



Mining Area C – Southern Flank

Public Environmental Review Document

May 2017

Document tracking

Item	Detail
Project name	Mining Area C – Southern Flank
Saved location of document	<u>Cabinets/Managed Documents/HEALTH SAFETY & ENVIRONMENT/HSE - Environment/Environment Operations/Environmental Management/Approvals/South Flank/Submissions/PER/PER_May 2017 for public release</u>
Prepared by	Sarah Williamson, Belinda Barnett
Reviewed by	Renelle Thorpe
Approved for release by	Gavin Price, Head of Environment Analysis and Improvement
Status/version number	Final/Rev 3
Date saved	3 May 2017
Cover photo	BHP Billiton Iron Ore Mining Area C

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal.

BHP Billiton Iron Ore proposes to develop and operate a new satellite iron ore deposit located immediately south of the existing Mining Area C operation at Southern Flank which will become part of the Mining Area C hub and increase disturbance within the existing Mining Area C operation (the Proposal). In accordance with the *Environmental Protection Act 1986* (WA) (EP Act), this Public Environmental Review (PER) has been prepared by BHP Billiton Iron Ore to describe the Proposal and its likely effects on the environment. The PER is available for a public review period of [4] weeks from 8 May 2017, closing on 6 June 2017.

Information on the proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the proposal, if implemented, on the environment. This may include relevant new information that is not in the Public Environmental Review, such as alternative courses of action or approaches.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*.

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the Public Environmental Review Document.

When making comments on specific elements in the PER document:

- Clearly state your point of view and give reasons for your conclusions.

- Reference the source of your information, where applicable.

- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

Your contact details – name and address.

Date of your submission

Whether you want your contact details to be confidential.

Summary of your submission, if your submission is long.

List points so that issues raised are clear, preferably by environmental factor.

Refer each point to the page, section and if possible, paragraph of the PER.

Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for submissions is Tuesday, 6 June 2017.

The EPA prefers submissions to be made electronically via the EPA's consultation hub at <https://consultation.epa.wa.gov.au>

Alternatively, submissions can be:

posted to: Chairman, Environmental Protection Authority, Locked Bag 10, East Perth 6892; or

delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth, Western Australia.

If you have any questions on how to make a submission, please contact the Office of the Environmental Protection Authority (OEPA), on (08) 6145 0800.

EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty. Ltd. (BHP Billiton Iron Ore) proposes to develop and operate a new satellite iron ore deposit, located immediately south of the existing Mining Area C operation, at Southern Flank, which will become part of the Mining Area C hub, and to increase the disturbance at the existing Mining Area C hub (the Proposal). The Proposal is located approximately 100 kilometres (km) northwest of Newman in the Pilbara region of Western Australia.

The Proposal will use existing ore processing facilities located at the Mining Area C hub, including, but not limited to, ore handling plant, stockyard and train load-out facilities coupled with the addition of new ore processing facilities within the current Mining Area C hub. Primary crushing and open-pit mining activities will take place in the Southern Flank locality. This reflects BHP Billiton Iron Ore's current approach of developing new ore-bodies that are able to use existing infrastructure at established mining hubs. This approach will minimise the amount of disturbance and therefore impacts associated with the Proposal.

The ore resource of the Southern Flank satellite ore body has been estimated at approximately 1,850 million tonnes (Mt). Production from the Southern Flank satellite mine (approximately 80 million tonnes per annum (Mtpa)) will replace declining iron ore supplies, which is currently produced by other BHP Billiton Iron Ore mining operations in the Pilbara and therefore enable BHP Billiton Iron Ore to sustain its current level of iron ore production from its Pilbara mines.

Mining will be undertaken using conventional open-pit iron ore mining activities both above and below the water table and will require mine dewatering ahead of mining to facilitate dry mining conditions. Approximately eight percent of the ore resource at the Southern Flank satellite ore body is estimated to be below the water table. Thus, the Proposal will require in-pit and ex-pit mine dewatering (i.e. groundwater abstraction) ahead of accessing ore resources that are below the water table to facilitate dry mining conditions.

Open pits will be developed using conventional drill and blast techniques. Ore will be transported via an overland conveyor to ore handling facilities at the Mining Area C hub and then transported by rail to Port Hedland for export.

This Public Environmental Review (PER) document provides supporting information to the Environmental Protection Authority (EPA) to enable it to undertake its assessment under s38 of the *Environmental Protection Act 1986* (WA) (EP Act). This document provides information about the existing environment, options considered for replacement of iron ore mined from BHP Billiton Iron Ore's Pilbara mines, an assessment of potential impacts of implementation of the Proposal, any proposed mitigation measures and as assessment of whether the Environmental Protection Authority's (EPA) objectives will be met. This PER document describes BHP Billiton Iron Ore's regional management approach to manage potential impacts of the EPA's environmental factors.

In 1998, the existing Mining Area C mining operation was approved under Part IV of the EP Act as the Multiple Iron Ore Mine Development Mining Area C Northern Flank via Ministerial Statement (MS) 491. A draft Environmental Management Plan (EMP) was attached to the Mining Area C Public Environmental Review, which provided details of the management requirements during construction and operation of the Deposit C and Brockman Detrital deposits. MS 491 provided an ongoing mechanism for the development of the remaining 12 deposits in the Northern Flank of Mining Area C (Proponent Commitment 2), subject to the EMP being reviewed and updated as deposits are developed (Proponent Commitment 3).

In 2016, Revision 6 of the EMP (EMP Revision 6) was accepted by the OEPA as the current version of the EMP. The EMP Revision 6 provided information on the potential environmental impacts as a result of mining of all 14 deposits within the Mining Area C Development Envelope. For the purposes of environmental impact assessments (EIAs) undertaken as part of EMP Revision 6, an impact assessment area of 11,377 hectares (ha) was used. The current MS 491 allows for clearing of up to 5,385 ha anywhere within the 11,377 ha, of which 4,792 ha have been cleared under MS 491 as of 31 December 2016. However, it is noted that the EMP update mechanism does not accommodate a change of the key characteristics for Mining Area C. Therefore, this Proposal includes a request for an additional 5,942 ha of disturbance within the EMP Revision 6 Indicative Impact Assessment Area.

Outcomes from the EIAs previously undertaken to support the development of the EMP Revision 6 are discussed in this document. As the additional clearing may occur anywhere in the 11,377 ha, the EIAs have assessed potential impacts for the entire 11,377 ha, not just the additional clearing.

As Southern Flank and Northern Flank (Mining Area C) operations will be operated as one hub it is proposed that MS 491 be replaced with a new MS. This document therefore provides information on the following:

- **Mining Area C (Northern Flank) Development Envelope:** The area (25,815 ha) currently approved as the development envelope under MS 491.
- **Additional Development Envelope:** The additional area (10,218 ha) that contains the Southern Flank satellite orebodies.
- **Proposed Mining Area C Development Envelope:** This is the proposed development envelope for the full Mining Area C hub. It consists of the Mining Area C (Northern Flank) Development Envelope and the Additional Development Envelope (Southern Flank) and will constitute the boundary of the new MS if approved.
- **Mining Area C Revision 6 EMP Impact Assessment Area:** The area (11,377 ha) that was used for the purposes of impact assessment in line with Condition 7 and commitments 2 and 3 of MS 491 via EMP Revision 6 in January 2016.
- **Indicative Additional Impact Assessment Area:** The indicative spatial area for the development of the Southern Flank ore body, based on the mine plan and design at the time of submission and is used as an assessment tool.

The locations of these areas are shown in Figure ES-1.

BHP Billiton Iron Ore has developed a regional management approach in consultation with government agencies, including the EPA, over a number of years. The approach is being implemented as part of an increased business focus on simplification to improve the way we do business and to achieve better environmental outcomes in five key areas: water planning; mine closure; biodiversity; noise and air quality. BHP Billiton Iron Ore considers that this Proposal provides an opportunity to further embed this approach.

BHP Billiton Iron Ore and its entities have operated in the Pilbara for over 50 years. BHP Billiton Iron Ore have undertaken numerous studies to support proposals in the Pilbara region, including in the vicinity of this Proposal. BHP Billiton Iron Ore have used its knowledge of the environment, together with an understanding of EIA in the Pilbara region, to undertake an assessment for this Proposal.

The assessment took into consideration the EPA's *Environmental Assessment Guideline 8 for Environmental Factors and Objectives* (EAG 8) (EPA, 2013a), the EPA's *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016a) and the OEPA Environmental scoping document (OEPA, 2016) to identify the following as preliminary key environmental factors:

- flora and vegetation;
- terrestrial fauna (including short-range endemics);
- subterranean fauna;
- hydrological processes;
- inland waters environmental quality;
- heritage;
- rehabilitation and decommissioning; and
- offsets.

Other environmental factors that were assessed as part of this Proposal are:

- landforms;
- terrestrial environmental quality;
- air quality (including greenhouse gas emissions);
- amenity; and
- human health (noise).

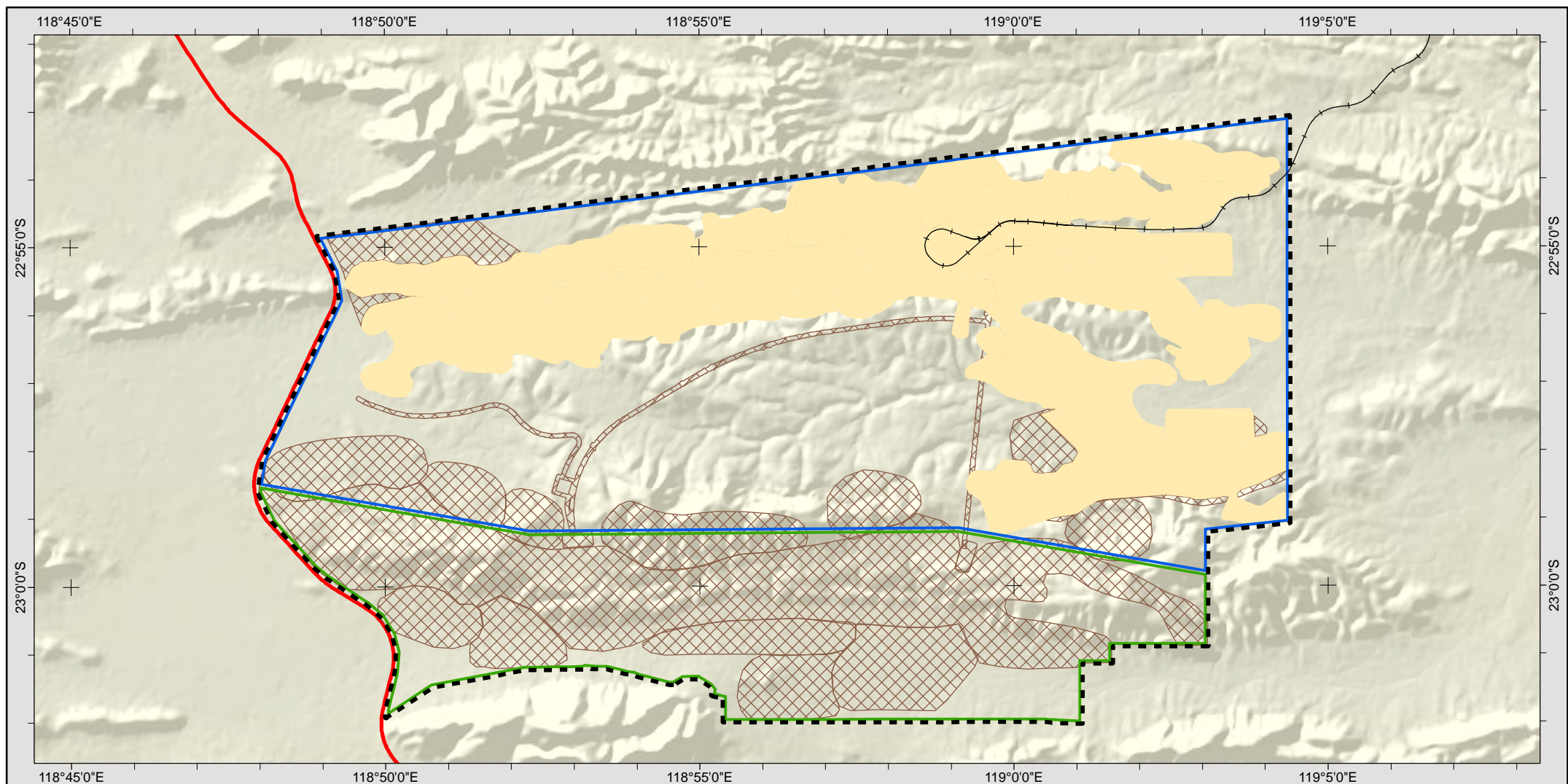
A summary of the potential impacts to the environmental factors considered during the impact assessment process is provided in Table ES-1, which includes the potential impacts associated with additional clearing within the Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a) impact assessment area, the potential impacts associated with the development of the ore body at Southern Flank and the potential cumulative impacts associated with the Proposed Mining Area C Development Envelope following implementation of the Proposal. The significance of the impact of the implementation of the Proposal on the environmental factors was assessed in line with the EPA's *EAG 9 for Application of a Significance Framework in the Environmental Impact Assessment Process* (EPA, 2013b). BHP Billiton Iron Ore have concluded that some factors may be considered preliminary key environmental factors as listed above.

Sections 11 and 12 respectively provide a description and evaluation of, the key and other environmental factors listed above. Section 12 details the potential impacts (both inherent and residual following application of the mitigation hierarchy) arising from the Proposal for those factors whose significance was determined to be a preliminary key factor. For those factors that were evaluated to be preliminary key environmental factors in the Environmental Scoping Document phase, Section 11 provides further discussion on what specific management actions BHP Billiton Iron Ore has taken to mitigate the proposed environmental impact of the Proposal in line with the mitigation hierarchy published in the *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014). A figure illustrating the range of actions taken to address the mitigation hierarchy is provided in Figure ES 2. Each discussion includes an evaluation of whether the EPA objective can be met.

Impact assessments undertaken as part of the Proposal for two factors that were considered to be preliminary key factors (Inland Waters Environmental Quality and Heritage) have demonstrated that these factors can meet the EPA objective without the need for application of the mitigation hierarchy or Ministerial Conditions and are therefore not considered likely to have a significant effect on the environment.

BHP Billiton Iron Ore has had due regard for the principles of ecological sustainable development of the EP Act. BHP Billiton Iron Ore has extensive regional data sets, and endorsed current management practises on which the environmental impact assessments were based, offering a high degree of confidence in impact assessments. Where inherent impacts have been assessed as significant the application of the mitigation hierarchy based on a robust scientific methodology has resulted in a reduction of potential impacts to a level BHP Billiton Iron Ore considers reasonable and all EPA objectives are considered to be met.

BHP Billiton Iron Ore considers that the information and assessment presented in this PER adequately identifies and addresses environmental impacts relevant to the Proposal, adequately addresses the environmental scoping document and is suitable to enable the EPA to undertake its assessment of the Proposal.



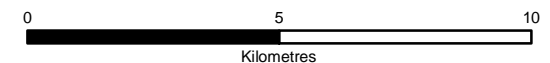
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Spatial Areas as Discussed in PER Document

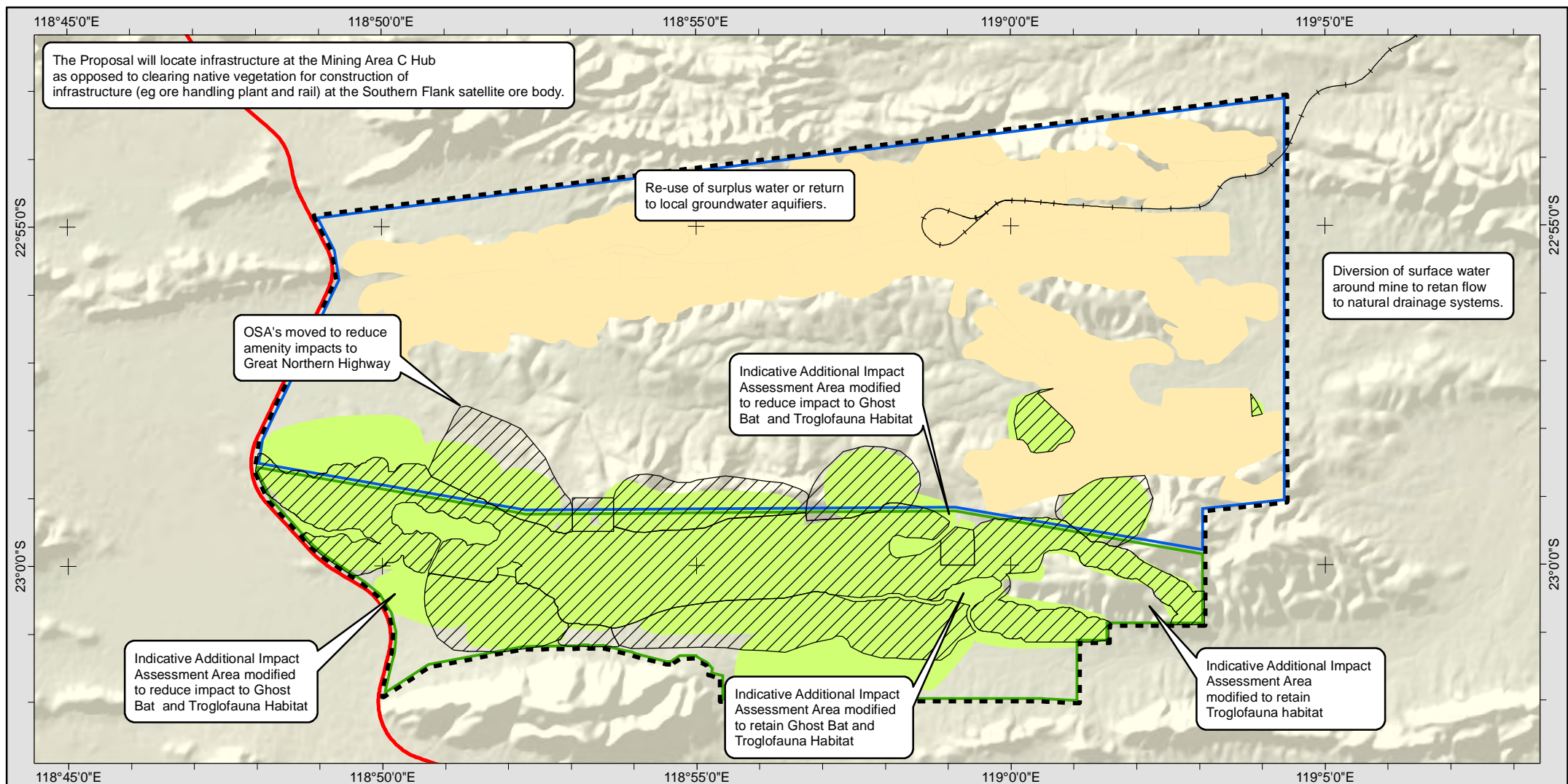
Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/047 REV B
Date: 12/01/2017	Checked: R. GREGORY	Figure: ES-1
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Implementation of the Mitigation Hierarchy

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/048 REV B
Date: 4/05/2017	Checked: R. GREGORY	Figure: ES-2
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Modified Indicative Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Page intentionally blank

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Flora and Vegetation		
EPA Objective		To protect flora and vegetation so that biological diversity and ecological integrity are maintained
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p>Indicative Additional Impact Assessment Area contains 11,612 ha of vegetation of which 727 ha is Pristine, 9,016 ha is Excellent, 658 ha is very good, and 312 ha is Good condition vegetation. Eight Priority flora taxa recorded. All species are known to exist outside the Proposed Mining Area C Development Envelope, and impacts are considered to be low. Fifteen vegetation associations have been recorded, with low to very low local conservation value.</p> <p>No Threatened flora species listed under the WC Act or the EPBC Act has been recorded in the Additional Development Envelope or Indicative Additional Impact Assessment Area.</p> <p>Six weeds have been recorded within the Additional Development Envelope, and seven have been recorded within the Indicative Additional Impact Assessment Area. Two of these weed species have not been recorded within the Mining Area C (Northern Flank) Development Envelope.</p> <p>It is unlikely that alterations to natural surface water flows will impact on mulga (<i>Acacia aneura</i>).</p> <p>There will be no impacts to groundwater-dependent vegetation within the Additional Development Envelope. No significant impacts to the Priority Ecological Communities (PECs) at Weeli Wolli Spring or Coondewanna Flats are likely to occur as a result of groundwater drawdown.</p> <p>No expected indirect impacts to the Coondewanna Flats PEC by groundwater mounding to 16 metres below ground level (mbgl) from injection of water at the Juna Downs managed aquifer recharge (MAR) borefield.</p>
	Mining Area C EMP Rev 6 Impact Assessment Area [B]	<p>The Mining Area C EMP Revision 6 Impact Assessment area contains 11,056 ha of vegetation of which none is Pristine, 3,292 ha is Excellent, 3,344 ha is Very Good and 317 ha is Good condition vegetation. Six Priority flora species recorded in the Mining Area C EMP Revision 6 Impact Assessment Area (note that this excludes one species that has been delisted since undertaking the environmental impact assessment for the EMP Revision 6). All species are known from records outside of the Mining Area C (Northern Flank) Development Envelope.</p> <p>No Threatened flora species listed under the WC Act or the EPBC Act have been recorded in the Mining Area C (Northern Flank) Development Envelope. Thirteen locally significant vegetation associations occur within the Mining Area C (Northern Flank) Development Envelope. Impacts to these are not considered significant.</p> <p>Twenty-one weeds have been recorded within the Mining Area C (Northern Flank) Development Envelope.</p> <p>It is unlikely that alterations to natural surface water flows will impact on downstream mulga (<i>Acacia aneura</i>).</p> <p>There will be no impacts to groundwater-dependent vegetation within the Mining Area C (Northern Flank) Development Envelope. Two areas surrounding the Mining Area C (Northern Flank) Development Envelope have been identified as supporting groundwater-dependent vegetation:</p> <ul style="list-style-type: none"> Weeli Wolli Spring Priority Ecological Community (PEC) (10 km east); and Ben's Oasis, a component of the Weeli Wolli PEC (12.5 km southeast). <p>Note that at the time of assessment the Coondewanna Flats PEC (1 km southwest) was also considered to be groundwater dependent, but subsequent studies have shown that it relies on surface water and soil moisture (see Section 11.1.4.3.4) It is predicted that there will be no significant impact to these areas from operations at Mining Area C; however, cumulative impacts with Hope Downs may result in decline of vegetation at Weeli Wolli Spring.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>Total native vegetation clearing if the Proposal is approved will be 25,053.2 ha (of which 19,671.2 ha relates to this Proposal) within the Proposed Mining Area C Development Envelope. A majority of this vegetation is considered to be in Very Good or better condition. Ten Priority flora species have been recorded within the Proposed Mining Area C Development Envelope.</p> <p>No Threatened flora, Threatened Ecological Communities (TECs) or PECs relating to have been recorded within the Proposed Mining Area C Development Envelope.</p> <p>Thirty-four vegetation associations have been recorded in the Proposed Mining Area C Development Envelope. Four are considered to be an 'Ecosystem at Risk', as defined by Kendrick (2001). These, and a further fifteen vegetation associations are located in the Proposed Mining Area C Development Envelope and are considered to have low local conservation significance. All of these communities occur extensively outside the Proposed Mining Area C Development Envelope. Impacts to these communities are considered to be low to very low and do not represent a significant increase to those impacts associated with the approved clearing under MS 491.</p> <p>Twenty-three introduced species have been recorded within the Proposed Mining Area C Development Envelope.</p> <p>Possible retraction of the silver paperbark (<i>Melaleuca argentea</i>) may occur upstream of Weeli Wolli Springs following closure of Hope Downs 1 and subsequent groundwater recovery. This community has been significantly altered from Hope Downs 1 operations and there is limited information on baseline conditions.</p> <p>No expected indirect impacts to the Coondewanna Flats PEC by groundwater mounding to 16 metres below ground level (mbgl) from injection of water at the Juna Downs MAR borefield</p>
Mitigation		<p><i>Avoid:</i> Where practical BHP Billiton Iron Ore will reduce disturbance to the Modified Indicative Impact Assessment Area. This may potentially avoid up to 4,107 ha of disturbance (of which 1,786 ha is rated to be Very Good or above condition), and may reduce impacts to conservation species <i>Rhagodia</i> sp Hamersley, seven populations may be avoided; and <i>Rostellurlaria adscendens</i> var. <i>latifolia</i>, one population may be avoided. It may also reduce impacts to two of the three vegetation associations classified as 'Ecosystems at Risk.'</p> <p><i>Minimise:</i> Reduction in fragmentation of locally significant vegetation associations.</p> <p><i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope.</p>
Outcomes		<p><i>Residual Impact:</i> Residual loss of vegetation of Good or above condition and loss of populations of conservation significant flora will occur, but regionally the significance of impacts to significant flora and vegetation associations is low.</p> <p><i>Offset:</i> Financial offsets will apply to up to 19,671.2 ha of native vegetation clearing. With mitigation it is likely that impacts may not exceed 15,693 ha.</p> <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor; biological integrity and ecological diversity can be maintained.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Terrestrial Fauna		
EPA Objective		To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p>Nine species of conservation significant vertebrate fauna have been recorded within the Additional Development Envelope. Seven of these have been recorded from the Indicative Additional Impact Assessment Area. All are well represented outside of the Additional Development Envelope.</p> <p>Impacts to the ghost bat are considered likely due to the loss of a number of caves that are used as roosts by the species; 33 caves occur within the Indicative Additional Impact Assessment Area.</p> <p>One SRE invertebrate fauna species (<i>Antichiropus</i> 'DIP007') has four of five records within the Indicative Additional Impact Assessment Area. Habitat for this species occurs outside the Indicative Additional Impact Assessment Area.</p> <p>No impacts to terrestrial fauna values of the Weeli Wolli Spring PEC are anticipated.</p>
	Mining Area C EMP Rev 6 Impact Assessment Area [B]	<p>Nine species of conservation significant vertebrate fauna have been recorded within the Mining Area C (Northern Flank) Development. Six were identified as receptors for the proposed EMP Revision 6 development.</p> <p>The ghost bat (<i>Macroderma gigas</i>; listed as Vulnerable under the WC Act in November 2015 and under the EPBC Act in May 2016) was identified as the only receptor where impacts could result in loss of individuals or reduced breeding success in the locality. Twelve caves (potential ghost bat habitat) have been recorded within the Mining Area C EMP Revision 6 Indicative Impact Assessment Area, and removal of an additional 6 caves were approved under previous revisions of the EMP.</p> <p>Three SRE invertebrate fauna species (<i>Antichiropus</i> 'DIP006', <i>Chenistonia</i> 'MYG088' and <i>Karaops banyjima</i>) have only been recorded within the Mining Area C EMP Revision 6 Indicative Impact Assessment Area.</p> <p>Suitable habitat for <i>Karaops banyjima</i> is known to occur in large continuous extents throughout the Mining Area C (Northern Flank) Development Envelope. Some potential habitat for <i>Antichiropus</i> 'DIP006' and <i>Chenistonia</i> 'MYG088' has been identified outside of the Mining Area C Revisoin 6 EMP Impact Assessment Area; however it is not continuous.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>Eleven species of conservation significant vertebrate fauna have been recorded within the Proposed Mining Area C Development Envelope. All are well represented regionally or nationally.</p> <p>Baseline terrestrial fauna studies indicate that no PECs or TECs relating to terrestrial fauna are located within the Proposed Mining Area C Development Envelope or within 10 km of it. The closest PEC of relevance to terrestrial fauna is the Weeli Wolli Spring PEC, which is located approximately 20 km east of the Proposed Mining Area C Development Envelope. No significant impacts to terrestrial fauna values of the Weeli Wolli Spring PEC are anticipated.</p> <p>Cumulative loss of ghost bat roosts increased from 18 caves located within the Mining Area C EMP Revision 6 Indicative Impact Assessment Area to 51 caves within the Proposed Mining Area C Development Envelope (prior to mitigation). Twelve caves occur outside indicative impact assessment areas.</p> <p>Cumulative loss of fauna habitats is not considered significant. There are no mapped fauna habitats restricted to the Proposed Mining Area C Development Envelope.</p> <p>Habitats for all SREs recorded within the Proposed Mining Area C Development Envelope are considered likely to occur outside Indicative Mining Area C EMP Revision 6 and Additional Impact Assessment Areas. Cumulative reduction of habitat for <i>Antichiropus</i> 'DIP007' is approximately 55%.</p>
Mitigation		<p><i>Avoid:</i> BHP Billiton Iron Ore will, where practical, restrict disturbance to within a Modified Indicative Impact Assessment Area, and as a minimum retain 150 m buffer around all ghost bat caves located outside of the Modified Indicative Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area. Following mitigation the number of caves that will be impacted within cumulative impact areas is reduced to 36, with the number retained increasing from 12 to 27. Modification of the Indicative Impact Assessment Area also results in a reduction of impacts to foraging habitat for the ghost bat by 173 ha.</p> <p><i>Minimise:</i> Clearing only within the Modified Indicative Impact Assessment Area results in a reduction in clearing of medium and high value fauna habitats.</p> <p><i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope, and will include the use of <i>Corymbia hamersleyana</i> which is considered key habitat for <i>Antichiropus</i> 'DIP007'.</p>
Outcomes		<p><i>Residual Impact:</i> The loss of caves within the Indicative Additional Impact Assessment Area and Mining Area C Revision 6 EMP Impact Assessment Area suitable to support ghost bat may result in a reduction of the Hamersley population by approximately 50 individuals. Modification of the Indicative Additional Impact Assessment Area has increased ghost bat caves retained from 12 to 27 (11 high value), and the removal of foraging habitat has been reduced by 173 ha. With mitigation it is predicted that ghost bats will persist in the Proposed Mining Area C Development Envelope following closure and rehabilitation. Even with mitigation, it is likely that the population size will be reduced but that at closure the species will persist in the area.</p> <p>Additional mitigation strategies including construction of artificial roosts and management of foraging habitat will be considered as part of a management plan for the species.</p> <p><i>Offset:</i> The level of residual impacts to the ghost bat warrants an offset commitment. Therefore, continued study of the ecology of the ghost bat in the Pilbara will be undertaken to provide information to assist in identifying key habitats (roosting and foraging) for the species. This work will be published so that it is available to third-party operators in the Pilbara and will be considered during future mining developments undertaken by BHP Billiton Iron Ore.</p> <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor with the implementation of mitigation and management measures biological integrity and ecological diversity can be maintained.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Subterranean Fauna		
EPA Objective		To protect subterranean fauna so that biological diversity and ecological integrity are maintained
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p><u>Stygofauna</u> Six species are only known from the Groundwater Assessment Area. Four of these species occur within the vicinity of the Weeli Wolli Spring PEC and are considered likely to occur along Weeli Wolli Creek outside the area of impact. The fifth species, <i>Notobathynella</i> sp. is also considered likely to occur outside the area of impact. The sixth species, <i>Paramelitidae</i> sp. S04 (BR South) has been recorded from 21 samples over a range of 11 km. There is strong evidence that the distribution of this species extends outside the Groundwater Assessment Area, and hence the conservation threat to this species is considered low.</p> <p><u>Troglofauna</u> Eighteen species are known only from the proposed pit areas within the Indicative Additional Impact Assessment Area (plus three species are only known from within it and the Mining Area C EMP Revision 6 Impact Assessment Area). Current habitat data suggest that four species may be restricted to habitats that occur only within the Indicative Additional Impact Assessment Area, and for one its status is uncertain due to insufficient information on species ecology. It is noted that all of these species are known only from a single record (4 of the 5 are singletons) or drill hole, and therefore there is little information from which to infer likely ranges or habitats.</p>
	Mining Area C EMP Rev 6 Impact Assessment Area [B]	<p><u>Stygofauna</u> Four species (nr <i>Epactophanes</i> sp. B01, <i>Dussartcyclops</i> sp. B10, <i>Bathynella</i> sp. 2 and nr <i>Notobathynella</i> sp. S01) are known only from Mining Area C EMP Revision 6 Groundwater Assessment Area. The ranges of nr <i>Epactophanes</i> sp. B01, <i>Bathynella</i> sp. 2 and <i>Dussartcyclops</i> sp. B10 are unclear, and the potential threat to these species is uncertain because of their occurrence in single drill holes. nr <i>Notobathynella</i> sp. S01 occurs only 77 m from the edge of the Mining Area C EMP Revision 6 Groundwater Assessment Area, and given the proximity of this record to areas of minimal groundwater drawdown it is considered likely that its range extends into areas that are classified as undisturbed. Consequently, the level of threat to nr <i>Notobathynella</i> sp. S01 is likely to be low.</p> <p><u>Troglofauna</u> Twenty species are known only from the proposed pit areas within the Mining Area C EMP Revision 6 Impact Assessment Area. Based on a detailed habitat assessment, the inferred ranges of 17 of the 20 species are considered to extend beyond the proposed pit areas. The status of the three remaining species (<i>Hanseniella</i> sp. B08, <i>Symphyella</i> sp. B03, and <i>Parajapygidae</i> sp. S03) is uncertain because there is currently little information from which to infer likely ranges of these species.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p><u>Stygofauna</u> Fifty three stygofauna species have been recorded from the cumulative area of groundwater drawdown associated with Proposal. Twenty of these species have not been recorded outside proposed areas of impact. Of these twenty species, three may be impacted by cumulative mining within the sub-catchments: nr <i>Epactophanes</i> sp. B01: known from a single specimen that occurs 1.5 km from the edge of the modelled cumulative drawdown footprint. Due to the lack of information on the species, the actual impacts are unknown. <i>Dussartcyclops</i> sp B10: range for this species is unclear as it is only known from a single record (three animals). <i>Bathynella</i> sp. 2: range for this species is unclear as it is only known from a single record (four animals).</p> <p><u>Troglofauna</u> One hundred twenty seven species have been recorded from within the Proposed Mining Area C Development Envelope; 88 of these species have not been recorded elsewhere. Forty one species are known only from proposed pit areas within the Proposed Mining Area C Development Envelope. Habitat assessments and a review based on species' ecology suggests that all but eight of these species are likely to occur outside the indicative impact assessment areas. All but one of these species are currently only known from a single record or drill hole, and therefore there is currently little information from which to infer likely ranges or habitats.</p>
Mitigation		<p><i>Avoid:</i> Where practical, BHP Billiton Iron Ore will restrict disturbance to the Modified Indicative Impact Assessment Area. With respect to subterranean fauna this restriction will:</p> <ul style="list-style-type: none"> • reduce the number of potentially restricted species by seven to none; • one species of uncertain status has been removed from potential disturbance areas taking it to nine uncertain status species (six troglofauna and three stygofauna); • three species added to the Modified Indicative Additional Impact Assessment Area, but all are considered unlikely to be restricted to habitats within it. <p><i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope.</p> <p><i>Offset:</i> BHP Billiton will continue to undertake research into troglofauna habitats and taxonomy.</p>
Outcomes		<p><i>Residual Impact:</i> Implementation of the Proposal will result in a net loss of subterranean fauna habitat. Extensive troglofauna surveys, including the use of leading technology such as optical televiewer and a 3D habitat model, have been undertaken in conjunction with a habitat assessment that has suggested that all but eight species either occur or have habitat available outside of the cumulative impact assessment area. . It is noted that all but one of these species are known only from a single record (seven of the eight are singletons) or drill hole, and therefore there is little information from which to infer likely ranges or habitats. Three stygofauna species may be impacted by cumulative mining within the Coondewanna and Weeli Wolli sub-catchments. Two of these taxa are only known from a single location and therefore it is difficult to infer species range. The third species has been recorded in bores of another stygofauna species that occurs outside the cumulative area of drawdown, and therefore it is considered likely that it occurs over a similar range. <i>Offset:</i> The level of residual impacts to troglofauna warrant an offset commitment. Therefore, continued study of habitats and distribution of troglofauna within Pilbara will be undertaken to provide information to assist in impact assessment and conservation of this faunal group. This work will be published so that it is available to third-party operators in the Pilbara and will be considered for future mining developments undertaken by BHP Billiton Iron Ore.</p> <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor with the implementation of mitigation and management measures.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Hydrological Processes		
EPA Objective		To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p>The modelling carried out for the proposed Additional Impact Assessment Area and Development Envelope (BHP Billiton Iron Ore, 2016a) (based on the 2016 mine plan) predicts the following potential impacts (additional to those from Mining Area C and Hope Downs 1):</p> <ul style="list-style-type: none"> The additional Southern Flank resource is approximately 8% below the water table and will require proactive dewatering. Dewatering volumes will vary over the mine life and will move between surplus and deficit. Dewatering rates of up to 60 GL/a may be required for short periods. Drawdown at Coondewanna flats will increase to between 8-22 m (from 6-9.5 m) without application of mitigation options such as Managed Aquifer Recharge. No significant change to drawdown (average drawdown changes from 1.6 to 1.75 m) as a result of the Southern Flank ore body development, in comparison to the prediction of drawdown resulting from the 14 deposits at Mining Area C and Hope Downs mining area at the Weeli Wolli Spring and Ben's Oasis receptors. <p>No creek diversions are proposed within the Additional Development Envelope.</p> <p>The water balance for the Southern Flank satellite mine is negative with periods of surplus. During period of surplus water, is proposed that the water be used as an operational water supply, with any surplus water disposal to be managed via managed aquifer recharge (MAR) or infiltration basin schemes. MAR or infiltration returns water from dewatering activities to the same water catchment to that which it was extracted from, effectively retaining the water within the same catchment and minimising loss of ground water. During times of water deficient, water demand is likely to be met from dewatering activities from the existing Mining Area C mine.</p> <p>The closest indicative pit design is located 100 m from the 10,000 year annual recurrence interval (ARI) floodplain of Pebble Mouse Creek; therefore, creek capture is not considered to pose a risk.</p> <p>The Indicative Additional Impact Assessment Area impacts approximately 3.5% of the Weeli Wolli Creek subcatchment, 5% of the Coondewanna subcatchment and less than 1% of the Fortescue Marsh Catchment Area (also known as the Fortescue River Upper Catchment).</p>
	Mining Area C EMP Rev 6 Impact Assessment Area [B]	<p>The modelling and hydrological impact assessment was inclusive of mining of all 14 deposits within the current Mining Area C (Northern Flank) Development Envelope (BHP Billiton Iron Ore, 2015a) (based on the 2014 mine plan). The assessment predicted the following:</p> <ul style="list-style-type: none"> The maximum dewatering rate may be up to 42,000 kL/d (15.3 GL/a). The maximum cumulative groundwater drawdown (including third-party operations at Hamersley Hope Downs 1 Mine Project) at: <ul style="list-style-type: none"> Coondewanna Flats is predicted to be between 6 m and 9.5 m. With mitigation, this can be reduced and maintained at less than 1 m. Ben's Oasis is likely to be less than about 2 m without mitigation; and Weeli Wolli Spring is likely to be less than 1 m (after the period of proposed mitigation by Rio Tinto Iron Ore). Post-closure, the recovery of the groundwater system is likely to take hundreds of years at Coondewanna Flats and Ben's Oasis, but tens of years at Weeli Wolli Spring. The scenario of leaving open voids at A and E Deposits post-closure is predicted to result in a reduction in the final recovery of groundwater levels, particularly at Coondewanna Flats. All 14 pits at Mining Area C will be backfilled above the historic water table to mitigate this impact at Mining Area C. The surface water system is located within the Fortescue Marsh Catchment Area, within this areas the potential impact of mining 14 deposits within the Mining Area C (Northern Flank) Development Envelope equates to 0.18% of the whole catchment area.
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>Potential impacts, inclusive of potential impacts from the Proposal and existing operations at Mining Area C and those from third party operations in the area (Hope Downs 1) were assessed.</p> <p>The maximum cumulative groundwater drawdown (including third-party operations at Hamersley Hope Downs 1 Mine Project) at:</p> <ul style="list-style-type: none"> Coondewanna Flats is predicted to be between 8 and 22 m, however, the impact is considered minor as the vegetation has been established to not be groundwater-dependent and surface water impacts are minimal. Ben's Oasis is likely to be less than approximately 1 m. Weeli Wolli Spring is likely to be between 1 and 2.5 m (after the period of proposed mitigation by Rio Tinto Iron Ore). <p>The majority of the Proposal area is located in the Fortescue Marsh Catchment Area and this impact is predicted to impact less than 1% of the Fortescue Marsh Catchment Area.</p> <p>Ongoing monitoring and adaptive management in line with the objectives outlined in the Central Pilbara Water Resource Management Plan (CPWRMP), will ensure that appropriate mitigation measures (such as managed aquifer recharge and pit backfill) are applied to prevent significant impact to the key ecohydrological receptors. Appropriate mitigation techniques have been tested and are available for implementation.</p>
Mitigation		<p><i>Minimise:</i></p> <ul style="list-style-type: none"> Surplus dewatering volumes will continue to be used as a process supply to minimise requirement for additional water supply bores within the catchment. Consistent with the Department of Water (DoW) Mine Water in Mining Guideline (DoW, 2013b), and where practicable and feasible, surplus groundwater will continue to be preferentially returned to the aquifer through MAR, if volumes are higher than required for process supply. MAR systems will be located in dolomite and alluvial aquifers, effectively storing water for future use by the mine and reducing potential extent of drawdown at Coondewanna Flats. Surface water will continue to be diverted around the mining footprint to the extent practicable to minimise the loss of surface water flow in the natural drainage systems. Backfilling of below the water table mine voids will be used as required to mitigate potential impacts to ecohydrological receptors. <p><i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope.</p>
Outcomes		<p><i>Residual Impact:</i> BHP Billiton Iron Ore currently has a plan that incorporates a hierarchy of management options (e.g. monitoring, aquifer recharge) in line with the DoW guidelines for the management of water in the Pilbara region (DoW, 2013a). It is proposed that this plan will be incorporated into the CPWRMP and continue to be used to manage and minimise the potential impacts to hydrological processes for the Mining Area C hub. Approvals issued under Part V of the EP Act and <i>Rights in Water and Irrigation Act 1914</i> (RIWI Act) 5C licence will support the management plan. The residual impact following application of management options and minimisation activities is not considered significant. Implementation of the plan is proposed to be managed via a ministerial condition.</p> <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor; hydrological regimes can be maintained so that environmental values are protected.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Inland Waters Environmental Quality		
EPA Objective		To maintain the quality of groundwater and surface water so that environmental values are protected.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	Proposed surface water modifications (e.g. diversion of natural surface water flows around pit areas) within the Southern Flank ore body development will not materially impact water quality in the surface water catchment. The Proposal will potentially mobilise additional sediment to the natural drainage systems arising from the overburden storage areas (OSAs), ore stockpiles and native vegetation clearing in general. Rainfall and surface water runoff from mining areas has the potential to increase sediment-laden water transmitted to the environment and natural drainage systems. However, the potential for increases in surface water sediment loading will be minimal overall, following the design and implementation of sediment basin interceptors Groundwater in the Southern Flank deposits is of high quality and as such is suitable for return to groundwater via injection with a low risk to the receiving aquifer water quality. The potential risk for acid and metalliferous drainage (AMD) impacts on groundwater and surface water is considered negligible based on the fact that the waste characterisation shows AMD potential is low to negligible.
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	Proposed pit and OSAs within the additional disturbance have the potential to impact surface water resources by changing local surface water flow patterns, by affecting surface water runoff volumes and quality, by increasing the risk of erosion and sedimentation or by contamination from chemicals or hydrocarbons. Potential impacts on natural surface water quality resulting from the extra disturbance within the Mining Area C EMP Revision 6 Impact Assessment Area are negligible. The impact assessment undertaken concluded that the potential for AMD is low due to the oxidised nature of the ore. Impacts to surface water due to chemical or hydrocarbon spills potentially occur but this is not expected to be an issue due to the installation of appropriate fuel, hydrocarbon and chemical containment and storage facilities.
	Cumulative (Proposed Mining Area C Development Envelope)	Proposed surface water modifications will not materially impact water quality in the surface water catchment. Groundwater in the catchments is of high quality and as such is suitable for return to groundwater via injection with a low risk to receiving aquifer water quality. The potential risk for AMD impacts on groundwater and surface water is considered negligible across the Proposed Mining Area C Development Envelope.
	[A + B]	
Mitigation		<i>Avoid:</i> Diversion of surface water around operational mining area to maintain natural surface water flows downstream. <i>Minimise:</i> Implementation of sedimentation basin to reduce sediment in surface water. <i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope.
Outcomes		<i>Residual Impact:</i> Preliminary AMD analysis and risk assessment have shown that the risk of AMD impacts to water quality as low to negligible. This coupled with the business preference to back fill below water table (BWT) pit voids to manage water quality within the local water catchments means that it is not anticipated that water quality will be significantly effected as a result of implementation of the Proposal. The Proposal meets the EPA's objective for this factor. Following impact assessment this factor is not considered likely to have a significant impact. BHP Billiton Iron Ore therefore considers that Inland Waters Environmental Quality is not a key environmental factor and can be addressed under Part V of the EP Act and the RIWI Act licencing.

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Heritage		
EPA Objective		<p>To ensure that historical and cultural associations are not adversely affected.</p> <p>(Note: this factor now forms part of Social Surroundings factor whose objective is To protect social surroundings from significant harm)</p>
Potential Impacts	Mining Area C EMP Rev 6 Impact Assessment Area [B]	<p>The Mining Area C (Northern Flank) Development Envelope (including the Mining Area C EMP Revision Impact Assessment Area) lies wholly within the Banjima Native Title claim area. Archaeological and ethnographical surveys have been conducted; and where required, approvals under s18 of the Aboriginal Heritage Act 1972 (AH Act) were received to impact heritage sites. Identified heritage sites are avoided where practicable through design, planning and engineering solutions. Within the Proposed Mining Area C Development Envelope BHP Billiton Iron Ore identified 576 heritage places, 274 of which are located within the EMP Revision 6 Impact Assessment Area. Twenty-five of these have been fully impacted under s18 approval by the Mining Area C development and 17 sites have been partially impacted.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>The Proposed Mining Area C Development Envelope lies mostly within the Banjima Native Title claim, with the southeast corner lying within the Nyiyaparli Native Title claim. BHP Billiton Iron Ore is committed to working cooperatively with the Banjima and Nyiyaparli people and has formalised this commitment through comprehensive Indigenous Land Use Agreements (ILUAs) executed with the Nyiyaparli people in 2012 and the Banjima people in October 2015. The ongoing dialogue and consultation established via the ILUAs will continue. To date, up to 200 archaeological and ethnographical surveys have been conducted in the Proposed Mining Area C Development Envelope in consultation with the Banjima and Nyiyaparli people. Over 1,500 potential heritage places have been identified within this development envelope, of which 75% occur within the indicative impact assessment areas. All places are classed as 'other place's or as 'site's as per Section 5 of the <i>Aboriginal Heritage Act 1972</i> (AH Act). No places located within the Proposed Development Envelope are classed as government protected, exclusion zones or managed areas. All section 5 classed sites are managed in compliance with the ILUAs and the AH Act. The Proposal will impact 17 archaeological sites and partially impact (~30%) one ethnographic site in addition to those already impacted within the Mining Area C EMP Revision 6 Impact Assessment Area. Although more intensive surveys have been undertaken within the Development Envelope than elsewhere within the Banjima claim area, resulting in an overestimation of impacts regionally, the estimated impact regionally to heritage places based on current data represents approximately 25% of the places within the claim area.</p>
Mitigation		<p><i>Avoid:</i></p> <ul style="list-style-type: none"> The Proposed Mining Area Development Envelope specifically avoided the Mount Robinson exclusion area. The mine plan and design was modified to avoid, where practical, heritage places. This resulted in approximately 15% of heritage places being avoided <p><i>Minimise:</i></p> <ul style="list-style-type: none"> Heritage places have been recorded to a detailed level to mitigate against their loss. The detailed recording is considered a mitigation as it preserves the information contained in the site. An extensive excavation project has been undertaken in partnership with the relevant Traditional Owners to better understand the cultural landscape and the sequence of early occupation of the area to ensure any impacts to the landscape are minimised. <p><i>Rehabilitate:</i> BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope.</p>
Outcomes		<p><i>Residual Impact:</i> The impacts predicted from implementation of the Proposal do not present a significant impact to biophysical features of heritage significance.</p> <p><i>Offset:</i> The significance of impact does not warrant application of offsets.</p> <p>The Proposal meets the EPA's objective for this factor. Following impact assessment, this factor is not considered likely to have a significant impact, therefore it is not considered a key environmental factor by BHP Billiton Iron Ore. BHP Billiton Iron Ore considers that this factor can be managed under the AH Act.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Rehabilitation and Decommissioning		
EPA Objective		To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p>The proposed mine closure strategy will take an adaptive management approach for the Proposed Mining Area C Development Envelope. Key focus areas will be:</p> <ul style="list-style-type: none"> • erodibility of final OSA (landform) design, including ongoing assessment of waste material; • management and or mitigation of potential groundwater impacts as a results of BWT pit voids or lakes; and • validation of the low acid and metalliferous drainage (AMD) risk. <p>Ongoing monitoring of groundwater drawdown and any impacts on ecohydrological receptors (for example, Weeli Wolli Spring), will be the main adaptive management closure drivers at Southern Flank. This outcome-oriented strategy will, where required, mitigate impacts on receptors by BWT pit voids in the Additional Development Envelope to above the water table with inert waste material, minimise legacy issues associated with empty pits post-mining and reduce final OSA landform area for rehabilitation through operations dumping waste material in-pit, as much as practicable. No tailings storage facilities are planned as part of the Proposal.</p>
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	<p>The current approved Mine Closure Plan is to continue backfilling depleted pits within the Mining Area C (Northern Flank) Development Envelope with waste material in accordance with the mine plan and where practicable to minimise legacy issues associated with voids post mining and impact on final landforms. This is reflected in the updated Mining Area C Mine Closure Plan.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>Alterations of landforms, management of AMD, OSA rehabilitation, backfill of BWT pits to above the water table, and landform engineering (abandonment bunds) remain key closure aspects in the updated Mining Area C Mine Closure Plan.</p>
Mitigation		<p><i>Avoid:</i> Ensure pit abandonment bunds adequately control unauthorised pit access post-closure for pits adjacent the Great Northern Highway. If required, removing open-pit edges by backfilling material to buttress pit walls may be necessary.</p> <p><i>Minimise:</i></p> <ul style="list-style-type: none"> • Augmentation of aquifer recovery should aquifer recovery time lag post-closure prove unacceptable. • Ongoing monitoring of groundwater drawdown. <p><i>Rehabilitate:</i></p> <ul style="list-style-type: none"> • BHP Billiton Iron Ore will undertake progressive rehabilitation within the Proposed Mining Area C Development Envelope. • Armouring component of OSA rehabilitation based on using local competent material and adaptive management to achieve erosionally stable final OSA slope angles. • Final landform revegetation - topsoil material placed on the outer surface of landforms with consideration of growth media characteristics and depth required for suitable plant growth for establishing the target vegetation community and supporting agreed final land use. • Backfilling of below the water table pit voids to above the pre-mining water table, as required, based on impacts to key ecohydrological receptors.
Outcomes		<p><i>Residual Impact:</i> BHP Billiton Iron Ore considers that potential residual impacts are low and propose that impacts can be managed via implementation of the Mine Closure Plan. Implementation of the plan is proposed to be managed via a Ministerial condition.</p> <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Offsets		
EPA Objective		To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	Clearing of an additional 13,858 ha of Very Good to Excellent condition vegetation will be required to implement the development of the Southern Flank ore body. Where significant residual impacts are identified following rehabilitation of up 13,858 ha, BHP Billiton Iron Ore will provide environmental offsets via the Pilbara Conservation Fund, or alternatively, delivered consistent with contemporary offset guidance. Approximately 4,239 ha of High suitability SRE habitat occurs in the Indicative Additional Impact Assessment Area (a majority of this is habitat for <i>Antichiropus</i> 'DIP007'). It is considered that removal of this habitat will likely have a moderate to high impact on SRE fauna.
	Mining Area C EMP Rev 6 Impact Assessment Area [B]	Clearing of an additional 5,942 ha of Very Good to Excellent condition vegetation within the 11,377 ha Mining Area C EMP Revision 6 Impact Assessment Area will be required to facilitate the development of the Southern Flank ore body. Where significant residual impacts are identified following rehabilitation of up 5,942 ha, BHP Billiton Iron Ore will provide environmental offsets via the Pilbara Conservation Fund, or alternatively, delivered consistent with contemporary offset guidance. Approximately 612 ha of High suitability SRE habitat occurs in the Mining Area C EMP Revision 6 Impact Assessment Area. It is considered that removal of this habitat will likely have a moderate to high impact on SRE fauna.
	Cumulative (Proposed Mining Area C Development Envelope)	Total native vegetation clearing if the Proposal is approved will be 25,185 ha (of which 19,671.2 ha relates to this Proposal) within the Proposed Mining Area C Development Envelope. The majority of this vegetation is considered to be in Very Good or better condition. Rehabilitation of up to 19,671.2 ha is proposed as part of the Southern Flank Mine Closure Plan.
	[A + B]	
Mitigation		<p>Modification of the Indicative Additional Impact Assessment Area has increased the number of ghost bat caves retained from 12 to 27 (11 high value), and the removal of foraging habitat has been reduced by 173 ha. BHP Billiton Iron Ore will commit to retaining a 150 m buffer around all ghost bats roosts that occur outside the Mining Area C Revision 6 EMP Impact Assessment Area and the Modified Indicative Additional Impact Assessment Area.</p> <p>Modification of the Indicative Additional Impact Assessment Area has reduced clearing of Medium and High value fauna habitats as follows:</p> <ul style="list-style-type: none"> Gorge/Gully – clearing reduced from 465 ha to 383 ha. Crest/Slope – clearing reduced from 6,427 ha to 6,414 ha. Major Drainage Line – clearing reduced from 21 ha to 0 ha. Mulga – clearing reduced from 874 ha to 496 ha. Sand Plain – clearing reduced from 429 ha to 135 ha. <p>Rehabilitation of SRE habitat areas with <i>Corymbia hamersleyana</i>.</p>
Outcomes		<p>Where significant residual impacts are identified following rehabilitation, BHP Billiton Iron Ore will provide environmental offsets via the Pilbara Conservation Fund, or alternatively, delivered consistent with contemporary offset guidance. With the application of mitigation measures, it is likely that the total vegetation clearing can be reduced to 15,693 ha, however a conservative offset amount of 19,671.2 ha is proposed.</p> <p>BHP Billiton Iron Ore further proposes:</p> <ul style="list-style-type: none"> Continued study of the ecology of the ghost bat in the Pilbara will be undertaken to contribute to the current understanding of this species. Funding additional studies on troglofauna habitats and taxonomy to further understand of species and their distribution in the Pilbara. This could include environmental DNA studies and taxonomic study of Diplurans. <p>This factor is considered a preliminary key environmental factor. The Proposal meets the EPA objective for this factor; residual environmental impacts and/or uncertainty have been addressed through the application of offsets.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Landforms		
EPA Objective		To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	<p>The following land systems are located within the Additional Development Envelope:</p> <ul style="list-style-type: none"> • Newman; • Boolgeeda; • Platform; • Wannamunna; and • Pindering. <p>The following soil management units (SMUs) have been recorded within the Additional Development Envelope:</p> <ul style="list-style-type: none"> • ridgelines; • scree slopes; • undulating stony plains; • drainage lines; and • hardpan wash plains <p>The soils and landforms in the Indicative Additional Impact Assessment Area are not considered rare or important in the Pilbara region and they are not of scientific interest or play an integral role in maintaining existing ecological or physical processes in the region.</p>
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	<p>The following land systems are located within the Approved Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • Newman; • Boolgeeda; • Platform; and • Wannamunna. <p>The following SMUs are located within the Approved Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • ridgelines; • scree slopes; • undulating stony plains; and • drainage lines <p>The soils and landforms in the Mining Area C EMP Revision 6 Impact Assessment Area are not considered rare or important in the Pilbara region and they are not of scientific interest or play an integral role in maintaining existing ecological or physical processes in the region.</p>
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	<p>Overall, the following land systems are located within the Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • Newman; • Boolgeeda; • Platform; • Wannamunna; and • Pindering. <p>Overall, the following SMUs have been recorded within the Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • ridgelines; • scree slopes; • undulating stony plains; • drainage lines; and • hardpan wash plains. <p>Landforms within the Proposed Mining Area C Development Envelope are not considered rare, of scientific interest or of ecological importance. The variety and integrity of the landforms in the region will not be significantly altered in the region as a result of the Proposal.</p>
Mitigation		As the impacts are not significant, no application of the mitigation hierarchy is required. This factor can be adequately managed via the updated Mine Closure Plan.
Outcomes		<p>Landforms within the Proposed Mining Area C Development Envelope are not considered rare, of scientific interest or of ecological importance. The variety and integrity of the landforms in the region will not be significantly altered in the region as a result of the Proposal.</p> <p>Following impact assessment, BHP Billiton Iron Ore considers that the Proposal meets the EPA's objective for this factor. Landforms is therefore not considered a key environmental factor for this Proposal and can be addressed under Part V of the EP Act.</p>

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Terrestrial Environmental Quality		
EPA Objective		To maintain the quality of land and soils so that environmental values are protected.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	A preliminary AMD Risk Assessment (BHP Billiton Iron Ore, 2016b) has been carried out for the Southern Flank Development. This study assessed AMD potential as low to very low. Within the resource and mining model, no blocks of fresh rock with acid-forming potential, classified as AMD 1 (NAPP greater than or equal to 3), and were identified. Minor amounts of weathered and detrital material (less than 3.5% overall), designated AMD 2 and 3, respectively, is present; however, sulphur in this material is likely oxidised and unlikely to have acid-generating capacity. Ongoing geochemical assessment will be undertaken to validate risks assessed for AMD 2 and 3 material.
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	Potential sources of impacts include mining of potentially acid-forming (PAF) material during operations, generation of waste materials, and storage and handling of dangerous goods. Potential sources of AMD during operations are: <ul style="list-style-type: none"> mine waste and by association OSAs; pits (pit wall, wall rock). Mining Area C is a low-sulphur system, with material classified as PAF characterised by a low net acid production potential (NAPP) of an average less than 5 to 6 kg H ₂ SO ₄ /t (sulfuric acid per tonne) and thus not likely to generate elevated acidity. Potential impacts from contamination are considered low for Mining Area C operations. Existing waste disposal procedures and practices are considered to be effective and PAF and AMD are managed through the Mine Closure Plan.
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	Overall, potential impacts from contamination are low for the Proposal. Existing waste disposal procedures and practices are considered effective.
Mitigation		Precautions will be taken for materials that have been found to have minor amounts of weathered and detrital materials by placing them more than 10 m from the final OSA rehabilitation surfaces. Approvals under Part V of the EP Act and under the <i>Dangerous Goods Safety Act 2004 (WA)</i> will be sought for the handling and storage of dangerous goods and the construction and operation of landfills.
Outcomes		The potential impact to Terrestrial Environmental Quality as a result of the Proposal are considered not significant and the EPA objective can be met. Following impact assessment, BHP Billiton Iron Ore considers that the Proposal meets the EPA's objective for this factor. Terrestrial Environmental Quality is therefore not considered a key environmental factor for this Proposal and can be addressed under Part V of the EP Act.

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Air Quality		
EPA Objective		To maintain air quality and minimise emissions so that environmental values are protected.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	The BHP Billiton Iron Ore licence for Newman was used as guidance to assess the significance of impacts from the Southern Flank Development. Air quality modelling undertaken for the prediction of potential impacts was carried out under worst-case meteorological and mining configuration (i.e. mining activity nearest the receptors and at maximum volume). While the maximum predicted particulate concentrations at the accommodation camps is slightly above the guidance, ongoing monitoring of background air quality shows that this is typical of the Pilbara region. It is expected that, with the use of fixed plant engineered controls, proactive operational controls and changes already implemented in mine design, these impacts can be minimised and the EPA objective can be met. The expected maximum greenhouse gas emissions are anticipated to contribute 0.22% of Australia's and 1.09% of Western Australia's 2014/15 greenhouse inventory.
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	Within the Approved Mining Area C Development Envelope there are two owned and managed accommodation camps: Packsaddle and Mulla Mulla. Air quality monitoring undertaken for the prediction of potential impacts was carried out under worst case meteorological and mining configuration (i.e. mining activity nearest the receptors and at maximum volume). The 95th percentile prediction of PM ₁₀ ground level concentrations are 59 µg/m ³ at the Packsaddle accommodation village and 44 µg/m ³ at the Mulla accommodation village with standard controls included. Based on these predictions, it can be concluded that implementation of the Proposal will not result in air quality impacts that could be considered significant as they are typical of the Pilbara region, as natural background levels have been measured as similar to these predictions. BHP Billiton Iron Ore will continue to manage Mining Area C operations to protect the environment and human health and amenity from impacts resulting from activities associated with the operations. Based on CO ₂ -e calculations and estimations, it is concluded that greenhouse gas emissions from Mining Area C are not significant and can be minimised through the application of best practice.
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	The BHP Billiton Iron Ore licence for Newman was used as guidance to assess the significance of impacts from the Proposal. Air quality monitoring undertaken for the prediction of potential impacts was carried out under worst case meteorological and mining configuration (i.e. mining activity nearest the receptors and at maximum volume). The 95th percentile predictions of PM ₁₀ were 72 and 61 µg/m ³ respectively. Background monitoring in the region shows that natural high background events account for between 3 and 6 instances of above 70 µg/m ³ and therefore the cumulative prediction are not considered significantly different to natural particulate emissions in the region. It is expected that, with the use of fixed plant engineered controls, proactive operational controls and changes already implemented in mine design, these impacts can be minimised and the EPA objective can be met. Predictive modelling of total suspended particulate (TSP) was also undertaken to inform assessment of amenity impacts to Great Northern Highway as discussed below. The expected maximum greenhouse gas emissions are anticipated to contribute 0.48% of Australia's and 2.37% of Western Australia's 2014/15 greenhouse inventory.
Mitigation		BHP Billiton Iron Ore designs and implements a series of fixed plant and mobile plant dust abatement controls. These include but are not limited to foggers, water canyons, surfactants, belt washes. These controls will minimise potential impacts to air quality.
Outcomes		Following impact assessment, BHP Billiton Iron Ore considers that the Proposal meets the EPA's objective for this factor. Air quality is therefore not considered a key environmental factor for this Proposal.

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Amenity		
EPA Objective		To ensure that impacts to amenity are reduced as low as reasonably practicable.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	Six key viewpoint sites were identified and analysed for potential visual impacts. Visibility risk to the Great Northern Highway as a result of particulate emissions was assessed. The visual impact of the Proposal along the Great Northern Highway adjacent to the Proposal is predicted to be moderate. It is predicted that for approximately 30% of the year there is a medium risk (visibility of 2 km or less) to visibility along the highway when mining is occurring in the near vicinity of the highway with detrimental wind conditions.
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	Nine potential key viewpoint sites were identified and analysed for potential impacts to view sheds. The highest potential impact to a view shed is along the Great Northern Highway located immediately east of the Approved Mining Area C Development Envelope.
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	Potential visibility and visual impacts to users of the Great Northern Highway discussed above were assessed on a 'cumulative' basis, which was inclusive of potential impacts from the Proposal and existing operations at Mining Area C.
Mitigation		The mine design has been modified to relocate OSAs further from the Great Northern Highway to reduce visibility and amenity impacts to highway users. BHP Billiton Iron Ore will, where practical, restrict vegetation clearing and undertake progressive rehabilitation of OSAs and associated mining infrastructure.
Outcomes		Following impact assessment, BHP Billiton Iron Ore considers that the Proposal meets the EPA's objective for this factor. Amenity is therefore not considered a key environmental factor for this Proposal and can be addressed under Part V of the EP Act.

Table ES-1: Summary of potential impacts, proposed mitigation and outcomes (continued)

Note: Factors that are considered to be preliminary key environmental factors are shaded in light green.

Human Health (Noise)		
EPA Objective		To protect human health from significant harm.
Potential Impacts	Indicative Additional Impact Assessment Area for Development of Southern Flank [A]	Under worst-case meteorological conditions and worst-case mining locations (fleet located at the surface and closest to the camps), received noise levels at the Packsaddle Accommodation Village are below assigned night time noise regulations (less than 35 dB (A)). At the Mulla Accommodation Village, noise levels under worst-case conditions are predicted to be up to 4.3 dB (A) above the 35 dB (A) assigned noise level. However, modelling was undertaken for the worst-case scenario (mining at highest rates nearest receptors and during worst-case meteorological conditions). It is highly likely that the assigned noise levels will be met as this worst-case scenario is highly unlikely to occur. Indoor noise levels at the accommodation camps are predicted to be 11.8 dB (A) and are therefore compliant with the Australian standard of less than 25 dB (A) for indoor noise.
	Mining Area C EMP Revision 6 Impact Assessment Area [B]	Received noise levels are predicted to be below assigned noise levels. BHP Billiton Iron Ore will continue to manage Mining Area C operations to protect the amenity of occupants at the camps from noise and vibration impacts resulting from activities associated with the operations.
	Cumulative (Proposed Mining Area C Development Envelope) [A + B]	The potential noise impacts resulting from the Proposal and current operations at the Mining Area C hub are in line with requirements of the Environmental Protection (noise) regulations.
Mitigation		Where possible BHP Billiton Iron Ore will minimise night time mining activities undertaken near key receptors.
Outcomes		Following impact assessment, BHP Billiton Iron Ore considers that the Proposal meets the EPA's objective for this factor. Human health (noise) is therefore not considered a key environmental factor for this Proposal.

Page intentionally blank

Contents

1. Introduction	15
1.1 Overview and purpose	15
1.2 The proponent.....	15
1.3 Proposal location and tenure	16
1.4 The Proposal context	16
1.5 Structure of this document	20
2. Proposal description	21
2.1 Development overview.....	21
2.1.1 Mining method.....	21
2.1.2 Ore processing and transport.....	22
2.1.3 Overburden management	22
2.1.4 Mine dewatering, water use and disposal of surplus water	22
2.2 Key characteristics of the Proposal.....	22
2.3 Development of the mining operation	24
2.4 Development envelope	24
2.5 Existing approvals	26
2.5.1 State Agreement Act	26
2.5.2 Other operations within the area	26
2.5.3 Environmental Protection Act 1986 Part IV approvals.....	30
2.5.4 Environmental Protection Act 1986 Part V approvals	30
2.5.4.1 Native vegetation clearing permits.....	30
2.5.4.2 Licence to Operate	32
2.5.5 Rights in Water and Irrigation Act 1914	32
3. Development justification and alternatives considered	35
3.1 Proposal rationale and benefits.....	35
3.2 Evaluation of alternatives	37
3.2.1 Evaluation of crusher and ore transport alternatives	38
3.2.2 Use of existing fixed infrastructure at Mining Area C	39
3.2.3 Evaluation of waste rock disposal alternatives	39
3.2.4 Evaluation of option not to conduct the Proposal.....	39
4. Consultation	41
4.1 Key stakeholders.....	41
4.2 Stakeholder comments and proponent responses	42
4.3 Ongoing consultation	42
5. Regional biophysical environment	47
5.1 Biogeographic region	47

5.2	Regional climate	47
5.3	Regional topography	49
5.4	Regional geology	49
5.5	Regional land systems	50
5.6	Regional hydrology	50
5.7	Biodiversity	51
6.	Social environment.....	57
6.1	Socio-economic setting	57
6.1.1	Pastoralism.....	57
6.1.2	Mining.....	57
6.1.3	Conservation reserves	58
6.1.4	Tourism	58
6.1.5	Population centres	58
6.2	Aboriginal heritage	59
6.3	European heritage.....	59
7.	Environmental impact assessment process.....	61
7.1	State environmental assessment process	61
7.2	Commonwealth environmental assessment process.....	63
7.3	Legislation, policy and guidance	63
7.4	Principles of ecologically sustainable development.....	84
7.5	Principles of environmental impact assessment.....	86
8.	Environmental studies and survey effort.....	89
9.	Identification of environmental factors	105
9.1	Determining the environmental factors	105
9.2	Environmental impact assessment studies and review of environmental factors.....	106
10.	Regional management approach	109
10.1	Adaptive management	109
10.2	Environmental governance hierarchy	111
10.3	Project environmental and Aboriginal heritage reviews	112
11.	Assessment of preliminary key environmental factors	113
11.1	Flora and vegetation	113
11.1.1	EPA objective	113
11.1.2	Relevant legislation, guidelines and policies.....	113
11.1.3	Existing environment.....	113
11.1.3.1	Survey effort	113
11.1.3.2	Vegetation	120
11.1.3.3	Vegetation condition.....	129
11.1.3.4	Flora	129

11.1.3.5	Existing impacts	135
11.1.4	Potential impacts	138
11.1.4.1	Direct Impacts	138
11.1.4.1.1	Vegetation	138
11.1.4.1.2	Conservation significant flora	144
11.1.4.2	Indirect impacts of the Proposal.....	148
11.1.4.3	Regional cumulative impacts	150
11.1.4.3.1	Vegetation	150
11.1.4.3.2	Flora	151
11.1.4.3.3	Weeli Wolli Spring PEC.....	151
11.1.4.3.4	Coondewanna Flats PEC.....	153
11.1.5	Mitigation and residual impacts.....	154
11.1.6	Proposed management approach.....	156
11.1.6.1	Internal management approach	156
11.1.6.2	Regulatory management.....	157
11.1.6.3	Summary and predicted outcome	157
11.2	Terrestrial fauna	158
11.2.1	EPA objective	158
11.2.2	Relevant legislation, guidelines and policies.....	158
11.2.3	Existing environment.....	159
11.2.3.1	Survey effort	159
11.2.3.2	Habitats	166
11.2.3.3	Existing impacts	178
11.2.3.4	Fauna community.....	178
11.2.4	Potential impacts	178
11.2.4.1	Direct impacts.....	179
11.2.4.1.1	Habitats	179
11.2.4.1.2	Conservation significant species.....	181
11.2.4.2	Indirect impacts	204
11.2.4.3	Regional cumulative impacts	207
11.2.4.3.1	Habitats	207
11.2.4.3.2	Conservation significant species.....	207
11.2.4.3.3	Weeli Wolli Spring PEC.....	208
11.2.5	Mitigation and residual impacts.....	210
11.2.6	Proposed management approach.....	212
11.2.6.1	Internal management approach	212
11.2.6.2	Regulatory management.....	213
11.2.7	Summary and predicted outcome	217

11.3	Subterranean fauna	218
11.3.1	EPA objective	218
11.3.2	Relevant legislation, guidelines and policies.....	218
11.3.3	Existing environment	218
11.3.3.1	Survey effort	218
11.3.3.2	Troglofauna habitats	225
11.3.3.3	Stygofauna habitats.....	225
11.3.3.4	Troglofauna community.....	226
11.3.3.5	Stygofauna community.....	233
11.3.3.6	Potential impacts	233
11.3.3.7	Direct impacts.....	238
11.3.3.7.1	Troglofauna species	238
11.3.3.7.2	Troglofauna habitats	239
11.3.3.7.3	Stygofauna species	253
11.3.3.7.4	Stygofauna habitats.....	256
11.3.3.8	Indirect impacts	257
11.3.3.8.1	Troglofauna	257
11.3.3.8.1	Stygofauna	258
11.3.3.9	Cumulative impacts	260
11.3.3.9.1	Weeli Wolli Spring PEC.....	260
11.3.4	Mitigation and residual impacts.....	261
11.3.5	Proposed management approach.....	263
11.3.5.1	Internal management approach	263
11.3.5.2	Regulatory management.....	263
11.3.6	Summary and predicted outcome	264
11.4	Hydrological processes	266
11.4.1	Introduction and EPA objective	266
11.4.2	Relevant legislation, guidelines and policies.....	266
11.4.3	Existing environment.....	266
11.4.4	Hydrological assessment overview	268
11.4.4.1	Groundwater modelling	268
11.4.4.2	Surface water modelling.....	271
11.4.5	Potential impacts	272
11.4.5.1	Groundwater.....	274
11.4.6	Potential cumulative impacts – groundwater	276
11.4.7	Potential impacts – surface water	279
11.4.8	Potential cumulative impacts– surface water	280
11.4.9	Mitigation and residual impacts	280

11.4.10	Proposed management approach.....	282
11.4.11	Summary and predicted outcome	284
11.5	Inland waters environmental quality	287
11.5.1	Introduction and EPA objective	287
11.5.2	Relevant guidelines and approvals	287
11.5.3	Existing environment.....	287
11.5.4	Potential impacts	290
11.5.5	Mitigation and residual impacts.....	292
11.5.6	Proposed management approach.....	293
11.5.7	Predicted outcome	293
11.6	Heritage.....	293
11.6.1	Introduction and EPA objective	293
11.6.2	Relevant guidelines and approvals	293
11.6.3	Existing environment.....	293
11.6.4	Potential impacts	296
11.6.4.1	Cumulative impacts	297
11.6.5	Mitigation and residual impacts.....	301
11.6.6	Proposed management approach.....	302
11.6.7	Predicted outcome	303
11.7	Rehabilitation and decommissioning	305
11.7.1	Introduction and EPA objective	305
11.7.2	Relevant legislation, guidelines and approvals	305
11.7.3	Existing environment.....	305
11.7.4	Potential impacts	306
11.7.4.1	Acid and metalliferous drainage.....	307
11.7.4.2	Soil management and landform engineering	308
11.7.4.3	OSA rehabilitation	309
11.7.4.4	Below water table pit voids and pit lake assessment.....	310
11.7.5	Mitigation and residual impacts.....	312
11.7.6	Proposed management approach.....	314
11.7.6.1	Internal management approach	314
11.7.7	Predicted outcome	314
11.8	Offsets.....	316
11.8.1	Introduction and EPA objective	316
11.8.2	Existing environment.....	316
11.8.3	Mitigation and residual impacts.....	316
11.8.4	Proposed management approach.....	322
11.8.5	Predicted outcome	323

12. Other environmental factors	325
12.1 Landforms	325
12.1.1 Introduction and EPA objective	325
12.1.2 Relevant guidelines and approvals	325
12.1.3 Existing environment	325
12.1.4 Potential impacts – Proposal and cumulative	327
12.1.5 Mitigation and residual impacts	329
12.1.6 Proposed management approach	329
12.1.7 Predicted outcome	329
12.2 Terrestrial environmental quality	330
12.2.1 Introduction and EPA objective	330
12.2.2 Relevant guidelines and approvals	330
12.2.3 Potential impacts – Proposal and cumulative	330
12.2.4 Mitigation and residual impacts	331
12.2.5 Proposed management approach	331
12.2.6 Predicted outcome	331
12.3 Air quality and atmospheric gases	331
12.3.1 Introduction and EPA objective	331
12.3.2 Relevant guidelines	332
12.3.3 Existing environment	333
12.3.4 Potential impacts	333
12.3.5 Mitigation and residual impacts	335
12.3.6 Proposed management approach	336
12.3.7 Predicted outcome	336
12.4 Amenity	336
12.4.1 Introduction and EPA objective	336
12.4.2 Relevant guidelines	337
12.4.3 Existing environment	337
12.4.4 Potential impacts	338
12.4.5 Mitigation and residual impacts	340
12.4.6 Proposed management measures	340
12.4.7 Predicted outcome	340
12.5 Human health (noise)	340
12.5.1 Introduction and EPA objective	340
12.5.2 Relevant guidelines	341
12.5.3 Existing environment	341
12.5.4 Potential impacts	341
12.5.5 Mitigation and residual impacts	343

12.5.6	Proposed management measures	343
12.5.7	Predicted outcome	343
13.	Conclusion	345
14.	References.....	347
15.	Appendices.....	365

List of Tables

Table 1:	Key characteristics of the Proposal.....	23
Table 2:	Terminology and definitions of areas referred to in this Proposal	24
Table 3:	BHP Billiton Iron Ore current NVCPs.....	30
Table 4:	Recent environmental research projects in Western Australia supported or funded by BHP Billiton Iron Ore.	36
Table 5:	Summary of consultation with stakeholders	43
Table 6:	Land systems present in the Pilbara that are present within the Proposed Mining Area C Development Envelope (descriptions from van Vreeswyk <i>et al.</i> 2004).	50
Table 7:	Legislation, policies and guidance material relevant to this Proposal	64
Table 8:	Consideration of the principles of ecologically sustainable development.....	84
Table 9:	Summary of impact assessment studies undertaken for the Proposal.....	91
Table 10:	Preliminary key and other environmental factors.....	105
Table 11:	Summary of flora and vegetation surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope	115
Table 12:	Vegetation associations recorded in the Proposed Mining Area C Development Envelope (those with local significance are highlighted in grey).....	121
Table 13:	Vegetation condition (based on Keighery, 1994) in the Proposed Mining Area C Development Envelope	129
Table 14:	Conservation significant flora recorded in the Proposed Mining Area C Development Envelope and surrounds (species present in the Proposed Mining Area C Development Envelope are highlighted in grey)	131
Table 15:	Introduced flora species recorded in the Proposed Mining Area C Development Envelope	137
Table 16:	Impact Assessment Areas for flora and vegetation	138
Table 17:	Impact assessment for locally significant vegetation associations in the Proposed Mining Area C Development Envelope (from Onshore Environmental, 2017).....	142
Table 18:	Number of records and number of plants (or estimated % ground cover) for Priority flora taxa occurring in the Proposed Mining Area C Development Envelope, Indicative Additional Impact Assessment Area and Mining Area C Revision 6 EMP Impact Assessment Area	145
Table 19:	Current pre-European extent of vegetation associations that occur in the Proposed Mining Area C Development Envelope (Shepherd <i>et al.</i> , 2002), the area represented in the Proposed Mining Area C Development Envelope, cumulative BHP Billiton Iron Ore disturbance footprint, and cumulative third-party disturbance footprint (percentages are a proportion of the current pre-European extent for each vegetation association).....	151

Table 20: Potential cumulative impact to the ten Priority flora occurring in the Proposed Mining Area C Development Envelope (summarised from BHP Billiton Iron Ore, 2016j)	152
Table 21: Summary of clearing before and after mitigation	154
Table 22: Actions that may be taken to reduce impacts to flora and vegetation	156
Table 23: Key impacts to flora and vegetation previously assessed, proposed changes and cumulative extent in the Proposed Mining Area C Development Envelope	157
Table 24: Summary of Level 2 and targeted surveys undertaken within the Proposed Mining Area C Development Envelope	160
Table 25: Summary of survey effort for terrestrial vertebrate fauna surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope	165
Table 26: SRE fauna and habitat survey effort within the Proposed Mining Area C Development Envelope	165
Table 27: Fauna habitats in the Proposed Mining Area C Development Envelope.....	169
Table 28: SRE habitat zones in the Proposed Mining Area C Development Envelope	174
Table 29 – Impact Assessment Areas for Terrestrial Fauna	179
Table 30: Area of major vertebrate fauna habitats in the Impact Assessment Areas.....	180
Table 31: Area of SRE habitat zones in impact assessment areas.....	180
Table 32: Conservation significant vertebrate fauna species recorded in the Proposed Mining Area C Development Envelope or considered to possibly occur	182
Table 33: Confirmed and potential SRE taxa recorded in the Proposed Mining Area C Development Envelope	188
Table 34: Location of caves in the Proposed Mining Area C Development Envelope and adjacent BHP Billiton Iron Ore tenure	195
Table 35: Actions taken to reduce impacts to terrestrial fauna.....	213
Table 36: Draft Proposed Environmental Management Plan Provisions – Terrestrial Fauna – Ghost Bats	215
Table 37: Draft Proposed Environmental Management Plan Provisions – Terrestrial Fauna – Short Range Endemic Species.....	216
Table 38: Summary of key terrestrial fauna factors for the Proposal	217
Table 39: Summary of troglifauna samples collected in the Proposed Mining Area C Development Envelope and surrounds (Bennelongia, 2016a).	219
Table 40: Summary of stygofauna samples collected in the Groundwater Assessment Area and surrounding catchments (Bennelongia, 2016b)	219
Table 41: Summary of timing of all troglifauna surveys undertaken within the Proposed Mining Area C Development Envelope	220
Table 42: Summary of timing of all stygofauna surveys undertaken within the Mining Area C EMP Revision 6 Groundwater Assessment Area and Groundwater Assessment Area	221
Table 43: Summary of timing of all stygofauna surveys undertaken within Reference Areas.....	222
Table 44: Troglifauna species recorded in the Proposed Mining Area C Development Envelope....	227
Table 45: Stygofauna species recorded in the Groundwater Assessment Area or Mining Area C EMP Revision 6 EMP Groundwater Assessment Area	234
Table 46: Impact Assessment Area for Subterranean Fauna.....	237
Table 47: Key findings from the troglifauna impact assessments	241

Table 48: Summary of information on likely ranges of the five potentially restricted troglofauna species	252
Table 49: Summary of troglofauna species only recorded within Indicative Additional Impact Assessment Areas	262
Table 50: Actions taken to reduce impacts to subterranean fauna.....	263
Table 51: Draft Proposed Environmental Management Plan Provisions – Subterranean Fauna (troglofauna).....	263
Table 52: Summary of key subterranean fauna factors for the Proposal	265
Table 53: Impact assessment areas for hydrological processes	272
Table 54: Summary of groundwater hydrology impacts for the Proposal	277
Table 55: Potential surface water impacts of the Proposal.....	279
Table 56: Actions taken to reduce impacts to hydrological processes	281
Table 57: Draft Proposed Environmental Management Plan Provisions – Hydrological Processes – Coondewanna Flats	285
Table 58: Proposed Environmental Management Plan Provisions – Hydrological Processes – Weeli Wolli Spring	286
Table 59: Impact assessment areas for inland waters environmental quality	290
Table 60: Summary of inland waters environmental quality potential impacts	291
Table 61: Impact assessment areas for Heritage	296
Table 62: Proposed Environmental Management Plan Provisions - Heritage.....	304
Table 63: Existing and proposed areas subject to a Mine Closure Plan	306
Table 64: Impact assessment areas for rehabilitation and decommission factor	306
Table 65: Potential Impacts for Rehabilitation and decommissioning of the Proposal.....	312
Table 66: Actions taken for rehabilitation and decommissioning factor to reduce impacts post-operations	313
Table 67: Impact assessment areas for offsets factor	316
Table 68: Summary of proposed actions to reduce the Proposal residual impacts.....	317
Table 69: Total clearing to which financial offsets will apply.....	322
Table 70: Potential landform impacts from the proposal	329
Table 71: Potential impacts to terrestrial environmental quality	331
Table 72: Viewpoints surveyed in the visual landscape impact assessment	339

List of Figures

Figure 1: Regional overview.....	17
Figure 2: Central Pilbara overview.....	18
Figure 3: BHP Billiton Iron Ore Tenure	19
Figure 4: Development Envelope.....	25
Figure 5: Spatial areas discussed in this PER document	27
Figure 6: Modified footprint	29
Figure 7: Land disturbance within Proposed Mining Area C Development Envelope as at end December 2016	31

Figure 8: Biogeographic region	48
Figure 9: Regional hydrogeology and catchments	52
Figure 10: Public environmental review assessment process	62
Figure 11: BHP Billiton Iron Ore's adaptive management approach	110
Figure 12: BHP Billiton Iron Ore's environmental governance hierarchy.....	111
Figure 13: Location of flora and vegetation survey sites and Level 2 survey boundaries undertaken in the Proposed Mining Area C Development Envelope and surrounds	118
Figure 14: Vegetation associations in the Proposed Mining Area C Development Envelope	125
Figure 15: Vegetation condition within the Proposed Mining Area C Development Envelope	130
Figure 16: Weed affected areas.....	136
Figure 17: Impacts to conservation significant vegetation within the Proposed Mining Area C Development Envelope.....	143
Figure 18: Impacts to conservation significant flora populations within the Proposed Mining Area C Development Envelope.....	146
Figure 19: Impacts to flora and vegetation following mitigation	155
Figure 20: Location of fauna surveys undertaken in the Proposed Mining Area C Development Envelope and surrounds	163
Figure 21: Location of short-range endemic fauna surveys and survey sites undertaken in the Proposed Mining Area C Development Envelope and surrounds.....	167
Figure 22: Vertebrate fauna habitats and key habitat features within the Proposed Mining Area C Development Envelope.....	173
Figure 23: Short-range endemic habitat zones within the Proposed Mining Area C Development Envelope	177
Figure 24: Location of conservation significant vertebrate fauna in the Proposed Mining Area C Development Envelope and surrounds.....	186
Figure 25: Location of SRE invertebrate fauna within the Proposed Mining Area C Development Envelope	190
Figure 26: Location of ghost bat caves in the Proposed Mining Area C Development Envelope and surrounds	194
Figure 27: Inferred extent of habitat for <i>Antichiropus</i> 'DIP007'	202
Figure 28: Cumulative assessment of impacts to ghost bat roosts located in the eastern Hamersley IBRA subregion	209
Figure 29: Impacts to ghost bat caves and <i>Antichiropus</i> 'DIP007' habitat following mitigation.....	211
Figure 30: Location of troglofauna samples collected in the Proposed Mining Area C Development Envelope and surrounds	223
Figure 31: Location of stygofauna samples collected in the Coondewanna and Weeli Wolli sub-catchments.....	224
Figure 32: Troglofauna species potentially restricted to the Indicative Additional Impact Assessment Area and/or the Mining Area C Revision 6 EMP Impact Assessment Area (or species whose range outside is considered uncertain	250
Figure 33: Widespread surrogate troglofauna in the Proposed Mining Area C Development Envelope	251
Figure 34: Stygofauna species potentially restricted to the cumulative Groundwater Assessment Areas	255

Figure 35: Widespread surrogate stygofauna in the Proposed Mining Area C Development Envelope	259
Figure 36: Conceptual groundwater flow within project area.....	270
Figure 37: Combined operations water balance forecast	271
Figure 38: Dewatering and water effecting areas	273
Figure 39: Surface water catchments and flow directions	289
Figure 40: Heritage survey areas, places and approvals	299
Figure 41: Cumulative impacts to Heritage sites within the Central Pilbara	301
Figure 42: Mitigation of impact of Heritage places within the Proposed Mining Area C Development Envelope	302
Figure 43: Land systems located within the Proposed Mining Area C Development Envelope and surrounds	328

List of Appendices

Appendix 1	Authority to Act on Behalf of Joint Ventures	366
Appendix 2	Mining Area C Life of Project Environmental Management Plan Revision 6	367
Appendix 3	Adherence of the Proposal to EPA Requirements and Draft Environmental Management Plan	368
Appendix 4	Flora and Vegetation Environmental Impact Assessment Supporting Documents	369
Appendix 5	Terrestrial Vertebrate Fauna Supporting Documents	370
Appendix 6	Subterranean Fauna Environmental Impact Assessment Supporting Documents.....	371
Appendix 7	Hydrological Impact Assessment Supporting Documents	372
Appendix 8	Heritage Section 18 Approval and draft Culutral Heritage Management Plan	373
Appendix 9	Air Quality Modelling Summary	374
Appendix 10	Visual Impact Assessment	375
Appendix 11	Noise Environmental Impact Assessment	376
Appendix 12	Mining Area C Closure Plan and Acid Mine Drainage Risk Assessment	377
Appendix 13	Offsets Form.....	378

Abbreviations, acronyms and key terminology

Abbreviation, Acronym or Key Terminology	Meaning
%	percent
ACMC	Aboriginal Cultural Material Committee
AER	annual environmental report
AH Act	<i>Aboriginal Heritage Act 1972 (WA)</i>
Air NEPM	Ambient Air Quality National Environment Protection Measure
AMD	acid and metalliferous drainage
ARI	average recurrence interval
BHP Billiton Iron Ore	One of the BHP Billiton businesses
BIF	banded iron formation
BWT	below water table
CAR	Comprehensive, adequate, representative (National Reserve System)
CO ₂ -e	Carbon Dioxide Equivalent
CPWRMP	Central Pilbara Water Resource Management Plan
DAA	Department of Aboriginal Affairs
dB(A)	Decibels (A-weighted), Loudness as perceived by the human ear
DEC	Department of Environment and Conservation (now DPaW)
DER	Department of Environment Regulation
development envelope	'The maximum area within which the disturbance footprint will be located' as per the requirements of <i>Environmental Assessment Guideline 1 for Defining the Key Characteristics of a Proposal</i> (EAG 1) (EPA, 2012a).
DMA	Decision Making Authority
DMP	Department of Mines and Petroleum
DoW	Department of Water
DoTE	Department of the Environment (now Department of Environment and Energy)
DPaW	Department of Parks and Wildlife
EAG	environmental assessment guideline
environmental factor	'An environmental factor is described as the part of the environment that may be impacted by an aspect of the proposal. There are 15 environmental factors which have been selected to be relevant and practical for the EIA process.' (EPA, 2013b)
EIA	environmental impact assessment
EMP	Environmental Management Plan
EMS	environmental management system
EP Act	<i>Environmental Protection Act 1986 (WA)</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</i>
EPA	Environmental Protection Authority
ESD	environmental scoping document
GARD	Global Acid Rock Drainage
GIS	Geographic information systems
GL/a	gigalitre per annum
ha	hectare
H ₂ SO ₄	Sulfuric Acid
Hope Downs 1	Refers to the third party mine operated Hamersley Hope 1 Mine Project located to the east of the Proposed Mining Area C Development Envelope
IBRA	Interim Biogeographic Regionalisation for Australia
ILUA	Indigenous Land Use Agreements
key environmental factor	'A factor is termed a key environmental factor if the EPA considers that there is currently a lack of confidence that the proposal is likely to meet the environmental objective for that factor. Key environmental factors are

Abbreviation, Acronym or Key Terminology	Meaning
	considered through the full assessment process. At the conclusion of its assessment, the EPA reports to the Minister for Environment on the key environmental factors.' (EPA, 2013b)
kL	Kilolitres
kL/d	Kilolitres per day
km	kilometre
km ²	square kilometre
LA ₁₀	is the noise level just exceeded for 10% of the measurement period, A-weighted and calculated by Statistical Analysis
m	metre
mbgl	metre below ground level
mm	millimetres
mm/s	millimetres per second
µm	micrometre
mg/L	milligram per litre
MS	Ministerial Statement
mitigation hierarchy	'There are four steps in the mitigation hierarchy – avoid, minimise, rehabilitate and offset....It is expected that the first three steps of the mitigation hierarchy are to be applied to the greatest extent practicable before determining the residual impact and, if significant, any consideration of an offset.' (Government of Western Australia, 2014)
ML/d	megalitre per day
Mt	million tonnes
Mtpa	million tonnes per annum
NAPP	net acid production potential
NVCP	native vegetation clearing permit
OEPA	Office of the Environmental Protection Authority
OLC	overland conveyor
OSA	overburden storage area
P1, P2, P3, P4	Priority 1, 2, 3 or 4 flora or fauna species, as determined by the Department of Parks and Wildlife and maintained on the Priority flora and fauna list.
PAF	potentially acid-forming
PEAHR	Project Environment and Aboriginal Heritage Review
PEC	Priority Ecological Community
PER	Public Environmental Review
PM ₁₀	Particulate matter with an equivalent aerodynamic equal to or less than 10 µm in diameter.
preliminary key environmental factor	'At the level of assessment stage, the key environmental factors are described as preliminary key environmental factors , as further consideration through the assessment process may either confirm them as key environmental factors, or find that they are no longer key environmental factors as the objective can be met without the need for conditions.' (EPA, 2013b)
Proposal	To develop and operate a new satellite iron ore deposit located immediately south of the existing Mining Area C operation at Southern Flank which will become part of the Mining Area C operations
RIWI Act	<i>Rights in Water and Irrigation Act 1914</i> (WA)
SMUs	soil management units
SRE	Short-range endemic
TAR	Triennial aquifer review
TSP	total suspended particulates
WAIO	Western Australia Iron Ore – represents the same entity as BHP Billiton Iron Ore

Abbreviation, Acronym or Key Terminology	Meaning
WC Act	<i>Wildlife Conservation Act 1950 (WA)</i>
WCED	World Commission on Environment and Development
WMAT	waste material

1. Introduction

1.1 Overview and purpose

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) currently operates an iron ore mining operation at Mining Area C (Northern Flank) under Ministerial Statement (MS) 491, located approximately 100 kilometres (km) northwest of Newman township in the Pilbara region of Western Australia (Figure 1). BHP Billiton Iron Ore is seeking environmental approval under Part IV of the *Environmental Protection Act 1986* (EP Act) to develop and operate a satellite ore body at Southern Flank as part of its Mining Area C operations and to expand the scope of disturbance currently approved at the Mining Area C hub (the Proposal) (Figure 2) under a single ministerial statement and development envelope (Proposed Mining Area C Development Envelope) (Figure 3).

Other BHP Billiton Iron Ore deposits are reaching the end of their economic life, with available ore reserves insufficient to meet current production volume by approximately 2020. Additional ore sources are required to provide sufficient feed to sustain the current level of iron ore production from the BHP Billiton Iron Ore Pilbara mines. The Southern Flank ore body has been identified as one option to sustain current quantities of iron ore.

The Proposal will involve conventional open-pit iron ore mining of the mineralised Marra Mamba Iron Formation. The bulk of this orebody lies above the water table but will require mine dewatering for the ore below the water table in advance to facilitate dry mining conditions.

A Referral Form was submitted for the Proposal in accordance with s38(1) of the EP Act and the Western Australian Environmental Protection Authority's (EPA) *General Guide on Referral of Proposals* (EPA, 2010). The level of assessment was set as a Public Environmental Review (PER) with a 4-week public review period.

The purpose of this PER is to provide information to the public, EPA and other decision making authorities (DMAs) on the Proposal and its potential environmental impacts. The PER will also support the EPA's environmental impact assessment (EIA) of the Proposal. This document provides information regarding the preliminary key environmental factors that were determined in the Environmental Scoping Document (ESD) (EPA, 2016b) and other environmental factors relevant to the Proposal, as well as details of a range of technical studies that have been carried out to address potential impacts for each of the relevant environmental factors.

BHP Billiton Iron Ore has used extensive regional data sets to undertake environmental impact assessments, resulting in a high degree of confidence in the identification of potential environmental impacts. Where residual impacts have been assessed as significant the application of the mitigation hierarchy has resulted in a reduction of potential impacts and the EPA objective being met. Where there is technical or data uncertainty, this has been documented and the precautionary principle applied.

BHP Billiton Iron Ore has comprehensively evaluated the characteristics and potential impacts of this Proposal and considers that, with the proposed management measures, this Proposal meets the EPA objectives.

1.2 The proponent

This Proposal is submitted by BHP Billiton Iron Ore of 125 St. George's Terrace, Perth, Western Australia, acting as manager and agent for the proponent, Mount Goldsworthy Joint Venture.

The Mount Goldsworthy Joint Venture comprises the companies listed below with their respective interests:

- BHP Billiton Minerals Pty Ltd (ABN 93 008 694 782) 85%;
- Mitsui Iron Ore Corporation Pty Ltd (ABN 16 050 157 456) 7%; and
- Itochu Minerals & Energy of Australia Pty (ABN 44 009 256 259) 8%.

BHP Billiton Iron Ore has the authority to act for the Mount Goldsworthy Joint Venture and is authorised as the manager and agent of the proponent to submit this Proposal and execute the works as approved (Appendix 1). All references to BHP Billiton Iron Ore in this PER are references to it acting in that capacity.

1.3 Proposal location and tenure

The Proposal area is located in the Pilbara region of Western Australia (Figure 1) and is located approximately 100 km northwest of the Newman township in the Pilbara region of Western Australia (Figure 2). The Southern Flank ore body is positioned approximately 8 km south of BHP Billiton Iron Ore's Mining Area C Development Envelope (Figure 2). The Proposal area is located primarily on Mineral Lease ML281SA and therefore also subject to the same State Agreement legislation as the current mining operations at Mining Area C (Figure 3).

1.4 The Proposal context

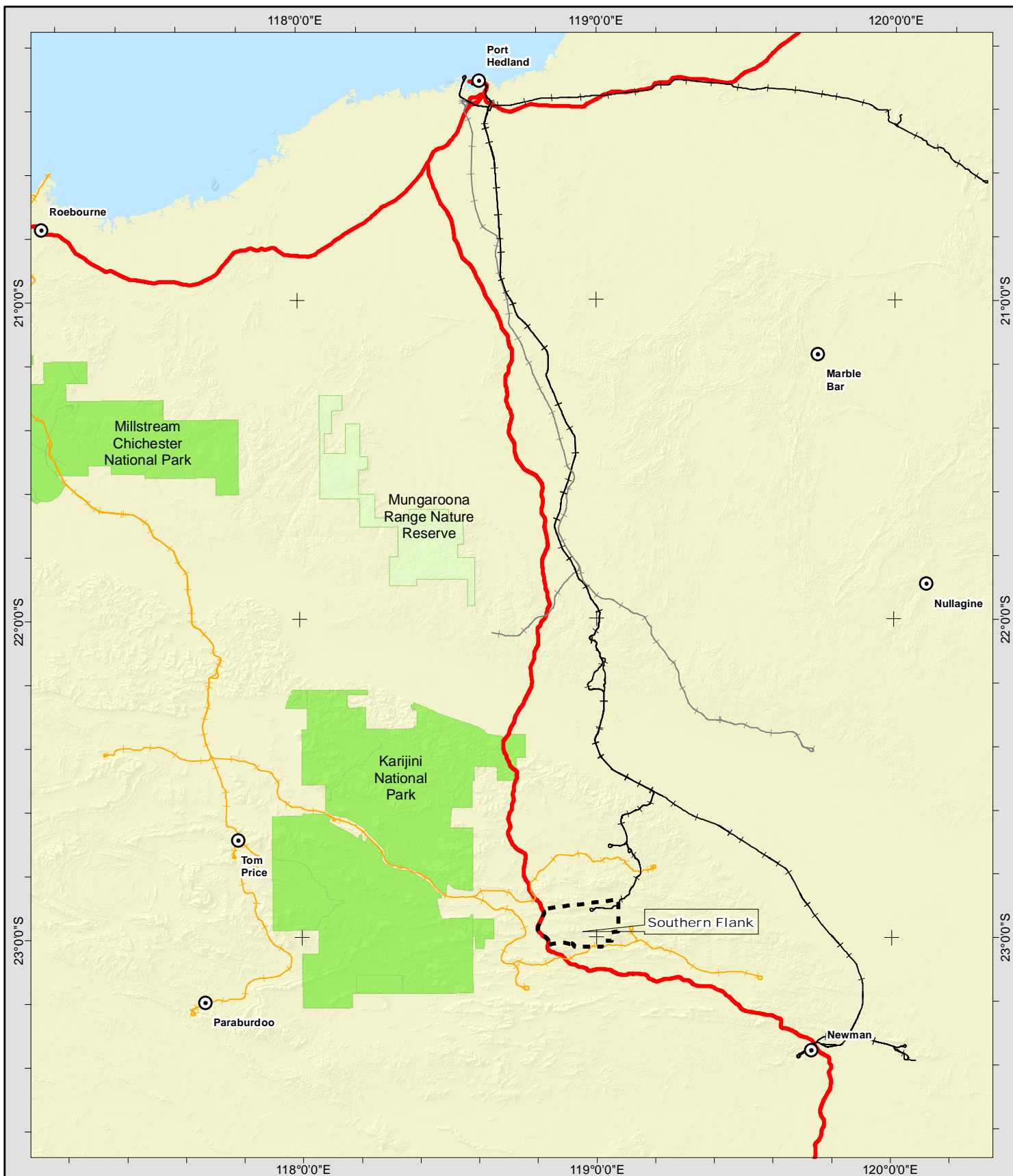
BHP Billiton Iron Ore proposes to extract approximately 80 million tonnes per annum (Mtpa) of iron ore from the Southern Flank orebody, or a total of approximately 150 Mtpa from the Mining Area C operation. The Southern Flank orebody represents an option for long-term replacement of the BHP Billiton Iron Ore Yandi Operations. The Proposal is predominately comprised of above water table mining through conventional open-cut mining methods, however will involve extraction of groundwater in advance of mining to allow campaign mining of iron ore and overburden below the groundwater table.

The existing Mining Area C operation comprises approval for 14 deposits under MS 491. The Southern Flank orebody will form part of the Mining Area C operation and if approved will operate under a new single MS, and MS 491 will be superseded. Therefore, this Proposal is a Revised Proposal.

BHP Billiton Iron Ore is currently seeking approval of a Strategic Proposal in respect to development of new iron ore mines, expansion of existing iron ore mines and associated infrastructure in the Pilbara under the strategic assessment provisions of the Western Australian EP Act and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Southern Flank orebody development was originally included within the scope of the Strategic Proposal being assessed under the EP Act (BHP Billiton Iron Ore, 2016c). To meet Business requirements, BHP Billiton Iron Ore requested under s43A of the EP Act for the exclusion of the Southern Flank deposit from the Strategic Proposal, in February 2016. The EPA consented to this request on 14 March 2016. While the Proposal has been excised from the scope of the Strategic Proposal, impacts of the Proposal are included in the cumulative impact assessment that was undertaken for the Strategic Proposal.

The Southern Flank deposit was not excluded from the scope of the Strategic Proposal being assessed under the EPBC Act (BHP Billiton Iron Ore, 2016d). If the Commonwealth Strategic Proposal is approved, the Proposal will be subject to requirements of the Program endorsed by the Commonwealth Environment Minister and conditions of the class of actions decision. These approvals will regulate potential impacts to Matters of National Environmental Significance.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Regional Overview

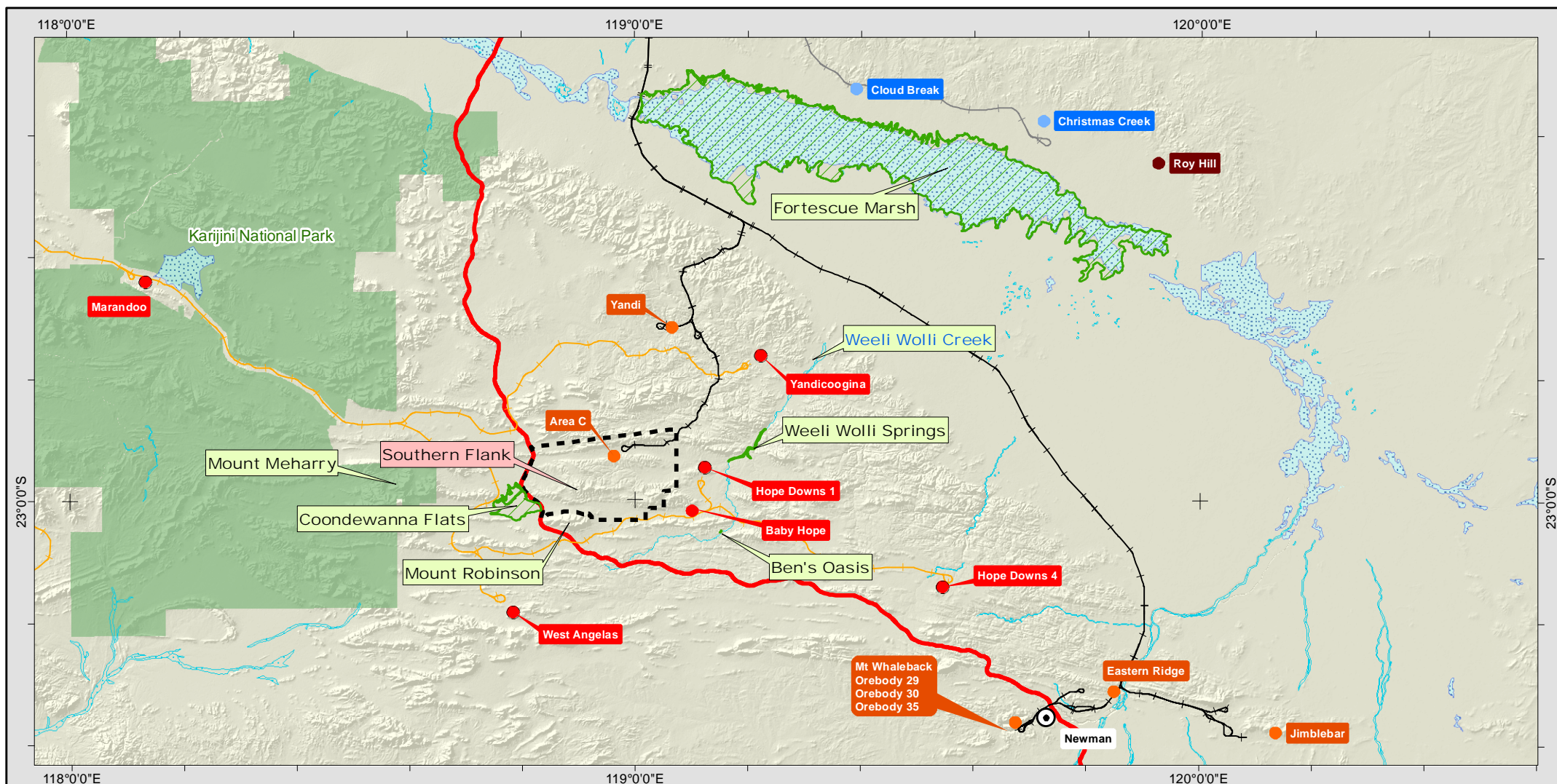
Scale @ A4: 1:1,800,000	Prepared: S. TRINDER	Project No: A780/012 REV B
Date: 1/02/2017	Checked: R. GREGORY	Figure: 1
Revision: REV B	Reviewed: S. WILLIAMSON	

- ⊙ Town
- ▬ Proposed Mining Area C Development Envelope
- BHP Billiton Rail
- FMG Rail
- Rio Tinto Rail
- Highway
- National Park
- Nature Reserve

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 20 40
Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Central Pilbara Overview

Scale @ A4: 1:1,000,000	Prepared: S. TRINDER	Project No: A780/013 REV B
Date: 21/02/2017	Checked: R. GREGORY	Figure: 2
Revision: REV B	Reviewed: S. WILLIAMSON	



Town

Major Active Iron Ore Mines

- BHP Billiton
- Fortescue Metals Group
- Rio Tinto
- Roy Hill Holdings

Environmental Receptors Relevant to Proposal

- ▨ Priority Ecological Community

- Proposed Mining Area C Development Envelope

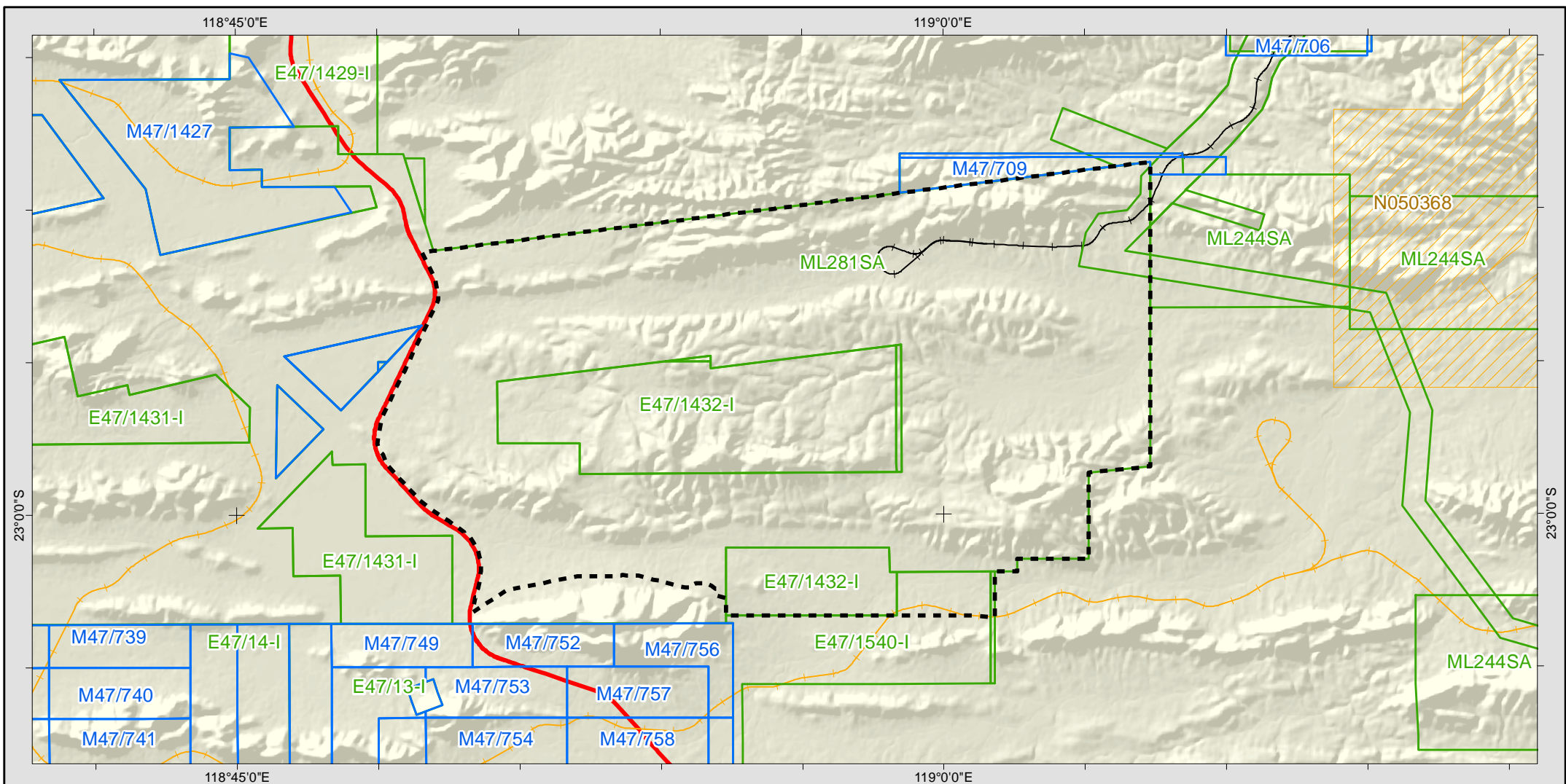
- BHP Billiton Rail
- FMG Rail
- Rio Tinto Rail
- Great Northern Highway
- Watercourse Areas - Non-perennial
- Land Subject To Inundation
- Karijini National Park

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 20 40 60
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK BHP Billiton Iron Ore Tenure

Scale @ A4: 1:200,000	Prepared: S. TRINDER	Project No: A780/014 REV B
Date: 25/01/2017	Checked: R. GREGORY	Figure: 3
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- BHP Billiton Tenement - Application
- BHP Billiton Tenement - Granted
- BHP Billiton Freehold Leasehold Easement
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately map users are required to determine the suitability of use for any particular purpose.



0 5 10
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

As part of Condition 7 and Proponent Commitments 1, 2 and 3 of MS 491, BHP Billiton Iron Ore sought and received acceptance of Environmental Management Plan (EMP) Revision 6 (BHP Billiton Iron Ore, 2015a) in January 2016. The EIA that was undertaken for this EMP revision included a life of mine assessment of all 14 deposits in the Northern Flank that are approved under MS 491 and comprised an indicative impact assessment area of 11,377 ha. The current approved disturbance for the Mining Area C Northern Flank operation under MS 491 is 5,385 ha. The predicted environmental impacts from additional clearing, located in the Mining Area C Development Envelope, are documented in EMP Revision 6 (BHP Billiton Iron Ore, 2015a) and are discussed in Section 11 of this PER document. As the additional clearing may occur anywhere in the 11,377 ha the EIAs have taken a precautionary approach and assessed and reported on the potential impacts for the entire 11,377 ha, not just the additional clearing. This additional clearing forms part of this Proposal.

1.5 Structure of this document

The structure of this document is as follows:

- | | |
|-------------|---|
| Section 1: | Provides an overview of the proponent, the Proposal, its location and land tenure. |
| Section 2: | Provides a description of the Proposal, a summary of the physical and operational elements of the Proposal and existing environmental approvals |
| Section 3: | Provides the justification for the development and gives an overview of alternatives considered. |
| Section 4: | Describes BHP Billiton Iron Ore's consultation approach and consultation undertaken as part of the Proposal. |
| Section 5: | Describes the regional biophysical environment for the Proposal and surrounding areas. |
| Section 6: | Describes the regional social environment for the Proposal and surrounding areas. |
| Section 7: | Describes the process used to undertake the EIA presented in this public environmental review document. |
| Section 8: | Summarises the environmental studies and survey effort undertaken as part of this Proposal. |
| Section 9: | Describes the process used to identify relevant environmental factors. |
| Section 10: | Describes BHP Billiton Iron Ore's environmental management system (EMS) and use of regional management plans. |
| Section 11: | Provides an assessment of each of the preliminary key environmental factors, identifies potential impacts, evaluates the significance of the EPA environmental factors and describes the application of the mitigation hierarchy and proposed management measures in relation to this Proposal. |
| Section 12: | Provides an assessment of each of the other environmental factors, identifies potential impacts, evaluates the significance of the EPA environmental factors, and describes the application of the mitigation hierarchy and proposed management measures in relation to this Proposal |
| Section 13: | Provides the conclusion for this document. |
| Section 14: | Provides a reference list of documents referred to in this Proposal. |

2. Proposal description

The Mining Area C operation was approved in 1998 under Part IV of the EP Act as the Multiple Iron Ore Mine Development Mining Area C Northern Flank via MS 491. A draft Environmental Management Plan (EMP) was attached to the Mining Area C Public Environmental Review, which provided details of the management requirements during construction and operation of the Deposit C and Brockman Detrital deposits. MS 491 provided an ongoing mechanism for the development of the remaining 12 deposits in the Northern Flank of Mining Area C (Proponent Commitment 2), subject to the EMP being reviewed and updated as deposits are developed (Proponent Commitment 3). Since 1998 five updated versions of the EMP have been submitted and endorsed by the Office of the Environmental Protection. EMP Revision 6 undertook a cumulative impact of all 14 deposits originally approved under MS 491 and therefore was indicative of a Life of Project EMP.

The current MS 491 allows for 5,385 ha of clearing anywhere within a nominal area of 11,377 ha and a Development Envelope of 25,053.2 ha. For the purpose of impact assessment, EMP Revision 6 used an indicative impact assessment area of 11,377 ha.

This Proposal seeks an increase in the clearing within the current approved Development Envelope of 5,942 ha and an extension of the Development Envelope by 10,218 ha to the south of the current development envelope to allow for the development of the Southern Flank satellite ore body. Associated with the Southern Flank ore body development is additional clearing of 13,729.2 ha (for a total of 19,761.2 ha additional), this clearing also is part of the Proposal.

2.1 Development overview

The key components of the Proposal are:

- Campaign open-cut mining at the Southern Flank satellite orebody at a nominal base mining rate of 80 Mtpa;
- Primary crushing of ore at the Southern Flank satellite orebody;
- Transportation of ore mined at Southern Flank via overland conveyor to stockpiles and ore handling facilities located at the Mining Area C hub;
- Use of existing and addition of new ore processing facilities, train loadout and associated infrastructure at the Mining Area C hub;
- Dewatering of the orebody aquifers and the preferential use of the water for operational purposes, with an option to manage the surplus volumes via managed aquifer recharge or infiltration basins, as outlined in the proposed Central Pilbara Water Resource Management Plan (CPWRMP) (discussed in Section 11.4);
- Clearing of 19,671.2 ha Native Vegetation. Of this clearing 13,729.2 ha is related to clearing for the development of the satellite Southern Flank orebody and associated infrastructure and 5,942 ha is related to additional clearing for development of the 14 deposits at Mining Area C located in the currently Approved Mining Area C Development Envelope; and
- Extension of overburden storage areas (OSAs) for current Mining Area C operations (OSA 14).

2.1.1 Mining method

The Proposal involves campaign mining of iron ore and overburden through conventional open-cut mining methods. Campaign mining involves drilling, blasting, and categorisation of blasted material into iron ore or waste rock.

2.1.2 Ore processing and transport

The Proposal will be supported by expanded infrastructure and facilities at the existing Mining Area C hub up to a nominal combined processing rate of 150 Mtpa of blended ore. Primary crushing will occur at Southern Flank, and an overland conveyor will be used to transport crushed ore to the Mining Area C hub.

Approximately 1,850 million tonnes (Mt) of iron ore is estimated to be mined over the life of the Proposal.

Access to some of the orebodies in the Southern Flank development will require mine dewatering ahead of mining to facilitate dry mining conditions. Ore will be railed to Port Hedland via the BHP Billiton Iron Ore main line.

2.1.3 Overburden management

Overburden will be stockpiled in approved OSAs. Where possible, overburden will be progressively placed back into the pit void to minimise required clearing and to assist in achieving closure objectives at the Southern Flank orebody. Topsoil, where safely stripped prior to mining activity occurring, will first be removed and placed into stockpile areas for later use in rehabilitation. The likelihood of encountering small volumes of potentially acid-forming (PAF) material is low given the lithologies underlying the Southern Flank footprint (i.e. Mount McRae Shale). Technical studies to assess the likelihood of encountering PAF and a broader assessment of acid and metalliferous drainage (AMD) risk have been carried out. This is further explained in Section 11.5.

2.1.4 Mine dewatering, water use and disposal of surplus water

The Proposal will require in-pit and ex-pit mine dewatering (i.e. groundwater abstraction) to facilitate dry mining conditions. Groundwater abstraction (i.e. dewatering volumes and monitoring) is regulated by the Department of Water (DoW) licensing (5C licence) and groundwater operating strategies under the *Rights in Water and Irrigation Act 1914* (RIWI Act).

During operations, the abstracted water will be used preferentially to supply the Proposal's water requirements. Surplus water not used at the Proposal's mining operations will be managed in accordance with the CPWRMP. This Plan will include the following hierarchy of management options:

- reused on-site in mining operations;
- transferred to other nearby operations for use onsite; or
- returned to the aquifer via managed aquifer recharge at Camp Hill or Juna Downs or via infiltration basins.

In relation to the hierarchy of preferred options stated above, it is important to note that managed aquifer recharge into the dolomite formations and orebodies has been shown to be a suitable option for the management of surplus water. The overall strategy is further explained in Section 11.4.

2.2 Key characteristics of the Proposal

Environmental Assessment Guideline 1 for Defining the Key Characteristics of a Proposal (Environmental Assessment Guideline (EAG) 1 (EPA, 2012a)) provides guidance on the Key Proposal Characteristics. In accordance with the guidance provided in EAG 1, BHP Billiton Iron Ore has developed key characteristics for the Proposal (Table 1).

Table 1: Key characteristics of the Proposal

Summary of the Proposal

Proposal Title	Mining Area C Southern Flank
Proponent Name	BHP Billiton Iron Ore Pty Ltd on behalf of the Mount Goldsworthy Joint Venture
Short Description	The Proposal is to revise the existing Mining Area C operations, approximately 100 km northwest of Newman in the Shire of East Pilbara. The scope of the Proposal is to develop and operate an open-cut mine on a satellite orebody located at Southern Flank, with construction of an overland conveyor from the Southern Flank orebody to infrastructure at the Mining Area C hub and to increase the disturbance at the existing Mining Area C hub. The scope includes exploration activity, as well as the construction and operation of associated infrastructure.

Physical Elements

Element	Location	Current Approval (MS 491)	Proposed Change	Proposed Extent Authorised
Native Vegetation Clearing	Additional Development Envelope. Proposed Mining Area C Development Envelope (Proposed Extent). Refer Figure 4.	Clearing of 5,385 ha anywhere within a nominal impact assessment area of 11,377 ha and a Development Envelope of 25,815 ha.	An increase in the Proposed Mining Area C Development Envelope by 10,218 ha. The Proposal represents 19,671.2 ha of additional clearing, of which 5,942 ha is within the Mining Area C EMP Revision 6 Impact Assessment Area.	Clearing no more than 25,053.2 ha within a 36,032 ha Proposed Mining Area C Development Envelope.

Operational Elements

Element	Location	Current Approval	Proposed Change	Proposed Extent Authorised
Dewatering	Dewatering will occur within the Proposed Mining Area C Development Envelope as shown in Figure 4.	RIWI licence allows for abstraction of up to 15.3 gigalitres per annum (GL/a) of groundwater.	Up to an additional 22 GL/a of groundwater abstraction (peak).	Dewatering from the Mining Area C hub mine will be undertaken in accordance with licencing under the RIWI Act. at a nominal maximum volume of 37 GL/a.
Surplus water management	Surplus water will be re-used within the Proposed Mining Area C Development Envelope. Managed aquifer recharge systems or infiltration basins will be located within or in the vicinity of the Proposed Mining Area C Development Envelope.	EP Act Part V approval for Managed Aquifer Recharge of 5.84 GL/a.	Management in accordance with the CPWRMP.	Management in accordance with the CPWRMP.

2.3 Development of the mining operation

BHP Billiton Iron Ore proposes to commence mining at Southern Flank in approximately 2020, subject to market conditions and all relevant government approvals. According to the proposed mine plan, dewatering for those areas where mining is below the water table is expected to commence a number of years (approximately up to 5 years) following assessment and approval of this Proposal.

2.4 Development envelope

In accordance with EAG 1 (EPA, 2012a), a 'development envelope' has been defined for this Proposal and is illustrated in Figure 4. This is the area in which BHP Billiton Iron Ore is seeking approval to implement the Proposal.

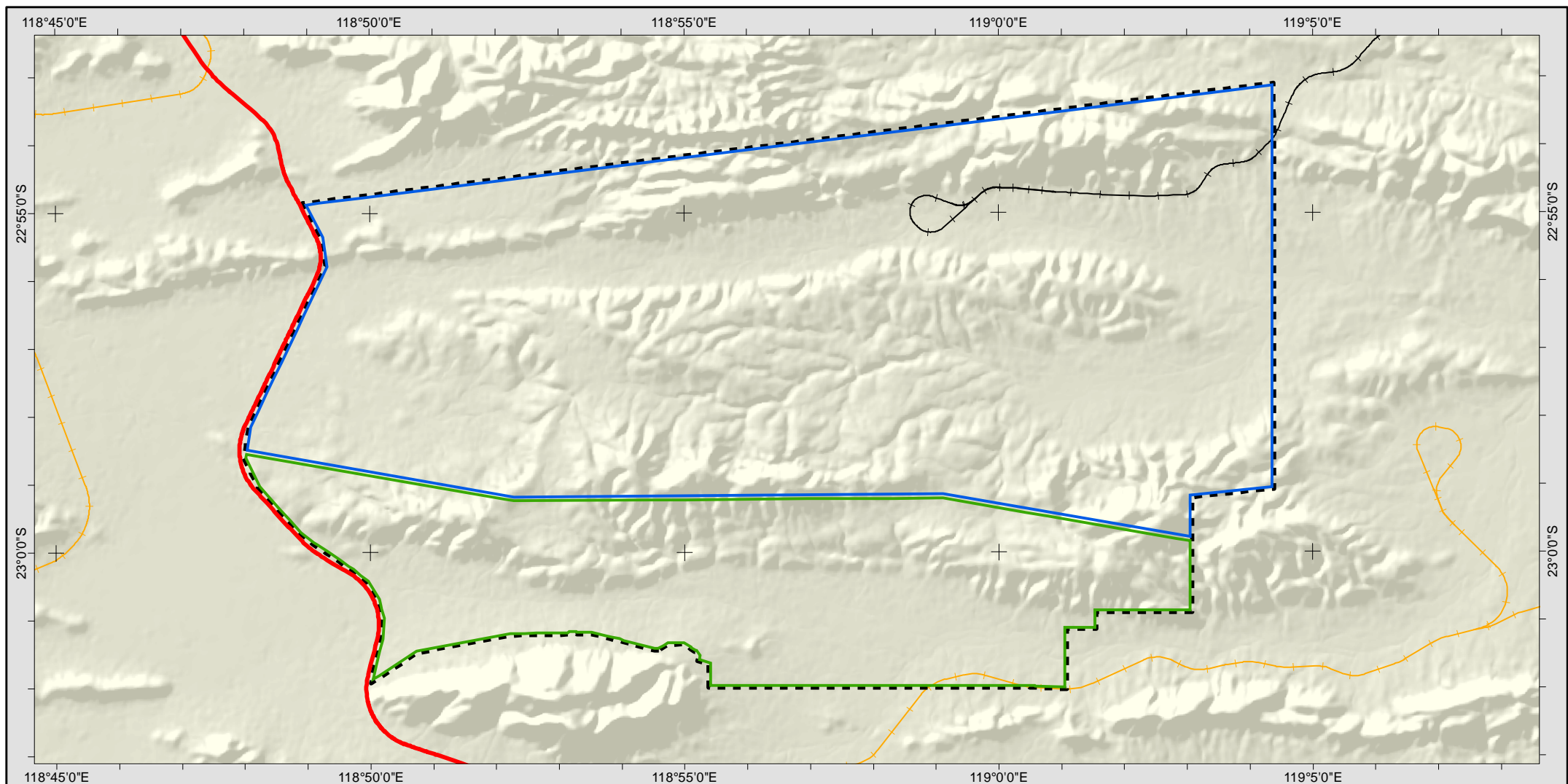
Figure 5a illustrates and Table 2 defines the current Approved Development Envelope (Approved Mining Area C Northern Flank Development Envelope) It also shows the areas that has been assessed in accordance with an indicative footprint, based on current mine plan and design. The Groundwater Assessment Area, and its relativity to the Development Envelope is shown in Figure 5b.

Table 2: Terminology and definitions of areas referred to in this Proposal

Area	Definition
Proposed Mining Area C Development Envelope	This spatial area is the proposed development envelope for the Mining Area C hub. It consists of the addition of the Approved Mining Area C (Northern Flank) Development Envelope and the Additional Development Envelope and will constitute the boundary of the new MS if approved.
Approved Mining Area C (Northern Flank) Development Envelope	This spatial area is the boundary currently approved as the development envelope under MS 491.
Mining Area C EMP Revision 6 Impact Assessment Area ¹	This is the spatial area that was used for EIAs for the development of EMP Revision 6 in January 2016 in line with Condition 7 of MS 491.
Additional Development Envelope	This spatial area is the additional development envelope to that currently approved under MS 491.
Indicative Additional Impact Assessment Area	This is the indicative spatial area based on the mine plan and design at the time of submission and is used as an assessment tool for the flora and vegetation, terrestrial fauna and subterranean fauna (troglofauna) factors.
Mining Area C EMP Revision 6 Groundwater Assessment Area ²	This spatial area represents the 2 m drawdown contour as assessed for impact under EMP Revision 6.
Groundwater Assessment Area	This spatial area represents the additional area that has a predicted drawdown of 2 m or more as a result of this Proposal. This area is used as an EIA tool for the hydrological processes, inland environmental water quality and subterranean fauna (stygofauna) factors.
Modified Indicative Additional Impact Assessment Area	This is the Indicative Additional Impact Assessment Area following application of the 'avoid' element of the mitigation hierarchy.

¹ In supporting environmental impact assessments undertaken for this Proposal this area is called the Approved Impact Assessment Area.

² In supporting EIAs and modelling report this area is referred to as the Approved Groundwater Assessment Area.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Development Envelope

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/015 REV B
Date: 1/02/2017	Checked: R. GREGORY	Figure: 4
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C
- Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail



0 2 4
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

The Indicative Additional Impact Assessment Area is used for the purposes of the impact assessments undertaken by BHP Billiton Iron Ore and presented in this PER. It is an assessment tool that has been developed based on the mine plan and design at the time of submission. As the mine plan and design may evolve over time, implementation of the Proposal may result in different areas of actual disturbance within the Proposed Mining Area C Development Envelope. It is anticipated that any changes would be minor.

In light of this, a conservative approach has been taken for assessing the impacts of the Proposal. The footprint adopted in the Indicative Additional Impact Assessment Area includes a buffer and represents a credible 'worst-case' implementation scenario. This assessment approach provides future flexibility for the location of mine components within the Proposed Mining Area C Development Envelope while also ensuring full extent of environmental impacts have been identified and assessed.

The 'mitigation hierarchy' was applied to the footprint in the Indicative Additional Impact Assessment Area to determine the residual impacts. This involved modifications to the indicative footprint to avoid some of the potential impacts, in particular to avoid impacts to known ghost bat (*Macroderma gigas*) roosts and identified prospective troglodfauna habitat. The resultant indicative modified footprint is shown in Figure 6. The predicted impacts were then reviewed and determined that the residual impacts of the modified credible worst-case implementation scenario can be managed.

While the Indicative Additional Impact Assessment Area and Modified Indicative Additional Impact Assessment Area are assessment tools only, BHP Billiton Iron Ore will, where practicable, align Proposal disturbance with the areas shown as the Modified Indicative Additional Indicative Impact Assessment Area shown in Figure 6.

2.5 Existing approvals

2.5.1 State Agreement Act

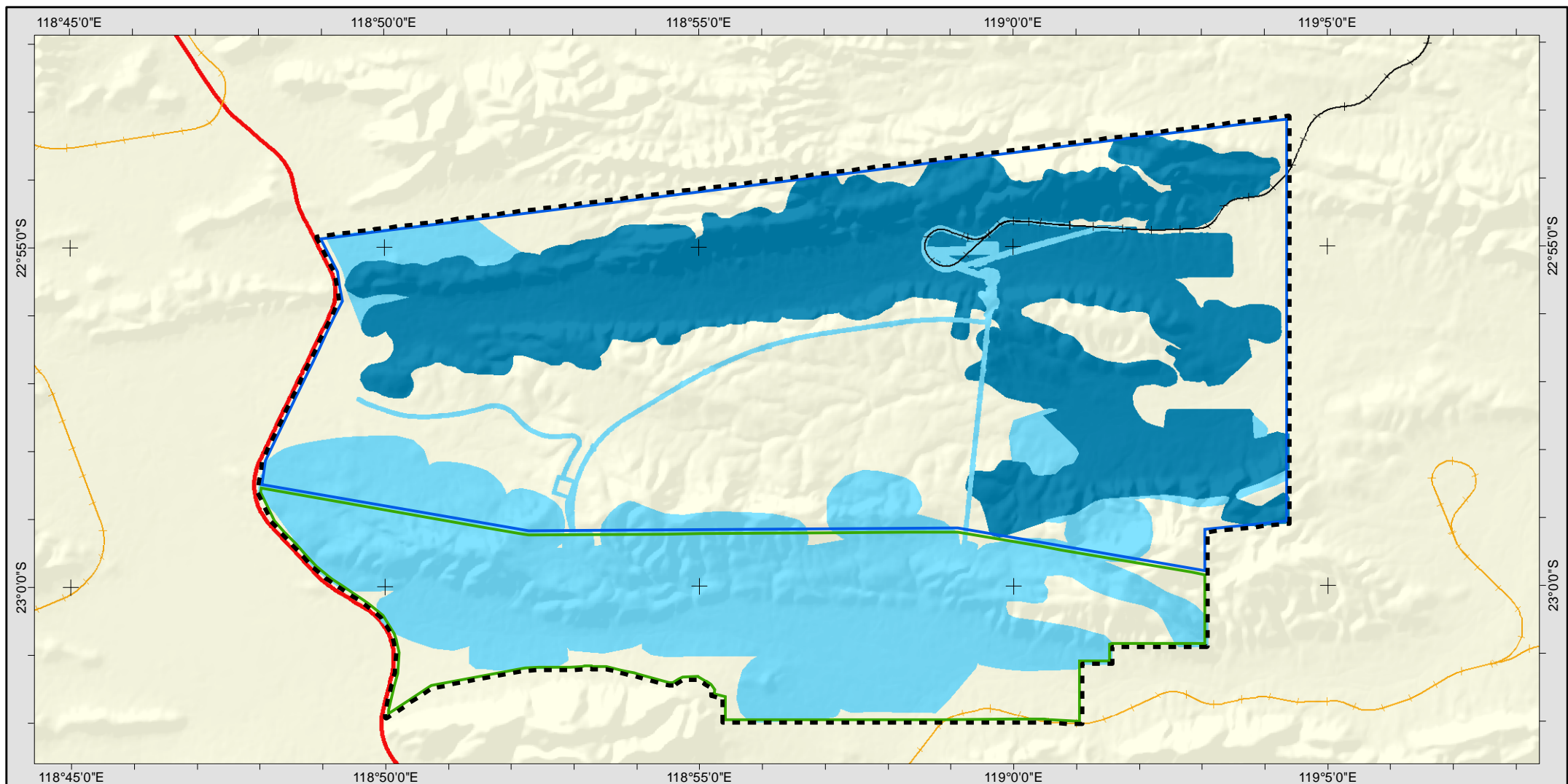
The Proposal is located on land that is held pursuant to the *Iron Ore (Mount Goldsworthy) Agreement Act 1964*. Mining Area C has been the subject of multiple approved proposals under this Agreement since 2002.

2.5.2 Other operations within the area

BHP Billiton Iron Ore currently operates a number of iron ore mines and associated rail and port infrastructure within the Pilbara region of Western Australia (Figure 1 and Figure 2). Current BHP Billiton Iron Ore mining operations in proximity to the Proposal include:

- Yandi, located northeast of the Proposal; and
- Newman Joint Venture hub, located approximately 90 km southwest of the Proposal, which consists of Mount Whaleback, Eastern Ridge and Orebodies 29, 30 and 35.

Hope Downs Management Services Pty Ltd also operates within the Northern Flank Valley (North and South Deposits) with the approved Hope Downs 1 mining operation located immediately adjacent to the eastern boundary of the current approved Mining Area C operation and the approved Baby Hope operation located immediately to the southeast. Other mining operations in the broader area include West Angelas and Yandicoogina.



BHP BILLITON IRON ORE

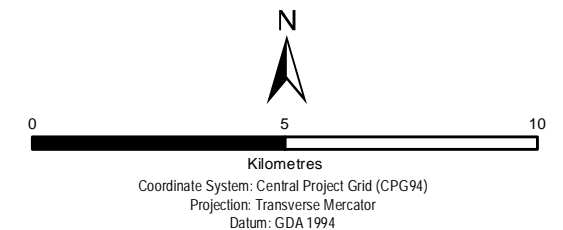
MINING AREA C - SOUTHERN FLANK

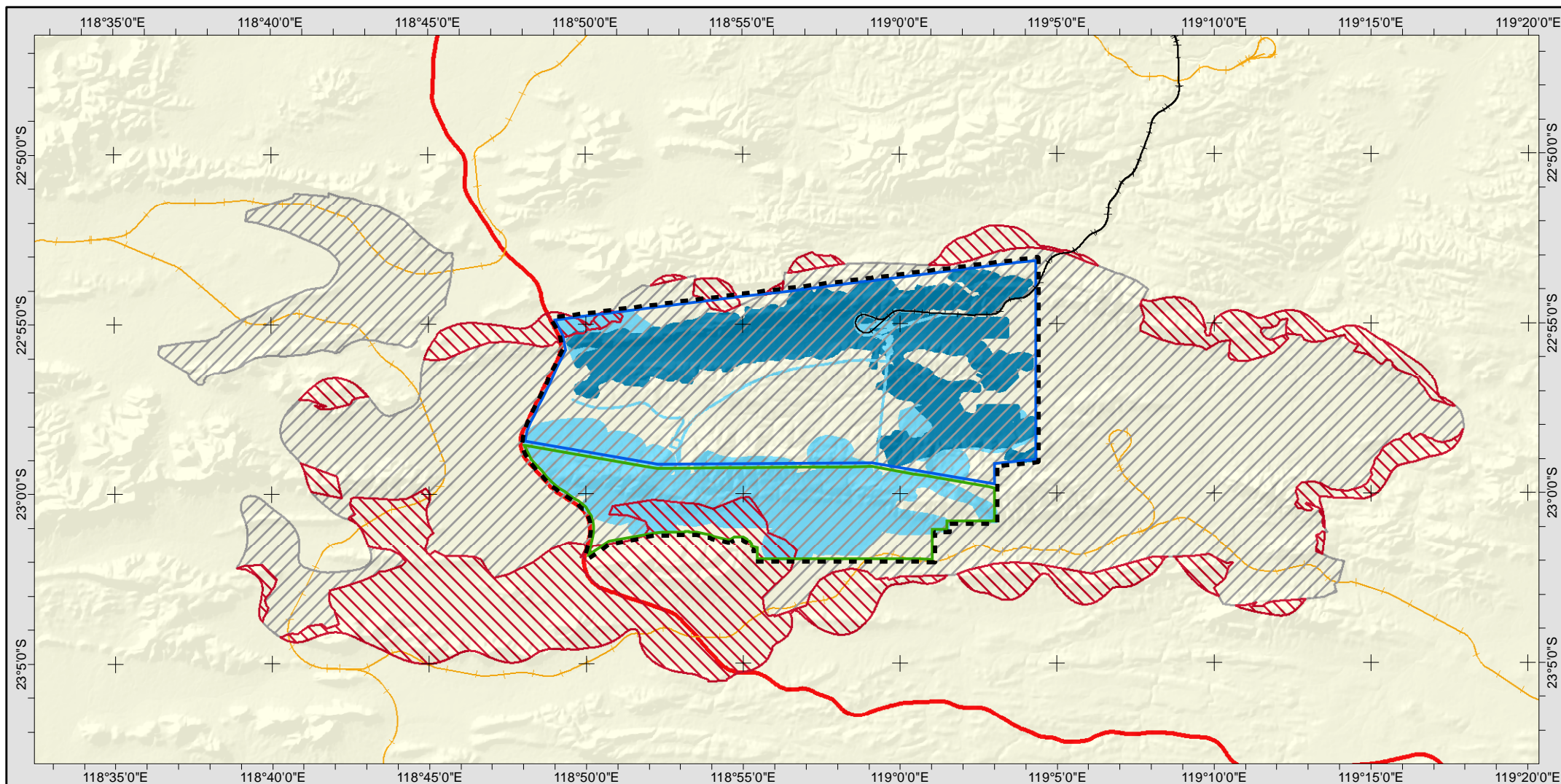
Spatial Areas Discussed in this PER

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/016 REV B
Date: 13/02/2017	Checked: R. GREGORY	Figure: 5a
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately map users are required to determine the suitability of use for any particular purpose.





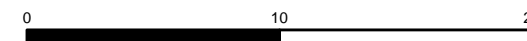
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Groundwater Assessment Area

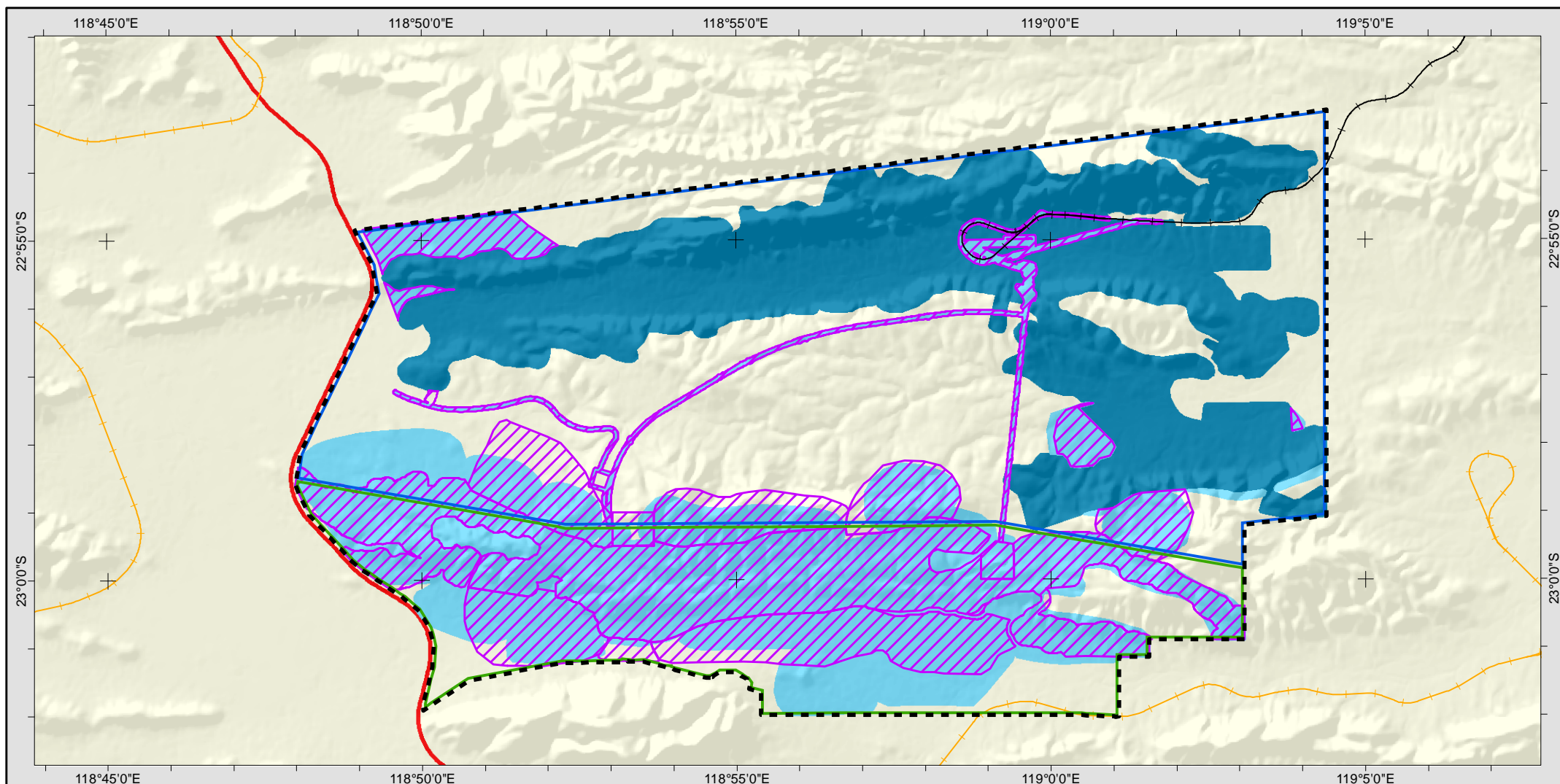
Scale @ A4: 1:300,000	Prepared: S. TRINDER	Project No: A780/017 REV B
Date: 25/01/2017	Checked: R. GREGORY	Figure: 5b
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Groundwater Assessment Area
- Mining Area C EMP Rev 6 Groundwater Assessment Area
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Modified Footprint

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/018 REV B
Date: 13/02/2017	Checked: R. GREGORY	Figure: 6
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Modified Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 2.5 5
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

2.5.3 Environmental Protection Act 1986 Part IV approvals

In 1998, BHP Billiton Iron Ore received approval under Part IV of the EP Act for the Multiple Iron Ore Mine Development Mining Area C Northern Flank via MS 491. BHP Billiton Iron Ore prepared a draft EMP, which was appended to the PER (Woodward-Clyde, 1997). The initial draft EMP was prepared in accordance with PER Proponent Commitment 1 and provided details of the management requirements during construction and operation of the C and Brockman Detrital deposits, the Mining Area C ore handling facilities, train loadout facility and associated mine services and infrastructure. The EMP was finalised in 2003 prior to the commencement of operations at Mining Area C. MS 491 provides an ongoing mechanism for the development of the remaining 12 deposits (Proponent Commitment 2), subject to the EMP being reviewed and updated as deposits are developed (Proponent Commitment 3). The current MS 491 allows for clearing of up to 5,385 ha anywhere within an area of 11,377 ha, of which 4,792 ha have been cleared as of 31 December 2016 (Figure 7).

Following approval of this Proposal, a new MS will be issued that will cover the existing Mining Area C Northern Flank operations and the proposed Southern Flank satellite orebody operations, and MS 491 will be superseded. The Proposal accommodates additional clearing within the Mining Area C Development Envelope assessed in line with Proponent Commitments 2 and 3 under MS 491 and accepted as part of EMP Revision 6 by the Office of the Environmental Protection Authority (OEPA).

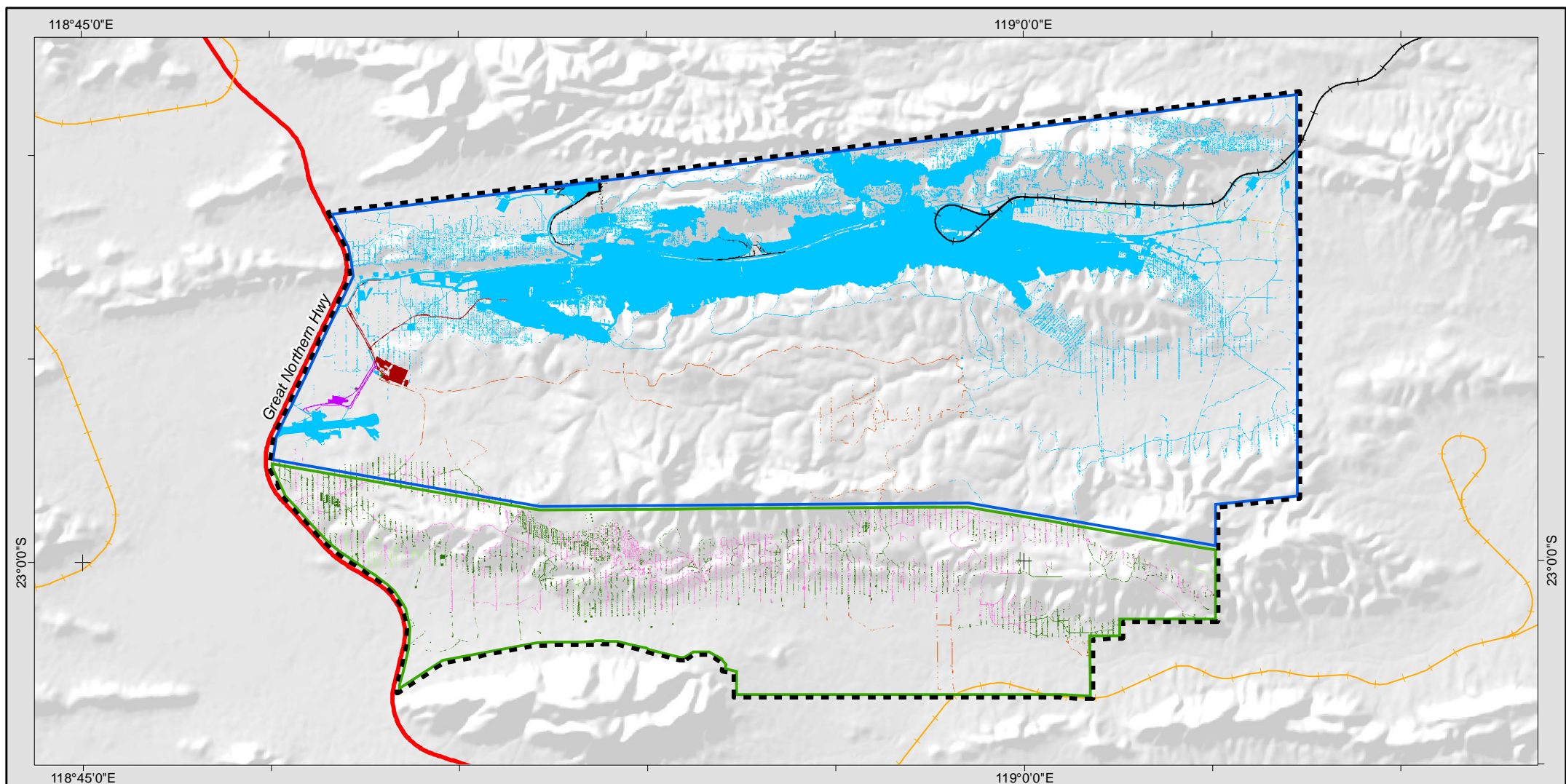
2.5.4 Environmental Protection Act 1986 Part V approvals

2.5.4.1 Native vegetation clearing permits

Under Part V of the EP Act, BHP Billiton Iron Ore currently holds three active native vegetation clearing permits (NVCPs) over parts of the Proposed Mining Area C Development Envelope for mineral exploration and production and associated activities (Table 3). The permits have been issued by the Department of Mines and Petroleum (DMP).

Table 3: BHP Billiton Iron Ore current NVCPs

Permit number	Purpose	Area of clearing approved (ha)	Total amount cleared to Dec 2016 (ha)	Area remaining (ha)	Expiry date
CPS 4337/1 Mulla Mulla camp	Mine camp and associated infrastructure.	70	50	20	31 July 2017
CPS 7139/1 Central Pilbara West Exploration Strategic Permit	Rehabilitation, geotechnical investigations, access tracks, mineral exploration, hydrogeological drilling, water bores and association activities.	1,000	4	996	30 November 2026
CPS 4630/2	Southern Flank Exploration.	280	280	0	Surrendered; superseded by CPS 7139/1
CPS 2295/1	Mineral Exploration Southern Flank.	305	238	NA	Expired
CPS 4831/3 Mining Area C Warehouse	Mineral production and associated infrastructure.	38	21	17	10 March 2017
	Total	1693	593	1033	



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Land Disturbance within Proposed Mining Area C Development Envelope as at the end of Dec 2016

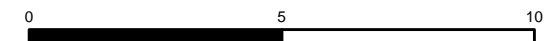
Scale @ A4: 1:150,000	Prepared: J. ROBERTS	Project No: A780/019 REVC
Date: 6/02/2017	Checked: R. GREGORY	Figure: 7
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Disturbance Footprint by Approval

- Clearing under Exemption - (31 ha)
- Ministerial Statement, 491 - (4792 ha)
- NVCP, 2295 - (238 ha)
- NVCP, 4337 - (50 ha)
- NVCP, 4630 - (281 ha)
- NVCP, 4831 - (21 ha)
- NVCP, 5105 - (2 ha)
- Mining Act - (45 ha)
- State Agreement (22 ha)

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organization consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Exploration activities in the Proposed Mining Area C Development Envelope are currently being carried out and were reported on in the 2016 *Annual Environmental Report* (AER) (BHP Billiton Iron Ore, 2016e). In accordance with Part V Division 2 of the EP Act, BHP Billiton Iron Ore has obtained NVCPs, where necessary, from the DMP for exploration works.

A requirement of an approved NVCP is to report back to the DMP annually for the life of each permit. Further details of the conditions and reporting requirements of these NVCPs can be found in the 2016 AER (BHP Billiton Iron Ore, 2016e). Clearing undertaken to date under the permits as outlined in Table 3 is shown in Figure 7.

2.5.4.2 Licence to Operate

BHP Billiton Iron Ore currently holds a Licence to Operate for the current approved Mining Area C operations, namely Mining Area C Operations: L7851/2002/6.

BHP Billiton Iron Ore has consulted with the Department of Environment Regulation (DER) regarding this Proposal. A licence amendment will be sought for all activities that trigger a prescribed premises requirement under Schedule 1 of the Environmental Protection Regulations 1987, if or when this Proposal is approved under Part IV of the EP Act.

The current approved Mining Area C operation has environmental reporting and statutory requirements in accordance with BHP Billiton Iron Ore's Licence to Operate, issued by the DER under Part V of the EP Act. As required, BHP Billiton Iron Ore reports annually on key environmental parameters for its mining operations in its AER. The report includes reporting requirements, such as exploration and mining activities, overburden management, land disturbance, topsoil management, rehabilitation activities and monitoring, surface water and groundwater quality, air quality monitoring and particulate matter management, native flora and weed management, and native fauna and introduced species. For more information on these environmental parameters, please refer to the 2016 BHP Billiton Iron Ore AER (BHP Billiton Iron Ore, 2016e).

2.5.5 Rights in Water and Irrigation Act 1914

The Proposal will involve conventional open-pit iron ore mining activities below the water table and will require mine dewatering ahead of mining below the water table to facilitate dry mining conditions.

BHP Billiton Iron Ore holds several 5C licences for dewatering or water abstraction that support the current approved Mining Area C operations:

- GWL110044(9): licences dewatering for mining operations; and
- GWL178477 (1) and GWL174613 (1): licence abstraction from potable borefields west of current mining operations.

Groundwater has been monitored and reported in annual and triennial aquifer review reports since 2001. The current groundwater well licence permits the annual abstraction within the Approved Mining Area C Development Envelope of 15,330,000 kilolitres (kL). This dewatering is carried out in accordance with the Groundwater Operating Strategy for Mining Area C (BHP Billiton Iron Ore, 2015b). The licensed activities include dewatering, dust suppression, mine processes, construction and potable water supply.

BHP Billiton Iron Ore's triennial aquifer review (TAR) for the current Mining Area C operations (BHP Billiton Iron Ore, 2016f) provides a history of groundwater monitoring in adjacent areas. The TAR also includes an analysis of groundwater levels and water quality trends.

BHP Billiton Iron Ore's TAR for Mining Area C (BHP Billiton Iron Ore, 2016f) has reported that:

- Groundwater levels upgradient of Coondewanna Flats (an environmental receptor) continue to respond to regional rainfall events, and no changes from dewatering at Mining Area C have been observed at the receptor.
- Water levels downgradient of Weeli Wolli Spring (an environmental receptor) are dominated by dewatering stresses from Hope Downs, and no changes from dewatering at Mining Area C have been observed at the receptor.
- Abstraction at the Mining Area C borefield did not result in adverse impacts to groundwater quality during the review period.
- During the financial year 2016, the total groundwater abstracted was 52% of the approved allocation.
- The abstracted water is weakly acidic to weakly alkaline with pH ranging from 6.8 to 8.7.

For the Proposal, additional groundwater abstraction (i.e. dewatering volumes and monitoring) will be managed by DoW licensing (5C licence) and a groundwater operating strategy under the RIWI Act and implemented in accordance with the proposed CPWRMP. BHP Billiton Iron Ore has consulted with the DoW regarding the proposed strategy and management plan.

Page intentionally blank

3. Development justification and alternatives considered

This section outlines the rationale for and benefits of the Proposal and summarises the alternatives considered. The intent of this section is to provide an overview of the alternative locations, plans and designs that have been considered by BHP Billiton Iron Ore during development of the Proposal and how these have been optimised to minimise environmental impacts resulting from the Proposal. This is in line with Clauses 5 and 10.2.4 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012*.

3.1 Proposal rationale and benefits

The demand for iron ore makes mining a vital component of the State and national economy. In 2015, despite a sharp decline in commodity prices, the value of the Western Australian mineral and petroleum industry reached just over \$91 billion (DMP, 2016a). Iron ore is the State's most valuable sector of the mining industry, accounting for approximately \$50 billion (70%) of the total mineral sales in 2015. Almost 741 Mt of iron ore were exported during 2015, representing an increase of 8% from 2014 (DMP, 2016a).

As of March 2016, Western Australia had an estimated \$94 billion worth of resource projects under construction or in the committed stage of development, with a further \$44 billion identified as being allocated to planned or possible projects in coming years (DMP, 2016a). This Proposal sustains approximately 10% of Western Australians iron ore current exports and therefore will provide significant revenues and contribute to ongoing construction activities that are planned for the State.

The Proposal will sustain mining output for BHP Billiton Iron Ore as existing deposits are depleted as the current level of production at the existing BHP Billiton Iron Ore mining operations in the Pilbara region cannot be sustained. It is expected that the life of the Mining Area C mining operation, inclusive of Northern and Southern Flanks, will be approximately 30 years, commencing in approximately 2020.

If implemented, the Proposal will result in economic and community benefits for both Australia, Western Australia and the Pilbara region by:

- providing royalties and taxation payments from the sale of iron ore products;
- contributing to the value of mineral exports;
- delivering capital investment;
- continuing direct and indirect employment opportunities in the Pilbara region;
- continuing demand for goods and services and thereby supporting the Pilbara regional economy; and
- contributing to the sustainability of the Pilbara iron ore industry.

The Proposal is located adjacent to the existing Mining Area C operation and wherever possible will make use of the existing or upgraded ore processing facilities, non-processing infrastructure, utilities, rail facilities, infrastructure, communications, roads, camps and other assets. This will vastly reduce the disturbance footprint and the amount of new infrastructure that would have otherwise been necessary for a project of this volume and scale, especially when compared to a new greenfield development.

New employment will be created during the mine construction phase of the Proposal, and the operating life of existing mining operations and rail infrastructure in the Pilbara region will be extended. This will maintain the overall operational workforce within the Pilbara.

The Banjima and Nyiyaparli people (the Traditional Owners) will continue to benefit under the terms of the respective Indigenous Land Use Agreements (ILUAs) across the area. These ILUAs aim to deliver economic and social benefits to the Indigenous stakeholders.

BHP Billiton Iron Ore is committed to providing employment opportunities to local Indigenous peoples through a number of pathways including traineeships on the job or through a relevant registered training organisation, apprenticeships, graduate roles and general recruitment

In addition, the ongoing mining activities of BHP Billiton Iron Ore in the Pilbara region will continue to support existing social and economic development projects, as well as contribute to future projects.

The above aspects make the Proposal a highly desirable option, for the benefit of both the Pilbara iron ore industry and the wider community.

BHP Billiton Iron Ore is also an industry leader in providing research advancements in the study of Pilbara species distribution and attributes. BHP Billiton Iron Ore contributes to the scientific community and the Pilbara environment through support and funding of research projects and other environmental initiatives. A number of these endeavours are listed in Table 4. Further research into species that are present in the Proposal area (e.g. ghost bats and troglodfauna) will be undertaken as part of this ongoing research work.

Table 4: Recent environmental research projects in Western Australia supported or funded by BHP Billiton Iron Ore.

Environmental Initiative	Outcome
Rehabilitation	
Pilbara Seed Atlas	Climate-controlled seed store on site.
Restoration Seed Bank	Significant improvement to seed management practices, resulting in a step change in revegetation of rehabilitated areas.
Pilbara Restoration Initiative	
Pilbara Rehabilitation Group	
Ecohydrology	
Coondewanna Flats ecohydrology study	Determination of groundwater-dependent ecosystem requirements.
Wetland values of eastern Pilbara	Identification and evaluation of ecohydrological assets and their ecological linkages.
Dynamics of woody vegetation and water in the central Pilbara	Improved understanding of biogeochemistry of floodplain and riparian landscapes, dynamics of water and tree populations in riparian woodlands, and woody scrub encroachment, fire and climate.
Ecological responses of native fish to extreme flow variability in arid Australia	Understanding of the impact of altered water flows on native fish in arid Australia.
Regional habitat mapping and modelling	
Regional vegetation and habitat mapping	Standardisation of environmental studies approach.

Environmental Initiative		Outcome
Ecological community–level modelling	Conservation significant species habitat modelling	Production of a consolidated vegetation and habitat map for all BHP Billiton Iron Ore tenements.
Conservation significant species habitat modelling		Modelled approach to identifying biodiversity values of the Pilbara.
Troglofauna habitat modelling		
Terrestrial fauna		
Pilbara leaf-nosed bat genetic research	Genetic mapping of threatened species for population linkages.	
Ghost bat ecology	Genetic studies, hormone analysis, diet analysis, regional surveys.	
Northern quoll ecology	Study on northern quoll ecology and demography, including analysis of influence of previously disturbed areas on species.	
Airlie Island skink regional survey	Survey of Pilbara coastline between Onslow and Derby to determine additional locations of this species and map suitable habitat.	
Pilbara olive python genetic study	Analysis of Pilbara olive python populations to determine if any genetic substructuring is present.	
Habitat fragmentation study	Study to determine the impacts of linear infrastructure on vertebrate fauna and the use of culverts to mitigate these impacts.	
Taxonomy		
WAMinals	Making invertebrate taxonomic information more robust and available to the public through the Western Australian Museum.	
Western Australian Herbarium	Improved taxonomic key for flora of the Pilbara, including increased collection of voucher specimens.	
Western Australian Museum	Improved taxonomic key for invertebrate fauna of the Pilbara, including increased collection of voucher specimens.	
Pilbara mygalomorph genetic study	Analysis of all available mygalomorph taxa within the Pilbara to determine genetic lineages.	
Idiopid taxonomic review	Taxonomic review of West Australian idiopid spiders.	

3.2 Evaluation of alternatives

BHP Billiton Iron Ore undertakes an iterative planning and design process whereby initially a number of broad alternatives are assessed and as the project planning matures the design, location and mine plans become more detailed. During this iterative process, BHP Billiton Iron Ore retains a focus on reducing the environmental impacts of its activities as far as it is reasonably practicable.

As part of the planning and design process for this Proposal, a number of broad alternatives with respect to location, plans and designs were assessed prior to referral of the Proposal. These included development of:

- iron ore resources able to be transported to the existing Yandi ore processing facilities; and
- new deposits with associated processing facilities and connections to the existing rail network.

After strategic consideration of these alternatives the development of a satellite orebody in the vicinity of Mining Area C was selected as the preferred investment alternative by BHP Billiton Iron Ore. These decisions are determined via the alternative option phase of the project whereby various alternatives are evaluated against one another to ensure the most optimal alternatives are progressed through the project. Whilst the decision to proceed with the Proposal is reflective of many variables, key amongst them are resource ore characteristics that can support high production rates, favourable product offering, low strip ratio, low processing intensity and above the water table position of many of the planned pits. This alternative was referred to the OEPA in May 2016.

Following the BHP Billiton Iron Ore decision of the preferred investment alternative, the internal project evaluation process further integrates environmental considerations into BHP Billiton Iron Ore's investment decision-making to ensure that potential impacts to the environment are minimised. This is completed through the value optimisation phase of the project where various design alternatives are traded off against one another to ensure the most optimal design, with respect to the triple bottom line, are progressed through the project. Major benefits include the reduction of the disturbance footprint through the use of existing fixed infrastructure located at Mining Area C and the consideration of environmental factors, such as ecology, dust and noise generation, through advanced engineering design. Specific alternatives that have been evaluated as part of the value optimisation phase are discussed below. Further optimisation of the design and mine plan will continue prior to execution of the project. Any optimisation will continue to focus on minimisation of environmental impacts.

3.2.1 Evaluation of crusher and ore transport alternatives

Through the project evaluation, two overland conveyer (OLC) alternatives were considered these were either 'single-flight series' or a 'Dual-flight parallel' OLC arrangement. The key differentiating factors that influenced the decision, were the:

- increased operability through reduced interaction with mining operations thus improving safety;
- lower production risk due to reduced concentration of production throughput; and
- lower interaction with planned OSAs.

Optimisation of the final design incorporated factors such as, but not limited to minimisation of environmental and heritage impacts, safety, maintainability, initial capital cost and future operating costs.

Consideration during planning and design of crushers, ore handling infrastructure and transport, was made of the following.

Dust. The location of crushers, ore handling infrastructure and conveyors was chosen in consideration of the location of key receptors at the accommodation camps to minimise impacts of dust emissions to these receptors. Various dust emissions control technologies were reviewed for inclusion into the engineering design, to assist in minimisation of emissions and hence reduction in impacts.

Power Consumption. Through the assessment of various ore transportation alternatives and routes, reduced power consumption became a key driver in the final decision on the selected OLC route. A reduction in power consumption ultimately reduces greenhouse gas emissions.

Consumable Use. Through the assessment of various ore transportation alternatives and routes, reduced consumable use became a key driver in the final decision on the selected OLC route. For example, this included the conveyor belts utilised in the OLC. Ultimately, this results in lower amounts of landfill and use of materials.

The optimisation of crusher and transport locations and designs have resulted in a reduction in potential dust emissions, landfill volumes and greenhouse gas emissions.

3.2.2 Use of existing fixed infrastructure at Mining Area C

Where possible, existing fixed infrastructure at Mining Area C will be used, in part, to reduce the environmental disturbance footprint of the Southern Flank operations and avoid duplication of infrastructure.

3.2.3 Evaluation of waste rock disposal alternatives

The mine plan has been modified, where practical to allow waste to be progressive in-filled during the life of the Southern Flank mine, rather than being stored in out of pit OSAs. This will minimise the footprint needed for OSAs and reduce the quantity of native vegetation required for the Proposal. The location of the OSAs was modified to reduce the potential visual and amenity impacts to Great Northern Highway users. Further information on these potential impacts is provided in Section 12.4. The use of progressive infill and movement of OSAs have resulted in potential vegetation disturbance, amenity and visual impacts being reduced.

3.2.4 Evaluation of option not to conduct the Proposal

The Proposal will sustain the current level of BHP Billiton Iron Ore's production in the Pilbara as the Southern Flank production volume will replace existing deposits as they become depleted. If the Proposal were not to proceed, the State would forego substantial economic benefits, including the:

- loss of social, economic and employment opportunities in the Pilbara and in the State;
- loss in value of Western Australia's and Australia's raw materials exports;
- loss of royalty revenue to the Western Australian Government;
- non-utilisation of viable iron ore deposits at Southern Flank; and
- decline in production from BHP Billiton Iron Ore Pilbara mining operations.

Not proceeding will also result in the premature reduction of the existing workforce at the Yandi operations, as well as a loss of support to the Pilbara community and infrastructure.

If the Proposal does not proceed, the world's demand for iron ore will ultimately be met through the development of iron ore deposits elsewhere, which may have more potential for environmental impacts than this Proposal. Potentially, these alternative deposits could be located overseas, which will result in the loss of benefits to the Pilbara, the State and Australia.

Page intentionally blank

4. Consultation

4.1 Key stakeholders

BHP Billiton's commitment to community engagement is articulated in the Company's *Code of Business Conduct* (BHP Billiton, 2016a), which states:

Our ability to build relationships and work collaboratively and transparently with our host communities is critical to our long term success. BHP Billiton aims to be valued and respected by the communities in which we operate.

To support this commitment, BHP Billiton Iron Ore has comprehensive Company standards and dedicated resources to ensure its activities are underpinned by continuous community engagement and feedback.

BHP Billiton Iron Ore undertakes regular and ongoing stakeholder engagement as part of its core business activities. BHP Billiton's Our Requirements³ Community sets out the Company's approved mandatory and minimum performance requirements for community engagement (BHP Billiton, 2016b). BHP Billiton aims to facilitate regular, open and honest dialogue to understand expectations, concerns and interests of stakeholders and to incorporate them into business planning to help build strong, mutually beneficial relationships.

Based on an analysis of the Proposal location, affected land users, and potential impacts and risks, BHP Billiton Iron Ore has identified the following key stakeholders who have, will continue to be, or will be engaged as part of this Proposal:

Western Australian Government Departments

Office of Environmental Protection Authority (OEPA)
Department of Parks and Wildlife (DPaW)
Department of Water (DoW)
Department of Mines and Petroleum (DMP)
Department of Environment Regulation (DER)
Department of State Development
Department of Aboriginal Affairs (DAA)
Shire of East Pilbara

Traditional Owners and Community

Newman Community Consultative Group
Banjima Implementation Committee and Environment Subcommittee
Nyiyaparli Implementation Committee and Environment Subcommittee

Other stakeholders (e.g. Department of Regional Development) will be engaged as part of the public submission process that forms part of the PER process (see Section 7) or specifically if requested.

³ BHP Billiton Our Requirements documents set out minimum company standards, processes and procedures that must be met across the globe.

The objective of the stakeholder engagement for this Proposal is to:

- confirm the approval process for the development of the Proposal with relevant government agencies and local authorities;
- provide information and an opportunity to comment for groups or individuals who may potentially be interested in the development of the Proposal;
- periodically provide updated information and results of the environmental assessment and planning process to stakeholders as more information becomes available; and
- where practicable, allow for adjustments to the design or management of the Proposal to accommodate the concerns or issues raised by stakeholders during the consultation process.

4.2 Stakeholder comments and proponent responses

Table 5 outlines the consultation that has been undertaken to date in relation to this Proposal. The table documents broad-level comments raised by stakeholders and provides BHP Billiton Iron Ore's response to these comments.

4.3 Ongoing consultation

BHP Billiton Iron Ore will continue to engage relevant stakeholders as the Proposal and the EIA process progress to ensure that all concerns have been addressed. BHP Billiton Iron Ore, as part of the PER process, will provide a Supplementary Report that provides a response to public submissions provided to BHP Billiton Iron Ore by the OEPA.

Table 5: Summary of consultation with stakeholders

Stakeholder	Consultation Details	Topics/Issues Discussed	Proponent Response
State Agencies			
OEPA	3 March 2016 – Overview of Southern Flank Project given, including discussion on approvals pathway, preliminary key factors, schedule and consultation plan.	Outcome was that OEPA supports referral of revised Mining Area C and inclusion of extra disturbance at Mining Area C into one PER process.	BHP Billiton Iron Ore referred the project as a Revised Proposal to the Mining Area C ministerial approval.
	13 May 2016 – Discussion on referral and scoping document.	OEPA to review and provide comments on draft referral document.	OEPA comments addressed in referral document. BHP Billiton Iron Ore reviewed and provided comments on the draft ESD.
	5 September 2016 – Discussion on preliminary outcomes from EIAs.	Outcomes from impact assessments for preliminary key factors were presented and discussed.	Agreement for OEPA to attend detailed session on ghost bat impact assessment with DPaW.
DPaW	23 March 2016 – Overview of Southern Flank Project given, including discussion on approvals pathway, preliminary key factors, schedule and consultation plan with a focus on biological factors.	Recommended BHP Billiton Iron Ore confirm public availability of information pertaining to Ben's Oasis and with the EPA for any information on the chocolate wattled bat.	Subsequent EIA demonstrated that the current Proposal predicts no impacts different from those assessed in EMP Revision 6 at Weeli Wolli Spring and Ben's Oasis and therefore no specific biological EIAs were required for the Priority Ecological Community (PEC).
	23 May 2016 – Outcomes of EIAs for flora and vegetation, terrestrial fauna and subterranean fauna presented. Detailed discussion on preliminary results from ghost bat studies.	Advised that assessment of impacts to flora populations required. DPaW advised that any conclusions relating to the ghost bat should be based on sound scientific evidence. Where outcomes are not certain, BHP Billiton Iron Ore should provide assumptions and limitations and, if required, detail any further work that will be undertaken. If artificial roosts are proposed, the current roost should be used as a demonstration of this mitigating option. Request for early engagement on ghost bat work and outcomes, given short duration of public review period. Ensure ecological basis for use of 2 m drawdown contour for stygofauna is clear.	BHP Billiton Iron Ore committed to a peer review of ghost bat studies and further early engagement regarding the outcomes of these studies.

Stakeholder	Consultation Details	Topics/Issues Discussed	Proponent Response
	23 September 2016 – Detailed discussion held regarding ghost bat work undertaken to date, key findings and proposed management measures.	Population estimation based on DNA. Short-term and long-term management measures. Ability and ease of direct cave location and monitoring. Artificial roosts.	Detailed information of ghost bat sampling and impact assessment, including peer review evaluation to be included within PER and Appendices.
DoW	20 April 2016 – Overview of Southern Flank Project given.	Due to the advanced and different approach to groundwater modelling, a third-party review of the modelling work was suggested.	An independent review of the groundwater modelling work has been commissioned and will be included in the PER document.
	20 June 2016 – Detailed discussion on approach to numerical groundwater modelling was held.	DoW requested a formal review of the final model documents early in the submission process. DoW is comfortable that the modelling approach is an appropriate tool for the purposes of predicting impacts of the Proposal, given the range of uncertainty in the early stages of the project.	Modelling and detailed technical reports will be made available to DoW early in the process.
DER	19 September 2016 – Overview of the project, work undertaken and findings to date were presented.	Scope and spatial characteristics of the Proposal. Overview provided on hydrological, air quality and amenity aspects of the Proposal.	DER requested that BHP Billiton Iron Ore provide an approvals strategy, including timing for the Part V process related to this project. DER requested clarification of the water surplus from the Proposal.
DAA	Meetings have been ongoing and will continue to be so prior to submission. DAA has agreed to the process and timeframes proposed by BHP Billiton Iron Ore.	Timeframes, number and significance of potential sites, process to ensure timely and accurate assessment by the DAA and the Aboriginal Cultural Material Committee.	BHP Billiton Iron Ore has committed to ongoing consultation with the DAA. BHP Billiton Iron Ore will submit the relevant site cards on a weekly basis. BHP Billiton Iron Ore will keep Banjima people involved pre-submission.
Other			
Banjima Implementation Committee	May 26 2016 – Overview of project scope and key elements provided to implementation committee.	Items raised by implementation committee were provision for more closure information, keen to understand approach to and outcomes of cumulative impacts, and request that Weeli Wolli Creek and Coondewanna Flats impacts are assessed.	BHP Billiton Iron Ore committed to providing further information on closure and water impact assessment approach and outcomes.
Banjima Environment Subcommittee Meeting	14 September 2016 – Discussions were held on process for input to the PER, and an overview of key matters of interest was presented.	Project scope and key environmental issues were discussed (e.g. water, closure, and subterranean fauna). Overview of	BHP Billiton Iron Ore committed to supply draft PER to the group and offered additional briefings prior to public submissions period.

Stakeholder	Consultation Details	Topics/Issues Discussed	Proponent Response
		process and timing for the PER was outlined and discussed.	
Niyiyaparli Environment Subcommittee	7 September 2016 – Discussions were held on process for input to PER, and overview of key matters of interest was presented.	Project scope and key environmental issues were discussed (e.g. water, closure subterranean fauna). Overview of process and timing for the PER was outlined and discussed.	BHP Billiton Iron Ore committed to supply draft PER to the group and offered additional briefings prior to public submissions period.
Banjima people	27-29 September 2016 – Field visit to Southern Flank heritage sites with six Banjima elders and archaeologist.	Description of Southern Flank proposal given on site, results of ethnographic and archaeological surveys and potential impacts of Proposal were discussed. Discussion specifically with regard to the upcoming s18 application.	Banjima people requested avoidance of sites where possible that archaeological material from sites to be salvaged in accordance with best practise prior to disturbance, stone arrangements to be recorded and stored for return to site at closure. Banjima expressed no objection to s18 application for disturbance of ethnographic and archaeological sites. BHP Billiton committed to where practical and safe to fulfil requests made by Banjima people.
Newman Community Consultative Group	November 2016 – Overview of Southern Flank Proposal.	Overview of Proposal information presented, including timing, location and general description of Proposal, area of environmental study and consultation mechanisms for Proposal.	Ongoing consultation regarding Proposal to occur.

Page intentionally blank

5. Regional biophysical environment

BHP Billiton Iron Ore has been operating in the Pilbara region since the late 1960s. The environmental baseline and monitoring data acquired during this time offer an excellent foundation in assessing the potential environmental factors and impacts for new proposals. The available existing environmental knowledge and its relevance to this Proposal is described below.

5.1 Biogeographic region

The Proposal is situated in the Pilbara bioregion as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell, 1995). The Pilbara bioregion is divided into four subregions; the Proposal lies in the Hamersley subregion. The Hamersley subregion (Figure 8) forms the southern section of the Pilbara Craton (Kendrick, 2001). This subregion is characterised by mountainous areas of Proterozoic sedimentary ranges and plateaux, dissected by gorges. The vegetation of the subregion is dominated by *Eucalyptus leucophloia* over *Triodia* hummock grassland on skeletal soils atop mountains and slopes, while swathes of mulga woodland occur over hard and soft grasses on fine-textured soils of the plains and valleys (Kendrick, 2001).

Approximately 50 km north of the Proposal area is the Fortescue Marsh, which is listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001) and is a proposed Ramsar site (DEC, 2009). It is also listed as a PEC by DPaW.

5.2 Regional climate

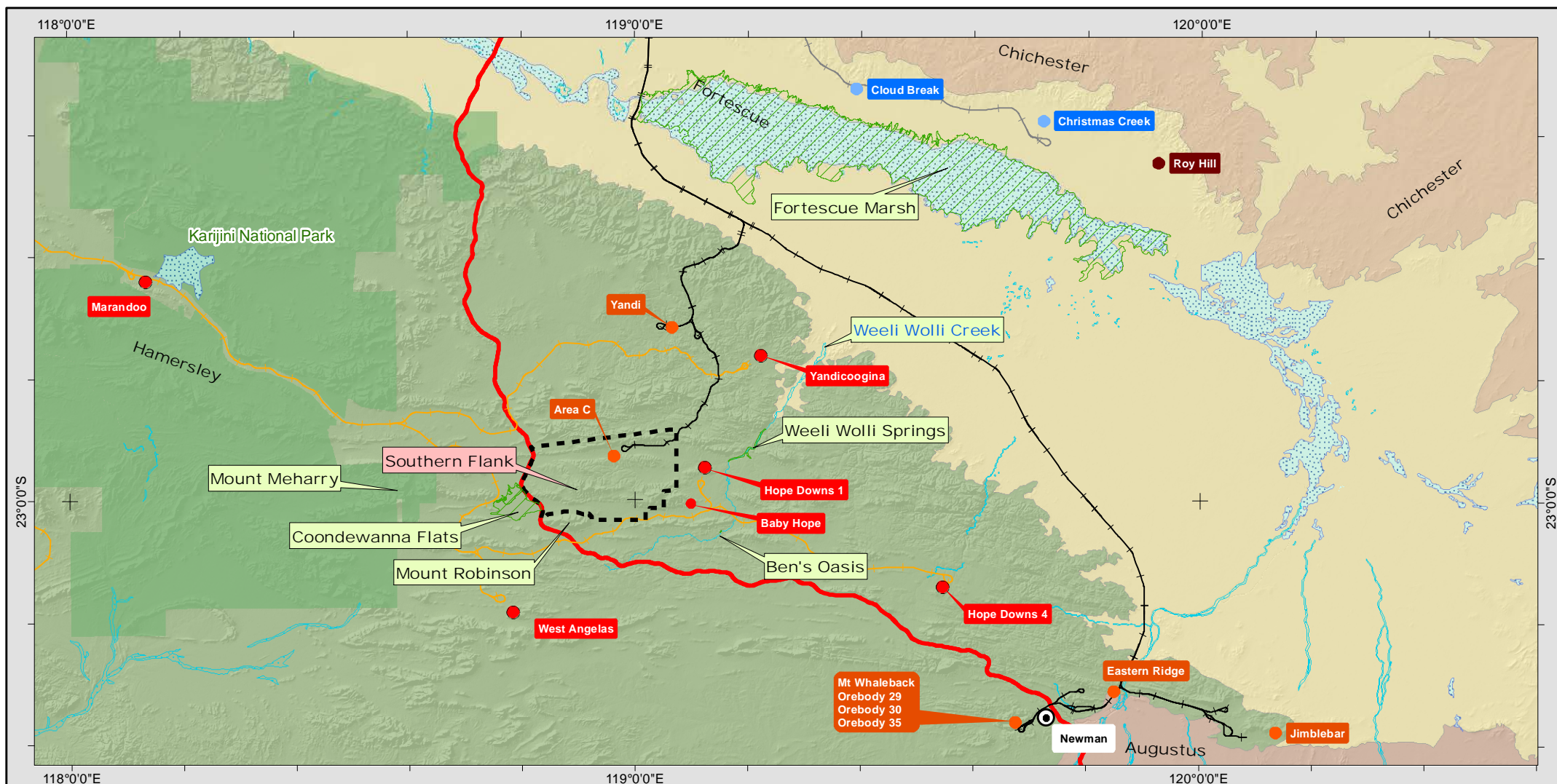
The Pilbara bioregion is characterised by a semi-arid climate resulting from the influence of tropical maritime and continental air masses and receives primarily summer rainfall. Cyclones can occur during summer, bringing heavy rain and potentially destructive winds to coastal and inland towns. The general seasonal characteristics of this region are hot summers with periodic, heavy rains and mild winters with occasional rainfalls.

Regional temperatures are warmest from October to April, with average monthly maximum temperatures exceeding 30°C during this period. Temperatures are coolest from May to September, with average monthly minimum temperatures below 15°C. The average daily maximum temperature in January is approximately 36°C, while the average daily minimum temperature in July is as low as 13.8°C.

The Pilbara region has a highly variable rainfall, which is dominated by the occurrence of tropical cyclones mainly during the period January to March. The tropical storms from the north bring sporadic and drenching thunder storms. With the exception of these very large events, rainfall can be erratic and localised due to thunderstorm activity. Therefore, rainfall from a single site may not be representative of the spatial variability of rainfall over an entire catchment during an event.

The total annual average rainfall is approximately 310 millimetres (mm) at Newman. The majority of rainfall occurs between December and March, peaking in February, with an average of approximately 81 mm. September and October exhibit the driest conditions, with an average rainfall below 4 mm.

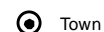
The Wittenoom Bureau of Meteorology station is located approximately 190 km northwest of Newman and is the closest station that records evaporation. Annual average evaporation for Wittenoom is 3,142 mm per year, which exceeds annual rainfall by greater than 2,500 mm per year.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Biogeographic Region

Scale @ A4: 1:1,000,000	Prepared: S. TRINDER	Project No: A780/020 REV B
Date: 21/02/2017	Checked: R. GREGORY	Figure: 8
Revision: Rev B	Reviewed: S. WILLIAMSON	



Town

Major Active Iron Ore Mines

- BHP Billiton
- Fortescue Metals Group
- Rio Tinto
- Roy Hill Holdings
- BHP Billiton Rail
- FMG Rail
- Rio Tinto Rail

Environmental Receptors Relevant to Proposal

- ▨ Priority Ecological Community



Proposed Mining Area C Development Envelope

— Great Northern Highway

▨ Watercourse Area - Non-perennial

▨ Land Subject To Inundation

▨ Karijini National Park

IBRA V6.1 Sub Region

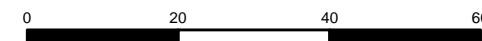
▨ Augustus

▨ Chichester

▨ Fortescue

▨ Hamersley

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

5.3 Regional topography

The main physiographic units in the area are the Hamersley Plateau and the Fortescue Valley (Beard, 1975). Prominent topographic features in the region are Mount Robinson (1,142 m), the Governor (1,051 m) and Mount Meharry (1,250 m).

The Proposed Mining Area C Development Envelope is located in the central Hamersley Range, which, together with the Ophthalmia Range, comprises the majority of the Hamersley Plateau. The Hamersley Plateau is composed of rugged hill country characterised by long strike ridges and hills rising over 300 m above the surrounding plains. The surfaces of these ridges are largely covered with skeletal soils with areas of exposed rock.

The ranges in the Proposal area contain gorges and ridges typical of the region, with gorges approximately 40 m deep, 300 m in width and ranging from 250 m to 1,500 m in length. The ridges are flanked by the Northern Flank valley in the north, the Blackwater valley through the centre and the Southern Flank valley in the south. Outwash plains are gently undulating with overlying alluvial and colluvium soils. The ranges in the northern area (Packsaddle Range) feature of the Brockman Iron Formation and contains a number of deposits, including the Brockman Detrital Deposit. South of the Northern Flank valley is the Jirrapalpur Range and the Southern Flank, which are part of the Marra Mamba Iron Formation and topographically lower than the Packsaddle Range. The Marra Mamba Iron Formation also forms ridges to the southwest of Mining Area C, including the, Alligator, Boundary and Parallel ridges. Similarly, the Brockman Iron Formation extends into the western section of Mining Area C, where it forms the western extension to the Packsaddle Range and the Wildflower Range, as well as the Governor-Mount Robinson Range.

5.4 Regional geology

The Pilbara bioregion, where the Proposal is located, is situated in the south-eastern corner of the Pilbara Craton. The cratonic basement comprises Archaean granite-greenstone and is unconformably overlain by the late Archaean to Early Proterozoic deposits of the Hamersley Basin. The Hamersley Basin can be divided into three stratigraphic groups: the Fortescue, Hamersley and Turee Creek groups. Of these groups, the Fortescue and Hamersley groups outcrop in the immediate area of the Proposal.

The Hamersley Group is seen throughout the Hamersley Basin and forms the outcrop of Mining Area C. It is a sedimentary sequence comprising banded iron formations (BIFs), shales and dolomites with minor felsic volcanics and intrusive dolerite dykes and sills. The group contains both the Brockman and Marra Mamba Iron formations, which together host most of the known major iron ore deposits in the Pilbara region.

The six lower-most formations of the Hamersley Group that exist within the area are listed below in order of increasing age:

1. Weeli Wolli Formation.
2. Brockman Iron Formation, comprising:
 - Yandicoogina Shale Member (shale and BIF);
 - Joffre Member (BIF with minor shale bands);
 - Whaleback Shale Member (interbedded shale, chert and BIF); and
 - Dales Gorge Member (interbedded BIF and shale).
3. Mount McRae Shale (graphitic and chloritic shales interbedded with BIF).
4. Mount Sylvia Formation (shale, dolomite and BIF bands).

5. Wittenoom Formation, comprising:

- Bee Gorge Member (calcareous shale and dolomite);
- Paraburdoo Member (dolomite – karstic in part); and
- West Angela Member (manganese-rich shale with minor BIF and chert bands).

6. Marra Mamba Iron Formation, comprising:

- Mount Newman Member (BIF with thin shale bands);
- MacLeod Member (BIF with extensive interbedded shales and ‘podded’ BIF horizons); and
- Nammuldi Member (cherty BIF with occasional shale bands).

5.5 Regional land systems

The Proposal occurs within the Hamersley Plateaux Zone of the Fortescue Province of the Western Region of the soil-landscape zones of Western Australia (Tille, 2006). The dominant landform features within this zone are rocky ranges and hills and stony plains. Rugged hills, ridges, dissected plateaux and mountains occur on the basalt, BIF and sandstone of the Hamersley Basin, the most notable examples being the Chichester and Hamersley ranges.

Five land systems occur within the Proposed Mining Area C Development Envelope (Table 6). The dominant land systems present are the Newman and Boolgeeda land systems, comprising the plateaux, ridges, mountains and hills and their associated drainage zones of this section of the Hamersley Range.

Table 6: Land systems present in the Pilbara that are present within the Proposed Mining Area C Development Envelope (descriptions from van Vreeswyk *et al.* 2004).

Land System	Percentage of Pilbara IBRA present in Development Envelope	Description
Boolgeeda	7,748 km ² or 4.3%	Stony plains with hard Spinifex grasslands or Mulga shrublands. The geology is quaternary colluvium.
Newman	14,580 km ² or 8%	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
Pindering	351 km ² or 0.2%	Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.
Platform	1570 km ² or 0.9%	Narrow, raised plains and highly dissected slopes on partly consolidated colluvium below the footslopes of hill systems such as Newman, relief mostly up to about 30 m but occasionally considerably greater.
Wannamunna	577 km ² or 0.3%	Level alluvial plains with prominent grove patterns of vegetation and shallow loamy soils over hardpan and broad internal drainage plains with deeper more clayey soils, relief up to 5 m. The system is found in south central parts of the survey area as broad flats within the Hamersley Ranges (Newman land system).

5.6 Regional hydrology

The hydrology of the Pilbara is marked by infrequent, high-intensity rainfall events associated with cyclonic rainfall and long, dry periods with high potential evaporation rates. Thus, the hydrology of the

Pilbara is one of extremes, ranging from drought to major floods; and water is a highly variable resource (DoW, 2010).

Natural watercourses within the Pilbara region are ephemeral and flow in response to rainfall. The primary mechanism for runoff occurs when the rate of rainfall exceeds the infiltration capacity of the soil (MWH, 2014). This mechanism is commonly associated with high-intensity cyclonic rainfall and impervious catchments.

The Proposal intersects several surface water catchments. To the east, the catchments are part of the internally draining Coondewanna Flats catchment, an 860 km² catchment that terminates at Lake Robinson within Coondewanna Flats. The western sections of the Proposal area drain into tributaries of Pebble Mouse Creek and Weeli Wolli Creek, which both flow into the Fortescue Marsh sub-catchment Area (also known as the Upper Weeli Wolli catchment and Upper Fortescue catchment) (Figure 9).

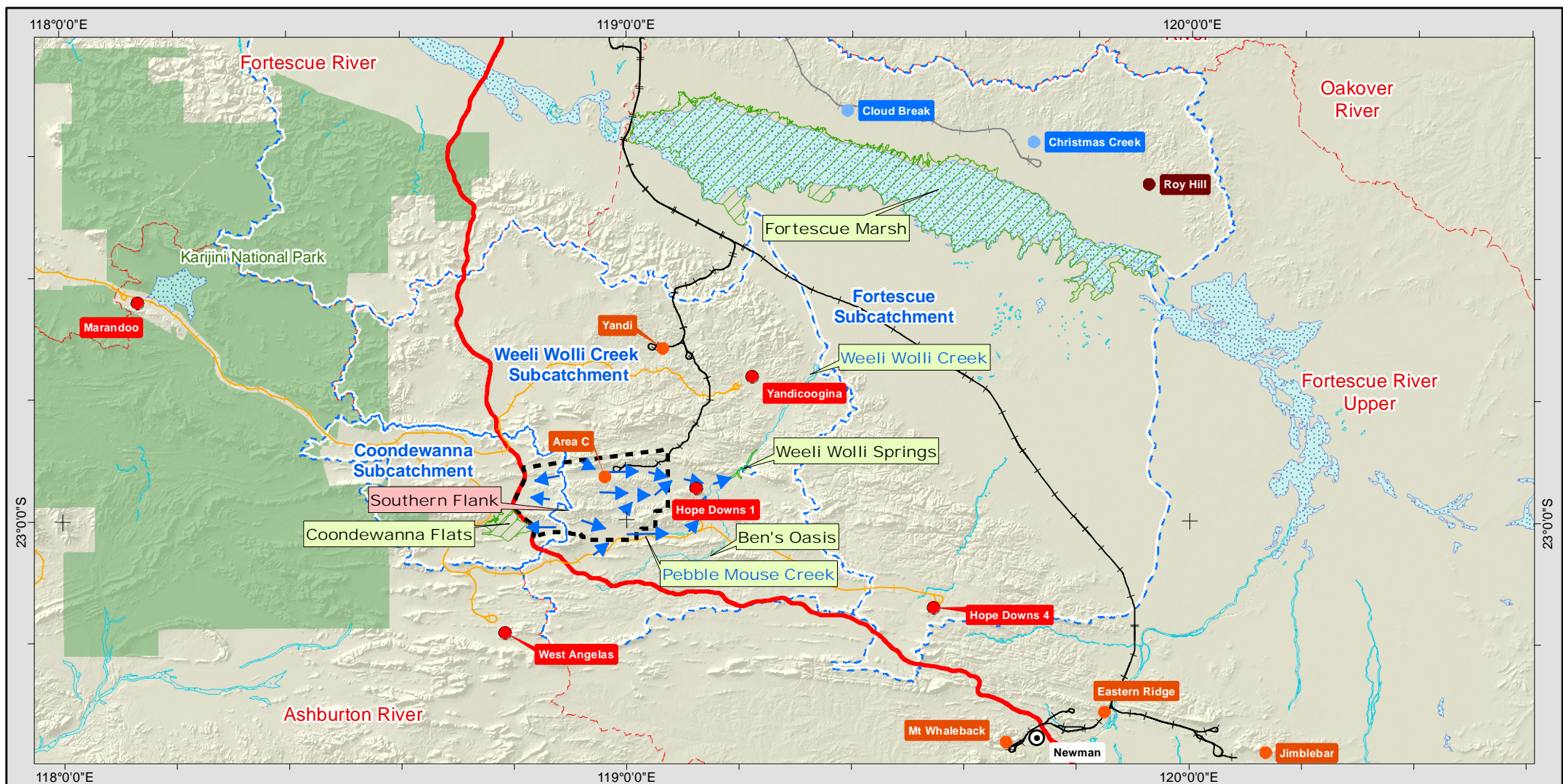
Groundwater resources in the Pilbara are replenished through the process of direct infiltration from rainfall and from surface water flows. This groundwater is most readily accessed via alluvial channels and surface water drainage lines (DoW, 2010). Regionally, groundwater flow is a reflection of topography, flowing in a northerly direction towards the coast. There are a range of aquifer types in the Pilbara, with the majority of aquifers in the central and eastern Pilbara comprising complex fractured-rock aquifers with irregular structures and various recharge mechanisms.

Within the Proposed Mining Area C Development Envelope, groundwater flows from west to east through dolomite in the Northern Flank and Southern Flank valleys from Coondewanna Flats, which is a major recharge basin, to Weeli Wolli Spring, where groundwater is forced to the surface and discharges into Weeli Wolli Creek. Locally, groundwater flow within the orebody aquifers is small and broadly aligns with the surface topography (Figure 9).

5.7 Biodiversity

The Proposed Mining Area C Development Envelope is situated within the Hamersley-Pilbara biodiversity hotspot, one of Australia's 15 National Biodiversity Hotspots (Commonwealth of Australia, 2014) is a unique and ancient landscape, with variable climates and diverse geology, situated in a biogeographic transition zone between the tropical north and the semi-arid zone. It provides habitat for a number of threatened, endemic and fire-sensitive species and communities (Commonwealth of Australia, 2014) and has one of the most diverse reptile assemblages in the world (Doughty *et al.*, 2011). The Pilbara's endemic species include mammals, such as the little red kaluta (*Dasykaluta rosamondae*) and Pilbara leaf-nosed bat (*Rhinonicterus aurantia*); reptiles, such as the Pilbara rock monitor (*Varanus pilbarensis*) and Pilbara barking gecko (*Underwoodisaurus seorsus*); plants, such as the ironplant (*Astrotricha hamptoni*); and a highly diverse and largely endemic subterranean fauna community. It also provides protected habitats for a number of rare or threatened species, including the northern quoll (*Dasyurus hallucatus*) and ghost bat (*Macroderma gigas*).

The Pilbara Biological Survey, undertaken by the DPaW between 2002 and 2007, systematically studied the vertebrate and invertebrate fauna across the Pilbara bioregion using stratified and standardised survey techniques (see McKenzie *et al.* (2009)).



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Regional Hydrogeology and Catchments

Scale @ A4: 1:1,000,000	Prepared: S. TRINDER	Project No: A780/021 REV B
Date: 21/02/2017	Checked: R. GREGORY	Figure: 9
Revision: REV B	Reviewed: S. WILLIAMSON	



Town

Active Major Iron Ore Mines

- BHP Billiton
- Fortescue Metals Group
- Rio Tinto
- Roy Hill Holdings
- BHP Billiton Rail
- FMG Rail
- Rio Tinto Rail

Environmental Receptors Relevant to Proposal

- ▨ Priority Ecological Community



Proposed Mining Area C Development Envelope

- Great Northern Highway
- - - WA Hydrographic Subcatchment
- - - WA Hydrographic Catchment
- ▨ Watercourse Area - Non-perennial
- ▨ Land Subject To Inundation
- Ground Water Flow Direction
- ▨ Karijini National Park

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 20 40 60
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Vegetation mapping of the Pilbara region has been completed on a broad scale (1:1,000,000) by Beard (1975) and subsequently refined by Shepherd *et al.* (2002). Mining Area C is situated in the Hamersley Plateau in the Eremaean Botanical Province of Western Australia as per Beard (1975) who broadly mapped the area as ranges and valley plains. The most common vegetation associations within the region were:

- *Eucalyptus leucophloia* (snappy gum) and *Triodia wiseana* (hard spinifex) tree steppe occurring on hills and tall woodlands of *Eucalyptus camaldulensis* (river red gum); and
- *Eucalyptus victrix* (coolibah) and *Acacia aneura* (mulga) along drainage lines and in groves within the valley floors.

There are two vegetation associations (as mapped by Shepherd *et al.* (2002)) within the Proposed Mining Area C Development Envelope:

- Hamersley 18: Low woodland; mulga (*Acacia aneura*); and
- Hamersley 82: Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*.

While the pre-European extent for each vegetation association was close to 100%, less than 10% of each association occurs within formal or informal reserves.

BHP Billiton Iron Ore commissioned Onshore Environmental to consolidate several decades of vegetation mapping commissioned by BHP Billiton Iron Ore into a single regional geographic information system (GIS) dataset and report (Onshore Environmental, 2014). The consolidated dataset provides methodical and nomenclature consistency across BHP Billiton Iron Ore's tenure and is updated on an ongoing basis as more surveys are completed. Supplementary field assessments were undertaken to address any gaps in baseline data or to verify the results from earlier surveys. Vegetation associations are currently mapped over 422,425 ha of BHP Billiton Iron Ore tenure. Onshore Environmental (2016) identified eight significant flora species within the Proposed Mining Area C Development Envelope which are discussed in detailed in Section 12.1.

Fauna habitat maps are developed routinely during vertebrate fauna surveys undertaken for BHP Billiton Iron Ore. These are generally developed at the local scale to assist in EIA for mining approvals. In 2014, Biologic Environmental Survey reviewed and consolidated fauna habitat mapping within BHP Billiton Iron Ore tenure to develop a single regional GIS dataset and report (Biologic, 2014a). The consolidated dataset provides methodological and nomenclatural consistency across BHP Billiton Iron Ore's tenure and is updated on an ongoing basis as more surveys are completed. Biologic (2014a) identified 17 major fauna habitat types within BHP Billiton Iron Ore tenure, of which nine occur within the Proposed Mining Area C Development Envelope.

Short-range endemics (SREs) are defined as terrestrial and freshwater invertebrates with naturally small distributions and that may inhabit discontinuous or fragmented habitats (EPA, 2009). Harvey (2002) proposed a range criterion for terrestrial SRE species of less than 10,000 square kilometres (km²) (or 100 x 100 km), which has been adopted by regulatory authorities in Western Australia (EPA, 2009). SRE invertebrate species often share similar biological, behavioural and life history characteristics that influence their restricted distributions and limit their wider dispersal (Harvey, 2002).

Currently there are seven taxonomic groups of SREs in Western Australia. However, the majority of SRE species and communities are not currently listed, partly due to incomplete taxonomic or ecological knowledge and hence the invertebrate taxonomy for species groups considered to contain SRE taxa is highly dynamic with most SRE groups in the Pilbara being incomplete, or in various stages of development, depending upon the group in question (BHP Billiton Iron Ore, 2015c).

Many terrestrial invertebrate species in the Pilbara are only known from a handful of locations where intensive sampling has been undertaken. Species distributions are therefore dependent upon the size and extent of targeted surveys, as well as the ecology, behaviour, and natural history of the species in question, much of which remains uncertain, especially where the species is undescribed. As of 30 May 2013, a total of 144 SRE or potential SRE species had been recorded within the Pilbara bioregion. Currently, there are 18 confirmed or potential SRE species within the Proposed Mining Area C Development Envelope (Biologic, 2016a).

Subterranean fauna are categorised as either stygofauna or troglotauna. Stygofauna are aquatic and inhabit vugs, fissures and other spaces in groundwater aquifers, while troglotauna are air-breathing and inhabit similar spaces in the unsaturated zone (between the groundwater and the surface). Subterranean fauna usually exhibit adaptations to life underground that include the loss of eyes and skin pigmentation, elongation of appendages and sensory structures, and development of a vermiform body shape. The majority of subterranean fauna in Western Australia are invertebrates.

Subterranean species have very limited dispersal capabilities, meaning many species have localised distributions (Gibert & Deharveng, 2002; Lamoreux, 2004). According to Eberhard *et al.* (2009), about 70% of Pilbara stygofauna species are likely to be SREs, with many of them having much smaller ranges than the generalised range criterion of 10,000 km² proposed for SRE species by Harvey (2002). An even higher proportion of troglotauna species are likely to be SREs (Lamoreux, 2004), with almost all species having ranges two or three orders of magnitude less than Harvey's SRE criterion (Halse & Pearson, 2014). Species with restricted ranges are vulnerable to significant species loss following habitat destruction or environmental changes (Ponder & Colgan, 2002; Fontaine *et al.*, 2007). Subterranean species are therefore often a focus of EIAs.

The Pilbara has very high subterranean species richness. Some species are believed to be relics of previous communities present when the climate was wetter, and there is a good representation of species that have moved laterally underground and speciated since the climate has become drier, such as those recorded for stygofaunal ostracods and troglotaunal schizomids. It is conservatively estimated that the Pilbara supports approximately 500 to 550 species of stygofauna, and more than 650 morphospecies of troglotauna have been collected from the Pilbara to date (Bennelongia, 2016a, b).

Two PECs⁴ occur in the vicinity of the Proposed Mining Area C Development Envelope (information reproduced from DPaW, 2014) (see Figure 9):

- Weeli Wolli Spring community (Priority 1): Weeli Wolli Spring's riparian woodland and forest associations are unusual as a consequence of the composition of the understorey. The sedge and herbfield communities that fringe many of the pools and associated water bodies along the main channels of Weeli Wolli Creek have not been recorded from any other wetland site in the Pilbara. The spring and creekline are also noted for their relatively high diversity of stygofauna and this is probably attributed to the large-scale calcrete and alluvial aquifer system associated with the creek. The valley of Weeli Wolli Spring also supports a very rich microbat assemblage.
- Coolibah-lignum flats: *Eucalyptus victrix* over *Muehlenbeckia* community: Woodland or forest of *Eucalyptus victrix* (coolibah) over thicket of *Duma* (*Muehlenbeckia*) *florulenta* (lignum) on red

⁴ Possible threatened ecological communities that do not meet survey criteria or are not adequately defined are added to a priority ecological community list maintained by DPaW. They are ranked 1, 2 or 3 in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological communities that are adequately known, and are rare but not threatened or meet criteria for near threatened, or that have been recently removed from the threatened list, are placed in priority 4. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in priority 5 (DPaW, 2014).

clays in run-on zones. Associated species include *Eriachne benthamii*, *Themeda triandra*, *Aristida latifolia*, *Eulalia aurea* and *Acacia aneura*. A series of sub-types have been identified, two of which occur near Southern Flank):

- Priority 3(i) Coolibah and mulga (*Acacia aneura*) woodland over lignum and tussock grasses on clay plains (Coondewanna Flats and Wanna Munna Flats); and
- Priority 1 Coolibah woodlands over lignum (*Duma (Muehlenbeckia) florulenta*) over swamp wandiree (Lake Robinson is the only known occurrence).

Page intentionally blank

6. Social environment

6.1 Socio-economic setting

The primary land uses in the Pilbara region are:

- pastoralism;
- mining;
- conservation;
- tourism; and
- population centres.

Each of the primary land uses is further described below.

6.1.1 Pastoralism

Pastoralism has been an extensive and important industry in the Pilbara region since the early twentieth century (SLWA, 2010). Pastoral activities involve the free-range grazing of stock over vast areas of land with approximately 58% of the Pilbara IBRA region allocated to pastoral grazing.

Feeder cattle (for live export or slaughter export trade) are now the predominant stock type run by the majority of pastoralists in the Pilbara region (SLWA, 2010). As of 2012, the Pilbara pastoral industry was valued at \$52 million (DRD, 2015).

Carwardine *et al.* (2014) identified the main impacts of these grazing animals in the Pilbara as 'compaction and erosion of soil, loss of grazing-sensitive plant species, reduced native grass biomass, introduction of weed seeds and trampling of seedlings and mature plants'. Grazing pressure and pastoralism are recognised threats to conservation-significant species, including the greater bilby (Southgate *et al.*, 2007) and northern quoll (Hill & Ward, 2010).

Pastoral leases in the vicinity of the Proposal area include Juna Downs and Marillana pastoral stations. Adjacent to and west of the Proposal area is the Juna Downs Pastoral Lease Exclusion area. This area was excluded from the Juna Downs pastoral lease in 2015, becoming unallocated Crown land. The Department of Lands has direct responsibility for all unallocated Crown land, with DPaW responsible for the management of weeds, feral animals and fire prevention. Consultation with DPaW indicates that this area has been excluded from pastoral lease so as to contribute to the National Reserve System, commonly referred to as the comprehensive, adequate and representative (CAR) system of protected areas. However, this area is not as yet formally recognised as conservation reserve, and formal vesting and management arrangements have yet to be completed by the state government for this area.

6.1.2 Mining

The Pilbara is a globally significant mining and energy region, with these industries accounting for 78% (\$33 billion) of the total value of exports from the region in 2012/13 (DRD, 2015) and provides employment to approximately 18,500 people in the Pilbara (Pilbara Development Commission, 2015).

Iron ore is the primary commodity mined in the region, and the vast majority (more than 90%) of Australia's iron ore comes from the Pilbara (DRD, 2015). There are at least 25 iron ore mines currently operating in the Pilbara, the majority of which are located around the towns of Newman and Tom Price (DMP, 2014). These mines collectively contribute to the export of more than 500 Mtpa of iron ore, which

is railed or trucked from the mines to one of three port facilities located at Port Hedland, Cape Lambert and Karratha (DMP, 2014; DRD, 2015).

In addition to iron ore, manganese, gold, silver and copper are also mined in the Pilbara, although to a much lesser extent (DRD, 2015).

Potential impacts of mining activities in the Pilbara bioregion include the loss, degradation and fragmentation of flora and fauna habitat, the increasing use of water resources and alteration of hydrological regimes, soil and water contamination and the alteration of fire regimes (Carwardine *et al.*, 2014). All of these potential impacts have been assessed and detailed in this PER document.

6.1.3 Conservation reserves

Land reserved for conservation purposes amounts to approximately 7% of the Pilbara region, with the major reserves being Karijini and Millstream-Chichester national parks. These parks are supplemented by smaller conservation reserves, such as Mungaroona Range Nature Reserve and Meentheena Conservation Park. In WA, conservation reserves include national parks, conservation parks and nature reserves. Conservation reserves are also sometimes collectively called the “conservation estate”. Conservation reserves are areas of land which are specially set aside under law to protect environmental value(s) inherent to them. Development in and use of conservation reserves is usually restricted to only those activities which are compatible with conservation of environmental values.

6.1.4 Tourism

The Pilbara is increasingly recognised for its natural values, and the region has experienced an increase in tourism. Tourism plays an important role in the Pilbara economy by supporting diversification of the economy (Pilbara Development Commission, 2015).

An annual visitor expenditure of over \$360 million benefits small, locally owned businesses in the accommodation, food services and other retail sectors (Pilbara Development Commission, 2014). The main tourist attraction in the Pilbara is the natural environment, although industrial and cultural or heritage attractions exist. Natural environment tourist attractions in the Pilbara include (Pilbara Development Commission, 2015):

- national parks;
- gorges, pools and swimming holes (many of which are in national parks);
- islands and marine attractions;
- coastal or beach destinations; and
- outstanding landscapes and isolation.

Tourism within the conservation reserves in the Pilbara is regulated by DPaW; however, tourism undertaken within other tenure and at entry points (e.g. roads and off-road tracks) is not easily regulated and therefore has the potential to result in adverse environmental impacts (Carwardine *et al.*, 2014). Impacts include the introduction of exotic species, vegetation fragmentation, increased risk of fire and pressure on sensitive communities from infrastructure developments.

6.1.5 Population centres

The Pilbara region is a large, sparsely populated region with the main population centres being the City of Karratha and the towns of Port Hedland and Newman (DRD, 2015). The majority of established centres have been developed to support the resources sector, with other significant towns including Tom Price and Paraburdoo. Population growth has been predominantly driven by the expansion of the

resources sector in the region, with total population increasing from approximately 43,000 in 2003 to 67,500 in 2015 in line with the rapid expansion of the resources sector over that time (DRD, 2015).

6.2 Aboriginal heritage

The Pilbara region hosts a prolific number of Aboriginal rock engravings, some of the most well-known being on the Burrup Peninsula (outside of the Proposal boundary). There are numerous Aboriginal reserves within the Pilbara region, such as Ethel Creek and the Weeli Wolli area. These Aboriginal reserves are Crown land set aside for public purposes (DIA, 2010). The Aboriginal reserve near Weeli Wolli occurs outside the Proposal boundary. Aboriginal heritage sites within the Pilbara bioregion are mainly ethnographic sites that are generally associated with the Dreamtime and ceremonies or archaeological sites that are the remains of material culture. A number of these sites in the Pilbara hold considerable visual amenity value (e.g. rock art and creeks or waterholes at water source sites).

BHP Billiton Iron Ore has conducted large-scale archaeological and ethnographic surveys to identify places of cultural significance within the Pilbara region. Those surveys are ongoing and undertaken with participation by the relevant Traditional Owners of the area. All identified sites are managed in consultation with the Traditional Owners and in compliance with the AH Act.

The Proposed Mining Area C Development Envelope lies mostly within the Banjima Native Title claim, with the southeast corner lying within the Nyiyaparli Native Title claim. BHP Billiton Iron Ore is committed to working cooperatively with the Banjima and Nyiyaparli people and has formalised this commitment through comprehensive ILUAs executed with the Nyiyaparli people in 2012 and the Banjima people in October 2015. The ILUAs provide opportunities for both parties and facilitate long-term collaboration. The ILUAs also outline how BHP Billiton Iron Ore works in partnership with the Nyiyaparli and Banjima people to manage cultural heritage and the environment.

6.3 European heritage

In Western Australia, the *Heritage of Western Australia Act 1990* makes provision for the preservation of places of historic significance. Under the Act, places identified as meeting the criteria outlined in s47 of the Act are placed on the State Register of Heritage Places. Places of Commonwealth heritage significance are protected under Part 15 of the EPBC Act.

European settlement of the Pilbara region began in the 1860s (van Vreeswyk *et al.*, 2004), with pastoralism dominating the region for the next 100 years as European settlers arrived with livestock to establish sheep and cattle stations. Many of the European heritage sites in the Pilbara region relate to these historic pastoral stations, natural features (such as pools) and town sites.

The inHerit database (Heritage Council of Western Australia, 2015) indicates that there are over 90 heritage places in the Shire of East Pilbara. No European heritage sites are present within the Proposed Mining Area C Development Envelope.

Page intentionally blank

7. Environmental impact assessment process

7.1 State environmental assessment process

The Proposal was referred to the Western Australian EPA under s38 of the EP Act on 23 May 2016 (BHP Billiton Iron Ore, 2016g). On 4 July 2016, the EPA determined that the Proposal required an environmental assessment at PER level with a four-week public review period (EPA, 2016b). The process for a PER environmental assessment is set out in the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012* (EPA, 2012b) prescribed under the EP Act. It should be noted that these Administrative Procedures were superseded by new procedures in 2016, however, as BHP Billiton Iron Ore referred the Proposal prior to the change in procedures, BHP Billiton Iron Ore has undertaken assessment as per *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012*.

On 25 July 2016, the EPA issued an ESD (EPA, 2016b) for the Proposal. The purpose of an ESD is to:

- provide proposal-specific guidelines on the preliminary key environmental factors that are to be addressed during the environmental review;
- identify the required work that needs to be carried out; and
- provide details on the timing of the environmental review.

The purpose of a PER is to document the proponents assessment of the potential impacts of a proposal with regards to the environmental factors as outlined in the ESD. The EIA will be conducted in accordance with various relevant EPA procedures, position statements and guidance documents, as detailed in the subsections below.

The PER must address all elements of the ESD (EPA, 2016b). The EPA expects the proponent to consult with relevant stakeholders to ensure any environmental factors important to the public are addressed. The PER should document all consultation undertaken (Section 4).

Once the PER is submitted, the EPA will determine whether the PER document adequately addresses the requirements of the ESD and the EPA's expectations. If acceptable, the EPA will release the PER for the public review period, during which time the public can provide submissions. After the public review period closes, the EPA will provide a summary of comments to the proponent (along with copies of all submissions received). The proponent must then adequately respond to topics raised in the public comments.

Following this process, the EPA then assesses the Proposal including the PER document, the submissions received, and the proponent's response to submissions. After consultation with the proponent, key government agencies, and other relevant stakeholders on the draft conditions, the EPA will submit its assessment report, containing its recommendation on whether the Proposal may be implemented and the recommended conditions of approval, to the Minister for Environment and to the public.

Within 14 days of publication of the EPA's assessment report, any person may lodge an appeal to the Minister for Environment against the recommendations or content of the report. After appeals are considered, the Minister determines whether or not the proposal should be implemented and decides on the conditions that implementation of the Proposal is subject to.

The environmental assessment process for a PER is detailed in Figure 10.

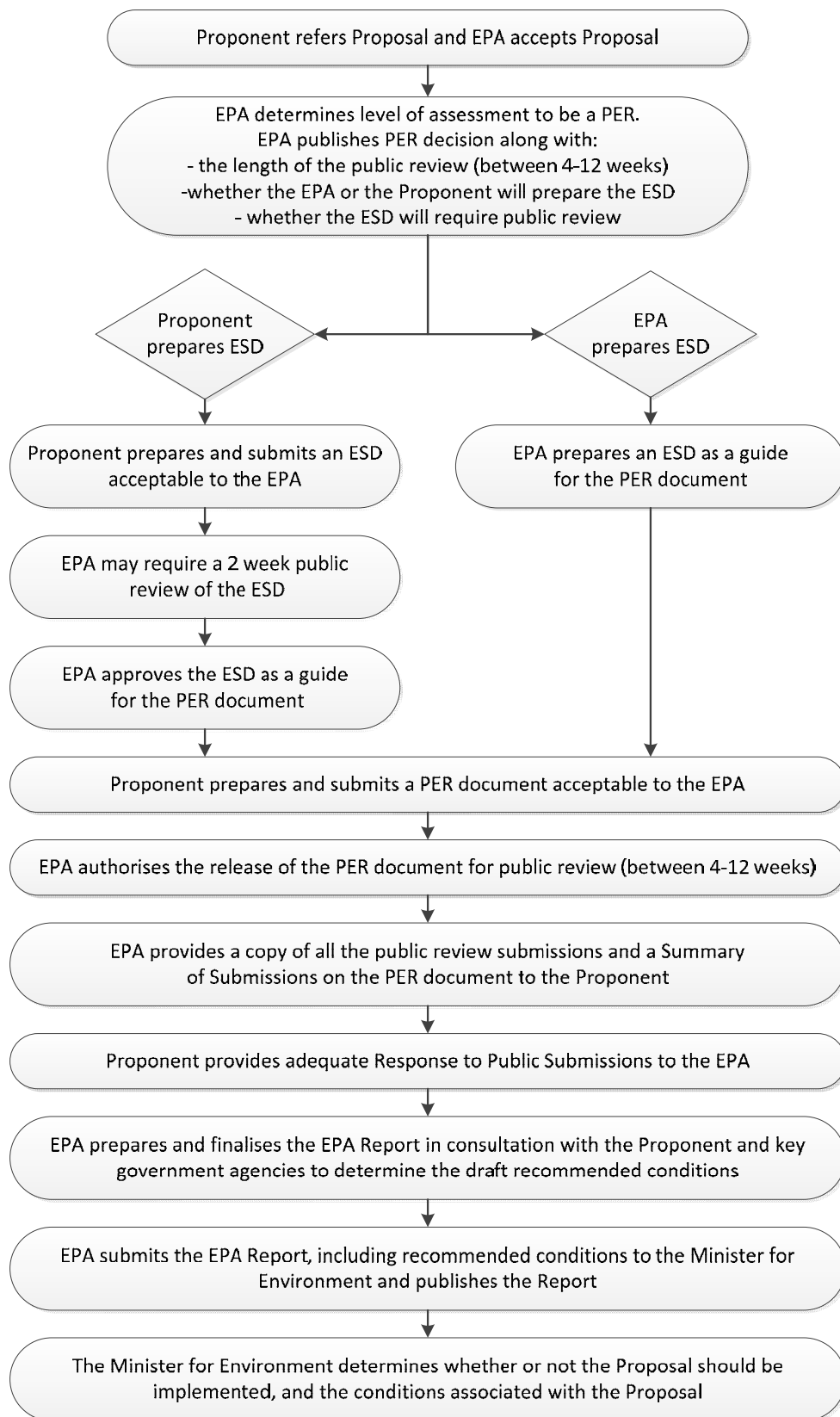


Figure 10: Public environmental review assessment process

7.2 Commonwealth environmental assessment process

BHP Billiton Iron Ore is seeking approval of a Strategic Assessment Program under the strategic assessment provisions of the EPBC Act (BHP Billiton Iron Ore, 2016d). A strategic assessment is conducted in accordance with Part 10 of the EPBC Act. Strategic assessments provide an alternative approach to project-by-project impact assessment under Part 9 of the EPBC Act and examine proposed developments at a broader landscape scale and timeframe in relation to the requirements of the EPBC Act, taking into consideration impacts on matters of national environmental significance (the protected matters).

The Impact Assessment Report prepared as part of the Commonwealth strategic assessment process considered potential impacts to Matters of National Environmental Significance within the footprint of this Proposal. Matters of National Environmental Significance relevant to this Proposal are the ghost bat (*Macroderma gigas*), northern quoll (*Dasyurus hallucatus*), Pilbara leaf-nosed bat (*Rhinonicterus aurantia*) and Pilbara olive python (*Liasis olivaceus barroni*). All of these species are listed under the state *Wildlife Conservation Act 1950* and are assessed in Section 11.2.4.

7.3 Legislation, policy and guidance

The Proposal is required to comply with relevant legislation and regulations and is guided by relevant policies and strategies. The relevant legislation, regulations, policies, strategies, EPA position statements, EPA guidance statements and other guidance documents relevant to this Proposal are outlined in Table 7. A summary of how BHP Billiton Iron Ore has addressed the guidance outlined within the ESD for this Proposal is also provided in Table 7.

A range of other relevant guidance, policies and legislation has also informed the impact assessments undertaken for this Proposal.

Table 7: Legislation, policies and guidance material relevant to this Proposal

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
EPA Legislation				
General	EP Act.	<p>The EP Act provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with those things.</p> <p>The object of the act is to protect the environment of the State of Western Australia, having regard to a number of principles described in s. 4A of the EP Act.</p>	<p>Flora and vegetation, terrestrial fauna, subterranean fauna, landforms, hydrological processes, inland waters environmental quality, heritage, air quality, human health, amenity and terrestrial environmental quality may be impacted by matters regulated by the EP Act.</p> <p>The EIA detailed in this PER document has been conducted in accordance with Part IV of the EP Act.</p> <p>Approval of the Proposal is sought under Part IV of the EP Act.</p> <p>Further approvals (e.g. works approvals, clearing permits or environmental licences) may be required under Part V of the EP Act.</p>	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Terrestrial fauna – Section 11.2 • Subterranean fauna – Section 11.3 • Hydrological processes – Section 11.4 • Landforms and terrestrial environmental quality – Sections 12.1 and 12.2 • Inland waters environmental quality – Section 11.5 • Air quality – Section 12.3 • Amenity – Section 12.4 • Heritage – Section 11.6 • Human health – Section 12.5
Policy and Guidance Considered in this Proposal				
Flora and Vegetation; Terrestrial Fauna	<i>Position Statement No. 2: Environmental Protection of Native Vegetation</i> (EPA, 2000a).	<p>This position statement outlines the EPA's expectations with regards to impact assessment and management of land clearing.</p> <p>The EPA adopts the principles and related objectives and actions of the National Strategy for the</p>	<p>The assessment detailed in the PER demonstrates that clearing required in relation to the Proposal is environmentally acceptable because:</p> <ul style="list-style-type: none"> • different options have been compared to evaluate protection of biodiversity at the species and ecosystem levels, and it is 	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Terrestrial fauna – Section 11.2

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>Conservation of Australia's Biological Diversity.</p> <p>The EPA considers that clearing in non-agricultural areas of the state may be environmentally acceptable if the proponent demonstrates clearly that the proposal meets the elements set out in Section 4.3 of the position statement and that actions to meet the two key objectives of the National Strategy for the Conservation of Australia's Biological Diversity are being met, namely:</p> <p>By the year 2000 Australia will be:</p> <ul style="list-style-type: none"> • Arresting and reversing the decline of remnant native vegetation; and • Avoiding or limiting any further broad-scale clearance of native vegetation, consistent with ecologically sustainable management and bioregional planning, to those instances in which regional biological diversity objectives are not compromised. <p>This position statement also requires that if the project is large, there is a 'comprehensive, adequate and secure representation of scarce or endangered habitats within the project area and/or areas which are</p>	<p>demonstrated that all reasonable steps have been taken to avoid, minimise or mitigate disturbance of existing native vegetation;</p> <ul style="list-style-type: none"> • no known species of plant or animal is likely to significantly impacted as a consequence of the Proposal and the risks to threatened species are considered to be acceptable; • no association or community of indigenous plants or animals is likely to be significantly impacted as a result of the Proposal; • vegetation removal under the Proposal will not compromise any vegetation type by taking it below the threshold level of 30% of the pre-clearing extent of the vegetation type; • the on-site and off-site impacts of the project have been identified and BHP Billiton Iron Ore's impact assessments have indicated that these can be managed to an acceptable level. 	

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>biologically comparable to the project area, protected in secure reserves'.</p> <p>The proponent also needs to demonstrate the proposal meets these elements and that actions to meet the two key objectives of the national Strategy for the conservation of Australia's Biological Diversity are being met.</p>		
Flora and Vegetation; Terrestrial Fauna	<i>Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection</i> (EPA, 2002a).	<p>This position statement provides a basis for outlining the requirements of biodiversity protection and the requirements for terrestrial biological surveys for EIA in Western Australia.</p> <p>In particular:</p> <p>The EPA expects proponents to demonstrate in their proposals that all reasonable measures have been undertaken to avoid impacts on biodiversity. Where some impact cannot be avoided, the proponent must demonstrate that the impact will not result in unacceptable loss. Information gathered for EIA must meet state, national, and international agreements, legislation and policy in regard to biodiversity conservation.</p> <p>The EPA will use the IBRA as the largest unit for EIA decision-making in relation to the conservation of biodiversity.</p>	<p>Extensive baseline studies and detailed EIAs have been undertaken to document the biodiversity of the area and to determine likely impacts from the Proposal.</p> <p>All surveys have been undertaken in accordance with EPA standards, requirements and protocols and have obtained sufficient information to address biodiversity conservation and ecological function values. Detailed genetic studies have been undertaken on the ghost bat to support the impact assessment process.</p> <p>All reasonable measures have been undertaken to avoid impacts to biodiversity, including through implementation of the mitigation hierarchy (avoid, mitigate, rehabilitate, offset). While there will be impacts to biodiversity from implementation of the Proposal, these are not considered to result in an unacceptable loss.</p> <p>Supporting documentation has been made available via the PER process. All data collected during these surveys have been</p>	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Terrestrial fauna – Section 11.2

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>The EPA expects proponents to ensure that terrestrial biological surveys provide sufficient information to address both biodiversity conservation and ecological function values in the context of the type of proposal being considered and the relevant EPA objectives for protection of the environment.</p> <p>The EPA expects that terrestrial biological surveys will be made publicly available and will contribute to the bank of data available for the particular region, to aid the overall biodiversity understanding and assessment by facilitating transfer into state biological databases.</p>	submitted to DPaW via the licence returns process.	
Flora and Vegetation	<i>Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for EIA in Western Australia</i> (EPA, 2004a).	<p>This guidance statement:</p> <ul style="list-style-type: none"> provides the general standards and a common framework for terrestrial flora and vegetation surveys for EIA in Western Australia, the quality and quantity of information that should be derived from these surveys, and the consequent analysis, interpretation and reporting; and is primarily directed at the subset of biodiversity contained in all terrestrial vascular plants. 	All botanical surveys undertaken for BHP Billiton Iron Ore have been undertaken in compliance with EPA Guidance Statement 51.	<ul style="list-style-type: none"> Flora and vegetation – Section 11.1

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		The guidance assists in the interpretation and application of the general principles outlined in Position Statement 3 (EPA, 2002a) and Position Statement 2(EPA, 2000a).		
Flora and Vegetation	<i>Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment</i> (EPA & DPaW, 2015).	This guide was developed by the EPA to ensure that data collected for EIA are of an appropriate standard. It provides detailed guidance on survey methods for botanical surveys undertaken in Western Australia.	All botanical surveys undertaken post 2015 for BHP Billiton Iron Ore are conducted in accordance with the requirements of this document. There has been no work undertaken specifically for this project since this time.	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1
Flora and Vegetation; Landforms; Rehabilitation and Decommissioning	<i>Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems</i> (EPA, 2006).	<p>This guidance statement promotes the use of completion criteria and definitions for the rehabilitation of natural ecosystems that:</p> <ul style="list-style-type: none"> Allow success to be measured within realistic timeframes; Are sufficiently precise to allow outcomes to be effectively audited, but are also flexible when required; Are based on sound scientific principles; and Acknowledge the consequences of permanent changes to landforms, soils and hydrology. <p>These include standard criteria that apply to all projects, as well as site-specific criteria used to measure the recovery of ecosystems relative to reference sites.</p> <p>Other key areas of discussion are the importance of scientific research</p>	<p>Rehabilitation objectives as detailed in the <i>Mining Area C – Southern Flank Mine Closure Plan</i> (Appendix 12) have been set in line with this guidance.</p> <p>The completion criteria set out in the guidance have been applied in the impact assessment where relevant.</p> <p>Environmental land factors are detailed in this Proposal, in line with the guidance statement.</p>	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Terrestrial fauna – Section 11.2 • Rehabilitation and decommissioning – Section 11.7 • Landforms – Section 12.1

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		and long-term monitoring of outcomes and the effective management of information required to measure outcomes.		
Flora and Vegetation; Subterranean Fauna; Hydrological Processes; Inland Waters Environmental Quality.	<i>Environmental and Water Assessments Relating to Mining and Mining Related Activities in the Fortescue Marsh Management Area. Advice of the EPA to the Minister for Environment under Section 16(e) of the EP Act, EPA Report 1484 (EPA, 2013c).</i>	This is a strategic advice prepared by the EPA and provided to the Minister for Environment under s. 16(e) of the EP Act. The advice aims to provide consistent guidance for agencies and proponents to help streamline project assessment and approval processes to deliver positive environmental outcomes for the Fortescue Marsh. The advice divides the Fortescue Marsh management area into zones according to key environmental values, which are prioritised according to relative environmental significance. For each environmental value, management objectives are identified and strategies to achieve these objectives are outlined.	EIAs completed for this Proposal were undertaken in a manner that considered the recommendations in this s. 16(e) report. Cumulative impacts were assessed for the Proposal with existing operations at Mining Area C, taking in account existing land disturbance and dewatering activities. The potential impacts of the Proposal are considered unlikely to extend into the Fortescue Marsh land system.	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Subterranean fauna – Section 11.3 • Hydrological processes – Section 11.4 • Inland Waters Environmental Quality – Section 11.5
Flora and Vegetation; Terrestrial Fauna; Subterranean Fauna; Hydrological Processes; Inland Waters Environmental Quality.	<i>Western Australian Water in Mining Guideline, Water Licensing Delivery Series, Report No 12 (DoW, 2013b).</i>	This guideline sets out how to meet the DoW's regulatory requirements for mining projects across Western Australia. It draws on the RIWI Act, policies, water allocation plans and regional experience in water management issues. The guideline provides advice on water management issues that need to be considered in mine planning	This Proposal is consistent with the mine water management objectives detailed in the guideline. This guideline will be considered and applied where relevant in relation to on-site water management.	<ul style="list-style-type: none"> • Flora and vegetation – Section 11.1 • Terrestrial fauna – Section 11.2 • Subterranean fauna – Section 11.3 • Hydrological Processes – Section 11.4

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		and the type of information the DoW may require as part of the licence assessment process.		<ul style="list-style-type: none"> Inland Waters Environmental Quality – Section 11.5
Terrestrial Fauna	<i>Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia</i> (EPA, 2009).	<p>This guidance statement addresses the general standards and common framework, including risk-based assessment, for the sampling and assessment of SRE invertebrate fauna for EIA in Western Australia. It sets out the EPA's current expectations in respect of the quality and quantity of information derived from these surveys and the consequent analysis, interpretation and reporting.</p> <p>The guidance provides information that the EPA will consider when assessing proposals where SRE invertebrate taxa are relevant environmental factors in the assessment.</p>	All SRE surveys undertaken for BHP Billiton Iron Ore since 2009 have been undertaken in accordance with this guidance statement.	<ul style="list-style-type: none"> Terrestrial fauna – Section 11.2
Terrestrial Fauna	<i>Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment</i> (EPA & DEC, 2010).	<p>This guide is specific to terrestrial vertebrate fauna. It provides advice on fauna sampling techniques and methodologies for different regions of the state and the analysis, interpretation and reporting requirements for EIA. It should be read in conjunction with Guidance Statement 56 (EPA, 2004b).</p> <p>The guide is intended for use when planning and undertaking terrestrial vertebrate fauna surveys for assessment of the impacts of</p>	<p>All surveys undertaken for BHP Billiton Iron Ore since 2010 have adopted the methods outlined in this guidance document where relevant and practical. The amount of survey work undertaken in the Proposed Mining Area C Development Envelope exceeds the requirements for an assessment of this size and scope.</p> <p>There are no specific published guidelines for surveying ghost bats. Therefore, methods for ghost bat surveys and monitoring have been developed over multiple years with various methodologies</p>	<ul style="list-style-type: none"> Terrestrial fauna – Section 11.2

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>development generally (including new infrastructure, mining and native vegetation clearing), as well as for projects that are submitted for formal assessment under Part IV of the EP Act.</p> <p>The guide provides detail on the different levels of terrestrial vertebrate fauna surveys that may be required for EIA.</p>	<p>tested to determine the most suitable technique. This work exceeds the recommended approach detailed in the technical guide.</p>	
Terrestrial Fauna	<p><i>Guidance Statement 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia</i> (EPA, 2004b).</p>	<p>This guidance statement:</p> <ul style="list-style-type: none"> addresses the general standards and a common framework for terrestrial fauna and fauna assemblages for EIA in Western Australia, the quality and quantity of information derived from these surveys, and the consequent analysis, interpretation and reporting; and is primarily directed at the subset of biodiversity contained in all terrestrial faunal groups. <p>The guidance statement assists in the interpretation and application of the general principles outlined in Position Statement No. 3 (EPA, 2002a) and should be read in conjunction with Guidance Statement No. 51 (EPA, 2004a) when planning for biological surveys</p>	<p>All vertebrate fauna surveys undertaken for BHP Billiton Iron Ore since 2004 been undertaken in accordance with the requirements of this guidance statement. The amount of survey work undertaken in the Proposed Mining Area C Development Envelope exceeds the requirements of the guidance for an assessment of this size and scope.</p>	<ul style="list-style-type: none"> Terrestrial fauna – Section 11.2

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		for EIA, and when practicable fauna and vegetation surveys should be coordinated.		
Subterranean Fauna	<i>Guidance Statement No. 54a: Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia</i> (EPA, 2007).	<p>Guidance Statement 54 has been withdrawn, but Draft Guidance Statement 54a should still be used to provide information on sampling techniques.</p> <p>The guidance statement outlines the EPA's position in relation to what are acceptable sampling efforts and methodologies for subterranean fauna. A framework is provided for determining whether an area is likely to have significant subterranean faunal values.</p> <p>The draft guidance statement also describes reporting requirements, including that results of subterranean fauna surveys should be available for public review in the EIA review documentation.</p>	All subterranean fauna surveys undertaken for BHP Billiton Iron Ore since issue of this guidance have been undertaken in accordance the requirements of this draft guidance statement where relevant and practical. The amount of survey work undertaken in the Proposed Mining Area C Development Envelope exceeds the requirements of the guidance for an assessment of this size and scope.	<ul style="list-style-type: none"> • Subterranean fauna – Section 11.3
Subterranean Fauna	<i>EAG 12: Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia</i> (EPA, 2013d).	<p>This guideline provides guidance on the relevant impact assessment methods where subterranean fauna are likely to be a factor, particularly the standards of survey and the type of information required to understand impacts.</p> <p>The guideline sets out the EPA's preferred approach for the consideration of subterranean fauna in EIAs. It aims to ensure that the standard of survey and the type of information provided to the EPA</p>	<p>All surveys undertaken for BHP Billiton Iron Ore since issue of this guidance have been undertaken in accordance the requirements of this draft guidance statement where relevant and practical. The amount of survey work undertaken in the Proposed Mining Area C Development Envelope exceeds the requirements of the guidance for an assessment of this size and scope.</p> <p>The impact assessment has been undertaken in accordance with this guideline.</p>	<ul style="list-style-type: none"> • Subterranean fauna – Section 11.3

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>have a sound scientific basis to enable the EPA to understand impacts.</p> <p>Where survey alone has not provided sufficient evidence to determine distribution, the guidance recommends the use of surrogates to assist in predictions of impact.</p> <p>Draft Guidance Statement 54a (EPA, 2007) (described above) should still be used to provide information on sampling techniques.</p>		
Hydrological Processes; Inland Waters Environmental Quality	<i>Australian Groundwater Modelling Guidelines</i> (Barnett <i>et al.</i> , 2012). Waterlines. National Water Commission	This guideline aims to promote a consistent and sound approach to the development of groundwater flow and solute transport models in Australia.	All groundwater modelling used to inform this assessment was carried out in accordance with this guideline. Groundwater modelling is discussed in Section 11.4, Hydrological Processes. Also note that the outcomes of the groundwater modelling were used to inform the Mine Closure Plan, which is discussed in Section 11.5, Rehabilitation and Decommissioning.	<ul style="list-style-type: none"> • Hydrological processes – Section 11.4 • Inland waters environmental quality – Section 11.5 • Rehabilitation and decommissioning – Section 11.7
Hydrological Processes.	<i>Pilbara Groundwater Allocation Plan. Water Resource Allocation and Planning Report series. Report No 55.</i> (DoW, 2013c)	<p>This plan sets out how the DoW will manage groundwater in the Pilbara through allocation limits, water licensing and ongoing monitoring and evaluation. It provides a framework for licensing decisions and adaptive groundwater management across the Pilbara region.</p> <p>The plan also includes licensing policy that applies across the region, mainly for managing water associated with mining. For</p>	EIAs carried out to inform the hydrological processes and inland waters environmental quality factors have been carried out in accordance with this plan. Allocation limits for licences, where required, will be determined on application to the DoW through the <i>Rights in Water and Irrigation Act 1914</i> .	<ul style="list-style-type: none"> • Hydrological processes – Section 11.4 • Inland waters environmental quality – Section 11.5

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		fractured-rock aquifers, water availability will be assessed on a case-by-case basis through licensing. Detailed guidance on assessing licence applications for mining is provided in the DoW's <i>Western Australian water in mining</i> guideline (DoW, 2013b).		
Hydrological Processes	<i>Position Statement No. 4: Environmental Protection of Wetlands</i> (EPA, 2004c)	This position statement defines important environmental values and functions of wetlands and establishes principles for the environmental protection of wetlands in general. A number of principles are articulated to provide guidance for the restoration, maintenance and enhancement of wetlands.	This Proposal has assessed the water attributes consistent with the approach in this position statement. The management approach for wetlands, as outlined in the CPWRMP (Appendix 7) is in alignment with the holistic approach in the position statement, in that environmental assets are managed according to the tiered management approach.	<ul style="list-style-type: none"> Hydrological processes – Section 11.4
Inland Waters Environmental Quality	<i>Australian and New Zealand Guidelines for Fresh and Marine Water Quality</i> (ANZECC & ARMCANZ, 2000)	This guideline aims to achieve the sustainable use of Australia's and New Zealand's water resources by protecting and enhancing their quality while maintaining economic and social development.	These guidelines have been used to assist in the evaluation of the significance of potential impacts associated with the Proposal for the hydrological processes (Section 11.4) and inland waters environmental quality (Section 11.5) factors. Surface water quality and sedimentation in particular are discussed in Section 11.5. Groundwater and surface water quality will also be regulated through the Part V licensing process, which will include a Groundwater operation strategy that adopts where relevant and practical these guidelines.	<ul style="list-style-type: none"> Inland waters environmental quality – Section 11.5

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
Inland Waters Environmental Quality	<i>State Water Quality Management Strategy No. 6: Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Guidelines Nos. 4 & 7: National Water Quality Management Strategy)</i> (Government of Western Australia, 2004).	This framework has been developed to implement the National Water Quality Management Strategy Guidelines Nos. 4 and 7 for ambient waters in Western Australia. The scope of the framework relates primarily to environmental protection and water quality matters and notes that the ANZECC Guidelines referred to above will be used by default unless more appropriate information for local water resources is available.	This strategy has been used to assist in the development of the CPWRMP for Proposal for management measures for the hydrological processes (Section 11.4) and inland waters environmental quality (Section 11.5) factors. Surface water quality and sedimentation in particular are discussed in Section 11.5. Groundwater and surface water quality will also be regulated through the Part V licensing process, which will include a Groundwater operation strategy that adopts where relevant and practical this strategy.	<ul style="list-style-type: none"> Inland waters environmental quality – Section 11.5
Heritage	<i>Guidance for the Assessment of Environmental Factors: Assessment of Aboriginal Heritage. No 41.</i> (EPA, 2004d).	This guidance statement provides guidance for consideration of Aboriginal heritage in circumstances where the heritage values are linked directly to the physical and biological attributes of the environment and when the protection and management of those attributes are threatened as a result of a proposed development.	<p>Mining activities have the potential to impact Aboriginal cultural heritage.</p> <p>Aboriginal heritage sites have been identified through surveys and Traditional Owner agreements and assessed for potential cultural significance. Site characteristics have been documented, with no sites identified that have heritage values that are significantly impacted biophysically.</p> <p>The assessment summarised in Section 11.6 is consistent with this Guidance Statement.</p>	<ul style="list-style-type: none"> Heritage – Section 11.6
Heritage	<i>Aboriginal Heritage Due Diligence Guidelines, Version 3.0</i> (DAA & DPC, 2013).	These guidelines assist land users to understand and meet their obligations under the AH Act.	<p>Mining activities have the potential to impact Aboriginal cultural heritage.</p> <p>In accordance with the guidelines, archaeological and ethnographical surveys have been conducted to identify and characterise heritage sites. Where sites</p>	<ul style="list-style-type: none"> Heritage – Section 11.6

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
			cannot be avoided, a ministerial consent under s. 18 of the AH Act has been sought.	
Rehabilitation and Decommissioning	<i>Environmental Protection Bulletin No. 19: EPA Involvement in Mine Closure</i> (EPA, 2013e).	The purposes of this bulletin is to outline the roles of the DMP and the EPA in mine closure and explain the circumstances when the EPA will assess mine closure. The EPA will only assess rehabilitation and decommissioning aspects of mine closure where there are potentially significant impacts or risks associated with mine closure that cannot be adequately regulated by the DMP for mine sites that are not subject to the <i>Mining Act 1978</i> .	Potential impacts associated with rehabilitation and decommissioning have been assessed for this Proposal and, in association with this bulletin, have informed the preparation of the Mining Area C Mine Closure Plan (Appendix 12).	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7
Rehabilitation and Decommissioning	Guidelines for Preparing Mine Closure Plans (DMP & EPA, 2015).	The aim of this guideline is to ensure that, for every mine in Western Australia, a planning process is in place so that the mine can be closed, decommissioned and rehabilitated to meet the DMA's and EPA's objectives for rehabilitation and decommissioning. The guideline includes provisions for the consideration of surface water management and groundwater management in mine closure.	The Mine Closure Plan has been updated in accordance with these guidelines. The provisions in the guideline regarding the consideration of surface water management and groundwater management in mine closure have informed the preparation of the updated Mining Area C Mine Closure Plan (Appendix 12).	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7
Rehabilitation and Decommissioning	<i>Assessment and Management of Contaminated Sites</i> (DER, 2014).	The purpose of this document is to provide guidance on the assessment and management of contaminated sites in Western Australia within the legislative framework provided by the <i>Contaminated Sites Act 2003</i> and	This guideline has been considered in the development of the Mining Area C Mine Closure Plan (Appendix 12).	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		<p>the <i>Contaminated Sites Regulations 2006</i> and the revised national site assessment framework provided in the <i>National Environment Protection (Assessment of Site Contamination) Measure 1999</i>.</p> <p>This guideline has been prepared to assist environmental practitioners, including environmental consultants and auditors, when planning and implementing the assessment and management of contaminated sites and when preparing reports.</p>		
Rehabilitation and Decommissioning	<i>Tailing Storage Facilities in Western Australia – Code of Practice</i> (DMP, 2013).	This code will assist those involved with tailings storage facilities to meet their legislative obligations for work health and safety under the <i>Mines Safety and Inspection Act 1994</i> and environmental matters under the <i>Mining Act 1978</i> .	No tailings storage facilities are planned as part of this Proposal, and therefore this code is not relevant.	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7
Rehabilitation and Decommissioning	<i>Guide to Preparation of a Design Report for Tailings Storage Facilities</i> (DMP, 2015).	This guide has been provided to assist tailing storage facility (TSF) designers with preparing the design report for a TSF. It describes the preferred structure of the design report for TSFs that should be submitted to the DMP in accordance with Section 4 of the Mining Proposal guidelines as required by the <i>Mining Act 1978</i> and the <i>Tailings Storage Facilities in Western Australia – Code of Practice</i> .	No tailings storage facilities are planned as part of this Proposal, and therefore this guide is not relevant.	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7
Terrestrial Environmental Quality;	<i>Leading Practice Sustainable Development Program</i>	This guideline is part of a program that aims to identify the key issues affecting sustainable development in	The principals of this handbook have informed the update of the Mining Area C Mine Closure Plan (Appendix 12), with	<ul style="list-style-type: none"> Terrestrial Environmental Quality – Section 12.2

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
Rehabilitation and Decommissioning	<i>for the Mining Industry – Managing Acid and Metalliferous Drainage</i> (Commonwealth Department of Industry, Tourism and Resources, 2007).	the mining industry and to provide information and case studies that identify a more sustainable approach for the industry. This particular guideline focuses on AMD and minimising risks to human and environmental health in the mining industry. The guideline stipulates that it is crucial to assess the risk of AMD as early as possible; and if AMD has been determined to be a potential risk, efforts should be focused on prevention or minimisation, rather than control or treatment.	particular emphasis on carrying out risk assessments to determine the potential AMD risk for the Proposal.	<ul style="list-style-type: none"> Rehabilitation and decommissioning – Section 11.7
Offsets	<i>Environmental Protection Bulletin No 1: Environmental Offsets – Biodiversity</i> (EPA, 2014a).	This bulletin clarifies how the EPA will consider offsets through the EIA process.	This bulletin has informed BHP Billiton Iron Ore on the EPA's position and has enabled BHP Billiton Iron Ore to understand how to apply the mitigation hierarchy to this Proposal and also to inform where offsets apply to significant residual impacts, which will remain after implementation of the mitigation hierarchy.	<ul style="list-style-type: none"> Offsets – Section 11.8
Offsets	<i>WA Environmental Offsets Policy</i> (Government of Western Australia, 2011).	This policy provides a framework for the consistent application of environmental offsets to protect and conserve environmental and biodiversity values.	The policy has informed BHP Billiton Iron Ore's application of the mitigation hierarchy and offsets approach. The policy framework and BHP Billiton Iron Ore's consideration of the policy is provided below: <ul style="list-style-type: none"> BHP Billiton Iron Ore's mitigation hierarchy focuses on avoidance and minimisation of impacts prior to any offset approach being considered. 	<ul style="list-style-type: none"> Offsets – Section 11.8

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
			<ul style="list-style-type: none"> Environmental offsets will be applied within a framework of adaptive management, which is integral to the management framework as detailed in Section 11.8 of this PER. 	
Offsets	<i>WA Environmental Offsets Guidelines</i> (Government of Western Australia, 2014).	<p>These guidelines complement the <i>WA Environmental Offsets Policy</i> (Government of Western Australia, 2011) by clarifying the determination and application of environmental offsets in Western Australia.</p> <p>These guidelines expand on the offsets policy to ensure that the basis for decision-making on environmental offsets is understood by decision-makers.</p>	<p>The policy has informed BHP Billiton Iron Ore's application of the mitigation hierarchy and offsets approach. The policy framework and BHP Billiton Iron Ore's consideration of the policy is provided below:</p> <ul style="list-style-type: none"> BHP Billiton Iron Ore's mitigation hierarchy focuses on avoidance and minimisation of impacts prior to any offset approach being considered. <p>Environmental offsets will be applied within a framework of adaptive management, which is integral to the management framework as detailed in Section 11.8.4 of this PER.</p>	<ul style="list-style-type: none"> Offsets – Section 11.8
Landforms	<i>Environmental Protection Bulletin 23: Guidance on the EPA Landforms Factor</i> (EPA, 2015a).	The purpose of this bulletin is to communicate how the landform environmental factor is considered by the EPA in the EIA process. This bulletin aims to provide proponents with some high-level guidance on the EPA's objective for the landforms factor to consider when developing their proposal or scheme.	The high-level guidance provided in this bulletin has been considered during the preparation of the Proposal and the Mining Area C Mine Closure Plan (Appendix 12).	<ul style="list-style-type: none"> Landforms – Section 12.1

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
Terrestrial Environmental Quality	<i>Environmental Protection (Unauthorised Discharges) Regulations 2004 (WA).</i>	These regulations make it an offence to discharge prohibited materials without approval. Prohibited materials listed in Schedule 1 include a range of liquid solutions, such as acids, alkalis, hydrocarbons, sewage and solutions containing heavy metals. Prohibited materials listed in Schedule 2 include a range of materials, such as rubber, tyres, plastic and timber that must not be burnt so as to discharge visible smoke into the environment.	BHP Billiton Iron Ore will comply with these Regulations in relation to the discharge of prohibited materials in relation to this Proposal.	<ul style="list-style-type: none"> • Terrestrial environmental quality – Section 12.2
Terrestrial Environmental Quality	<i>Global Acid Rock Drainage Guide (GARD Guide). International Network for Acid Prevention, 2010.</i>	<p>The GARD Guide deals with the prediction, prevention and management of drainage produced from sulphide mineral oxidation, often termed “acid rock drainage” (ARD). It also addresses metal leaching caused by sulphide mineral oxidation.</p> <p>The GARD Guide is intended as a state-of-the-art summary of the best practices and technology to assist mine operators and regulators to address issues related to sulphide mineral oxidation.</p>	The Guide has informed BHP Billiton Iron Ore’s Rehabilitation and Decommissioning Approach (Section 11.7).	<ul style="list-style-type: none"> • Terrestrial environmental quality – Section 12.2
Terrestrial Environmental Quality	<i>Australian Water Guidelines for Fresh and Marine Waters (ANZECC/ARMCANZ, 2000) and its updates.</i>	The aim of the ANZECC 2000 Guidelines is to provide authoritative guidance on fresh and marine water quality management issues in both New Zealand and Australia. Basic	The Guide has informed BHP Billiton Iron Ore’s Rehabilitation and Decommissioning Approach (Section 11.7) as well as management of hydrological resources (Section 11.4).	<ul style="list-style-type: none"> • Terrestrial environmental quality – Section 12.2 • Hydrological processes - Section 11.4

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
		sediment quality information is also included. The document is a part of Australia's National Water Quality Management Strategy which provides a national approach for achieving sustainable use of Australia's water resources by protecting and enhancing water quality while maintaining economic and social development.		
Air Quality and Atmospheric Gases; Amenity.	<i>Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses</i> (EPA, 2005a).	This guidance statement provides generic guidance on separation distances (buffers) with a focus on protecting sensitive land uses from unacceptable impacts on amenity, with considerations that should be addressed in the absence of adequate site-specific studies and modelling of emissions.	This guidance statement provides guidance where site-specific studies and modelling has not taken place. Modelling of air emissions has been undertaken for the PER, with verification via site-specific measurements. As the air model has determined the likely received levels, the separation distance guidance is applicable as a conceptual planning tool only. Modelling of particulate emissions and site-specific photomontage analysis has been undertaken as part of the amenity factor assessment. The visual assessment has assessed the likely visual amenity impact; thus, the separation distance guidance is applicable as a conceptual planning tool only in relation to amenity.	<ul style="list-style-type: none"> • Air quality and atmospheric gases – Section 12.3 • Amenity – Section 12.4
Air Quality and Atmospheric Gases	<i>A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other</i>	This guideline requires preparation of a plan for the management of dust and associated contaminants arising from clearing and mining activities.	In line with Section 12.3 of the PER, the current operations at Mining Area C currently have an active site-based management plan for air quality, which will be used for management of dust for the Southern Flank satellite orebody.	<ul style="list-style-type: none"> • Air quality and atmospheric gases – Section 12.3

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
	<i>Related Activities</i> (DEC, 2011).			
Air Quality and Atmospheric Gases	<i>Environmental Protection Bulletin No. 24: Greenhouse Gas Emissions and Consideration of Projected Climate Change Impacts in the EIA Process</i> (EPA, 2015b).	This bulletin requires the identification and greenhouse gas emissions, the facility to be designed to maximise energy efficiency and minimise greenhouse gas emissions and analysis of greenhouse gas intensity of the facility and how it compares to published literature.	The predicted greenhouse gas emissions for this Proposal have been presented and compared with literature. The design of the Proposal has taken into account energy efficiency, and climate change implications are part of BHP Billiton Iron Ore's standard business planning processes.	<ul style="list-style-type: none"> • Air quality and atmospheric gases – Section 12.3
Air Quality and Atmospheric Gases	<i>National Greenhouse Accounts (NGA) Factors</i> (Commonwealth Department Environment, 2015).	This document outlines the default factors for use in estimating greenhouse gas emissions and developing greenhouse gas inventories.	These factors have been used in the calculation of expected greenhouse gas emissions.	<ul style="list-style-type: none"> • Air quality and atmospheric gases – Section 12.3
Amenity	<i>Guidance Statement No. 33: Environmental Guidance for Planning and Development</i> (EPA, 2008).	This guidance statement provides information to developers to assist in land use planning to protect, conserve and enhance the environment during planning, with particular guidance outlined for biophysical, pollution and social elements of planning.	The guidance has been used to describe the attributes and values of the land in and surrounding the Proposal area. The guidance has been used to inform the visual impact assessment undertaken for this Proposal.	<ul style="list-style-type: none"> • Amenity – Section 12.4
Human Health	<i>EAG 13: Consideration of Environmental Impacts from Noise</i> (EPA, 2014b).	This guidance statement provides guidance on predicting whether noise emissions may cause significant environmental impacts and on provision of regulatory standards for noise.	The regulatory standards set by this guidance statement were used in the noise impact assessment (Appendix 11) to determine any potential environmental impacts from noise. In particular, the screening procedure in Appendix 1 of the guidance statement was used to determine that a detailed noise assessment should be undertaken.	<ul style="list-style-type: none"> • Human Health – Section 12.5

Factor/area	State Legislation, Policy and Guidance	Considerations	Proposal Relevance	Section in this Document Sections
Human Health	<i>Environmental Protection (Noise) Regulations 1997.</i>	Regulation 8 of these regulations outlines how to determine the assigned levels that must be complied with under Regulation 7. These assigned levels are used to determine the significance of impacts.	The regulatory standards set by Regulation 7 of these regulations were used in the noise impact assessment (Appendix 11) to determine the relevant assigned noise level for assessment of the potential impacts from noise.	<ul style="list-style-type: none">• Human Health – Section 12.5

7.4 Principles of ecologically sustainable development

The concept of sustainable development came to prominence at the World Commission on Environment and Development (WCED) in the report entitled *Our Common Future*, which defined sustainable development as (WCED, 1987):

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

In recognition of the importance of sustainable development, the Commonwealth Government developed a National Strategy for Ecologically Sustainable Development (Commonwealth of Australia, 1992) that defines ecologically sustainable development as:

Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

The principles of ecologically sustainable development are incorporated into the EP Act. These principles are:

- The Precautionary Principle;
- The Principle of Intergenerational Equity;
- The Principle of the Conservation of Biological Diversity and Ecological Integrity;
- Principles in relation to Improved Valuation, Pricing and Incentive Mechanisms; and
- The Principle of Waste Minimisation.

Table 8 provides a summary of how BHP Billiton Iron Ore has considered the principles of ecologically sustainable development for the Proposal.

Table 8: Consideration of the principles of ecologically sustainable development

OEPA Principle	Description in EP Act	Relevant Yes/No	If Yes, Consideration
Precautionary Principle	<p>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by:</p> <ul style="list-style-type: none"> • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • An assessment of the risk-weighted consequences of various options. 	Yes	<p>Biological surveys, EIAs and application of the mitigation hierarchy have been carried out in line with the precautionary principle. Specialist technical impact assessments have been carried out to assess potential impacts and propose potential management strategies. Where information is not available this has been noted. As a result, BHP Billiton Iron Ore has carefully evaluated all environmental impacts in this PER. Where the potential for serious or irreversible damage was identified, mitigation measures, including avoiding impacts where practical, have been applied and a precautionary approach taken when residual risk is uncertain.</p>

OEPA Principle	Description in EP Act	Relevant Yes/No	If Yes, Consideration
Inter-generational Equity	The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Yes	BHP Billiton Iron Ore has prepared a credible EIA to inform the environmental assessment process. Regional datasets have been used to assess impacts to health, diversity and productivity of the environment surrounding the Proposal. Mine closure technical studies and modelling have been carried out to inform this impact assessment and a Mine Closure Plan developed to ensure the Proposal is closed in a manner to ensure that the health, diversity and productivity of the environment is maintained for future generations. Where, residual impacts were identified following mitigation offsets are proposed.
Conservation of Biological Diversity and Ecological Integrity	Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Yes	Baseline biological surveys have been completed. Technical impact assessments have been completed to determine potential impacts to biological diversity. Management measures, including adaptive management, have been proposed to mitigate biodiversity and ecological impacts associated with implementation of the Proposal. Management measures and closure objectives are developed to ensure conservation of biological diversity.
Improved Valuation, Pricing and Incentive Mechanisms	<p>Environmental factors should be included in the valuation of assets and services.</p> <p>The polluter pays principle - those who generate pollution and waste should bear the cost of containment, avoidance or abatement.</p> <p>The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.</p> <p>Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.</p>	Yes	<p>Environmental factors have been considered throughout the development of this Proposal. Specialist technical studies have been carried out to optimise the mine design so as to minimise environmental impacts and to inform detailed environmental impact evaluations and management measures that aim to minimise pollution and waste.</p> <p>BHP Billiton Iron Ore will seek a Part V operating licence that will ensure that when or if pollution is generated that is paid for in line with legislation.</p> <p>BHP Billiton has regular, open and honest engagement with our stakeholders helps us to identify, understand and prioritise the sustainability issues and opportunities that matter most to our stakeholders</p>

OEPA Principle	Description in EP Act	Relevant Yes/No	If Yes, Consideration
			and to our business. BHP Billiton has identified measurable sustainability targets for these material sustainability issues and undertake an annual cycle of identification, prioritisation, validation and review of these issues and targets. The target and progress against these targets are reported in the annual Sustainability Report. The Proposals predicted impacts, including emissions, will form part of the reporting against these BHP Billiton Sustainability Targets.
Waste Minimisation	All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Yes	Standard waste management measures are a key element for the implementation of this Proposal. It is standard practice for the Proponent to apply the waste management hierarchy (i.e. avoid, reduce, reuse, recycle, recover, treat, contain and dispose) to all sites, and this will be the case in relation to this Proposal.

7.5 Principles of environmental impact assessment

The principles of EIA are outlined in the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012* (EPA, 2012b), as follows:

- 1) Consult with all stakeholders, including the EPA, decision-making authorities, other relevant government agencies and the local community as early as possible in the planning of their proposal, during the environmental review and assessment of their proposal, and where necessary during the life of the project. BHP Billiton Iron Ore undertakes regular consultation with stakeholders and has commenced consultation specific to this Proposal (see Section 4).
- 2) Ensure the public is provided with sufficient information relevant to the EIA of a proposal to be able to make informed comment, prior to the EPA completing the assessment report. BHP Billiton Iron Ore will release this PER document once it is approved for release by the OEPA as outlined in the EIA process in Figure 10.
- 3) Use best practicable measures and genuine evaluation of options or alternatives in locating, planning and designing their proposal to mitigate detrimental environmental impacts and to facilitate positive environmental outcomes and a continuous improvement approach to environmental management. BHP Billiton Iron Ore has assessed alternatives, optimised mine design and applied the mitigation hierarchy as outlined in Sections 3, 10 and 11.
- 4) Identify the environmental factors likely to be impacted and the aspects likely to cause impacts in the early stages of planning for their proposal. The onus is on the proponent through the EIA process to demonstrate that the unavoidable impacts will meet the EPA objectives for environmental factors and therefore their proposal is environmentally acceptable. BHP Billiton Iron Ore will address this principle via this PER document and the OEPA ESD provides details to address this principle.

- 5) Consider the following, during project planning and discussions with the EPA, regarding the form, content and timing of their environmental review:
- a) The activities, investigations (and consequent authorisations) required to undertake the environmental review. BHP Billiton Iron Ore addressed this during pre-referral consultation and via the ESD.
 - b) The efficacy of the investigations to produce sound scientific baseline data about the receiving environment. All investigations/impact assessments and surveys have been carried out in accordance with EPA guidelines. BHP Billiton Iron Ore has operating in the Pilbara are for 50 years and during this time has gathered an extensive regional data sets on which the EIAs were based offering a high degree of confidence in impact assessments. Data have been gathered by qualified and relevant personnel and has shown to be (via independent review and use by regulating agencies) to be scientifically robust. Where residual impacts have been assessed as significant for this Proposal the application of the mitigation hierarchy based on a robust scientific methodology has resulted in a reduction of potential impacts to a level BHP Billiton Iron Ore considers reasonable.
 - c) The documentation and reporting of investigations. This PER document addresses this principle.
 - d) The likely timeframes in which to complete the environmental review; and use best endeavours to meet assessment timelines. BHP Billiton Iron Ore has agreed timelines for completing the impact assessment process via acceptance of the ESD and to date has maintained this timeline.
- 6) Identify in their environmental review, subject to the EPA's guidance:
- a) Best practicable measures to avoid, where possible, and otherwise minimise, rectify, reduce, monitor and manage impacts on the environment. BHP Billiton Iron Ore has detailed measures for relevant environmental factors in Sections 11 and 12.
 - b) Responsible corporate environmental policies, strategies and management practices, which demonstrate how the Proposal can be implemented to meet the EPA's environmental objectives for environmental factors. Management practices are outlined for each factor in Sections 11 and 12. Corporate policies and strategies are summarised in Section 10.

BHP Billiton Iron Ore has taken these principles of EIA into consideration throughout the Proposal planning, impact assessments, consultation and development of the PER document.

Page intentionally blank

8. Environmental studies and survey effort

BHP Billiton Iron Ore has carried out an evaluation of potential impacts of the Proposal, taking into consideration all relevant factors identified by *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a). The outcomes of this evaluation, along with pre-referral consultation with the OEPA, has driven all technical EIA studies that have recently been carried out. Particular focus has been given to those preliminary key environmental factors identified as likely to receive the greatest potential impacts from the Proposal.

BHP Billiton Iron Ore has undertaken extensive baseline studies within the Proposed Mining Area C Development Envelope and surrounds and information from these studies has informed impact assessments undertaken for this Proposal. All surveys were undertaken in accordance with relevant EPA guidelines at the time of survey. This comprehensive baseline has informed targeted surveys to address ecological knowledge gaps and changes in conservation status or survey guidelines. In summary, there have been 22 flora and vegetation surveys, 21 terrestrial vertebrate fauna surveys and eight SRE invertebrate fauna surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope. Many of these surveys overlap areas, enabling the review of previous results and the capture of baseline biodiversity data over an extended period. Species observations from all surveys are maintained within the BHP Billiton Iron Ore biodiversity data set, quality checked and assured on a regular basis consistent with changing taxonomy, and conservation status. Almost 2,750 troglofauna samples have been collected within the Proposed Mining Area C Development Envelope, and almost 1,300 stygofauna samples have been collected from groundwater catchments in which it occurs. The surveys are summarised in the EIAs and supporting documents provided in Appendix 4 – Appendix 11.

An overview of the impact assessment studies specifically undertaken for the Proposal is presented in Table 9 (noting that this is a subset of those listed above). The EIAs undertaken for the Proposal have been developed primarily using data collected by or on behalf of BHP Billiton Iron Ore. Information on species' ecology and distribution has been supplemented by published species accounts and data available in the public domain and is considered accurate at the time of writing. Results from further studies may differ from those presented in this PER document, and BHP Billiton Iron Ore will continue to review information on Pilbara species as part of its adaptive management approach.

The cumulative EIAs undertaken for this Proposal relied on the data from a number of sources. The accuracy of the data not collected on behalf of BHP Billiton Iron Ore has not been verified; and unless there is evidence to the contrary, it has been assumed that it is accurate and collected in accordance with standard industry guidelines. BHP Billiton Iron Ore has made every effort to obtain relevant information and data available in the public domain at the time of referral but acknowledges that some information may have inadvertently been excluded.

Of note is that the validation of the conceptual groundwater model was limited due to lack of accessibility to monitoring points and datasets within the modelling domain and, in some cases, was limited to historic information only. Assumptions have been made about the influence of geology on groundwater where detailed data were not available.

The majority of data on Pilbara species were sourced from biological surveys undertaken for impact assessments undertaken in relation to mining environmental approvals. Therefore, there will be a bias towards the occurrence of species found on mining and exploration tenements. Biological surveys only provide a snapshot of the biological communities present at the time of survey; the absence of a record may not necessarily indicate that a species does not or will not occur within the survey area. This is unlikely to be a limitation for information within the Proposed Mining Area C Development Envelope as

a considerable amount of biological survey work has been undertaken over a 20-year period; however, it restricts the ability to undertake a comprehensive cumulative impact assessment.

Mine planning and design are iterative processes that are subject to change over time as more information becomes available from exploration or operational activities. The EIAs that are presented in this PER were based on mine plans available prior to July 2016. For this reason, the impact assessment information is presented for both the Indicative Additional Impact Assessment Area and the Additional Development Envelope to allow for movement of pits, OSAs and infrastructure within the Proposed Mining Area C Development Envelope.

Impact assessments were undertaken based on EPA guidance documents and legislation published and current at the time of referral. The EPA checklist has been completed for terrestrial biodiversity issues in line with the ESD and is provided in Appendix 3.

Table 9: Summary of impact assessment studies undertaken for the Proposal

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
Flora and vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained	<i>Mining Area C – Southern Flank Flora and Vegetation Environmental Impact Assessment</i> (Appendix 4).	This EIA study was carried out to review potential impacts on flora and vegetation arising from implementation of the Proposal and considered data collected during 22 flora and vegetation surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope. Data available from regional studies and information in publicly available databases were also considered.	<p><i>EPA Guidance Statement 51. Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia</i> (EPA, 2004a).</p> <p><i>EPA Position Statement 2. Environmental Protection of Native Vegetation in Western Australia</i> (EPA, 2000a).</p> <p><i>EPA Position Statement 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection</i> (EPA 2002)</p> <p><i>Technical Guide - Flora and Vegetation Surveys for Environmental Impact Assessment</i> (EPA & DPaW, 2015).</p>
		<i>Flora and vegetation survey – Area C and Surrounds</i> (Onshore Environmental, 2011) (Appendix 4).	This was a Level 2 Flora and Vegetation Survey undertaken in the Northern Flank and eastern areas of Mining area C. This report consolidates information from previous surveys undertaken at Mining Area C.	
		<i>Level 2 Flora and Vegetation Survey South Flank</i> (Onshore Environmental, 2012) (Appendix 4).	This was a Level 2 Flora and Vegetation Survey undertaken in the Southern Flank area.	
		<i>Mining Area C Flora and Vegetation Environmental Impact Assessment</i> . (Onshore Environmental, 2015) (Appendix 4).	This EIA study was carried out to review potential impacts on flora and vegetation arising from mining within all deposits at Mining Area C. The document considered data from all surveys undertaken within the development envelope and surrounding areas, plus information available in public databases.	
		<i>Coondewanna Flats Ecohydrological Study: Ecological Water Requirements of</i>	This study was undertaken to determine the ecological water requirement of vegetation as part of BHP Billiton Iron Ore's eco-hydrogeological investigation of the Coondewanna Flats (the Flats), located southwest of Mining Area C. The purpose	

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<i>Vegetation Report</i> (Astron Environmental, 2014).	of this work was to determine the eco-hydrological function of priority ecological communities (PECs) in order to inform ongoing management and monitoring of the Flats. The aim of management is to ensure the long term persistence of PECs at the Flats in response to changes in surface water and groundwater regimes associated with surrounding mining activities.	
Terrestrial fauna (including short-range endemics)	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained	<i>Mining Area C Southern Flank Environmental Impact Assessment for Ghost Bat (Macroderma gigas)</i> (Biologic, 2016b) (Appendix 5).	This study was an EIA of potential impacts to the ghost bat arising from implementation of the Proposal. The study considered work undertaken for BHP Billiton Iron Ore on ghost bat distribution, diet and cave attributes between 2011 and 2015 and the results from additional studies in 2015 and 2016 (Biologic, 2016b, below).	<p><i>EPA Position Statement No. 3. Terrestrial Biological Surveys as an Element of Biodiversity Protection</i> (EPA, 2002a).</p> <p><i>EPA Guidance Statement No. 56. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia</i> (EPA, 2004b).</p> <p><i>Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.</i> (EPA and DEC, 2010).</p>
		<i>Hamersley Range Ghost Bat Population Study 2015/2016.</i> (Biologic Environmental, Survey in prep).	<p>This survey was undertaken in conjunction with the University of Queensland and Murdoch University to:</p> <ul style="list-style-type: none"> Determine the presence of pregnant females within the Additional Development Envelope and surrounding BHP Billiton Iron Ore tenure; and Determine genetic relatedness of ghost bats within the Additional Development Envelope, surrounding BHP Billiton Iron Ore tenure, and API and Fortescue Metal Group tenure located in the north-western Hamersley Range. 	
		<i>Mining Area C and Southern Flank Desktop Review of Vertebrate Fauna</i> (Biologic, 2017) (Appendix 5).	Desktop review of all terrestrial vertebrate fauna surveys undertaken within the Proposed Mining Area C Development Envelope, and including results from database searches.	

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<i>South Flank Targeted Fauna Survey</i> (Biologic, 2016c) (Appendix 5).	This survey was undertaken to determine the presence, or likely presence, of the northern quoll, Pilbara olive python and northern brushtail possum within the Southern Flank area.	
		<i>Southern Flank Vertebrate Fauna Study</i> (Biologic, 2011) (Appendix 5).	Level 2 vertebrate fauna survey undertaken within the Southern Flank area.	
		<i>South Flank 2010 Bat Survey Report</i> (BatCall WA, 2011) (Appendix 5).	Targeted survey for conservation significant bat species within the Southern Flank area.	
		<i>Southern Flank Targeted Northern Quoll Survey</i> (Biologic, 2013) (Appendix 5).	This survey was undertaken to determine the presence of the northern quoll within the Southern Flank area. The survey employed survey techniques and survey effort that was consistent with DSEWPaC guidelines.	<i>EPBC Act referral guidelines for the endangered northern quoll, <u>Dasyurus hallucatus</u></i> (DSEWPaC, 2011).
		<i>Mining Area C – Southern Flank Environmental Impact Assessment of Short-range Endemic Fauna</i> (Biologic, 2016a) (Appendix 5).	This study was an EIA of potential impacts to terrestrial invertebrate fauna arising from implementation of the Proposal.	<i>EPA Position Statement No. 3. Terrestrial Biological Surveys as an Element of Biodiversity Protection</i> (EPA, 2002a). <i>EPA Guidance Statement No. 56. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia</i> (EPA, 2004b).
		<i>South Flank Baseline and Targeted SRE Fauna Survey</i> (Biologic, 2016d) (Appendix 5).	This study was undertaken to: <ul style="list-style-type: none"> • Address sampling gaps from the baseline studies; • Complete habitat assessment across the Proposed Mining Area C Development Envelope and surrounds; and 	<i>EPA Guidance Statement No. 20. Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia</i> (EPA, 2009).

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
			Determine the extent of habitat and population of the millipede <i>Antichiropus</i> 'DIP007'.	
		<i>Short Range Endemic Invertebrate Fauna Survey – South Flank</i> (Biota, 2011) (Appendix 5).	Level 2 baseline survey of short-range endemic invertebrate fauna within the Southern Flank area.	
		<i>South Flank Targeted Millipede Survey</i> (Biota, 2013) (Appendix 5).	Targeted survey for short-range endemic <i>Antichiropus</i> millipede within the Southern Flank area and surrounds.	
		<i>Mining Area C – Life of Project Environmental Management Plan Revision 6 Environmental Impact Assessment of Short-range Endemic Invertebrates</i> (Biologic, 2015a) (Appendix 5).	This EIA study was carried out to review potential impacts on terrestrial invertebrate SREs arising from mining within all deposits at Mining Area C. The document considered data from all surveys undertaken within the development envelope and surrounding areas, plus information available in public databases.	
		<i>Mining Area C Vertebrate Fauna Environmental Impact Assessment</i> (Biota, 2015a) (Appendix 5).	This EIA study was carried out to review potential impacts on terrestrial vertebrate fauna arising from mining within all deposits at Mining Area C. The document considered data from all surveys undertaken within the development envelope and surrounding areas, plus information available in public databases.	
Subterranean fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained	<i>Mining Area C, Southern Flank: Troglifauna Assessment</i> (Bennelongia 2016a) (Appendix 6).	This EIA study was carried out to review impacts of implementation of the Proposal on troglifauna, considering the results of almost 2,750 samples collected within the Proposed Mining Area C Development Envelope and a troglifauna habitat assessment undertaken by BHP Billiton Iron Ore (BHP Billiton Iron Ore, 2016h).	<i>EPA EAG 12. Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia</i> (EPA, 2013d). <i>EPA Guidance Statement No. 54a. Sampling Methods and Survey Considerations for</i>

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<i>Mining Area C, Southern Flank Stygofauna Assessment (Bennelongia, 2016b) (Appendix 6).</i>	This EIA study was carried out to review impacts of implementation of the Proposal on stygofauna, considering the results of more than 1,000 samples within the Groundwater Assessment Area. The Groundwater Assessment Area was considered to be any additional areas that were modelled to experience groundwater drawdown of 2 m or more as a result of the Proposal.	<i>Subterranean Fauna in Western Australia</i> (EPA, 2007).
		<i>Southern Flank Troglifauna Assessment (Bennelongia, 2016c).</i>	Troglifauna sampling undertaken between March and May 2016 to determine distribution of potentially restricted species.	
		<i>Southern Flank Stygofauna Assessment (Bennelongia, 2016d).</i>	Stygofauna sampling undertaken between July and September 2016 to determine distribution of potentially restricted species.	
		<i>South Flank Troglifauna Habitat Assessment (BHP Billiton Iron Ore, 2016h).</i>	A geological review of subterranean fauna habitats to determine the known and inferred extent of potential troglifauna habitats in relation to likely pit areas within the Indicative Additional Impact Assessment Area.	
		<i>Addendum for Modified Boundary: Mining Area C and Southern Flank Troglifauna Environmental Impact Assessment (Bennelongia, 2016e).</i>	Review of impacts to troglifauna if the Modified Additional Impact Assessment Area was adopted.	
		<i>Addendum based on Updated Habitat Assessment: Mining Area C and Southern Flank Troglifauna Environmental Impact</i>	Review of impacts to troglifauna considering outcomes of updated habitat assessment and considering restriction of impacts to proposed pit shell areas.	

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<p><i>Assessment</i> (Bennelongia, 2017).</p> <p><i>Mining Area C, Life of Project: Troglifauna Assessment</i> (Bennelongia, 2015a).</p> <p><i>Mining Area C, Life of Project: Stygofauna Assessment</i> (Bennelongia, 2015b).</p>	<p>This EIA study was carried out to review potential impacts troglifauna arising from mining within all deposits at Mining Area C. The document considered data from all surveys undertaken within the development envelope and surrounding areas, plus information available in public databases.</p> <p>This EIA study was carried out to review potential impacts stygofauna arising from mining within all deposits at Mining Area C. The document considered data from all surveys undertaken within the development envelope and surrounding areas, plus information available in public databases.</p>	
Hydrological processes	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected	<i>Mining Area C Revised Proposal Surface Water Impact Assessment</i> (MWH, 2016).	<p>This study was undertaken in 2016.</p> <p>The study included an EIA review of potential impacts to surface water (during operations and post closure) of the Proposal.</p>	<p><i>Operational Policy No. 1.02 Policy on Water Conservation/Efficiency Plans</i> (DoW, 2009).</p> <p><i>Pilbara Regional Water Plan 2010-2030</i> (DoW, 2010).</p> <p><i>Operational Policy No. 5.08 Use of Operating Strategies in the Water Licensing Process</i> (DoW, 2011).</p> <p><i>Western Australia Water in Mining Guideline</i> (DoW, 2013b).</p> <p><i>Pilbara Groundwater Allocation Plan</i> (DoW, 2013c).</p> <p><i>Pilbara Regional Water Supply Strategy: a Long-Term Outlook of Water Demand and Supply</i> (DoW, 2013a).</p> <p><i>Use of Mine Dewatering Surplus</i> (DoW, 2013d).</p>

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<i>Hydrogeological Impact Assessment and Water Management Summary</i> (BHP Billiton Iron Ore, 2016a).	The assessment area encompassed the three identified environmental receptors in the area – Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis – and also included cumulative impact predictions and closure. This report summarises the outcomes of the modelling and impact assessment (during operations and post closure of the Proposal) undertaken by BHP Billiton Iron Ore in 2016.	As above plus <i>Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area. Advice of the EPA to the Minister for Environment under Section 16(e) of the EP Act. EPA Report 1484. Perth, Western Australia. (EPA, 2013c).</i> Limitations associated with the model include: <ul style="list-style-type: none"> Assumptions in the 2016 mine plan (i.e. rate, sequence, timing and depth of pushbacks). Assumptions in closure settings (particularly backfill properties and evaporation rates). Consultation with DoW as per details provided in Section 4.
		<i>Coondewanna Flats Phase III Water Assessment</i> (URS, 2014).	The scope of this study was developed in consultation with Astron Environmental (2014a). This report presents the results and preliminary interpretations of hydrogeological data collected during site investigations conducted in April and May 2014. The aim of this investigation was to increase the level of knowledge of the surface water, groundwater and subsequent soil moisture in the Coondewanna Flats area.	<i>Priority Ecological Communities for Western Australia Version 21 (DPaW, 2014).</i>
		<i>Coondewanna Flats Eco-Hydrological Review and Conceptual Model</i> (AQ2, 2015).	This report combines the assessment findings of the Astron Environmental (2014a) and URS (2014) studies for the Coondewanna Flats area to develop an integrated eco-hydrological model.	
		<i>Mining Area C Environmental Management Plan Revision 6 Surface Water Assessment</i> (RPS Aquaterra, 2015).	This study was undertaken in 2014 and finalised in 2015. The study included an environmental impact assessment review of potential impacts to surface water (during operations and post closure) from the	<i>Operational Policy No.1.02 Policy on water conservation/efficiency plans</i> (DoW, 2009). <i>Pilbara Regional Water Plan 2010-2030</i> (DoW, 2010).

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
			proposed EMP Revision 6 development at Mining Area C.	<p><i>Operational Policy No. 5.08 Use of operating Strategies in the water licensing process</i> (DoW 2011).</p> <p><i>Western Australia Water in Mining Guideline</i> (DoW 2013a).</p> <p><i>Pilbara Groundwater Allocation Plan</i>, (DoW 2013b).</p> <p><i>Pilbara Regional Water Supply Strategy: a long-term outlook of water demand and supply</i> (DoW 2013c).</p> <p><i>Use of mine dewatering surplus</i> (DoW 2013d).</p>
		<i>Hydrogeological Assessment for Mining Area C</i> (RPS Aquaterra, 2014).	This groundwater modelling and assessment was completed in 2014. The assessment area encompassed the three identified environmental receptors in the area: Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis and also included cumulative impact predictions and closure.	<p>As above.</p> <p>Limitations associated with the model include:</p> <ul style="list-style-type: none"> Assumptions in the 2014 mine plan (i.e. rate, sequence, timing and depth of pushbacks). Assumptions in closure settings (particularly backfill properties and evaporation rates).
		<i>Mining Area C Hydrological Impact Assessment and Water Management Summary</i> (BHP Billiton Iron Ore, 2016a).	This report summarises the outcomes of the modelling and impact assessment (during operations and post closure) undertaken by RPS Aquaterra in 2014.	As above.
Inland waters environmental quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental	<i>Mining Area C Revised Proposal Surface Water Impact Assessment</i> (MWH, 2016).	<p>This study was undertaken in 2016.</p> <p>The study included an EIA review of potential impacts to surface water (during operations and post closure) of the implementation of the Proposal.</p>	<p><i>Water Quality Protection Guidelines – Mining and Mineral Processing</i> (DoW, 2000)</p> <p>Limitation: This report was carried out based on the mine plan at the time the report was commissioned. As the mine plan evolves, surface water infrastructure will be revised and updated as required.</p>

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
	values, ecological, social, protected. both and are	<i>Hydrogeological Impact Assessment and Water Management Summary</i> (BHP Billiton Iron Ore, 2016a).	The assessment area encompassed the three identified environmental receptors in the area – Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis – and also included cumulative impact predictions and closure. This report summarises the outcomes of the modelling and impact assessment (during operations and post closure of the Proposal) undertaken by BHP Billiton Iron Ore in 2016	As above. Limitations associated with the model include: <ul style="list-style-type: none"> Assumptions in the 2016 mine plan (i.e. rate, sequence, timing and depth of pushbacks). Assumptions in closure settings (particularly backfill properties and evaporation rates). Consultation with DoW as per details provided in Section 4.
		<i>Mining Area C Environmental Management Plan Revision 6 Surface Water Assessment</i> (RPS Aquaterra, 2015).	This study was completed in 2014. This was a desktop environmental impact assessment review of potential impacts to surface water (during operations and post closure) from the proposed EMP Revision 6 development at Mining Area C.	As above. Limitation: This report was carried out based on the mine plan at the time the report was commissioned. As the mine plan evolves, surface water infrastructure will be revised and updated as required.
		<i>Hydrogeological Assessment for Mining Area C</i> (RPS Aquaterra, 2014).	This groundwater modelling and assessment was completed in 2014. The assessment area encompassed the three identified environmental receptors in the area: Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis and also included cumulative impact predictions and closure.	Limitations associated with the model include: <ul style="list-style-type: none"> Assumptions in the 2014 mine plan (i.e. rate, sequence, timing and depth of pits). Assumptions in closure settings (particularly backfill properties and evaporation rates).
		<i>Mining Area C Hydrological Impact Assessment and Water Management Summary</i> (BHP Billiton Iron Ore, 2016a).	This report summarises the outcomes of the modelling and impact assessment (during operations and post closure) undertaken by RPS Aquaterra in 2014.	As above.
Heritage	To ensure that historical and cultural associations are not adversely affected.	A number of archaeological and ethnographical surveys have been carried out.	Surveys have covered the Proposed Mining Area C Development Envelope.	<i>EPA Guidance Statement No. 41. Assessment of Aboriginal Heritage</i> (EPA, 2004d). Consultation with the Traditional Owners (Banjima and Nyiyaparli people, as per details provided in Section 4.

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
Rehabilitation and decommissioning closure (integrating factor)	To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.	<i>South Flank Iron Ore Project – Soil and Landform Assessment</i> (Outback Ecology, 2012a)	This study was completed in 2012. The study was commissioned to undertake a soil and landform survey of the indicative disturbance area of the Proposal to provide baseline information and assist in the planning of soil resource management and future rehabilitation activities.	<i>Guidelines for Mining Proposals in Western Australia</i> (DMP, 2016b). <i>Environmental Protection Bulletin No. 23: Guidance on the EPA's Landforms Factor</i> <i>Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems</i> (EPA, 2006) Limitation: Assessment of AMD risk is based on material classification taken from resource or mining models produced by BHP Billiton Iron Ore. AMD classification within resource models is based on geochemical assays of drill-hole data.
		<i>South Flank Preliminary AMD Risk Assessment</i> (BHP Billiton Iron Ore, 2016b)	This risk assessment was completed in 2016 and assessed the risk of AMD generation at all deposits at Southern Flank. The assessment focussed on source, pathways and receptors.	
		<i>Mining Area C Acid and Metalliferous Drainage Risk Assessment</i> (Klohn Crippen Berger, 2014).	This study was completed in 2014 and reviewed the potential impacts to key environmental receptors from potentially acid-forming materials (during operations and post closure) within the Mining Area C deposits.	
		<i>Mining Area C Baseline Soil and Landform Survey and Impact Assessment</i> (MWH Australia, 2015).	This baseline survey was undertaken in 2014. The report incorporates the results of the 2011 survey (Outback Ecology 2012).	The soil surveys were conducted in accordance with the Western Australia (WA) Department of Mines and Petroleum (DMP), formerly the WA Department of Industry and Resources (DoIR), <i>Guidelines for Mining Proposals in Western Australia</i> (DoIR 2006).
		<i>Mining Area C Assessment Study Area Soil and Landform Assessment</i> (Outback Ecology, 2012b).	This baseline survey was completed in 2011 and covered part of the proposed EMP Revision 6 development area.	
Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms.	<i>South Flank Preliminary AMD Risk Assessment</i> (BHP Billiton Iron Ore, 2016b).	This risk assessment was completed in 2016 and assessed the risk of AMD generation at all deposits at Southern Flank. The assessment focussed on source, pathways and receptors. This study was completed in 2012.	<i>Guidelines for Mining Proposals in Western Australia</i> (DMP, 2016b). <i>Environmental Protection Bulletin No. 23 –: Guidance on the EPA's Landforms Factor.</i>

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
		<i>South Flank Iron Ore Project – Soil and Landform Assessment</i> (Outback Ecology, 2012).	This study was completed in 2012. The study was commissioned to undertake a soil and landform survey of the indicative disturbance area of the Proposal to provide baseline information and assist in the planning of soil resource management and future rehabilitation activities. This baseline survey was completed in 2011 and covered the majority of the Additional Development Envelope.	<i>Guidance Statement No. 6 –: Rehabilitation of Terrestrial Ecosystems</i> (EPA, 2006) Limitation: Assessment of AMD risk is based on material classification taken from resource/ or mining models produced by BHP Billiton Iron Ore. AMD classification within resource models are based on geochemical assays of drill hole data.
		<i>Area C EMP Revision 6 Landscape and Visual Impact Assessment</i> (Urbis, 2015).	This study was completed in January 2015. The study included data captured from pre-determined vantage points in the vicinity of Mining Area C. It also utilised modelling to assess the impact (during operations and post closure) on viewsheds and landscape character types in the Pilbara region.	
Terrestrial environmental quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.	<i>South Flank Preliminary AMD Risk Assessment</i> (BHP Billiton Iron Ore, 2016b).	This risk assessment was completed in 2016 and assessed the risk of AMD generation at all deposits at Southern Flank. The assessment focussed on source, pathways and receptors.	Commonwealth Department of Industry, Tourism and Resources [DITR] (2007) <i>Leading Practice Sustainable Development Program for the Mining Industry - Managing Acid and Metalliferous Drainage</i> . International Network for Acid Prevention (2012) <i>Global Acid Rock Drainage Guide</i> (GARD Guide). Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000), <i>Australian Water Guidelines for Fresh and Marine Waters</i> (and its updates). Limitation: Assessment of AMD risk is based on material classification taken from resource/ or mining models produced by BHP Billiton Iron Ore.
		<i>Mining Area C Preliminary Acid and Metalliferous Drainage Risk Assessment</i> (Klohn Crippen Berger, 2014).	This study was completed in 2014. This study reviewed the potential impacts to key environmental receptors from potentially acid-forming materials within the Mining Area C deposits during operations and post closure.	

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
				AMD classification within resource models are based on geochemical assays of drill hole data.
Air quality (and atmospheric gases)	To maintain air quality for the protection of the environment and human health and amenity.	<i>Memorandum – Updated Air Quality Modelling for South Flank</i> (PEL, 2016) (Appendix 9).	This study was completed in 2016. The modelling was undertaken to inform an impact assessment for potential air quality impacts resulting from the Proposal.	<i>Air Quality Modelling Guidance Notes, Department of Environment, Government of Western Australia, March 2006.</i> <i>National Greenhouse Accounts (NGA) Factors</i> (Commonwealth Department of Climate Change and Energy Efficiency 2010). Limitation: Modelling was undertaken based on the mine plan current at the time of modelling. Mine planning is an iterative process, and the plan is subject to change at any time
		<i>Air Quality Assessment for Mining Area C</i> (Pacific Environment Limited, 2015).	The modelling and impact assessment was completed in 2015. This study utilised modelling to assess air quality based on current and planned dust controls at selected sensitive receptors within the regional area.	
Amenity	To ensure that impacts to amenity are reduced to as low as reasonably practicable.	<i>South Flank Project: Landscape and Visual Impact</i> (360 Environmental, 2013) <i>South Flank Project: Landscape and Visual impact (Addendum)</i> (BHP Billiton Iron Ore, 2016i) (Appendix 10).	The original study was undertaken in 2013. The impact assessment determined the potential impact of the Southern Flank mine as proposed in 2013 on visual amenity via photomontage analysis. The addendum reviewed the original impact assessment in light of the changes to mine design in 2016.	<i>EPA Guidance Statement No. 33. Environmental Guidance for Planning and Development</i> (EPA, 2008). <i>Visual Landscape Planning in Western Australia: A Manual for Evaluation, Assessment, Siting and Design</i> (DPI, 2007). Limitation: Impact assessments were undertaken based on the mine plan current at the time of assessment. Mine planning is an iterative process, and the plan is subject to change at any time.
		<i>Area C EMP Revision 6 Landscape and Visual Impact Assessment</i> (Urbis, 2015).	This study was completed in 2015. It included data captured from pre-determined vantage points in the vicinity of the proposed EMP Revision 6 development. The study also utilised modelling to assess the impact on viewsheds and landscape character types (during operations and post closure).	
Human health (noise)	To ensure that human health is	<i>South Flank Environmental Noise</i>	This study was completed in 2016.	<i>EAG 13 for the Consideration of Environmental Impacts from Noise</i> (EPA, 2014b).

Factor	EPA Objective	Survey/Investigation	Summary	Study standard, guidance and limitations
	not adversely affected.	<i>Assessment</i> Document No: 1401562-1-200 (SVT, 2016) (Appendix 11).	The study utilised modelling to assess a range of potential development scenarios and determine noise levels at selected sensitive receptors within the regional area. This was inclusive of determining noise impacts from this Proposal and cumulatively with existing operations at Mining Area C.	Limitations: The modelling was carried out based on the mine plan at the time the report was commissioned. The financial year 2038 scenario was used as a high case for assessing potential impacts.
		<i>Environmental Noise Assessment: Mining Area C</i> (SVT, 2014).	This study was completed in 2014. This study utilised modelling to assess a range of potential development scenarios and determine noise levels at selected sensitive receptors within the regional area.	As above. Limitations: The modelling was carried out based on the mine plan at the time the report was commissioned. The Financial Year 2027 scenario was used as a high case for assessing potential impacts.

Page intentionally blank

9. Identification of environmental factors

BHP Billiton Iron Ore has completed baseline studies (Table 9) and EIAs (Sections 11 and 12) to determine the potential environmental impacts and significance of the identified environmental factors against the EPA significance framework (EPA, 2013b).

9.1 Determining the environmental factors

In March 2016, BHP Billiton Iron Ore met with officers from the OEPA and discussed the results of the baseline studies, which assisted in further definition of this Proposal, the Proposed Mining Area C Development Envelope and the focus of key studies. The Environmental Scoping Document issued by the OEPA on 19 September 2016 provided an outline of preliminary key factors that are relevant to this Proposal. This PER document has been prepared in line with the ESD (OEPA, 2016).

The environmental factors, as defined in *EAG 8 for Environmental Factors and Objectives* (EAG 8) (EPA, 2013a) and EPA's Statement of Environmental Principles, Factors and Objectives (EPA, 2016), were determined and include the preliminary key environmental factors detailed in Table 10, as well as other environmental factors that were considered in relation to this assessment but are not considered to be preliminary key environmental factors (these factors are discussed in Section 11 and Section 12 respectively).

Table 10: Preliminary key and other environmental factors

EPA Environmental Factor	Relevant Aspects
Preliminary Key Environmental Factors	
Flora and Vegetation	Clearing of native vegetation, dewatering and potential alteration to surface water flows.
Terrestrial Fauna (Vertebrate Fauna including Short-range Endemics)	Clearing of habitat, dewatering, alterations and disruptions to surface water flows and pools, vehicle movement and waste disposal.
Subterranean Fauna (Stygofauna and Troglodfauna)	Excavation for mining activities. Abstraction of groundwater for mining activities.
Hydrological Processes	Surface water diversions. Dewatering of groundwater for mining activities.
Inland Waters Environmental Quality	Construction and operation of Proposal including dewatering of groundwater for mining activities, discharge of excess water, waste landforms, storage and use of hazardous materials and hydrocarbons, and waste facilities (landfill, wastewater treatment plant). Post closure aspects, such as waste landforms and pit lakes, will be addressed under the Rehabilitation and Decommissioning factor.
Heritage	Clearing of native vegetation and excavation for mining activities. Dewatering of groundwater for mining activities. Alteration to hydrological processes.
Offsets (integrating factor)	Clearing of approximately 19,671.2 ha of native vegetation in Category 1 to 4 according to <i>Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment</i> (EPA & DPaW, 2015) (equivalent to 'Good' to 'Excellent' condition or better) in the Hamersley IBRA subregion.

EPA Environmental Factor	Relevant Aspects
Other Environmental Factors	
Landforms	Alteration of the existing landforms but installation of mining landforms such as pits, OSA and infrastructure.
Terrestrial Environmental Quality	Use or exposure of potential harmful substances and generation of potential harmful waste material.
Air Quality	Particulate emissions from mobile equipment such as blasting and loading and hauling ore and from fixed plant such as crushing, screening and stockpiling ore.
Amenity	Visual amenity resulting from mine operations such as OSAs and pits.
Human Health	Noise from operation of mine infrastructure such as haul trucks, conveyors and ore crushing and screening.

9.2 Environmental impact assessment studies and review of environmental factors

Following scope definition and consultation with the OEPA, environmental impact studies were undertaken to quantify the potential environmental impacts and determine the significance of the identified environmental factors against the EPA significance framework (EPA, 2013b). This document outlines the key findings of the studies and significance determination.

For each environmental factor, the following information is provided (Sections 11 and 12):

- Context, including a concise description of the relevant environmental values.
- Environmental aspects and the potential direct and indirect impacts resulting from the Proposal.
- A description of mitigation and management measures proposed.
- The regulation process required to ensure that potential impacts are managed.
- A statement of the outcome and justification to demonstrate that the EPA's objective would be achieved.

BHP Billiton Iron Ore has applied the significance framework detailed in *EAG for Application of a Significance Framework in the Environmental Impact Assessment Process* (EPA, 2013b) during the assessment of this Proposal. The significance framework has been applied to determine the significance of both inherent and residual impacts, post application of the mitigation hierarchy. The evaluation of significance of inherent impacts informed proposed management measures and indicated where ministerial conditions may be required. The framework was then re-applied to determine significance of residual impacts to determine where offsets may apply.

BHP Billiton Iron Ore has considered the mitigation hierarchy in the *Western Australian Environmental Offsets Guidelines* (Government of Western Australia, 2014) and the EPA's bulletin *Environmental Protection Bulletin No.1: Environmental Offsets* (EPA, 2014a), which describes how the EPA will consider offsets through the EIA process. The mitigation hierarchy steps comprise:

- **Avoid:** Avoidance is the primary and preferred strategy for managing significant impacts to the environment. Avoidance directly removes the potential impact to the environment. Avoidance

of impacts may involve comprehensive planning and suitable site selection, such as altering the location of infrastructure to avoid known locations of threatened ecological communities or of sensitive habitats. BHP Billiton Iron Ore considers impact avoidance as the preferred strategy for managing significant impacts to the environment through this Proposal.

- **Minimise:** After practicable avoid measures have been considered or implemented, mitigation measures to minimise the remaining significant impacts (if any) will be investigated and implemented to reduce impacts to an acceptable level.
- **Rehabilitate:** After practicable avoid and minimise measures have been considered or implemented, rehabilitation will be applied with the aim of reducing impacts to an acceptable level.
- **Offset:** If, after the first three steps of the mitigation hierarchy have been considered and applied, it is anticipated that there would be actual or reasonably foreseeable residual significant impacts to the environment, offset measures will be proposed, and BHP Billiton Iron Ore anticipates that these would become conditions of the MS.

BHP Billiton Iron Ore considers that the potential impacts for the preliminary key environmental factors can be appropriately managed through the implementation of specific and regional management plans and the application of Ministerial conditions. The management plans that are applicable to the implementation of this Proposal include:

- Mining Area C Closure Plan (Appendix 12);
- Conditional Environmental Management Plan (to be developed); and
- CPWRMP (Appendix 7).

Page intentionally blank

10. Regional management approach

10.1 Adaptive management

Consistent with the regional management approach detailed in the recently published and released PER Strategic Proposal (BHP Billiton Iron Ore, 2016c), BHP Billiton Iron Ore uses adaptive management to enable the consideration of changing conditions and improvements in knowledge. This assists BHP Billiton Iron ore with overcoming future challenges to environmental management as results of evolving political, social and natural environments. It also provides the necessary flexibility to respond to changes in conservation significance; to the development of new technologies; and to improvements in the understanding of assets, values, species, threatening processes and impacts (e.g. climate change).

Adaptive management is a structured, iterative process of decision-making with the capacity to validate predicted impacts and to develop appropriate responses to emerging issues through monitoring of and adaptation to environmental, economic and social changes. An integral component to adaptive management is the application of the mitigation hierarchy (avoid, minimise, rehabilitate and offset).

Successful planning and execution in managing relevant environmental factors in the Pilbara requires a holistic, long-term view of broad scale of landscape focussed outcomes coupled with progressive operations-level activities. A key driver of this requirement is the regional scale and long life span of BHP Billiton Iron Ore's proposed future mining activities in the Pilbara. This driver necessitates the use of a management approach that is both regional and adaptable over time. Where possible this Proposal has evaluated potential impacts on a regional scale, however, this is somewhat limited due to the availability of granularity in regional data. Management plans that have been, or will be, developed as part of the Proposal consider outcomes and adaptive management on a regional scale, for example the CPWRMP considers management on a catchment scale.

BHP Billiton Iron Ore's adaptive management (Figure 11) uses a cycle of monitoring, reporting and implementing change where required. It allows an evaluation of the mitigation controls so that either they are progressively improved and refined or alternative solutions are adopted to ensure the outcome-based objectives are achieved. BHP Billiton Iron Ore's adaptive management is underpinned by its corporate commitments, which collectively articulate BHP Billiton Iron Ore's core values and minimum performance standards for environmental management and sustainability.

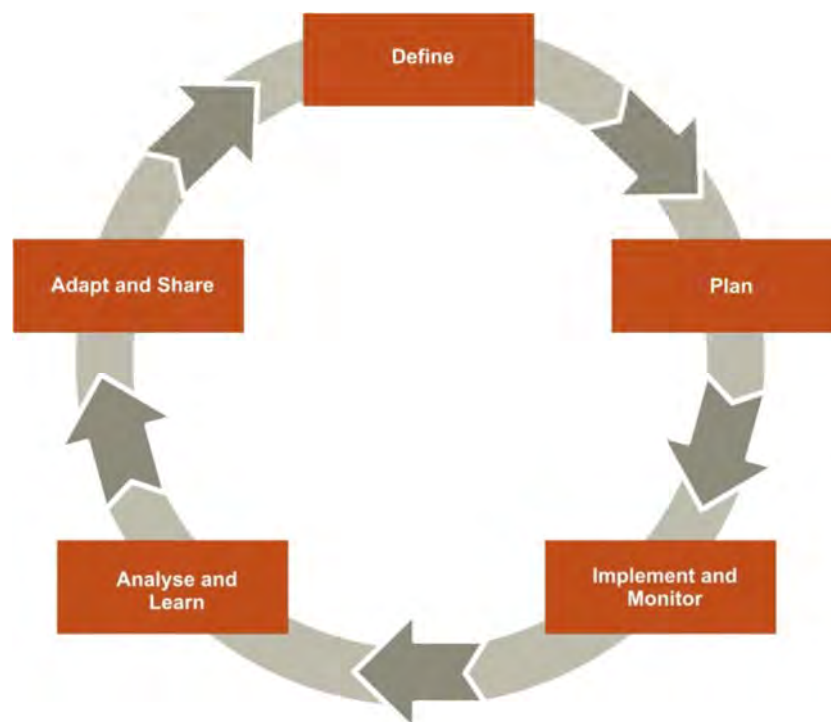


Figure 11: BHP Billiton Iron Ore's adaptive management approach

The five key steps of adaptive management are:

- **Define:** Conduct baseline and impact assessments (including cumulative impact assessments where required) to understand how the proposed operation or expansion may impact the environment (e.g. downstream impacts to environmental factors resulting from proposed mine dewatering). This information will be used to identify key risks and define acceptability criteria in accordance with BHP Billiton Iron Ore's internal risk management frameworks and in consultation with key stakeholders. This step will also define outcome-based environmental objectives consistent with regulatory and internal requirements and set performance criteria to ensure the outcomes are met.
- **Plan:** Develop management plans that describe how the performance criteria or outcome-based objectives will be met through the application of the mitigation hierarchy, monitoring and reporting measures.
- **Implement and Monitor:** Implement management tools and monitor against performance criteria during construction and operations and into closure and rehabilitation. Conduct internal audits to verify management tools are being implemented in line with regulatory and internal standards.
- **Analyse and Learn:** Use monitoring data to verify models, validate assumptions and identify relevant internal and external changes (e.g. change in regulatory requirements, improved understanding, or advancements in technology) and address those changes where applicable. Review and assess data and information acquired to ensure that management tools, performance criteria or outcome-based objectives remain appropriate over the life of the operation and for closure.
- **Adapt and Share:** Report management performance and relevant metrics according to external and internal reporting requirements (e.g. AER, BHP Billiton Annual Sustainability Report). Where shortcomings in or improvement opportunities for the management approach are

identified, adapt the management approach. Implement and communicate the changes with a view to sharing learnings externally and contributing to improvements across the industry.

An integral component of adaptive management is the application of the mitigation hierarchy (avoid, minimise, rehabilitation, offset which is further discussed in Section 11.

10.2 Environmental governance hierarchy

BHP Billiton Iron Ore has an internal environmental governance hierarchy (Figure 12) that enables the business to meet its environmental objectives and legal compliance requirements and provides for continual improvement in environmental performance. The governance hierarchy has been developed in accordance with relevant international, national and state policies and agreements.

BHP Billiton's environmental governance hierarchy comprises three tiers: Corporate level, Asset level (business, e.g. Iron Ore) and Operations (site level). At the Corporate level, BHP Billiton's Corporate Charter – *Our BHP Billiton Charter* – identifies the values that underpin business activities. Measurable, minimum performance standards are defined in Our Requirements documents. These standards apply to all Assets and support the development and implementation of EMS. BHP Billiton's *Our Requirements Environment and Climate Change* (BHP Billiton, 2016c) is the key guidance document for environmental management across all operations. BHP Billiton reports its corporate-wide sustainability performance in the BHP Billiton Annual Sustainability Report.

At the Asset level, BHP Billiton Iron Ore's Health, Safety and Environmental Management System (referred to herein as the EMS), which includes regional strategies and plans, is the governance system that addresses environmental outcomes for the Pilbara region.

Site-specific management, monitoring and reporting is undertaken in a manner consistent with Corporate- and Asset-level governances. Management plans, procedures and registers are examples of the internal controls that underpin day-to-day operational activities. BHP Billiton Iron Ore publicly reports its environmental compliance performance in its AER in accordance with any environmental approval conditions.

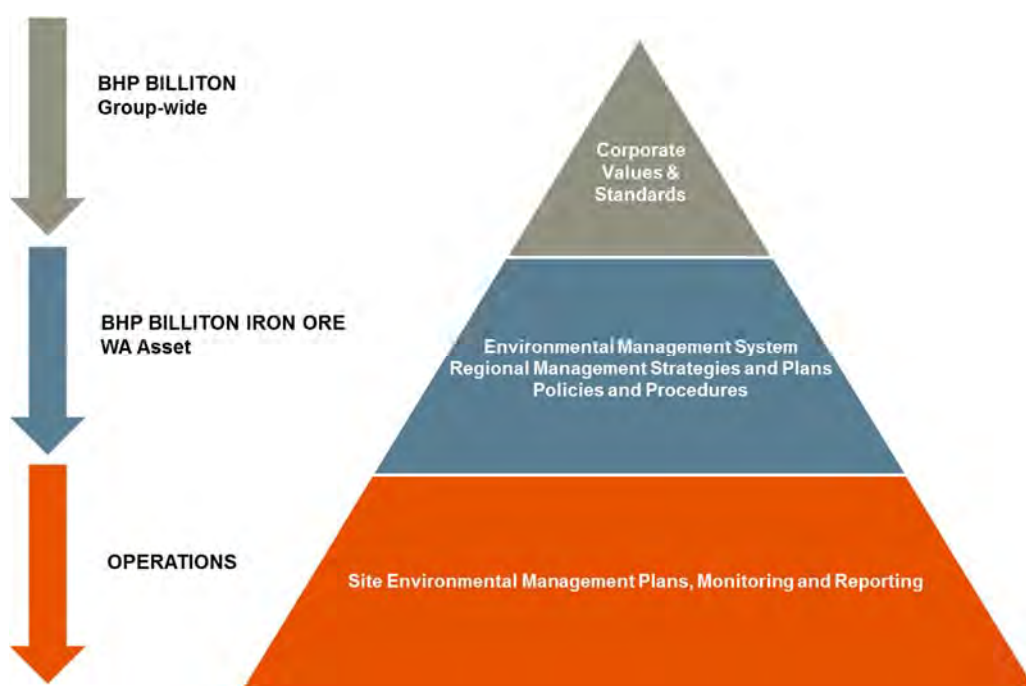


Figure 12: BHP Billiton Iron Ore's environmental governance hierarchy

10.3 Project environmental and Aboriginal heritage reviews

To support the documents identified in Figure 12, when considering land disturbance related activities, BHP Billiton Iron Ore has an internal Project Environmental and Aboriginal Heritage Review (PEAHR) process. The purpose of the process is to manage the implementation of environmental, Aboriginal heritage, land tenure and legal commitments prior to and during land disturbance. All ground disturbance activities will be required to meet the requirements of the PEAHR process, as well as relevant legislative and regulatory requirements, BHP Billiton Iron Ore's Sustainable Development Policy and where practical and relevant industry standards, and codes of practice. Additionally, the PEAHR process provides a mechanism whereby technical and professional advice can be provided to the business regarding environmental aspects, land access and Aboriginal heritage planning and management issues. The PEAHR system consists of an electronic workflow process linked to a geographical information system. The objectives of the PEAHR process are to:

- identify the significant environmental, Aboriginal heritage and legal aspects of proposed activities;
- ensure that, through appropriate environmental, Aboriginal heritage and land access planning and management, BHP Billiton Iron Ore activities comply with all legal and other obligations;
- avoid, minimise and mitigate the number and nature of environmental, Aboriginal heritage and land tenure impacts and ensure adequate environmental performance of BHP Billiton Iron Ore operations; and
- provide a mechanism for continuous improvement.

11. Assessment of preliminary key environmental factors

This section discusses the potential environmental impacts associated with the Proposal for each preliminary key environmental factor, and includes information from surveys and the latest technical impact assessments completed in the Proposed Mining Area C Development Envelope. From this work, potential and cumulative impacts associated with the Indicative Additional Impact Assessment Area, additional disturbance within the Mining Area C EMP Revision 6 Impact Assessment Area and Additional Development Envelope have been defined. In response to these potential impacts, description of BHP Billiton Iron Ore's management and mitigation is outlined.

11.1 Flora and vegetation

11.1.1 EPA objective

The EPA applies the following objective, according to *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect flora and vegetation:

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

11.1.2 Relevant legislation, guidelines and policies

The discussion of the existing environment, impacts to and management of flora and vegetation in the Proposed Mining Area C Development Envelope has been compiled in consideration of relevant state legislation and EPA policies and guidance. Table 7 details the relevant EPA documents as identified in the *Mining Area C – Environmental Scoping Document* (OEPA, 2016) and their relevance to this Proposal. Other relevant legislation includes the EPBC Act and the *Wildlife Conservation Act 1950* (WC Act).

11.1.3 Existing environment

11.1.3.1 Survey effort

Twenty flora and vegetation surveys were undertaken wholly or partially within the Proposed Mining Area C Development Envelope between 1997 and 2011; they comprise 11 Level 2 surveys (one or two seasons), two Level 1 surveys and seven targeted surveys (for conservation significant flora or weeds) (Table 11; Figure 13). All surveys undertaken post-2004 have been undertaken in accordance with the EPA's (2004a) *Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*. In total, 782 quadrats have been surveyed within the Proposed Mining Area C Development Envelope (Figure 13). All areas within the Proposed Mining Area C Development Envelope that have been surveyed post-2004 have had a minimum of two seasons of survey, using a stratified approach such that all landforms and vegetation associations present have been sampled, and there is adequate geographic coverage. It is also noted that all Level 1 and Level 2 surveys undertaken for BHP Billiton Iron Ore include targeted searches for conservation significant species, and surveys undertaken post-2009 have been undertaken in accordance with BHP Billiton Iron Ore's Flora and Vegetation survey guidelines which were developed in conjunction with DPaW to ensure consistency in approach for all surveys undertaken for the Company.

A further 26 flora and vegetation surveys have been undertaken on behalf of BHP Billiton Iron Ore in close proximity to the Proposed Mining Area C Development Envelope (but not overlapping it). These surveys are summarised in Appendix 4.

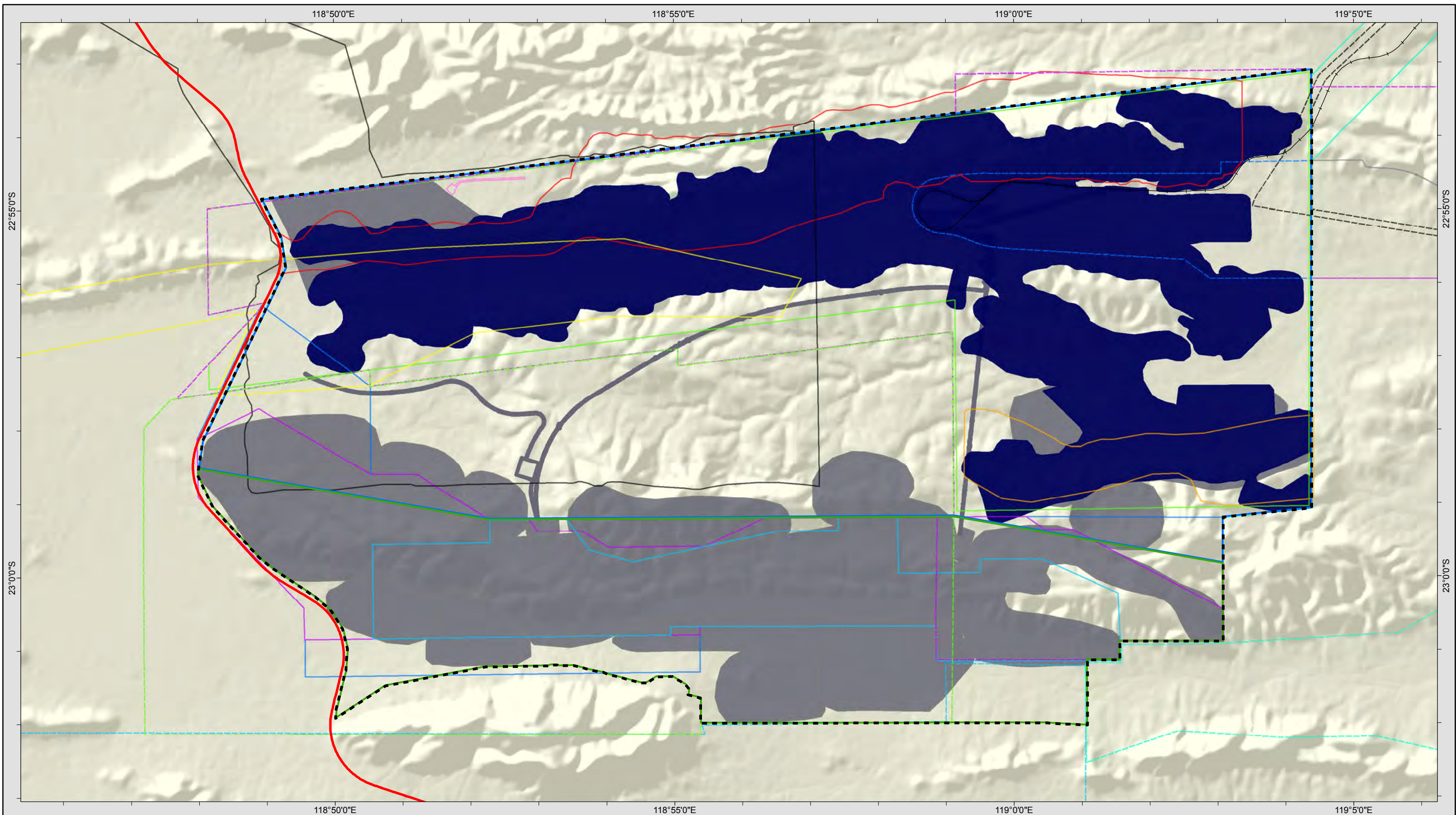
Page intentionally blank

Table 11: Summary of flora and vegetation surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope

Report	Survey Type / Seasonal Conditions	Survey Area	Survey Date	Survey Effort (No. quadrats)	Experience of Personnel	Location of Survey	Conservation Significant Flora Recorded	Introduced (Weed) Taxa Recorded
Mine, Port & Rail Operations Weed Control – Area C June 2014 (Astron Environmental, 2014b)	Targeted weed Good	Not relevant	12- 17 June 2014	No quadrats, targeted searches	Experienced environmental technicians for weed identification and control	Infrastructure areas within existing Mining Area C operations; not within the Indicative Additional Impact Assessment Area	Not recorded	<i>*Rumex vesicaria</i> , <i>*Cenchrus ciliaris</i> , <i>*Chloris barbata</i> , <i>*Chloris virgata</i> , <i>*Citrus colocyntis</i> , <i>*Citrus lanatus</i> , <i>Conyza bonariensis</i> , <i>*Cynodon dactylon</i> , <i>*Echinochloa colona</i> , <i>*Euphorbia hirta</i> , <i>*Lactuca serriola</i> , <i>*Lycopersicon esculentum</i> , <i>*Solanum nigrum</i> , <i>*Sonchus oleraceus</i> , <i>*Tridax procumbens</i> , <i>*Malvastrum americanum</i>
Mine, Port & Rail Operations Weed Control- Area C, March 2014 (Astron Environmental, 2014b)	Targeted weed Good	Not relevant	11-15 March 2014	No quadrats, targeted searches	Experienced environmental technicians for weed identification and control	Infrastructure areas within existing MAC operations; not within the Indicative Additional Impact Assessment Area	Not recorded	<i>*Rumex vesicaria</i> , <i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Cenchrus setiger</i> , <i>*Chloris barbata</i> , <i>*Chloris virgata</i> , <i>*Citrus colocyntis</i> , <i>*Citrus lanatus</i> , <i>*Conyza bonariensis</i> , <i>*Conyza sumatrensis</i> , <i>*Digitaria ciliaris</i> , <i>*Echinochloa colona</i> , <i>*Euphorbia hirta</i> , <i>*Malvastrum americanum</i> , <i>*Solanum nigrum</i> , <i>*Sonchus oleraceus</i> , <i>*Vachellia farnesiana</i>
Level 2 Flora and Vegetation Survey Mudlark Leases (Onshore Environmental, 2012)	Level 2 Excellent (2011) Excellent (2012)	36,601 ha	4-24 February 2011, 17-26 June 2011, 9-20 July 2011, 1-9 July 2012, 20-29 July 2012.	259 quadrats (50x50m) 7 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Covers a small area in the south-east of the Additional Development Envelope	Priorato 1 taxa: <i>Eragrostis</i> sp. Mt Robinson (S. van Leeuwen 4109), <i>Eremophila</i> sp. West Angelas (S. van Leeuwen 4068), <i>Triodia</i> sp. Karijini (S. van Leeuwen 4111). Priority 2 taxa: <i>Aristida lazaridis</i> , <i>Hibiscus</i> sp. Gurinbiddy Range (M.E. Trudgen MET 15708), <i>Oxalis</i> sp. Pilbara (M.E. Trudgen 12725). Priority 3 taxa: <i>Acacia effusa</i> , <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> , <i>Dampiera metallorum</i> , <i>Grevillea saxicola</i> , <i>Indigofera gilesii</i> , <i>Olearia mucronata</i> , <i>Pilbara trudgenii</i> , <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794), <i>Rostellularia adscendens</i> var. <i>latifolia</i> , <i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642), <i>Solanum kentrocaule</i> , <i>Themeda</i> sp. Hamersley Station (M.E. Trudgen 11431), <i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739). Priority 4 taxa: <i>Acacia bromilowiana</i> , <i>Eremophila magnifica</i> subsp. <i>magnifica</i> , <i>Goodenia nuda</i> , <i>Ptilotus mollis</i> .	<i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Cenchrus setiger</i> , <i>*Chloris virgata</i> , <i>*Citrus colocyntis</i> , <i>*Flaveria trinervia</i> , <i>*Malvastrum americanum</i> , <i>*Portulaca oleracea</i> , <i>*Setaria verticillata</i> , <i>*Sigesbeckia orientalis</i> , <i>*Sonchus oleraceus</i> and <i>*Vachellia farnesiana</i>
Level Two Flora and Vegetation Survey Southern Flank (Onshore Environmental, 2012)	Level 2 Poor (2010) Good (2011)	18,631 ha	22 March – 1 April 2010, 12– 24 May 2010, 16-29 September 2010, 22-27 June 2011	220 quadrats (50x50m) 169 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Including the Additional Development Envelope and extending outside (south) to include northern half of Mt Robinson	<i>Lepidium catapycnon</i> (V, P4), <i>Dampiera metallorum</i> ms (P3), <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4), <i>Sida</i> sp. Barlee Range (S van Leeuwen 1642) (P3), <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3), <i>Aristida lazaridis</i> (P2), <i>Pilbara trudgenii</i> (P2), <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3), <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3), <i>Triodia</i> sp. Mt. Ella (ME Trudgen 12739) (P3), <i>Themeda</i> sp. Hamersley Station (M. E. Trudgen 11431) (P3), <i>Acacia bromilowiana</i> (P4), <i>Ptilotus mollis</i> (P4)	<i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Malvastrum americanum</i> , <i>*Setaria verticillata</i> , <i>*Vachellia farnesiana</i> , <i>*Cucumis melo</i> subsp. <i>agrestis</i> , <i>*Stylosanthes hamata</i>

Report	Survey Type / Seasonal Conditions	Survey Area	Survey Date	Survey Effort (No. quadrats)	Experience of Personnel	Location of Survey	Conservation Significant Flora Recorded	Introduced (Weed) Taxa Recorded
Area C and Surrounds Study Area, Level 2 Flora and Vegetation Survey (Onshore Environmental, 2011)	Level 2 Poor	29,414 ha	26 Nov – 6 Dec 2009, 9-18 Feb 2010, 14-21 June 2010	221 quadrats (50x50m) 152 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Covering the Current Approved Development Envelope	<i>Lepidium catapycnon</i> (V, P4), <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3), <i>Aristida lazaridis</i> (P2), <i>Stylidium weeliwolli</i> (P2), <i>Vittadinia</i> sp. Coondewanna Flats (S. van Leeuwen 4684) (P1), <i>Acacia subtiliformis</i> (P3), <i>Fimbristylis sieberiana</i> (P3), <i>Goodenia</i> sp. East Pilbara (A.A. Mitchell PRP 727) (P3), <i>Nicotiana umbratica</i> (P3), <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3), <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3), <i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642), (P3), <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4), <i>Goodenia nuda</i> (P4)	<i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Chloris barbata</i> , <i>*Chloris virgata</i> , <i>*Cynodon dactylon</i> , <i>*Datura leichhardtii</i> , <i>*Malvastrum americanum</i> , <i>*Setaria verticillata</i> , <i>*Sigesbeckia orientalis</i> , <i>*Vachellia farnesiana</i>
Southern Flank NVCP Extension Flora, Vegetation and Fauna Survey (ENV Australia, 2010a)	Level 1 Good	1,800 ha	16 -20 November 2009, 2 December 2009	42 quadrats (50x50m) 37 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists accompanied with experienced Pilbara biologists	Within the Additional Development Envelope	<i>Rhagodia</i> sp. Hamersley (M. Tridgen 17794) (P3)	<i>*Cenchrus ciliaris</i> , <i>*Malvastrum americanum</i>
Newman to Yandi Transmission Line Flora and Vegetation Assessment (ENV Australia, 2009)	Level 2 Good	2,076 ha	5-15 May 2009	151 quadrats (50x50m) 8 quadrats within Proposed Mining Area C Development Envelope	Experienced Pilbara botanists accompanied with experienced Pilbara biologists	Fringes the northeast corner of the Current Approved Development Envelope	<i>Goodenia</i> sp. East Pilbara (AA Mitchell PRP 727) (P1), <i>Euphorbia</i> sp. Bruce Rock (S. van Leeuwen 3861, <i>Acacia subtiliformis</i> (P3), <i>Goodenia nuda</i> (P3), <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3)	<i>*Rumex vesicaria</i> , <i>*Aerva javanica</i> , <i>*Argemone ochroleuca</i> subsp. <i>ochroleuca</i> , <i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Chloris virgata</i> , <i>*Citrus colocynthis</i> <i>*Cucumis melo</i> subsp. <i>agrestis</i> , <i>*Cynodon dactylon</i> , <i>*Malvastrum americanum</i> , <i>*Setaria verticillata</i> , <i>*Solanum nigrum</i> , <i>*Vachellia farnesiana</i>
Flora and Vegetation Assessment Area C Mining Operations Environmental Management A, D, P1 and P3 Deposits (Woodman Environmental Consulting, 2009)	Level 2 Good	17,805 ha	12 April - 16 May, 9 – 13 June and 23-27 June 2008	62 quadrats (50x50m) 56 quadrats within Proposed Mining Area C Development Envelope	Experienced Pilbara botanists and accompanied with experienced botanists	Extends east towards Weeli Wolli Creek from the northeast sector of the Current Approved Development Envelope	<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4), <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3), <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3)	<i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Malvastrum americanum</i> , <i>*Sigesbeckia orientalis</i>
Field Survey for Priority and Rare Flora Area C Southern Flank (Pilbara Flora, 2008)	Targeted Good	4,351 ha	15 -20 May 2008	No quadrats, targeted searches	Experienced Pilbara botanists and biologist	Within the Additional Development Envelope	<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	<i>*Bidens bipinnata</i>
Southern Flank Exploration Lease Flora and Vegetation Assessment (ENV Australia, 2008)	Level 2 Poor	7,627 ha	16- 23 November 2007, 5-11 December 2007	109 quadrats (50x50m) 108 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Within the Additional Development Envelope	<i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3), <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	<i>*Bidens bipinnata</i> , <i>*Cenchrus ciliaris</i> , <i>*Setaria verticillata</i>
Area C – R Deposit Flora and Vegetation Assessment (ENV Australia, 2007)	Level 2 Poor	1,428 ha	24-30 October 2006	72 quadrats (50x50m) 72 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Southeast corner of the Current Approved Development Envelope	<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	<i>*Bidens bipinnata</i> , <i>*Sigesbeckia orientalis</i>

Report	Survey Type / Seasonal Conditions	Survey Area	Survey Date	Survey Effort (No. quadrats)	Experience of Personnel	Location of Survey	Conservation Significant Flora Recorded	Introduced (Weed) Taxa Recorded
Packsaddle Wastewater Treatment Plant (Ecologia Environment, 2005)	Level 1 Good	11 ha	13 July 2005	No quadrats completed; transects surveyed	Experienced Pilbara botanist and biologist	Adjacent to Packsaddle Village within Current Approved Development Envelope	<i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3)	* <i>Malvastrum americanum</i>
Area C Deposits D, E and F Biological Survey (Ecologia Environment, 2004a)	Level 2 Good	6,485 ha	21-24 May 2004	35 quadrats (100x100m) 35 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	MAC pits within Current Approved Development Envelope	None	* <i>Bidens bipinnata</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i> , * <i>Sigesbeckia orientalis</i>
Packsaddle Range Biological Survey (Ecologia Environment, 2004b)	Level 2 Good	5,093 ha	29-4 May 2004	52 quadrats (100x100m) 48 quadrats within Proposed Mining Area C Development Envelope	Highly experienced Pilbara botanists	Packsaddle Range along the northern extent of the Current Approved Development Envelope	None	* <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i>
Mining Area C Rail Corridor Rare Flora Survey (Phase 2) (Biota, 2003)	Targeted Good	7,768 ha	21-31 March 2002	No quadrats, targeted searches	Experienced Pilbara botanist	North-eastern sector of the Current Approved Development Envelope	None	None
Mining Area C Rail Corridor Rare Flora Survey (Biota, 2002)	Targeted Poor	7,768 ha	12-18 November 2001	No quadrats, targeted searches	Experienced Pilbara botanist with field assistant	North-eastern sector of the Current Approved Development Envelope	None	None
Mining Area C Village and Access Road Rare and Priority Flora (Ecologia Environment, 2002)	Targeted Good	11 ha	17 March 2002	No quadrats, targeted searches	Experienced Pilbara botanist and biologist	North-west sector of the Current Approved Development Envelope, dissecting Packsaddle Range	None	* <i>Sigesbeckia orientalis</i>
Area C to Yandi Rail Line Baseline Weed Survey (Ecologia Environment, 2001)	Targeted Poor	7,768 ha	16-17 October 2001	No quadrats, targeted searches	Field team not reported	North-eastern sector of the Current Approved Development Envelope	Not recorded	* <i>Rumex vesicaria</i> , * <i>Argemone ochroleuca</i>
Marillana Creek Western Access Corridor – Biological Assessment (HGM, 1999)	Level 2 Good	37,715 ha	23-30 April 1999	22 quadrats (100x100m) No quadrats within Proposed Mining Area C Development Envelope	Field team not reported	Southern extent of rail alignment within; north-west sector	None	* <i>Bidens bipinnata</i> , * <i>Malvastrum americanum</i>
Mining Area C Biological Survey (Ecologia Environment, 1998a)	Level 2 Good	Area not recorded	1997	132 quadrats (100x100m) 90 quadrats within Proposed Mining Area C Development Envelope	Experienced botanists	Northern extent of the Current Approved Development Envelope	<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	* <i>Argemone ochroleuca</i> , * <i>Bidens bipinnata</i> , * <i>Datura leichhardtii</i> , * <i>Lysimachia arvensis</i> , * <i>Malvastrum americanum</i> , * <i>Sonchus oleraceus</i>



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of Flora and Vegetation Surveys undertaken
in the Proposed Mining Area C Development
Envelope and Surrounds

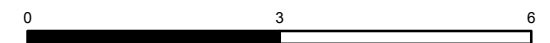
Scale @ A3: 1:90,000	Prepared: M. LYTTLE	Project No: A780/022 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 13a
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail

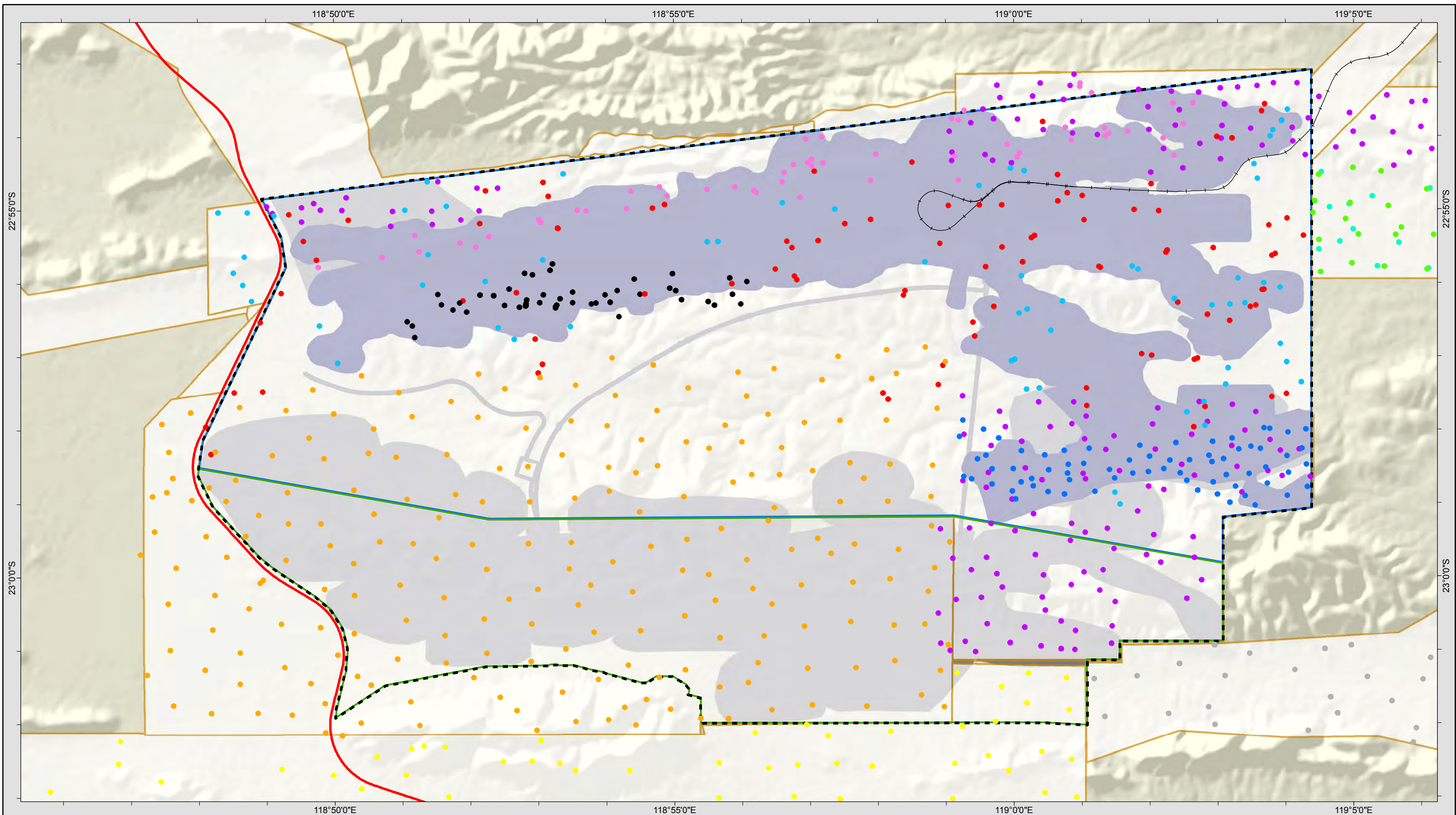
- Marillana Creek Western Access Corridor – Biological Assessment, HGM (1999)
- Southern Flank Exploration Lease Flora and Vegetation Assessment, ENV (2008a)
- Southern Flank NVCP Extension Flora, Vegetation and Fauna Survey, ENV (2010a)
- Field Survey for Priority and Rare Flora Area C Southern Flank, Pilbara Flora (2008a)
- Mining Area C Biological Survey, Ecologia Environment (1998a)
- Flora and Vegetation Assessment Area C Mining Operations Environmental Management A, D, P1 and P3 Deposits, Woodman Environmental Consulting (2009a)
- Area C Deposits D, E and F Biological Survey, Ecologia Environment (2004b)
- Area C – R Deposit Flora and Vegetation Assessment, ENV (2007)
- Packsaddle Range Biological Survey, Ecologia Environment (2004a)
- Packsaddle Wastewater Treatment Plant, Ecologia Environment (2005a)
- Jinayri Infrastructure Corridors Flora and Vegetation Survey, Woodman Environmental Consulting (2010)
- Newman to Yandi Transmission Line Flora and Vegetation Assessment, ENV (2009)

- Area C and Surrounds Study Area, Level 2 Flora and Vegetation Survey, Onshore Environmental (2011a)
- Jinayri to Area C Access Corridor Flora and Vegetation Survey, ENV (2010b)
- Level 2 Flora and Vegetation Survey Mudlark Leases, Onshore Environmental (2013)
- Southern Flank to Jinidi Level 2 Flora and Vegetation Survey, Biota (2012)
- Level Two Flora and Vegetation Survey Southern Flank, Onshore Environmental (2012a)

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of Flora and Vegetation Survey Sites undertaken
in the Proposed Mining Area C Development
Envelope and Surrounds

Scale @ A3: 1:90,000	Prepared: M. LYTTLE	Project No: A780/023 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 13b
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment
- Indicative Additional Impact Assessment Area
- Level 2 Flora and Vegetation Survey Boundary
- Great Northern Highway
- BHP Billiton Rail

- Area C Deposits D, E and F Biological Survey, Ecologia Environment (2004b)
- Area C and Surrounds Study Area, Level 2 Flora and Vegetation Survey, Onshore Environmental (2011a)
- Area C – R Deposit Flora and Vegetation Assessment, ENV (2007)
- Flora and Vegetation Assessment Area C Mining Operations Environmental Management A, D, P1 and P3 Deposits, Woodman Environmental Consulting (2009a)
- Jinayri Infrastructure Corridors Flora and Vegetation Survey, Woodman Environmental Consulting (2010)

- Jinayri to Area C Access Corridor Flora and Vegetation Survey, ENV (2010b)
- Level 2 Flora and Vegetation Survey Mudlark Leases, Onshore Environmental (2013)
- Level Two Flora and Vegetation Survey Southern Flank, Onshore Environmental (2012a)
- Mining Area C Biological Survey, Ecologia Environment (1998a)
- Packsaddle Range Biological Survey, Ecologia Environment (2004a)
- Southern Flank to Jinidi Level 2 Flora and Vegetation Survey, Biota (2012)

Liability
BHP Billiton does not warrant that this map is free from errors or omissions. BHP Billiton shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

11.1.3.2 Vegetation

Vegetation mapping of the Pilbara region was completed on a broad scale (1:1,000,000) by Beard (1975). Mining Area C is situated in the Hamersley Plateau in the Eremaean Botanical Province of Western Australia as per Beard (1975), who broadly mapped the area as ranges and valley plains. The most common vegetation associations in the Proposed Mining Area C Development Envelope are *Eucalyptus leucophloia* (snappy gum) and *Triodia wiseana* (hard spinifex) tree steppe occurring on hills and tall woodlands of *Eucalyptus camaldulensis* (river red gum), *Eucalyptus victrix* (coolibah) and *Acacia aneura* (mulga) along drainage lines and in groves within the valley floors.

The original vegetation mapping undertaken by Beard (1975) was refined by Shepherd *et al.* (2002). There are two vegetation associations (as mapped by Shepherd *et al.* (2002)) in the Proposed Mining Area C Development Envelope:

- Hamersley 18: Low woodland; mulga (*Acacia aneura*); and
- Hamersley 82: Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*.

Onshore Environmental identified 34 vegetation associations in the Proposed Mining Area C Development Envelope (Onshore Environmental, 2017; Appendix 4). Twenty-four of these associations occur in the Additional Development Envelope, and 29 occur in the Indicative Additional Impact Assessment Area (Figure 14 and Table 12). Twenty-eight vegetation associations were mapped within the Approved Mining Area C (Northern Flank) Development Envelope, of which 21 occur within the Mining Area C Revision 6 EMP Impact Assessment Area (Onshore Environmental, 2015; Appendix 4).

At the complex level, vegetation within the Proposed Mining Area C Development Envelope is well represented and well reserved within the Pilbara bioregion. None of the vegetation associations are analogous with either Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) within the Pilbara. There are two PECs that occur within 20 km of the Proposed Mining Area C Development Envelope; the Coondewanna Flats PEC and the Weeli Wolli Spring PEC. These are discussed in detail in Sections 11.1.4.3.4 and 11.1.4.3.3.

Broadscale mapping at the vegetation association level occurs over a limited extent within the Pilbara, so inference at this fine scale is not possible. However, BHP Billiton Iron Ore has recently merged and collated vegetation association maps from 162 historical baseline surveys within their Pilbara tenure into a single consolidated map (Onshore Environmental, 2014 and subsequent revisions). The vegetation map represents a unique database on which to undertake preliminary impact assessment at the vegetation association level. The fine scale vegetation map covers 4,296 km² (429,623 ha), which represents 2.36% of the total Pilbara region. Based on this database, none of the vegetation associations within the Development Envelope are considered to be locally endemic or unique, and it is unlikely that any would be considered poorly reserved (D. Brearley, Onshore Environmental, pers. comm. 2017).

Fifteen vegetation associations were considered to have local significance (see Table 12) as they contain at least one conservation significant flora species. Four of these also comprised vegetation that is considered to be an 'Ecosystem at Risk' by Kendrick (2001).

Table 12: Vegetation associations recorded in the Proposed Mining Area C Development Envelope (those with local significance are highlighted in grey)

Map Code	Broad Floristic Formation	Vegetation Association	Ecosystem At Risk	No. Cons. Sig. Flora	AREA (ha)					
					Total Mapped	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 Impact Assessment Area	Cleared
CALCRETE PLAINS										
CP TwTa Ese AbPIAyp	Triodia Hummock Grassland	Hummock Grassland of Triodia wiseana and Triodia angusta with Open Mallee of Eucalyptus socialis subsp. eucentrica and Open Shrubland of Acacia bivenosa, Petalostylis labicheoides and Acacia pyrifolia var. pyrifolia on light brown clay loam on calcrete plains and rises.	n	-	10,246	29	0	17	0	<1
FLOODPLAINS										
FP Ev Aa EuaErbTt	Eucalyptus Woodland	Woodland of Eucalyptus victrix over Low Woodland of Acacia aptaneura over Open Tussock Grassland of Eulalia aurea, Eriachne benthamii and Themeda triandra on orange clay loam on floodplains.	n	-	122	1	1	<1	0	0
FP AaApApt TtChfErb	Acacia Low Open Forest	Low Open Forest of Acacia aptaneura, Acacia paraneura and Acacia pteraneura over Open Tussock Grassland of Themeda triandra, Chrysopogon fallax and Eriachne benthamii on red brown clay loam on floodplains.	n	-	10,214	5	5	3	0	0
FP AaAcaoAp ErInSolPto ArcErdiArj	Acacia Low Open Woodland	Low Open Woodland of Acacia aptaneura, Acacia catenulata subsp. occidentalis and Acacia paraneura over Low Open Shrubland of Eremophila lanceolata, Solanum lasiophyllum and Ptilotus obovatus over Very Open Tussock Grassland of Aristida contorta, Eragrostis dielsii and Aristida jerichoensis var. subspinulifera on red brown clay loam on hardpan intergrove plains.	n	-	5,761	1	0	1	0	<1
FP TtEua ExAa AprAtpErlo	Themeda Tussock Grassland	Tussock Grassland of Themeda triandra and Eulalia aurea with Low Woodland of Eucalyptus xerothermica and Acacia aptaneura over Open Shrubland of Acacia pruinocarpa, Acacia tumida var. pilbarensis and Eremophila longifolia on red brown clay loam on unincised drainage lines and floodplains.	y	2	2,009	114	0	47	17	18
FOOTSLOPES										
FS Ts CdHc AancAiGrw h	Triodia Hummock Grassland	Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of Corymbia deserticola subsp. deserticola and Hakea chordophylla over Open Shrubland of Acacia ancistrocarpa, Acacia inaequilatera and Grevillea wickhamii subsp. hispidula on red brown sandy loam on footslopes and stony plains.	n	4	45,322	4,444	1,404	999	2,261	1,705
FS TsTpTw Ell AbApaAnc	Triodia Hummock Grassland	Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835), Triodia pungens and Triodia wiseana with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia and Open Shrubland of Acacia bivenosa, Acacia pachyachra and Acacia ancistrocarpa on red brown loam on footslopes and low undulating hills.	n	-	6,687	38	0	0	38	21
GORGES AND GULLIES										
GG CcolCfEll ErmuThmb Cya	Callitris Low Open Forest	Low Open Forest of Callitris columellaris, Corymbia ferritcola and Eucalyptus leucophloia subsp. leucophloia over Open Tussock Grassland of Eriachne mucronata, Themeda sp. Mt Barricade (M.E. Trudgen 2471) and Cymbopogon ambiguus and Very Open Hummock Grassland of Triodia pungens on orange brown loam on upper gorges.	n	1	584	15	11	15	0	<1
GG CfEllFib AhDovmAs ha CyaErmuThmb	Corymbia Low Woodland	Low Woodland of Corymbia ferritcola, Eucalyptus leucophloia subsp. leucophloia and Ficus brachypoda over Open Shrubland of Acacia hamersleyensis, Dodonaea viscosa subsp. mucronata and Astrotricha hamptonii over Open Tussock Grassland of Cymbopogon ambiguus, Eriachne mucronata and Themeda sp. Mt Barricade on red brown loam along clifflines and gorges.	n	5	3,685	1,570	613	727	256	33
GG TtErmuThmb EllChCf AtpGoroPI	Themeda Tussock Grassland	Tussock Grassland of Themeda triandra, Eriachne mucronata and Themeda sp. Mt Barricade with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia, Corymbia hamersleyana and Corymbia ferritcola over High Shrubland of Acacia tumida var. pilbarensis, Gossypium robinsonii and Petalostylis labicheoides on red brown sandy loam in narrowly incised rocky drainage lines.	n	2	1,030	628	128	103	107	6

Map Code		Broad Floristic Formation	Vegetation Association	Ecosystem At Risk	No. Cons. Sig. Flora	AREA (ha)				
						Total Mapped	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 Impact Assessment Area
HILL CRESTS AND UPPER HILL SLOPES										
HC TpTwTs EIICh AarGooKe ve	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia pungens</i> , <i>Triodia wiseana</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over Low Shrubland of <i>Acacia arida</i> , <i>Gompholobium oreophilum</i> and <i>Keraudrinia velutina</i> subsp. <i>elliptica</i> on red brown loam on hills.	n	-	5,277	130	0	0	103	27
HC Tw Ah EkkEgCh	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia wiseana</i> with Shrubland of <i>Acacia hamersleyensis</i> and Open Mallee of <i>Eucalyptus kingsmillii</i> subsp. <i>kingsmillii</i> , <i>Eucalyptus gamophylla</i> and <i>Corymbia hamersleyana</i> (mallee form) on red brown loam and silty loam on hill crests.	n	-	4,901	1,027	267	220	148	87
HC TwTsTp EIICh Ah	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia wiseana</i> , <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over Open Shrubland of <i>Acacia hamersleyensis</i> on red brown clay loam on hill crests and upper hill slopes.	n	-	8,049	83	24	58	20	5
HILL SLOPES AND UNDULATING LOW HILLS										
HS AaApr ErjpAmarC ocf TwTp	Acacia Low Woodland	Low Woodland of <i>Acacia aptaneura</i> and <i>Acacia pruinocarpa</i> over Shrubland of <i>Eremophila jucunda</i> subsp. <i>pulcherrima</i> , <i>Acacia marramamba</i> and <i>Codonocarpus cotinifolius</i> over Open Hummock Grassland of <i>Triodia wiseana</i> and <i>Triodia pungens</i> on red brown loam on hill slopes.	n	2	715	529	170	473	0	51
HS TbrTw EII	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia brizoides</i> and/or <i>Triodia wiseana</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> on brown sandy loam on steep hill slopes.	n	-	12,977	2,143	229	293	859	139
HS Tp AaApr ErfrAmarS egl	Triodia Open Hummock Grassland	Open Hummock Grassland of <i>Triodia pungens</i> with Low Open Woodland of <i>Acacia aptaneura</i> and <i>Acacia pruinocarpa</i> over Open Shrubland of <i>Eremophila fraseri</i> , <i>Acacia marramamba</i> and <i>Senna glutinosa</i> subsp. <i>x luerssenii</i> on red brown loam on undulating hills.	n	-	391	42	42	42	0	7
HS Tp EII SeggGrwh ErII	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia pungens</i> with Scattered Low Trees of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and Scattered Shrubs of <i>Senna glutinosa</i> subsp. <i>glutinosa</i> , <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> and <i>Eremophila latrobei</i> subsp. <i>latrobei</i> on skeletal orange brown loam on stony hill slopes.	n	-	378	91	81	66	5	4
HS TsTw Eg GrwhSegg Ab	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) and <i>Triodia wiseana</i> with Very Open Mallee of <i>Eucalyptus gamophylla</i> over Open Shrubland of <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> , <i>Senna glutinosa</i> subsp. <i>glutinosa</i> and <i>Acacia bivenosa</i> on red brown sandy clay loam on hill slopes.	n	-	1,032	<1	<1	<1	0	0
HS TsTwTp EIICh AhiAaa	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835), <i>Triodia wiseana</i> and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over Low Open Shrubland of <i>Acacia hilliana</i> and <i>Acacia adoxa</i> var. <i>adoxa</i> on red brown sandy loam on hill slopes.	n	4	44,324	10,123	2,908	3,455	1,544	788
HS TwTpTbr EII Ep	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia wiseana</i> , <i>Triodia pungens</i> and <i>Triodia brizoides</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Mallee of <i>Eucalyptus pilbarensis</i> on red brown loam on steep hill slopes.	n	-	2,339	14	10	10	0	<1
HS TwTpTs EII AprAaAnc	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia wiseana</i> , <i>Triodia pungens</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Shrubland of <i>Acacia pruinocarpa</i> , <i>Acacia aptaneura</i> and <i>Acacia ancistrocarpa</i> on red brown loam on plains and low hills.	n	-	1,304	336	0	104	178	11
MAJOR DRAINAGE LINES										
MA EcrEvEx ApypAtpGo ro TtEuaCyp	Eucalyptus Low Open Forest	Low Open Forest of <i>Eucalyptus camaldulensis</i> subsp. <i>refulgens</i> , <i>Eucalyptus victrix</i> and <i>Eucalyptus xerothermica</i> over High Shrubland of <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Gossypium robinsonii</i> over Open Tussock Grassland of <i>Themeda triandra</i> , <i>Eulalia aurea</i> and <i>Cymbopogon procerus</i> on red brown clay loam on major drainage lines.	y	2	3,970	49	49	30	0	<1

Map Code	Broad Floristic Formation	Vegetation Association	Ecosystem At Risk	No. Cons. Sig. Flora	AREA (ha)					
					Total Mapped	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 Impact Assessment Area	Cleared
MA AtpAypAs e Ecr ThmbTtCyp	Acacia High Shrubland	High Shrubland of <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> and <i>Acacia sericophylla</i> with Scattered Trees of <i>Eucalyptus camaldulensis</i> subsp. <i>refulgens</i> over Open Tussock Grassland of <i>Themeda</i> sp. Mt Barricade (M.E. Trudgen 2471), <i>Themeda triandra</i> and <i>Cymbopogon procerus</i> on brown loam and gravels on major drainage channels.	y	-	255	41	0	0	0	0
MEDIUM DRAINAGE LINES										
ME TpTlo ExAciCh PIAppGoro	<i>Triodia</i> Hummock Grassland	Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia longiceps</i> with Low Woodland of <i>Eucalyptus xerothermica</i> , <i>Acacia citrinoviridis</i> and <i>Corymbia hamersleyana</i> over High Shrubland of <i>Petalostylis labicheoides</i> , <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> and <i>Gossypium robinsonii</i> on red brown clay loam on medium drainage lines and surrounding floodplains.	n	3	10,915	1,857	516	534	375	67
ME TtAriCya ChEII AmPIAnI	<i>Themeda</i> Open Tussock Grassland	Open Tussock Grassland of <i>Themeda triandra</i> , <i>Aristida inaequiglumis</i> and <i>Cymbopogon ambiguus</i> with Low Open Woodland of <i>Corymbia hamersleyana</i> and <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Shrubland of <i>Acacia monticola</i> , <i>Petalostylis labicheoides</i> and <i>Androcalva luteiflora</i> on red brown alluvium on minor and medium drainage lines.	n	2	1,584	207	68	72	0	7
ME TtChfEua ExEvCh PIAppAyp	<i>Themeda</i> Tussock Grassland	Tussock Grassland of <i>Themeda triandra</i> , <i>Chrysopogon fallax</i> and <i>Eulalia aurea</i> with Low Open Woodland of <i>Eucalyptus xerothermica</i> , <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> and Shrubland of <i>Petalostylis labicheoides</i> , <i>Acacia pachyacra</i> and <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> on red sandy loam on medium drainage lines.	n	-	1,775	25	0	0	<1	3
ME TtEuaEte AppAtpPI EvCh	<i>Themeda</i> Tussock Grassland	Tussock Grassland of <i>Themeda triandra</i> , <i>Eulalia aurea</i> and <i>Eriachne tenuiculmis</i> with High Shrubland of <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Petalostylis labicheoides</i> and Open Woodland of <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> on red brown silty loam on medium drainage lines and flood plains.	n	-	851	24	0	0	7	12
MINOR DRAINAGE LINES										
MI AtpPIAm TpTs ChEII	<i>Acacia</i> Open Scrub	Open Scrub of <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>Petalostylis labicheoides</i> and <i>Acacia monticola</i> over Open Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of <i>Corymbia hamersleyana</i> and <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> on red brown sandy loam on minor drainage lines.	n	3	5,671	1,763	561	698	425	134
MI PIAtPAm ChEII TwTp	<i>Petalostylis</i> Shrubland	Shrubland of <i>Petalostylis labicheoides</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia monticola</i> with Low Open Woodland of <i>Corymbia hamersleyana</i> and <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Hummock Grassland of <i>Triodia wiseana</i> and <i>Triodia pungens</i> on red brown loam on minor drainage lines.	n	-	1,108	155	116	95	16	7
STONY PLAINS										
SP AaApr TmTwTp TtChfAri	<i>Acacia</i> Low Open Forest	Low Open Forest of <i>Acacia aptaneura</i> and <i>Acacia pruinocarpa</i> over Open Hummock Grassland of <i>Triodia melvillei</i> , <i>Triodia wiseana</i> and <i>Triodia pungens</i> over Tussock Grassland of <i>Themeda triandra</i> , <i>Chrysopogon fallax</i> and <i>Aristida inaequiglumis</i> on red brown loam on plains.	y	2	7,717	389	209	212	26	102
SP AcaoAa ArobDiaChf	<i>Acacia</i> Low Open Forest	Low Open Forest of <i>Acacia catenulata</i> subsp. <i>occidentalis</i> and <i>Acacia aptaneura</i> over Very Open Tussock Grassland of <i>Aristida obscura</i> , <i>Digitaria ammophila</i> and <i>Chrysopogon fallax</i> on red brown clay loam on lower stony plains.	y	1	89	68	68	43	0	1
SP TpTb Eg PIAbAanc	<i>Triodia</i> Hummock Grassland	Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia basedowii</i> with Open Mallee of <i>Eucalyptus gamophylla</i> and Shrubland of <i>Petalostylis labicheoides</i> , <i>Acacia bivenosa</i> and <i>Acacia ancistrocarpa</i> on red brown loamy sand on stony plains and footslopes.	n	-	2,363	134	0	27	92	126
SP TpTm AaExAcao ApaErffAads	<i>Triodia</i> Hummock Grassland	Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia melvillei</i> with Low Open Woodland of <i>Acacia aptaneura</i> , <i>Eucalyptus xerothermica</i> and <i>Acacia catenulata</i> subsp. <i>occidentalis</i> and Open Shrubland of <i>Acacia pachyacra</i> , <i>Eremophila forrestii</i> subsp. <i>forrestii</i> and <i>Acacia adsurgens</i> on red brown clay loam or silty loam on stony plains and floodplains.	n	4	37,659	3,205	1,739	1,807	150	128



Map Code	Broad Floristic Formation	Vegetation Association	Ecosystem At Risk	No. Cons. Sig. Flora	AREA (ha)					
					Total Mapped	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 Impact Assessment Area	Cleared
SP TsTwTp EgEt AbApaApr	Triodia Hummock Grassland	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835), <i>Triodia wiseana</i> and <i>Triodia pungens</i> with Very Open Mallee of <i>Eucalyptus gamophylla</i> and <i>Eucalyptus trivalva</i> over Open Shrubland of <i>Acacia bivenosa</i> , <i>Acacia pachyacra</i> and <i>Acacia pruinocarpa</i> on red brown sandy loam and clay loam on stony plains.	n	3	5,257	1,150	455	564	342	38
OTHER										
Unmapped			NA	NA	NA	120	30	28	26	1,952

Vegetation Association

Not mapped

Cleared

CP TwTa Ese AbPIApyp

Hummock Grassland of Triodia wiseana and Triodia angusta with Open Mallee of Eucalyptus socialis subsp. eucentrica and Open Shrubland of Acacia bivenosa, Petalostylis labicheoides and Acacia pyrifolia var. pyrifolia on light brown clay loam on calcrete plains and rises.

FP AaAcaoAp ErInSolPto ArcErdiArj

Low Open Woodland of Acacia aptaneura, Acacia catenulata subsp. occidentalis and Acacia paraneura over Low Open Shrubland of Eremophila lanceolata, Solanum lasiophyllum and Ptilotus obovatus over Very Open Tussock Grassland of Aristida contorta, Eragrostis dielsii and Aristida jerichoensis var. subspinulifera on red brown clay loam on hardpan intergrove plains.

FP AaApApt TtChfErb

Low Open Forest of Acacia aptaneura, Acacia paraneura and Acacia pteraneura over Open Tussock Grassland of Themeda triandra, Chrysopogon fallax and Eriachne benthamii on red brown clay loam on floodplains.

FP Ev Aa EuaErbTt

Woodland of Eucalyptus victrix over Low Woodland of Acacia aptaneura over Open Tussock Grassland of Eulalia aurea, Eriachne benthamii and Themeda triandra on orange clay loam on floodplains.

FP TtEua ExAa AprAtpErlo

Tussock Grassland of Themeda triandra and Eulalia aurea with Low Woodland of Eucalyptus xerothermica and Acacia aptaneura over Open Shrubland of Acacia pruinocarpa, Acacia tumida var. pilbarensis and Eremophila longifolia on red brown clay loam on unincised drainage lines and floodplains.

FS Ts CdHc AancAiGrwh

Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of Corymbia deserticola subsp. deserticola and Hakea chordophylla over Open Shrubland of Acacia ancistrocarpa, Acacia inaequilatera and Grevillea wickhamii subsp. hispidula on red brown sandy loam on footslopes and stony plains.

FS TsTpTw EII AbApaAanc

Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835), Triodia pungens and Triodia wiseana with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia and Open Shrubland of Acacia bivenosa, Acacia pachyachra and Acacia ancistrocarpa on red brown loam on footslopes, low undulating hills and stony plains.

GG CcoICfEII ErmuThmbCya

Low Open Forest of Callitris columellaris, Corymbia ferritcola and Eucalyptus leucophloia subsp. leucophloia over Open Tussock Grassland of Eriachne mucronata, Themeda sp. Mt Barricade (M.E. Trudgen 2471) and Cymbopogon ambiguus and Very Open Hummock Grassland of Triodia pungens on orange brown loam on upper gorges.

GG CfEIIFib AhDovmAsha CyaErmuThmb

Low Woodland of Corymbia ferritcola, Eucalyptus leucophloia subsp. leucophloia and Ficus brachypodaover Open Shrubland of Acacia hamersleyensis, Dodonaea viscosa subsp. mucronata and Astrotricha hamptonii over Open Tussock Grassland of Cymbopogon ambiguus, Eriachne mucronata and Themeda sp. Mt Barricade on red brown loam along cliffines and gorge walls.

GG TtErmuThmb EIICHcf AtpGoroPI

Tussock Grassland of Themeda triandra, Eriachne mucronata and Themeda sp. Mt Barricade with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia, Corymbia hamersleyana and Corymbia ferritcola over High Shrubland of Acacia tumida var. pilbarensis, Gossypium robinsonii and Petalostylis labicheoides on red brown sandy loam on narrowly incised rocky drainage lines.

HC TpTwTs EIICH AarGooKeve

Hummock Grassland of Triodia pungens, Triodia wiseana and Triodia sp. Shovelanna Hill (S. van Leeuwin 3835) with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia and Corymbia hamersleyana over Low Shrubland of Acacia arida, Gompholobium oreophilum and Keraudrinia velutina subsp. elliptica on red brown loam on hill crests and upper hill slopes.

HC Tw Ah EkkEgCh

Hummock Grassland of Triodia wiseana with Shrubland of Acacia hamersleyensis and Open Mallee of Eucalyptus kingsmillii subsp. kingsmillii, Eucalyptus gamophylla and Corymbia hamersleyana (mallee form) on red brown loam and silty loam on hill crests.

HC TwTsTp EIICH Ah

Hummock Grassland of Triodia wiseana, Triodia sp. Shovelanna Hill (S. van Leeuwen 3835) and Triodia pungens with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia and Corymbia hamerselyana over Open Shrubland of Acacia hamersleyensis on red brown clay loam on hill crests and upper hill slopes.

HS AaApr ErjpAmarCocf TwTp

Low Woodland of Acacia aptaneura and Acacia pruinocarpa over Shrubland of Eremophila jucunda subsp. pulcherrima, Acacia marramamba and Codonocarpus cotinifolius over Open Hummock Grassland of Triodia wiseana and Triodia pungens on red brown loam on steep hill slopes.

HS TbrTw EII

Hummock Grassland of Triodia brizoides and/or Triodia wiseana with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia on brown sandy loam on steep hill slopes.

HS Tp AaApr ErfrAmarSegl

Open Hummock Grassland of Triodia pungens with Low Open Woodland of Acacia aptaneura and Acacia pruinocarpa over Open Shrubland of Eremophila fraseri, Acacia marramamba and Senna glutinosa subsp. x luerssenii on red brown loam on undulating hills.

HS Tp EII SeggGrwhErlI

Hummock Grassland of Triodia pungens with Scattered Low Trees of Eucalyptus leucophloia subsp. leucophloia and Scattered Shrubs of Senna glutinosa subsp. glutinosa, Grevillea wickhamii subsp. hispidulaand Eremophila latrobei subsp. latrobei on skeletal orange brown loam on stony hill slopes.

HS TsTw Eg GrwhSeggAb

Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835) and Triodia wiseana with Very Open Mallee of Eucalyptus gamophylla over Open Shrubland of Grevillea wickhamii subsp. hispidula, Senna glutinosa subsp. glutinosa and Acacia bivenosa on red brown sandy clay loam on hill slopes.

HS TsTwTp EIICH AhiAaa

Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835), Triodia wiseana and Triodia pungens with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia and Corymbia hamersleyana over Low Open Shrubland of Acacia hilliana and Acacia adoxa var. adoxa on red brown sandy loam on hill slopes.

HS TwTpTbr EII Ep

Hummock Grassland of Triodia wiseana, Triodia pungens and Triodia brizoides with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia over Open Mallee of Eucalyptus pilbarensis on red brown loam on steep hill slopes.

HS TwTpTs EII AprAaAanc

Hummock Grassland of Triodia wiseana, Triodia pungens and Triodia sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Woodland of Eucalyptus leucophloia subsp. leucophloia over Open Shrubland of Acacia pruinocarpa, Acacia aptaneura and Acacia ancistrocarpa on red brown loam on plains and low hills.

MA AtpApypAse Ecr ThmbTtCyp

High Shrubland of Acacia tumida var. pilbarensis, Acacia pyrifolia var. pyrifolia and Acacia sericophylla with Scattered Trees of Eucalyptus camaldulensis subsp. refulgens over Open Tussock Grassland of Themeda sp. Mt Barricade (M.E. Trudgen 2471), Themeda triandra and Cymbopogon procerus on brown loam and gravels on major drainage channels.

MA EcrEvEx ApypAtpGoro TtEuaCyp

Low Open Forest of Eucalyptus camaldulensis subsp. refulgens, Eucalyptus victrix and Eucalyptus xerothermica over High Shrubland of Acacia pyrifolia var. pyrifolia, Acacia tumida var. pilbarensis and Gossypium robinsonii over Open Tussock Grassland of Themeda triandra, Eulalia aurea and Cymbopogon procerus on red brown clay loam on major drainage lines.

ME TpTlo ExAciCh PIApypGoro

Hummock Grassland of Triodia pungens and Triodia longiceps with Low Woodland of Eucalyptus xerothermica, Acacia citrinoviridis and Corymbia hamerselyana over High Shrubland of Petalostylis labicheoides, Acacia pyrifolia var. pyrifolia and Gossypium robinsonii on red brown clay loam on medium drainage lines and surrounding floodplains.

ME TtAriCya ChEII AmPIAnI

Open Tussock Grassland of Themeda triandra, Aristida inaequiglumis and Cymbopogon ambiguus with Low Open Woodland of Corymbia hamerselyana and Eucalyptus leucophloia subsp. leucophloia over Open Shrubland of Acacia monticola, Petalostylis labicheoides and Androcalva luteiflora on red brown alluvium on minor and medium drainge lines.

ME TtAriCya ChEII AmPIAnI

Open Tussock Grassland of Themeda triandra, Aristida inaequiglumis and Cymbopogon ambiguus with Low Open Woodland of Corymbia hamerselyana and Eucalyptus leucophloia subsp. leucophloia over Open Shrubland of Acacia monticola, Petalostylis labicheoides and Androcalva luteiflora on red brown alluvium on minor and medium drainage lines..

ME TtChfEua ExEvCh PIApaApyp

Tussock Grassland of Themeda triandra, Chrysopogon fallax and Eulalia aurea with Low Open Woodland of Eucalyptus xerothermica, Eucalyptus victrix and Corymbia hamersleyana and Shrubland of Petalostylis labicheoides, Acacia pachyacra and Acacia pyrifolia var. pyrifolia on red sandy loam on medium drainage lines.

ME TtEuaEte ApypAtpPI EvCh

Tussock Grassland of Themeda triandra, Eulalia aurea and Eriachne tenuiculmis with High Shrubland of Acacia pyrifolia var. pyrifolia, Acacia tumida var. pilbarensis and Petalostylis labicheoides and Open Woodland of Eucalyptus victrix and Corymbia hamersleyana on red brown silty loam on medium drainage lines and flood plains.

MI AtpPIAm TpTs ChEII

Open Scrub of Acacia tumida var. pilbarensis, Petalostylis labicheoides and Acacia monticola over Open Hummock Grassland of Triodia pungens and Triodia sp. Shovelanna Hill (S.van Leeuwen 3835) with Low Open Woodland of Corymbia hamerselyana and Eucalyptus leucophloia subsp. leucophloia on red brown sandy loam on minor drainage lines.

MI PIAtpAm ChEII TwTp

Shrubland of Petalostylis labicheoides, Acacia tumida var. pilbarensis and Acacia monticola with Low Open Woodland of Corymbia hamerselyana and Eucalyptus leucophloia subsp. leucophloia over Open Hummock Grassland of Triodia wiseana and Triodia pungens on red brown loam on minor drainage lines.

SP AaApr TmTwTp TtChfAri

Low Open Forest of Acacia aptaneura and Acacia pruinocarpa over Open Hummock Grassland of Triodia melvillei, Triodia wiseana and Triodia pungens over Tussock Grassland of Themeda triandra, Chrysopogon fallax and Aristida inaequiglumis on red brown loam on stony plains.

SP AcaoAa AroBDiaChf

Low Open Forest of Acacia catenulata subsp. occidentalis and Acacia aptaneura over Very Open Tussock Grassland of Aristida obscura, Digitaria amophila and Chrysopogon fallax on red brown clay loam on lower stony plains.

SP TpTb Eg PIAbAanc

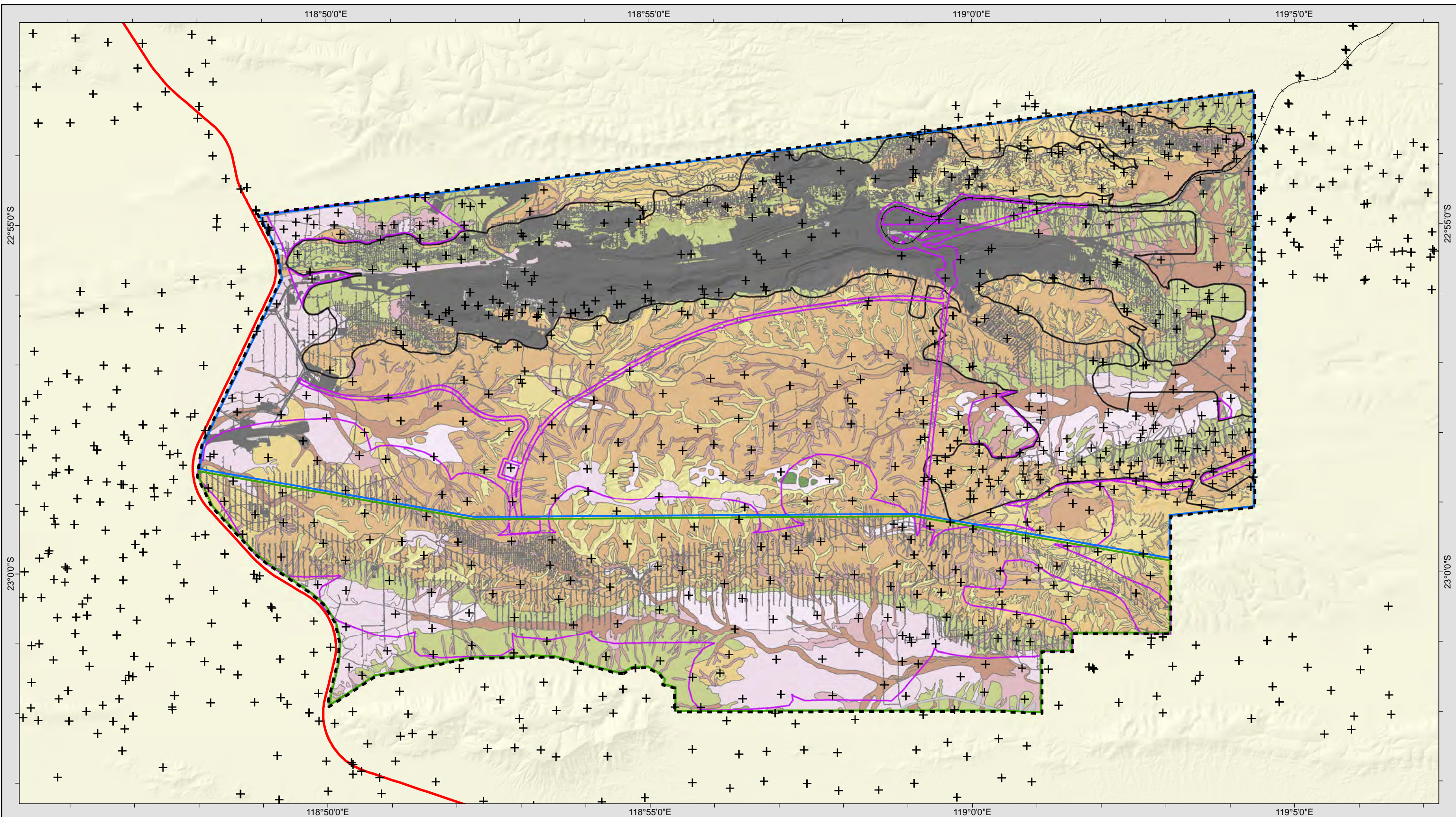
Hummock Grassland of Triodia pungens and Triodia basedowii with Open Mallee of Eucalyptus gamophylla and Shrubland of Petalostylis labicheoides, Acacia bivenosa and Acacia ancistrocarpa on red brown loamy sand on stony plains and footslopes.

SP TpTm AaExAcao ApaErffAads

Hummock Grassland of Triodia pungens and Triodia melvillei with Low Open Woodland of Acacia aptaneura, Eucalyptus xerothermica and Acacia catenulata subsp. occidentalis and Open Shrubland of Acacia pachyacra, Eremophila forrestii subsp. forrestii and Acacia adsurgens on red brown clay loam or silty loam on stony plains and floodplains.

SP TsTwTp EgEt AbApaApr

Hummock Grassland of Triodia sp. Shovelanna Hill (S. van Leeuwen 3835), Triodia wiseana and Triodia pungens with Very Open Mallee of Eucalyptus gamophylla and Eucalyptus trivalva over Open Shrubland of Acacia bivenosa, Acacia pachyacra and Acacia pruinocarpa on red brown sandy loam and clay loam on stony plains.



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Vegetation Associations in the Proposed
Mining Area C Development Envelope

Scale @ A3: 1:95,000	Prepared: M. LYTTLE	Project No: A780/025 REV C
Date: 3/05/2017	Checked: B. BARNETT	Figure: 14a
Revision: Rev C	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail
- Vegetation Survey Sites

Vegetation Association

- Not mapped
- Cleared
- CP TwTa Ese
- FP AaAcaoAp ErInSolPto
- ArcErdiArj
- FP AaApApt
- FP Ev Aa EuaErbTt
- FP TtEua ExAa
- FS Ts CdHc
- FS TsTpTw Eil AbApaAanc
- GG CcolCfEil ErmuThmbCya

- GG CfEilFib AhDovmAsh
- CyaErnuThmb
- GG TtErnuThmb EilChCf
- AtpGoroPI
- HC TpTwTs EilCh
- HC Tw Ah
- HC TwTsTp EilCh
- HS AaApr ErjpAmarCocf
- HS TbrTw Eil
- HS Tp AaApr
- HS Tp Eil SeggGrwhErll
- HS TsTw Eg GrwhSeggAb

- HS TsTwTp EilCh
- HS TwTpTbr Eil Ep
- HS TwTpTs Eil AprAaAanc
- MA AtpAypAse Ecr ThmbTtCyp
- MA EcrEvEx ApypAtpGoro
- TtEuaCyp
- ME TpTlo ExAcich
- PIAypGoro
- ME TtAniCya ChEil
- ME TtChfEua ExEvCh
- PIAaAypyp
- ME TtEuaEte ApypAtpPI

- MI AtpPIAm TpTs
- MI PIAtPAm ChEil TwTp
- SP AaApr TmTwTp
- SP AcaoAa ArobDiaChf
- SP TpTb Eg PIAbAanc
- SP TpTm AaExAcao
- ApaErfAads
- SP TsTwTp EgEt

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Vegetation Associations in the Proposed
Mining Area C Development Envelope

Scale @ A3: 1:95,000	Prepared: M. LYTTLE	Project No: A780/026 REV C
Date: 3/05/2017	Checked: B. BARNETT	Figure: 14b
Revision: Rev C	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Vegetation Association
- Great Northern Highway
- BHP Billiton Rail

Liability
BHP Billiton does not warrant that this map is free from errors or omissions. BHP Billiton shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organization consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

11.1.3.3 Vegetation condition

A majority of the vegetation in the Proposed Mining Area C Development Envelope, including the Additional Development Envelope, was considered to be in Good or better condition (Table 13 and Figure 15). Vegetation condition in the Indicative Additional Impact Assessment Area was generally rated as Pristine, Excellent or Very Good (Table 13).

Vegetation in areas of higher relief, with restricted access by stock and supporting less palatable plant species, retained higher condition scores in the range of Excellent to Pristine. This includes the northern fringe of the Proposed Mining Area C Development Envelope, the majority of uplands occurring south of the existing infrastructure and mining operations, and the deep rocky gorge habitats through the central sectors. Vegetation condition declines to Very Good or Good on drainage lines and flood plains, as well as on areas of Packsaddle Range where exploration activities have occurred or the impact of stock is greater. The major impact on lowland vegetation is the result of grazing by cattle, which has contributed to changes in native vegetation structure and composition, the introduction of weed species, and surface instability.

Table 13: Vegetation condition (based on Keighery, 1994) in the Proposed Mining Area C Development Envelope

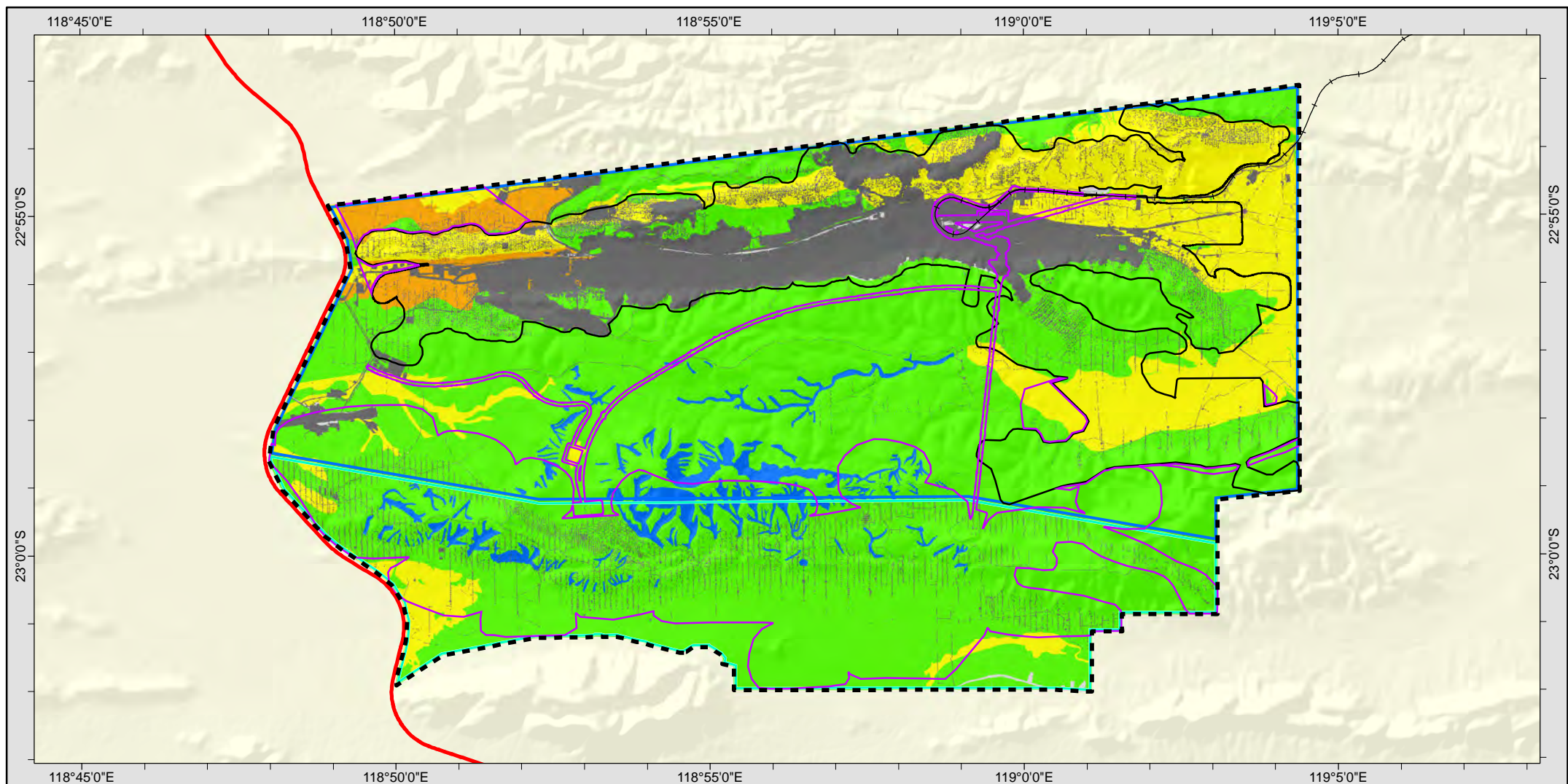
Vegetation Condition	Area (ha)				
	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	Mining Area C Revision 6 EMP Impact Assessment Area	Cleared
Pristine	1,190	513	727	0	7
Excellent	22,508	8,573	9,016	3,292	2,162
Very Good	5,936	589	658	3,344	1,131
Good	773	0	312	317	461
Unmapped	145	29	28	41	1,721

11.1.3.4 Flora

Four hundred and seventy-nine flora taxa (including varieties and subspecies) from 53 families and 166 genera have been recorded in the Proposed Mining Area C Development Envelope. Species representation was greatest among the Fabaceae, Poaceae, Malvaceae, Asteraceae, Amaranthaceae, Myrtaceae, Chenopodiaceae, Goodeniaceae, Scrophulariaceae and Solanaceae families, which is typical for the Pilbara bioregion. The most speciose genus was *Acacia* (51 taxa), followed by *Senna* (19 taxa), *Sida* (17 taxa), *Eremophila* (15 taxa), *Ptilotus* (14 taxa) and *Triodia* (11 taxa).

A search of the EPBC Act Protected Matters Database (DotE, 2016a) and the DPaW database (DPaW, 2016a) identified two Threatened flora species (both listed as Vulnerable) within a 50 km radius of the Proposed Mining Area C Development Envelope: *Lepidium catapycnon* (listed under the EPBC Act) and *Thryptomene wittweri* (listed under the EPBC Act and WC Act). *Lepidium catapycnon* is listed as a Priority 4 flora by DPaW. Neither species has been recorded in the Proposed Mining Area C Development Envelope nor is the habitat for *Thryptomene wittweri* considered to occur.

Fifty Priority flora have been recorded within 25 km of the Proposed Mining Area C Development Envelope (DPaW, 2016a) (Table 14). Ten of these have been recorded in the Proposed Mining Area C Development Envelope, and eight of these species occur in the Additional Impact Assessment Area (Table 14).



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Vegetation Condition within the Proposed Mining Area C Development Envelope

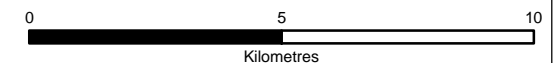
Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/027 REV B
Date: 7/02/2017	Checked: B. BARNETT	Figure: 15
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area

Vegetation Condition

- Pristine
- Excellent
- Very Good
- Good
- Not mapped
- Cleared
- Great Northern Highway
- BHP Billiton Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Table 14: Conservation significant flora recorded in the Proposed Mining Area C Development Envelope and surrounds (species present in the Proposed Mining Area C Development Envelope are highlighted in grey)

Species	Habitat	Recorded in ADE	Recorded in IAIAA	Recorded in MAC EMP R6	Habitat Present	Cons. Code*	Likelihood of Presence
<i>Acacia bromilowiana</i>	Red skeletal stony loam, orange-brown pebbly, gravel loam, laterite, banded ironstone, basalt. Rocky hills, breakaways, scree slopes, gorges, creek beds.	Y	Y	N	Y	4	Recorded
<i>Acacia dawsoniana</i>	Stony red loamy soils. Low rocky rises, along drainage lines.	N	N	N	Y	3	Low
<i>Acacia effusa</i>	Scree slopes of low ranges.	N	N	N	Y	3	Moderate
<i>Acacia subtiliformis</i>	Rocky calcrete plateau.	N	N	N	Y	3	Moderate
<i>Adiantum capillus-veneris</i>	Moist, sheltered sites in gorges and on cliff walls.	N	N	N	Y	2	Moderate
<i>Amaranthus centralis</i>	Alluvial plains and valleys, sandplains, rocky or gravelly hills and rises, and ephemeral watercourses and run-on areas.	N	N	N	Y	3	Low
<i>Aristida lazardii</i>	Deep loam soils or sand.	Y	Y	Y	Y	2	Recorded
<i>Aristida jerichoensis</i> var. <i>subspinulifera</i>	Hardpan plains.	Y	Y	Y	Y	3	Recorded
<i>Barbula ehrenbergii</i>	Iron rich weathered conglomerate on gorge walls.	N	N	N	Y	1	Low
<i>Bothriochloa decipiens</i> var. <i>cloncurrans</i>	Woodlands on a range of soil types.	N	N	N	Y	1	Moderate
<i>Calotis latiuscula</i>	Rocky hillsides, floodplains, rocky creeks or river beds.	N	N	N	Y	3	Moderate
<i>Calotis squamigera</i>	Pebbly loam.	N	N	N	Y	1	Moderate
<i>Dampiera anonyma</i>	Skeletal red-brown to brown gravelly soil over banded ironstone, basalt, shale and jaspilite. Hill summits, upper slopes (above 1,000 m).	N	N	N	N	3	Low
<i>Dampiera metallorum</i>	Skeletal red-brown gravelly soil over banded ironstone. Steep slopes, summits of hills.	N	N	N	N	3	Low
<i>Eragrostis</i> sp. Mt Robinson (S. van Leeuwen 4109)	Red-brown skeletal soils, ironstone. Steep slopes, summits.	N	N	N	N	1	Low
<i>Eremophila forrestii</i> subsp. <i>Pingandy</i> (M.E. Trudgen 2662)	Flat plain with thin soil underlain by partly consolidated colluvium.	N	N	N	Y	2	Moderate

Species	Habitat	Recorded in ADE	Recorded in IAIAA	Recorded in MAC EMP R6	Habitat Present	Cons. Code*	Likelihood of Presence
<i>Eremophila forrestii</i> subsp. <i>viridis</i>	Moderately to steeply sloping lower tip of hill spur. Soil: Red-brown very gravelly loam with gravel, pebble surface.	N	N	N	Y	3	Moderate
<i>Eremophila magnifica</i> subsp. <i>magnifica</i>	Skeletal soils over ironstone.	Y	Y	Y	Y	4	Recorded
<i>Eremophila magnifica</i> subsp. <i>velutina</i>	Skeletal soils over ironstone. Summits. Rocky breakaways.	N	N	N	Y	3	High
<i>Eremophila</i> sp. Hamersley Range (K. Walker KW 136)	Rocky gullies and gorges. Steep rocky hill slopes and summits, high in the landscape.	N	N	N	Y	1	Moderate
<i>Eremophila</i> sp. West Angelas (S. van Leeuwen 4086)	High in landscape, summit of hill, gently undulating to steep terrain, skeletal red gritty soil over massive banded iron of the Brockman Iron Formation.	N	N	N	Y	1	Moderate
<i>Eremophila</i> sp. Snowy Mountain (S. van Leeuwen 3737)	Gently undulating to steep terrain, skeletal soil over banded iron of the Brockman Iron Formation.	N	N	N	N	1	Low
<i>Eucalyptus lucens</i>	Ironstone. Rocky slopes and mountain tops, high in the landscape.	N	N	N	N	1	Low
<i>Fimbristylis sieberiana</i>	Mud, skeletal soil pockets. Pool edges, sandstone cliffs.	N	N	N	N	3	Low
<i>Geijera salicifolia</i>	Skeletal soils, stony soils. Massive rock scree, gorges.	N	N	N	Y	3	Low
<i>Grevillea saxicola</i> [#]	Orange/brown loam soils on steep breakaway and scree slopes (often with southerly aspects)	Y	N	N	Y	3	Recorded
<i>Pleurocarpaea gracilis</i>	Skeletal, brown gritty soil over ironstone. Hill summit.	N	N	N	N	3	Low
<i>Goodenia lyrata</i>	Red sandy loam. Near claypan.	N	N	N	N	3	Moderate
<i>Goodenia</i> sp. East Pilbara (A.A. Mitchell PRP 727)	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains.	N	N	N	Y	3	Moderate
<i>Hibiscus</i> sp. Gurinbiddy Range (M.E. Trudgen MET 15708)	Gullies and steep, rocky hill slopes.	N	N	N	Y	2	Moderate
<i>Indigofera gilesii</i>	Pebbly loam amongst boulders & outcrops. Hills.	N	N	N	Y	3	Moderate

Species	Habitat	Recorded in ADE	Recorded in IAIAA	Recorded in MAC EMP R6	Habitat Present	Cons. Code*	Likelihood of Presence
<i>Iotasperma sessilifolium</i>	Cracking clay, black loam. Edges of waterholes, plains.	N	N	N	N	3	Low
<i>Lepidium catapycnon</i>	Skeletal soils. Hillsides.	N	N	N	Y	4	Moderate
<i>Myriocephalus nudus</i>	Moist areas, along rivers & creeks, granite outcrops.	N	N	N	Y	1	Low
<i>Nicotiana umbratica</i>	Shallow soils. Rocky outcrops.	Y	N	Y	Y	3	Recorded
<i>Oldenlandia</i> sp. Hamersley Station (A.A. Mitchell PRP 1479)	Cracking clay, basalt. Gently undulating plain with large surface rocks, flat crabholed plain.	N	N	N	N	3	Low
<i>Oxalis</i> sp. Pilbara (M.E. Trudgen 12725)	Shaded gully on the lower slopes of a large hill, in the flowline in the gully. Soil: pebbly/gravelly red-brown loam amongst boulders.	N	N	N	Y	2	Moderate
<i>Pilbara trudgenii</i>	Skeletal, red stony soil over ironstone. Hill summits, steep slopes, screes, cliff faces.	N	N	N	N	3	Low
<i>Ptilotus mollis</i>	Stony hills, scree slopes.	N	N	N	Y	4	Moderate
<i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794)	Floodplains, hardpan plains.	Y	Y	Y	Y	3	Recorded
<i>Rhynchosia bungarensis</i>	Pebbly, shingly coarse sand amongst boulders. Banks of flow line in the mouth of a gully in a valley wall.	N	N	N	Y	4	Low
<i>Rostellularia adscendens</i> var. <i>latifolia</i>	Ironstone soils. Near creeks, rocky hills.	Y	Y	Y	Y	3	Recorded
<i>Scaevola</i> sp. Hamersley Range basalts (S. van Leeuwen 3675)	Skeletal, brown gritty soil over basalt. Summits of hills, steep hills.	N	N	N	N	2	Low
<i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642)	Skeletal red soils pockets. Steep slope.	Y	Y	N	Y	3	Recorded
<i>Sida</i> sp. Hamersley Range (K. Newbey 10692)	-	N	N	N	Y	1	Moderate
<i>Stylidium weeliwolli</i>	Gritty sand soil, sandy clay. Edge of watercourses.	N	N	N	N	2	Low
<i>Tetratheca fordiana</i>	Shale pocket amongst ironstone.	N	N	N	N	1	Low
<i>Themeda</i> sp. Hamersley Station (M.E. Trudgen 11431)	Red clay. Clay pan, grass plain.	N	N	N	Y	3	Moderate

Species	Habitat	Recorded in ADE	Recorded in IAIAA	Recorded in MAC EMP R6	Habitat Present	Cons. Code*	Likelihood of Presence
<i>Thryptomene wittweri</i>	Skeletal red stony soils. Breakaways, stony creek beds.	N	N	N	Y	T, V	Low
<i>Triodia</i> sp. Karijini (S. van Leeuwen 4684)	Summit and steep hill slopes, high in the landscape.	N	N	N	N	1	Moderate
<i>Triodia</i> sp. Mt. Ella (M.E. Trudgen 12739)	Light orange-brown, pebbly loam. Amongst rocks & outcrops, gully slopes.	Y	Y	N	Y	3	Recorded
<i>Vittadinia</i> sp. Coondewanna Flats (S. van Leeuwen 4684)	Floodplains, hardpan plains.	N	N	N	Y	1	Moderate

Not identified in database search.

None of the native plant taxa recorded from the Proposed Mining Area C Development Envelope were considered to be range extensions, potentially new species, or locally endemic or restricted species. One introduced taxon (**Stylosanthes hamata*) represented a large range extension of approximately 400 km south-west of the nearest known occurrences. This record was restricted to the verge of Great Northern Highway and has subsequently been eradicated as part of BHP Billiton Iron Ore's weed management program.

Twenty-three introduced (weed) species have been recorded in the Proposed Mining Area C Development Envelope during baseline surveys (Table 15 and Figure 16), none of which are listed under the *Biosecurity and Agriculture Management Act 2007* (WA). Twenty one species have been recorded in the Approved Mining Area C (Northern Flank) Development Envelope. The ulcardo melon and mimosa bush have been recorded in the Additional Development Envelope but not in the Approved Mining Area C (Northern Flank) Development Envelope.

A recent audit of weed management at Mining Area C has confirmed that no weeds listed under the *Biosecurity and Agriculture Management Act 2007* have been introduced to site since the commencement of operations. A population of pie melon (**Citrullus lanatus*) was recorded in operations areas and eradicated.

11.1.3.5 Existing impacts

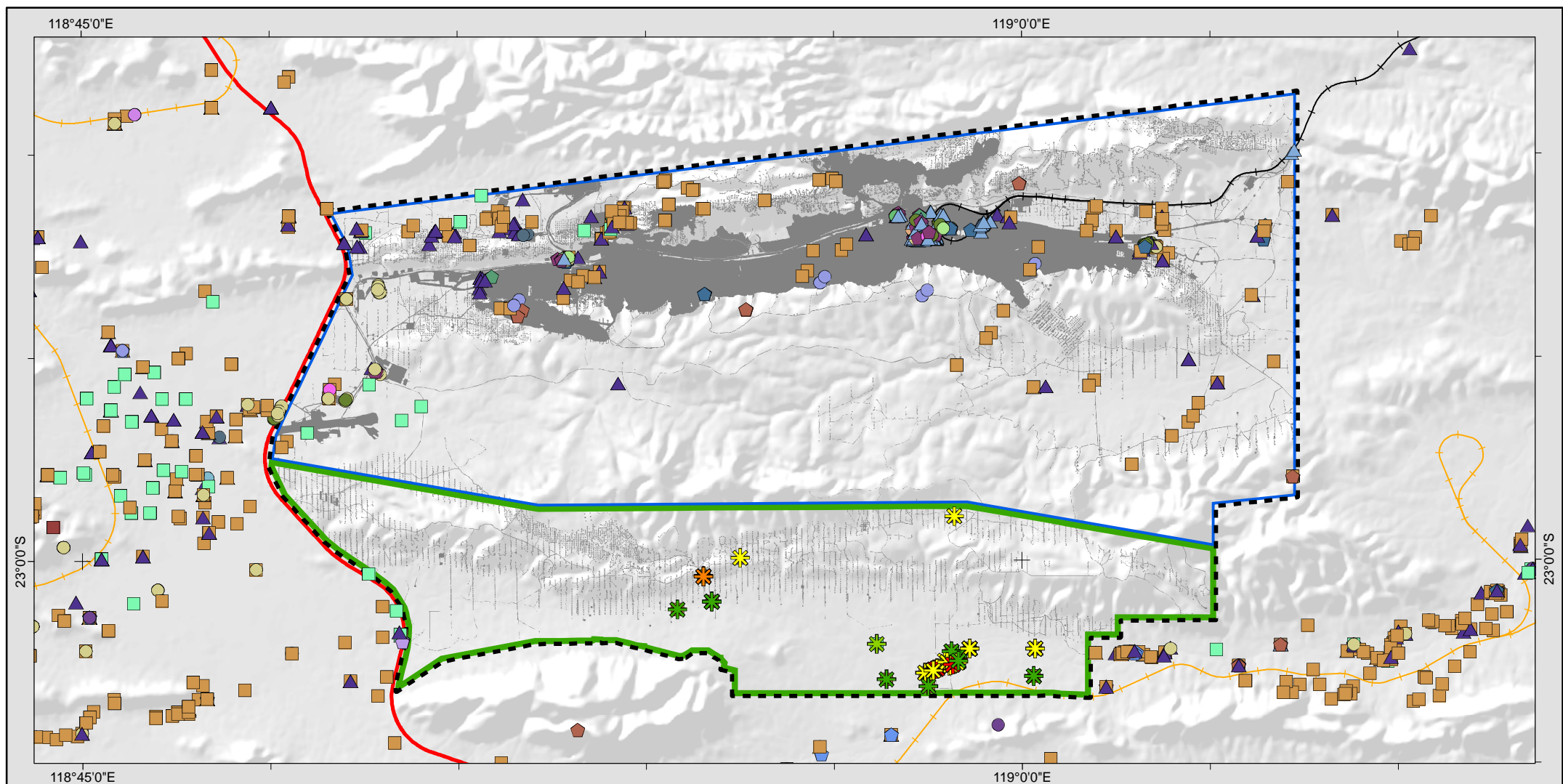
Vegetation clearing has been undertaken in the Proposed Mining Area C Development Envelope under previously approved Part IV and Part V approvals. As of December 2016, a total of 5,482 ha have been cleared within the Proposed Mining Area C Development Envelope (Figure 7) as permitted via the following approvals and licences:

- MS 491: 4,792 ha
- Clearing under exemption (e.g. firebreaks): 31 ha
- NVCP 2295: 238 ha
- NVCP CPS 4337: 50 ha
- NVCP CPS 4630: 281 ha
- NVCP CPS 4831: 21 ha
- NVCP CPS 5105: 2 ha
- Mining Act: 45 ha
- State Agreement: 22 ha

This clearing has resulted in the removal of:

Priority flora:

- *Aristida jerichoensis* var. *subspinulifera* – approximately 129 individuals
- *Aristida lazarides* – approximately 7 individuals
- *Eremophila magnifica* subsp. *magnifica* – approximately 1 individual
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) – approximately 5 individuals
- *Rostellularia adscendens* var. *latifolia* - approximately 15 individuals



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Weed Affected Areas

Scale @ A4: 1:150,000	Prepared: J. ROBERTS	Project No: A780/028 REV C
Date: 30/03/2017	Checked: R. GREGORY	Figure: 16
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- BHPBIO Disturbance Footprint (Dec 2016)
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

Species Observations (Weeds) outside Additional Development Envelope

- Aerva javanica
- Bidens bipinnata
- Cenchrus ciliaris
- Cenchrus setiger
- Chloris barbata
- Chloris virgata
- Citrullus colocynthis
- Citrullus lanatus
- Conyza bonariensis
- Cucumis myriocarpus
- Cynodon dactylon
- Datura leichhardtii

- Digitaria ciliaris
- Echinochloa colona
- Euphorbia hirta
- Flaveria trinervia
- Lactuca serriola
- Malvastrum americanum
- Rumex vesicarius
- Setaria verticillata
- Sigesbeckia orientalis
- Solanum nigrum
- Sonchus oleraceus
- Stylosanthes hamata
- Vachellia farnesiana

Species Observations (Weeds) inside Additional Development Envelope

- Bidens bipinnata
- Cenchrus ciliaris
- Malvastrum americanum
- Setaria verticillata
- Vachellia farnesiana



0 2 4
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Table 15: Introduced flora species recorded in the Proposed Mining Area C Development Envelope

Weed Species	Proposed Mining Area C Development Envelope	Approved Mining Area C (Northern Flank) Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area
<i>Bidens bipinnata</i> (bipinnate beggartick)	X	X	X	X
<i>Cenchrus ciliaris</i> (buffel grass)	X	X	X	X
<i>Cenchrus setiger</i> (birdwood grass)	X	X		
<i>Chloris barbata</i> (purpletop chloris)	X	X		
<i>Chloris virgata</i> (feathertop Rhodes grass)	X	X		
<i>Citrullus colocynthis</i> (colocynth)	X	X		
<i>Conyza bonariensis</i> (flaxleaf fleabane)	X	X		
<i>Conyza sumatrensis</i> (tall fleabane)	X	X		
<i>Cucumis melo</i> subsp. <i>agrestis</i> (ulcardo melon)	X		X	X
<i>Cynodon dactylon</i> (couch grass)	X	X		X
<i>Datura leichhardtii</i> (native thornapple)	X	X		
<i>Digitaria ciliaris</i> (summer grass)	X	X		
<i>Echinochloa colona</i> (awnless barnyard grass)	X	X		
<i>Euphorbia hirta</i> (asthma plant)	X	X		
<i>Lactuca serriola</i> (prickly lettuce)	X	X		
<i>Malvastrum americanum</i> (spiked malvastrum)	X	X	X	X
<i>Rumex vesicaria</i> (ruby dock)	X	X		
<i>Setaria verticillata</i> (whorled pigeon grass)	X	X	X	X
<i>Sigesbeckia orientalis</i> (indian weed)	X	X		
<i>Solanum nigrum</i> (black berry nightshade)	X	X		
<i>Sonchus oleraceus</i> (common sowthistle)	X	X		
<i>Tridax procumbens</i> (tridax)	X	X		
<i>Vachellia farnesiana</i> (mimosa bush)	X		X	X

Vegetation condition:

- Pristine - 7 ha
- Excellent – 2,162 ha
- Very Good – 1,131 ha
- Good – 461 ha
- Degraded/ unmapped⁵ - 1,721 ha

⁵ Area cleared prior to GIS mapping of vegetation association or condition

Vegetation associations:

Thirty-one vegetation associations have been subjected to clearing within the Proposed Mining Area C Development Envelope; six have been cleared by less than 1 ha, and 14 are considered to have local significance (Table 12). No vegetation association has had more than 10% of its mapped extent cleared within the Proposed Mining Area C Development Envelope. It is noted that GIS information is not available for some areas for which environmental assessments and clearing predate the collection of electronic vegetation association data in a format that could be consolidated into BHP Billiton Iron Ore's regional vegetation association database.

The impacts of existing clearing to vegetation and flora within the Proposed Mining Area C Development Envelope are considered low.

11.1.4 Potential impacts

This section summarises potential direct and indirect impacts from mining within the Proposed Mining Area C Development Envelope, and specifically, impacts from those activities undertaken within the Indicative Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assessment Area, and an assessment of potential cumulative impacts at a sub-regional or regional scale, as appropriate, and where information is available. The extents or boundaries used to assess the potential impacts of the Proposal and cumulative or regional extents vary for each factor. Table 16 details the areas assessed for the Flora and Vegetation factor.

Information has been summarised from flora and vegetation impact assessments undertaken in 2015 for update of the EMP Revision 6 (Onshore Environmental, 2015) and in 2016 for the Additional Impact Assessment Area (Onshore Environmental, 2017). Information from the 2015 impact assessments has been updated, where appropriate, in consideration of changes to species taxonomy, conservation listings or increased knowledge of species ecology or distribution. All supporting documents are provided in Appendix 4.

Table 16: Impact Assessment Areas for flora and vegetation

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Flora and Vegetation	Indicative Additional Impact Assessment Area and Additional Development Envelope. Mining Area C EMP Revision 6 Impact Assessment Area	Proposed Mining Area C Development Envelope, including Mining Area C EMP Revision 6 Impact Assessment Area and Indicative Additional Impact Assessment Area.	All areas within the Proposed Mining Area C Development Envelope. For Priority flora, this has also considered BHP Billiton Iron Ore and third-party footprints identified in BHP Billiton Iron Ore's Strategic Proposal (BHP Billiton Iron Ore, 2016c).

11.1.4.1 Direct Impacts

11.1.4.1.1 Vegetation

Twenty-four of the 34 vegetation associations mapped in the Proposed Mining Area C Development Envelope occur in the Additional Development Envelope and 29 occur in Indicative Additional Impact Assessment Area. Twenty-eight vegetation associations were mapped within the Approved Mining Area C (Northern Flank) Development Envelope, of which 21 occur within the Mining Area C EMP Revision 6 Impact Assessment Area. Only two vegetation types have more than 30% of their total mapped area

within the Indicative Additional Impact Assessment Area (HS AaApr ErjpAmarCocf TwTp and SP AcaoAa ArobDiaChf; see Table 12). Both are considered to be locally significant vegetation, as one supports two conservation significant flora species and the second is considered to be an 'Ecosystem at Risk' by Kendrick (2001). Onshore Environmental (2017) considered impacts to these vegetation associations from clearing to be low. Impacts to all vegetation associations within the Indicative Additional Impact Assessment Area were considered to be low to very low (Onshore Environmental, 2017).

There are no vegetation associations within the Proposed Mining Area C Development Envelope that are considered to be PECs or TECs.

Fifteen vegetation associations in the Proposed Mining Area C Development Envelope are considered to have local conservation significance (Table 12 and Figure 17), as they are classified as an 'Ecosystem at Risk' by Kendrick (2001) or support one or more conservation significant flora species.

Ten are considered to have very low local conservation significance as they are well represented outside the Indicative Additional Impact Assessment Area and support Priority flora that occur in multiple vegetation associations in the Proposed Mining Area C Development Envelope and wider Pilbara IBRA bioregion. Impacts to these are therefore considered to be very low and are not discussed further.

The remaining five vegetation associations have been determined to have low local conservation significance (Appendix 4) and are discussed further below.

'GG CcolCfElI ErmuThmbCya'

The vegetation association Low Open Forest of *Callitris columellaris*, *Corymbia ferritcola* and *Eucalyptus leucophloia* subsp. *leucophloia* over Open Tussock Grassland of *Eriachne mucronata*, *Themeda* sp. Mt Barricade (M.E. Trudgen 2471) and *Cymbopogon ambiguus* and Very Open Hummock Grassland of *Triodia pungens* on orange brown loam on upper gorges (GG CcolCfElI ErmuThmbCya) was considered locally significant as it supports one Priority 4 taxon (*Acacia bromilowiana*) which is restricted to this vegetation association. Only 2.6% of the mapped area⁶ for this vegetation association occurs within the Proposed Mining Area C Development Envelope (all within the Indicative Additional Impact Assessment Area) (Table 17). Significance of impact to this vegetation association type is therefore considered to be low (Onshore Environmental, 2017).

'GG CfElIFib AhDovmAsha CyaErmuThmb' and 'GG TtErmuThmb ElIChCf AtpGoroPI'

The vegetation association Low Woodland of *Corymbia ferritcola*, *Eucalyptus leucophloia* subsp. *leucophloia* and *Ficus brachypoda* over Open Shrubland of *Acacia hamersleyensis*, *Dodonaea viscosa* subsp. *mucronata* and *Astrotricha hamptonii* over Open Tussock Grassland of *Cymbopogon ambiguus*, *Eriachne mucronata* and *Themeda* sp. Mt Barricade (M.E. Trudgen 2471) on red brown loam along cliffines and gorges (GG CfElIFib AhDovmAsha CyaErmuThmb) was considered locally significant as it supports four P3 flora taxa and one P4 flora taxon. Three of the P3 flora taxa are restricted to this vegetation association (*Grevillea saxicola*, *Sida* sp. Barlee Range (S. van Leeuwen 1642), *Triodia* sp. Mt Ella (M.E. Trudgen 12739)). Approximately 43% of its mapped area⁵ occurs within the Proposed Mining Area C Development Envelope (Table 17).

⁶ BHP Billiton Iron Ore's vegetation association database has been developed from the consolidation of 162 historical baseline surveys undertaken by multiple consultants at differing scales. The database has been developed to standardize as far as possible this mapping which can be utilised to undertake preliminary impact assessments at the vegetation association level. BHP Billiton Iron Ore's vegetation association mapping covers approximately 4,300 km², which is about 2.4% of the total Pilbara region.

The vegetation association Tussock Grassland of *Themeda triandra*, *Eriachne mucronata* and *Themeda* sp. Mt Barricade (M.E. Trudgen 2471) with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia*, *Corymbia hamersleyana* and *Corymbia ferritcola* over High Shrubland of *Acacia tumida* var. *pilbarensis*, *Gossypium robinsonii* and *Petalostylis labicheoides* on red brown sandy loam in narrowly incised rocky drainage lines (GG TtErnuThmb EllChCf AtpGoroPI) was considered locally significant as it supports two P3 flora taxa and one P4 flora taxon. One of the P3 flora taxa (*Nicotiana umbratica*) is restricted to this vegetation association. Approximately 62% of its mapped area⁵ occurs within the Proposed Mining Area C Development Envelope.

The associations 'GG CfEllFib AhDovmAshA CyaErnuThmb' and 'GG TtErnuThmb EllChCf AtpGoroPI' occur in gorges. While the composition of keystone species found within local gorges is relatively consistent, vegetation structure is spatially variable within this landform, i.e. vegetation structure occurring on sheer gorge walls differs to that on scree slopes, which differs to that along ephemeral drainage channels etc. Even at the fine-scale of mapping undertaken for BHP Billiton Iron Ore, these spatial differences are very difficult to delineate on a vegetation map and hence, the most representative vegetation structure present within the gorge landform is typically described and mapped. This has contributed to the under-representation of this vegetation association within the vegetation association mapping, and therefore impacts to these vegetation types are likely to be over-estimated. Significance of impact to these vegetation associations is considered to be low (Onshore Environmental, 2017).

'HS AaApr ErjpAmarCocf TwTp'

The vegetation association Low Woodland of *Acacia aptaneura* and *Acacia pruinocarpa* over Shrubland of *Eremophila jucunda* subsp. *pulcherrima*, *Acacia marramamba* and *Codonocarpus cotinifolius* over Open Hummock Grassland of *Triodia wiseana* and *Triodia pungens* on red brown loam on hill slopes (HS AaApr ErjpAmarCocf TwTp) was considered locally significant as it supports one P3 flora and one P4 flora taxon. Approximately 81% of its mapped area occurs within the Proposed Mining Area C Development Envelope (Table 17).

The association 'HS AaApr ErjpAmarCocf TwTp' occurred within a very long unburnt remnant where large *Acacia pruinocarpa* trees had established in association with a canopy of mulga. Fire was the major factor influencing the *in situ* structure of this association, which otherwise would have been representative of the surrounding vegetation (which had been burnt more recently). Fire was the major factor influencing the low representation of this association within BHP Billiton Iron Ore's consolidated Pilbara mapping database. It is further noted that it does not occur in areas of unique or uncommon topography, and is considered highly unlikely to be uncommon in the landscape. Significance of impact to this vegetation association is therefore considered to be low (Onshore Environmental, 2017).

'SP AcaoAa ArobDiaChf'

'Valley floor mulga' within the Hamersley subregion is considered to be an 'Ecosystem at Risk' by Kendrick (2001). Vegetation association 'SP AcaoAa ArobDiaChf' is equivalent to 'valley floor mulga' given its occurrence on stony plains in areas of lower relief. It also supports one Priority 3 flora taxon (*Rhagodia* sp. Hamersley (M. Trudgen 17794)). Less than 50% of its mapped area occurs within the Indicative Additional Impact Assessment Area (Table 17). Two Principal Botanists from Onshore Environmental have undertaken baseline flora and vegetation survey work within the Proposed Mining Area C Development Envelope on a regular basis since 2004 (Dr Darren Brearley and Dr Jerome Bull). Both botanists have also undertaken surveys across the wider Hamersley Range, including targeted survey work by helicopter within Karijini National Park. The botanists can confirm that vegetation supporting *Acacia catenulata* subsp. *occidentalis* and *Acacia aptaneura* is common on plains between Newman and Roy Hill (approximate range 150 km). It is also noted that seven other vegetation associations within BHP Billiton Iron Ore's consolidated vegetation mapping database support *Acacia*

catenulata subsp. *occidentalis* and *Acacia aptaneura* as dominant upperstorey components, and are considered to be closely affiliated with 'SP AcaoAa ArobDiaChf'. As such, this vegetation association is not considered to be locally endemic or unique. Similarly, neither the vegetation association nor related ecosystem has been nominated as a PEC by DPaW since 'valley floor mulga' was identified as an 'Ecosystem at Risk' by Kendrick (2001) 16 years ago, suggesting a low level of perceived conservation significance. Onshore Environmental (2017) therefore considered the overall impact to be low.

There are 45 mulga dominant vegetation associations within BHP Billiton Iron Ore's consolidated vegetation association mapping database that can be considered analogous with 'valley floor mulga' within the Hamersley subregion and therefore considered to be an 'Ecosystem at Risk' (Kendrick 2001). The fine scale definition of these vegetation associations has contributed to the inflated percentage of the 'SP AcaoAa ArobDiaChf' represented within the Proposed Mining Area C Development Envelope. The diversity of mulga vegetation associations within the consolidated database reflects factors such as position in landscape and diversity of soil types, along with other factors including fire, frost and seasonality.

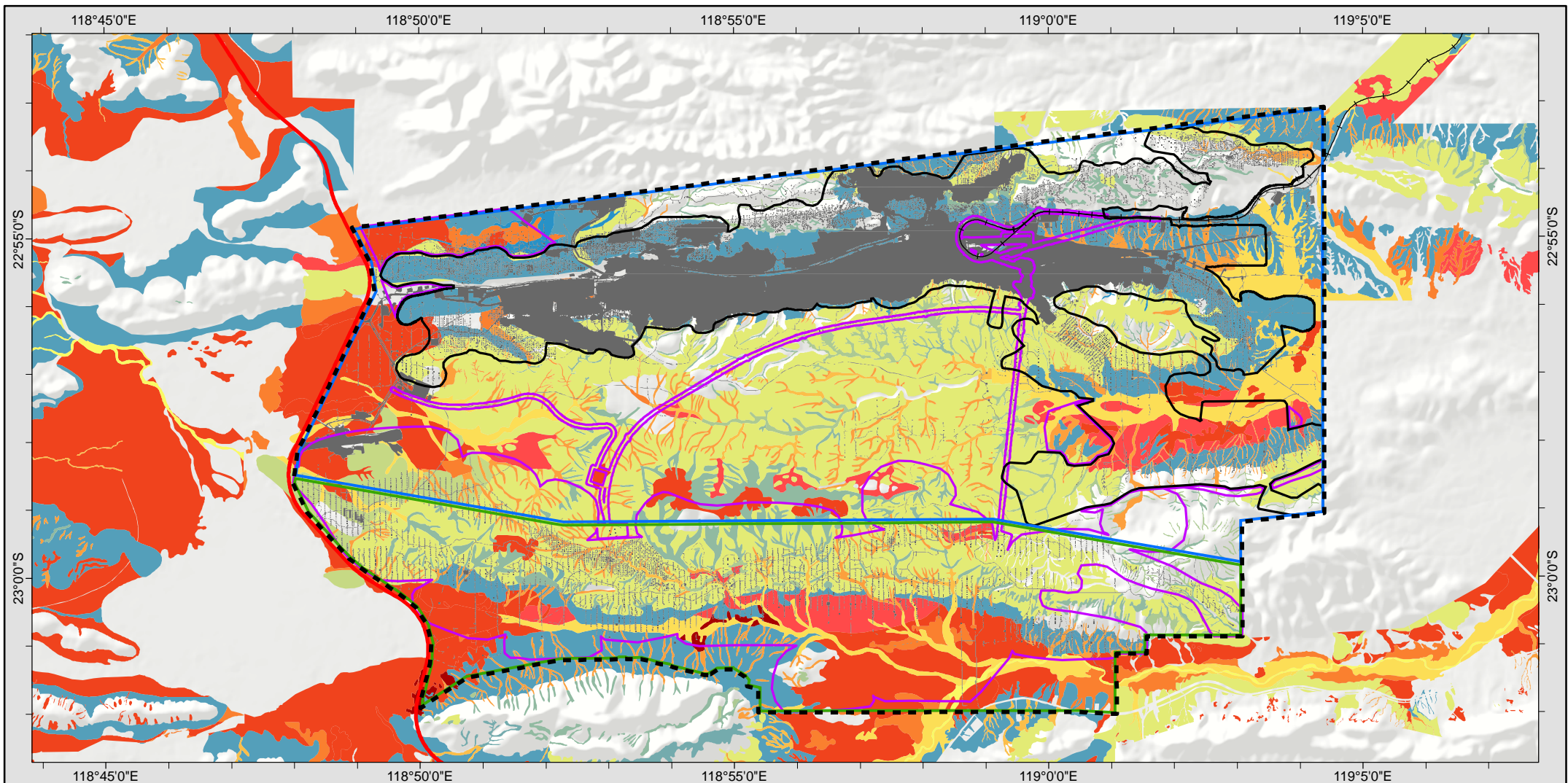
The distribution of mulga vegetation within the Pilbara is relatively well understood and has been defined through broad scale vegetation mapping (Heydenrych *et al.*, 2015). Mulga is a dominant feature of vegetation within the southern Pilbara as far north as latitude 22 degrees south, where it is replaced by *Acacia xiphophylla* in the Chichester Ranges. Mulga extends broadly from the Fortescue Valley into the Hamersley Range, and south into the Ashburton Botanical District. It is found in drainage basins and valley floors typical of the Fortescue Valley, the elevated washplains of Coondewanna Flats and Wanna Munna Flats (and Southern Flank/Mining Area C), footslope pediments of West Angelas, and steep hill slopes and breakaways of Mt Barricade, Mt Robinson and Parmelia Hill. Mulga vegetation dominates the drive northwest from Newman through the Hamersley Range, and is well represented within Karijini National Park. Mulga vegetation is known to extend as far north as BHP Billiton Iron Ore's Roy Hill tenements, where extensive stands in excellent condition have been observed. It is noted that vegetation mapping has not been completed for the Roy Hill tenements, and hence is not represented within BHP Billiton Iron Ore's consolidated Pilbara mapping database. However, vegetation at the Roy Hill tenements includes associations that are closely affiliated with mulga represented around Southern Flank and Mining Area C.

There is one vegetation association within the Proposed Mining Area C Development Envelope that contains species that are considered to be groundwater dependent. The vegetation association Low Open Forest of *Eucalyptus camaldulensis* subsp. *refulgens*, *Eucalyptus victrix* and *Eucalyptus xerothemica* over High Shrubland of *Acacia pyrifolia* var. *pyrifolia*, *Acacia tumida* var. *pilbarensis* and *Gossypium robinsonii* over Open Tussock Grassland of *Themeda triandra*, *Eulalia aurea* and *Cymbopogon procerus* on red brown clay loam on major drainage lines (MA EcrEvEx ApypAtpGoro TtEuaCyp). This vegetation association occurs along Pebble Mouse Creek within the Additional Development Envelope and approximately 30 ha occur within the Indicative Additional Impact Assessment Area. *Eucalyptus camaldulensis* subsp. *refulgens* is considered to be a facultative phreatophyte which utilises groundwater sources in an opportunistic fashion or during times of limited water supply and/or drought like conditions (Astron, 2010). Facultative phreatophytes are susceptible to extended periods of water stress and have good physiological and/or morphological adaptations to reduce their water demands during drought-like conditions. Regional groundwater levels in the vicinity of this section of Pebble Mouse Creek exceed 40 m in depth. It is therefore considered very unlikely that this vegetation association will be accessing groundwater that is subject to drawdown for mining operations. Impacts to this vegetation association are therefore considered low.

Table 17: Impact assessment for locally significant vegetation associations in the Proposed Mining Area C Development Envelope (from Onshore Environmental, 2017)

Vegetation Association	Characteristics Defining Local Significance	Proportion of Consolidated Mapping Area in all Proposed Disturbance Areas (%)*	Impact
GG CcolCfElI ErmuThmbCya	Supports one P4 flora, which is restricted to this vegetation association.	2.6	Low
GG CfElIFib AhDovmAshA CyaErmuThmb	Supports four P3 flora and one P4 flora taxon. Three of the P3 flora are restricted to this vegetation association.	20.5	Low
GG TtErmuThmb ElIChCf AtpGoroPI	Supports two P3 flora and one P4 flora taxon. One of the P3 flora is restricted to this vegetation association.	14.1	Low
HS AaApr ErjpAmarCocf TwTp	Supports one P3 flora and one P4 flora taxon.	73.0	Low
HS TsTwTp ElICh AhiAaa	Supports one P2, two P3 flora and one P4 flora taxon.	8.8	Very Low
FS Ts CdHc AancAiGrwh	Supports one P2 and three P3 flora taxa.	2.9	Very Low
SP AaApr TmTwTp TtChfAri	'Valley floor mulga' which is considered an 'ecosystem at risk.' Supports one P2 and two P3 flora taxa.	2.9	Very Low
SP AcaoAa ArobDiaChf	'Valley floor mulga' which is considered an 'ecosystem at risk.' Supports one P3 flora taxa.	48.3	Low
SP TpTm AaExAcao ApaErffAads	Supports one P2, two P3 flora and one P4 flora taxon.	5.5	Very Low
SP TsTwTp EgEt AbApaApr	Supports three P3 flora taxon.	18.9	Very Low
FP TtEua ExAa AprAtpErlo	'Valley floor mulga' which is considered an 'ecosystem at risk.' Supports one P2 and one P3 flora taxon.	2.9	Very Low
MI AtpPIAm TpTs ChElI	Supports one P2, one P3 flora and one P4 flora taxon.	15.9	Very Low
ME TtAriCya ChElI AmPIAnI	Supports one P3 flora and one P4 flora taxon.	4.8	Very Low
ME TpTlo ExAciCh PIAppyGoro	Supports three P3 flora taxa.	5.6	Very Low
MA EcrEvEx AppyAtpGoro TtEuaCyp	Major ephemeral watercourse which is considered an 'ecosystem at risk.' Supports two P3 flora taxa.	1.4	Very Low

* Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Impacts to Conservation Significant Vegetation within the Proposed Mining Area C Development Envelope

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/029 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 17
Revision: Rev B	Reviewed: S. WILLIAMSON	

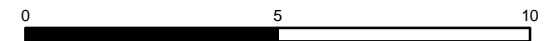
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

Local Conservation Significant Vegetation

- Cleared
- FP TtEua ExAa AprAtpErl
- FS Ts CdHc AancAiGrwh
- GG CcolCfElI ErmuThmbCya
- GG CfElIIFib AhDovmAsh
- CyaErmuThmb
- GG TtErmuThmb ElIchCf
- AtpGoroPI
- HS AaApr EripAmarCocf TwTp

- HS TsTwTp ElIch AhiAaa
- MA EcrEvEx ApppAtpGoro
- TtEuaCyp
- ME TpTto ExAcICh PIAppGoro
- ME TtArIcya ChElI AmPIAnI
- MI AtpPIAm TpTs ChElI
- SP AaApr TmTwTp
- SP TpTm AaExAcao
- ApaEffAads
- SP TsTwTp EgEt AbApaApr
- SP AcaoAa

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Obligate phreatophytic vegetation refers to vegetation that is completely or highly dependent on groundwater sources to survive, and within the vicinity of the Proposed Mining Area C Development Envelope the only obligate phreatophyte species is silver cadjepu, *Melaleuca argentea*. There are no vegetation associations within the Proposed Mining Area C Development Envelope that contain this species. It does occur within the Weeli Wolli PEC (including Ben's Oasis). Impacts to this community associated with groundwater drawdown are discussed in Section 11.1.4.3.3.

11.1.4.1.2 Conservation significant flora

Ten conservation Priority flora taxa have been recorded within the Proposed Mining Area C Development Envelope (Table 14). Eight of these have been recorded in the Indicative Additional Impact Assessment Area, and six have been recorded within the Mining Area C Revision 6 EMP Impact Assessment Area (Table 14). These species are discussed further below.

***Acacia bromilowiana* (Priority 4).** *Acacia bromilowiana* has been recorded as one population in the Proposed Mining Area C Development Envelope where it occurred in upper reaches of a gorge in the Indicative Additional Impact Assessment Area (Figure 18). The plants in this location provided an estimated 1% foliage cover (Table 18). It has also been recorded from just outside the southern boundary of the Proposed Mining Area C Development Envelope, occurring as more than 100 plants and providing up to 10% cover from seven point locations on the northern slopes of Mount Robinson (Onshore Environmental, 2012). Regionally, *Acacia bromilowiana* has been recorded from 63 locations across the southern third of the Pilbara (BHP Billiton Iron Ore, 2016j).

The impact of direct clearing of the single *Acacia bromilowiana* population associated with the Proposal is considered to be very low, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

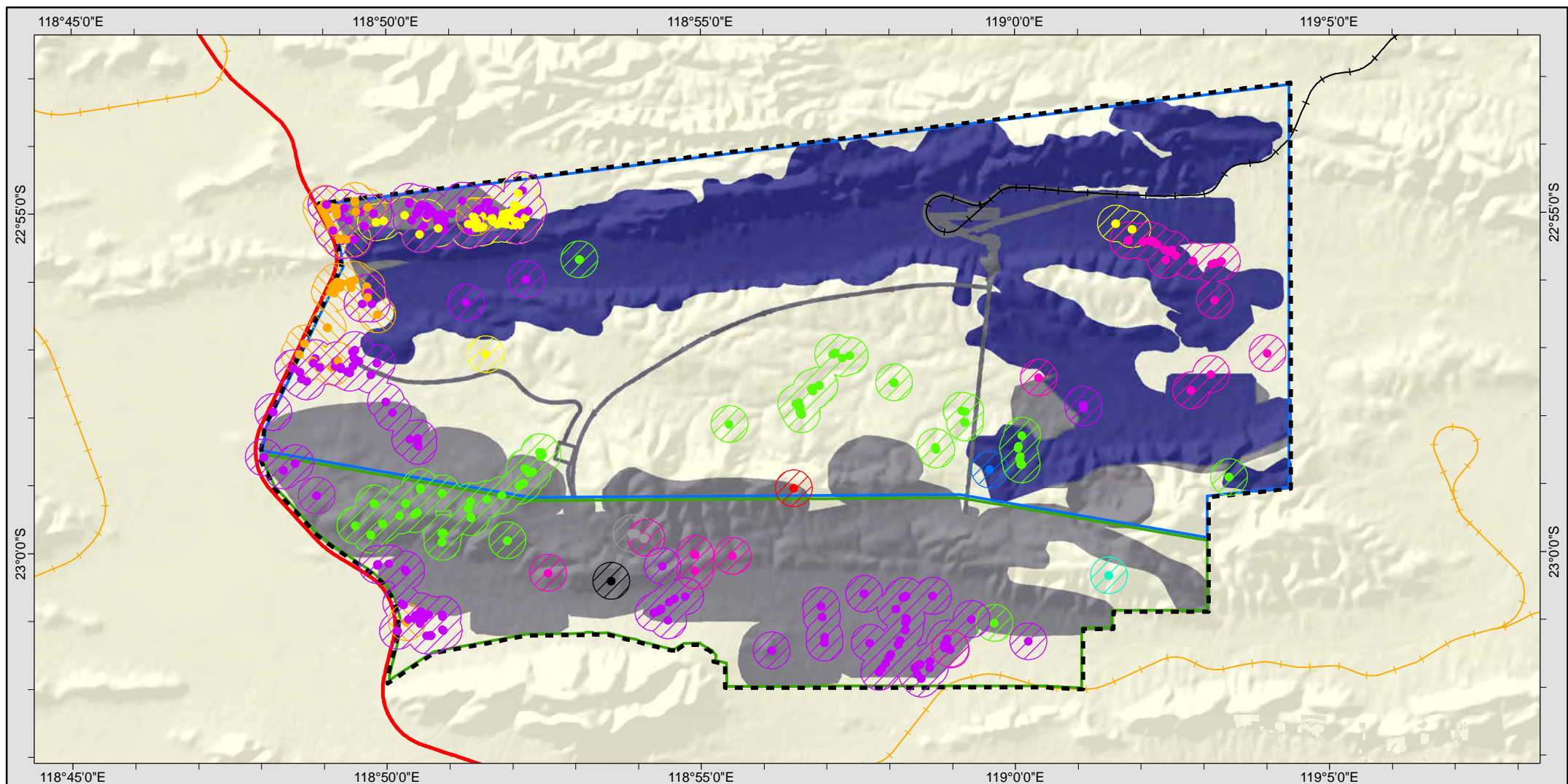
***Aristida jerichoensis* subsp. *subspinulifera* (Priority 3).** Five populations of *Aristida jerichoensis* subsp. *subspinulifera*, containing approximately 2,559 plants, have been recorded primarily within the northwest and western boundaries of the Proposed Mining Area C Development Envelope on stony plains and floodplains (Figure 18). Two of these populations, containing approximately 790 plants, occur in the Indicative Additional Impact Assessment Area (Table 18). Two populations containing approximately 161 plants occur within the Mining Area C EMP Revision 6 Impact Assessment Area.

The species has been recorded extensively west of the Proposed Mining Area C Development Envelope in BHP Billiton Iron Ore exploration leases and also occurs in large numbers in New South Wales and Queensland, with smaller populations in the Northern Territory, South Australia and Western Australia (outside of the Proposed Mining Area C Development Envelope) (BHP Billiton Iron Ore, 2016j).

The impact of direct clearing within four of the five populations of *Aristida jerichoensis* subsp. *subspinulifera* in the Proposed Mining Area C Development Envelope is considered to be low as more than 60% of known individuals within the Proposed Mining Area C Development Envelope occur outside proposed disturbance areas and it occurs commonly outside this area in Western Australia and other Australian states. It is considered very unlikely that implementation of the Proposal will result in a change to its conservation status.

Table 18: Number of records and number of plants (or estimated % ground cover) for Priority flora taxa occurring in the Proposed Mining Area C Development Envelope, Indicative Additional Impact Assessment Area and Mining Area C Revision 6 EMP Impact Assessment Area

Vegetation Association	No. Populations in Proposed Mining Area C Development Envelopment	No. Plants in Proposed Mining Area C Development Envelopment	No. Populations in Indicative Additional Impact Assessment Area	No. Plants in Indicative Additional Impact Assessment Area	No. Populations in Mining Area C EMP Revision 6 Impact Assessment Area	No. Plants in Mining Area C EMP Revision 6 Impact Assessment Area	No. Plants Cleared (up to December 2016)
<i>Acacia bromilowiana</i> (P4)	1	1% cover	1	1% cover	0	0	0
<i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3)	5	2,559	2	790	2	161	129
<i>Aristida lazaridis</i> (P2)	3	2,977	2	2,114	3	660	7
<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	10	676	3	196	3	83	1
<i>Grevillea saxicola</i> (P3)	1	55	0	0	0	0	0
<i>Nicotiana umbratica</i> (P3)	1	1	0	0	1	1	0
<i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3)	16	302	14	225	7	28	5
<i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3)	9	325	5	69	3	228	15
<i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3)	1	47	1	47	0	0	0
<i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739) (P3)	1	2-10% cover	1	2-10% cover	0	0	0



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Impacts to Conservation Significant Flora populations in the Proposed Mining Area C Development Envelope

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/030 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 18
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Conservation Significant Flora

- *Aristida lazaridis* (P2)
- *Aristida jerichoensis* var. *subsp. nullifera* (P3)
- *Grevillea saxicola* (P3)
- *Nicotiana umbratica* (P3)
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3)
- *Rostellularia adscendens* var. *latifolia* (P3)
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3)
- *Acacia bromilowiana* (P4)
- *Eremophila magnifica* subsp. *magnifica* (P4)

Significant Flora Populations

- *Aristida lazaridis* (P2)
- *Aristida jerichoensis* var. *subsp. nullifera* (P3)
- *Grevillea saxicola* (P3)
- *Nicotiana umbratica* (P3)
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3)
- *Rostellularia adscendens* var. *latifolia* (P3)
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3)
- *Acacia bromilowiana* (P4)
- *Eremophila magnifica* subsp. *magnifica* (P4)

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

***Aristida lazaridis* (Priority 2).** *Aristida lazaridis* has been recorded from three populations, containing almost 3,000 plants, in the Proposed Mining Area C Development Envelope (Figure 18 and Table 18). Two populations occur entirely or partially within the Indicative Additional Impact Assessment Area. It is estimated that 2,114 plants occur in the Indicative Additional Impact Assessment Area. Three populations containing approximately 600 plants occur within the Mining Area C EMP Revision 6 Impact Assessment Area. It also occurs extensively on lowland areas in adjacent BHP Billiton Iron Ore tenure (see Onshore Environmental, 2017; Appendix 4).

In Western Australia, *Aristida lazaridis* occurs in the Pilbara and Kimberley Interim Biogeographical Regionalisation for Australia (IBRA) bioregions, including Karijini National Park (BHP Billiton Iron Ore, 2016j). It also occurs in the Northern Territory and Queensland (BHP Billiton Iron Ore, 2016j).

The impact of direct clearing of *Aristida lazaridis* in the Proposed Mining Area C Development Envelope is considered to be low given the retention of a large number of populations in adjacent BHP Billiton Iron Ore tenure. It is considered very unlikely that implementation of the Proposal will result in a change to its conservation status.

***Eremophila magnifica* subsp. *magnifica* (Priority 4).** *Eremophila magnifica* subsp. *magnifica* has been recorded from ten populations, containing approximately 676 plants, in the Proposed Mining Area C Development Envelope (Figure 18). It was associated with rocky gorge sites, cliff faces and steep rocky slopes predominantly throughout the central sector. Three of the eight populations, containing a total of approximately 196 plants, occur in the Indicative Additional Impact Assessment Area (Table 18). Four populations, containing approximately 83 plants, occur within the Mining Area C EMP Revision 6 Impact Assessment Area.

Eremophila magnifica subsp. *magnifica* is widespread throughout the eastern two-thirds of the Hamersley IBRA subregion (BHP Billiton Iron Ore, 2016j; Onshore Environmental, 2017, see Appendix 4).

The impact of direct clearing of *Eremophila magnifica* subsp. *magnifica* in the Proposed Mining Area C Development Envelope is considered to be low as a number of populations will be retained within the Proposed Mining Area C Development Envelope and it occurs more widely in the Hamersley IBRA subregion. It is considered very unlikely that implementation of the Proposal will result in a change to its conservation status.

***Rhagodia* sp. Hamersley (M. Trudgen 17794) (Priority 3).** *Rhagodia* sp. Hamersley (M. Trudgen 17794) was recorded from 15 populations, containing approximately 302 plants (Figure 18 and Table 18), in the north-western, western and southern sectors of the Proposed Mining Area C Development Envelope where it occurred predominantly on floodplains. Fourteen populations, containing a total of approximately 225 plants, occur wholly or partly in the Indicative Additional Impact Assessment Area (Table 18). Seven populations containing approximately 28 plants occur within the Mining Area C EMP Revision 6 Impact Assessment Area.

Rhagodia sp. Hamersley (M. Trudgen 17794) has been frequently recorded in the eastern half of the Hamersley IBRA subregion and extends into the Fortescue IBRA subregion and Gascoyne IBRA bioregion (BHP Billiton Iron Ore, 2016j).

The impact of direct clearing of *Rhagodia* sp. Hamersley (M. Trudgen 17794) in the Proposed Mining Area C Development Envelope is considered to be low, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

***Rostellularia adscendens* var. *latifolia* (Priority 3).** *Rostellularia adscendens* var. *latifolia* was recorded from nine populations, containing approximately 325 plants (Figure 18), in the northeast and southeast sectors of the Proposed Mining Area C Development Envelope where it occurred primarily in broad medium drainage lines. Plants occurred as scattered individuals or populations of up to a maximum of 82 plants. Five populations, containing approximately 69 plants, occur in the Indicative Additional Impact Assessment Area (Table 18). Three populations containing approximately 228 plants occur within the Mining Area C EMP Revision 6 Impact Assessment Area.

Rostellularia adscendens var. *latifolia* occurs throughout the eastern half of the Hamersley IBRA subregion and extends into the Fortescue IBRA subregion. It is also widespread and common across the Northern Territory, South Australia, New South Wales, and Queensland (BHP Billiton Iron Ore, 2016j) and there are a number of records in Karijini National Park (Onshore Environmental, 2017; see Appendix 4).

The impact of direct clearing of *Rostellularia adscendens* var. *latifolia* in the Proposed Mining Area C Development Envelope is considered to be low, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

***Sida* sp. Barlee Range (S. van Leeuwen 1642) (Priority 3).** *Sida* sp. Barlee Range (S. van Leeuwen 1642) was recorded from one population, containing approximately 47 plants (Figure 18), in the Proposed Mining Area C Development Envelope. All plants occurred at the base of cliffs and on steep hill slopes. This population occurs in the Indicative Additional Impact Assessment Area.

Sida sp. Barlee Range (S. van Leeuwen 1642) occurs extensively throughout the southern Pilbara and northern Gascoyne IBRA bioregions, with five records occurring in Karijini National Park (BHP Billiton Iron Ore, 2016j). It has also been reported in low numbers from BHP Billiton Iron Ore's neighbouring tenements west and east of the Proposed Mining Area C Development Envelope.

The impact of direct clearing of the one population of *Sida* sp. Barlee Range (S. van Leeuwen 1642) in the Proposed Mining Area C Development Envelope is considered to be low, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

***Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3).** *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was recorded on red brown loam on stony slopes and upper plains from one population in the southern sector of the Proposed Mining Area C Development Envelope, providing ground coverage of between 2% to 10% (Table 18 and Figure 18). This population occurs in the Indicative Additional Impact Assessment Area.

Triodia sp. Mt Ella (M.E. Trudgen 12739) is known from 395 records throughout the south-eastern sector of the Pilbara IBRA bioregion and extending marginally into the Gascoyne bioregion. It has been recorded with increasing frequency in the Hamersley IBRA subregion in recent years and occurs at BHP Billiton Iron Ore's neighbouring tenements and in Rio Tinto Iron Ore's West Angelas tenement.

The impact of direct clearing of the one population of *Triodia* sp. Mt Ella (M.E. Trudgen 12739) in the Proposed Mining Area C Development Envelope is considered to be low, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

11.1.4.2 Indirect impacts of the Proposal

Alteration to surface water. The Proposal has the potential to impact surface water resources and thus flora and vegetation by:

- changing local surface water flow patterns;

- affecting surface water runoff volumes and quality;
- increasing the risk of erosion and sedimentation; or
- contamination from chemicals or hydrocarbons.

Surface water modelling predicted that there would be a net loss in surface water runoff from the natural hydrological cycle. However, these changes are not considered to be significant to the overall hydrological system at a regional scale, particularly in comparison to the large natural seasonal variations in catchment runoff (MWH, 2016). It is therefore concluded that changes to the surface hydrology are unlikely to have any significant impact on downstream flora and vegetation. Changes to surface water as a result of the Proposal are discussed further in Section 11.4.7.

The alteration of existing surface water regimes by project infrastructure may impact on susceptible downstream vegetation, most notably mulga-dominated vegetation associations situated on floodplains. Three vegetation associations in the Proposed Mining Area C Development Envelope (predominantly in the northwest and southern fringe) and the Indicative Additional Impact Assessment Area support mulga vegetation on stony plains and floodplains. While all three vegetation associations are susceptible to altered surface water flows, their extent is relatively small (321 ha in the Indicative Additional Impact Assessment Area), and it is unlikely that these communities will be impacted by the Proposal.

Proposed changes to surface hydrology are not likely to result in any significant alteration to the composition or structure of existing vegetation associations. While downstream vegetation is likely to be at highest risk from impacts associated with reduced surface water flows, increased sediment loading, and contamination, the potential impacts are determined to be not significant because the vegetation associations do not support high-risk species and are well represented regionally.

Alteration to groundwater. The Proposal has the potential to impact groundwater resources available to flora as a result of drawdown of water levels from dewatering and water supply abstraction. The lowering of groundwater levels during mine dewatering activities results in a propagation of drawdown and modification of the hydrological conditions away from the orebody aquifers and more regionally towards Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis.

Groundwater-dependent vegetation is associated with the Weeli Wolli Spring PEC, and potential impacts to this receptor are discussed in Section 11.1.4.3.3. The Coondewanna Flats PEC is not considered to be groundwater dependent; however, injection of surplus water into the Juna Downs Managed Aquifer Recharge (MAR) borefield north of the Coondewanna Flats PEC has the potential to develop local groundwater mounding, bringing groundwater closer to tree root zones which may potentially result in waterlogging of trees. This is discussed further in Section 11.1.4.3.4 and references therein.

Fire. Wildfire resulting from lightning strike is a natural phenomenon to which arid zone vegetation is well adapted, with many plant taxa reliant on heat and smoke to break seed dormancy and stimulate germination (Fox, 1978). However, increased access to previously remote areas can increase the frequency of fire through accidental occurrences and arson.

Vegetation associations that are more sensitive to fire include those associated with deep gorge habitats and dense mulga stands on floodplains. There is a mosaic of fire ages evident across the Proposed Mining Area C Development Envelope, with vegetation condition assessment confirming the majority of vegetation remains in Good or better condition despite this.

Fire is a natural occurrence in vegetation associations in the Proposed Mining Area C Development Envelope, and the increased risk posed by implementation of the Proposal is manageable and not considered a significant risk to vegetation or flora.

Introduced species. Domestic stock, such as cattle, are significant vectors for weed species in lowland areas of the Pilbara, including the Proposed Mining Area C Development Envelope. Vegetation condition typically declines across these lowlands due to alteration of native vegetation structure and composition, including a higher loading of introduced weed species. Increased vehicular access combined with disturbance (such as clearing for roads and other infrastructure) also has the potential to introduce or spread weed species.

Existing operations at Mining Area C have managed the introduction of weed species effectively through various strategies associated with prevention (quarantine) and control (targeted spray programs and progressive rehabilitation). Implementation of the Proposal is not expected to significantly increase the risk of weed invasion and spread, provided current management processes are maintained. These management processes will also be employed in implementation of the Proposal. As a result of the proven success of BHP Billiton Iron Ore's existing processes, a significant increase in the risk of weed invasion and spread is unlikely to occur.

Dust. Dust associated with iron ore mining in the Pilbara is generally chemically inert (Butler, 2009; Turner, 2013), so any potential impacts on plants are likely to be physical, including leaf abrasion, blocking of stomata and increased absorption of incident radiation, which in turn can elevate leaf temperature and negatively impact on photosynthetic processes and transpiration loss. These physical effects tend to be proportional to the amount of dust that vegetation is exposed to, the plant structures and the size of the dust particles (i.e. the higher the dust loading and the smaller the particle size, then the higher the risk) (Grierson, 2015).

In the Pilbara, dust generated by mining activities is likely to be both short-lived and transported for relatively short distances of 100 to 200 m, mainly at the time of service track construction (Grierson, 2015). Long-term observations of vegetation in close proximity to other mine sites across the Hamersley Range have demonstrated repeatedly the overall resilience of vegetation to extremely high levels of dust exposure. Plants coloured orange with dust for several years survive quite well, in part because plants in arid environments mainly grow in response to high rainfall and have very low metabolic rates outside of these periods. Growth periods thus also coincide with when (i) foliage is washed clean by rainfall and (ii) the lowest level of dust emissions due to damping down of the environment.

There is low risk of increased dusting to the vegetation forming the two subtypes of the Coondewanna Flats PEC, situated outside the southwest corner of the Proposed Mining Area C Development Envelope. Studies in the Pilbara on a range of species suggest that dust is unlikely to impact vegetation (Grierson, 2015); it is therefore considered unlikely that there will be dust impacts to the PEC.

11.1.4.3 Regional cumulative impacts

11.1.4.3.1 Vegetation

Based on the original mapping by Beard (1975) that was more recently refined by Shepherd *et al.* (2002), there are two vegetation associations represented in the Proposed Mining Area C Development Envelope: Hamersley 18 and Hamersley 82. Less than 2% of the total extent for each vegetation association mapped by Beard (1975) and later refined by Shepherd *et al.* (2002) are represented in the Proposed Mining Area C Development Envelope, and less than 5% occurs in cumulative BHP Billiton Iron Ore or third-party disturbance areas (Table 19). Using Beard's (1975) regional vegetation

association mapping, the cumulative impact to vegetation communities is considered unlikely to be significant.

The Proposal will be developed and operated as part of the existing Mining Area C operation, which was approved under MS 491. The Indicative Additional Impact Assessment Area intersects similar vegetation associations to those represented in the Approved Mining Area C (Northern Flank) Development Envelope, and none are of elevated conservation significance. All vegetation associations (and land systems) that may be disturbed by this Proposal are well represented in the Pilbara bioregion. Therefore, no significant cumulative impacts to vegetation are predicted.

Table 19: Current pre-European extent of vegetation associations that occur in the Proposed Mining Area C Development Envelope (Shepherd *et al.*, 2002), the area represented in the Proposed Mining Area C Development Envelope, cumulative BHP Billiton Iron Ore disturbance footprint, and cumulative third-party disturbance footprint (percentages are a proportion of the current pre-European extent for each vegetation association)

Vegetation Association	Current Pre-European Extent (ha)	Proposed Mining Area C Development Envelope (ha)	Cumulative BHP Billiton Iron Ore Disturbance (ha)	Cumulative Third-Party Disturbance (ha)
Hamersley 18	770,898	13,167 (1.7%)	35,994 (4.7%)*	4,878 (0.6%)
Hamersley 82	5,602,479	22,864 (0.4%)	54,590 (1.0%)*	15,594 (0.3%)

*This correlates with the area assessed for the BHP Billiton Strategic Proposal

11.1.4.3.2 Flora

Mapping of confirmed locations for each of the eight Priority flora species represented in the Indicative Additional Impact Assessment Area confirmed broadly similar distributional patterns extending between Newman and Tom Price (Appendix 4).

A regional assessment of cumulative impacts to Priority flora was undertaken for BHP Billiton Iron Ore's Strategic Proposal in early 2016 (BHP Billiton Iron Ore, 2016c). Potential cumulative impacts to those conservation significant species present within the Proposed Mining Area C Development Envelope are shown in Table 20. The data used for the assessment have been compiled from BHP Billiton Iron Ore's corporate database and DPaW's WA Herb and Threatened and Priority Flora List databases. The assessment used the best available information to determine cumulative impacts; however it was noted that there were a number of limitations to the assessment, including inaccuracy of data and erroneous records (which were where noted removed or corrected), currency of data (due to delays in submission and loading of data), and a bias of data collected from BHP Billiton Iron Ore and other mining company tenements (BHP Billiton Iron Ore, 2016c). These limitations were not unique to this assessment, and would be relevant to any cumulative impact assessment undertaken for the region. The cumulative impact from the Proposal and other proposed disturbance by BHP Billiton Iron Ore and third parties was considered unlikely to significantly reduce the representation of the ten taxa recorded in the Proposed Mining Area C Development Envelope.

11.1.4.3.3 Weeli Wolli Spring PEC

The Weeli Wolli Spring area is recognised as having multiple ecological values that collectively contribute to its DPaW listing as a Priority 1 Ecological Community. The community is described by DEC (2009a) as being:

‘...dominated by a fringing forest or tall woodland of Silver paperbark (*Melaleuca argentea*) and River Red Gum (*Eucalyptus camaldulensis*) over trees of Coolibah (*E. victrix*) and a dense shrub layer dominated by an assortment of wattles, in particular Pilbara Jam (*Acacia citrinoviridis*). The presence of permanent water and very moist sediment also provides suitable habitat for many sedges and herbs.”

Table 20: Potential cumulative impact to the ten Priority flora occurring in the Proposed Mining Area C Development Envelope (summarised from BHP Billiton Iron Ore, 2016j)

Species	No. of Records		
	Pilbara Area	Cumulative BHP Billiton Iron Ore Disturbance	Cumulative Third-Party/ Other Disturbance
<i>Acacia bromilowiana</i> (P4)	63	4	0
<i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3)	227	37	2
<i>Aristida lazardis</i> (P2)	203	83	0
<i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	548	142	102
<i>Grevillea saxicola</i> (P3)	97	3	0
<i>Nicotiana umbratica</i> (P3)	19	0	1
<i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3)	1309	396	11
<i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3)	253	54	5
<i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3)	130	32	8
<i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739) (P3)	394	136	3

There are several species of conservation interest, including one named after the spring (the Priority 2 *Stylidium weeliwollii*). This area supports the obligate phreatophyte *Melaleuca argentea*, which is highly sensitive to groundwater drawdown. *Eucalyptus camaldulensis* and *E. victrix* are considered to be facultative phreatophyte species.

A detailed assessment of hydrological impacts to the Weeli Wolli springs is provided in Section 11.4, and key aspects relating to flora and vegetation are summarised here.

The previously forecast residual drawdown at Weeli Wolli Spring presented in the EMP Revision 6 model was around 1.6 m at GWB0018 in 2054 (see Section 11.4). This drawdown is predicted to occur following closure of Hope Downs 1 (see Figure 2) and is attributed to the combined impacts of dewatering at Hope Downs 1 and Mining Area C (Northern Flank). Maximum drawdown at GWB0018 was modelled to be between 6 and 7 m in 2026 and coincides with the conclusion of Hope Downs dewatering.

Dewatering at Southern Flank is predicted to contribute between 0.2 and 0.5 m of drawdown at GWB0018 in 2054. This drawdown is modelled to occur following the end of aquifer replenishment and mitigation actions at Hope Downs 1. Cumulative groundwater drawdown from the Mining Area C combined operations and Rio Tinto Iron Ore’s Hope Downs 1 dewatering activities shows a far greater change, whereby water levels are significantly reduced in the lower catchment of the spring area. This drawdown, which shows a range of 3 to 14 m, is associated predominantly with abstraction from Hope

Downs 1. The timing and success of Hope Downs 1 closure plans to recover groundwater levels will be the key influence on groundwater level and potential for a continued impact at Weeli Wolli Spring.

Following closure of Hope Downs 1 the combined cumulative impacts show a range of 1 – 2.5 m drawdown at 2054 with a median drawdown of 1.75 m which is close to the previously assessed change of 1.6 m. Residual drawdown in the upper end of this range (>2 m) has potential to reduce water availability to *Melaleuca argentea* (if unmitigated) and may result in the population contracting east toward the spring. If this reduction occurs, it is predicted that the distribution of *Melaleuca argentea* will be smaller to that which occurred prior to development of the Hope Downs 1 mine. It is noted that this community has been significantly altered by drawdown and discharge associated with the Hope Downs 1 mine and there is limited information available on the baseline conditions of this community. Adaptive management measures such as aquifer recharge (as outlined in the CPWRMP) will be implemented to mitigate any impacts to an acceptable level.

11.1.4.3.4 Coondewanna Flats PEC

A number of studies addressing aspects of the ecohydrology of Coondewanna Flats have been completed in the past decade, and more recently a considerable volume of monitoring data has been collected. These studies have included a hydro-environmental assessment, monitoring of regional bores, analysis of tree water chemistry and leaf water potential, and development of an ecohydrological conceptual model (Appendix 7). A summary of key components of the conceptual ecohydrological model is as follows:

- It is an internally draining system relying on surface water runoff from the surrounding catchments.
- Surface water flows typically reach the Coondewanna Flats three out of every four years to replenish the soil moisture in the unsaturated zone, even when groundwater recharge does not occur. Groundwater is generally 20 m below ground level (mbgl).
- The vegetation communities are considered unlikely to rely on groundwater as:
 - There is abundant water in the soil profile to support the community for extended periods of time.
 - The depth to groundwater is beyond the range commonly associated with groundwater dependence.
 - Soil matric-potential and soil water chemistry indicate plant water abstraction from 0 to 5 mbgl and 6 to 15 mbgl.
 - Measured predawn leaf water potentials for all species are negative. Changes in leaf water potential have reflected changes in soil moisture and matric pressure.
- The estimated soil-water reservoir could sustain the vegetation community for a drought period of approximately nine years.

It is therefore considered very unlikely that any drawdown of groundwater levels below the Coondewanna Flats PEC will impact the community. Increased dust loading is also unlikely to cause an impact (see Section 11.1.4.2). Nevertheless, should subsequent studies indicate that the Coondewanna Flats PEC is groundwater dependent, mitigation measures such as managed aquifer recharge will be implemented.

Section 11.4.7 details potential changes to the surface water catchment for Coondewanna Flats. While there is a 6.9% reduction in total catchment size when the Proposal is implemented, this is considered unlikely to affect the size and frequency of surface water flows reaching Coondewanna Flats as the

majority of flows originate from the northern parts of the catchment that sits outside the Proposed Mining Area C Development Envelope.

Groundwater mounding from injection of water at the Juna Downs MAR borefield has potential to cause groundwater to intersect the tree root zone. Modelling shows that at the proposed injection rates the groundwater level is expected to increase from 22 mbgl to 16 mbgl (BHP Billiton Iron Ore, 2016a). At this level, reduction in root mass is considered unlikely and negative direct (loss of vegetation) or indirect (fragmentation) impacts to the Coondewanna Flats PEC are not expected.

11.1.5 Mitigation and residual impacts

BHP Billiton Iron Ore has carried out a review of the Western Australian Government's 'Mitigation Process', which is detailed in section 3 of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014). The four steps are:

- avoid;
- minimise;
- rehabilitate; and
- offset.

Following consideration of all data gathered during baseline surveys, additional targeted surveys and the outcomes of EIAs, BHP Billiton Iron Ore have concluded that impacts to flora and vegetation are not considered significant at a species or population level.

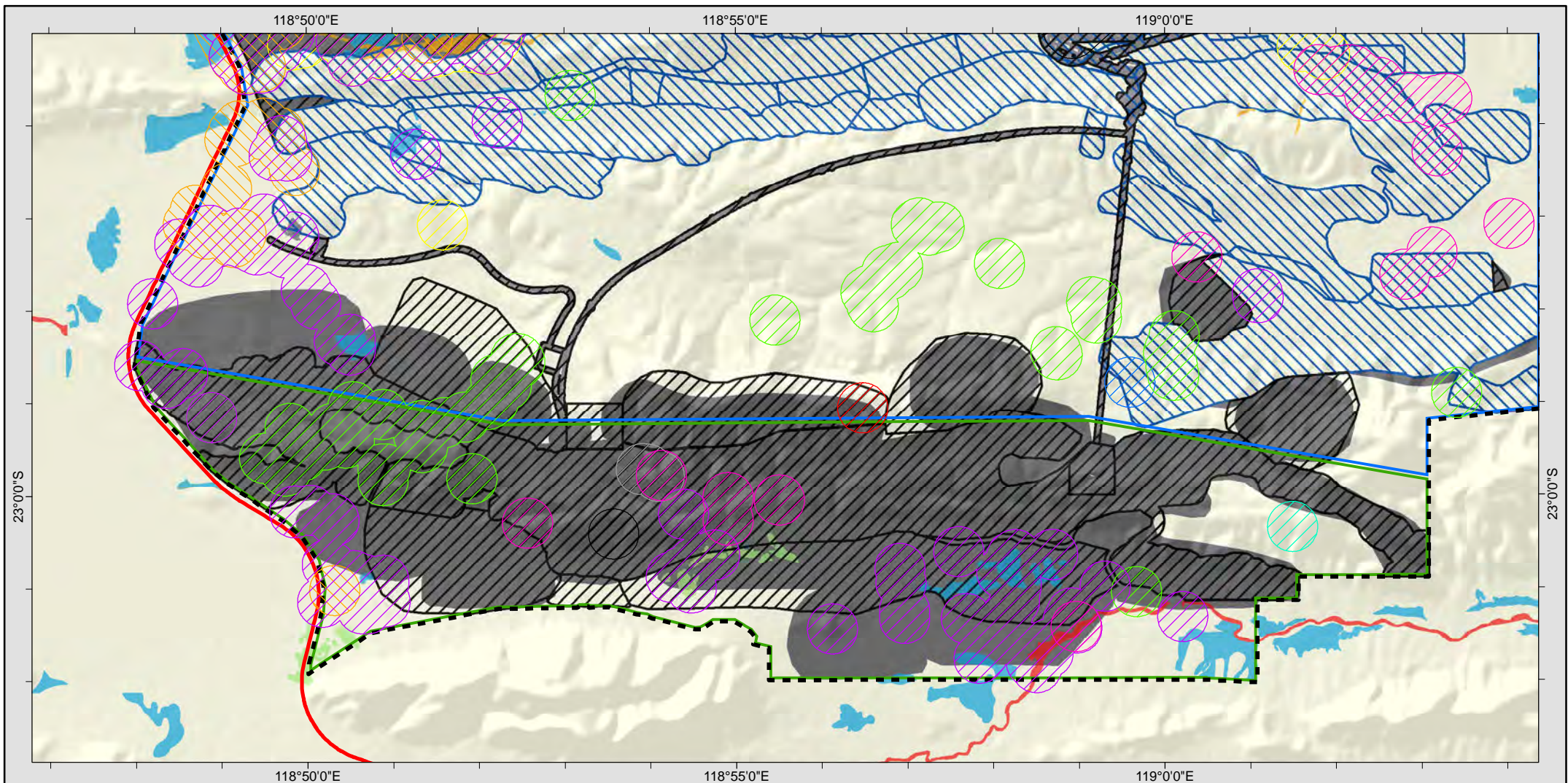
However, BHP Billiton Iron Ore have revised its indicative Proposal designs to ensure that they address the first two steps of the mitigation process, i.e. the designs have 'avoided' or 'minimised' impacts. The key drivers for revision of the Proposal design was related to other key factors where predicted impacts (pre-mitigation) were considered significant without mitigation, specifically for ghost bat cave avoidance and avoidance of suitable troglodfauna habitat. This holistic approach was used to ensure that the overall impact of the Proposal was minimised. Sections 11.2.5 and 11.3.4 provide details of mitigation applied to reduce impacts to ghost bat and troglodfauna habitat. As a consequence of the application of mitigation for those aspects, it is likely that impacts to flora and vegetation will be reduced.

The original referral to the OEPA in May 2016 estimated clearing of 19,800 ha, of which 5,942 ha was located in the current Mining Area C EMP Revision 6 Impact Assessment Area. The 19,800 ha of native vegetation clearing was subsequently amended under s43A of the EP Act, with the *Consent to a Change to Proposal during Assessment* granted by the EPA in April 2017. The revised clearing to be assessed under this Proposal is 19,671.2 ha.

Following implementation of the steps outlined in the Mitigation Process (Government of Western Australia, 2014), native vegetation clearing may be reduced to 15,693 ha (Table 21). BHP Billiton Iron Ore commit to, where practical, restricting disturbance to within the Indicative Modified Impact Assessment Area during detailed mine planning and design and during operations. This results in a potential 20% reduction in proposed clearing at the time of submission of this PER document. Despite the likely impact being less than originally proposed, a total of 19,800 ha of disturbance is still requested to provide flexibility in approach and to ensure that suitable offsets outcomes can be achieved.

Table 21: Summary of clearing before and after mitigation

Area	Original Referral (ha)	Following Mitigation (ha)
Pits and OSAs	13,000	8,932
Infrastructure	729.2	819
Additional disturbance at Mining Area C	5,942	5,942
Total	19,671.2	15,693



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Impacts to flora and vegetation following mitigation

Scale @ A4: 1:110,000	Prepared: M. LYTTLE	Project No: A780/031 REV A
Date: 30/03/2017	Checked: B. BARNETT	Figure: 19
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment
- Indicative Additional Impact Assessment Area
- Modified Indicative Additional Impact Assessment
- BHP Billiton Rail
- Great Northern Highway

Significant Flora Populations

- Aristida lazaridis* (P2)
- Aristida jerichoensis* var. *subspinulifera* (P3)

- Grevillea saxicola* (P3)
- Nicotiana umbratica* (P3)
- Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3)
- Rostellularia adscendens* var. *latifolia* (P3)
- Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)
- Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3)
- Acacia bromilowiana* (P4)
- Eremophila magnifica* subsp. *magnifica* (P4)

Significant Vegetation Association

- FP TtEua ExAa AprAtpErl
- MA EcrEvEx ApypAtpGoro TtEuaCyp
- SP AaApr TmTwTp
- SP ACaAa ArobDiaChf

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometers

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

The impact to two Priority flora species recorded in the Indicative Additional Impact Assessment Area may also be reduced. An evaluation of the change of impacts to flora and vegetation with implementation of the modified Indicative Additional Impact Assessment Area is provided in Appendix 4. Actions that may be taken to reduce potential impacts to flora and vegetation are summarised in Figure 19 and Table 22. The residual impact to flora and vegetation as a result of implementation of the Proposal are not considered significant at a species or population level. However, there will be a net loss of vegetation rated Good or above and therefore financial offsets will apply.

Table 22: Actions that may be taken to reduce impacts to flora and vegetation

Action Taken	Step in the 'Mitigation Process'	Reduction in Impact
Modification of Indicative Additional Impact Assessment Area	Avoid	<p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce the impact to the following conservation species and vegetation associations:</p> <ul style="list-style-type: none"> <i>Rhagodia</i> sp. Hamersley – impacts reduced from 11 populations to 4 populations. <i>Rostellularia adscendens</i> var. <i>latifolia</i> – impacts reduced from 5 populations to 4 populations. <p>If clearing is restricted to the Modified Indicative Additional Impact Assessment Area it will result in a reduction in the impact to two vegetation associations considered to be 'Ecosystems at Risk.' There will be a slight increase of clearing of the third vegetation association (SP AcaoAa ArobDiaChf) by 4 ha.</p>
Modification of Indicative Additional Impact Assessment Area	Avoid	<p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce the clearing of vegetation of Very Good or higher condition as follows:</p> <ul style="list-style-type: none"> Excellent – clearing reduced from 9,016 ha to 8,081 ha Very Good – clearing reduced from 658 ha to 469 ha <p>(Note there will be an increase of approximately 55 ha to clearing of vegetation in Pristine condition.)</p>
Modification of Indicative Additional Impact Assessment Area	Minimise	<p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce fragmentation of a number of locally significant vegetation associations and those that had more than 50% of their total mapped area in the Indicative Additional Impact Assessment Area.</p>
Ongoing Rehabilitation	Rehabilitate	<p>BHP Billiton Iron Ore undertakes progressive rehabilitation and ongoing performance assessment in areas where mining operations have been completed and further disturbance is unlikely. Further details are outlined in the Mine Closure Plan (Appendix 12)</p>

11.1.6 Proposed management approach

11.1.6.1 Internal management approach

The proposed management plan provisions for flora and vegetation due to groundwater change are outlined in Table 57 and Table 58. They include trigger criteria, response actions, monitoring and reporting. It is proposed that these management approaches will be formalised through regulation of an Environmental Management Plan via the Ministerial Statement and BHP Billiton Iron Ore's standard

Pilbara-wide Health, Safety and Environment system, including the PEHR process (see Section 10.3) which is based on application of the mitigation hierarchy (i.e. avoid, minimise, rehabilitate).

11.1.6.2 Regulatory management

Impacts to flora and vegetation will be managed by an environmental management plan regulated through the MS.

11.1.6.3 Summary and predicted outcome

Table 23 summarises impacts to flora and vegetation previously assessed under MS 491, additional changes likely to occur following implementation of the Proposal, and the cumulative extent in the Proposed Mining Area C Development Envelope.

In consideration of the outcomes of the EIA and proposed management measures, BHP Billiton Iron Ore propose that flora and vegetation representation, diversity, viability and ecological integrity at the species, population and community level can be maintained. BHP Billiton Iron Ore are therefore confident that the EPA objective for flora and vegetation can be met and that residual impacts to vegetation representation, diversity, viability and ecological integrity at the species, population and community level are not significant. BHP Billiton Iron Ore recognise that there will be a net loss of good or above rated vegetation and populations of conservation significant flora and therefore consider that financial offsets are applicable to address this net loss (see Section 11.8).

Table 23: Key impacts to flora and vegetation previously assessed, proposed changes and cumulative extent in the Proposed Mining Area C Development Envelope

Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 EMP Impact Assessment Area	Cumulative Extent in Proposed Mining AREA C Development Envelope (without Mitigation)	Cumulative Extent in Proposed Mining AREA C Development Envelope (with Mitigation)
<p>Eight species or priority flora recorded in the Indicative Additional Impact Assessment Area:</p> <ul style="list-style-type: none"> • <i>Acacia bromilowiana</i> (P4) • <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3) • <i>Aristida lazaridis</i> (P2) • <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4) • <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3) • <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3) • <i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3) • <i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739) (P3) 	<p>Six Priority flora present within the Approved Mining Area C (Northern Flank) Development Envelope. Six species recorded within the EMP Revision 6 Assessment Area:</p> <ul style="list-style-type: none"> • <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3) • <i>Aristida lazaridis</i> (P2) • <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4) • <i>Nicotiana umbratica</i> (P3) • <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3) • <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3) 	<p>Ten Priority flora in the Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • <i>Acacia bromilowiana</i> (P4) • <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3) • <i>Aristida lazaridis</i> (P2) • <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4) • <i>Grevillea saxicola</i> (P3) • <i>Nicotiana umbratica</i> (P3) • <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3) • <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3) • <i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3) • <i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739) (P3) 	<p>Ten Priority flora in the Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> • <i>Acacia bromilowiana</i> (P4) • <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P3) • <i>Aristida lazaridis</i> (P2) • <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4) • <i>Grevillea saxicola</i> (P3) • <i>Nicotiana umbratica</i> (P3) • <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794) (P3) • <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3) • <i>Sida</i> sp. Barlee Range (S. van Leeuwen 1642) (P3) • <i>Triodia</i> sp. Mt Ella (M.E. Trudgen 12739) (P3)

Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 EMP Impact Assessment Area	Cumulative Extent in Proposed Mining AREA C Development Envelope (without Mitigation)	Cumulative Extent in Proposed Mining Area C Development Envelope (with Mitigation)
		All species are considered to be well represented regionally.	All species are considered to be well represented regionally.
Fifteen vegetation associations with low to very low local conservation value.	Thirteen locally significant vegetation associations within the Approved Mining Area C (Northern Flank) Development Envelope. Ten were recorded within the EMP Revision 6 Assessment Area.	Fifteen vegetation associations with low to very low local conservation value. Cumulative impacts to vegetation to locally significant vegetation considered to be minor.	Three vegetation associations considered to be 'Ecosystems at Risk'. Reduced impacts to two of these vegetation associations. Cumulative impacts to vegetation to locally significant vegetation considered to be minor.
Indicative Additional Impact Assessment Area contains 11,612 ha of vegetation. Maximum clearing of Very Good or above vegetation: <ul style="list-style-type: none"> Pristine – 733 ha Excellent – 9,546 ha Very Good – 707 ha 	Approved Mining Area C (Northern Flank) Development Envelope contains 11,056 ha of vegetation. Maximum clearing of Very Good or above vegetation: <ul style="list-style-type: none"> Pristine – 0 ha Excellent – 4,734 ha Very Good – 4,333 ha 	Clearing of up to 19,671.2 ha of vegetation.	Clearing of up to 15,693 ha of vegetation.
Groundwater drawdown of approximately 0.2-0.5 m at Weeli Wolli Springs. No predicted impacts to the Weeli Wolli Spring or Coondewanna Flats PECs.	Residual drawdown at Weeli Wolli Springs of ~1.6 m in 2054. Cumulative impacts from groundwater drawdown may impact on vegetation at the Weeli Wolli Spring PEC.	No change to that approved under MS 491.	No change to that approved under MS 491.

11.2 Terrestrial fauna

11.2.1 EPA objective

The EPA applies the following objective, according to the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect terrestrial fauna:

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

11.2.2 Relevant legislation, guidelines and policies

The discussion of the existing environment, impacts and management of terrestrial fauna in the Proposed Mining Area C Development Envelope has been compiled in consideration of relevant state legislation and EPA policies and guidance. Table 7 details the relevant EPA documents as identified in

the *Mining Area C – Environmental Scoping Document* (OEPA, 2016) and their relevance to this Proposal.

11.2.3 Existing environment

11.2.3.1 Survey effort

Twenty-one vertebrate fauna surveys were undertaken wholly or partially in the Proposed Mining Area C Development Envelope between 1997 and 2016; these comprised seven Level 2 surveys (one or two seasons), five Level 1 surveys and nine targeted surveys (for conservation fauna) (the results of key surveys are shown in Table 24 and locations of survey areas and sites are shown in Figure 20). Targeted surveys for the ghost bat (*Macroderma gigas*) were undertaken in the area containing Mining Area C and Southern Flank between 2010 and 2016 (BatCall WA, 2011, Biologic, 2013, Biologic, 2015b). The following targeted surveys for conservation significant species recorded during baseline surveys or considered likely to occur based on available habitat or regional records have been undertaken within the Additional Development Envelope: northern quoll (*Dasyurus hallucatus*) surveys were undertaken 2012 and 2015 (Biologic, 2013, Biologic, 2016); and surveys for Pilbara olive python (*Liasis olivaceus barroni*) and northern brushtail possum (*Trichosurus vulpecula arnhemensis*) were undertaken in 2015 (Biologic, 2016).

All surveys undertaken post-2004 have been undertaken in accordance with the EPA *Guidance Statement 56: Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b) and all surveys undertaken post-2010 have been in accordance with the EPA and DEC's (2010) *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*. Where appropriate, surveys for species listed under the *Federal Environment Protection and Biodiversity Conservation Act 1999* have considered survey guidelines recommended by the Federal Department of the Environment and Energy (e.g. Commonwealth of Australia, 2010). All areas within the Proposed Mining Area C Development Envelope that have been surveyed for environmental approvals post-2004 have had a minimum of two seasons of survey using a stratified approach such that all landforms and fauna habitats present have been sampled, and to ensure there was adequate geographic coverage. It is also noted that all Level 1 and Level 2 surveys undertaken for BHP Billiton Iron Ore include targeted searches for conservation significant species, and surveys undertaken post-2009 have been undertaken in accordance with BHP Billiton Iron Ore's Vertebrate Fauna survey guidelines (BHP Billiton Iron Ore, 2016k) which were developed in conjunction with DPaW to ensure consistency in approach for all surveys undertaken for the Company.

A summary of survey information from all Level 2 and targeted surveys is provided in Table 24. Survey effort for all terrestrial fauna surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope is summarised in Table 25.

A further 18 vertebrate fauna surveys have been undertaken on behalf of BHP Billiton Iron Ore within 10 km of the Proposed Mining Area C Development Envelope (but not overlapping it), which provides contextual information for the area for use in impact assessment.

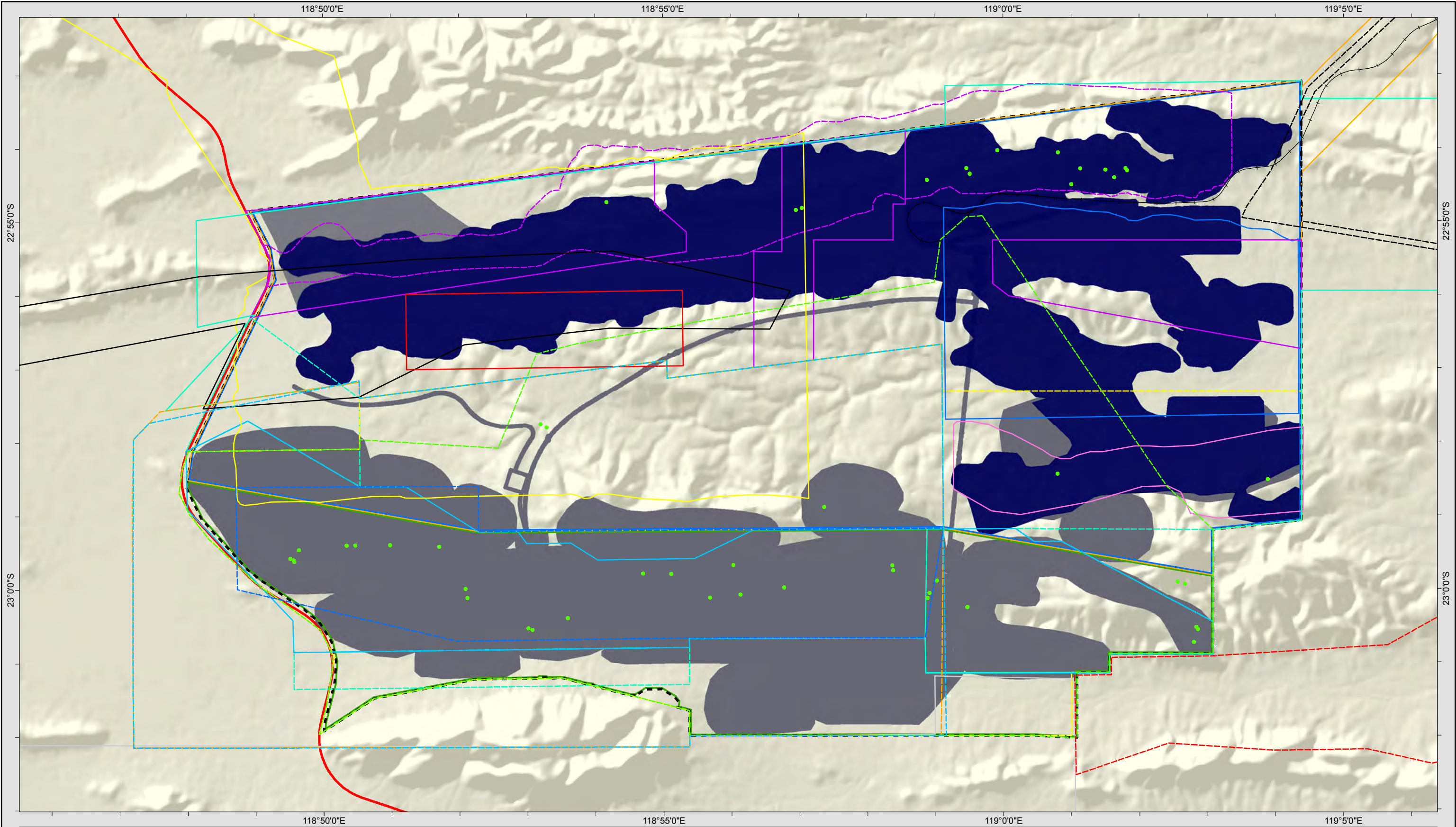
Table 24: Summary of Level 2 and targeted surveys undertaken within the Proposed Mining Area C Development Envelope

Survey	Mining Area C Biological Survey	Area C: Deposits D, E and F Biological Survey	Mining Area C Expansion Deposit E Bat Assessment	Area C R Deposit Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Terrestrial Vertebrate Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Bat Survey and Assessment	South Flank 2010 Bat Survey	Area C and Surrounds Fauna Study	Southern Flank Vertebrate Fauna Study	South Flank Bat Assessment Survey	Central Pilbara Ghost Bat Assessment	South Flank Targeted Northern Quoll Survey	Mudlark Vertebrate Fauna Study	Central Pilbara Ghost Bat Population and Roost Assessment: 2014	South Flank Targeted Fauna Survey
Consultant	ecologia	ecologia	ecologia	ENV	Outback Ecology	Specialized Zoological	Bat Call	Biologic	Biologic	Biologic	Biologic	Biologic	Biologic	Biologic	Biologic
Type	Single Phase Level 2	Single Phase Level 2	Targeted Survey	Single Phase Level 2	Single Phase Level 2	Bat Survey	Targeted Reconnaissance Survey for Bats	Two Phase Level 2	Two Phase Level 2	Targeted Bat Survey	Targeted Bat Survey	Targeted Survey	Two Phase Level 2	Targeted Bat Survey	Targeted Cons. Sig. Fauna Survey
Survey dates	14 Apr – 30 Apr 1998	28 May–7 Jun 2004	6-8 Sep 2005	22 Nov – 27 Nov 2006	17 Mar – 31 Mar 2008	17 -24 April 2008	Sep 2010 (2 days), Nov 2010 (1 day)	5 Oct – 18 Oct 2009 and 20 Mar – 1 May 2010	7 Apr – 19 Apr and 23 Aug – 4 Sep 2010	4-10 Nov 2011	24 Nov – 1 Dec 2012	24 June - 6 July, 13 -25 July 2012	12 – 19 May, 31 May – 11 June and 6-15 Oct 2011 19-22 Jan and 18-28 May 2012	12-16 Aug and 7-12 Nov 2014	19-22 Nov 2015. Cameras: 19 Nov – 17 Dec 2015
No. of trapping sites	11	6	0	4 full sites, 2 Elliott only sites.	4 full sites, 1 Funnel / Elliott only site	0	0	12 Sites. 5 run both Phases, 3 run first Phase only, 5 run second Phase only	10 Sites, two Phases	0	0	20	20	0	10
Trapping site configuration	CALM Pilbara grid	Linear transect or Grid. Varied, inconsistent.	N/A	2 pot trap, 2 funnel, 10 Elliott, 5 Cages	Linear transect or Grid. Varied, inconsistent.	N/A	N/A	Linear transect. 5 Bucket, 5 PVC, 20 Funnel, 20 Elliott, 2 Cage	Linear transect. 5 Bucket, 5 PVC, 20 Funnel, 20 Elliott, 2 Cage	N/A	N/A	20 Cage or large Elliott traps	Linear transect. 5 Bucket, 5 PVC, 20 Funnel, 20 Elliott, 2 Cage	N/A	Remote sensor camera
Nights trapped	Average of 5.9, range from 5 to 7	7	N/A	3 (3 sites), 4 (1 site)	Average of 5.6, range 4-7	N/A	N/A	6	6-8	N/A	N/A	14	7	N/A	N/A
Cage nights	0	0	N/A	100	48	N/A	N/A	216	280	N/A	N/A	3535	560	N/A	N/A
Elliott nights	1180	840	N/A	185	590	N/A	N/A	2160	2800	N/A	N/A	0	5600	N/A	N/A
Funnel nights	0	336	N/A	280	149	N/A	N/A	2160	2800	N/A	N/A	0	5600	N/A	N/A
Bucket nights	265	210	N/A	0	85.5	N/A	N/A	540	700	N/A	N/A	0	1400	N/A	N/A
PVC Pipe nights	265	210	N/A	0	85.5	N/A	N/A	540	700	N/A	N/A	0	1400	N/A	N/A
Pot nights ⁷	0	0	N/A	280	0	N/A	N/A	0	0	N/A	N/A	0	0	N/A	N/A
Total Trap nights	1710	1596	N/A	845	958	N/A	N/A	5616	7280	N/A	N/A	3535	14560	N/A	N/A

⁷ Small 500 ml 'pots' employed as a means of potentially trapping small sub-fossorial taxa.

Survey	Mining Area C Biological Survey	Area C: Deposits D, E and F Biological Survey	Mining Area C Expansion Deposit E Bat Assessment	Area C R Deposit Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Terrestrial Vertebrate Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Bat Survey and Assessment	South Flank 2010 Bat Survey	Area C and Surrounds Fauna Study	Southern Flank Vertebrate Fauna Study	South Flank Bat Assessment Survey	Central Pilbara Ghost Bat Assessment	South Flank Targeted Northern Quoll Survey	Mudlark Vertebrate Fauna Study	Central Pilbara Ghost Bat Population and Roost Assessment: 2014	South Flank Targeted Fauna Survey
Diurnal search (hrs)	62.5	39.3	Not stated (searched 10 gullies and gorges)	23	5	Not stated	N/A	51.2	152	N/A	N/A	320	58.3	N/A	40
Nocturnal search (hrs)	10	20		Not stated	5	0	N/A	48	48	N/A	N/A	0	80	N/A	N/A
Bird surveys (hrs)	44	35	N/A	18.5	22	N/A	N/A	35.3		N/A	N/A	0	40	N/A	N/A
Bird survey method	1 hr set-time period survey, 2 x AM, 1 x mid-day, 1 x PM	20 min set time period	N/A	Opportunistic	30 or 60 min set time period.	N/A	N/A	20 min set time period	20 min set time period	N/A	N/A	N/A	20 min set time period	N/A	N/A
Bat recording (nights)	0	3	2	4	0	4	1	23	22	20	N/A	0	22	N/A	N/A
Bat recording (hrs)	0	3	5	5.3	0	Unknown	8	>180	>180	160	N/A	0	>180	N/A	N/A
No. Caves Assessed	0	0	0	0	0	0	0	0	0		47	0	0	68	N/A
Bat survey method	Mist nets	ANABATTM	ANABATTM II, cave searches	ANABATTM	Conducted by Specialized Zoological	ANABATTM SD-1, gully searches, Harp trap, cave entrance examination using video or barrier	ANABATTM II, cave searches	ANABATTM II and ANABATTM SD-1, gully searches	ANABATTM II and ANABATTM SD-1, gully searches	Guano sheets, counts, still camera, video camera, SM2 Songmeter, cave searches	Cave assessment, nocturnal count, video camera, motion detecting camera, SM2	N/A	SM2, cave searches	Cave assessment, guano sheets, SM2, motion cameras, infrared video, 3D cave mapping,	N/A
Limitations	No cage traps used. Pre-ANABATTM and pre-funnel trap use. Single Phase only. Sites 6 and 11 Elliott traps only.	The cool winter weather is likely to have reduced the number of reptile species recorded.	Bat survey only	Fire on 24th November. Sites 1, 3, 4 and 6 affected. Pot traps instead of bucket or pipe. Pot traps not used at Sites 1 and 10.	South-west of survey area was burnt. Trap line configuration and layout varied considerably between sites. Trap line number	Bat survey only	Bat survey only	Bird surveys inconsistent between sites.	Prevailing dry conditions may have reduced capture rates.	Not all areas of caves able to be surveyed due to safety or access restrictions	Not all areas of caves able to be surveyed due to safety or access restrictions	None	None	Not all areas of caves able to be surveyed due to safety or access restrictions	Fire affected ~40 % of camera trapping sites in November.

Survey	Mining Area C Biological Survey	Area C: Deposits D, E and F Biological Survey	Mining Area C Expansion Deposit E Bat Assessment	Area C R Deposit Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Terrestrial Vertebrate Fauna Assessment	Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Bat Survey and Assessment	South Flank 2010 Bat Survey	Area C and Surrounds Fauna Study	Southern Flank Vertebrate Fauna Study	South Flank Bat Assessment Survey	Central Pilbara Ghost Bat Assessment	South Flank Targeted Northern Quoll Survey	Mudlark Vertebrate Fauna Study	Central Pilbara Ghost Bat Population and Roost Assessment: 2014	South Flank Targeted Fauna Survey
				Site 6 consisted of Elliotts around a pebble mound. Very limited trapping. Casual bird observations	of nights varied across sites. Bird survey periods varied in length.										
Notes				Australian Bustard is listed as recorded in the appendices, but text specifically says that it was not recorded.	Pit traps are not discriminated so a ratio of 50:50 is assumed. Bat survey conducted by Specialized Zoological (separate report)			Hair trap sites and camera traps were used. Extensive searches of gully systems and gorges for caves suitable for Ghost Bat and Pilbara Leaf-nosed Bat.	Hair trap sites and camera traps were used. Extensive searches of gully systems and gorges for caves suitable for Ghost Bat and Pilbara Leaf-nosed Bat.	24 nights of still camera recording, 4 nights of video camera recording, min. 48 nights of guano sheets.					



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of Level 2 Vertebrate Fauna Surveys
undertaken in the Proposed Mining Area C
Development Envelope and surrounds

Scale @ A3: 1:90,000	Prepared: M. LYTTLE	Project No: A780/032 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 20a
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Great Northern Highway
- BHP Billiton Rail

- Area C Deposits D, E and F Biological Survey, Ecologia (2004b)
- Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Bat Survey and Assessment, Specialised Zoological (2008)
- Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Terrestrial Vertebrate Fauna Assessment, Outback Ecology (2008)
- Area C South Flank Deposit Fauna Assessment, ENV (2008)
- Area C and Surrounds Vertebrate Fauna Survey, Biologic (2011)

- Central Pilbara Ghost Bat Population and Roost Assessment: 2014, Biologic (2015)
- Marillana Creek Western Access Corridor – Biological Assessment, HGM (1999)
- Mining Area C Biological Survey, Ecologia (1998a)
- Mining Area C Expansion Deposit E Bat Assessment, Ecologia (2005)
- Mining Area C R Deposit Fauna Assessment, ENV (2007)
- Mudlark Vertebrate Fauna Study, Biologic (2016)
- Newman to Yandi Transmission Line
- Terrestrial Vertebrate Fauna Assessment, ENV (2009)

- Packsaddle Range Biological Survey, Ecologia (2004a)
- South Flank 2010 Bat Survey Report, BatCall WA (2011)
- South Flank Bat Assessment Survey, Biologic (2011)
- South Flank NVCP Extension Flora, Vegetation and Fauna Survey, ENV (2010a)
- South Flank Targeted Fauna Survey, Biologic (2016)
- South Flank Targeted Northern Quoll Survey, Biologic (2013)
- Southern Flank Vertebrate Fauna Study, Biologic (2011)

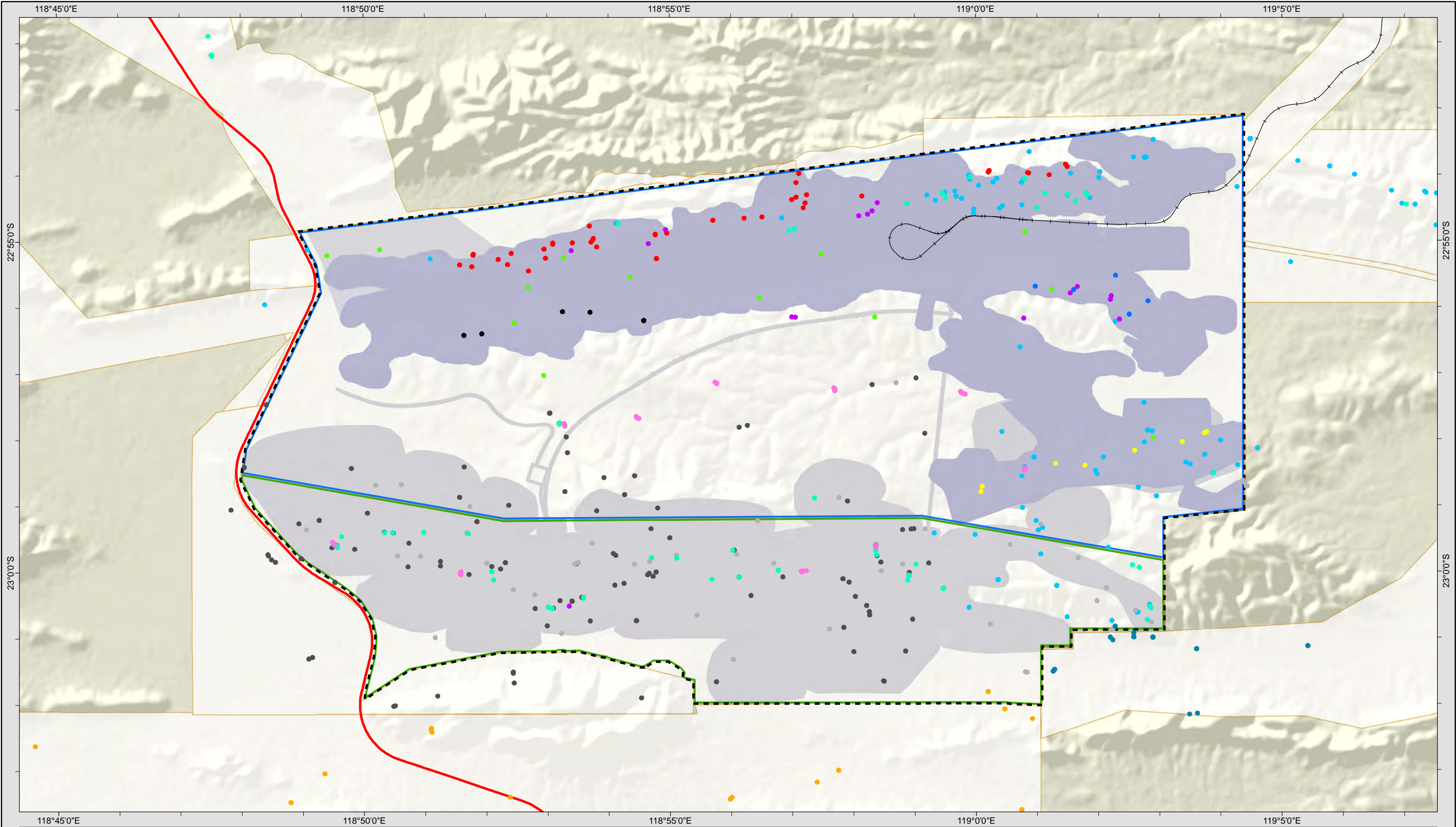
- South Flank to Jinidi Level 2 Vertebrate Fauna Survey, Biota (2012)


Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994





BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of Survey Sites and
Level 2 Vertebrate Fauna Survey Boundaries
undertaken in the Proposed Mining Area C
Development Envelope and surrounds

Scale @ A3: 1:100,000	Prepared: M. LYTTLE	Project No: A780/033 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 20b
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development

Approved Mining Area C (Northern Flank) Development Envelope

Additional Development Envelope

Mining Area C EMP Rev 6 Impact Assessment

Indicative Additional Impact Assessment Area

Level 2 Vertebrate Fauna Survey

Great Northern Highway

BHP Billiton Rail
- Area C Deposits D, E and F Biological Survey, Ecologia (2004b)

Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Bat Survey and Assessment, Specialised Zoological (2008)

Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Terrestrial Vertebrate Fauna Assessment, Outback Ecology (2008)

Area C and Surrounds Vertebrate Fauna Survey, Biologic (2011)

Central Pilbara Ghost Bat Population and Roost Assessment: 2014, Biologic (2015)
- Mining Area C Biological Survey, Ecologia

Mining Area C R Deposit Fauna Assessment, ENV (2007)

Mudlark Vertebrate Fauna Study, Biologic (2016)


Packsaddle Range Biological Survey, Ecologia (2004a)

South Flank Targeted Fauna Survey, Biologic (2016)

South Flank Targeted Northern Quoll Survey, Biologic (2013)

South Flank to Jinidi Level 2 Vertebrate Fauna Survey, Biota (2012)

Southern Flank Vertebrate Fauna Study, Biologic (2011)



03.256.5

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_033_E_MAC_Southern_Flank_PER_Map20b_RevB.mxd

Table 25: Summary of survey effort for terrestrial vertebrate fauna surveys undertaken wholly or partially within the Proposed Mining Area C Development Envelope

Trap/ Survey Type	Trap/ Survey Effort
Cage trap	4,739 trap nights
Elliott trap	13,355 trap nights
Funnel trap	11,325 trap nights
Pit trap	6,401 trap nights
Diurnal search	>751.3 person hours
Nocturnal search	211 person hours
Bird survey	194.8 person hours
Bat survey	101 recording nights/ >721.3 recording hours

Eight short-range endemic (SRE) invertebrate surveys have been undertaken wholly or partially in the Proposed Mining Area C Development Envelope (Table 26; Figure 21). Four completed baseline SRE sampling (collecting all SRE fauna), one undertook both baseline and targeted millipede *Antichiropus* 'DIP007' sampling, one undertook targeted millipede *Antichiropus* 'DIP007' sampling and two completed habitat assessments only (Table 26). All surveys undertaken post-2009 have been undertaken in accordance with the EPA's (2009) *Guidance Statement 20: Sampling of Short Range Endemic Fauna for Environmental Impact Assessment in Western Australia* and BHP Billiton Iron Ore's survey guidance for SREs (BHP Billiton Iron Ore, 2015c) which were developed in conjunction with DPaW and the Western Australian Museum to ensure consistency of survey approach across surveys.

Table 26: SRE fauna and habitat survey effort within the Proposed Mining Area C Development Envelope

Survey Area	Author	Survey Dates	Survey Type	SRE Sites	Targeted SRE Sites	Habitat Assessments
Area C: A, D, P1 and P3 Deposits	Outback Ecology 2008	April & June 2008	Baseline	15		
Area C: A, D, P1 and P3 Deposits	Outback Ecology 2009	April 2009	Habitat Assessment			23
Area C and Surrounds	Biota 2011a	Feb. & June 2010	Baseline	36		36
South Flank	Biota 2011b	Feb. & Aug. 2010	Baseline	25		25
South Flank	Biota 2013a	April/ May 2012	Targeted <i>Antichiropus</i> DIP007		11	
Mudlark	Biota 2013b	March & July 2011, & Feb. 2012	Baseline	1		1
Area C	Biologic 2015	Sept. 2014	Habitat Assessment			85
South Flank	Biologic 2016d	May 2016	Baseline & Targeted A. DIP007	13	32	90
	Totals			90	43	260

Overall, the extent of SRE fauna sampling and habitat assessments within the Proposed Mining Area C Development Envelope can be regarded as sufficient for the purposes of mapping SRE habitats and fauna distributions for the impact assessment, and to meet the requirements of current EPA guidance (Biologic, 2016a). All baseline surveys have used a stratified approach to ensure that all landforms and fauna habitats present have been sampled, and that there is adequate geographic coverage.

11.2.3.2 Habitats

All major fauna habitats present in the Proposed Mining Area C Development Envelope have been sampled during baseline surveys and scored High, Medium or Low using criteria including habitat suitability for conservation significant species and the diversity or uniqueness of the faunal community that it supports. Vertebrate fauna habitat maps were developed by Biologic (2014a) based on a combination of Onshore Environmental's vegetation mapping at Mining Area C and Southern Flank (Onshore Environmental, 2014) and findings of previous vertebrate fauna surveys that overlap the Proposed Mining Area C Development Envelope.

Nine major fauna habitats occur in the Proposed Mining Area C Development Envelope (Table 27 and Figure 22). There are no habitat types restricted to the Proposed Mining Area C Development Envelope. It is noted that some areas within the Proposed Mining Area C Development Envelope have been cleared or assessed prior to development of fauna habitats (denoted as 'Unmapped').

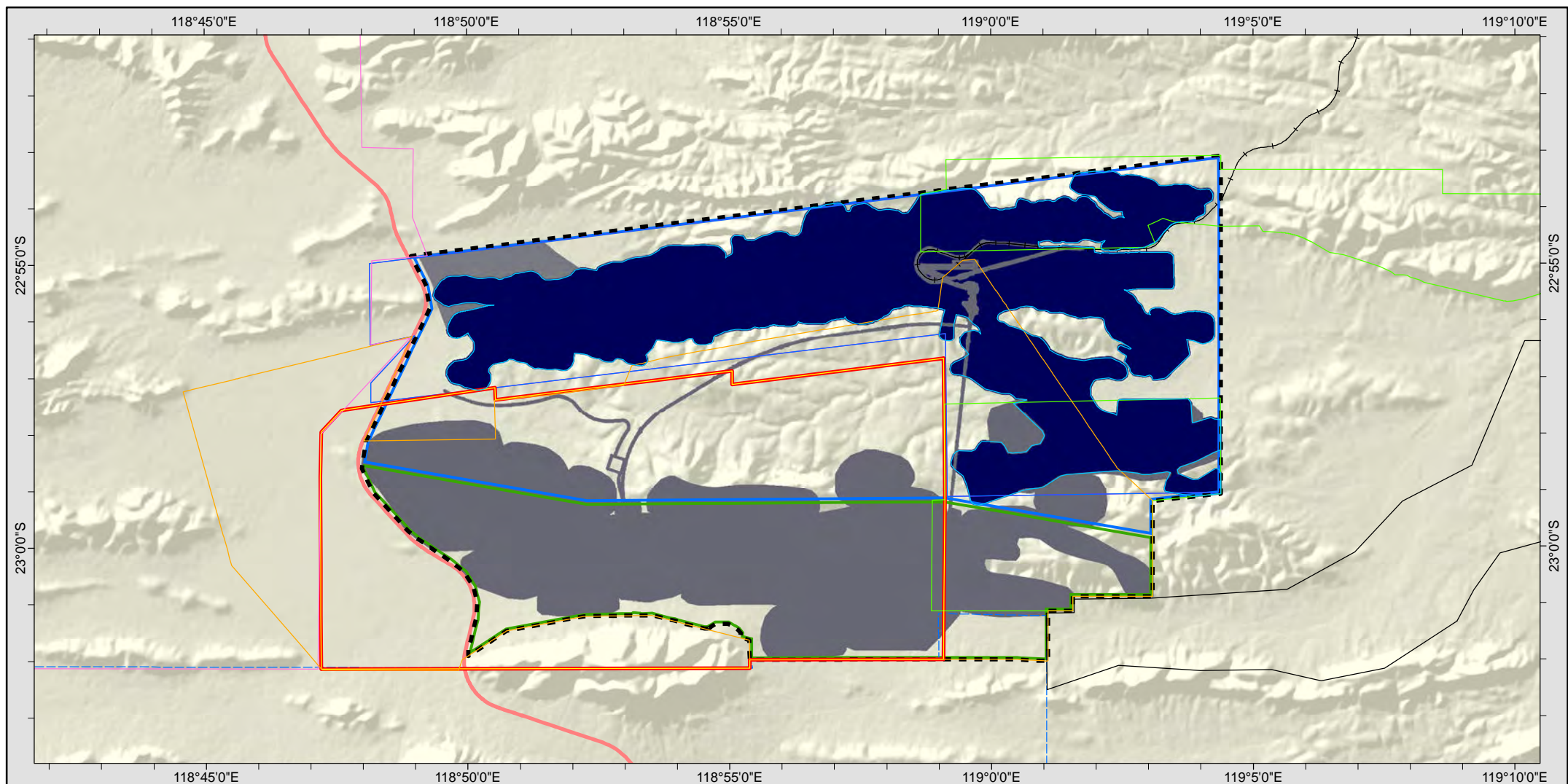
In addition to the major fauna habitats, significant habitat features, such as caves and waterholes, have been recorded across the proposed Mining Area C Development Envelope as part of baseline studies and targeted surveys (e.g. Biologic 2011, 2016c). Visual inspection of caves, nocturnal observations, SongMeter 2 (SM2) bat detectors, scat collection sheets and infrared video recorders were used to evaluate the level of use of the caves by ghost bats during latter surveys, and the relative importance of each cave was determined based on roost suitability (day, night or maternity) and usage.

Sixty-three caves have been recorded in the Proposed Mining Area C Development Envelope. Thirty-three caves suitable for use by ghost bats have been recorded in the Additional Development Envelope and 18 caves in the Mining Area C EMP Revision 6 Impact Assessment Area. These are shown in Figure 26 and discussed in further detail in Section 11.2.4.1.2

Only one semi-permanent waterhole has been recorded in the Proposed Mining Area C Development Envelope, and it occurs in the Additional Development Envelope (Figure 22).

The Coondewanna Flats PEC occurs immediately adjacent to the western boundary of the Proposed Mining Area C Development Envelope. While this PEC is recognised for its unique flora values, Lake Robinson (a component of the PEC) is a large ephemeral water body that provides habitat for water birds during periods of inundation.

The habitats in the Proposed Mining Area C Development Envelope have been classified into seven SRE habitat zones based on landform features, drainage features and vegetation features that influence SRE occurrence (Figure 23 and Table 28). Each zone contains one or several SRE habitat types. The methods and assumptions of this classification system are described in Biologic (2011) (see Appendix 5).



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Location of short-range endemic fauna surveys undertaken in the Proposed Mining Area C Development Envelope and surrounds

Scale @ A4: 1:180,000	Prepared: M. LYTTLE	Project No: A780/034 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 21a
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

- A Survey of the Short Range Endemic Invertebrate Fauna of South Flank to Jinidi, Biota (2013)
- Area C Deposit A, D, P1 and P3 SRE Survey, Outback Ecology (2008)
- Area C Deposit A, D, P1 and P3 SRE Habitat Assessment, Outback Ecology (2009)
- Area C Habitat Assessment EMP Rev 6 EIA, Biologic (2014)
- Area C and Surrounds Short Range Endemic Invertebrate Fauna Survey, Biota (2011)

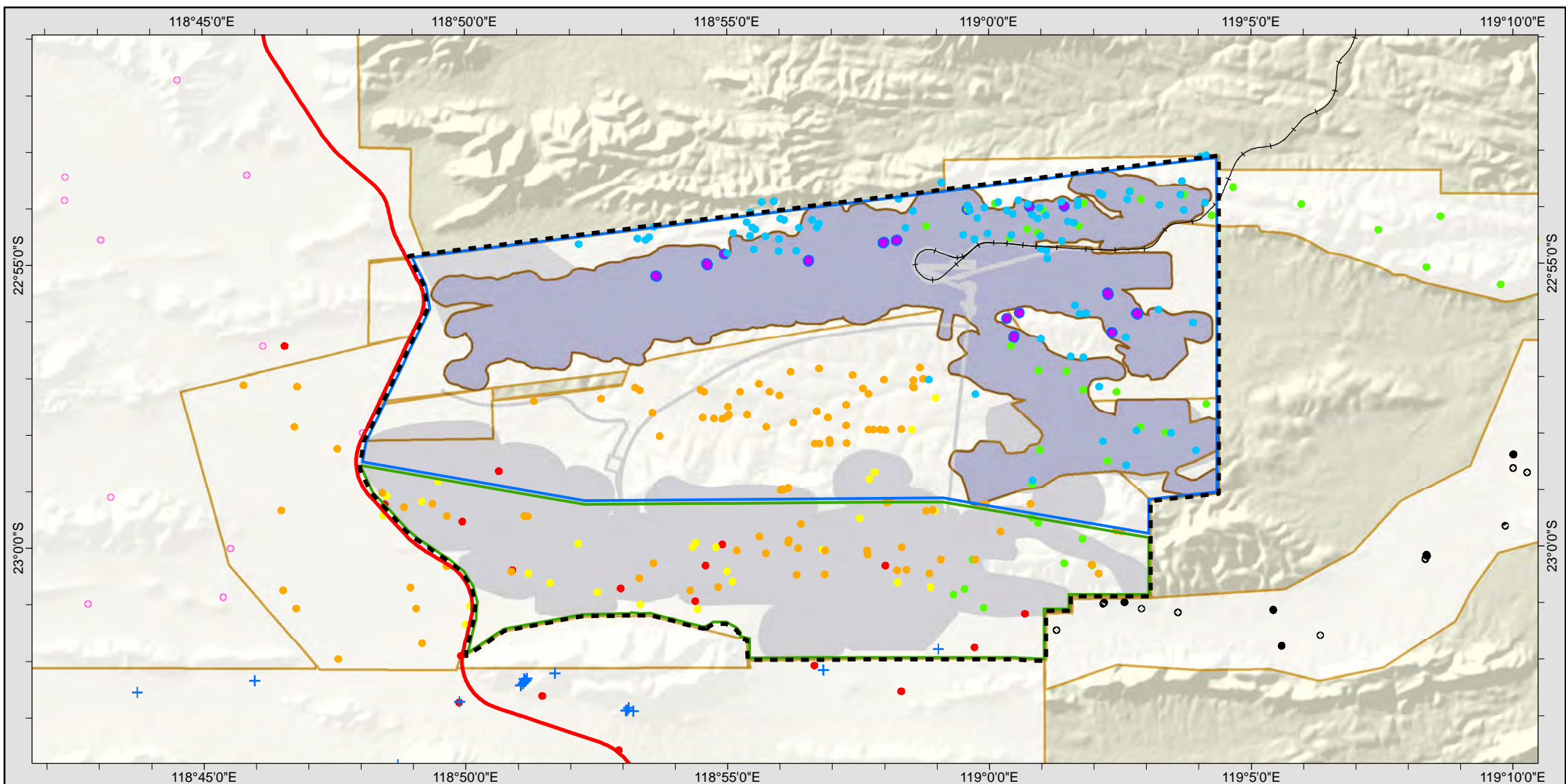
- Short Range Endemic Fauna Survey - South Flank, Biota (2011)
- South Flank Baseline and Targeted SRE Invertebrate Fauna Survey, Biologic (2015)
- South Flank Targeted Millipede Survey, Biota (2011)
- Targeted Survey for Short Range Endemic Invertebrate Fauna of Area C West, Biota (2013)
- Targeted Survey for Short Range Endemic Fauna in the Mudlark Survey Area, Biota (2013)



0 5
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of short-range endemic fauna survey sites undertaken in the Proposed Mining Area C Development Envelope and surrounds

Scale @ A4: 1:180,000	Prepared: M. LYTTLE	Project No: A780/035 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 21b
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway
- Short-range Endemic Survey Boundary

- Targeted Survey for Short Range Endemic Invertebrate Fauna of Area C West, Biota (2013)
- A Survey of the Short Range Endemic Invertebrate Fauna of South Flank to Jinidi, Biota (2013)
- Area C Habitat Assessment EIA, Biologic (2014)
- South Flank Baseline and Targeted SRE Invertebrate Fauna Survey, Biologic (2015)
- South Flank Targeted Millipede Survey, Biota (2011)
- Area C Deposit A, D, P1 and P3 SRE Survey, Outback Ecology (2008)
- Area C Deposit A, D, P1 and P3 SRE habitat Assessment, Outback Ecology (2009)
- Short Range Endemic Fauna Survey - South Flank, Biota (2011)
- Area C and Surrounds Short Range Endemic Invertebrate Fauna Survey, Biota (2011)
- + Targeted Survey for Short Range Endemic Fauna in the Mudlark Survey Area, Biota (2013)



0 5
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

Table 27: Fauna habitats in the Proposed Mining Area C Development Envelope

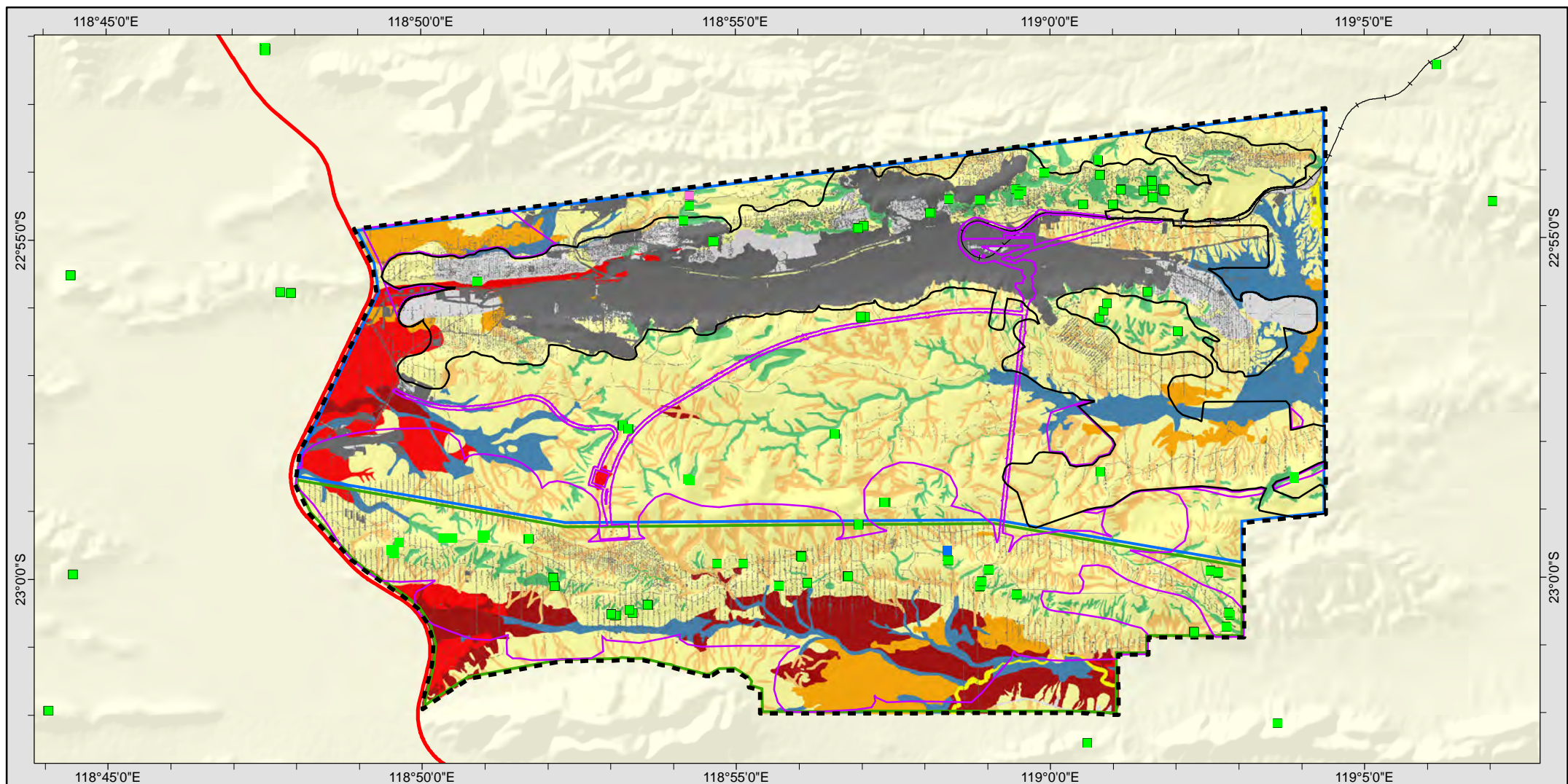
Habitat Type	Distinguishing Characteristics	Total Area Mapped (ha)*	Area (ha)					Habitat Value
			Proposed MAC Develop Envelope	Additional Develop Envelope	Indicative Additional Impact Assess Area	MAC EMP Rev 6 Impact Assess Area	Cleared (as of Dec 2016)	
Gorge/ Gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Drainage Area or Valleys). Caves and rock pools are most often encountered in this habitat type. Vegetation can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred.	4,900	1,564	450	457	393	43	<u>High</u> - Gorge/Gully habitats provide habitat for Pilbara olive python, northern quoll, Pilbara flat-headed blindsnake and Pilbara barking gecko. This habitat type also contains caves that support the local population of ghost bats and cliff face habitats suitable for peregrine falcons.
Crest/Slope	These fauna habitats tend to be more open and structurally simple than other fauna habitats and are dominated by varying species of spinifex. Common features of these habitats are rocky substrates, often with exposed bedrock, and skeletal red soils. Some Crest/Slope habitats within the Proposed Mining Area C Development Envelope are dissected by rocky gullies. This habitat is usually dominated by <i>Eucalyptus</i> woodlands, <i>Acacia</i> and <i>Grevillea</i> scrublands and <i>Triodia</i> low hummock grasslands. Dolerite Hills are also a part of this habitat type in some sections of	191,987	18,696	5,170	5,916	4,391	1,571	<u>Medium</u> – Provides habitat for the western pebble-mound mouse, which is largely restricted to this habitat type.

Habitat Type	Distinguishing Characteristics	Total Area Mapped (ha)*	Area (ha)					Habitat Value
			Proposed MAC Develop Envelope	Additional Develop Envelope	Indicative Additional Impact Assess Area	MAC EMP Rev 6 Impact Assess Area	Cleared (as of Dec 2016)	
	Proposed Mining Area C Development Envelope.							
Minor Drainage Line	These are characterised by sloping sides vegetated with hummock-forming grasses and valley bases dominated by thick <i>Acacia</i> species. Rocky outcropping is common throughout these valleys, and crumbling breakaways form boulder piles in some locations. Previously mapped as Valley in the EMP Revision 6.	11,170	2,886	1,041	1,272	471	156	<u>Low</u> – No conservation significant species restricted to or largely reliant on this habitat type.
Major Drainage Lines	This habitat is created by episodic rainfall that scours the landscape when draining. Mature river red gums and coolibahs over river pools and open, sandy or gravelly riverbeds characterise this habitat type. The eucalypt species (<i>E. victrix</i> and <i>E. camaldulensis</i>) typically contain a number of significant tree hollows used by parrots and owls for roosting and nesting. In ungrazed areas, the vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain and can include reed beds around pools.	13,148	63	38	20	<0.1	4	<u>High</u> - Suitable habitat for migratory bird species, including the rainbow bee-eater, as well as a locally high diversity of bird species. Provides potential breeding and foraging sites for the grey falcon and peregrine falcon. Provides habitat and dispersal opportunities for the Pilbara olive python and Pilbara flat-headed blindsnake.

Habitat Type	Distinguishing Characteristics	Total Area Mapped (ha)*	Area (ha)					Habitat Value
			Proposed MAC Develop Envelope	Additional Develop Envelope	Indicative Additional Impact Assess Area	MAC EMP Rev 6 Impact Assess Area	Cleared (as of Dec 2016)	
Stony Plain	These are erosional surfaces of gently undulating plains, ridges and associated foot slopes. They are characterised by open shrubland of mixed acacias and other shrubs (particularly <i>Petalostylis labicheoides</i>) and open spinifex (<i>Triodia pungens</i>) grasslands with abundant coarse fragments up to the size of stones. Trees are mixed, consisting of <i>Eucalyptus xerothermica</i> in association with <i>Acacia aneura</i> and <i>Corymbia hamersleyana</i> . Previously mapped as Stony/Sand Plain in some areas in EMP Revision 6.	47,452	1,607	1,494	1,132	0	42	<u>Low</u> - Habitat is widespread in the Pilbara region and does not exclusively support any conservation significant species in the Proposed Mining Area C Development Envelope.
Mulga	This habitat includes woodlands and other ecosystems in which mulga (<i>Acacia aneura</i>) is dominant, either as the principal acacia or mixed with others. It consists of groves on stony soils with tussock grasses and occasionally spinifex.	38,525	1,203	629	849	149	126	<u>Medium</u> - Mulga habitat supports the Pilbara flat-headed blindsnake and also supports a relatively unique and diverse faunal assemblage, with numerous species restricted to this habitat type.
Sand Plain	Sand Plain habitat is characterised by relatively deep sandy soils supporting dense spinifex grasslands and sparse shrubs. This habitat transitions into patches of mulga in places.	54,862	1,108	279	394	110	185	<u>Medium</u> - Supports a diverse fauna community, particularly fossorial species, which are usually restricted to this habitat type. (Note that, at a regional scale, this habitat is considered to have high

Habitat Type	Distinguishing Characteristics	Total Area Mapped (ha)*	Area (ha)					Habitat Value
			Proposed MAC Develop Envelope	Additional Develop Envelope	Indicative Additional Impact Assess Area	MAC EMP Rev 6 Impact Assess Area	Cleared (as of Dec 2016)	
								conservation value due to the potential presence of the greater bilby).
Drainage Area/ Floodplain	Characterised by low and sparse vegetation compared to Major Drainage Lines. Consisted of <i>Acacia</i> low woodland sometimes with scattered <i>Eucalyptus xerothermica</i> and <i>Corymbia hamersleyana</i> . The understorey generally lacks density and often consists solely of sparse tussock grassland, often of <i>*Cenchrus ciliaris</i> where it has been introduced. The substrate can be sandy in places but generally consists of a loam gravel or stone. Previously mapped as Stony/Sand Plain in some areas in the EMP Revision 6.	36,863	2,284	575	668	469	93	<u>Medium</u> – Provides suitable habitat for a number of conservation significant species, including the Pilbara flat-headed blindsnake. Pilbara olive python may use this habitat during dispersal.
Hardpan Plain	Gently inclined alluvial plains with shallow loams. Typically covered by low scattered woodlands of mulga in groves arranged at right angles to the direction of sheet water flow. In areas where the hardpan is close to the surface and soil depth is insufficient to support trees, an open scrub may persist.	6,121	13	0	2	0	0	<u>Low</u> – May provide habitat for water birds when inundated. No significant species are expected to be reliant on this habitat.
Unmapped		NA	1,128	28	29	1,011	3,261	NA

* From Biologic (2014a) and updated in subsequent revisions.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK **Vertebrate Fauna Habitats and Key Habitat Features** **within the Proposed Mining Area C** **Development Envelope**

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/036 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 22
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Vertebrate Fauna Habitat Locations**
 - Cave
 - Waterhole
 - Artificial Ghost Bat Roost
 - BHP Billiton Rail
 - Great Northern Highway

- Vertebrate Fauna Habitat**
- Cleared
 - Not mapped
 - Drainage Area/Floodplain
 - Gorge/Gully
 - Hardpan Plain
 - Hillcrest/Hillslope
 - Major Drainage Line
 - Minor Drainage Line
 - Mulga Woodland
 - Sand Plain
 - Stony Plain

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

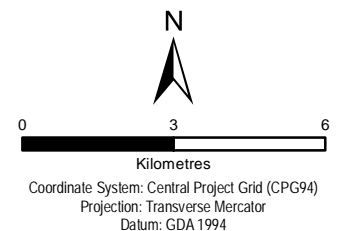


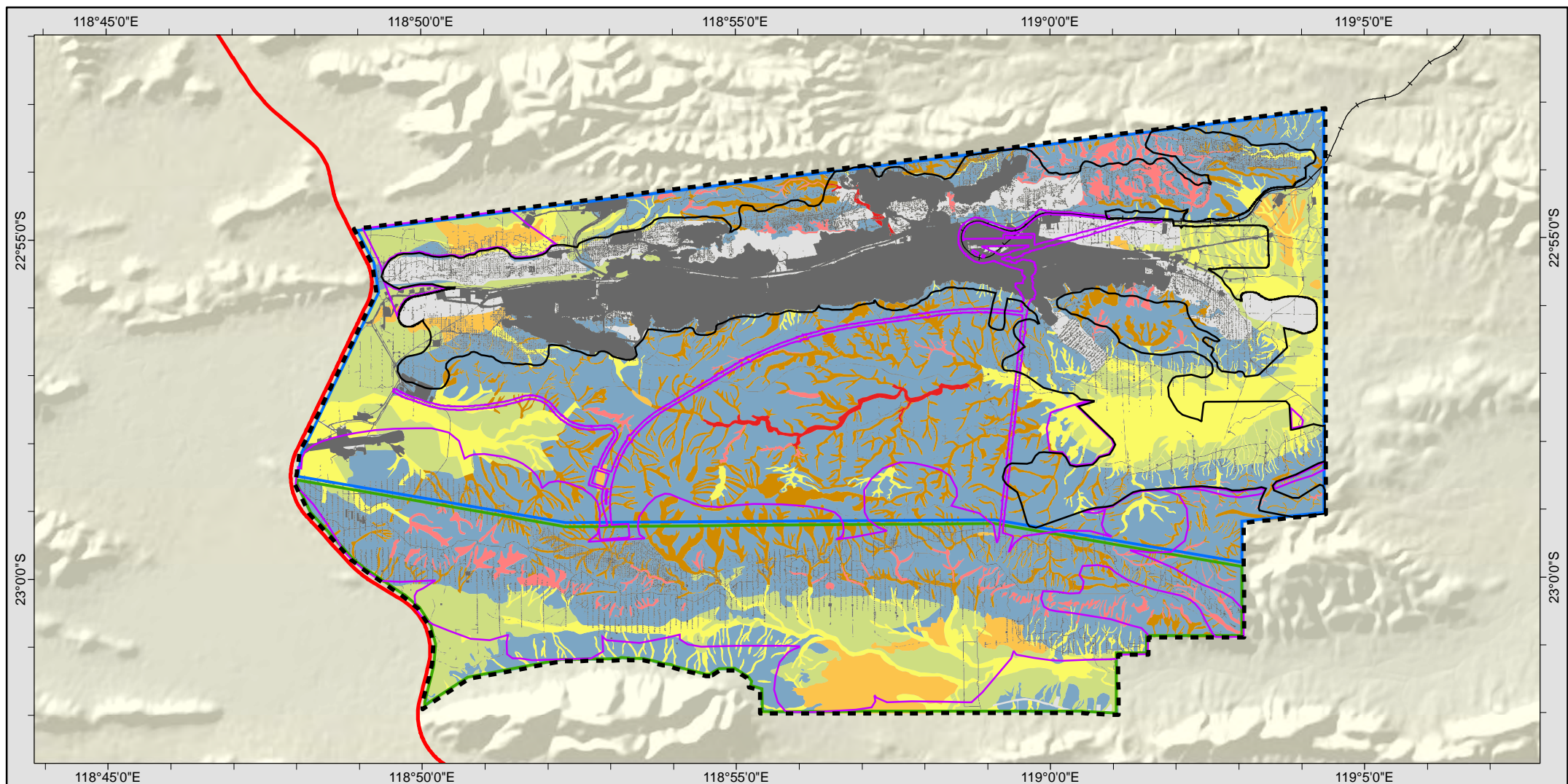
Table 28: SRE habitat zones in the Proposed Mining Area C Development Envelope

Habitat Zone	Distinguishing Characteristics	Habitat Suitability Rank*	Area (ha)				
			Proposed MAC Develop Envelope	Additional Development Envelope Area	Indicative Additional Impact Assessment Area	Mining Area C EMP Rev 6 Impact Assessment Area	Cleared
Major gorge/ gully systems	Comprises a series of massive, deeply incised gorge/deep gully/ chasm systems occurring only in the more mountainous areas. They feature interconnected rocky habitats, such as gorges/deep gullies, ridges/breakaways, scattered rocky outcrops/boulder piles, and wide expanses of shallow/open gullies leading down the steep, open faces.	5 – High (south facing) 4 – Moderate/ High (north facing)	903	449	378	239	19
River gorges	Comprises deeply incised low to moderate gorges carved by moderate or major drainage lines, where the base of the gorge is relatively flat, and the vertical or near vertical faces offer consistent shade. It forms in highly mountainous areas, usually at the base of steep slopes, or in deeply incised rolling hills. The habitat types in this zone may include gorges/deep gullies, drainage lines, drainage foci, and ridges/breakaways in areas where one face is more deeply incised than another.	5 - High	128	0	0	18	15
Shallow open gullies/ ridges	Comprises all other gully/valley systems and moderate to tall ridgelines that are not considered to be major gorge/gully systems or river gorges. The dominant habitat types in this zone are shallow/ open gullies and ridges/breakaways, which vary from moderate-low to high suitability, depending on slope, aspect, the abundance of rocky outcropping, and vegetation structure and density. At the landscape scale, this zone forms a reasonably well-connected network.	3 - Moderate	3,124	769	1,087	353	78

Habitat Zone	Distinguishing Characteristics	Habitat Suitability Rank*	Area (ha)				
			Proposed MAC Develop Envelope	Additional Development Envelope Area	Indicative Additional Impact Assessment Area	Mining Area C EMP Rev 6 Impact Assessment Area	Cleared
Hill slopes/ crests	Comprises the remaining rocky habitats on open slopes and hill crests that do not feature major outcrops, ridges, or gullies. Such areas generally have skeletal soils and open vegetation (often <i>Triodia</i> hummock grassland with scattered <i>Corymbia/ Eucalyptus</i> spp.) that can provide pockets of protection from exposure. Steeper, south-facing hill slopes can also provide some protection.	1 – Low; however, they can contain suitable microhabitats.	15,752	5,170	5,701	2,762	1,104
Drainage areas	Comprises drainage lines and foci and vegetation groves associated with the major and minor drainage lines. These areas are dominated by dense shrubland and groves/thickets of <i>Acacia</i> (<i>A. aneura</i> (mulga) and other species) and <i>Eucalyptus/Corymbia</i> species; therefore, the majority of SRE habitats are based on vegetation and detritus. Slope and aspect are more or less irrelevant to SRE suitability here; instead, the density and structure of vegetation influences the complexity of detrital microhabitats and the amount of shelter available. Isolation is generally low, as the groves and drainage line habitats form an interconnected network of vegetation-based habitats along the course of the drainage line and floodplains.	2 – Moderate/ Low	3,706	887	1,096	1,147	165

Habitat Zone	Distinguishing Characteristics	Habitat Suitability Rank*	Area (ha)				
			Proposed MAC Develop Envelope	Additional Development Envelope Area	Indicative Additional Impact Assessment Area	Mining Area C EMP Rev 6 Impact Assessment Area	Cleared
Mulga woodland	Comprises mulga groves that occur on open plains. These areas are distinguished from the surrounding shrubland/grassland of the open plains by providing more shade and a greater abundance of leaf litter and detrital microhabitats. Mulga groves in the Proposed Mining Area C Development Envelope tend to occur on deep clay-loam soils that provide optimal burrowing habitats for many mygalomorph spiders and scorpions. This zone generally occurs in large or well-connected patches and shares many habitat similarities with the Drainage areas.	2 – Moderate/ Low	1,029	628	729	98	64
Open plains	Comprises the remaining open, flat habitats on detrital or alluvial plains that do not feature significant groves/thickets, drainage features, or rocky outcrops. Moderately dense shrubland on the plains can provide patches of detrital microhabitats throughout; however, the low levels of habitat complexity, shelter, and isolation generally make these areas unsuitable for SRE species.	1 - Low	4,262	1,774	1,745	771	275
Unmapped		NA	1,646	28	7	1,605	3,762

* From Biologic (2016a); see Appendix 5.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Short-range Endemic Habitat Zones within the Proposed Mining Area C Development Envelope

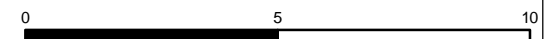
Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/037 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 23
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

Short-range Endemic Habitats

- Not mapped
- Cleared
- Hill slopes/ crests
- Open Plains
- Drainage Areas
- Mulga Woodland
- Shallow Open Gullies/ Ridges
- Major Gorge/ Gullies
- River Gorge

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

11.2.3.3 Existing impacts

Clearing has been undertaken in the Proposed Mining Area C Development Envelope under previously approved Part IV and Part V approvals. As of December 2016, 5,482 ha have been cleared. Less than 50 ha of vertebrate fauna habitats classified as High habitat value have been cleared to date (Table 27). The habitat that has been subjected to the highest amount of clearing is the Crest/ Slope habitat. This habitat is considered to have Medium value for vertebrate fauna, which is based on it being the preferred habitat type for the Priority 4 western pebble-mound mouse. Less than 35 ha of SRE habitat mapped as high suitability for SREs have been cleared as of December 2016. It is noted, however, that 3,762 ha of unmapped habitat has also been cleared.

11.2.3.4 Fauna community

Two hundred and forty vertebrate fauna species have been recorded during surveys that overlap the Proposed Mining Area C Development Envelope, comprising 30 native and eight introduced mammals, 108 birds, 86 reptiles and eight amphibians. Database searches and literature reviews suggest that approximately 300 species may occur in the area.

The baseline survey that correlates geographically with the Additional Development Envelope recorded 161 vertebrate fauna species, comprising 26 native and seven introduced mammals, 68 birds, 58 reptiles and two amphibians (Biologic, 2011). A summary of all surveys undertaken in the Proposed Mining Area C Development Envelope and species lists from each of these surveys is provided in Appendix 5.

Eleven conservation significant species have been recorded in the Proposed Mining Area C Development Envelope. A further two species are considered to possibly occur, based on a Naturemap database search undertaken in January 2017 (DPaW, 2017) and other records housed in BHP Billiton Iron Ore's internal database. Information on these species is provided in Section 11.2.4.1.2.

Thirteen species have been recorded from invertebrate taxonomic groups known to contain SRE species within the Proposed Mining Area C Development Envelope. A number of juvenile or female specimens have also been collected from these groups that have not been identified to species level due to lack of morphological characteristics or suitability to undertake genetic studies (classified as 'sp indet.'). The groups recorded were: millipedes (Myriapoda); selenopid spiders (Selenopidae); pseudoscorpions (Pseudoscorpiones); mygal spiders (Mygalomorphae) and slaters (Isopods).

Twelve confirmed or potential SRE species have been recorded in the Mining Area C EMP Revision 6 Impact Assessment Area. Four confirmed and one potential SRE invertebrate taxa have been recorded in the Additional Development Envelope with the four confirmed SRE species also being recorded within the Indicative Additional Impact Assessment Area. These species are discussed in detail in Section 11.2.4.1.

11.2.4 Potential impacts

This section summarises potential direct and indirect impacts from mining within the Proposed Mining Area C Development, and specifically, impacts from those activities undertaken within the Indicative Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assessment Area, and an assessment of potential cumulative impacts at a sub-regional or regional scale, as appropriate, and where information is available. The extents or boundaries used to assess the potential impacts of the Proposal and cumulative or regional extents vary for each factor. Table 29 details the areas assessed for the terrestrial fauna factor.

Information has been summarised from terrestrial vertebrate and SRE invertebrate fauna impact assessments undertaken in 2015 for update of the EMP Revision 6 (Biologic, 2015a; Biota, 2015) and

in 2016 for the Additional Impact Assessment Area (Biologic 2016a, b), and information from a terrestrial vertebrate fauna desktop review undertaken in 2017 (Biologic, 2017). Information from the 2015 impact assessments has been updated, where appropriate, in consideration of changes to species taxonomy, conservation listings or increased knowledge of species ecology or distribution. All supporting documents are provided in Appendix 5.

Table 29 – Impact Assessment Areas for Terrestrial Fauna

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. including Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Terrestrial Fauna (vertebrate fauna and SRE invertebrates).	Indicative Additional Impact Assessment Area and Additional Development Envelope. Mining Area C EMP Revision 6 Impact Assessment Area.	Proposed Mining Area C Development Envelope, including Mining Area C EMP Revision 6 Impact Assessment Area and Indicative Additional Impact Assessment Area.	All areas within the Proposed Mining Area C Development Envelope. For conservation significant fauna this has considered BHP Billiton Iron Ore and third-party footprints identified in BHP Billiton Iron Ore's Strategic Proposal (BHP Billiton Iron Ore, 2016c). An assessment of ghost bats has been undertaken across the eastern Hamersley IBRA subregion.

11.2.4.1 Direct impacts

11.2.4.1.1 Habitats

Vegetation clearing to accommodate development is the most direct impact likely to affect native fauna as it causes direct alteration of the land surface, making it unsuitable as habitat for most species. Implementation of the Proposal will result in the removal of native vegetation, rocks and soil; and the loss of individual fauna, in particular small ground-dwelling mammals and reptiles.

Nine major vertebrate fauna habitats occur in the Proposed Mining Area C Development Envelope, with all of these also occurring in the Indicative Additional Impact Assessment Area (Table 30). Seven of these occur within the Mining Area C EMP Revision 6 Impact Assessment Area, although one of these seven covers less than 0.1% of it.

The most common habitat in the Proposed Mining Area C Development Envelope is the Crest/Slope habitat, comprising approximately 61% of the total area and 53% of the Additional Development Envelope. It also comprises more than half of the Indicative Additional Impact Assessment Area (55%; Table 30). The Crest/Slope habitat is considered to have Medium conservation value, which is based on the fact that it is the primary habitat for the western pebble-mound mouse. Crest/Slope habitat is extremely common in the Hamersley IBRA subregion, with almost 192,000 ha mapped across BHP Billiton Iron Ore tenure alone. Removal of this habitat type is not considered to be significant at a local or regional scale.

The two fauna habitats classified to have high conservation value to vertebrate fauna are Gorge/Gully and Major Drainage Line. Gorge/Gully comprises less than 5% of the Additional Development Envelope and Indicative Additional Impact Assessment Area (Table 30). It is classified as having High value to vertebrate fauna as it provides habitat for a number of conservation significant species in the Pilbara, including the Pilbara olive python and northern quoll. Almost one third of the total mapped area of this habitat type occurs within the Proposed Mining Area C Development Envelope; however, it is also common in surrounding third party tenure to the north and in Karijini National Park to the west. Impacts

to this habitat type are considered moderate as these habitats generally contain caves which ghost bats use as roosts.

The Major Drainage Line habitat comprises less than 1% of the Additional Development Envelope and the Indicative Additional Impact Assessment Area, and less than 0.1 ha occurs in the Mining Area C EMP Revision 6 Impact Assessment Area (Table 30). Impacts to this habitat type are not considered to be significant at a local or regional scale.

Table 30: Area of major vertebrate fauna habitats in the Impact Assessment Areas

Habitat Type	Habitat Classification	Total Area Mapped (ha)	Proposed Mining Area C Development Envelope (ha) (Proportion of Total Area Mapped)	Indicative Additional Impact Assessment Area (ha) (Proportion of Total Area Mapped)	EMP Revision 6 Impact Assessment Area (ha) (Proportion of Total Area Mapped)
Gorge/Gully	High	4,282	1,564 (32%)	457 (9%)	393 (8%)
Crest/Slope	Medium	191,807	18,696 (10%)	5,916 (3%)	4,391 (2%)
Minor Drainage Line	Low	11,170	2,886 (26%)	1,272 (11%)	471 (4%)
Major Drainage Line	High	13,148	63 (<1%)	20 (<1%)	<0.1 (0%)
Stony Plain	Low	47,452	1,607 (3%)	1,132 (2%)	0 (0%)
Mulga	Medium	38,525	1,203 (3%)	849 (2%)	149 (<1%)
Sand Plain	Medium	54,862	1,108 (2%)	394 (<1%)	110 (<1%)
Drainage Area/ Floodplain	Medium	36,863	2,284 (6%)	668 (2%)	469 (1%)
Hardpan Plain	Low	6,121	13 (<1%)	2 (<1%)	0 (0%)
Unmapped	NA	NA	1,128	29	1,011
TOTAL*		404,981	30,552 (7%)	10,739 (3%)	6,994 (1%)

Seven SRE habitat zones have been identified in the Proposed Mining Area C Development Envelope. Six of these occur within the Indicative Additional Impact Assessment Area and all occur within the Mining Area C Revision 6 Impact Assessment Area (Table 28 and Table 31). Three of the habitats (Major gorge/gully systems, River gorges and Hill slopes/crests (*Antichiropus* 'DIP007' habitat)) are considered to have high suitability for SRE fauna. Approximately 4,239 ha of High suitability SRE habitats occur in the Indicative Additional Impact Assessment Area (a majority of this is habitat for *Antichiropus* 'DIP007') and 612 ha of High suitability SRE habitats occur in the Mining Area C EMP Revision 6 Impact Assessment Area (Table 31). Biologic (2015a, 2016) considered that removal of these habitats will likely have a moderate to high impact on SRE fauna.

Table 31: Area of SRE habitat zones in impact assessment areas

Habitat Type	Habitat Classification	Area (ha)			
		Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area
Major gorge/gully systems	5 – High	903	450	378	239
River gorges	5 – High	128	0	0	18

Habitat Type	Habitat Classification	Area (ha)			
		Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area
Hill slopes/crests (<i>Antichiropus</i> 'DIP007' habitat)	5 – High	7,038	3,518	3,861	355
Hill slopes/crests (non- <i>Antichiropus</i> 'DIP007' habitat)	1 – Low	8,714	1,652	1,840	2,407
Shallow open gullies/ ridges	3 – Moderate	3,124	768	1,087	353
Drainage areas	2 – Moderate/ Low	3,706	887	1,096	1,148
Mulga woodland	2 – Moderate/ Low	1,029	629	729	98
Open plains	1 – Low	4,262	1,774	1,745	771

11.2.4.1.2 Conservation significant species

Eleven vertebrate fauna species of conservation significance have been recorded in the Proposed Mining Area C Development Envelope, of which nine have been recorded in the Indicative Additional Impact Assessment Area and eight have been recorded within the Mining Area C EMP Revision 6 Impact Assessment Area (Table 32). A further three species were identified in the database search as occurring within the area and are considered to potentially occur (Table 32).

Four confirmed SRE species, comprising two millipedes and two mygalomorph spiders, have been recorded within the Indicative Additional Impact Assessment Area. A juvenile mygalomorph spider from the Barychelidae family has also been recorded in the Additional Development Envelope and is considered to be a potential SRE (Table 33). Excluding *Antichiropus* 'DIP007', all of the confirmed SRE species have been recorded outside of the Proposed Mining Area C Development Envelope.

Within the Mining Area C EMP Revision 6 Impact Assessment Area three additional confirmed SRE species have been recorded; a millipede, mygalomorph spider and a selenopid spider (Table 33).

Impacts to all conservation significant species recorded or potentially occurring within the Proposed Mining Area C Development Envelope are discussed further below.

Northern quoll (*Dasyurus hallucatus*). The northern quoll is listed as Endangered under the EPBC Act and WC Act, primarily because of the impact of cane toads on populations in the Northern Territory and Queensland and the perceived threat associated with the arrival of cane toads in Western Australia. In addition to this, the northern quoll is susceptible to predation by feral cats, dogs, dingoes and foxes; and reduced population sizes mean they are also vulnerable to other threatening processes, such as habitat loss associated with mining developments and inappropriate fire regimes (Woinarski *et al.*, 2014).

Table 32: Conservation significant vertebrate fauna species recorded in the Proposed Mining Area C Development Envelope or considered to possibly occur

Species Name	Conservation Status	Records in the Proposed Mining Area C Development Envelope	Records in the Additional Development Envelope Area	Records in the Indicative Additional Impact Assessment Area	Records in the Mining Area C Revision 6 Impact Assessment Area	Records within 20 km of the Proposed Mining Area C Development Envelope	Locality Records in the Pilbara Area (from BHP Billiton Iron Ore, 2016J). ¹
Northern quoll <i>Dasyurus hallucatus</i>	EPBC Act Endangered WC Act Schedule 2	Scat records from two locations (Biologic, 2011; Biota 2012)	One record	No records	No records	Scats recorded approximately 5 km northwest and a male quoll observed 5 km east.	1,605
Pilbara leaf-nosed bat <i>Rhinonicterus aurantia</i>	EPBC Vulnerable WC Act Schedule 3	Recorded from two locations	One record	One record	One record	One record 6 km north-west, one record 17 km to the south-east.	347
Pilbara olive python <i>Liasis olivaceus barroni</i>	EPBC Act Vulnerable WC Act Schedule 3	Recorded from four locations	Two records	Two records	One record	One record 8 km west, one record 10 km south, one record 1 km southeast, one record 15 km southeast, three records at BHP Billiton Iron Ore's Jinidi project (20 km east), six records at BHP Billiton Iron Ore's Yandi project (15 to 20 km north), three records along Weeli Wolli Creek (20 km east).	185

Species Name	Conservation Status	Records in the Proposed Mining Area C Development Envelope	Records in the Additional Development Envelope Area	Records in the Indicative Additional Impact Assessment Area	Records in the Mining Area C Revision 6 Impact Assessment Area	Records within 20 km of the Proposed Mining Area C Development Envelope	Locality Records in the Pilbara Area (from BHP Billiton Iron Ore, 2016J). ¹
Ghost bat <i>Macroderma gigas</i>	EPBC Act Vulnerable WC Act Schedule 3	Recorded from 96 locations; 63 caves recorded ²	54 records; 36 caves recorded	49 records; 33 caves	18 caves	Recorded from 171 locations; 35 caves recorded in BHP Billiton Iron Ore tenure.	997
Grey falcon <i>Falco hypoleucos</i>	WC Act Schedule 3	Recorded from five locations	Three records	Three records		One record 16 km southwest.	94
Rainbow bee-eater <i>Merops ornatus</i>	EPBC Act Migratory WC Act Schedule 5	Recorded from five locations	One record	No records		Recorded from multiple locations (in excess of 50) from north, south, east and west of the Proposed Mining Area C Development Envelope boundary.	(1958)
Peregrine falcon <i>Falco peregrinus</i>	WC Act Schedule 7	Recorded from two locations.	No records	No records		Recorded from two locations approximately 11 km west and northwest, and one location at Weeli Wolli Creek approximately 13 km east.	207

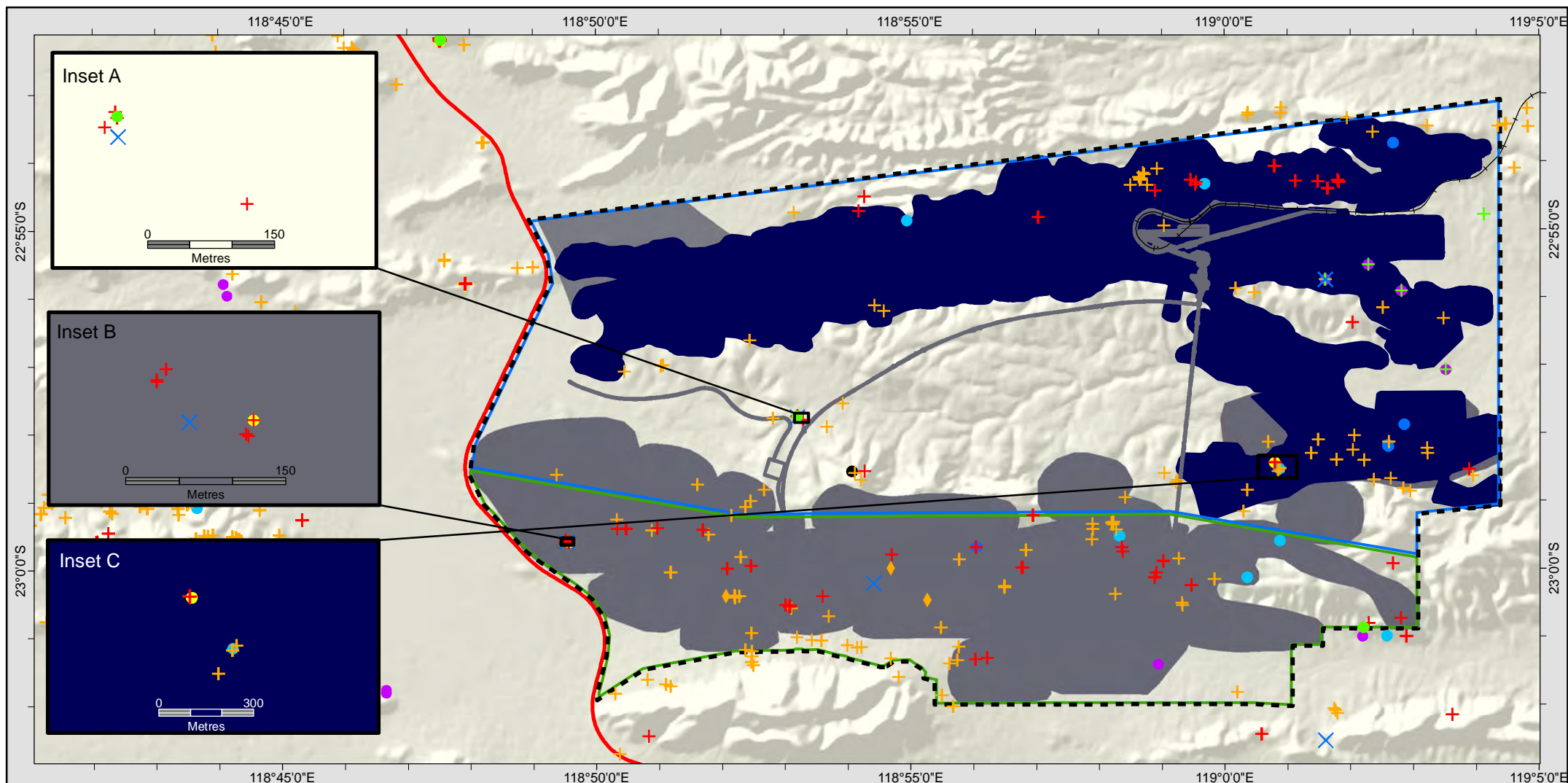
Species Name	Conservation Status	Records in the Proposed Mining Area C Development Envelope	Records in the Additional Development Envelope Area	Records in the Indicative Additional Impact Assessment Area	Records in the Mining Area C Revision 6 Impact Assessment Area	Records within 20 km of the Proposed Mining Area C Development Envelope	Locality Records in the Pilbara Area (from BHP Billiton Iron Ore, 2016J). ¹
Fork-tailed swift <i>Apus pacificus</i>	EPBC Act Migratory WC Act Schedule 5	Recorded from five locations.	No records	No records		Recorded from four locations in BHP Billiton Iron Ore's Jinidi project approximately 20 km east of the Proposed Mining Area C Development Envelope boundary.	(37)
Pilbara flat-headed blind-snake <i>Anilius ganei</i>	DPaW Priority 1	Recorded from four locations	One record	One record		One record approximately 4 km south, and one record approximately 19 km southeast.	84
Pilbara barking gecko <i>Underwoodisaurus seorsus</i>	DPaW Priority 2	Recorded from six locations	Recorded from three locations	Recorded from three locations	Recorded from three locations	Three records south (200 m, 11 km and 17 km from the Proposed Mining Area C Development Envelope boundary), one record 20 km southwest, one record 8 km west, and one record 6 km east.	27
Western pebble-mound mouse <i>Pseudomys chapmani</i>	DPaW Priority 4	113 recorded locations	48 records	31 records	36 records	More than 1,000 recorded locations from north, south, east and west of the Proposed Mining Area C Development Envelope boundary.	3,396

Species Name	Conservation Status	Records in the Proposed Mining Area C Development Envelope	Records in the Additional Development Envelope Area	Records in the Indicative Additional Impact Assessment Area	Records in the Mining Area C Revision 6 Impact Assessment Area	Records within 20 km of the Proposed Mining Area C Development Envelope	Locality Records in the Pilbara Area (from BHP Billiton Iron Ore, 2016J). ¹
Common greenshank <i>Tringa nebularia</i>	EPBC Act Migratory WC Act Schedule 5	No records	No records	No records		Identified in Naturemap search (40 km radius; DEC, 2016). ³	(145)
Northern brushtail possum <i>Trichosurus vulpecula arnhemensis</i>	WC Act Schedule 3	No records	No records	No records		One record (scat) approximately 2 km west of the Proposed Mining Area C Development Envelope boundary.	214
Short-tailed mouse <i>Leggadina lakedownensis</i>	DPaW Priority 4	No records	No records	No records		Two record approximately 20 km west northwest of the Proposed Mining Area C Development Envelope boundary.	158

1. Caves recorded have been assessed for use by the ghost bat in Section 11.2.4.1.2

2. Numbers in parentheses were not reported in BHP Billiton Iron Ore (2016j).

3. The Naturemap search (DEC, 2016) returned a record for the southwest subspecies of barking owl (*Ninox connivens connivens*), which is a Priority 2 species. This record is considered erroneous and is not discussed further in this assessment.



Spatial Data - Business Development BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Location of conservation significant vertebrate fauna in the Proposed Mining Area C Development Envelope and surrounds

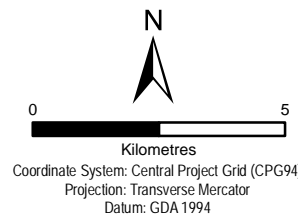
Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/038 REVC
Date: 30/03/2017	Checked: B. BARNETT	Figure: 24a
Revision: Rev C	Reviewed: S. WILLIAMSON	

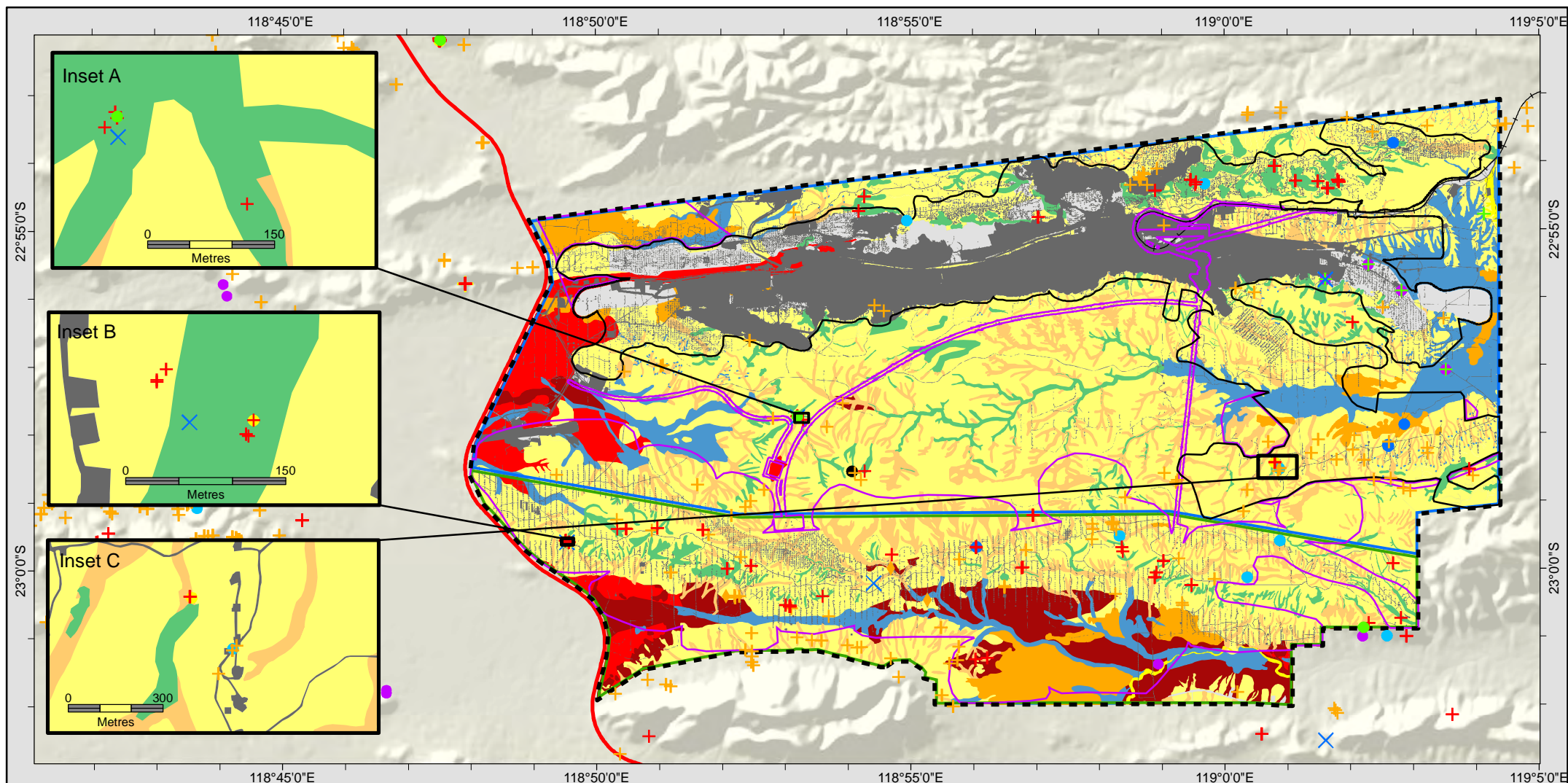
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

- ### Significant Fauna Observations
- Fork-tailed Swift (S5)
 - Ghost bat (V)
 - Grey falcon (S3)
 - Northern brushtail possum (S3)
 - Northern quoll (E)
 - Peregrine falcon (S7)

- Pilbara barking gecko (P2)
- Pilbara flat-headed blind-snake (P1)
- Pilbara leaf-nosed bat (V)
- Pilbara olive python (V)
- Rainbow Bee-eater (S5)
- Western pebble-mound mouse or Ngadjji (P4)

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.





Spatial Data - Business Development BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Location of conservation significant vertebrate fauna in the Proposed Mining Area C Development Envelope and surrounds with Habitats

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/039 REV C
Date: 8/02/2017	Checked: B. BARNETT	Figure: 24b
Revision: Rev C	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

Significant Fauna Observations

- Fork-tailed Swift (S5)
- Ghost bat (V)
- Grey falcon (S3)
- Northern brushtail possum (S3)
- Northern quoll (E)
- Peregrine falcon (S7)
- Pilbara barking gecko (P2)
- Pilbara flat-headed blind-snake (P1)
- Pilbara leaf-nosed bat (V)
- Pilbara olive python (V)
- Rainbow Bee-eater (S5)
- Western pebble-mound mouse or Ngadji (P4)

Vertebrate Fauna Habitat

- Cleared
- Not mapped
- Drainage Area/Floodplain
- Gorge/Gully
- Hardpan Plain
- Hillcrest/Hillslope
- Major Drainage Line
- Minor Drainage Line
- Mulga Woodland
- Sand Plain
- Stony Plain

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



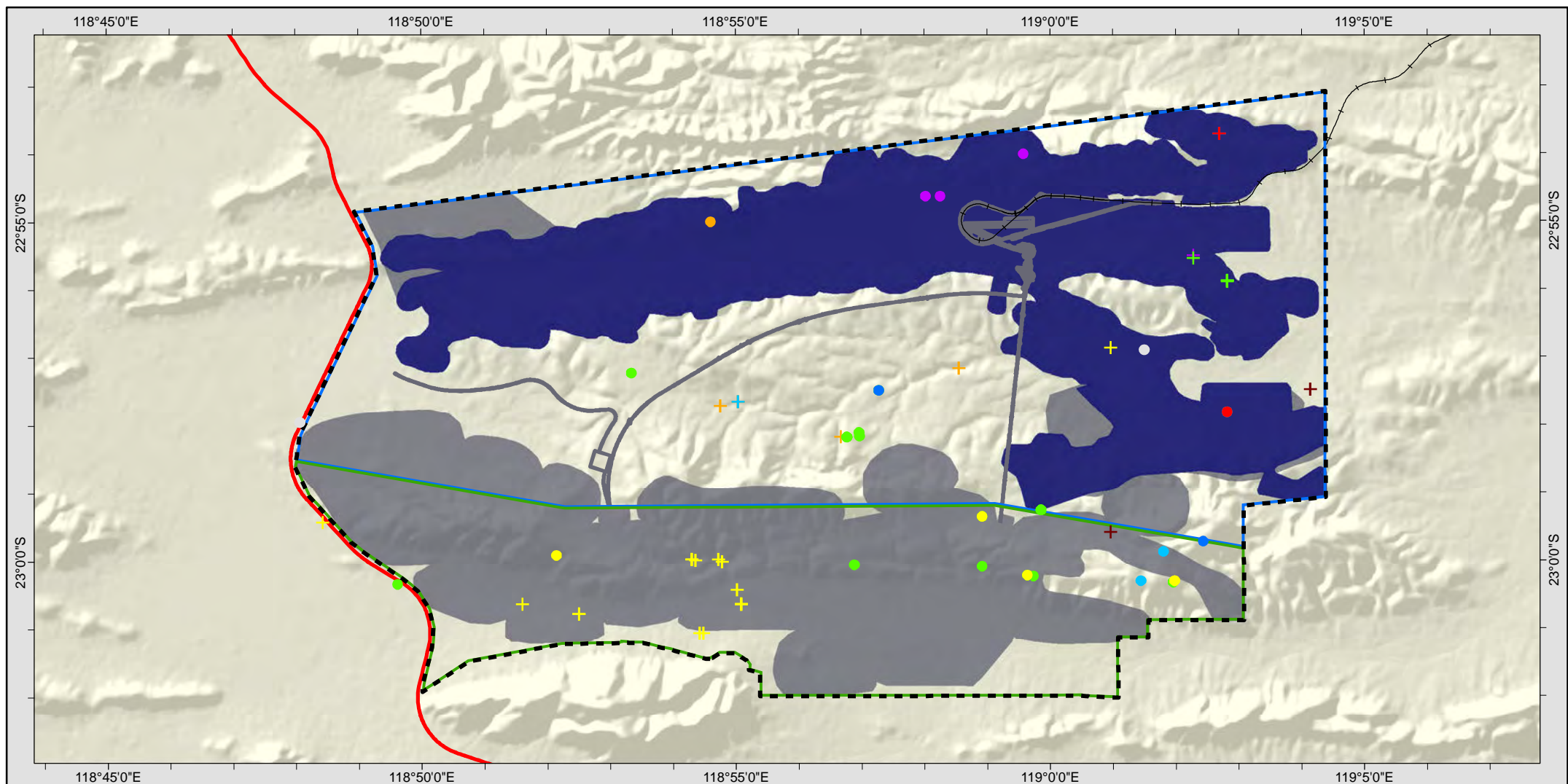
0 2 4
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Table 33: Confirmed and potential SRE taxa recorded in the Proposed Mining Area C Development Envelope

Taxon	SRE Status	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area	Outside Proposed Mining Area C Development Envelope
Myriapoda						
<i>Antichiropus</i> `DIP006`	Confirmed SRE	1				
<i>Antichiropus</i> `sp. indet. (juv.)` (Likely `DIP006`)	Potential SRE, Likely A. `DIP006`,	2			1	
<i>Antichiropus</i> `DIP007`	Confirmed SRE	5	5	4		
<i>Antichiropus</i> `sp. indet. (juv. and female)` (Likely `DIP007`)	Potential SRE, Likely A. `DIP007`,	18	8	6		1
<i>Austrostrophus</i> `DIP018`	Confirmed SRE	3	2	1		1
Selenopidae						
<i>Karaops banyjima</i>	Confirmed SRE	1			1	
<i>Karaops</i> `sp. indet. (juv.)`	Potential SRE	1			1	
? <i>Karaops</i> `sp. indet. (juv.)`	Potential SRE	4				
Pseudoscorpiones						
<i>Synsphyronus</i> `PSE014`	Confirmed SRE	1			1	1
Mygalomorphae						
<i>Aname</i> `MYG104`	Confirmed SRE	1			1	1
Barychelidae indet. (juv.)	Potential SRE	3	1			
<i>Chenistonia</i> `MYG088`	Confirmed SRE	3			1	

Taxon	SRE Status	Proposed Mining Area C Development Envelope	Additional Development Envelope	Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area	Outside Proposed Mining Area C Development Envelope
<i>Conothele</i> `MYG282-DNA`	Confirmed SRE	1			1	16
<i>Kwonkan</i> `MYG339-DNA`	Confirmed SRE	16	15	13	1	1
<i>Missulena langlandsi</i>	Confirmed SRE	4			4	2
<i>Teyl</i> `MYG027`	Confirmed SRE	2			2	2
<i>Yilgarnia</i> `MYG197`	Confirmed SRE	2	1	1		1
Isopoda						
<i>Spherillo</i> `south-flank`	Potential SRE	2				



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Location of SRE Invertebrate Fauna in the
Proposed Mining Area C Development Envelope

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/040 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 25a
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C
- Development Envelope
- Additional Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Great Northern Highway

Short-range Endemic Invertebrate Fauna

- *Aname* 'MYG104'
- *Antichiropus* 'DIP006'
- *Antichiropus* 'DIP007'
- *Antichiropus* indet.
- *Austrostrophus* 'DIP018'
- *Barychelidae* indet. (juv.)
- *Chenistonia* 'MYG088'

- *Conothele* 'MYG282-DNA'
- *Karaops banyjima*
- *Karaops* indet. (juv.)
- *Kwonkan* 'MYG339-DNA'
- *Missulena langlandsi*
- *Spherillo* 'south-flank'
- *Synsphyronus* 'PSE014'
- *Teyl* 'MYG027'
- *Yilgarnia* 'MYG197'

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 5
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Northern quolls mostly favour rocky habitats (e.g. escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines and treed creek lines) as denning or shelter habitat, and foraging occurs in the vegetated areas surrounding their dens (DSEWPaC, 2011).

The ecology of northern quolls is complex as they use habitats in a variety of ways for denning and foraging, and an individual can use multiple den sites. Northern quolls will den during the day and leave den sites to forage during the night. They are generally considered to be solitary, with females having mutually exclusive denning areas, but can have overlapping foraging areas. Populations fluctuate annually, which is likely to be related to the abundance, dispersion and renewability of food (Oakwood, 2002). Both sexes usually change dens every night, with females each using up to 55 dens (Oakwood, 2008).

There are records of northern quolls from only two locations in the Proposed Mining Area C Development Envelope, and both occur outside the Indicative Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assessment Area. Evidence of northern quoll has been confirmed in the Proposed Mining Area C Development Envelope from a scat recorded in gorge/gully habitat in the central-western area (Biologic, 2011) and from four fresh scats that are considered likely to be of northern quoll in gorge/gully habitat in the southeast portion of the Additional Development Envelope (Biota, 2012) (Figure 24). Biologic (2013) considered that the presence of scats in the area reflected transient use by northern quolls and may represent a dispersing individual or possibly a breeding male. Regional likelihood mapping undertaken by Biota (2012) considered the Proposed Mining Area C Development Envelope to occur in an area unlikely to support northern quolls, although core habitat for the species (comprising Gorge/Gully and Major Drainage Line habitats; see Figure 22 and Table 27) does occur. Both core habitat and foraging habitat for the northern quoll occurs within the Proposed Mining Area C Development Envelope (Figure 22).

Approximately 1,564 ha of Gorge/ Gully habitat occur within the Proposed Mining Area C Development Envelope, of which 457 ha occur within the Indicative Additional Impact Assessment Area and 393 ha occurs within the Mining Area C EMP Revision 6 Impact Assessment Area (Figure 22). Approximately 63 ha of Major Drainage Line habitat occur within the Proposed Mining Area C Development Envelope, of which 20 ha occur within the Indicative Additional Impact Assessment Area and <0.01 ha occur within the Mining Area C EMP Revision 6 Impact Assessment Area (Figure 22). Suitable foraging habitat comprises the Gorge/Gully habitat and habitats surrounding these areas, often the Major and Minor Drainage Lines. Individuals would likely disperse/ move along Major Drainage Lines. All of these habitats are contiguous with surrounding areas and are not considered to be uncommon in this part of the Hamersley Range.

Given the lack of species records from the area (despite the extent of survey work undertaken for this species within the Proposed Mining Area C Development Envelope and surrounds (13,355 Elliot trap nights, 4,739 cage trap nights, 1,217 camera trap nights, plus extensive diurnal and nocturnal targeted searches (Table 25) over a period of almost 20 years) and the presence of apparently suitable core habitat, it is considered that the northern quoll currently occurs only transiently or at very low density in the Proposed Mining Area C Development Envelope. The magnitude of impacts to the northern quoll arising from implementation of the Proposal is therefore considered minor, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

Pilbara leaf-nosed bat (*Rhinonicterus aurantia*). The Pilbara leaf-nosed bat is listed as Vulnerable under the EPBC Act and WC Act, primarily due to the potential loss of roost sites associated with mining activities, and in particular the recommencement of mining at historically abandoned shafts that have subsequently become important roost sites (DotE, 2016b).

Colonies of the Pilbara leaf-nosed bat are found in three distinct areas: in the mines of the eastern Pilbara, scattered throughout the Hamersley Range in smaller colonies, and in sandstone formations south of the Hamersley Range in a small number of significant colonies (Armstrong, 2001). There are confirmed roosts at Bamboo Creek mine, Copper Hills mine, Klondyke Queen mine, and Lalla Rookh mine; one cave in Barlee Range; and 16 other likely permanent occurrences (DotE, 2016b).

The Pilbara leaf-nosed bat has a very limited ability to conserve heat and water and requires very hot (28 to 32°C) and humid (96% to 100%) roost sites in caves or abandoned mines (Armstrong, 2001). Such caves are relatively uncommon in the Pilbara (Armstrong and Anstee, 2000; Armstrong, 2001), which limits the availability of diurnal roosts for this species.

There are records of Pilbara leaf-nosed bat from only two locations in the Proposed Mining Area C Development Envelope, despite extensive baseline and targeted surveys for conservation significant bats in the area and the presence of apparently suitable habitat. Records are from a single call recorded from a cave in the central-east of the Proposed Mining Area C Development Envelope and from a cave in the western end of the Additional Development Envelope (Figure 24). Both records were considered to come from a single itinerant or dispersing individual from either the well-documented Koodaideri roost some 35 km north or the Kalgan Creek roost approximately 76 km southeast (B. Bullen, Bat Call WA, pers. comm., 2014). With these being the only records from the extensive bat survey effort previously completed in the Proposed Mining Area C Development Envelope and surrounding locality, the data strongly suggest there are no roost sites or important foraging areas for this species present. The magnitude of impacts arising from implementation of the Proposal is therefore considered minor, and it is very unlikely that implementation of the Proposal will result in a change to the Pilbara leaf-nosed bat's conservation status.

Ghost bat (*Macroderma gigas*). The ghost bat has recently been listed as Vulnerable under both the EPBC Act and WC Act (2015 and 2016, respectively). The key threats to this species have been identified as habitat loss from mining, either due to destruction or disturbance of roost sites and nearby areas or to collapse or reworking of old mine adits; disturbance of breeding sites, primarily due to human visitation; modification to foraging habitat; and mortality from cane toad ingestion (Threatened Species Scientific Committee, 2016). An assessment of potential impacts to the ghost bat arising from implementation of the Proposal has been completed by Biologic (2016b) in conjunction with Bat Call WA (Appendix 5). The impact assessment has been developed considering the results of ghost bat studies undertaken for BHP Billiton Iron Ore since 2011 and was peer reviewed by Mr Norm McKenzie, a wildlife researcher with over 45 years' experience (McKenzie, 2016; see Appendix 5). Results from this assessment are summarised below.

The ghost bat occurs across northern Australia from the Pilbara region of Western Australia to central Queensland. In the Pilbara bioregion, it occurs in all four IBRA subregions, with a majority of the population occurring in the Chichester subregion. Here, most populations occur in disused mines where up to 500 bats are known to occur. In the Hamersley subregion, populations are more widespread and much smaller in size with most occurring in natural roosts. A recent estimate of its population size within the Pilbara has been given as 1300-2000 individuals (Threatened Species Scientific Committee, 2016); Biologic & BatCall WA (2014) estimated the Hamersley subregion to contain 300-400 individuals. Preferred habitat is typically deep, complex caves beneath bluffs or low rounded hills composed of Marra Mamba Iron Formation or Brockman Iron Formation or in granite tors (Armstrong and Anstee, 2000). It has a varied diet comprising primarily mammals and birds, although reptiles and invertebrates are also consumed (Biologic & BatCall WA, 2014).

Previous studies by Worthington Wilmer *et al.* (1994) have indicated that across Australia the ghost bat is restricted to a few, highly disjunct maternity sites and that females have strong and long-term female

philopatry⁸. Further studies undertaken by Worthington Wilmer *et al.* (1999) included sampling from the Chichester Range in the Pilbara region, and indicated that gene flow is male-mediated in the ghost bat. Ghost bats move between a number of caves seasonally, or as dictated by weather conditions, and require a range of cave sites (Hutson *et al.*, 2001). Outside the breeding season, male bats are known to disperse widely, most likely during the wet season when conditions would allow bats to use caves that would otherwise not be suitable. Within the Hamersley subregion, Armstrong and Anstee (2000) concluded that there are small groups of ghost bats may move about within a local area and that multiple groups may use a cave. Recent studies in the Hamersley subregion (Appendix 5) suggest that there are no or few centralised maternity roosts, and roosts used by pregnant females are more numerous and may vary across years.

Armstrong and Anstee (2000) refer to the presence of two natural maternity roosts in the Hamersley Range, with one further roost in the Chichester Range. Recent work undertaken by Biologic (in prep.) in conjunction with the University of Queensland has documented the presence of pregnant females at seven caves in BHP Billiton Iron Ore's tenure in the eastern Hamersley Range during 2014 and 2015. Three occur in the Proposed Mining Area C Development Envelope.

For the purposes of impact assessment and management, all caves in the Proposed Mining Area C Development Envelope, and a subset of caves in adjacent BHP Billiton Iron Ore tenure, have been classified as having High or Low value to ghost bats according to the following criteria:

- Low –considered currently to be used only as a feeding roost or have shown no sign of ghost bat use over multiple years of survey.
- High – All other caves, i.e. has suitable physical attributes for a day or maternity roost, ghost bats may have been recorded in the roost, and scat counts have indicated continual use over a period of years.

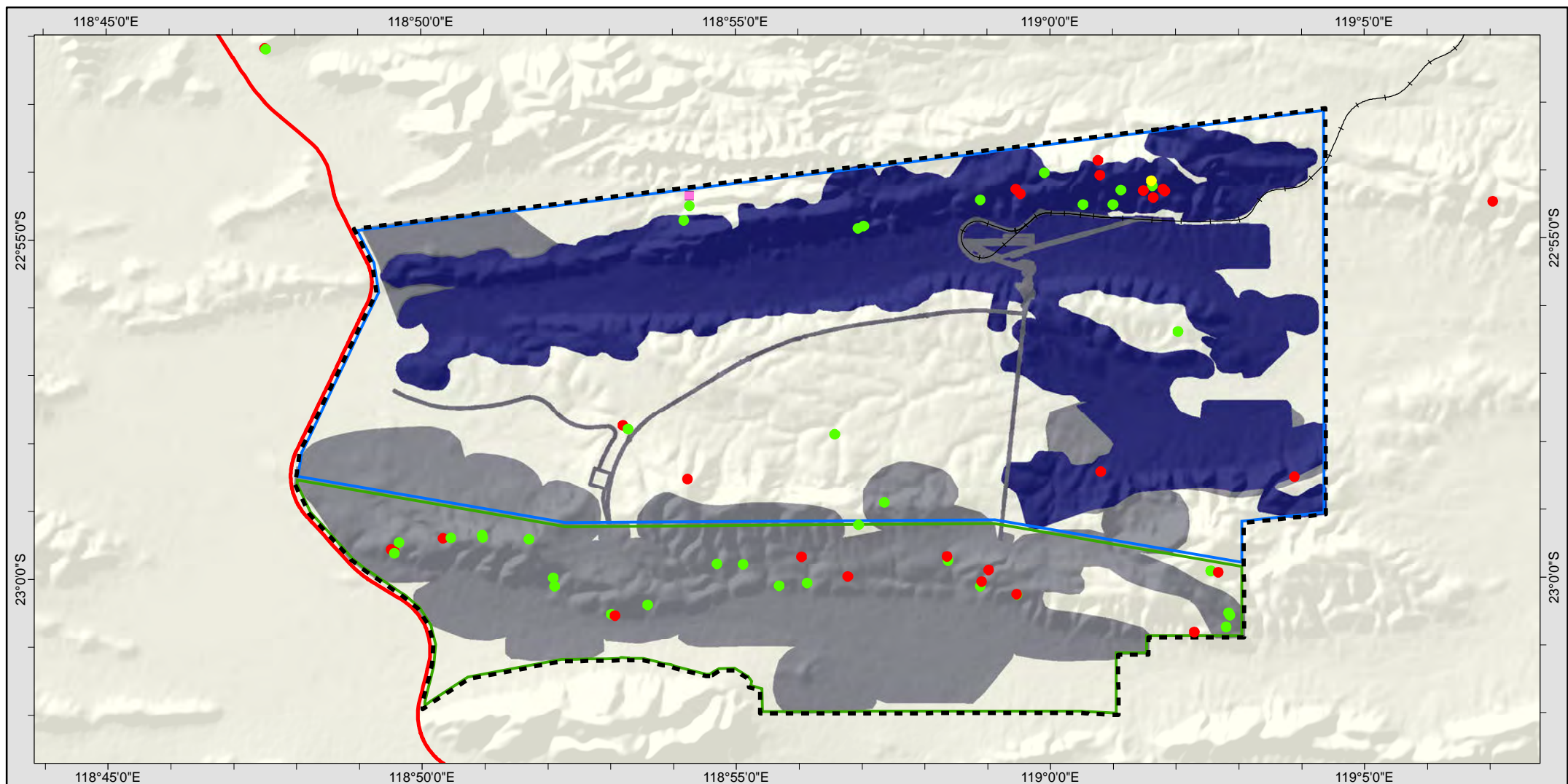
A majority of caves outside of the Proposed Mining Area C Development Envelope are unclassified as insufficient data are available to determine importance of the roost.

Sixty-three caves have been recorded to date in the Proposed Mining Area C Development Envelope (Figure 26 and Table 34). Twelve High value and 21 Low value caves (totalling 33 caves) have been recorded in the Indicative Additional Impact Assessment Area and 18 (ten High and eight Low) occur within the Mining Area C EMP Revision 6 Impact Assessment Area (Table 35). In total, 51 caves fall within approved or proposed areas of impact (Mining Area C EMP Revision 6 Impact Assessment Area and Indicative Additional Impact Assessment Area) (Table 34).

The 12 caves located outside the proposed areas of impact are widely spaced (up to 10 km apart); and given that ghost bats appear to move from cave to cave regularly (probably to access emerging high value foraging areas as they exhaust previous foraging areas), without mitigation it is considered unlikely that the ghost bat would persist within the Proposed Mining Area C Development Envelope during active mining operations in similar numbers or at all. Whilst there are numerous caves to the west and north east that may accommodate displaced individuals (21 known caves are within 10 km of the Proposed Mining Area C Development Envelope), this would likely put pressure on the surrounding area that is assumed to be operating at carrying capacity⁹. Displaced individuals would likely perish or outcompete other groups.

⁸ The tendency of an organism to remain in or habitually return to an area.

⁹ The maximum, equilibrium number of organisms of a particular species that can be supported indefinitely in a given environment, given the food, habitat and other necessities available in the environment.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Location of Ghost Bat Caves in the
Proposed Mining Area C Development Envelope
and surrounds

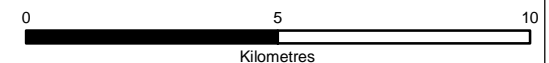
Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/042 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 26
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area

Bat Caves

- High
- Low
- Unclassified
- Artificial Ghost Bat Roost
- BHP Billiton Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Table 34: Location of caves in the Proposed Mining Area C Development Envelope and adjacent BHP Billiton Iron Ore tenure

Location	No. Caves in area (by classification)		
	High	Low	Total
Proposed Mining Area C Development Envelope	25	38	63
Additional Development Envelope	23	13	36
Indicative Additional Impact Assessment Area	12	21	33
Mining Area C EMP Revision 6 Impact Assessment Area	10	8	18
Estimate for Pilbara	Not available	Not available	317

Clearing will reduce the area available for foraging and therefore the removal of habitat could have either a high or low impact on the bats, depending on whether it corresponds with their foraging grounds. For the purposes of impact assessment, areas within 2 km of a ghost bat roost are considered to be foraging habitat (although this may not necessarily correspond with actual areas of foraging; see Appendix 5 for more detail on the determination of foraging areas). It is estimated that 20,920 ha of foraging habitat occurs within the Proposed Mining Area C Development Envelope, of which 8,579 ha (41%) occurs within the Indicative Additional Impact Assessment Area and 6,418 ha (29%) occurs within the Mining Area C EMP Revision 6 Impact Assessment Area. Some of this area will likely be reutilised by ghost bats following rehabilitation (either progressive or at closure), as studies (Biologic, 2015b) indicate that the species has a varied diet that comprises mostly common species (including the house mouse, *Mus musculus*).

It is estimated that the Proposed Mining Area C Development Envelope supports a population of approximately 50 individuals, of which approximately half occurs within the Additional Development Envelope and Indicative Additional Impact Assessment Area and the other half occurs within the Mining Area C EMP Revision 6 Impact Assessment Area. The estimate for the Hamersley IBRA subregion is 300 to 400 individuals, which comprises one genetic population (Spencer and Tedeschi, 2016). Without mitigation, the removal of up to 33 caves in the Indicative Additional Impact Assessment Area may result in a reduction of the Hamersley subregion population by between 6% and 8%. Removal of all caves within the Proposed Mining Area C Development Envelope (51 within all impact assessment areas), may result in a reduction of the Hamersley subregion population by between 12% and 17% and the Pilbara region by less than 1%. It is noted that preliminary genetic studies (Spencer and Tedeschi, 2016) estimated the ghost bat population of the Hamersley subregion to be between 700 and 800 individuals. At a species level, the loss of individuals within the Proposed Mining Area C Development Envelope is considered negligible even without application of mitigation.

Other possible impacts to the ghost bat include:

- **Noise:** Impacts from increased noise are considered to be minor. Noise modelling was undertaken by SVT (2016) (Appendix 9) to determine potential noise levels at the entrances to known caves in the Additional Development Envelope and the Indicative Additional Impact Assessment Area. All levels were predicted to be below 70 dB, with the highest levels ranging between 65 dB and 69.1 dB at three caves: SF15 (High), SF22 (Low) and SF31 (Low). SF15 falls in the Indicative Additional Impact Assessment Area, so it may potentially be removed by mining activities. A study undertaken by Bullen and Creese (2014) suggested that sound levels

up to 70 dB are unlikely to result in ghost bats leaving their roost; therefore, the impacts of mining-related sound emissions are unlikely to be significant.

- *Vibrations:* It is suggested that ghost bats will be able to tolerate vibrations of up to 15 mm/s (R. Bullen, pers. comm.), although there has been no specific research undertaken to support this. Furthermore, it would be very difficult to undertake an assessment of vibration tolerance at Southern Flank given the low likelihood of locating a continual population of bats within a cave for study. A vibration assessment undertaken by SVT (2016) predicted likely vibration levels at various distances for single hole and simultaneous blasting of 10 holes in soft and hard ground types. For 10 blast holes in soft ground, the received vibration levels are predicted to be 3.4 mm/s at 1 km and 0.4 mm/s at 2 km, whilst for hard ground, the received vibration levels are predicted to be 19.6 mm/s at 1 km and 6.9 mm/s at 2 km. It is predicted that at 1.1 km a vibration of 15 mm/s will be experienced. One cave (AC13) is located approximately 1.1 km from mining operations at Hope Downs 1. This cave continues to be used by ghost bats, and hormone analysis shows that pregnant females were using this cave in 2014 (Biologic, in prep). It is considered highly likely that the soft ground type would be applicable to caves at Southern Flank, based on current geological knowledge. The impacts of vibrations on retained caves are considered to be low.
- *Dust:* Vegetation clearing, mining, hauling and vehicle movements will result in an increase in airborne particulate matter. A result of this could be a decline in vegetation quality, although no prior studies have been able to detect a significant adverse impact of airborne dust on plant function in the Pilbara (Grierson, 2015). If vegetation was to be affected this could impact faunal assemblages by reducing both food and habitat resources. Even though ghost bats detect prey via sound, they also have excellent vision and it is possible that high dust levels could irritate their eyes or reduce vision and affect their ability to capture prey. The dust modelling for the Proposal (Pacific Environment, 2016) indicates that high dust events are likely at certain locations and times; however a low risk rating is predicted for the majority of the year. Continued implementation of existing dust suppression strategies will result in a low likelihood of the ghost bat being affected by dust.
- *Infrastructure:* Ghost bats are known to become entangled in barbed wire due to their low elevation flying pattern (Armstrong and Anstee, 2000). Recently, a mummified adult male was retrieved from a barbed wire fence in the Juna Downs pastoral lease (Biologic, in prep). The use of barbed wire fencing within mining areas is limited to areas required to comply with safety guidelines such as for use in explosive storage. The impacts from infrastructure are considered negligible.
- *Invasive species:* There is recent evidence that ghost bats predate on cane toads and are susceptible to their toxicity (Purtill 2014; White *et al.*, 2016). If cane toads expand into the Pilbara (as predicted by some models e.g. Urban *et al.* [2007]; Kearney *et al.* [2008]; Molloy *et al.* [2015]) populations in the Chichester sub-region (where populations are at their highest) will be particularly susceptible. Mining activity may assist in the rate of spread of cane toads, through vehicle movements and available surface water in the form of turkey nests and waste water treatment facilities. No dewatering discharge is planned for the Proposal. Other invasive species such as buffel grass (*Cenchrus ciliaris*), or any plant species that excludes native species, may degrade habitat in the area, however this is considered unlikely to impact on the ghost bat. Standard weed control measures will assist in reducing the impact of introduced plant species. Disturbance and mining activities (such as refuse disposal) may increase populations of the introduced house mouse (*Mus musculus*), which appears to form a significant component of the ghost bat diet in the Hamersley subregion. The impacts of invasive species

facilitated by mining activities are considered to be low. The impacts of cane toads can be reduced by onsite management.

The magnitude of impacts from implementation of the Proposal is considered unlikely to be significant to the ghost bat at a species or a population¹⁰ level (McKenzie, 2016), and implementation of the Proposal is unlikely to result in a change to its conservation status. Implementation of the Proposal will likely have a significant impact on the ghost bat at an assemblage¹¹ level during the period of mining operations. With mitigation, the long-term impact to the ghost bat assemblage within the Proposed Mining Area C Development Envelope is considered to be moderate.

Pilbara olive python (*Liasis olivaceus barroni*). The Pilbara olive python is listed as Vulnerable under both the EPBC Act and WC Act. Threats to the Pilbara olive python include predation of juveniles and prey species by cats and foxes (noting that impacts from foxes predominantly occur in the coastal regions), loss of habitat to gas and mining developments, deliberate killing by humans (either as road kills or mistaken identification as a brown snake), and degradation of water holes due to tourism (Threatened Species Scientific Committee, 2008; DotE, 2016c).

The Pilbara olive python is primarily nocturnal and tends to shelter in small caves or under vegetation during the day, although it is occasionally active after sunrise, particularly in the warmer summer months (DotE, 2016c). In the winter months, adult pythons can sometimes be found basking in the morning sun (DotE, 2016c). The breeding season of the Pilbara olive python extends from June to August, when males will travel up to 3 km in search of a mate (DotE, 2016c). There are limited studies on this species' home range, but those that have been undertaken estimate it to be between 88 and 449 ha (DotE, 2016c).

The Pilbara olive python is known from a number of sites throughout the Pilbara and is associated with drainage systems, including areas with localised drainage and semi-permanent watercourses (DotE, 2016c). In the Hamersley IBRA subregion, the Pilbara olive python is most often encountered in the vicinity of permanent waterholes in rocky ranges or among riverine vegetation (DotE, 2016c).

There have been four records of the Pilbara olive python within the Proposed Mining Area C Development Envelope. Within the Indicative Additional Impact Assessment Area there has been a single confirmed record (a dead individual), as well as probable scats from two locations. There is suitable habitat present in the form of Gorge/Gully habitat throughout much of the Proposed Mining Area C Development Envelope, including the Additional Development Envelope (Table 27), although only one near-permanent water hole has been recorded during baseline and targeted surveys (Figure 22). While there is ample potential habitat for this species in the Proposed Mining Area C Development Envelope and surrounding areas, there are relatively few records from this region of the Hamersley Range (Table 32). This may, however, reflect the difficulties in recording this species rather than the scarcity of pythons, as the species is not easy to survey and is largely nocturnal.

The key impact to the Pilbara olive python arising from implementation of the Proposal is loss of habitat; approximately 1,564 ha of Gorge/Gully habitat occur within the Proposed Mining Area C Development Envelope, of which 457 ha occur within the Indicative Additional Impact Assessment Area and 393 ha occur within the Mining Area C EMP Revision 6 Impact Assessment Area (Table 30).

¹⁰ Population is defined as all the individuals of one species in a given area. For the purposes of this impact assessment, the population is defined as the population within the Hamersley subregion, as genetic studies indicate gene flow occurs across the subregion.

¹¹ The definition of assemblage adopted for this impact assessment is: the smallest functional community of plants or animals. This is considered to be the group of ghost bats residing within the Proposed Mining Area C Development Envelope.

Fragmentation of Pilbara olive python habitat will occur at a local level due to construction of pits and OSAs, but rehabilitation of these areas will reduce this impact upon closure. As Pilbara olive pythons will readily cross roads and infrastructure areas, fragmentation impacts from construction and operation of roads and conveyors are unlikely to be significantly different from operations approved under MS 491.

Other key impacts to the Pilbara olive python, including predation of juveniles and prey species and deliberate killing by humans, are unlikely to be increased by implementation of the Proposal, provided current management programs are maintained.

The magnitude of impacts to the Pilbara olive python arising from implementation of the proposal is considered minor, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

Grey falcon (*Falco hypoleucos*). The grey falcon is listed as Vulnerable under the WC Act, primarily due to the species' very low estimated population size (less than 1,000 individuals) and low number of estimated breeding pairs (200 to 350) (Garnett *et al.*, 2011). Evidence of recent declines in the species is, however, lacking (Reid and Fleming, 1992).

Threatening processes are not well understood for this species and are largely speculative. They include grazing by introduced herbivores, which has resulted in habitat degradation; clearing for agriculture; and introduction of watering points that may have favoured the more mesic-adapted peregrine falcon (Garnett *et al.*, 2011).

The grey falcon tends to have a distribution centred on ephemeral or permanent drainage lines (Garnett *et al.*, 2011) with numerous records from the Fortescue Marsh region. Grey falcons prefer sparsely treed, open plains and drainage lines for hunting and typically nest in the abandoned nest of a raptor or corvid (Slater *et al.*, 2009) in trees or man-made structures, most notably repeater towers. It is a highly mobile and dispersive or migratory species, wintering in northern Australia and dispersing towards the coast during droughts (Marchant and Higgins, 1993).

This species has been recorded from five locations in the Proposed Mining Area C Development Envelope. Three of these records are from the Additional Development Envelope and the Indicative Additional Impact Assessment Area (Table 32) and were all recorded during January/February 2008 (ENV Australia, 2008). The remaining two records were made along Packsaddle Range in 2004 (ecologia, 2004b). The records within the Proposed Mining Area C Development Envelope likely reflect the nomadic nature of the species; and this, along with the relatively small amount of suitable habitat (ephemeral or permanent drainage lines, i.e. Major Drainage Line habitat), suggests that there is unlikely to be a permanent or regular presence in the Proposed Mining Area C Development Envelope. The magnitude of impacts to the grey falcon arising from implementation of the Proposal is therefore considered negligible, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

Rainbow bee-eater (*Merops ornatus*). The rainbow bee-eater is listed as Migratory under the EPBC Act and under Schedule 5 of the WC Act. It is not considered threatened: the IUCN listing for this species is Least Concern, and it is not discussed in the *Action Plan for Australian Birds 2010* (Garnett *et al.*, 2011). It is extremely common and widespread in Western Australia and the Pilbara region (Biota, 2015a).

The rainbow bee-eater has been recorded from five locations in the Proposed Mining Area C Development Envelope. One record is from the Additional Development Envelope, but outside of the Indicative Additional Impact Assessment Area. Three records occur within the Mining Area C EMP Revision 6 Impact Assessment Area. There are over 135,000 records nationally for this species

(ALA, 2016). There are no breeding records of this species from the Proposed Mining Area C Development Envelope, and breeding habitat (sandy banks) is limited in it. The magnitude of impacts to the rainbow bee-eater arising from implementation of the Proposal is therefore considered negligible, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

Pilbara flat-headed blindsnake (*Anilius ganei*). The Pilbara flat-headed blindsnake is endemic to the Pilbara region and is currently listed as a Priority 1 species by the DPaW. It is a fossorial species, and little is known about its ecology, but it appears to occur in a range of habitats: Wilson and Swan (2010) state that it is associated with moist gorges and gullies, and Biologic (2014) has identified it as potentially occurring in the Calcrete Areas, Mulga, Crest/Slope and Gorge/Gully habitats mapped in BHP Billiton Iron Ore tenure. It was originally listed because it was known from just a few scattered records, but this species has now been more recently recorded from 84 records in the region, including in the Millstream-Chichester National Park. Given the distribution of known records and habitats known to support this species, it almost certainly occurs in Karijini National Park; the absence of records is likely due to limited sampling.

The Pilbara flat-headed blindsnake has been recorded from five locations in the Proposed Mining Area C Development Envelope, of which one record occurs in the Additional Development Envelope and the Indicative Additional Impact Assessment Area and three occur within the Mining Area C EMP Revision 6 Impact Assessment Area (Figure 24). Habitat types suitable for this species (especially Mulga (1,203 ha within the Proposed Mining Area C Development Envelope; 849 ha within the Indicative Additional Impact Assessment Area; 149 ha within the Mining Area C EMP Revision 6 Impact Assessment Area), Crest/Slope (18,696 ha within the Proposed Mining Area C Development Envelope; 5,916 ha within the Indicative Additional Impact Assessment Area; 4,391 ha within the Mining Area C EMP Revision 6 Impact Assessment Area) and Gorge/Gully (1,564 ha within the Proposed Mining Area C Development Envelope; 457 ha within the Indicative Additional Impact Assessment Area; 393 ha within the Mining Area C EMP Revision 6 Impact Assessment Area) are relatively common in the Proposed Mining Area C Development Envelope outside of the impact assessment areas (Table 30). These habitats are also widespread and common outside the Proposed Mining Area C Development Envelope (Table 30). Based on the low number of records in the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area and the availability of suitable habitat for this species outside of it, including in the conservation estate, the magnitude of impacts to the Pilbara flat-headed blindsnake arising from implementation of the Proposal is considered to be minor, and it is very unlikely that implementation of the Proposal will result in a change to its conservation status.

Pilbara barking gecko (*Underwoodisaurus seorsus*). The Pilbara barking gecko is a relatively recently described species (having been distinguished from the more widespread and common *Underwoodisaurus milli*) that is endemic to the Pilbara and is currently listed as a Priority 2 species by the DPaW. It is believed to be rare and has a relatively small distribution for a vertebrate (Doughty and Oliver, 2011), with current records spanning a distance of approximately 240 km. It is unknown whether its distribution is continuous between these areas or if it occurs as a series of isolated populations. It is a saxicoline (rock-loving) species; and given the amount of available habitat, it is considered very likely that there are additional occurrences in this known range (including in Karijini National Park). It is, however, considered unlikely that its distribution is much larger than the current range estimate and probably does not extend beyond the Hamersley IBRA subregion. Further, it appears to be a relictual species, and the possible effects of increases in global temperature in the coming decades are of particular concern (Doughty and Oliver, 2011).

The Pilbara barking gecko has been recorded from six locations in the Proposed Mining Area C Development Envelope; three of these locations occur in the Additional Development Envelope (three

in the Indicative Additional Impact Assessment Area) and three occur within the Mining Area C EMP Revision 6 Impact Assessment Area.

All the records in the Proposed Mining Area C Development Envelope occur in or adjacent to Minor Drainage Line habitat (2,886 ha within the Proposed Mining Area C Development Envelope; 1,272 ha within the Indicative Additional Impact Assessment Area and 471 ha within the Mining Area C EMP Revision 6 Impact Assessment Area) or Gorge/Gully (1,564 ha within the Proposed Mining Area C Development Envelope; 457 ha within the Indicative Additional Impact Assessment Area and 393 ha within the Mining Area C EMP Revision 6 Impact Assessment Area) habitats. These habitats are relatively common within its range and also occur in Karijini National Park. There is also evidence that this species will inhabit caves (M. O'Connell, Biologic, pers. comm., [2015]).

The approximate distribution for the Pilbara barking gecko is 643,500 ha, with over half of this area occurring in Karijini National Park. Habitat mapping is not available for this area, but it is estimated that approximately 90,000 ha within its range comprises core habitat for the species. The removal of an additional 1,460 ha (less than 2% of estimated core habitat) is therefore considered unlikely to have a significant impact on the species.

BHP Billiton Iron Ore recognises that the Pilbara barking gecko is a range-restricted species that will require management to ensure that the EPA's environmental objectives are met. However, the impacts to habitat for the Pilbara barking gecko arising from implementation of the Proposal are considered to be minor, and it is considered unlikely that implementation of the Proposal will result in a change to its conservation status.

Western pebble-mound mouse (*Pseudomys chapmani*). The western pebble-mound mouse is listed as a Priority 4 species by the DPaW, as this species has experienced a significant decline in its range from the Gascoyne and Murchison regions and is now largely restricted to the Pilbara region (van Dyck and Strahan, 2008). The species is listed as Least Concern in the *Action Plan for Australian Mammals*, and threats from mining activities are not considered a significant threatening process for the species (Woinarski *et al.*, 2014).

The characteristic mounds constructed by colonies of these mice are commonly recorded in the region, and the species has been recorded during all surveys conducted in the Proposed Mining Area C Development Envelope (excluding those for which the scope was to target specific species, e.g. ghost bat and northern quoll). Its preferred habitat includes the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (van Dyck and Strahan, 2008).

The western pebble-mound mouse has been recorded from 113 locations in the Proposed Mining Area C Development Envelope; 48 of these locations occur in the Additional Development Envelope and 36 occur within the Mining Area C EMP Revision 6 Impact Assessment Area. A large component of the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area contains habitat preferred by this species, i.e. Crest/Slope habitat (18,696 ha within the Proposed Mining Area C Development Envelope; 5,916 ha within the Indicative Additional Impact Assessment Area and 4,391 ha within the Mining Area C EMP Revision 6 Impact Assessment Area), but this habitat is also widespread and common outside the Proposed Mining Area C Development Envelope (191,987 ha mapped within BHP Billiton database) (Table 30), including in Karijini National Park. The western pebble-mound mouse is generally considered common within suitable habitat in the Pilbara; and although there will be a loss of a number of mounds following implementation of the Proposal, it is considered very unlikely that this will have a significant impact on the species, and its conservation status is also considered very unlikely to change.

***Antichiropus* 'DIP007'**. There are five confirmed records of the SRE species *Antichiropus* 'DIP007' (representing adult male specimens), and a further 18 records of juvenile or female *Antichiropus* millipedes considered likely to belong to the same species, based on their occurrence in the same, or similar continuous habitats. Thirteen of these records have been recorded outside the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area, and one has been recorded outside of the Proposed Mining Area C Development Envelope (Table 33).

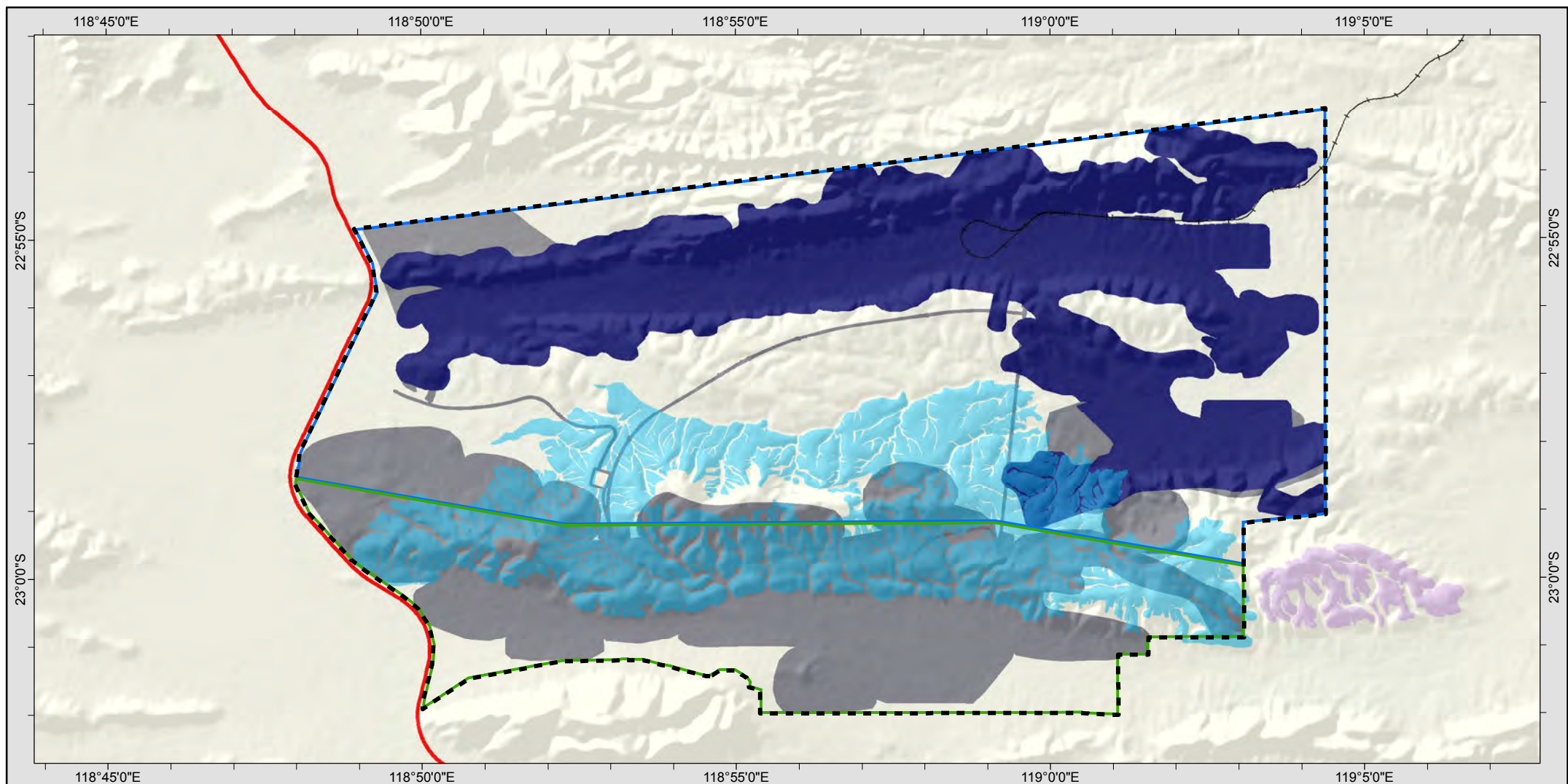
The primary habitat for *Antichiropus* 'DIP007' is considered to be the hill Slope/Crest habitats where the mallee eucalypt, *Corymbia hamersleyana*, occurs (Appendix 5). Patches of dense, sheltered leaf litter debris and deep loam soils occurring at the base of these mallee trees on Hill Slope/Crest habitats appears to provide a microhabitat refuge for the millipede species to aestivate within. Limited dispersal downslope from Hill Slope/Crest habitats where *Corymbia hamersleyana* (mallee form) occurs may be evident from pitfall trapped specimens in nearby gullies, minor drainage lines, and Mulga groves, but there are few records from sampling in these habitats (Biologic 2016c). Habitat for this species is limited to the south, west and north and targeted survey work in suitable habitat (Biologic 2016c) has not recorded the species beyond the inferred habitat extent. Habitat considered potentially suitable for *Antichiropus* 'DIP007' occurs within adjacent Hope Downs tenure (Figure 27); however there has been no survey work undertaken there to confirm its presence and there are currently no known records from this area.

Within the Proposed Mining Area C Development Envelope habitat considered suitable for *Antichiropus* 'DIP007' covers approximately 7,038 ha (Table 31 and Figure 27). Approximately 3,518 ha occur in the Indicative Additional Impact Assessment Area, and 355 ha occur in the Mining Area C EMP Revision 6 Impact Assessment Area.

Indirect impacts to the species arising from alteration to surface water and groundwater flows; hydrocarbon spills or contamination; introduced species; and increased vibrations, noise and dust are unlikely and considered to be minor (Biologic, 2016a); however, a reduction of the species habitat, and increased fragmentation of that which remains, may make it more susceptible to threatening processes such as fire.

Without mitigation, it is considered that the direct removal of the estimated extent of suitable habitat for *Antichiropus* 'DIP007' and associated habitat fragmentation will have a moderate to high impact on this species; however, it is considered likely that the species will persist within the 2,876 ha retained within the Mining Area C Development Envelope. This area of habitat may be increased if suitable microhabitats for the species (i.e. leaf litter and soils at the base of the mallee eucalypt, *Corymbia hamersleyana*), is successfully reinstated in rehabilitated areas and fragmentation is reduced.

***Antichiropus* 'DIP006'**. There is one confirmed record of the SRE species *Antichiropus* 'DIP006' (an adult male specimen), and a further two records of juvenile *Antichiropus* millipedes considered likely to belong to the same species, based on their occurrence in the same or similar continuous habitats. These records all occur along the Packsaddle Range within Major Gorge/Gully habitats (two in the Mining Area C EMP Revision 6 Impact Assessment Area, and one in areas approved under Revision 4 of the EMP), whereas *Antichiropus* 'DIP007' records occur along Southern Flank in Hill Slope/Crest habitats, and sampling data suggest it is unlikely that the two species of *Antichiropus* millipedes co-occur.



Spatial Data - Business Development
BHP BILLITON IRON ORE

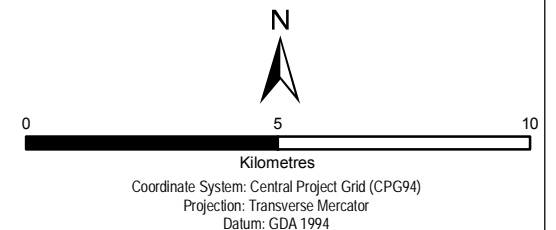
MINING AREA C - SOUTHERN FLANK

Inferred Extent of Habitat for *Antichiropus* 'DIP007'

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/043 REV B
Date: 30/03/2017	Checked: B. BARNETT	Figure: 27
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Inferred *Antichiropus* 'DIP007' Habitat
- Inferred *Antichiropus* 'DIP007' Habitat (Unverified)
- BHP Billiton Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Knowledge of the primary habitat for *Antichiropus* 'DIP006' is limited; all three records were collected from the top of south facing Major gorge/ gully habitats (within gullies and beneath south-facing ridges) along the Packsaddle Range. Based on what is known of the genus, patches of dense leaf litter and deep soils are expected to comprise the most likely refugial microhabitats, but it remains unknown whether suitable microhabitats for *Antichiropus* 'DIP006' may also occur under the mallee form of the eucalypt, *Corymbia hamersleyana* on the nearby Hill Slope/Crest habitats along Packsaddle Range, such as is the case for *Antichiropus* 'DIP007'. Biologic (2015a) regarded the level of impact for direct removal of habitat for *Antichiropus* 'DIP006' within the Mining Area C EMP Revision 6 Impact Assessment Area to be high.

***Chenistonia* 'MYG088'**

There are three confirmed records of the SRE species *Chenistonia* 'MYG088' recorded from south-facing ridges, gullies, and gorges within the Mining Area C EMP Revision 6 Impact Assessment Area. Regional context and habitat information regarding this species is limited, as the one male and two female specimens recorded from the Proposed Mining Area C Development Envelope are the only members of the genus known from the Pilbara region. The sites where the species was recorded appeared to be dominated by rocky substrates on slopes, therefore it is inferred that *Chenistonia* 'MYG088' builds burrows within small patches of soil among rocks in gullies and beneath ridges.

Two of the confirmed records of this species (one male and one female) were located within areas approved for mining under Revision 4 of the Mining Area C EMP, while the third record occurs within the Mining Area C EMP Revision 6 Impact Assessment Area. Biologic (2015a) regarded the level of impact for direct removal of south-facing Major Gorge/Gully systems (the assumed habitat for the species) along Packsaddle Range within the Mining Area C EMP Revision 6 Impact Assessment Area to be high. Habitat extents are presented in Table 28 and Section 11.2.3.2.

***Kwonkan* 'MYG339-DNA'**

There are 17 records for *Kwonkan* 'MYG339-DNA'. Thirteen records occur within the Indicative Additional Impact Assessment Area and there is one record from within the Mining Area C EMP Revision 6 Impact Assessment Area. There is currently one known record outside the Proposed Mining Area C Development Envelope, which occurs west of the highway on Coondewanna Flats. All records of this species were recorded within drainage habitats, and due to the extent and connectivity of suitable habitat to areas outside of the Proposed Mining Area C Development Envelope, this taxon is considered very likely to also occur outside of it (Biologic 2016c). Impacts to this species are therefore considered to be low.

Other SRE taxa

Austrostrophus 'DIP018', *Yilgarnia* 'MYG197' and Barychelidae indet. (juv.) have all been recorded outside of the Additional Development Envelope, the former two also having been recorded outside of the Proposed Mining Area C Development Envelope. Suitable habitat for these taxa is regarded as likely to occur beyond the Proposed Mining Area C Development Envelope (Biologic 2016c), and impacts to these species are therefore considered to be low.

Karaops banyjima has only been recorded from one adult female specimen collected from a south-facing ridge habitat within the Mining Area C EMP Revision 6 Impact Assessment Area, although other unidentified juvenile *Karaops* specimens are known to occur throughout the Proposed Mining Area C Development Envelope (Biologic 2016c). Suitable habitat for *Karaops* spiders is expected to occur throughout and beyond the Proposed Mining Area C Development Envelope within the cracks and crevices of rocky outcrops found in major and minor gorges/ gullies, ridges and breakaways, and

boulder piles. Although the only confirmed record of *Karaops banyjima* occurs within the Mining Area C EMP Revision 6 Impact Assessment Area, the wider local extent of suitable habitats within and beyond the Proposed Mining Area C Development Envelope suggests that the direct impacts on this species are likely to be no more than moderate.

Potentially occurring vertebrate fauna species

Three vertebrate fauna species have been identified as potentially occurring within the Proposed Mining Area C Development Envelope, but have not been recorded during any surveys undertaken to date.

The common greenshank (*Tringa nebularia*) is a migratory species (listed under Schedule 5 of the WC Act) which occurs predominantly in coastal regions with only a few low frequency records associated with significant inland wetlands (Johnstone and Storr, 1998). This species presence was only determined from a database search, and is considered to possibly be associated with the Fortescue Marsh. It is considered unlikely to occur within the Proposed Mining Area C Development Envelope due to the lack of available habitat, and therefore impacts to this species are considered to be negligible.

The northern brushtail possum (*Trichosurus vulpecula arnhemensis*) has recently (November 2015) been listed as a conservation significant species in Western Australia (under Schedule 3 of the WC Act). It has a very restricted distribution in the Pilbara region, with a majority of records occurring within the Chichester Range or northern Pilbara. The nearest record to the Proposed Mining Area C Development Envelope is from a scat recorded approximately 15 km to the east (Astron-Biologic, 2010). No records for this species were returned in database searches. It is largely known from gorges and major drainage lines with eucalypt woodland (Biologic 2011). A targeted survey for the northern brushtail possum was undertaken within the Additional Development Envelope in late 2015 (Biologic, 2016d). There was no evidence of this species presence within the area, and it is considered unlikely that there is a significant or continual population within the Proposed Mining Area C Development Envelope. Core habitat is provided by the Gorge/ Gully and Major Drainage Line Habitats, with foraging habitat comprising these areas and surrounding habitats. Dispersal corridors are likely to be via the Major Drainage Line habitat. Impacts to the northern brushtail possum from the Proposal are considered to be low.

In the Pilbara, the Priority 4 short-tailed mouse (*Leggadina lakedownensis*) is strongly associated with native grasslands on cracking clay substrate (Gibson and McKenzie, 2009). This habitat is not present within the Proposed Mining Area C Development Envelope. Given the lack of habitat and species records, despite considerable survey effort using suitable techniques (Table 25), the probability of this species being impacted by the Proposal is considered to be very low.

11.2.4.2 Indirect impacts

Habitat fragmentation. Habitat fragmentation can cause division and isolation of local populations of animals through disruption of movement patterns. Species most likely to experience such isolation would be those inhabiting continuous stretches of habitat and those with less mobility, such as SRE invertebrates, fossorial herpetofauna and small terrestrial mammals (e.g. western pebble-mound mouse, Pilbara barking gecko, and Pilbara flat-headed blindsnake). However, even highly mobile species, such as bats, may experience disruptions if they are unwilling to fly across large cleared areas while foraging.

Reduced gene flow between separated local groups of these animals could result in founder effects, genetic drift and increased inbreeding. A reduction in population size due to habitat fragmentation may result in loss of allelic richness and gene diversity and may exacerbate local reductions in species numbers (Lande, 1999). For a number of species, this can be remedied by successful rehabilitation;

however, there are currently no available data to show success of recolonisation by conservation significant species.

Areas where fragmentation is most likely to occur are in the eastern section of the Proposed Mining Area C Development Envelope where the Indicative Additional Impact Assessment Area and previous disturbance will create a barrier for fauna dispersal between the northern and eastern part of the Jirrapalpur Range.

The risk of indirect impacts to SRE and vertebrate fauna habitats from habitat fragmentation is regarded as low to moderate and is increased from that approved under MS 491.

Fire. Fire is a natural process in the Pilbara that commonly arises through lightning strike, but human activities have the potential to increase the frequency or intensity of fires. An increase in vehicle traffic, mining area machinery use and site-based personnel activity increases the risk of fire. This could impact terrestrial fauna directly through injury or death or indirectly through loss or alteration (due to increased frequency) of fauna habitats. The increased fire risk is considered to be minor for vertebrate fauna and a majority of SRE species and will be managed in accordance with existing management strategies such as retention of fire breaks and retention of emergency firefighting equipment and trained emergency response staff.

Regarding *Antichiropus* 'DIP007', it is unclear the extent to which this species is affected by fire; however, as fires occur frequently on hill crests in the Pilbara individuals of this species are likely to survive in deep soil in which they aestivate or within patches of unburnt habitat. A reduction in population range and/ or size will possibly increase the impact of fire; however, maintenance of current fire management strategies will likely alleviate this particularly if patches of unburnt habitat (refuges) exist in the short to medium term to allow the recolonisation of burnt areas after fire. If current fire management strategies can maintain a mosaic of burnt and unburnt patches throughout the remaining habitat, the risk is considered low.

Light, dust, noise and vibration. Artificial light could disrupt navigation, cause barriers to movement, impact foraging activity, cause abandoning of roosts and nests and expose nocturnal animals to nocturnal predators (Rich and Longcore, 2006). Additional impacts associated with artificial light are considered to be minor and will be managed according to existing management strategies.

Vegetation clearing, mining, hauling and vehicle movements will result in an increase in airborne particulate matter. Dust can indirectly affect fauna by altering the structure and composition of native vegetation. Continued implementation of existing dust suppression strategies will result in additional impacts to vertebrate fauna from dust being minor.

Responses to noise and vibration vary among species and individuals according to the characteristics of the noise and its duration, life history characteristics of the species, habitat type, season, activity at the time of exposure, sex and age of the individual, level of previous exposure and whether other stresses are present at the time of exposure (Busnel and Fletcher, 1978). Additional impacts to most vertebrate fauna species arising from noise and vibration are considered low. Impacts to the ghost bat are addressed in Section 11.2.4.1.2.

To date there have been no recorded impacts to terrestrial fauna as a result of light, dust, noise or vibration emissions from existing operations.

Alteration to hydrology. A detailed assessment of the impacts of surface water alteration was undertaken by MWH (2016) (see Section 11.4). Key components of this assessment in relation to impacts to terrestrial fauna are summarised below.

Alteration of surface water hydrology may impact upon terrestrial fauna by reducing the quality of fauna habitats by creating or removing surface water pools, which some species may be reliant upon as part of their life cycle; or by altering the quality of surface water runoff through increased sedimentation. None of the conservation significant species present in the Additional Development Envelope rely wholly on surface water, and therefore none are likely to be impacted by changes.

At a regional scale, the Additional Development Envelope comprises approximately 5% of the total Coondewanna subcatchment area, 3.5% of the total Weeli Wolli Creek subcatchment area and less than 1% of the total Fortescue Marsh catchment area. Impacts to these receptors are not considered significant at a regional scale (MWH, 2016) and therefore are unlikely to significantly impact terrestrial fauna that use these areas.

Impacts from groundwater drawdown are not considered to be significant. Impacts to the Weeli Wolli Spring PEC are discussed in Section 11.2.4.3.3.

Introduced species. The introduction and spread of feral animals and weeds through increased human activity and disturbance could result in changes to species composition, fire frequency and abundance of native communities.

While the impacts of weeds on fauna has generally been neglected (Adair, 1995), they can significantly alter the vegetation of a fauna habitat where infestations occur, resulting in significant declines in species richness or diversity of local fauna (Adair and Groves, 1998). Introduced flora (weed) species may be spread as a result of mobile mining equipment, ground disturbance, construction and ongoing activities of the Proposal.

Introduced fauna species may impact native fauna through a range of factors, including predation, competition for food and shelter, habitat destruction and the spread of diseases. Putrescible waste and artificial water points around camps, offices and crib rooms could attract both native and introduced animals. Apart from the physical threats (entangling in packing material, bottles and cans), animals could also be more vulnerable to introduced predators and road accidents.

Continued implementation of existing feral animal and weed control measures, that have demonstrated that introduction species have not significantly impacted local terrestrial fauna, will result in the additional impacts from introduced species on vertebrate fauna being minor.

Vehicle movements. Increased vehicle movements in the Proposed Mining Area C Development Envelope arising from the Proposal may result in an increase in vehicle collisions with wildlife. Roadkill on access tracks has the potential to decrease the abundance of vertebrate fauna species at a local level, including conservation significant fauna species, such as the Pilbara olive python. Road mortality is of particular concern for nocturnal species foraging or travelling near roads at night and species that tend to be active on roads (e.g. basking, foraging) during daytime. Roadkill also attracts scavengers, including birds of prey, which may themselves become victims of vehicle accidents.

As most of the vertebrate fauna potentially affected by vehicle movements are well represented throughout the surrounding area and the Pilbara region, the loss of individuals due to increased vehicle activity is expected to have a minimal impact on the abundance and conservation status of local fauna populations.

11.2.4.3 Regional cumulative impacts

11.2.4.3.1 Habitats

The cumulative loss of fauna habitats is difficult to quantify at a regional scale due to the lack of Pilbara wide fauna habitat mapping, a non-standardised approach to mapping between consultants and proponents, and the lack of availability of this information. Because of this, BHP Billiton Iron Ore used landform mapping to predict impacts at a regional scale from implementation of its strategic environmental assessment (BHP Billiton Iron Ore, 2016b). This assessment indicated the predicted impacts to all landforms under the full development scenario (including the Proposal) was less than 1.5%, with the majority being under 1% (BHP Billiton Iron Ore, 2016c). Additional land clearing associated with implementation of the Proposal is negligible at the landform scale.

11.2.4.3.2 Conservation significant species

For a majority of conservation significant species assessed in Section 11.2.4.1.2 the impacts are considered to be minor and therefore cumulative impacts are unlikely to be significant and are not discussed further in this document. Impacts to the Pilbara olive python, ghost bat, western pebble-mound mouse, Pilbara barking gecko and Pilbara flat-headed blindsnake were identified in BHP Billiton Iron Ore's Strategic Proposal to require considered management to meet the EPA's objective for terrestrial fauna (BHP Billiton Iron Ore, 2016c). With the exception of the ghost bat (which is discussed below), implementation of the Proposal is unlikely to alter the assessment for these species and they are not discussed further in this document. The potential impacts were determined to be low for the majority of short range endemic species located in the Proposed Mining Area C Development Envelope. Due to the inherent immobility of short range endemic species all those species that have potential impacts greater than low do not occur outside of the Proposed Mining Area C Development Envelope so assessment of regional cumulative impacts is not warranted.

An assessment of cumulative impacts to the ghost bat within the Hamersley Range has been undertaken by Biologic (2015b; see Appendix 5). Key findings from this assessment are summarised below.

It is estimated that the Proposed Mining Area C Development Envelope supports a population of approximately 50 individuals. The estimate for the Hamersley IBRA subregion is 300 to 400 individuals (Biologic, 2016b), which comprises one genetic population; although it is noted that the population could be almost 800 individuals (Spencer and Tedeschi, 2016). Without mitigation, the removal of up to 51 caves in the Proposed Mining Area C Development Envelope may result in a reduction of the Hamersley subregion population by between 12% and 17%. At a Pilbara regional scale, this would be a reduction of approximately 1%. At a species level, this reduction would be negligible.

It is noted that there are limitations for undertaking a cumulative impact assessment on ghost bats at a regional level as:

- the species has only recently been listed as a threatened species, and hence may not have been targeted during surveys for conservation significant species (e.g. ghost bats weren't considered in targeted fauna surveys for the Baby Hope Downs project located adjacent to the Proposed Mining Area C Development Envelope (Biota, 2015b));
- most surveys for bats in the Pilbara rely on detection using acoustic recorders or to a lesser extent harp trapping or mist netting. Both techniques rely on detection of individuals during the survey period, and based on current data these techniques are considered unlikely to record ghost bats utilising an area. Acoustic detectors are particularly unreliable for ghost bats;

- there are few, if any, surveys undertaken within the region that have similar survey intensity and methods to those undertaken on BHP Billiton Iron Ore tenure. Data that are available in the public domain, generally lack detailed information on roost locations; and
- surveys that have recorded ghost bats have generally been undertaken for mining companies, and therefore most records will correlate with mining tenure.

The above limitations are relevant for data obtained with respect to Ghost Bats from other sources, not BHP Billiton Iron Ore datasets. Therefore assessment of potential impacts, including cumulatively for the Proposed Mining Area C Development Envelope as discussed in Section 11.2.4.1.2 are considered robust.

There are two active mining operations (both operated by Rio Tinto or its joint ventures) within the vicinity of the Proposed Mining Area C Development Envelope; Hope Downs (located approximately 50 m east) and West Angelas (located approximately 15 km south-east). The ghost bat was first recorded at West Angelas in 1979 (Biologic, 2014b), and monitoring has been occurring since August 2000. It is still detected around West Angelas from the presence of fresh scat material in the monitoring caves and calls on SM2 detectors (Biologic, 2014b); however, how they are using the area is unknown.

The ghost bat has also been recorded at Hope Downs (Bullen, pers. com., 2016) and within the boundary of a new deposit (Biota, 2012), Baby Hope, which has been recently approved and shares a south-eastern boundary with the Proposed Mining Area C Development Envelope. Although the ghost bat was not a species targeted during the fauna survey for this project (Biota, 2015b), it was not picked up on SM2s deployed for Pilbara leaf-nosed bats (although see note above about the efficacy of this technique to record ghost bats).

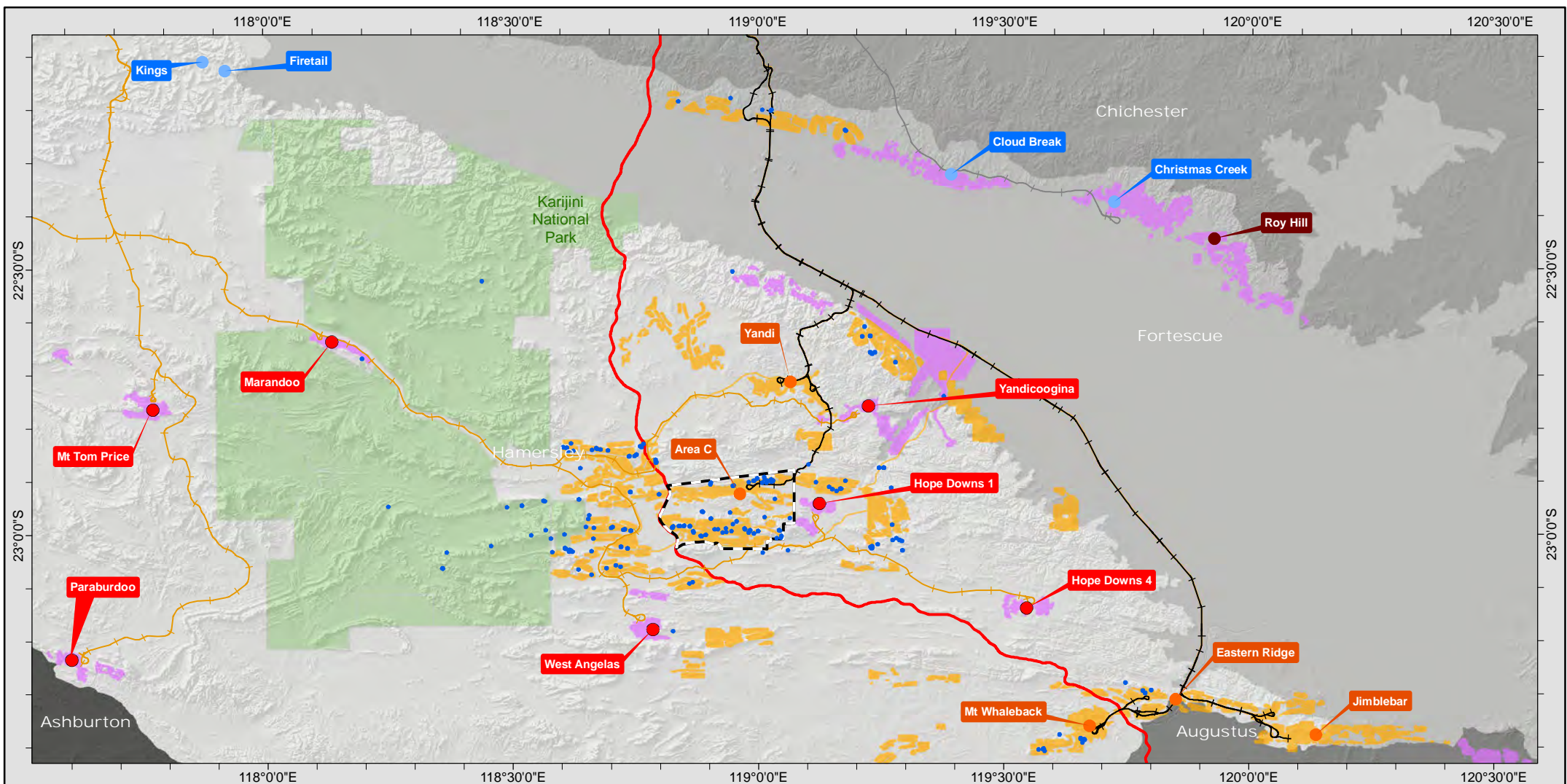
More broadly in the Hamersley Range, it is difficult to specifically assess the occurrence or continued presence of the ghost bat around mining operations due to the limitations described above. Figure 28 displays known roosts in the Pilbara (Biologic and Bat Call, 2014) and footprints (BHP Billiton Iron Ore and third-party) identified under the full development scenario during BHP Billiton Iron Ore's Strategic Proposal (BHP Billiton Iron Ore, 2016c). Almost all known caves occur in BHP Billiton Iron Ore tenure or in Karijini National Park and have been identified during surveys conducted for BHP Billiton Iron Ore (Figure 28). It is considered highly likely that caves occur outside these areas, and these will be identified during surveys for other mining companies' operations in the area.

Irrespective of this, it appears that a large proportion of known caves occur in or adjacent to areas planned for mining; and without mitigation, cumulative impacts to the species are likely. BHP Billiton Iron Ore will therefore continue to undertake research on the ghost bat to understand the ecology of the Hamersley population, current and future impacts from the Company's mining operations, and actions that can be implemented to reduce impacts to the species.

11.2.4.3.3 Weeli Wolli Spring PEC

The Weeli Wolli Spring PEC is recognised as a focal point for Pilbara birds (DEC, 2009), whilst Weeli Wolli Creek (including the area containing the springs) and Marillana Creek support an isolated population of the chocolate wattled bat (*Chalinolobus morio*), which occurs largely in southern Australia. This species is not listed as a conservation significant species and is listed as Least Concern on the International Union for the Conservation of Nature (IUCN) Red List.

A detailed assessment of impacts to the Weeli Wolli Spring PEC is provided in Section 11.4, and key aspects relating to terrestrial fauna are summarised here.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Cumulative Assessment of Impacts to Ghost Bat Roosts Located in the Eastern Hamersley IBRA Subregion

Scale @ A4: 1:1,150,000	Prepared: M. LYTTLE	Project No: A780/044 REV B
Date: 13/02/2017	Checked: B. BARNETT	Figure: 28
Revision: Rev B	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- BHPBIO Full Conceptual Development Scenario
- Reasonably Forseeable Third Party Mines
- Known Pilbara Ghost Bat Roosts
- BHP Billiton Rail
- FMG Rail
- Rio Tinto Rail
- Great Northern Highway
- Karijini National Park

IBRA V6.1 - Subregions

- Ashburton
- Augustus
- Chichester
- Fortescue
- Hamersley

Major Active Iron Ore Mines

- BHP Billiton
- Fortescue Metals Group
- Rio Tinto
- Roy Hill Holdings

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 30 60
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

The previously forecast residual drawdown at Weeli Wolli Spring presented in the EMP Revision 6 model was around 1.6 m at GWB0018 in 2054 (see Section 11.4). This drawdown occurs following closure of Hope Downs 1 and is attributed to the combined impacts of Hope Downs 1 and Mining Area C dewatering. Maximum drawdown at GWB0018 was modelled to be between 6 and 7 m in 2026 and coincides with the conclusion of Hope Downs dewatering.

Dewatering at Southern Flank is predicted to contribute between 0.2 and 0.5 m of drawdown at GWB0018 in 2054. This drawdown is modelled to occur following the end of aquifer replenishment and mitigation actions at Hope Downs 1. Cumulative groundwater drawdown from the Mining Area C Combined Operations and Rio Tinto Iron Ore's Hope Downs 1 dewatering activities shows a far greater change, whereby water levels are significantly reduced in the lower catchment of the spring area. This drawdown, which shows a range of 3 to 14 m, is associated predominantly with abstraction from Hope Downs 1. The timing and success of Hope Downs 1 closure plans to recover groundwater levels will also influence the water level and potential for a continued impact at Weeli Wolli Spring.

Following closure of Hope Downs 1 the combined cumulative impacts show a range of 1 – 2.5 m drawdown at 2054 with a median drawdown of 1.75 m which is close to the previously assessed change of 1.6 m. Residual drawdown in the upper end of this range (>2 m) has potential to reduce water availability to *Melaleuca argentea* and may result in the population contracting east toward the spring. This contraction of vegetation cover is considered unlikely to impact on the terrestrial faunal values of the PEC or the persistence of the chocolate wattled bat within the area.

11.2.5 Mitigation and residual impacts

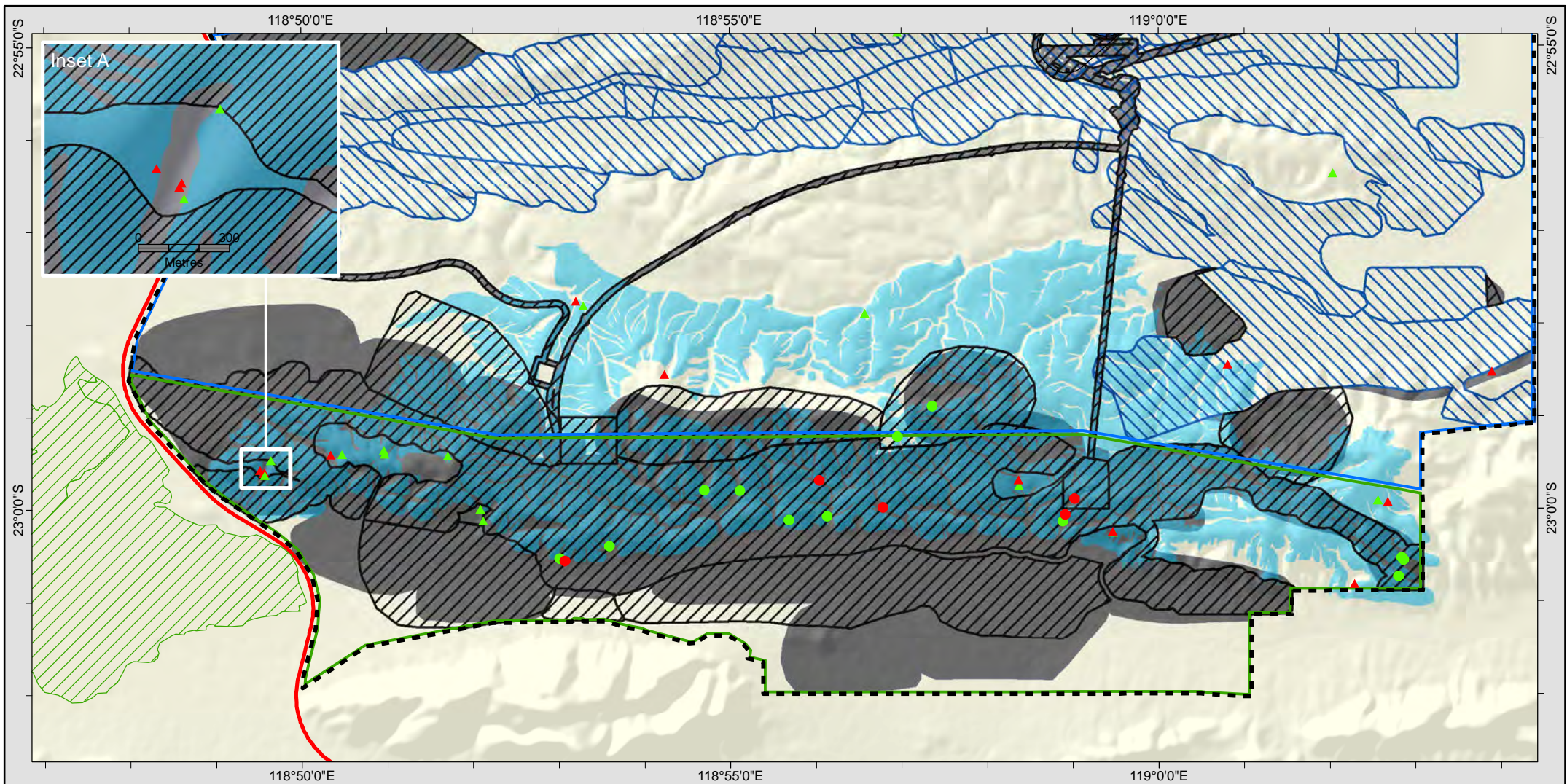
BHP Billiton Iron Ore have carried out a review of the Western Australian Government's 'Mitigation Process', which is detailed in Section 3 of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014). The four steps are:

- avoid;
- minimise;
- rehabilitate; and
- offset.

Following consideration of all data gathered during baseline surveys, additional targeted surveys and the outcomes of environmental impact assessments, BHP Billiton Iron Ore have revised its indicative Proposal designs to ensure that these designs address the first two steps of the Mitigation Process, i.e. the designs have 'avoided' or 'minimised' the impact on terrestrial fauna as far as reasonably practicable.

The original referral to the OEPA in May 2016 estimated clearing of 19,671.2 ha, of which 5,942 ha is located in the current Mining Area C EMP Revision 6 Impact Assessment Area but was in excess of the total disturbance area approved under MS 491. Following implementation of the steps outlined in the mitigation process (Government of Western Australia, 2014), native vegetation clearing may be reduced to 15,693 ha. Implementing this mitigation process at the environmental impact assessment stage have enabled BHP Billiton Iron Ore to present a potential 20% reduction in proposed clearing at the time of submission of this PER document.

Impacts to the ghost bat have been reduced following modification of the Indicative Additional Impact Assessment Area. Fifteen caves considered suitable for use by the ghost bat (seven classified as High value) have been removed from the Modified Indicative Additional Impact Assessment Area (Figure 29), with the number of caves classified as High reduced from 12 to five caves. The total number of caves impacts has been reduced from 51 to 36 caves.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Impacts to Ghost Bat Caves and *Antichiropus* 'DIP007' Habitat Following Mitigation

Scale @ A4: 1:110,000	Prepared: M. LYTTLE	Project No: A780/045 REV C
Date: 30/03/2017	Checked: B. BARNETT	Figure: 29
Revision: Rev C	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- Modified Indicative Additional Impact Assessment Area
- Inferred *Antichiropus* 'DIP007' Habitat
- Priority Ecological Community

Bat caves in proposed impact areas

- High
- Low

Bat caves outside proposed impact areas

- High
- Low
- BHP Billiton Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 3 6
Kilometers

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Three High value caves (all classified as day roosts, and one has shown evidence of use as a maternity roost) will be retained in the western end of the Additional Development Envelope within 1 km of the Coondewanna Flats PEC, which is considered likely to be used when foraging by the ghost bats. Impacts to foraging habitat are reduced by approximately 173 ha. The retained High value caves are located between 90 and 480 m from proposed impacts.

Depending on the mine sequencing, ghost bats may persist in the western and/or eastern end of the Additional Development Envelope during mining operations. It is considered unlikely that bats will persist in caves that are in close proximity to active mining areas and infrastructure due to localised levels of noise, dust and light; however as the life of the Proposal is 30 years, the disturbance to caves will unlikely occur concurrently and ghost bats should be able to move to areas within the Proposed Mining Area C Development Envelope away from active mining areas. The modifications will therefore likely reduce the number of individuals impacted during mining and increase the number of individuals that may return post mining when compared to predicted impacts prior to mitigation.

If the ghost bat is unable to persist within the Proposed Mining Area C Development Envelope during mining, the retention of caves in the west and east is likely to provide sufficient habitat for re-establishment of individuals and breeding upon closure, particularly once rehabilitated areas can support prey species. Nevertheless, a reduction in numbers would be expected as approximately half of the high value caves are planned to be removed and the gap between the east and west caves could reduce the ability of ghost bats to respond to natural or man-made events such as fire, drought and noise. An estimate of the actual reduction in numbers is difficult but given that half of the high value caves in the immediate area and surrounds are planned for removal, a reduction of individuals by approximately half could be reasonably expected.

Modification of the Indicative Additional Impact Assessment Area has reduced the amount of habitat for *Antechinus* 'DIP007' that will be cleared within the Proposed Mining Area C Development Envelope; however it is considered unlikely that this will reduce impacts to the species as retained habitat occurs in a number of isolated areas.

Application of the mitigation hierarchy has predicted that the residual impact to terrestrial fauna is not significant at a species and population level and that biological diversity and ecological integrity can be maintained.

Actions taken to mitigate impacts on terrestrial fauna are summarised in Table 35.

11.2.6 Proposed management approach

11.2.6.1 Internal management approach

The proposed management plan provisions (both management and outcome based) for terrestrial fauna are outlined in Table 36 and Table 37. These include management actions, monitoring and reporting details and trigger criteria and response actions where relevant. It is proposed that these management provisions will be formalised through regulation of an Environmental Management Plan via the Ministerial Statement and BHP Billiton Iron Ore's standard Pilbara-wide Health, Safety and Environment system. A draft of the management plan which includes the management provisions outlined in Table 36 and Table 37 and is located in Appendix 3.

Table 35: Actions taken to reduce impacts to terrestrial fauna

Action Taken	Step in the 'Mitigation Process'	Reduction in Impact
Modification of Indicative Additional Impact Assessment Area	Avoid	<p>A restriction of impacts to within the Modified Indicative Additional Impact Assessment Area will reduce impacts to the ghost bat as follows:</p> <ul style="list-style-type: none"> the number of caves retained in the Proposed Mining Area Development Envelope will be increased from 12 to 27 (11 high value), and the removal of foraging habitat has been reduced by 173 ha.
Modification of Indicative Additional Impact Assessment Area	Minimise	<p>A restriction of impacts to within the Modified Indicative Additional Impact Assessment Area will reduce clearing of Medium and High value vertebrate fauna habitats as follows:</p> <ul style="list-style-type: none"> Gorge/Gully – clearing reduced from 457 ha to 376 ha. Crest/Slope – clearing reduced from 5,916 ha to 5,860 ha. Major Drainage Line – clearing reduced from 20 ha to 0 ha. Mulga – clearing reduced from 849 ha to 432 ha. Sand Plain – clearing reduced from 394 ha to 115 ha. Drainage Area/Floodplain – clearing reduced from 668 ha to 625 ha. <p>A restriction of impacts to within the Modified Indicative Additional Impact Assessment Area will reduce clearing of High value SRE habitat zones as follows:</p> <ul style="list-style-type: none"> Major Gorge/ Gully systems – clearing reduced from 378 ha to 294 ha.
Buffers around ghost bat roosts outside impact assessment areas	Avoid/ minimise	BHP Billiton Iron Ore will commit to retaining a 150 m buffer around all ghost bats roosts that occur outside the Mining Area C Revision 6 EMP Impact Assessment Area and the Modified Indicative Additional Impact Assessment Area.
Research into ghost bat ecology in the Pilbara	Minimise/offset	<p>Continued study of the ecology of the ghost bat in the Pilbara will provide more information to assist in identifying key habitats (roosting and foraging) for the species that can be considered in mine plans.</p> <p>This work will be published so that it is available to third-party operators in the Pilbara and for future mining developments undertaken by BHP Billiton Iron Ore.</p>
Inclusion of preferred habitat species of <i>Antechinus</i> 'DIP007' into rehabilitation	Rehabilitation	Rehabilitation of disturbed areas using <i>Corymbia hamersleyana</i> .

11.2.6.2 Regulatory management

Impacts to terrestrial fauna will be managed as conditioned by the MS.

Page intentionally blank

Table 36: Draft Proposed Environmental Management Plan Provisions – Terrestrial Fauna – Ghost Bats

To meet the requirements of Condition(s) X of Ministerial Statement X

EPA Factor and objective:	Terrestrial fauna – to protect terrestrial fauna so that biological diversity and ecological integrity are maintained		
Key environmental values:	Ghost Bats – listed as Vulnerable under both the EPBC Act and WC Act (2015 and 2016, respectively).		
Objective:	Minimise impacts to ghost bats as far as practicable, as a result of BHP Billiton Iron Ore activities.		
Outcome:	Maintain long term viability of ghost bat population in the Development Envelope.		
Key impacts and risks:	Risk to biological diversity and/or ecological integrity of ghost bats, due to direct loss of habitat (roosts) or indirect impacts due to loss of foraging habitat.		
Management-based provisions			
Management Actions	Management Targets	Monitoring	Reporting
Condition clause number and text	Condition clause number and text	Condition clause number and text	Condition clause number and text
<p>Avoid</p> <ul style="list-style-type: none">Avoid direct impacts to ghost bat buffer areas, by implementing the PEHR process prior to land disturbance. <p>Minimise</p> <ul style="list-style-type: none">Minimise impacts to all known ghost bat cave locations and foraging habitat, by avoiding direct impacts where practicable and implementing the PEHR process prior to land disturbance. <p>Rehabilitation</p> <ul style="list-style-type: none">Progressive rehabilitation within foraging range will be undertaken using <i>Eucalyptus leucophloia</i> or other large tree species (<2 km from ghost bat caves).	No unauthorised disturbance beyond the Development Envelope or within the Ghost Bat cave buffer zones.	<p>Quarterly land disturbance reconciliation (hectares and spatial footprint).</p> <p>Rehabilitation monitoring undertaken in accordance with the Mine Closure Plan and WAIO Rehabilitation monitoring standard.</p>	<p>Notification of management target or objective potential non-compliance will be provided to the OEPA within 7 days of that potential non-compliance being known. A report including any corrective actions identified will be provided to the OEPA via email, once an investigation into the potential non-compliance has been completed.</p> <p>An annual compliance assessment report will be submitted as part of the Annual Environment Report, which will be submitted to OEPA by 1 October each year. This will include key outcomes from the ghost bat research.</p>
Outcomes-based provisions			
Environment criteria: <ul style="list-style-type: none">Trigger criteriaThreshold criteria	Response actions: <ul style="list-style-type: none">Trigger level actionsThreshold level actions	Monitoring	Reporting
Condition clause number and text	Condition clause number and text	Condition clause number and text	Condition clause number and text
<p>Trigger criteria – no sign of ghost bat use in High importance caves or artificial roosts (if applicable) within the Proposed Mining Area C Development Envelope, within 5 years of cessation of operations.</p> <p>Threshold criteria – no sign of ghost bat use in High importance caves or artificial roosts (if applicable) within the Proposed Mining Area C Development Envelope, within 10 years of cessation of operations.</p>	<p>Response actions to trigger/threshold criteria exceedance may include, but are not limited to:</p> <ul style="list-style-type: none">Construction/relocation (as appropriate) of, or alteration to, artificial ghost bat habitat;Reintroduction of ghost bats from captive breeding facilities or other natural colonies within the Pilbara, as appropriate; and/orRemediate foraging habitat to ensure that it contains feeding trees and suitable habitat for prey species within 2 km of cave locations.	<p>Five yearly monitoring of High value ghost bat roosts in Proposed Mining Area C Development Envelope following cessation of operations.</p> <p>Methods will be informed by the results from the ongoing research programme and may include scat counts and genetic/ hormone analysis.</p>	<p>Notification of threshold criteria or outcome potential non-compliance will be provided to the OEPA within 7 days of that potential non-compliance being known. A report including any corrective actions identified will be provided to the OEPA via email, once an investigation into the potential non-compliance has been completed.</p> <p>An annual compliance assessment report will be submitted as part of the Annual Environment Report, which will be submitted to OEPA by 1 October each year.</p>

Table 37: Draft Proposed Environmental Management Plan Provisions – Terrestrial Fauna – Short Range Endemic Species

To meet the requirements of Condition(s) X of Ministerial Statement X

EPA Factor and objective:	Terrestrial fauna – to protect terrestrial fauna so that biological diversity and ecological integrity are maintained		
Key environmental values:	Habitat for Short Range Endemic species <i>Antichiropus</i> ‘DIP007’, <i>Antichiropus</i> ‘DIP006’ and <i>Chenistonia</i> ‘MYG088’		
Objective:	Minimise impacts to <i>Antichiropus</i> ‘DIP007’, <i>Antichiropus</i> ‘DIP006’ and <i>Chenistonia</i> ‘MYG088’ habitats as far as practicable.		
Key impacts and risks:	Risk to biological diversity and/or ecological integrity of <i>Antichiropus</i> ‘DIP007’, <i>Antichiropus</i> ‘DIP006’ and <i>Chenistonia</i> ‘MYG088’ due to direct loss of habitat.		
Management-based provisions			
Management Actions	Management Targets	Monitoring	Reporting
<i>Condition clause number and text</i>	<i>Condition clause number and text</i>	<i>Condition clause number and text</i>	<i>Condition clause number and text</i>
<div>Minimise<ul style="list-style-type: none">Minimise impacts to <i>Antichiropus</i> ‘DIP007’ habitat (<i>Corymbia hamersleyana</i>), by avoiding direct impacts where practicable and implementing the PEAHR process prior to land disturbance.Minimise impacts to <i>Antichiropus</i> ‘DIP006’ and <i>Chenistonia</i> ‘MYG088’ inferred habitat, by avoiding direct impacts where practicable and implementing the PEAHR process prior to land disturbance.</div> <div>Rehabilitation<ul style="list-style-type: none">Progressive rehabilitation as described in the Mine Closure Plan will be implemented using local top soil, and include the use of <i>Corymbia hamersleyana</i> material in habitat suitable to support <i>Antichiropus</i> ‘DIP007’.</div>	<div>No unauthorised disturbance beyond the Development Envelope</div>	<div>Quarterly land disturbance reconciliation (hectares and spatial footprint).</div> <div>Rehabilitation monitoring undertaken in accordance with the Mine Closure Plan and WAIO Rehabilitation monitoring standard.</div>	<div>Notification of management target or objective non-compliance will be provided to the OEPA and DPAW within 7 days of that potential non-compliance being known. A report including any corrective actions identified will be provided to the OEPA and DPAW via email, once an investigation into the non-compliance has been completed.</div> <div>An annual compliance assessment report will be submitted as part of the Annual Environment Report, which will be submitted to OEPA by 1 October each year.</div>

11.2.7 Summary and predicted outcome

Table 38 below summarises impacts to terrestrial fauna previously assessed under MS 491, additional changes that may occur following implementation of the Proposal, and the cumulative extent in the Proposed Mining Area C Development Envelope.

In consideration of the outcomes of the environmental impact assessment and proposed management measures, BHP Billiton Iron Ore consider that terrestrial fauna representation, diversity, viability and ecological function at the species, population and community level can be maintained. Nevertheless, residual impacts to terrestrial fauna are considered possible, but are not significant. As a precaution, offsets are applicable for this factor (see Section 11.8).

Table 38: Summary of key terrestrial fauna factors for the Proposal

Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area	Cumulative extent in Proposed Mining Area C Development Envelope (without Mitigation)	Cumulative extent in Proposed Mining Area C Development Envelope (with Mitigation)
<p>Nine conservation significant species recorded in the Additional Development Envelope:</p> <ul style="list-style-type: none"> Northern quoll; Pilbara leaf-nosed bat; Pilbara olive python; Ghost bat; Grey falcon; Rainbow bee-eater; Pilbara flat-headed blindsnake; Pilbara barking gecko; Western pebble-mound mouse. <p>The northern quoll and rainbow bee-eater have not been recorded in the Indicative Additional Impact Assessment Area.</p>	<p>Eleven conservation significant vertebrate fauna species recorded within Current Approved Development Envelope (two species identified in the Revision 6 EMP have subsequently been delisted). These species are:</p> <ul style="list-style-type: none"> Northern quoll; Pilbara leaf-nosed bat; Pilbara olive python; Ghost bat; Grey falcon; Rainbow bee-eater; Peregrine falcon; Fork-tailed swift; Pilbara flat-headed blindsnake; Pilbara barking gecko; Western pebble-mound mouse. 	<p>Eleven conservation significant vertebrate fauna species recorded in Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> Northern quoll; Pilbara leaf-nosed bat; Pilbara olive python; Ghost bat; Grey falcon; Rainbow bee-eater; Peregrine falcon; Fork-tailed swift; Pilbara flat-headed blindsnake; Pilbara barking gecko; Western pebble-mound mouse. 	<p>Eleven conservation significant vertebrate fauna species recorded in Proposed Mining Area C Development Envelope:</p> <ul style="list-style-type: none"> Northern quoll; Pilbara leaf-nosed bat; Pilbara olive python; Ghost bat; Grey falcon; Rainbow bee-eater; Peregrine falcon; Fork-tailed swift; Pilbara flat-headed blindsnake; Pilbara barking gecko; Western pebble-mound mouse.
<p>Thirty-three caves in Indicative Additional Impact Assessment Area:</p> <ul style="list-style-type: none"> 12 High value 21 Low value <p>Removal of 8,579 ha of foraging habitat for ghost bats.</p>	<p>Removal of up to 12 ghost bat roosts, plus a further six caves approved under previous EMP revisions. Removal of 6,418 ha of foraging habitat for ghost bats.</p>	<p>Fifty-one caves in cumulative impact areas:</p> <ul style="list-style-type: none"> 20 High value (7 containing pregnant females) 31 Low value <p>Removal of 14,997 ha of foraging habitat for ghost bats.</p>	<p>Up to 36 caves in modified cumulative impact areas:</p> <ul style="list-style-type: none"> 14 High value 22 Low value <p>Removal of 14,824 ha of foraging habitat for ghost bats.</p>

Indicative Additional Impact Assessment Area	EMP Revision 6 Impact Assessment Area	Cumulative extent in Proposed Mining Area C Development Envelope (without Mitigation)	Cumulative extent in Proposed Mining Area C Development Envelope (with Mitigation)
No SRE taxa restricted to the Indicative Additional Impact Assessment Area. One taxon, <i>Antichiropus</i> 'DIP007' has a distribution that is likely restricted to the Proposed Mining Area C Development Envelope. Approximately 55% of its habitat occurs within the Indicative Additional Impact Assessment Area.	Three SRE invertebrates only recorded within the Mining Area C EMP Revision 6 Impact Assessment Area : <ul style="list-style-type: none"> <i>Antichiropus</i> 'DIP006' <i>Chenistonia</i> 'MYG088' <i>Karaops banyjima</i> Habitat for all three species potentially occurs outside this area.	Four confirmed SRE species currently only known from the Proposed Mining Area C Development Envelope. Habitat for all species potentially occurs outside of it, but fragmentation of habitats may occur.	Four confirmed SRE species currently only known from the Proposed Mining Area C Development Envelope. Habitat for all species potentially occurs outside of it, but fragmentation of habitats may occur.

11.3 Subterranean fauna

11.3.1 EPA objective

The EPA applies the following objective, according to the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect subterranean fauna:

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

11.3.2 Relevant legislation, guidelines and policies

The discussion of the existing environment, impacts and management of subterranean fauna in the Proposed Mining Area C Development Envelope and Groundwater Assessment Area has been compiled in consideration of relevant state legislation and EPA policies and guidance. Table 7 details the relevant EPA documents as identified in the *Mining Area C – Environmental Scoping Document* (OEPA, 2016) and their relevance to this Proposal.

11.3.3 Existing environment

11.3.3.1 Survey effort

Baseline and targeted troglofauna and stygofauna surveys were undertaken in the Proposed Mining Area C Development Envelope and Coondewanna and Weeli Wolli Creek subcatchments between 2007 and 2016. To date, almost 2,750 samples¹² targeting troglofauna have been collected in the Proposed Mining Area C Development Envelope (Table 39), and almost 1,200 samples targeting stygofauna have been collected within the catchments (Table 40). Locations of drill holes sampled are shown in Figure 30 and Figure 31. Details of sampling dates for all troglofauna surveys undertaken in the Proposed Mining Area C Development Envelope are provided in Table 41. Details of sampling dates for all stygofauna surveys undertaken in the Groundwater Assessment Area and surrounds are provided in Table 42 and Table 43.

¹² A sample is considered to comprise a trap and a scrape. The use of only one of these techniques is considered a half sample.

All surveys have been undertaken in accordance with the EPA's *Guidance Statement 54: Guidance for the assessment of environmental factors: consideration of subterranean fauna in groundwater and caves during environmental impact assessment in Western Australia* (EPA, 2003), *Guidance Statement 54a: Sampling methods and survey considerations for subterranean fauna in Western Australia (Technical Appendix to Guidance Statement No. 54)* (EPA, 2007) and post-2013, have also been undertaken in accordance with the EPA's *EAG 12: Consideration of subterranean fauna in environmental impact assessment in WA* (EPA, 2013d).

All areas within the Proposed Mining Area C Development Envelope that have been surveyed for environmental approvals have had a minimum of two seasons of survey and where possible have used a stratified approach to ensure that all likely fauna habitats present have been sampled and there is adequate geographic coverage. It is noted that collection of samples for troglofauna and stygofauna samples are largely limited to BHP Billiton Iron Ore tenure in areas where drill holes are available, and for stygofauna, where these intersect the water table.

Overall, the extent of subterranean fauna sampling and habitat assessments within proposed impact areas is considered sufficient for the purposes of impact assessment, and to meet the requirements of current EPA guidance.

Table 39: Summary of troglofauna samples collected in the Proposed Mining Area C Development Envelope and surrounds (Bennelongia, 2016a).

Area	Scrape	Trap	Total*
Approved Mining Area C (Northern Flank) Development Envelope'	1,799	1,661	3,460
Additional Development Envelope	1,221	812	2,033
Total	3,020	2,473	5,493

* The number of samples collected was calculated as samples = (no. scrape + no S or D trap)/2

Table 40: Summary of stygofauna samples collected in the Groundwater Assessment Area and surrounding catchments (Bennelongia, 2016b)

Area	No. Samples*
Groundwater Assessment Area	224
Mining Area C EMP Revision 6 Groundwater Assessment Area	742
Weeli Wolli and Coondewanna sub-catchments outside the Groundwater Assessment Area and Mining Area C EMP Revision 6 Groundwater Assessment Area (Reference Area)	222
Total	1,170

* One sample = 6 net hauls for stygofauna

Table 41: Summary of timing of all troglofauna surveys undertaken within the Proposed Mining Area C Development Envelope

STUDY AREA	ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
Baseline Surveys						
A Deposit	5 December 2007 - 4 February 2008	11 March - 14 May 2008				
B Deposit	17 March - 14 May 2008	25 July - 22 September 2008	29 March - 5 June 2011			
C Deposit	17 January - 12 March 2008					
D Deposit	11 January - 13 March 2008	12 March - 14 May 2008				
E Deposit	9 January - 14 March 2008	13 March - 14 May 2008				
F Deposit	4 December 2007 - 5 February 2008	5 February - 9 April 2008				
R Deposit	1 April - 3 June 2008	5 August - 2 October 2008				
P1 Deposit	12 December 2007 - 11 February 2008	4 February - 2 April 2008	25 February - 12 June 2009	6 June - 6 August 2012	6 August 2012	
P2 Deposit	12 December 2007 - 11 February 2008	26 February - 6 June 2009	11 April - 24 June 2010	23 June - 24 June 2010		
P3 Deposit	13 December 2007 - 11 February 2008	4 February - 13 April 2008	26 February - 6 June 2009	7 April - 24 June 2009	24 June - 28 June 2009	
P4 Deposit	17 March - 18 June 2008	13 October - 26 November 2008	8 April - 28 June 2009	26 June - 28 June 2009		
P5 Deposit	9 April - 19 June 2008	13 October - 27 November 2008				
P6 Deposit	18 April - 21 June 2008	8 October - 11 December 2008	10 December - 11 December 2008			
Southern Flank	18 March 2010 - 10 August 2010	17 April - 9 August 2012				
Targeted Surveys						
A Deposit				6 March 2015 – 6 May 2015		
B Deposit				6 March 2015 – 6 May 2015	15-24 Feb 2016	27 April- 03 May 2016
F Deposit				6 March 2015 – 5 May 2015		
R Deposit				5 March 2015 – 6 May 2015	15-24 Feb 2016	27 April- 03 May 2016

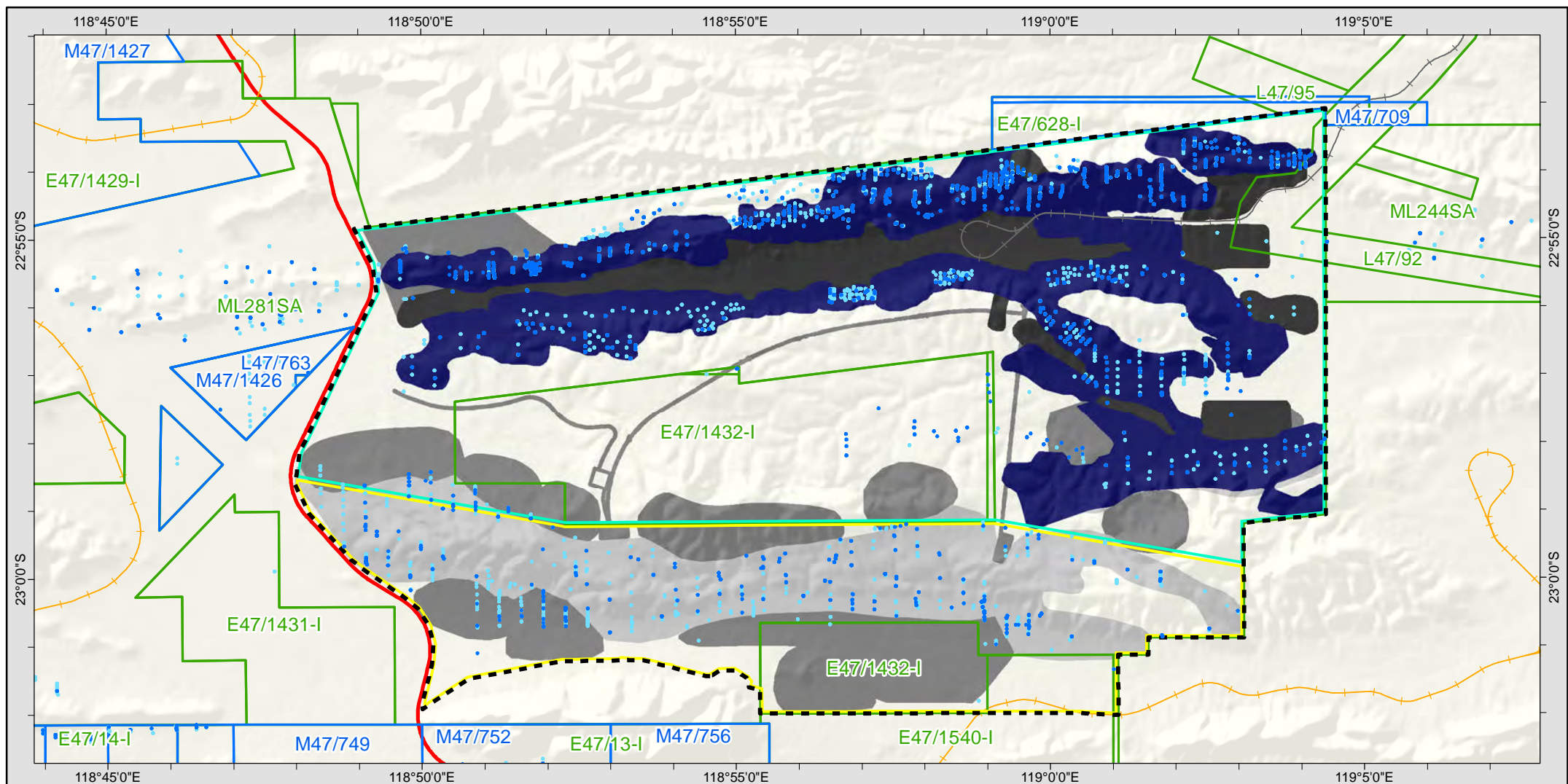
STUDY AREA	ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
P1 Packsaddle	29 March - 2 April 2008	30 July 2009	6 November 2013 - 9 January 2014; 17 February 2014 - April 2014			
P2 Packsaddle		30 July 2009	8 November 2013 - 9 January 2014; 18 February 2014 - April 2014	4 March 2015 – 5 May 2015		
P3 Packsaddle		30 July 2009	9 November 2013 - 9 January 2014; 19 February 2014 - April 2014			
P4 Packsaddle	13 April- 23 April 2008	22 July 2008		5 March 2015 – 5 May 2015		
P5 Packsaddle	22 April- 23 April 2008	21 July 2008		5 March 2015 – 5 May 2015		
P6 Packsaddle	20 April- 24 April 2008					
Southern Flank				5 March 2015 – 7 May 2015	15-24 Feb 2016	27 April- 03 May 2016

Table 42: Summary of timing of all stygofauna surveys undertaken within the Mining Area C EMP Revision 6 Groundwater Assessment Area and Groundwater Assessment Area.

STUDY AREA	ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
A Deposit	7 - 9 December 2008	5 September 2011	6 March 2015			
B Deposit	5-7 May 2008	5 March 2010	24 May 2010			
D Deposit	5-7 May 2008					
F Deposit	6 December 2007	5-7 May 2008				
R Deposit	10 April 2008	25 May 2010				
P1 Deposit	29 May 2008					
P3 Deposit	13 April 2008	25-26 June 2010				
P6 Deposit	21 April 2008					
Southern Flank	21 April 2008	16 Feb – 28 March 2010	04 May – 26 June 2010	07 March – 11 July 2012	17 Feb – 29 April 2016	24-25 August 2016

Table 43: Summary of timing of all stygofauna surveys undertaken within Reference Areas.

STUDY AREA	JINIDI	MINING AREA C	MUDLARK	TANDANYA
Round 1	6 July 2008 (Orebody 16)			
Round 2	12 July 2008 (Orebody 41)		15 - 19 July 2008 (Alligator Jaws, South East Corner)	
Round 3	10 - 17 December 2008 (Orebody 16 & 41)			
Round 4	18 February 2009 (Orebody 15)		13 - 14 February 2009 (Alligator Jaws)	
Round 5		11 - 13 March 2009 (Camp Hill, Mt Wildflower, Wanna Manna)		
Round 6		10 - 12 July 2009 (Camp Hill, Mt Wildflower, Wanna Manna)		
Round 7	23 June - 2 July 2009 (Orebody 15, 16 & 41)			
Round 8		5 May 2010 (Camp Hill)		
Round 9	13 July 2011 (Upper Weeli Wolli)			
Round 10	15 - 18 August 2011 (Rhodes Ridge, Upper Weeli Wolli)			
Round 11	2 - 3 November 2011 (Rhodes Ridge, Upper Weeli Wolli)			
Round 12		25 September 2014 (Packsaddle West)		
Round 13		26 February 2015 (Packsaddle West)		
Round 14	20 March 2015 (Upper Weeli Wolli)	20 March 2015 (Packsaddle East)		
Round 15		27 June 2016 (Packsaddle West)		28 - 30 June 2016 (Floodplain, Mick Bore, Noose, Sweetview, Fork North)
Round 16			22 - 25 August 2016 (Alligator Jaws, Caymen, Parallel Ridge, South East Corner)	



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

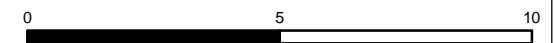
Location of Troglifauna Samples Collected in the
Proposed Mining Area C Development Envelope
and surrounds

Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/046 REV D
Date: 30/03/2017	Checked: B. BARNETT	Figure: 30
Revision: Rev D	Reviewed: S. WILLIAMSON	

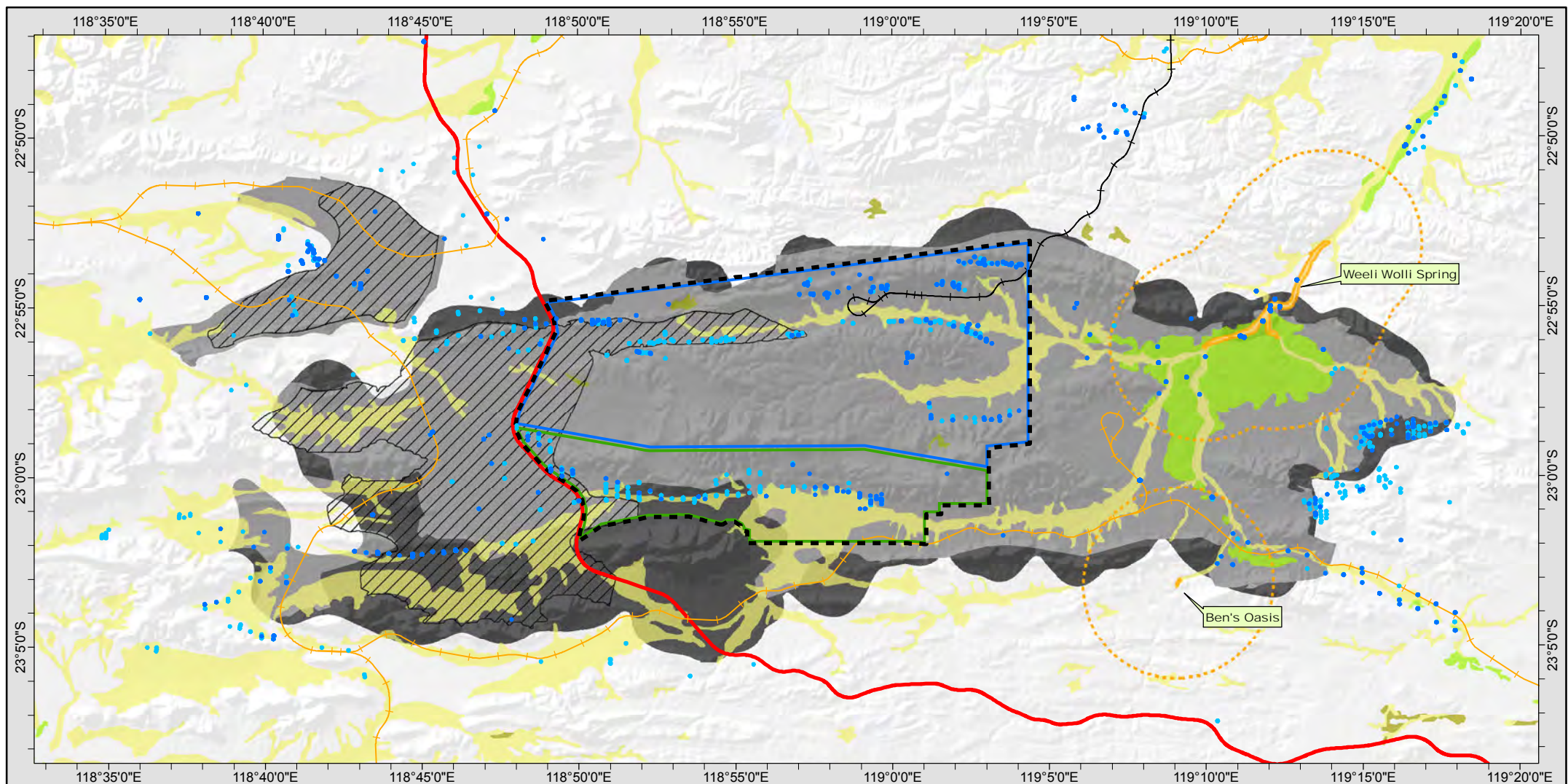
- Positive for Troglifauna
- Negative for Troglifauna
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area (Other)
- Mining Area C EMP Rev 6 Impact Assessment Area (Pit)

- Indicative Additional Impact Assessment Area (Other)
- Indicative Additional Impact Assessment Area (Pit)
- BHP Billiton Tenement - Application
- BHP Billiton Tenement - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Highways

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



Spatial Data - Business Development
BHP BILLITON IRON ORE

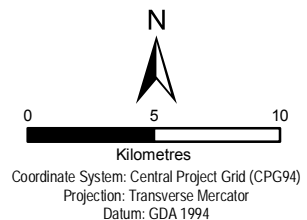
MINING AREA C - SOUTHERN FLANK Location of Stygofauna Samples Collected in the Coondewanna and Weeli Wolli sub-catchments

Scale @ A4: 1:300,000	Prepared: M. LYTTLE	Project No: A780/047 REVC
Date: 30/03/2017	Checked: B. BARNETT	Figure: 31
Revision: Rev C	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Groundwater Assessment
- Mining Area C EMP Rev 6 Groundwater Assessment Area
- Positive for Stygofauna
- Negative for Stygofauna
- Area of Mounding ≥ 2 metres
- Weeli Wolli Priority Ecological Community - Boundary
- Weeli Wolli Priority Ecological Community - Buffer

- Alluvium - unconsolidated silt, sand and gravel
- Colluvium - unconsolidated quartz and rock fragments in soil
- Calcrete - sheet carbonate usually formed in major drainage lines
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



11.3.3.2 Troglifauna habitats

The geology of the Proposed Mining Area C Development Envelope comprises four habitat types relevant to troglifauna. These are 'hardcap zone', detritals, mineralised rock and BIF host rock. The hardcap zone, formed from continued weathering of the surface of the deposits and surrounding landscape, constitutes a semi-continuous carapace across the ranges. The formation of hardcap is not limited to a particular rock type and has been observed on unconsolidated sediments, BIF and ore (Crowe, 2012). This zone can be extremely variable in texture and is known to contain frequent voids and cavities. Cavities on a scale of metres are occasionally observed during drilling and mining. Hardcap formation is usually strongest near the surface and often grades into semi-hardcap and then unaltered rock with depth. This stratum is considered to provide important habitat for troglifauna.

The detritals can be divided into Recent Quaternary detritals and three classes of Tertiary detritals. Quaternary detritals usually comprise a mix of ore and shale in a silty matrix and are regarded by BHP Billiton Iron Ore (2016h) as suitable for troglifauna, although there is little sampling evidence that this is the case. The deepest Tertiary detrital class consists of haematite conglomerate or silt and clay, with limited capacity to support troglifauna. The middle Tertiary detrital class consists of vuggy breccia, sand and calcrete that are suitable for troglifauna, together with lenses of clay that are not. The upper Tertiary detrital class consists of gravelly siltstone and siltstone that are likely to provide troglifauna habitat.

The mineralised rock that is BIF contains voids and cavities as a result of weathering; it usually provides important troglifauna habitat. This mineralised BIF is a target for mining when iron ore levels within it are high, although it may also provide suitable habitat for troglifauna when ore concentrations are below commercial grade.

The BIF host rock, precursor to iron ore, consists of finely bedded chert, iron oxides and silicates. The texture of this rock type is fine-grained and dense, with few to no voids and essentially no intergranular pore spaces. Interbedded within the iron formation are shales and cherts that can form bands up to 40 m thick. The shales and cherts are similarly non-porous. Thus, it is unusual for BIF host rock to contain significant troglifauna habitat.

11.3.3.3 Stygofauna habitats

The Proposed Mining Area C Development Envelope occurs in the subcatchment of Weeli Wolli Creek, which is a tributary of the Fortescue River (for more detail refer to Sections 5.6 and 11.4). The Weeli Wolli Creek subcatchment is divided into three subcatchments: 1) Upper Weeli Wolli Creek subcatchment (1,877 km²); 2) Marillana Creek subcatchment (2,050 km²); and 3) Lower Weeli Wolli Creek subcatchment (210 km²) into which the first two flow. The Weeli Wolli Creek subcatchment is flanked by the Coondewanna subcatchment (862 km²), which is part of the Ashburton River catchment. Groundwater sometimes flows across the catchment divide between the Upper Weeli Wolli Creek subcatchment and the Coondewanna subcatchment (URS, 2014). Suitable habitat for stygofauna occurs within both the Upper Weeli Wolli and Coondewanna subcatchments; highest potential habitat occurs where depth to groundwater is less than 40 m within geological units that contain vugs or cavities (e.g. calcrete).

Upper Weeli Wolli subcatchment. The local hydrogeology in the Upper Weeli Wolli Creek subcatchment has been described in RPS (2014), and the information is summarised here. Weeli Wolli Creek and its tributaries flow along valleys confined by outcrops of the Marra Mamba Iron and Brockman Iron formations. Preferential weathering of the Wittenoom Formation between these outcrops has resulted in a low-lying area that has since been filled with Tertiary detrital deposits largely composed of alluvium sourced from the surrounding outcrops and chemically precipitated calcrete. Tertiary

sediments are up to 75 m thick upstream of Weeli Wolli Spring and approximately 20 m thick at the spring.

In the bedrock under Weeli Wolli Spring and the calcrete aquifer immediately upstream of it there are the Wittenoom Formation; Mount Sylvia Formation (low permeability); Mount McRae Shale (low permeability); and Brockman Iron Formation (unmineralised and of low permeability).

The Brockman Iron Formation and Mount McRae Shale are particularly resistant to erosion and form a prominent ridge (the Wildflower Range) along the northern extent of the Upper Weeli Wolli subcatchment. Weeli Wolli Creek flows through this ridge (across the regional geological strike) in a narrow fault-controlled valley. Under the creek, the erosion-resistant Brockman Iron and Mount McRae formations rise to shallow subcrops (i.e. they form a rock bar).

The Tertiary sediments contain an extensive calcrete deposit that has a saturated thickness of around 5 m and is vuggy and permeable. Based on the morphology of Australian groundwater calcrete and because the base of the calcrete sits just below the water table, Weeli Wolli Spring is likely to be an area of active calcrete formation. The calcrete is incised by the creek channel, which is in-filled with Quaternary alluvium. The calcrete is underlain by poorly sorted alluvium of clay, sands and gravels that overlies the bedrock.

Coondewanna subcatchment. The local hydrogeology in the Coondewanna subcatchment has been described in URS (2014) and is summarised here. The Coondewanna subcatchment operates as an internally draining system. However, it is hydraulically connected to the regional aquifer systems and overflows to the east during extreme flood events. According to site-specific data and modelling, except during flood events the local aquifers in and around the Coondewanna subcatchment mostly act as discrete or semi-discrete compartments controlled by structure and stratigraphy.

The key hydrogeological units present in the Coondewanna subcatchment comprise: Tertiary detrital valley-fill; calcrete/silcrete; and dolomite.

Overall, the structure of aquifers in the Coondewanna subcatchment is highly variable and not well documented. Weathered, vuggy and karstic formations associated with hydrated zones, dolomite in the Wittenoom Formation, and alluvial successions may act as locally significant aquifers. Calcrete/silcrete horizons show only small cavities and vugs, which may mean the upper detrital zone contains perched aquifers with which calcrete is associated.

The northeast to southwest striking dolerite dykes in the southeast of the catchment form hydraulic barriers and impede groundwater flow, causing local mounding and shallow water tables upstream of the dykes. The water table is around 18 to 23 mbgl in most of the subcatchment. There is a drop of around 30 m in groundwater levels (to 50+ mbgl) in the southeast.

11.3.3.4 Troglofauna community

A total of 3,585 specimens of troglofauna have been collected in the Proposed Mining Area C Development Envelope (Appendix 6). These specimens represent at least 126 species from 19 orders (Table 44). Eighty-eight of these species have only been recorded from within the Proposed Mining Area C Development Envelope to date, although a number of these have a wide distribution within it (Table 44). Insects were numerically dominant, and schizomids were also relatively common. Most species, however, occurred at very low abundance, and 49 species were represented by only one specimen (singleton).

Table 44: Troglotauna species recorded in the Proposed Mining Area C Development Envelope

Shading indicates species only known from pit areas within the Indicative Additional Impact Assessment Area (IAIAA; orange), Mining Area C EMP Revision 6 Impact Assessment Area (R6; green), or both (blue). Note: MACR = areas outside indicative impact assessment areas within the Proposed Mining Area C Development Envelope (PMACDE).

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
Chelicerata					
Arachnida					
Pseudoscorpiones					
<i>Lagynochthonius</i> 'PSE039'	21	7	9	Yes	PMACDE (Deposits B, F, P6, Southern Flank), Jinidi
<i>Lagynochthonius</i> 'PSE045'		3	1	No	PMACDE (Deposit P4)
<i>Lagynochthonius</i> 'PSE046'		8	1	No	PMACDE (Deposits P1, P2, P4)
<i>Lagynochthonius</i> sp. B19			1	No	PMACDE (Deposit P1)
<i>Lagynochthonius</i> sp. S03		3	2	No	PMACDE (Deposits P2, P3)
<i>Tyrannochthonius</i> 'PSE050'		6	2	No	PMACDE (Deposit P4)
<i>Tyrannochthonius</i> 'PSE055'		12	1	No	PMACDE (Deposits A, F, P4, P5, P6)
<i>Tyrannochthonius</i> 'PSE066'	4	4	2	Yes	PMACDE (Deposits A, B, R, P1, Southern Flank) Weeli Wolli
<i>Tyrannochthonius</i> sp. B14	1			No	PMACDE (Southern Flank)
<i>Tyrannochthonius</i> sp. S05*		1		No	PMACDE (Deposit P4)
<i>Indohya</i> 'PSE005'	2	7		No	PMACDE (Deposits B, C, P4, Southern Flank)
<i>Indohya</i> sp. S02		2		No	PMACDE (Deposit P6)
Palpigradi					
<i>Eukoeneria</i> sp. S01		5		Yes	PMACDE (Deposits P4, P5, P6) Mudlark
Palpigradi sp. B01	7	11	4	Yes	PMACDE (Deposits A, D, F, P3, P4, Southern Flank), Jimblebar, Jinidi, Mindy, Orebody 19, Packsaddle East, Whaleback
Schizomida					
<i>Draculoides</i> 'SCH012'		58	3	No	PMACDE (Deposits P1, P2, P3)
<i>Draculoides</i> 'SCH013'		24	2	No	PMACDE (Deposits P3, P4, P5, P6)
<i>Draculoides</i> 'SCH018'		6		Yes	PMACDE (Deposit R), Elsewhere in the Pilbara
<i>Draculoides</i> 'SCH022'	15	8	3	Yes	PMACDE (Deposit P6, Southern Flank), Jinidi, Packsaddle East, Weeli Wolli
<i>Draculoides</i> 'SCH023'	11	1	13	No	PMACDE (Deposits F, R, Southern Flank)
<i>Draculoides</i> sp. B16	2		3	No	PMACDE (Southern Flank)
<i>Draculoides</i> sp. B20	4			No	PMACDE (Southern Flank)
<i>Draculoides</i> sp. B32			4	No	PMACDE (Southern Flank)
<i>Draculoides</i> sp. B46*		3		No	PMACDE (Deposit B)
<i>Draculoides</i> sp. B47		13		No	PMACDE (Deposits A, B)

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
<i>Draculoides</i> sp. B58			2	No	PMACDE (Deposit R)
<i>Draculoides</i> sp. B59-DNA	2			No	PMACDE (Southern Flank)
Araneae					
?Gnaphosidae sp. B01			1	No	PMACDE (Southern Flank)
Gnaphosidae sp. B01		1		No	PMACDE (Deposit P2)
Gnaphosidae sp. S01*		1		No	PMACDE (Deposit P1)
nr <i>Encoparthria</i> sp. B01	9	2		Yes	PMACDE (Deposits B, D), Jinidi
Linyphiidae sp. B03 (=Araneae sp. S05)	3	23	12	Yes	PMACDE (Deposits B, P1, P2, P3, P4), Juna Downs
?Theridiidae sp. B01		1		No	PMACDE (Deposit D)
<i>Prethopalpus julianneae</i>	1			No	PMACDE (Southern Flank)
<i>Prethopalpus maini</i>	5			No	PMACDE (Southern Flank)
<i>Prethopalpus pearsoni</i>		3		No	PMACDE (Deposit P4)
<i>Prethopalpus</i> sp. (Araneae sp. S07)		1		No	PMACDE (Deposit P5)
<i>Prethopalpus</i> sp. B03 (ex Araneomorphae/ Oonopidae sp. B03)*		1		No	PMACDE (Deposit D)
<i>Prethopalpus</i> sp. B06		2		No	PMACDE (Deposits B, R)
<i>Prethopalpus</i> sp. B15	1			No	PMACDE (Southern Flank)
<i>Prethopalpus</i> sp. B18 (=Araneae sp. S05)		3	3	No	PMACDE (Deposits P2, P4)
<i>Prethopalpus</i> sp. B24	1			No	PMACDE (Southern Flank)
<i>Anapistula</i> sp. B02		1		No	PMACDE (Deposit R)
<i>Pelcinus</i> sp. B02		7	1	No	PMACDE (Deposits B, P3, P4, P5)
<i>Pelcinus</i> sp. B05			1	No	PMACDE (Southern Flank)
Opiliones					
<i>Dampetrus</i> sp. B01 (nr <i>isolatus</i>)		7		Yes	PMACDE (Deposits B, C, P2), Packsaddle East
Opiliones sp. B02		1		Yes	PMACDE (Deposit P2) , Packsaddle East
Crustacea					
Malacostraca					
Isopoda					
Armadillidae sp. B07		3	1	No	PMACDE (Deposit B)
<i>Troglarmadillo</i> sp. B03		14		No	PMACDE (Deposits A, D, E, F)
<i>Troglarmadillo</i> sp. B11		28	1	No	PMACDE (Deposits F, P1)

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
<i>Troglarmadillo</i> sp. B13	3		2	No	PMACDE (Southern Flank)
<i>Troglarmadillo</i> sp. B14	12			No	PMACDE (Southern Flank)
<i>Troglarmadillo</i> sp. B36			1	No	PMACDE (Southern Flank)
<i>Troglarmadillo</i> sp. B37			3	No	PMACDE (Southern Flank)
<i>Troglarmadillo</i> sp. B57			1	No	PMACDE (Deposit P1)
nr <i>Andricophiloscia</i> sp. B16	1			No	PMACDE (Southern Flank)
<i>Philosciidae</i> sp. B03	17			No	PMACDE (Southern Flank)
<i>Philosciidae</i> sp. B15	1			No	PMACDE (Southern Flank)
Myriapoda					
Chilopoda					
Geophilida					
<i>Australoschendyla</i> sp. B06	2			No	PMACDE (Southern Flank)
<i>Chilenophilidae</i> sp. B07	1			No	PMACDE (Southern Flank)
Scolopendrida					
<i>Cryptops</i> sp. B07 (=Scolopendrida sp. S02)	2	1	2	Yes	PMACDE (Deposits P2, P5), Jinidi
<i>Cryptops</i> sp. B10 (=Scolopendrida sp. S05)		1		Yes	PMACDE (Deposit P1), Eastern Ridge
<i>Cryptops</i> sp. B15		2		Yes	PMACDE (Deposits R, P2), Juna Downs
<i>Cryptops</i> sp. B16	2		1	No	PMACDE (Southern Flank)
<i>Cryptops</i> sp. B39		1		No	PMACDE (Deposit P2)
<i>Cormocephalus</i> 'CHI003'		1	1	Yes	PMACDE (Deposits P2, P4), Elsewhere in the Pilbara
Scolopendrida sp. B01*		1		No	PMACDE (Deposit A)
Diplopoda					
Polydesmida					
<i>Polydesmida</i> sp. B11			1	No	PMACDE (Southern Flank)
Polyxenida					
<i>Lophoturus madecassus</i>	33	91	29	Yes	PMACDE (Deposits A, B, F, R, P1, P2, P3, P4, P5, Southern Flank), Eastern Ridge, Jimblebar, Jinidi, Juna Downs, Mindy, Mudlark, Orebody 19, Orebody 31, Orebody 39, , Packsaddle East, Whaleback, Yandi, Elsewhere in the Pilbara
Spirobolida					
Trigoniulidae sp.			1	Yes	PMACDE (Deposit R), Orebody 19, , Packsaddle East, Elsewhere in the Pilbara
Pauropoda					
Tetramerocerata					
<i>Allopaupopus</i> sp. B11	1			Yes	PMACDE (Southern Flank), Mudlark

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
Paupodidae sp. B01	1	23		Yes	PMACDE (Deposits B, C, E, R, P5, P6), Jimblebar, Orebody 31, Elsewhere in the Pilbara
Paupodidae sp. B04		3		Yes	PMACDE (Deposits R, P4), Jimblebar, Whaleback, Elsewhere in the Pilbara
Paupodidae sp. B12		1		No	PMACDE (Deposit P3)
Paupodidae sp. B13*		1		No	PMACDE (Deposit P4)
Paupodidae sp. B14	2	2	1	No	PMACDE (Deposits P2, P3, Southern Flank)
Paupodidae sp. B15			1	No	PMACDE (Deposit P4)
Paupodidae sp. B16			1	No	PMACDE (Deposit P3)
Symphyla					
Cephalostigmata					
<i>Hanseniella</i> sp. B07	6	1		No	PMACDE (Southern Flank)
<i>Hanseniella</i> sp. B08		6		No	PMACDE (Deposits P2, P3)
<i>Hanseniella</i> sp. B34	1			No	PMACDE (Southern Flank)
<i>Hanseniella</i> sp. B35			1	No	PMACDE (Southern Flank)
<i>Hanseniella</i> sp. B36-DNA			1	No	PMACDE (Southern Flank)
<i>Scutigerella</i> sp. B03	5		3	No	PMACDE (Southern Flank)
<i>Symphyella</i> sp. B03		1		No	PMACDE (Deposit R)
Hexapoda					
Entognatha					
Diplura					
Japygidae 'DPL002'	6	15	3	Yes	PMACDE (Deposits A, B, E, R, P1, P4, P6, Southern Flank), Eastern Ridge, Jimblebar, Jinidi, Juna Downs, Mudlark, Orebody 18, Orebody 31, Whaleback, Elsewhere in the Pilbara
Japygidae 'DPL005'	2			No	PMACDE (Southern Flank)
Japygidae 'DPL007'	2	1		No	PMACDE (Deposit R, Southern Flank)
Projapygidae sp. B05*		1		No	PMACDE (Deposit P4)
Parajapygidae 'DPL020'		4		Yes	PMACDE (Deposits P1, P2, P3), Jinidi
Parajapygidae 'DPL023'	2			No	PMACDE (Southern Flank)
Parajapygidae 'DPL024'	1			No	PMACDE (Southern Flank)
Parajapygidae sp. B25	1			No	PMACDE (Southern Flank)
Parajapygidae sp. B27		1		No	PMACDE (Deposit P2)
Parajapygidae sp. S03		1		No	PMACDE (Deposit P6)
Insecta					
Thysanura					
Atelurinae sp. B02 (= ? <i>Atelurodes</i> sp. S02)		13		Yes	PMACDE (Deposits P5, P6), Eastern Ridge, Jimblebar, Jinidi, Juna Downs, Mudlark, Orebody 18, Orebody 31, Orebody 39, Whaleback, Yandi, Weeli Wolli, Elsewhere in the Pilbara
Atelurinae sp. B04		1		No	PMACDE (Deposit B)

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
<i>Dodecastyla crypta</i>	8	43	26	No	PMACDE (Deposits A, B, C, D, E, F, R, P1, P2, P3, P4, Southern Flank)
<i>Trinemura</i> sp. B02 (nr <i>watsoni</i>)	2	3		Yes	PMACDE (Deposits R, P4), Jinidi
<i>Trinemura</i> sp. B09			7	No	PMACDE (Deposit P3, Southern Flank)
Blattodea					
Blattidae sp. B06	27	35	32	Yes	PMACDE (Deposits B, P2, P3, P4, R, Southern Flank), Jinidi
<i>Nocticola</i> `BLA001`		85		Yes	PMACDE (Deposits A, C, D, E, F, P1, P3, P4, P5, P6), Eastern Ridge, Jinidi, Mudlark, Orebody 18, Orebody 19, , Packsaddle East, Whaleback, Elsewhere in the Pilbara
<i>Nocticola</i> `BLA003`	33	148	44	Yes	PMACDE (Deposits A, B, F, P1, P2, P3, P4, P5, P6, Southern Flank), Jinidi, Juna Downs, Yandi, Weeli Wolli
<i>Nocticola</i> `cockingi` ms	19	22	11	No	PMACDE (Deposit R, Southern Flank)
<i>Nocticola</i> `quartermainei` ms	5	11	4	Yes	PMACDE (Deposits A, B, D, E, Southern Flank), Weeli Wolli
Hemiptera					
Hemiptera sp. B02 (=Fulgoridae sp. S01)	29	46	3	Yes	PMACDE (Deposits B, F, R, P1, P2, P3, P4, P5, P6), Eastern Ridge, Jimblebar, Jinidi, Orebody 19, Orebody 39, Whaleback, Elsewhere in the Pilbara
Meenoplidae sp. B02 (=Meenoplidae sp. S01)	42	352	84	Yes	PMACDE (Deposits A, B, C, F, R, P1, P2, P3, P4, P5, Southern Flank), Jinidi, Packsaddle East
Meenoplidae sp. B03 (winged, remnant eyes)		29		Yes	PMACDE (Deposit P1), Jimblebar, Jinidi, Mindy, Mudlark, Orebody 19, Orebody 21/22, Elsewhere in the Pilbara
Meenoplidae sp. B04 (small eyes, faint pigment)	8			Yes	PMACDE (Southern Flank), Whaleback, Weeli Wolli, Elsewhere in the Pilbara
Meenoplidae sp. B13			22	No	PMACDE (Southern Flank)
Coleoptera					
`Gracilanillus` sp. B09			1	No	PMACDE (Southern Flank)
Bembidiinae sp. B01*		1		No	PMACDE (Deposit D)
Bembidiinae sp. B08		3		Yes	PMACDE (Deposit B), Elsewhere in the Pilbara
<i>Typhlozuphium humicolum</i>		6	1	Yes	PMACDE (Deposits A, P3, P4, P6), Jinidi
<i>Typhlozuphium longipenne</i>		1		No	PMACDE (Deposit P2)
<i>Typhlozuphium</i> sp. B02	6		1	No	PMACDE (Southern Flank)
<i>Typhlozuphium</i> sp. B03		1		No	PMACDE (Deposit F)
Cryptorhynchinae sp. S03		1		No	PMACDE (Deposit P4)
Curculionidae Genus 1 sp. B02 (=Curculionidae sp. S02)	21	33	14	Yes	PMACDE (Deposits B, D, F, P1, P2, P3, P4, P6, Southern Flank), Juna Downs, Elsewhere in the Pilbara
<i>Ptinella</i> sp. B01			49	Yes	PMACDE (Deposit P1, Southern Flank), Eastern Ridge, Juna Downs, Weeli Wolli, Elsewhere in the Pilbara
<i>Rodwayia</i> sp. B02			1	No	PMACDE (Southern Flank)

Species	No. Individuals			Recorded Outside PMACDE	Distribution
	IAIAA	R6	MACR		
Pselaphinae sp. B01	1	7	4	Yes	PMACDE (Deposits B, P2, B, Southern Flank), Eastern Ridge, Jimblebar, Jinidi, Orebody 19, Orebody 31, Elsewhere in the Pilbara
Pselaphinae sp. B12			1	No	PMACDE (Southern Flank)
nr <i>Claviger</i> sp. B01			1	No	PMACDE (Southern Flank)
Coleoptera gen 1 sp. B06			2	Yes	PMACDE (Deposit P2), Juna Downs
Diptera					
Sciaridae sp. B01	11	346	162	Yes	PMACDE (Deposits A, B, R, P2, P3, P4, Southern Flank), Eastern Ridge, Jimblebar, Jinidi, Juna Downs, Mindy, Mudlark, Orebody 31, Whaleback, Elsewhere in the Pilbara
Sciaridae sp. B05			1	No	PMACDE (Southern Flank)

* Species restricted to areas approved for impact under Revision 5 of the Mining Area C EMP so not considered in Revision 6 EMP assessment.

Within the Approved Mining Area C (Northern Flank) Development Envelope, 1,650 specimens of troglofauna have been collected, representing at least 81 species from 17 orders (Table 44). In the Additional Development Envelope, 405 specimens of troglofauna have been collected, representing at least 51 species from 16 orders (Table 44).

Within the Mining Area C EMP Revision 6 Impact Assessment Area (pits only), 1,627 specimens of troglofauna have been collected, representing at least 78 species from 16 orders (Table 44). In the Indicative Additional Impact Assessment Area, 600 specimens of troglofauna have been collected, representing at least 51 species from 16 orders (Table 44).

Forty-one of the 126 species recorded in the Proposed Mining Area C Development Envelope to date have only been recorded in proposed impact assessment areas. These species are discussed further in Section 11.3.3.7.1.

11.3.3.5 Stygofauna community

A total of 6,289 specimens of stygofauna have been collected within the Weeli Wolli and Coondewanna subcatchments (i.e. the Groundwater Assessment Area, Mining Area C EMP Revision 6 Groundwater Assessment Area and Reference Area) (Table 45, Appendix 6), comprising at least 60 species from ten higher level groups (flatworms, nematodes, rotifers, segmented worms, mites, ostracods, copepods, syncarids, amphipods and isopods) (Appendix 6).

In the Groundwater Assessment Area, 27 stygofauna species have been recorded (Table 45), ten of which have not been recorded outside the area of cumulative groundwater drawdown. Two species (*Ainudrilus* sp. WA26 (PSS) and *Bathynella* sp. 1) have only been recorded from the Groundwater Assessment Area; four (*Dussartyclops* sp. B10, nr *Epactophanes* sp. B01, *Bathynella* sp. 2 and nr *Notobathynella* sp. S01) have only been recorded from the Mining Area C EMP Revision 6 Groundwater Assessment Area; and four (Halacaridae sp. B01, *Schizopera* sp. B02, *Notobathynella* sp. and Paramelitidae sp. S04 (BR South)) have records that only occur within both these areas. These species are discussed further in Section 11.3.3.7.3.

Weeli Wolli Spring itself is the richer of the two parts of the Weeli Wolli Spring PEC, with 26 stygofauna species recorded in this part of the Weeli Wolli Spring PEC and its buffer. Of these, 24 were collected in the Groundwater Assessment Area or Mining Area C EMP Revision 6 Groundwater Assessment Area. Only three species have been collected in the Ben's Oasis buffer.

11.3.3.6 Potential impacts

This section summarises potential direct and indirect impacts from mining within the Proposed Mining Area C Development Envelope. For troglofauna these are impacts from those activities undertaken within the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area (mine pits only), and for stygofauna these are within the Groundwater Assessment Area and Mining Area C EMP Revision 6 Groundwater Assessment Area (Table 46). Potential cumulative impacts within the catchment for stygofauna and troglofauna are considered where information is available.

Information has been summarised from stygofauna and troglofauna impact assessments undertaken in 2015 for update of the EMP Revision 6 (Bennelongia 2015a, b) and in 2016 for the Additional Impact Assessment Area (Bennelongia 2016a, b). Information from the 2015 impact assessments has been updated, where appropriate, in consideration of changes to species taxonomy, conservation listings or increased knowledge of species ecology or distribution. All supporting documents are provided in Appendix 6.

Table 45: Stygofauna species recorded in the Groundwater Assessment Area or Mining Area C EMP Revision 6 EMP Groundwater Assessment Area

Shading indicates species only known from the Groundwater Assessment Area (GAA; orange), Mining Area C EMP Revision 6 Groundwater Assessment Area (R6GAA; green), or both (blue). Note: RA = areas outside groundwater assessment areas

Taxonomy	Lowest ID	No. Individuals			Recorded outside of impact areas	Occurs in PEC buffer	Other Occurrences, Comments
		GAA	R6GAA	RA			
Platyhelminthes							
Turbellaria	Turbellaria sp.		5		Not assessed in EIAs ¹		Probably widespread ²
Nematoda							
	Nematoda sp.	45	94	282	Not assessed in EIAs ¹	WW	Probably widespread ²
Rotifera							
Eurotatoria							
Bdelloidea							
Philodinidae	<i>Rotaria</i> sp.		1		Not assessed in EIAs ¹		Probably widespread ²
	Bdelloidea sp. 2:2		3	500	Not assessed in EIAs ¹		Probably widespread ²
	Bdelloidea sp. 2:3			101	Not assessed in EIAs ¹		Probably widespread ²
	Bdelloidea sp. 5:4		1		Not assessed in EIAs ¹		Probably widespread ²
Monogononta							
Flosculariacea							
Filiniidae	<i>Filinia</i> sp.	2	5	6	Not assessed in EIAs ¹		Probably widespread ²
Annelida							
Aphanoneura							
Aeolosomatidae	<i>Aeolosoma</i> sp. 1 (PSS)		1		Yes		Pilbara-wide ^{2,3}
Clitellata							
Haplotaxida							
Naididae	<i>Dero nivea</i>			180	Yes		Cosmopolitan ⁵
	<i>Pristina longiseta</i>		5		Yes		Cosmopolitan ⁵
Phreodrilidae	Phreodrilidae sp. S06	1			Yes		Elsewhere in Pilbara ⁴
	Phreodrilidae with dissimilar ventral chaetae	20	23	76	Yes	WW, BO	Pilbara-wide ^{2,3}
	Phreodrilidae with similar ventral chaetae		12	14	Yes		Pilbara-wide ^{2,3}

Taxonomy	Lowest ID	No. Individuals			Recorded outside of impact areas	Occurs in PEC buffer	Other Occurrences, Comments
		GAA	R6GAA	RA			
Tubificidae	<i>Ainudrilus</i> sp. WA26 (PSS)	11			No	WW	Known only from these records
Enchytraeida							
Enchytraeidae	Enchytraeidae sp. S01		19		Yes		Packsaddle Range in approved drawdown, previously assessed
	<i>Enchytraeus</i> sp. 1 (PSS) Pilbara	1	16	172	Yes	WW	Species complex, Pilbara-wide ^{2,3}
	<i>Enchytraeus</i> sp. 2 (PSS) Pilbara	1	1		Yes	WW	Species complex, Pilbara-wide ^{2,3}
Arthropoda							
Chelicerata							
Arachnida							
Trombidiformes							
Halacaridae	Halacaridae sp. B01	1	1		No	WW	Known only from these records
Unionicolidae	<i>Recifella</i> sp. P1 (nr <i>umala</i>) (PSW)	1			Yes	WW	Hamersley Range ²
Crustacea							
Ostracoda							
Popocopida							
Candonidae	<i>Areacandona</i> cf. <i>mulgae</i>		1		Yes	WW	Near West Angelas ²
	<i>Meridiescandona facies</i>	35	5	19	Yes	WW	Weeli Wolli catchment ⁷
	<i>Meridiescandona lucerna</i>		1		Yes	WW	Weeli Wolli catchment, eastern Fortescue ^{3,7}
	<i>Meridiescandona marillanae</i>			16	Yes	WW	Lower Weeli Wolli, Marillana catchments ³
	<i>Notacandona boultoni</i>	43	3	2	Yes	WW	Weeli Wolli catchment ³
	<i>Notacandona modesta</i>	20	5		Yes	WW	Eastern Upper Weeli Wolli catchment ⁴
	<i>Origocandona grommike</i>			8	Yes	WW	Camp Hill and perhaps more widely ³
Cyprididae	<i>Cypretta seurati</i>			15	Yes		Cosmopolitan ^{8,9,10}
Limnocytheridae	<i>Gomphodella yandii</i>	76	1	22	Yes	WW	Eastern Weeli Wolli catchment ³
Maxillopoda							
Calanoida							
Ridgewayiidae	<i>Stygoidridgewayia trispinosa</i>		1	1	Yes		Pilbara, Exmouth peninsula ¹¹
Cyclopoida							
Cyclopidae	<i>Diacyclops cockingi</i>	85	53	11	Yes	WW	Pilbara-wide ^{2,12}
	<i>Diacyclops humphreysi</i>	28	41	1142	Yes	WW	Pilbara-wide ^{2,13}
	<i>Diacyclops sobeprolatus</i>		2	72	Yes		Pilbara-wide ^{2,13}
	<i>Dussartcyclops</i> sp. B10		3		No		Known only from this record, impacts previously assessed
	<i>Mesocyclops brooksi</i>	2		8	Yes	WW	Southern Australia ^{2,12}
	<i>Metacyclops pilbaricus</i>		1	13	Yes		Pilbara-wide ^{2,13}
	<i>Metacyclops</i> sp. B01 (nr <i>pilbaricus</i>)		1		Yes		Central Pilbara ^{2,13}
	<i>Microcyclops varicans</i>		1	63	Yes		Cosmopolitan ¹⁴

Taxonomy	Lowest ID	No. Individuals			Recorded outside of impact areas	Occurs in PEC buffer	Other Occurrences, Comments
		GAA	R6GAA	RA			
	<i>Pilbaracyclops</i> sp. B03 (nr <i>frustratio</i>)		3		Yes		Central Pilbara ^{2,13}
	<i>Thermocyclus decipiens</i>		1		Yes		Cosmopolitan ¹⁴
Harpacticoida							
Ameiridae	<i>Gordanitocrella trajani</i>	74	23	63	Yes	WW	Eastern Weeli Wolli catchment ^{3,15}
Canthocamptidae	<i>Australocamptus</i> sp.		1	25	Yes		Coondewanna catchment
	nr <i>Epactophanes</i> sp. B01		1		No		Known only from this record, impacts previously assessed
Miraciidae	<i>Schizopera</i> sp. B02	7	1		No	WW	Known only from these records ⁴
Parastenocarididae	<i>Parastenocaris jane</i>		1		Yes		Pilbara-wide ^{2,13}
Malacostraca							
Syncarida							
Bathynellidae	<i>Bathynella</i> sp. 1	1			No	WW	Known only from this record
Bathynellidae	<i>Bathynella</i> sp. 2		4		No		Known only from this record, previously assessed
Parabathynellidae	<i>Atopobathynella</i> sp. B04		15		Yes		Eastern Weeli Wolli catchment ³
	<i>Notobathynella</i> sp.	2	2		No		Known only from these records ⁴
	nr <i>Billibathynella</i> sp. B02 (=Parabathynellidae sp. S03)	15	57		Yes		Weeli Wolli and Coondewanna catchments ³
	nr <i>Notobathynella</i> sp. S01		21		No		Known only from these records ³ , previously assessed
Amphipoda							
Paramelitidae	<i>Chydaekata</i> sp. B01		4	7	Yes		Coondewanna catchment ³
	<i>Chydaekata</i> sp. E	27	7	6	Yes	WW, BO	Lower Weeli Wolli catchment ³
	<i>Maarrka weeliwollii</i>	3	7	11	Yes	WW	Lower Weeli Wolli and Marillana catchments ³
	Paramelitidae Genus 2 sp. B02	44	211	9	Yes	WW, BO	Eastern Weeli Wolli catchment ³
	Paramelitidae Genus 2 sp. B03		5	6	Yes	WW	Lower Weeli Wolli and Marillana catchments ³
	Paramelitidae sp. B03	175	30	6	Yes		Weeli Wolli catchments ³
	Paramelitidae sp. B04			1	Yes		Known only from a single drill hole ³
	Paramelitidae sp. B16			4	Yes		Lower Weeli Wolli and Marillana catchments ⁴
	Paramelitidae sp. S04 (BR South)	55	33		No		Known only from these records ³
Isopoda							
Tainisopidae	<i>Pygolabis weeliwolli</i>	16	7	20	Yes	WW	Lower Weeli Wolli and Marillana catchments ^{3,16,17}

Table 46: Impact Assessment Area for Subterranean Fauna

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal extent (Cumulative Impacts)	Regional extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Subterranean Fauna (stygo fauna)	Groundwater Assessment Area	Groundwater Assessment Area and Mining Area C EMP Revision 6 Groundwater Assessment Area	As for Mining Area C Revised Proposal Extent. This area is predicted from modelling that is inclusive of third party operations such as Hope Downs 1 and therefore Proposed Extent is representative of potential regional impacts.
Subterranean Fauna (troglotauna)	Indicative Additional Impact Assessment Area and Additional Development Envelope (pit areas with buffer only). Mining Area C EMP Revision 6 Impact Assessment Area (pit areas with buffer only).	Mining Area C EMP Revision 6 Impact Assessment Area and Indicative Additional Impact Assessment Area	As per the Proposed Mining Area C Revised Proposal Extent, as there is little description on troglotauna species and/or no information available for regional records.

The sampling of subterranean fauna has inherent limitations given the available sampling methods and the current state of knowledge on the ecology and taxonomy of troglotauna and stygo fauna. Study of subterranean fauna is in its infancy and knowledge of species, populations and communities is rapidly advancing, with BHP Billiton Iron Ore providing extensive data and support for ongoing work on subterranean fauna in the Pilbara (e.g. Trotter *et al.*, 2017). Sampling currently shows a bias to within mining tenure and therefore regional representation is not well understood. Notwithstanding these limitations, BHP Billiton Iron Ore has applied rigour in sampling, data and impact assessment and is confident in our ability to adaptively manage impacts to subterranean fauna.

Potential limitations include:

- **Constrained sampling:** Subterranean fauna sampling is likely to underestimate the true ranges of most species because it is spatially constrained. Drill holes are usually only available for sampling within the tenements of the proponent company and only in areas considered prospective for mining.
- **Low abundance species:** Reliable definition of the ranges of low abundance species requires extensive sampling (Miller *et al.*, 1989, Guisan *et al.*, 2006). Despite a general trend for low abundance species to have smaller ranges than abundant species (Brown, 1984), many low abundance species have widespread, patchy occurrence (Maurer, 1990). Thus, few direct inferences can be drawn about the likely ranges of species collected in the impact assessment areas from few samples, especially species collected as singletons. The likely ranges of these species are most accurately defined using the known ranges of related species and the potential continuity of the surrounding habitat (see EPA, 2013d).
- **Incomplete and inconsistent taxonomy:** The majority of species recorded within the Proposed Mining Area C Development Envelope are undescribed and are only known from within it. A taxonomic database for undescribed troglotauna species in Western Australia, such as would be provided by WAMinals (<http://museum.wa.gov.au/research/databases/waminals>) is largely incomplete and if the same species is collected by different consultancies it is usually given different informal names. This adds to the difficulty of determining accurate species ranges,

and a number of species may have larger ranges than described in this report. For example, Rio Tinto Iron Ore's Baby Hope Downs project lies immediately adjacent to Southern Flank within the same ridge. It is likely that the Southern Flank troglofauna community extends into this area but none of the species recorded in the Baby Hope Downs area have the same nomenclature as species at the Proposed Mining Area C Development Envelope (Biota, 2015c). This may be due to the inconsistent application of taxonomy and the lack of species descriptions for most troglofauna within the Pilbara. In fact, from photographs the dipluran Japygidae sp. at Baby Hope Downs appears to possibly be Japygidae 'DPL002' collected widely in the central Pilbara and the schizomid *Draculoides* sp. BHD4 belongs to lineage within *Draculoides* that is represented by six species at Mining Area C. It is possible that *Draculoides* sp. BHD4 is recorded under a different name within the Proposed Mining Area C Development Envelope.

11.3.3.7 Direct impacts

11.3.3.7.1 Troglofauna species

Mining may potentially impact species that have all or most of their range restricted to proposed pit areas within the Indicative Additional Impact Assessment Area or Mining Area C EMP Revision 6 Impact Assessment Area or cumulatively if all known records occur within these two areas.

Impact assessments for troglofauna were undertaken by Bennelongia (2015a, 2016a) and are provided in Appendix 6. The assessments included a determination of the likelihood of habitats from which restricted troglofauna were recorded extending outside the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area. When inferring the ranges of individual species using habitat profiling and mapping, it is often necessary to make some assumptions about which of the potentially prospective geological units are actually used by that species. These assumptions depend on factors such as the number of drill holes yielding the species, capture methods, and whether more than one geological unit was present within a hole. Other assumptions about the innate biological constraints on the maximum range of a species may also be made, depending on the variation in life history characteristics of related species and current scientific understanding and knowledge of some species. To ensure these assumptions are accounted for, BHP Billiton Iron Ore has applied the categories described below to indicate the likelihood of species being restricted to the Indicative Additional Impact Assessment Area and/or the Mining Area C EMP Revision 6 Impact Assessment Area to ensure that impact assessments are undertaken on best on available data. Three likelihood categories were used:

- *Possibly*. The available information suggests there is $\geq 40\%$ probability that the species is restricted.
- *Unlikely*. The available information suggests there is $\leq 40\%$ probability that the species is restricted.
- *Uncertain*. There is insufficient information to assign a probability of the species being restricted. Given that the species is known only from the indicative impact assessment areas, it is treated as likely to be restricted.

Twenty of the 126 species recorded in the Proposed Mining Area C Development Envelope have only been recorded from the Indicative Additional Impact Assessment Area, and 20 have been recorded only from the Mining Area C EMP Revision 6 Impact Assessment Area. One species is only known from records within the two areas. Twenty-two of the 41 species only recorded from impact assessment areas are singletons (i.e. only known from single records) and a further two have multiple records from a single bore.

Four species (three of which are singletons, and one has multiple records from a single bore) are considered to *possibly* be restricted to the Indicative Additional Impact Assessment Area and for one

(which is a singleton) the status is *uncertain*. The remaining 15 species are considered *unlikely* to be restricted to the Indicative Additional Impact Assessment Area. Note that further investigations were undertaken in relation to the above five species as discussed in detail below.

The status of three of the 20 species (*Hanseniella* sp. B08, *Symphyella* sp. B03, and *Parajapygidae* sp. S03) only known from the Mining Area C EMP Revision 6 Impact Assessment Area is considered *uncertain* because there is currently little information on which to infer the likely ranges for each of these species. The latter two species are only known from single records.

Indohya 'PSE005', which is the only species with records restricted to both impact areas, is considered *unlikely* to be restricted to areas of proposed or approved impact.

Key findings from the assessment are provided in Table 47 and Figure 32.

Impact assessments undertaken for the Proposal suggest that of the 126 species recorded in the Proposed Mining Area C Development Envelope, the Proposal may impact eight species i.e. 6% or less. Of these eight species, half are *possibly* impacted and half have *uncertain* potential impacts. Six are only known from single records (i.e. singletons) and a further one species is only known from multiple records from a single bore. Based on the fact that 6% or less of species may be impacted, BHP Billiton Iron Ore considers that the impacts to troglofauna resulting from the Proposal are not significant. The impact assessment also concluded that the the potential impact to troglofauna populations and assemblages are likely to meet the EPA objective.

11.3.3.7.2 Troglofauna habitats

Detailed habitat assessments have been undertaken for each potentially restricted species within the Proposed Mining Area C Development Envelope (BHP Billiton Iron Ore, 2015d, 2016h), and the results of these were considered for the impact assessment in the previous section. There are inherent scientific difficulties with the undertaking of an impact assessment for troglofauna habitats as:

- Different species use different habitats (geological units, e.g. West Angela, Mount Newman, Detritals) within the strata, and these generally do not correlate with surficial geological mapping;
- The suitability of each of these geological units depends on the species type, the depth from the surface, and the microhabitats within them (i.e. porosity, vuggyness, cracks and voids); and
- Areas that are saturated (i.e. intersect the water table) are not suitable for troglofauna, but these areas may change with natural fluctuations or variations in groundwater levels.

Nevertheless, it is possible to determine relative impacts to troglofauna habitats based on the extent of these subsurface habitats outside the proposed areas of impact (pit voids) and if there are any barriers to movement on a macro scale, which can be determined from the presence of dykes or faults (although the latter may also encourage movement of troglofauna between geological units).

Based on the troglofauna habitat assessments completed for Southern Flank (BHP Billiton Iron Ore, 2016h) suitable troglofauna habitat is hosted within the Mount Newman units of the Marra Mamba Iron Formation, West Angela units of the Wittenoom Formation and the Tertiary Detritals. Above the water table, Mount Newman extends beyond areas of impact to the north and east at the western end of the orebody, and also forms a large area between areas of impact and also to the southeast. West Angela is present outside areas of impact in an east-west direction extending for kilometres along the south of the central and eastern parts of the orebody. Detritals are extensive to the south of Southern Flank, filling a broad valley north of Mount Robinson.

Hardcap alteration across Southern Flank is generally observed in the upper 15-30 m of bedrock, although it has been interpreted to depths of around 100 m in areas of deep detritals, such as in the south of the deposit outside areas of impact. In general, the hardcap alteration ranges from extremely hardcapped, which is angular, porous and exceptionally vuggy to semi-hardcap alteration that is angular, porous, pitted material with little to no vugs. The main structural features present are two thrust faults, which dip shallowly to the south and are observed to be continuous across the entire Southern Flank area. Distribution of widespread troglofauna species throughout Southern Flank suggests that these faults do not limit connectivity through the Southern Flank deposit (Figure 33), although this may not be the case for all species. A dolerite dyke has been interpreted in the western end of the deposit; however this exists beneath the water table and is therefore not thought to influence troglofauna mobility across the Proposal area.

Within Mining Area C, troglofauna habitat occurs in both the Packsaddle and Jirrpulpur Ranges. Within the Packsaddle Range it is hosted within the Tertiary Detritals, Joffre and Dales Gorge Members of the Brockman Iron Formation. Within the Jirrpulpur Range it occurs in the Tertiary Detritals, West Angelas Member of the Wittenoom Formation, and the Mount Newman and MacLeod Members of the Marra Mamba Iron Formation. Above water table Joffre extends north outside of the Proposed Mining Area C Development Envelope. Tertiary Detritals fill a deep valley between the Packsaddle and Jirrpulpur Ranges and are extensive outside the Mining Area C EMP Revision 6 Impact Assessment Area. The MacLeod Member continues outside of the Mining Area C EMP Revision 6 Impact Assessment Area to the south of the Jirrpulpur Range.

Hardcap alteration at Mining Area C is common, especially through the Packsaddle Range. It is often strongest near the surface and grades into semi-hardcap and then unaltered rock with depth. Core photos from along the Packsaddle Range showed the hardcap alteration to be exceptionally vuggy with larger cavities also present in some locations.

A troglofauna habitat assessment for the Approved Mining Area C (Northern Flank) Development Envelope (BHP Billiton Iron Ore, 2015d) showed that the area has been subjected to a number of major deformation events that have caused wide scale folding and faulting. East-west trending normal faults (south block down) occur throughout Packsaddle Range. At a regional scale this is mapped as one major fault. Major and minor thrust faults (south block up) have been identified throughout the Jirrpulpur Range, mostly cross cutting the Mount Newman and West Angela Members of the Marra Mamba Iron Formation. There was no evidence found during the habitat assessment that suggested that these faults restrict movement of troglofauna, on the contrary it was considered that fault fracturing may aid dispersal in some instances (BHP Billiton Iron Ore, 2015d).

Table 47: Key findings from the troglofauna impact assessments

Species in bold may be *possibly* restricted to the Indicative Additional Impact Assessment Area or their status is *uncertain*

Taxon	Total Records	Summary of Findings	Predicted Outcome
<i>Anapistula</i> sp. B02	1	Another species of the genus (<i>Anapistula</i> sp. B01) has a known linear range of 17 km in the central Pilbara (Bennelongia unpublished data). This suggests that moderately wide ranges can be expected for species of <i>Anapistula</i> . <i>Anapistula</i> sp. B02 is known from a single record occurring 650 m within R Deposit. The record of this species occurs within consolidated alluvium, logged by BHP Billiton Iron Ore as tertiary detritals (TD3, TD2 and TD1) (BHP Billiton Iron Ore, 2015d). Based on geological mapping the alluvium is continuous to the north, extending well outside of the R Deposit pit. Hence, it is expected that <i>Anapistula</i> sp. B02 will not be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
nr <i>Andricophiloscia</i> sp. B16	1	Recorded from one sample (trap) in Southern Flank. There are limited data on species distribution on other members of nr <i>Andricophiloscia</i> as most are only known from a single specimen. Trap depth suggests that this species occurs in the West Angela Member which at this location does not extend outside the Indicative Additional Impact Assessment Area in this location.	Limited information available from single record. Currently considered to <i>possibly</i> be restricted to the Indicative Additional Impact Assessment Area.
Atelurinae sp. B04	1	Atelurinae sp. B04 is a singleton record approximately 150 m within the boundary of B Deposit. It occurs in unmineralised shales and BIF of the MacLeod Member with hardcap occurring from 0-13 m and semi-hardcap from 13-33 m depth. Similar suitable habitat in the MacLeod Member extends to the west and south of the B Deposit pit.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Australoschendyla</i> sp. B06	2	Recorded from two holes with a linear range of 6.6 km and likely from detritals that occur in the top 30 to 40 m from which these holes intersect. The detritals in these locations extend outside the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Chilenophilidae</i> sp. B07	1	Recorded from one hole in detritals. At this location, the detritals extend outside the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Cryptops</i> sp. B39	1	Species of <i>Cryptops</i> have been found to be very wide-ranging in the Pilbara and, for this reason, it is considered likely that most species collected as troglofauna are troglophiles with a surface dispersal phase in their life history. <i>Cryptops</i> sp. B39 is known from a single record from within P2 Deposit. The record is located within the mapped colluvium, which has been	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP

Taxon	Total Records	Summary of Findings	Predicted Outcome
		logged as detritals TD3. The Joffre Member below the colluvium is characterised by unmineralised BIF with hardcap alteration to 36 m depth. The Joffre Member outcrops in the drill hole directly to the north and extends north of the P2 Deposit pit boundary (BHP Billiton Iron Ore 2015d). Faulting in the area may also provide fractures that act as conduits for movement for this species (BHP Billiton Iron Ore, 2015d).	Mining Area C EMP Revision 6 Impact Assessment Area.
Cryptorhynchinae sp. S03	1	Cryptorhynchinae sp. S03 is known from a single record within P4 Deposit in a drill hole containing unenriched Joffre BIF with some hardcap and semi-hardcap. Hardcap is known to extend beyond both the northern and southern boundaries of P4 Deposit pit. Joffre BIF extends to the north of the maximum pit extent (BHP Billiton Iron Ore, 2015d). Given the prospective habitat outside the proposed mine pit at P4 Deposit and the reasonably widespread nature of other species of the family Curculionidae, Cryptorhynchinae sp. S03 is considered unlikely to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Draculoides</i> sp. B20	4	Recorded from four locations in the Indicative Additional Impact Assessment Area with a linear range of at least 10 km. Records are from drill holes intersecting the Mount Newman or MacLeod Members in both mineralised and unmineralised stratigraphy. The species appears to occur in and possibly move between these two BIF units.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Draculoides</i> sp. B47	9	<i>Draculoides</i> sp. B47 has been recorded from a number of drill holes at both A Deposit and B Deposit and has a known linear range of 4.4 km. It has primarily been recorded in the following geologies: hardcap Marra Mamba and alluvials/colluvials at A Deposit; and alluvials/colluvials and both mineralised and un-mineralised Marra Mamba at B Deposit (BHP Billiton Iron Ore unpublished data). Given the demonstrated distribution of this species, it is likely <i>Draculoides</i> sp. B47 occurs outside of the Mining Area C EMP Revision 6 Impact Assessment Area, in the area immediately south of A Deposit, where similar geology is present (BHP Billiton Iron Ore, 2015d; BHP Billiton Iron Ore unpublished data).	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Draculoides</i> sp. B59-DNA	2	Recorded from two individuals within one drill hole located approximately 5 m from the boundary of Indicative Additional Impact Assessment Area. The linear range of other <i>Draculoides</i> within Southern Flank range between 0.2 km and more than 10 km. This species has been recently differentiated from <i>Draculoides</i> sp. B16 and hence a detailed habitat assessment has not been undertaken; however, it is assumed that it will utilise weathered BIF. Given the proximity of this location to the edge of the Indicative Additional Impact Assessment Area it is considered likely that this species occurs in habitats outside.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
Gnaphosidae sp. B01	1	A single Gnaphosidae sp. B01 specimen has been collected within the P2 Deposit approximately 95 m from the northern boundary of the pit. The record is within the mapped	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP

Taxon	Total Records	Summary of Findings	Predicted Outcome
		geological unit Martite goethite (Joffre) and hardcap alteration has been identified from 0-24 m depth (BHP Billiton Iron Ore, 2015d). Both the hardcap and Joffre units that provide habitat for this species have been modelled to extend about 500 m to the north of the collection site of Gnaphosidae sp. B01 (BHP Billiton Iron Ore, 2015d). Furthermore, the stratigraphy of P2 Deposit is cross cut by a number of faults and splays. This fracturing may provide conduits for troglofauna movement through a number of stratigraphies prospective for troglofauna, as evidenced by the records of troglobitic species to the north of the P2 Deposit pit.	Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Hanseniella</i> sp. B07	7	Recorded from four drill holes in Southern Flank and one location at Deposit R (in the Mining Area C EMP Revision 6 Impact Assessment Area), with a linear range of 24 km. Analysis of record locations suggests that its preferred habitat is detritals, and there is continuity of this unit outside of the Indicative Additional Impact Assessment Area in the locations from which these species have been recorded.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Hanseniella</i> sp. B08	4	<i>Hanseniella</i> sp. B08 was recorded from four drill holes on the margin between P3 Deposit and P2 Deposit. All four of the drill holes contain unmineralised BIF (Brockman Iron Formation) with hardcap that becomes semi-hardcap with depth. Mapping suggests that surface expression of Brockman Formation (Joffre) extends continuously to the north and east of the P2 Deposit proposed pit. Furthermore, P2 Deposit is cross cut by a number of faults and splays (BHP Billiton Iron Ore, 2015d), which most likely provides conduits for movement of troglofauna.	It is <i>uncertain</i> whether this species is restricted to Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Hanseniella</i> sp. B34	1	Recorded from one location with colluvium and alluvium geologies. At this location, this unit extends north outside of the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Indohya</i> 'PSE005'	9	<i>Indohya</i> 'PSE005' has been collected widely within the Proposed Mining Area C Development Envelope. The species has a range of at least 21 km, although all known locations are currently within the Mining Area C EMP Revision 6 Impact Assessment Area and Indicative Additional Impact Assessment Areas. An assessment of habitats from which it has been recorded suggests that it is a relatively mobile species that is capable of inhabiting various lithologies. Based on the wide documented range of the species across multiple geologies, it is considered unlikely that <i>Indohya</i> 'PSE005' is restricted to the Indicative Additional Impact Assessment and Current Mining Area C EMP Revision 6 Impact Assessment Area. It probably also occurs outside the Proposed Mining Area C Development Envelope.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area.

Taxon	Total Records	Summary of Findings	Predicted Outcome
<i>Indohya</i> sp. S02	2	The two records of <i>Indohya</i> sp. S02 have been collected very close to the proposed pit boundary at P6 Deposit (75 m and 35 m from the boundary). Based on regional geological mapping, these drill holes occur in ferricrete (laterite, unmineralised shales). Based on the mapped geology and the topography of the area, there are no barriers to this species moving within the same or similar geological units outside of the Project Area (BHP Billiton Iron Ore, 2015d). It is likely that <i>Indohya</i> sp. S02 occurs more widely in the adjacent habitat.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Japygidae</i> `DPL005`	2	Recorded from two locations over a linear range of 15 km. Species from this family are known to have ranges over 20 km, and it is believed that a significant number have an above ground dispersal phase that enables them to be moderately widespread. The geological units suggest that it occurs in the Mount Newman or West Angela members, but it may also occur in the upper detritals. The ecology of Japygidae species suggests that this species is likely to be widespread in the Southern Flank area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Japygidae</i> `DPL007`	3	Recorded from two locations, one at Southern Flank and one at Deposit R (in the Mining Area C EMP Revision 6 Impact Assessment Area), with a linear range of 6 km. At both locations, it was recorded in colluvium and alluvium. These extend beyond the Indicative Additional Impact Assessment Area at these locations.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Parajapygidae</i> `DPL023`	2	Recorded from two locations at Southern Flank with a linear range of 3 km. One record is from colluvium and alluvium geology, which extends outside of the Indicative Additional Impact Assessment Area at this location.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Parajapygidae</i> `DPL024`	1	Recorded from a single location. The drill hole intersected 6 m of scree over extensive West Angela and Mount Newman Members, which appear to be restricted to the Indicative Additional Impact Assessment Area at this location. Parajapygidae is known to contain a number of species that are moderately widespread and have an above ground dispersal phase; however, some may be restricted to the subsurface and have a limited range. It is either a troglophile occupying surface scree therefore has an above ground dispersal phase ensuring it likely to have a wide distribution or a troglobite in Marra Mamba Formation that is likely to be restricted to the Indicative Additional Impact Assessment Area.	It is <i>uncertain</i> whether this species is restricted to the Indicative Additional Impact Assessment Area.
<i>Parajapygidae</i> sp. B25	1	Recorded from a single location, in a hole mapped as consolidated alluvium. At this location, the geology extends outside of the Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.

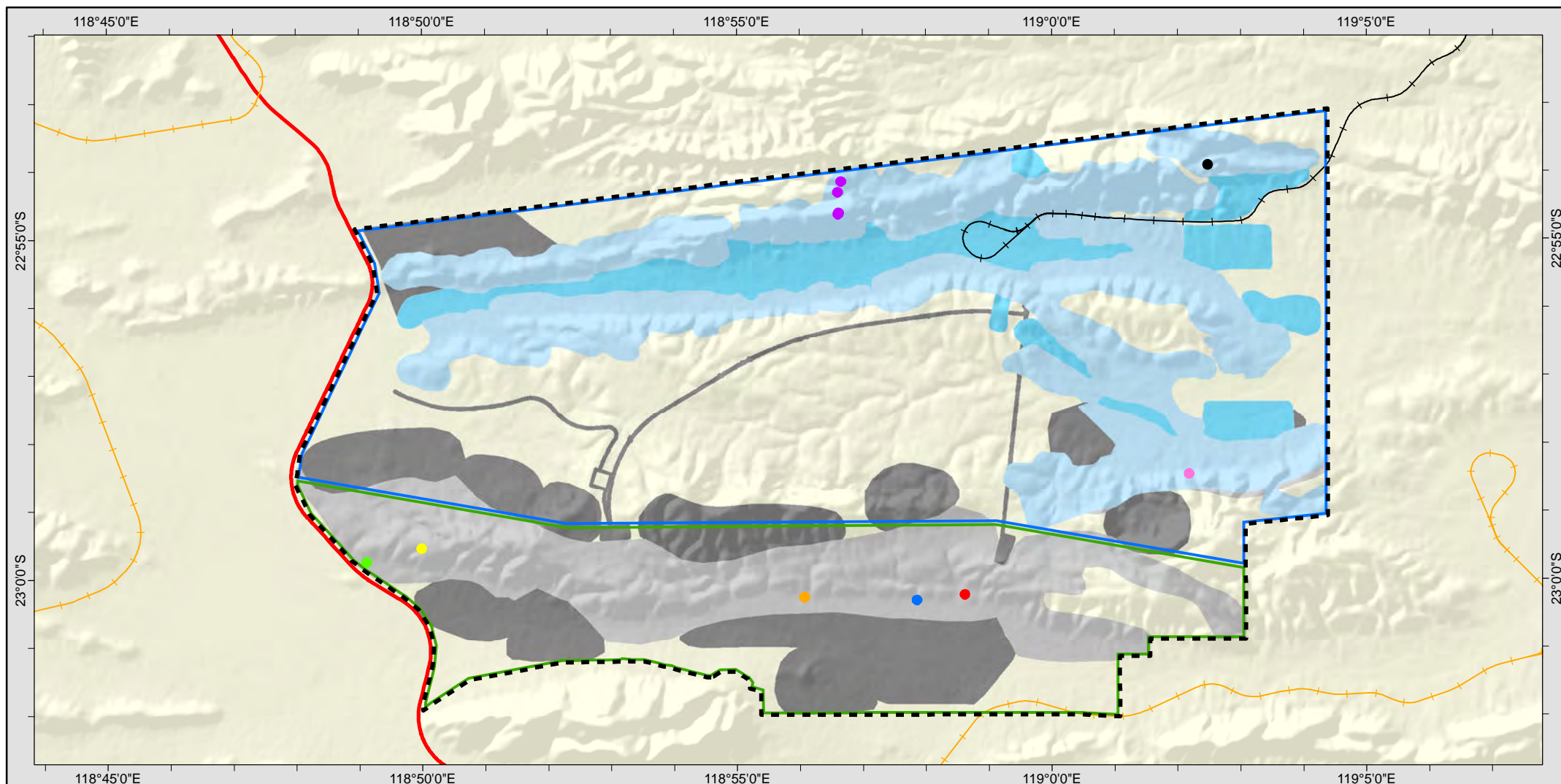
Taxon	Total Records	Summary of Findings	Predicted Outcome
Parajapygidae sp. B27	1	Parajapygidae sp. B27 is known from a single record within P2 Deposit. It occurs in an area mapped as unmineralised Joffre BIF, with hardcap occurring from 0-12 m and semi-hardcap occurring from 12-36 m. Unmineralised Joffre BIF extends continuously outside of the P2 Deposit pit with a surface expression of approximately 4.7 km ² . Furthermore, a number of faults and splays occur at P2 Deposit (BHP Billiton Iron Ore, 2015d). This fracturing may provide conduits for troglofauna movement. The extension of Joffre BIF and faults and splays outside P2 Deposit reduces the likelihood that Parajapygidae sp. B27 is restricted to the mine pit within this deposit.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
Parajapygidae sp. S03	1	Parajapygidae sp. S03 is known from a single record within P6 Deposit. The geology of the drill hole consists of mineralised detritals (TD3) and Dales Gorge Member with hardcap occurring from 0 to 27 m (BHP Billiton Iron Ore, 2015d). Hardcap is known to extend outside of the Mining Area C EMP Revision 6 Impact Assessment Area, but the remainder of the geology in the surrounding area is not well understood (BHP Billiton Iron Ore, 2015d). Parajapygidae sp. S03 probably occurs outside P6 Deposit pit but the limited data for this species (and family) and the poor understanding of the geology nearby mean there is uncertainty about the likely range of this species.	It is <i>uncertain</i> whether this species is restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
Pauropodidae sp. B12	1	The taxonomy of pauropods in Australia is not well established (Scheller 2013) but some species in the Pilbara have extensive ranges, such as Pauropodidae sp. B01 (known linear range of 287 km), while other species typically have smaller ranges in the order of 10 km or less (Bennelongia, unpublished data). Pauropodidae sp. B12 is known from a single record, which was collected approximately 120 m inside the northern boundary of the P3 Deposit. Drill-hole logs suggest Pauropodidae sp. B12 occurs within hardcapped Weeli Wolli Formation BIF. Based on the surface geological mapping both the Weeli Wolli Formation and the hardcap alteration extend well to the north of the P3 Deposit pit (BHP Billiton Iron Ore, 2015d).	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
Philosciidae sp. B03	17	This species was recorded on three occasions from the same drill hole with 17 individuals recorded. A number of these records were from traps, whose depth corresponded with the Mount Newman Member. One record is from a scrape, and therefore this record may have come from a different type of geology; other Philosciidae species are known to occur in detritals (e.g. Philosciidae sp. B15 below) and can be wide ranging. The Mount Newman Member at this location does not extend outside the Indicative Additional Impact Assessment Area.	Currently considered to <i>possibly</i> to be restricted to the Indicative Additional Impact Assessment Area.
Philosciidae sp. B15	1	Recorded from one drill hole, which only intersected detritals above the water table. At this location, the detritals extend outside the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative

Taxon	Total Records	Summary of Findings	Predicted Outcome
			Additional Impact Assessment Area.
<i>Prethopallus julianneae</i>	1	Known from a single record in the Indicative Additional Impact Assessment Area. Record is from a scrape sample, so unknown which geology type it could occur in, but it is considered likely to have been occupying the Mt Newman Member. MacLeod Member, a predominantly shale and chert upper layer of the Marra Mamba Formation, does occur more widely and may possibly also be suitable habitat although there is not strong evidence of <i>Prethopallus</i> species using this geology. The Mt Newman Member at the location of this record does not extend continuously outside the Indicative Additional Impact Assessment Area and the species probably has a small range.	It is considered <i>possibly</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Prethopallus maini</i>	5	Known from five drill holes across Southern Flank with a linear range of 18 km. Records from most drill holes it was recorded from suggest that it occurs in the Mount Newman Member or in hardcap that extend outside the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Prethopallus pearsoni</i>	3	<i>Prethopallus pearsoni</i> has a known linear range of 0.9 km at P4 Deposit. The drill holes from which it has been recorded occur within mapped unit Martite goethite (Joffre) and have been logged as Joffre Member with hardcap alteration present at depths of up to 30 m (BHP Billiton Iron Ore, 2015d). The modelled stratigraphy indicates that both the hardcap alteration and the Joffre units in which this species occurs extend to the north well beyond the pit boundary (BHP Billiton Iron Ore, 2015d). It is expected that the range of <i>Prethopallus pearsoni</i> is larger than currently documented and that the species occurs beyond the Mining Area C EMP Revision 6 Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Prethopallus</i> sp. B06	2	<i>Prethopallus</i> sp. B06 is known from two records at Mining Area C. One specimen was collected 20 m from the pit boundary of R Deposit and the other was at B Deposit. These records are separated by a linear distance of 7.7 km and an extensive sequence of alluvial deposits (BHP Billiton Iron Ore, 2015c). Although the specimens were collected from drill holes comprising Marra Mamba (including hardcap nearer the surface), it is likely this species makes some use of the alluvials that occur between R Deposit and B Deposit. Furthermore, suitable habitat in the hardcapped Marra Mamba extends to the north of B Deposit pit boundary; and suitable Marra Mamba habitat extends to the north of R Deposit (BHP Billiton Iron Ore, 2015d). It is, therefore, considered unlikely that <i>Prethopallus</i> sp. B06 is restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Prethopallus</i> sp. B15	1	Recorded as bycatch in a stygofauna haul in Southern Flank, which intersected the Marra Mamba Iron Formation and detritals. It is considered likely to occur within the West Angela	Limited information available from single record collected as by-catch.

Taxon	Total Records	Summary of Findings	Predicted Outcome
		Member, which does not extend outside the Indicative Additional Impact Assessment Area at this location. There is, however, an unidentified <i>Prethopalpus</i> record from approximately 750 m northwest of this location, which was recorded within the Mt Newman Member which is continuous outside at this location. If this unidentified species is <i>Prethopalpus</i> sp. B15 then it is unlikely to be restricted to the Indicative Additional Impact Assessment Area.	Currently considered to <i>possibly</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Prethopalpus</i> sp. B24	1	Recorded from one sample in Southern Flank, which intersected detritals and mineralised West Angela and Mount Newman members stratigraphy. All these units are continuous outside the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Prethopalpus</i> sp. (Araneae sp. S07)	1	<i>Prethopalpus</i> sp. (Araneae sp. S07) is known from a single record about 360 m within P5 Deposit. The record occurs within the mapped unit Brockman Formation (Mt Whaleback Shale). Hardcap has been logged from 0 to 21 m depth in the area, and it is likely that this hardcap and the shallower Dales Gorge Member are the units providing the suitable habitat for this species (BHP Billiton Iron Ore 2015d). Habitat mapping has shown hardcap extends from the collection site to beyond of the pit boundary.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Symphyella</i> sp. B03	1	<i>Symphyella</i> sp. B03 is known from a single record within the R Deposit pit. It occurs within the Marra Mamba Formation where hardcap has been identified from 0 to 10 m depth (BHP Billiton Iron Ore, 2015d). Suitable habitat exists in the hardcapped MacLeod Member, which extends to the south of R Deposit. The hardcapped detritals to the north may also provide suitable habitat for this species. <i>Symphyella</i> sp. B03 probably occurs outside R Deposit pit but the limited data for this species (and genus) mean there is uncertainty about the range of the species.	It is <i>uncertain</i> whether this species is restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
?Theridiidae sp. B01	1	Species of Theridiidae have very rarely been collected as troglofauna in the Pilbara (Bennelongia unpublished data), so related species provide little basis for inferring the likely range of ?Theridiidae sp. B01. ?Theridiidae sp. B01 is known from a single record at D Deposit, approximately 120 m from the pit boundary. The collection site is within mapped colluvium and alluvium (detritals of ore, chert and BIF clasts) and Marra Mamba formation (Mount Newman Member and MacLeod Members) (BHP Billiton Iron Ore, 2015d). Suitable habitat within the detritals extends within and to the north of D Deposit and suitable habitat within the Mt Newman and MacLeod Members extends well to the south beyond the proposed mine pit (BHP Billiton Iron Ore, 2015d). While the range characteristics of the Theridiidae family are unknown, its occurrence in widespread colluvium and alluvium suggests the range of ?Theridiidae sp. B01 extends outside the Mining Area C EMP Revision 6 Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.

Taxon	Total Records	Summary of Findings	Predicted Outcome
<i>Troglarmadillo</i> sp. B03	6	Troglarmadillo species in the Pilbara typically have ranges of 2-3 km (Halse and Pearson 2014). By comparison, <i>Troglarmadillo</i> sp. B03 is a wide-ranging species with a linear range of 17 km. The species has been recorded from six drill holes in A Deposit, D Deposit, E Deposit and F Deposit. It occurs within mapped geological units alluvium/ colluvium and martite goethite supergene ore (BHP Billiton Iron Ore, 2015d). The moderately extensive range of the species and its occurrence in alluvium / colluvium at A, D, E and F deposits suggests it makes use of Tertiary detritals as habitat. Hence, <i>Troglarmadillo</i> sp. B03 is also likely to occur within the extensive Tertiary detrital deposits stretching along the valley to the north of the Range, where there has been almost no sampling because of the lack of drill holes.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Troglarmadillo</i> sp. B14	12	Recorded on four occasions from two drill holes at depths corresponding with detritals which extend continuously to the south of the Indicative Additional Impact Assessment Area. The range of these records is 11.2 km. It probably occurs patchily in detritals throughout the Southern Flank ridge, including areas south of the Indicative Additional Impact Assessment Area.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.
<i>Typhlozuphium longipenne</i>	1	<i>Typhlozuphium longipenne</i> is known from a single record occurring within an area of Joffre units that are mostly enriched (Fe >50%) and have hardcap and semi-hardcap alteration from the surface to about 70 m depth (BHP Billiton Iron Ore, 2015d). Limited stratigraphic information is available to the north and south of the mine pit boundary at P2 and P3 Deposits but current resource modelling shows that suitable habitat for troglofauna is present in the Joffre Member to the north of the pit boundaries (BHP Billiton Iron Ore, 2015d). Further, the stratigraphy of P2 Deposit is cross cut by a number of faults and splays that may provide conduits for troglofauna movement to the north of the P2 Deposit mine pit.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Typhlozuphium</i> sp. B03	1	<i>Typhlozuphium</i> sp. B03 is known from a single record in F Deposit. Stratigraphy of the drill hole in which it was collected was not logged but, based on geological mapping, the outcropping unit is colluvium and alluvium (Tertiary detritals). Alluvial and colluvial material extends continuously outside of the F Deposit pit to the west and north (BHP Billiton Iron Ore, 2015d). It is likely that <i>Typhlozuphium</i> sp. B03 occurs only in the vicinity of Mining Area C but, if the species occurs in the Tertiary detritals within the mine pit, it probably also occurs beyond the pit.	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.
<i>Tyrannochthonius</i> 'PSE055'	17	<i>Tyrannochthonius</i> 'PSE055' has been recorded from 12 drill holes and has a linear range of 18.25 km across Mining Area C at Deposits A, F, P4 and P6. It is considered highly likely to occur in similar habitat across and potentially beyond its linear range and therefore is considered unlikely to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area (Bennelongia, 2017).	It is considered <i>unlikely</i> to be restricted to the Mining Area C EMP Revision 6 Impact Assessment Area.

Taxon	Total Records	Summary of Findings	Predicted Outcome
<i>Tyrannochthonius</i> sp. B14	1	Known from one specimen in the Indicative Additional Impact Assessment Area. The genus is typically known from small numbers of specimens, but those with multiple records usually have small ranges (though there are exceptions). The geology from which this species was recorded is unknown; but it is considered likely that it occurs from within the Mt Newman Member which is continuous to the south of the Indicative Additional Impact Assessment Area. Ten other troglafauna species have been recorded from this area indicating it is likely suitable habitat for this species.	It is considered <i>unlikely</i> to be restricted to the Indicative Additional Impact Assessment Area.



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Troglofauna species potentially restricted to the
Indicative Additional Impact Assessment Area and/or the
Mining Area C Rev 6 EMP Impact Assessment Area (or
species whose range outside is considered uncertain)

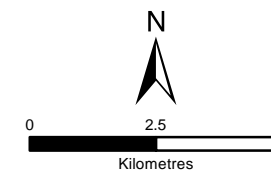
Scale @ A4: 1:150,000	Prepared: M. LYTTLE	Project No: A780/048 REV D
Date: 30/03/2017	Checked: B. BARNETT	Figure: 32
Revision: Rev D	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Current Approved Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area (Other)
- Mining Area C EMP Rev 6 Impact Assessment Area (Pit)

- Indicative Additional Impact Assessment Area (Other)
- Indicative Additional Impact Assessment Area (Pit)
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

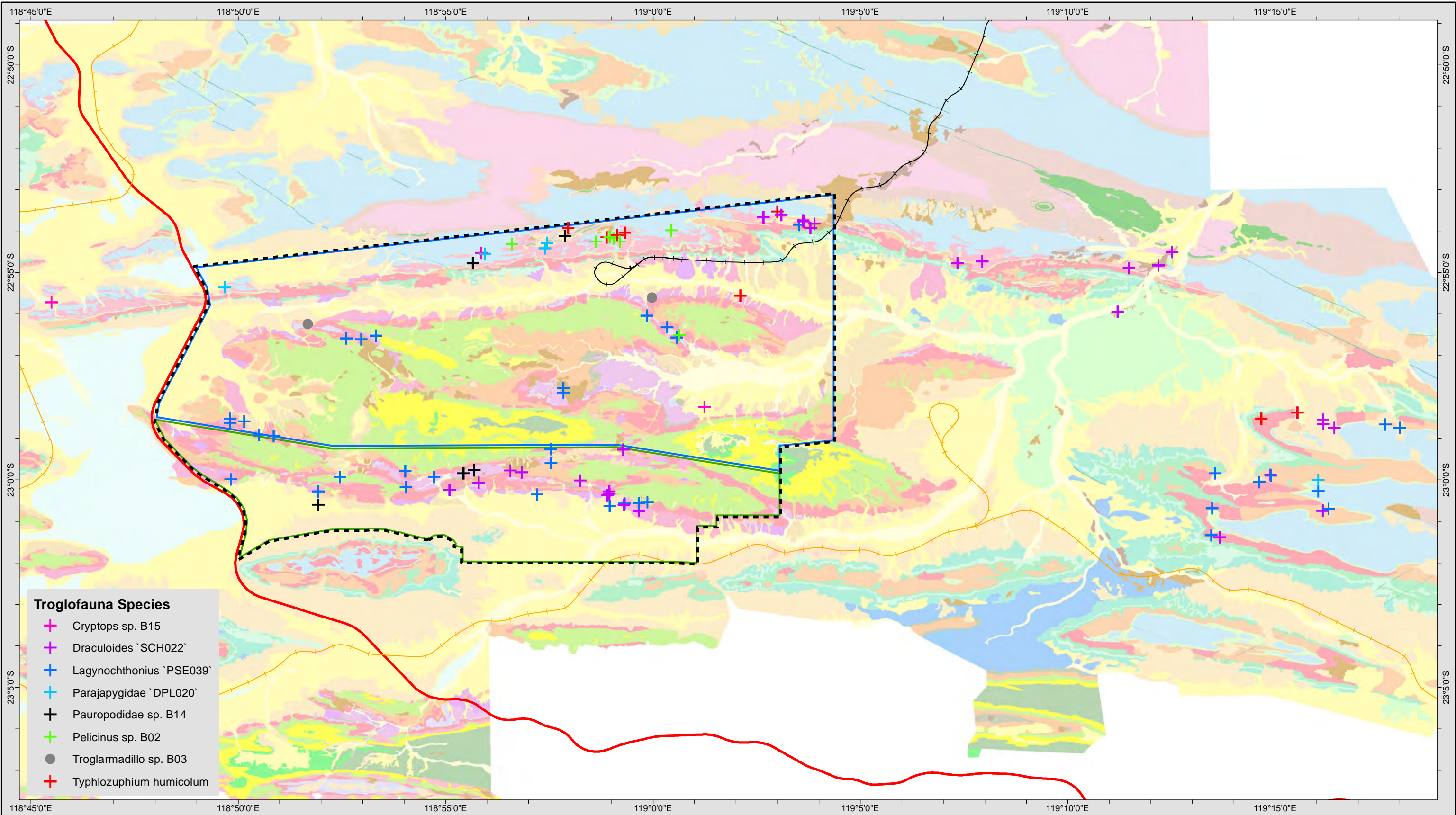
Restricted Troglofauna

- Hanseniella* sp. B08
- Parajapygidae* 'DPL024'
- Parajapygidae* sp. S03
- Philosciidae* sp. B03
- Prethopalpus julianneae*
- Prethopalpus* sp. B15
- Symphyella* sp. B03
- nr *Andricophiloscia* sp. B16



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Troglofauna Species

- ✚ Cryptops sp. B15
- ✚ Draculoides `SCH022`
- ✚ Lagynochthonius `PSE039`
- ✚ Parajapygidae `DPL020`
- ✚ Pauropodidae sp. B14
- ✚ Pelicinus sp. B02
- Trogarmadillo sp. B03
- ✚ Typhlozuphium humicolum



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Widespread surrogate troglofauna in the
Proposed Mining Area C Development Envelope

Scale @ A3: 1:160,000	Prepared: M. LYTTLE	Project No: A780/049 REV A
Date: 30/03/2017	Checked: B. BARNETT	Figure: 33
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Additional Development Envelope
- Current Approved Development Envelope
- 1:20000 Surficial Geology
- AFj - Jeerinah - Shale, chert, mudstone & dolomite
- AFjd - Jeerinah - Dolerite sills
- AFjm - Jeerinah - Roy Hill Shale (marker chert)
- AFjr - Jeerinah - Roy Hill Shale
- AHd - Wittenoom - Unknown Member
- AHda - Wittenoom - West Angela Member
- AHdb - Wittenoom - Bee Gorge Member
- AHdp - Wittenoom - Paraburdoo Member
- AHm - Marra Mamba - MacLeod Member
- AHmn - Marra Mamba - Mt Newman Member
- AHmu - Marra Mamba - Nammuldi Member
- AHr - Mt McRae Shale
- AHs - Mt Sylvia Formation
- CID - Robe - Oolitic channel iron deposit
- Cza - Alluvium (consolidated)
- Czb - Silcrete (indurated)
- Czc - Colluvium & alluvium
- Czcb - Colluvium & alluvium (chert & BIF clasts)
- Czci - Indurated colluvium (Canga)
- Czcm - Colluvium & alluvium (ore, chert & BIF clasts)
- Czco - Colluvium & alluvium (ore clasts)
- Czi - Unknown
- Czk - Calcrete
- Czl - Ferricrete (laterite)
- Czm - Oakover - Micritic lacustrine limestone
- Czp - Playa deposits
- Czpi - Consolidated ferruginous pisolites
- Czci - Indurated Czc / Czcb
- H1 - Martite (microplaty haematite)
- H2 - Martite goethitic supergene ore (ochereous)
- H2/PHbj - Martite goethitic supergene ore (ochereous)
- H2/PHbw - Martite goethitic supergene ore (ochereous)
- H2/PHhd - Martite goethitic supergene ore (ochereous)
- PHbd - Brockman - Dales Gorge (BIF & Shale)
- PHbj - Brockman - Joffre (BIF with chert & shale)
- PHbw - Brockman - Mt Whaleback Shale
- PHby - Brockman - Yandicoogina Shale
- PHj - Weeli Wolli - BIF
- PKd - Dolerite sills
- Pd - Dolerite dykes
- Pdd - Dolerite dykes
- Pds - Weeli Wolli - Dolerite sills
- Qa - Alluvium (drainage channels) - unconsolidated silt, sand and gravel
- Qc - Talus & colluvium
- Tmco - Alluvial haematite (red ochre detritals)

— BHP Billiton Rail
— Rio Tinto Rail
— Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 5 10
Kilometres

Coordinate System: GCS GDA 1994
Datum: GDA 1994

Numerous dolerite intrusives have been mapped throughout the Mining Area C region (BHP Billiton Iron Ore, 2015d). Dolerite sills intrude the Weeli Wolli Formation and the Yandicoogina Shale Member in the Mining Area C region. They can be seen outcropping in some northern areas of the Packsaddle Range and directly to the north of these areas. Thickness of the sills range from 10 cm to over 100 m with the thicker sills being better exposed due to less weathering and alteration. The troglofauna habitat assessment (BHP Billiton Iron Ore, 2015d) found that the suite of post-tectonic cross-cutting dolerite dykes observed in the Mining Area C region is highly weathered and friable. Major dykes trending in a north-west south-east direction occur between the boundaries of a number of the deposits. The troglofauna habitat assessment determined that at least one of these dykes is unlikely to represent a barrier to movement for troglofauna due its weathered nature, with the species (*Draculoides* sp. SCH012) occurring on both sides of the dyke (BHP Billiton Iron Ore, 2015d).

As modification of the Indicative Additional Impact Assessment Area (see Section 11.3.4) did not avoid impacts to all troglofauna species *possibly* restricted to the proposed areas of impact (pits and buffers) a further assessment (Bennelongia, 2017; Appendix 6) was undertaken using information from an updated habitat assessment for each of the five potentially impacted species that focussed on the proposed pit areas as the primary area of impact (BHP Billiton Iron Ore, 2016h). The updated habitat assessment utilised updated imagery obtained using an optical televiewer (OTV) and development of a 3D habitat model for each species using Leapfrog™ geological modelling software. The revised impact assessment (Bennelongia, 2017) used the data from the habitat assessment as a surrogate approach to impact assessment. This approach is consistent with the EPA's (2013d) Environmental Assessment Guideline.

The revised impact assessment concluded that habitat for three troglofauna species (*Prethopalpus juliannae*, Philosciidae sp. B03 and nr *Andricophiloscia* sp. B16) occurs outside the current pit shell footprint, and for one of these species (nr *Andricophiloscia* sp. B16) habitat also occurs outside of the pit buffer. It is uncertain if habitat for *P. juliannae* also occurs outside the pit buffer.

As all five potentially impacted species are known from a single drill hole (and all but one from a single animal) it is difficult to determine habitat from which the animal occurs. Therefore there remains some uncertainty about the likelihood of habitat occurring outside the pit shell (and buffer) for the remaining two species (i.e. *Prethopalpus* sp. B15 and Parajapygidae 'DPL024') as this is contingent on the type of habitat being used by the species. It is also noted that there is scientific uncertainty as to whether Parajapygidae 'DPL024' is a troglobite or a troglophile; if it is the latter it is considered very unlikely to be restricted to areas of impact.

A summary of information on the likely ranges of the five potentially restricted species is presented in Table 48.

Table 48: Summary of information on likely ranges of the five potentially restricted troglofauna species

Species	Habitat Present Outside	
	Pit Shell	Pit Buffer
<i>Prethopalpus</i> sp. B15	Yes if species occurs in detritals otherwise uncertain	Yes if species occurs in detritals otherwise uncertain
<i>Prethopalpus juliannae</i>	Yes	Uncertain
Philosciidae sp. B03	Yes	Yes
nr <i>Andricophiloscia</i> sp. B16	Yes	Yes
Parajapygidae 'DPL024'	Yes if species occurs in detritals otherwise uncertain	Yes if species occurs in detritals otherwise uncertain

This further assessment of habitat availability for these five species has resulted in the reduction of potential impacts to troglofauna species. The impact and habitat assessments have resulted in six species of troglofauna with an *uncertain* impact from a total of 126 species within the Proposed Mining Area C Development Envelope. This potential impact is not considered significant.

11.3.3.7.3 Stygofauna species

Impact assessments for stygofauna were undertaken by Bennelongia (2015b, 2016b) and are provided in Appendix 6. Key findings are provided below.

For the purposes of the impact assessment, the Groundwater Assessment Area was considered to be all areas modelled with a groundwater drawdown of 2 m or greater that have not previously been assessed under MS 491. The groundwater model considered cumulative impacts from existing operations at Mining Area C and Hope Downs in addition to those predicted for the additional impacts from the Proposal. In the Pilbara, a modelled drawdown of 2 m or greater is considered to have the potential to impact on stygofauna because it represents the point where the scale of anthropogenic change exceeds the extent of natural fluctuations in baseline groundwater levels. Pre-drawdown conditions are represented by a single value in the modelling, rather than a consideration of the range of natural groundwater fluctuations. For the purposes of this impact assessment, a conservative approach has been adopted that assumes that any drawdown greater than 2 m will result in complete removal of 100% stygofauna habitat from this area, in reality this may not be the case.

Potential impacts to stygofauna from the Proposal are:

- Direct impacts – due to removal of habitat through pit excavation and groundwater drawdown; and
- Indirect impacts – from reduced habitat quality, including water quality changes, changed habitat structure, reduced energy sources, or ingress of pollutants (see Humphreys [2009]). It is considered that reduced habitat quality is more likely to result in lowered animal densities rather than to threaten species persistence.

The considerable extent and habitat connectivity of the alluvial aquifers (and to a lesser extent the calcrete deposits) of the Tertiary detrital valley-fill successions in the Weeli Wolli and Coondewanna subcatchments probably provide for easy dispersal of stygofauna species between areas of groundwater drawdown and surrounding aquifers. A number of taxa (amphipods and isopods) occur both in the Groundwater Assessment Area and the Mining Area C EMP Revision 6 Groundwater Assessment area and in surrounding catchments. This suggests there are few, if any, physical barriers to restrict the wider ranges of species occurring in the cumulative groundwater drawdown areas.

Of the 53 species recorded in the cumulative Groundwater Assessment Areas, ten species are known only from areas of cumulative groundwater drawdown (i.e. the Groundwater Assessment Area, the Mining Area C EMP Revision 6 Groundwater Assessment Area or both areas). Four species (the worm *Ainudrilus* sp. WA26 (PSS), mite Halacaridae sp. B01, copepod *Schizopera* sp. B02, and syncarid *Bathynella* sp. 1) have been recorded within the vicinity of Weeli Wolli Spring (Figure 34). Given that habitat connectivity along Weeli Wolli Creek is likely to be high for all stygofaunal species, the potential conservation threat to all four species is considered to be low.

Four individuals of the syncarid *Notobathynella* sp. have been recorded; two from a bore within the Mining Area C EMP Revision 6 Groundwater Assessment Area and two from a bore 13.4 km away within the Groundwater Assessment Area (Figure 34). It is unclear whether the specimens in the two locations are the same or separate species; however as both bores are within 1.5 km of the edge of the Groundwater Assessment Area or Mining Area C EMP Revision 6 Groundwater Assessment Area and

there appears to be no hydrological barrier preventing the species' range(s) from extending eastwards or southwards into areas of no impact, the conservation threat to *Notobathynella* sp. is considered to be low irrespective of whether the specimens belong to one or two species.

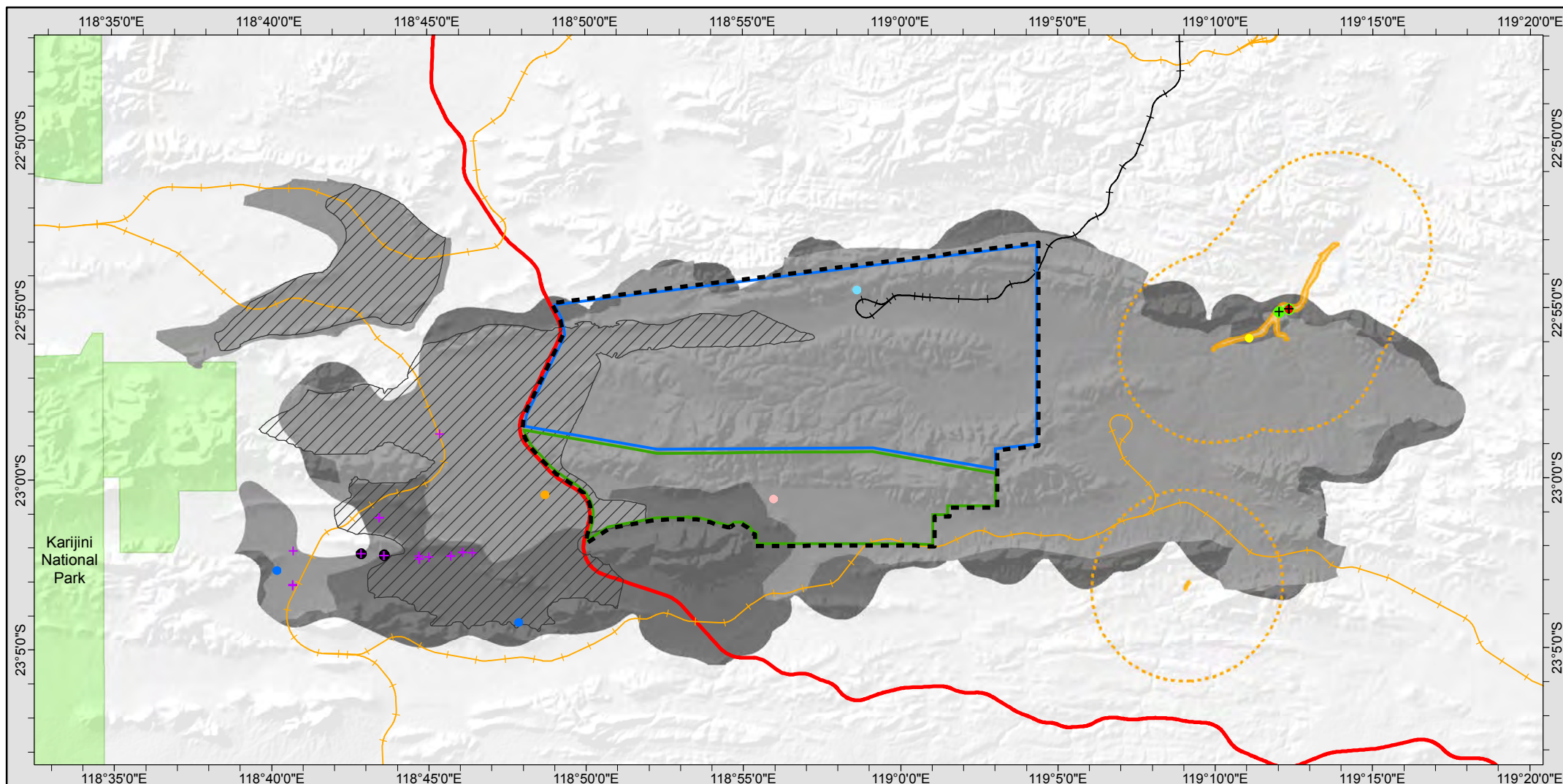
Eighty-seven individuals of *Paramelitidae* sp. S04 (BR South) have been recorded in 21 samples from 13 drill holes with a linear range of approximately 11 km. While there is no hydrological barrier, such as a dyke, to prevent a broad western extension of the range of *Paramelitidae* sp. S04 (BR South), the depth to groundwater increases in the west (Figure 34) and the effect of greater depth on the suitability of habitat for *Paramelitidae* sp. S04 (BR South) is unknown. However, locally *Paramelitidae* sp. S04 (BR South) is certain to occur outside the Groundwater Assessment Area on the western side of bore EXR0733. This bore is located only 5 m within the Groundwater Assessment Area. While there are no figures on the size of home ranges of stygofauna species within an aquifer, the ranges of larger, active stygofauna species such as amphipods are likely to extend over distances of at least several metres. On this basis, the animal collected from bore EXR0733 may itself have been partially occupying the habitat outside the Groundwater Assessment Area.

The habitat to the west of bore EXR0733 is hydrogeologically the same as that around the bore. It also provides habitat for *Paramelitidae* sp. S04 (BR South) as illustrated by the collection of another individual of *Paramelitidae* sp. S04 (BR South) approximately 4 km west at bore AN0119R (once again inside the Groundwater Assessment Area by 280 m) (Figure 34). A conservative interpretation is that the 4 km of habitat outside the Groundwater Assessment Area that lies between the two records must form part of the range of *Paramelitidae* sp. S04 (BR South).

Given the strong evidence that the distribution of *Paramelitidae* sp. S04 (BR South) extends outside the Groundwater Assessment Area, the conservation threat to the species from groundwater drawdown associated with the Proposal is considered to be low.

Four species, the copepods nr *Epactophanes* sp. B01 and *Dussartcyclops* sp. B10, and the syncarids nr *Notobathynella* sp. S01 and *Bathynella* sp. 2, have only been recorded within the Mining Area C EMP Revision 6 Groundwater Assessment Area. In assessing whether groundwater drawdown is likely to threaten the conservation status of these four species, it was recognised that the ranges of the species are likely to have been underestimated because of the low numbers of records of three of the four species. While habitat connectivity appears to be high throughout the Mining Area C EMP Revision 6 Groundwater Assessment Area, the ranges of nr *Epactophanes* sp. B01, *Bathynella* sp. 2 and *Dussartcyclops* sp. B10 are unclear because of their occurrence as a singleton or from a single location respectively, therefore the potential threat to these species is uncertain.

nr *Epactophanes* sp. B01 is known from a single specimen along the northern edge of the Groundwater Assessment Area (Figure 34). The specimen was dissected and slide-mounted for identification, so genetic analysis is not possible. It belongs to the harpacticoid family Canthocamptidae, which is commonly collected as stygofauna in the Pilbara (Karanovic 2006; Halse *et al.* 2014). Some canthocamptid species have been observed to have considerable ranges (tens of kilometres), while others appear to have tightly restricted distributions (<5 km). While there is evidence of broad habitat connectivity for species of amphipod between the collecting site and the Marillana Creek catchment to the north (at least five species of amphipod or isopod occur within both catchments; see Appendix 6), the range of nr *Epactophanes* sp. B01 may be determined by intrinsic characteristics of the species, water chemistry or other factors. The record of this species occurs approximately 1.5 km from the Groundwater Assessment Area, and it is noted that updated modelling has reduced this distance from that modelled for the Mining Area C EMP Revision 6 Groundwater Assessment Area. The potential impacts to nr *Epactophanes* sp. B01 are unclear because of their occurrence as a singleton, therefore the potential threat to these species is uncertain.



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Stygofauna species potentially restricted
to the cumulative Groundwater Assessment Areas

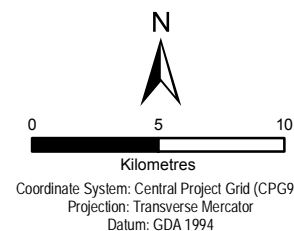
Scale @ A4: 1:300,000	Prepared: M. LYTTLE	Project No: A780/050 REVA
Date: 30/03/2017	Checked: B. BARNETT	Figure: 34
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development
- Current Approved Development
- Additional Development Envelope
- Groundwater Assessment Area
- Mining Area C EMP Rev 6 Groundwater Assessment Area
- Weeli Wolli Priority Ecological Community - Boundary
- Weeli Wolli Priority Ecological Community - Buffer
- Karijini National Park
- Area of Mounding ≥ 2 metres
- Great Northern Highway
- BHP Billiton Rail
- Rio Tinto Rail

Potentially Restricted Stygofauna

- Ainudrilus* sp. WA26 (PSS)
- Bathynella* sp. 1
- Bathynella* sp. 2
- Dussarticyclops* sp. B10
- Halacaridae* sp. B01
- Notobathynella* sp.
- Paramelitidae* sp. S04 (BR South)
- Schizopera* sp. B02
- nr *Epactophanes* sp. B01
- nr *Notobathynella* sp. S01

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Dussartcyclops sp. B10 is known from three specimens from one drill-hole (Figure 34). It belongs to the family Cyclopidae, which is very commonly collected as stygofauna in the Pilbara (Karanovic 2006; Halse *et al.* 2014). The genus *Dussartcyclops* has been collected a number of times in the Pilbara, with *Dussartcyclops mortoni* having a range of 12 km and *Dussartcyclops* sp. B11 having a range of 16 km, while other species appear to have more tightly restricted distributions. Despite some evidence of habitat connectivity between the collection site and other parts of the Coondewanna catchment, the likely range of *Dussartcyclops* sp. B10 is currently unclear and whether the proposed development poses a threat to the species is unknown.

At the time of assessment for the Mining Area C EMP Revision 6, a record of nr *Notobathynella* sp. S01 was recorded only 77 m from the edge of the Mining Area C EMP Revision 6 Groundwater Assessment Area and its range was considered to almost certainly extend into areas unlikely to be impacted. Consequently, the level of threat to nr *Notobathynella* sp. S01 was assessed as low (Bennelongia, 2016a). A subsequent revision of the groundwater model (2016) shows that one record of nr *Notobathynella* sp. S01 occurs within 5 m of the edge of the Groundwater Assessment Area, and therefore the level of threat to this species remains low.

Bathynella sp. 2 is known from four animals collected as by-catch in a troglotauna net scrape from one drill-hole at Southern Flank (Figure 34). It belongs to the order Syncarida that are a common element of stygal communities worldwide and are frequently collected during stygofauna surveys in Australia. Some Western Australian species of the family Parabathynellidae have been studied both genetically (Abrams *et al.* 2012; Guzik *et al.* 2008) and taxonomically (e.g. Cho and Humphreys, 2010; Cho *et al.* 2005). Some species of the family Bathynellidae in the Pilbara (to which the genus *Bathynella* belongs) are currently the subject of a PhD study by Guilia Perina (see Perina *et al.* 2016). The available data indicate there is high diversity of *Bathynella* species and that ranges are typically short. *Bathynella* sp. 2 was collected in the Mining Area C EMP Revision 6 Groundwater Assessment Area at Southern Flank and is treated as separate species from *Bathynella* sp. 1 recorded at Weeli Wolli in the Groundwater Assessment Area because they are 27 km apart (although they are both genus level identifications). If the range of *Bathynella* sp. 2 extends >5.4 km southwards it would occur outside the cumulative drawdown area. The animal was collected from a dry drill-hole in 2016 that sits in a flood plain between Southern Flank and Mt Robinson that extends to the west, east and south. With only one record the likely range of *Bathynella* sp. 2 is unknown and it is uncertain how this species may be impacted by the Proposal.

Note that there are inherent scientific limitations in undertaking an assessment of impacts to stygofauna species generally within the areas of impact as discussed in Section 11.3.3.6. Notwithstanding these, BHP Billiton Iron Ore has considered all available data and ecological knowledge of stygofauna species and is therefore confident that the impact assessments undertaken are robust.

Based on the fact that of the 53 stygofauna species located in the groundwater assessment areas the impact to all but three species (whose impact is uncertain due to lack of scientific knowledge of the species) is low, it is considered that the impact to stygofauna species as a result of the Proposal is not significant and no further mitigation or offsets are required.

11.3.3.7.4 Stygofauna habitats

Maximum drawdown footprints have been used to assess potential impacts to stygofauna within the assessment area. The 2 m contour line was used as a precautionary threshold for impact as it was considered that drawdown of greater than 2 m may pose a potential risk to stygofauna species, although this risk is dependent on species mobility and the extent of suitable deeper habitat in which the species may persist.

Suitable habitat for stygofauna is hosted below water table within the enriched units of the Marra Mamba Iron Formation, West Angela units of the Wittenoom Formation, calcrete aquifers around Weeli Wolli Spring and the Tertiary Detritals. Sections of these habitats inside the 2 m footprint will be dewatered with changes closer to mining operations being greater but changes to water table will reduce with distance. Some sections of habitat close to orebodies with significant below water table resources are likely to be dewatered completely but the extent of dewatering is difficult to estimate for aquifers further away as total aquifer thickness is hard to define. Large areas of habitat remain outside the impact footprint including tertiary detritals in valleys to the south and west of South Flank, calcrete aquifers downstream of Weeli Wolli Spring and aquifers associated with Ben's Oasis.

Tertiary detritals can range from coarse sand and gravels with abundant pore space through to clay rich layers with microscopic voids and low habitat availability. Similarly calcretes can range from vuggy material with significant pore space to crystalline deposits with very little pore space. Connection between voids in calcretes is variable and can be created during formation or by chemical dissolution post-deposition.

Mapping of widespread surrogate stygofauna within the Upper Weeli Wolli and Coondewanna catchments suggests that there are few barriers to movement for stygofauna (Figure 35).

Note that there are inherent scientific limitations in undertaking an assessment of impacts to stygofauna habitats generally within the areas of impacts as discussed in Section 11.3.3.6. Notwithstanding these, BHP Billiton Iron Ore has made consideration of all available data and knowledge of stygofauna habitats and is therefore confident that the impact assessments undertaken are robust.

As suitable habitat for stygofauna remains outside of the Proposed Mining Area C Development Envelope and Groundwater Assessment Area the impact to stygofauna habitat is not considered significant.

11.3.3.8 Indirect impacts

11.3.3.8.1 Troglofauna

Current scientific knowledge of indirect impacts on troglofauna as a results of mining and associated activities is limited. Factors potentially reducing habitat quality and which will therefore have an indirect impact on troglofauna include changed habitat structure, reduced energy sources, ingress of pollutants and reduced humidity. Bennelongia (2016a) considered it likely that these factors would reduce animal densities rather than threaten species persistence, and therefore none of the below impacts are considered significant to troglofauna. Possible consequences of likely factors are (Bennelongia, 2016a):

(1) Percussion from blasting. Blasting may have indirect effects on troglofauna through reducing or altering underground structure (usually via rock fragmentation and collapse of voids). It is also possible that blast impacts could detrimentally affect some troglofauna directly through concussion. However, both types of effects are likely to dissipate rapidly with distance from the pit and blasting is not considered here as a significant impacting activity beyond the pit boundary.

(2) Overburden stockpiles and waste dumps. These artificial landforms may reduce inputs of nutrients and dissolved organic matter to subterranean habitats as a result of reduced organic matter on the surface and perhaps reduced rainfall recharge. Rainfall may sometimes run off stockpiles rather than infiltrating through them. While stockpiles and dumps may create a shadow of reduced energy and nutrient sources, this may reduce the quality of habitat. Tree roots, which may provide an important source of energy and nutrients to troglofauna, are removed by all forms of land clearing. These indirect impacts may reduce the quality of habitat but are not considered here as a significant impacting activity for the Proposal.

(3) Contamination of landforms by hydrocarbons. Any contamination is likely to be localised and minimised by engineering and management practices for the containment of hydrocarbon products. It is not considered a likely risk to troglofauna.

(4) Lowering the watertable in the vicinity of the mine pits. Lower water tables are sometimes thought to have the potential to impact on troglofauna by altering humidity. The humidity requirements of troglofauna have rarely been studied. While it has been stated that some cave species may persist at humidity greater than about 80% (Humphreys, 1990), species in the landscape matrix are more likely to require humidity of very close to 100% (Howarth, 1980; Hadley *et al.*, 1981). While pit excavation can cause drying of habitat through the walls of the pit, in most situations dewatering below an undisturbed surface probably has little effect on humidity at depth. Therefore, this aspect is unlikely to result in a significant impact to troglofauna.

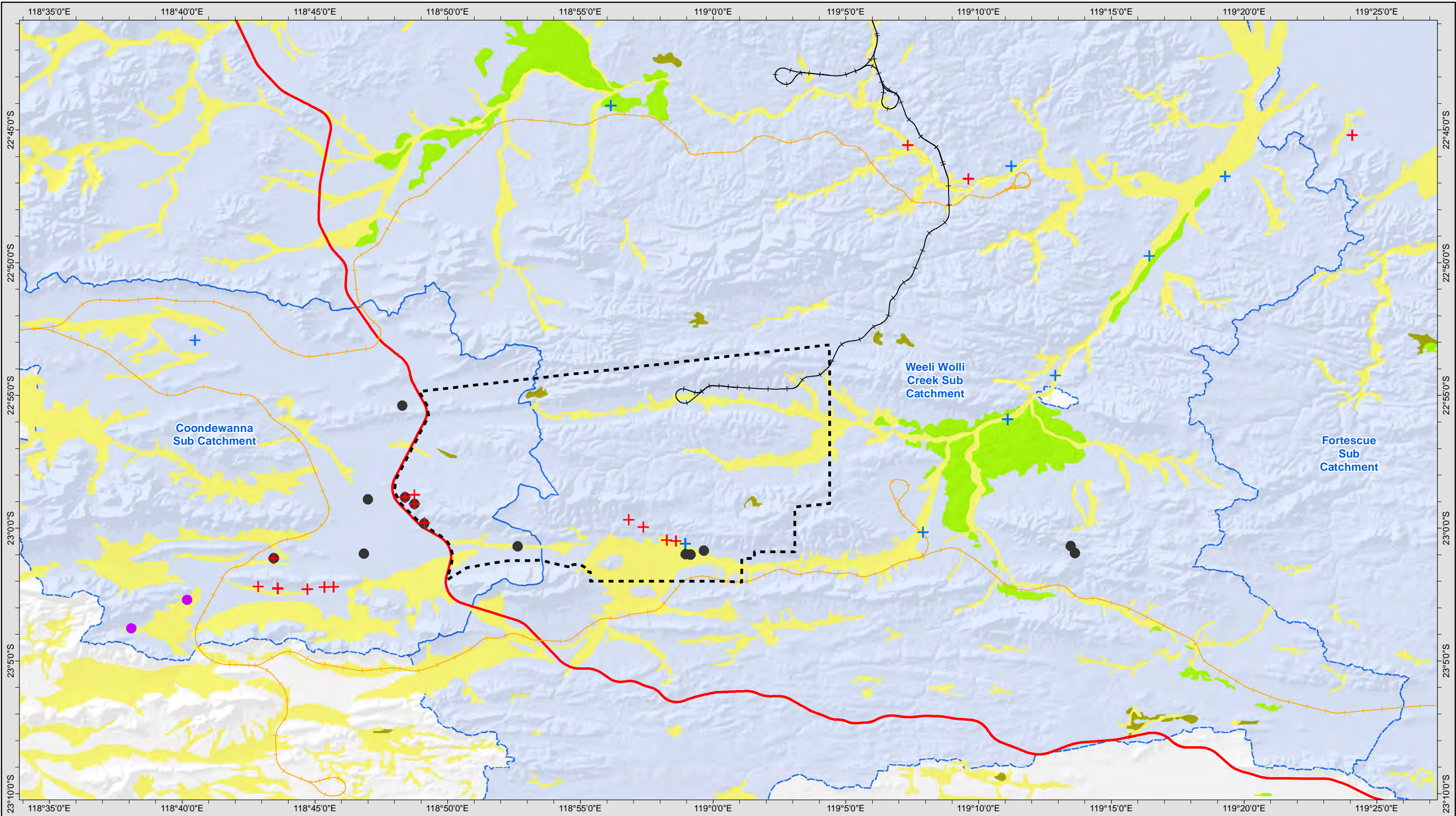
11.3.3.8.1 Stygofauna


Current scientific knowledge of indirect impacts of reduced habitat quality, rather than direct habitat removal as a results of mining and associated activities is limited. Factors potentially reducing habitat quality include water quality changes, changed habitat structure, reduced energy sources, or ingress of pollutants (see Humphreys, 2009). Bennelongia (2016d) considered that reduced habitat quality is more likely to result in lowered animal densities than to threaten species persistence and therefore none of the below impacts are considered significant to stygofauna. Possible consequences of likely factors are (Bennelongia, 2016d):

(1) Water quality changes. In most situations, water quality changes occupy relatively small areas (Rösner, 1998; Zhu *et al.*, 2001), although increases in groundwater salinity may be more extensive (Commander *et al.*, 1994; Sharma and Al-Busaidi, 2001) and salinity changes may potentially threaten some species in the Pilbara, where stygofauna occur mostly in fresh water (<1,000 mg/L). The tolerance of stygofauna species in the Groundwater Assessment Area to increased salinity is unknown but based on surface studies it is likely that overall stygofauna species richness will decline sharply if groundwater salinity reaches 2,000 mg/L (Pinder *et al.*, 2010). Changes of this magnitude have been observed in parts of the Pilbara as a result of mining (Commander *et al.*, 1994). It is not predicted that implementation of the Proposal will results in changes to salinity of groundwater and therefore the potential impact to stygofauna habitat as a result of water quality changes is considered very low.

(2) Percussion from blasting. Blasting may have a direct effect on stygofauna through percussion and indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and causing transient increases in groundwater turbidity. Subterranean fauna have been collected adjacent to areas where blasting is occurring regularly, suggesting that impacts are experienced only over short distances and are unlikely to be significant.

(3) Overburden stockpiles and waste dumps. These artificial landforms may cause localised reduction in rainfall recharge and associated entry of dissolved organic matter and nutrients. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are unlikely to significantly impact on stygofauna as lateral movement of groundwater should bring in carbon and nutrients. These indirect impacts may reduce the quality of habitat but are not considered here as a significant impacting activity for the Proposal.





Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Widespread surrogate stygofauna in the Upper Weeli Wolli and Coondewanna subcatchments


Scale @ A3: 1:250,000	Prepared: M. LYTTLE	Project No: A780/051 REV A
Date: 30/03/2017	Checked: B. BARNETT	Figure: 35
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Stygofauna Species**
- Australocamptus sp.
 - + Maarrka weeliwollii
 - Paramelitidae sp. B03
 - nr Billibathynella sp. B02
 - + (=Parabathynellidae sp. S03)

- ▬ Proposed Mining Area C Development Envelope
- ▬ WA Hydrographic Subcatchment

- Alluvium - unconsolidated silt, sand and gravel
- Colluvium - unconsolidated quartz and rock fragments in soil
- Calcrete - sheet carbonate usually formed in major drainage lines
- + BHP Billiton Rail
- + Rio Tinto Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



0 5 10
Kilometres

Coordinate System: GCS GDA 1994
Datum: GDA 1994

(4) Aquifer recharge from run-off over disturbed ground. Quality of recharged water within mine sites is often poor because of rock break-up and soil disturbance (e.g. Gajowiec, 1993; McAuley and Kozar, 2006). Impacts will be minimised through management of surface water and installing drainage channels, sumps and pump in the pit to prevent recharge through the pit floor. While poor quality of recharge water may reduce population densities, it is unlikely to affect species persistence and is therefore not considered significant for this Proposal.

(5) Contamination of groundwater by hydrocarbons. Any contamination is likely to be localised and will be minimised by engineering and management practices to ensure the containment of hydrocarbon products. Therefore the potential impacts are not considered significant for this Proposal.

11.3.3.9 Cumulative impacts

None of the species identified within the Proposed Mining Area C Development Envelope have been identified within the Rio Tinto's adjacent Baby Hope project area, although there is almost certainly a continuation of the communities in Southern Flank into this area. The lack of taxonomic consistency between adjacent tenements is likely due to the fact that a majority of species recorded within the Pilbara are undescribed and a taxonomic database for undescribed troglotauna species in Western Australia, such as would be provided by WAMinals (see limitations at the start of Section 11.3.3.6) is largely incomplete. Therefore if the same species is collected by different consultancies it is usually given different informal names.

Impacts to stygofauna presented in Sections 11.3.3.7.3 and 11.3.3.9.1 have considered cumulative impacts associated with approved mining operations at Mining Area C and Rio Tinto's Hope Downs operations - the only mining operations currently operating within the subcatchment. It is noted that the Groundwater Assessment Area has been determined from groundwater drawdown modelling using information available to BHP Billiton Iron Ore in the public domain.

Therefore the conclusions with respect to potential cumulative impacts to troglotauna and stygofauna are consistent with those presented in Section 11.3.3.6.

11.3.3.9.1 Weeli Wolli Spring PEC

A hydrological impact assessment has been undertaken that considers likely impacts to Weeli Wolli Spring based on dewatering associated with the Proposal and cumulative operations within the subcatchment. This document is provided in Appendix 7, and key outcomes relevant to stygofauna outlined below.

Groundwater drawdown associated with the Proposal is not expected to exceed 1 m at Weeli Wolli Spring; dewatering at Southern Flank is predicted to contribute between 0.2 and 0.5 m drawdown at Weeli Wolli in 2054, which is modelled to occur following the end of aquifer replenishment and mitigation actions at Hope Downs (BHP Billiton Iron Ore, 2016l).

Cumulative groundwater drawdown from dewatering activities shows a more significant change, whereby water levels in the Weeli Wolli Spring area will be lowered within a range of 3 to 14 m. This is primarily associated with abstraction from Hope Downs. The timing and success of Hope Downs closure plans to recover groundwater levels will also influence the water level and potential for a continued impact at Weeli Wolli Spring.

Following closure of Hope Downs the combined cumulative impacts show a range of 1 – 2.5 m of maximum drawdown at 2054 with a median drawdown of 1.75 m which are similar to the previously assessed change of 1.6 m (BHP Billiton Iron Ore, 2016l). This drawdown is less than 2 m, which is considered to be the level of change considered likely to impact on stygofauna. As a precaution, the

CPWRMP outlines a number of management measures and mitigation options that can be used as part of BHP Billiton Iron Ore's adaptive management to ensure that potential impacts to stygofauna resulting from drawdown are minimised. Management measures include, but are not limited to, managed aquifer recharge or infiltration basins.

Habitat connectivity along Weeli Wolli Creek is likely to be high for all stygofaunal species (Bennelongia, 2016b), and there are a number of species that occur in both Weeli Wolli Creek and Marillana Creek (e.g. *Meridiescandona marillanae*). Whilst the revised groundwater model shows a slight increase in the area of calcrete potentially impacted by cumulative operations within the subcatchment, the conservation values of individual stygofauna species occurring in the PEC are unlikely to be threatened because of the existence of abundant stygofauna habitat downstream.

No groundwater drawdown is anticipated at the Ben's Oasis component of the Weeli Wolli Spring PEC as a result of dewatering from the Proposal or cumulative drawdown within the Upper Weeli Wolli subcatchment.

The potential impacts to subterranean fauna based on the predicted changes to the Weeli Wolli Spring PEC, as discussed above, are not considered significant.

11.3.4 Mitigation and residual impacts

BHP Billiton Iron Ore has carried out a review of the Western Australian Government's 'Mitigation Process', which is detailed in Section 3 of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014). The four steps are:

- avoid;
- minimise;
- rehabilitate; and
- offset.

Following consideration of all data gathered during baseline surveys, additional targeted surveys and the outcomes of EIAs, BHP Billiton Iron Ore has revised its indicative Proposal designs to ensure that these designs address the first two steps of the Mitigation Process, i.e. the designs have 'avoided' or 'minimised' the impact on subterranean fauna as far as reasonably practicable.

The initial impact assessment undertaken for troglofauna (Bennelongia, 2016a) identified a number of species that may be restricted to pit areas associated with the Proposal. A review of this assessment area was undertaken and a Modified Indicative Additional Impact Assessment Area developed for Southern Flank, in accordance with the steps outlined in the Mitigation Process (Government of Western Australia, 2014). As a result, there are seven fewer troglofauna species potentially restricted to the Modified Indicative Additional Impact Assessment Area (Bennelongia, 2016e). The modification does include three new species, but all are considered *unlikely* to be restricted to habitats within the Modified Indicative Additional Impact Assessment Area. Four species remained possibly restricted under both scenarios and for one species there is limited information to assess if this modification will reduce impacts; this species remains as *uncertain*. Further work was undertaken with respect to habitat for these five species (Section 11.3.3.7.2). This work concluded that the impact to three species remained uncertain. The modification does not alter the outcomes for those species that occur in the Mining Area C EMP Revision 6 Impact Assessment Area. A summary of the changes to the impact assessment is provided in Table 49 and actions taken to reduce the impacts of the Proposal on subterranean fauna are summarised in Table 50.

Table 49: Summary of troglofauna species only recorded within Indicative Additional Impact Assessment Areas

Species *uncertain* are shown in bold.

Higher Group Species	Assessed IAIAA	Modified IAIAA	No. of Animals	No. of Holes	Likely Range (km)	Restriction Category
Arachnida						
Pseudoscorpiones						
<i>Indohya</i> 'PSE005'	x	x	9	9	21	Unlikely
<i>Tyrannochthonius</i> sp. B14	x	x	1	1	-	Unlikely
Schizomida						
<i>Draculoides</i> sp. B20	x	x	4	4	10.0	Unlikely
<i>Draculoides</i> sp. B59-DNA	x		2	1	-	Unlikely
<i>Draculoides</i> sp. B32		x	4	1	-	Unlikely
Araneae						
?Gnaphosidae sp. B01		x	1	1	-	Unlikely
<i>Prethopalpus julianneae</i>	x	x	1	1	-	Uncertain
<i>Prethopalpus maini</i>	x		5	5	17.8	Unlikely
<i>Prethopalpus</i> sp. B15	x	x	1	1	-	Uncertain
<i>Prethopalpus</i> sp. B24	x	x	1	1	-	Unlikely
Malacostraca						
Isopoda						
nr <i>Andricophiloscia</i> sp. B16	x	x	1	1	-	Unlikely
<i>Philosciidae</i> sp. B03	x	x	17	1	-	Unlikely
<i>Philosciidae</i> sp. B15	x	x	1	1	-	Unlikely
<i>Troglarmadillo</i> sp. B14	x	x	12	2	11.2	Unlikely
Symphyla						
Cephalostigmata						
<i>Australoschendyla</i> sp. B06	x		2	2	6.6	Unlikely
<i>Chilenophilidae</i> sp. B07	x		1	1	-	Unlikely
<i>Hanseniella</i> sp. B07	x	x	7	5	24.1	Unlikely
<i>Hanseniella</i> sp. B34	x	x	1	1	-	Unlikely
Entognatha						
Diplura						
<i>Japygidae</i> 'DPL005'	x		2	2	14.5	Unlikely
<i>Japygidae</i> 'DPL007'	x		3	2	5.7	Unlikely
<i>Parajapygidae</i> 'DPL023'	x	x	2	2	3.1	Unlikely
<i>Parajapygidae</i> 'DPL024'	x	x	1	1	-	Uncertain
<i>Parajapygidae</i> sp. B25	x		1	1	-	Unlikely
Insecta						
Coleoptera						
nr <i>Claviger</i> sp. B01		x	1	1	-	Unlikely
TOTAL	21	17				

Table 50: Actions taken to reduce impacts to subterranean fauna

Action Taken	Step in the 'Mitigation Process'	Reduction in Impact
Modification of Indicative Additional Impact Assessment Area	Avoid	Modification of the Indicative Additional Impact Assessment Area has: <ul style="list-style-type: none"> reduced the number of potentially restricted species by seven; one species of uncertain status has been removed from potential disturbance areas; three species added to the Modified Indicative Additional Impact Assessment Area, but all are considered <i>unlikely</i> to be restricted to habitats within it.
Retention of potential troglofauna habitat suitable for six uncertain species outside pit shells	Minimise	Minimise impacts to habitats considered to be potentially suitable for potentially restricted troglofauna.

Following application of the mitigation hierarchy and actions above, BHP Billiton Iron Ore have concluded that the residual impacts are not significant and therefore the application of offsets is not warranted for this factor.

However, BHP Billiton Iron Ore will continue to support continued research into subterranean fauna habitats and taxonomy to increase understanding of subterranean species and their distribution in the Pilbara. These studies may include environmental DNA studies and taxonomic study of Diplurans.

11.3.5 Proposed management approach

11.3.5.1 Internal management approach

The proposed management provisions for subterranean (troglofauna) fauna are outlined in Table 51. The proposed management provisions in relation to interface of stygofauna and hydrological processes are outlined in Table 57 and Table 58. These include management actions, monitoring and reporting details and trigger criteria and response actions where relevant. It is proposed that these management provisions will be formalised through regulation of an Environmental Management Plan via the Ministerial Statement and the BHP Billiton Iron Ore's standard Pilbara-wide Health, Safety and Environment system. A draft of the management plan, which includes the management provisions outlined in Table 51, is located in Appendix 3.

11.3.5.2 Regulatory management

Impacts to subterranean fauna will be managed via an environmental management plan regulated by the MS.

Table 51: Draft Proposed Environmental Management Plan Provisions – Subterranean Fauna (troglofauna)

To meet the requirements of Condition(s) X of Ministerial Statement X

EPA Factor and objective:	Subterranean Fauna – to protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Key environmental values:	Subterranean fauna (troglofauna) species to which impacts from the Proposal are <i>uncertain</i> * - <i>Hanseniella</i> sp. B08, <i>Symphyella</i> sp. B03, <i>Parajapygidae</i> sp. S03, <i>Prethopalpus</i> sp. B15, <i>Philosciidae</i> sp. B03; and <i>Parajapygidae</i> 'DPL024'.

Objective:	Minimise impacts, as far as practicable, to habitat for subterranean fauna (troglofauna) species to which impacts from the Proposal are <i>uncertain</i> .		
Key impacts and risks:	Risk to biological diversity and/or ecological integrity of subterranean fauna (troglofauna), due to direct loss of habitat (mine pits).		
Management-based provisions			
Management Actions	Management Targets	Monitoring	Reporting
<i>Condition clause number and text</i>	<i>Condition clause number and text</i>	<i>Condition clause number and text</i>	<i>Condition clause number and text</i>
<p>Minimise</p> <ul style="list-style-type: none">Minimise impacts to subterranean fauna (troglofauna) species to which impacts from the Proposal are <i>uncertain</i>*, by avoiding clearing for mine pits outside the Modified Indicative Additional Impact Assessment area where practicable and implementing the PEAHR process prior to land disturbance.	No unauthorised disturbance beyond the Development Envelope.	Quarterly land disturbance reconciliation (hectares and spatial footprint).	<p>Notification of management target or objective potential non-compliance will be provided to the OEPA within 7 days of that potential non-compliance being known. A report including any corrective actions identified will be provided to the OEPA via email, once an investigation into the potential non-compliance has been completed.</p> <p>An annual compliance assessment report will be submitted as part of the Annual Environment Report, which will be submitted to OEPA by 1 October each year.</p>

In consideration of the outcomes of the EIA and proposed management measures, BHP Billiton Iron Ore considers that subterranean fauna (troglofauna) is a key environmental factor for the Proposal as the Proposal will result in a net loss of subterranean fauna habitat.

In undertaking impact assessments associated with the Proposal for subterranean fauna BHP Billiton Iron Ore have had due regard for the principles of ecological sustainable development of the EP Act.

11.3.6 Summary and predicted outcome

In consideration of the outcomes of the EIA and proposed management measures, BHP Billiton Iron Ore considers that subterranean fauna (troglofauna) is a key environmental factor for the Proposal as the Proposal will result in a net loss of subterranean fauna habitat.

In undertaking impact assessments associated with the Proposal for subterranean fauna BHP Billiton Iron Ore have had due regard for the principles of ecological sustainable development of the EP Act.

Based on these principles, BHP Billiton Iron Ore have undertaken what it considers reasonable approach to the application of the mitigation hierarchy and assessment of significance of residual impacts. BHP Billiton Iron Ore consider that the EPA objective for subterranean fauna will be met. Table 52 summarises impacts to subterranean fauna previously assessed under MS 491, additional changes likely to occur following implementation of the Proposal, and the cumulative extent in the Proposed Mining Area C Development Envelope.

Table 52: Summary of key subterranean fauna factors for the Proposal

Indicative Additional Impact Assessment Area/ Groundwater Assessment Area	MAC EMP Revision 6 Impact Assessment Area/ Groundwater Assessment Area	Cumulative Impacts (without Mitigation)	Cumulative Impacts (with Mitigation)
Troglofauna			
<p>Twenty species of troglofauna only known from within the Indicative Additional Impact Assessment Area.</p> <p>One species only known from the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area.</p>	<p>Twenty species of troglofauna only known from within the Mining Area C EMP Revision 6 Impact Assessment Area.</p> <p>One species only known from the Indicative Additional Impact Assessment Area and Mining Area C EMP Revision 6 Impact Assessment Area.</p>	<p>Four species considered to be <i>possibly restricted</i> to the Indicative Additional Impact Assessment Area:</p> <ul style="list-style-type: none"> • nr <i>Andricophiloscia</i> sp. B16, • <i>Prethopalpus julianneae</i>, • <i>Prethopalpus</i> sp B15, • Philosciidae sp. B03). <p>Impacts to four species that occur in the Indicative Additional Impact Assessment Area or Mining Area C EMP Revision 6 Impact Assessment Area are <i>uncertain</i>:</p> <ul style="list-style-type: none"> • Parajapygidae 'DPL024', • <i>Hanseniella</i> sp. B08, • Parajapygidae sp. S03, • <i>Symphyella</i> sp. B03. 	<p>Impacts to six species are <i>uncertain</i>. Three occur in the Indicative Additional Impact Assessment Area</p> <ul style="list-style-type: none"> • <i>Prethopalpus</i> sp B15, • Philosciidae sp. B03, • Parajapygidae 'DPL024'. <p>Three occur in the Mining Area C EMP Revision 6 Impact Assessment Area</p> <ul style="list-style-type: none"> • <i>Hanseniella</i> sp. B08, • Parajapygidae sp. S03, • <i>Symphyella</i> sp. B03.
Stygofauna			
<p>Six species are known only from the Groundwater Assessment Area or this area and the Mining Area C EMP Revision 6 Drawdown Area;</p> <ul style="list-style-type: none"> • <i>Ainudrilus</i> sp. WA26 (PSS), • Halacaridae sp. B01, • <i>Schizopera</i> sp. B02, • <i>Bathynella</i> sp. 1, • <i>Notobathynella</i> sp, • Paramelitidae sp. S04 (BR South) <p>All are considered likely to occur outside.</p>	<p>Four species are known only from the Mining Area C EMP Revision 6 Groundwater Assessment Area:</p> <ul style="list-style-type: none"> • nr <i>Epactophanes</i> sp. B01, • <i>Dussartcyclops</i> sp. B10 • nr <i>Notobathynella</i> sp. S01. • <i>Bathynella</i> sp. 2 	<p>Seven of the ten species restricted to the Groundwater Assessment Area and/or the Mining Area C EMP Revision 6 Groundwater Assessment Area are considered likely to occur outside. It is uncertain whether three species occur outside these areas as all are only known from single drill holes and therefore information on the likely range is unknown. These species are:</p> <ul style="list-style-type: none"> • nr <i>Epactophanes</i> sp. B01, • <i>Dussartcyclops</i> sp. B10 • <i>Bathynella</i> sp. 2 	<p>Due to the uncertainty of the range of nr <i>Epactophanes</i> sp. B01, <i>Bathynella</i> sp. 2 and <i>Dussartcyclops</i> sp. B10 it is unknown whether mitigation will reduce impacts to these species.</p>

11.4 Hydrological processes

11.4.1 Introduction and EPA objective

The EPA applies the following objective, according to the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect hydrological processes:

To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.

11.4.2 Relevant legislation, guidelines and policies

The discussion of the existing environment, impacts and management of hydrological processes in the Proposed Mining Area C Development Envelope has been compiled in consideration of relevant State legislation, EPA Policies and Guidance. Table 7 details the relevant EPA documents as identified in the Mining Area C – Southern Flank Environmental Scoping Document (OEPA, 2016) and their relevance to this Proposal.

Other relevant guidelines which have informed the assessment against this factor include:

- *Pilbara Regional Water Plan 2010-2030* (DoW, 2010);
- *Pilbara Regional Water Supply Strategy: a Long-term Outlook of Water Demand and Supply* (DoW, 2013a);
- *Strategic Policy 2.09: Use of Mine Dewatering Surplus* (DoW, 2013d);
- *Operational Policy No. 1.02: Policy on Water Conservation/Efficiency Plans, Achieving Water Use Efficiency Gains through Water Licensing* (DoW, 2009); and
- *Operational Policy No. 5.08: Use of Operating Strategies in the Water Licensing Process* (DoW, 2011).

Studies, investigations and surveys undertaken to date, the study area covered, and the relevant guidelines referred to and any limitations of the studies have been previously listed in Table 9.

11.4.3 Existing environment

An overview of the conceptual groundwater model, including ecohydrological aspects, is given below.

Regional groundwater flow occurs predominantly in the aquifers of the Wittenoom Dolomite (particularly the karstic Paraburdoo member) and overlaying Tertiary detritals. As such, regional groundwater flow is concentrated in the valleys and intervening alluvial plains of the Proposed Mining Area C Development Envelope and surrounds.

Prior to mining-related activities in the wider catchment, groundwater flows were from west to east (from Coondewanna Flats to Weeli Wolli Spring). Water levels ranged from approximately 660 mAHD to approximately 560 mAHD over this area. The pre-mining depth to water table varied based on topography but was generally closer to the land surface in low-lying areas. At Coondewanna Flats the water table ranged from 18 to 25 mbgl and within the Weeli Wolli Spring PEC water levels ranged from 3 to 8 mbgl.

From a surface water catchment perspective, the Additional Development Envelope straddles the boundary between the Weeli Wolli Creek and Coondewanna catchments. The western portion of the development drains westwards across the Great Northern Highway into Lake Robinson within the

internally draining Coondewanna catchment. The eastern portion drains into tributaries of Weeli Wolli Creek, which discharges into the Fortescue Marsh (refer Figure 9).

Water supply abstraction in the Approved Mining Area C (Northern Flank) Development Envelope commenced in 2001 from C Deposit (the local Marra Mamba aquifer) and the western end of the North Flank Valley (regional aquifer), with additional temporary abstractions used during construction of the railway line and Coondewanna airstrip. Dewatering commenced at Mining Area C in mid-2010.

The Hope Downs Management Services Pty Ltd approved Hope Downs 1 Mining operations are located within the Northern Flank Valley. Dewatering commenced in January 2007 and is proposed to continue until the end of 2025 (i.e. until the end of mining and infilling) (HDMS, 2000). This is predicted to have a significant impact on flows at Weeli Wolli Spring and Rio Tinto Iron Ore are artificially supporting the system until the natural flow returns to within 10% of pre-mining rates. This is potentially up to 20 years after decommissioning (HDMS, 2000).

Key environmental groundwater and surface water receptors within the vicinity of the Proposal are:

1. The Water Resource (surface and groundwater);
2. Coondewanna Flats (including Lake Robinson); and
3. Weeli Wolli Spring (including Ben's Oasis)

The location of these assets are presented on Figure 9 and a description of the environmental receptors and hydrological dependency is summarised below for the water resource and was previously explained in Section 11.1 and 11.3.

The groundwater resource consists of three primary aquifers within the Upper Weeli Wolli catchment including:

- a) the orebody aquifer developed through mineralisation of the BIF;
- b) the Wittenoom dolomite, which is located within the topographic low areas; and
- c) the overlying alluvial tertiary detrital sediments.

The aquifer yields, permeability and storage volumes vary laterally and vertically through each aquifer unit. The hydraulic connection between the aquifer systems (including between groundwater and surface water systems) is considered to be variable and constrained by structural controls, mineralisation and vertical permeabilities.

Figure 36 shows the conceptual model for groundwater movement across the catchment. Groundwater recharge primarily occurs in the Coondewanna Flats area as a result of surface water ponding in Lake Robinson, and subsequent infiltration, after large rain events. A small proportion of groundwater recharge takes place across the remainder of the catchment, which is associated with seasonal surface water flow in Weeli Wolli Creek and diffuse rainfall recharge occurring in areas with exposed bedrock and along minor drainage lines. Groundwater moves broadly from west to east from Coondewanna to Weeli Wolli Spring via the Northern Flank and Southern Flank valleys within the tertiary detritals and Wittenoom dolomites.

Discharge from the groundwater system is mainly by outflow to the surface at Weeli Wolli Spring and groundwater throughflow beneath the springs. Evaporation and tree usage of groundwater, particularly around Weeli Wolli Spring, accounts for the remainder of pre-mining groundwater outflow from the catchment. While water moves broadly from west to east it is estimated that this takes in the order of

hundreds of years due to the range of hydrogeological conditions along the pathway. This is reflected in the relatively slow rate of drawdown propagation and in the modelled aquifer recovery times.

Groundwater through flow exiting the Upper Weeli Wolli catchment at Weeli Wolli Spring is estimated to be 12 ML/d. Of the total volume abstracted as part of the Proposal, between 50% and 70% is predicted to be from aquifer storage and the remainder from through flow.

Water usage and dewatering within the Approved Mining Area C (Northern Flank) Development Envelope is currently managed under Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a).

The Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a) contains management objectives, management actions, monitoring requirements, indicators and trigger criteria, contingency actions and reporting requirements to meet the intent of Condition 5 of MS 491. These are discussed further in Section 11.4.10.

11.4.4 Hydrological assessment overview

The hydrological impact assessment (Appendix 7) considered the following hydrological change aspects at key water dependent receptors (Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis) and also the water resource:

- Groundwater level (addressed in this Section 11.4.6);
- Groundwater quality (addressed in Section 11.5.4 - Inland Waters Environmental Quality);
- Surface water flow volume and persistence (addressed in this Section); and
- Surface water quality (addressed in Section 11.5.4 - Inland Waters Environmental Quality).

The assessment was completed in context to the broader adaptive management approach for the Upper Weeli Wolli catchment (also known as the Fortescue Marsh catchment area), which focuses on the key water dependent receptors, including the water resource and importantly considers impact in relation to outcome-based thresholds which have been already adopted for the key assets. The approach allows for the progressive development of scientific knowledge and therefore sets precautionary thresholds and objectives which reflect this level of technical knowledge, including the application of preventative and mitigating controls.

11.4.4.1 Groundwater modelling

Groundwater modelling has been carried out for the Proposal (BHP Billiton Iron Ore, 2016l, 2015a). Definition of assessment areas relevant to each factor and the isolated and cumulative cases are given in Section 11.4.5.

The objectives of the modelling were to provide predictions of the likely magnitude and timing of changes to the groundwater levels due to future dewatering of the Mining Area C and Southern Flank deposits across the modelling domain and specifically at three eco-hydrological receptors; Weeli Wolli Spring, Ben's Oasis and Coondewanna Flats. The modelling provided an evaluation of the potential drawdown impacts associated with dewatering activities at the 14 deposits at Mining Area C (with inclusion of Hope Downs 1) and the additionality of the potential impacts for Southern Flank dewatering activities. The modelling also provided a prediction of the cumulative changes at these receptors from activities at Southern Flank, current Mining Area C and planned operations (i.e. mining of all 14 deposits) and Hope Downs (operated by Rio Tinto). Predictions covered periods of both active mining and mine closure across the various mining assets. The modelling was undertaken on a catchment scale domain so was not confined to the Proposed Mining Area Development Envelope, and therefore represents the worst case scenario for prediction of potential impacts. The model domain and modelling approach is discussed in more detail in Appendix 7.

The model covered an area with a wide range of data density, with Southern Flank and areas east toward Ben's Oasis having the least long term data. As a result predictions for these areas using a single model would have significant uncertainty as many different model calibrations would be possible.

To enable a robust assessment, multiple models were constructed where key parameters for regional connectivity were allowed to vary to achieve calibration (BHP Billiton Iron Ore, 2016I). This provided a range of plausible models in areas with scarce data that could be used for assessment.

The initial model set comprised 2,000 variants, of these 192 calibrated with sufficient confidence to be used in the impact assessment. The resulting outputs are presented as a range of drawdown responses as a result of dewatering from proposed operations at Southern Flank, as well as cumulative response from other operations.

The outputs have been presented as series of percentile bands for both drawdown and abstraction volumes. Percentile cutoffs at 20% and 80% have been used for the purposes of informing EIA. In this case, low percentiles represent a smaller drawdown footprint and dewatering requirement while the high percentiles represent a larger drawdown footprint and dewatering requirement. These percentiles represent the likelihood that the actual impact will be less than the value indicated e.g.: for the P80 2 m contour line, there is 80% probability that drawdown will be less than 2 m. This distribution is a result of assumptions made in the modelling process (including conceptual model and aquifer geometry) as well as the accuracy and completeness of the monitoring data sets. Importantly, previous modelling results and field monitoring generally fall between the 20th and 80th percentile of the model outputs, demonstrating that this approach is both consistent with previous work and represents observations from the catchment.

For the purposes of the assessment the 80th percentile of drawdown was selected as a conservative case for changes to water levels. This case was used to assess potential changes at key water dependent receptors including Weeli Wolli Creek, Ben's Oasis and Coondewanna Flats.

A water balance forecast was generated for the combined Northern and Southern Flank operations based on modelled dewatering volumes and is shown in Figure 37.

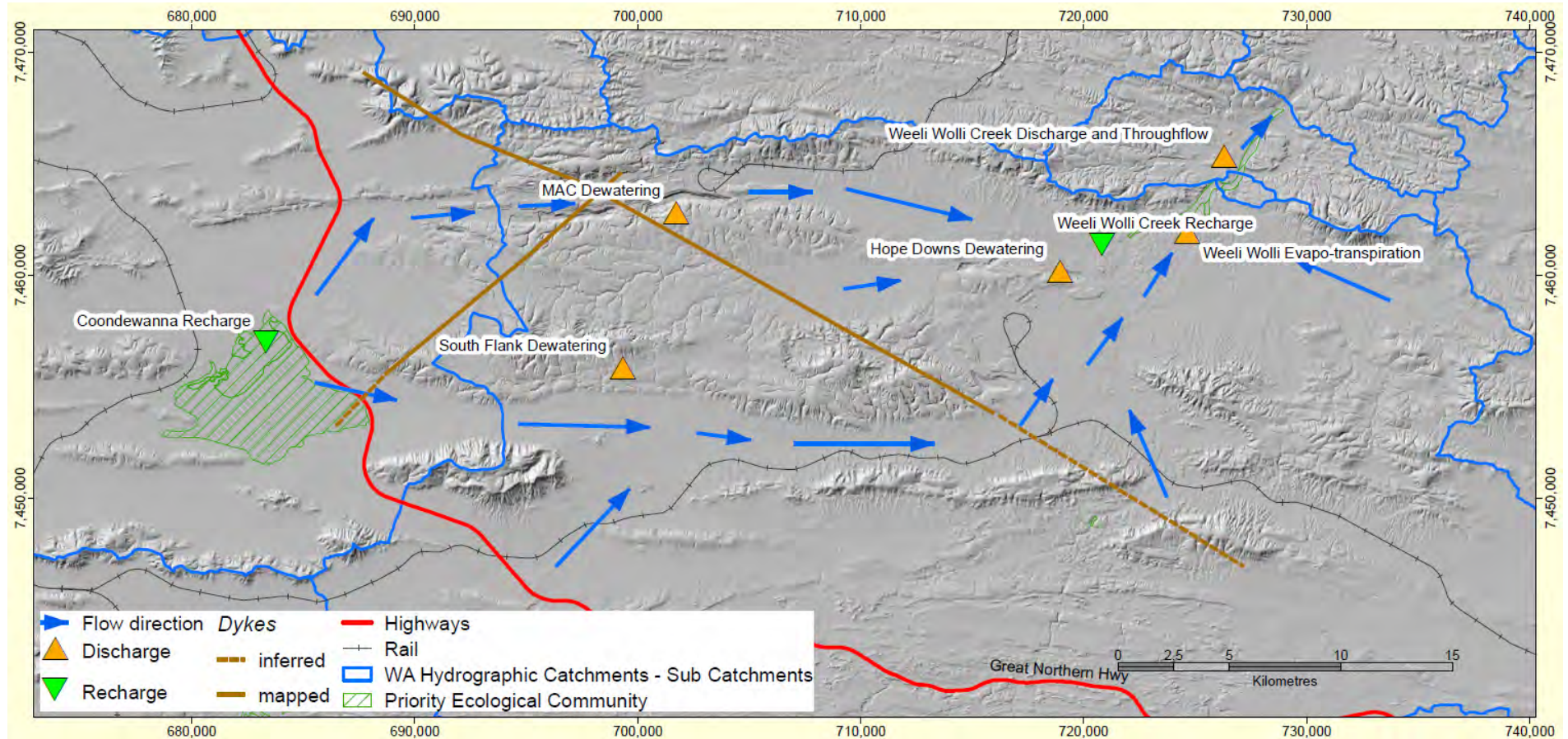


Figure 36: Conceptual groundwater flow within project area

Dewatering activities planned within the Indicative Additional Impact Assessment Area means that the Southern Flank ore body is net water negative as a stand-alone operation; but considered as a single operation with the current Approved Mining Area C Development Envelope, the combined water balance moves towards neutral. As a result it is anticipated the majority of production water supplies will be delivered from dewatering activities across the Mining Area C hub. If dewatering rates drop below the water demand, strategic advance dewatering will be carried out or an alternative water supply borefield will be developed. Any potential impacts to the environment from the Camp Hill borefield has been assessed as part of the development of the Mining Area C EMP Revision 6 for both water supply and managed aquifer recharge (MAR) purposes and subsequently an assessment of a MAR borefield at Juna Downs has been undertaken. Periods of surplus are expected and will continue to be managed with reference to the guidance of the DoW (2013d), *Strategic Policy 2.09 Use of Mine Dewatering Surplus* and will be preferentially returned to ground through injection into MAR borefields.

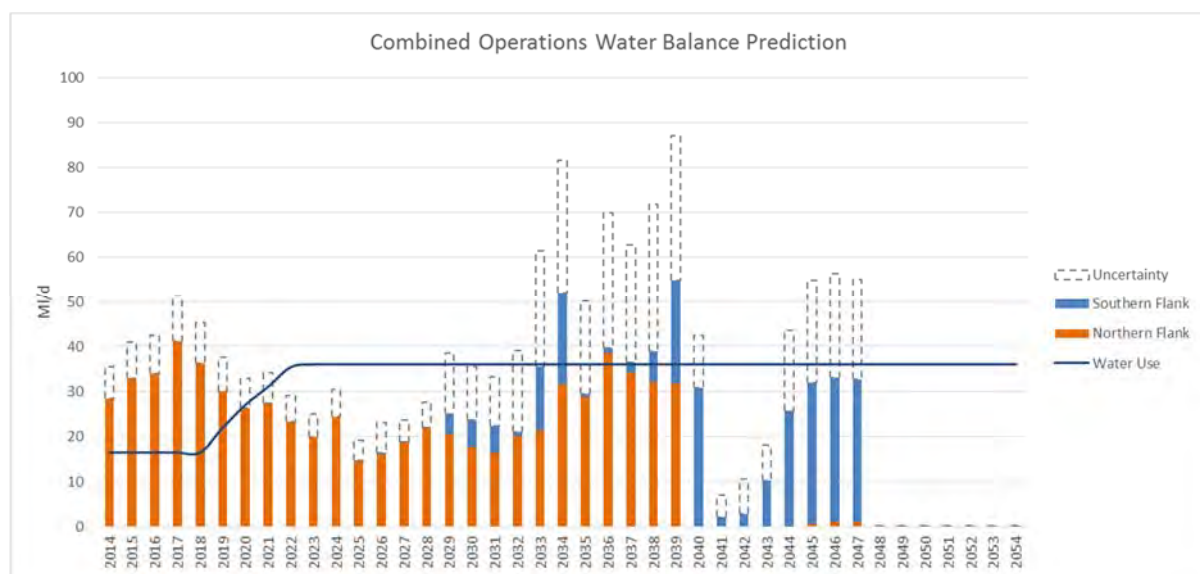


Figure 37: Combined operations water balance forecast

Key dewatering activities and water effecting areas are shown diagrammatically in Figure 38.

11.4.4.2 Surface water modelling

Surface water modelling and a cumulative impact assessment have been carried out for the Indicative Additional Impact Assessment Area (MWH, 2016) and for the additional disturbance associated with Mining Area C (RPS, 2015).

Surface water modelling was completed for the Proposal using the 2 dimensional TUFLOW model (WBM, 2016). Direct rainfall was applied on the model grid based on design rainfall depths calculated by interpolating values from the 1987 Bureau of Meteorology Intensity-Frequency-Duration (IFD) data and the probable maximum precipitation as estimated using the Generalised Short Duration Method. Infiltration data were similarly developed. It was not practical to apply direct rainfall on the Pebble Mouse Creek catchment area due to its large size (166 km² upstream of Southern Flank). Instead, this drainage line was inserted as a boundary condition into the TUFLOW model using a flow hydrograph developed from the RORB runoff routing model. A total of 18 models were run for pre-development and post development scenarios at rainfall events ranging from the 2-year to 10,000-year annual recurrence interval (ARI).

11.4.5 Potential impacts

BHP Billiton Iron Ore commissioned RPS Aquaterra (RPS, 2013) to undertake a hydrogeological assessment for Mining Area C EMP Revision 6. Pit designs and development rates for all deposits associated with EMP Revision 6 (derived from the 2014 mine plan) were included in model predictions. For the Proposal a hydrogeological assessment was carried out using an updated groundwater model that incorporated the Southern Flank mine plans and dewatering requirements.

BHP Billiton Iron Ore commissioned MWH (MWH, 2016) to carry out a Surface Water EIA which has informed assessment of the Indicative Additional Impact Assessment Area and Additional Development Envelope.

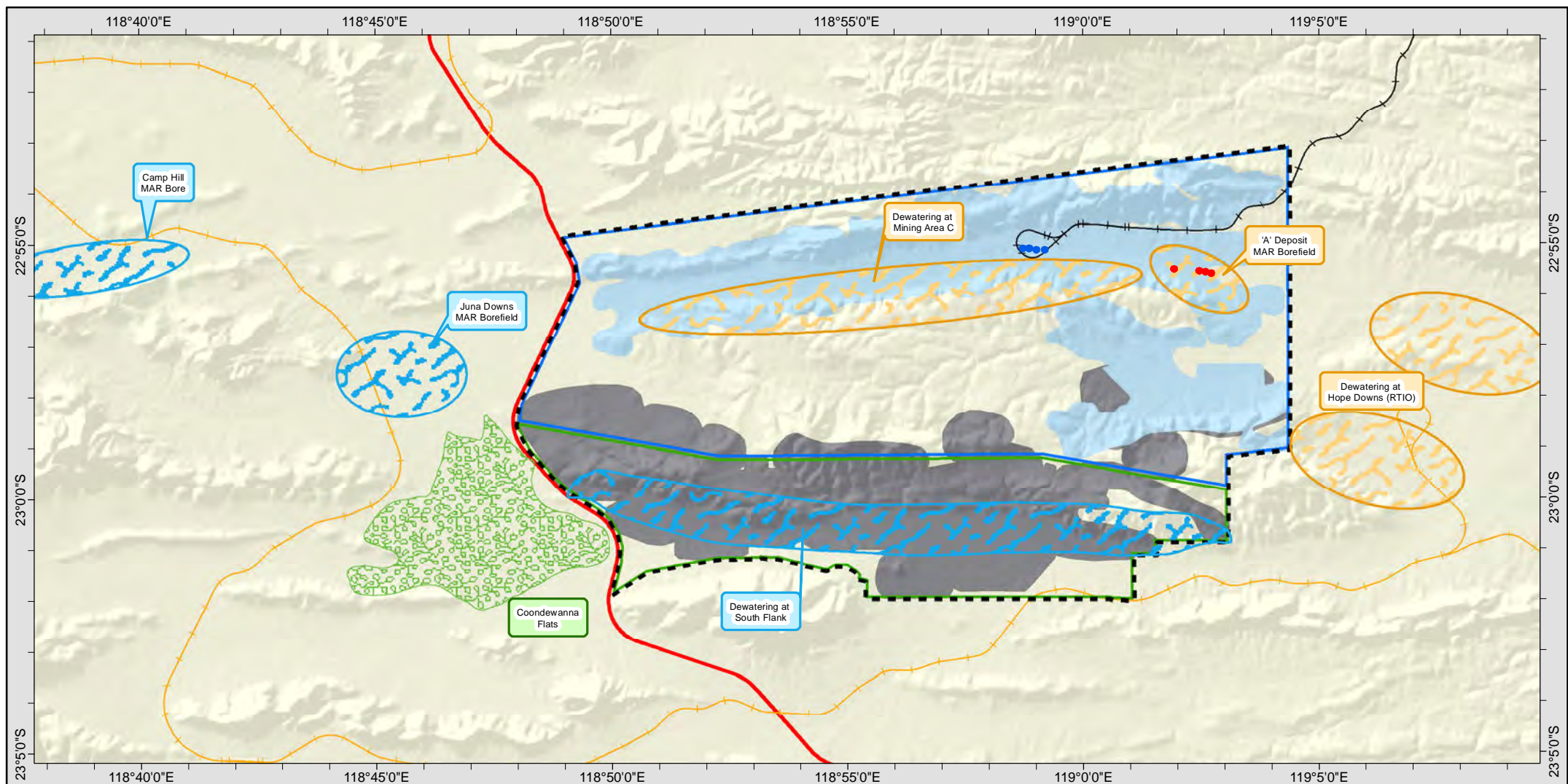
A range of technical studies were also collectively used to inform and develop the BHP Billiton Iron Ore Mining Area C Hydrological Impact Assessment (Appendix 7), which supports this Proposal application.

Discussion relating to the potential impacts of groundwater dewatering on stygofauna habitat is provided in Section 11.3.3.7.4 and the potential impacts on groundwater and surface water dependent vegetation is provided in Section 11.1.4.

The extents, or boundaries, used to assess the potential impacts of this Proposal, of the Revised Proposal (that is this Proposal plus the existing Mining Area C operations) and cumulative or regional extents vary for each factor. Table 53 details the areas assessed for this Hydrological Processes factor.

Table 53: Impact assessment areas for hydrological processes

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Hydrological Processes	<p>Modelled over Coondewanna and Weeli Wolli subcatchments and is inclusive of potential impacts from the proposed Southern Flank ore body, Mining Area C current operations and Hope Downs 1 project. Impact assessment determined the significance of additional impact from dewatering activities.</p> <p>For surface water catchment impacts, the Impact assessment areas are used for assessment of potential impacts.</p>	<p>Modelled over Coondewanna and Weeli Wolli subcatchments and is inclusive of potential impacts from the proposed Southern Flank ore body, Mining Area C current operations and Hope Downs 1 project. Impact assessment determines the overall impact the Proposal, existing Mining Area C operations and third party operations at Hope Downs.</p>	<p>Assessed over Coondewanna, Weeli Wolli and Fortescue subcatchments inclusive of third party operators Hamersley Hope Downs Management Services Hope Downs 1 Project and Baby Hope Project.</p>



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Dewatering and water effecting areas

Scale @ A4: 1:200,000	Prepared: M. LYTTLE	Project No: A780/052 REVA
Date: 30/03/2017	Checked: B. BARNETT	Figure: 38
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Current Approved Development Envelope
- Additional Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment
- Indicative Additional Impact Assessment Area
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- Deposit A MAR Bores
- Rail Loop Supply Bores
- Dewatering**
 - Receptors
 - Water Effecting Activities -
 - Water Effecting Activities -



0 5
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

Ground disturbance activities, such as the creation of pits, OSAs and other infrastructure, will occur within the Weeli Wolli Creek and Coondewanna subcatchments and, collectively, within the regional Fortescue Marsh catchment area (also known as the Upper Fortescue River catchment). Some of the ore bodies in the Indicative Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assessment Area lie below the water table based on the mine design at the time of referral of this Proposal. Therefore, the Proposal will require in-pit and ex-pit dewatering (i.e. groundwater abstraction) to facilitate dry mining conditions ahead of mining.

For the purposes of this section, the Mining area C EMP Revision 6 Groundwater Assessment Area defines the area bound by a 2 m drawdown contour that is predicted from modelling undertaken for the dewatering of the 14 deposits within the Mining Area C Development Envelope and the Hope Downs 1 operations. The potential impacts to the hydrological processes, inland water environmental quality factors, stygofauna and groundwater dependent vegetation (GDV) elements associated with extra disturbance at Mining Area C used this assessment area. Those for stygofauna were discussed in Section 11.3.3.7 and to GDV in Section 11.1.4.

The potential impacts resulting from the dewatering activities for the Southern Flank ore body development used an area termed the Groundwater Assessment Area. This area is defined as the area where the cumulative (Southern Flank, Mining Area C and Hope Downs 1 dewatering) modelled drawdown is 2 m or more over and above the natural climatic fluctuations which extends beyond the Proposed Mining Area C Development Envelope (see Figure 5).

11.4.5.1 Groundwater

The following groundwater-affecting activities have been assessed as part of the hydrological change assessment undertaken for the Proposal.

Dewatering. Dewatering is a key mining activity to access BWT ore and will take place across three nominal deposits located in the Additional Development Envelope and in multiple deposits in the Mining Area C EMP Revision 6 Impact Assessment Area. The lowering of groundwater levels during mine dewatering activities may result in the natural groundwater level being drawn down and the potential modification of the natural groundwater and surface water conditions in the orebody and the region, and potentially modification of the regional key water receptors of Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis.

Water supply. A water supply borefield may be required once mine dewatering volumes fall below water demand volumes. The potential impacts from water supply occur from lowering of groundwater levels and are as described above for dewatering.

Water supplies for the Proposal will continue to be delivered from proactive dewatering activities. The Camp Hill borefield located 15 km west of Mining Area C was impact assessed by BHP Billiton Iron Ore as part of the work supporting the development of the Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a) as one of the potential options for a future source of mine water to meet processing, construction and dust suppression demand.

Management of surplus water. Surplus mine water will occur during periods when the mine water demand is less than the dewatering rate. Surplus mine dewatering can be managed through various methods, some of which may alter groundwater levels, impact riparian tree health or change water quality.

Potential surplus management methods include: use by operations, discharge to surface water, evaporation, supply to third parties and return to aquifer via MAR. Of these methods, use by operations and MAR (through infiltration and injection) are the preferred approaches for surplus management. Use

on site is predominately related to dust suppression. By using surplus dewater for this purpose it negates the need to seek another water supply for this activity thereby reducing the overall stress on local aquifers. The use of MAR, rather than surface discharge, results in the surplus water being returned to the same or nearby catchments and therefore there is less net loss of water from the aquifer. The ongoing MAR trial at Mining Area C (currently located at A Deposit) demonstrated a feasible option for mitigating drawdown. As a result a MAR strategy has been developed to address the surplus requirements of the combined operation which involves progressive development of MAR borefields.

Surplus is planned to be sent to MAR borefields at Juna Downs and Camp Hill, both of which were assessed as options in the work supporting the Mining Area C EMP Revision 6. There is potential for groundwater mounding from the MAR borefield at Juna Downs to interact with the root systems of the vegetation at the Coondewanna Flats PEC. Modelling has been carried out for Juna Downs (Appendix 7) and mounding triggers and thresholds have been developed to prevent detrimental change at the PEC (Table 57). Mounding triggers will be developed for Camp Hill, prior to this option being executed, to prevent impacts to vegetation using a similar approach.

MAR can also be achieved using infiltration to groundwater through surface water drainage lines, where the underlying geology is favourable. This approach is currently in use at Mining Area C in an area north west of the mine known as Runaway Valley, where large gravel deposits underly the drainage line. In this case discharge volumes are limited to prevent permanent water flow and mounding is monitored to prevent inundation of root systems in adjacent vegetation.

Other surplus disposal options have been considered and discounted either on the basis of cost (evaporation), availability (third-party supply) or potential environmental impact (discharge to surface water).

Pit void. Pit voids that extend below the natural water table may provide an ongoing source of groundwater reduction via evaporation from the surface of the formed lake in the void. The effects of the lowered groundwater levels are as described in for dewatering.

Once dewatering ceases the recovery of the water level to pre-mining levels will be controlled by natural recharge from the catchment and will take considerably longer than the pumping period. An outcome based management strategy will be used to reduce the risk of pit lakes on the surrounding aquifer. The backfilling of pit voids to above pre-mining water is one option available as part of the mine closure strategy and will be considered where ongoing monitoring is indicating that impacts to water quality or quantity as a result of pit lakes are potentially above those predicted as part of this Proposal.

The modelling carried out for the Proposal showed that:

- An expected 20-60 ML/d of dewatering volume of which approximately 42 ML/d will result from the 14 deposits at Mining Area C and the remainder from the Southern Flank ore body development.
- Drawdown at Coondewanna will be between approximately 8 and 22 m (without mitigation), of which approximately 6-9.5 m results from 14 deposits at Mining Area C and the remainder (2-12.5 m) from the Southern Flank ore body development.
- Drawdown at Weeli Wolli Spring will be on average 1.75 m (without further mitigation other than that planned by Rio Tinto Iron Ore), of which approximately 1.25 to 1.55 m results from 14 deposits at Mining Area C and the remainder (0.2 to 0.5m) from the Southern Flank ore body development.

- The scenario of leaving open voids at A and E Deposits in the Mining Area C current operations post-closure is predicted to lead to a permanent reduction in the groundwater levels at closure, particularly at Coondewanna Flats. However, this risk is mitigated by commitments to backfill pit voids as detailed in the Mining Area C Closure Plan (BHP Billiton Iron Ore, 2016m).

Table 54 summarises the potential groundwater hydrological impacts of the Proposal.

Average drawdown predicted at two key receptors (Weeli Wolli Spring and Ben's Oasis) as a result of the Proposal are lower than the regional drawdown from current operations in the catchment. The Proposal may result in an increased drawdown of groundwater under Coondewanna Flats but studies have demonstrated that the vegetation is not groundwater dependent. Therefore the predicted impacts to hydrological processes are not considered significant. However, ongoing monitoring and adaptive management tools (see Section 11.4.10) will be implemented to verify predictions and associated potential impacts.

11.4.6 Potential cumulative impacts – groundwater

From a cumulative impact assessment perspective, the following BHP Billiton Iron Ore and third party operations were included in the assessment:

- proposed additional groundwater drawdown from the Additional Impact Assessment Area;
- groundwater drawdown from the Current Mining Area C EMP Revision 6 Impact Assessment Area; and
- Hope Downs Management Services Hope 1 Iron Ore Mine (third-party – based on publicly available information).

Hope Downs Management Services 'Baby Hope Mine Project' is located immediately to the south-east of the Additional Development Envelope, however, is not a below-water table operation and as such, was not considered in this cumulative groundwater modelling assessment.

The regional groundwater drawdown response to Mining Area C dewatering is predicted to propagate out from the Marra Mamba orebodies in an east-west direction following the higher transmissivity Wittenoom dolomite and detrital aquifers. The extent of drawdown associated with dewatering Brockman deposits will be less significant owing to low permeability rocks (shale and BIF) around these deposits limiting the propagation of drawdown.

The Mining Area C EMP Revision 6 predicted a water level change, which was predicted to extend preferentially towards Coondewanna Flats (~6-9.5 m), with a smaller, and much later, change predicted at Weeli Wolli Spring (~1.6 m). The extent of drawdown from Northern Flank to Ben's Oasis was considered unlikely owing to geological controls, catchment boundary features and the distance from Northern Flank.

Modelling carried out to inform the potential impacts of Southern Flank (BHP Billiton Iron Ore, 2016I) anticipates no material change to that previously predicted and assessed for the preparation Mining Area C Revision 6 for Weeli Wolli Spring and Ben's Oasis (BHP Billiton Iron Ore, 2015a).

Coondewanna may experience falling groundwater levels as a result of dewatering the western Marra Mamba deposits of Southern Flank and Northern Flank, and to a lesser extent through dewatering of the eastern Marra Mamba deposits in these areas. The forecast drawdown range at Coondewanna predicted in the Mining Area C EMP Revision 6 model was between 6 and 9.5 m by 2036. The cumulative model, incorporating the additional dewatering at Southern Flank shows that, without mitigation, total drawdown would be between 8 and 22 m in the central area of Coondewanna Flats by 2047 at which point water levels begin to recover.

Table 54: Summary of groundwater hydrology impacts for the Proposal

Indicative Additional Impact Assessment Area	Mining Area C EMP Revision 6 Impact Assessment Area	Proposed Extent (Revised Proposal)
Additional 20-60 ML/d (7-22 GL/a) of groundwater abstraction (peak) from Southern Flank	The maximum dewatering rate may be up to 42,000 kL/d (15.3 GL/a).	A total of 60-100 ML/d (22-37 GL/a).
<p>Drawdown beneath Coondewanna is predicted to be between 8 and 22 m at GWB0039 without mitigation. Studies indicate this will not impact PEC as it relies on surface water rather than groundwater.</p> <p>Southern Flank is predicted to contribute approximately 0.2 to 0.5 m to a cumulative drawdown at Weeli Wolli Springs in 2054 (without mitigation).</p>	<p>Drawdown beneath Coondewanna is expected to be between 6 m and 9.5 m. With mitigation (e.g. MAR) this can be reduced and maintained at less than 1m</p> <p>Ben's Oasis is likely to be less than about 2 m without mitigation; and</p> <p>Weeli Wolli Spring is likely to be less than approximately 1.6 m without additional mitigation (after the period of proposed mitigation by Rio Tinto Iron Ore).</p>	<p>Drawdown beneath Coondewanna is predicted to be between 8 and 22 m at GWB0039. Studies indicate this will not impact PEC as it relies on surface water rather than groundwater.</p> <p>Weeli Wolli Spring is likely to be less than an average of 1.75 m (after the period of proposed mitigation by Rio Tinto Iron Ore).</p>
<p>The scenario of leaving open pit voids at Highway Deposit is predicted to have additional reduction in the final recovery groundwater levels at Coondewanna Flats and Weeli Wolli Spring, without mitigation.</p> <p>Mitigating options such as backfilling and managed aquifer recharge will be implemented if ongoing monitoring indicates groundwater levels lower than those predicted.</p>	<p>The scenario of leaving open voids at A and E Deposits post-closure is predicted to have a potential reduction in the final recovery groundwater levels, particularly at Coondewanna Flats, without mitigation.</p> <p>BHP Billiton Iron Ore has committed to backfilling these voids to mitigate the potential reduction in final groundwater levels.</p>	<p>The scenario of leaving open voids at A, E and Highway Deposits post-closure is predicted to have a potential reduction in the final recovery groundwater levels, particularly at Coondewanna Flats and Weeli Wolli Spring.</p> <p>Mitigating options such as backfilling and managed aquifer recharge will be implemented if ongoing monitoring indicates groundwater levels lower than those predicted.</p>

Coondewanna Flats is classified as a PEC based on vegetation and habitat aspects. Based on the above predictions and the fact that data shows that the vegetation is not groundwater dependent it is concluded that the Proposal will not have a significant impacts to the Coondewanna Flats PEC. Impacts to water quality are discussed in Section 11.5 which also concludes that impacts to the PEC are not significant.

Modelling of cumulative groundwater drawdown from the combined Mining Area C - Northern and Southern Flank operations and Hope Downs dewatering showed water levels are reduced in the Weeli Wolli Spring area. Drawdown during the peak of dewatering activities shows a range of 3 to 14 m at GWB0018 and is associated predominantly with abstraction from Hope Downs.

The hydraulic connection between the recharge area at Coondewanna Flats and spring flow at Weeli Wolli Spring means that a significant and permanent drawdown at Coondewanna Flats may cause a reduction in water level in the aquifer at Weeli Wolli Spring, potentially impacting stream flow. Groundwater modelling for closure scenarios discussed in Section 11.7.4.4 show that long-term groundwater recovery at Weeli Wolli Spring may be limited if water levels are permanently reduced at Coondewanna Flats. Modelling and field data show that current measures such as MAR, tree watering

and infiltration are plausible mitigation options for managing any long term impacts at Weeli Wolli Spring.

Following closure of Hope Downs (including the aquifer replenishment and mitigation actions outlined in HDMS, 2000) the combined cumulative impacts show a range of 1 to 2.5 m drawdown at Weeli Wolli Spring in 2054 with a median drawdown of 1.75 m. Dewatering at Southern Flank is predicted to contribute between 0.2 and 0.5 m of drawdown at GWB0018 in 2054. The forecast residual drawdown at Weeli Wolli Spring predicted in the Mining Area C EMP Revision 6 model was around 1.6 m at GWB0018 in 2054. As discussed in Section 11.1.4.3.3, a drawdown of less than 2 m at this location is considered unlikely to be detrimental to the Silver paperbark population in the Weeli Wolli Spring PEC.

Allowing for differences in modelling methods between proponents, data limitations (e.g. baseline conditions for Weeli Wolli Spring) and technical uncertainties inherent in long term forecasts, this range of drawdown is not represent a significant impact to the water resource, Coondewanna Flats or Weeli Wolli Spring receptors.

As part of the development of the Mining Area C EMP Revision 6, groundwater levels were predicted to rise and fall in the vicinity of the Camp Hill borefield as the system was assessed to be used for both surplus MAR and subsequently as a water supply borefield. The groundwater mounding was predicted to be up to 40 m. Operational borefield management and design will ensure that water levels remain >10 m from the ground surface during surplus injection.

Additional modelling has since been carried out on the planned injection of surplus water at the Juna Downs MAR scheme. The scheme has the potential to mitigate (reduce) the drawdown at Coondewanna Flats. MAR has advantages over other surplus water disposal options, such as direct discharge to surface drainages, by having a small surface disturbance footprint. However, as managed aquifer recharge effectively replenishes groundwater systems at much higher rates than natural recharge processes, it has the potential to elevate groundwater levels (i.e. create a groundwater 'mound') in a zone around the injection bores for a period of time. Modelling predicts the progression and extent of the MAR groundwater mound over the 18-year operating life of the MAR scheme (2016 to 2034) and indicates that mounding is likely to peak around 17 m below ground surface in 2028. At this depth it is unlikely to have a negative impact on the nearby vegetation.

The analysis of the predictions of the various numerical groundwater models (BHP Billiton Iron Ore, 2016l) indicates that groundwater within the entire catchment area will be affected to some extent from the cumulative mine related activities from both this Mining Area C hub and Hope Downs, but is not considered significant.

Although groundwater drawdown and changes to the water resource attributed to this Proposal activities could extend >10 km west and east of the mine, the resulting impacts to the groundwater resource and groundwater dependent ecosystem are considered to be manageable with adaptive management (see discussion in Section 11.4.10). It is recognised that dewatering activities have the potential for localised drawdown the groundwater level during operations, the use of an adaptive management approach will ensure that the EPA objective to protect the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, can be met at the key water assets.

In summary the potential cumulative impact to groundwater hydrology of the Proposal, existing Mining Area C operation and third party operations is:

- Predicted drawdown at Coondewanna of 8 to 22 m - it is not considered that this will result in an impact to the vegetation, which is surface-water dependent.

- An average drawdown of 1.75 m at Weeli Wolli Spring following a period of mitigation by Rio Tinto at Hope Downs 1 operations – it is not considered that this will result in impacts to the ecohydrological aspect of the springs.
- A predicted drawdown of 1m at Ben Oasis– it is not considered that this will result in impacts to the ecohydrological aspect oasis.
- Post-closure, the recovery of the groundwater system is likely to take hundreds of years at Coondewanna Flats and Ben's Oasis, and tens of years at the Weeli Wolli Spring without mitigation (such as MAR).

11.4.7 Potential impacts – surface water

The following surface water-affecting activities have been assessed as part of the hydrological change assessment.

Reduced surface water availability. Proposed pit and OSA developments have the potential to impact surface water resources and have the potential to impact surface water resources by:

- changing local surface water flow patterns, or
- affecting surface water runoff volumes and quality (the latter is discussed in Section 11.5.4).

Surface water ultimately flows towards Weeli Wolli Creek and supports Coondewanna Flats.

Previous surface water assessment has determined that surface water flow would increase slightly (~0.5%) in the Coondewanna subcatchment and decrease ~0.8% in the Weeli Wolli Spring subcatchment.

The outcomes from the assessment of the potential impact of the Proposal on surface water are documented in Table 55.

Water quality and sedimentation impacts assessed are discussed in Section 11.5 – Inland Waters Environmental Quality and indirect impacts to flora and vegetation and terrestrial fauna from surface water modifications are discussed in Section 11.1 and 11.2.

Table 55: Potential surface water impacts of the Proposal

Additional Development Envelope	Proposal Mining Area C EMP Revision 6 Impact Assessment Area	Proposed Extent (Revised Proposal)
<p>No creek diversions are proposed in the Proposed Southern Flank Development Envelope. The closest Southern Flank indicative pit design is located 100 m away from the 10,000-year ARI floodplain of the Pebble Mouse Creek, therefore, creek capture is not considered to pose a risk. OSAs located in 100 year floodplain have potential to add sediment to drainage systems. OSA design and sediment management systems will control this risk.</p> <p>The Indicative Additional Impact Assessment Area impacts approximately:</p> <ul style="list-style-type: none"> - 3.5% of the Weeli Wolli Spring sub-catchment area; - 4.7% of the Coondewanna sub-catchment area and; - less than 1% of the Fortescue Marsh catchment. <p>This predicted change is considered minimal with respect to overall catchment volumes as runoff remains within historic ranges.</p>	<p>From a hydrological perspective, relevant impacts assessed were interruption to existing surface water flow patterns. It was predicted that impacts to surface water flows were not significant as the Mining Area C EMP Revision 6 Impact Assessment Area equates to 0.18% of the Fortescue Marsh sub-catchment area. This predicted change is considered minimal with respect to overall catchment volumes as runoff remains within historic ranges.</p>	<p>Predicted Impact of Proposal to surface water catchment are not significant as runoff volumes are expected to remain within historic ranges.</p>

11.4.8 Potential cumulative impacts– surface water

From a cumulative impact assessment perspective, the following BHP Billiton Iron Ore and third-party operations were included in the assessment:

- ground-disturbance associated with the Indicative Additional Impact Assessment Area;
- current approved ground-disturbance associated with the Mining Area C EMP Revision 6 Impact Assessment Area;
- approved ground disturbance associated with the Hope Downs Management Services 'Hope 1 Iron Ore Mine' (third-party – based on publicly available information and aerial photography); and
- approved ground disturbance associated with the Hope Downs Management Services 'Baby Hope Mine Project' (third-party operation – based on publicly available information and aerial photography).

For surface water engineering, the DMP generally require consideration of the probable maximum flood (PMF) event for mine closure. The 10,000-year ARI event was considered representative of the PMF event and was used to assess flood conditions in the Southern Flank mine area and inform closure design.

Modelling of flood events has shown no risk of creek capture for Pebble Mouse Creek, the most significant drainage feature within the mine footprint. Minor drainage will runoff into some pits but these are not considered to have a significant impact on the total runoff volumes reaching Fortescue Marsh.

The reduction in catchment area consequently reduces peak flows and volumes but is not considered to be significant on a regional scale.

In summary the potential cumulative impacts to surface water are:

- a reduction in surface water flow into Coondewanna catchment of approximately 6.9%;
- a reduction in surface water flow into Upper Weeli Wolli catchment of 6.2% from cumulative BHP Billiton Iron Ore operations and 7.2% including third party operations impacts; and
- a reduction in surface water flow into the Fortescue Marsh catchment of 2% from BHP Billiton Iron Ore and third party operations.

11.4.9 Mitigation and residual impacts

BHP Billiton Iron Ore has carried out a review of the Western Australian Government's 'Mitigation Process', which is detailed in Section 3 of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014). The four steps are:

- avoid;
- minimise;
- rehabilitate; and
- offset.

Following consideration of all data gathered during baseline surveys, additional targeted surveys and the outcomes of EIAs, BHP Billiton Iron Ore has considered this Proposal and addresses the first three steps of this hierarchy to meet the Hydrological Processes factor.

Actions taken are summarised in Table 56.

Table 56: Actions taken to reduce impacts to hydrological processes

Action Taken	Step in the 'Mitigation Process'	Reduction in Impact
Dewatering volumes will continue to be used as a process supply when dewatering rates are in excess of demand requirements.	Minimise	The predicted water balance indicates that this is likely to occur at various stages between 2021 and 2034. The activity will see dewatering water being preferentially used over a stand-alone water supply borefield, minimising the net draw on the water resources. Water transfer between Northern Flank and Southern Flank will increase water use efficiency. Sourcing water from third party surplus will be considered where practicable.
Consistent with the DoW Mine Water in Mining Guideline (DoW, 2013b), and where practicable and feasible, surplus groundwater will continue to be preferentially returned to the aquifer through MAR.	Minimise and Mitigate	This practice will be used to reduce the extent and duration of groundwater drawdown and mitigate the impact to water resources, for example to mitigate drawdown at Coondewanna Flats if required. However, it is recognised that there are practicable and aquifer limitations with MAR. It is not part of the Proposal to undertake surface water discharge and currently it is not predicted that this option will be required. In the event that surface water discharge is required, necessary statutory approvals will be sought at this time.
Surplus water is planned to be introduced into the proposed Camp Hill borefield from about 2018 onwards, as well as Juna Downs, effectively storing water into the dolomite and alluvial aquifers.	Minimise	The MAR borefields may be reversed and the borefield will be pumped as a water supply (approximated to be post 2040). Camp Hill and Juna Downs are proposed as suitable potential storage location. Planned injection of surplus water at the Juna Downs MAR scheme has the potential to reduce the extent of drawdown as Coondewanna Flats.
Surface water will continue to be diverted around the mining footprint to the extent practicable to minimise the loss of surface water flow in the natural drainage systems.	Minimise	This will minimise reduction in runoff volumes by enabling catchments which are intercepted by infrastructure to be directed downstream.
Where practical, BHP Billiton Iron Ore will restrict clearing of vegetation to the Modified Additional Impact Assessment Area, this will reduce the impact to the Weeli Wolli surface water catchment area.	Avoid	The reduction in clearing will result in the following changes to the surrounding catchment areas <ul style="list-style-type: none"> • 3.2% of the Weeli Wolli Spring sub-catchment; • 7.6% of the Coondewanna sub-catchment and; • less than 1% of the Fortescue Marsh catchment The modification to the impact assessment area has resulted in a reduction in impacts to catchment area for the Weeli Wolli Spring Catchment, no change to the Fortescue March catchment but a slight increase at the Coondewanna Catchment. The impacts are still within regional and seasonal variations in the catchments

Backfilling of below the water table mine voids as a mitigation option is further discussed in Section 11.7.5, Rehabilitation and Decommissioning.

The residual impacts following implementation of the above actions is not considered significant and therefore does not warrant application of offsets for this factor.

11.4.10 Proposed management approach

11.4.10.1 Internal management approach

The strategic approach to site water management is the same as is currently outlined in the EMP Revision 6 (BHP Billiton Iron Ore, 2015a). This utilises a regional water management strategy (with underlying catchment plans) to meet our commitments and obligations and also provide a regionally consistent methodology for identifying and managing water related environmental and community risks, considering:

- Hydrological changes (baseline, current and future conditions of groundwater, soil moisture and surface water) resulting from BHP Billiton Iron Ore dewatering operations.
- Receiving receptors (water resources, environment, social and third-party operations), identified value and hydrological dependency (groundwater, soil moisture and/or surface water).
- Potential impacts (predicted and actual) attributable to BHP Billiton Iron Ore mining activities.
- Required risk-based adaptive management techniques that are feasible (tested and practicable) to mitigate potential impacts to acceptable levels during operations and closure.

Regional water management uses an adaptive management approach, via the CPWRMP. This process uses the findings of ongoing ecohydrogeological technical studies to inform the management actions required to achieve outcome-based objectives. Adaptive management is risk based and will be used proactively to counteract, mitigate or manage potential impacts (both predicted and actual) to an acceptable level. This approach has been incorporated into the Mining Area C EMP Revision 6 to manage impacts to water receptors.

The adaptive management approach is cyclic and involves the definition of key water assets for which a hydrological baseline is determined (if possible) and objectives set. These objectives for those water assets relevant to the Proposal are:

- For Weeli Wolli Creek: to prevent any significant impact on Weeli Wolli Spring (including Ben's Oasis) as a result of BHP Billiton Iron Ore operations
- For Coondewanna Flats: to prevent any significant impact on priority vegetation communities within Coondewanna Flats (including Lake Robinson) as a result of BHP Billiton Iron Ore operations; and to minimise impact on groundwater levels and quality and to minimise potential impacts on the surrounding environment.

Any potential changes to the water assets are predicted through monitoring and modelling and managed by establishing and implementing appropriate management options. Ongoing monitoring and reviewing of data and options is undertaken regularly to ensure impacts are avoided, mitigated or minimised. Management options for the Mining Area C hub may include, but not be limited to, transfer of surplus water between Northern and Southern Flank, storage of water for use in turkey's nests, infiltration basins, sediment basins or MAR and irrigation of trees. A number of these options (e.g. MAR and infiltration) return groundwater to the same aquifer thereby mitigating the potential for groundwater drawdown. Further discussion on management and mitigation options is described in the CPWRMP (Appendix 7).

As part of this approach BHP Billiton Iron Ore have undertaken a number of ecological studies to better understand connection between our operations and receptors and their reliance on water. As a result of these studies management thresholds have been defined (for Coondewanna Flats) and to date no significant change to the key ecohydrological receptors have been observed.

Some water risks will be mitigated by closure commitments as detailed in the Mine Closure Plan (BHP Billiton Iron Ore, 2016m). An adaptive management approach is used in developing closure plans and has identified mitigating controls for water risks such as backfilling pits. A commitment to backfill to above water table at A and E deposits is considered to mitigate the risk of long term drawdown from these pits.

The approach addresses the overall water catchment management area and the specific BHP Billiton Iron Ore operations within the catchment (Central Pilbara, Mining Area C hub). It applies catchment scale water management principles, allows for future approval processes and will simplify and provide transparency on water management criteria, risks, controls and water licences.

The regional water management approach requires that specific regulatory commitments are linked to outcome-based objectives and adaptive management methods for significant receptors if impacted by BHP Billiton Iron Ore operations.

11.4.10.2 Site-specific management approach

The current accepted Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a) contains management objectives, management actions, monitoring requirements, indicators and trigger criteria, contingency actions and reporting requirements. These have been reviewed and where still relevant, integrated into the CPWRMP.

As a result of modelling carried out to inform this assessment, BHP Billiton Iron Ore considers the following changes to the current triggers and thresholds are appropriate for Coondewanna Flats:

- Coondewanna ecohydrological communities are unlikely to be dependent upon groundwater and therefore the predicted magnitude and rate of change in hydrological conditions outlined above are unlikely to result in an impact to the PEC. As a result of these findings, this assessment suggests that the current Condition 5 of MS 491 (BHP Billiton Iron Ore, 2015a) outlining two water level investigation triggers for Coondewanna Flats be removed. Should tree condition monitoring or future studies indicate Coondewanna is groundwater dependent, mitigation measures such as water injection or tree watering will be implemented.
- New modelling suggests that there may be potential for mounding as a result of the proposed Juna Downs MAR scheme. As such, BHP Billiton Iron Ore is proposing to establish upper water level targets and thresholds, along with ecological indicators to prevent detrimental changes at the PEC. These are presented in Table 57.

With regard to Weeli Wolli Spring and Ben's Oasis, BHP Billiton Iron Ore considers that it has met its previously accepted commitments to review the triggers at Weeli Wolli Spring in line with the following from the EMP Revision 6 (BHP Billiton Iron Ore, 2015a):

- **at notification of pre-closure of Rio Tinto Iron Ore's Hope Downs mining operation:** this commitment is not yet applicable; however, it is carried over into the CPWRMP and will remain a commitment;
- **if other BHP Billiton Iron Ore BWT operations are approved in the catchment:** the modelling carried out to inform this PER assessment is considered to have met this commitment; however, the commitment will be carried over into the CPWRMP for future application, should it be required;
- **if changes are identified via the annual or triennial aquifer review process:** this commitment will be carried over into the CPWRMP; and
- **as required by BHP Billiton Iron Ore:** this commitment will be carried over into the CPWRMP.

Table 57 and Table 58 presents the proposed management plan provisions for the Proposal. Management is also discussed in the CPWRMP (Appendix 7).

11.4.10.3 Regulatory management approach

Hydrological processes at the current approved Mining Area C area are managed by the following regulatory processes:

- MS;
- 5C licence and associated Groundwater Operating Strategy;
- Part V licence; and
- DMP's Mine and EPA's Guidelines for the Preparation of Mine Closure Plans.

This management approach will continue under this Proposal. Dewatering volumes will continue to be managed through the DoW groundwater licensing process. Table 57 and Table 58 presents the proposed management plan provisions for the Proposal. It is proposed that these management provisions will be formalised through regulation of an Environmental Management Plan via the Ministerial Statement and the BHP Billiton Iron Ore's standard Pilbara-wide Health, Safety and Environment system. A draft of the management plan (CPWRMP) which includes the management provisions outlined in Table 57 and Table 58 is located in Appendix 7.

11.4.11 Summary and predicted outcome

In consideration of the outcomes of the EIA and proposed management measures, BHP Billiton Iron Ore considers that the hydrological regimes of groundwater and surface water can be maintained so that existing and potential uses, including ecosystem maintenance, are protected. This will be achieved through the application of the CPWRMP, which includes outcome based objectives, management actions and relevant triggers and thresholds that are summarised below.

Table 57: Draft Proposed Environmental Management Plan Provisions – Hydrological Processes – Coondewanna Flats

To meet the requirements of Condition(s) X of Ministerial Statement X.

EPA Factor and objective:	Hydrological Processes - To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.		
Key environmental values:	Coondewanna Flats Priority Ecological Community		
Outcome:	No net-loss of the biological diversity and/or ecological integrity of the Coondewanna Flats Priority Ecological Community, as a result of BHP Billiton Iron Ore activities.		
Key impacts and risks:	Coondewanna Flats Priority Ecological Community (PEC) has the potential to be impacted from surplus water discharge, resulting in changes to the biological diversity and.or ecological integrity of the PEC.		
Outcome-based provisions			
Environment criteria: <ul style="list-style-type: none">Trigger criteriaThreshold criteria	Response actions: <ul style="list-style-type: none">Trigger level actionsThreshold level actions	Monitoring	Reporting
Condition clause number and text	Condition clause number and text	Condition clause number and text	Condition clause number and text
Water Quantity in the Coondewanna Flats Priority Ecological Community Monitoring Zone – Groundwater level <ul style="list-style-type: none">Trigger criteria – <15 mbgl¹ at any of the following monitoring bores: GWB0039M, HCF0032M, HCF0044M and HCF0045MThreshold criteria – <7 mbgl² at any of the following monitoring bores: GWB0039M, HCF0032M, HCF0044M and HCF0045M	Response actions to trigger criteria exceedance may include, but are not limited to: <ul style="list-style-type: none">Commence vegetation monitoring;Decrease surplus water discharge rate; andAlter surplus water discharge regime Response actions to threshold criteria exceedance may include, but are not limited to: <ul style="list-style-type: none">Decrease suplus water discharge rate;Alter surplus water discharge regime; andCease surplus water discharge	Monthly monitoring of groundwater levels (mbgl) of GWB0039M, HCF0032M, HCF0044M and HCF0045M during operations (i.e. active dewatering / surplus water discharge).	Notification in the event that the threshold criteria has been exceeded or potential non-compliance to the outcome, will be provided to the OEPA and DoW within 7 days of that potential non-compliance being known. A report including any corrective actions identified will be provided to the OEPA and DoW via email, once an investigation into the potential non-compliance has been completed. An annual compliance assessment report will be submitted as part of the Annual Environment Report and Annual Aquifer Report, which will be submitted to OEPA by 1 October each year.
Tree health of indicator tree species ³ in the Coondewanna Flats Priority Ecological Community Monitoring Zone. Monitoring of tree heath will be undertaken in response to trigger of groundwater level <15 mbgl. <ul style="list-style-type: none">Trigger criteria – Statistically significant canopy decline (defined as Crown Condition Score (CCS) compared to reference trees over four consecutive monitoring periods within monitoring sites 12, 15 or 20.Threshold criteria – Statistically significant canopy decline (defined as Crown Condition Score (CCS) compared to reference trees over eight consecutive monitoring periods; or death of any tree (contributable to water stress), within monitoring sites 12, 15 or 20.	Response actions to trigger criteria exceedance may include, but are not limited to: <ul style="list-style-type: none">Decrease surplus water discharge rate; andAlter surplus water discharge regime Response actions to threshold criteria exceedance may include, but are not limited to: <ul style="list-style-type: none">Decrease suplus water discharge rate;Alter surplus water discharge regime; andCease surplus water discharge	Following exceedance of water quantity trigger criteria: <ul style="list-style-type: none">Biannual Crown Condition Score (CCS) of indicator tree species³ at monitoring sites 12, 15 and 20 and three reference sites on BHP Billiton Iron Ore tenure.	

¹ Corresponds to the point at which groundwater levels could interact with the roots of *E. victrix*, further details in Appendix C of CPWRMP.

² Groundwater Level: Corresponds to the point at which groundwater levels could interact with the roots Acacia species, further details in Appendix C of CPWRMP.

³ Species: *E. victrix* (AQ2, 2016). Details of species water dependency provided in Appendix C of CPWRMP.

Table 58: Proposed Environmental Management Plan Provisions – Hydrological Processes – Weeli Wolli Spring

EPA Factor and objective:	Hydrological Processes - To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.		
Key environmental values:	Weeli Wolli Spring Priority Ecological Community		
Outcome:	No net-loss of the biological diversity and/or ecological integrity of the Weeli Wolli Spring Priority Ecological Community, as a result of BHP Billiton Iron Ore activities.		
Key impacts and risks:	Weeli Wolli Spring Priority Ecological Community (PEC) has the potential to be impacted from groundwater, resulting in changes to the biological diversity and.or ecological integrity of the PEC. However, this drawdown is predominantly associated with abstraction from Hope Downs.		
Outcome-based provisions			
Environment criteria: <ul style="list-style-type: none">Trigger criteria	Response actions: <ul style="list-style-type: none">Trigger level actions	Monitoring	Reporting
Trigger criteria for change in risk profile of impacts attributable to BHP Billiton Iron Ore activities: <ul style="list-style-type: none">At notification of pre-closure of Rio Tinto Iron Ore’s Hope Downs mining operation;If other BHP Billiton Iron Ore below water table operations are approved in the catchment;If changes are identified via the annual or triennial aquifer review process; andAs required by BHP Billiton Iron Ore.	Response actions to trigger criteria exceedance may include, but are not limited to: <ul style="list-style-type: none">If there is a change in risk profile of impacts attributable to BHP Billiton Iron Ore activities, BHP Billiton Iron Ore will review Weeli Wolli Spring management provisions, and submit to OEPA and DoW for review and endorsement.	Monthly monitoring of groundwater levels (mbgl) within the Weeli Wolli Spring Priority Ecological Community Monitoring Zone during operations (i.e. active dewatering / surplus water discharge): <ul style="list-style-type: none">At receptor:<ul style="list-style-type: none">GWB0016DM;GWB0016SM;GWB0017DM;GWB0017SM;GWB0018DM;GWB0018SM;GWB0032DM; andGWB0021SM;Early warning:<ul style="list-style-type: none">GWB0013M;GWB0014BM;GWB0015M; andHEPX0001	Reporting in the event that the trigger criteria has been exceeded will be as per the Ministerial Statement Compliance Assessment Plan and relevant Groundwater Operating Strategy. Annual reporting will be conducted as per the Ministerial Statement Compliance Assessment Plan and relevant Groundwater Operating Strategy.

11.5 Inland waters environmental quality

11.5.1 Introduction and EPA objective

Mining projects have the potential to impact the quality of inland water environments through the construction and operation of the Proposal, as well as through the discharge of surplus water back into the environment. This section provides an overview of these issues and the relevant supporting studies and investigations.

The EPA applies the following objective, according to the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect inland waters environmental quality:

To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

11.5.2 Relevant guidelines and approvals

As part of the preparation of this assessment against the inland waters environmental quality factor, all EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The following guiding documents were also relevant in the consideration of impacts to inland waters environmental quality:

- *Water Quality Protection Guidelines No 1. Water Quality Management in Mining and Mineral Processing: An Overview* (Water and Rivers Commission, 2000a);
- *Operational Policy No. 1.02. Policy on Water Conservation/Efficiency Plans, Achieving Water Use Efficiency Gains through Water Licensing* (DoW, 2009);
- *Operational Policy No. 5.08. Use of Operating Strategies in the Water Licensing Process* (DoW, 2011);
- *Water Quality Protection Note No. 30. Groundwater Monitoring Bores* (DoW, 2006);
- *Water Quality Protection Guidelines No. 4. Mining and Mineral Processing, Installation of Minesite Groundwater Monitoring Bores* (Water and Rivers Commission, 2000b);
- *Water Quality Protection Guidelines No. 5. Mining and Mineral Processing, Minesite Water Quality Monitoring* (Water and Rivers Commission, 2000c);
- *Water Quality Protection Guidelines No. 9. Mining and Mineral Processing, Acid Mine Drainage* (Water and Rivers Commission, 2000d);
- *Water Quality Protection Guidelines No. 11. Mining and Mineral Processing, Mine Dewatering* (Water and Rivers Commission, 2000e); and
- *Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area* (EPA, 2013c).

11.5.3 Existing environment

The existing mining infrastructure at Mining Area C is located in the main Northern Flank valley. This main valley is relatively linear, being contained by the ridgelines lying along its north and south sides. The existing mining developments straddle the catchment divide between the Coondewanna subcatchment to the west and the Weeli Wolli Creek subcatchment to the east. The catchment divide

extends to the Additional Development Envelope where the eastern end of the valley drains west into Coondewanna while the rest of the area drains east into Pebble Mouse creek and on into Weeli Wolli Creek. Surface water catchments boundaries and flow directions are shown in Figure 39.

Mining Area C contains a second valley, located south of the main North Flank valley which drains into the main North Flank valley downstream of the mine development areas to the east. This second valley is wider and has a larger catchment area than the main Northern Flank valley.

Southern Flank valley receives drainage from the higher ground north of the main valley and from the north-eastern slopes of Mount Robinson. Drainage from the Southern Flank ridgeline generally passes through narrow valleys or gorges before reaching the valley floor. The valley floor drains into Pebble Mouse creek which enters Southern Flank valley from the south and continues on to the east.

Following a rainfall event, runoff from the ridgelines is relatively concentrated and rapid. Upon entering the natural valley floor, these discharges tend to spread out over a wider flow zone and slow down, thus reducing the flow peak and sediment-carrying capacity. Where runoff from the steeper valley sides enters the valley floor, sediment deposits have accumulated; and in the more confined main North Flank valley, these deposits can influence the valley floor drainage patterns.

Discharges from the north-western area of the Northern Flank valley enter the main valley through a break in the north side ridgeline. Based on the valley floor contours, discharges from this subcatchment currently flow eastwards into the Weeli Wolli Creek drainage system; however, it is likely that historically these discharges would have oscillated between flowing east and flowing west, depending on the shape of the accumulated sediment delta. During flood events, discharges from this subcatchment would be relatively concentrated when passing through the ridgeline, then would spread out over a wider flow zone and slow down upon entering the valley floor.

Water quality in the catchment is considered to be good, with baseline surface water quality as expected for a relatively undisturbed catchment with total dissolved solids up to 100 mg/L. Groundwater in the catchment typically has a low salinity with a typical total dissolved solids range between 600 and 700 mg/L. This is considered to be a consequence of rainfall recharge and throughflow mechanisms in the aquifer. Groundwater chemistry in the valley aquifers have a predominantly carbonate signature as a result of the dolomite aquifers in these areas and groundwater has a slightly basic pH, typically between 7 and 8.

No significant changes in groundwater or surface water quality have been observed since mining commenced. Minor fluctuations in salt levels have been linked to rainfall with groundwater becoming slightly fresher following large rainfall events.

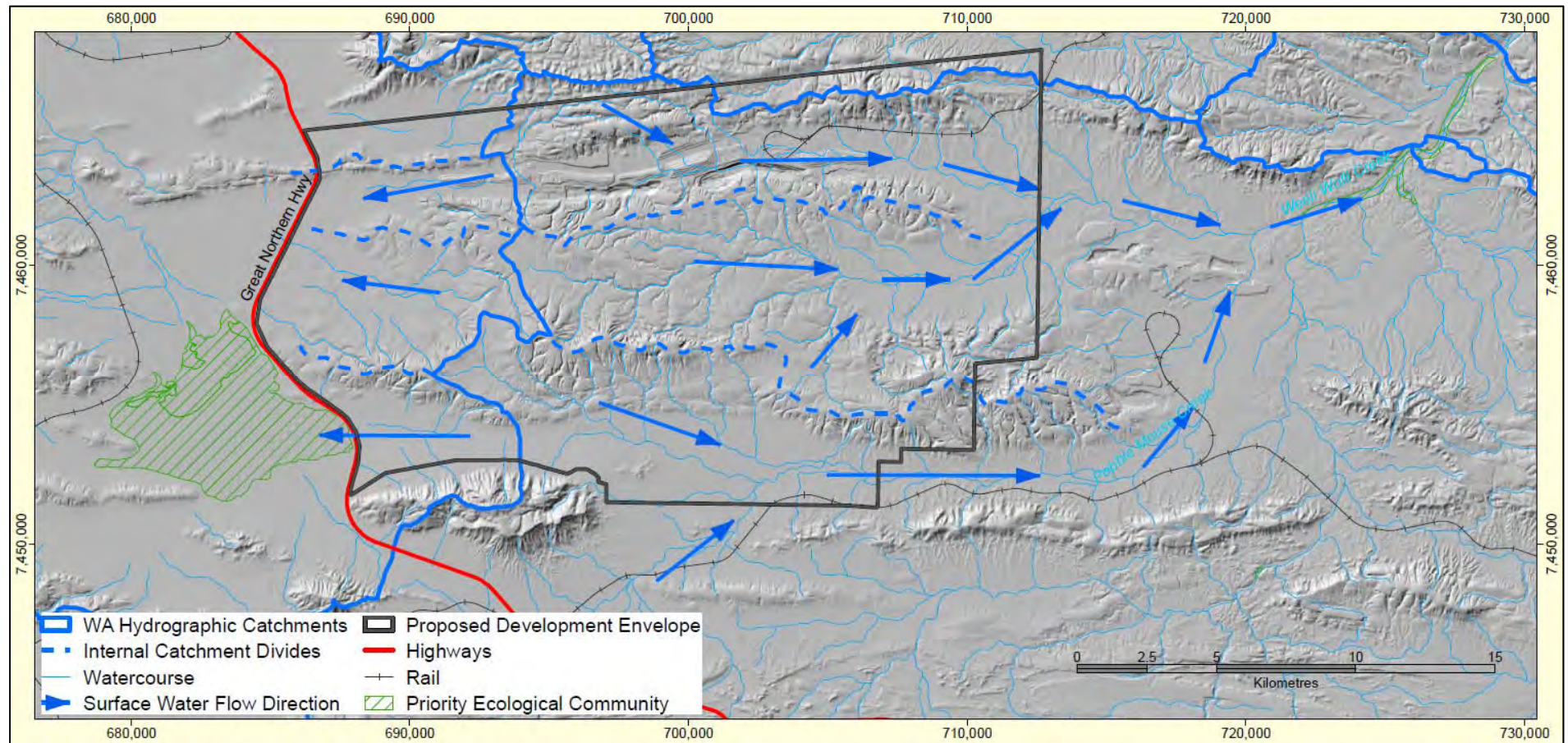


Figure 39: Surface water catchments and flow directions

11.5.4 Potential impacts

The extents, or boundaries, used to assess the potential impacts of this Proposal, of the Revised Proposal (that is this Proposal plus the existing Mining Area C operations) and cumulative or regional extents vary for each factor. Table 59 details the impact assessment area for the Inland Waters Environmental Quality factor.

Table 59: Impact assessment areas for inland waters environmental quality

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Inland Waters Environmental Quality	Assessment of Coondewanna and Weeli Wolli subcatchments. Includes potential impacts from the proposed Southern Flank ore body, Mining Area C current operations and Hope Downs 1 project. Impact assessment determined the significance of additional catchment reduction due to the Proposal.	Assessment of Coondewanna and Weeli Wolli subcatchments. Includes potential impacts from the proposed Southern Flank ore body, Mining Area C current operations and Hope Downs 1 project. Impact assessment determined the cumulative impacts of the Proposal, existing Mining Area C operations and third party operations at Hope Downs.	As per Mining Area C Revised proposal Extent as impacts assessed for whole catchments and inclusive of third party operators.

The following surface water potential impacts have been assessed as part of the hydrological change assessment:

- Reduced surface water availability.** Surface water flow and runoff will be intercepted and diverted to prevent inflow to and inundation of the open pits and to prevent flooding of infrastructure. Proposed pit and OSA developments have the potential to impact surface water resources by:
 - increasing the risk of erosion and sedimentation, or
 - introducing contamination to the subsurface from chemicals.

As described previously, the surface water ultimately flows east towards Weeli Wolli Creek with a smaller percentage going west towards Coondewanna Flats.
- The storage and handling of waste products.** The inappropriate handling and management of soluble waste materials has the potential to contaminate surface water and groundwater.
- Acidic or saline pit lakes.** The water within pit voids may increase in salinity through concentration, or develop AMD characteristics via interactions with the wall rocks. The altered water quality may remain isolated within the pit or under some hydrological conditions, groundwater may flow through the pit and therefore the pit may alter the downstream groundwater chemistry.

As discussed in Section 11.7.4.1, AMD risk is considered low to very low due to the lack of AMD source material. As a result the risk of acidic pit lakes in the Proposed Mining Area C Development Envelope has been assessed as low to negligible. Potential exists for pit lakes to become saline overtime and as such an adaptive management approach will be taken. BWT pit void backfill is a mitigating option if required to maintain suitable surface and groundwater quality.

Changes to surface water volumes within the catchment are detailed in Table 55 of Section 11.4.7. Section 11.4 includes an assessment of changes to Hydrological Processes which considers changes to surface water catchments. Potential impacts to specific receptors are discussed in more detail in Section 11.1.4.3.3 (Weeli Wolli) and Section 11.1.4.3.4 (Coondewanna). No significant changes to surface water quality in either the Weeli Wolli catchment or Coondewanna catchment have been observed from monitoring data as a result of operations to date and no changes are predicted for water quality as a result of the Proposal.

A summary of impacts the proposed change and the proposed extent is provided in Table 60.

Table 60: Summary of inland waters environmental quality potential impacts

Proposal	Proposed Extent (Revised Proposal)
<p>Proposed OSA 36 encroaches on the Pebble Mouse Creek 100-year floodplain, which is a potential erosional risk. Current management of OSAs such as landform design, waste characterisation and rock armouring will ensure this risk is minimised. This management is further discussed in Section 11.7.</p> <p>It is predicted that even in a 1 in 10,000 flood event there is no significant impact to quality of water in Pebble Mouse Creek as there is no risk of creek capture for Pebble Mouse Creek</p> <p>The likelihood of the formation of acidic or saline pit lakes (if they are present) is considered low to negligible.</p> <p>Proposed pit and OSA developments for the P2, P5, P6 and R deposits and modifications to the existing indicative deposit and OSA boundaries have the potential to impact surface water resources by changing local surface water flow patterns, by affecting surface water runoff volumes and quality, by increasing the risk of erosion and sedimentation, or by contamination from chemicals or hydrocarbons.</p> <p>It is predicted that there is no significant impact to surface water flow, runoff volumes or quality for additional disturbance. With current management practises with respect to chemical and hydrocarbon containment it is predicted that risk of contamination to surface water is low. The current storage and containment management for chemical and hydrocarbons has resulted in no surface water or groundwater contamination to date.</p>	<p>Assessment shows that there is not predicted to be significant impacts to water quality as a results of the Proposal.</p>
<p>Potential impacts on natural surface water quality are negligible. The risk assessment concluded that the potential for AMD is low due to the oxidised nature of the ore.</p>	<p>Overall, AMD is not considered to pose a risk to inland waters environmental quality.</p>

<p>The Proposal will potentially mobilise additional sediment to the natural drainage systems arising from the OSAs, ore stockpiles and native vegetation clearing in general. Rainfall and surface water runoff from mining areas has the potential to increase sediment-laden water transmitted to the environment or to natural drainage systems. However, the potential for increases in surface water sediment loading will be minimal overall, following the design and implementation of sediment basin interceptors. The use of sedimentation basins have resulted in no incidence of sediment laden runoff from Mining Area C operations.</p>	<p>Following the construction of sediment basin interceptors as part of the revised proposal, it is not considered that there will be significant impacts to the surrounding environment from increased sediment load in surface water.</p>
<p>While there may be potential for impacts to surface water due to spillage of chemicals or hydrocarbons, this is not expected to be an issue due to the proposed installation of appropriate fuel, hydrocarbon and chemical containment and storage facilities. The current storage and containment management for chemical and hydrocarbons has resulted in no surface water or groundwater contamination to date.</p>	<p>While there may be potential for impacts to surface water due to spillage of chemicals or hydrocarbons, this is not expected to be an issue due to the proposed installation of appropriate fuel, hydrocarbon and chemical containment and storage facilities in the Proposed Mining Area C Development Envelope.</p>

As assessment of surface and groundwater flow and quality in the catchment has shown that AMD risk is low, impacts to water quality from sedimentation is low and potential contamination of waters resulting from chemical or hydrocarbon storage is low.

Therefore it is concluded that is no significant risk to inland water environmental quality predicted due to implementation of the Proposal.

11.5.5 Mitigation and residual impacts

For the three key environmental receptors in the catchment there is considered to be negligible risk from the proposed development for the following reasons:

- Coondewanna Flats will have a small reduction in catchment area but surface runoff into the catchment is expected to be maintained within historic ranges. Sediment control for water entering Coondewanna Flats will reduce the likelihood of impacts due increased sediment in surface water.
- Weeli Wolli Creek and spring system will have a small reduction in catchment area but surface runoff into the catchment is expected to be maintained within historic ranges. Sediment control for water entering the Weeli Wolli catchment will reduce the likelihood of impacts due increased sediment in surface water.
- The surface water catchment supporting Ben's Oasis is outside of the development footprint with project development and operations unlikely to impact water quality in this catchment.

Where possible, surface water flows will be diverted around operational areas with the aim of maintaining water flow volumes as far as practicable.

Although only 8% of the proposed ore in the Indicative Additional Development Envelope is below the water table, if not backfilled, the orebody at the western end of the Indicative Additional Development Envelope has the potential to remain as a pit lake, which ultimately could become saline. An adaptive management approach will be taken to manage pit lake salinity such that BWT pit void backfilling deployed if required to maintain suitable groundwater and surface water quality. With backfilling of pits available as a mitigation measure to manage the potential for pit lakes to become saline and or acidic

over time is not considered that salinity or acidic pit lakes are possible in relation to this Proposal and is the primary reason why BHP Billiton Iron Ore considers that Inland Waters Environmental Quality is not considered to be a key environmental factor.

Following application of the mitigation hierarchy, the residual impacts are not considered significant and therefore the application of offsets is not warranted.

BHP Billiton Iron Ore also considers that general chemical and contamination risks can be managed as part of its standard Pilbara-wide Health, Safety and Environment Management System.

11.5.6 Proposed management approach

Sediment management has been successful to date at Mining Area C. Sediment traps and retention ponds have been installed along the main drainage channels which have prevented any significant sediment loads leaving site. Monitoring of water leaving site has shown sediment levels to be consistently below licence requirements. Due to similarities in sediment source material (Marra Mamba ore) and runoff volumes it is expected that the use of sediment ponds and monitoring will also be successful when applied to the Southern Flank mining areas.

BHP Billiton Iron Ore considers that this environmental factor can be addressed by actions outlined in Table 60, those discussed in Section 11.5.5 and outlined in the Mine Closure Plan (Appendix 12).

11.5.7 Predicted outcome

This Proposal meets the EPA's objective for the inland waters environmental quality factor, with potential impacts not considered significant and it is therefore not considered to be a key environmental factor. BHP Billiton Iron Ore considers that this factor can be addressed under Part V of the EP Act.

11.6 Heritage

11.6.1 Introduction and EPA objective

The EPA applies the following objectives, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a) in its assessment of proposals in relation to heritage:

To ensure that historical and cultural associations are not adversely affected.

11.6.2 Relevant guidelines and approvals

The following guiding document is relevant in the consideration of impacts to Aboriginal heritage:

- *EPA Guidance Statement No. 41, Assessment of Aboriginal Heritage* (EPA 2004d); and
- *Aboriginal Heritage Act (1972)* (AH Act).

Table 7 details the relevant EPA documents as identified in the Mining Area C – Southern Flank Environmental Scoping Document (OEPA, 2016) and their relevance to this Proposal.

11.6.3 Existing environment

The Proposed Mining Area C Development Envelope is situated within the determined Native Title of the Banjima People. BHP Billiton Iron Ore is committed to working cooperatively with the Banjima People and have formalised this commitment through a comprehensive Indigenous Land Use Agreement (ILUA) executed on the 28 October 2015. The BHP Billiton Iron Ore Banjima ILUA covers the entire Banjima Native Title determination area, which spans an area of 8,263 square kilometres (826,300 hectares).

The ILUA governs the delivery of Native Title and associated indigenous approvals and facilitates long term collaboration and outlines how BHP Billiton Iron Ore works in partnership with the Banjima People to manage cultural heritage. The Heritage Protocol outlined in Annexure A of the BHP Billiton Iron Ore Banjima ILUA includes detailed processes and provisions about the way in which heritage surveys, consultations and submissions are conducted. As part of these agreements, BHP Billiton Iron Ore and the Native Title groups have agreed to specific cultural heritage commitments in relation to the management of heritage sites, including the recognition, mapping and capture of places of ethnographic importance (referred to as 'confidential areas'). BHP Billiton Iron Ore will seek to avoid impacts to these confidential areas in line with its obligations under the agreements.

The heritage values of the Proposed Mining Area C Development Envelope have been determined by BHP Billiton Iron Ore, heritage consultants and members of the Banjima by conducted over 200 ethnographic and archaeological heritage surveys within the Proposed Mining Area C Development Envelope. BHP Billiton Iron ore have specifically consulted with these stakeholders regarding the Proposal. BHP Billiton Iron Ore has spent over 2,000 working days in the field undertaking survey works in relation to the Proposal. The methodology of the survey is based on pedestrian transects that cover the entire Proposed Mining Area C Development Envelope. All heritage places have been mapped and recorded (Figure 40). The information is then managed in a spatially enabled database. All surveys were conducted by qualified archaeologist and anthropologists in partnership with Banjima participants. Over 7 million dollars has been spent on heritage surveys and heritage research in the Proposed Mining Area C Development Envelope.

The general significance of heritage places range from being:

- External (Government) Protected Areas:- are heritage places that have been identified through legislative or regulatory processes. These places have been *gazetted* or officially set aside by either a legislative or regulatory body under a specific Act of Parliament (e.g. section 19 of the AHA) at either State or Commonwealth level. This type of heritage place therefore may be included on either a State or Federal Heritage List or Register and are protected by legislation;
- Agreement exclusion zones:- these are heritage places where BHP Billiton Iron Ore has made a commitment to avoid via land use agreement ranging from a contractual commitment to rights reserved;
- Actively managed areas:- these are heritage place where agreement on significance has not been reached or where there is an agreed high culture value (but do not warrant an exclusion zone or are not externally protected) or areas where BHP Billiton Iron Ore consider site may be listed as protected in the future. These sites are considered to have higher cultural heritage value than those classed as sites under section 5 of the AHA;
- Section 5 heritage sites:- as determined by the ACMC under the AHA; and
- Other places:- these are considered to be of low cultural heritage value and or are yet to be assessed under the AHA.

Further detail on significance is provided in the Draft Cultural Heritage Management Plan in Appendix 8. Archaeological surveys have identified over 1,500 places within the Proposed Mining Area C development envelope that show evidence of past human occupation and interaction with the environment and these have been discussed with the relevant Aboriginal People. These places are classed as other places until such time as they are assessed and or classified with the traditional owners or by the ACMC.

The Proposed Mining Area Development Envelope specifically avoided the Mount Robinson significant site, as agreed with the traditional owners as an exclusion zone (see Section 11.6.5).

The places located within the Proposed Mining Area Development Envelope include Rockshelters (~20%), Rockshelters containing artefacts (~65%), Stone Arrangements/Man made Structures (~7%), Artefact Scatters (~6%), Scarred Trees (2%), quarry (<1%) and one Engraving. None of the places located in the development envelope are externally protected areas or exclusion zones. Two actively managed areas (Jandaru Jibalba and Stone Arrangement Relocation) are present within the Proposed Mining Area C Development Envelope, one (Jandaru Jibalba) is within the Mining Area C EMP Revision 6 Impact Assessment Area. The management strategy for this site is that it will be avoided and will be managed via the PEAHR process. Further information for this site is not included here or in the Cultural Heritage Management Plan (CHMP) as the site is considered culturally sensitive by the Banjima people. Information pertaining to the second actively managed site (Stone Arrangement Rockshelther) is included in the CHMP, except for the specific location which is withheld in line with the ILUA.

To date, 18 sites within the Proposed Mining Area C Development Envelope have been classed as section 5 heritage sites (see Figure 40a). All of these and the remaining heritage places are very common in the central Pilbara and widely distributed across the broader landscape (see Section 11.6.4.1).

One of the sites is a registered ethnographic site, DAA 25664 (Djadjiling) is within the Proposed Mining Area C Development Envelope. Djadjiling was initially referenced as part of Native Title preservation evidence in June 2007 (Canning, 2008). The reference provided little detail as to why and on what basis the range was recorded as an ethnographic site and how it relates to any other places of significance in the area. During ethnographic surveys undertaken by John Gleason with the Banjima people in 2008 where Senior Lore Men such as David Stock and Gordon Yuline attended, no mention was made of the Djadjiling being an ethnographic site.

The assessment of whether these places are formally nominated as heritage sites under the AHA is undertaken by the Aboriginal Cultural Material Committee (ACMC) with support from the DAA. To be formally nominated as a site under the AHA these places have to meet criteria under section 5 of the AHA. The ACMC makes this assessment. The ACMC advises the Minister on the significance of the relevant sites and give recommendations on the project and potential mitigation. The Minister considers this guidance and other relevant factors before giving conditional approval or rejecting the proposal under s18.

In a consent letter dated the 24 August 2009 (Our Ref 25-05661) Minister Kim Hames (Minister for Indigenous Affairs) granted consent under s18 of the AH Act for portions of the Additional Development Envelope and DAA 25664 (Djadjiling Ethnographic Site) to be impacted for the purpose of exploration activities for identifying and delineating iron ore mineralisation to facilitate the later development of iron ore operations. Under this consent, BHP Billiton Iron Ore has conducted significant exploration activities as part of the Southern Flank study, which includes but is not limited to >2,000 drill holes and clearing for access tracks. The approximate current disturbance footprint from exploration activities is approximately 274 ha. BHP Billiton Iron Ore is compliant with the conditions outlined in this consent.

As part of this Ministerial consent, BHP Billiton Iron Ore is required to include information on any archaeological places which may be impacted in any subsequent s18 (under the AH Act) application. A s18 application that has been submitted and approved as part of this Proposal is in line with the Ministerial consent. BHP Billiton Iron Ore submitted 79 places within the Proposed Mining Area C Development Envelope to the DAA under s18 of the AHA and 18 of these were found to meet the criteria outlined in section 5 of the DAA (see Appendix 8).

11.6.4 Potential impacts

The extents, or boundaries, used to assess the potential impacts of this Proposal, of the Revised Proposal (that is this Proposal plus the existing Mining Area C operations) and cumulative or regional extents vary for each factor. Table 61 details the impact assessment area for the heritage factor.

Table 61: Impact assessment areas for Heritage

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Heritage	Proposed Mining Area C Development Envelope	As for Proposal Extent plus Approved Mining Area C (Northern Flank) Development Envelope and Mining Area C EMP Revision 6 Impact Assessment Area	As for the Revised Proposal extent with consideration of cultural significance regionally.

Within the Proposed Mining Area C Development Envelope BHP Billiton Iron Ore identified over 1500 potential heritage places, 25 of these have been fully impacted under s18 approval by the Mining Area C development and 17 sites have been partially impacted. The Proposal may potentially impact ~1200 potential archaeological places and partially impact (~30%) one ethnographic site DAA 25664 (Djadijiling) (Figure 40). Note that the majority of these potential heritage places are classed as “other places” under the significance classifications, although some are yet to be assessed by the ACMC. It is likely that the majority of these potential places will remain at the “other places” significance level based on recent application (see below). The significance of impact to the ethnographic site is not considered significant particularly as the ethnographic surveys undertaken by John Gleason with the Banjima people in 2008 where Senior Lore Men such as David Stock and Gordon Yuline attended, made no mention of the Djadijiling being an ethnographic site and did not highlight this site as being of significance to the Banjima people.

Rockshelters, with or without walls and or artefacts, constitute the main (~85%) potential heritage places within the Proposed Mining Area C Development Envelope. Twenty five percent (~25%) of these places are located outside of the Indicative Impact Areas (Additional and EMP Revision 6). Many of the other types of sites (in total ~420 potential places) are also located outside of the proposed impact areas: stone arrangements (25%), artefacts (25%), engraving (0%), quarries (57%), and scarred tree (27%).

Within surveyed areas, BHP Billiton Iron Ore is aware of the spatial location of each heritage place and, where practical, adopt engineering solutions to avoid them. Requirements around the management and minimising impacts to significant heritage places and values are embedded within the BHP Billiton global Indigenous people's policy.

An application was tabled at the ACMC on 14 December 2016 with regard to the heritage places that will be impacted within the first five years of the Proposal. The places have been recorded to a detailed level to mitigate against their loss. The detailed recording is considered a mitigation as it preserves the information contained in the heritage place. Additionally BHP Billiton Iron Ore has conducted an extensive excavation project in partnership with the relevant Aboriginal People to better understand the cultural landscape and the sequence of early occupation of the area. Approvals under the AH Act, in relation to subsequent impacts of further sites will be sought in line with legislative and ILUA contractual requirements.

On 24 January 2017 BHP Billiton Iron Ore received ministerial consent under s18 of the AHA to use the land for the purpose of all things associated with open cut iron ore mining. Of the 78 places submitted the ACMC and the Minister, it was assessed that 18 places (i.e 23% of those submitted) met Section 5 of the AHA and The Minister gave consent to impact these sites. No specific mitigation or management conditions formed part of the consent. BHP Billiton Iron Ore is currently working with the local Aboriginal elders to evaluate and establish salvage and mitigation options.

Baseline and targeted flora and fauna surveys are undertaken to inform environmental approvals and management. These surveys are undertaken in line with the Western Australian EPA's Guidance Statement No. 51 (EPA, 2004a), as well as other relevant EPA position statements, and are generally in line with the recently released Technical Guide - Flora and Vegetation Surveys for EIA (EPA & DEC, 2015). BHP Billiton Iron Ore will engage with relevant Native Title groups in identifying indigenous considerations relevant to these surveys, including bush food and bush medicine as part of its ongoing consultation undertaken as part of the ILUA. BHP Billiton Iron Ore is working closely with the Banjima Aboriginal group on their care for country plan, which includes identification and management of things such as bush medicine and traditional food.

Detailed heritage site investigations and EIA have shown that potential environmental impacts of the Proposal do not cause a significant impact to any identified heritage site. The past surveys with Banjima and Nyiyaparli participation have not indicated a direct link between identified heritage sites and the presence or absence of certain biophysical attributes of the environment.

Based on the above, BHP Billiton considers that there is no significant impacts to heritage sites as a result of any predicted biological impacts arising from the Proposal.

11.6.4.1 Cumulative impacts

BHP Billiton Iron Ore has completed numerous research projects focusing on cumulative impact within BHP Billiton Iron Ore operations and the wider Pilbara region. These projects have focused on increasing the understanding of cumulative impact in the Pilbara region and include projects focused on rare site types. All projects have been undertaken in collaboration and partnership with traditional owners, contractors and academic institutions.

Figure 41 shows the overall context for cumulative heritage site impacts in the central Pilbara based on BHP Billiton Iron Ore's comprehensive data set.

BHP Billiton Iron Ore has undertaken surveys across ~15% of the full Banjima claim area. BHP Billiton currently manages approximately 4,085 known potential heritage sites with the Banjima Claim. Approximately 40% of these places are located within the Proposed Mining Area C Development Envelope. Figure 41 shows that most of these sites are currently avoided by BHP Billiton Iron ore operations.

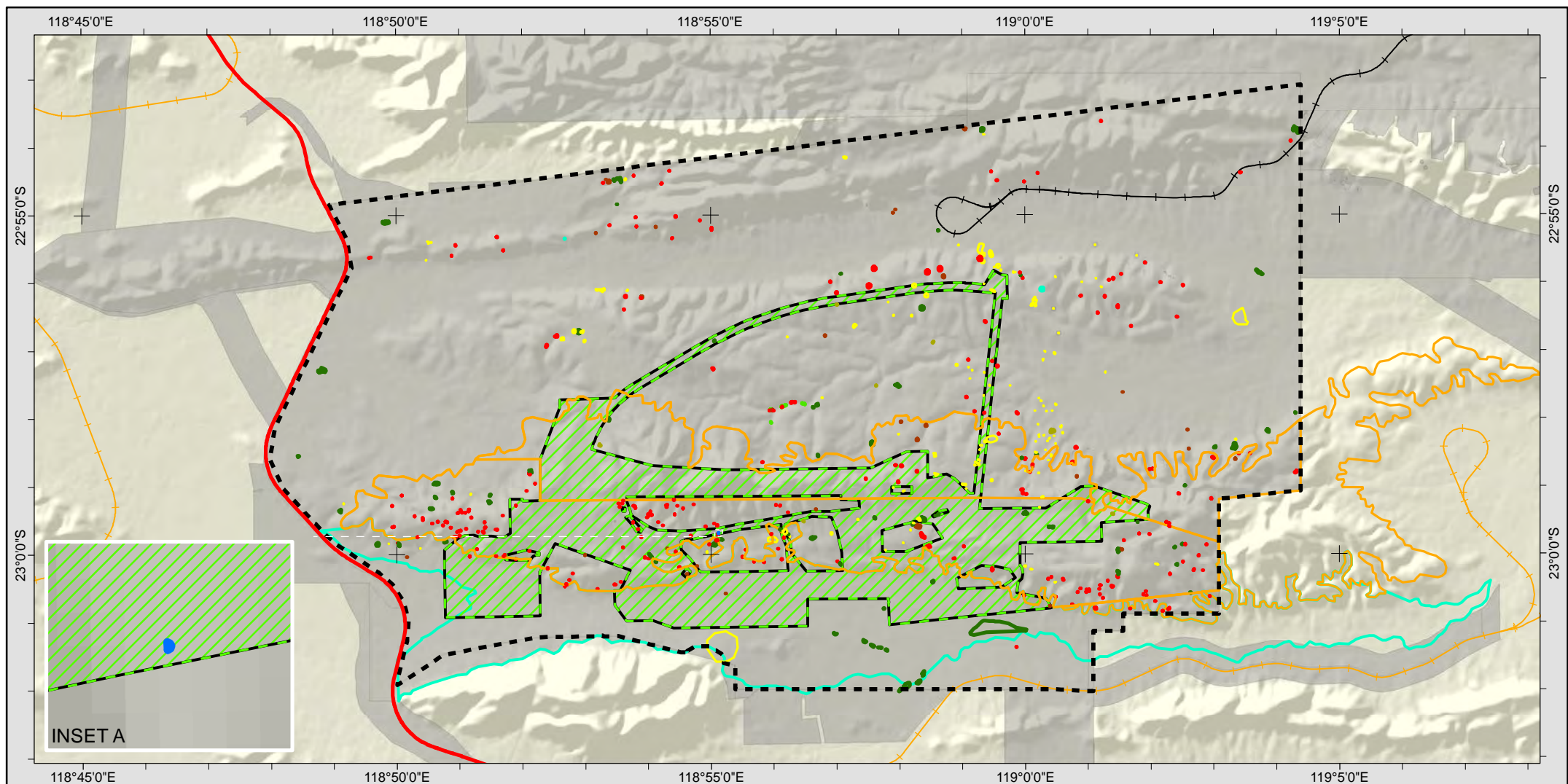
The assessment of potential regional cumulative impacts from a regional perspective were based on the current potential places known by BHP Billiton Iron Ore within the Banjima claim area (826,300 hectares). On a regional scale the Proposal may impact the following potential heritage places:

- Rockshelters – 40% of the known potential places in the Banjima claim area are within the indicative impact areas.
- Stone Arrangments – 59 % of the known potential places in the Banjima claim area are within the indicative impact areas.
- Artefacts - ~8% of the known potential places in the Banjima claim area are within the indicative impact areas.

- Engravings - ~3% of the known potential places in the Banjima claim area are within the indicative impact areas
- Quarries - ~4.5% of the known potential places in the Banjima claim area are within the indicative impact areas
- Scarred trees – 25% of the known potential places in the Banjima claim area are within the indicative impact areas

It should be noted that due to the fact that more survey work has been undertaken within the Proposed Mining Area C Development Envelope than elsewhere in the Banjima claim area impact statistics are likely overestimated.

Noting that the majority of the potential places in the Proposed Mining Area C Development Envelope are classed as 'other places' or may be section 5 sites (pending assessment) it is concluded that the cumulative impact of the Proposal does not represent a significant impact to heritage sites regionally.



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Heritage Survey Areas, Places and Approvals

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/053 REV B
Date: 3/05/2017	Checked: R. GREGORY	Figure: 40
Revision: Rev B	Reviewed: S. WILLIAMSON	

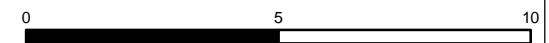
Heritage Places

- Artefacts
- Djadjiling (DAA Site 25664)
- Engraving
- Man Made Structure
- Modified or Scarred Tree
- Mythological
- Painting
- Quarry
- Rockshelter

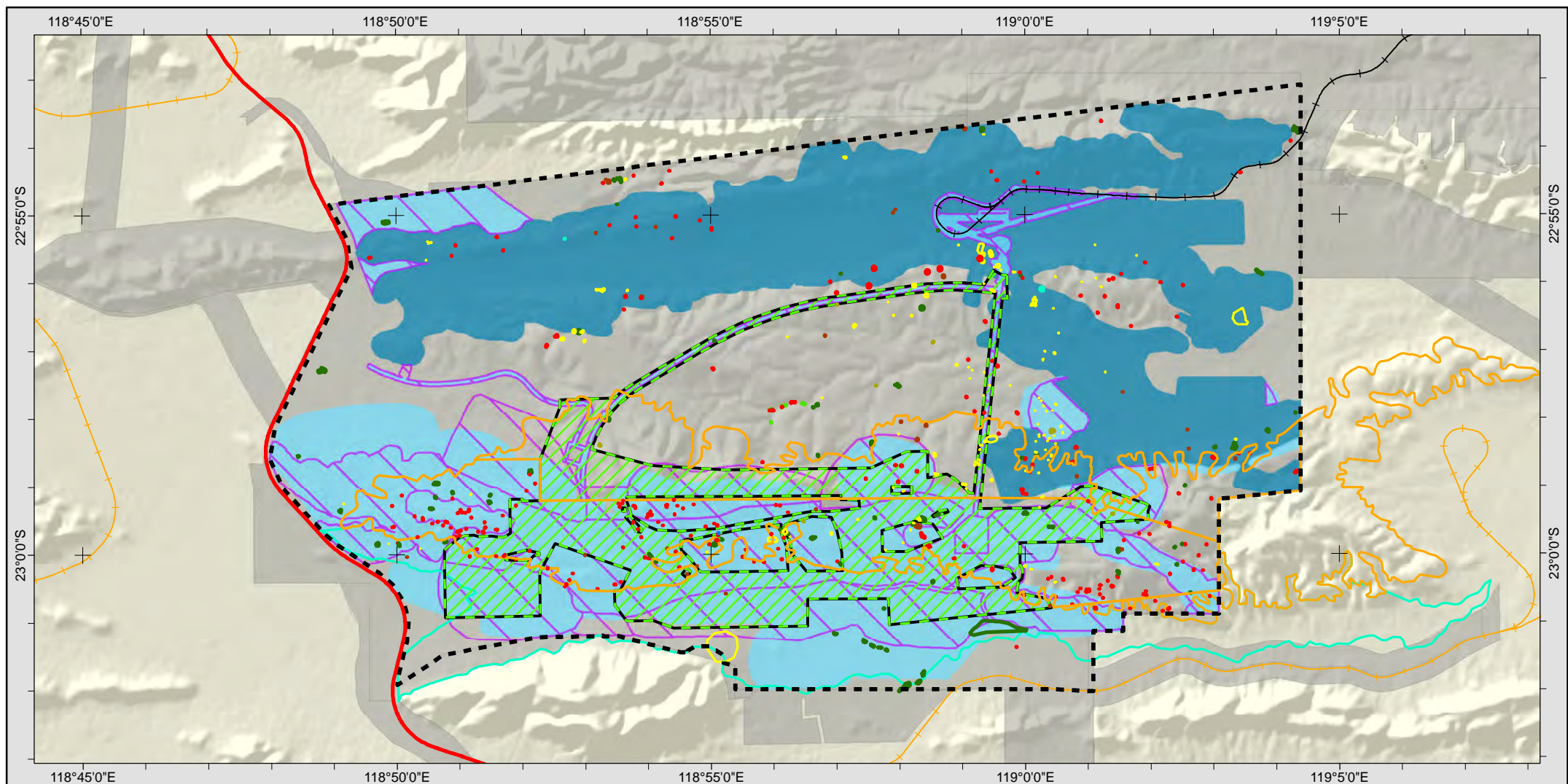
Proposed Mining Area C Development Area

- Southern Flank Section 18 The Land
- Heritage Survey Areas
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Heritage Survey Areas, Places and Approvals

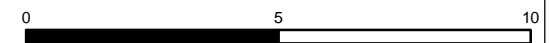
Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/054 REV B
Date: 3/05/2017	Checked: R. GREGORY	Figure: 40a
Revision: Rev B	Reviewed: S. WILLIAMSON	

Heritage Places

- Artefacts
- Djadjiling (DAA Site 25664)
- Engraving
- Man Made Structure
- Modified or Scarred Tree
- Mythological
- Painting
- Quarry
- Rockshelter
- Proposed Mining Area C Development Area
- Southern Flank Section 18 The Land
- Heritage Survey Areas

- +— BHP Billiton Rail
- +— Rio Tinto Rail
- +— Great Northern Highway
- Indicative Additional Impact Assessment Area
- Mining Area C EMP Rev 6 Impact Assessment Area
- Modified Indicative Additional Impact Assessment Area

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.



Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

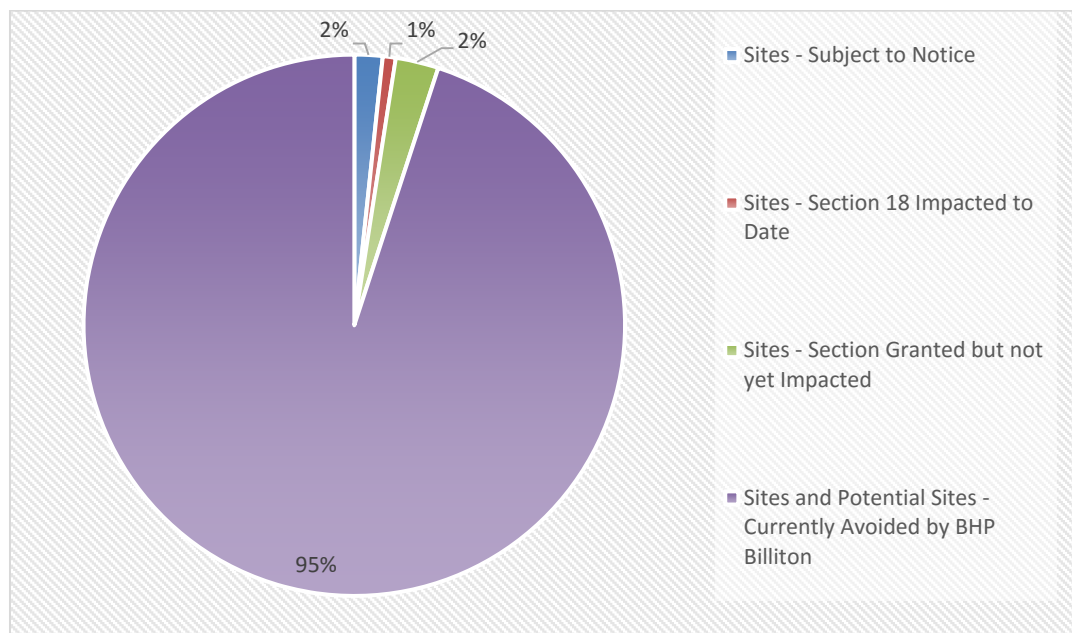


Figure 41: Cumulative impacts to Heritage sites within the Central Pilbara

11.6.5 Mitigation and residual impacts

Where technically possible, BHP Billiton Iron Ore works to avoid sites through early planning and engineering solutions. For the Southern Flank development optimisation of the mine plan has resulting in a reduction in the potential impact to heritage sites for the 10 year mine footprint and optimisation of the mine plan and design will continue during detailed planning process to ensure best practice is continuously applied to reduce any impacts.

Subject to BHP Billiton Iron Ore's land use agreement with the relevant Native Title group (ILUA), BHP Billiton Iron Ore only seeks approval to disturb potential sites under the AHA where this is not avoidable. Hence the approvals process under s18 is progressively developed with the 5 year mine planning circle. Current avoidance activities have shown that most of the heritage places have been avoided (Figure 42).

Changes to the mine design (Modified Indicative Impact Assessment Area) has resulted in a reduction in impact to potential heritage places of approximately 15% (in addition to the ~25% located in the Development Envelope but not within the impact assessment areas). By site type this reduction is as follows:

- Rockshelters – a reduction of ~17%;
- Scarred Trees – a reduction of 4%; and
- Artefacts – a reduction of ~13%.

The DAA has undertaken an assessment of the 76 places subject of the current s18 submission to inform the ACMC process and has concluded that only 18 heritage places met the requirements of section 5 of the AH Act. It is likely that subsequent s18 applications will not elevate all current potential heritage places within the Proposed Mining Area C Development Envelope.

During the original definition of the Proposed Mining Area C Development Envelope BHP Billiton Iron Ore specifically avoided inclusion of Mount Robinson which is classed as an exclusion zone.

The residual impact to heritage sites as a result of potential impacts to the biophysical environment is not considered significant as ongoing avoidance of impacts to heritage sites through mine planning and design modifications will continue to occur.

It is believed that impacts to heritage sites can be managed through BHP Billiton Iron Ores standard management as detailed below and therefore this factor does not warrant application of offsets.

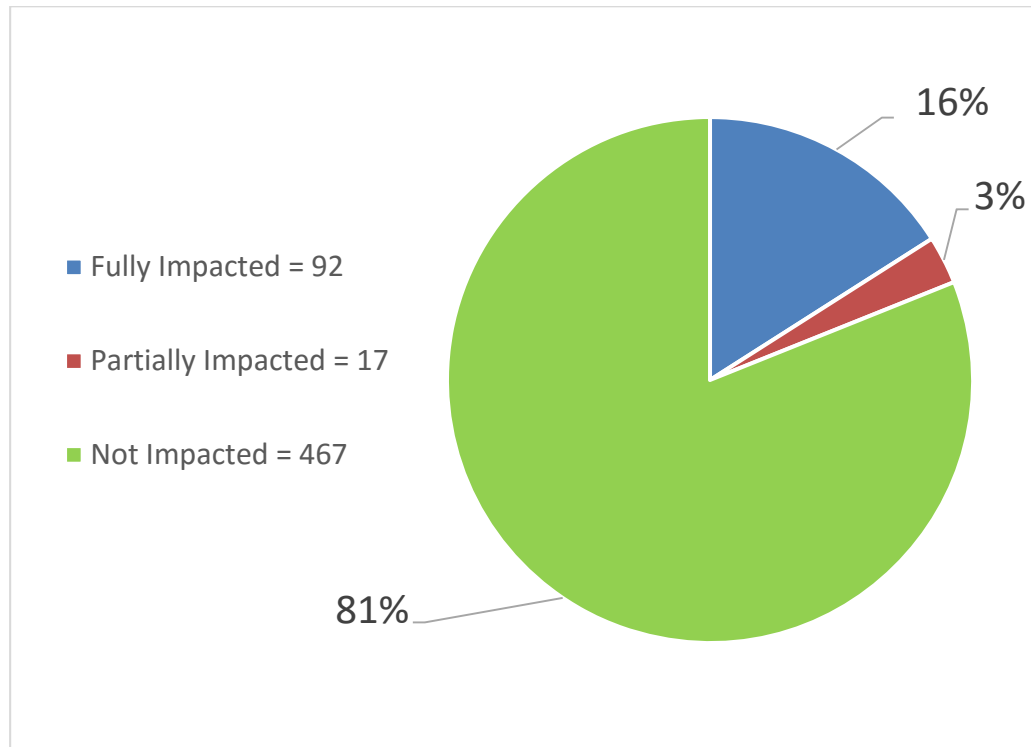


Figure 42: Mitigation of impact of Heritage places within the Proposed Mining Area C Development Envelope

11.6.6 Proposed management approach

BHP Billiton Iron Ore manages and protects Aboriginal heritage in compliance with the State and Federal legislation. Potential impacts to heritage sites are managed through BHP Billiton Iron Ore's internal heritage management processes, including via the PEHR process. These processes are based on guidelines drafted by the DAA and include measures to identify significant heritage sites during planning phases so as to avoid or minimise potential heritage impacts. If any heritage site cannot practically be avoided, BHP Billiton Iron Ore will consult with the relevant Aboriginal group and seek consent from the Minister under s18 of the AH Act prior to undertaking any activities that may disturb the site.

As part of the ILUA agreements, a structured engagement framework between BHP Billiton Iron Ore and the agreement signatories on how Indigenous considerations are incorporated into future proposals has been agreed. BHP Billiton Iron Ore has committed to early engagement starting at project inception, linking to key project and approval milestones, and continuing through until closure and rehabilitation. These issues go beyond those typically considered during project approvals, including things such as bush food, bush medicine and ephemeral rock pools. These agreements require consultation between parties prior to disclosure of culturally sensitive information on specific sites that are subject of approvals under AH Act or EP Act. The engagement framework forms part of BHP Billiton Iron Ore's overall approach to manage and protect Aboriginal heritage in compliance with the AH Act and the EP Act.

This holistic approach to management of archaeological, ethnographic and environmental considerations address the fundamentals of the mitigation hierarchy and are based around the ILUA agreements including those with the Nyiyaparli and Banjima peoples.

For this Proposal, BHP Billiton Iron Ore has commenced, and will continue, to work with relevant Aboriginal groups to identify Indigenous considerations and to incorporate these in project development. A key part of this engagement will be consultation on how the mitigation hierarchy is applied to these considerations. Management of these issues will be tracked and reported to the groups through the existing committee structures established under the relevant land use agreements.

A mine closure plan has been prepared and will provide completion criteria and closure options for the Proposal supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. Throughout the operations phase, iterations of the mine closure plan will progressively refine the closure options with available data, enabling detailed designs and completion criteria to be developed and progressive rehabilitation works to occur. As mining draws to a close, the detailed closure designs will be executed, and the site will move into the post-closure period of monitoring, reporting, completion and sign off. In all cases, the focus for the application of the relevant controls is on achieving the defined completion criteria and following the mitigation hierarchy of control.

Relevant Native Title parties will be consulted in the development of management plans and Indigenous considerations will be incorporated into the plan as appropriate. This may include the identification and inclusion of appropriate bush food and bush medicine plants into the rehabilitation seed mix.

The proposed management provisions for heritage are outlined in Table 62.

11.6.7 Predicted outcome

Significant heritage and environmental survey work has been undertaken with the relevant people to understand, record and (where practical) design around the heritage values present. The Proposal will impact a number of archaeological sites and places and partially impact one ethnographic site. The sites have been recorded to a detailed level to mitigate against their loss.

Additionally, BHP Billiton Iron Ore has conducted an extensive excavation projects in partnership with local Aboriginal people to better understand the cultural landscape and the sequence of early occupation of the area.

This Proposal meets the EPA's objective for the heritage factor, and it is not considered that potential impacts to biophysical environment as a result of the proposal will result in significant impacts to any heritage sites. Therefore BHP Billiton Iron Ore considers that this factor is not a key factor and can be addressed under the provisions of the EP Act and AH Act.

Table 62: Proposed Environmental Management Plan Provisions - Heritage

EPA Factor and objective:	Heritage – To ensure that historical and cultural associations are not adversely affected.		
Key environmental values:	Cultural heritage value of local indigenous people		
Objective:	Minimise impacts to heritage places, as far as practicable.		
Outcome:	Maintain cultural heritage in the Development Envelope.		
Key impacts and risks:	Direct impact to cultural heritage places.		
Management-based provisions			
Management Actions	Management Targets	Monitoring	Reporting
A s18 approval in place to impact the site.	No heritage place impacted prior to s18 approval in place Compliance with s18 conditions.	Regular site audits to verify no clearing outside of s18 approved area.	Notification to the regulatory authority and relevant parties, upon confirmation of unauthorised clearing or ILUA commitment not met.
PEAHR must be in place prior to land disturbance.	No clearing without PEAHR approval in place.	PEAHR verifications to verify no unauthorised clearing.	
Ongoing consultation and survey with Banjima people to detail, record and conduct cultural salvage of all heritage places potentially impacted where possible and practical.	Consultation at a minimum every 6 months Active participatioin of Banjima people in relevant surveys.	Recording of outcomes of consultation and tracking of commitments with Banjima people in line with ILUA.	

11.7 Rehabilitation and decommissioning

11.7.1 Introduction and EPA objective

BHP Billiton Iron Ore is committed to environmental stewardship. This section discusses the potential post-closure impacts of the Proposal on the environment and describes BHP Billiton Iron Ore's approach to rehabilitation and decommissioning.

The EPA applies the following objective, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a), in its assessment of proposals in relation to rehabilitation and decommissioning:

To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.

11.7.2 Relevant legislation, guidelines and approvals

As part of the preparation of this assessment of the rehabilitation and decommissioning preliminary key environmental factor, all applicable EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

Other relevant guidelines that have informed the assessment for this factor include:

- *Planning for Integrated Mine Closure: Toolkit* (ICMM, 2008);
- *Mine Void Water Issues in Western Australia* (Johnson & Wright, 2003);
- *Strategic Framework for Mine Closure* (ANZMEC & MCA, 2000);
- *EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA, 2008);
- *EPA Position Statement No. 5: Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia* (EPA, 2004e);
- *EPA EAG No. 8: Environmental principles, factors and objectives* (EPA, 2013a); and
- *EPA Position Statement No. 8: Environmental Protection in Natural Resource Management* (EPA, 2005b).

Studies, investigations and surveys undertaken to date, the study area covered, and the relevant guidelines referred to and any limitations of the studies have been previously listed in Table 9.

11.7.3 Existing environment

BHP Billiton Iron Ore is working towards implementing a hub-based management approach for its mining operations as opposed to managing each deposit separately. Currently, a Mine Closure Plan has been developed in consultation with the DMP. This documents the proposed rehabilitation and closure strategy for existing Mining Area C operations, inclusive of all 14 deposits. Table 63 lists the areas included in the current Mine Closure Plan, the additional new areas included in this proposal that require a Mine Closure Plan. Closure planning for the additional areas that form part of this Proposal are now addressed in the updated in Appendix 12 which includes additional detail on rehabilitation and decommissioning to the sections below.

Assessment of rehabilitation against completion criteria will be applied throughout the various stages of rehabilitation planning, operations and management as part of BHP Billiton Iron Ore's adaptive

management practices. Assessment of progressive rehabilitation during the early years of ecosystem development ensures that corrective actions can be carried out if necessary without disturbing older rehabilitation, and while mining operations are still nearby.

Completion criteria standards and milestones will be formally reviewed at regular intervals in accordance with DMP/EPA guidelines. Where necessary they will be revised by mutual agreement between BHP Billiton Iron Ore, key stakeholders and regulatory authorities to adopt any significant advances in cost-effective rehabilitation techniques. More frequent reviews can take place where improvement opportunities are identified through ongoing research and development programs including landform trials, improved knowledge on the ecosystem development derived from rehabilitation monitoring programs, greening initiatives and collection of additional site specific data. These activities are all normal 'business as usual' practices within BHP Billiton Iron Ore.

Table 63: Existing and proposed areas subject to a Mine Closure Plan

Areas subject to the Current Approved Mining Area C Mine Closure Plan (BHP Billiton Iron Ore, 2016m).	Additional new areas subject to this Revised Proposal that require a Mine Closure Plan	Total areas now addressed under the updated Mining Area C Mine Closure Plan
The area currently known as the Multiple Iron Ore Development Mining Area C Northern Flank (deposits A, B, C, D, E, F, R, P1, P2, P3, P4, P5, P6 and the Brockman Detrital Deposit) as approved under MS 491. This approved management plan applies to 5,385 ha of disturbance within the Approved Mining Area C Development Envelope of 25,815 ha.	The development of the new satellite deposits, OSAs and associated infrastructure at Southern Flank. An additional 19,671.2 ha of native vegetation in Good or above condition, (5992 ha of which is located in the EMP Revision 6 Mining Area C Impact Assessment Area) will potentially be disturbed and require progressive rehabilitation.	A total of 25,053.2 ha of disturbed vegetation in Good or above condition will require progressive rehabilitation in the Revised Proposed Development Envelope of 36,032 ha. The objective of the new Mine Closure Plan is to create a safe, stable and non-polluting landscape consistent with surrounding environmental values.

11.7.4 Potential impacts

The extents, or boundaries, used to assess the potential impacts of this Proposal, of the Revised Proposal (that is this Proposal plus the existing Mining Area C operations) and cumulative or regional extents vary for each factor. Table 64 details the impact assessment area for this factor.

Table 64: Impact assessment areas for rehabilitation and decommission factor

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Rehabilitation and Decommissioning (integrating factor).	Indicative Additional Impact Assessment Area and Additional Development Envelope. Mining Area C EMP Revision 6 Impact Assessment Area.	As for Proposal Extent plus Approved Mining Area C (Northern Flank) Development Envelope.	As for Proposal Extent but considered in regional context where relevant (e.g. hydrological processes).

The key closure aspects investigated when updating closure strategy and the Mine Closure Plan were:

- AMD;
- soil management and landform engineering;
- OSA rehabilitation and erosion control; and
- BWT pit voids and pit lake assessment.

11.7.4.1 Acid and metalliferous drainage

Acid drainage

AMD has the potential to degrade surface water and groundwater resource quality if not properly managed, including interaction with ecohydrological receptors. Potential environmental impacts associated with AMD include groundwater contamination, surface water contamination and the exposure of ecosystems to toxic substances.

A preliminary Acid Metalliferous Drainage Risk Assessment Study (BHP Billiton Iron Ore, 2016b) was carried out for the Proposal, which is available in Appendix 12 and a summary of outcomes detailed below. This assessment concluded that Southern Flank ore body and the 14 deposits at Mining Area C has a low to very low risk of AMD release to groundwater, surface water or soil material. The assessment was based on geochemical assay data from over 80,000 drill hole samples, results of which were incorporated into the resource model. An assessment of net acid production potential (NAPP) was undertaken which subsequently allows an AMD code/classification to be assigned.

Calculation of NAPP values within the Southern Flank and Mining Area C resource models use standard exploration geochemical analytes (S, MgO, CaO and LOI) results. A NAPP value of greater than or equal to three (3 kg sulfuric acid per tonne ($\text{H}_2\text{SO}_4/\text{tonne}$)) was considered the threshold for being potentially acid forming rock. The NAPP values were validated through acid base accounting tests of 236 drill hole samples from the Additional Development Envelope. The resource models determined that there is no areas of waste rock considered potential acid-forming (PAF) material, classified as AMD 1 ($\text{NAPP} \geq 3$).

Less than 3.5% of waste rock material planned to be mined consists of weathered bedrock and detrital material with $\text{NAPP} \geq 3$, sulphur in this material is likely oxidised and unlikely to have acid generating capacity. Applying the precaution principle, these materials will not be exposed in the outer layer of the final OSA rehabilitation surface. As part of normal closure activities and investigations additional geochemical assessment will be undertaken of these weathered waste rock types to further update any storage requirements within OSAs.

Sulphide bearing lignites are known in the area within some detrital units and potentially present an AMD risk. Only five drill holes from over 4,300 drill holes drilled at Southern Flank have intersected lignite clays, these clays occur within the Tertiary Detrital 2 unit. The lignite clay horizons intersected have limited lateral continuity, depths >90 m below ground surface and are located >180 m from any proposed pit boundary. Lignite clays at Southern Flank are assessed as presenting a very low AMD risk.

Metalliferous drainage

To date, 25 samples collected from Southern Flank ore body have been analysed for total elemental composition as well as for water leachable component. The results of multi-element chemical analyses, including the calculated global abundance indicators (GAI), can provide a very conservative indication of how the measured elemental abundances compare to average 'crustal' abundances. Results for total elemental data indicate potential enrichment of arsenic, chromium, lead, antimony and selenium in

some of the samples. Leach testing data indicate that none of the potentially enriched metals and metalloids leach at concentrations exceeding Australian drinking water or stock water guidelines. These results demonstrate that there is a low risk of waste rock and pit wall rock adversely impacting environmental conditions within the Proposed Mining Area C Development Envelope.

In addition to the AMD testing data for Southern Flank samples, BHP Billiton Iron Ore has collected AMD testing data for similar deposits across the BHP Billiton Iron Ore operations. The regional AMD geochemistry database is used to assess data trends within and across geographical areas for common stratigraphic units. The results for other deposits are consistent with the data collected from ore deposits within the Proposed Mining Area C Development Envelope.

BHP Billiton Iron Ore have collected an extensive geological assay database for total metals for exploration and mine planning. This assay database contains data collected by x-ray fluorescence analysis for:

- Standard assay suite – Fe, SiO₂, Al₂O₃, TiO₂, CaO, P, S, MgO, Mn, K₂O, Na₂O, and LOI 1000; and
- Extended assay suite – As, Ba, Cl, Co, Cr, Cu, Ni, Pb, Sn, Sr, V, Zn, and Zr.

The geological assay database is compared to results for specific AMD geochemistry testing. Correlations are developed to provide indications of material variability. Also, AMD risk is modelled in geological models based on assay and other geological data such as weathering characteristics. Model assumptions are tested using the results of detailed static and kinetic AMD geochemical testing.

BHP Billiton Iron Ore's ongoing sampling and analysis program, which forms part of the AMD Management Framework, utilises multi-disciplinary drilling programs all across the BHP Billiton Iron Ores operations to continually strengthen the regional environmental geochemical database. This allows capitalisation on pre-planned drilling programs to target deposits of specific importance as well as deposits and stratigraphies to improve the current database.

BHP Billiton Iron Ore will use planned drilling programs, including a targeted Southern Flank drilling program planned for the first two quarters of 2017, to continue building on existing databases with respect to the total elemental and static leach data available for Southern Flank. Samples will be collected based on proportional waste tonnages for waste stratigraphic units. Degree of weathering and location with respect to pre-mining water table are also considered when planning sample collection and testing programs.

The geochemical testing program has been and will continue to be based on key industry standard documents, including:

- The Draft Guidance Materials Characterisation Baseline Data Requirements for Mining Proposals (DMP 2016c);
- Leading Practice Sustainable Development Program for the Mining Industry - Preventing Acid and Metalliferous Drainage (DITR 2006);
- Global Acid Rock Drainage (GARD) Guide (INAP 2010); and
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price, 2009).

11.7.4.2 Soil management and landform engineering

Topsoil management, including stripping, stockpiling and use, are governed by internal BHP Billiton Iron Ore standards and procedures. Soil stripping and the associated scheduling and planning forms part of the ongoing mine planning process. As part of standard progressive rehabilitation practices,

where possible, topsoil and surface vegetation are directly returned to a suitable rehabilitation area, or stockpiled as required. Where direct return is not feasible the length of topsoil storage is minimised to reduce loss of viable seeds and decline of nutrients. Use of individual topsoil stockpiles would be no greater than 25 years. Subsoil can also be stockpiled separately where the material is suitable for rehabilitation. Should the topsoil balance be identified as being in deficit during ongoing works and/or mine planning then further options, including using subsoil, will be investigated and included in regular updates to the Mine Closure Plan.

BHP Billiton Iron Ore's internal standards require revegetation be conducted to establish plant species on final landforms. The depth and characteristics of newly constructed landforms, surface soils and subsoils are managed to be suitable for plant growth in terms of their structure, water holding capacity, and for establishing target vegetation communities and supporting the agreed final land use.

Post-closure final landform design aims to be safe, stable and non-polluting without requiring ongoing maintenance. The post mining land use will be determined through stakeholder consultation. In advance of the final post mining land use being agreed for Mining Area C, BHP Billiton Iron Ore will assume a native pastoral ecosystem, capable of supporting low intensity grazing as the provisional post mining land use. The provisional land use provides an interim target to which closure and rehabilitation planning can work towards.

For surface water engineering, DMP require consideration of higher order rainfall events for closure design purposes. The 10,000 year ARI was considered appropriate to assess the flood conditions in the Additional Development Envelope post-closure. Modelling of flood events has shown no risk of creek capture by pit voids for Pebble Mouse Creek, the most significant drainage feature within the mine footprint.

Three of the westernmost pits at Southern Flank are located adjacent the Great Northern Highway. Consideration will be given to ensuring pit abandonment bunds not only meet regulatory requirements but adequately mitigate unauthorised public access safety risk post-closure. If necessary other measures, such as buttressing pit walls, will be assessed based on future geotechnical design parameters.

For the purposes of this Proposal, a summary of previously assessed impacts, the proposed change and the proposed extent is provided in Table 65.

11.7.4.3 OSA rehabilitation

OSA rehabilitation requires the availability of competent material for use in or on the final landform. A waste characterisation and erosion modelling study of OSA landform stability with Marra Mamba Iron Formation rock (Landloch, 2013), including material from Mining Area C, provides an analogue to Marra Mamba waste characteristics at Southern Flank. This study, along with operational experience from progressive OSA rehabilitation at Mining Area C, reinforces that some Marra Mamba units are susceptible to erosion. Therefore, sheeting or rock armouring of final OSA landforms with competent waste material will be required. Typical design criteria for final OSA landforms in Marra Mamba use a conservative <10 deg slope angle and armouring with competent waste rock to achieve stable landform.

For Southern Flank landforms this will be considered the base case to develop stable landforms, however, as mine planning and design develop over the life of mine use of such conservative slope angles may not be required to achieve stable landforms. BHP Billiton Iron Ore's procedures will be used to inform final OSA landform design criteria within the Additional Development Envelope.

All mined materials are coded with a waste material (WMAT) class of 1, 2 or 3 in mine models. Each class has the following specifications:

- WMAT class 1 represents competent material suitable for the rock armour component of OSA landform rehabilitation.
- WMAT class 2 material has physical characteristics that potentially make it problematic for use as rock armour.
- WMAT class 3 waste does not have physical characteristics suitable for OSA final landform rehabilitation.

Southern Flank mine planning to date has identified requirements for approximately 50 Mt of rock armour material for OSA rehabilitation, and no WMAT class 1 exists in the vicinity; however, approximately 84 Mt of inert WMAT class 2 was identified. The closure strategy for Southern Flank landforms will be to use a <10deg conservative slope for final landforms, this base case may be modified as part of adaptive management practises over the life of mine (based on ongoing waste characterisation and mine design).

Detailed final OSA landform designs are completed as part of BHP Billiton Iron Ore's annual five year planning cycle for areas that will become available during the five year timeframe. Experience and outcomes from ongoing testing and progressive OSA rehabilitation work being undertaken at Mining Area C will be used to drive adaptive management practices for OSA rehabilitation at Southern Flank and inform final landform design that meets the closure criteria and objectives.

Ongoing physical waste characterisation will be undertaken to validate the usefulness of WMAT class 2 for rehabilitation. Refinements in waste scheduling and in-pit dumping through iterative mine plan may provide an opportunity to reduce the OSA footprint and volume of rock armour material required for rehabilitation.

During the initial mining stages soil stripping gets undertaken with stockpiles managed as per the BHP Billiton Iron Ore Rehabilitation Standard (BHP Billiton Iron Ore, 2016n) and other procedures. Relevant plans and databases are prepared, updated and maintained. For final OSA landforms topsoil material placed on the outer surface of landforms takes into consideration the growth media characteristics. The depth and characteristics of newly constructed landforms, surface soils and subsoils are managed to be suitable for plant growth in terms of their structure, water holding capacity, and for establishing target vegetation communities and supporting the agreed final land use.

Where available, topsoil is used to provide a suitable medium for plant establishment and a source to regenerate vegetation. Revegetation uses local provenance native seed from the Pilbara IBRA region consistent with vegetation associations and native species recorded in the Additional Development Envelope. Once established, vegetative cover should be self-sustaining and similar to the surrounding undisturbed vegetation.

11.7.4.4 Below water table pit voids and pit lake assessment

Based on preliminary mine planning, the Southern Flank ore body has a number of pits that will have below water table mining activity. Pit lakes may develop in some pit voids, depending on the final depth of the voids after mining and infilling. High evaporation rates and engineered isolation from overland flow means the pit lakes may not recover to pre-mining groundwater levels. Groundwater outflow from the pit lakes will therefore be minimal. Evaporation may cause pit lake salinity to increase over time, it is anticipated salinity levels may reach hypersaline/brackish as defined in ANZECC guidelines as >40g/L⁻¹. This increase would be expected to be very gradual and occur over century scale timeframes and it is more likely to be similar to other saline water bodies in the area. For example, the Forstecue Marsh has highly variable salinity levels depending on levels of rainfall recharge and evaporation (DEC, 2009b). The potential for density-driven saline plumes for any pit lakes is considered to be low, such

that it is not expected that saline water will be discharged from any pit lakes. Saline water will therefore remain local to the pit as there will be minimal throughflow and therefore it is considered the formation of pit lakes will not produce detrimental impacts on groundwater and surface water quality.

Modelling shows unmitigated drawdown from open pit lakes at Southern Flank has the potential to impact Weeli Wolli Spring at closure, with modelling results suggesting leaving the largest below water table pit void open may have a 0.5-0.7 m drawdown (BHP Billiton Iron Ore, 2016a; 2016m) at the spring. However this risk, if realised, can be mitigated by plausible solutions such as backfill or enhanced recharge. Over time ongoing monitoring, studies, and improved understanding of cumulative regional groundwater impacts, will reduce the range of outcomes thereby enabling adaptive management practices, if warranted, to minimise impacts. Modelling also shows that successful closure at other operations closer to the spring is likely to be the key influence in controlling the risk of long term impact at Weeli Wolli Spring.

BHP Billiton Iron Ore intends to meet ecological objectives and ensure key groundwater dependent receptors are viable at closure by take an adaptive management approach to below water table pit voids and pit lakes. This outcome-based approach takes into consideration surface water quality, groundwater quality and groundwater levels at key ecohydrological receptors (i.e. Weeli Wolli Spring, Coondewanna Flats and Ben's Oasis) and local systems. Backfilling below water table pits will be undertaken if required as a mitigation option to manage risks at key receptors and to water quality.

Furthermore, preliminary mine plan iterations have shown potential to improve waste management and increase in-pit waste dumping as part of operational waste movement. In this scenario waste dumping can focus on minimising below the water table pit voids. Closure strategy at Southern Flank will drive mine plan revisions towards achieving greater volumes of operational in-pit waste dumping, particularly for below water table pit voids, where practicable.

Post-mining recovery time for aquifer rebound at key receptors may take longer than expected, however, this will be influenced by operational groundwater management strategies. If warranted, a number of options are available to augment recovery and mitigate time lag in aquifer rebound. These options include water injection and enhanced recharge using pit voids or dedicated infiltration basins

Pit lakes may result in an increase in local levels of groundwater salinity. Other alterations to groundwater chemistry are not anticipated. As this will be a gradual change it is likely that local terrestrial fauna species will adapt to this change over time and will use potential pit lakes similar to other saline water bodies in the region (e.g. Fortescue March).

The presence of saline waterbodies is unlikely to alter local fauna communities, with the exception of migratory birds that may use them when moving through the area. As revegetation will not be undertaken adjacent to the pit lakes, it is unlikely that animals other than birds would access them due to increased exposure and risk of predation. When salinity levels increase, it is unlikely that any animals other than waterbirds would utilise it.

The presence of pitlakes is unlikely to increase the abundance of introduced (feral) species, particularly if salinity levels render it unsuitable to be used for drinking. Whilst cane toads are known to utilise inland waterbodies, and can tolerate high levels of salinity (Wijethunga *et al.*, 2016), current distribution models suggest it unlikely that they will extend as far south as Mining Area C.

It is therefore considered that the long-term impacts of pit lakes to fauna are minor, but there may be some net positive benefit through the provision of refugia to migratory species. As there will be minimal through flow of saline water out of pits, impacts to adjacent stygofauna and groundwater dependent vegetation communities are considered minor to negligible.

More detailed information pertaining to the potential changes to the surrounding terrestrial and hydrological environment resulting from the Proposal is provided in the new Mining Area C Mine Closure Plan.

A succinct summary of potential impacts of the proposed change and the proposed extent is provided in Table 65.

Table 65: Potential Impacts for Rehabilitation and decommissioning of the Proposal

Proposal		Proposed Extent (Revised Proposal)
Additional Development Envelope	Mining Area C EMP Revision 6 Impact Assessment Area	
<p>A key aspect is the alteration of the landform that will occur for Mining Area C through the creation of OSAs and overland infrastructure. The integrity and stability of built landforms is a relevant aspect for the proposed development for operational, closure and post-closure phases of the project.</p> <p>The potential risk of AMD and impacts on groundwater, surface water and soil quality is considered low to negligible.</p> <p>The Mining Area C Mine Closure Plan describes management of the site post-operations phase.</p>	<p>Addition of the Proposed Southern Flank Development Envelope expands the footprint of landform disturbance but is not considered significant from an alteration of landforms perspective due to current mining activities in the area.</p> <p>The potential risk for AMD impacts on groundwater, surface water and soil quality is considered low to negligible.</p> <p>Pit lakes may occur as a result of the Southern Flank Development but impacts on key receptors is anticipated to be managed through backfill (if required) and /or augmentation of aquifer recovery. Water quality within pit lakes is anticipated to be saline but due to hydrological characteristics in the area there will no significant impact on regional surface or groundwater.</p> <p>The Mining Area C Mine Closure Plan has been updated and describes the management of the site post-operations phase.</p>	<p>AMD risk is low to negligible. Potential Impacts to key receptors are expected to be managed through adaptive management practices, in particular backfill and/or augmenting aquifer recovery being used as a mitigation option, if required.</p>

11.7.5 Mitigation and residual impacts

BHP Billiton Iron Ore has carried out a review of the Western Australian Government's 'Mitigation Process', which is detailed in Section 3 of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014). The four steps are:

- avoid;
- minimise;
- rehabilitate; and
- offset.

Following consideration of all data gathered during baseline surveys, additional targeted surveys and the outcomes of EIAs, BHP Billiton Iron Ore has revised its indicative Proposal designs to ensure that these designs address the first two steps of the Mitigation Process, i.e. the designs have 'avoided' or

‘minimised,’ and plans are also in place to address the third step ‘rehabilitate’ to meet the rehabilitation and decommissioning factor.

Actions taken are summarised in Table 66.

Table 66: Actions taken for rehabilitation and decommissioning factor to reduce impacts post-operations

Action Taken	Step in the ‘Mitigation Process’	Reduction in Impact
Ensure pit abandonment bunds adequately control unauthorised pit access post-closure for pits adjacent the Great Northern Highway. Following detailed geotechnical assessment, if required, removing open-pit edges by backfilling material to buttress pit walls may be necessary.	Avoid and Minimise	This action has the potential to minimise proximity and safety risk to the public and liability to the state post-closure.
Armouring component of OSA rehabilitation based on using local competent material and adaptive management to achieve erosionally stable final OSA slope angles.	Rehabilitate	Rock armour and conservative landform design criteria decrease the likelihood of erosion of rehabilitated landforms.
Final landform revegetation - topsoil material placed on the outer surface of landforms with consideration of growth media characteristics and depth required for suitable plant growth for establishing the target vegetation community and supporting agreed final land use.	Rehabilitate	Allows establishment of target vegetation communities on rehabilitated landforms which are similar to the surrounding undisturbed vegetation and supports the agreed final land use.
Backfilling of below the water table pit voids to above the pre-mining water table at Mining Area C to above historic water table level. Backfilling of below the water table pits at Southern Flank, as required, based on ongoing monitoring of drawdown at key ecohydrological receptors and groundwater and/or surface water quality impacts.	Minimise and Rehabilitate	Reduce groundwater drawdown and quality impact to key ecohydrological receptors.
Augmentation of aquifer recovery should aquifer recovery time lag post-closure be greater than predicted as part of this, and any additional, assessments undertaken as part of adaptive management practises.	Minimise and Rehabilitate	Minimise spike in post-mining peak aquifer drawdown.

Following application of these actions and regulation under the MS of a Mine Closure Plan the residual impacts are not considered significant and do not warrant application of offsets for this factor.

11.7.6 Proposed management approach

11.7.6.1 Internal management approach

The proposed mine closure strategy will take an adaptive management approach for the Proposed Mining Area C Development Envelope. Southern Flank is not expected to be operational until at least 2020 with mine schedules and sequencing at a preliminary stage and yet to be finalised. Iterative mine planning and deposit sequencing will continue throughout the active mine life. BHP Billiton Iron Ore undertakes progressive rehabilitation and ongoing performance assessment in areas where mining operations have been completed and further disturbance is unlikely.

Recognising the importance of mine planning in facilitating the success completing of rehabilitation has been critical in achieving successful rehabilitation. Embedding closure and rehabilitation planning in the Life of Asset and 5 Year Planning process has resulted in rehabilitation being included as part of the mining process rather than being considered an add on or separate part of mining. This allows identification of areas available for rehabilitation so that plans for executing final landform earthworks and rehabilitation within the subsequent five year timeframe are integrated with mine plans. To allow appropriate landform design, planners now use waste characterisation information and with site input, model design options to identify the most appropriate rehabilitation plan for any given situation. An adaptive approach to rehabilitation has allowed learnings from work carried out over the past five years at Mining Area C, and other BHP Billiton Iron Ore sites to improve rehabilitation outcomes. For example, slopes at Mining Area C are being reworked to improve rehabilitation success using information from ongoing studies and research.

Outcomes from ongoing research and studies will provide further validation of prediction and impact and therefore drive the closure strategy for the Mining Area C hub. This outcome-based strategy will, where required, mitigate impacts on receptors by backfilling below the water table pit voids with inert waste material to above pre-mining groundwater levels, minimise legacy issues associated with empty pits post mining and reduce final OSA landform area for rehabilitation through operations dumping waste material in-pit, as much as practicable.

The current approved Mining Area C Mine Closure Plan has been updated to reflect this Proposal and provides more detail on closure strategy. As such, BHP Billiton Iron Ore considers that the updated Mining Area C Mine Closure Plan (Appendix 12) satisfactorily addresses the rehabilitation and decommissioning factor.

11.7.6.2 Regulatory management approach

The rehabilitation and decommissioning factor is managed by the following regulatory processes:

- MS
- *Iron Ore (Mount Goldsworthy) Agreement Act 1964*; and
- *Guidelines for the Preparation of Mine Closure Plans* (DMP & EPA, 2015).

This management approach will continue under this Proposal. It is proposed that management will be formalised through regulation of Mine Closure Plan via the Ministerial Statement and the BHP Billiton Iron Ore's standard Pilbara-wide Health, Safety and Environment system. A draft of the closure plan is located in Appendix 12.

11.7.7 Predicted outcome

BHP Billiton Iron Ore is obliged under the tenure requirements of the Mining Lease, issued under the *Iron Ore (Mount Goldsworthy) Agreement Act 1964*, to ensure that premises are closed,

decommissioned and rehabilitated in a manner consistent with current government standards and without unacceptable liability to the state. To support this, the updated Mining Area C Mine Closure Plan has been updated to include the Proposal. Based on the discussions above, the residual impact of the Proposal on Rehabilitation and Decommissioning is not considered significant.

BHP Billiton Iron Ore proposes that the EPA's objective for the Rehabilitation and Decommissioning factor can be met and managed via a condition as part of a new MS which requires the implementation of the Mine Closure Plan.

11.8 Offsets

11.8.1 Introduction and EPA objective

The EPA applies the following objective, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a), in its assessment of proposals in relation to offsets:

To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.

As part of the preparation of this assessment against the offsets preliminary key factor, all applicable EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

Studies undertaken for the Proposal are summarised in Table 9 and detailed information provided in relevant subsections in Section 11 and Appendix 4 to Appendix 11.

As discussed previously in Section 10, an integral component of adaptive management is the application of the mitigation hierarchy consistent with the guiding principles outlined in the *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014). The mitigation hierarchy of ‘avoid, minimise, rehabilitate and offset’ has been considered in this Proposal and will be implemented during the implementation phases to ensure, as far as reasonably practicable, that impacts are first avoided, then minimised, rehabilitated and finally offset if significant residual impacts are unavoidable. This approach is consistent with the EPA guidance and state government policy.

11.8.2 Existing environment

Currently, MS 491 authorises 5,385 ha of native vegetation clearing, which is not subject to offsets. This Proposal is seeking an additional clearing allocation of 19,671.2 ha.

Table 67 details the impact assessment area for this factor.

Table 67: Impact assessment areas for offsets factor

EPA Environmental Factor	Proposal Extent	Mining Area C Revised Proposal Extent (Cumulative Impacts)	Regional Extent (i.e. incl. Third-Party and BHP Billiton Iron Ore Strategic Proposal)
Offsets (integrating factor).	Indicative Additional Impact Assessment Area and Additional Development Envelope. Mining Area C EMP Revision 6 Impact Assessment Area (additional flora and vegetation disturbance).	As for Proposal Extent.	Not applicable.

11.8.3 Mitigation and residual impacts

A summary of all proposed actions identified to reduce the residual impact of the Proposal is presented in Table 68.

Table 68: Summary of proposed actions to reduce the Proposal residual impacts

EPA Factor	Action Taken	Step in the <i>WA Environmental Offsets Guidelines</i> 'Mitigation Process'	Reduction in Impact
Flora and vegetation	Modification of Indicative Additional Impact Assessment Area	Avoid/ Minimise	<p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce the impact to the following conservation species and vegetation associations:</p> <ul style="list-style-type: none"> <i>Rhagodia</i> sp. Hamersley – impacts reduced from 11 populations to 4 populations. <i>Rostellularia adscendens</i> var. <i>latifolia</i> – impacts reduced from 5 populations to 4 populations. <p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce reduced clearing of vegetation of Very Good or higher condition as follows:</p> <ul style="list-style-type: none"> Excellent – clearing reduced from 9,473 ha to 8,581 ha Very Good – clearing reduced from 1,464 ha to 512 ha <p>If clearing is restricted to within the Modified Indicative Additional Impact Assessment Area it will reduce fragmentation of a number of locally significant vegetation associations and those that had more than 50% of their total mapped area in the Indicative Additional Impact Assessment Area.</p>
	Ongoing Rehabilitation	Rehabilitate	<p>BHP Billiton Iron Ore undertakes progressive rehabilitation and ongoing performance assessment in areas where mining operations have been completed and further disturbance is unlikely. Further details are outlined in the Mine Closure Plan (Appendix 12).</p>

EPA Factor	Action Taken	Step in the WA Environmental Offsets Guidelines 'Mitigation Process'	Reduction in Impact
Terrestrial fauna	Modification of Indicative Additional Impact Assessment Area	Avoid/ Minimise	<p>Modification of the Indicative Additional Impact Assessment Area has reduced the impact to the following conservation species:</p> <ul style="list-style-type: none"> ghost bat – the number of caves retained in the Proposed Mining Area Development Envelope will be increased from 12 to 27 (11 high value), and the removal of foraging habitat has been reduced by 173 ha. <p>Modification of the Indicative Additional Impact Assessment Area has reduced clearing of Medium and High value fauna habitats as follows:</p> <ul style="list-style-type: none"> Gorge/Gully – clearing reduced from 465 ha to 383 ha. Crest/Slope – clearing reduced from 6,427 ha to 6,414 ha. Major Drainage Line – clearing reduced from 21 ha to 0 ha. Mulga – clearing reduced from 874 ha to 496 ha. Sand Plain – clearing reduced from 429 ha to 135 ha. <p>Note there will be a slight increase to clearing of Drainage Area/ Floodplain habitat (from 703 ha to 705 ha) as previously detailed in Section 11.2.5 and Table 35.</p>
	Research into ghost bat ecology in the Pilbara	Minimise/offset	<p>Continued study of the ecology of the ghost bat in the Pilbara will provide more information to assist in identifying key habitats (roosting and foraging) for the species that can be considered in mine plans.</p> <p>This work will be published so that it is available to third-party operators in the Pilbara and for future mining developments undertaken by BHP Billiton Iron Ore.</p> <p>The ongoing study has already commenced and it is intended that the current study will continue for a minimum of 12 months. Following this, a review of results will be undertaken and further studies may continue for up to 2 additional years.</p>
	Reduce impact of clearing on <i>Antichoropus</i> 'DIP 007'	Minimise	Rehabilitation of SRE habitat areas with <i>Corymbia hamersleyana</i> .

EPA Factor	Action Taken	Step in the WA Environmental Offsets Guidelines 'Mitigation Process'	Reduction in Impact
	Buffers around ghost bat roosts outside impact assessment areas	Avoid/ minimise	BHP Billiton Iron Ore will commit to retaining a 150 m buffer around all ghost bats roosts that occur outside the Mining Area C EMP Revision 6 Impact Assessment Area and the Modified Indicative Additional Impact Assessment Area.
	Inclusion of preferred habitat species of <i>Antichiropus</i> 'DIP007' into rehabilitation	Rehabilitation	Rehabilitation of disturbed areas using <i>Corymbia hamersleyana</i> .
Subterranean fauna	Modification of Indicative Additional Impact Assessment Area	Avoid	Modification of the Indicative Additional Impact Assessment Area has: <ul style="list-style-type: none"> reduced the number of potentially restricted species by seven; one species of uncertain status has been removed from potential disturbance areas; and three species added to the Modified Indicative Additional Impact Assessment Area, but all are considered unlikely to be restricted to habitats within it.
	Retention of potential troglofauna habitat suitable for five potentially restricted species outside pit shells	Avoid/ minimise	Minimise impacts to habitats considered to be potentially suitable for potentially restricted troglofauna.

EPA Factor	Action Taken	Step in the WA Environmental Offsets Guidelines 'Mitigation Process'	Reduction in Impact
Hydrological processes	Implementation of the Proposal in accordance with the DoW <i>Western Australian Water in Mining Guideline</i> (DoW, 2013b).	Minimise	<p>Impacts on the groundwater resource and regional ecohydrological receptors will be reduced by:</p> <ul style="list-style-type: none"> Proactive dewatering volumes will continue to be used as a process supply when dewatering rates fall below water demand requirements; continuing to preferentially return groundwater to the aquifer through managed aquifer recharge and / or infiltration ponds, effectively storing water into the dolomite and alluvial aquifers for use later in the mine life; Surplus water is planned to be introduced into the proposed Camp Hill borefield from about 2018 onwards, as well as Juna Downs, effectively storing water into the dolomite and alluvial aquifers; and diverting surface water around the mining footprint to the extent practicable to minimise the loss of surface water flow in the natural drainage systems. Restrict clearing to the modified impact assessment area to reduce impact to the Weeli Wolli subcatchment area <p>as previously detailed in Table 56.</p>
Inland Waters Environmental Quality	Installation of Sediment Traps	Avoid	The installation of sediment traps will ensure that water quality is not impacted by sediment run-off from mining operations
	Backfill of Below Water Table Pits	Mitigate	<p>All mine pits at the 14 deposits at Mining Area C will be backfilled to above historic water table level.</p> <p>Backfilling of below the water table pit voids to above the pre-mining water table at the Southern Flank ore body will be implemented, if required, to maintain suitable groundwater and surface water quality.</p>
Heritage	Modification of Indicative Additional Impact Assessment Area	Avoid	Implementation of the modified impact assessment area may result in an average of 15% reduction (17% for Rockshelters, 4% for Scarred Trees and 13% for Artefacts) in the number of heritage places potentially impacted by the Proposal.

EPA Factor	Action Taken	Step in the <i>WA Environmental Offsets Guidelines</i> 'Mitigation Process'	Reduction in Impact
Rehabilitation and Decommissioning	Minimising post-operational environmental legacy issues	Avoid and minimise	<p>The key closure aspects investigated will reduce post-operational impacts by:</p> <ul style="list-style-type: none"> • Ensure pit abandonment bunds adequately control unauthorised pit access post-closure for pits adjacent the Great Northern Highway. Following detailed geotechnical assessment, if required, removing open-pit edges by backfilling material to buttress pit walls may be necessary; • Armouring component of OSA rehabilitation based on using local competent material and adaptive management to achieve erosionally stable final OSA slope angles; • Final landform revegetation - topsoil material placed on the outer surface of landforms with consideration of growth media characteristics and depth required for suitable plant growth for establishing the target vegetation community and supporting agreed final land use; • Backfilling of below the water table pit voids to above the pre-mining water table, as required, based on impacts to key ecohydrological receptors; and • Augmentation of aquifer recovery should aquifer recovery time lag post-closure prove unacceptable.
Amenity	Modification to Mine Layout	Avoid and minimise	<p>Mine design and, in particular, the relocation of OSAs to reduce amenity impacts to the Great Northern Highway. See Section 12.4.5 for further details.</p>

The evaluation of residual impacts was detailed in factor specific sections within Section 11. This evaluation resulted in financial offsets for Flora and Vegetation (due to the net loss of vegetation rated as good or above) and for terrestrial fauna (due to potential impacts to the ghost bat habitat). For all other factors, residual impact was not considered significant enough to require the application of offset, however, as a precautionary measures a commitment is made in Section 11.3.5 relating to troglofauna.

It should be noted that modification of the Indicative Additional Impact Assessment Area was driven by the requirement to reduce the significance of impact to ghost bat and troglofauna habitat, as these elements of the potential impacts as a result of implementation of the Proposal, were assessed as being the most significant. BHP Billiton Iron Ore commit to where practical restrict clearing to the modified impact assessment area. As detailed in Section 11.2.5, BHP Billiton Iron Ore as a minimum will retain 150 m buffer around the ghost bat caves located outside of the Modified Indication Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assesment Area. Therefore there will

be a corresponding impact reduction to flora and vegetation, habitats and heritage places within these buffers.

The offsets proposed for ghost bats (and proactive commitment for troglodfauna) is a research offset, as defined in the offset guidelines. The offset value is that data obtained will advance the knowledge of the ecology of the ghost bat species (and troglodfauna) habitats and distribution and assist in quantifying the potential impacts of individual or cumulative mining operations on the these species within the Hamersley region. The majority of information will be obtained prior to significant implementation of the Southern Flank satellite ore body and hence will help inform ongoing management measures, triggers, thresholds and contingency measures that will be implemented via the Condition Environmental Management Plan.

As with all major development projects, this Proposal will progress through a series of design stages (which BHP Billiton Iron Ore refers to as Investigation, Selection, Development) prior to the start of construction. Detailed mine planning also occurs iteratively as greater resource definition becomes available through infill drilling and geotechnical analysis. Whilst a range of mitigation measures have been identified, the ability to commit to these actions (except the commitment to retain buffers around ghost bat caves as noted above) will be subject to the final mine design.

As a consequence, BHP Billiton Iron Ore has adopted a conservative approach in identifying the Proposal offset obligation. Whilst the extent of native vegetation clearing may be reduced from 19,671.2 ha to 15,693 ha if all actions are implemented, for the purpose of this PER it has been assumed that the disturbance area defined in the Proposal referral (19,671.2 ha) represents an upper limit to the area to which offsets will apply. BHP Billiton Iron Ore is confident that mitigation measures will be implemented to reduce this footprint and associated impacts to key environmental factors and that application of these measures can be considered as part of offset accounting obligations anticipated within any approval conditions. This is represented in Table 69.

Table 69: Total clearing to which financial offsets will apply

Disturbance Area approved under MS 491	Additional New Areas subject to this Proposal to which Offsets will apply	Total Clearing to which Offsets Apply
5,385 ha	19,671.2 ha	19,671.2 ha

11.8.4 Proposed management approach

11.8.4.1 Internal management approach

A BHP Billiton Iron Ore Offsets Strategy is currently being developed and will continue to be developed throughout 2016 in parallel to the EPA's update of the *WA Environmental Offsets Guideline* (Government of Western Australia, 2014) 'to include further information on the use of metrics in determining offsets and on the determination and application of offsets for cumulative impacts', through avenues such as established strategic working groups.

In August 2016, BHP Billiton Iron Ore, along with other regulators and industry representatives, was invited to take part in the Pilbara Strategic Conservation Fund (the Fund) working group meeting, an initiative of the OEPA to determine how financial offset contributions will be used. BHP Billiton Iron Ore is pleased to be part of this group and contribute to the development of this new fund, and other supporting initiatives, such as contribution agreements, regional strategies and implementation plans over the next year.

In the meantime, as the Fund further develops, the Regulatory requirement offsets form has been compiled to support this Proposal and is attached at Appendix 13.

11.8.4.2 Regulatory management approach

The offsets environmental factor is managed by the following regulatory process: MS condition.

11.8.5 Predicted outcome

BHP Billiton Iron Ore proposes that the objective of the offsets factor can be met to counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.

Where significant residual impacts are identified following rehabilitation, BHP Billiton Iron Ore will provide environmental offsets via the Pilbara Conservation Fund, or alternatively, delivered consistent with contemporary offset guidance. With the application of mitigation measures, it is likely that the total vegetation clearing can be reduced to 15,693 ha, however a conservative offset amount of 19,671.2 ha is proposed.

BHP Billiton Iron Ore further proposes:

- Continued study of the ecology of the ghost bat in the Pilbara will be undertaken to contribute to the current understanding of this species.
- Funding additional studies on troglafauna habitats and taxonomy to further understand of species and their distribution in the Pilbara. This may include environmental DNA studies and taxonomic study of Diplurans.

Page intentionally blank

12. Other environmental factors

12.1 Landforms

12.1.1 Introduction and EPA objective

The following section discusses the existing environment and impact assessment as it relates to the landforms in the Proposed Mining Area C Development Envelope and surrounds.

The EPA applies the following objective, according to *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect landforms:

To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.

12.1.2 Relevant guidelines and approvals

As part of the preparation of this assessment of the landforms environmental factor, all EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The following guiding documents were also relevant in the consideration of impacts to landforms:

- *Guideline for Mining Proposals in Western Australia* (DoIR, 2006).
- *Environmental Protection Bulletin No. 23: Guidance on the EPA's Landforms Factor* (EPA, 2015a)
- *Leading Practice Sustainable Development Program for the Mining Industry* (DITR, 2006)
- *Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems* (EPA, 2006)

Studies, investigations and surveys undertaken to date, the study area covered, and the relevant guidelines referred to and any limitations of the studies have been previously listed in Table 9.

12.1.3 Existing environment

Environmental Protection Bulletin No. 23: Guidance on the EPA's Landforms Factor (EPA, 2015a) includes five criteria, which are applied as the basis for determining the significance of a landform. An overview of these and their applicability to the Proposal is below:

1. **Variety** – the nine landforms identified within the Proposed Mining Area C Development Envelope (previously discussed in Section 5.5: Hill crests, Gorges and Gullies, Hill slopes, Foot slopes, Calcrete plains, Major drainage lines, Major drainage lines, and Minor drainage lines) are not considered to be important examples of their type within the Pilbara Region.
2. **Integrity** – the existing Mining Area C Development Envelope has been impacted by development activities related to the existing Mining Area C Proposal. Within the Additional Development Envelope, activities carried out to date include mineral and hydrogeological exploration.
3. **Ecological importance** – while the landforms within the Proposed Mining Area C Development Envelope form part of the Fortescue Marsh catchment area (also known as the Upper Fortescue River catchment area), they are not considered to play an integral role in maintaining existing ecological and physical processes. Nearby areas of ecological importance are the Coondewanna Flats, which occur to the west of (but outside of) the Proposed Mining Area C Development Envelope and the Weeli Wooli Creek (and Ben's Oasis), which occur to the east of (but outside of) the Proposed Mining Area C Development Envelope.

4. **Scientific importance** – The landforms area not of recognised to be of scientific interest as a reference site or an example of where important natural processes are operating
5. **Rarity** – the landforms are not considered to be rare or relatively rare, nor are they considered to be one of the few of its type at a national, regional or local level.

A Soil and Landform Assessment has been carried out across the majority of the Additional Development Envelope (Outback Ecology, 2012a) to provide baseline information and assist in the planning of soil resource management and future rehabilitation activities. The soils and landforms that encompass the Additional Development Envelope are, for the most part, similar to those that encompass the Approved Mining Area C Development Envelope, recorded in both 2011 and 2014 by Outback Ecology.

A land system includes a number of land-units and is classified by the recurring pattern of topography, soils and vegetation. Land systems have been mapped in the Additional Development Envelope as part of Technical Bulletin No. 92 (Van Vreeswyk *et. al.*, 2004). These recurring patterns can be seen using aerial photography or other remotely sensed imagery and are typically ground-truthed with field surveys. The Additional Development Envelope encompasses five land systems, four of which are also found in the Approved Mining Area C Development Envelope. These are illustrated in Figure 43 and are as follows:

- Newman¹³;
- Boolgeeda⁵;
- Platform⁵;
- Wannamunna⁵; and
- Pindering.

Surface soil profiles recorded in the Additional Development Envelope have been divided into five major soil management units (SMUs) (Outback Ecology, 2012), four of which were also recorded in the Approved Mining Area C Development Envelope (with two combined and presented as one SMU) (MWH, 2015). These are as follows:

- ridgelines¹⁴;
- scree slopes⁶;
- undulating stony plains;
- drainage lines; and
- hardpan washplains.

As for the soil materials recorded in the Approved Mining Area C Development Envelope, the physical and chemical properties of the soil materials from the SMUs in the Additional Development Envelope are relatively similar, with the major difference between the soils present being the amount of coarse material present (Outback Ecology, 2012a).

¹³ Newman, Boolgeeda, Platform and Wannamunna land systems are also recorded in the Approved Mining Area C Development Envelope.

¹⁴ These two SMUs were combined and recorded as one SMU in the current Approved Mining Area C Development Envelope due to limited differences between the physical and chemical properties of the soil materials.

The soil material from ridgelines is typified by a large amount of coarse material. These soils are considered suitable for rehabilitation purposes, with the high percentage of coarse material suitable for application to upper and middle slopes of waste landforms.

The soil material from the scree slopes has similar physical and chemical properties to the material from the ridgelines, except that the depth of the soil profile is greater. These soils and those from ridgelines are suitable for rehabilitation placement on the upper, middle and lower slopes of waste landforms.

The depth of soil from the undulating stony plains is variable and reflects the topography of these areas. These soils have a moderate capacity to retain soil moisture, which will enable them to support a higher amount of plant growth and soil biological activity. They are considered most suitable for rehabilitation of middle and lower slopes of landforms.

The drainage lines in the study area receive a disproportionate amount of moisture and nutrients from the surrounding landscape. The physical and chemical properties are relatively benign and are unlikely to pose any major issues related to the rehabilitation of reconstructed landforms.

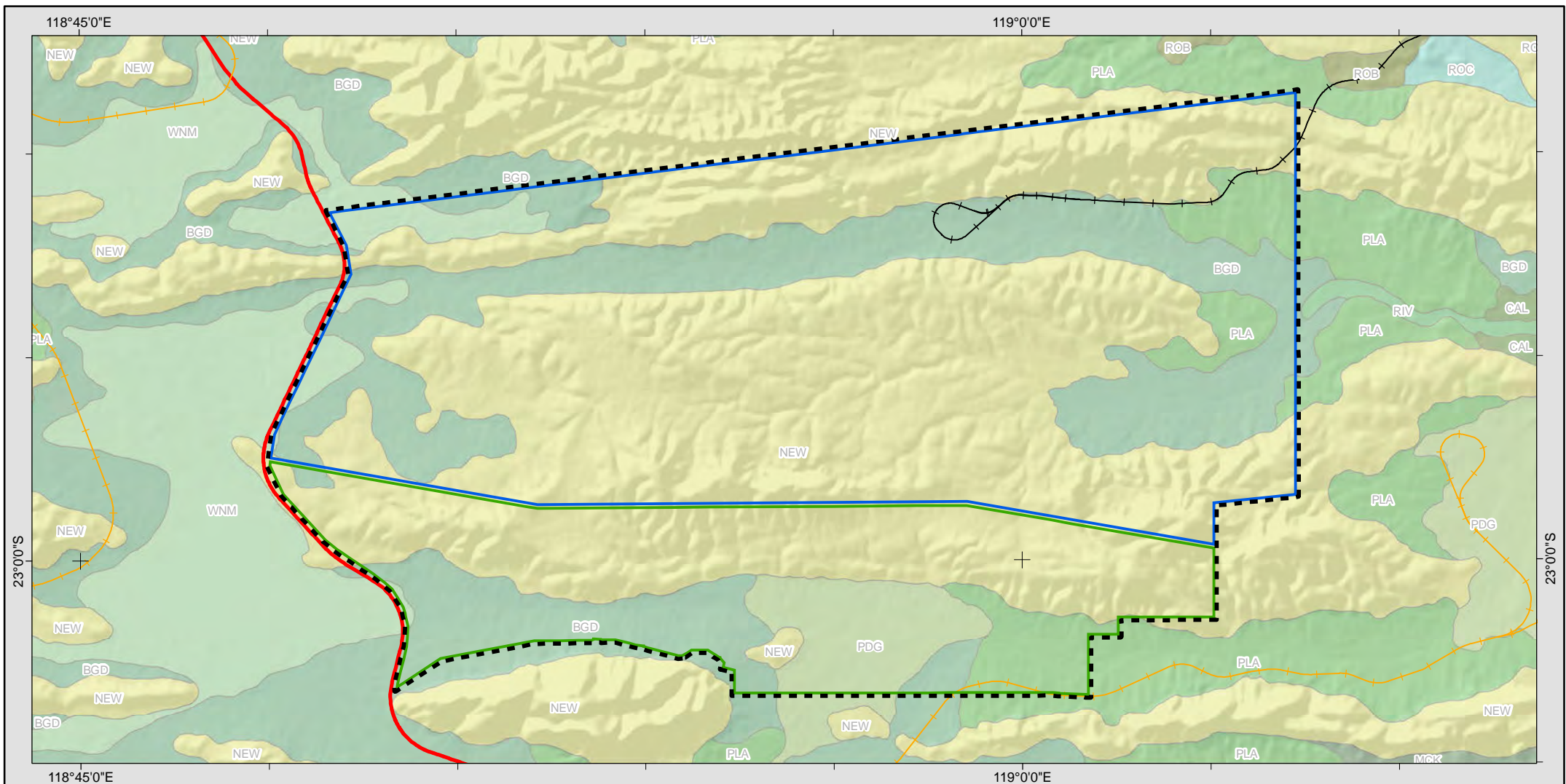
The hardpan washplains are the most productive SMU of all the five SMUs. These areas receive runoff from the ridgelines and are broad, diffuse areas with comparatively deep soil profiles. These soils are characterised as being non-sodic, although Emerson Test results indicate that the upper 20 cm may have some material that is unstable. However, given the relatively low clay content of these materials, it is considered unlikely that the partial clay dispersion identified will pose any major issues in terms of its use for rehabilitation purposes.

12.1.4 Potential impacts – Proposal and cumulative

Alteration of the landform will occur through the creation of pits, OSAs and overland infrastructure. The integrity and stability of built landforms has been considered as part of this Proposal.

Project machinery and equipment that disturbs and transports soil has the potential to cause a range of impacts, including:

- Repeated handling of soil by excavation, grading, loading, transporting and dumping can lead to the breakdown of soil structure, increasing susceptibility to erosion and reducing capacity to support vegetation. Surface soil materials contained a relatively high percentage of coarse material but were slightly dispersive and are therefore considered prone to structural decline and erosion.
- Handling of surface soil materials when wet could lead to a decline in structural stability and an increase in impacts associated with clay dispersion.
- Compaction by trafficking of heavy machinery and equipment reduces the soil material's capacity to capture and store water and to support vegetation, particularly if close to the final surface of a landform.
- Interruption of local surface drainage patterns by stockpiles may cause accelerated erosion of the material within the stockpiles, downstream sedimentation or the dehydration of the soil profile in other areas.



Spatial Data - Business Development
BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK Land systems located within the Proposed Mining Area C Development Envelope and surrounds.

Scale @ A4: 1:150,000	Prepared: S. TRINDER	Project No: A780/055 REVA
Date: 30/03/2017	Checked: R. GREGORY	Figure: 43
Revision: Rev A	Reviewed: S. WILLIAMSON	

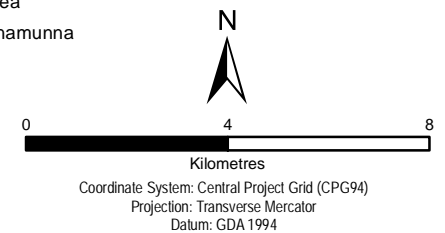
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway

Liability
BHPBIO does not warrant that this map is free from errors or omissions. BHPBIO shall not be in any way liable for loss, damage or injury to the user of this map or any other person or organisation consequent upon or incidental to the existence of errors or omissions on this map. This map has been compiled with data from numerous sources with different levels of reliability and is considered by the authors to be fit for its intended purpose at the time of publication. However, it should be noted that the information shown may be subject to change and ultimately, map users are required to determine the suitability of use for any particular purpose.

Rangeland Land Systems - WA

- BGD - Boolgeeda
- CAL - Calcrete
- MCK - McKay
- NEW - Newman
- PDG - Pindering

- PLA - Platform
- RIV - River
- ROB - Robe
- ROC - Rocklea
- WNM - Wannamunna



BHP Billiton Iron Ore recognises that some soils, derived from different positions within the landscape, will have differing suitability for placement on reconstructed landforms. Based on the abovementioned assessments however, there are few physical or chemical properties that are considered likely to cause concern if the soil materials are used for rehabilitation purposes. BHP Billiton Iron Ore have undertaken waste characterisation and soil assessment to inform closure and rehabilitation planning.

Table 70: Potential landform impacts from the proposal

PROPOSAL		Proposed Extent (Revised Proposal)
Associated with Additional Disturbance at Mining Area C (EMP Revision 6)	Associated with Southern Flank Development	
Landforms and soils within the Mining Area C Development Envelope are not considered rare, of scientific interest or of ecological importance. The variety and integrity of the landforms in the region will not be significantly altered in the region as a result of the Proposal. The predicted change to the landforms and soils as a result of the additional disturbance at Mining Area C is not significant.	Landforms and soils within the Additional development envelope are not considered rare, of scientific interest or of ecological importance. The variety and integrity of the landforms in the region will not be significantly altered in the region as a result of the Proposal. The predicted change to the landforms and soils as a result of the Southern Flank development is not significant.	Landforms within the Proposed Mining Area C development envelope are not considered rare, of scientific interest or of ecological importance. The variety and integrity of the landforms in the region will not be significantly altered in the region as a result of the Proposal.

12.1.5 Mitigation and residual impacts

BHP Billiton Iron Ore will implement the internal PEAHR process to minimise impacts to landforms from ground disturbance.

Progressive rehabilitation will also be implemented across the Proposal in accordance with the updated Mining Area C Mine Closure Plan (BHP Billiton Iron Ore, 2016m).

Residual impacts to landforms with implementation of the PEAHR process and rehabilitation will not be significant and will not warrant ministerial conditions or offsets.

12.1.6 Proposed management approach

The landforms factor in the original approval of MS 491 was determined by the OEPA to be a key factor. However, a review of this Proposal against the Environmental Protection Bulletin No. 23: Guidance on the EPA's Landforms Factor (EPA, 2015a) concludes that this Proposal is not considered to be significant impact from a landform perspective due to no significant impacts to landforms resulting from implementation of the Proposal.

BHP Billiton Iron Ore considers that the landforms factor can be managed as part of its standard Pilbara-wide Health, Safety and Environment Management System; it is also addressed under the Mine Closure Plan, which has been developed to support this Proposal.

12.1.7 Predicted outcome

In consideration of the outcomes of the soils and landforms assessment and proposed management measures outlined in the updated Mining Area C Mine Closure Plan (BHP Billiton Iron Ore, 2016m), BHP Billiton Iron Ore considers that the EPA objective for landforms to protect variety and integrity of distinctive physical landforms so that environmental values can be met and that the residual impacts

are not significant with implementation of the Proposal. Landforms is therefore considered not a key factor for this Proposal.

12.2 Terrestrial environmental quality

12.2.1 Introduction and EPA objective

This section provides an overview of BHP Billiton Iron Ore's completed geochemical characterisation studies and investigations in relation to the Proposal during operations. Potential AMD impacts during closure are discussed in Section 11.7.4.1.

BHP Billiton Iron Ore has assessed the potential risk of AMD from the Proposal. A more detailed overview is included in the updated Mining Area C Mine Closure Plan (Appendix 12).

The EPA applies the following objective, according to the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016), in its assessment of proposals that may affect terrestrial environmental quality:

To maintain the quality of land and soils so that environmental values are protected.

12.2.2 Relevant guidelines and approvals

As part of the preparation of this assessment of the terrestrial environmental quality factor, all EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The materials geochemical characterisation program has also considered the following guiding documents, where practicable:

- *Leading Practice Sustainable Development Program for the Mining Industry - Managing Acid and Metalliferous Drainage* (DITR, 2007) ;
- GARD Guide (INAP, 2010); and
- *Australian Water Guidelines for Fresh and Marine Waters* (ANZECC/ARMCANZ, 2000) and its updates.

12.2.3 Potential impacts – Proposal and cumulative

A preliminary *AMD Risk Assessment Study* (BHP Billiton Iron Ore, 2016b) has been carried out for the Indicative Additional Impact Assessment Area and the Mining Area C EMP Revision 6 Impact Assessment Area (BHP Billiton Iron Ore, 2015a).

As discussed in Section 11.7.4.1, AMD potential at the Additional Development Envelope has been assessed as low/negligible. No blocks of PAF material (classified AMD 1) have been identified in the resource or mine models, which therefore supports a low to negligible risk of AMD release. Minor amounts of weathered and detrital material, designated AMD 2 and 3, respectively, are present in the resource or mine model and have some potential to be an AMD hazard. These materials will be treated by being placed, where possible, more than 10 m from the final OSA rehabilitation surfaces. Additionally, ongoing geochemical test work will be used to refine the risk presented by AMD 2 and AMD 3 material.

A more comprehensive summary of the potential changes to the surrounding terrestrial environmental quality resulting from the operation of mining in the Additional Development Envelope is provided in the updated Appendix 12. For the purposes of this Proposal, a summary of impacts from the proposed change and the proposed extent (cumulative impacts) is provided in Table 71.

Table 71: Potential impacts to terrestrial environmental quality

PROPOSAL		Proposed Extent (Revised Proposal)
Associated with Additional Disturbance at Mining Area C (EMP Revision 6)	Associated with Southern Flank Development	
Potential impacts from contamination are considered low for Mining Area C operations. Existing waste disposal procedures and practices are considered effective.	<p>A preliminary <i>AMD Risk Assessment Study</i> (BHP Billiton Iron Ore, 2016b) has been carried out for Southern Flank. This study assessed AMD potential as low to very low.</p> <p>Within the Southern Flank resource and mining models, no blocks of fresh rock with acid-forming potential were identified.</p>	Overall, potential contamination from AMD are considered low to negligible for the Revised Proposal operations. Existing waste disposal procedures and practices are considered effective.

12.2.4 Mitigation and residual impacts

Applying the precautionary principle, materials with NAPP >3 will be placed more than 10 m from the final OSA rehabilitation surfaces.

Residual impacts to terrestrial environmental quality with implementation are considered to not be significant and will not warrant ministerial conditions or offsets.

12.2.5 Proposed management approach

Given that the potential impacts from contamination are low to negligible for the Proposal, existing waste disposal procedures and practices are considered effective.

12.2.6 Predicted outcome

Implementation of the Proposal will meet the EPA objective to maintain the quality of land and soils so that environmental values are protected. The inherent and residual impacts are not significant, and therefore Terrestrial Environmental Quality is not considered a key environmental factor.

12.3 Air quality and atmospheric gases

12.3.1 Introduction and EPA objective

BHP Billiton Iron Ore has commissioned Pacific Environment (2015 and 2016) to carry out atmospheric plume modelling to predict the potential impacts of the Proposal on local and regional air quality and atmospheric gases. The outcomes from the modelling are provided in Appendix 9. An assessment of the modelling outcomes is detailed below.

BHP Billiton Iron Ore has predicted the greenhouse gas emissions for the Proposal to assess the potential impact of greenhouse gas emissions associated with the Proposal.

This section presents the a description of the existing environment with respect to air quality, a summary of the outcomes of the latest modelling and impact assessment, which have determined the potential impacts to air quality in the Indicative Additional Impact Assessment and the Mining Area C EMP Rev

6 Impact Assessment Area. This section then presents the potential cumulative impacts of this Proposal and the current Mining Area C operations. And finally it closes with a review of current management actions and any changes to these proposed as part of this Proposal.

The EPA applies the following objective, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a), in its assessment of proposals that may affect air quality:

To maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.

12.3.2 Relevant guidelines

As part of the preparation of this assessment against the Air Quality factor, all EPA, and other relevant, policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The following guidance documents were also relevant in the consideration of impacts to air quality:

- *National Environment Protection Council Act 1994* (Cth) and *National Environment Protection Measure for Ambient Air Quality* (Air NEPM);
- *Guidance Statement No. 18: Prevention of Air Quality Impacts from Land Development Sites* (EPA, 2000b);
- *Guidance Statement No. 12: Minimising Greenhouse Gas Emissions* (EPA, 2002b); and
- *National Greenhouse and Energy Reporting Act 2007*.

Below is a review of guidance for air quality that were deemed applicable for this assessment. The Air NEPM sets air quality standards for major air pollutants. The Ambient Air Quality NEPM criteria for the PM₁₀ fraction of particulate matter have been established in relation to protection of human health and it represents a threshold that is applied in general throughout Australia, without reference to relevant regionally specific conditions.

The recent health risk assessment undertaken for Port Hedland “confirmed the NEPM for PM₁₀¹⁵ was intended for an urban setting rich in combustion PM and that it was reasonable to expect that it might not apply to Port Hedland because the particulate matter in Port Hedland was crustal (of natural origin)” and is an area that is subject to naturally elevated levels of background particulate matter (DoH, 2016). Due to similarities in regional particulate matter characteristics (i.e. iron ore mining and processing operations and naturally high background) this conclusion is relevant for inland Pilbara locations where the Proposal is located. Therefore the Ambient air quality NEPM is not deemed as appropriate guidance for this assessment.

Currently the Mt Whaleback operations in Newman have a Part V licence that stipulates a value of 70 µg/m³, averaged over 24 hours for PM₁₀. This value is deemed applicable for assessment of significance of potential impacts to air quality from this Proposal, as the particulate matter composition and background regional particulate matter concentrations in this air shed is similar in nature to those expected for the Proposal.

¹⁵ PM₁₀ refers to the fraction of particulate matter (PM) with an equivalent aerodynamic equal to or less than 10 µm in diameter.

The predicted total suspended particulates (TSPs) resulting from the Proposal has been deemed the most appropriate on which to base an assessment of potential impacts to visibility and amenity. This aspect of this atmospheric plume modelling is discussed in detail in Section 12.4 of this PER document.

The Mt Whaleback Part V licence values for PM₁₀ were used as guidance in the assessment of the significance of impacts to air quality resulting from the Proposal to the following nearest sensitive receptors:

- the Packsaddle Accommodation Camp (approximately 1.2 km north of the current Mining Area C and approximately 8.5 km north of the Indicative Additional Impact Assessment Area);
- the Mulla Accommodation Camp (approximately 2.5 km southwest of the current Mining Area C and 3 km north of the Indicative Additional Impact Assessment Area); and
- Great Northern Highway (50 m west of the current and proposed development envelopes).

12.3.3 Existing environment

The semi-arid landscape of the Pilbara is a naturally dusty environment with wind-blown dust a significant contributor to ambient dust levels in the region, with background monitoring showing that in many instances the background dust is higher than NEPM criteria, again indicating that this criteria is not appropriate for the region. Ongoing monitoring of background particulate matter levels surrounding Newman have shown that background level are higher than the 70 µg/m³ typically around 3-6 times per annum. Previous air quality assessments undertaken for the Mining Area C operation have shown that particulate matter emissions from the operation may result in elevated dust levels at accommodation camps and visible particulate emissions on the highway if not managed with mitigating controls.

12.3.4 Potential impacts

The main potential air quality issues resulting from this Proposal are particulate emissions associated with:

- excavating and handling of iron ore and overburden, including blasting;
- wind erosion from iron ore stockpiles and OSAs; and
- vehicle movements associated with the transfer of iron ore and overburden.

BHP Billiton Iron Ore utilised site-specific and national pollution inventory emission estimation techniques to calculate source-specific emission rates (Pacific Environment, 2015 and 2016). Based on the predicted mining schedule, the highest production rate year that is predominately located nearest the sensitive receptors is estimated to be 2031. Therefore, all emission estimations and potential impacts at the nearest sensitive receptors were based on this year as it is representative of a credible worst case scenario. It should be noted that the mine plan utilised for this assessment was accurate at the time of the assessment but is subject to change following optimisation of the mine plan.

Dispersion modelling was conducted by Pacific Environment (2015 and 2016) using the CALPUFF dispersion model combined with the Weather Research and Forecasting (WRF) Model for generation of meteorological inputs. Background particulate emissions were determined from monitoring data collected at a suitable background location near Newman.

The modelling was conducted for a number of scenarios to assess the ground-level impact of the emissions from the Proposal. These included prediction of ground level impact from the Southern Flank development in isolation including background (Pacific Environment, 2016), the predictions of ground level impact of mining the 14 deposits at Mining Area C (Pacific Environment, 2015) and a cumulative

assessment of impacts of operations at Mining Area C, Southern Flank and background (Pacific Environment, 2016).

BHP Billiton Iron Ore routinely designs and implements a number of controls in the fixed plant and mine design of the Proposal as standard practise to minimise impacts to receptors. Therefore, the modelling results presented below can be considered as partly mitigated. The controls are documented in Appendix 9 and include, but are not limited to, fogging systems, water cannons, enclosures and water carts.

Modelling of the mine plan and design associated with the Indicative Additional Impact Assessment Area, predicted the maximum concentrations of the PM₁₀ fraction of particulate matter for the scenario one are predicted to be 92 µg/m³ at the Mulla Mulla accommodation village and 31 µg/m³ at the Packsaddle accommodation village. The modelling outputs shows that the ground level concentrations rapidly decrease from the maximum to the fifth highest prediction by between 15 and 50% and therefore the maximums can be regarded as isolated high events. Furthermore, the modelling undertaken is representative of the worst case year where mining occurs nearest the receptors and assumes highest activity of mining equipment. Maximum predictions usually occur during unfavourable but infrequent meteorological conditions. The likelihood that these three aspects occur concurrently is highly unlikely and therefore it is highly unlikely that predicted maximums will eventuate. Therefore the 95th percentile prediction is more relevant for comparison with guidance to evaluate significance.

The 95th percentile prediction for the Southern Flank ore body with background was 41 µg/m³ and 25 µg/m³ for Mulla Mulla and Packsaddle accommodation villages respectively, which are significantly lower than the maximums, and below the 70 µg/m³ guidance for significance. For the 14 deposits at Mining Area C the 95th percentile prediction is 59 µg/m³ at the Packsaddle accommodation village and 44 µg/m³ at the Mulla Mulla accommodation village with standard controls included. Based on these predictions, it can be concluded that implementation of the Proposal will not result in air quality impacts that could be considered significant.

The maximum predicted total suspended particle (TSP) concentrations expected on the Great Northern Highway range from 195 to 412 µg/m³. Again, the modelling shows that the maximums are isolated high events, with the 95th percentile predictions much lower with a range of 138 to 315 µg/m³. These predictions have been used to inform the visibility assessment as outlined in the amenity section.

Greenhouse gas emissions resulting from the Proposal will be generated through the combustion of hydrocarbons, clearing of native vegetation, the use of explosives during blasting operations and the use of electricity.

The maximum annual emission of greenhouse gases for the Southern Flank development over the life of the mine is predicted to be equivalent to 909 kilotonnes of carbon dioxide (CO₂-e). This corresponds to 0.22% of Australia's and 1.09% of Western Australia's financial year 2014 greenhouse inventory (Department of the Environment and Energy, 2016). The average CO₂-e emissions for the Proposal over the life of the mine is predicted to be 385 kilotonnes of CO₂-e per annum (or 0.46% of Western Australia's emissions on average).

12.3.4.1 Cumulative impacts

The cumulative impact of the Proposal with the existing operation at Mining Area C was modelled. The maximum PM₁₀ concentration predicted at the Packsaddle and Mulla Mulla camps is 208 and 127 µg/m³ respectively. Like Proposal outcomes, the modelling was undertaken for a worst case foreseeable scenario and it is unlikely that this scenario in reality will occur. Therefore, the maximums can be considered as isolated unforeseeable high events. The 95th percentile predictions for cumulative

modelling are predicted to be 72 and 61 $\mu\text{g}/\text{m}^3$ respectively. Background monitoring in the region shows that natural high background events account for between 3 and 6 instances of above 70 $\mu\text{g}/\text{m}^3$ and therefore the cumulative prediction are not considered significantly different to natural particulate emissions in the region.

Proactive operational management measures, such as predictive meteorological monitoring, combined with proactive application of water and surfactants to haul roads will mitigate ground level impacts of particulate emissions. These measures have been shown to be effective methods at the existing Mining Area C operations to minimise impacts to camps and residents.

Based on the above, BHP Billiton Iron Ore considered that potential impacts from PM_{10} emissions are not significant and that the EPA objective can be met.

The maximum predicted cumulative TSP concentrations expected on the Great Northern Highway range from 180 to 415 $\mu\text{g}/\text{m}^3$. Again, the modelling shows that the maximums are isolated high events with the 95th percentile predictions much lower with a range of 130 to 315 $\mu\text{g}/\text{m}^3$. This impact is similar to that predicted for the Proposal in isolation. The relevance of these prediction on amenity is discussed in Section 12.4.

The maximum annual cumulative $\text{CO}_2\text{-e}$ emissions is 1,975 kilotonnes of $\text{CO}_2\text{-e}$, with the average annual $\text{CO}_2\text{-e}$ emissions over the life of the mine being 1,200 kilotonnes of $\text{CO}_2\text{-e}$. The maximum cumulative emissions represent 0.48% of Australia's and 2.37% of Western Australia's financial year 2014 $\text{CO}_2\text{-e}$ inventory.

The predicted greenhouse gas emissions were compared with typical iron ore mining operations, and it was found that the worst-case scenario is less intensive than an average iron ore mine (Norgate & Haque, 2010).

Based on the fact that the Proposal adds low percentages to both Australia's and Western Australia's greenhouse inventory and has low intensity compared with other like industries, the impacts are considered minor on a national basis.

12.3.5 Mitigation and residual impacts

To reduce the potential impacts from particulate matter emissions resulting from the Proposal a number of OSAs were removed from or relocated in the mine design (Figure 6). During more detailed mine design and optimisation, the location of the conveyors linking the Southern Flank ore body to the existing Mining Area C infrastructure were relocated to the north which resulted in these being located closer to the Mulla Mulla accommodation village.

The predicted impacts were re-modelled with an updated mine plan and design according to the Modified Indicative Additional Impact Assessment Area to determine the effect of the above modifications (Pacific Environment, 2016).

While this optimisation of the mine design and plan, resulted in other environmental benefits, including reduce disturbance and power use, it resulted in a slight increase to predictions of ground level concentrations of particulate matter at the Mulla Mulla accommodation village but resulted in a large reduction in predicted concentrations of TSP and PM_{10} along the Great Northern Highway adjacent to the Proposed Mining Area C Development Envelope.

The predicted maximum cumulative TSP and PM_{10} concentrations at potential receptors on the Great Northern Highway reduced by up to 30% (approximately 130 $\mu\text{g}/\text{m}^3$) for both scenarios with the movement of the OSAs. The 95th percentile cumulative PM_{10} concentration at Mulla Mulla and

Packsaddle accommodation villages is predicted to increase by up to 19% ($112 \mu\text{g}/\text{m}^3$) as a result of the redesign of the OSAs the movement of the conveying system. Again, this is not considered significant in comparison with typical regional background particulate levels. The predictions of TSP have been used to inform the visibility assessment discussed in the amenity section.

Overall, with the mitigation discussed above and the additional management measures outlined below, BHP Billiton Iron Ore consider that residual impacts do not constitute a significant impact to the environment. Therefore air quality is not considered to be a key factor for the Proposal.

12.3.6 Proposed management approach

12.3.6.1 Internal management

A number of management tools and mitigation has already been designed and integrated into the assessment of impacts detailed above. This includes but is not limited to the following:

- water sprays or enclosures on crushers;
- transfer chutes, either enclosed or fitted with skirts and dust curtains;
- fogging systems and/or covers or hoods installed in processing plants;
- water cannons on stockpiles;
- bulk ore conditioning sprays installed, where practicable, on conveyors;
- water carts operating on OSAs and run-of-mine pads;
- surfactant application to haul roads; and

Proactive operational management measures, such as predictive meteorological monitoring, combined with proactive application of water and surfactants to haul roads will mitigate the predicted impacts detailed above. These measures have been shown to be effective methods at the existing Mining Area C operations to minimise impacts to camps and residents. The proactive and reactive use of these controls will ensure that dust emissions and potential impacts to the accommodation camps and the highway are minimised.

BHP Billiton Iron Ore has a process for identifying and implementing opportunities to improve energy efficiency across its operations. In addition, the risk to the business due to changing climate is addressed as part of the ongoing business planning processes.

12.3.6.2 Regulatory management

Particulate emissions will be subject to the requirements of the EP Act and greenhouse gas emissions the *National Greenhouse and Energy Reporting Act 2007*.

12.3.7 Predicted outcome

The Proposal meets the EPA's objective for the air quality and atmospheric gases factor. BHP Billiton Iron Ore considers that this factor can be managed via the requirements of the EP Act.

12.4 Amenity

12.4.1 Introduction and EPA objective

The following section discusses the existing environment and impact assessment as it relates to the amenity of the Proposed Mining Area C Development Envelope and surrounds.

360 Environmental Consultants (2016) and Urbis (2015) were appointed to carry out Landscape and Visual Impact Assessments to inform this Proposal. Following field investigations, view-shed and photomontage analysis was carried out for several potential sensitive receptor sites to determine potential direct impacts on landscape character and visual amenity. These studies are provided in Appendix 10.

In addition, PEL conducted a visibility risk assessments with respect to the potential for particulate matter (dust) to impair visibility along the section of the Great Northern Highway that is adjacent to the Proposal and to the existing Mining Area C operations.

The EPA applies the following objective, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a), in its assessment of proposals that may result in impacts to amenity:

To ensure that impacts to amenity are reduced as low as reasonably practicable.

12.4.2 Relevant guidelines

As part of the preparation of this assessment for the amenity factor, all EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The following guidance documents were also relevant in the consideration of impacts to amenity:

- *Visual Landscape Planning in Western Australia: A Manual for Evaluation, Assessment, Siting and Design* (DPI, 2007);
- *Statement of Planning Policy No. 2: Environment and Natural Resources Policy* (WAPC, 2003);
- *Pilbara Planning and Infrastructure Framework* (WAPC, 2012); and
- *Victoria State Environmental Protection Policy (Ambient Air Quality) No. S19* (EPA VIC, 1999).

An equation developed by Baddock *et al.* (2014) allows conversion of total suspended particulates to visibility in kilometres. The predicted concentrations of TSP from atmospheric plume modelling were utilised to determine visibility distance, which in turn was used to assess visibility risk along the Great Northern Highway. High risk was defined as visibility less than 1 km, medium risk as between 1 and 2 km and low risk as greater than 2 km.

12.4.3 Existing environment

Mining and associated infrastructure (e.g. rail, camps) are prominent land features within 20 km of the Proposed Mining Area C Development Envelope. There are also several pastoral leases in this area. Therefore the natural form of the landscape has already been modified. The area has low visitation numbers but is accessible and potential visible from the Great Northern Highway by through traffic.

The Great Northern Highway is located on the western boundary of the Proposed Mining Area C Development Envelope. This highway is one of two main routes available for north–south traffic, and it connects the southwest, midwest and Pilbara regions in Western Australia. It is used by tourists as well as by both national and regional freight and mining-related traffic.

The Governor and Mount Robinson are two elevated locations from which the Proposal may be visible.

The following have been identified by 360 Environmental (2013) or Urbis (2015) as key viewpoints within 20 km of the Proposed Mining Area C Development Envelope:

- Mount Robinson: approximately 500 m from the southern boundary of the Proposed Mining Area C Development Envelope;
- The Governor: 3 km from the southeast corner of the Proposed Mining Area C Development Envelope;
- Hope Down Accommodation Villages;
- Weeli Wolli Springs;
- Mt Meharry; and
- the Great Northern Highway: running along the western boundary of the Proposed Mining Area C Development Envelope.

12.4.4 Potential impacts

360 Environmental (2013) identified 14 preliminary viewpoints, or potential sensitive receptor sites, based on a desktop risk of impact and site significance matrix. The risk and significance of these sites were verified and surveyed in the field with six were determined to be sensitive sites (based on local significance and accessibility) and as such were further assessed during the impact assessment phase as key viewpoints. Urbis as part of the development of Mining Area C EMP Revision 6 identified and assessed nine viewpoints, all of which were also studied by 360 Environmental. All the sites are listed in Table 72. The nine potential sensitive viewpoint sites were identified and analysed for potential impacts. Impacts were assessed on the basis of predicted changes to amenity from current, thereby evaluating if the Proposal will result in a change to an already altered landscape features.

Following the 360 Environmental (2013) visual impact assessment, changes to the footprint and location of pits, OSAs and infrastructure were made in 2016. This included but was not limited to the location of ore handling infrastructure and rail and train loading facilities, which are no longer planned to be located south of the mining area. As a result of the high potential for visual impact from the OSAs that were located adjacent to the Great Northern Highway, these OSAs have been moved to the east to avoid or minimise these impacts.

In light of these changes, a re-assessment of the potential impact at the six key viewpoints identified by 360 Environmental (2013) (and provided in Appendix 10) has been undertaken. The original and updated potential impacts are summarised in Table 72.

Table 72: Viewpoints surveyed in the visual landscape impact assessment

Site No.	Site Name	Potential Visual Risk (EMP Revision 6 Impact Assessment Area)	Potential Visual Risk – Southern Flank Original Footprint	Potential Cumulative Visual Risk – Modified Footprint
1	Great Northern Highway south	Low – screened from operations	Medium – OSA and pit area further from view site.	Medium – overall impact is unchanged. Changes include removal of rail and ore processing facilities but slight increase to height of one OSA visible from this viewpoint.
2	The Governor	Not assessed	Low – less traffic and view of OSA and pit area shielded.	Low – overall visual impact is unchanged.
3	Great Northern Highway adjacent to the Proposed Mining Area C Development	Moderate	High – significant use of highway by tourist and mine employees, OSA direct view.	High – overall impact is slightly reduced due to movement of OSA.
4	Great Northern Highway adjacent to the Proposed Mining Area C Development Envelope #2	High	High – significant use of highway by tourist and mine employees, OSA direct view.	Medium – overall impact is reduced due to movement of OSA.
5	Great Northern Highway adjacent to Mining Area C Access Road	Moderate	Medium- slightly elevated which allow view of mining and OSA in distance	Medium, overall impact is unchanged.
6	Mount Robinson	Low	Medium – elevated site but less traffic	Medium – changes have resulted in some OSA being less visible and some more visible; overall impact is unchanged
7	Hope Downs Accommodation Villages	Primary Camp – Negligible, Secondary Camp - low	Not Assessed	Low
8	Weeli Wolli Springs	No Impacts	Not Assessed	Site is 14 km away and lies in a depressed valley, therefore no visual impact is predicted.
9	Mt Meharry	Very Low	Not to determine to be a key viewpoint	Very Low

The visibility risk from particulate matter emissions prior to the mine design modification was predicted to be high approximately 20% of the time, ranging from 8% to 53% along sections of the highway. The risk was rated as medium for approximately 37% of the time, meaning that the visibility was potentially reduced to less than 2 km for approximately 57% of the time, and greater than 2 km for 43% of the year. Note that the predicted TSP that was utilised for this assessment considered the worst-case year, that is mining activity concentrated at the western area (i.e. nearest Great Northern Highway). Therefore, this risk would not be present for the life of the mine.

Regardless, the mine design was modified to reduce this visibility and visual risk arising from the Proposal (see Section 12.4.5).

12.4.4.1 Cumulative impacts

The visual impact assessment discussed above predicted the potential impact from viewpoints that considered Mining Area C existing operations, and therefore the assessment represents potential cumulative impacts. Impacts were predicted based on a worst case scenario, which is a concentration of mining activity on the western portion of the Proposed Mining Area C Development Envelope.

The visibility assessment was undertaken using predicted cumulative TSP concentrations (see Section 13.4.4.1); and therefore the potential impacts discussed above represent potential cumulative visual amenity impacts resulting from the Proposal.

12.4.5 Mitigation and residual impacts

The scope and footprint of the Proposal have changed over time. The visual impact resulting from the original and modified footprints is shown in Appendix 9. The mine design was modified to reduce the number of OSAs near the highway, which resulted in a reduction of potential visibility impact to the Great Northern Highway. The occurrence of a potential high risk (less than 1 km visibility) on the highway was reduced from 20% to approximately 6% as result of this change, and medium risk (1 to 2 km visibility) was reduced to approximately 28% of the time. Therefore, visibility is predicted to be greater than 2 km more than 66% of the time. Note that this estimation is based, as above, on the scenario where mining is occurring immediately adjacent to the highway, so visibility impacts are expected to be less than this for the majority of the mine life. The movement of OSAs closest (within approximately 50 m) to the Great Northern Highway in the mine design has resulted in a reduction to the visual impacts predicted for the highway adjacent to the Proposal from both a viewpoint and potential impacts from particulate emissions (TSP) perspective.

BHP Billiton Iron Ore will where practical restrict clearing of native vegetation and development of OSAs in line with the indicative modified impact assessment area.

Based on the reduction in potential amenity impacts following application of the mitigation hierarchy the residual potential impacts to amenity as a result of the Proposal are not considered significant.

12.4.6 Proposed management measures

Management measures proposed to minimise particulate emissions were discussed in Section 12.3.6. With respect to management of visual amenity impacts, progressive rehabilitation of OSAs and in-fill of pits will be undertaken to reduce progressively reduce the visibility of large scale mining activities and structures. This should result in minimisation of the visual impact from the viewpoints discussed above. BHP Billiton Iron Ore also has an existing consultation program that includes a public complaints and response process. In the event that public complaints in relation to amenity impacts are noted, management measures will be reviewed.

12.4.7 Predicted outcome

This Proposal meets the EPA's objective for the amenity factor. BHP Billiton Iron Ore considers that this factor can be addressed via requirements of the EP Act.

12.5 Human health (noise)

12.5.1 Introduction and EPA objective

BHP Billiton Iron Ore appointed SVT Consultants to carry out noise modelling to determine the potential noise impacts arising from the Proposal (SVT, 2014; 2016). These studies are provided in Appendix 11.

This section presents the assessed impacts to human health (noise) in the Mining Area C EMP Revision 6 Impact Assessment Area as presented in the Mining Area C EMP Revision 6 (BHP Billiton Iron Ore, 2015a). Following this is a summary of the outcomes of the latest modelling and impact assessment, which have determined the potential impacts to noise in the Indicative Additional Impact Assessment Area. This section then presents the potential cumulative impacts of this Proposal and the current Mining Area C operations. Finally it closes with a review of current approved management actions and any changes to these proposed as part of this Proposal.

The EPA applies the following objective, according to the *EAG 8 for Environmental Factors and Objectives* (EPA, 2013a), in its assessment of proposals that may result in impacts to human health:

To ensure that human health is not adversely affected.

12.5.2 Relevant guidelines

As part of the preparation of this assessment for the human health factor, all EPA policies and guidance documents were reviewed. Those policies and guidance considered relevant to this particular factor are summarised in Table 7.

The following guiding documents were also relevant in the consideration of impacts to human health (noise):

- Australian Standard 2107:2000, Acoustics: Recommended Design Sound Levels and Reverberation Times for Building Interiors; and
- EAG 13 Consideration of environmental impacts from noise (EPA, 2014b)

The assigned noise levels used as guidance to assess the significance of the potential outdoor impacts arising from the Proposal are consistent with the *Environmental Protection (Noise) Regulations 1997* and are as follows: Packsaddle and Mulla Mulla Accommodation Villages – 35 dB(A) (decibels a-weighted) (LA_{10}) (noise level exceeded for 10% of the measurement period).

For indoor noise, *Australian Standard 2107:2000* was used as guidance to assess noise with the following criterion: Packsaddle and Mulla Mulla accommodation villages – 25 dB (A) ($L_{Aeq, T}$)

Vibration levels in millimetres per second (mm/s) and linear noise levels from blasting were also modelled for the purpose of informing the terrestrial fauna impact assessment, specifically for potential impacts to ghost bat caves.

12.5.3 Existing environment

The nearest noise-sensitive receptors to the Proposal are:

- the Packsaddle Accommodation Village, located in the northwest area of the Proposed Mining Area C Development Envelope; and
- the Mulla Mulla Accommodation Village, located approximately in the midwest area of the Proposed Mining Area C Development Envelope.

12.5.4 Potential impacts

Excessive noise and vibration has the potential to impact environmental and social values in the Proposed Mining Area C Development Envelope and surrounds (e.g. residential areas, other land users, fauna and caves).

The main sources of noise from the Proposal are expected to be associated with:

- mobile plant, such as excavators, graders, haul trucks and drill rigs;
- fixed plant, such as conveyors, ore processing facilities and the rail loader; and
- blasting noise.

The noise impact assessment undertaken for the Mining Area C EMP Revision 6 (SVT, 2014) predicted that the noise levels without mitigation at the Mulla Mulla Accommodation Village met the assigned levels and predicted that noise levels without mitigation at the Packsaddle Accommodation Village were slightly above (~0.8 dB) assigned levels. The noise modelling was undertaken with worst case assumptions, that is with all equipment functioning, equipment located at surface level and located nearest the receptors and during worst case meteorological conditions. This scenario is highly unlikely to eventuate in reality meaning the noise predictions are highly conservative and likely to be overestimated. Therefore, the potential and likelihood for noise to be above the criteria is low.

SVT (2016) carried out noise modelling on a number of scenarios including those for cumulative impacts with existing Mining Area C operations (Appendix 11):

- Scenario 1 – the Southern Flank ore body in isolation under maximum fleet configuration;
- Scenario 2 – the Southern Flank ore body in isolation with maximum activity in the pit nearest sensitive locations;
- Scenario 3 – Scenario 1 plus emissions from existing operations at Mining Area C (inclusive of P1E operations) (cumulative assessment)
- Scenario 4 – Scenario 2 plus emissions from existing operations at Mining Area C (inclusive of P1E operations) (cumulative assessment);
- Scenario 5 – Scenario 1 plus emissions from existing operations at Mining Area C (exclusive of P1E operations) (cumulative assessment); and
- Scenario 6 – Scenario 2 plus emissions from existing operations at Mining Area C (exclusive of P1E operations) (cumulative assessment).

In line with meteorological guidance, modelling assumed worst-case meteorological conditions. Also, worst-case mining assumptions were made. These included the following assumptions:

- All mining fleet and fixed plant is operating at once.
- All mining fleet is located at the surface (i.e. noise from equipment is not shielded by pits).
- Mining fleet is located either nearest to the receptor (Scenarios 2, 4 and 6) or represents maximum fleet numbers (Scenarios 1, 3 and 5).

It is unlikely that these conditions will exist concurrently at any point during operation of the mine.

Each of the six scenarios was assessed against relevant assigned noise levels, and noise contour maps were created for the surrounding area.

For the Southern Flank ore body development the assigned noise levels were met at the Packsaddle Accommodation Village. The noise model predicted that the noise levels may be above the assigned levels at the Mulla Mulla Accommodation Village by as much as 4.3 dB(A) when the mining fleet is located closest to the camp. However, given that the modelling undertaken assumed worst-case mining conditions, there is a low probability that the assigned level will be exceeded during normal operations.

The indoor noise levels were found to be well below the criterion outlined in AS2107.

12.5.4.1 Cumulative impacts

The predicted impact for the Proposed Mining Area C Development Envelope shows that the existing Mining Area C equipment operating in the P1E Deposit dominates impacts to the Packsaddle Accommodation Village. The predicted cumulative outcomes at the Packsaddle and Mulla Mulla accommodation villages are similar to those found for the Southern Flank ore body development (Additional Development Envelope) in isolation and it can therefore be concluded that there is it highly likely that noise regulations will be met at the accommodation villages.

Blasting noise and vibration impacts were also modelled by SVT (Appendix 11). These data have been used to assess potential impacts to fauna (see Section 11.2.4.2).

12.5.5 Mitigation and residual impacts

The modelling shows that, in all but the worst case scenario which is highly unlikely to eventuate, noise impacts resulting from the Proposal are predicted to meet relevant criteria. Therefore, no further mitigation is proposed. In the event that noise complaints are received from persons housed in the accommodation, BHP Billiton Iron Ore will ensure that night-time noise impacts (post-7pm) are minimised by managing when and where night time mining activity is undertaken in the vicinity of Mulla Mulla and Packsaddle accommodation villages.

The inherent and residual impacts of noise emissions to key receptors following implementation of the Proposal are not considered significant as it is predicted that noise regulations will be met.

12.5.6 Proposed management measures

12.5.6.1 Internal management

Noise management, including implementation and maintenance of any controls, will be managed via BHP Billiton Iron Ore's Pilbara-wide Health, Safety and Environment Management System. No complaints regarding noise have been received as a result of current operations, indicating that current noise management measures are effective in minimising impacts from noise.

12.5.6.2 Regulatory management

Potential noise impacts will continue to be managed in line with the Environmental Protection (Noise) Regulations 1997.

12.5.7 Predicted outcome

This Proposal meets the EPA's objective for the human health factor, and it is therefore not considered a key environmental factor. BHP Billiton Iron Ore considers that this factor can be managed in line with the EP Act and the Environmental Protection (Noise) Regulations 1997.

Page intentionally blank

13. Conclusion

This document has provided information about the existing environment and potential impacts of implementation of the Proposal. It has also summarised the potential impacts associated with this Proposal and the Mining Area C currently operations. Where possible, a regional impact has also been assessed.

This PER has also explained BHP Billiton Iron Ore's new regional management approach to potential impacts for each of the EPA's environmental factors and has suggested potential implementation conditions to address those factors that may be considered key environmental factors.

BHP Billiton Iron Ore has had due regard for the principles of ecological sustainable development of the EP Act. BHP Billiton Iron Ore has extensive regional data sets, and proven current management practises on which the EIAs were based, resulting in a high degree of confidence in impact predictions. Where inherent impacts have been assessed as significant the application of the mitigation hierarchy based on a robust scientific methodology has resulted in a reduction of potential impacts to a level BHP Billiton Iron Ore considers reasonable.

Environmental Impact Assessments undertaken by BHP Billiton Iron Ore have concluded that for all factors outlined in the environmental scoping document that the EPA objective can be met and either the inherent or residual impacts to the environment resulting from the Proposal are not significant. In some cases (e.g. Terrestrial Fauna) the objective is met by the implementation of offsets.

This PER has provided supporting information to the EPA to undertake an assessment of the Proposal against EPA objectives. Billiton Iron Ore considers that the information and assessment presented in this PER adequately identifies and addresses environmental impacts relevant to the Proposal, adequately addresses the environmental scoping document and is suitable to enable the EPA to undertake its EIA of the Proposal.

Page intentionally blank

14. References

360 Environmental (2013). *South Flank Project Landscape and Visual Impact Assessment*. Report for BHP Billiton Iron Ore.

Abrams, K.M., Guzik, M.T., Cooper, S.J.B., Humphreys, W.F., King, R.A., Cho, J.L., and Austin, A.D. (2012). What lies beneath: Molecular phylogenetics and ancestral state reconstruction of the ancient subterranean Australian Parabathynellidae (Syncarida, Crustacea). *Molecular Phylogenetics and Evolution* 64, 130-144.

Adair, R. J. (1995). The threat of environmental weeds to biodiversity in Australia: a search for solutions. Pages 184-201 in R. A. Bradstock, T. D. Auld, D. A. Keith, R. T. Kingsford, D. Lunney, and D. Sivertsen, editors. *Conserving Biodiversity: Threats and Solutions*. S. Beatty & Sons: Sydney

Adair, R.J. and Groves, R.H. (1998). *Impact of Environmental Weeds on Biodiversity: A Review and Development of a Methodology*. National Weeds Program, Canberra.

ALA (2016). *Atlas of Living Australia Database*. *Merops ornatus* records. Downloaded 22 January 2016.

Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000), *Australian Water Guidelines for Fresh and Marine Waters* and its updates

Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (ANZMEC/MCA) (2000) *Strategic Framework for Mine Closure*, Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, National Library of Australian Catalogue Data

AQ2 (2015) Coondewanna Flats Eco-hydrology Review and Conceptual Model. Unpublished report for BHP Billiton Iron Ore.

Armstrong K. (2001) The distribution and roost habitat of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. *Wildlife Research* 28, 95–104.

Armstrong N.K. and Anstee D.S. (2000) The ghost bat in the Pilbara: 100 years on. *Australian Mammalogy* 22, 83-101.

Astron Environmental Services (2010) Jimblebar Iron Ore Project Ophthalmia Dam (and downstream) Phreatophytic Vegetation Assessment. Report for BHP Billiton Iron Ore.

Astron Environmental (2014a). *Coondewanna Flats Ecohydrological Study Ecological Water Requirements of Vegetation Report*. Report for BHP Billiton Iron Ore.

Astron Environmental (2014b). Mine, Port & Rail Operations Weed Control - Area C June 2014. Report for BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

Astron and Biologic Environmental Survey (2010). West Packsaddle Flora and Fauna Assessment. Unpublished report for BHP Billiton Pty Ltd.

Baddock M.C, Strong, C.L., Leys, J.F., Heidenreich, S.K., Tews, E.K., and McTainsh, G.H. (2014). A visibility and total suspended dust relationship. *Atmospheric Environment* 89, 329 – 336.

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A (2012). *Australian Groundwater Modelling Guidelines*. *Waterlines Report*. National-Water Commission. Canberra, ACT

Bat Call WA (2011). South Flank 2010 Bat Survey Report. Unpublished report for BHP Billiton Iron Ore.

Beard J. (1975). *Vegetation survey of Western Australia: Pilbara, map and explanatory memoir 1:1,000,000 series*, University of Western Australia Press, Perth, Western Australia.

Bennelongia (2015a). *Mining Area C, Life of Project: Troglifauna Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2015b). *Mining Area C, Life of Project: Stygofauna Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2016a). *Mining Area C Southern Flank Troglifauna Impact Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2016b). *Mining Area C Southern Flank Stygofauna Impact Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2016c). *Mining Area C Southern Flank: Troglifauna Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2016d) *Mining Area C Southern Flank: Stygofauna Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2016e) *Addendum for Modified Boundary: Mining Area C and Southern Flank Troglifauna Environmental Impact Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Bennelongia (2017). *Addendum based on Updated Habitat Assessment: Mining Area C and Southern Flank Troglifauna Environmental Impact Assessment*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

BHP Billiton (2016a). Code of Business Conduct. Available at: <http://www.bhpbilliton.com/aboutus/ourcompany/codeofbusconduct>.

BHP Billiton (2016b). Our Requirements Community. Available at: http://www.bhpbilliton.com/~media/bhp/documents/aboutus/ourcompany/governance/160404_gld_community.pdf?la=en.

BHP Billiton (2016c). Our Requirements Environment and Climate Change. Available at: http://www.bhpbilliton.com/~media/bhp/documents/aboutus/ourcompany/governance/160411_gld_environmentclimatechange.pdf?la=en.

BHP Billiton Iron Ore (2014). *Growth Media Management Procedure v. 3.0*. BHP Billiton Iron Ore, Perth, Western Australia.

BHP Billiton Iron Ore (2015a). *Mining Area C Life of Project Environmental Management Plan Revision 6*. BHP Billiton Iron Ore, Perth, Western Australia.

BHP Billiton Iron Ore, (2015b). *GWL Operating Strategy for Mining Area C (Number 0019544, Version 4.0, 2015)*. BHP Billiton Iron Ore, Perth, Western Australia.

BHP Billiton Iron Ore (2015c). Short-range Endemic Assessment Methods Version 2.0. BHP Billiton Iron Ore Internal Document.

BHP Billiton Iron Ore (2015d). Mining Area C Troglofauna Habitat Assessment, BHP Billiton Iron Ore Pty Ltd, 70 pp.

BHP Billiton Iron Ore, (2015e). *Mining Area C Hydrological Impact Assessment and Water Management Summary*. BHP Billiton Iron Ore, Perth, Western Australia.

BHP Billiton Iron Ore (2016a). Hydrological Impact Assessment and Water Management Summary. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016b). South Flank Preliminary AMD Risk Assessment. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016c). BHP Billiton Iron Ore Pilbara Strategic Proposal. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016d). BHP Billiton Iron Ore Pilbara Strategic Assessment Impact Assessment Report. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016e). BHP Billiton Iron Ore Pty Ltd Annual Environmental Report. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016f). Triennial aquifer review 2016. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016g). Mining Area C Southern Flank Referral Form. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016h). South Flank Troglofauna Habitat Assessment. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016i). South Flank Project Landscape and Visual Impact Addendum. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016j). BHP Billiton Iron Ore Pilbara Strategic Proposal: Flora and Vertebrate Fauna Screening Assessment. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016k). Guidance for Vertebrate Fauna Surveys in the Pilbara Version 5.0. BHP Billiton Iron Ore Internal Document.

BHP Billiton Iron Ore (2016l). South Flank Numerical Groundwater Modelling. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016m). Mining Area C Mine Closure Plan. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

BHP Billiton Iron Ore (2016n). Rehabilitation Standard v. 2.0. BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

Biologic Environmental Survey Pty Ltd (Biologic) and BatCall WA (2014). *Pilbara Regional Ghost Bat Review*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2011). *Southern Flank Vertebrate Fauna Survey*. Report for BHP Billiton Pty Ltd.

Biologic Environmental Survey (Biologic) (2013). *South Flank Targeted Northern Quoll Survey*. Report for BHP Billiton Pty Ltd.

Biologic Environmental Survey (Biologic) (2014a). *Consolidation of regional fauna habitat mapping: BHP Billiton Iron Ore Pilbara tenure*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2014b). *West Angelas – Deposit B and F Ghost Bat Assessment 2014*. Report for Robe River Joint Venture.

Biologic Environmental Survey (Biologic) (2015a). *Mining Area C – Life of Project Environmental Management Plan Revision 6 Environmental Impact Assessment of Short-range Endemic Invertebrates*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2015b). *Central Pilbara Ghost Bat Population and Roost Assessment: 2014*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2016a). *Mining Area C Southern Flank Environmental Impact Assessment of Short Range Endemic Invertebrates*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2016b). *Mining Area C Southern Flank Environmental Impact Assessment for Ghost Bat (*Macroderma gigas*)*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2016c). *South Flank Baseline and Targeted SRE Fauna Survey*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2016d). *South Flank Targeted Fauna Survey*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (2017). *Mining Area C and Southern Flank Desktop Review of Vertebrate Fauna*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biologic Environmental Survey (Biologic) (in prep). *Hamersley Range Ghost Bat Population Study 2015/2016*. Report for BHP Billiton Iron Ore, Perth, Western Australia.

Biota Environmental Science (Biota) (2002). Mining Area C Rail Corridor. Rare Flora Survey. Unpublished report for BHP Billiton Pty Ltd.

Biota Environmental Science (Biota) (2003). Mining Area C Rail Corridor. Seasonal Rare Flora Survey (Phase II). Unpublished report for BHP Billiton Pty Ltd.

Biota Environmental Science (Biota) (2011). Short Range Endemic Invertebrate Fauna Survey – South Flank. Unpublished report for BHP Billiton Pty Ltd.

Biota Environmental Science (Biota) (2012). *South Flank to Jinidi Level 2 Vertebrate Fauna Survey*. Report for BHP Billiton Iron Ore.

Biota Environmental Science (Biota) (2013). South Flank Targeted Millipede Survey (letter). Unpublished report for BHP Billiton Pty Ltd.

Biota Environmental Science (Biota) (2015a). *Mining Area C Vertebrate Fauna Environmental Impact Assessment*. Report prepared for BHP Billiton Iron Ore, Perth, Western Australia.

Biota Environmental Science (Biota) (2015b). *Baby Hope Downs Troglotauna Survey, Phase 2*. Report prepared for Rio Tinto.

Biota Environmental Science (Biota) (2015c). *Baby Hope Downs Deposit Targeted Fauna Survey*. Report prepared for Rio Tinto.

Brown, J.H. (1984). On the relationship between abundance and distribution of species. *American Naturalist* 124, 255-279.

Bullen, R. and Creese, S. (2014). A note on the impact on Pilbara leaf-nosed and ghost bat activity from cave sound and vibration levels during drilling operations. *The Western Australian Naturalist* 29: 145-154.

Busnel, R.G. and Fletcher, J.L. (Eds.) (1978). *Effects of Noise on Wildlife*. Academic Press, New York.

Butler R (2009). *Vulnerability of Plant Functional Types to Dust Deposition in the Pilbara, NW Australia*. Honours Thesis, School of Plant Biology, The University of Western Australia.

Canning S (2008). An Ethnographic Survey of the BHP Billiton South Flank Project, Closed Report.

Carwardine J., Nicol S., van Leeuwen S., Walters B., Firn J., Reeson A., Martin T. and Chadès I. (2014). Priority threat management for Pilbara species of conservation significance. Report prepared by the CSIRO, Brisbane, Queensland.

Cho, J.-L., and Humphreys, W.F. (2010). Ten new species of the genus *Brevisomabathynella* Cho, Park and Ranga Reddy, 2006 (Malacostraca, Bathynellacea, Parabathynellidae) from Western Australia. *Journal of Natural History* 44, 993-1079.

Cho, J.-L., Park, J.-G., and Humphreys, W.F. (2005). A new genus and six species of the Parabathynellidae (Bathynellacea, Syncarida) from the Kimberley region, Western Australia. *Journal of Natural History* 39, 2225-2255.

Commander, D.P., Mills, C.H. and Waterhouse, J.D. (1994). Salinisation of mined-out pits in Western Australia. In: 'Water Down Under 94, Adelaide, November 1994', Adelaide, pp. 527-532.

Commonwealth Department of Industry, Tourism and Resources (DITR) (2006a). Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure and Completion. Commonwealth of Australia, Canberra.

Commonwealth Department of Industry, Tourism and Resources (DITR) (2006b). Leading Practice Sustainable Development Program for the Mining Industry – Mine Rehabilitation. Commonwealth of Australia, Canberra.

Commonwealth Department of Industry, Tourism and Resources (DITR) (2007). *Leading Practice Sustainable Development Program for the Mining Industry - Managing Acid and Metalliferous Drainage*, Commonwealth of Australia, Canberra.

Commonwealth of Australia (1992). *National Strategy for Ecologically Sustainable Development, December 1992*. Canberra, Australia.

Commonwealth of Australia (2010). *Survey guidelines for Australia's threatened mammals*. Canberra, Australia.

Commonwealth of Australia (2014). *Australia's 15 National Biodiversity Hotspots*. <http://www.environment.gov.au/topics/biodiversity/biodiversity-conservation/biodiversity-hotspots/nationalbiodiversity-hotspots>. Accessed: 7 April 2014.

Commonwealth Department of Environment (2015). *National Greenhouse Accounts (NGA) Factors*, Australian Government, Canberra, ACT.

Crowe, M. (2012). *Guidelines for Geological Interpretation in the Hamersley Province*. Unpublished internal document for BHP Billiton Iron Ore.

Department of Aboriginal Affairs and Department of Premier and Cabinet. (2013). *Aboriginal Heritage - Due Diligence Guidelines, Version 3.0*. Perth, Western Australia

Department of Environment and Conservation (DEC) (2009). Biodiversity values of Weeli Wolli Spring: A priority ecological community [online]. Available <<https://www.dpaw.wa.gov.au/images/documents/about/science/pubs/infosheets/sdis003.pdf>>. Accessed 17.01.17.

Department of Environment and Conservation (DEC) (2009) Resource Condition Report for Significant Western Australian Wetland: Fortescue Marshes. Department of Environment and Conservation. Perth, Australia

Department of Environment and Conservation (2011). *A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities*, Perth, Western Australia.

Department of Environment and Conservation (DEC) (2016). Naturemap Database Search [online]. Available <<http://naturemap.dec.wa.gov.au>>. Accessed 14.06.17.

Department of Environment Regulation (DER) (2014). *Assessment and Management of Contaminated Sites*. Perth, Western Australia.

Department of the Environment (DotE) (2016a). Interactive Environmental Database Reporting Tool Search [online]. Available<www.environment.gov.au>. Accessed 17.01.17.

Department of the Environment (DotE) (2016b). *Rhinonictes aurantia* (Pilbara form) in Species Profile and Threats Database [online]. Department of the Environment, Canberra. Available <<http://www.environment.gov.au/sprat>>. Accessed 19.02.16.

Department of the Environment (DotE) (2016c). Species profile and threats database - olive python (Pilbara subspecies) [online]. Prepared by the Commonwealth Department of the Environment (DotE). Canberra, ACT. Available <<http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>>. Accessed 07.06.16.

Department of the Environment and Energy (2016). Australian Greenhouse Emissions Information System [online]. Available <<http://ageis.climatechange.gov.au>>. Accessed 07.09.16.

Department of Health (DoH) (2016). Port Hedland Air Quality Health Risk Assessment for Particulate Matter. Environmental Health Directorate. Government of Western Australia, Department of Health, Perth, Western Australia.

Department of Indigenous Affairs (DIA) (2010). What is a reserve? [online]. Australian Department of Indigenous Affairs, Perth, Western Australia. Available <www.dia.wa.gov.au/en/Land/Land-Facts/04-What-is-a-Reserve>. Accessed 11.03.13.

Department of Industry and Resources (DoIR) (2006). *Guidelines for Mining Proposals in Western Australia*. Perth, Western Australia.

Department of Mines and Petroleum (DMP) (2013). *Tailings Storage Facilities in Western Australia – Code of Practice*. Perth, Western Australia.

Department of Mines and Petroleum (DMP) (2014). *Western Australian mineral and petroleum statistical digest (2014-2015)*. Department of Mines and Petroleum, Perth, Western Australia.

Department of Mines and Petroleum (DMP) (2015). *Guide to the Preparation of a Design Report for Tailings Storage Facilities (TSFs)*. Perth, Western Australia.

Department of Mines and Petroleum and Environmental Protection Authority (DMP and EPA) (2015) *Guidelines for Preparing Mine Closure Plans*. Perth, Western Australia.

Department of Mines and Petroleum (DMP) (2016a). Latest Statistics Release [online]. Available <<http://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx>>. Accessed 07.07.16.

Department of Mines and Petroleum (DMP) (2016b). Guideline for mining proposals in Western Australia [online]. Available <<http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-213.pdf>>. Accessed 17.01.17.

Department of Mines and Petroleum (DMP) (2016c). Draft Guidance Materials Characterisation Baseline Data Requirements for Mining Proposals [online]. Available <http://www.dmp.wa.gov.au/Documents/Environment/ENV-DraftGuidance_MaterialsCharacterisationDataProposal.pdf>. Accessed 13.01.17.

Department of Parks and Wildlife (DPAW) (2014). Priority Ecological Communities for Western Australia Version 21 [online]. Species and Communities Branch, Department of Parks and Wildlife, Kensington, Western Australia. Available <https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Priority_ecological_communities_list.pdf>. Accessed 13.07.16.

Department of Parks and Wildlife (DPAW) (2016a). Threatened and Priority Flora Database Search [online]. Database Search Request Report provided to BHP Billiton Iron Ore, unpublished.

Department of Parks and Wildlife (DPAW) (2017). Naturemap database search [online]. <<https://naturemap.dpaw.wa.gov.au>>. Accessed: 19.01.17.

Department of Planning and Infrastructure (DPI) (2007). *Visual Landscape Planning in Western Australia: A Manual for Evaluation, Assessment, Siting and Design*. Perth, Western Australia.

Department of Resource and Development (DRD) (2015). *Pilbara: a region in profile 2014*. Report prepared by the Western Australian Department of Regional Development, Perth, Western Australia.

Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) (2011). *Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered northern quoll, Dasyurus hallucatus*. Canberra, Australian Capital Territory.

Department of Water (DoW) (2000). *Water Quality Protection Guidelines for Mining and Mineral Processing Nos. 1-11*.

Department of Water (DoW) (2006). *Water Quality Protection Note No 30. Groundwater Monitoring Bores*. Western Australian Department of Water, Perth, Western Australia.

Department of Water (DoW) (2009). *Operational Policy No. 1.02 Policy on water conservation/efficiency plans*. Western Australian Department of Water, Perth, Western Australia.

Department of Water (DoW) (2010). *Pilbara regional water plan 2010-2030*. Report prepared by the Western Australian Department of Water, Perth, Western Australia.

Department of Water (DoW) (2011). *Operational Policy No. 5.08 Use of Operating Strategies in the water licensing process*. Perth, Western Australia.

Department of Water (DoW) (2013a). *Pilbara regional water supply strategy: a long term outlook of water demand and supply*, Report No. 1. October 2013. Perth, Western Australia.

Department of Water (DoW) (2013b). *Western Australian Water in Mining Guideline. Water licensing delivery series*. Report no. 12. May 2013. Perth, Western Australia.

Department of Water (DoW) (2013c). *Pilbara Groundwater Allocation Plan. Water resource allocation and planning report series*. Report No 55. Perth, Western Australia.

Department of Water (DoW) (2013d). *Strategic Policy 2.09 Use of mine dewatering surplus*. Perth, Western Australia.

Doughty, P. and Oliver, P.M. (2011). A new species of *Underwoodisaurus* (Squamata: Gekkota: Carphodactylidae) from the Pilbara region of Western Australia. *Zootaxa* 3010: 20-30.

Doughty P., Rolfe J., Burbidge A., Pearson D. and Kendrick P. (2011). *Herpetological assemblages of the Pilbara biogeographic region, Western Australia: ecological associations, biogeographic patterns and conservation*. Records of the Western Australian Museum, Supplement 78: 315–341.

Eberhard S.M., Halse S.A., Williams M.R., Scanlon M.D., Cocking J.S. and Barron H.J. (2009). Exploring the relationship between sampling efficiency and short range endemism for groundwater fauna in the Pilbara region. *Western Australia. Freshwater Biology* 54: 885–901.

Ecologia Environment (Ecologia) (1998a). *Mining Area C Biological Survey*. Unpublished report prepared for BHP Iron Ore Pty Ltd.

Ecologia Environment (Ecologia) (2001). *Mining Area C to Yandi Rail Line Baseline Weed Survey*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

Ecologia Environment (Ecologia) (2002). *Mining Area C Village and Access Road Rare and Priority Flora Survey*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

Ecologia Environment (Ecologia) (2004a). *Area C: Deposits D, E and F Biological Survey*. Unpublished report prepared for BHP Iron Ore Pty Ltd.

Ecologia Environment (Ecologia) (2004b). *Packsaddle Range Biological Survey*. Unpublished report prepared for BHP Iron Ore Pty Ltd.

Ecologia Environment (Ecologia) (2005). *Packsaddle Wastewater Treatment Plant Flora and Vegetation Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

ENV Australia (2007). *Area C: R Deposit Flora and Vegetation Assessment*. Unpublished report prepared for BHP Iron Ore Pty Ltd.

ENV Australia (2008). *Area C Southern Flank Deposit Fauna Assessment*. Unpublished report for BHP Billiton Pty Ltd.

ENV Australia (2009). *Newman to Yandi Transmission Line Flora and Vegetation Assessment*. Unpublished report for Worley Parsons Pty Ltd.

ENV Australia (2010a). *South Flank NVCP Extension Flora, Vegetation and Fauna Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

ENV Australia (2010b). *Jinayri to Area C Access Corridor Flora, Vegetation and Fauna Survey*. Report prepared for BHP Billiton Iron Ore. Perth, Western Australia.

Environment Australia (2001). *A Directory of Important Wetlands in Australia*, Third Edition, Environment Australia, Canberra, Australian Capital Territory.

Environmental Protection Authority (EPA) (2000a). *Environmental Protection of Native Vegetation: Clearing of native vegetation with particular reference to agricultural areas*. Position Statement No. 2. Perth, Western Australia.

Environmental Protection Authority (EPA) (2000b). *Prevention of Air Quality Impacts from Land Development Sites*, Guidance Statement No. 18. Perth, Western Australia.

Environmental Protection Authority (EPA) (2002a) *Terrestrial Biological Surveys as an Element of Biodiversity Protection*, Position Statement No. 3. Perth, Western Australia.

Environmental Protection Authority (EPA) (2002b) *Minimising Greenhouse Gas Emissions*, Guidance Statement No. 12. Perth, Western Australia.

Environmental Protection Authority (EPA) (2003). *Guidance Statement 54: Guidance for the assessment of environmental factors: consideration of subterranean fauna in groundwater and caves during environmental impact assessment in Western Australia*. Environmental Protection Authority, Perth.

Environmental Protection Authority (EPA) (2004a). *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*, Guidance Statement No. 51. Perth, Western Australia.

Environmental Protection Authority (EPA) (2004b). *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*, Guidance Statement No. 56. Perth, Western Australia.

Environmental Protection Authority (EPA) (2004c). *Environmental Protection of Wetlands*. Position Statement No. 4. Perth, Western Australia.

Environmental Protection Authority (EPA) (2004d). *Assessment of Aboriginal Heritage*, Guidance Statement No. 41. Perth, Western Australia.

Environmental Protection Authority (EPA) (2004e). *Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia*. Position Statement No. 5. Perth, Western Australia.

Environmental Protection Authority (EPA) (2005a). *Separation Distances between Industrial and Sensitive Land Uses* Guidance Statement No. 3. Perth, Western Australia.

Environmental Protection Authority (EPA) (2005b). *Environmental Protection in Natural Resource Management. Guidance Statement No. 8*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2006). *Rehabilitation of Terrestrial Ecosystems. Guidance Statement No. 6*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2007). *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia, Draft Guidance Statement No. 54a*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2008). *Environmental Guidance for Planning and Development, Guidance Statement No. 33*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2009). *Sampling for Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in WA, Guidance Statement No. 20*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2010). *General Guide on Referral of Proposals to the Environmental Protection Authority under Section 38 of the Environmental Protection Act 1986*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2012a). *Environmental Assessment Guideline 1 for Defining the Key Characteristics of a Proposal*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2012b). Environmental Impact Assessment (Part IV Division 1 and 2) Administrative Procedures 2012. *Western Australian Government Gazette No. 223*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013a). *Environmental Assessment Guideline 8 for Environmental Factors and Objectives*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013b). *Environmental Assessment Guideline 9 for Application of a significance framework in the environmental impact assessment process (focusing on key environmental factors)*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013c). *Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area*. Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the *Environmental Protection Act 1986*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013d). *Environmental Assessment Guideline 12 for Consideration of Subterranean fauna in environmental impact assessment in Western Australia*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013e) *Environmental Protection Bulletin No.19 EPA involvement in mine closure*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2013f) *Environmental Assessment Guideline 6 – Timelines for Environmental Impact Assessment of Proposals*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2014a) *Environmental Protection Bulletin No. 1 – Environmental Offsets – Biodiversity*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2014b). *Environmental Assessment Guideline 13 for Consideration of environmental impacts from noise*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2014c). *Cumulative environmental impacts of development in the Pilbara region*. Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986. Perth, Western Australia.

Environmental Protection Authority (EPA) (2015a). *Environmental Protection Bulletin No.23. Guidance on the EPA landforms factor*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2015b). *Environmental Protection Bulletin No. 24: Greenhouse gas emissions and consideration of projected climate change impacts in the EIA process*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2016a). *Statement of Environmental Principles, Factors and Objectives*. Perth, Western Australia.

Environmental Protection Authority (EPA) (2016b). Public Notice: Monday advertisements, 4 July 2016 [online]. Available <<http://www.epa.wa.gov.au/proposals/mining-area-c-southern-flank>>. Accessed 04.07.16.

Environmental Protection Authority and Department of Environment and Conservation (EPA and DEC) (2010). *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*. Perth, Western Australia.

Environmental Protection Authority and Department of Parks and Wildlife (EPA and DPaW) (2015). *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment*. Perth, Western Australia.

Environmental Protection Authority Victoria (EPA VIC) (1999). *State Environmental Protection Policy (Ambient Air Quality), No 519*. Melbourne, Victoria.

Fontaine B., Bouchet P. and Van Achterberg K. (2007). The European Union's 2010 target: putting rare species in focus. *Biological Conservation* 139: 167–185.

Fox, J.E.D. (1978). Fire regeneration study. *Mulga Research Centre Ann. Rept.* 1: 7-8.

Gajowiec, B. (1993). Impact of lead/zinc ore mining on groundwater quality in Trzebionika mine (southern Poland). *Mine Water and the Environment* 12, 1-10.

Garnett, S. T., J. K. Szabo, and G. Dutson (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing.

Gibert J. and Deharveng L. (2002). Subterranean ecosystems: a truncated functional biodiversity. *BioScience* 52: 473–481.

Gibson, L.A. and McKenzie, N.M. (2009). Environmental associations of small ground-dwelling mammals in the Pilbara region, Western Australia. *Records of the West Australian Museum Supplement* 78: 91-122.

Government of Western Australia (2004). *State Water Quality Management Strategy Document No. 6*. Perth, Western Australia.

Government of Western Australia (2009). *Pilbara Water in Mining Guideline. Report No. 34*. Perth, Western Australia.

Government of Western Australia (2011). *WA Environmental Offsets Policy*. Perth, Western Australia.

Government of Western Australia (2014). *WA Environmental Offsets Guidelines*. Perth, Western Australia.

Grierson, P. (2015). *Dust suppression and likelihood of adverse impact on Acacia sp. East Fortescue at Orebody 31*. Report for BHP Billiton Iron Ore.

Guisan, A., Broennimann, O., Engler, R., Vust, M., Yoccoz, N.G., Lehmann, A. and Zimmermann, N.E. (2006). Using niche-based models to improve sampling of rare species. *Conservation Biology*, 20, 501-511.

Guzik, M.T., Abrams, K.M., Cooper, S.J.B., Humphreys, W.F., Cho, J.-L., and Austin, A.D. (2008). Phylogeography of the ancient Parabathynellidae (Crustacea: Bathynellacea) from the Yilgarn region of Western Australia. *Invertebrate Systematics* 22, 205-216.

Hadley, N.F., Ahearn, G.A. and Howarth, F.G. (1981). Water and metabolic relations of cave-adapted and epigeal lycosid spiders in Hawaii. *Journal of Arachnology* 9, 215-222.

Halse S.A. and Pearson G.B. (2014). Troglifauna in the vadose zone: comparison of scraping and trapping results and sampling adequacy. *Journal of Subterranean Biology* 13: 17–34

Halse, S.A., Scanlon, M.D., Cocking, J.S., Barron, H.J., Richardson, J.B., and Eberhard, S.M. (2014) Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. *Records of the Western Australian Museum Supplement* 78, 443-483.

Harvey M. (2002). Short-range endemism among the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* 16: 555-570.

HDMS (2000). *Hope Downs Iron Ore Project – Public Environmental Report / Public Environment Review*. August 2000.

Heritage Council of WA (2015). inHerit database. Viewed: 30 July 2015. Accessed at: <http://inherit.stateheritage.wa.gov.au/Public/>. Heritage Council of Western Australia, State Heritage Office, Perth, Western Australia.

Heydenrych, B., Parsons, B. and Berkinshaw, T. (2015) *Conservation Action Plan for the Pilbara Bioregion. Summary Report (Draft)*. Greening Australia, Perth.

HGM (1999). *Marillana Creek Western Access Corridor – Biological Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

Hill B. and Ward S. (2010). National recovery plan for the northern quoll *Dasyurus hallucatus* [online]. Available <<http://www.environment.gov.au/system/files/resources/8744fe3f-3a94-431f-906c-975719d42f4f/files/northern-quoll.pdf>>. Accessed 10.06.14.

Howarth, F.G. (1980). The zoogeography of specialized cave animals: a bioclimatic model. *Evolution* 34, 394-406.

Humphreys, W.F. (1990). The biology of a troglobitic schizomid (Chelicerata: Schizomida) in the caves of Cape Range, Western Australia. *Acta Zoologica Fennica* 190, 181-186.

Humphreys, W.F. (2009) Hydrogeology and groundwater ecology: Does each inform the other? *Hydrogeology Journal* 17: 5-21

Hutson, A.M., Mickleburgh, S.P. and Racey, P.A. (2001). *Microchiropteran Bats – Global Status Survey and Conservation Action Plan*. IUCN/SSC Chiroptera Specialist Group, Gland, Switzerland and Cambridge, UK.

ICMM (2008). *Planning for integrated mine closure: Toolkit*. International Council on Mining and Metals, London, United Kingdom

International Network for Acid Prevention (INAP) (2010). *Global acid rock drainage guide*. Report prepared by the International Network for Acid Prevention, Salt Lake City, Utah.

Johnson, S.L. and Wright, A.H (2003). *Mine Void Water Resource Issues in Western Australia*. Water and Rivers Commission Resource Science Division.

Johnstone, R. E., and G. M. Storr (1998). *Handbook of Western Australian Birds Volume I - Non-Passerines (Emu to Dollarbird)*. Western Australian Museum, Perth.

Karanovic, T. (2006). Subterranean copepods (Crustacea, Copepoda) from the Pilbara region in Western Australia. *Records of the Western Australian Museum Supplement* 70, 1-239.

Kearney, M., Phillips, B.L., Tracy, C.R., Christian, K.A., Betts, G. and Porter, W.P. (2008). Modelling species distributions without using species distributions: the cane toad in Australia under current and future climates, *Ecography* 31: 423–434.

Keighery, B. J. (1994). *Bushland Plant Survey: a Guide to Plant Community Survey for the Community*. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

Kendrick (2001) *Bioregion: Pilbara 3 Subregion (PIL3)*. Department of Conservation and Land Management, Perth.

Klohn Crippen Berger (2014). *Mining Area C Preliminary Acid and Metalliferous Drainage Risk Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

Lamoreux J. (2004). Stygobites are more wide-ranging than troglobites. *Journal of Cave and Karst Studies*. 66:18–19.

Lande, R. (1999). Extinction Risks from Anthropogenic, Ecological and Genetic Factors. In: *Genetics and the Extinction of Species* (Eds: Landweber L.F. and Dobson, A. P.) Princeton University Press, Princeton, New Jersey

Landloch Pty Ltd (2013). Development of Erosionally Stable Final Batter Shapes. Marra Mamba Ore Bodies. Report prepared for BHP Billiton Iron Ore Pty Ltd, Perth, Western Australia.

Marchant S. and Higgins P.J. (1993). *Handbook of Australian, New Zealand and Antarctic birds, vol. 2*. Oxford University Press: Melbourne.

Maurer, B.A. (1990). The relationship between distribution and abundance in a patchy environment. *Oikos* 58, 181-189.

McAuley, S.D. and Kozar, M.D. (2006). Groundwater quality in unmined areas and near reclaimed surface coal mines in the northern and central Appalachian coal regions, Pennsylvania and West Virginia. *US Geological Survey Scientific Investigations Report*. Reston, Virginia, pp.57

McKenzie, N.L. (2016.) *Peer Review of: Biologic (2016) Mining Area C – Southern Flank Environmental Impact Assessment for Ghost Bat*. Letter to BHP Billiton Iron Ore Pty Ltd, Perth, Western Australia.

McKenzie N.L., van Leeuwen S. and Pinder A.M. (2009). Introduction to the Pilbara Biodiversity Survey, 2002-2007. *Records of the Western Australian Museum Supplement* 78: 3-89.

Miller, R.I., Stuart, S.N. and Howell, K.M. (1989). A method for analysing rare species distribution patterns utilising GIS technology: the rare birds of Tanzania. *Landscape Ecology*, 2, 173-189.

Molloy, S.W., Davis, R.A., Dunlop, J. and van Etten, E.J.B. (2015). *Spatial Modelling for the Northern Quoll in the Pilbara: Informing the Management of a Unique and Isolated Population of an Endangered and Iconic Species*. Edith Cowan University and Department of Parks and Wildlife, Western Australia

MWH (2014). *Development of Pilbara landscape ecohydrological units*. Report prepared for BHP Billiton Iron Ore.

MWH (2015). *Mining Area C Baseline Soil and Landform Survey and Impact Assessment*. Report prepared for BHP Billiton Iron Ore Pty Ltd.

MWH (2016). *Mining Area C Revised Proposal Surface Water Impact Assessment*. Report prepared for BHP Billiton Iron Ore Pty Ltd.

Norgate and Haque (2010). Energy and Greenhouse Gas impacts of Mining and Minerals Processing operations. *Journal of Cleaner Production* 18: 266-274.

Oakwood M. (2002). Spatial and social organization of a carnivorous marsupial *Dasyurus hallucatus* (Marsupialia: Dasyuridae). *Journal of Zoology London* 257: 237-248.

Oakwood, M. (2008). Northern Quoll *Dasyurus hallucatus*. *The Mammals of Australia*. (Ed: R. Strahan). Sydney, Reed New Holland.

Office of the Environmental Protection Authority (OEPA) (2016). *Environmental Scoping Document*. Perth, Western Australia.

Onshore Environmental (2011). *Level 2 Flora and Vegetation Survey Area C and Surrounds*. Report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2012). *Southern Flank Study Area Level 2 Flora and Vegetation Survey*. Report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014). *Consolidation of regional vegetation mapping, BHP Billiton Iron Ore Pilbara tenure*. Report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2015). *Mining Area C Flora and Vegetation Environmental Impact Assessment*. Report for BHP Billiton Iron Ore.

Onshore Environmental (2017). *Mining Area C Southern Flank. Flora and Vegetation Impact Assessment*. Report prepared for BHP Billiton Iron Ore.

Outback Ecology (2012a). *South Flank Project Soil and Landform Assessment*. Report prepared for BHP Billiton Iron Ore.

Outback Ecology (2012b). *Mining Area C Assessment Study Area Soil and Landform Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

Pacific Environment Ltd (2016). *Memorandum Updated Air Quality Modelling for South Flank Proposal*. Report prepared for BHP Billiton Iron Ore.

Perina, G., Huey, J., Comancho, A, Horwitz, P. and Koenders, A. (2016). Remarkable biodiversity of a neglected group of stygofauna: Bathynellidae (Bathynellacea, Crustacea) in the north of Western

Australia. *International Conference on Subterranean Biology, 13-17 June 2016, Fayetteville, Arkansas*. International Society for Subterranean Biology, http://www.speleobiology.com/icsb2016/wp-content/uploads/bsk-pdf-manager/ICSB_2016_Abstracts_2.pdf, p. 75.

Pilbara Development Commission (2015). *Economic profile* [online]. Available <<http://www.economicprofile.com.au/pilbara/economy/regional-exports>>. Accessed 25.08.15.

Pilbara Flora (2008). Field Survey for Priority and Rare Flora Area C Southern Flank. Report prepared for BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

Pinder, A.M., Halse, S.A., Shiel, R.J. and McRae, J.M. (2010). An arid zone awash with diversity: patterns in the distribution of aquatic invertebrates in the Pilbara region of Western Australia. *Records of the Western Australian Museum Supplement* 78, 205-246.

Ponder W. and Colgan D.J. (2002). What makes a narrow range taxon? Insights from Australian freshwater snails. *Invertebrate Systematics* 16: 571–582.

Price, WA. (2009). Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. CANMET - Mining and Mineral Sciences Laboratories. Smithers, British Columbia.

Purtill, J (2014). *Ghost bat autopsy finds cane toad bones, explains population's freefall in NT, Qld: expert*. <http://www.abc.net.au/news/2014-10-14/cane-toad-carnivorous-ghost-bat-local-extinction-kakadu/5793464> (Published: 14 October 2014).

Reid J. and Fleming M. (1992). The conservation status of birds in arid Australia. *Rangeland Journal* 14, 65–91.

Rich, C. and Longcore, T (eds) (2006). *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington.

Rösner, U. (1998). Effects of historical mining activities on surface water and groundwater - an example from northwest Arizona. *Environmental Geology* 33, 224-230.

RPS Aquaterra (2014). *Hydrogeological Assessment for Mining Area C*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

RPS Aquaterra (2015). *Mining Area C Environmental Management Plan Revision 6 Surface Water Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd

RPS (2013). *Hydrological Assessment for Mining Area C*. Report prepared for BHP Billiton Iron Ore.

SAI Global (2000). *Australian Standard 2107:2000, Acoustics: Recommended Design Sound Levels and Reverberation Times for Building Interiors*.

Scheller, U. (2013). Pauropoda (Myriapoda) in Australia, with descriptions of new species from Western Australia. *Records of the Australian Museum Supplement* 82, 133 pp.

Sharma, R.S. and Al-Busaidi, T.S. (2001). Groundwater pollution due to a tailings dam. *Engineering Geology* 60, 235-244.

Shepherd D.P., Beeston G.R. and Hopkins A.J.M. (2002). *Native vegetation in Western Australia – extent, type and status, Resource Management Technical Report 249*. Western Australian Department of Agriculture, Perth, Western Australia.

Slater, P., Slater, P. and Slater, R. (2009). *The Slater Field Guide to Australian Birds*. 2nd Ed. Reed New Holland Publishers. Sydney.

State Library of Western Australia (SLWA) (2010). Western perspectives of a nation: pastoral [online]. Available <<http://slwa.wa.gov.au/wepon/land/html/pastoral.html>>. Accessed 30.10.15.

Southgate R., Paltridge R., Masters R. and Carthew S. (2007). Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert, Australia. *Ecography* 30: 759–776.

Spencer, P.B.S. and Tedeschi, J (2016). *An initial investigation into the genetic diversity, structure and short-range spatial-use by Ghost Bats in the Hamersley subregion of the Pilbara*. Unpublished report prepared by Murdoch University for Biologic Environmental Survey and BHP Billiton Iron Ore

SVT (2014). *Environmental Noise Assessment: Mining Area C*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd. Perth, Western Australia.

SVT (2016). *South Flank Environmental Noise Assessment*. Report prepared for BHP Billiton Iron Ore. Perth, Western Australia.

Thackway and Cresswell (1995) *An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program Version 4*, Australian Nature Conservation Agency, Canberra.

Threatened Species Scientific Committee (2008). Commonwealth Conservation Advice on *Liasis olivaceus barroni* (Olive Python (Pilbara subspecies)) [online]. Available <<http://www.environment.gov.au/biodiversity/threatened/species/pubs/66699-conservation-advice.pdf>>. Accessed 07.07.16.

Threatened Species Scientific Committee (2016). Commonwealth Conservation Advice *Macroderma gigas* (ghost bat) [online]. Available <<http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf>>. Accessed 07.07.16.

Tille P. (2006). *Soil-landscapes of Western Australia's rangelands and arid interior, resource management technical report 313*. Report prepared by the Western Australian Department of Agriculture and Food, Perth, Western Australia.

Trotter, A.J., McRae, J.M., Main, D.C. and Finston, T.L. (2017) Speciation in fractured rock landforms: towards understanding the diversity of subterranean cockroaches (Dictyoptera: Nocticolidae: *Nocticola*) in Western Australia. *Zootaxa* 4250: 143-170.

Turner GF (2013). *Vulnerability of Plant Functional Types to Mining Dust Deposition at the Jack Hills, Western Australia*. Masters Thesis, School of Plant Biology, The University of Western Australia.

Urban, M. C., Phillips, B. L., Skelly, D. K., and Shine, R. (2007). The cane toad's (*Chaunus [Bufo] marinus*) increasing ability to invade Australia is revealed by a dynamically updated range model. *Proc. R. Soc. B* 274: 1413–1419.

Urbis (2015). *Area C EMP Revision 6 Landscape and Visual Impact Assessment*. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

URS (2014). *Coondewanna Flats Phase III Water Assessment*. Report prepared for BHP Billiton Iron Ore.

- van Dyck, S. and Strahan, R. (Eds.) (2008). *Mammals of Australia. 3rd Edition*. Australian Museum, Sydney.
- van Vreeswyk A. M. E., Payne A. L., Leighton K. A. and Hennig P. (2004). *An inventory and condition survey of the Pilbara region*. Western Australian Department of Agriculture, Perth, Western Australia
- Water and Rivers Commission (2000a). Water Quality Protection Guidelines No 1. *Water Quality Management in Mining and Mineral Processing: An Overview*. Perth, Western Australia.
- Water and Rivers Commission (2000b). Water Quality Protection Guidelines No. 4. *Mining and Mineral Processing, Installation of Minesite Groundwater Monitoring Bores*. Perth, Western Australia.
- Water and Rivers Commission (2000c). Water Quality Protection Guidelines No. 5. *Mining and Mineral Processing, Minesite Water Quality Monitoring*. Perth, Western Australia.
- Water and Rivers Commission (2000d). Water Quality Protection Guidelines No. 9. *Mining and Mineral Processing, Acid Mine Drainage*. Perth, Western Australia.
- Water and Rivers Commission (2000e). Water Quality Protection Guidelines No. 11. *Mining and Mineral Processing, Mine Dewatering*. Perth, Western Australia.
- WBM (2016). TUFLOW User Manual. Build 2016-12-AC-iDP-w64 [online]. Available <<http://www.tuflow.com/Download/TUFLOW/Releases/2016-03/TUFLOW%20Manual.2016-03.pdf>>. Accessed 17.01.17.
- Western Australian Planning Commission (WAPC) (2003). *State Planning Policy No. 2: Environment and Natural Resources Policy for Western Australia*. Perth, Western Australia.
- Western Australian Planning Commission (WAPC) (2012). *Pilbara Planning and Infrastructure Framework Press*. Perth, Western Australia.
- White, A.W., Morris, I., Madani, G. and Archer, M. (2016). Are Cane Toads *Rhinella marina* impacting Ghost Bats *Macroderma gigas* in Northern Australia. *Australian Zoologist* In-Press
- Wilson, S. and Swan, G. (2008). *A Complete Guide to Reptiles of Australia*. 2nd Edition. New Holland Publishers (Australia), Sydney.
- Woinarski, J. C. Z., A. A. Burbidge, and P. L. Harrison (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Victoria.
- Woodman Environmental Consulting (2009). *Flora and Vegetation Assessment Area C Mining Operation Environmental Management Plan A, D, P1 and P3 Deposits*. Unpublished report prepared for BHP Billiton Iron Ore.
- Woodman Environmental Consulting (2010). *Jinayri Infrastructure Corridors Flora and Vegetation Survey*. Unpublished report prepared for BHP Billiton Iron Ore.
- World Commission on Environment and Development (1987). *Our Common Future*. Oxford University Press, England.
- Worthington Wilmer, J., Moritz, C., Hall, L., & Toop, J. (1994). Extreme population structuring in the threatened ghost bat, *Macroderma gigas*: evidence from mitochondrial DNA. *Proceedings of the Royal Society of London B Biological Sciences* 257: 193-198.
- Worthington Wilmer, J., Hall, L., Barratt, E., & Moritz, C. (1999). Genetic structure and male-mediated gene flow in the Ghost Bat (*Macroderma gigas*). *Evolution* 53: 1582-1591.

Woodward-Clyde (1997). *Multiple Iron Ore Development Project Public Environmental Review: Mining Area C*. Prepared for BHP Iron Ore Pty Ltd.

Zhu, C., Hu, F.Q., and Burden, D.S. (2001). Multi-component reactive transport modeling of natural attenuation of an acid groundwater plume at a uranium mill tailings site. *Journal of Contaminant Hydrology* 52, 85-108.

15. Appendices

Appendix 1 Authority to Act on Behalf of Joint Ventures

Appendix 2 Mining Area C Life of Project Environmental Management Plan Revision 6

Appendix 3 Adherence of the Proposal to EPA Requirements and Draft Environmental Management Plan

Appendix 4 Flora and Vegetation Environmental Impact Assessment Supporting Documents

Appendix 5 Terrestrial Vertebrate Fauna Supporting Documents

Appendix 6 Subterranean Fauna Environmental Impact Assessment Supporting Documents

Appendix 7 Hydrological Impact Assessment Supporting Documents

Appendix 8 Heritage Section 18 Approval and draft Culutral Heritage Management Plan

Appendix 9 Air Quality Modelling Summary

Appendix 10 Visual Impact Assessment

Appendix 11 Noise Environmental Impact Assessment

Appendix 12 Mining Area C Closure Plan and Acid Mine Drainage Risk Assessment

Appendix 13 Offsets Form