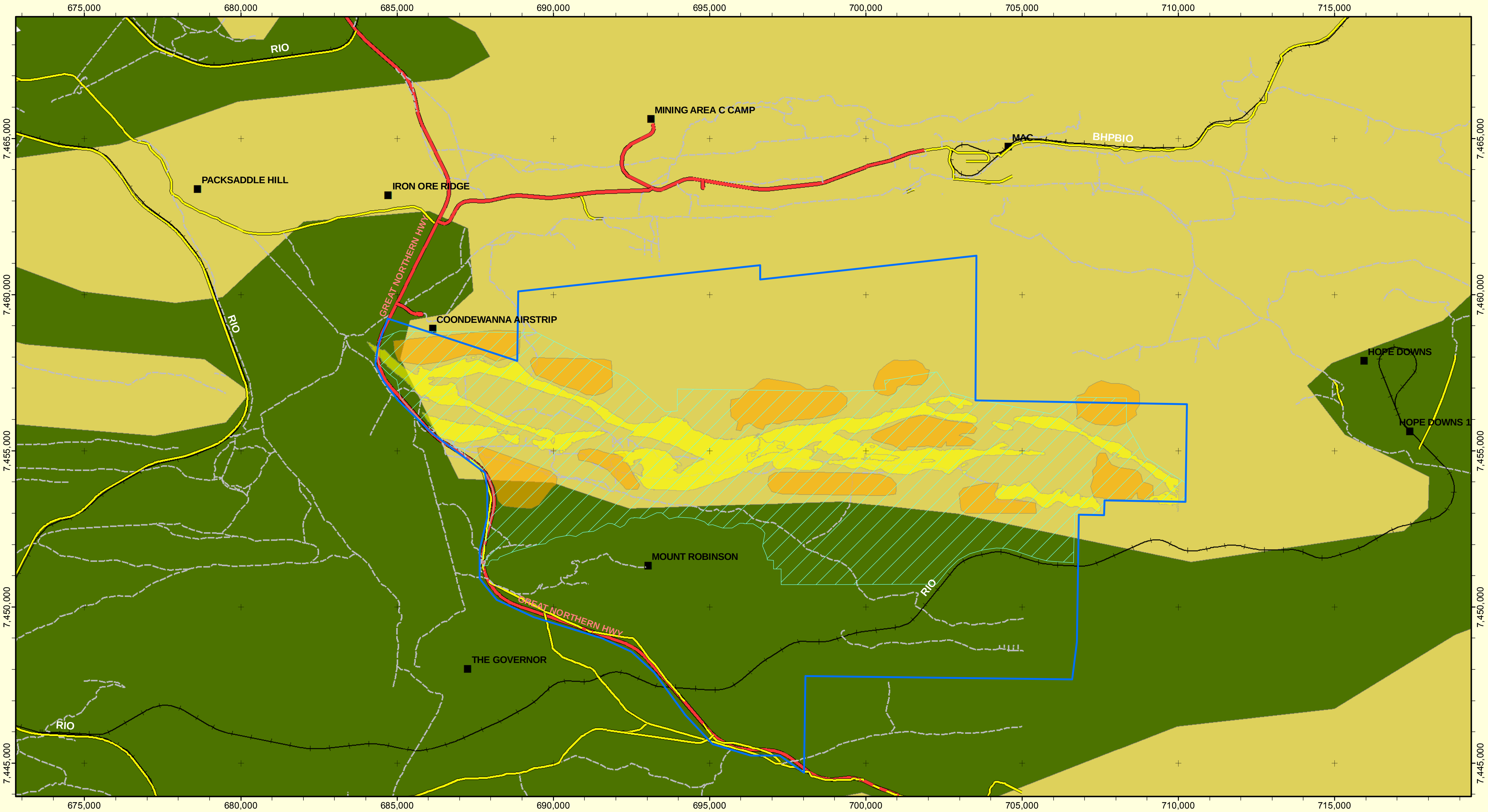
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 8 - Surface Water Features.mxd



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South Flank Visual Impact Assessment

Vegetation

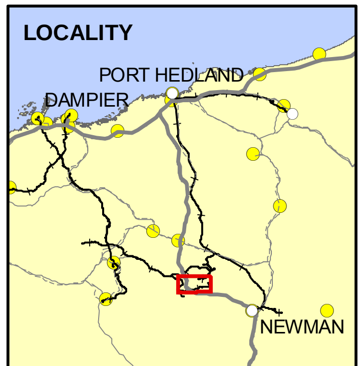
N

0 1 2 4 6 8
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 9
	Reviewed: F.Donaldson	

LOCALITY



0 400
Kilometres

LEGEND

Data source: Vegetation dara supplied by CALM.
Roads, railway & project areas supplied by BHP.

- South Flank Iron Ore Project
- Indicative Disturbance Area
- Proposed Pit
- Proposed OSAs

Beard Vegetation

- Spinifex Grassland: Tree steppe
- Eucalyptus woodland, Low Woodland: Mulga

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Railways
- Infrastructure and Places

360 environmental

Aboriginal Heritage Act
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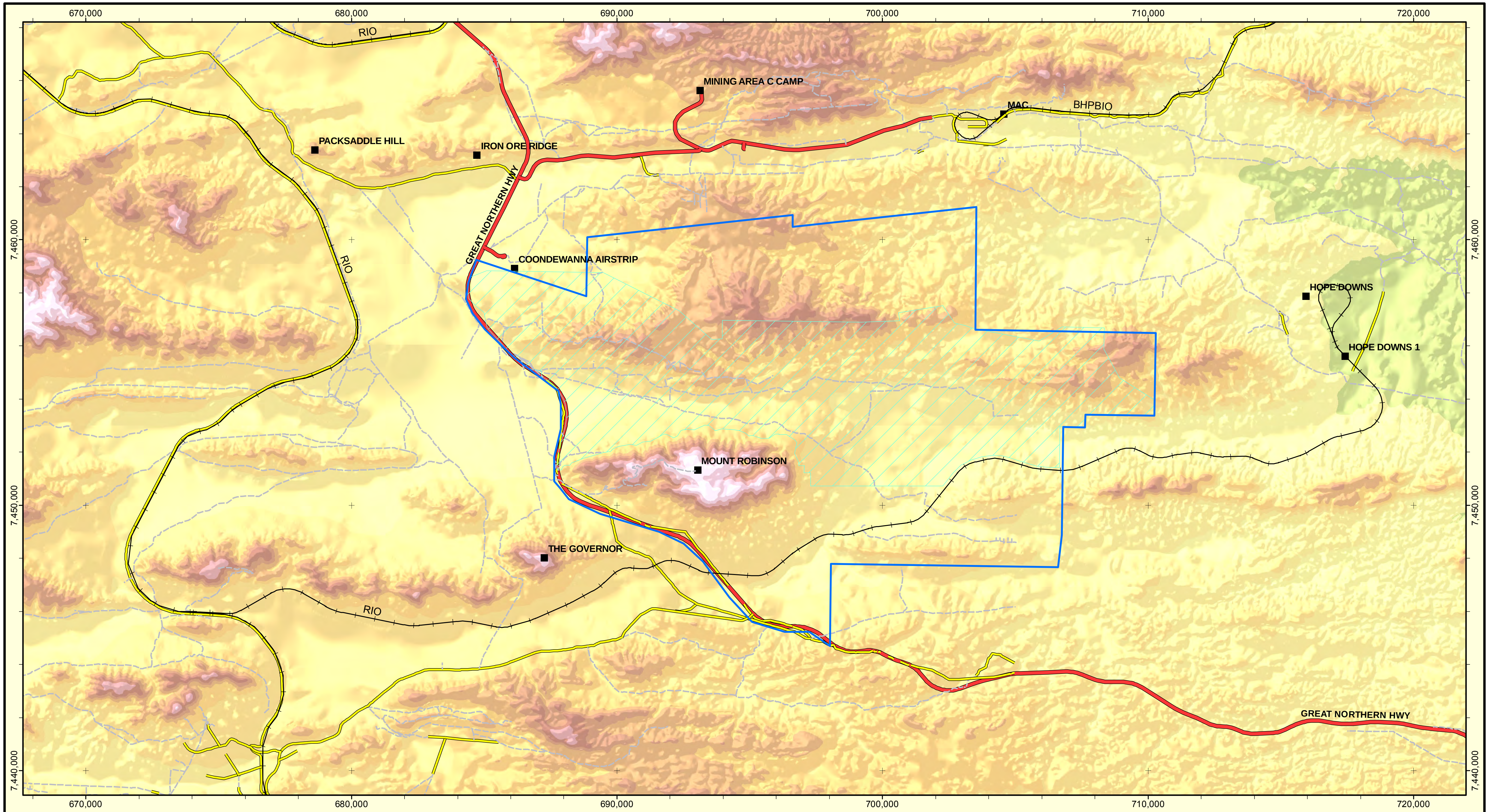
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 9 - Vegetation.mxd



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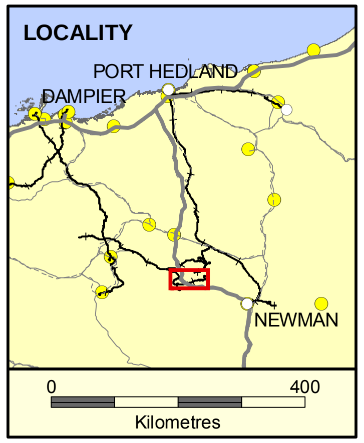
South Flank Visual Impact Assessment
Landform Relief - Pre-Development

0 2 4 8
Kilometres
Datum & Projection: GCS_GDA94 Zone 50

Scale @ A3: 1:140,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 10a
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

Data source: Elevation data supplied by Landgate 2012
Roads, railways & project areas supplied by BHP 2012.

- South Flank Iron Ore Project
- Indicative Disturbance Area

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Railways

Elevation (m)

- 398 - 465
- 466 - 548
- 549 - 614
- 615 - 664
- 665 - 703
- 704 - 743
- 744 - 783
- 784 - 829
- 830 - 879
- 880 - 932
- 933 - 995
- 996 - 1,068
- 1,069 - 1,244

- Infrastructure & Places

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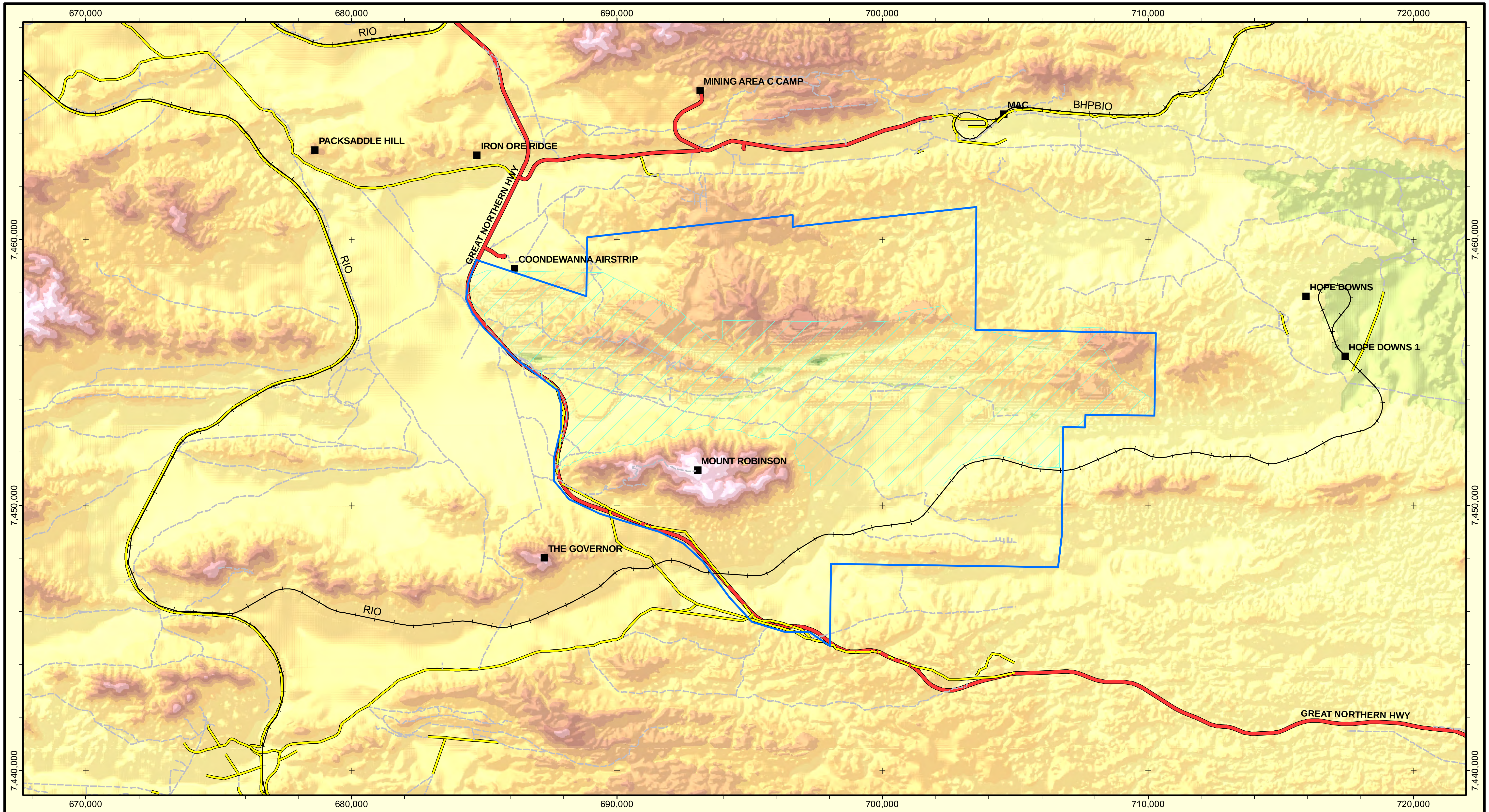
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 10a - Landform Relief.mxd



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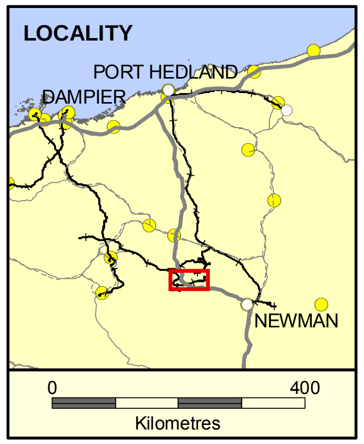
South Flank Visual Impact Assessment

Landform Relief - Post-Development

0 2 4 8
Kilometres
Datum & Projection: GCS_GDA94 Zone 50

Scale @ A3: 1:140,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 10b
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

Data source: Elevation data supplied by Landgate 2012
Roads, railways & project areas supplied by BHP 2012.

- South Flank Iron Ore Project
- Indicative Disturbance Area

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Railways

Elevation (m)

- 398 - 503
- 504 - 555
- 556 - 611
- 612 - 670
- 671 - 714
- 715 - 752
- 753 - 794
- 795 - 845
- 846 - 899
- 900 - 951
- 952 - 1,018
- 1,019 - 1,100
- 1,101 - 1,244

- Infrastructure & Places

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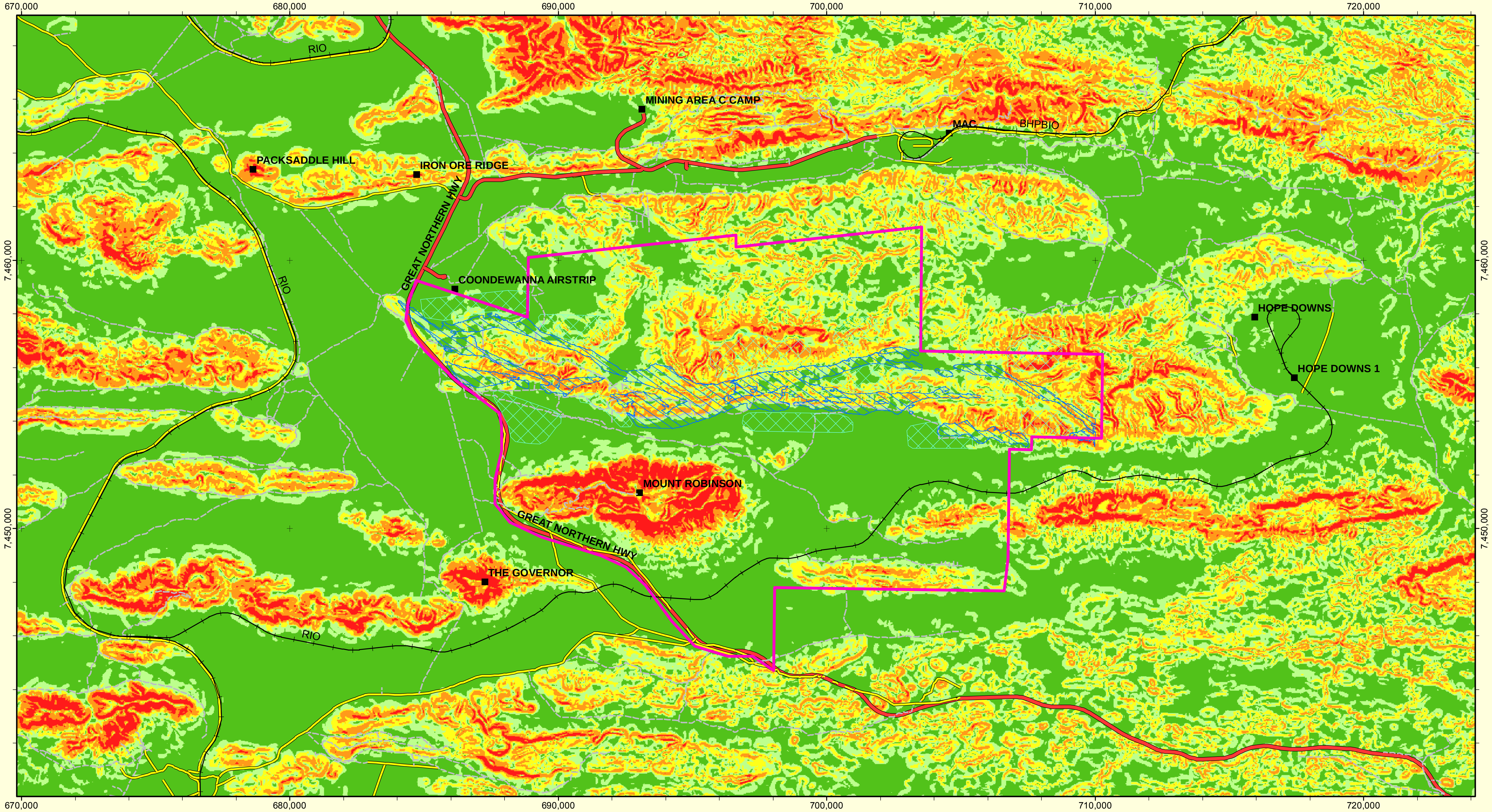
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 10b - Landform Relief.mxd



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South Flank Visual Impact Assessment

Slope of Terrain - Pre-Development

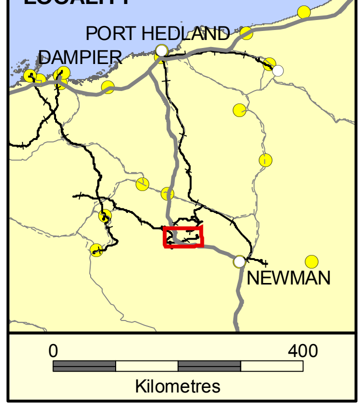
N

0 1.5 3 6 9
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:140,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 11a
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

South Flank Iron Ore Project
Proposed Pit
Proposed OSAs

Slope of Terrain (Degrees)

- 0 - 2°
- 2 - 5°
- 5 - 10°
- 10 - 20°
- More than 20°

Infrastructure and Places

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Railways

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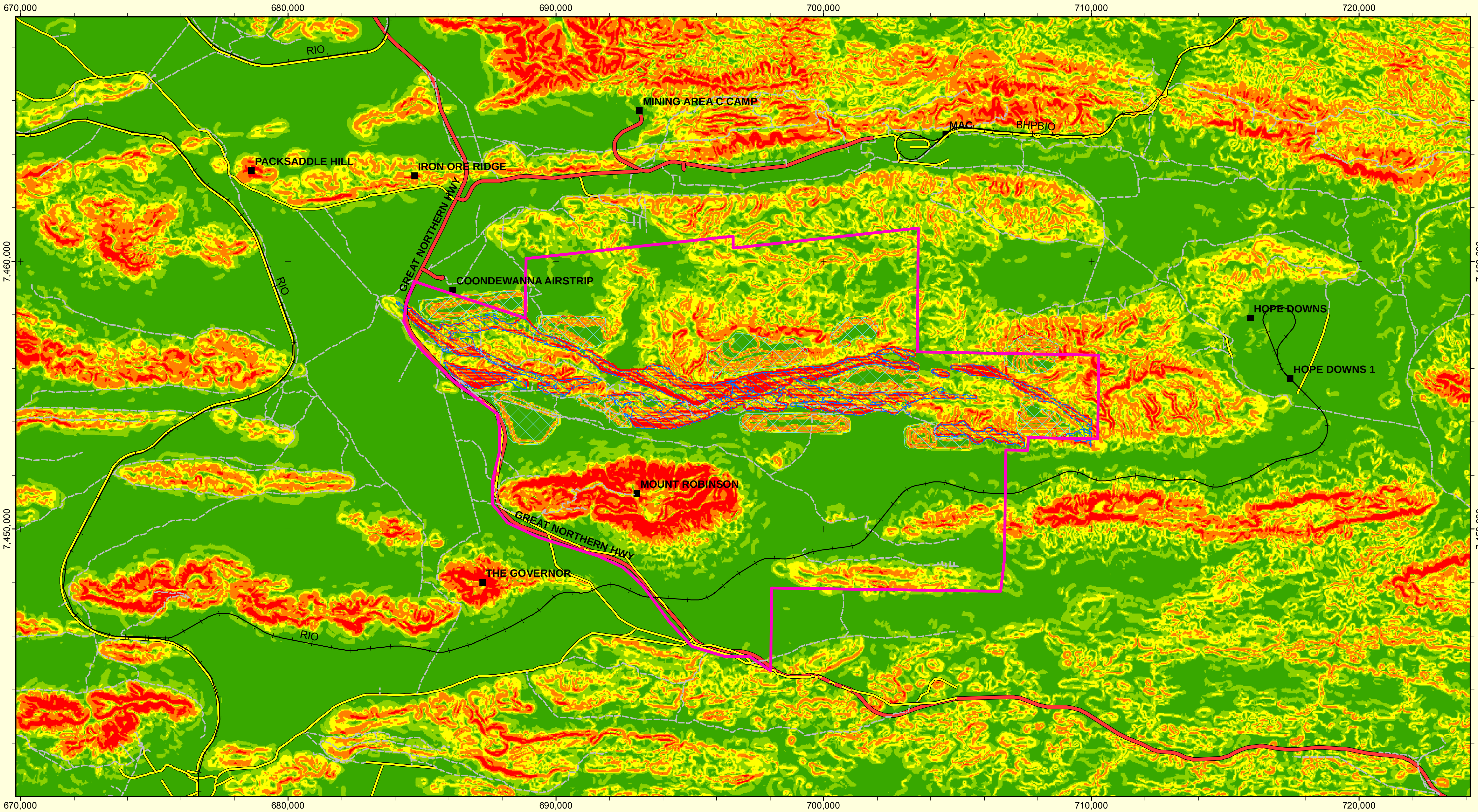

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South Flank Visual Impact Assessment

Slope of Terrain - Post-Development

0 1.5 3 6 9
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:140,000	Prepared: T.Donohue	Project No: RES048
Date: 02/05/2012	Checked: J.N.Rao	Figure: 11b
	Reviewed: F.Donaldson	

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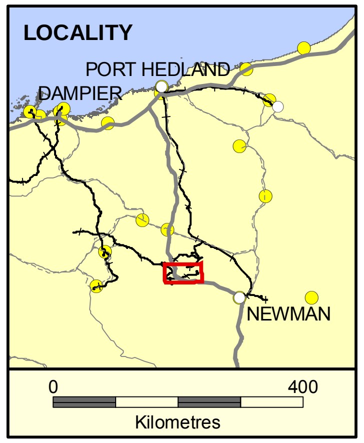

LEGEND

South Flank Iron Ore Project
Proposed Pit Footprint
Proposed OSA Footprint

Slope of Terrain (Degrees)
0 - 2°
2 - 5°
5 - 10°
10 - 20°
More than 20°

Infrastructure and Places

Transport Network
Road - sealed
Road - unsealed
Track
Railways

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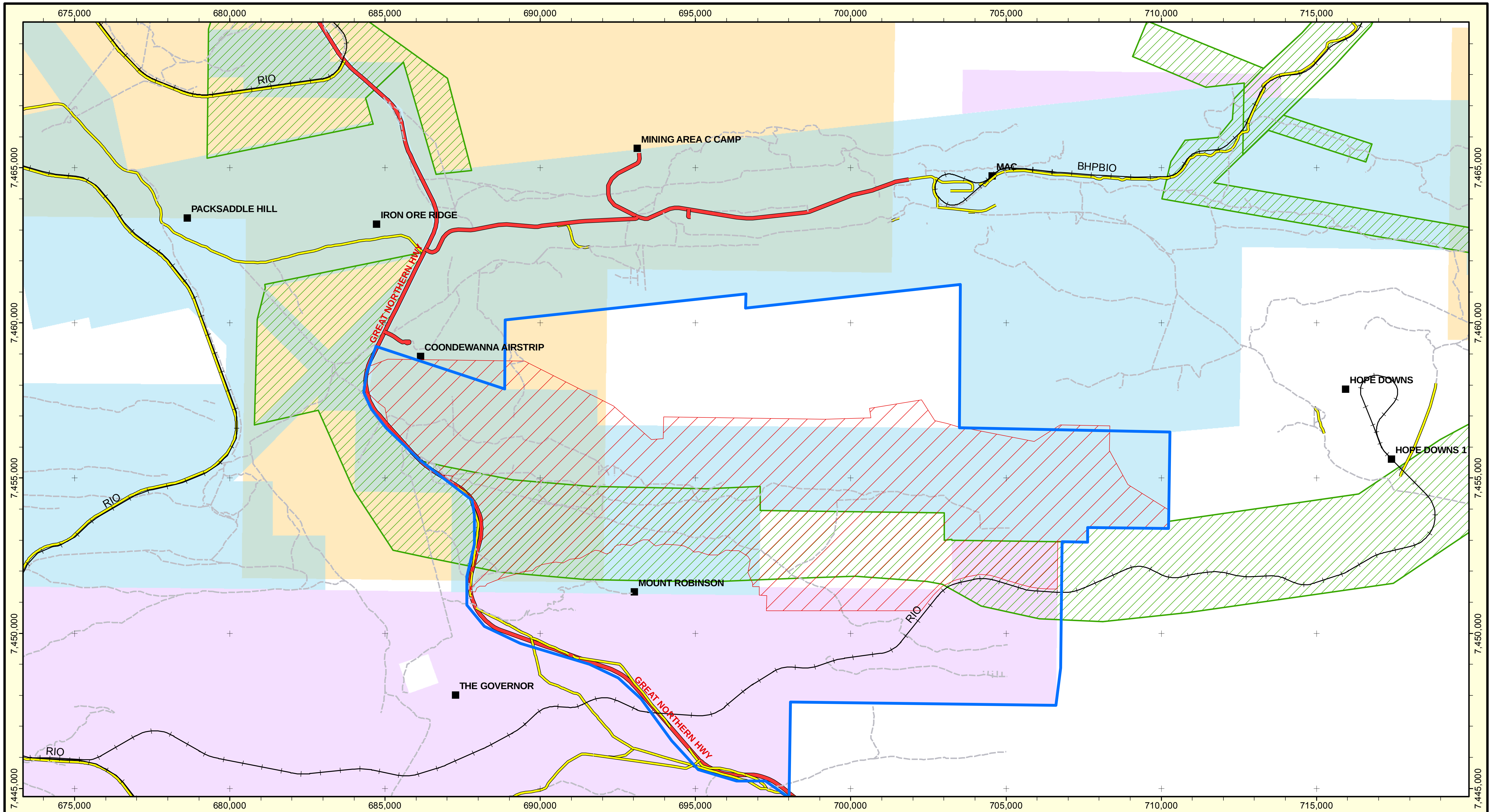
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 11b - Slope of Terrain(Regional).mxd



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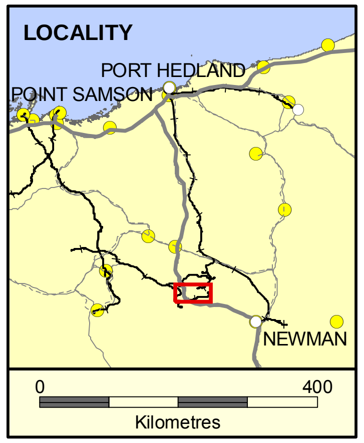
South Flank Visual Impact Assessment
Land Use

N
0 1 2 4 6 8
Kilometres
Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A3: 1:120,000	Prepared: T.Donohue	Project No: RES048
Date: 03/05/2012	Checked: J.N.Rao	Figure: 12
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

- South Flank Iron Ore Project
- Indicative Disturbance Area

BHP Tenements
- Mineral Lease
- Exploration Licence

Tenure Type
- General Purpose Lease
- Miscellaneous Licence
- Pilbara Pastoral Stations
- Infrastructure and Places

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 12 - Landuse.mxd

3.2 Valued Characteristics within the Visual Landscape

3.2.1 Valued and Preferred Characteristics

Key character indicators for classifying the landscape into preference categories have been identified by CALM (1994). These character indicators can be categorised into 'most preferred' and 'least preferred' landscapes when referring to natural, rural and built landscapes. Most preferred landscape indicators are defined as "landscapes and features that are highly valued by the community and that contribute to the visual character of the landscape" (DPI 2007). Least preferred landscape indicators are defined as "landscapes and features that are not valued by the community and that detract from the visual character of the landscape" (DPI 2007).

In the case of this study, the Hamersley Ranges were identified as 'most preferred' landscapes due to the following features:

- The presence of water bodies such as waterfalls, springs, and water pools in the adjacent Karijini National Park;
- A high degree of perceived naturalness and ancientness, due to the old, weathered and rugged look of the landscape;
- High vegetation diversity such as: species of spinifex and eucalypt;
- High degree of topographic variety and vertical relief i.e. Mt Robinson and Mt Meharry;
- Wide panoramic field of views from the top of elevated areas combined with favourable weather conditions for most of the year;
- Distinctive displays of colour including: red – orange soils and outcropping rocks contrasting with light spinifex vegetation and eucalypts; and
- Outstanding combinations of landform, geological, vegetation and water features in one area resulting in a large number of varied and positive view experiences.

Some of the pastoral landscape within the study area was also identified as 'most preferred' landscapes due to the following features:

- Presence of windmills/windpumps within the landscape;
- Water tanks along unsealed roads surrounding the sites; and
- Juna Downs, a homestead that is a significant pastoral farming homestead within the study area.

‘Least preferred’ landscapes have also been identified. These include:

- Evidence of mining at Mining Area C; and
- Unmaintained windmills/windpumps.

3.2.2 Visual Quality

Characteristics of the landscape that are valued by society are related to visual quality. Visual quality can be termed as the relative visual character of a landscape, based on an overall visual impression held by society (CALM 1994). This term is slightly different to view experience as visual quality is a society based measure which contributes to the overall appeal of a region, whereas a view experience is the impression that an individual experiences when looking at a view. A high visual quality of a region for society can be defined by a large frequency and variety in positive view experiences by an individual. Visual quality generally increases with greater:

- Value or rarity of a natural landscape;
- Variety in topography or relief and outstanding landform i.e. a rock cliff or face instilling a sense of awe;
- Vegetation and landscape diversity; and
- Frequency and variety of positive view experiences.

Visual quality is described in *Reading the Remote, Landscape Characters of Western Australia* (CALM 1994) as “the relative visual character of a landscape, expressed as an overall visual impression or value held by society after perceiving an area of land/water”.

It is expected that the emission of dust clouds from the Project will likely affect visual quality in the vicinity of the Project. As this assessment focuses on the visual impact of the mine on visual quality, the full impact of dust on the view of surrounding areas outside of the Project was not evaluated.

As the distribution of dust particles are heavily affected by prevailing environmental conditions, the results of the AQA can only be considered as indicative for the concentrations of particulate matter that are likely to be encountered during the operations phase of the Project.

4 Field Assessment Results

The viewpoints identified in the desktop analysis were visited by foot and vehicle between the 23 April and 25 April 2012. GPS waypoints, field notes and digital photographs were taken at each site. The digital photographs were later used in the photomontage analysis.

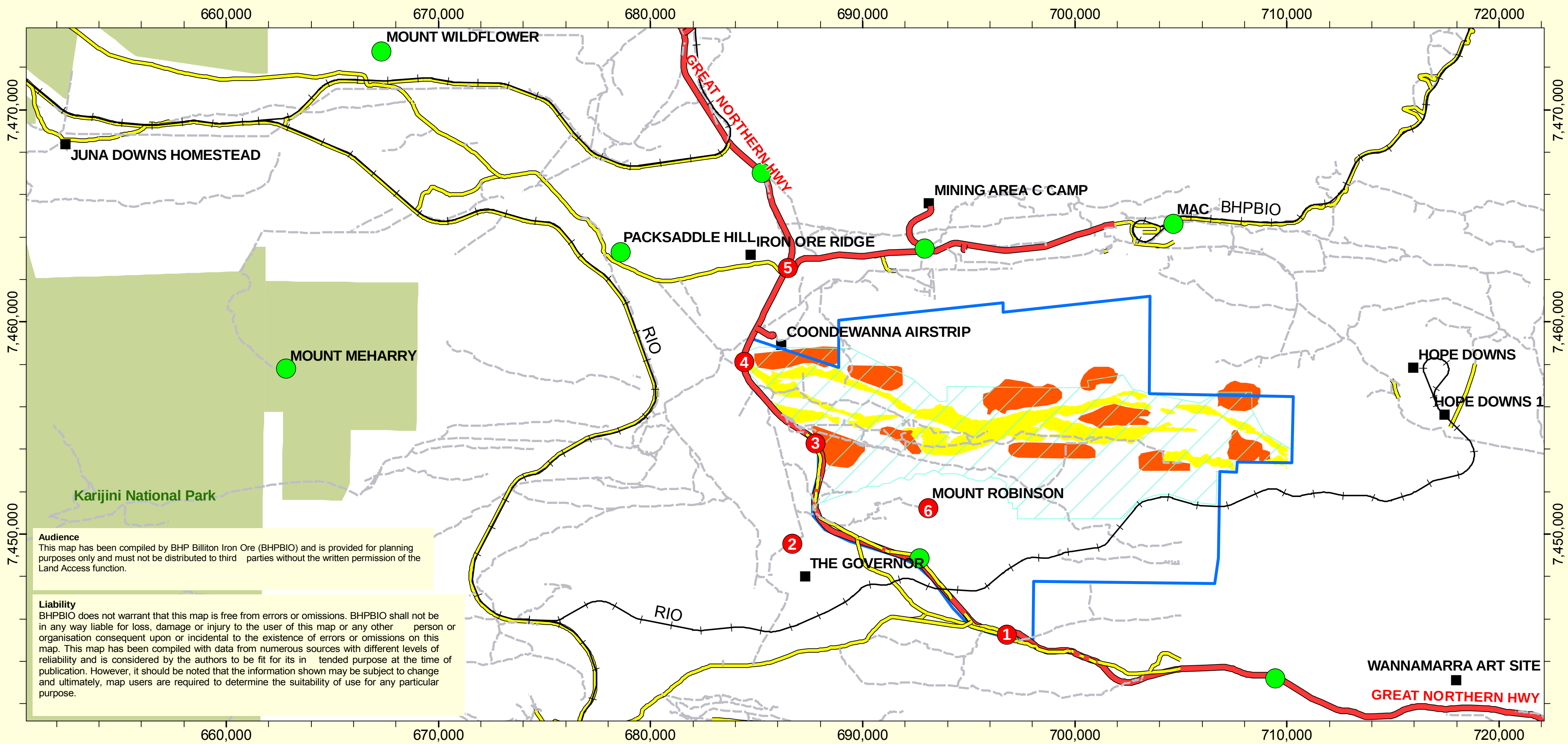
4.1 Viewpoints and Key Viewpoints

Based on the desktop analysis, a total of 13 viewpoints were determined and visited in the field. These are shown in Figure 13. Of these, six were identified as 'key' viewpoints, based on field estimates of potential visual impact and level of viewpoint importance. Table 4 summarises the characteristics of these key viewpoints, which are organised by Level of Significance, as defined in Table 3.

Table 4: Key Viewpoints

Significance Level	View Location	Significance Comment
Level 1	GNH, Coondewanna Flats (Viewpoints 1,3,4)	Significant State Highway, heavily used by tourists, locals and mining employees.
Level 2	GNH, Hamersley Range (Viewpoint 5) Mt Robinson (Viewpoint 6)	Significant tourist lookout and elevated area. Lower in significance due to further distance from development. Highest publically accessible point within the South Flank Site. Low significance due to bad track condition. This site was not visited during the field assessment.
Level 3	The Governor (Viewpoint 2)	Elevated area on a track off GNH. Locally significant area for tourists however accessibility and low visitor traffic contribute to a lower overall significance.

Figure 13 also illustrates the numbering system used for the key viewpoints. Figure 14 shows the aspects (direction) of the digital photos taken on site (presented in Section 4.2).



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South Flank Visual Impact Assessment

Recreational Sites & Viewpoints

N

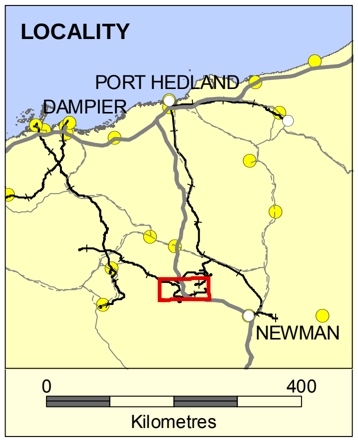
0 5 10 20

Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A4: 1:270,000	Prepared: T.Donohue	Project No: RES048
Date: 03/08/2012	Checked: J.N.Rao	Figure: 13
	Reviewed: F.Donaldson	

LOCALITY



LEGEND

Data source:
All data supplied by BHP unless otherwise specified

Viewing Locations Assessed in the Field
- Viewpoint
- Key Viewpoint
- South Flank Iron Ore Project
- Indicative Disturbance Area
- Proposed OSAs
- Proposed Pit

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways
- Recreation Sites & Existing Mining Places
- Karijini National Park

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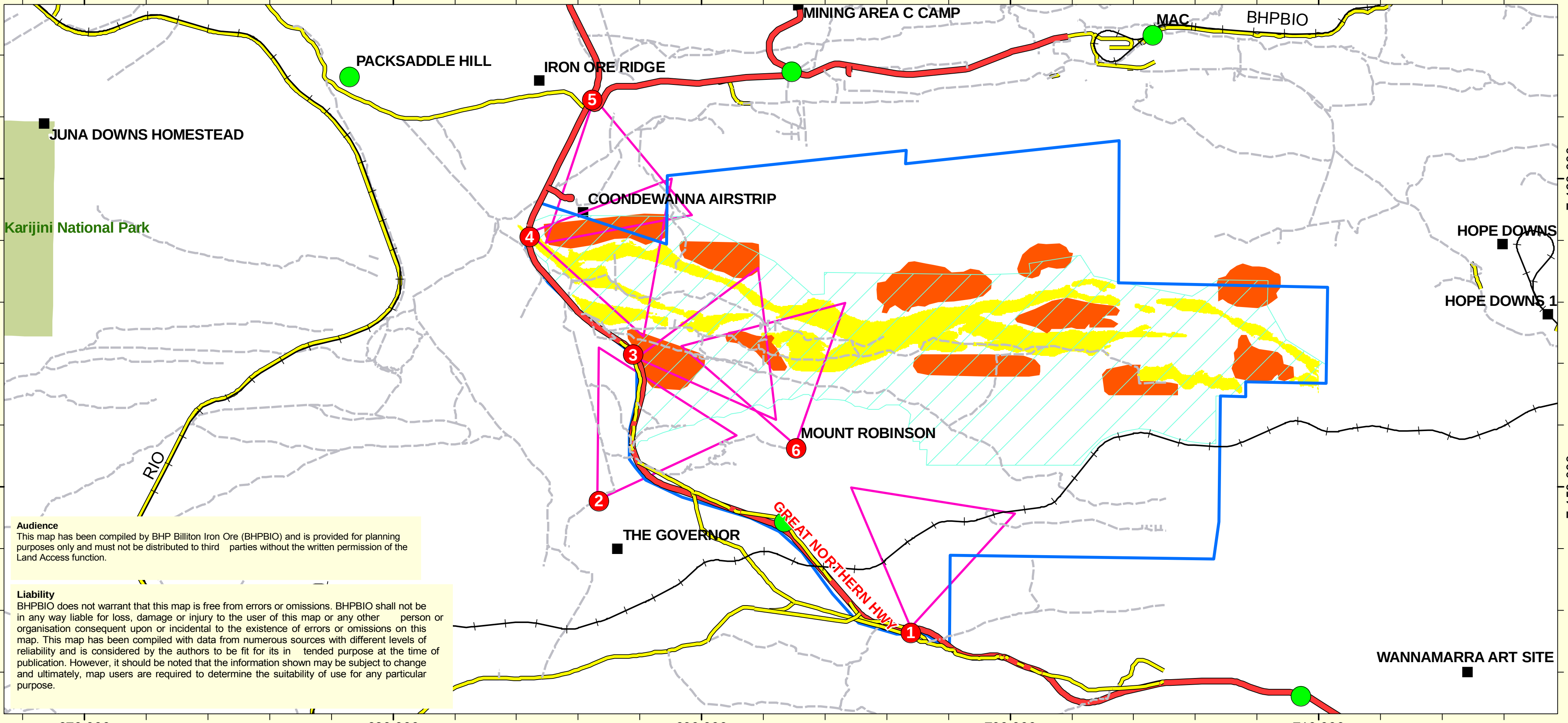

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South Flank Visual Impact Assessment

Key Viewpoint Photo Aspects

N

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Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @ A4: 1:190,000	Prepared: T.Donohue	Project No: RES048
Date: 03/08/2012	Checked: J.N.Rao	Figure: 14
	Reviewed: F.Donaldson	

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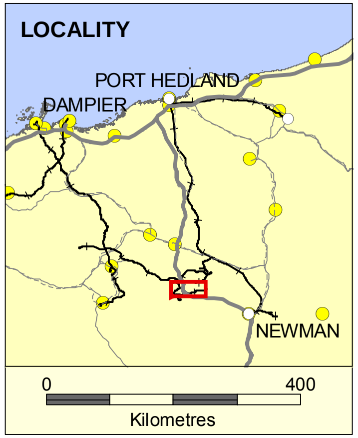

LEGEND

Data source:
All data supplied by BHP unless otherwise specified

Viewing Locations Assessed in the Field
- Viewpoint
- Key Viewpoint
- Photomontage Aspect
- South Flank Iron Ore Project
- Indicative Disturbance Area
- Proposed OSAs
- Proposed Pit

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways
- Recreation Sites & Existing Mining Places
- Karijini National Park

360 environmental

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 SF Figure 14 - SF Recreation sites & visual access.mxd

4.2 Views from Key Viewpoints

Table 5: Viewpoint 1 View

VIEWPOINT 1: VIEW ALONG GNH	
Visual location	View north and north-east along GNH.
Viewpoint elevation	707.55 m Australian Height Datum (AHD).
Viewing distance	7.2 km to closest proposed infrastructure.
Visual setting	Background extends from 6.5 - 16+ km.
Motion of viewer	Highway speed up to 110 km/h.
Vegetation cover	Moderate <70%.
Vegetation type	Low eucalyptus woodland and mulga shrublands.
Canopy density	Moderate >40%.
Land use	Major state highway.
Potential visual risk	Moderate.
Percentage of total development area visible	5 - 10%.
Valued landscape characteristics	Panoramic views of Mt Robinson in the midground, Hamersley Range in the background. Foreground relatively flat.
View experience	Relatively positive due to topographic and vegetation diversity.
VMO	The pit area and OSA could be camouflaged through revegetation within the landscape so they are not evident from this view.

Plate 4: Existing View from Viewpoint 1

Table 6: Viewpoint 2 View

VIEWPOINT 2: PUBLIC ACCESS TRACK OFF THE GNH	
Visual location	Elevated area along public access vehicle track off GNH.
Viewpoint elevation	736.38 m AHD.
Viewing distance	3.62 km to closest proposed infrastructure.
Visual setting	Midground 500 m - 6.5 km.
Motion of viewer	Local traffic, walking, stationary.
Vegetation cover	Very Low <20%.
Vegetation type	Low eucalyptus woodland and mulga shrubland.
Canopy density	Low <10%.
Land use	Public access track.
Potential visual risk	Moderate - Low, Western edge of development visible.
Percentage of total development area visible	10%.
Valued landscape characteristics	Mt Robinson to the right of the view, and the Hamersley Range in the distance.
View experience	Relatively neutral to positive, due to large variety in plant species.
VMO	The landforms prominent within this view could be retained and kept as the dominant feature within the landscape. OSA heights could also be kept lower than the horizon. This viewpoint is a lower priority for mitigation due to low viewer traffic.

Plate 5: Existing View from Viewpoint 2

Table 7: Viewpoint 3 View

VIEWPOINT 3: VIEW ALONG THE GNH	
Visual location	Views north to east along GNH.
Viewpoint elevation	697.41 m AHD.
Viewing distance	300 m to closest proposed infrastructure.
Visual setting	Foreground 0 - 500 m.
Motion of viewer	Highway speed up to 110 km/h.
Vegetation cover	Very Low <5%.
Vegetation type	Low Eucalyptus woodland and mulga shrubland.
Canopy density	Very Low <5%.
Land use	Major state highway.
Potential visual risk	High.
Percentage of total development area visible	40 - 50%.
Valued landscape characteristics	Views of Mt Robinson and the Hamersley Range in the distance, relatively low variety in plant species.
View experience	Relatively neutral.
VMO	Views to the mine development could be screened and ridge lines kept intact so natural landscape character is preserved. OSAs could be revegetated.

Plate 6: Existing View from Viewpoint 3

Table 8: Viewpoint 4 View

VIEWPOINT 4: VIEW ALONG GNH	
Visual location	View east and south – east along the GNH.
Viewpoint elevation	707.96 m AHD.
Viewing distance	200 m to closest proposed infrastructure.
Visual setting	Foreground 0 – 500 m.
Motion of viewer	Highway speed up to 110 km/h.
Vegetation cover	Low <10-20%.
Vegetation type	Low eucalyptus woodland and mulga shrublands.
Canopy density	Moderate <30% (east), low <5% (south-east).
Land use	Major state highway.
Potential visual risk	High.
Percentage of total development area visible	10 - 15%.
Valued landscape characteristics	Pleasant assortment of vegetation species and wildflowers. Flat landscape results in wide panoramic views.
View experience	Neutral to positive, due to variety in vegetation.
VMO	Screening of the mining development infrastructure could be completed and elevated landforms retained in the background. Ridge lines could be kept intact so as to preserve landscape character and block out views to the remaining development.

Plate 7: Existing View from Viewpoint 4

Table 9: Viewpoint 5 View

VIEWPOINT 5: VIEW ALONG THE GNH	
Visual location	View east and south-east along GNH.
Viewpoint elevation	731.53 m AHD.
Viewing distance	4.65 km to closest proposed infrastructure.
Visual setting	Mid-ground 500 - 6.5 km.
Motion of viewer	Highway speed up to 110 km/h.
Vegetation cover	Low <5%.
Vegetation type	Low eucalyptus woodland: Mulga; Spinifex Grassland: Tree steppe.
Canopy density	Very Low <5% due to elevated panoramic view.
Land use	Major state highway.
Potential visual risk	Moderate to High.
Percentage of total development area visible	10 - 20%.
Valued landscape characteristics	Relatively high elevation results in panoramic views of the landscape, with Mt Robinson visible in the background. A water feature is also visible.
View experience	Positive due to panoramic view and variety in features.
VMO	The view experience could be maintained by limiting the extent to which the development is evident from this view though revegetation. Prominence of plant cover could be minimised as much as possible.

Plate 8: Existing View from Viewpoint 5

Table 10: Viewpoint 6 View

VIEWPOINT 6: MT ROBINSON LOOKOUT	
Visual location	View north, north-east, north-west.
Viewpoint elevation	1157.17 m AHD.
Viewing distance	1.5 km to closest proposed infrastructure.
Visual setting	Mid-ground 500 m to 6.5 km.
Motion of viewer	Stationary / walking.
Vegetation cover	Low <5%.
Vegetation type	Low eucalyptus woodland: Mulga.
Canopy density	Very Low <5%.
Land use	Public lookout.
Potential visual risk	High.
Percentage of total development area visible	70%.
Valued landscape characteristics	High elevation results in panoramic view of the site.
View experience	Positive, due to panoramic view, elevation, and variety in features.
VMO	Keeping the ridgelines within the development and limiting development to the lower areas of the landscape will maintain some landscape character. Enhancement of the lookout and track up to the lookout could be used for people who want to view the mining landscape.

Image Source: BHP Billiton Iron Ore (2012)

Plate 9: Existing Aerial View from Viewpoint 6, facing NNE

As this viewpoint was inaccessible during the field visit, an oblique aerial photograph of the development area taken above Mt Robinson was used which exaggerates visibility, due to the increased elevation above Mt Robinson.

5 Visual Impact Simulation Results

5.1 Viewshed Analysis

The specific viewsheds for the viewpoints selected for analysis are illustrated in Figures 15 – 20. Distance zones are also depicted, illustrating the extents of the foreground, midground and background. These areas are purely for illustrative purposes. Viewshed analyses do not consider the effects of vegetation screening, heights, canopy density or the effects of dust obscuring distant objects and can only provide conservative estimate of visibility applicable to a planning and risk mitigation perspective. An additional viewshed analysis was also performed for the entire length of the GNH a known source of viewers, as the development may potentially be visible throughout much of its length. This viewshed is presented in Figure 21.

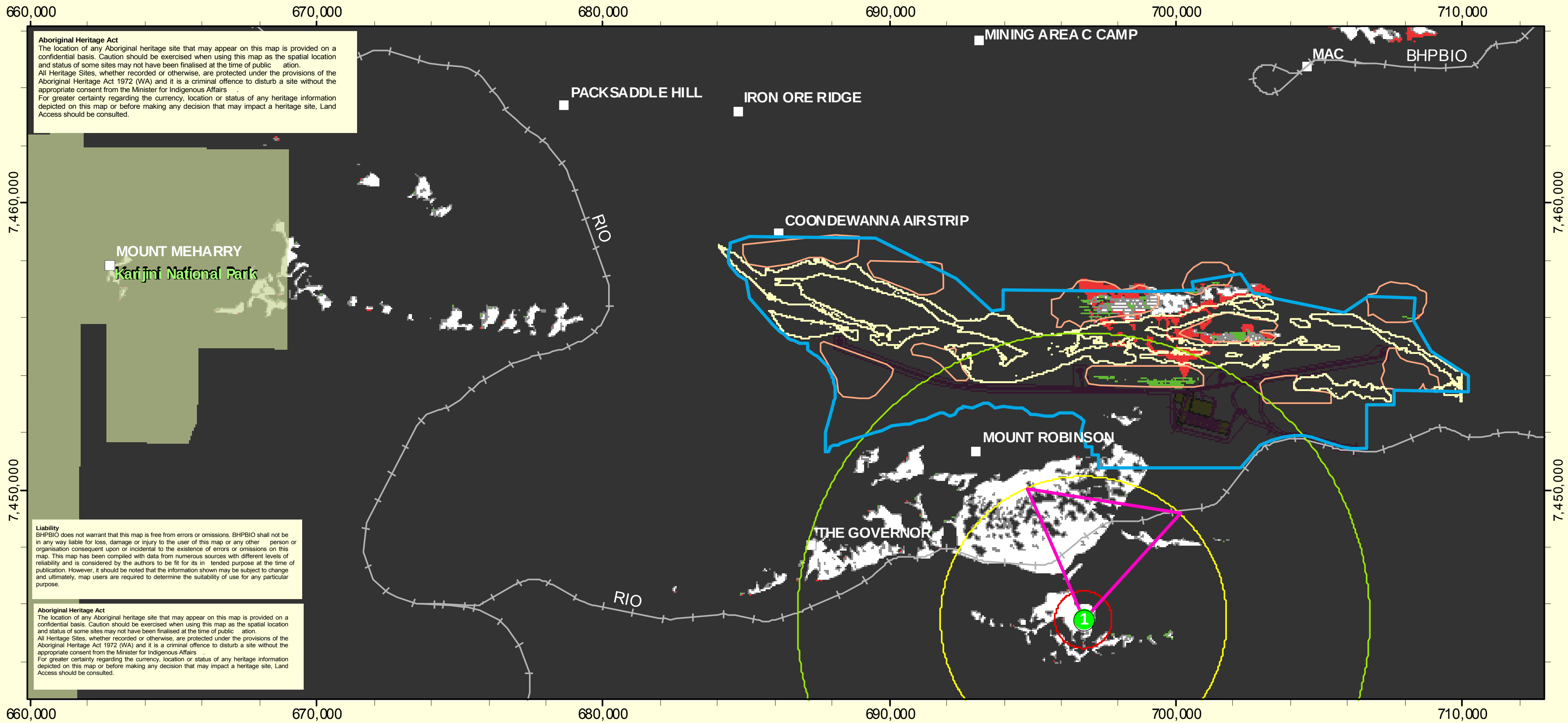
The viewsheds in Figure 15 – 21 illustrate a highly detailed schematic of visual impact, both before, and as a result of the development. Two elevation models were produced from 10 m contour data as well as from 3D CAD drawings of the proposed pit and OSAs. This resulted in a pre-development and post-development topography, incorporating the 3D profiles of OSAs and the pit (Figures 10a and 10b), enabling the calculation of both pre-development and post-development viewsheds. By performing simple logical expressions, the changes to the viewshed which are a result of the proposed development may be determined.

This was done as OSAs have the potential to block out views of the landscape behind them. The excavation of the pit may also be obscured if the excavation is below the visual plane of a viewer (Figure 3). The viewsheds in Figures 15 – 21 illustrate four different conditions. The first, in black, represents areas of the site which are always obscured. The second in red, represents areas that will be obscured when development of the site is completed. The green areas represent areas that will be made visible as a result of the development, should ridgelines be altered. Areas which are not coloured represent areas which are always visible before and after the development (no change).

The results of all key viewpoint viewsheds and the GNH viewshed, were then combined to produce a summary viewshed which identifies areas of the site that are theoretically visible before and after the development to viewers travelling along the GNH as well as those standing at any key viewpoint (Figure 22).

5.1.1 Viewshed Analysis Results

The results of the viewshed analyses are illustrated in Figures 15 – 22.



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South Flank Visual Impact Assessment

Key Viewpoint 1 Viewshed Analysis

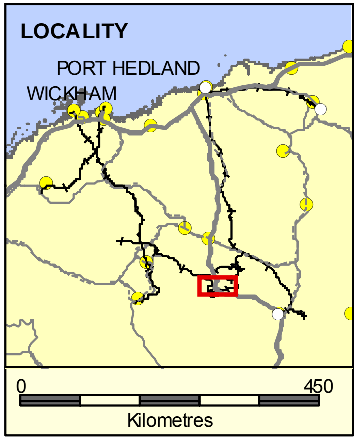
N

0 3 6 12
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:200,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 15
	Reviewed: M.Rhodes	

LOCALITY



LEGEND

Viewpoint 1

Infrastructure and Places
- Places
- Indicative Disturbance Area
- Photomontage Aspect
- Railways
- Pit
- OSAs
- Karijini National Park
- CE-1 Rail
- CE-1 Footprint

Visual Risk
- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

360

Datasource: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

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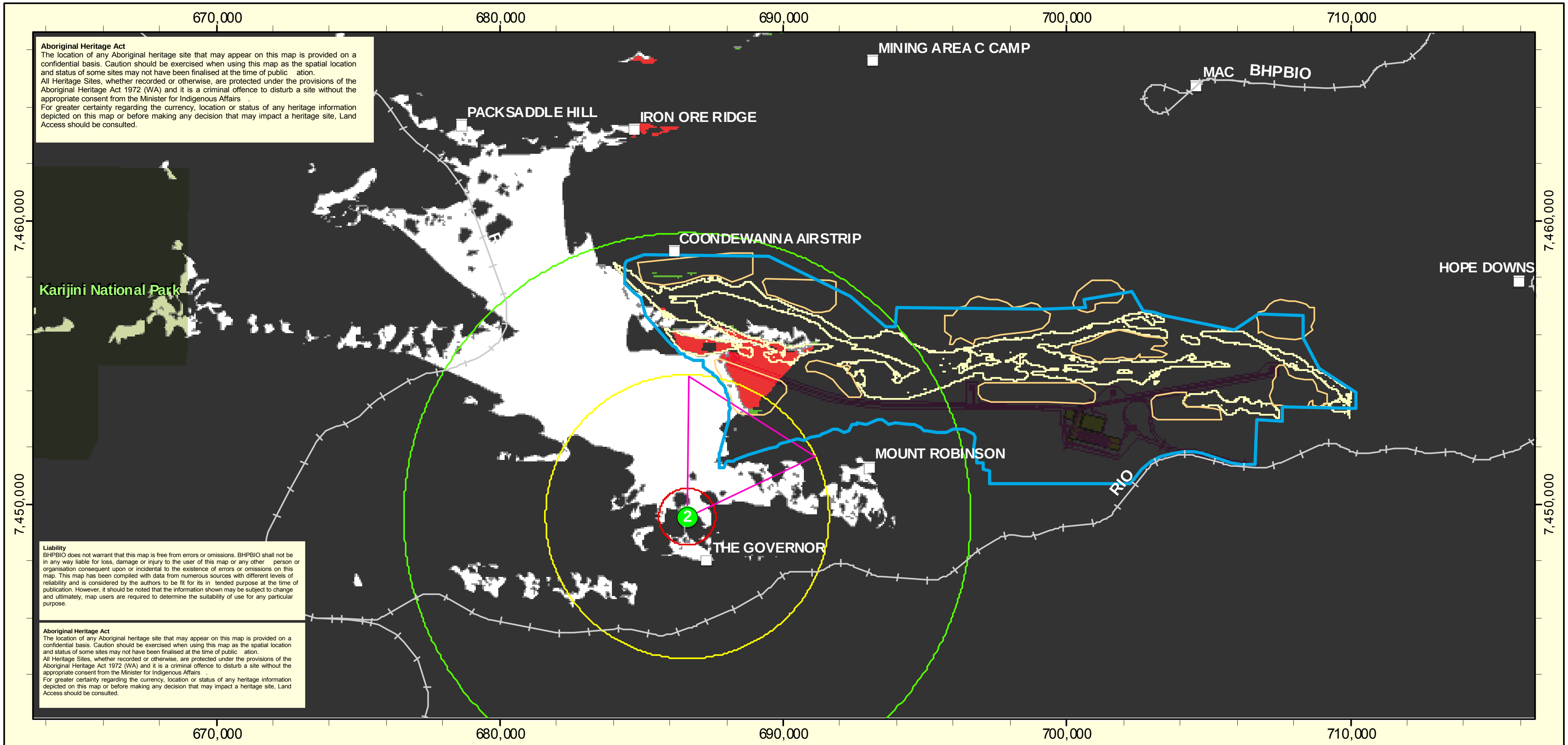
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 15 - SF Viewpoint 1 Viewshed Analysis.mxd



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South Flank Visual Impact Assessment

Key Viewpoint 2 Viewshed Analysis

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Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:200,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 16
	Reviewed: M.Rhodes	

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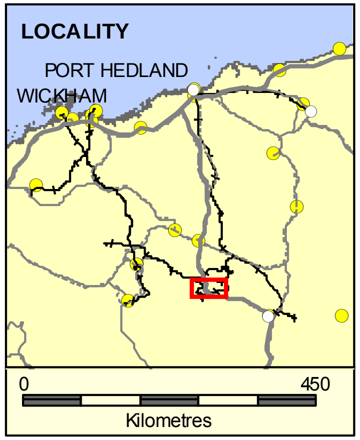

LEGEND

Viewpoint 2

Infrastructure and Places
- Places
- Railways
- Indicative Disturbance Area
- Photomontage Aspect
- Karijini National Park
- CE-1 Rail
- CE-1 Footprint
- OSAs
- Pit

Visual Risk
- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

Data source: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
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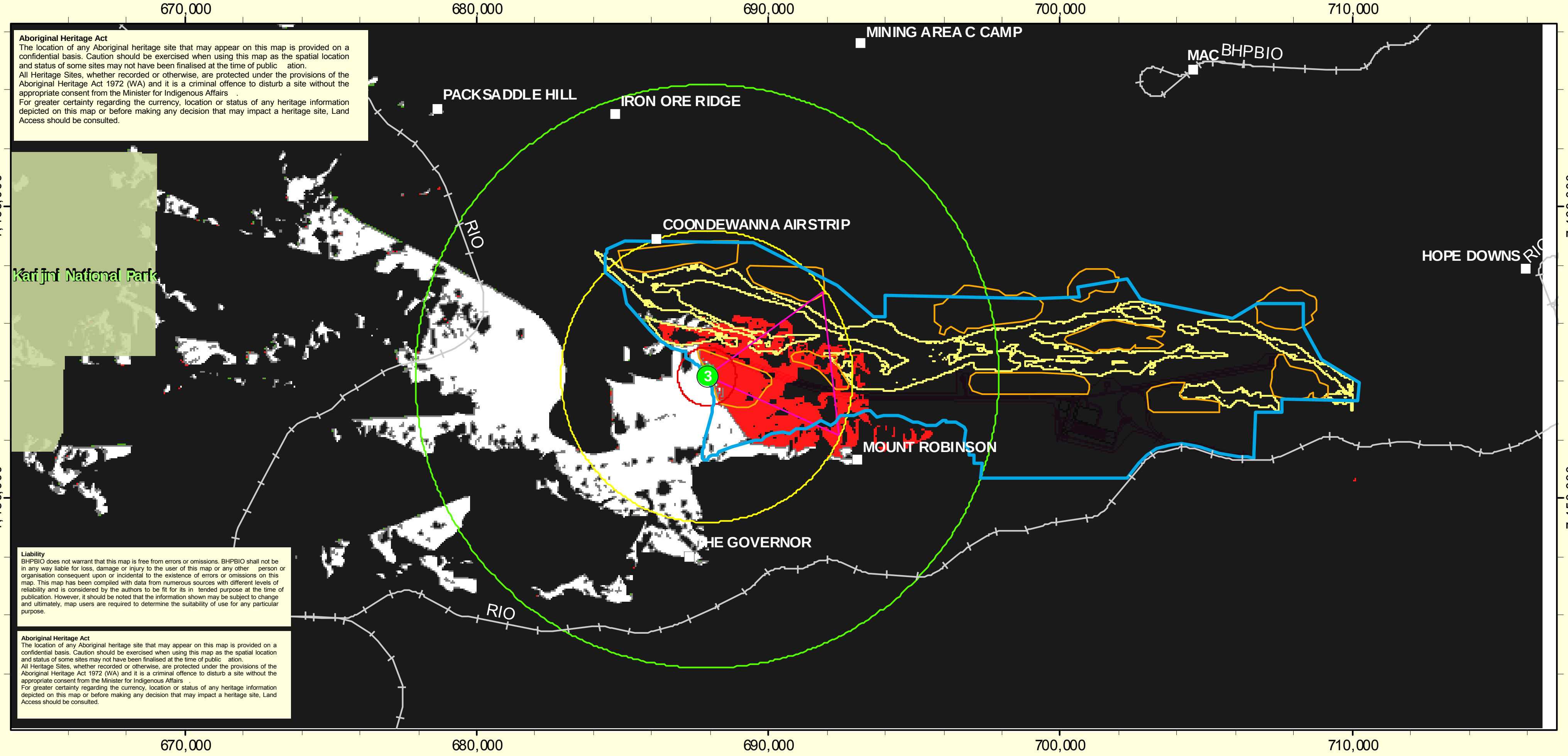

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Key Viewpoint 3 Viewshed Analysis

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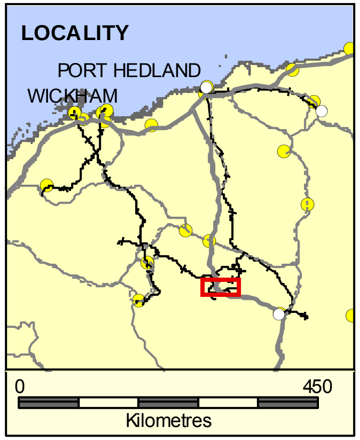
Date: 10/01/2013	Checked: F.Donaldson	Figure: 17
	Reviewed: M.Rhodes	



LEGEND

Viewpoint 3

Infrastructure and Places

- Places
- Indicative Disturbance Area
- Railways
- OSAs
- Pit
- Karijini National Park
- Photomontage Aspect
- Central Plant Rails
- Central Plant Footprint

Visual Risk

- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis

- Always Obscured
- Obscured due to Development
- Visible due to Development
- Always Visible

Datasource: Aerial photography supplied by Landgate 2012
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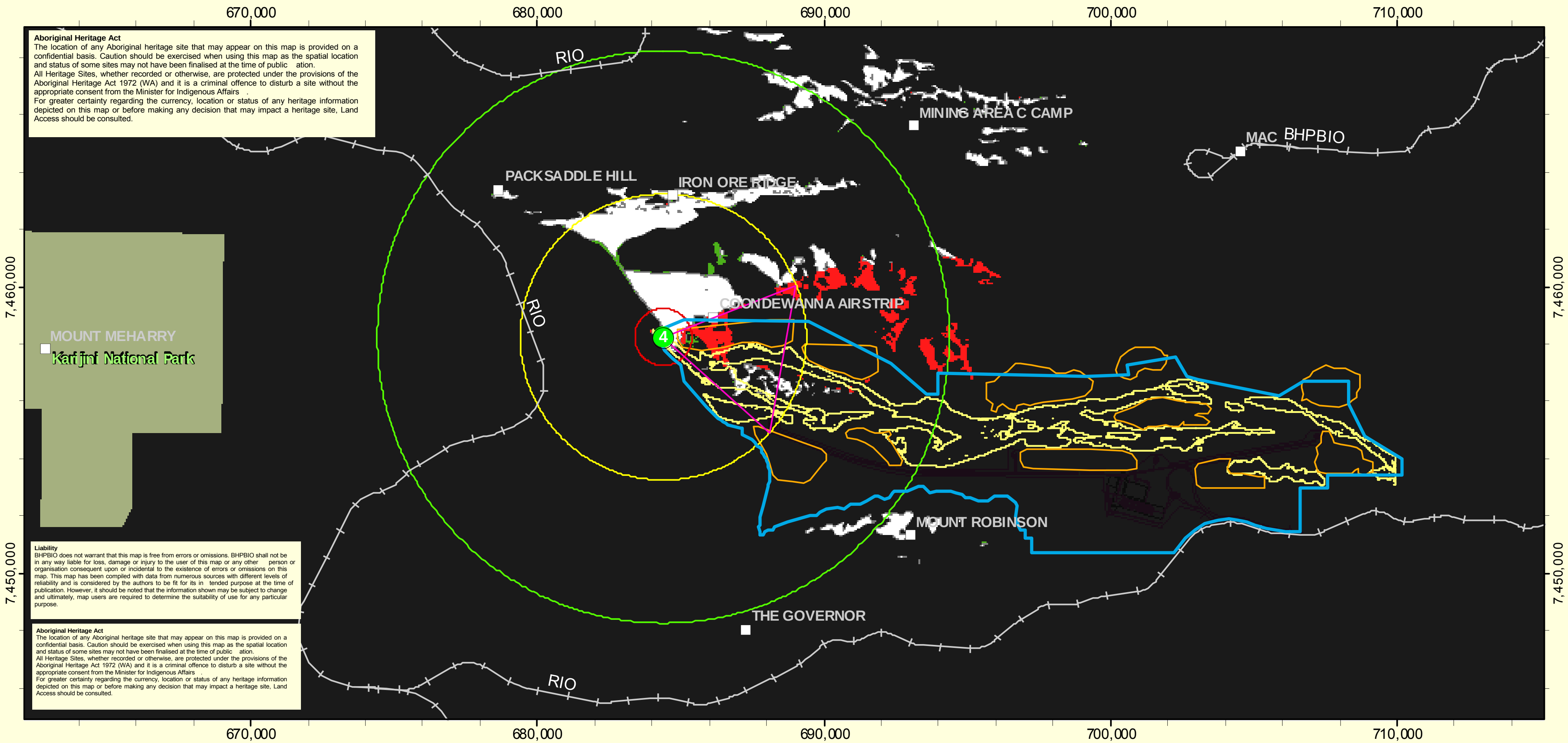

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South Flank Visual Impact Assessment
Key Viewpoint 4 Viewshed Analysis

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Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:200,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 18
	Reviewed: M.Rhodes	

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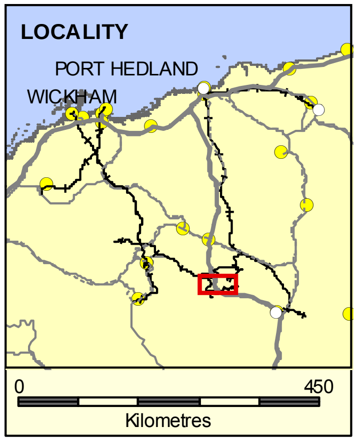

LEGEND

Viewpoint 4

Infrastructure and Places
- Places
- Indicative Disturbance Area
- Photomontage Aspect
- Karijini National Park
- OSAs
- Pit
- Central Plant Rails
- Central Plant Footprint
- Railways

Visual Risk
- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

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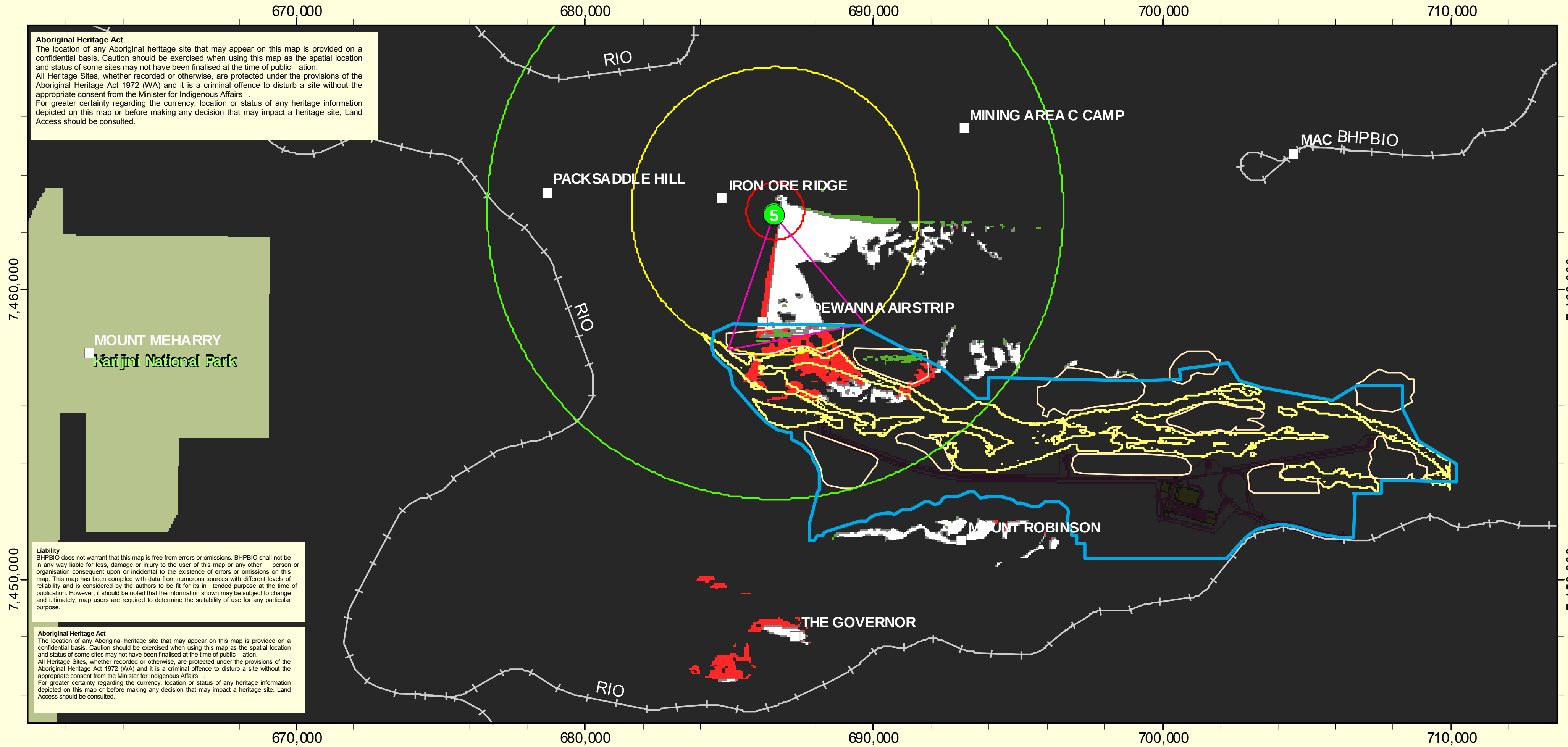

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South Flank Visual Impact Assessment

Key Viewpoint 5 Viewshed Analysis

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Date: 10/01/2013	Checked: F.Donaldson	Figure: 19
	Reviewed: M.Rhodes	

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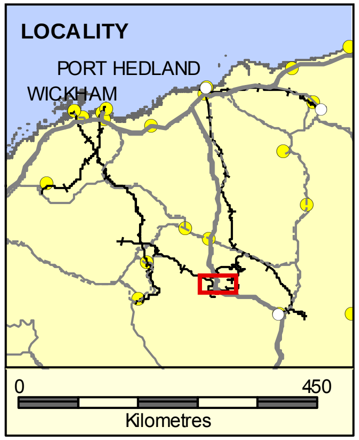

LEGEND

Viewpoint 5

Infrastructure and Places
- Places
- Indicative Disturbance Area
- Photomontage Aspect
- Railways
- Karijini National Park
- OSAs
- Pit
- Central Plant Rails
- Central Plant Footprint

Visual Risk
- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

Data source: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

360

Mining Tenements
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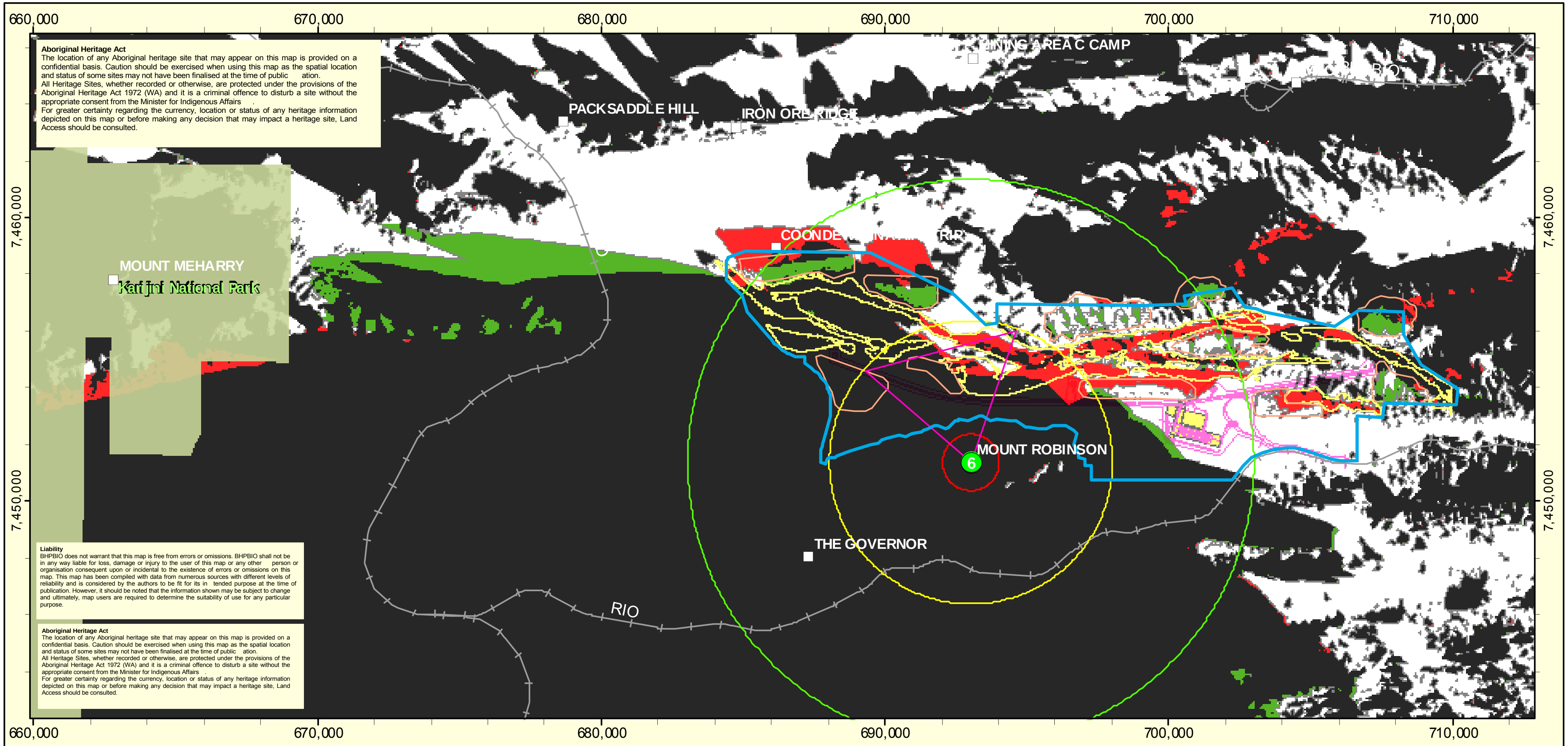

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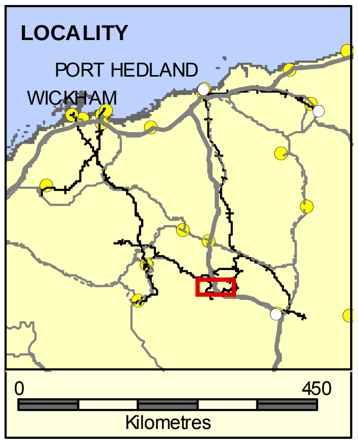
South Flank Visual Impact Assessment

Key Viewpoint 6 Viewshed Analysis

N
0 3 6 12
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:200,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 20
	Reviewed: M.Rhodes	



LEGEND

Viewpoint 6

Infrastructure and Places
- Places
- Indicative Disturbance Area
- Photomontage Aspect
- OSAs
- Pit
- Central Plant Rails
- Central Plant Footprint
- Railways
- Karijini National Park

Visual Risk
- High Risk
- Moderate-High Risk
- Moderate Risk

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

Data source: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

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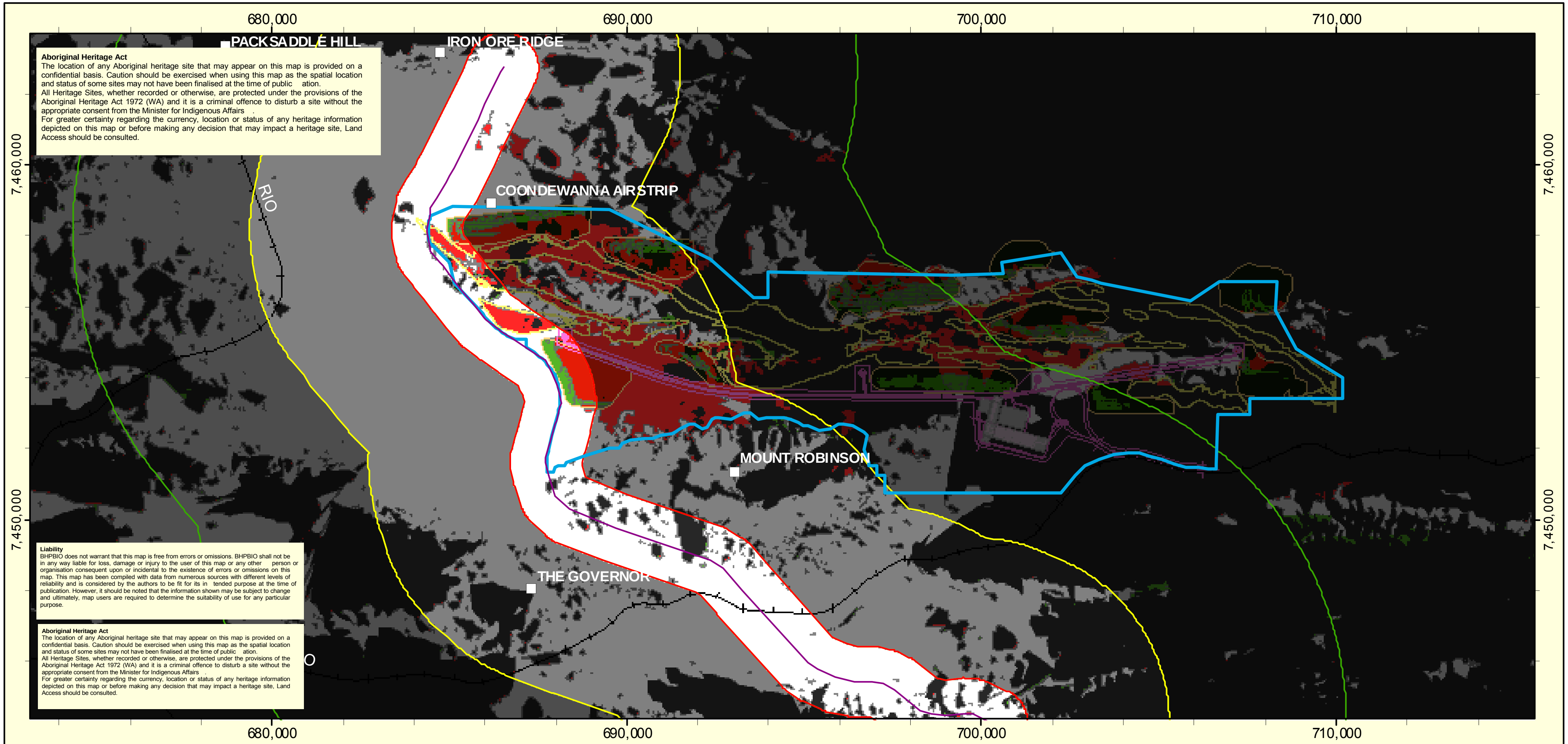
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 20 - SF Mt Robinson Viewshed Analysis.mxd



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South Flank Visual Impact Assessment

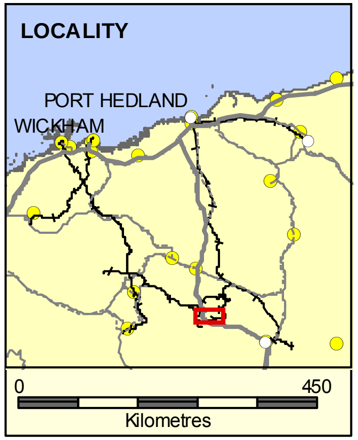
Great Northern Highway Viewshed Analysis

N

0 2 4 8 12
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:160,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 21
	Reviewed: M.Rhodes	



LEGEND (The brighter the colour, the higher the visibility risk and priority for mitigation)

Infrastructure and Places
- Places
- Indicative Disturbance Area

Visual Risk
- High Risk
- Moderate Risk
- Low Risk
- Railways
- Central Plant Footprint
- Central Plant Rails
- OSAs
- Pit

Viewshed Analysis
- Always Obscured
- Obscured due to Development
- Made Visible due to Development
- Always Visible

360

Mining Tenements
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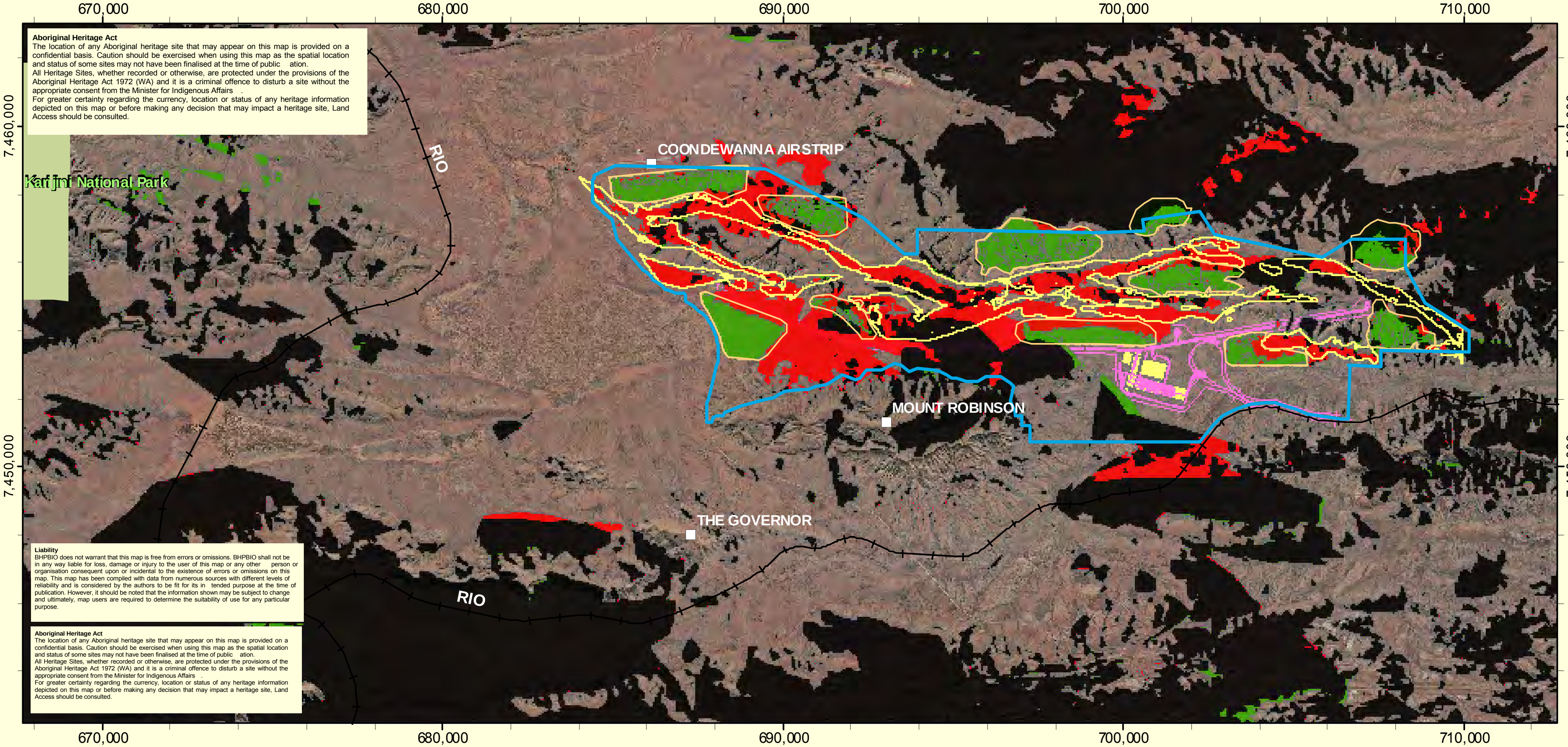
Data source:
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 21 - SF Great Northern Hwy Viewshed Analysis.mxd



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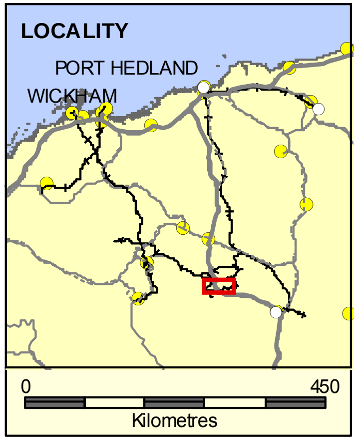
South Flank Visual Impact Assessment
South Flank Summary Viewshed Analysis

N
0 2.5 5 10
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:170,000	Prepared: J.N.Rao	Project No: RES048
Date: 10/01/2013	Checked: F.Donaldson	Figure: 22
	Reviewed: M.Rhodes	

LOCALITY



LEGEND

Indicative Disturbance Area
Railways

Infrastructure and Places

Places
OSA Footprints
Pit Shells
Karijini National Park
Central Plant Rails
Central Plant Footprint

Viewshed Analysis

Alway Obscured
Obscured due to Development
Visible due to Development
Always Visible

Data source: Aerial photography supplied by Landgate 2012
Conservation areas supplied by DEC 2012
South Flank pit shells and site layout supplied by BHP 2012
Infrastructure places supplied by BHP 2012

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K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 Figure 22 - SF Sum Viewshed Analysis.mxd

5.2 Photomontage Analysis

Photomontages have been used in this study to provide help with the visualisation of potential mine infrastructure in relation to the natural landscape. Photomontages were generated for all the relevant and publicly accessible viewpoints. Unlike the viewshed analysis, photo montaging does incorporate some aspects of vegetation, while viewshed analyses does not take into account the effect of vegetation screening, vegetation heights or canopy densities. To help improve the accuracy of the views, some aspects of vegetation characteristics have been described qualitatively in conjunction with the photomontage analysis, specifically:

- Descriptions and quantitative estimations of canopy density, vegetation characteristics and vegetation density; and
- Incorporation of vegetation screening into the photomontages as a guide to the effectiveness of various species.

5.2.1 Photomontage Analysis Results

The results of the photomontage analysis are presented in Plates 10 – 15, where a pre-development (existing) view image is compared to an annotated post-development photomontage. The photomontages use a general artificial colour scheme to highlight the locations of visible features. This results in a very conservative estimate of visual impact as visibility is greatly exaggerated. The 3D site model that was used to generate the photomontages is illustrated in Figure 23. The plant infrastructure was represented as blocks that were given a vertical offset of 30m. This was done as the details of plant infrastructure placements were not known. The vertical exaggeration has the additional benefit of providing a more conservative estimate of visibility.

All the annotated photomontages follow a general colour scheme as defined in Figure 23a.

5.2.2 Dust Modelling

The AQA identified the western edge of the Indicative Disturbance Boundary as having the highest risk of dust emissions. Three scenarios were considered in the model; no control, standard control and leading dust control measures. The concentrations of dust (PM_{10}) interpreted from the AQA results are given in Figures 24a, 24b and 24c respectively (PAEHolmes 2012). A relationship between dust concentration and light attenuation was not determined, although it is likely that a strong relationship exists that could potentially alter views at the viewpoints.

The impact of dust on views of the landscape has been included some photomontages to provide an indicative guide based on the relative concentration of airborne dust particles (Plates 17 and 18) (PAEHolmes 2012).

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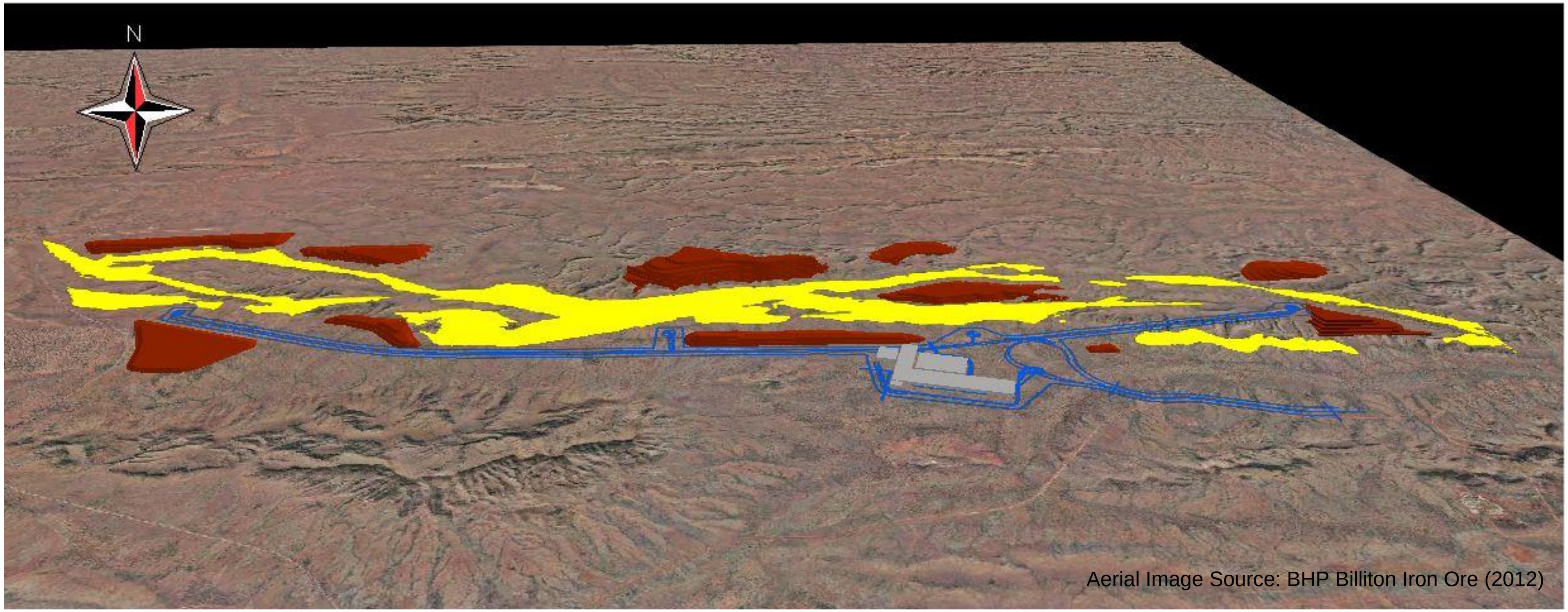


Figure 23: The 3D Site Model Used in the Photomontages

The model is fully georeferenced and is easily manipulated. Rail loops and conveyors are coloured in blue, the plant layout is coloured as the grey block, proposed OSA design (approximated) in red-brown, and the pit shell in yellow.

	OSAs
	Pit shell
	Rail loops and conveyors
	Processing plant

Plate 10a: Pre-development View from Viewpoint 1

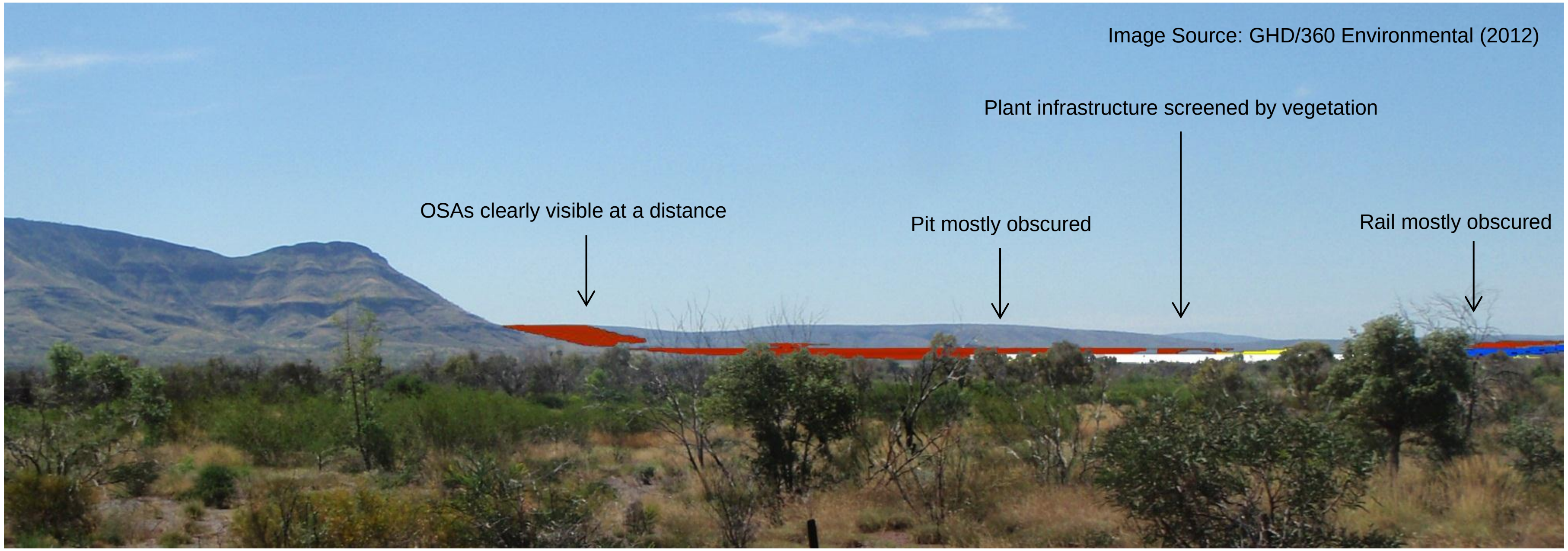


Plate 10b: Viewpoint 1 Post-development Photomontage

Shows the proposed OSA locations (red) and the proposed pit shell (yellow). Site infrastructure (white) and rail lines (blue) are heavily obscured by vegetation and are unlikely to be visible.

Plate 11a: Pre-development View from Viewpoint 2

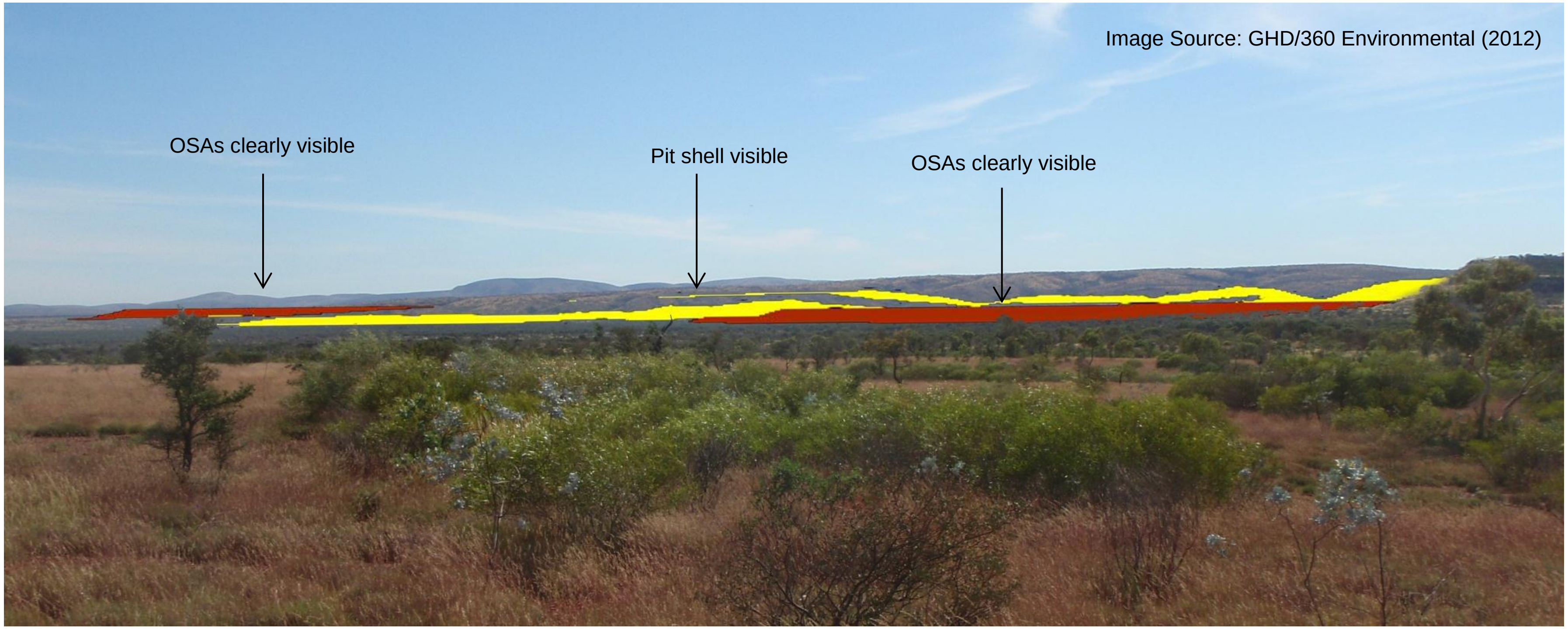


Plate 11b: Viewpoint 2 Post-development Photomontage

Areas shown are pit locations (yellow) and potential OSAs (red).

Plate 12a: Pre-development View from Viewpoint 3

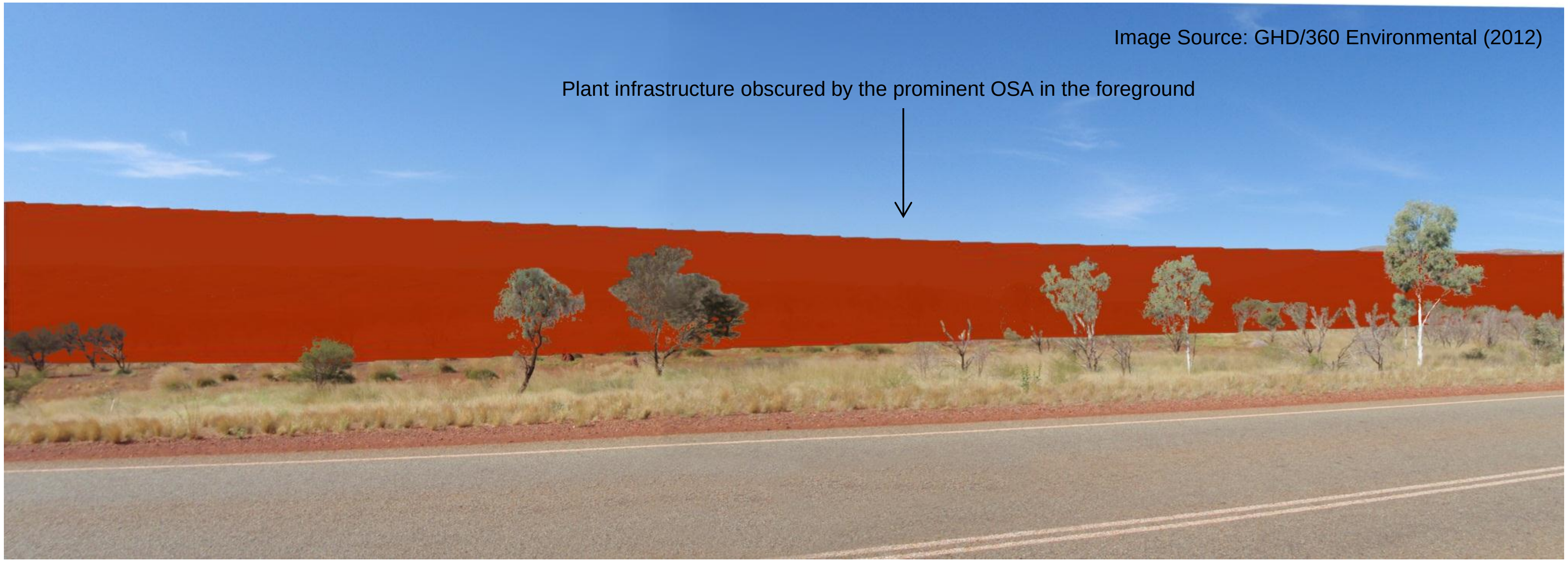


Plate 12b: Viewpoint 3 Photomontage

Plate 13a: Pre-development View from Viewpoint 4

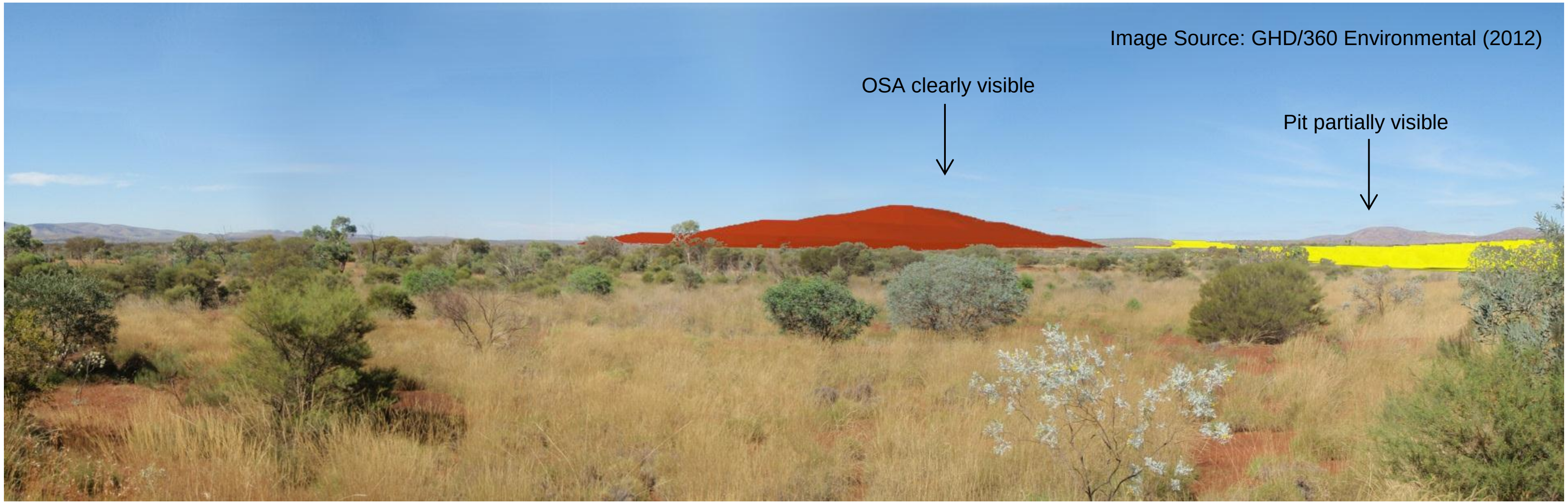


Plate 13b: Viewpoint 4 Post-development Photomontage

Shows pit areas (yellow) and OSA locations (red) visible.

Plate 14a: Pre-development View from Viewpoint 5

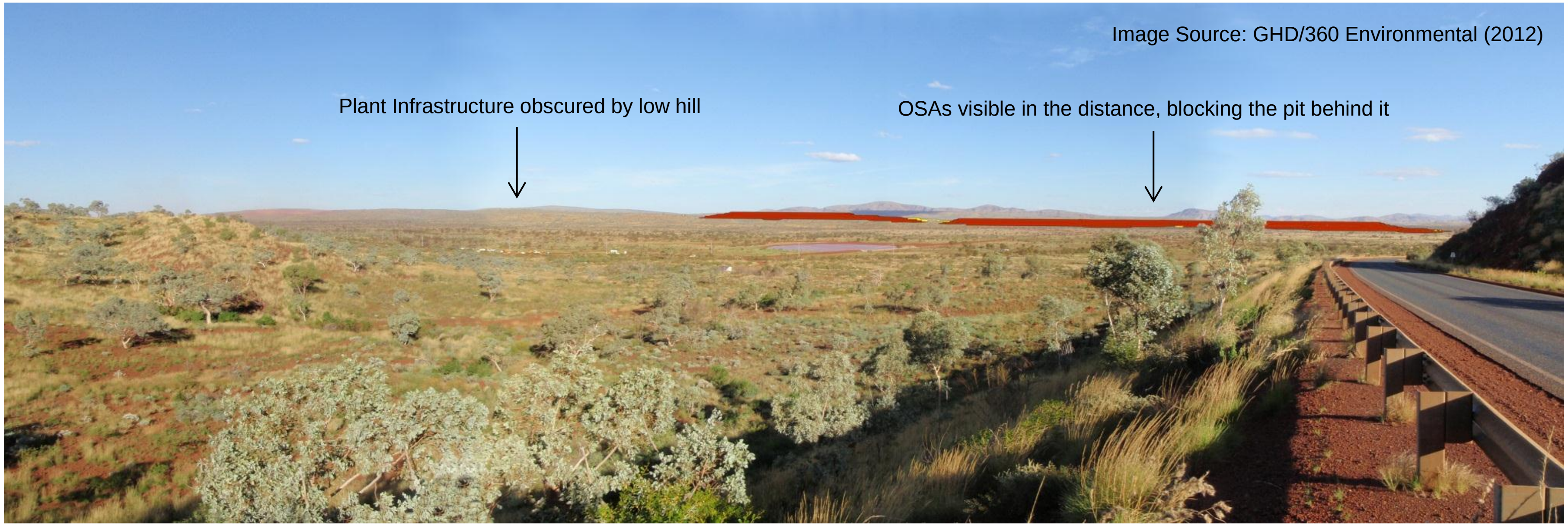


Plate 14b: Viewpoint 5 Post-development Photomontage

Shows locations of OSAs (red). Other site infrastructure such as conveyors and rail lines are unlikely to be visible from this distance, and hence are not drawn.

Image Source: BHP Billiton Iron Ore (2012)

Plate 15a: Pre-development View from Viewpoint 6, facing NNE

As this viewpoint was inaccessible during the field visit, an oblique aerial photography of the development area taken above Mt Robinson was used, and will greatly exaggerate visibility, due to the increased elevation above Mt Robinson.

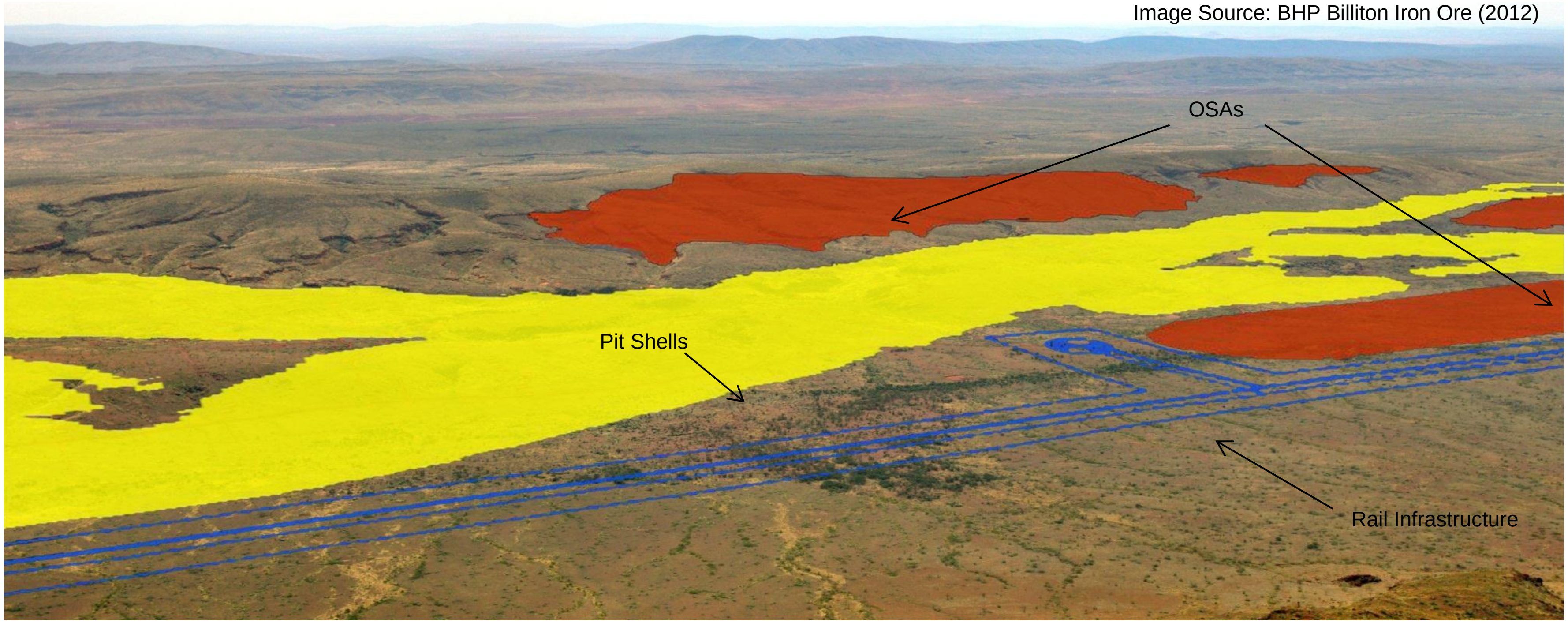
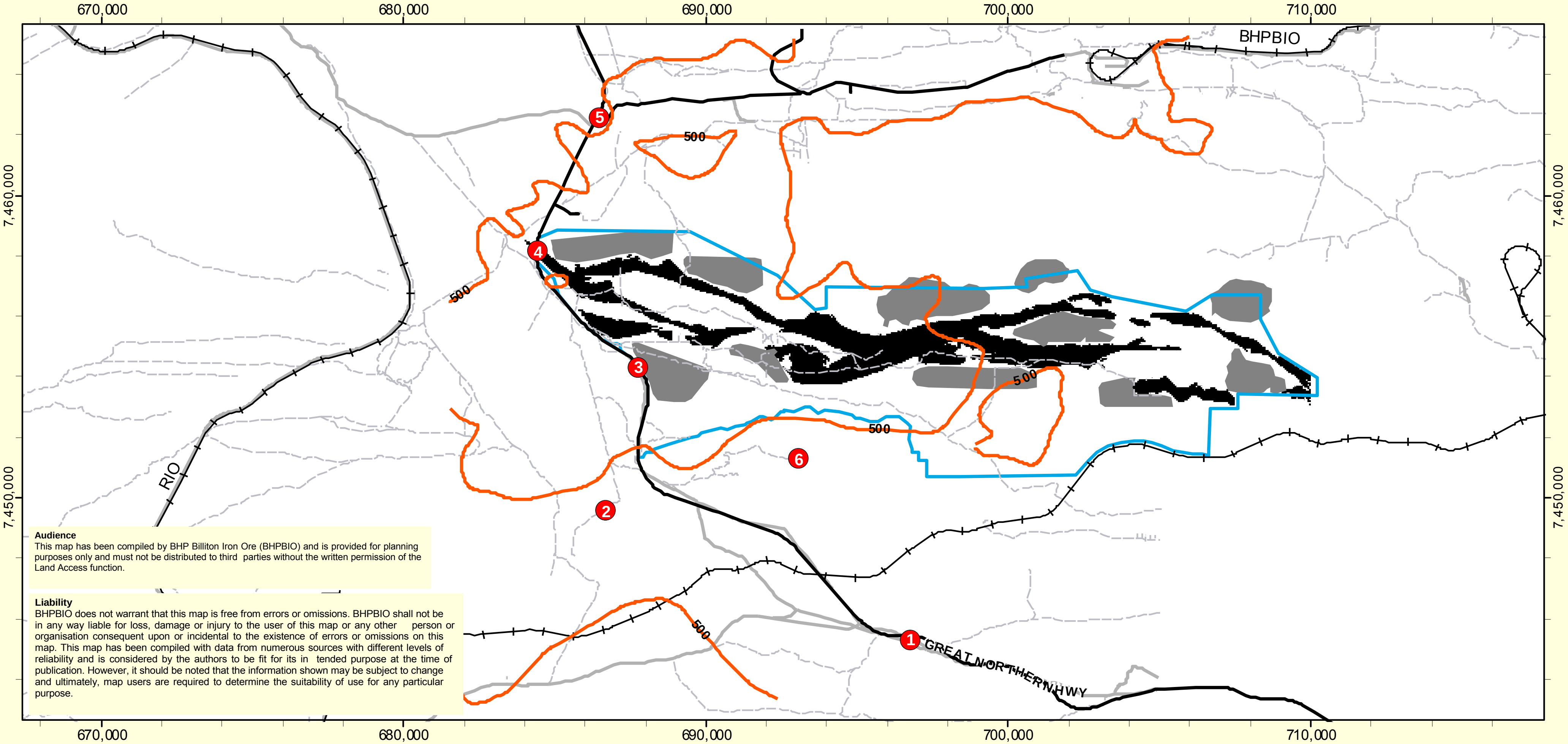


Plate 15b: Viewpoint 6 Post-development Photomontage

Shows the proposed pit shell (yellow), the proposed OSAs (red), rail lines and conveyors (blue). As this viewpoint was not visited during the site visit, this oblique aerial photo provided by BHP Billiton Iron Ore, taken from the air was used instead; this greatly exaggerates visibility from the top of Mt Robinson.



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South Flank Visual Impact Assessment

Predicted PM10 Dust Concentrations (No Control)

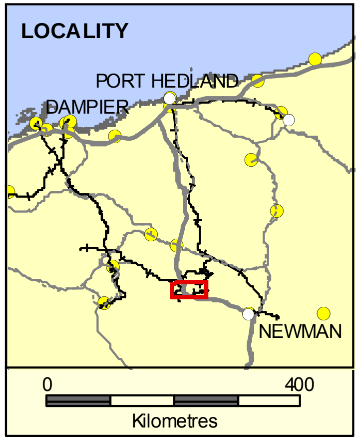
N

0 3.5 7 14
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:190,000	Prepared: J.N. Rao	Project No: RES048
Date: 03/08/2012	Checked: F. Donaldson	Figure: 24a
	Reviewed: M. Rhodes	

LOCALITY



LEGEND

Data source:
All data supplied by BHP unless otherwise specified

- Key Viewpoint
- Indicative Disturbance Area
- Proposed OSAs
- Proposed Pit

PM10 Dust Concentration
- Predicted - 500 ug/m3

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways

Native Title Claim Information
Native Title Claims information has been sourced from the Native Title Spatial Services (NTSS), Geographic Services, Landgate. NTSS accepts no responsibility for the use of this information and reference should be made to the National Native Title Tribunal (NNTT) for confirmation of all claim interests and extents.

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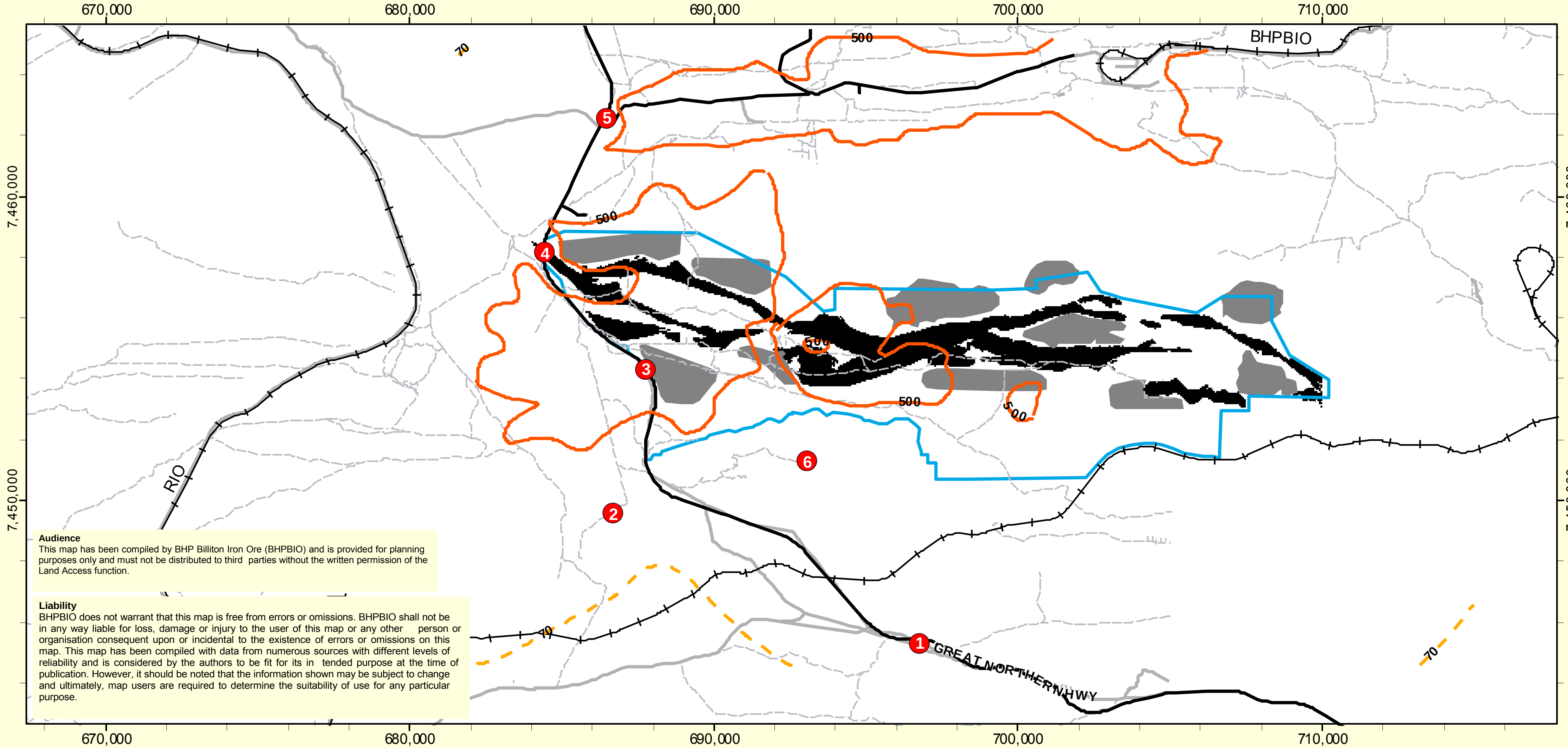
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 SF Figure 24a - PM10 concentrations No Control.mxd



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South Flank Visual Impact Assessment

Predicted PM10 Dust Concentrations (Standard Control)

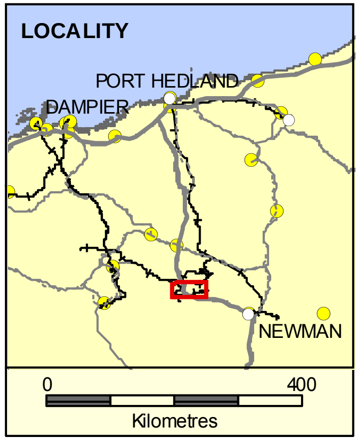
N

0 3.5 7 14
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:190,000	Prepared: J.N. Rao	Project No: RES048
Date: 10/01/2013	Checked: F. Donaldson	Figure: 24b
	Reviewed: M. Rhodes	

LOCALITY



LEGEND

Data source:
All data supplied by BHP unless otherwise specified

- Key Viewpoint
- Indicative Disturbance Area
- Proposed OSAs
- Proposed Pit

PM10 Dust Concentration (ug/m3)

- 500 ug/m3
- NEPM Guideline - 70 ug/m3

Transport Network

- Road - sealed
- Road - unsealed
- Track
- Railways

360

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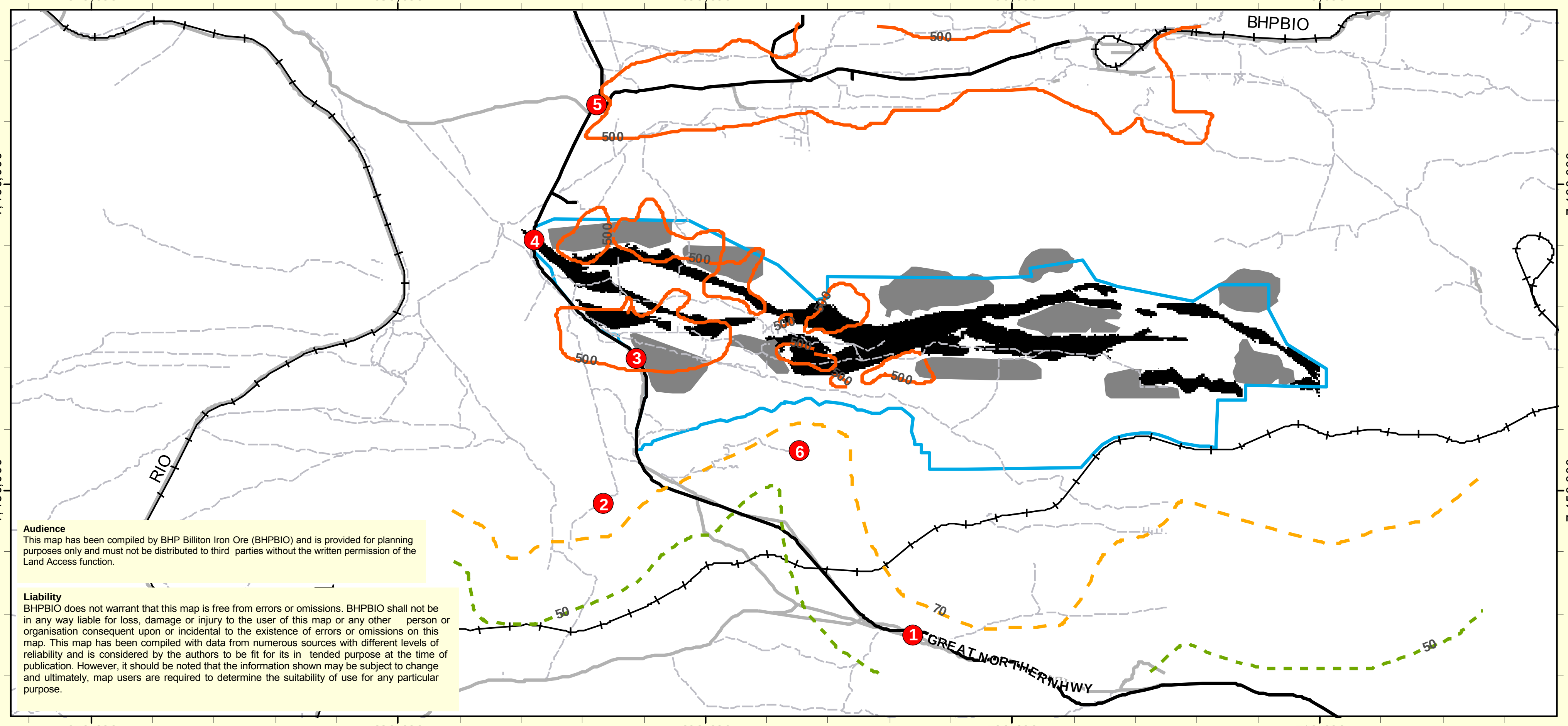
K:\Projects\4.0 RES\RES048 South Flank Marillana EIA GHD\Figures\Checked SF\RES048 SF Figure 24a - PM10 concentrations Std Control.mxd



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South Flank Visual Impact Assessment

Predicted PM10 Dust Concentrations (Leading Control)

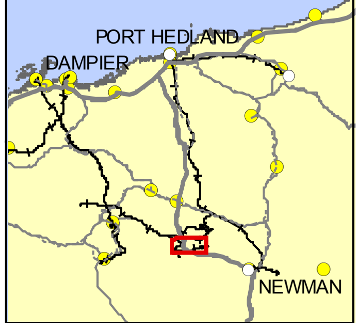
N

0 3.5 7 14
Kilometres

Datum & Projection: GCS_GDA94 MGA Zone 50

Scale @A4: 1:190,000	Prepared: J.N. Rao	Project No: RES048
Date: 10/01/2013	Checked: F. Donaldson	Figure: 24c
	Reviewed: M. Rhodes	

LOCALITY



LEGEND

Data source:
All data supplied by BHP unless otherwise specified

- Key Viewpoint
- Indicative Disturbance Area
- Proposed OSAs
- Proposed Pit

PM10 Dust Concentration
- Predicted - 500 ug/m3
- NEPM Guideline - 70 ug/m3
- NEPM Guideline - 50 ug/m3

Transport Network
- Road - sealed
- Road - unsealed
- Track
- Railways

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5.3 Potential Visual Impacts

5.3.1 Viewshed Analysis Results

In general, the viewshed analysis and photomontage analysis has determined that the development will be potentially visible from key viewpoints along the GNH and elevated areas at viewpoint 6 and viewpoint 2 (Figure 13). In light of this, VMOs should be taken into account and recommendations presented in Section 7 should be considered so visual character is maintained. Some of the VMOs may not be achievable and should be subjected to future cost-benefit analysis.

The landscape of the Hamersley area absorbs change and retains its natural character well because of the rugged landscape of elevated areas and gullies that screen many mining areas from major roads. Similarly, the sparseness and scale of vegetation in the region means that cleared areas do not particularly stand out against naturally vegetated backgrounds from long distances. The South Flank development is adjacent to a major highway and is not screened by significant topography or vegetation between Mt Robinson and Iron Ore Ridge.

The operation is likely to be prominently visible at most locations along the GNH adjacent to the site, particularly viewpoints 3 and 4 (Figure 17 and 18). Fortunately, the majority of site features visible will be OSAs, which have an added benefit of blocking out more potentially sensitive features directly behind them. They also have the potential to be blended into the landscape through rehabilitation. The earlier rehabilitation takes place, the quicker that blending will be achieved.

The viewshed analysis for the GNH (Figure 21) will enable prioritisation of mitigation strategies along this stretch of the GNH. Areas in brighter red denote higher priorities for visual impact mitigation. Areas within one kilometre of the Highway are considered to have a high priority, areas between one to five kilometres a moderate priority and areas beyond five kilometres a low priority, as they are relatively lower in prominence.

The CE-1 hub location is well screened from most viewpoints (with the exception of viewpoint 6, in Figure 20), and is located a considerable distance from key viewpoints. Due to the high elevation of viewpoint 6, most of the site will be visible, with the exception of the pit (Figure 20). However, the condition of the access track means that there would be potentially limited opportunity for access to this viewpoint.

As expected, most areas of the proposed pit will not be visible from key viewpoints, due to it being below the visual plane of viewers, coupled with the effect of vegetation screening from low-lying vegetation. It is unlikely that the pit will constitute a high visual impact apart from it being a source of dust (e.g. during drilling and blasting). The viewshed analysis clearly identifies that OSAs will be the most prominent visible feature.

The viewshed analysis also provides some insight into the benefit of maintaining ridgelines. Of particular concern are the areas in green, i.e. areas that will be made visible post-development. These areas may contain sensitive infrastructure and as a result, degrade view experience. This is usually the result of a ridgeline being removed, exposing the areas behind it, or an increase in the elevation of an area that was previously not visible (in the case of some OSAs). Figure 22 shows a small strip of green area directly adjacent to the central plant, which will be made visible if the ridgeline between Viewpoint 5 and the GNH is removed. This is not expected to be a significant problem as BHP Billiton Iron Ore's internal position is to maintain ridgelines where possible.

The results of the viewshed analysis are typical of a fully developed mine. Impacts to visual amenity during construction and early operational phases of the Project will likely be different; OSA heights may not be sufficient to block out areas behind them as predicted in the viewshed analyses.

5.3.2 Photomontage Results

The photomontages that were created for the study mostly involved panoramic views with a wide field of view (>150^{o}), approximating the field of view of the human eye. As design elements for the South Flank site have yet to be finalised, the accuracy of the photomontages is limited. As shown by the viewshed analysis, most pit areas will not be visible as they are below the visual plane of a viewer.

The photomontages confirm some of the findings of the viewshed analysis; due to proximity, high points and areas along the GNH will see the highest visual impact to the landscape character. Mine infrastructure other than OSAs are mostly obscured. The photomontages of viewpoint 3 (Plates 4a to 4c) indicate the plant infrastructure and rail may be visible, however in reality this is considered unlikely as the plant layout was given a vertical exaggeration of 30 m to provide a conservative estimate of visual impact. Similarly, it is unlikely that rail lines will be prominently visible from the distance of this viewpoint.

Although the visual risk for Mt Robinson is High Impact (Table 8), the condition of the access track and the difficulty of the terrain may contribute to lowering the number of visitors, hence can be considered to be less of a priority site for visual impact mitigation. Many areas of the track at Mt Robinson are also surrounded by low crests, which may often block out some areas of the view. This is evident in Figure 20, where visible areas only start in an elliptical shape roughly 10 km from the viewpoint.

5.3.3 Dust Modelling

As the western boundary of the Project was found to have the highest dust concentrations in all three emission scenarios described in the AQA, it is likely to have a large impact on visibility and view experiences along the adjacent stretch of the GNH (Figure 24a, b and c). The cumulative viewshed analysis (Figure 22) showed that views into the Indicative Project Area are fairly restricted due to the positioning of the OSA and Pit. This may reduce the potential impact of dust on easterly views into the Project area from the GNH. There may however be significant impacts on westerly views from the GNH that may result in reduced visual quality.

In the AQA's 'No Control' scenario, Viewpoints 3 and 4 will likely encounter dust concentrations in excess of 500 µg/m^3 (Figure 24a). The more likely 'Standard Control' scenario shows that although Viewpoint 4 falls below the 500 µg/m^3 contour, it is still likely to be affected heavily by dust issues, although not as much as Viewpoint 3 which will still experience much elevated dust concentrations (Figure 24b). Despite 'Leading Control' of dust emissions, little change will be seen at Viewpoints 3 and 4, although the impact of dust on the surrounding landscape and other sensitive receptors will be largely reduced (Figure 24c). Viewpoint 3 will still experience dust concentrations higher than 500 µg/m^3, while Viewpoint 4 will be slightly lower than this.

It is important to consider that key viewpoints were chosen based on locations that had potentially direct views into the Project area in addition to having relatively high visitor traffic. Although the impact of dust is interpreted in relation to these viewpoints, the cumulative impacts that dust may have on other areas of the landscape are just as important in mitigating visual impact. Ideally, the 'Leading Control' scenario has the least visual impact on the surrounding landscape and is therefore highly recommended. In particular, westerly views of Coondewanna Flats will be less impacted in this scenario.

6 Potential Visual Impact Mitigation Strategies

6.1 Summary of Mitigation Strategies

Some options for mitigating impacts to landscape value were considered. The South Flank site is surrounded by some sensitive viewing locations that have the potential to be impacted by the mining development, primarily through the impact of dust, and OSA siting. Mining areas are generally perceived by the public as unattractive areas of development, exacerbated by dust and exposed un-vegetated areas of the landscape (ie. pit and pre-revegetation overburden). Therefore, the siting and design of the mining area and associated infrastructure should consider some form of visual impact mitigation (DPI 2007).

6.1.1 Early Rehabilitation

Rehabilitation is a key ongoing component of mine closure. One key aim of rehabilitation is to "ensure the long-term stability of soils, landforms and hydrology required for the sustainability of sites" (EPA 2006). Therefore, as much as possible, important vegetation and landforms should be rehabilitated back to their original state.

Early rehabilitation (particularly of OSAs) is considered to be the most effective visual impact mitigation strategy available. Early rehabilitation has the potential to stabilise the batters of the feature and should be conducted as soon as the first bench is established, progressively working upwards as the feature is constructed. Rehabilitation through revegetation helps with stabilisation of soil, through reduced wind erosion and therefore potentially reducing dust emissions (vegetation stands also have the potential to trap airborne particles), in addition to significant environmental benefits (DMP 2006).

Early rehabilitation will ensure that vegetation planted will mature throughout the life of mine, ie. as the mine grows, vegetation maturation will result in features progressively blending into the landscape. Early rehabilitation is considered a leading practice by the DMP and is highly recommended to improve public perception and visual amenity. By beginning planting trials as soon as the project commences, visual impact can be minimised and rehabilitation capacity increased.

6.1.2 Maintaining Ridgelines

The maintaining of ridgelines can also reduce changes to existing viewsheds. The sides of ridges are often what is visible from viewers at a distance. Leaving these unaltered reduces to overall visual impact of the Project. As seen in Figure 21, areas that may become visible through the Project development are usually the result of a ridge being removed (in many cases by the proposed Pit). Despite a relatively small impact from this for South Flank, BHP Billiton Iron Ore maintains ridgelines wherever possible.

6.1.3 Vegetation Screens

As noted in the field survey, vegetation has a large potential for screening out unwanted visibility as well as reducing the prominence of site features and should be used as often as possible. The downside of this strategy is that it can take a long time for species native to the Pilbara to reach maturity, often with no guarantee of success. The limited height of a vegetation screen in the early years will make design considerations crucial. Vegetation screeds have the added benefit of trapping larger dust particles, although smothering of immature plant species may be a problem.

Three species have been identified as particularly suitable; *Acacia aneura*, *Eucalyptus victrix* and *Eucalyptus leucophloia*. The mixed planting of Acacia and Eucalyptus species is recommended due to their mutualistic relationship. Acacia, being a legume species is capable of nitrogen fixation, which may improve the health of other species, including Eucalypts.

Acacia aneura (commonly known as mulga) is suitable for screening in that it can form dense stands between 1.2 and 10 m at maturity. Growth rates for this species are extremely variable, estimated to take 10 years to reach a height of three metres (Singh 2010). This species is tolerant of a wide variety of soil types and rainfall levels.

Eucalyptus victrix, commonly known as western coolabah is a large Eucalypt species, native to the Pilbara region. It is tolerant of wide soil types and is capable of withstanding drought. This species takes around five years to reach two metres and produces a dense cover of low leaves during its youth, making it ideal for a vegetation screen. *Eucalyptus leucophloia* displays similar characteristics to *Eucalyptus victrix*.

A typical planting scenario for the Pilbara involves seed collection in autumn, roughly in the March – April timeframe. Planting of seeds will commence at the beginning of the rainy season, between November and December. The planting of spinifex species may also be undertaken although the density of spinifex varies seasonally and may also cause increased fire risk during the dry months.

A vegetation screen area can also be used as a clearing offset area. This may encourage native wildlife to populate the screen area following disturbance to their original habitat within the development area. There are however important considerations with vegetation screens. As the vegetation landscape of the study area has not been significantly altered historically, it may be possible that the density and distribution of vegetation at present is at maximum capacity; introducing additional individuals may upset the equilibrium of the ecosystem resulting in high seedling mortality.

Planting itself presents some risk; typically a good planting scheme is one that achieves a maximum of 50% mortality in seedlings, i.e. twice as many seedlings as are needed will be planted. A mine rehabilitation specialist should be consulted to assess the potential impacts of dust emissions and environmental conditions prior to planting.

6.1.4 Infrastructure Siting and Design

The design and siting of built infrastructure, storage areas and mining pits should consider visual amenity at the mine closure stage. Furthermore, the aim should be for structures to avoid visual identification from key viewing locations. This can be achieved by the use of natural landscape colours and/or camouflage, for example painting buildings olive green or rust brown, as opposed to white. Positioning key site infrastructure in between the low lying hills in the area may also reduce visual impact.

The siting of Project infrastructure used in the study does screen out sensitive views. However as OSAs are the most prominent features that contribute to visual impact, efforts should be taken to minimise their impact on the landscape. As OSAs eventually settle out over time through weathering, the feature can look unattractive in the short to medium time scales, with their angles, sharp edges and barren surfaces. In particular, a gently sloping batter and narrow bench width will allow for a more natural appearance. The OSAs used in this study used a batter slope of 15^{o}, and a bench width of 20 m. The DMP recommends slopes of no greater than 20^{o} although consideration should be given to soil characteristics, rainfall, drainage and existing topography (DMP nd). The average slope of the surrounding landscape is on the order of 10^{o}. Establishing wider and gentler OSAs will reduce their inherent visual impact although this may increase the required clearing footprint.

Mine infrastructure, particularly buildings, should be concealed as much as possible as they are not in keeping with the character of the area. This could include painting buildings a colour similar to the landscape. The colour should be non-reflective dark brown, olive green or red-brown. This colouring has the potential to limit the visibility of infrastructure from key viewpoint locations. As the site is situated between three publicly accessible high points, Mt Robinson to the south, Mt Meharry and The Governor to the east and the Hamersley Range to the north, efforts should be made to make the site stand out as little as possible from the landscape.

Mitigation measures could include retaining as much native vegetation as possible, which will help obscure the site from a distance. Recessing infrastructure such as rail lines and conveyors into the terrain will also help with reducing visual impact where possible. Housing some site infrastructure in a shed-type environment may be effective in reducing visual impact as well.

6.1.5 Viewing Platforms

Rather than attempting to screen or mitigate the impact to the landscape, the visibility of the mine from the GNH could be embraced as an asset. A viewing platform could be considered as a tourist point, with an opportunity for BHP Billiton Iron Ore to showcase the operations of the mine, including relevant biodiversity conservation information or rehabilitation methods and efforts, to strengthen positive public perception. However, given the inherent potential for high dust concentrations, this option may need to be considered from a health and safety point of view.

6.1.6 Man-made Screening

Large earth mounds/ exclusion bunds or walls may be constructed from material that is similar to the natural landscape, form and colour. The walls or mounds would be vegetated and aim to conceal the mining area and distract attention away from the mine.

An example of how this effect could work is shown in Plate 16, where the Great Northern Highway, has been cut into a low hill. While the photo is actually of a cut through a hill, a similar visual effect could be achieved by mounding along the road through targeted areas. This method is extremely effective in reducing visibility, especially if visible areas are in close proximity to the road. The construction of earth walls when the visible infrastructure is located further away from the viewer can reduce peripheral views of the landscape, initially resulting in a more negative experience than one without a mound constructed. Throughout the life of the mine, these can be revegetated to promote a more natural appearance and thereby improving aesthetics.

Plate 16: Resulting Visual Screening When Earth is Laid to Form a Wall

Man-made fences are generally not considered to be appropriate as they potentially stand out from the landscape and will require additional cleared area. The use of fencing may be warranted during the initial clearing and construction stage, for example during clearing and overburden dumping. As the OSAs would not have reached a height that will screen areas behind it, visual impact may be potentially lower with a fence in place during this phase. The height of a fence would eventually be exceeded by a revegetated OSA which would also block out unwanted views from behind it.

Revegetation of OSA material in the long term allows the feature to blend into the landscape; OSAs are usually considered to be features that eventually are used as post-mine closure landforms. From a distance, a successfully revegetated OSA will appear similar to the terrain texture and eventual weathering of the bench and batter profiles will produce a more naturalised appearance over time.

7 Recommendations

7.1 General Recommendations

By critically evaluating each potential mitigation strategy, a set of recommendations can be proposed. These take into account the effectiveness of a mitigation measure at a particular key viewpoint, as well as its ability to preserve landscape character. The sections below provide recommendations on the most appropriate mitigation strategy from a visual point of view for each key viewpoint. Engineering, environmental and safety considerations will also be required prior to the mitigations being finalised and implemented. Viewpoints have been arranged in order of increasing priority for mitigation. Priority can be represented as a function of viewpoint significance (affected by visitor traffic and regional importance; defined in Section 4.1), potential visual impact (defined in Section 5), and the feasibility of the proposed mitigation strategy (Section 6).

As expected, viewshed analyses and photo montaging determined that the stretch of the GNH running adjacent to the site is of high concern. Figure 21 illustrates visual risk and mitigation prioritisation areas. Bright green and clear areas intersecting with mine features should have some form of visual impact mitigation. Recommendations for individual viewpoints are summarised below.

In general, early revegetation of OSAs is recommended as a visual impact mitigation strategy as well as a stakeholder expectation. Figure 22 illustrates areas of priority for revegetation. The green and clear coloured areas that fall within the OSAs are those that will be visible, and these areas could therefore be re-vegetated. Figure 21 greatly exaggerates visibility, as the area south of Mt Robinson is, in reality, heavily vegetated, potentially acting as a natural vegetation screen, in addition to trapping some dust emissions (Plate 4). A mine rehabilitation specialist should be consulted to produce an appropriate early revegetation plan.

7.2 Recommendations for Key Viewpoints

7.2.1 Viewpoint 3 (Plate 12) – High Priority

Viewpoint 3 constitutes a high visual impact and high mitigation priority zone (Figure 17). As the most prominent visible feature at this stretch of highway will be the OSA, which will be much taller than the surrounding topography, there is limited ability for vegetation screens or earth mounds (Plate 17b). A more likely alternative would be to plant vegetation on the side of the OSA facing the GNH, this will make the feature less prominent. Air quality modelling has identified that this viewpoint will be within the area of the GNH most heavily affected by dust with concentrations in excess of 500 µg/m^3.

The photomontages in Plates 17 attempt to simulate the effect of dust by considering the findings of the AQA. It is likely that early revegetation of the OSA will reduce the overall impact of dust at this viewpoint through trapping of larger particles.

7.2.2 Viewpoint 4 (Plate 13) – High Priority

This viewpoint is currently classified as having a high impact risk. This site could be used for a vegetation screen/environmental offset area, forming a new habitat for native fauna, which may have future benefits in relation to mine site rehabilitation. A viewing platform could be erected here (Plate 18b). As some areas of the pit may be visible from this viewpoint, a viewing platform may effectively highlight BHP Billiton Iron Ore's mining operations as well as educating the public on the environmental protection measures in place at the site. If early rehabilitation is done at this Viewpoint, it may demonstrate BHP Billiton Iron Ores commitment to leading environmental practices to viewers at the platform.

This viewpoint is also known to be potentially affected heavily by dust. The construction of a viewing platform at this Viewpoint may need to be evaluated from a health and safety perspective. Leading dust control measures are highly recommended as they significantly reduce dust concentrations here.

7.2.3 Viewpoint 1 (Plate 10) – Medium Priority

As viewpoint 1(Figure 15) comprises of high landscape value due to the views of Mt Robinson, an earth wall or other man made feature should not be erected as they may result in a negative view experience. As some of the operation areas visible are located on a hill slope with a relatively high elevation, a vegetation screen will be limited in its ability to reduce the visibility of the site. As the existing vegetation was also of excellent health at the time of the field assessment, it is unlikely that the planting of additional vegetation will significantly reduce visual impact. As this viewpoint is located further away than other key viewpoints, it is of medium priority for mitigation. The OSAs could be revegetated, in addition to preserving the stands of vegetation between the highway and the development area.

Under leading dust control measures, this viewpoint falls within the NEPM dust concentration guideline of 70 µg/m^3. If early revegetation of OSAs is carried out, it is possible that this value may drop further.

7.2.4 Viewpoint 5 (Plate 14) – Medium Priority

Being in an elevated position, Viewpoint 5 naturally will have a potential for views into the Project. Revegetating OSA sides would help the site blend into the landscape more effectively, and hence would reduce visual impact at this viewpoint. The low lying hill to the east of the Project could be kept intact as it blocks out views of the plant behind it. There are some dust issues present at this Viewpoint, although these are primarily caused by Mining Area C operations. The field assessment did not show visually unappealing levels of dust at this Viewpoint. It is likely that views over the Project area will be obscured by dust clouds.

7.2.5 Viewpoint 6 (Plate 15) – Medium Priority

Mt Robinson is not considered as a high priority due to the difficulty in accessing the viewpoint. As the viewpoint also constitutes a generally positive view experience, obtrusive features should not be erected. A possible alternative is to erect an information board at the site explaining the extents of BHP Billiton Iron Ore's operation, perhaps with a map highlighting environmental offset areas and profiles of native flora and fauna.

This is the only viewpoint where views of the actual processing plant including stackers, reclaimers, rail lines and stockpiles are likely to be visible. Plant infrastructure could be painted with natural colours such as brown or red to reduce prominence. Under leading dust mitigation measures, this Viewpoint falls under the NEPM Guideline concentration of 70 $\mu g/m^3$. Early revegetation of OSAs is also recommended and may lower this value further.

7.2.6 Viewpoint 2 (Plate 11) – Low Priority

Viewpoint 2 is considered to have a low priority due to the low numbers of visitors and the low accessibility of the viewpoint. If this viewpoint is chosen for visual impact mitigation, the most appropriate strategy would be a vegetation screen at the viewpoints or an earth wall closer to the site. Dust is not considered to be a major issue at this site as dust modelling shows that views of Mt Robinson will not be as altered as at other locations, being slightly above the NEPM guideline of 70 $\mu g/m^3$.

7.3 Post-mitigation Visual Impact Simulations

Plates 17 to 18 illustrate a post-mitigation photomontage, simulating the view of the site from the viewpoints. The effect and locations of dust clouds were also estimated based on dust concentration contours under standard control measures.

8 Conclusion

This LVIA assessed the visual impact of the Project based on preliminary designs of the pit and OSAs at the cessation of mining (i.e. full pit and OSA development). There is likely to be additional impact in the construction and operation phase of the Project, (for example dust contributing to negative view experiences). The results of this analysis are specific to the indicative engineering designs of the pit and OSAs.

In general, the most effective visual impact mitigation measure was found to be early revegetation of OSA material. This has several benefits to visual amenity (reduced erosion, conformity with the natural landscape, dust trapping, positive public perception and long term rehabilitation benefits) in addition to the inherent environmental benefits:

- reduced wind erosion contributing to dust emissions;
- reduced water erosion contributing to gullying and topsoil removal;
- conformity with the natural landscape when viewed from a distance;
- habitat for native fauna and flora species;
- potential for trapping airborne dust particles;
- potential for preserving soil surface moisture thereby contributing to less dust emissions;
- positively perceived by regulators and the public; and
- reduced time and effort spent on rehabilitation during mine closure.

Early revegetation efforts are also considered a leading mine rehabilitation practice, and is viewed upon positively by regulators and members of the public. As the South Flank Project is located in such close proximity to the Great Northern Highway, this presents an opportunity for BHP Billiton Iron Ore to demonstrate leading environmental management practices.

The current design and siting of the Project limits visibility of sensitive plant infrastructure. However, high dust emissions may reduce visual amenity of the surrounding landscape, particularly of Coondewanna Flats to the west. If leading dust control measures are implemented, visual amenity will be significantly improved.

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Plate 17a: Viewpoint 3 Before Proposed Mitigation Measures with Indicative Dust Plumes

Plate 17b: Viewpoint 3 After Proposed Mitigation Measures with Indicative Dust Plumes

Plate 18a: Viewpoint 4 Prior to Mitigation Measures with Indicative Dust Plumes

Plate 18b: Viewpoint 4 After Proposed Mitigation Measures with Indicative Dust Plumes

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It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary. All information on site layouts and infrastructure is based on proposed designs and may not reflect significant future changes.