Iron Bridge

Our Ref: UID 52029
Your Ref:

Dr Paul Vogel
Chair
Environmental Protection Authority
The Atrium
168 St Georges Terrace
PERTH WA 6000

17th September 2015

Dear Dr Vogel

REFERRAL OF A PROPOSAL TO THE ENVIRONMENTAL PROTECTION AUTHORITY UNDER SECTION 38(1) OF THE ENVIRONMENTAL PROTECTION ACT 1986 – THE IRON BRIDGE PORT FACILITY

IB Operations Pty Ltd (IBO) wishes to formally refer the Iron Bridge Port Facility (the IB Port Facility) to the Environmental Protection Authority for assessment under Section 38 of the *Environmental Protection Act 1986*. Please find enclosed a completed referral form for consideration, with accompanying supporting information documentation and shapefiles on CD.

The IB Port Facility consists of new infrastructure to be constructed within the Herb Elliott Port Precinct at the Port Hedland Inner Harbour in the Pilbara region of Western Australia. The IB Port Facility will accept magnetite concentrate slurry from the North Star Magnetite Project, whereupon the slurry will be dewatered and the concentrate product stored for export. Infrastructure required to outload and export the magnetite concentrate is not subject to this referral.

If you have any queries regarding the enclosed information, please contact Andrew Winzer, Senior Environmental Advisor, on 6218 8914 or at awinzer@fmgl.com.au.

Yours sincerely

J Clements (SNR STUDY MANAGER)

pp **SIMON CARTER**
Chief Executive Officer, Iron Bridge

Enc.

Attachment 1 EPA referral form
Attachment 2 Supporting Documentation, Appendices and Shapefiles (CD)

Iron Bridge

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POSTAL ADDRESS PO Box 6915, East Perth, Western Australia 6892
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Template - 662CO-0000-TE-DC-0003_0

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

EPA REFERRAL FORM

Referral of a Proposal to the Environmental Protection Authority under Section 38 of the *Environmental Protection Act 1986.*

PURPOSE OF THIS FORM

Section 38 of the *Environmental Protection Act 1986* (EP Act) makes provision for the referral to the Environmental Protection Authority (EPA) of a proposal (significant proposals, strategic proposals and proposals under an assessed scheme) by a proponent, a decision making authority (DMA), or any other person.

The purpose of this form is to ensure that EPA has sufficient information about a proposal to make a decision about the nature of the proposal and whether or not the proposal should be assessed under Part IV of the EP Act. Information provided in the referral form must be brief (no more than 30 pages), sharp and succinct to achieve the purposes of this form.

This form does not prevent the referrer from providing a supplementary referral report. Should a referrer choose to submit a supplementary referral report please ensure the following.

i. Information is short, sharp and succinct.
ii. Attachments are below eight megabytes (8 MB) as they will be published on the EPA's website (exemptions apply) for public comment. To minimise file size, "flatten" maps and optimise pdf files.
iii. Cross-references are provided in the referral form to the appropriate section/s in the supplementary referral report.

This form is to be used for all proposals[1] which can be referred to the EPA under section 38 of the EP Act; i.e. referrals from: **proponents** of proposals (significant proposals, strategic proposals, derived proposals, proposals under an assessed scheme); **DMAs** (significant proposals); and **third parties** (significant proposals).

This form is divided into several sections, including; Referral requirements and Declaration; Part A - Information of the proposal and proponent; and Part B Environmental Factors. Guidance on successfully completing this form is provided throughout the form and is also available in the EPA's *Environmental Assessment Guideline for Referral of a Proposal under s38 of the EP Act (EAG 16)*.

Send completed forms to
Office of the Environmental Protection Authority
Locked Bag 10, East Perth WA 6892

or

Email: Registrar@epa.wa.gov.au

Enquiries
Office of the Environmental Protection Authority
Locked Bag 10, East Perth WA 6892
Telephone: 6145 0800
Fax: 6145 0895
Email: info@epa.wa.gov.au
Website: www.epa.wa.gov.au

[1] Please note that this form consolidates and replaces the following forms: *Referral of a Proposal by the Proponent to the EPA under section 38(1) of the EP Act*; *Referral of a Proposal by a third party to the EPA under section 38(1) of the EP Act*; and *Referral of a development proposal to the EPA by the decision making authority*.

Referral requirements and Declaration

The following section outlines the referral information required from a proponent, decision making authority and third party.

(a) Proponents

Proponents are expected to complete all sections of the form and provide GIS spatial data to enable the EPA to consider the referral. Spatial GIS data is necessary to inform the EPA's decision.

The EPA expects that a proponent will address Part B of the form as thoroughly as possible to demonstrate whether or not the EPA's objectives for environmental factors can be met.

If insufficient information is provided the EPA will request more information and processing of the referral will commence once the information is provided or the EPA decides to make a precautionary determination on the available information.

Proponent to complete before submitting form	
Completed all the questions in Part A (essential)	☒ Yes ☐ No
Completed all the questions in Part B	☒ Yes ☐ No
Completed all other applicable questions	☒ Yes ☐ No
Included Attachment 1 – any additional document(s) the proponent wishes to provide	☒ Yes ☐ No
Included Attachment 2 – confidential information (if applicable)	☐ Yes ☒ No
Enclosed an electronic copy of all referral information, including spatial data and contextual mapping but clearly separating any confidential information	☒ Yes ☐ No
Completed the Declaration	☒ Yes ☐ No
What is the type of proposal being referred? ** a referred proposal seeking to be declared a derived proposal*	☒ significant ☐ strategic ☐ derived* ☐ under an assessed scheme
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☒ No
If yes, what level of assessment? *API = Assessment of Proponent Information* *PER = Public Environmental Review*	☐ API Category A ☐ API Category B ☐ PER

NB: The EPA may apply an Assessment on Proponent Information (API) level of assessment when the proponent has provided sufficient information about:

- the proposal;
- the proposed environmental impacts;
- the proposed management of the environmental impacts; and
- when the proposal is consistent with API criteria outlined in the *Environmental Impact Assessment (Part IV Division 1 and 2) Administrative Procedures 2012*.

If an API A formal level of assessment is considered appropriate, please refer to Environmental Assessment Guideline No. 14 *Preparation for an Assessment on Proponent Information (Category A) Environmental Review Document EAG 14* (EAG14).

Declaration

I, JONATHON CLEMENTS, *(full name)* declare that I am authorised on behalf of IB OPERATIONS PTY LTD (being the person responsible for the proposal) to submit this form and further declare that the information contained in this form is true and not misleading.

Signature	J Clements	Name (print)	JONATHON CLEMENTS		
Position	SNR STUDY MANAGER	Organisation	FMG PTY LTD		
Email	jclement@fmgl.com.au				
Address	Street No. Level 2, 87	Street Name	ADELAIDE TCE		
	Suburb EAST PERTH		State W.A	Postcode 6004	
Date	17/9/15				

(b) Decision-making authority

The EPA expects decision-making authorities to complete applicable sections of Part A of the form and provide the proponent an opportunity to provide additional information in Part B of the form where appropriate.

Wherever possible the DMA should obtain relevant spatial information from the proponent and provide this to the EPA with the referral.

DMA to complete before submitting form	
Completed all the questions in Part A (essential)	☐ Yes ☐ No
Provided Part B to the proponent for completion	☐ Yes ☐ No
Completed all other applicable questions	☐ Yes ☐ No
Included Attachment 1 – any supporting information	☐ Yes ☐ No
Enclosed an electronic copy of all referral information, including spatial data and contextual mapping	☐ Yes ☐ No
Completed the below Declaration	☐ Yes ☐ No
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☐ No
What is the type of proposal being referred?	☐ significant proposal ☐ significant proposal under an assessed scheme

Declaration

I, ..., *(full name)* submit this referral to the EPA for consideration of the environmental significance of its impacts.

Signature		Name (print)		
Position		Organisation		
Email				
Address	Street No.	Street Name		
	Suburb		State	Postcode
Date				

(c) Third Party

Third parties are asked to have consideration for the Significance Test outlined in Part A Section 1.5 of this form before referring a significant proposal to the EPA. The EPA will only consider proposals that are likely, if implemented, to have a significant effect on the environment.

Third parties are to provide sufficient information to clearly identify the significant proposal, the proponent, and their reasons for referring the proposal. This can be done by completing as much of Part A of the form as possible, taking into consideration the information available. Third parties may wish to fill in Part B of the form to advance their own views of the significance of the environmental impacts and the need for EPA assessment.

In most cases the EPA will seek additional information from the proponent. This will be to confirm or amend the identity of the proponent, the proposal, and to allow the proponent opportunity to provide its views on the significance of the environmental impacts and the need for EPA assessment.

Third Party to complete before submitting form	
Complete all applicable questions in Part A and B	☐ Yes ☐ No
Completed the Declaration	☐ Yes ☐ No
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☐ No

Declaration

I, ……………………………………………………, *(full name)* submit this referral to the EPA for consideration of the environmental significance of its impacts.

Signature		Name (print)			
Email					
Position		Organisation			
Address	Street No.	Street Name			
	Suburb		State	Postcode	
Date					

PART A: Information on the proposal and the proponent

All fields of Part A must be completed by the proponent and/or decision-making authority for this document to be processed as a referral. Third party referrers are only expected to fill in the fields they have information for.

1 PROPONENT AND PROPOSAL DESCRIPTION

1.1 The proponent of the proposal

Proponent and/or DMA to complete	
Name of the proponent	IB Operations Pty Ltd
Joint Venture parties (if applicable)	
Australian Company Number(s)	165 513 557
Postal Address *(Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State)*	PO Box 6915 EAST PERTH WA 6892
Key proponent contact for the proposal *Please include: name; physical address; phone; and email.*	Sean McGunnigle Level 2, 87 Adelaide Terrace EAST PERTH WA 6004 Ph: 6218 8888
Consultant for the proposal (if applicable) *Please include: name; physical address; phone; and email.*	Andrew Winzer Level 2, 87 Adelaide Terrace EAST PERTH WA 6004 Ph: 6218 8888

1.2 Proposal

Proposal is defined under the EP Act to mean a "project, plan, programme policy, operation, undertaking or development or change of land use, or amendment of any of the foregoing, but does not include scheme". Before completing this section please refer to Environmental Protection Bulletin 17 – Strategic and derived proposals (EPB 17) and Environmental Assessment Guideline for Defining the Key Characteristics of a proposal (EAG 1).

Proponent and/or DMA to complete	
Title of the proposal	Iron Bridge Port Facility
What project phase is the proposal at?	☐ Scoping ☒ Feasibility ☐ Detailed design ☐ Other ______________
Proposal type *More than one proposal type can be identified, however for filtering purposes it is recommended that only the primary proposal type is identified.*	☐ **Power/Energy Generation** ☐ Hydrocarbon Based – coal ☐ Hydrocarbon Based – gas ☐ Waste to energy ☐ Renewable – wind ☐ Renewable – wave ☐ Renewable – solar ☐ Renewable – geothermal

Proponent and/or DMA to complete	
	☐ **Mineral / Resource Extraction** ☐ Exploration – seismic ☐ Exploration – geotechnical ☐ Development ☐ **Oil and Gas Development** ☐ Exploration ☐ Onshore – seismic ☐ Onshore – geotechnical ☐ Onshore – development ☐ Offshore – seismic ☐ Offshore – geotechnical ☐ Offshore – development ☐ **Industrial Development** ☐ Processing ☐ Manufacturing ☐ Beneficiation ☐ **Land Use and Development** ☐ Residential – subdivision ☐ Residential – development ☐ Commercial – subdivision ☐ Commercial – development ☐ Industrial – subdivision ☐ Industrial – development ☐ Agricultural – subdivision ☐ Agricultural – development ☐ Tourism ☐ **Linear Infrastructure** ☐ Rail ☐ Road ☐ Power Transmission ☐ Water Distribution ☐ Gas Distribution ☐ Pipelines ☐ **Water Resource Development** ☐ Desalination ☐ Surface or Groundwater ☐ Drainage ☐ Pipelines ☐ Managed Aquifer Recharge ☐ **Marine Developments** ☒ Port ☐ Jetties ☐ Marina ☐ Canal ☐ Aquaculture

Proponent and/or DMA to complete	
	☐ Dredging *If other, please state below:* ☐ **Other** ______________

Proponent and/or DMA to complete	
Description of the proposal – describe the key characteristics of the proposal in accordance with EAG 1.	The Iron Bridge Port Facility (the Facility) will provide the capacity to stockpile and outload up to 10.1 mtpa (Million tonnes per annum) of magnetite concentrate produced by the North Star Magnetite Mine. The Facility will include a concentrate dewatering plant and a stockyard for storing of magnetite concentrate prior to export. These components are located on undeveloped land within Fortescue Metals Group Ltd's (Fortescue) Anderson Point lease area. **Slurry Pipeline** Magnetite concentrate is delivered to the Facility via a slurry pipeline from the North Star Magnetite Mine. **Diversion Pond** A Concentrate Diversion Pond will be located east of the Port entrance and will provide holding capacity for contents of the slurry pipeline in the event of prolonged failure of the Dewatering Plant or shutdowns. **Dewatering Plant** The Dewatering Plant extracts water from the North Star Magnetite concentrate slurry. The Dewatering Plant is capable of handling 1,540 tonnes per hour. Dewatered concentrate is delivered to the stockyard stacker via a conveyor. **Stockyard** The stockyard is a shed-covered stockpile with stacking and reclaiming facilities. The stacking circuit stacks from a travelling tripper conveyor supported from the roof of the shed. The concentrate is reclaimed by a rail-mounted bucket-wheel reclaimer for delivery to Fortescue's outload circuit. The Reclaim circuit is capable of reclaiming 10,000 tonnes per hour.

Proponent and/or DMA to complete	
	The covered stockpile is capable of storing up to 300,000 tonnes of magnetite concentrate. **Fortescue's outload circuit is not subject to this proposal.** **Return Water Pipeline** This excess water from the Dewatering Plant is returned to the North Star Mine Site via a dedicated return water pipeline. The Facility will occupy approximately 10.2 ha of land, of which 10.15 ha will be required to be cleared of native vegetation. Of this, 2.01 ha will require removal of mangrove vegetation. Key Characteristics Table (Table 1) on page 16 of Supporting Documentation.
Timeframe in which the proposal is to occur (including start and finish dates where applicable).	Site development works – April 2016 Construction – October 2016 Commissioning – August 2017
Details of any staging of the proposal.	There is no staging of the proposal.
What is the current land use on the property, and the extent (area in hectares) of the property?	The Iron Bridge Port Facility is located adjacent to Fortescue Metals Group Ltd's Anderson Point Port Precinct.
Have pre-referral discussions taken place with the OEPA? If yes, please provide the case number. If a case number was not provided, please state the date of the meeting and names of attendees.	Yes 26 February 2015 27 May 2015 31 July 2015 Attendees: Mike Pengelly, Hans Jacob
DMA (Responsible Authority) to complete	
For a proposal under an assessed scheme (as defined in section 3 of the EP Act, applicable only to the proponent and DMA) provide details (in an attachment) as to whether: • *The environmental issues raised by the proposal were assessed in any assessment of the assessed scheme.* • *The proposal complies with the assessed scheme and any environmental conditions in the assessed scheme.*	

1.3 Strategic / derived proposals

Complete this section if the proposal being referred is a strategic proposal or you are seeking the proposal to be declared a derived proposal. Note: Only a proponent may refer a strategic proposal and seek a proposal to be declared a derived proposal.

Proponent to complete	
Is this referred proposal a strategic proposal?	☐ Yes ☒ No
Are you seeking that this proposal be declared a derived proposal?	☐ Yes ☒ No
If you are seeking that this proposal be declared a derived proposal, what is the Ministerial Statement number (MS #) of the associated strategic proposal?	MS #: ______________

1.4 Location

Proponents and DMAs must provide spatial data. Please refer to EAG 1 for more detail.

Proponent, DMA and Third Party to complete	
Name of the Local Government Authority in which the proposal is located.	Town of Port Hedland
Location: a) street address; lot number; suburb; and nearest road intersection; or b) if remote the nearest town; and distance and direction from that town to the proposal site.	Port Hedland Port Precinct – Anderson Point
Have maps and figures been included with the referral (consistent with EAG 1 where appropriate)? *The types of maps and figures which need to be provided (depending on the nature of the proposal) include:* • *maps showing the regional location and context of the proposal; and* • *figures illustrating the proposal elements.*	☒ Yes ☐ No
Proponent and DMA to complete	
Have electronic copies of spatial data been included with the referral? ***NB:*** *Electronic spatial (GIS or CAD) data, geo-referenced and conforming to the following parameters:* • *GIS: polygons representing all activities and named;* • *CAD: simple closed polygons representing all activities and named;* • *datum: GDA94;* • *projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA);* • *format: ESRI geodatabase or shapefile, MapInfo Interchange Format, Microstation or AutoCAD..*	☒ Yes ☐ No

1.5 Significance test and environmental factors

Proponent, DMA and Third Party to complete	
What are the likely significant environmental factors for this proposal?	☒ Benthic Communities and Habitat ☒ Coastal Processes ☐ Marine Environmental Quality ☐ Marine Fauna ☐ Flora and Vegetation ☐ Landforms ☐ Subterranean Fauna ☐ Terrestrial Environmental Quality ☐ Terrestrial Fauna ☐ Hydrological Processes ☐ Inland Waters Environmental Quality ☒ Air Quality & Atmospheric Gases ☒ Amenity ☐ Heritage ☐ Human Health ☒ Offsets ☐ Rehabilitation and Decommissioning
Having regard to the Significance Test (refer to Section 7 of the *EIA Administrative Procedures 2012*) in what ways do you consider the proposal may have a significant effect on the environment and warrant referral to the EPA?	IB Operations Pty Ltd consider that the impact to the environment is not significant enough to warrant formal assessment.

1.6 Confidential information

All information will be made publically available unless authorised for exemption under the EP Act or subject to the Freedom of Information Act 1992.

Proponent to complete	
Does the proponent request that the EPA treat any part of the referral information as confidential? *Ensure all confidential information is provided in a separate attachment in hard copy.*	☐ Yes ☒ No

2 REGULATORY CONSIDERATIONS

This section applies to the Local, State and Commonwealth regulatory considerations for the referred proposal.

2.1 Government approvals

2.1.1 State or Local Government approvals

DMA to complete	
What approval(s) is (are) required from you as a decision-making authority?	
Is rezoning of any land required before the proposal can be implemented? If yes, please provide details.	☐ Yes ☐ No

2.1.2 Regulation of aspects of the proposal

Complete the following to the extent possible.

Proponent to complete	
Do you have legal access required for the implementation of all aspects of the proposal? *If yes, provide details of legal access authorisations / agreements / tenure.* *If no, what authorisations / agreements / tenure is required and from whom?*	☒ Yes ☐ No An agreement has been reached between IB Operations Pty Ltd and The Pilbara Infrastructure, the leaseholder and owner of the existing infrastructure at Anderson Point.

Outline both the existing approvals and approvals that will be / are being sought as a part of this proposal.

Proponent to complete			
Aspects* of the proposal	Type of approval	Legislation regulating this activity	Which State agency /entity regulate this activity?
Dewatering and Stockpile of magnetite concentrate	Works Approval and Licence	EP Act 1986 – Part V	DER
Export of up to 10.1 mtpa of magnetite concentrate	Licence Amendment	EP Act 1986 – Part V	DER
Clearing	Native Vegetation Clearing Permit	EP Act 1986 – Part V	DER

**e.g. mining, processing, dredging*

2.1.3 Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* approvals

Refer to the assessment bilateral agreement between the Commonwealth of Australia and the State of Western Australia for assistance on this section.

Proponent to complete	
1. Does the proposal involve an action that may be or is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)?	☐ Yes ☒ No *If no continue to Part A section 2.1.4.*
2. What is the status of the decision on whether or not the action is a controlled action?	☐ Proposal not yet referred ☒ Proposal referred, awaiting decision (referred in parallel) ☐ Assessed – controlled action ☐ Assessed – not a controlled action
3. If the action has been referred, when was it referred and what is the reference number (Ref #)?	Date: ___NA_____ Ref #: _____*NA*____
4. If the action has been assessed, provide the decision in an attachment. Has an attachment been provided?	☐ Yes ☐ No
5. Do you request this proposal to be assessed under the bilateral agreement?	☐ Yes ☒ No

Complete the following to the extent possible for the Public Comment of EPBC Act referral documentation.

Proponent to complete	
6. Have you invited the public to comment on your referral documentation?	☐ Yes ☒ No
7. How was the invitation published?	☐ newspaper ☐ website
8. Did the invitation include all of the following?	
(a) brief description of the action	☐ Yes ☐ No
(b) the name of the action	☐ Yes ☐ No
(c) the name of the proponent	☐ Yes ☐ No
(d) the location of the action	☐ Yes ☐ No
(e) the matters of national environmental significance that will be or are likely to be significantly impacted	☐ Yes ☐ No
(f) how the relevant documents may be obtained	☐ Yes ☐ No

Proponent to complete	
(g) the deadline for public comments	☐ Yes ☐ No
(h) available for public comment for 14 calendar days	☐ Yes ☐ No
(i) the likely impacts on matters of national environmental significance	☐ Yes ☐ No
(j) any feasible alternatives to the proposed action	☐ Yes ☐ No
(k) possible mitigation measures	☐ Yes ☐ No
9. Were any submissions received during the public comment period?	☐ Yes ☐ No
10. Have public submissions been addressed? If yes provide attachment.	☐ Yes ☐ No

2.1.4 Other Commonwealth Government Approvals

Proponent, DMA and Third Party to complete			
Is approval required from other Commonwealth Government/s for any part of the proposal?		☐ Yes ☒ No *If yes, please complete the table below.*	
Agency / Authority	Approval required	Application lodged?	Agency / Local Authority contact(s) for proposal
		☐ Yes ☐ No	
		☐ Yes ☐ No	

3. SUPPORTING INFORMATION

Please attach copies of any relevant information on the proposal, supporting evidence and / or existing environmental surveys, studies or monitoring information undertaken and list the documents below.

Proponent, DMA and Third Party to complete			
(1)	Iron Bridge Port Facility – Referral Supporting Document	Andrew Winzer	Additional information regarding the proposal and its impact to the environment. Also includes all appendices and figures.

PART B: ENVIRONMENTAL FACTORS

The purpose of Part B is to assist the EPA to determine the significance of the likely environmental impacts of the proposal in accordance with the EPA's *Environmental Assessment Guideline for Environmental factors and objectives* (EAG 8) and *Environmental Assessment Guideline for Application of a significant framework in the EIA process* (EAG 9). Referrers completing Part B should refer closely to EAG 8 and EAG 9.

The EPA has prepared *Referral of a Proposal under s38 of the EP Act EAG No.16 - Appendix A* (Appendix A) to assist in identifying factors and completing the below table. Further guidance can be found in the guidance and policy documents cited in Appendix A under each factor.

How to complete Part B
For each environmental factor, that is likely to be significantly impacted by the implementation of the proposal, make a copy of the table below and insert a summary of the relevant information relating to the proposal. The table can be broken down into more than one table per factor, if the need arises. For example the hydrological processes factor can be presented in two separate tables, one for surface water and one for groundwater, or similarly one for construction and one for operations.

For complex proposals a supplementary referral report can be provided in addition to the referral form. If this option is chosen the table must still be completed (summaries are acceptable) to assist the Office of the EPA with statistical reporting and filtering proposals for processing.

Proponents expecting an API level of assessment must provide information in accordance with the EPA's *Environmental Assessment Guideline for Preparation of an API-A environmental review document* (EAG 14).

For each of the significant environmental factors, complete the following table (Questions 1 – 10).

PLEASE REFER TO ATTACHED SUPPORTING DOCUMENTATION FOR DISCUSSION OF SIGNIFICANT ENVIRONMENTAL FACTORS

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in EAG 8*	Benthic Communities and Habitat
2	EPA Objective, *as defined in EAG 8*	*To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.*
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	EPA Assessment Guideline No. 3 Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA, 2009).

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	Consultation with Port Hedland Port Authority, Office of the Environmental Protection Authority, Department of Environment Regulation, Department of State Development, Department of the Environment (Cwlth) Care for Hedland. Details of consultation provided in supporting documentation.
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See supporting documentation.
6	Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.	See supporting documentation
7	Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed: • *Avoidance - avoiding the adverse environmental impact altogether;* • *Minimisation - limiting the degree or magnitude of the adverse impact;* • *Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and* • *Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.*	See supporting documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
8	Residual impacts – review the residual impacts against the EPA objectives. *It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:* • *quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;* • *putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and* • *comparison against any established environmental policies, guidelines, and standards.*	See supporting documentation
9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to* *EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See supporting documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in* [EAG 8]	Coastal Processes
2	EPA Objective, *as defined in* [EAG 8]	*To maintain the morphology of the sub-tidal, intertidal and supra-tidal zones and the local geophysical processes that shape them*
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	Department of Planning's State Coastal Planning Policy No. 2.6
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	Consultation with Port Hedland Port Authority, Office of the Environmental Protection Authority, Department of Environment Regulation, Department of State Development Care for Hedland. Details of consultation provided in supporting documentation.
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See supporting documentation
6	Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.	See supporting documentation
7	Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed: • *Avoidance - avoiding the adverse environmental impact altogether;* • *Minimisation - limiting the degree or magnitude of the adverse impact;* • *Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and* • *Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.*	See supporting documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
8	Residual impacts – review the residual impacts against the EPA objectives. *It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:* • *quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;* • *putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and* • *comparison against any established environmental policies, guidelines, and standards.*	See supporting documentation
9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See supporting documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in* EAG 8	Air Quality and Atmospheric Gases
2	EPA Objective, *as defined in* EAG 8	*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.*
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	Environmental Protection Bulletin No. 2 – Port Hedland Dust and Noise (EPA, 2009)
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	Consultation with Port Hedland Port Authority, Office of the Environmental Protection Authority, Department of Environment Regulation, Department of State Development Care for Hedland. Details of consultation provided in supporting documentation.
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See Supporting Documentation
6	Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.	See Supporting Documentation
7	Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed: • *Avoidance - avoiding the adverse environmental impact altogether;* • *Minimisation - limiting the degree or magnitude of the adverse impact;* • *Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and* • *Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.*	See Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
8	Residual impacts – review the residual impacts against the EPA objectives. *It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:* • *quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;* • *putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and* • *comparison against any established environmental policies, guidelines, and standards.*	See Supporting Documentation
9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in* *EAG 8*	Amenity (Noise)
2	EPA Objective, *as defined in* *EAG 8*	*To ensure that impacts to amenity are reduced as low as reasonably practicable*
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	Environmental Protection (Noise) Regulations 1997: Gazetted to present a fair and effective set of rules to govern noise emissions. The regulations are the 'prescribed standard' under the EP Act. State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning. EAG13: EPA Considerations of environmental impacts from noise (EPA, 2004): *Where noise emissions likely to be caused by the implementation of a proposal are regulated by the noise regulations or dealt with in SPP 5.4, the EPA expects proponents to use best practice design and noise management and to demonstrate how the proposal will be implemented to achieve compliance with the se statutory and policy instruments.* Port Hedland Air Quality and Noise Management Plan (DSD, 2010)

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	Consultation with Port Hedland Port Authority, Office of the Environmental Protection Authority, Department of Environment Regulation, Department of State Development Care for Hedland. Details of consultation provided in supporting documentation.
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See Supporting Documentation
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9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in EAG 8*	Offsets
2	EPA Objective, *as defined in EAG 8*	*To counterbalance any significant residual environment impacts or uncertainty through the application of offsets*
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	WA Environmental Offsets Policy Environmental Protection Bulletin No. 1 WA Environmental Offsets Guideline
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	Consultation with Port Hedland Port Authority, Office of the Environmental Protection Authority, Department of Environment Regulation, Department of State Development Care for Hedland. Details of consultation provided in supporting documentation.
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See Supporting Documentation
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Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
8	Describe any assumptions critical to your conclusion (in Question 9). e.g. particular mitigation measures or regulatory conditions.	See Supporting Documentation

In circumstances where there was some uncertainty on the level of significance of a particular factor it is recommended that a brief summary (no longer than 1 - 2 paragraphs) is provided on the steps taken to determine why a factor was not considered to be significant.

Iron Bridge

Iron Bridge Port Facility – Referral Supporting Document

September 2015

662PO-0000-RP-EN-0001

	Iron Bridge Port Facility – Part IV Referral Supporting Documentation		**662PO-0000-RP-EN-0001**
Revision Number	**0**		
Status	**IFU - ISSUED FOR USE**		
Author	Matt Dowling, Andrew Winzer	Signature	
Checked	Clayton Brandwood	Signature	
Checked	Ken Wilyman	Signature	
Approved	Simon Carter	Signature	17/9/15
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**NA**		

	Iron Bridge Port Facility – Part IV Referral Supporting Documentation		**662PO-0000-RP-EN-0001**
Revision Number	**0**		
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Author	Matt Dowling, Andrew Winzer	Signature	
Checked	Clayton Brandwood	Signature	
Checked	Ken Wilyman	Signature	
Approved	Simon Carter	Signature	
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**NA**		

EXECUTIVE SUMMARY

IB Operations Pty Ltd proposes to construct the Iron Bridge Port Facility (IB Port Facility) adjacent to Fortescue Metals Group Ltd's Herb Elliott Port Precinct (Herb Elliott Port), located within the Port Hedland Inner Harbour in the Pilbara Region of Western Australia. IB Operations Pty Ltd is the managing entity for the Iron Bridge Joint Venture, a joint venture partnership between FMG Iron Bridge Pty Ltd and Formosa Steel IB Pty Ltd. IB Operations Pty Ltd is the proponent for this Proposal.

The IB Port Facility will accept magnetite concentrate as a slurry from the North Star Mine, located approximately 110km south of Port Hedland. Upon arrival at the IB Port Facility, the concentrate slurry will be dewatered with the excess water returned back to the North Star Mine or used for operational purposes within the IB Port Facility or the Herb Elliott Port. The North Star Mine is also part of the Iron Bridge Joint Venture, but is not subject to this referral.

The dewatered magnetite concentrate will then be stacked within a covered stockpile until a suitable volume has been received for export. Magnetite concentrate will then be reclaimed from the stockpile and loaded into bulk carrier ships for export via Fortescue Metals Group Ltd's outload circuit. This 'outload circuit', consisting of Herb Elliott Port infrastructure i.e. causeway conveyor, transfer stations, wharf and shiploader does not form part of this Proposal.

This document describes IB Operations Pty Ltd's proposal and provides an assessment of the proposal against key preliminary environmental factors, identified through previous discussions with the Office of the Environmental Protection Authority. These factors are:

- Benthic Primary Producer Habitat (BPPH);
- Coastal Processes;
- Air Quality (Dust);
- Amenity (Noise); and
- Offsets (for loss of BPPH).

IB Operations Pty Ltd have undertaken a range of desktop modelling studies to support the assessment of the environmental impact of the proposal on these environmental factors. The outcomes of these studies are presented in Section 5 of this document. Section 5 of this document also demonstrates the management strategies that will be adopted during the operation of the IB Port Facility to ensure impacts are either avoided, minimised or mitigated to as low as reasonably practicable. A summary of the impact of the proposal on Matters of National Environmental Significance are presented in Section 6.

IB Operations Pty Ltd is confident that the Proposal can be implemented to meet the EPA's objectives.

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1. INTRODUCTION

IB Operations Pty Ltd (IBO) proposes to develop the Iron Bridge Port Facility (the IB Port Facility), located in the Port Hedland Port Precinct, in the Pilbara Region of Western Australia. The IB Port Facility will accept magnetite concentrate slurry from the North Star Magnetite Mine, located approximately 110 km South of Port Hedland, whereupon it will be dewatered and stockpiled prior to export.

This document has been prepared as supporting information for formal referral of the Proposal to the Western Australian Environmental Protection Authority (EPA) in accordance with Section 38 of the *Environmental Protection Act 1986* (EP Act) and the Commonwealth Department of Environment in accordance with the *Environmental Protection Biodiversity and Conservation Act 1999* (EPBC Act).

1.1 Purpose of this Document

This document presents supporting information to accompany the referral of the Proposal to the EPA. This document presents a description of the key components of the Proposal and an assessment of the environmental impacts of the proposal in accordance with Environmental Assessment Guideline 14, published by the EPA.

1.2 Proponent

The proponent for the Iron Bridge Port Facility is IB Operations Pty Ltd (IBO). IBO is a joint venture company between FMG Iron Bridge Pty Ltd and Formosa Steel IB Pty Ltd. Under the Joint Venture agreement, IBO is the managing entity for the Iron Bridge Joint Venture.

IB Operations Pty Ltd is located in East Perth, Western Australia:

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Simon Carter
Director, Iron Bridge Operations

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1.3 Proposal Location

The IB Port Facility is located within Fortescue Metals Group Ltd's (Fortescue) Herb Elliott Port Precinct (Herb Elliott Port) at Anderson Point, located within the Town of Port Hedland in the Pilbara Region of Western Australia. The location of all infrastructure associated with the Port Facility is depicted in Figure 1. Anderson Point is approximately 1.7 km south of the western end of Port Hedland.

1.4 Assessment Approach

The preliminary key environmental factors associated with this proposal are summarised in Section 5.1. These factors are identified as a result of IBO's understanding of the existing environment, the potential impacts posed by the Proposal and through discussions with the OEPA.

IBO has undertaken a suite of environmental studies in order to fully understand the receiving environment and the impacts associated with the proposal. These studies include a Benthic Primary Producer Habitat Survey and Impact Assessment, Hydrodynamic Modelling and Impact Assessment, Sediment Transport Impact Assessment, Surface Water Impact Assessment, Dust Emissions Source Characterisation Study, Dust Modelling and Noise Modelling.

These studies and all other available data provide a high level of certainty regarding the key environmental factors and the level of impact posed by the Proposal on the environment. This document outlines these factors, discusses the potential impacts, assesses the impact to the environment as a result of the proposal and outlines management measures to be adopted to reduce the level of these impacts such that the Proposal will meet the EPA's objectives.

The Port Hedland Harbour has been extensively studied as a result of the numerous developments that have occurred there, particularly in the last 5 years. Projects that have been formally assessed by the EPA in recent years include:

- Stage A Port and North-South Rail (Fortescue Metals Group)
- Harriett Point RGP5 (BHP Billiton Iron Ore)
- Nelson Point RGP6 (BHP Billiton Iron Ore)
- Third Berth and Associated Infrastructure (Fortescue Metals Group)
- South West Creek Dredging and Reclamation (Port Hedland Port Authority)
- Outer Harbour Development (BHP Billiton Iron Ore)

- Lumsden Point General Cargo Facility (Pilbara Ports Authority)
- Roy Hill Iron Ore – Port Infrastructure
- Utah Point Berth Project (Pilbara Ports Authority)

The environmental data available from these and other 'not assessed' projects allows for a much greater understanding of the environmental impacts associated with developments in the Port precinct. Furthermore, the management and mitigation measures implemented for these projects and their effectiveness at reducing environmental impacts are well documented.

1.5 Alternative Options Considered

IBO has considered a number of alternatives for location of infrastructure associated with the IB Port Facility to minimise disturbance to the environment without interrupting current Herb Elliott Port operations.

Alternative options were evaluated against a number of broad criteria including environmental impacts, conflicting land uses with Fortescue and other parties, ability to complement and support adjacent logistics and safety.

The alternative options considered as part of this proposal are summarised below:

Option A: The IB Port Facility is located to the west of the causeway to Australia Island. This option would result in approximately 6 hectares (ha) of disturbance to mangroves and require large volumes of fill material. This location is within the Department of State Development's (DSD) Strategic Infrastructure Corridor for the Boodarie Strategic Industrial Area (BSIA) and therefore is not supported by the State.

Option B: The IB Port facility is located to the east of the Herb Elliott Port stockyards. This option takes advantage of an area of land to the east of the Herb Elliott Port infrastructure that does not support mangrove vegetation. This option requires large amounts of fill and extensive lengths of conveyors. This option also requires additional transfer points and dust management has the potential to be an ongoing concern. Option B, when considering the Port Hedland Port Authority's Best Practice Guidelines for dust management does not provide an efficient approach to management of dust.

Option C: This option uses an area within the Herb Elliott Port stockyards and undeveloped land to the east. Option C requires three separate crossings of existing infrastructure at Herb Elliott Port, significantly increasing safety risks for the existing operations. In addition, Option C is spatially constrained with regards to the covered stockpile layout and is also subject to extensive lengths of conveyors, with the attendant dust issues highlighted in Option B.

Option D: This option uses previously disturbed land to the east of the Herb Elliott Port stockyards. This option would result in the least disturbance to mangroves, however the footprint is within the BSIA infrastructure corridor mentioned above highlighted in Option A. The State will not support this option.

Option E: This option is located to the east of the causeway to Australia Island. This location results in some minor disturbance to mangrove communities, but integrates with existing materials handling infrastructure and does not interfere with future DSD plans for infrastructure associated with the BSIA. This option also provides an efficient approach for dust management with conveyor lengths and numbers of transfer stations minimised. Option E has therefore been selected as the preferred option for development.

All Port Facility options considered are depicted in Figure 2.

1.5.1 No Development Option

Whilst no development would result in no environmental disturbance in this location, the Iron Bridge Joint Venture still requires access to a Port Facility in order to deliver its product to its customers. The relatively small amount of disturbance associated with this Proposal, in an area that is already highly disturbed from existing operations and managed specifically for the purpose of export of iron ore, is considered to have far less environmental impact than a potential greenfields Port project, which would also result in significant amounts of dredging to provide navigation channels, turning circles and berth pockets.

1.6 Applicable Legislation and Guidelines

The following section provides a brief legislative context for the IB Port Facility and a summary of associated environmental approvals. Key environmental legislation and regulations relevant to this Project are described below.

1.6.1 *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* (WA) (EP Act) is the primary legislation that governs environmental impact assessment and protection in Western Australia. Part IV of the EP Act requires proposals that have a significant impact on the environment to be subject to formal environmental impact assessment. IBO is referring the Proposal to the EPA under Section 38(1) of the EP Act to determine whether a formal assessment is required. Consultation with the OEPA to date suggests the proposal will not require assessment and a Part V clearing permit will need to be sought by IBO.

Part V of the EP Act regulates the clearing of native vegetation and pollution caused by emissions and discharges from prescribed premises. IBO will submit Works Approvals and

Licence applications to the Department of Environment Regulation for the proposed infrastructure where required.

1.6.2 *Environment Protection and Biodiversity Conservation Act 1999*

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides for the protection of nationally and internationally important flora, fauna, ecological communities and heritage places; defined as Matters of National Environmental Significance (MNES).

Under the EPBC Act, a proposal or action which will, or is likely to, have a significant impact on a MNES is required to be referred to the Department of Environment (DoE) for a decision as to whether the proposal constitutes a controlled action. If the Proposal is deemed a controlled action, implementation will consequently be subject to an assessment from the Federal Minister for Environment. IBO does not consider that the Proposal is likely to have a significant impact on Matters of National Environmental Significance, but will refer the Proposal to the Department of Environment for legislative certainty.

1.6.3 *Rights in Water and Irrigation Act 1914*

The *Rights in Water and Irrigation Act 1914* (RIWI Act) (WA) is the primary legislation under which the Department of Water (DoW) manages and allocates terrestrial water resources in Western Australia. Water for construction purposes will be met through Fortescue's existing Section 5C licence for the Port.

1.6.4 Dust Management Guidelines in Port Hedland

Guidance on the assessment and management of air quality include:

- Environmental Protection Bulletin No. 2: Port Hedland Dust and Noise
- National Environment Protection (Ambient Air Quality) Measure (NEPM).
- Air Quality and Air Pollution Modelling Guidance Notes (DoE, 2006)
- A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities (DEC, 2011).

These best practice guidelines are an integral reference for all new developments at Port Hedland and include leading practice examples for the main activities leading to the generation of dust: unloading, stacking, stockpiles, reclaiming, conveyors and transfers, and ship loading.

Dust has the potential to impact on both human health and amenity. Particulate matter of 10 microns (μm) in aerodynamic diameter (PM_{10}) or smaller can penetrate the lungs and enter the bloodstream. Exposure to these small particulates has the potential to exacerbate respiratory problems, particularly in young children and older adults (DSD, 2010).

The *National Environment Protection (Ambient Air Quality) Measure* (Ambient Air NEPM), sets uniform standards and goals for six 'criteria' pollutants (including PM_{10} particles) in ambient air. The standard for PM_{10} set in the Ambient Air NEPM is 50 µg/m^3 (24 hour average) with a target of five exceedances per year (NEPC, 1998).

The Ambient Air NEPM applies to urban areas with populations greater than 25,000. The Chamber of Minerals and Energy (CME) has submitted a response to the review of the existing AAQ NEPM suggesting that it should not be used as a regulatory instrument in regional, industrial towns.

In 2009 the Port Hedland Dust Management Taskforce (PHDMT) was established. The taskforce, which reports to the Premier, includes representatives from the following:

- the Town of Port Hedland;
- Pilbara Ports Authority (PPA);
- iron ore exporters (including BHPBIO, Fortescue, Roy Hill Infrastructure); and
- relevant Government departments (including the Department of Health, Department of Planning and the Department of Environment Regulation).

In 2010, the PHDMT published the *Port Hedland Air Quality and Noise Management Plan* (DSD, 2010) to enable a framework for effective dust management strategies within Port Hedland. The taskforce made a number of recommendations which have been addressed:

- Establishment of a comprehensive network of air quality measuring devices throughout the Port Hedland area, including South Hedland;
- Adoption of an interim air quality guideline measure for the national standard for PM_{10};
- Development of leading practice dust management guidelines; and
- Undertaking of a Health Risk Assessment (HRA) which will investigate potential health risks from particulate matter and address concerns about air quality and its possible effect on community health following the increased level of port activity.

The PHDMT commissioned a series of studies that considered the application of the national PM_{10} standard to Port Hedland. Expert toxicologists confirmed the national standard for PM_{10} was designed for an urban setting and considered that a departure from the Air NEPM may be justified for Port Hedland as the particulate matter is composed of crustal iron ore dust (other health studies have focused on fine material or organic compounds in an urban setting). The taskforce recommended the adoption of an interim standard for air quality at Port Hedland for PM_{10} of 70 µg/m^3 (24 hour average) with 10 exceedances per year (as determined at the Taplin Street monitoring station) (DSD, 2010). The PHDMT agreed that this measure sets an appropriate level of protection for the community whilst requiring industry to adopt current best practice techniques and operate on a continuous improvement basis (DSD, 2010). This standard has since been adopted as the appropriate criteria for air quality management in Port Hedland (DSD, 2010).

A guidance document applicable to this Proposal is the *Pilbara Ports Authority Dust Management Guidelines: Leading Practice DOC-EH009* (PPA, 2015). The Leading Practice Guideline is based on a review of national and international best practices for the management of dust in bulk materials handling processes for the main activities leading to the generation of dust: unloading, stacking, stockpiles, reclaiming, conveyors and transfers, and ship loading (see Section 5, Table 8 for discussion on air quality).

2. PROJECT DESCRIPTION

2.1 Project Location and Existing Land Use

The site for the proposed IB Port Facility is located adjacent to Fortescue's existing Herb Elliott Port Facility. The proposed location for the IB Port Facility subject to this Proposal is shown in Plate 1. The bare saltmarsh area visible in the plate constitutes the majority of the disturbance.

Plate 1: Proposed Location for the Iron Bridge Port Facility

Fortescue own and operate, through its wholly owned subsidiary The Pilbara Infrastructure Pty Ltd (TPI), the Herb Elliott Port facilities at Anderson Point, within the Port Hedland Port precinct. A general arrangement of the Port Facility in relation to the existing infrastructure at the Herb Elliott Port Facility is shown in Figure 3.

2.2 Project Overview

The Iron Bridge Joint Venture requires access to Port facilities for the export of magnetite concentrate from its North Star Mine, located approximately 110 km south of Port Hedland.

Magnetite concentrate produced by the North Star Mine will be pumped as a slurry via a pipeline to the proposed IB Port Facility. Upon arrival at the IB Port Facility, the concentrate slurry will be dewatered and the filter cake stacked in a covered stockpile until sufficient material is available for export. The dewatered concentrate is then reclaimed and loaded onto vessels via Fortescue's outloading facilities for delivery to customers. The infrastructure required for the IB Port Facility is described in Section 2.3. The entire footprint of the IB Port Facility is 10.2 ha, of which 0.05 ha is already cleared. The infrastructure required for this Proposal will not disturb any marine environment. The key characteristics of the proposal are detailed in Section 2.2.1 below.

2.2.1 Key Characteristics

Table 1: Proposal Summary

Summary of Proposal	
Project Name	Iron Bridge Port Facility
Proponent Name	IB Operations Pty Ltd
Short Description	A facility to accept magnetite concentrate slurry from the North Star Mine, dewater the slurry and stockpile the concentrate in a covered stockpile prior to export. Excess water will be returned to North Star Mine. Magnetite will be reclaimed from the stockpile for export via Herb Elliott Port outload infrastructure.
Project Schedule	Approval to commence development and construction – April 2016 Construction April 2016 – August 2017 Load Commissioning – August 2017

Table 2: Physical Elements

Element	Location	Proposed Extent
Infrastructure Associated with the Port Facility	Figure 3	Up to 10.2 ha within a 10.2 ha Port Facility Envelope.

Table 3: Operational Elements

Element	Location	Proposed Extent
Slurry Pipeline	Figure 3	Approximately 1km on areas previously disturbed under Ministerial Statement 690.
Concentrate Diversion Pond	Figure 3	Located largely in an area previously disturbed, may disturb up to 0.63 ha of highly disturbed vegetation.
Dewatering Facility	Figure 3	Nominally 1,770 tonnes of slurry per hour.
Return Water Pipeline	Figure 3	5 GLpa returned to North Star Mine or used for operations within the Port Facility or Herb Elliott Port precinct.
Stacking Circuit	Figure 3	Nominally 3,540 tonnes of ore per hour
Stockpile	Figure 3	Nominally 300,000 tonnes of magnetite concentrate in a covered stockpile
Reclaim Circuit	Figure 3	Nominally 10,000 tonnes of ore per hour to extent of project boundary.

2.2.2 Exclusions

The IB Port Facility project boundary is depicted in Figure 2 (highlighted in pink). This referral does not include the Herb Elliott Port outload circuit. Any modifications that may need to be made to the outload circuit to enable it to handle the magnetite product can be managed through amendments to the existing Operating Licence (L8194/2007/3).

2.2.3 Relationship to Other Projects

North Star

The Iron Bridge Joint Venture Project is being implemented in two stages.

Stage 1 of the Project is the construction and operation of the North Star Hematite Project. This stage of the Project targets an oxide (mag-hematite) zone which overlies a larger magnetite ore body. Stage 1 is a 10 Mtpa iron ore mine producing 2 Mtpa of magnetite concentrate. Magnetite produced by the mine is dewatered on site and will be trucked to Port Hedland for export using the existing infrastructure at Herb Elliott Port. The Hematite Project was referred to the EPA in July 2012 and was not formally assessed. IBO has subsequently obtained secondary environmental approvals to allow for construction and operation of the mine. Stage 1 is currently fully constructed and is in the commissioning phase. The stockpile, handling and export of 2 Mtpa of magnetite concentrate at Herb Elliott Port is approved under Part V of the EP Act (W5749/2014/1). The export of the magnetite concentrate produced by Stage 1 of the

Project is not dependent on the construction of the IB Port Facility and is not subject to this referral.

Stage 2 of the Project is a larger, 30 Mtpa mine (the North Star Magnetite Project). This Project was referred to the EPA in October 2012 and formally assessed through a Public Environmental Review (Assessment No. 1947). The EPA released its report on the Magnetite Project (Report No. 1514) in June 2014 and the Minister released the Ministerial Statement (MS 993) on 9 January 2015.

The Magnetite Project was also assessed by the Commonwealth Department of the Environment under the EPBC Act (EPBC 2012/6689). The Federal Minister authorised the controlled action on 6 February 2015. It is the magnetite concentrate produced by the North Star Stage 2 Mine, delivered via its approved slurry pipeline that will be handled and stockpiled by the IB Port Facility subject to this referral.

Note: construction and operation of the North Star Magnetite Project has not yet commenced.

Herb Elliott Port Facility

Fortescue, through its wholly owned subsidiary The Pilbara Infrastructure Pty Ltd (TPI) own and operate the Herb Elliott Port. TPI and IBO have reached agreement with regards to port services provided by TPI. These agreements will enable IBO commercial access to TPI's Port facilities and additional infrastructure which operate under the Railway and Port (TPI) Agreement Act 2004on land governed by the existing leases and licences from the Pilbara Ports Authority (PPA).

2.3 Project Infrastructure

The IB Port Facility will accept magnetite concentrate slurry from the North Star Magnetite Mine, located approximately 110 km South of Port Hedland, whereupon it will be dewatered and stockpiled prior to export.

2.3.1 Slurry Pipeline

A slurry pipeline will deliver magnetite concentrate to the Dewatering Plant. A 3 km length of pipeline is required to be constructed to link the Dewatering Plant and the slurry pipeline approved under the North Star Magnetite Project (Figure 3). The pipeline is likely to be installed above ground and buried at locations to avoid conflicts with existing infrastructure and access roads within the Herb Elliott Port precinct. A final pipeline alignment will be dependent on negotiations with third parties on the most appropriate point to cross infrastructure corridors. No disturbance to vegetation is required for the installation of the 3 km of slurry pipeline. An indicative pipeline route is demonstrated in Figure 3.

A concentrate diversion pond will be located to the east of the port entrance and will provide holding capacity for contents of the slurry pipeline in the unlikely event of a prolonged failure of the Dewatering Plant. The concentrate diversion pond is located largely on previously disturbed land and may remove up to 0.63 ha of highly disturbed vegetation.

2.3.2 Dewatering Plant

The Dewatering Plant receives material from the slurry pipeline into two agitated storage tanks from which the slurry is pumped to pressure filters for dewatering (Figure 3). The Dewatering Plant is designed to process 10.1 Mtpa magnetite concentrate. The plant filters the magnetite concentrate at approximately 8% moisture content. The dewatering plant discharges the dewatered concentrate onto the Stacking Circuit. After the filtered concentrate is discharged, the filters are washed and any residue is then pumped back to a clarifier tank. This tank thickens the slurry for return back to the storage tanks. Overflow from the clarifier is sent back to the North Star mine via the return water pipeline. A small portion of the overflow is recycled for use in washing the filter pads.

2.3.3 Stacking Circuit

The stacking circuit receives product from the dewatering plant and discharges at the Stockpile Shed tripper. The stacking circuit consists of a conveyor with transfer station and a stacking conveyor with travelling tripper.

2.3.4 Stockpile

The magnetite is stockpiled in a storage shed large enough to maintain up to 300,000 tonnes of concentrate (Figure 3). The stacking conveyor is suspended from the apex of the shed. At capacity, the stockpile shed will contain a stockpile of 200,000 tonnes and a second stockpile of 100,000 tonnes. During outloading, the 200,000 tonne stockpile is depleted whilst stacking continues on the 100,000 tonne stockpile.

2.3.5 Reclaim Circuit

The reclaim circuit takes material from the stockpile and discharges the material onto the outload circuit. The reclaim circuit consists of:

- A bi-directional bucket-wheel Bridge Reclaimer
- A reclaim conveyor and transfer station
- A transfer conveyor and transfer station
- A sample station

The reclaimer is rail mounted and is capable of reclaiming stockpiles in both directions for the full length of the stockpile shed. The stacking circuit can continue to operate while the Reclaimer is operating.

The sample station will cut samples from the reclaim circuit prior to discharge to the outload circuit. Samples will be tested to provide data for moisture, size distribution and grade determination.

2.3.6 Return Water Pipeline

The return water pipeline will follow the same route as the slurry pipeline and will connect to the return water pipeline approved under the North Star Magnetite Project.

2.3.7 Power Requirements

Power requirements for this Proposal will be met from the existing Herb Elliott Port supply by installing new connections to Horizon Power's South West Creek Substation and Alinta's Tiger Substation. A switchroom within the IB Port Facility will distribute power to the new infrastructure.

2.3.8 Water Requirements

Water for construction will be met from the existing Anderson Point water supply network. Water during operations will be supplied from the water extracted from the magnetite concentrate by the dewatering plant. This water will also supply the belt scraper sprays, belt washing stations, dust sprays and general service.

2.3.9 Bulk Earthworks

Approximately 400,000 m^3 of fill material will be required to form a raised pad on which to place the IB Port Facility. This material will be sourced from existing quarries or suppliers in the Port Hedland area and is not related to this proposal.

2.3.10 Ancillary Facilities

A crib room and ablutions block will be established for the operations and maintenance workforce. A local potable water storage tank with a nominal two day operational usage capacity will be provided to the crib facility.

2.3.11 Workforce

During construction approximately 300 personnel will be required. The construction workforce will be housed at Fortescue's existing accommodation in South Hedland.

2.4 Tenure

TPI hold a lease over the Herb Elliott Port from the Pilbara Port Authority. As described in Section 2.2.3, TPI and IBO have an agreement for access to TPI's lease area and existing port facilities.

2.5 Approval Timeframes

Approval timeframes for the IB Port Facility are provided in Table 4.

Table 4: Key Milestone Dates

Milestone	Date
Approvals in Place to Commence Site Development	April 2016
Approvals in Place to Commence Construction	October 2016
Commence Load Commissioning	August 2017

3. STAKEHOLDER CONSULTATION

Consultation with key stakeholders and the community is an important element of the environmental impact assessment process. IBO considers that consultation with the community, key stakeholders and decision-making authorities is vitally important to ensure all parties have the opportunity to make informed comment about the proposal.

3.1 Stakeholder Identification and Engagement

IBO has developed a Communications Strategy to recognise key stakeholders and plan for their engagement with the proposal at the earliest opportunity in a format applicable to their level of interest and involvement. Key stakeholders identified for the IB Port Facility are:

Government (State and Commonwealth)

- Environmental Protection Authority (EPA)
- Department of the Environment (Cwlth)
- Department of State Development
- Department of Environment Regulation
- Department of Water
- Department of Mines and Petroleum
- Department of Parks and Wildlife

Local Government

- Town of Port Hedland

Indigenous Groups

- Native Title Claimants – Kariyarra
- Aboriginal Corporations – Yamitji Marlpa Aboriginal Corporation

Community Interest Groups

- Care for Hedland

3.2 Stakeholder Comments and Outcomes

A summary of stakeholder consultation for the proposal to date and where specific comments, if any, are addressed in the document is shown in Table 5.

Table 5: Summary of Iron Bridge Port Facility Consultation

Stakeholder	Date	Format	Comments Raised	Where Addressed
Department of State Development (DSD)	Monthly	Meeting	Several options conflict with DSD Boodarie Strategic Infrastructure Corridor associated with Boodarie Strategic Industrial Area. Option E supported.	Section 1.5
OEPA	26 February 2015 27 May 2015 31 July 2015	Meeting Meeting Presentation	Benthic habitat and coastal processes are potential key factors but also noise and dust due to increased product handling.	Section 4, Table 8
Care for Hedland	12 March 2015	Presentation Note, the presentation given to Care for Hedland was based on Option A but also applicable to Option E.	Disturbance to mangroves Impacts to water quality in the harbour Surface water management Re-use of excess water for dust suppression	Section 4, Table 8
Department of Environment Regulation (DER)	12 March 2015 4 August 2015	Presentation Presentation	Covered stockyards Dust Boundary Monitor Network shared with Fortescue	Section 4, Table 8
Town of Port Hedland (ToPH)	13 March 2015	Presentation	Re-use of excess water for other Port users	Executive Summary,Section 2, Table 3

Stakeholder	Date	Format	Comments Raised	Where Addressed
Pilbara Port Authority (PPA)	24 March 2015 4 August 2015	Presentation Presentation	A Port Facility Development Application is being progressed by IBO. PPA and IBO have entered into an agreement to detail certain matters in relation to their engagement in connection with the development of the Port Facility by the Iron Bridge Joint Venture. Mangrove Offsets	Section 1.5 Section 4, Table 8
EPA Chair and OEPA	26 March 2015	Presentation	Consider the following EPA Guidance Statements: EAG 8-Environmental principles, factors and objectives EAG 9-Application of a significance framework in the environmental impact assessment process Dust modelling to be cumulative Mangrove Offsets to be addressed	Section 4, Table 8 Section 8 Section 4, Table 8 Section 4, Table 8
Department of the Environment (DoE)	12 June 2015 20 August 2015	Presentation Presentation	Mangrove Offsets Address the potential impacts of the proposal on the Airlie Island Skink	Section 6. Section 6.4

3.3 Ongoing Consultation

IBO will continue to consult with key stakeholders during the construction and operations phases. In addition, Fortescue maintains a community office in South Hedland where stakeholders can access information on all of Fortescue's developments, including the Iron Bridge Joint Venture with Formosa.

4. ENVIRONMENTAL STUDIES AND EFFORT

IBO has considered the key environmental factors for this proposal and has undertaken a range of environmental studies to support the assessment of the environmental impacts associated with this proposal. All studies have undertaken in accordance with guidance statements with reference to regulatory thresholds and targets.

All studies are detailed in Table 6.

Table 6: Environmental Studies and Surveys

Factor	Title	Study Area and Type	Study standard/guidance and Limitations	Appendix
Benthic Primary Producer Habitat	North Star Stage 2 Port Expansion: Benthic Primary Producer Habitat Survey and Impact Assessment	Port Hedland Local Assessment Unit (LAU). Desktop study utilising BPPH mapping undertaken for previous proposals within the Port Hedland LAU.	EAG3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment – provides guidance on assessing potential impacts, including cumulative loss in WA's marine environment. (EPA, 2009) Guidance for the Assessment of Environmental Factors No. 1: Guidance statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA, 2001) Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland. (EPA , 2011)	Appendix 1
	North Star Stage 2 Marine Studies: Hydrodynamic Impact Assessment - Option E	Port Hedland and surrounding offshore area from Depuch Island to Larrey Point, extending 60 km offshore (Figure 3-2 of Appendix 2). Desktop assessment utilising a range of data sources (Table 3-1 of Appendix 2)		Appendix 2
	North Star Stage 2 Marine Studies: Sediment Transport Impact Assessment - Option E	Port Hedland and surrounding offshore area from Depuch Island to Larrey Point, extending 60 km offshore (Figure 3-2 of Appendix 3). Desktop assessment utilising a range of data sources (Table 3-2 of Appendix 3)		Appendix 3

Factor	Title	Study Area and Type	Study standard/guidance and Limitations	Appendix
	North Star Stage 2, Port Expansion Environmental Marine Studies: Surface Water Impact Assessment	Desktop assessment of the proposal area pre and post development.		Appendix 4
Coastal Processes	North Star Stage 2 Marine Studies: Hydrodynamic Impact Assessment - Option E	Port Hedland and surrounding offshore area from Depuch Island to Larrey Point, extending 60 km offshore (Figure 3-2 of Appendix 2). Desktop assessment utilising a range of data sources (Table 3-1 of Appendix 2)	State Coastal Planning Policy No. 2.6	Appendix 2
	North Star Stage 2 Marine Studies: Sediment Transport Impact Assessment - Option E	Port Hedland and surrounding offshore area from Depuch Island to Larrey Point, extending 60 km offshore (Figure 3-2 of Appendix 3). Desktop assessment utilising a range of data sources (Table 3-2 of Appendix 3)		Appendix 3

Factor	Title	Study Area and Type	Study standard/guidance and Limitations	Appendix
	North Star Stage 2, Port Expansion Environmental Marine Studies: Surface Water Impact Assessment	Desktop assessment of the proposal area pre and post development.		Appendix 4
Air Quality	Dust Assessment - North Star Stage 2 Export Facility	Desktop assessment of the proposal area, inclusive of Port Hedland airshed. Several modelling runs were performed both with the Proposal in isolation and cumulative with all other dust sources.	Environmental Protection Bulletin No. 2: Port Hedland Dust and Noise (EPA, 2009b) National Environment Protection (Ambient Air Quality) Measure (NEPM). Air Quality and Air Pollution Modelling Guidance Notes (DoE, 2006) A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities (DEC, 2011)	Appendix 5
Noise	Magnetite Facility Stage 2 Environmental Noise Assessment	Desktop assessment of the proposal area, inclusive of sensitive receptors in proximity to the Proposal. Two modelling runs were performed using worst case scenarios.	Environmental Protection (Noise) Regulations 1997: Gazetted to present a fair and effective set of rules to govern noise emissions. The regulations are the ‘prescribed standard’ under the EP Act.	Appendix 6

Factor	Title	Study Area and Type	Study standard/guidance and Limitations	Appendix
			State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning. EAG13: EPA Considerations of environmental impacts from noise (EPA, 2004): *Where noise emissions likely to be caused by the implementation of a proposal are regulated by the noise regulations or dealt with in SPP 5.4, the EPA expects proponents to use best practice design and noise management and to demonstrate how the proposal will be implemented to achieve compliance with the se statutory and policy instruments*. Port Hedland Air Quality and Noise Management Plan (DSD, 2010)	

5. ASSESSMENT OF PRELIMINARY KEY ENVIRONMENTAL FACTORS

The purpose of this section is to summarise key considerations in the environmental assessment of the proposal and show how the proposal can be managed to meet the EPA's objectives for each preliminary key environmental factor.

5.1 List of Preliminary Key Environmental Factors

The preliminary key environmental factors identified as a result of IBO's understanding of the existing environment, the potential impacts posed by the Proposal and through discussions with the OEPA, are listed in Table 7.

Table 7: Preliminary Key Environmental Factors Table

Factor	Envelope	Environmental Aspect	Impact
Benthic Primary Producer Habitat	Port Facility	Clearing of BPPH Chemical and Hydrocarbon Spill potentially caused by lube bays and fuel facilities Concrete piling in inter tidal zone exposing Potential Acid Sulphate Soils (PASS)	Loss of BPPH Degradation of BPPH
Coastal Processes	Port Facility	Port Facility located within supra and inter tidal zones	Changes to Hydrodynamics Sedimentation and Erosion
Air Quality	Port Facility	Materials Handling and associated activities resulting in dust emissions	Health and Amenity
Amenity	Port Facility	Materials Handling and associated activities resulting in noise emissions	Health and Amenity

In addition, this document will discuss Matters of National Environmental Significance (to satisfy requirements of the EPBC Act (1999)) and Offsets (to satisfy requirements of EAG 8).

5.2 Discussion

An assessment of the impact of the proposal on the preliminary key environmental factors is presented in Table 8.

Table 8: Assessment Table – Preliminary Key Environmental Factors

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
Benthic Primary Producer Habitat: *To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales*				
Context Relevant policies and guidelines include: • *EAG3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment* (EPA, 2009a) • *Guidance for the Assessment of Environmental Factors No. 1: Guidance statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline* (EPA, 2001) • *Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland*. (EPA , 2011) To provide a consistent basis for assessment of cumulative impacts to BPPH in and around Port Hedland, the EPA have released spatial data for the Port Hedland Local Assessment Unit (LAU) (EPA , 2011). The LAU and the extent of BPPH mapped within this area is demonstrated in Figure 4. The BPPH present in the Port Hedland LAU includes mangroves, corals, seagrass, turfing algae, macroalgae, reef habitat and sandy (benthic micro-algal) habitat. The most dominant habitat was identified as bare sediment. Mangroves include the species *Avicennia marina*, *Rhizophora stylosa*, and a small proportion of *Ceriops australis* (WorleyParsons, 2015a). Previous studies of potential acid sulphate soil (PASS) for Fortescue's AP5 Project have demonstrated that whilst PASS material may be present, the sediments contain high levels of $CaCO_3$ which provide buffering capacity (WorleyParsons, 2011). Note that although shell fragments were identified in the samples analysed, which increases the apparent Acid Neutralising Capacity (ANC) of a sample during laboratory analysis, this was compensated for by increasing the Fineness Factor (FF) proportionally. The FF is a unitless parameter to characterise the chemical availability of the $CaCO_3$ within the sediment and is minimised to 1.5 when it is available in a fine powder-like form. For samples containing shell fragments, the FF was increased to 2 to compensate for the reduced chemical availability of the $CaCO_3$ (WorleyParsons, 2011). The risk of acidification is therefore low.	Clearing of BPPH Chemical and Hydrocarbon Spill caused by lube bays and fuel facilities Concrete piling in inter tidal zone exposing Potential Acid Sulphate Soils (PASS) Chemical and Hydrocarbon Spills	**Control Measures** Bunding to be placed around any refuelling area. Spill kits to be available in the event of a chemical or hydrocarbon spill. **Avoidance** Final design to reduce the footprint of the port facility to as small as reasonably practicable. **Minimisation** All disturbance to be undertaken in accordance with established Ground Disturbing Permit (GDP) process. Only small amounts of soil will be excavated for concrete foundations, therefore, the risk of acidification of PASS is extremely low. **Management** Implement a Mangrove Protection Management Plan (Appendix 7). Health of mangrove communities will be monitored under the Mangrove Protection Management Plan. Implement existing Acid Sulphate Soil Management Plan. Stormwater to be directed to a central sump to allow sediments to settle before evaporation or release to the surrounding environment.	A Mangrove Protection Management Plan (MPMP) will be implemented. This plan incorporates an offsets plan. The MPMP will specify the methods, procedures and management required to avoid and minimise impacts to mangrove habitat.	The proposal has been designed to limit the disturbance to BPPH to as low as reasonably practicable. The proposal can be managed to meet the EPA's objective for BPPH subject to: • A MPMP being implemented; and • An offset condition being applied to a native vegetation clearing permit to counterbalance the significant residual impact due to the permanent loss of mangrove habitat in an area that is already above threshold limits. • An Acid Sulphate Soils Management Plan will be developed prior to the construction phase. • A Chemical; and Hydrocarbon management Plan will be developed prior to the construction phase.

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
Key Study Findings BPPH mapping exists over the area subject to this proposal (WorleyParsons, 2015a), depicted in Figure 5. This includes: • *Avicennia marina* closed canopy, seaward edge • *A. marina* scattered • *Rhizophora stylosa*/*A. marina* closed canopy • Tecticornia Open Samphire All vegetation is considered to be in excellent condition. **Impacts** • Direct loss of 2.01 hectares (ha) of mangrove habitat • Direct loss of 8.14 ha of samphire saltmarsh habitat • Cumulative loss of mangroves as a result of the proposal will increase from 14.45% to 14.53% • No indirect loss of BPPH predicted (see Coastal Processes factor below) • Potential contamination from chemicals and hydrocarbons • Potential degradation from acid sulphate soils				
Coastal Processes: *To maintain the morphology of the sub-tidal, intertidal and supra-tidal zones and the local geophysical processes that shape them*				
Context The Department of Planning's State Coastal Planning Policy No. 2.6 guides coastal planning activities and provides objectives to guide coastal development, including port developments. These objectives are: • Protect conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance. • Provide for public foreshore areas and access to the coast • Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities. • Ensure the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria. The hydrodynamics of the coastal waters near Port Hedland and within the Port Hedland Inner Harbour are dominated by a large tidal range that drives strong flood and ebb tidal currents (WorleyParsons, 2015b). These currents are of scales of about 1 m/s in the near shore region, and greater than 1 m/s in the estuary entrances and	IB Port Facility located within supra and inter tidal zones	Modelling has demonstrated that there will be negligible impacts from the proposal. Therefore, no specific mitigation actions are required to manage residual impacts to coastal processes. A Surface Water Management Plan will be implemented to manage stormwater to mitigate residual impacts to coastal processes	Not required	The proposal has been designed to limit the disturbance to coastal processes to as low as reasonably practicable. The proposal can be managed to meet the EPA's objective for Coastal Processes.

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
deeper channels in the tidal creeks during peak ebb and flood tides (WorleyParsons, 2015b). The tidal currents are typically aligned along local bathymetric contours (WorleyParsons, 2015b). Substantial areas of mudflats occur along the coastline and within the Port Hedland estuary. The bathymetry is typically flat and shallow, typical of intertidal flats in the region. Winds in summer are quite persistent from the west/northwest and typically result in a long-term drift towards the north and east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn and winter (WorleyParsons, 2015b). Tides at Port Hedland are semi-diurnal and macro-tidal with a mean spring tidal range of 5.5 m (WorleyParsons, 2015b). Wind roses for Port Hedland Airport show the onshore wind climate is dominated by north-westerly onshore winds and south-easterly offshore winds. Offshore at Beacon 15 (approximately 20 km north-west of the Project site), the north-westerly onshore winds and south-easterly offshore winds are also evident, with a moderately higher occurrence of westerly winds and more consistent directionality to these dominant wind directions than that at Port Hedland Airport. Within the Inner Harbour, waves are influenced by local bathymetry and sheltering and are predominantly generated by local winds. **Key Study Findings** Modelling has demonstrated that there is negligible changes to the rate of sediment accretion or erosion as a result of the proposed development (WorleyParsons, 2015c). Similarly, the study has demonstrated that there is a negligible change to peak flow velocities within the Port Hedland Inner Harbour as a result of the presence of the IB Port Facility (WorleyParsons, 2015b). This is largely a result of the Port Facility being located on relatively high ground that is inundated infrequently. **Impacts** • No indirect loss to BPPH • Negligible increase in accretion or erosion in or around proposal area • Negligible increase in mean current velocities and inundation patterns in or around proposal area				

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
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.*				
Context Guidance on the assessment and management of air quality include: • Environmental Protection Bulletin No. 2: Port Hedland Dust and Noise (EPA, 2009b) • National Environment Protection (Ambient Air Quality) Measure (NEPM). • Air Quality and Air Pollution Modelling Guidance Notes (DoE, 2006) • A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities (DEC, 2011). In 2010, the PHDMT published the *Port Hedland Air Quality and Noise Management Plan* (DSD, 2010) to enable a framework for effective dust management strategies within Port Hedland. The taskforce made a number of recommendations which have been addressed. These include: • Establishment of a comprehensive network of air quality measuring devices throughout the Port Hedland area, including South Hedland; • Adoption of an interim air quality guideline measure for the national standard for PM_{10}; • Development of leading practice dust management guidelines; and • Undertaking of a Health Risk Assessment (HRA) which is scheduled for completion in Q4 FY2015. The HRA will investigate potential health risks from particulate matter and address concerns about air quality and its possible effect on community health following the increased level of port activity. Monitoring for PM_{10} was completed at the end of May 2014. Monitoring for other elements of concern such as silica, mineral fibres, sulphur oxides (SO_x) and nitrogen oxides (NO_x), will continue until the end of February 2015. The PPA developed best practice guidelines for the management of dust impacts associated with the activities and operations taking place within the area controlled by the PPA. The *Dust Management Guidelines: Leading Practice A232535* (PPA, 2015) sets out findings based on a review of national and international best practice and describes what is broadly considered to be leading practice for dust management in bulk materials handling processes. The Pilbara is a naturally dusty environment with wind-blown dust a significant contributor to dust levels in the region. In Port Hedland, operations at the Port increases dust levels. The PHDMT recognises that Port Hedland is a naturally dusty environment and is not an urban environment. A	Materials Handling and associated activities resulting in dust emissions	Note, modelling suggests that there will be no increased dust levels as a result of the proposed development and that dust levels may decrease. However, mitigation actions are listed below. **Avoidance** The magnetite concentrate is stored at approximately 8% moisture content. This is well above dust extinction moisture level. Integration of the existing Fortescue Air Management System (AQMS) with the IBO AQMS Boundary Monitor Dust Network will provide an effective dust management tool. **Minimisation** Product inloading is via a slurry pipeline and all stacking and reclaiming occurs within the covered area, therefore potential dust emissions from the facility are minimised. Belt wash stations will be installed at specific IBO outload circuit transfer stations to avoid carry back of the product. All belt wash emissions will be captured in a sump and slurried back to the IB Port Facility for dewatering.	Dust can be managed under the conditions of a licence under Part V of the EP Act	The proposal can be managed to meet the EPA's objective for air quality (dust) subject to the emissions being managed under Part V Licence.

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
PM_{10} level of 70 $\mu g/m^3$ has been set at the Taplin Street receptor. There must be no more than 10 exceedances of this level per year. **Key Study Findings** The cumulative scenario (existing, approved and IBO) was modelled to determine the impact that the introduction of 10 Mtpa of magnetite concentrate would have on dust levels in the Port Hedland airshed (PEL, 2015). The cumulative scenario based on Fortescue exporting 165 Mtpa of hematite ore and IBO exporting 10 Mtpa of magnetite concentrate, the predicted number of exceedances of the PHDMT PM_{10} level actually falls from 9 to 6 exceedances per year at the Taplin Street receptor. This is due to the emission characteristics of the magnetite product which has zero (or very low emissions) from stacking, reclaiming and shiploading displacing the inload of 10Mtpa of hematite (PEL, 2015). **Impacts** Potential for impacts to health and amenity				
Amenity: *To ensure that impacts to amenity are reduced as low as reasonably practicable*				
Context Noise characteristics such as vibration, tonality (humming or whining), modulation (changes in level of pitch) or impulsiveness (hammering) can increase the level of annoyance and a decrease in the amenity of residents. Noise management in Western Australia is implemented through the Environmental Protection (Noise) Regulations 1997 which operate under the *Environmental Protection Act 1986.* A PHIC cumulative noise assessment has identified that cumulative noise emissions from industry in Port Hedland currently exceed the regulatory noise levels (SVT, 2015). **Key Study Findings** Under a worst case scenario, the addition of the IB Port Facility will not increase cumulative noise levels (PEL, 2015). As a result, no noise mitigation measures are required for the Port Facility. **Impacts** Potential for impacts to health and amenity	Materials Handling and associated activities resulting in noise emissions	**Best Practice** The IB Port Facility will utilise new, modern equipment and will be maintained in good working order. **Minimisation** Stacking and Reclaiming will occur within a covered area. This will attenuate much of the noise associated with the handling of magnetite concentrate.	Noise can be managed under the provisions of the Environmental Protection (Noise) Regulations.	The proposal can be managed to meet the EPA's objective for amenity (noise).
Offsets: *To counterbalance any significant residual environment impacts or uncertainty through the application of offsets*				
Context The loss of 2.01 ha within the Port Hedland LAU constitutes a significant residual impact as the cumulative loss of mangroves in this area is already greater than 10%. Whilst areas of the	Not applicable	Not applicable	The Mangrove Protection Management Plan specifies a range of measures to offset the loss of 2.01 ha of mangroves including: • Identifying new mangrove habitat using results of Annual Mangrove Recruitment Surveys	The proposal can be managed to meet the EPA's objectives provided there is an offset applied to a native vegetation clearing permit to counterbalance the residual impact to mangrove communities.

Inherent Impact	Environmental Aspects	Mitigation Actions to Address Residual Impacts	Proposed Regulatory Mechanisms for Ensuring Mitigation	Outcome to Demonstrate that Proposal Meets EPA Objective.
inner harbour are demonstrating mangrove recruitment, permanent recruitment of 2.01 ha of mangroves remains uncertain.			which have occurred at the Herb Elliott Port since 2006. New mangrove habitat has been reported to occur in the following ways: o Excavation of sand cheniers through construction phase earthworks o Localised seepage along the Port Facility embankment o Excavation of artificial tidal creek channels o Discharge of stormwater to an area that receives partial tidal inundation • Once these newly created mangrove habitats are identified, further investigations aimed at increased recruitment and survival rates is proposed. • This approach is seen as a viable alternative to artificially creating suitable habitat for mangrove seedlings to propagate.	

6. MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The EPBC Act provides for the protection of nationally and internationally significant flora, fauna, ecological communities and heritage places. Under the EPBC Act, the following are Matters of National Environmental Significance (MNES):

- World heritage properties.
- National heritage places.
- Wetlands of international importance (listed under the RAMSAR Convention).
- Listed threatened species and ecological communities.
- Migratory species protected under international agreements.
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- Nuclear actions (including uranium mines).

The proposal has been separately referred to the Department of Environment.

6.1 EPBC Act Objectives

The objectives of the EPBC Act are to:

- Provide for the protection of the environment, especially for MNES.
- Conserve Australian biodiversity.
- Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.
- Enhance the protection and management of important natural and cultural places.
- Control the international movement of wildlife, wildlife specimens and products made or derived from wildlife.

Guidance on the assessment and management of MNES exists at a Federal government level, as shown in Table 9.

Table 9: Commonwealth Guidance for Assessment and Management of MNES

Document	Description
Environment Protection and Biodiversity Conservation Act 1999	Provides guidance for the preparation and evaluation of impact assessment. The Act aims to prevent significant impacts occurring to Matters of National Environmental Significance.
Matters of National Environmental Significance: Impact Guidelines 1.1 *Environment Protection and Biodiversity Conservation Act 1999* (2009)	Provides overarching guidance for the assessment of proposed actions to determine whether the action is likely to have significant impacts on a matter protected under national environmental law.
Matters of National Environmental Significance: Impact Guidelines 1.2 Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies (2010)	This guideline helps to determine whether or not to submit a referral to the DoE and whether approval is required under the EPBC Act.
Draft EPBC policy statement: Use of environmental offsets under the *Environment Protection and Biodiversity Conservation Act 1999* (2007)	The purpose of this draft policy statement is to outline the Australian Government's position on the use of environmental offsets under the EPBC Act. The aim is to ensure the consistent, transparent and equitable use of environmental offsets under the Act.
Discussion paper: Use of environmental offsets under the *Environment Protection and Biodiversity Conservation Act 1999* (2007)	The purpose of this paper is to facilitate the development of a public policy and internal guidance for the application of environmental offsets under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
National Assessment Guidelines for Dredging	Sets out the framework for the environmental impact assessment and permitting of the ocean disposal of dredged material.
National Strategy for the Management of Coastal Acid Sulphate Soils (2000)	Outlines the objectives for the identification, avoidance and mitigation of Acid Sulfate Soils.
Australian Ballast Water Management Requirements (Version 5, 2013)	Management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels.

6.2 Studies

Studies relevant to the IB Port Facility include:

- Protected Matters Search Tool – 7 July 2015 (DoE, 2015)
- Report for Pilbara Gateway Port – Flora and Vegetation, Vertebrate Fauna and Short Range Endemic Fauna Assessment (GHD, 2012)

6.3 Existing Environment

6.3.1 Fauna Habitat

A survey of the wider study area identified 11 fauna habitat types. Of these only two occur within the proposal footprint (GHD, 2012). These are:

- Mangroves
- Samphire and intertidal mudflats.

As a result, the range of conservation significant fauna species that are likely to occur within the proposed footprint or immediate surrounds is limited. These species are discussed further in Section 6.3.2.

Impacts from the loss of 10.15 ha of fauna habitat are discussed in Section 6.4.1.

6.3.2 Listed Threatened Species

The Protected Matters Search Tool identified that the listed threatened species shown in Table 10 may potentially occur within a 10km radius around the proposed IB Port Facility, including those occurring within marine waters (DoE, 2015). Migratory wetland bird species are listed in Section 6.3.3. Those species that are likely to occur within the Inner Harbour or utilise the habitat within the footprint of the Port Facility are discussed below.

Marine Mammals

Jenner and Theile (2008) note that no publications exist for any cetacean surveys in the Port Hedland area and the use of the Inner Harbour by smaller cetaceans such as dolphins cannot be confirmed, although it is reasonable to expect that dolphins would enter the Inner Harbour to forage. There have been sporadic sightings of individual dugongs in and around the Inner Harbour. Port Hedland is not considered an important aggregation area for dugongs (Prince, 2001) and a lack of extensive seagrass meadows within the harbour suggests the area is not suitable habitat for the dugong.

Marine Reptiles

According to the Protected Matters Search Tool, the Short-nosed Seasnake (*Aiipysurus apraefrontalis*) is listed as Critically Endangered under the EPBC Act and may potentially occur within waters around Port Hedland. There is no information regarding the potential for this seasnake to occur within the Inner Harbour, however, given its preferred habitat is reefs and shallow waters along the outer reef edge in water depths of 10m (DoE, 2015), it is highly unlikely that this seasnake would occur within the Inner Harbour.

Pendoley Environmental (2009) provides a summary of the use of the Inner Harbour by marine turtles. Based on satellite tracking of Flatback Turtles, inter-nesting Flatback Turtles were not expected to occur within the Inner Harbour. Green and Leatherback Turtles may both forage in the Inner Harbour and tidal creeks, with mangroves being used as an opportunistic food source. There is an anecdotal report of a Loggerhead Turtle south of Finucane Island and juvenile green turtles have been identified within the Inner Harbour. They are likely to feed on sea grass and algal mats and may use the mangrove habitat for an additional food source.

Fish

The Green Sawfish may occur within the Inner Harbour and tidal creeks based on its known range and preferred habitat.

Terrestrial Reptiles

The Airlie Island Ctenotus (Vulnerable) has been recorded multiple times over a wide area surrounding Port Hedland (GHD, 2012). All known records of this species have been from coastal mudflats, samphire and coastal grasses. It is likely the conservation status of the Airlie Island Skink will be downgraded in the future (given the number of times it has been recorded in the wider Pilbara area), which would in turn downgrade the value of this habitat type (GHD 2012).

Table 10: Threatened Fauna Species (Marine and Terrestrial)

Species	Status	Type of Presence in the Area
Marine Mammals		
Blue Whale (*Balaenoptera musculus*)	Endangered	Unlikely
Humpback Whale (*Megaptera novaeangliae*)	Vulnerable	Unlikely
Bryde's Whale (*Balaenoptera edeni*)	Migratory	Unlikely
Orca (*Orcinus orca*)	Migratory	Unlikely
Indo-Pacific Humpback Dolphin (*Sousa chinensis*)	Migratory	Potentially
Spotted Bottlenose Dolphin (*Tursiops aduncus*)	Migratory	Potentially
Dugong (*Dugong dugon*)	Migratory	Potentially
Terrestrial Mammals		
Northern Quoll (*Daysurus hallucatus*)	Endangered	Unlikely
Mulgara (*Dasyurus blythii/cristicauda*)	Vulnerable	Unlikely
Bilby (*Macrotis lagotis*)	Vulnerable	Unlikely
Marine Birds		
Southern Giant Petrel (*Macronectes giganteus*)	Endangered	Potentially
Fork-tailed Swift (*Apus pacificus*)	Migratory	Potentially
Lesser Frigatebird (*Fregata ariel*)	Migratory	Potentially
White-bellied Sea Eagle (*Haliaeetus leucogaster)*	Migratory	Likely
Barn Swallow (*Hirundo rustica*)	Migratory	Potentially
Rainbow Bee-eater (*Merops ornatus*)	Migratory	Potentially
Reptiles		
Short-nosed Sea snake (*Aiipysurus apraefrontalis*)	Critically Endangered	Unlikely
Loggerhead Turtle (*Caretta caretta*)	Endangered	Potentially
Leatherback Turtle (*Dermochelys coriacea*)	Endangered	Potentially
Green Turtle (*Chelonia mydas*)	Vulnerable	Potentially
Hawksbill Turtle (*Eretmochelys imbricata*)	Vulnerable	Potentially
Flatback Turtle (*Natator depressus*)	Vulnerable	Unlikely

Species	Status	Type of Presence in the Area
Airlie Island Ctenotus	Vulnerable	Potentially
Fish		
Great White Shark (*Carcharodon carcharias*)	Vulnerable	Unlikely
Dwarf Sawfish (*Pristis clavata*)	Vulnerable	Unlikely
Green Sawfish (*Pristis zijsron*)	Vulnerable	Potentially
Whale Shark (*Rhincodon typus*)	Vulnerable	Unlikely
Manta Ray (*Manta birostris*)	Migratory	Unlikely

6.3.3 Migratory Wetland Species

Species previously recorded within the Inner Harbour include the Great Egret, Cattle Egret, Grey-tailed Tattler, Eastern Curlew, Greater Sandplover and Marsh Sandpiper (GHD, 2012), (BHB Billiton, 2011). The intertidal mudflats located within the footprint of the proposal may provide habitat for migratory wetland species. Extensive areas of intertidal mudflat habitat occurs in the area to the east and west of Port Hedland.

The protected matters search tool identified the migratory wetland bird species as potentially occurring within the area are listed in Table 11 (DoE, 2015):

Table 11: Migratory Birds

Common Name	Species Name
Common Sandpiper	*Actitis hypoleucos*
Great Egret	*Ardea alba*
Cattle Egret	*Ardea ibis*
Ruddy Turnstone	*Arenaria interpres*
Sharp-tailed Sandpiper	*Calidris acuminate*
Red Knot	*Calidris canatus*
Curlew Sandpiper	*Calidris ferruginea*
Pectoral Sandpiper	*Calidris melanotos*
Red-necked Stint	*Calidris ruficollis*
Long-toed Stint	*Calidris subminuta*
Great Knot	*Calidris tenuirostris*
Greater Sand Plover	*Charadrius leschenaultia*
Lesser Sand Plover	*Charadrius mongolus*
Oriental Plover	*Charadrius veredus*
Oriental Pratincole	*Glareola maldivarum*
Grey-tailed Tattler	*Heterscelus brevipes*

Common Name	Species Name
Broad-billed Sandpiper	*Limicola falcinellus*
Bar-tailed Godwit	*Limosa lapponica*
Black-tailed Godwit	*Limosa limosa*
Eastern Curlew	*Numenius madagascariensis*
Little Curlew	*Numenius minutus*
Whimbrel	*Numenius phaeopus*
Eastern Osprey	*Pandion cristatus*
Pacific Golden Plover	*Pluvialis fulva*
Grey Plover	*Pluvialis squatarola*
Painted Snipe	*Rostratula benhgalensis*
Wood Sandpiper	*Tringa glareola*
Marsh Sandpiper	*Tringa stagnatilis*
Terek Sandpiper	*Xenus cinereus*

6.4 Impact Assessment

6.4.1 Loss of Wetland Habitat

The proposal will result in the removal of approximately 8.14 ha of samphire saltmarsh and approximately 2.01 ha of mangrove habitat, a total loss of 10.15 ha.

Listed threatened species that are likely to utilise saltmarsh or mangrove habitat for nesting or foraging include migratory birds, the Airlie Island Ctenotus, and the White-Bellied Sea Eagle. The loss of 10.15 ha of habitat should be considered with reference to the extensive areas of mangrove, saltmarsh/mudflat and wetland systems present along the Pilbara coast from Exmouth to the RAMSAR wetlands at Eighty Mile Beach and Mandora Marsh. Even when considering the cumulative loss of habitat within the Port Hedland LAU, the loss of 10.15 ha of saltmarsh and mangrove habitat is not considered to be a significant impact to the conservation of any listed threatened species.

6.4.2 Indirect Impacts

Ship movements on marine fauna

Fortescue currently holds a Part V licence under the EP Act for the export of up to 175 Mtpa of iron ore. No further increase in export tonnage is proposed. As a result of this proposal, up to 10 Mtpa of magnetite concentrate will be loaded onto ships using Fortescue's existing port infrastructure and exported.

The export of 10 Mtpa of magnetite will involve the loading of approximately 57 ships per year. There is no change to the amount of ship movements in and out of Port Hedland as a result of this proposal. The movement of all shipping through Port Hedland has already been considered in the assessment of Fortescue's port development. As a result, there is no additional impact to marine fauna above that which has already been assessed.

Introduction of marine pests

The construction and operation of the IB Port Facility will not introduce marine pests into the local environment. As discussed earlier in this section, the export of magnetite concentrate, whilst not part of this referral, will not result in a change to the volume of ship movements through the Inner Harbour. As a result there is no increased risk of introduction of marine pest species from this Proposal. The risk of marine pest species has already been considered in the assessment of the port facilities at Anderson Point.

Light spill

The Port Facility will be a 24 hour operation and will require some additional lighting for safe operations during night hours. It is not expected that the amount of light emitted by the IB Port Facility will be significantly greater than the light currently emitted by Herb Elliott Port.

Sedimentation of marine habitat

As discussed in Table 8, the proposal will not cause appreciable sedimentation of mangrove or benthic habitat. As a result there will be no indirect impacts caused by sedimentation as a result of the proposal.

Acid sulphate soils

As discussed in Table 8, it is unlikely that acid sulphate soils will be exposed as a result of this proposal. Therefore, there will be no impacts to fauna habitat resulting from acidification of local waters.

6.5 Management of Impacts

Impacts to fauna at the Herb Elliott Port are managed under Fortescue's *Conservation Significant Fauna Management Plan (100-PL-EN-0022).* This plan has been implemented at Fortescue's port facilities since the commencement of port operations and has been successful in avoiding, minimising and mitigating the impact of the port on fauna.

In addition, Fortescue also managed risk of introduction of marine pests through the implementation of its *Introduced Marine Pest Management Plan (P-PL-EN-0017).*

IBO commits to implementing these fauna management practices for the proposed IB Port Facility. Management measures include:

- Direct lighting onto active construction and operational areas to minimise the potential for light overspill resulting in fauna disturbance, injuries or death.

- Ensure all vehicles, plant and equipment are clean and certified weed free prior to entry into Fortescue controlled sites to prevent degradation of fauna habitat.
- Control feral animals to minimise impacts to conservation significant fauna.
- Remove all waste material to landfill facilities.
- Speed limit restrictions to limit dust lift-off and reduce vehicle strikes
- Implement monitoring programs for conservation significant fauna species.

6.6 Predicted Outcome

The proposed IB Port Facility has a small disturbance footprint and is adjacent to Fortescue's existing port operations. These operations have co-existed with the environment at the Inner Harbour since operations commenced without significant impact to fauna species. It is predicted that the implementation of established and successful fauna management practices outlined in Fortescue's *Conservation Significant Fauna Management Plan (100-PL-EN-0022)* will ensure that the level of impact on MNES will be negligible.

7. PRINCIPLES OF THE EP ACT

The EP Act sets out five principles by which protection of the environment is to be achieved in Western Australia. Consideration has been given to these five principles by IBO and the manner in which they have been applied is outlined in Table 12.

Table 12: Principles of Environmental Protection

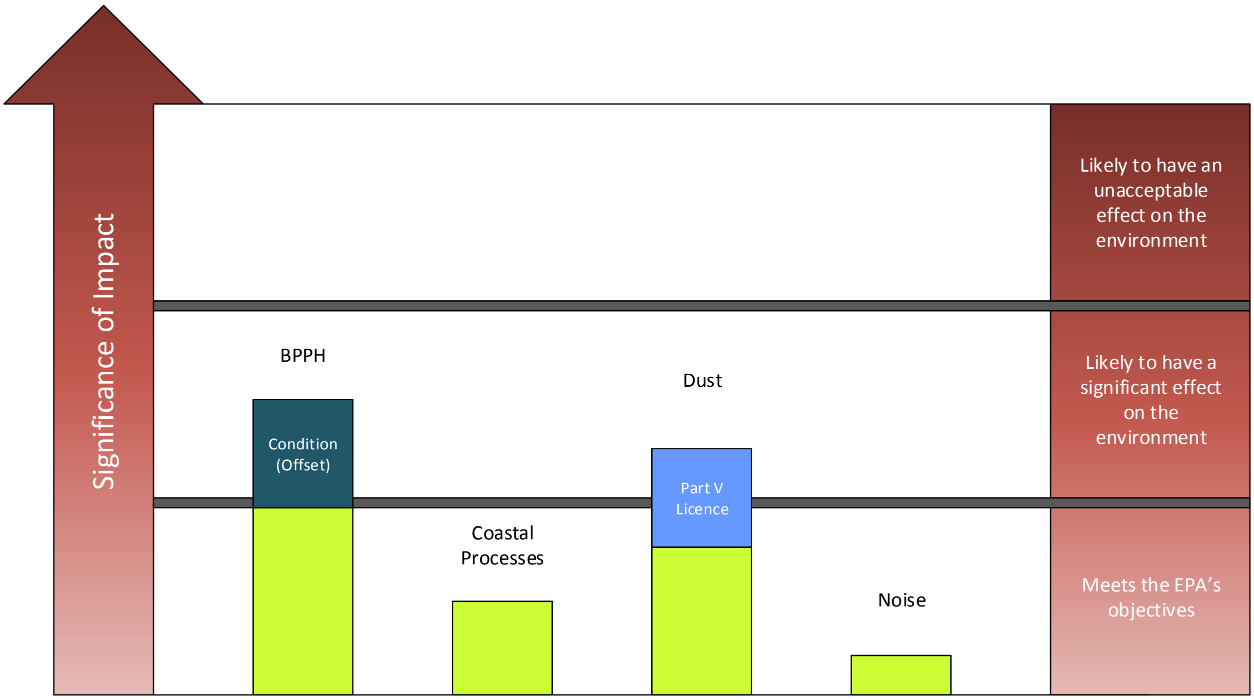
Principle	Consideration Given by the Project	Relevant Section in the Document
1. Precautionary Principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment • An assessment of the risk-weighted consequences of various options.	The Proponent recognises the importance of minimising environmental impacts as it is vital in ensuring the proponent's longevity, success, growth and positioning in domestic and global markets. This will be achieved by successful management of potential risks to the environment. IBO operates under Fortescue's existing environmental management system (EMS) that addresses all of its activities with potential to affect the environment. The key elements of the EMS include assessing environmental risk arising from environmental aspects with the intention of identifying issues early in the process to enable planning for avoidance and/or mitigation. Part of this process includes undertaking detailed site investigations of the biological and physical environs. Where these investigations identify significance conservation issues, management measures are incorporated into project design to avoid, where practicable, or minimise any potential impacts. As a result this project has been designed to minimise potential impacts to key environmental values of the local flora, fauna and marine environment.	Table 8.
2. Intergenerational 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.	The Proponent's decision-making processes incorporate sustainability principles and the implementation of new and better technologies where feasible. The proponent aims to inspire an ethic and attitude that strives for continuous improvement and ongoing learning. IBO encourages employees to engage in positive attitudes and behaviour concerning respect for the environment. We recognise sustainability cannot be achieved without the contribution and action of the entire team.	Section 2, Table 8

Principle	Consideration Given by the Project	Relevant Section in the Document
3. Conservation of Biological Diversity and Ecological Integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Conservation of biological diversity and ecological integrity is fundamental to the Proponent's approach to environmental management and is a major environmental consideration for the Project. Biological investigations have been undertaken by the Proponent early in the project planning process to identify values of environmental conservation significance required to be protected from disturbance. This Project has been designed to minimise potential impacts to the key environmental values of the surrounding flora and vegetation and significant fauna species.	Section 1, Section 2, Table 8.
4. Improved valuation, pricing and incentives mechanisms Environmental factors should be included in the valuation of assets and services. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. 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. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentives 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.	The Proponent acknowledges the need for improved valuation, pricing and incentive mechanisms and endeavours to pursue these principles when and wherever possible. For example: • Environmental factors have heavily influenced project design • The Proponent has put in place procedures that will ensure that pollution-type impacts are minimised as far as practicable.	Section 1, Table 8.
5. Waste Minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	The Proponent's approach to waste management is, in order of priority: • Avoid and reduce at source • Reuse and recycle • Treat and/or dispose. Dust and Noise emissions have been reduced to lowest reasonably practicable through Project design.	Section 2, Table 8.

8. CONCLUSION

Schematic 1 below provides IBO's diagrammatic representation of the level of impact posed by the Proposal on the Key Preliminary Environmental Factors. The diagram demonstrates how the application of mitigation options, such as a Part V Native Vegetation Clearing Permit offset condition and operating licence conditions for management of dust emissions will result in the Proposal which meeting the EPA's objectives.

Schematic Map 1: Application of the EPA's Significance Framework



IBO predict there to be a loss of 2.01 ha of mangrove communities within the Port Hedland LAU, where the cumulative loss of mangroves is already above threshold levels. IBO believe that clearing of 2.01 ha of mangrove habitat can be managed under the Native Vegetation Clearing Permit process and can therefore be implemented to meet the EPA's objectives. IBO will implement a Mangrove Protection Management Plan (Appendix 7), which will include details of offset measures.

Other aspects of the Proposal can be managed to meet the EPA's objectives.

- The presence of the IB Port Facility has a negligible impact on tidal velocities and sedimentation.
- The substitution of 10 Mtpa of hematite ore from Fortescue's Part V Licence with 10 Mtpa of magnetite concentrate is predicted to result in a reduction in the number of PM_{10} exceedances at the Taplin Street receptor. This is due to the magnetite handling

properties, its high moisture content and the storage of the magnetite concentrate in a covered facility.

- The operation of the IB Port Facility will have no impact on noise levels at any sensitive receptor.

Therefore, IBO consider that this proposal does not require formal assessment and can be managed under Part V of the EP Act.

EPBC Act Assessment

It is unlikely the proposal will significantly impact MNES species because:

- Species identified in the protected matters search tool, and through numerous surveys of the area, have high mobility and there is unlikely to be any direct loss of MNES fauna species as a result of the proposal;
- The area to be disturbed does not include significant habitat for the majority MNES species identified;
- The mangrove and tidal flat habitat within the proposal footprint may be foraging habitat for migratory bird species, however this habitat is widespread and a 10.15 ha loss is not considered a significant impact on a regional scale; and
- There is no impact to marine environments.

The environmental management measures proposed for the construction period of the Proposal will ensure impacts to Threatened terrestrial and marine fauna will be minimised. These measures will be communicated and enforced through the CEMP.

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Figure 1: Location of Proposal

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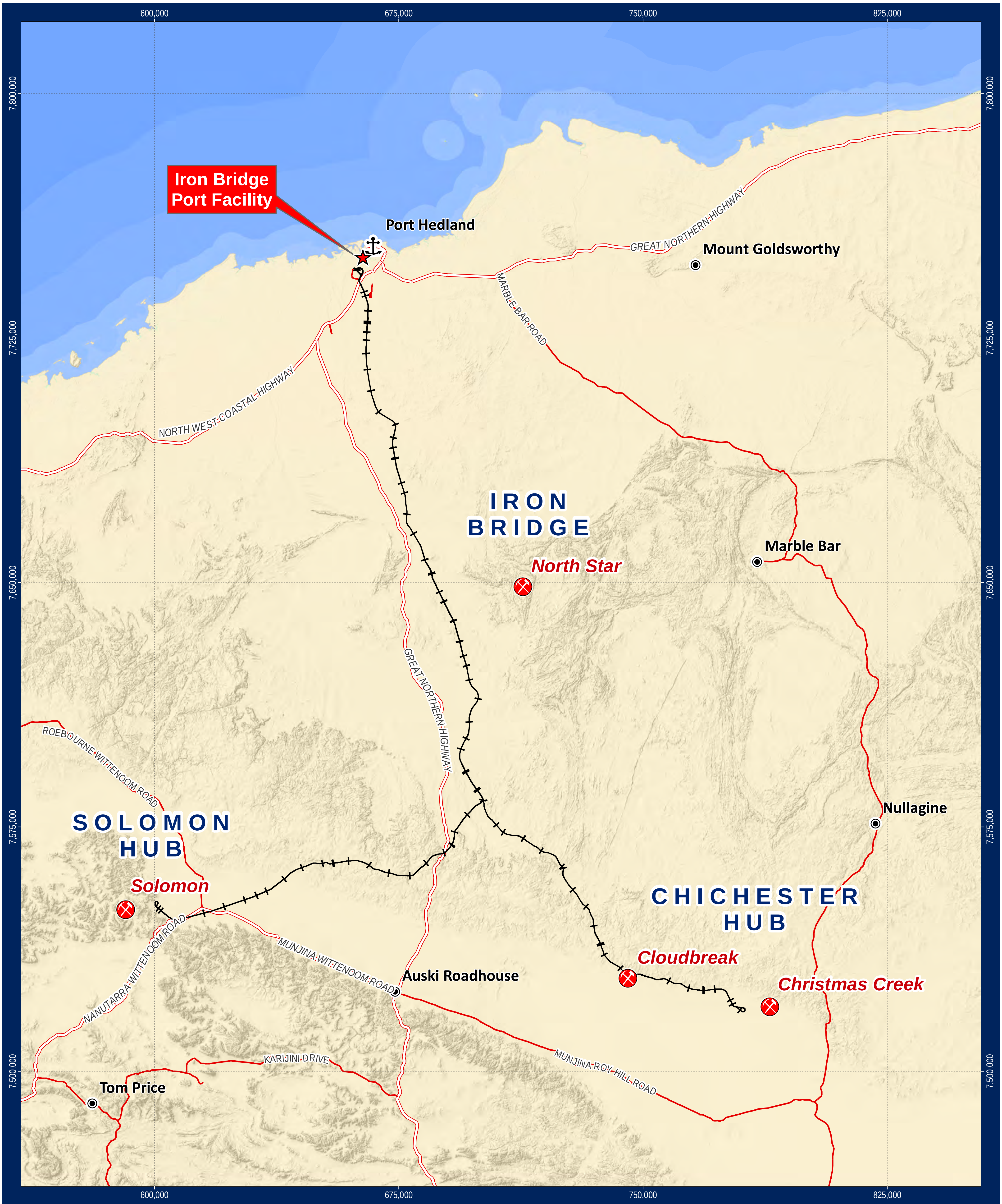

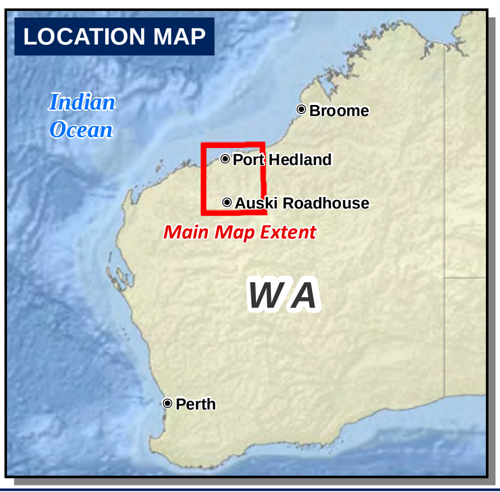

Map Legend

- Towns
- Ports
- Iron Bridge Port Facility
- FMG Mines
- FMG Rail Alignments

Roads

- Principal Road
- Secondary Road

Data Source(s):
GOV Roads sourced from Landgate
All Other Data - FMG Sourced

N W E S

0 10 20 30 40 50
Kilometres

Iron Bridge Port Facility - Location
North Star - Iron Bridge Project

Requested By: Matthew Dowling
Drawn By: A. McGonagle
Revised By: amcgonagle
Approved By: P. Mastalir
Scale: 1:1,100,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: 661PO_0000_MP_EN_0008.001_r0

Date: 6/08/2015
Size: A3P
Revision: 0
Confidentiality: 0

Iron Bridge

Figure 2: Port Options Analysis

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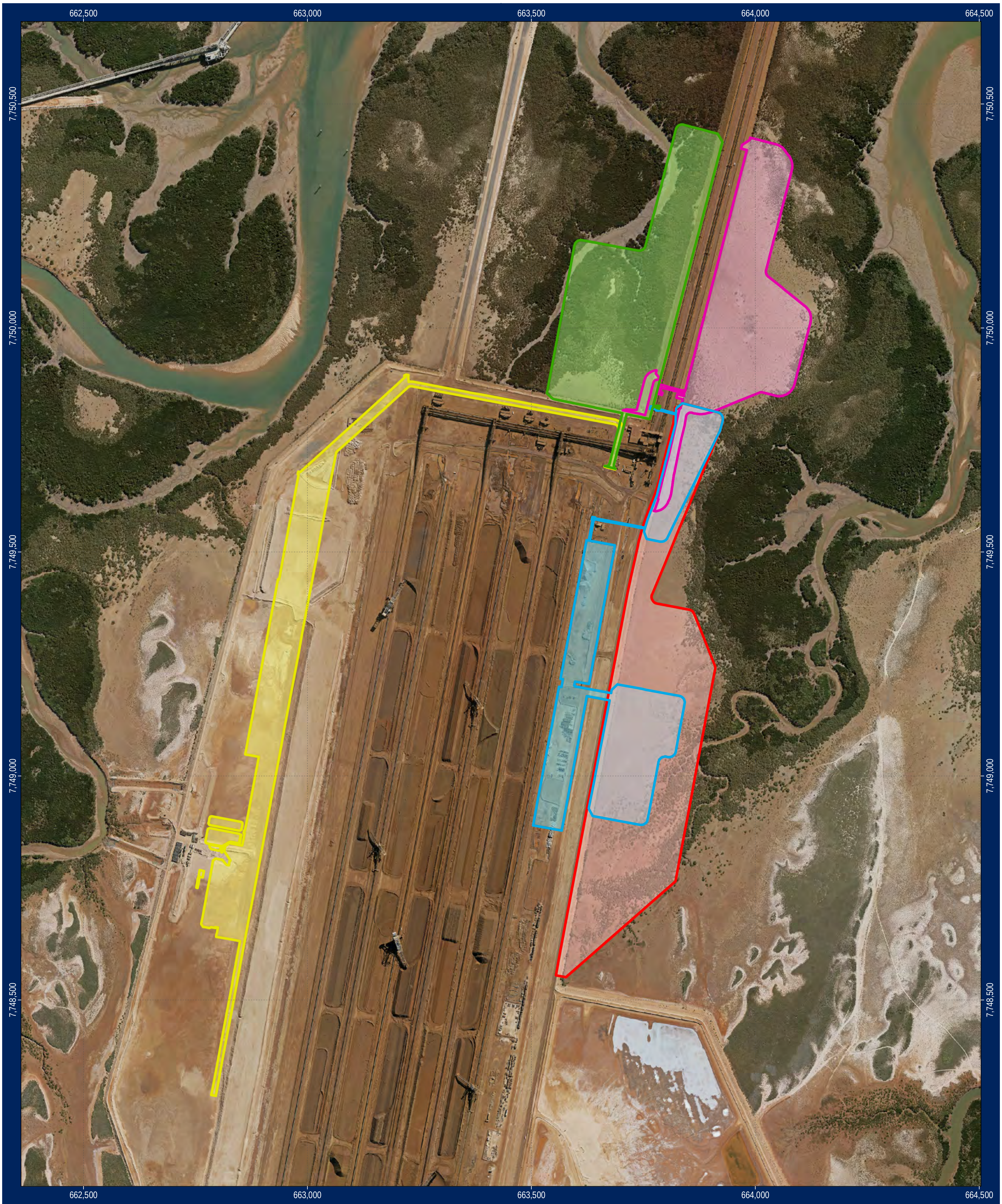

Map Legend

Port Options

- Option A
- Option B
- Option C
- Option D
- Option E

Data Source(s):
All Data FMG Sourced
Aerial Imagery captured June 2015

N W E S

0 100 200 300 400 500
metres

Iron Bridge Port Facility - Port Options
North Star - Iron Bridge Project

Requested By: Matthew Dowling — Date: 4/09/2015
Drawn By: A. McGonagle — Size: A3P
Revised By: amcgonagle — Revision: 1
Approved By: P. Mastalir — Confidentiality: 0
Scale: 1:8,000
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Document Name: 661PO_0000_MP_EN_0008.002_r1

Iron Bridge

Figure 3: Port Facility General Arrangement

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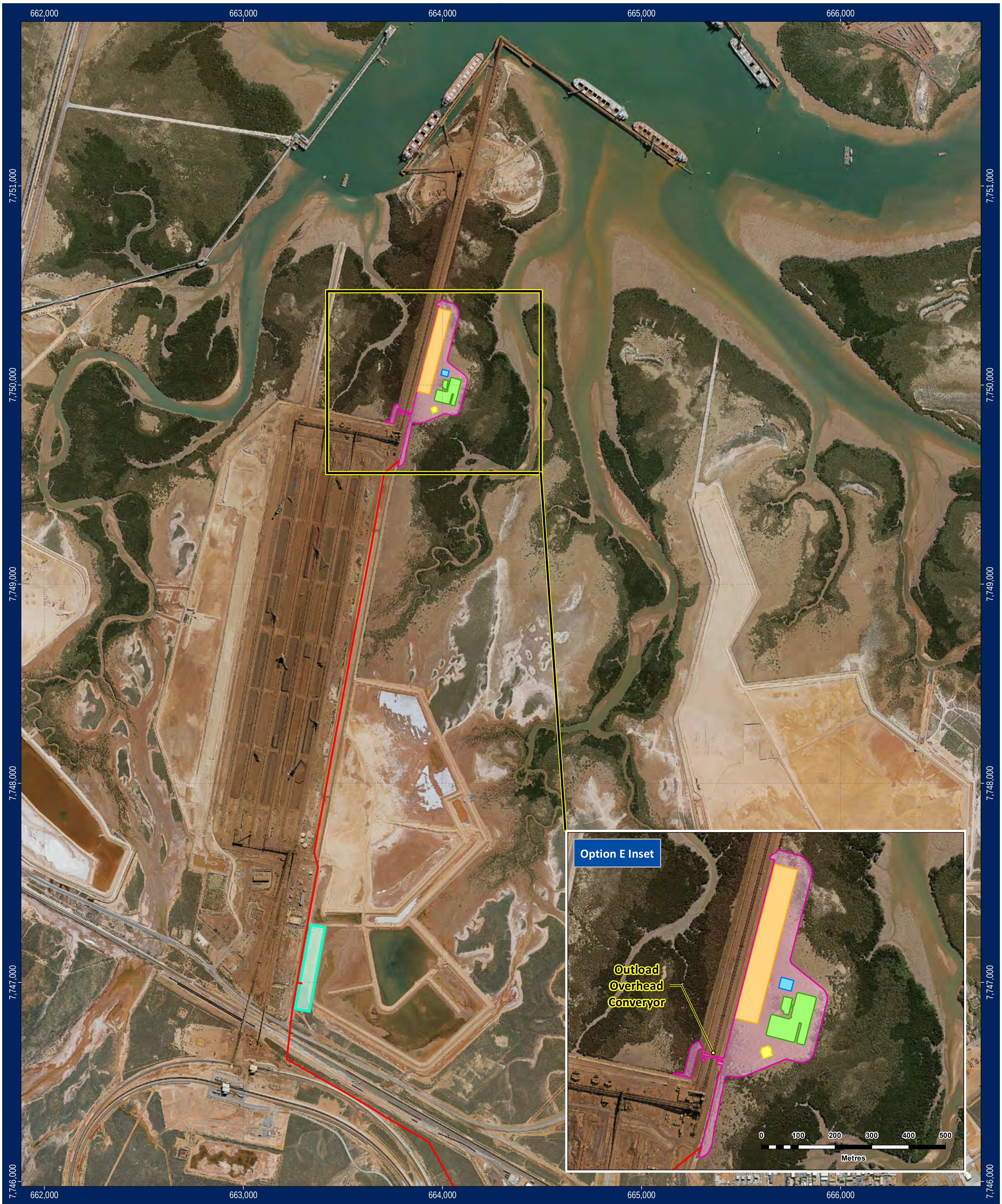

Map Legend

- Option E
- Concentrate Dewatering Facility
- Stockpiles
- Settlement Pond
- Switchroom
- Concentrate Diversion Pond
- Stage 2 Concentrate Pipeline

Data Source(s):
All Data FMG Sourced
Aerial Imagery captured June 2015

N
W E
S

0 200 400 600 800 1,000
metres

Iron Bridge Port Facility – General Arrangement
North Star - Iron Bridge Project

Requested By: Matthew Dowling
Drawn By: A. McGonagle
Revised By: amcgonagle
Approved By: P. Mastalir
Scale: 1:18,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: 661PO_0000_MP_EN_0008.003_r1

Date: 4/09/2015
Size: A3P
Revision: 1
Confidentiality: 0

Iron Bridge

Figure 4: Port Hedland LAU BPPH Mapping

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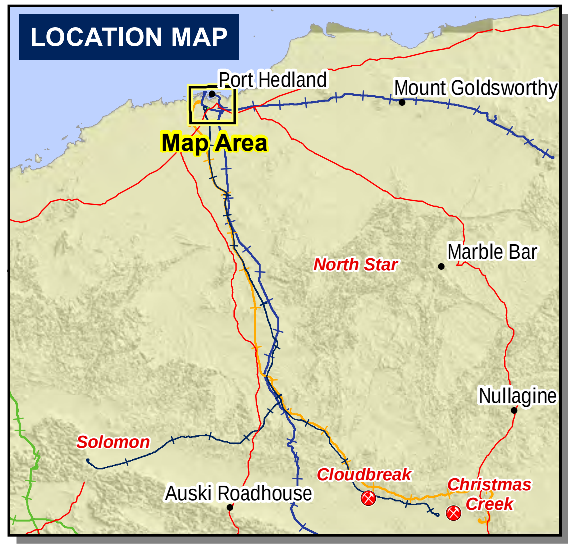

Map Legend

- Port Facility - Option E
- Local Assessment Unit: Inner Port Hedland Port Area (EPA 2011)
- Saltmarsh Classification
- Mangrove Classification

Data Source(s):
Local Assessment Unit: Inner Port Hedland Port Area (EPA 2011)
Mangrove and Saltmarsh Classifications, Worley Parsons, 2015
All other Data - FMG Sourced

N W E S

0 1 2 3 4 5
Kilometers

Iron Bridge Port Facility – LAU
North Star - Iron Bridge Project

Requested By: Matthew Dowling
Drawn By: A. McGonagle
Revised By: amcgonagle
Approved By: P. Mastalir
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Document Name: 661PO_0000_MP_EN_0008.005_r1

Date: 4/09/2015
Size: A3L
Revision: 1
Confidentiality: 0

Iron Bridge

Figure 5: BPPH Mapping within Port Facility Footprint

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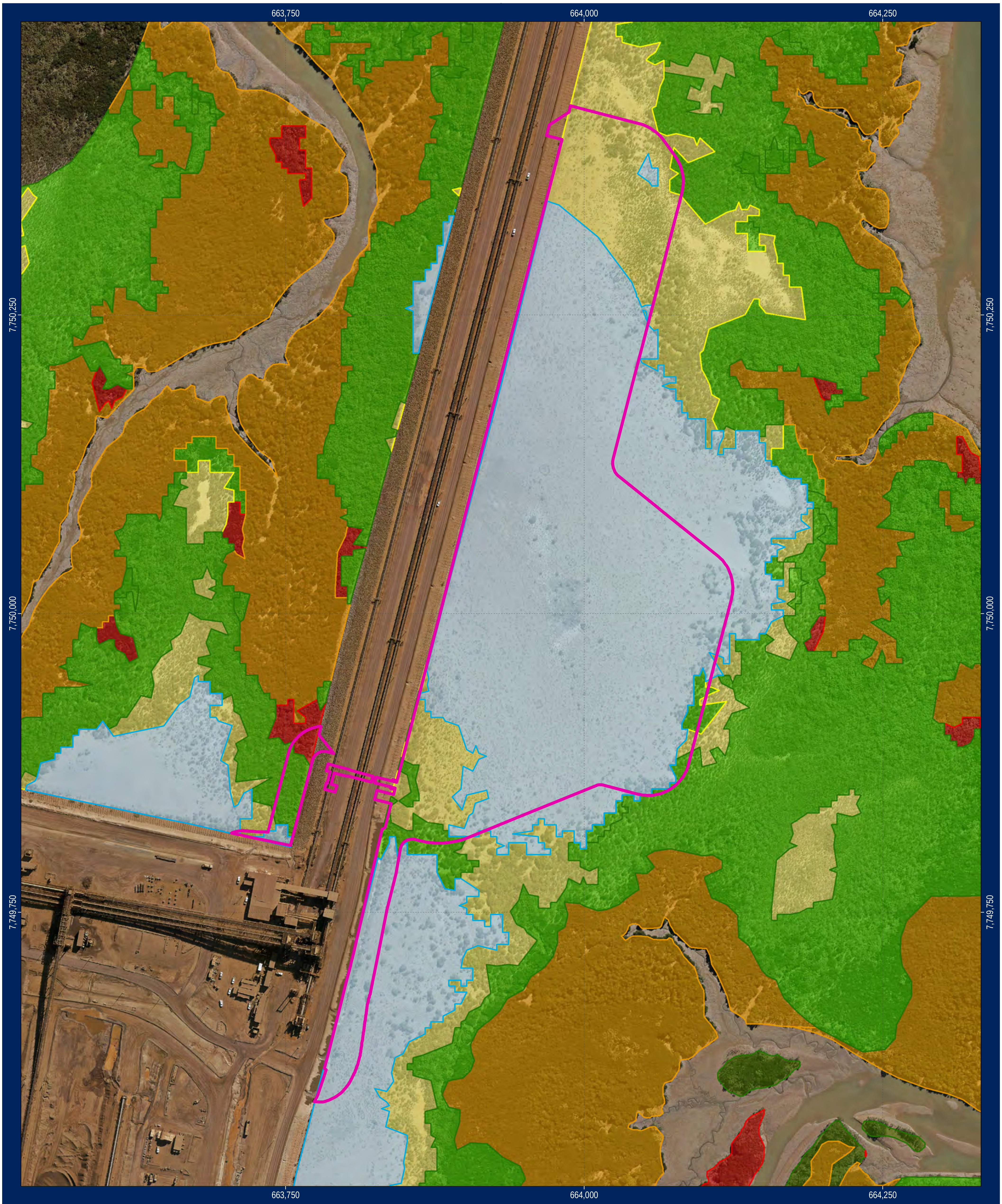

Map Legend

- Option E footprint - 10.34 ha
- Saltmarsh Classification - 8.18 ha

Mangrove Classification

- A. marina (continuous, landward edge) - 0.374 ha
- A. marina (continuous, seaward edge)
- A. marina scattered - 1.604 ha
- R. stylosa
- R. stylosa / A. marina (continuous) - 0.039 ha

Data Source(s):
Mangrove and Saltmarsh Classifications, Worley Parsons, 2015
All Other Data - FMG Sourced
Aerial Imagery captured June 2015

N W E S

0 20 40 60 80 100
metres

Iron Bridge Port Facility – BPPH Mapping
North Star - Iron Bridge Project

Requested By: Matthew Dowling
Drawn By: A. McGonagle
Revised By: amcgonagle
Approved By: P. Mastalir
Scale: 1:3,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: 661PO_0000_MP_EN_0008.004_r1

Date: 4/09/2015
Size: A3P
Revision: 1
Confidentiality: 0

Iron Bridge

Appendix 1: BPPH Assessment (WorleyParsons, 2015a)

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North Star Magnetite Project

North Star Stage 2 Port Expansion

Benthic Primary Producer Habitat Survey and Impact Assessment

August 2015

201012-00530-EN-REP-BPPH

Rev 1

Iron Bridge

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1. GLOSSARY

The following terms are applicable to this document:

Table 1: Glossary of Terms

ABBREVIATION	DEFINITION
BPPH	Benthic Primary Producer Habitat
DER	Department of Environment Regulation
EAG	Environmental Assessment Guideline
EPA	Environmental Protection Authority
Fortescue	Fortescue Metals Group Ltd
Ha	Hectare
LAU	Local Assessment Unit
nm	Nautical Miles
PPA	Pilbara Port Authority
TPI	The Pilbara Infrastructure Pty Ltd

2. INTRODUCTION

2.1 Background

The Iron Bridge Port Facilities for the North Star Stage 2 Project will provide the capacity to stockpile and outload up to 10.1 Mtpa (dry) of North Star concentrate. These facilities will be built in Port Hedland, located approximately 1,660 km north of Perth, within the Pilbara region of Western Australia. The port of Port Hedland is managed by Pilbara Ports Authority, and is defined as 'water within a radius of 10 nautical miles (nm) of Hunt Point Beacon (Beacon 47)' (PHPA 2001). The harbour has been highly modified by dredging activities and development and operation of port-related industry.

The proposed Iron Bridge Port Facilities (herein referred to as the 'facility') will be located at Anderson Point, to the north of the TPI stockyard, on the eastern side of the causeway. This is adjacent to Fortescue's Herb Elliott Port, approximately 20°19'S, 118°34'E. Access to the site is via Utah Road off the Great Northern Highway.

The Dewatering Facility and Stockyard Facility will be located on previously undeveloped land. Figure 1 presents the proposed facility location.

As the proposal will require disturbance of mangrove and saltmarsh habitat, survey and assessment of potential impacts has been undertaken to confirm the spatial extent of the construction footprint and to ensure that disturbance is minimised.

Figure 1: Iron Bridge Dewatering Facility and Stockyard Location (Option E)

2.2 Scope of work and objectives

This report gives the results of the desktop BPPH study and the impact assessment based on the current plans for the NSS2 expansion works. This impact assessment will be used to address the requirements of EAG3 (EPA 2009) and to identify the potential direct and indirect impacts on BPPH associated with the proposed construction works.

The objectives of the BPPH impact assessment report are to:

1. Review the relevant Western Australian EPA guidelines for assessment of BPPH habitat and apply the recommended approach to impact assessment.
2. Describe the proposal and previous design options and justify the site selected.
3. Describe the benthic communities and habitats within the proposed disturbance area and their context within the Port Hedland LAU to determine their ecological significance
4. Define the direct and indirect impacts and determine the spatial extent of impact for the proposed development.

The following sections of the report address these objectives.

3. OBJECTIVE 1: ENVIRONMENTAL ASSESSMENT GUIDELINES

In order to assess the impacts of the proposal on BPPH in Port Hedland and Western Australia, the EPA has published several guidelines. These are outlined below.

3.1 Guidance Statement No. 1 (EPA 2001)

Guidance Statement No.1 is the "Guidance Statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline". This Guidance Statement specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline.

The four types of management areas are:

- Guideline 1: Regionally significant mangroves – Outside designated industrial areas and associated port areas
- Guideline 2: Other mangrove areas – Outside designated industrial areas and associated port areas

- Guideline 3: Regionally significant mangroves – Inside designated industrial areas and associated port areas
- Guideline 4: Other mangrove areas – Inside designated industrial areas and associated port areas.

Guideline 4 is applicable to Port Hedland Harbour. The EPA's expectations for this category are that impacts of development on mangrove habitat and ecological function of the mangroves in these areas be reduced to the minimum practicable level.

The EPA would consider the significance of the environmental impacts but would expect that the proposal in these zones is likely to be capable of being made environmentally acceptable. Accordingly, proposals in these areas will not be subject to a presumption against finding the proposal environmentally acceptable providing that:

- A high priority is placed on protecting tropical arid zone mangroves, habitat and dependent habitats; and
- Any development being planned and designed to keep impacts on mangroves, habitats and dependent habitats to a minimum practical level.

While mangrove habitat disturbance is predicted, these provisions have been taken into account for this proposal.

3.2 Environmental Assessment Guideline No. 3

EAG3 specifically addresses protection of BPPHs in Western Australia's marine environment. The EAG defines BPPH as seabed communities within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components (EPA 2009). The EPA recognises the fundamental ecological importance of BPPHs and the potential consequences of their loss. It is also acknowledged that almost all marine development proposals will result in the loss of some of these important habitats (EPA 2009).

For the purposes of this study, the following definitions were adopted:

- BPPs are primarily marine plants such as macroalgae, seagrasses, mangroves, turf algae and benthic microalgae, but also include the scleractinian corals (which gain a large proportion of their energy from internal symbiotic microalgae); and
- BPPHs are a combination of the BPPs and the substrata that can support them. BPPHs not only include areas of existing BPPs, but also areas that previously supported them or

may be colonised by them in the future. Examples of BPPHs include coral reefs, seagrass meadows, mangrove forests, intertidal mud flats and seabed where macroalgal, coral or seagrass communities have grown and could grow.

Other benthic habitats such as those dominated by sessile organisms (e.g. soft corals, sponges and ascidians) are recognised as being important, but the loss of or damage to these habitats would be treated separately as part of the environmental impact assessment process.

The construction activities associated with this project will directly affect BPPH as defined by the EPA in EAG 3 within the proposed construction footprint. In accordance with the *Environment Protection Act 1986* (EP Act), all proposals that may result in disturbance to or loss of marine BPPH should adhere to the principles and guidelines recommended within EAG3 (EPA 2009).

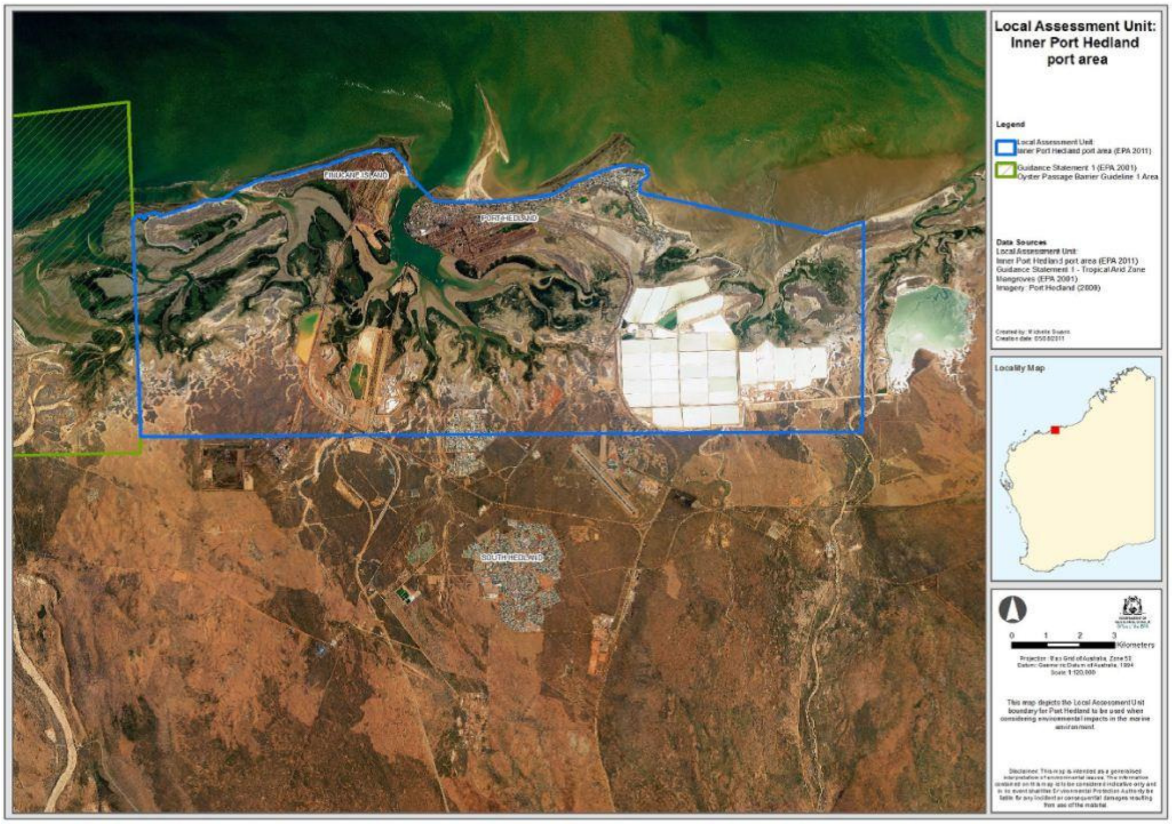
3.3 Environmental Protection Bulletin No. 14

An LAU is ‘a specific geographical area which provides the most effective boundaries for management of cumulative environmental impacts on marine habitats’ (EAG3, EPA 2009). The guidance for assessing BPPH in and around Port Hedland provides a set LAU boundary to aid proponents to comply with EAG 3 for proposals in Port Hedland. Historically, The EPA has noted that different proponents have defined different LAUs for assessing the cumulative losses of BPPH associated with their proposals in Port Hedland. This inconsistency in application of EAG No.3 resulted in the development of EP Bulletin No. 14 which provides a clear definition of the LAU for proposals in Port Hedland. All assessments within the area are expected to use this LAU (shown in Figure 2) for evaluating cumulative losses of BPPH from the date of issue in August 2011.

The Port Hedland LAU is 15,102.5 ha in area and is used for development related cumulative losses associated with the inner harbour, tidal creeks, barrier islands and the adjacent intertidal zone within the inner Port Hedland area. The northern boundary has been based on existing coastline data and inshore mangrove extent, while taking into account the temporal variation of the soft erodible coastlines and the spoil ground located immediately east of the harbour entrance.

The LAU shown in Figure 2 forms the basis of the cumulative loss assessment for the proposed facility.

Figure 2: Port Hedland Local Assessment Unit



3.4 Approach to impact assessment

To accurately define impacts to BPPH associated with the project, the impact assessment was conducted in accordance with EAG3.

The overarching principles given in EAG3 for the environmental protection of BPPH are:

1. All proponents should demonstrate consideration of options to avoid damage/loss of BPPH, by providing the rationale for selection of the preferred site and broad project design for example.

2. Where avoidance of BPPH is not possible, then design should aim to minimise damage/loss of BPPH (eg through iterative design and demonstrable application of Principle 3 below). Proponents will be required to justify that design in terms of operational needs and environmental constraints of the site.

3. Proponents will need to demonstrate 'best practicable' design, construction methods and environmental management aimed at minimizing further damage/loss of BPPH through indirect impacts and minimizing potential for recovery.

4. The EPA's judgement on environmental acceptability with respect to damage/loss of BPPH and the risk to ecological integrity will be based primarily on its consideration of the proponent's application of principles 1 to 3 and calculations of cumulative loss of each BPPH type within a defined LAU (the most 'realistic' scenario), together with supporting ecological information, and expert advice, as required.

The design options considered by the IBJV in order to address the first three principles are discussed in Section 4. As described in principle 4, the impacts need to be defined spatially and compared with the Port Hedland LAU, which is described in Section 5. The BPPH loss assessment is presented in Section 6.

4. OBJECTIVE 2: DESCRIPTION OF PROPOSAL

The NSS2 construction works being assessed in this BPPH survey and impact assessment includes the following:

- A dewatering facility and a covered magnetite stockyard to be located outside the Anderson Point lease areas on undeveloped land directly to the north east of the existing hematite stockyard, on the eastern side of the existing causeway to Anderson Point. This land is mainly comprised of scattered saltmarsh habitat with some mangroves, which will be removed during construction.

- An outload overhead conveyer from dewatering facility on to existing TPI shiploading infrastructure.

- Concentrate slurry and return water pipelines from the Port Hedland town boundary to the dewatering facility, following the existing FMG rail line to Anderson Point (Figure 1).

The site development will include:

- A total disturbance area of 10.2 hectares.

- Mangrove and saltmarsh habitat disturbance.

- Removal of the existing rock and mattress revetment.

- 372,000 m^3 of bulk fill.

- Installation of geo-fabric and rock-armour.

Approximately 372,000 m^3 of bulk fill material will be required to complete the site development. Fill material for the site development will be sourced from existing dredged material stockpiles at Anderson Point or will be imported from an offsite borrow pit or quarry. The batters will be lined with rock-armour for protection against storm events.

No dredging or spoil disposal will be required for this proposed construction works. Wastewater discharges will also not be required.

4.1 Design options considered

In order to address principle 1 and 2 of the EAG3, options were considered for the NSS2 construction works that included different locations and designs that minimised the development footprint. An option at Balla Balla was considered, however due to the pre-approvals in place (Ministerial Statement 945) it would not suit the requirements and would need further dredging activities to occur. Therefore in order to minimise environmental impacts and development costs, other options needed to be considered.

A feasibility study was undertaken by Fortescue that investigated several further options, including at either Anderson Point or Petermerer Inlet. Petermerer Inlet, located to the east of Port Hedland, was not considered suitable due a number of development and operational constraints for the establishment of a new port. Alternatively, Anderson Point which is located within the port of Port Hedland was considered a more suitable option as a TPI stockyard is already present and the Iron Bridge Port Facilities could be developed near this stockyard.

Overall, Anderson Point was considered a better site for the following reasons:

- Capital cost of development was substantially less than at other locations.
- Allowance for the future expansion of the Anderson Point hematite stockyard.
- Integration with the existing and future materials handling infrastructure.
- Suitable for future Stage 3 expansion infrastructure.
- Minimises environmental impact by reducing the area of BPPH to be cleared or dredged at alternative locations.

Several options at Anderson Point were also considered as part of the design process. These options, A to D, are presented in Appendix 1, including a summary figure of the different options. Aurecon (2015) addressed several different layouts of option A for the original BPPH survey and impact assessment. These were located to the north of the TPI stockyard on the west side of the causeway. These footprints differed slightly in the footprint shape and location and the areas of mangroves to be disturbed or removed. The preferred footprint was the smallest and the most unlikely to cause further indirect losses of mangrove habitat. However, consultation with the Department for State Development found that these options were within the proposed strategic infrastructure corridor that formed part of their Boodarie Strategic Industrial Area Development Plan (FMG 2015).

Instead, the preferred location has been determined to be north of the TPI stockyard, but to the east of the causeway, referred to as option E (Figure 1). This report addresses the benthic habitats within this footprint to the north east of the TPI stockyard (option E), and the associated impacts with the development of the project.

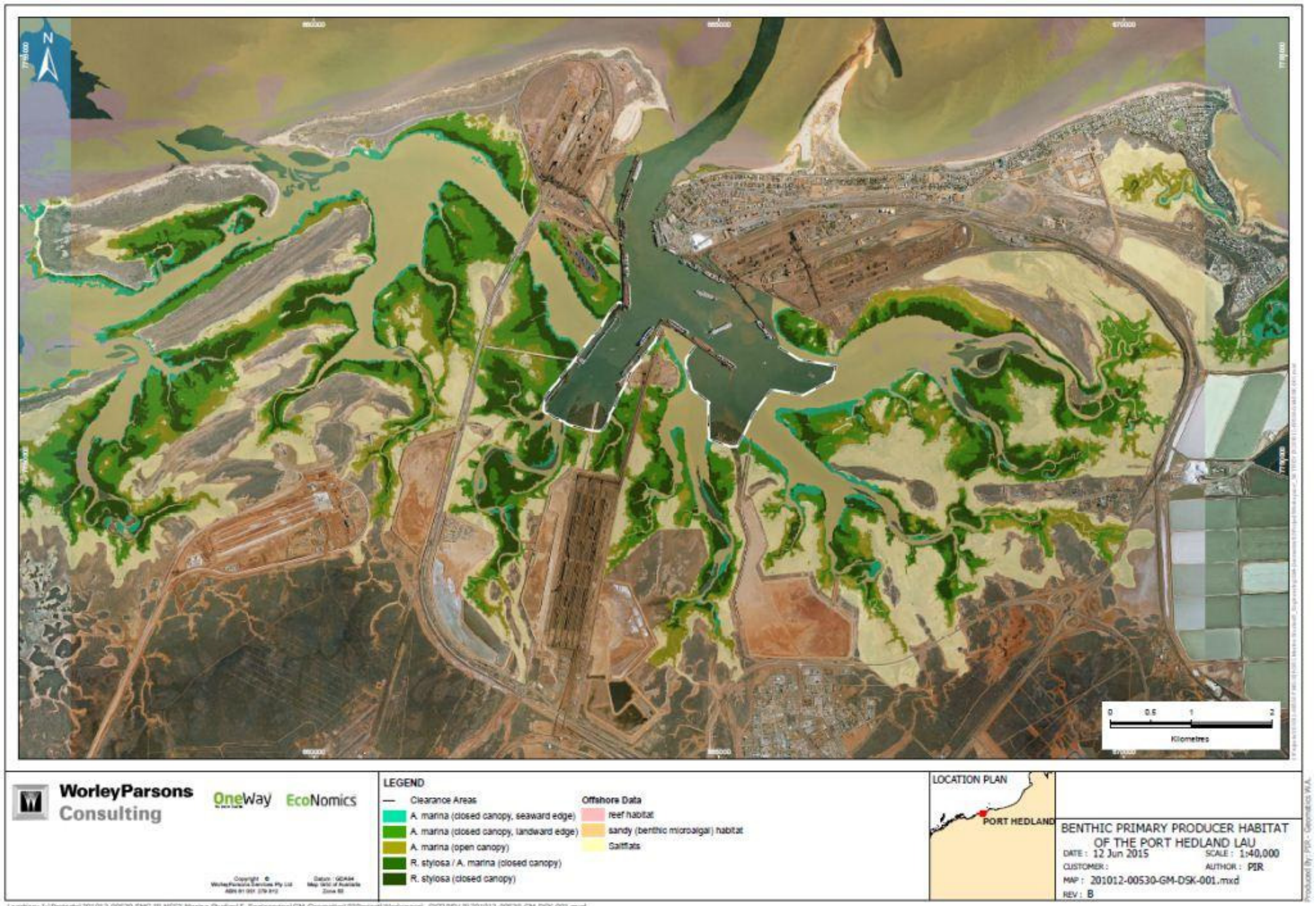
5. OBJECTIVE 3: BENTHIC COMMUNITIES AND HABITATS

5.1 Benthic habitat in the LAU

The BPPH ecology of the Port Hedland LAU was assessed previously during the cumulative loss assessment from a dredging project in South West Creek (WorleyParsons 2012). Data was collected through literature review and compilation of existing data including raw data collected from baseline investigations and ground truthing surveys, sonar surveys and satellite imagery analysis. Mangrove extent was adapted from the EPA report and recommendations for the Port Hedland Outer Harbour Development (EPA 2012). More recently, BPPH surveys were undertaken for the Lumsden Point General Cargo Facility within the project footprint at Lumsden Point (WorleyParsons 2013). During earlier phases of the NSS2 expansion, another BPPH survey was undertaken at Anderson Point within the areas of other location options (Aurecon 2015). All of this information has been compiled to produce an updated map of the BPPH within the LAU. This is presented in Figure 3.

The marine habitats found in Port Hedland are typical of those found along the arid coastlines of the Pilbara. The BPPH present in the Port Hedland LAU includes mangroves, corals, seagrass, turfing algae, macroalgae, reef habitat and sandy (benthic microalgal) habitat. The most dominant habitat was identified as bare sediment. Mangroves include the species *Avicennia marina*, *Rhizophora stylosa*, and a small proportion of *Ceriops australis*. All of these species are found elsewhere in the Port Hedland area and Pilbara region. None are listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* or the *Wildlife Conservation Act 1950*.

Figure 3: Updated BPPH map within the Port Hedland LAU



5.2 Benthic habitat in the NSS2 area

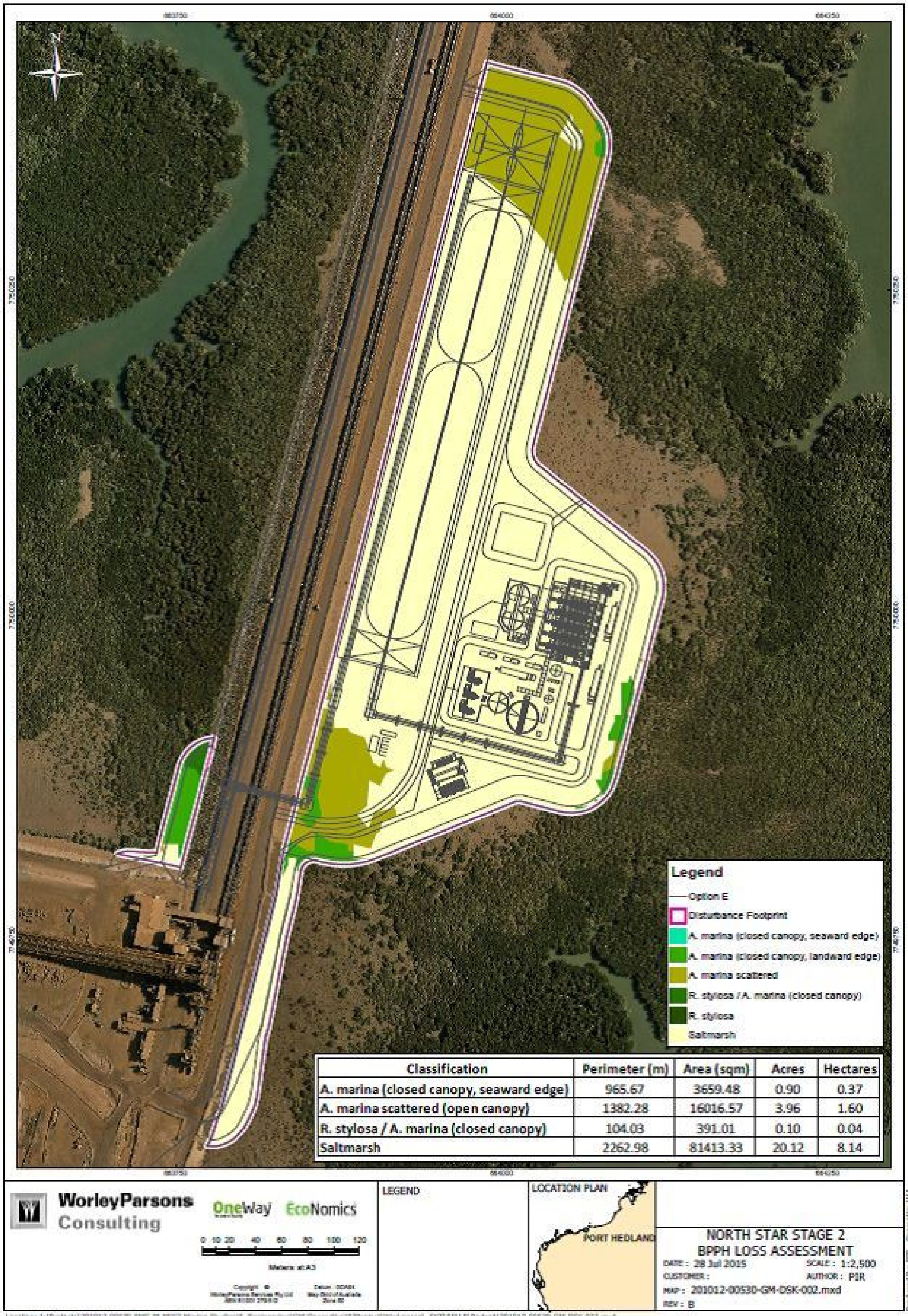
The dominant BPPH type within the project footprint has been identified primarily as saltmarsh. This habitat is very sparse, with low density vegetation as shown in Figure 4.

A. marina and *R. stylosa* mangroves are also present and have been mapped through aerial imagery. The density of the mangroves varied, from open to closed canopy (Figure 5). The mapped areas of BPPH within the proposed footprint are shown in Figure 6.

Figure 4: Saltmarsh within the NSS2 facility proposal footprint

Figure 5: Mangroves within the NSS2 facility proposal footprint

Figure 6: BPPH within the NSS2 area



Classification	Perimeter (m)	Area (sqm)	Acres	Hectares
A. marina (closed canopy, seaward edge)	965.67	3659.48	0.90	0.37
A. marina scattered (open canopy)	1382.28	16016.57	3.96	1.60
R. stylosa / A. marina (closed canopy)	104.03	391.01	0.10	0.04
Saltmarsh	2262.98	81413.33	20.12	8.14

6. OBJECTIVE 4: BPPH LOSS ASSESSMENT

6.1 Historical loss of BPPH

BPPH cumulative loss for the Port Hedland LAU were calculated from historic aerial photographs from 1964 used to create a baseline image of the area before major development and other anthropogenic activities. The total areas and estimated percentage impacts are presented in Table 2, based on the information given in the EPA Report 1503 (EPA 2014) and the Lumsden Point General Cargo Facility Cumulative Impact Assessment (WorleyParsons 2013).

Table 2: BPPH extent within the Port Hedland LAU as of July 2015

BPPH type	Historical area (ha)	Estimated cumulative loss including approved projects (including those not yet started) (ha)	Resultant extent of habitat (ha)	Percentage impact (%)
Mangroves	2,676	386.7	2289.3	14.45
Coral	19	0.1	19	0.7
Macroalgae	73	49	23	68
Sandy Habitat (potential MPB)	2349	253	2097	11
Saltmarsh (potential)	3394	1623	1771	48
Saltmarsh (actual)	628	327	301	52
Cyanobacterial mats (potential)	4274	1849	2425	43
Cyanobacterial mats (actual)	299	129	170	43

Within EAG3, six categories of marine ecological protection are identified based on the area type, for example, development areas or high protection areas. Associated with these are cumulative loss guidelines, which are tools to identify the risk to ecological integrity based on the cumulative loss within an area type.

The EPA have previously described the Port Hedland LAU as a Category F area (EPA 2009b), where cumulative loss guidelines have been significantly exceeded. However, a more recent assessment undertaken as part of the Outer Harbour Development proposal suggested that an overall level of mangrove loss from the Port Hedland LAU may be less than the 10% cumulative loss guideline (EPA 2012).

6.2 Direct loss of BPPH

The disturbance footprint of the project is 10.2 ha, which consists of mainly low density saltmarsh and some sparse mangrove. Some of the area (0.05 ha) has already been disturbed.

Direct loss of mangrove and saltmarsh will occur during the construction works in the location presented in Figure 6. The area of mangroves to be removed will be 2.01 ha, which includes 1.6 ha of open, sparse *A. marina* species, and 0.41 ha of closed canopy mangrove (Table 3). However, in a BPPH assessment, closed and open canopy mangroves are treated the same. Therefore, the total cumulative loss within the Port Hedland LAU would increase from 386.70 ha to 388.71 ha, or from 14.45% to14.53 % mangrove cumulative loss as a result of the proposed development (Table 4). While the cumulative loss has been given as 14.45%, this is only the gross loss. As the shorelines within the Port Hedland LAU are accreting and the abundance of mangroves are likely to be increasing, net loss would be more likely to represent approximately 5%. This facility proposal also contributes only 0.08 % mangrove loss.

The area of saltmarsh habitat to be removed is 8.14 ha, which consists of very sparse, low density vegetation cover. While this saltmarsh area has low ecological significance due to its low vegetation density, it is still treated as BPPH. Therefore the cumulative loss within the Port Hedland LAU would increase from 327.00 ha to 335.14 ha, or from 52 % to 53.37% (Table 4). While the cumulative loss percentage is above the recommended 10% loss guideline, saltmarsh loss due to the facility proposal contributes to only 1.37% of the total loss within the Port Hedland LAU for this respective habitat type.

Table 3: Maximum predicted mangrove and saltmarsh areas to be removed due to the proposed facility

Classification	Area (ha)
A. marina (closed canopy)	0.37
R. stylosa / A.marina (closed canopy)	0.04
A. marina (open)	1.6
Saltmarsh	8.14

Table 4: Estimated BPPH loss within the Port Hedland LAU

BPPH type	Benthic habitat area predicted to be lost due to the project (ha)	Cumulative loss area of LAU from historic and proposed losses (ha)	Estimated percentage of habitat category within LAU due to proposal	Estimated cumulative loss within LAU (%) (current loss and proposed loss)
Mangrove	2.01	(Current loss 386.7) Proposed loss is 388.71	0.08	(Current loss 14.45) Proposed loss is 14.53
Saltmarsh	8.14	(Current loss 327) Proposed loss is 335.14	1.37	(Current loss 52) Proposed loss is 53.37

6.3 Indirect loss of BPPH

No indirect losses of BPPH are anticipated as a result of the construction of the NSS2 project.

Hydrodynamic modelling was undertaken and found there would be no impacts to BPPH due to the development or operation of the facility (WorleyParsons, 2015a).

Sedimentation can be a cause of mangrove health decline, due to smothering of pneumatophores. Sedimentation can be caused by natural sediment movement, but can also be intensified through anthropogenic activities. Modelling for this project however shows that there will be no sediment movement above background caused by this proposed development (WorleyParsons 2015b). Therefore there is no indirect or irreversible loss of BPPH predicted to occur due to sedimentation.

Data collected from the long term mangrove monitoring program by Fortescue also confirms that no indirect impacts have resulted from operation of the facilities at Anderson Point. The monitoring program is part of a Mangrove Protection Management Plan which aims to detect impacts to mangroves or potential impacts so that mitigation may be undertaken as effectively as possible, It is therefore concluded that indirect impacts on the mangrove habitats outside the disturbance footprint from construction and operation of the NSS2 facility are also unlikely.

7. BENTHIC HABITAT LOSS ASSESSMENT SUMMARY

7.1 Irreversible BPPH losses

Irreversible losses will be located within the disturbance footprint, and will includes the sparse mangroves and saltmarsh habitats.

Table 5: Summary of estimated BPPH loss within the Port Hedland LAU

Benthic habitat category	% loss of habitat category within LAU due to proposal	Estimated cumulative loss within LAU (%)
Mangroves	0.08	14.53
Saltmarsh	1.34	53.37

7.2 Predicted impacts on BPPH

No other impacts are predicted to occur on other BPPH in relation to the development of the NSS2 facility.

7.3 Ecological significance of losses

No unusual, unique or highly significant habitat complexes were identified in the disturbance footprint.

The direct losses of coastal intertidal BPPH due to the construction activities for this project represent a very small fraction of the total BPPH found in Port Hedland. Saltmarsh habitat while ecologically important would be considered of less ecological significance than mangrove habitat which plays an important role in accumulating and stabilising coastal sediments, restricting erosion and reducing turbidity in coastal environments. It would also be preferable over the disturbance of habitat beyond the Port Hedland LAU where the quality of BPPH would also be higher away from the industrial activities. Therefore the ecological significance of estimated benthic community losses can be considered minimal.

Consistent with the intent of the protection of BPPH in port operational areas within EAG3, IBJV is committed to working with the PPA to increase mangrove habitat in the area in accordance with the mangrove rehabilitation plan.

8. CONCLUSION

The proposed NSS2 port facility has considered several design options to minimize the potential environmental impact and construction footprint on mangrove habitat within the Port Hedland LAU. The selection of Option E, on the eastern side of the causeway, to the north of the existing stockyard at Elliot Point is in an area where there is significantly less mangrove habitat and was considered the best option to minimise any direct or indirect impacts on BPPH.

The desktop survey of mangrove cover and distribution for this project found that a maximum of 2.01 ha of predominantly open canopy mangroves would be removed within the construction footprint. This represents only 0.08% cumulative loss within the Port Hedland LAU, which would increase the total cumulative loss to 14.53%. However, in general terms, the Port Hedland LAU is accreting and if net loss was used rather than gross loss it would represent around 5% mangrove loss instead. This indicates a far lower ecological impact to ecosystems within Port Hedland.

The saltmarsh area to be disturbed was found to be 8.14 ha, or only 1.37% cumulative loss within the Port Hedland LAU. Saltmarsh habitat while ecologically important would be considered of less ecological significance than mangrove habitat which plays an important role in accumulating and stabilising coastal sediments, restricting erosion and reducing turbidity in coastal environments. Therefore the loss of this low density saltmarsh was preferable over higher disturbance of mangroves.

While the cumulative loss numbers are above the 10% cumulative loss guideline for Category F established in EAG3, this is not intended to be applied as a rigid limit (EPA 2009). Currently, the cumulative loss is already beyond the 10% guideline and the additional area to be removed as part of this proposed facility is considered relatively minor.

The Pilbara Ports Authority is also committed to protecting and maintaining the ecological integrity of the mangroves within Port Hedland through continued implementation of its mangrove rehabilitation program with the intent to lower cumulative loss. IBJV will also be committed to supporting Pilbara Ports Authority with the mangrove rehabilitation program. Potential direct and indirect impacts to mangroves from construction and operation of the proposed facility will be managed through implementation of the Fortescue Mangrove Protection and Management Plan.

The ecological significance of the losses of BPPH arising from the proposed facility is considered to be minimal as the direct losses of intertidal habitat associated with the proposal are very low.

9. REFERENCES

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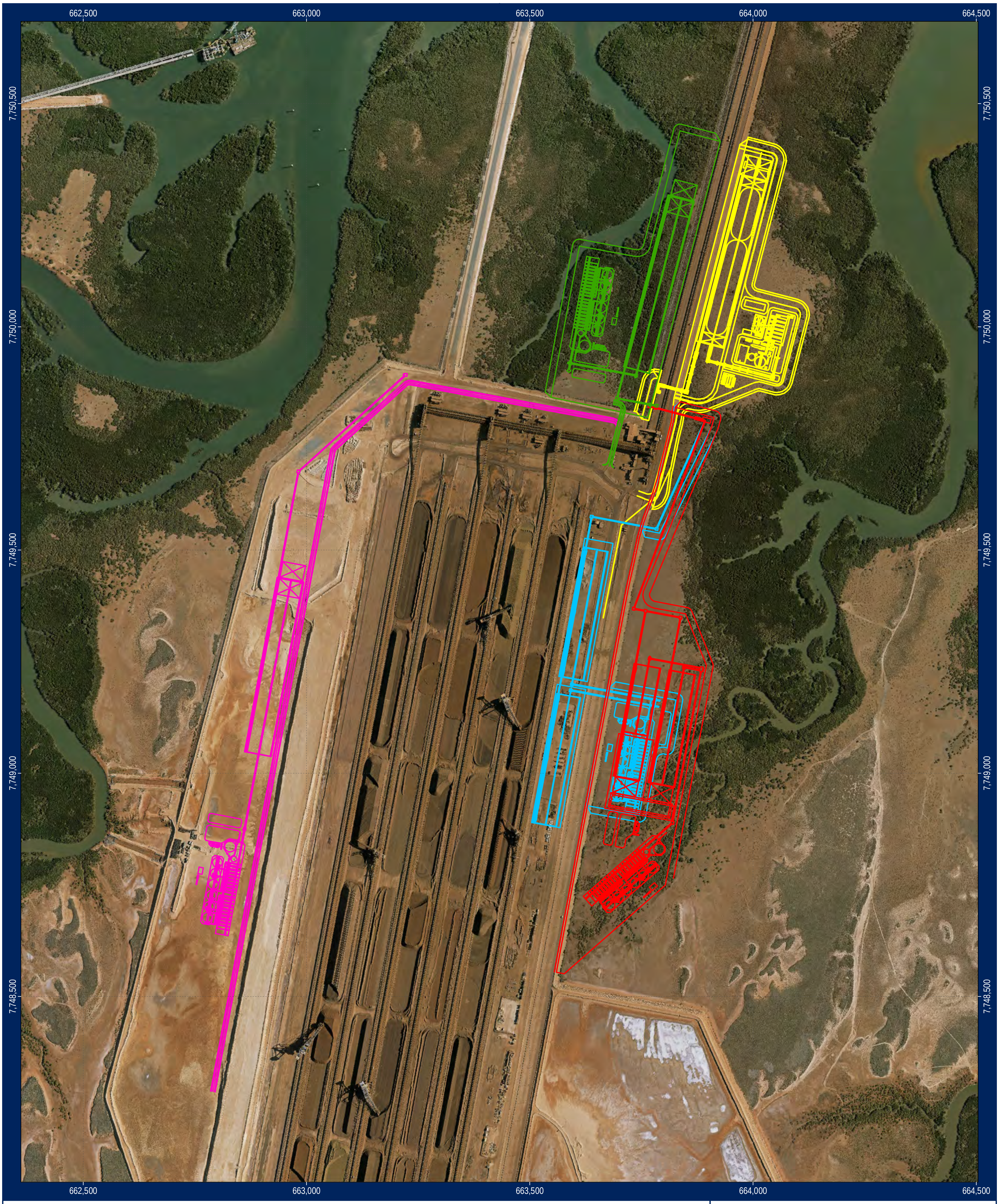
IB Operations (2015) North Star Magnetite Project Stage 2 North Star Magnetite V4 Feasibility Study Section O: Port Infrastructure. Iron Bridge Operations.

WorleyParsons (2015a) North Star Stage 2, Port Expansion Environmental Marine Studies Surface Water Impact Assessment Option E. Report prepared by WorleyParsons.

WorleyParsons (2015b) NSS2 Marine Studies Sediment Transport Impact Assessment – Option E. Report prepared by WorleyParsons.

Appendix 1 – Design Options Considered at Anderson Point



Map Legend

- Option A
- Option B
- Option C
- Option D
- Option E

Data Source(s):
All Data FMG Sourced

N W E S

0 100 200 300 400 500
metres

North Star Stage 2 Port Option Study
Options Overview

North Star - Iron Bridge Project

Requested By: Andrew Winzer
Drawn By: A. McGonagle
Revised By: amcgonagle
Approved By:
Scale: 1:8,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: 661PO_0000_MP_EN_0007.001_r0

Date: 20/05/2015
Size: A3P
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

Appendix 2: Hydrodynamic Assessment (WorleyParsons, 2015b)

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FMG

NSS2 Marine Studies

Hydrodynamic Impact Assessment - Option E

201012-00530 – CS-REP-0003

27 July 2015

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HYDRODYNAMIC IMPACT ASSESSMENT - OPTION E

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PROJECT 201012-00530 - NSS2 MARINE STUDIES

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CONTENTS

EXECUTIVE SUMMARY

The Iron Bridge Joint Venture (IBJV) is exploring options to develop the existing Anderson Point facility to support operation of the North Star Stage 2 export facility (NSS2). WorleyParsons has been commissioned by FMG to help with the facility's environmental approvals.

This report describes the Hydrodynamic Impact Assessment that was performed to identify and quantify any potential change in current and water-level conditions as a result of works related to the proposed facility (Option E).

The Hydrodynamic Impact Assessment was carried out using WorleyParsons' three-dimensional (3D) numerical hydrodynamic model of the Port Hedland region. The facility's effect on hydrodynamic conditions was assessed by applying the model to simulate conditions for both pre- and post-development. For modelling purposes, the pre-development case was defined by the port layout and bathymetry as of November 2013, updated with projects approved by the Environmental Protection Authority (EPA) in January 2015. The post-development case was based on the Option E layout. The model simulations incorporated all changes in bathymetry related to the proposed project footprint.

The numerical modelling simulations have been analysed to determine the extent of changes to the seasonal (summer and winter) flood and ebb tidal currents and water levels near the development area. A multi-faceted approach was applied to identify and quantify any modifications to the existing dynamics including:

- a peak and mean flood and ebb flow velocity assessment across the development area;
- a point comparison of flow velocity and water level at relevant locations.

Results of the assessment predict that impacts on tidal hydrodynamics, including current velocity and water-level conditions, are expected to be minimal and limited to the immediate areas near the proposed development. Key findings are:

- the largest difference in maximum flow velocities post development are localized to the east and southern boundaries of the project area, with a decrease in speed of <0.1m/s;
- the mean flow velocity is decreased at the east and south boundaries of the project area in post-development situation and the decrease is expected to be less than 0.05m/s;
- negligible differences in peak flow velocity are expected at all key output locations;
- a negligible difference in inundation patterns is expected between pre-development and post-development at the five key output locations.

ACRONYMS

3D	Three Dimensional
AHS	Australian Hydrographic Service
BoM	Bureau of Meteorology
CD	Chart Datum
EIA	Environmental Impact Assessment
DHI	Danish Hydraulic Institute
EPA	Environmental Protection Authority
FMG	Fortescue Metals Group
GDA	Geocentric Datum of Australia
Hs	significant wave height
HAT	Highest Astronomical Tide
IBJV	Iron Bridge Joint Venture
LAT	Lowest Astronomical Tide
MGA	Map Grid of Australia
MHWS	Mean High Water Spring Tide
MHWN	Mean High Water Neap Tide
MLWN	Mean Low Water Neap Tide
MLWS	Mean Low Water Spring Tide
MSL	Mean Sea Level
NSS2	North Star Stage 2
PHPA	Port Hedland Port Authority
SI	International System of Units
Tp	peak wave period
TPXO	TOPEX/Poseidon Global Tidal model
TSS	Total Suspended Sediment

1. INTRODUCTION

Iron Bridge Joint Venture (IBJV) is planning to develop the existing Anderson Point facility to support operation of the North Star Stage 2 export facility (NSS2). The key infrastructure components of the NSS2 Project include:

- Slurry Pipeline from Port Boundary to filter plant (North location);
- Dewatering Plant (East location);
- Covered stockpiles with stacker and bridge reclaimer; and
- A magnetite dedicated reclaim circuit.

The proposed development facilities are shown in Figure 1-1.

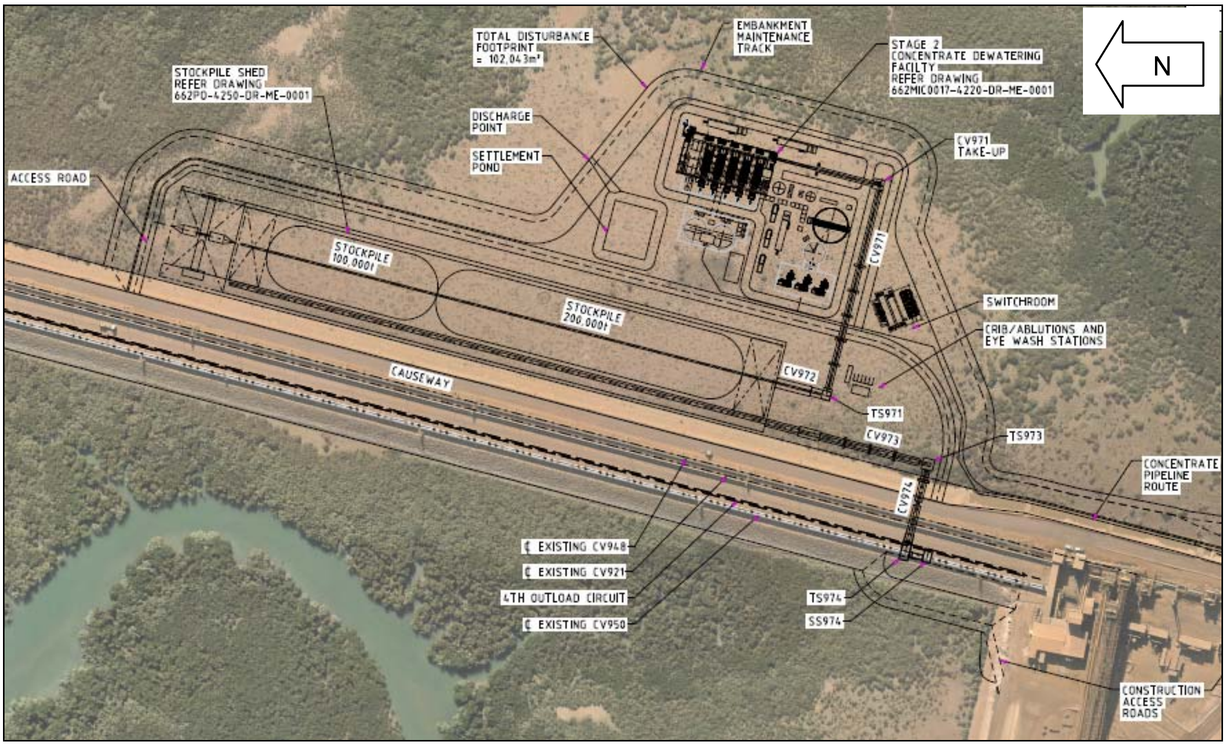


Figure 1-1: NSS2 proposed development layout, Option E

1.1 Project background

WorleyParsons has been commissioned by IBJV to conduct hydrodynamic and sediment transport impact assessment for a proposed NSS2 development on the east side of the causeway (Option E) to assess the hydrodynamic and sediment transport impact due to the proposed development.

The proposed development location is shown in Figure 1-2.

Figure 1-2: NSS2 proposed development location

To provide input to the Project's environment referral documentation, two numerical modelling studies are required to identify potential environmental effects resulting from the proposed construction work. These studies include:

- a Hydrodynamic Impact Assessment to quantify any potential change in current conditions and water levels as a result of the Project; and
- a Sediment Transport Impact Assessment (WorleyParsons, 2015) to quantify any potential change in sediment transport and morphology characteristics due to the proposed project.

This report presents the Project's Hydrodynamic Impact Assessment.

1.2 Scope of work

The Hydrodynamic Impact Assessment was undertaken to identify and quantify any potential changes in current conditions and water levels as a result of the proposed project. The assessment was based on numerical model predictions, applying the WorleyParsons 3D hydrodynamic model of the Port Hedland region.

The scope of work comprised application of the hydrodynamic model to provide water level and current conditions for both the pre- and post-development cases, highlighting any differences between the two. The model outputs were then used to identify the environmental impacts associated with observed changes in the region's hydrodynamics. The following tasks were undertaken:

- applying the WorleyParsons 3D Port Hedland hydrodynamic model using the MIKE3 FM-HD software module, including representation of both the pre- and post-development bathymetries;
- running two 14-day (one full length spring-neap tidal cycle) simulations to represent the seasonal variation (summer-winter) in wind and tidal condition for the pre- and post-development scenarios; and
- post processing of the model outcomes, including generation of spatial plots of peak and mean flow velocity across the Inner Harbour, as well as time-series of flow velocity and directions at key output locations.

The model application is described in Section 3. The Hydrodynamic Impact Assessment results, comparing model simulations for the pre- and post-development cases, are provided in Section 4.

1.3 Study datum

Water depths and levels presented in this report are referenced to Port Hedland Chart Datum (CD), unless otherwise stated, and are in units of metres.

Geographical positions are provided in the Map Grid of Australia (MGA 94) coordinate system, which employs the Geocentric Datum of Australia (GDA 94) Geodetic Datum, unless stated otherwise.

All units are in standard International System of Units (SI) unless otherwise stated, with all bearings and directions provided in degrees relative to True North.

2. CLIMATE DESCRIPTION

2.1 General Oceanography

The coastal regions of the North West Shelf near Port Hedland experience a tropical arid climate, with a quasi-monsoonal seasonal shift in wind direction and rainfall patterns.

The hydrodynamics of the coastal waters near this site, and within the Port Hedland estuary, are dominated by a large tidal range that drives strong flood and ebb tidal currents. These currents are of scales of about 1 m/s in the near shore region, and more than 1 m/s in the estuary entrances and deeper channels in the tidal creeks during peak ebb and flood tides. The tidal currents are typically aligned along local bathymetric contours. Substantial areas of drying mudflats occur along the coastline and within the Port Hedland estuary. The bathymetry is typically flat and shallow, typical of intertidal flats in the region.

In this region wind forcing is secondary to tidal forcing for local currents, although wind forcing drives residual flows along the coastline, which is an important transport mechanism for suspended sediments. The winds in summer are quite persistent from the west/north-west and typically result in a long-term drift towards the north and east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn and winter.

2.2 Tidal levels

Tides at Port Hedland are semi-diurnal and macro-tidal with a mean spring tidal range of 5.5 m (AHS 2012). Standard tidal levels are given in Table 2-1.

Table 2-1: Port Hedland tidal planes (AHS 2012)

Tidal plane	Elevation above CD (m)
HAT (highest astronomical tide)	7.5
MHWS (mean high water springs)	6.7
MHWN (mean high water neaps)	4.6
MSL (mean sea level)	4.0
MLWN (mean low water neaps)	3.3
MLWS (mean low water springs)	1.2
LAT (lowest astronomical tide)	0.0

A typical spring-neap cycle is shown in Figure 2-1 (first two weeks in April 2004), determined from harmonic analysis using the published constituents for Port Hedland (AHS 2012).

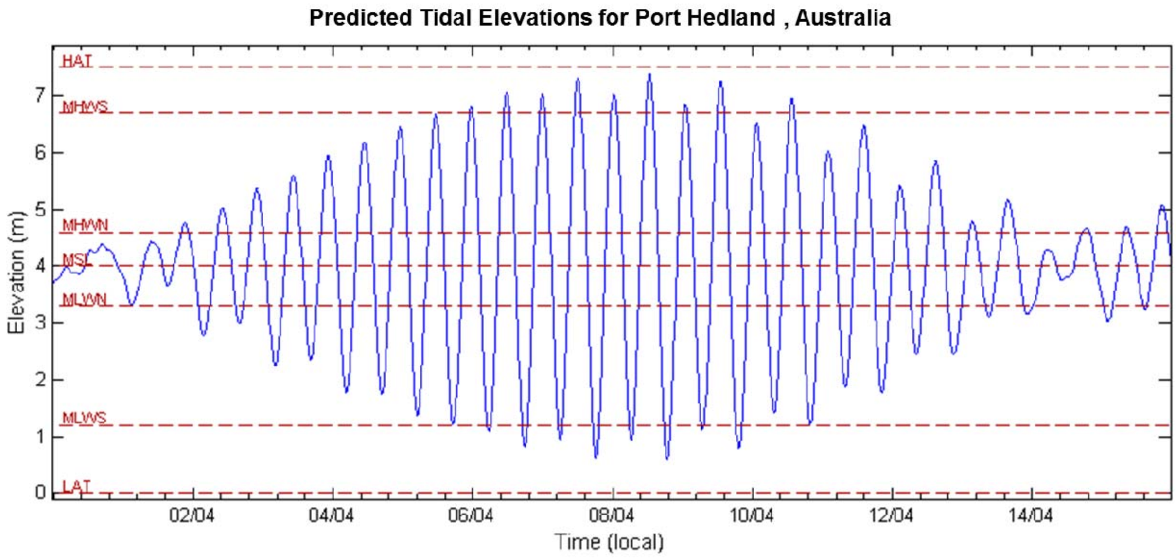


Figure 2-1: Typical spring-neap tidal cycle at Port Hedland

2.3 Winds

Wind roses presenting the seasonal variation in wind conditions at the onshore Bureau of Meteorology (BoM) weather station at Port Hedland Airport and the offshore PHPA buoy at Beacon 15 are given in Figure 2-2. The roses show the wind speed and proportion of time that winds occur from each direction sector during each season. A comprehensive long-term series of data is available at each site, with the roses based on an 18-year record (1993–2011) at Port Hedland Airport, and a 10-year record (2000–2009) at Beacon 15.

The wind roses for Port Hedland Airport show the onshore wind climate is dominated by north-westerly onshore winds and south-easterly offshore winds. Offshore at Beacon 15 (approximately 20 km north-west of the Project site), the north-westerly onshore winds and south-easterly offshore winds are also evident, with a moderately higher occurrence of westerly winds and more consistent directionality to these dominant wind directions than that at Port Hedland Airport. Recorded wind speeds at Beacon 15 are also approximately 10 to 15% higher than those measured at the airport station in most cases.

The highest winds at Port Hedland are associated with the passage of a tropical cyclone, which affect the region from November to April. High wind gusts may also be associated with thunderstorms and squalls. These can occur with limited warning but are short-lived localised events, generally lasting less than an hour.

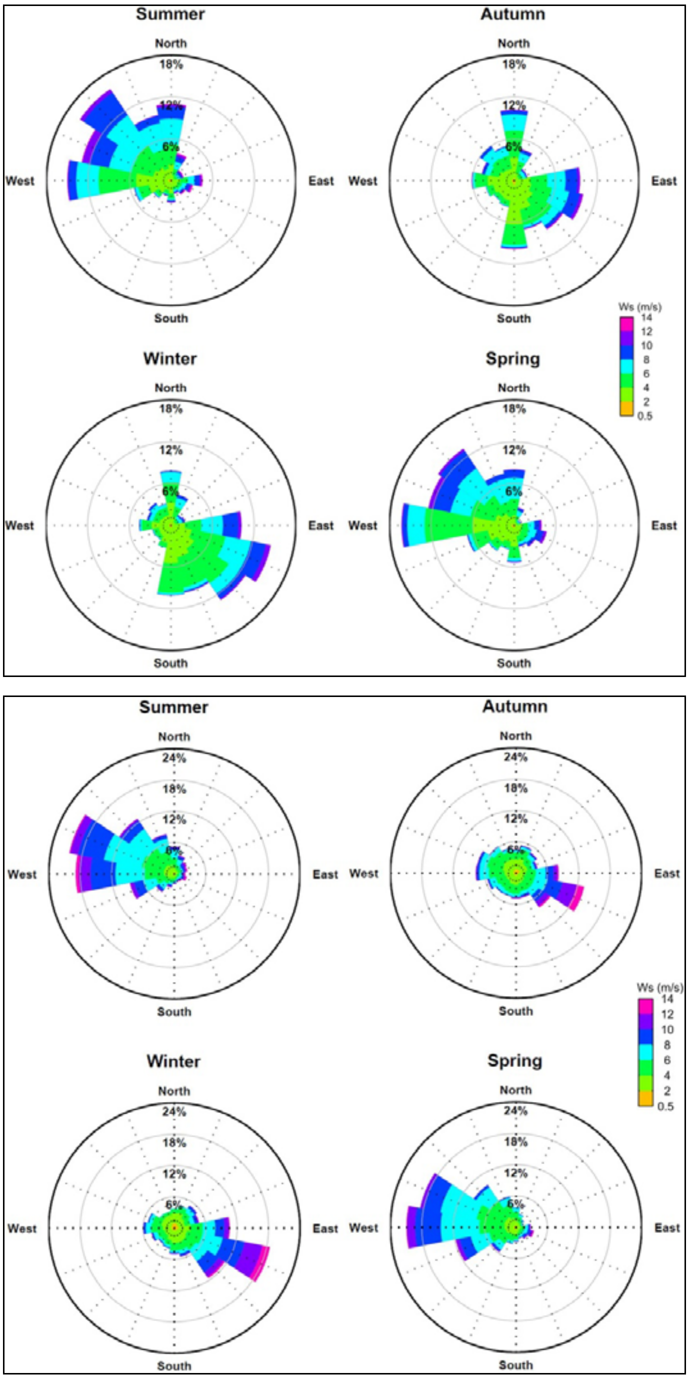


Figure 2-2: Seasonal wind roses at Port Hedland Airport (top) and Beacon 15 (bottom)

3. HYDRODYNAMIC MODEL

3.1 Introduction

WorleyParsons' existing calibrated and validated 3D hydrodynamic model of the Port Hedland region will be applied as the basis of modelling for the Hydrodynamic Impact Assessment. The model domain spans approximately 170 km from Depuch Island in the west to Larrey Point in the east, and extends from 40 to 60 km offshore. The large size of the domain allows an accurate representation of the tides offshore from Port Hedland within the model, which is integral to ensuring that tidal hydrodynamics within the Inner Harbour are correctly characterised.

3.2 Model description

MIKE 3 HD numerically solves the 3D incompressible Reynolds averaged Navier-Stokes equations subject to the assumptions of Boussinesq and of hydrostatic pressure. Thus the model consists of continuity, momentum, temperature, salinity and density equations and it is closed by a turbulent closure scheme. The free surface is taken into account using a sigma-coordinate transformation. Wetting and drying effects in intertidal areas are also accounted for in the model, which is particularly important to this study given the large tidal range at Port Hedland.

The equations are solved using an unstructured mesh applying a cell-centred finite volume method. A total of five different turbulent closures can be employed: constant eddy viscosity, Smagorinsky subgrid scale model, k model, k-e model, or a mixed Smagorinsky/k-e model. The equations allow wave radiation stress input to address surf area current due to wave breaking.

3.3 WorleyParsons existing models

WorleyParsons has undertaken numerous hydrodynamic, sediment transport and plume dispersion modelling projects in Port Hedland in the past. As part of these previous modelling studies, model calibration and validation exercises have been undertaken to improve the accuracy of the model. The data sets used for calibration and validation of the previous modelling studies included:

- physical sediment characterisation data including more than 100 particle-size distribution samples, collected from approximately 40 geochemical cores;
- Acoustic Doppler Current Profiler (ADCP) transects (Figure 3-1);
- 20 years of metocean data (current, wind and wave);

- 24 months of physico-chemical water quality data collected from more than 20 monitoring sites ;
- collection of total suspended soils (TSS) and turbidity samples to determine the relationship between TSS and turbidity within the inner port area;
- accurate determination of the extent and magnitude of actual plume dispersion using a mobile ADCP, in conjunction with a turbidity profiler during backacter and cutter suction dredging activities;
- daily *in situ* sediment deposition data collected at 11 inner port monitoring sites for approximately 18 months.

Following completion of these validation studies, WorleyParsons has a high level of confidence in the model accuracy.

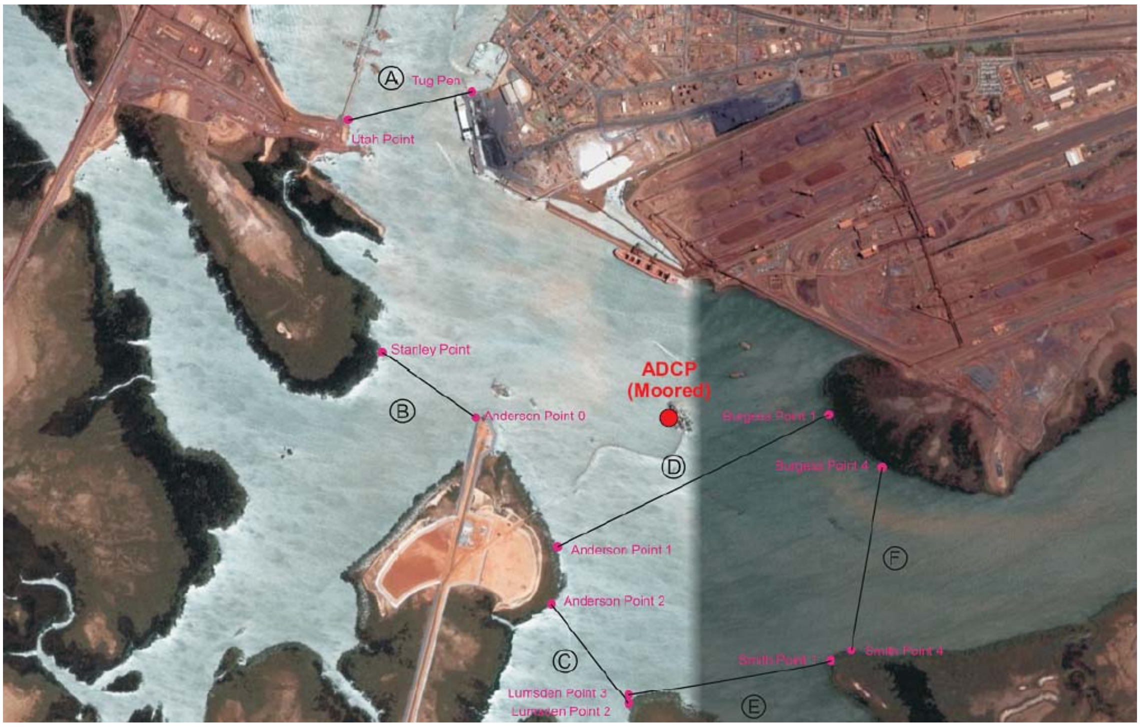


Figure 3-1: Locations of measurement data (ADCP transects and moored ADCP) for validation

3.4 Data sources

The existing WorleyParsons Port Hedland hydrodynamic model employed for this study was developed through a comprehensive investigation of data sources available within Port Hedland's Inner Harbour and offshore. The data sources used are summarised in Table 3-1.

Table 3-1: Key data sources used in the hydrodynamic model development

Data Type	Description	Year
Bathymetry	Various inshore and offshore bathymetric surveys provided by PHPA	1999–2013
Winds	Port Hedland Airport, BoM (118.6317°E, -20.3725S°).	1993–2011
	Beacon 15 (118.5167°E; -20.11667°S).	2001–2011
Water levels	Topex Poseidon Global Tide model (TPXO7.0)	
	Bedout Islet tide station (AHS 2012)	
	Depuch Island tide station (AHS 2012)	
	Offshore tide gauge (118.4667°E; -20.0167°S) – Halpern Glick Maunsell.	March to May 1998*
Currents	Offshore current meter (118.4667°E, -20.1531°S) – Halpern Glick Maunsell.	March to May 1998*
	Inner Harbour moored ADCP (118.582°E, -20.325°S) – Cardno Lawson Treloar	October and November 2007*
	Beacon 15 (118.5167°E, -20.11667°S).	2001–2011
	Beacon 16 (118.51012°E, -20.17222°S)	March 2010 – October 2012

*Previous validation with this data provided by PHPA.

3.5 Model domain and bathymetry

The large domain extent of the existing WorleyParsons Port Hedland hydrodynamic model captures the full effects of wind and tidal-induced forcing on the circulation within the coastal region near and within Port Hedland estuary. The offshore extent covers an area 60 km offshore from Port Hedland, to a water depth of approximately 30 m, and between Depuch Island in the west and Larrey Point in the east. The model domain's extent is presented graphically in Figure 3-2.

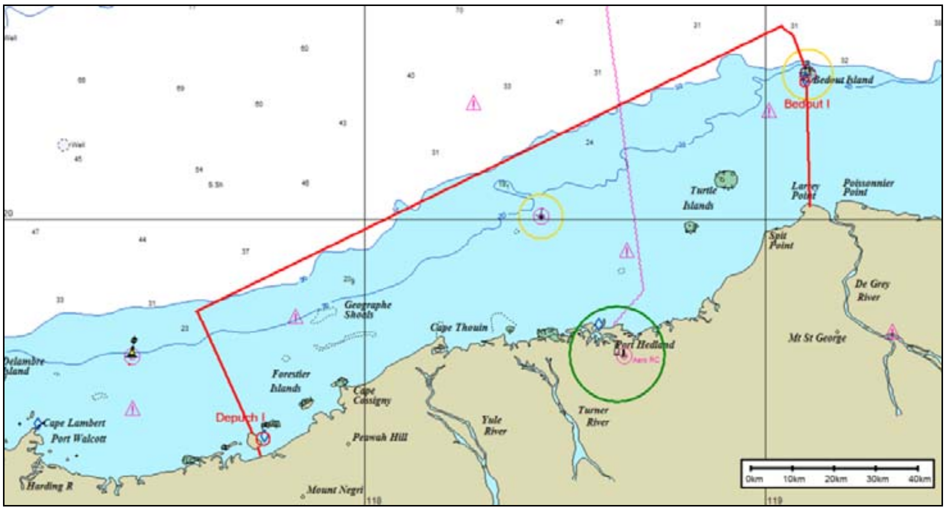


Figure 3-2: Mike 3 HD model domain (inside red boundary)

The model's local bathymetry is based on a series of hydrographic surveys, with dredging and developments included between 2000 and November 2013 including but not limited to:

1. Channel and harbour maintenance dredging
2. Hunt Point dredging and development
3. Utah Point dredging and development
4. Anderson Point dredging and development
5. Harriet Point dredging and development
6. Nelson Point dredging and development
7. South West Creek dredging and development
8. Stingray Creek dredging
9. Near shore – Offshore outer harbour survey

In addition, for the present study the existing model bathymetry was supplemented with data from the Port Hedland Outer Harbour survey (Fugro, 2012) provided by IBJV.

Future approved developments have been added onto the pre-development bathymetry in their full extent of approval in order to be in line with the guidelines in EPA (2009) on cumulative impact assessment. These include:

10. Hunt Point Marine Precinct (BHPBilliton)
11. Stingray Creek Small Vessel Cyclone Mooring Protection Facility (PPA)

12. South West Creek Dredging and Reclamation (PPA)
13. Lumsden Point General Cargo Facility (PPA)

Outside this area bathymetry data is extracted from the C-MAP digital chart database (DHI 2011). This bathymetry data was applied to represent the pre-development case in the model. For the post-development case the model bathymetry was adjusted to reflect proposed configuration described in Section 3.8.1.

The hydrodynamic model uses an unstructured computational mesh which allows for higher resolution around areas of specific interest or that have complex bathymetries or morphologies. Computational length scales of the triangles range from 2000 m at the coarsest scale down to 10 m at the finest scale, to minimise run time while still giving a suitable level of accuracy in results for the assessment. To maintain computational accuracy, it is ensured that the mesh traversed this length scale range by no more than a factor of two across the entire computational domain (i.e. smaller cells are no smaller than 50% of the larger adjacent cell).

A mesh showing the model bathymetry is shown in Figure 3-3. The mesh shows the pre-development bathymetry.

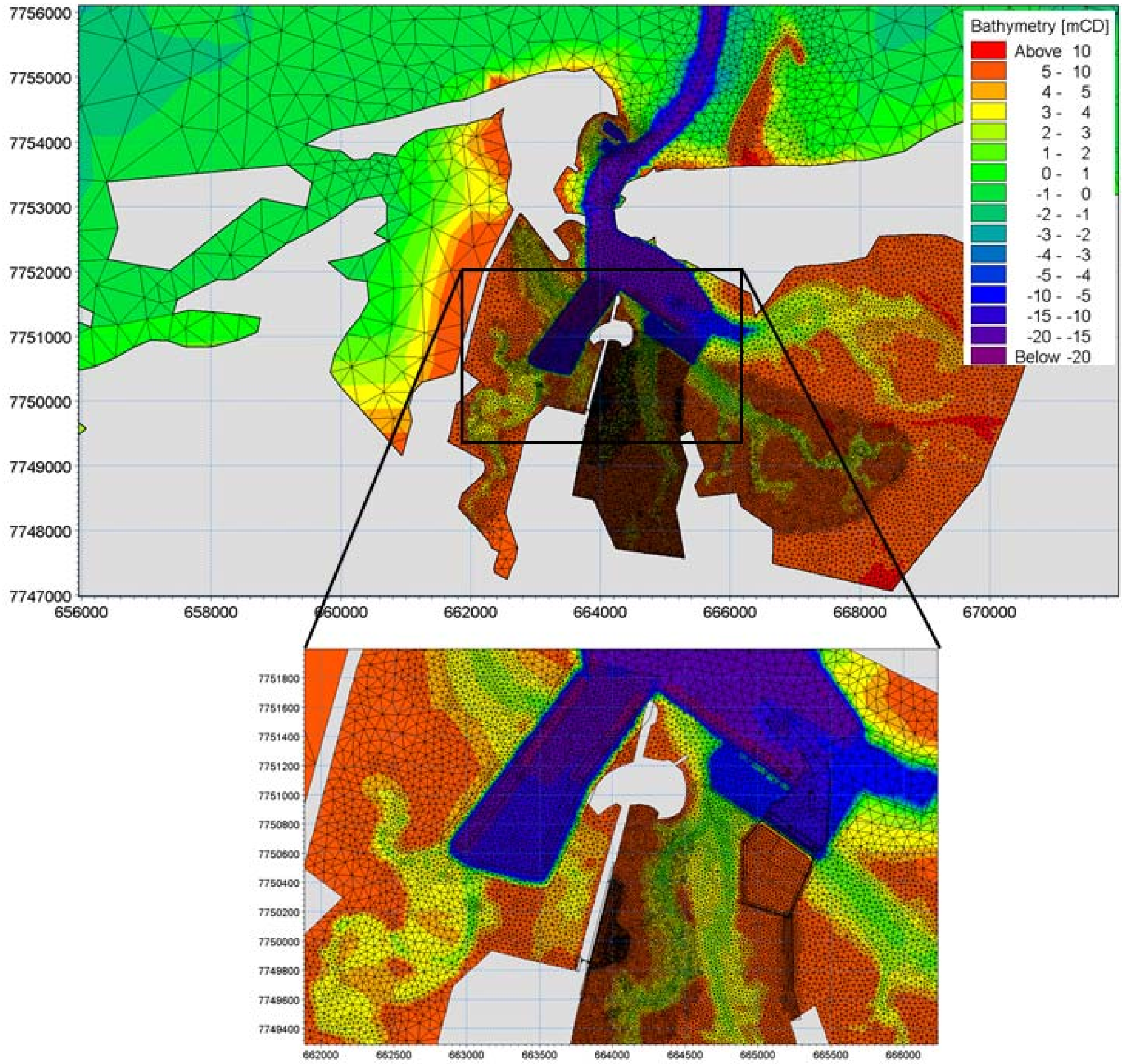


Figure 3-3: Model mesh showing pre-development model bathymetry, i.e. existing bathymetry updated with future stages of approved developments

In the vertical domain of the model, a sigma layer system was adopted, whereby the same number of vertical layers is present at each point of the computational domain irrespective of water depth. The sigma layers were set as equal across the model domain, with each layer spanning 20% of the local water depth. Five layers were considered appropriate to resolve the 3D hydrodynamics both offshore and near the project site, with these layers spread evenly across the vertical space.

3.6 Marine forcing functions

The main hydrodynamic driving forces at the sites can be divided into tidal and non-tidal processes. Compared with the tidal and wind forcing, the hydrology of the adjacent watershed (e.g. river discharge) plays a minor role in ambient currents. The local meteorological conditions (e.g. wind) are expected to contribute to surface currents, with these effects having more influence during slack and neap tide periods. Although waves are expected to influence the re-suspension of sediments, and are thus included in the Sediment Impact Assessment (WorleyParsons, 2015) their influence on the current regime is relatively insignificant compared with the dominant role that tides play on the Port Hedland region's hydrodynamics. As such, waves are not considered to be a significant forcing mechanism in the hydrodynamic model and are thus omitted. Also not included are ocean currents, which are unlikely to affect the hydrodynamic process within the Inner Harbour.

3.6.1 Tides

Tidal data at the hydrodynamic model's ocean boundaries are taken from the TPXO7.0 dataset. This is a global database of harmonic tidal constituents published by the US National Climatic Data Center derived from the 10-year TOPEX/Poseidon satellite mission. The astronomical tides are included on all the open boundaries by spatial interpolation of the tidal constituent data (amplitude and phase) provided by the TOPEX/Poseidon global tidal altimetry data (TPXO7.0). The eight dominant semi-diurnal and diurnal tidal constituents are used in the simulations, in addition to the yearly constituents (Sa and Ssa), given they account for most of the tidal amplitude.

At the model coastal boundaries, the TOPEX tidal data is supplemented with predictions at local tide stations, available in the Australian tide tables (AHS 2012). Constituents derived from the Depuch Island tidal station, located on the western boundary, are included in conjunction with the TPXO7.0 model data to generate an interpolated tide forcing along the western boundary. Tidal forcing on the eastern boundary will be generated by interpolation of the Bedout Islet tidal constituents and the TPXO7.0 data.

On all the open boundaries, the predicted water levels are site specific and vary in local time and along the boundary line. At the points along the boundary where water is flowing into the model domain, the flow is forced perpendicular to the boundary orientation, while at points where the water is flowing out of the model domain, the flow direction is extrapolated from the nearest points inside the model domain.

The model boundaries and location of the Bedout Islet and Depuch Island tidal stations are shown in Figure 3-2.

3.6.2 Ambient winds

Ambient wind conditions are analysed using offshore wind measurements at the Beacon 15 buoy, as well as land-based measurements from the Port Hedland Airport BoM station, 6 km inland of the Project site. All datasets have been interrogated and it appears that the consistent measurements at Beacon 15 during the selected simulation period are the most appropriate for hydrodynamic model forcing because they better represent local wind conditions over water.

3.7 Model set-up parameters

Key model parameters and formulations are summarised in Table 3-2.

Table 3-2: Key hydrodynamic model parameters and formulations

Parameter	Description	Value
Timestep	Maximum computational timestep	600 seconds
	Minimum computational timestep	0.01 seconds
Eddy viscosity	Smagorinsky formulation, constant	0.4 m^2/s
Bed resistance	Roughness height	Mangrove area: 0.3 m Remainder area: 0.065 m
Approximate spatial resolution	Open boundaries	2000 m
	Offshore and coastline >10 km from project site	500–2000 m
	Shoal areas and offshore <10 km from site	100–600 m
	Development site, navigation channel and Inner Harbour	10–120 m

3.8 Simulation scenarios

3.8.1 Project Layout

Two cases were set up ie., pre-development and post development conditions:

- **Case 0**: The pre-development case against which potential impacts are evaluated and quantified. This case includes the existing bathymetry updated with future stages of approved developments at Hunt Point, SW Creek, Lumsden Point, and Stingray Creek.
- **Case 1**: The post-development situation by including the project layout as shown in Figure 3-4.

Figure 3-4: Case 1 – post-development situation (Option E)

3.8.2 Periods of Simulation

The WorleyParsons Port Hedland hydrodynamic model was applied to simulate current velocities and water levels across the region for two seasonal scenarios. The seasonal scenarios represent typical summer and winter seasonal variation in wind and tidal components. The greatest hydrodynamic impacts expected during the seasonal scenarios have been ascertained from the output.

Scenarios are listed in Table 3-3. Winter and summer scenarios were run for both the pre-development case and post-development cases. Each scenario was run for a 14-day period to represent a complete tidal cycle.

Table 3-3: Hydrodynamic model simulation scenarios

Run	Seasonal Scenario	Period of simulation (excluding warm-up period)	Bathymetry
0-S	Summer	12:00 AM 02/01/2004 to 12:00 AM 16/01/2004	Case 0
0-W	Winter	12:00 AM 01/07/2004 to 12:00 AM 15/07/2004	Case 0
1-S	Summer	12:00 AM 02/01/2004 to 12:00 AM 16/01/2004	Case 1
1-W	Winter	12:00 AM 01/07/2004 to 12:00 AM 15/07/2004	Case 1

4. HYDRODYNAMIC IMPACT ASSESSMENT

This section describes the comparative assessment of predicted changes in current and water-level conditions pre- and post-development.

A detailed cross comparison was performed between the pre- and post-development cases for each of the modelled scenarios, along with a quantitative analysis to determine the magnitude of the expected hydrodynamic changes on locations immediately adjacent to the Project site. It was considered appropriate to adopt a multi-faceted approach to comprehensively quantify the impact of the development, with the separate components of this analysis comprising:

- a peak and mean flow velocity analysis;
- a point location analysis; and
- a mangrove inundation analysis.

The results from each of these separate analyses are presented in sections 4.1 to 4.2.

4.1 Flow velocity analysis

4.1.1 Approach

A spatial analysis of the representative current field, maximum and mean flood and ebb flow velocities were undertaken to analyse typical flow patterns within the adjacent waters to the proposed development, and to quantitatively assess its impact on the pre-development flow regime.

Representative current fields are presented as spatial flow velocity plots showing a snapshot of the flow at the time of peak current at the Project site for both flood and ebb tidal current.

The maximum flow velocity is calculated as the spatial maximum current speed (i.e. maximum current observed at each grid cell) during the peak flood and ebb tides of the simulation period.

Mean flow velocity is similarly calculated as the spatial mean current speed (i.e. mean current observed at each grid cell throughout the entire water column) during the peak flood and ebb tides through the simulation period.

4.1.2 Seasonal variation in current conditions

To assess the seasonal variation in the current conditions from the model results, depth averaged current speeds were extracted from the model results at one location (GDA94

MGA50, 664000E 7753000N) in the Port Hedland entrance channel. Figure 4-1 presents the predicted current conditions for each season for the pre-development case. For comparative purposes, the results are plotted across an identical timeframe (a 12-hour tidal cycle) for the highest spring tide observed to occur in each of the two seasons. The plot shows a consistent variation in current speed through the tidal cycle in each season, with the highest speeds predicted to occur during Winter. In terms of hydrodynamic impact, modelling results are therefore presented for the Winter scenario, which represents the higher peak currents and greater potential hydrodynamic impact than the Summer scenario.

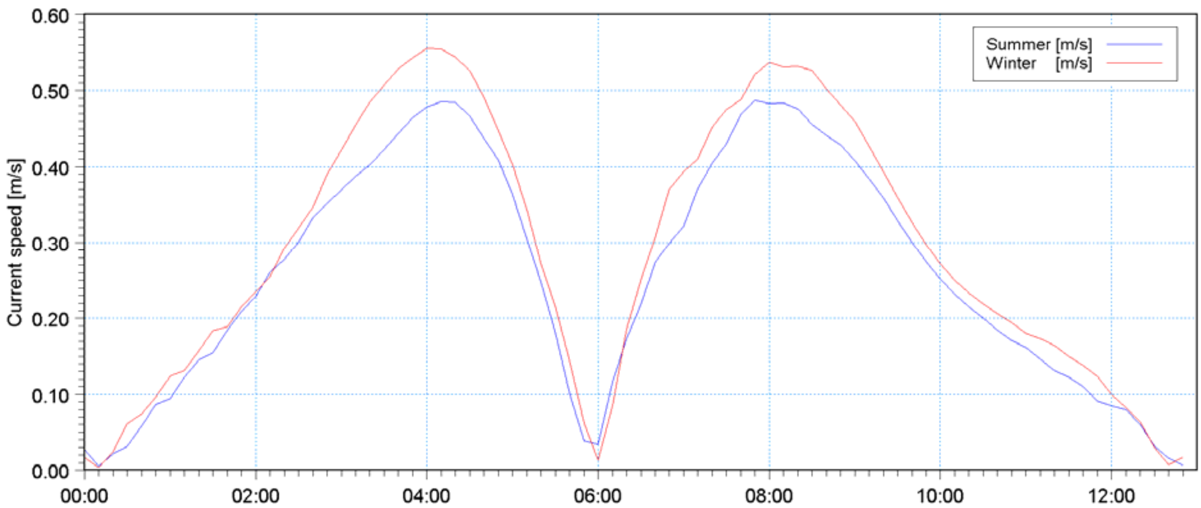


Figure 4-1: Summer-Winter current speed comparison

4.1.3 Representative current field

The typical representative current field pattern plots are shown in Figure 4-2 (Case 0), Figure 4-3 (Case 1). These plots compare the flow regime for peak ebb and flood currents for the different scenarios. The current field pattern plots for both ebb and flood show no changes including current speed and direction outside of the project area. Changes within the project area, with plots zooming in on the project area, are discussed in the next section.

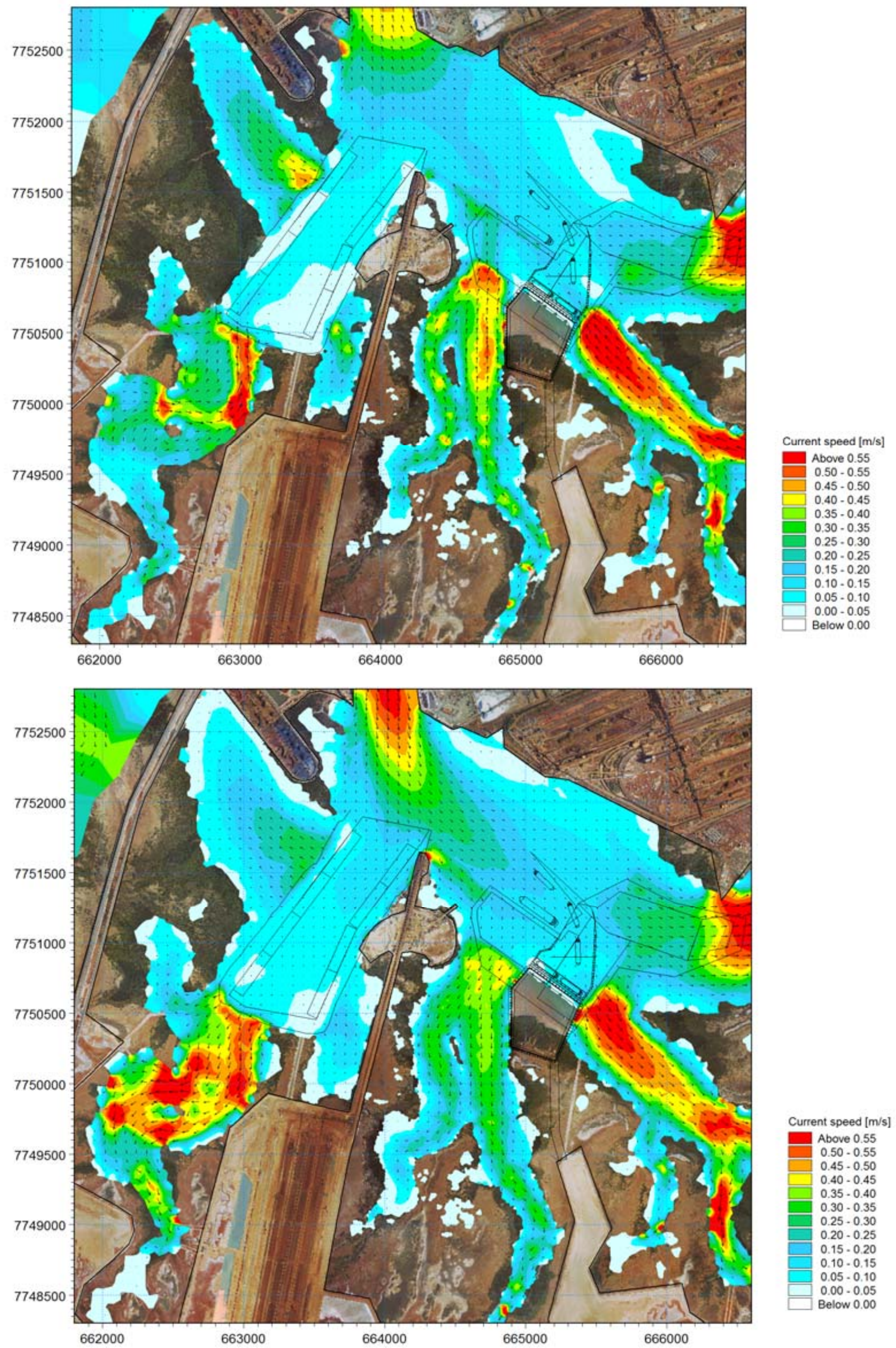
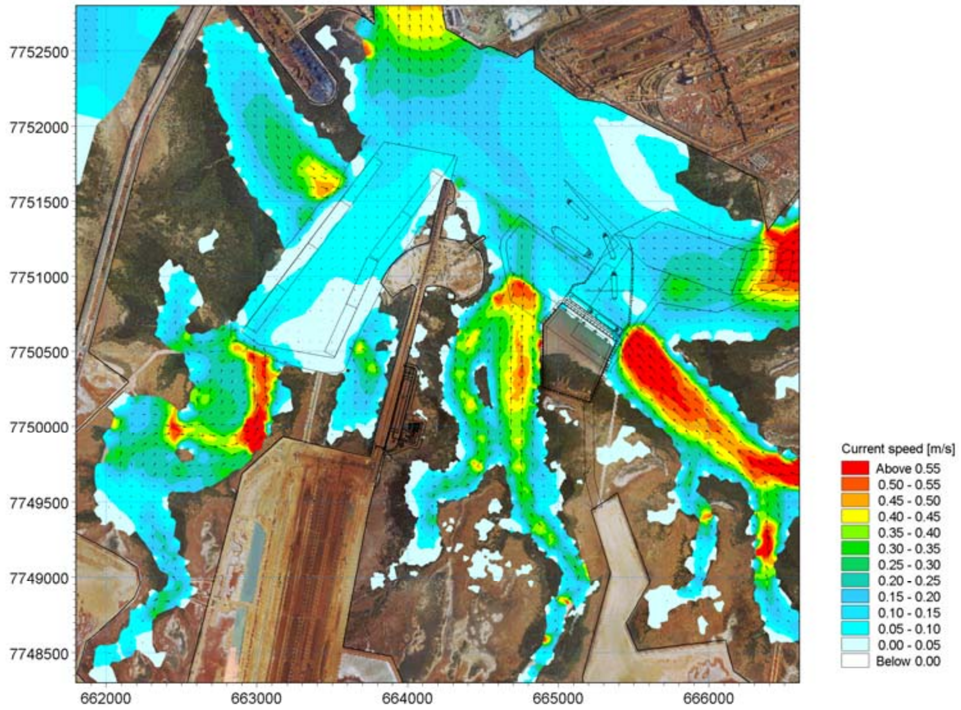


Figure 4-2: Representative current field, Case 0: Ebb (top) and Flood (bottom)



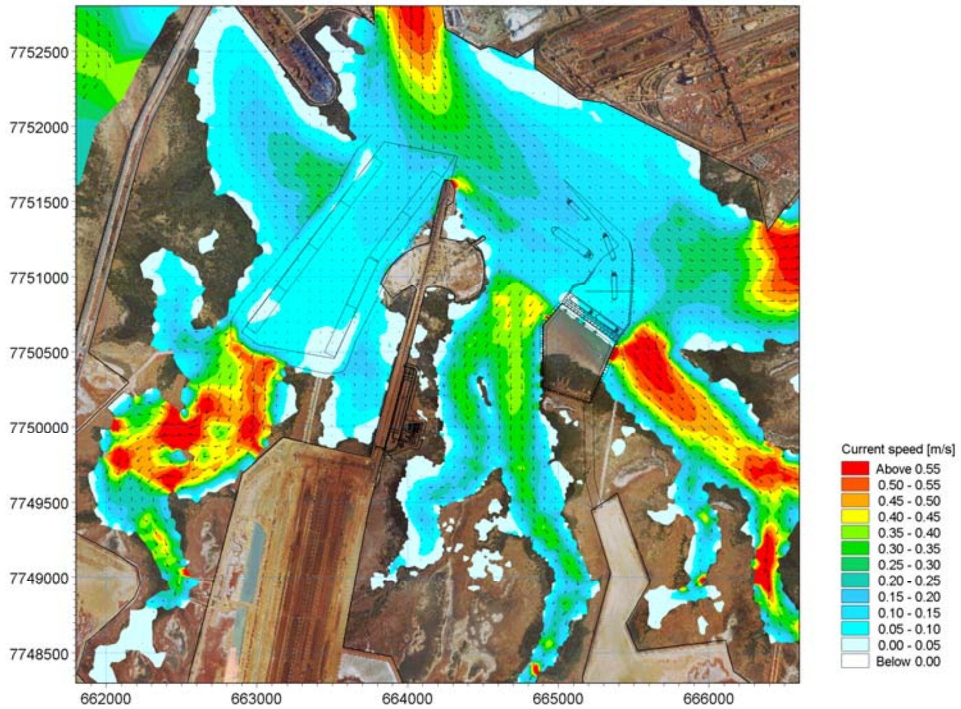


Figure 4-3: Representative current field, Case 1: Ebb (top) and Flood (bottom)

4.1.4 Impact on maximum current velocity

The maximum current velocity difference plots, showing change in maximum current speed between Case 1 and Case 0, for both the flood and ebb tide are presented in Figure 4-4. These plots highlight the impact on maximum current patterns (flood and ebb) of the proposed development (Case 1 vs. Case 0) across the proposed construction area as predicted in the modelled scenarios. In the plots, the footprint of the project is shown in grey colour since results inside the footprint are not meaningful.

The plots indicate:

- a negligible difference in maximum current velocity outside of the project area of the proposed development. This is expected due to the relatively small size of the proposed development compared to the size of the south creek, and the relative height of the zone where the proposed development is planned (above 6mCD, the higher part of the tidal zone);
- a decrease in maximum current velocity between Case 1 and Case 0 of less than 0.1m/s at the east and south boundaries of the project area;
- slight increase in maximum current velocity between Case 1 and Case 0 of <0.05m/s adjacent to the north-east corner of the development.

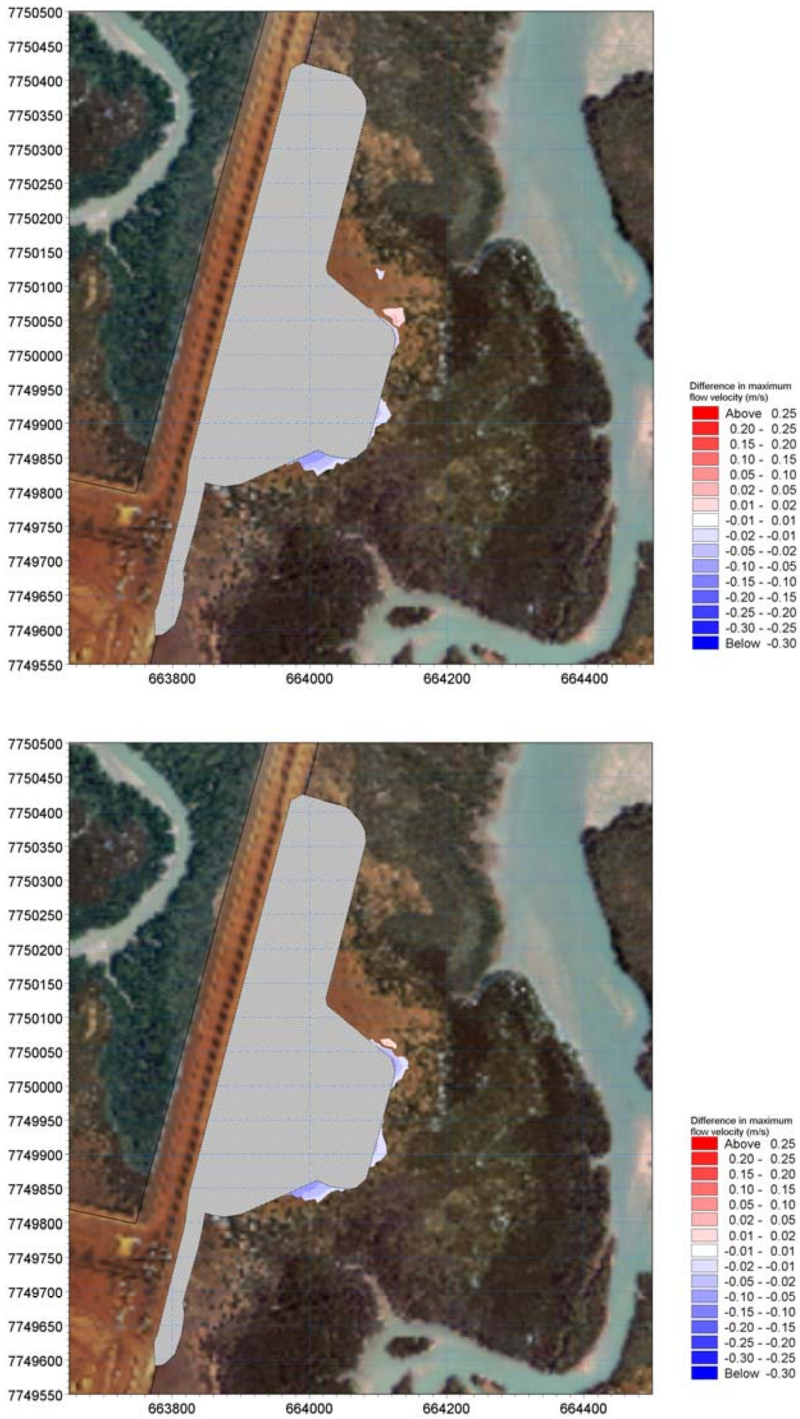


Figure 4-4: Difference in maximum flow velocity post-development (Case 1 vs. Case 0): ebb (top) and flood (bottom)

4.1.5 Impact on mean flow velocity

Velocity plots showing the mean flow velocity for ebb and flood tidal cycles are presented in Figure 4-5 and Figure 4-6 and the difference plot zoomed in on the project area is shown in Figure 4-7. In Figure 4-7, the footprint of the project is shown in grey colour.

The difference plots show that:

- both ebb and flood, there are no changes in mean flow velocity outside of the project area and a minor decrease (<0.05m/s) at the east and south boundaries of the project area;
- a small increase in the mean flow velocity (<0.02m/s) occurs at a localized area adjacent to the north-east corner of the development during ebb currents.

These results are in line with the impact on peak flow velocity as discussed in section 4.1.4, albeit with smaller absolute values for flow velocities and flow velocity differences.

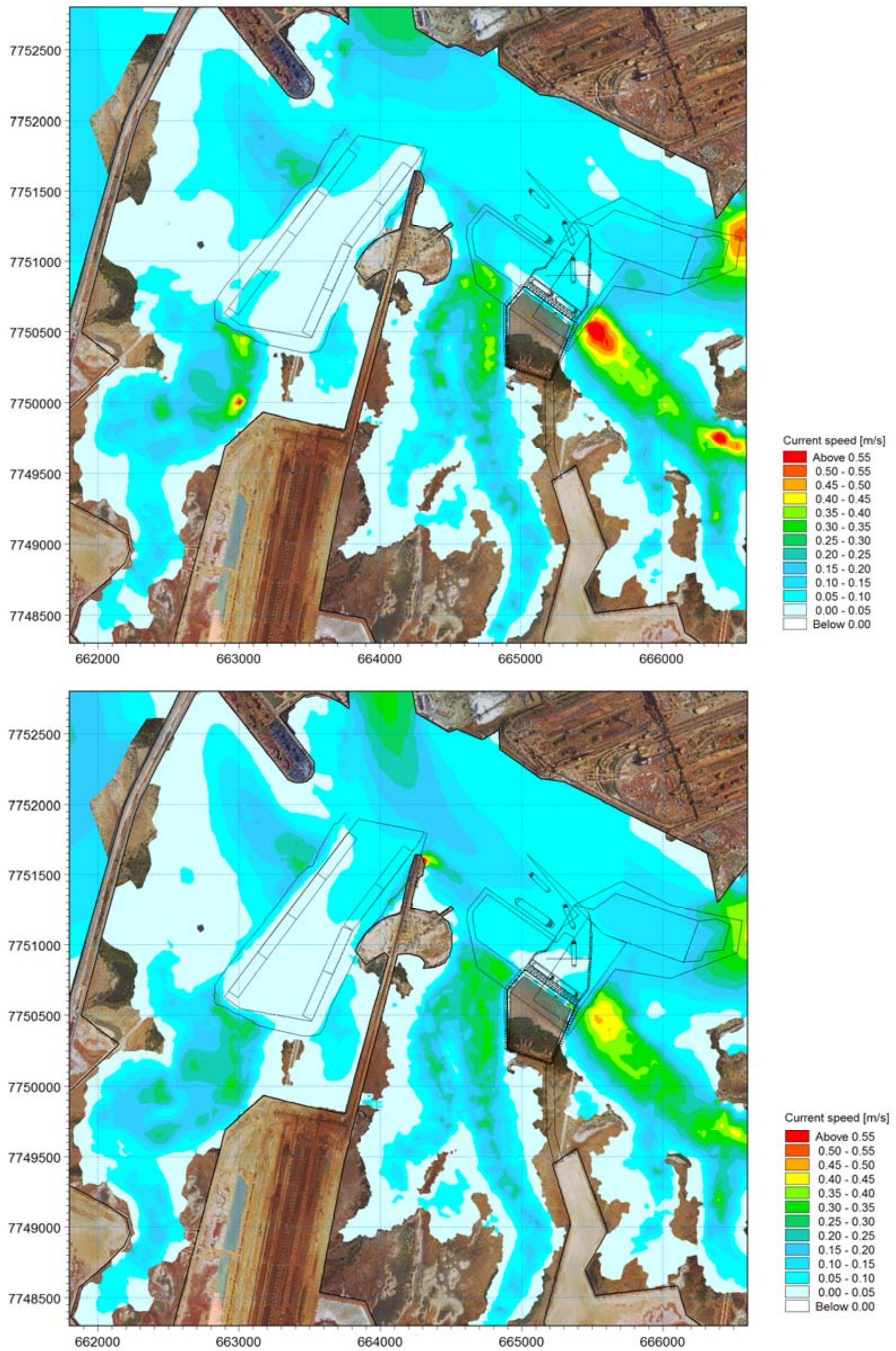
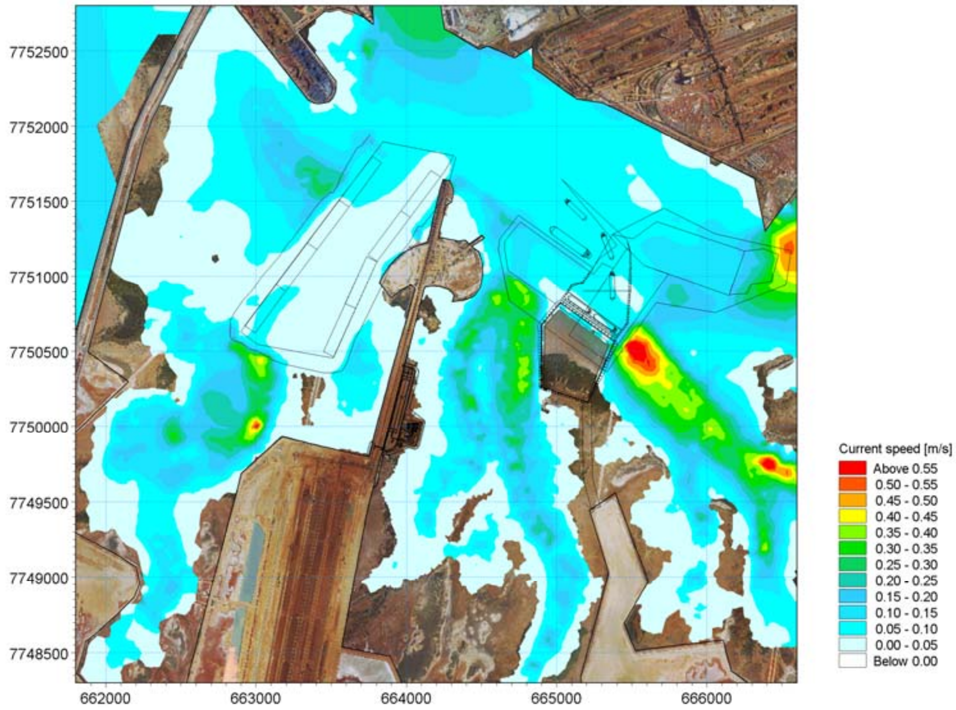


Figure 4-5: Mean flow velocity Case 0: Ebb (top) and Flood (bottom)



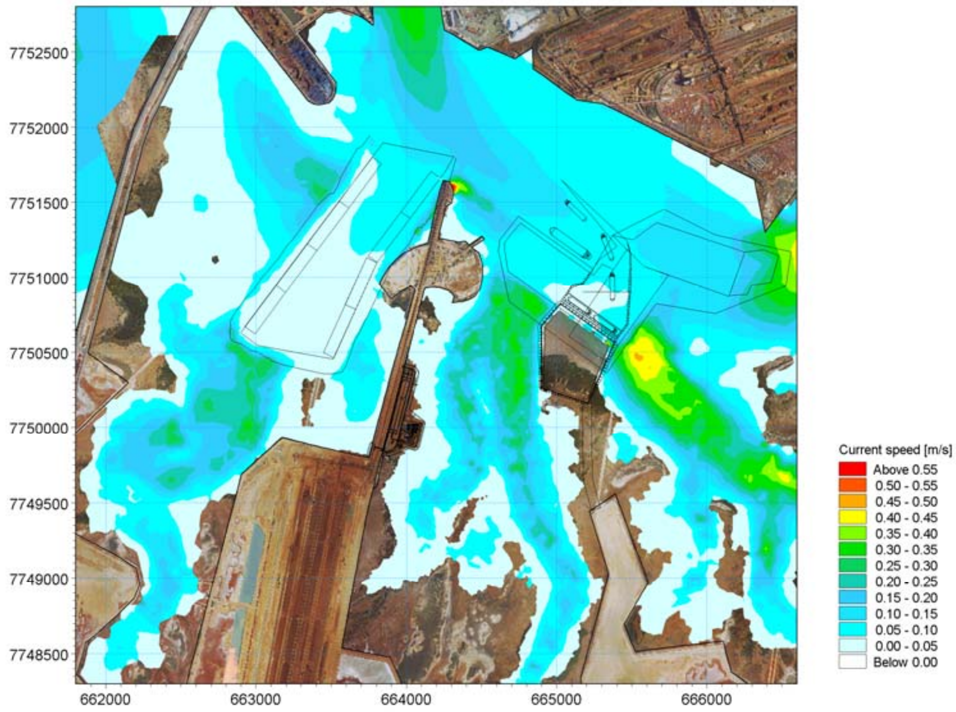


Figure 4-6: Mean flow velocity Case 1: Ebb (top) and Flood (bottom)

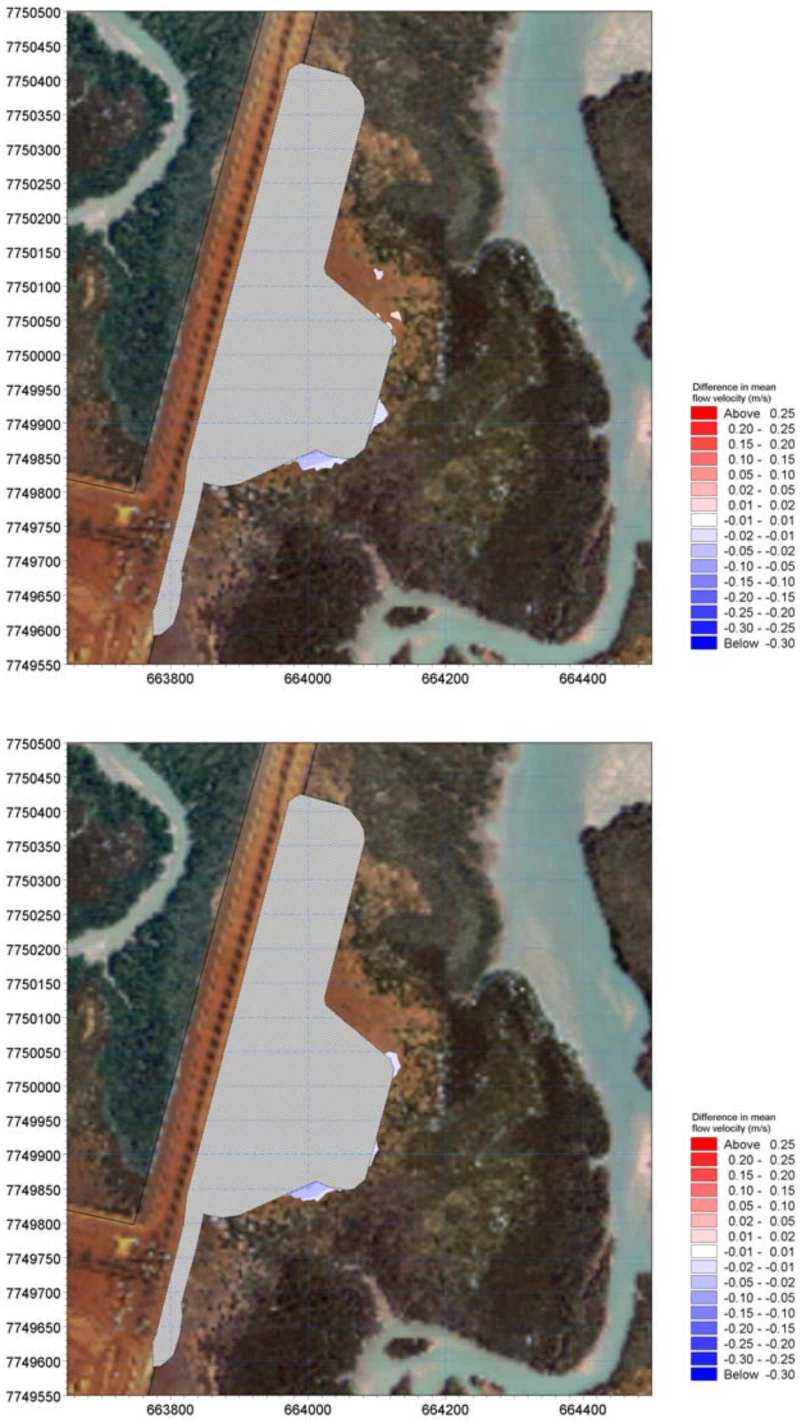


Figure 4-7: Difference in mean flow velocity post-development (Case 1 vs. Case 0: ebb (top) and flood (bottom)

4.2 Analysis at key output locations

A point location analysis was carried out to assess the impact of the development on hydrodynamic conditions at locations of sensitive environmental receptors near the development area. Five key output locations, which have different seabed and creek features (eg. divergence, bends, creek ends) in the vicinity of the project area, were selected for the analysis as shown in Figure 4-8. Key output point 5 is located adjacent to the dredged basin and output points 1, 2, 3, and 4 are located within the creek adjacent to the mangrove area. Different points may undergo different hydrodynamic conditions depending on the location. Coordinates and sea bed levels of these points are presented in Table 4-1.

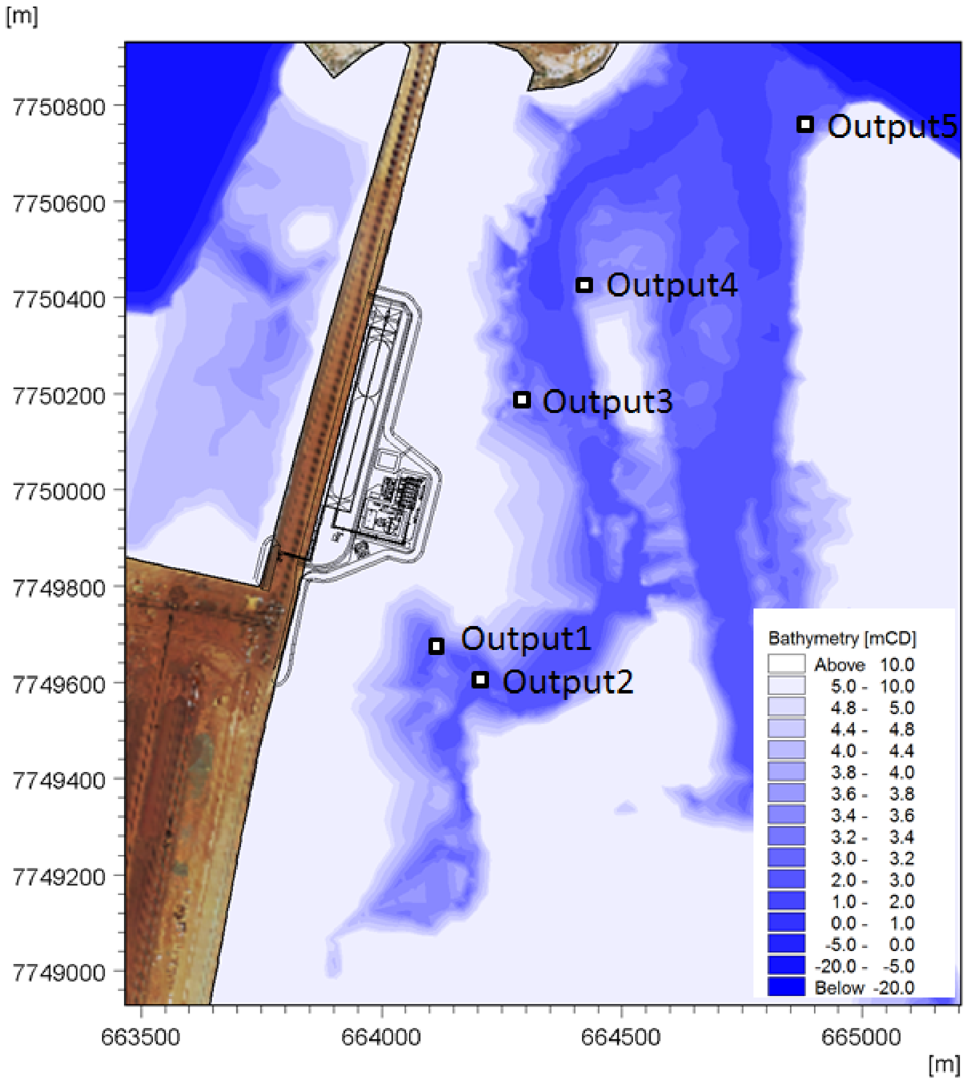


Figure 4-8: Five key output locations near the development area

At each key output location the current speed and direction were extracted and plotted for the 14-day tidal cycle simulated. Time series plots showing peak flow velocities and flow direction are shown in Figure 4-9 to Figure 4-13.

A summary of the co-ordinates of each key output location and the predicted impact of the development on peak current speeds is given in Table 4-1.

The results suggest that negligible differences in peak flow velocity are expected all key output locations, with a predicted change in peak flow velocity of less than 0.01 m/s.

Table 4-1: Summary of impact on peak current speeds at key output locations

Site	Easting	Northing	Bed Level (mCD)	Case 0 peak current speed (m/s)	Case 1 peak current speed (m/s)	Difference in peak current speed (Case 1 - Case 0)	
						(m/s)	%
1	664111	7749668	+3.1	0.34	0.34	<0.01	<0.1
2	664208	7749601	+2.6	0.41	0.41	<0.01	<0.1
3	664284	7750189	+3.6	0.30	0.30	<0.01	<0.1
4	664427	7750426	+3.5	0.36	0.36	<0.01	<0.1
5	664879	7750765	+3.0	0.56	0.56	<0.01	<0.1

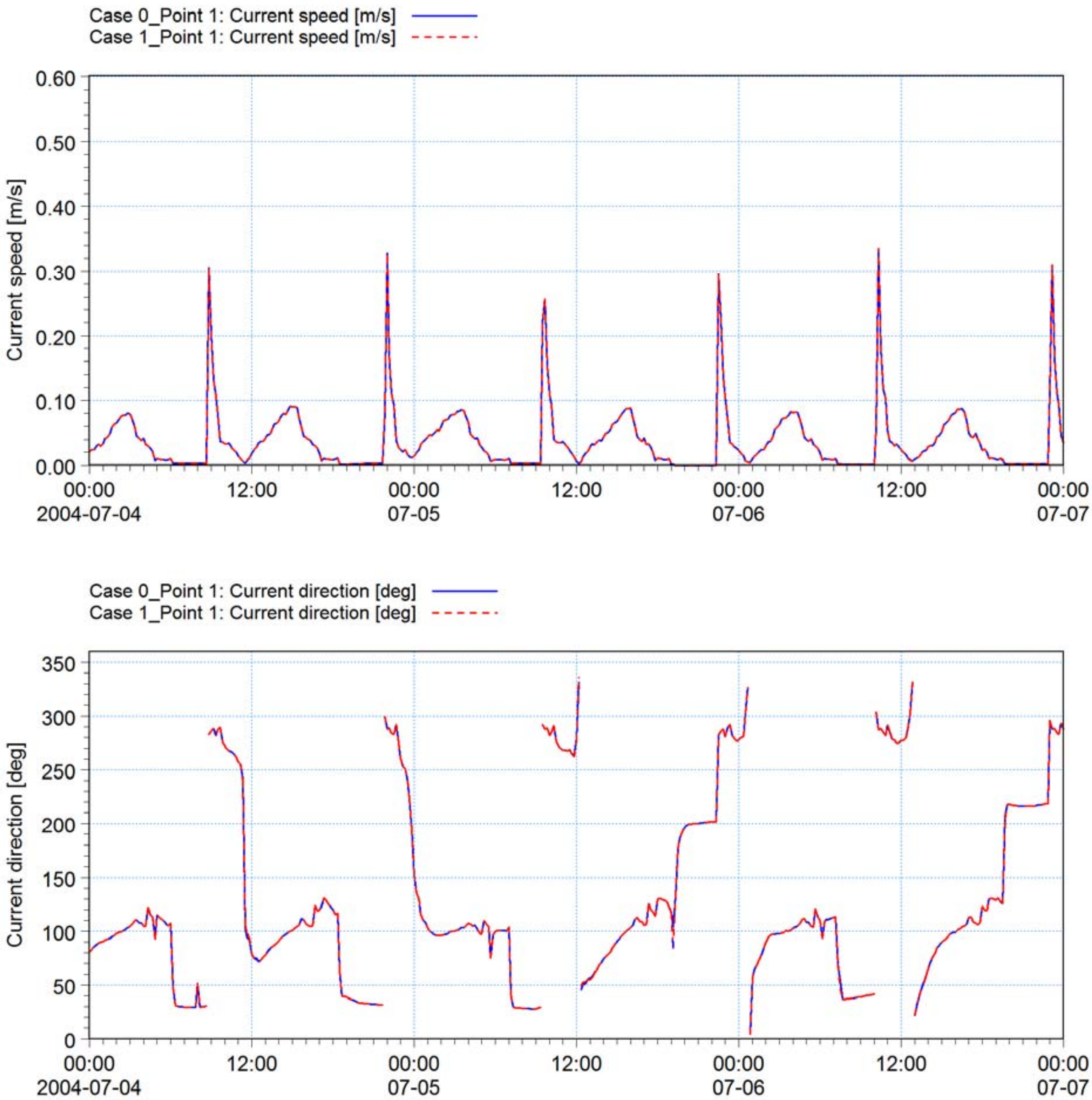


Figure 4-9: Comparison of current speed and direction for Case 0 and Case 1at key output location 1

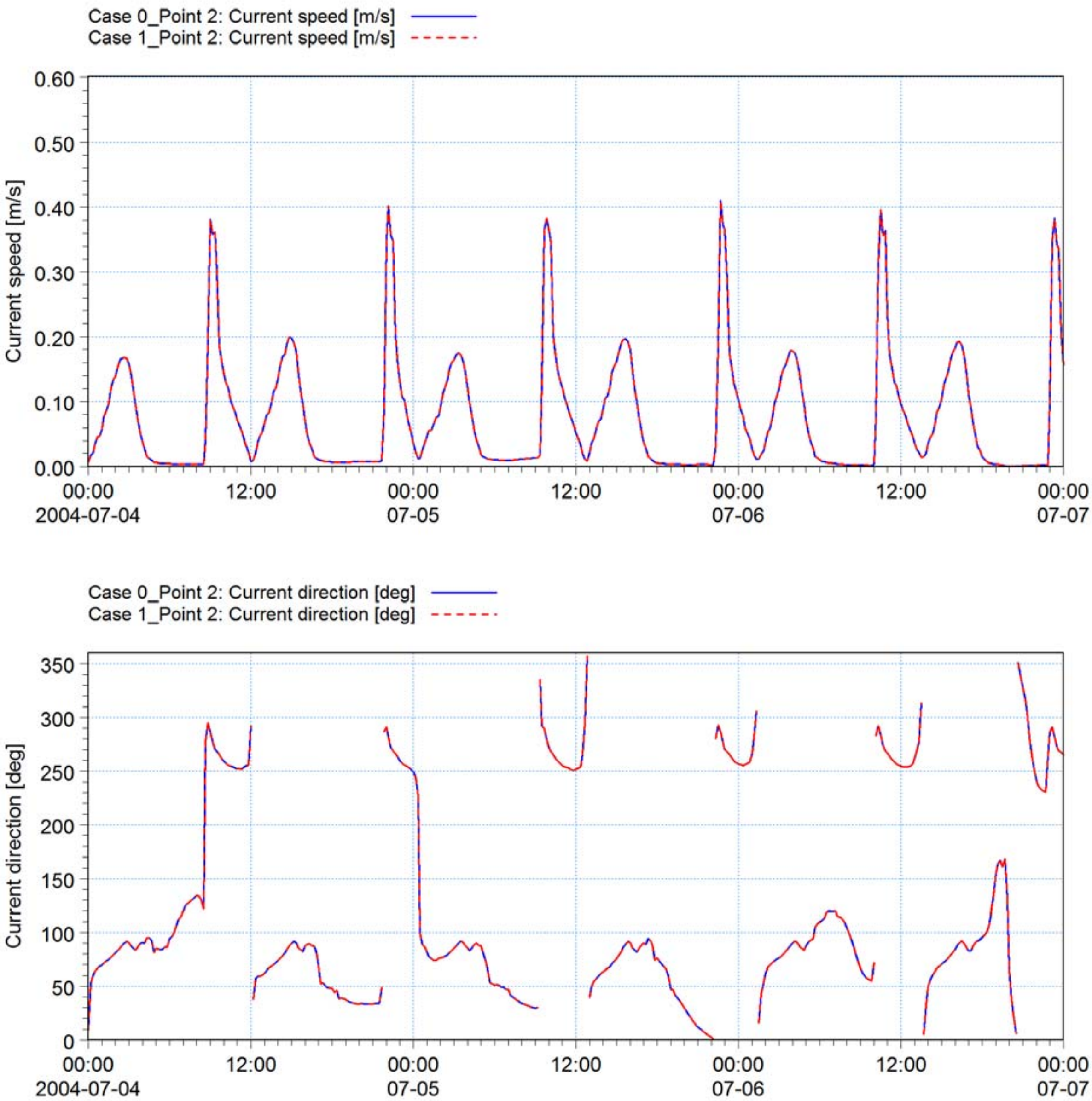


Figure 4-10: Comparison of current speed and direction for Case 0 and Case 1 at key output location 2

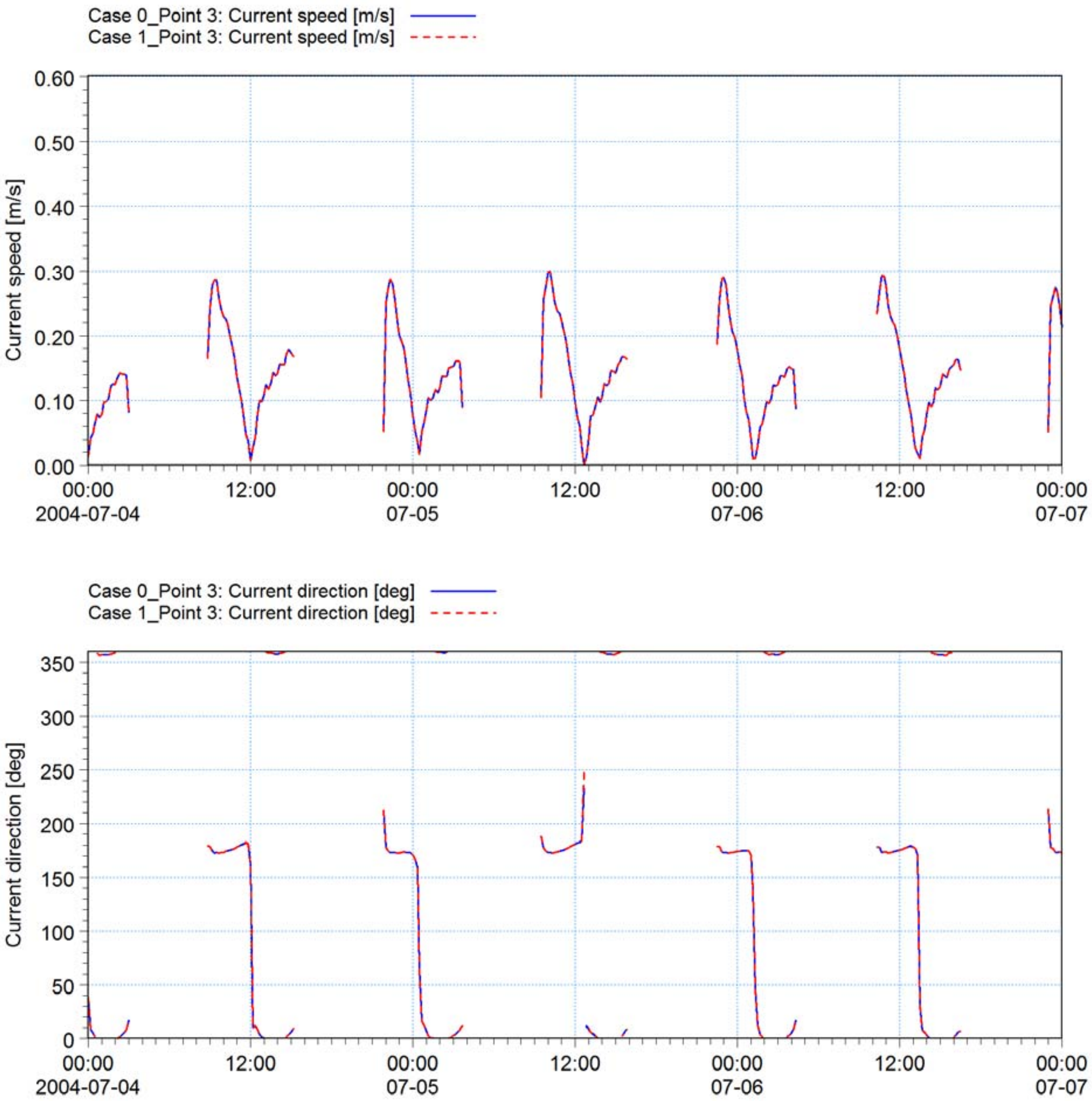


Figure 4-11: Comparison of current speed and direction for Case 0 and Case 1 at key output location 3

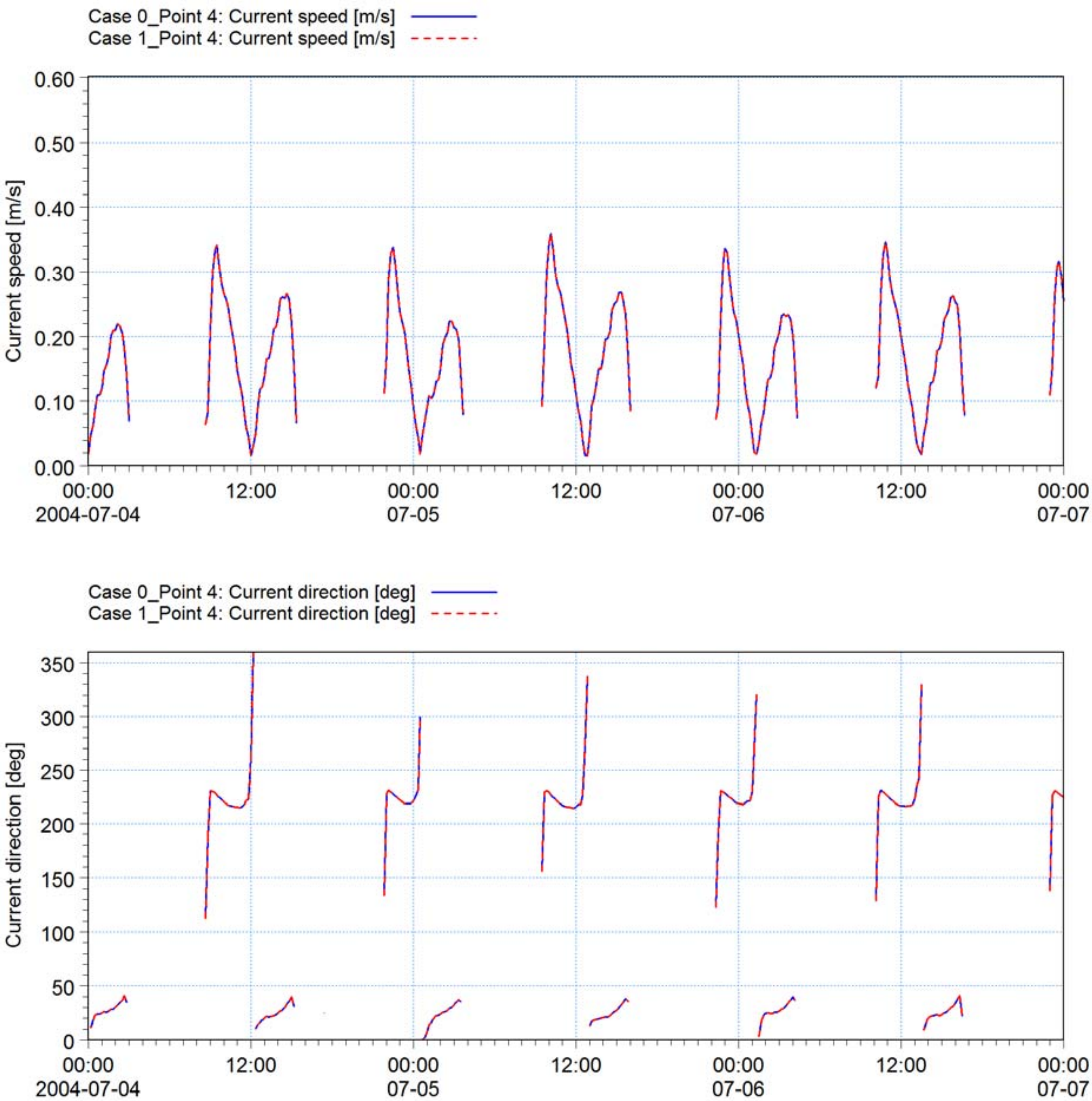


Figure 4-12: Comparison of current speed and direction for Case 0 and Case 1 at key output location 4

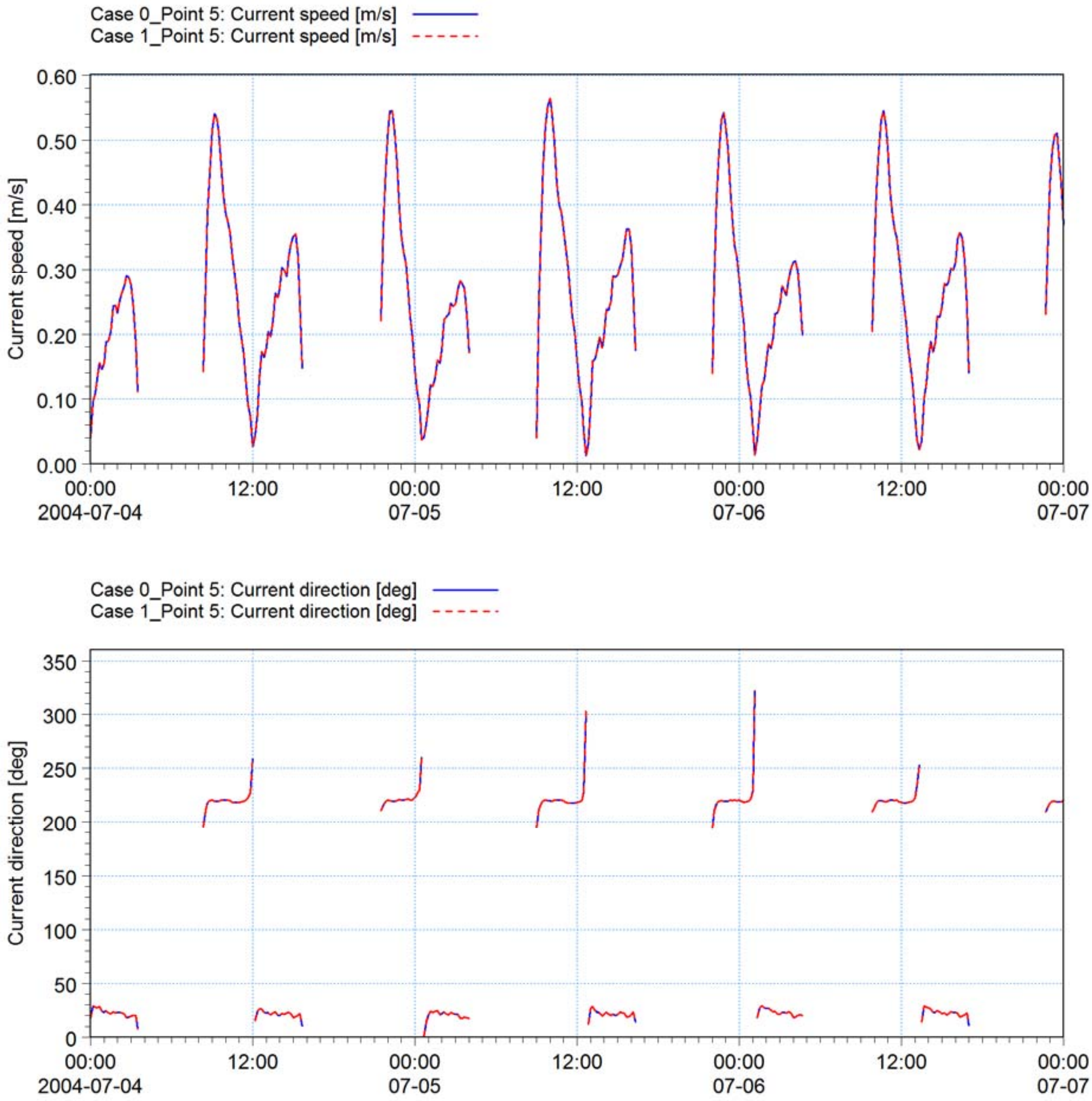


Figure 4-13: Comparison current speed and direction for Case 0 and Case 1 at key output location 5

4.2.1 Impact on inundation patterns

The effect of the proposed development on water levels was assessed in terms of predicted changes at five key output locations representative of sensitive areas of mangroves.

The results of this assessment are shown in Figure 4-14.

Results are presented as a series of submergence curve plots, showing the percentage of time during a spring-neap tidal cycle (x-axis) that water levels remain below a given height above chart datum (y-axis). Note that these output locations dry for part of the tidal cycle, hence submergences at low water are not shown.

The results of this assessment show, at the five output locations, that a negligible difference in inundation patterns is expected between case 0 and case 1.

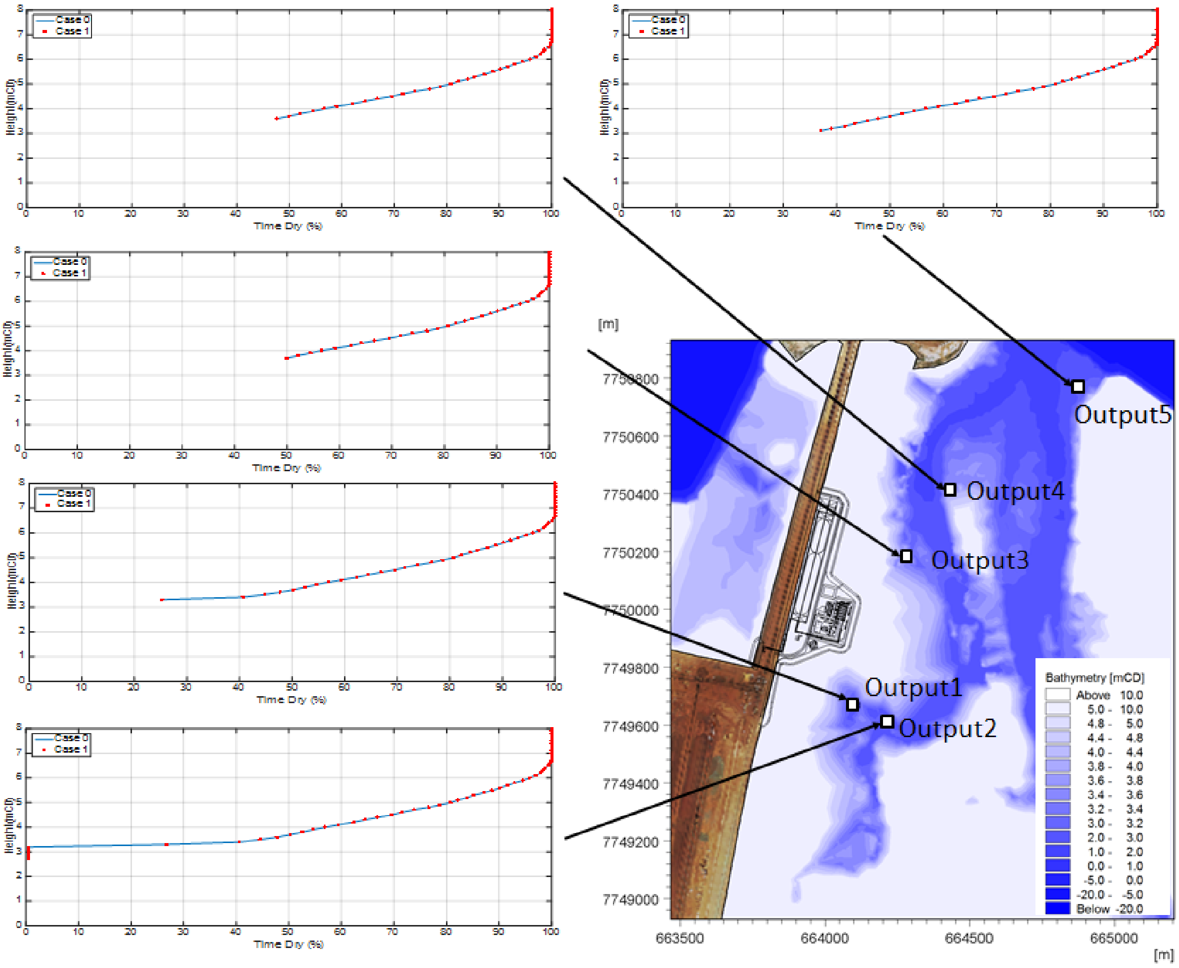


Figure 4-14: Submergence curves at five key output locations comparing inundation, Case 1 vs. Case 0

5. CONCLUSIONS

The hydrodynamic modelling undertaken in this assessment has enabled the potential change in current conditions and water levels associated with the proposed development for the IBJV port development to be investigated and quantified. This was achieved using a validated MIKE 3 HD model that was used to simulate hydrodynamic changes associated with the pre-development case (Case 0) and the proposed development (Case 1) by undertaking a peak flow, mean flow, point location and mangrove inundation analysis.

Simulations of hydrodynamic conditions for Case 0 and Case 1 predict the following potential changes in current velocity and water level:

- post-development flow velocity changes will be negligible outside of the immediate vicinity of the project area. This is expected due to the relatively small size of the proposed development compared to the size of the south creek, and the relative height of the zone where the proposed development is planned (higher part of the tidal zone);
- the flow velocity is decreased (<0.1m/s) at the east and south boundaries of the project area after the development;
- differences in peak flow velocity at all key output locations will be minor;
- difference in inundation patterns between case 0 and case 1 at five key output locations are negligible.

Based upon the modelling and analysis of results documented in this report, the development will have negligible impact on flow velocities and inundation patterns outside the immediate vicinity of the project area,

REFERENCES

Australian Hydrographic Service (AHS) 2012, *Australian National Tide Tables 2013*, Australian Hydrographic Office, Commonwealth of Australia.

Danish Hydraulic Institute (DHI) 2011, *MIKE C-MAP*, release 2011 SP7.

Environmental Protection Authority (EPA), 2009, Environmental Assessment Guidelines No. 3

Fugro Pelagos Inc. 2012, Port Hedland Outer Harbour Survey, 23.00002013

WorleyParsons 2015, FMG NSS2 Marine Studies, Sediment Transport Impact Assessment – Option E, 201012-00530-CS-REP-0004

Appendix 3: Sediment Transport Assessment (WorleyParsons, 2015c)

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WorleyParsons
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NSS2 Marine Studies

Sediment Transport Impact Assessment - Option E

201012-00530 – CS-REP-0004

27 July 2015

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PROJECT 201012-00530 - NSS2 MARINE STUDIES

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
0	Issued for use	A Karuna	D Hansen	P Nichols	27-07-15		

CONTENTS

EXECUTIVE SUMMARY

The Iron Bridge Joint Venture (IBJV) is exploring options to develop the existing Anderson Point facility to support operation of the North Star Stage 2 export facility (NSS2). WorleyParsons has been commissioned by FMG to help with the facility's environmental approvals.

This report describes the Sediment Transport Impact Assessment that was performed to identify and quantify any potential change in sediment transport and morphology characteristics as a result of works related to the proposed facility (Option E).

The Sediment Transport Impact Assessment was carried out using WorleyParsons Port Hedland Sediment Transport model, which consists of hydrodynamic module (HD), mud transport module (MD) and spectral wave module (SW). The facility's effects on sediment transport and morphology characteristics were assessed by applying the model to simulate conditions for both pre- and post-development. For modelling purposes, the pre-development case was defined by the port layout and bathymetry as of November 2013, updated with projects approved by the Environmental Protection Authority (EPA) in January 2015. The post-development case was based on the Option E layout. The model simulations incorporated all changes in bathymetry related to the proposed project footprint.

The results have been analyzed to predict:

- bed level change after one year simulation period for pre- and post- development cases;
- the difference in bed level change between pre- and post- development cases;
- the impact of development on morphology at locations near to the development area.

Results of the assessment predict that impact of project development on sediment transport and morphology characteristics is not significant. Key findings are:

- accretion in the project area of generally less than 0.03m is expected during an average year in both simulated cases;
- the impact of the proposed development on the morphology in the project area is within predicted natural variation and is therefore, likely to be negligible.

ACRONYMS

2D	Two Dimensional
AHS	Australian Hydrographic Service
BoM	Bureau of Meteorology
CD	Chart Datum
DHI	Danish Hydraulic Institute
FMG	Fortescue Metals Group
GDA	Geocentric Datum of Australia
Hs	significant wave height
HAT	Highest Astronomical Tide
IBJV	Iron Bridge Joint Venture
LAT	Lowest Astronomical Tide
MGA	Map Grid of Australia
MHWS	Mean High Water Spring Tide
MHWN	Mean High Water Neap Tide
MLWN	Mean Low Water Neap Tide
MLWS	Mean Low Water Spring Tide
MSL	Mean Sea Level
NSS2	North Star Stage 2
PHPA	Port Hedland Port Authority
SI	International System of Units
Tp	peak wave period
TPXO	TOPEX/Poseidon Global Tidal model

1. INTRODUCTION

Iron Bridge Joint Venture (IBJV) is planning to develop the existing Anderson Point facility to support operation of the North Star Stage 2 export facility (NSS2). The key infrastructure components of the NSS2 Project include:

- Slurry Pipeline from Port Boundary to filter plant (North location);
- Dewatering Plant (East location);
- Covered stockpiles with stacker and bridge reclaimer; and
- A magnetite dedicated reclaim circuit.

The proposed development facilities are shown in Figure 1-1.

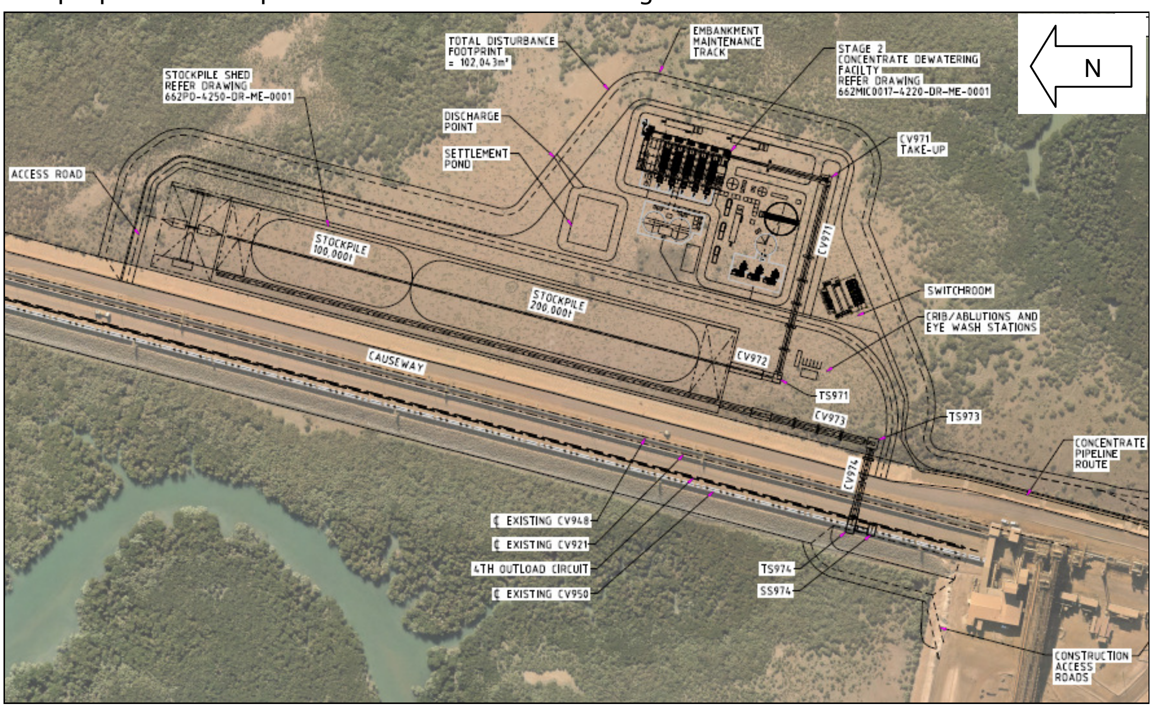

Figure 1-1: NSS2 proposed development layout, Option E

1.1 Project background

WorleyParsons has been commissioned by IBJV to conduct hydrodynamic and sediment transport impact assessment for a proposed NSS2 development on the east side of the causeway (Option E) to assess the hydrodynamic and sediment transport impact due to the proposed development.

The proposed development location is shown in Figure 1-2.

Figure 1-2: NSS2 proposed development location

To provide input to the Project's environment referral documentation, two numerical modelling studies are required to identify potential environmental effects resulting from the proposed construction work. These studies include:

- a Hydrodynamic Impact Assessment (WorleyParsons, 2015) to quantify any potential change in current conditions and water levels as a result of the Project; and
- a Sediment Transport Impact Assessment to quantify any potential change in sediment transport and morphology characteristics due to the proposed project.

This report presents the Project's Sediment Transport Impact Assessment.

1.2 Scope of work

A Sediment Transport Model was set up and applied to quantify any potential change in sediment transport and morphology characteristics due to the proposed project. The model includes the effect of currents, water levels and waves on the sediment transport.

A detailed description of the model is given in section 3.2.

1.3 Study datum

Water depths and levels presented in this report are referenced to Port Hedland Chart Datum (CD), unless otherwise stated, and are in units of metres.

Geographical positions are provided in the Map Grid of Australia (MGA 94) coordinate system, which employs the Geocentric Datum of Australia (GDA 94) Geodetic Datum, unless stated otherwise.

All units are in standard International System of Units (SI) unless otherwise stated, with all bearings and directions provided in degrees relative to True North.

2. CLIMATE DESCRIPTION

2.1 General Oceanography

The coastal regions of the North West Shelf near Port Hedland experience a tropical arid climate, with a quasi-monsoonal seasonal shift in wind direction and rainfall patterns.

The hydrodynamics of the coastal waters near this site, and within the Port Hedland estuary, are dominated by a large tidal range that drives strong flood and ebb tidal currents. These currents are of scales of about 1 m/s in the near shore region, and more than 1 m/s in the estuary entrances and deeper channels in the tidal creeks during peak ebb and flood tides. The tidal currents are typically aligned along local bathymetric contours. Substantial areas of drying mudflats occur along the coastline and within the Port Hedland estuary. The bathymetry is typically flat and shallow, typical of intertidal flats in the region.

In this region wind forcing is secondary to tidal forcing for local currents, although wind forcing drives residual flows along the coastline, which is an important transport mechanism for suspended sediments. The winds in summer are quite persistent from the west/north-west and typically result in a long-term drift towards the north and east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn and winter.

2.2 Tidal levels

Tides at Port Hedland are semi-diurnal and macro-tidal with a mean spring tidal range of 5.5 m (AHS 2012). Standard tidal levels are given in Table 2-1.

Table 2-1: Port Hedland tidal planes (AHS 2012)

Tidal plane	Elevation above CD (m)
HAT (highest astronomical tide)	7.5
MHWS (mean high water springs)	6.7
MHWN (mean high water neaps)	4.6
MSL (mean sea level)	4.0
MLWN (mean low water neaps)	3.3
MLWS (mean low water springs)	1.2
LAT (lowest astronomical tide)	0.0

A typical spring-neap cycle is shown in Figure 2-1 (first two weeks in April 2004), determined from harmonic analysis using the published constituents for Port Hedland (AHS 2012).

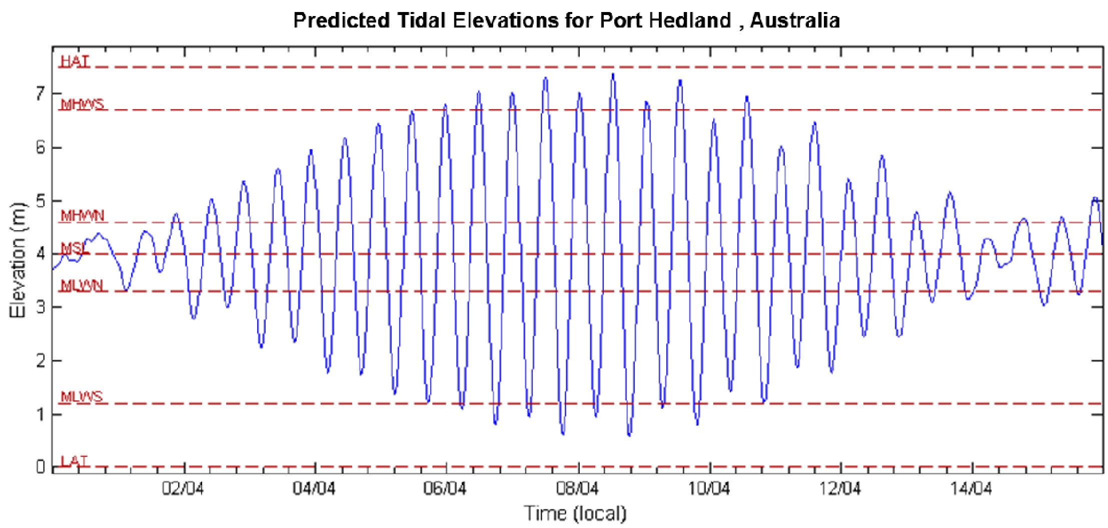

Figure 2-1: Typical spring-neap tidal cycle at Port Hedland

2.3 Winds

Wind roses presenting the seasonal variation in wind conditions at the onshore Bureau of Meteorology (BoM) weather station at Port Hedland Airport and the offshore PHPA buoy at Beacon 15 are given in Figure 2-2. The roses show the wind speed and proportion of time that winds occur from each direction sector during each season. A comprehensive long-term series of data is available at each site, with the roses based on an 18-year record (1993–2011) at Port Hedland Airport, and a 10-year record (2000–2009) at Beacon 15.

The wind roses for Port Hedland Airport show the onshore wind climate is dominated by north-westerly onshore winds and south-easterly offshore winds. Offshore at Beacon 15 (approximately 20 km north-west of the Project site), the north-westerly onshore winds and south-easterly offshore winds are also evident, with a moderately higher occurrence of westerly winds and more consistent directionality to these dominant wind directions than that at Port Hedland Airport. Recorded wind speeds at Beacon 15 are also approximately 10 to 15% higher than those measured at the airport station in most cases.

The highest winds at Port Hedland are associated with the passage of a tropical cyclone, which affect the region from November to April. High wind gusts may also be associated with thunderstorms and squalls. These can occur with limited warning but are short-lived localised events, generally lasting less than an hour.

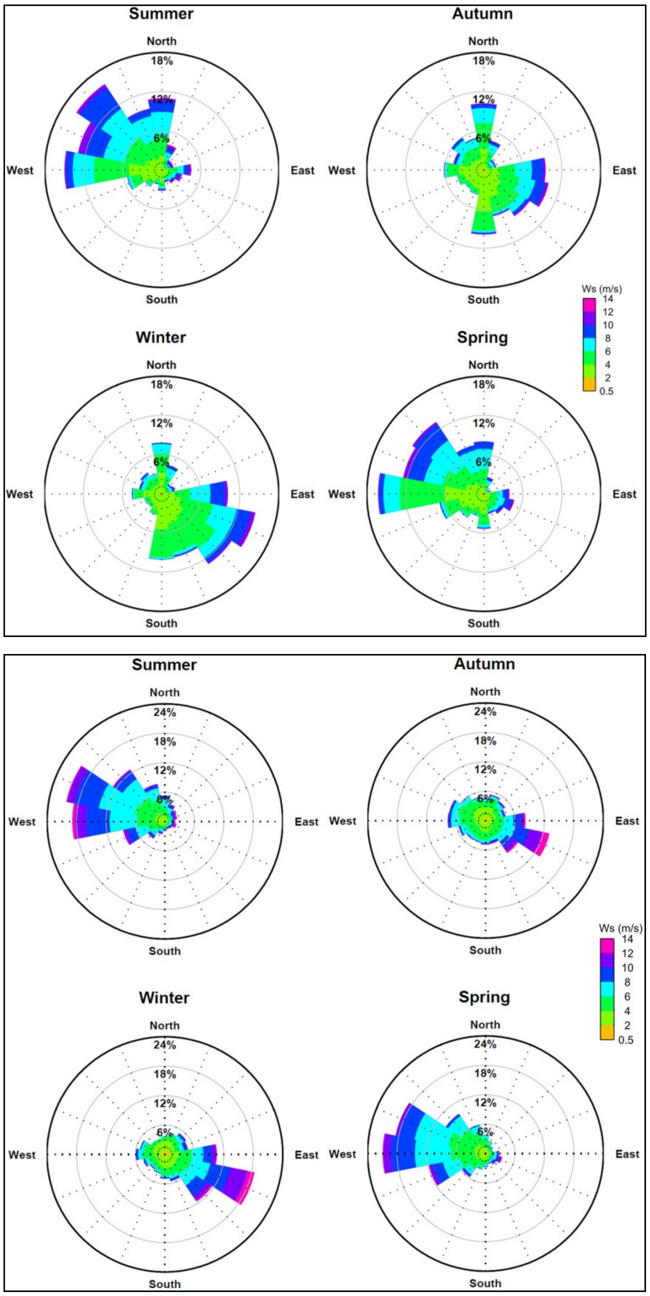

Figure 2-2: Seasonal wind roses at Port Hedland Airport (top) and Beacon 15 (bottom)

2.4 Waves

Seasonal wave roses, based on five years of measured wave data offshore at the Beacon 15 buoy, are shown in Figure 2-3. Wave heights (H_s) at Beacon 15 are below 2 m for 99.5% of the record, with this increasing to 99.8% of the time during winter and decreasing to 98.5% of the time during summer, when larger waves are more prevalent on account of the stronger onshore winds. Waves are from the north-west quadrant for approximately 92% of the record, with a low occurrence of waves from the east generated by easterly winds that prevail in winter at times when the oceanic swell is very low. The oceanic swell tends to be present all year with a peak energy period typically between 13 and 17 seconds.

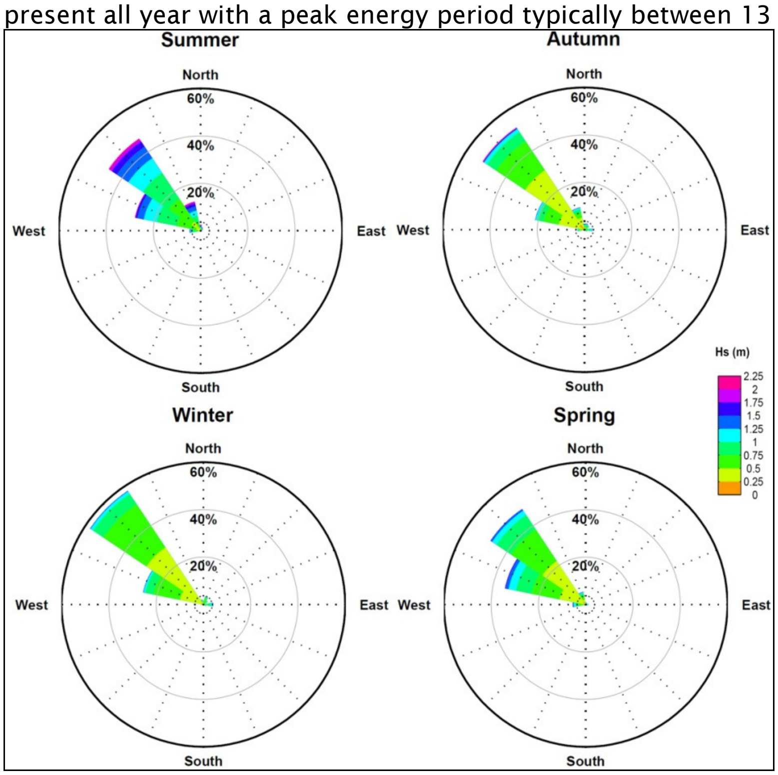

Figure 2-3: Seasonal wave height and direction roses at Beacon 15

Within the Inner Harbour waves are influenced by local bathymetry and sheltering and are predominantly generated by the local winds. Waves are an important consideration in the simulation of long-term sediment rate since given wave action affects re-suspension potential at the seabed.

3. SEDIMENT TRANSPORT MODEL

3.1 Introduction

WorleyParsons' existing calibrated and validated 2D hydrodynamic model of the Port Hedland region was applied as the basis of modelling for the Sediment Transport Impact Assessment. A 2D Sediment Transport Model was used to quantify any potential change in sediment transport and morphology characteristics due to the proposed project. The model includes the effect of currents, water levels and waves on the sediment transport.

3.2 Model description

The WorleyParsons Port Hedland Sediment Transport Model was based on the existing WorleyParsons 2D Hydrodynamic and the WorleyParsons Wave Model of Port Hedland.

The MIKE21 Coupled Flexible Mesh (FM) Hydrodynamic model is a dynamic 2D modelling system for applications within coastal, estuarine and river environments. The model consists of a number of modules, of which the following are relevant for purposes of this study:

- Hydrodynamic Module (HD)
- Mud Transport Module (MT)
- Spectral Wave Module (SW)

An overview of how the model modules are combined together with the available input data into the Sediment Transport Model is shown in Figure 3-1.

The SW module simulates the wave climate (growth, decay, and transformation of wind-generated waves and swell) in the Port Hedland region. This wave climate is used as input into the 2D Sediment Transport Model.

The HD module simulates water level variations and flows in response to a variety of forcing functions, such as wind and offshore water level.

The MT module describes the erosion, transport and deposition of silt, mud, and clay particles under the action of currents and waves. The model is able to simulate the presence of multiple fractions in multiple layers, as well as simulating the presence of fine sand.

The MT and HD modules were coupled which means that at each time step the model bathymetry was updated before proceeding to the next step of the hydrodynamics simulation.

MIKE21 FM also includes a sediment transport module (ST) for larger non-cohesive particles. This includes sand and gravel, which are also present in the inner harbour. However, these larger particles require significant turbulence, usually due to wave action, to stay in suspension. As wave action is very low in the project area, larger sediment fractions are unlikely to be brought in suspension and the ST module was not considered relevant for this study.

While it was not practically possible to calibrate the Sediment Transport Model, the existing WorleyParsons Hydrodynamic and Wave models used to force the morphology model have been calibrated and validated under previous studies.

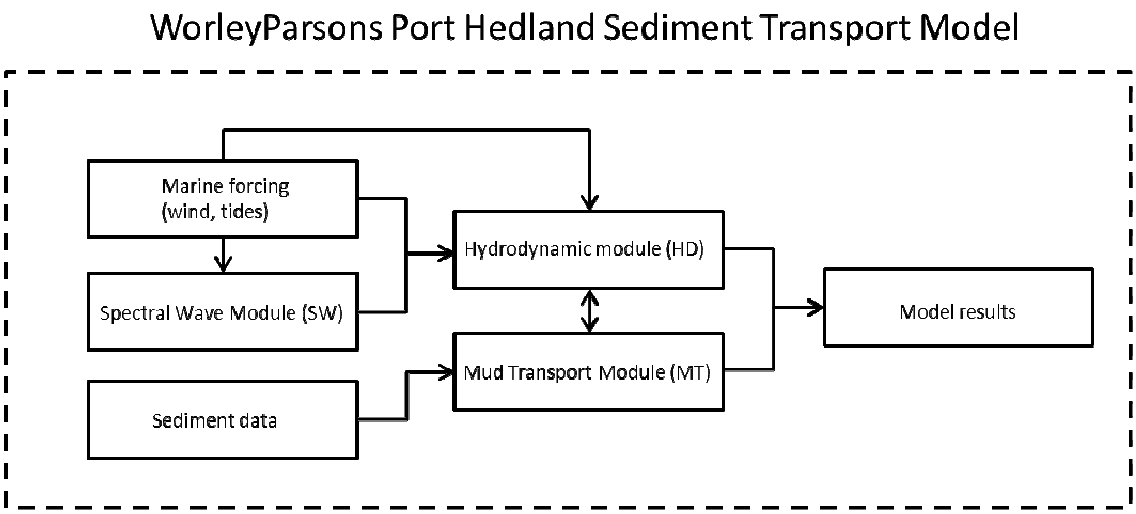

Figure 3-1: Overview of the WorleyParsons Port Hedland Sediment Transport Model

3.3 Model domain and bathymetry

The large domain extent of the WorleyParsons Port Hedland Sediment Transport Model captures the full effects of wind and tidal-induced forcing on the circulation within the coastal region near and within Port Hedland estuary. The offshore extent covers an area 60 km offshore from Port Hedland, to a water depth of approximately 30 m, and between Depuch Island in the west and Larrey Point in the east. The large size of the domain allows an accurate representation of the tides offshore from Port Hedland within the model, which is integral to ensuring that tidal hydrodynamics within the Inner Harbour are correctly characterised. The model domain’s extent is presented graphically in Figure 3-2.

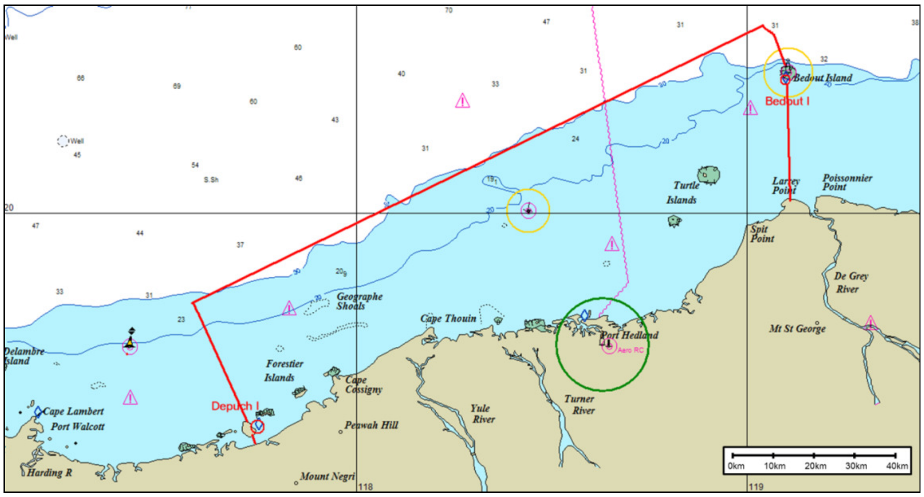

Figure 3-2: Mike 3 HD model domain (inside red boundary)

The model's local bathymetry is based on a series of hydrographic surveys, with dredging and developments included between 2000 and November 2013 including but not limited to:

1. Channel and harbour maintenance dredging
2. Hunt Point dredging and development
3. Utah Point dredging and development
4. Anderson Point dredging and development
5. Harriet Point dredging and development
6. Nelson Point dredging and development
7. South West Creek dredging and development
8. Stingray Creek dredging
9. Near shore – Offshore outer harbour survey

In addition, for the present study the existing model bathymetry was supplemented with data from the Port Hedland Outer Harbour survey (Fugro, 2012) provided by IBJV.

Future approved developments have been added onto the pre-development bathymetry in their full extent of approval in order to be in line with the guidelines in EPA (2009) on cumulative impact assessment. These include:

10. Hunt Point Marine Precinct (BHPBilliton)
11. Stingray Creek Small Vessel Cyclone Mooring Protection Facility (PPA)

12. South West Creek Dredging and Reclamation (PPA)
13. Lumsden Point General Cargo Facility (PPA)

Outside this area bathymetry data is extracted from the C-MAP digital chart database (DHI 2011). This bathymetry data was applied to represent the pre-development case in the model. For the post-development case the model bathymetry was adjusted to reflect proposed configuration described in Section 3.7.1.

The Sediment Transport Model uses an unstructured computational mesh which allows for higher resolution around areas of specific interest or that have complex bathymetries or morphologies. Computational length scales of the triangles range from 2000 m at the coarsest scale down to 10 m at the finest scale, to minimise run time while still giving a suitable level of accuracy in results for the assessment. To maintain computational accuracy, it is ensured that the mesh traversed this length scale range by no more than a factor of two across the entire computational domain (i.e. smaller cells are no smaller than 50% of the larger adjacent cell).

A mesh showing the model bathymetry is shown in Figure 3-3. The mesh shows the pre-development bathymetry.

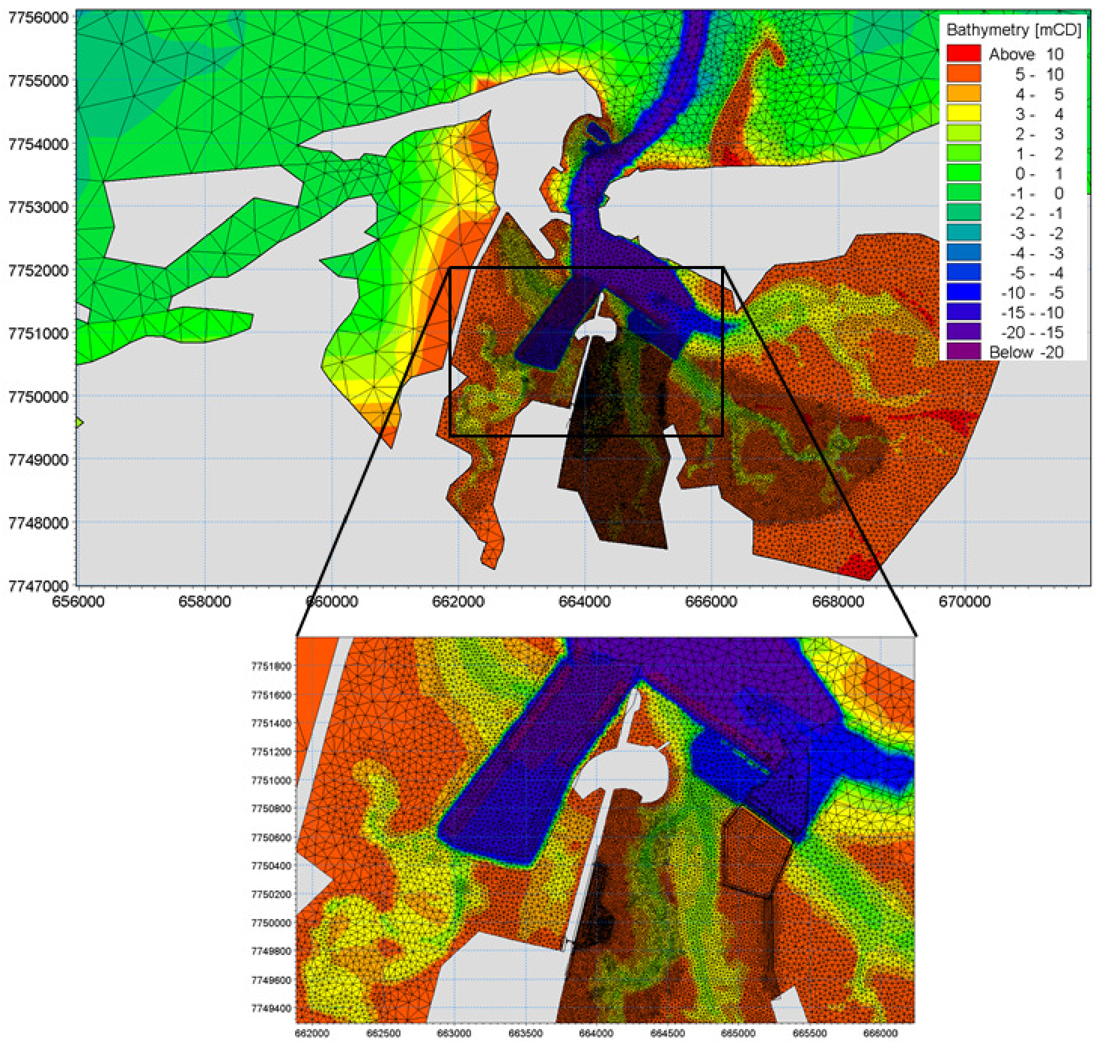

Figure 3-3: Model mesh showing pre-development model bathymetry, i.e. existing bathymetry updated with future stages of approved developments

3.4 Sediment properties

A literature review on available sediment data has been carried out to determine appropriate input into the sediment transport model.

Koskela Group (2007) carried out sediment sampling at a number of locations at Port Hedland in order to support maintenance dredging and disposal of dredged materials for the Port. The samples were analyzed for physical and chemical characteristics. WorleyParsons (2009) conducted several borehole investigations along the South West Creek for the Heng Shan project. WorleyParsons (2010) conducted sediment sampling within the South West Creek and the samples were analyzed for physical and chemical characteristics. Several borehole investigations have been carried out at South East Creek for Lumsden Point Development of Port Hedland (WorleyParsons, 2013).

Sediment sampling and borehole locations in the Koskela Group (2007), WorleyParsons (2009) and WorleyParsons (2013) surveys were in deep water away from the present project site and the characteristics of these sediments will not represent the sediment characteristics at the project site.

Sediment sampling from WorleyParsons (2009) and borehole locations from WorleyParsons, (2010) are shown in Figure 3-4. The following eight boreholes were selected as input data due to their vicinity of the project area and their position near the southern extent of the creek: PHPA 05, PHPA 08, PHPA 17, PHPA 19, PHPA 20, PHPA 25, PHPA 27, and PHPA 28. The particle size distribution curves for selected sediment samples were used as a basis for input into the Sediment Transport Model.

Figure 3-4: Borehole and sediment sampling locations

3.4.1 Sediment fraction distribution

Sediment data at the eight selected locations were used to determine the percentage of fines used as input in the model.

As discussed in Section 3.3, future approved developments have been incorporated in the model bathymetry. Thus, the scenarios modelled represent a situation where large parts of South West Creek were modelled as if they have been dredged. Surface sediment properties are likely to change after dredging due to settlement of a mud layer, which means that sediment fraction distribution is unlikely to be the same as the ones sampled at the dredging depth. Additionally there is no sediment data available in the immediate vicinity of the project area.

Spatial variation of the sediment fraction distribution in the model has been considered. However, a spatially uniform sediment fraction distribution was considered more appropriate since inclusion of the aforementioned uncertainties were not expected to improve model accuracy.

The fractions of non cohesive sediment such as gravel and course sand cannot be well represented in the MIKE21 MT module. Appropriately modelling sediment transport of larger non-cohesive fractions requires the MiKE21 ST module. However, for this project this is not deemed necessary since significant wave action and/or turbulence is required to bring these courser fractions into suspension and the project area is located in an area of low wave energy, as discussed in Section 3.2. Therefore the larger fractions of the material (>200 mm) are not represented in the model.

The average fraction distribution is taken at different borehole locations and the fraction distribution is normalised to create a layer which consists 100% of material smaller than 200 μm. The normalised fractions, including their maximum and minimum size as well as settling velocity are shown in Table 3-1.

Table 3-1: Fraction distribution and settling velocities

Fractions	Max size (μm)	Min size (μm)	Initial fraction distribution (%)	Settling velocity (m/s)
1 (fine sand)	200	60	27	0.0262
2 (silt)	60	2	31	0.0012
3 (clay)	2	1	5	2.81E-006
4 (sub-clay)	1	-	37	3.12E-007

3.4.2 Settling velocity

WorleyParsons (2010) present settling velocities of the different sediment fractions.

For the present study, a total of three fractions of fines are used for the finer component (diameter < 60 μm), with an additional fraction to address the finer sand component (60 μm < D_{50} < 200 μm). The proportions of the four components used in the model are summarised in Table 3-1.

3.5 Marine forcing functions

The main hydrodynamic driving forces at the sites can be divided into tidal and non-tidal processes. Compared with the tidal and wind forcing, the hydrology of the adjacent watershed (e.g. river discharge) plays a minor role in ambient currents. The local meteorological conditions (e.g. wind) are expected to contribute to surface currents, with these effects having more influence during slack and neap tide periods. Waves are expected to influence the re-suspension of sediments. Not included are ocean currents, which are unlikely to significantly affect the hydrodynamic and morphological processes within the Inner Harbour.

3.5.1 Tides

Tidal data at the hydrodynamic model's ocean boundaries are taken from the TPXO7.0 dataset. This is a global database of harmonic tidal constituents published by the US National Climatic Data Center derived from the 10-year TOPEX/Poseidon satellite mission. The astronomical tides are included on all the open boundaries by spatial interpolation of the tidal constituent data (amplitude and phase) provided by the TOPEX/Poseidon global tidal altimetry data (TPXO7.0). The eight dominant semi-diurnal and diurnal tidal constituents are used in the simulations, in addition to the yearly constituents (Sa and Ssa), given they account for most of the tidal amplitude.

At the model coastal boundaries, the TOPEX tidal data is supplemented with predictions at local tide stations, available in the Australian tide tables (AHS 2012). Constituents derived from the Depuch Island tidal station, located on the western boundary, are included in conjunction with the TPXO7.0 model data to generate an interpolated tide forcing along the western boundary. Tidal forcing on the eastern boundary will be generated by interpolation of the Bedout Islet tidal constituents and the TPXO7.0 data.

On all the open boundaries, the predicted water levels are site specific and vary in local time and along the boundary line. At the points along the boundary where water is flowing into the model domain, the flow is forced perpendicular to the boundary orientation, while at points where the water is flowing out of the model domain, the flow direction is extrapolated from the nearest points inside the model domain.

The model boundaries and location of the Bedout Islet and Depuch Island tidal stations are shown in Figure 3-2.

3.5.2 Ambient winds

Ambient wind conditions are analysed using offshore wind measurements at the Beacon 15 buoy, as well as land-based measurements from the Port Hedland Airport BoM station, 6 km inland of the Project site. All datasets have been interrogated and it appears that the consistent measurements at Beacon 15 during the selected simulation period are the most appropriate for hydrodynamic model forcing because they better represent local wind conditions over water.

While the dataset will capture some cyclone events, an independent assessment of hydrodynamic conditions during an extreme cyclone event was not in the scope of work.

3.5.3 Waves

The MIKE21 SW Wave Model was used to model the wave climate for the period of one year. The model was based on the existing WorleyParsons Port Hedland Wave Model but included the future approved projects in the bathymetry. The domain covers the harbour area and output includes values every 10 minutes for significant wave height (Hs) and peak wave period (Tp) for the year 2004.

The SW Wave Model was forced at offshore boundaries by a wave energy spectrum, extracted from simulations previously undertaken by WorleyParsons, as well as by wind measured at Beacon 15 offshore Port Hedland for the year 2004.

Spatial output of the SW model, representing wave conditions of the region for the simulation period, was used as input for the MT module.

3.6 Model set-up parameters

In the model, the deposition rate is formulated as a function of the settling velocity, the near-bed concentration and the actual critical bed shear stress for deposition. The settling velocity in this formulation depends on two key parameters, namely the grain size and an estimation of the level of flocculation, with larger grain sizes (i.e. those associated with sands) containing much higher settling velocities than finer materials. As such, sands are more readily deposited in the model than the fine silt and clay materials, which tend to remain suspended and transport greater distances in the model.

The erosion rate depends on the seabed properties; that is, whether the seabed is dense and consolidated or soft and only partly consolidated. In the present model, the bed is described as one layer with the material suspended and re-deposited due to wave and current action. A critical shear stress is usually set to determine whether the deposition material is re-suspended or not. The criterion for erosion is exceeded corresponding to the driving forces exceeding the sediment stabilising forces.

For the present study, a variable critical bed shear stress for deposition was employed. The critical shear stress for erosion was assumed constant. An overview of shear stress parameters is shown in Table 3-3.

One layer composed of four fractions of fine sediment was assumed in the MT model as described in section 3.4. The layer was assumed to be of the hard type, corresponding with a consolidated seabed. The mud layer was assumed to be evenly distributed within the harbour at the beginning of the simulation.

Further key hydrodynamic and sediment transport model parameters and formulations are shown in Table 3-2.

Table 3-2: Key Hydrodynamical and Sediment Transport Model parameters and formulations

Parameter	Description	Value
Timestep	Maximum computational timestep	600 seconds
	Minimum computational timestep	0.01 seconds
Eddy viscosity	Smagorinsky formulation, constant	0.4 m^2/s
Bed resistance	Manning Number	Mangrove area: 17 m^3/s Remainder area: 40 m^3/s
Approximate spatial resolution	Open boundaries	2000 m
	Offshore and coastline >10 km from project site	500–2000 m
	Shoal areas and offshore <10 km from site	100–600 m
	Development site, navigation channel and Inner Harbour	10–120 m
Bed parameters	Initial layer thickness over the domain at the start of the simulation	1m
	Density of bed layer	600 kg/m^3
	Bed roughness	0.001 m

Table 3-3: Critical shear stress parameters for all sediment fractions

Fractions	Critical shear stress for deposition (N/m^2)	Critical shear stress for erosion (N/m^2)
1 (fine sand)	0.3	0.6
2 (silt)	0.2	0.6
3 (clay)	0.1	0.6
4 (sub-clay)	0.07	0.6

3.7 Simulation Scenarios

3.7.1 Project Layout

Two cases were set up ie., pre-development and post development conditions:

- **Case 0**: The pre-development case against which potential impacts are evaluated and quantified. This case includes the existing bathymetry updated with future stages of approved developments at Hunt Point, SW Creek, Lumsden Point, and Stingray Creek.
- **Case 1**: The post-development situation by including the project layout as shown in Figure 3-5.

Figure 3-5: Case 1 – post-development situation (Option E)

3.7.2 Periods of Simulation

The model was run for pre-and post-development for a continuous one-year period. Selection of an appropriate year was required to ensure that the simulations were representative of typical conditions likely to be experienced at the proposed project site. WorleyParsons has selected this typical year based on analysis of a 10 year wind dataset at Beacon 15, on account of the influence of wind on drift currents at the project site

A seasonal analysis of the winds during each of the years that were representative of the typical range of wind speed and direction of an entire 10 year dataset at Beacon 15 (2004, 2007, 2008 and 2009) concluded that 2004 was the most representative (i.e. closest to the average), with the seasonal wind roses for this year shown in Figure 3-6. The roses show the same dominance of Westerly and North-Westerly winds during summer, with winds tending towards Westerly during spring. Autumn and winter also replicate the dominance of the South-Easterly winds observed at the Beacon 15 offshore site. As such, 2004 was selected as the appropriate year for the Sediment Transport Modelling.

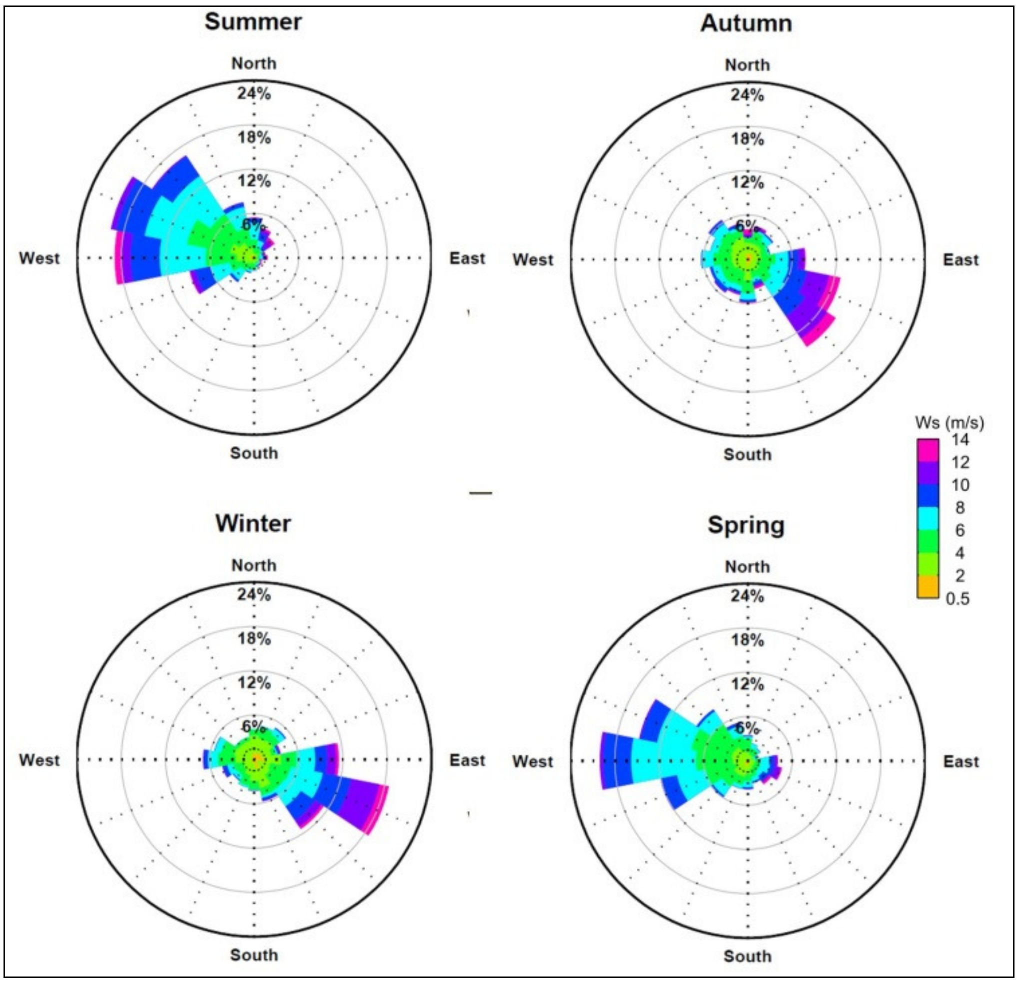

Figure 3-6: Seasonal wind roses for Port Hedland at Beacon 15 for January to December 2004

Table 3-4: Sediment transport model simulation scenarios

Run	Period of simulation (excluding warm-up period)	Bathymetry
0	12:00 AM 01/01/2004 to 12:00 AM 01/01/2005	Case 0
1	12:00 AM 01/01/2004 to 12:00 AM 01/01/2005	Case 1

3.8 Limitations

The sediment transport results are indicative only. The sedimentation rates are highly dependent on sediment availability and uncertainties are associated with the modelling of sediment transport and morphological changes. Typically, the order of magnitude error associated with sediment transport rate prediction based on numerical modelling is same as the order of magnitude of model predicted transport rate. However, since the impact assessment studies consider the difference in sediment transport in different situations, the error is not significant.

The Sediment Transport Model has not been calibrated or validated against site specific data as the baseline case (Case 0) does not yet exist. However, the wave and hydrodynamic models used to force the morphology model have been calibrated and validated under previous studies and the results presented are expected to be reasonably accurate.

The model used was focused on the vicinity of the present project area (development site, south creek, navigation channel and inner harbour) by applying a refined mesh for the project area while a coarse mesh has been applied for the area outside (see Figure 3-3 and Table 3-2 for spatial resolution). Therefore, the model results for areas beyond the project area should not be used for detailed interpretation.

Geotechnical data at the directly at the project site are not presently available. Therefore, the model is based on available geotechnical data near to the project site that closely represent the geotechnical characteristics of the project area (close to a creek in shallow water depths adjacent to mangrove areas).

The study does not consider alternative sources of sediment, such as that generated by shipping activities, propeller wash and sediment load from the inner harbor creek tributaries during runoff events, which could result in increased sedimentation within the inner harbor. The sediment transport rates from these alternative sources will be similar for Case 0 and Case 1since the project footprint is away from the area influenced by these sources. Therefore, it is not required to include these sources on sediment impact assessment. However, the results should not be used to assess sediment transport for individual cases (for Case 0 or Case 1individually without considering the difference between the two cases).

4. SEDIMENT TRANSPORT IMPACT ASSESSMENT

4.1 Impact on project area morphology

The predicted change in bed level after one year of simulation for pre- and post-development cases is presented in Figure 4-1 and Figure 4-2, respectively. Case 0 is presented to provide a reference to evaluate the impact of Case 1. Based on the figures, accretion up to 0.03m is observed in largest part of the project area over the course of an average year for both Case 0 and Case 1. In addition, erosion upto 0.12m is observed in localized areas within the creek especially adjacent to the mangrove areas for both Case 0 and Case 1.

The model results indicate that the change in seabed level in the vicinity of the project area undergoes approximately up to the 7.25mCD contour level, which represents the high tide level within the simulation period. The areas above this contour level does not undergo appreciable change in seabed level and these areas are not colour coded in the plots.

The difference in seabed change between Case 1 and Case 0 is shown in Figure 4-3. A minor increase in accretion (less than 0.1cm, which can be considered to be negligible) is observed at two small localized areas near to the project location. There is no difference in change in seabed level in the rest of the areas between Case1 and Case 0. Thus, the difference in accretion or erosion is expected to be negligible after development of Option E.

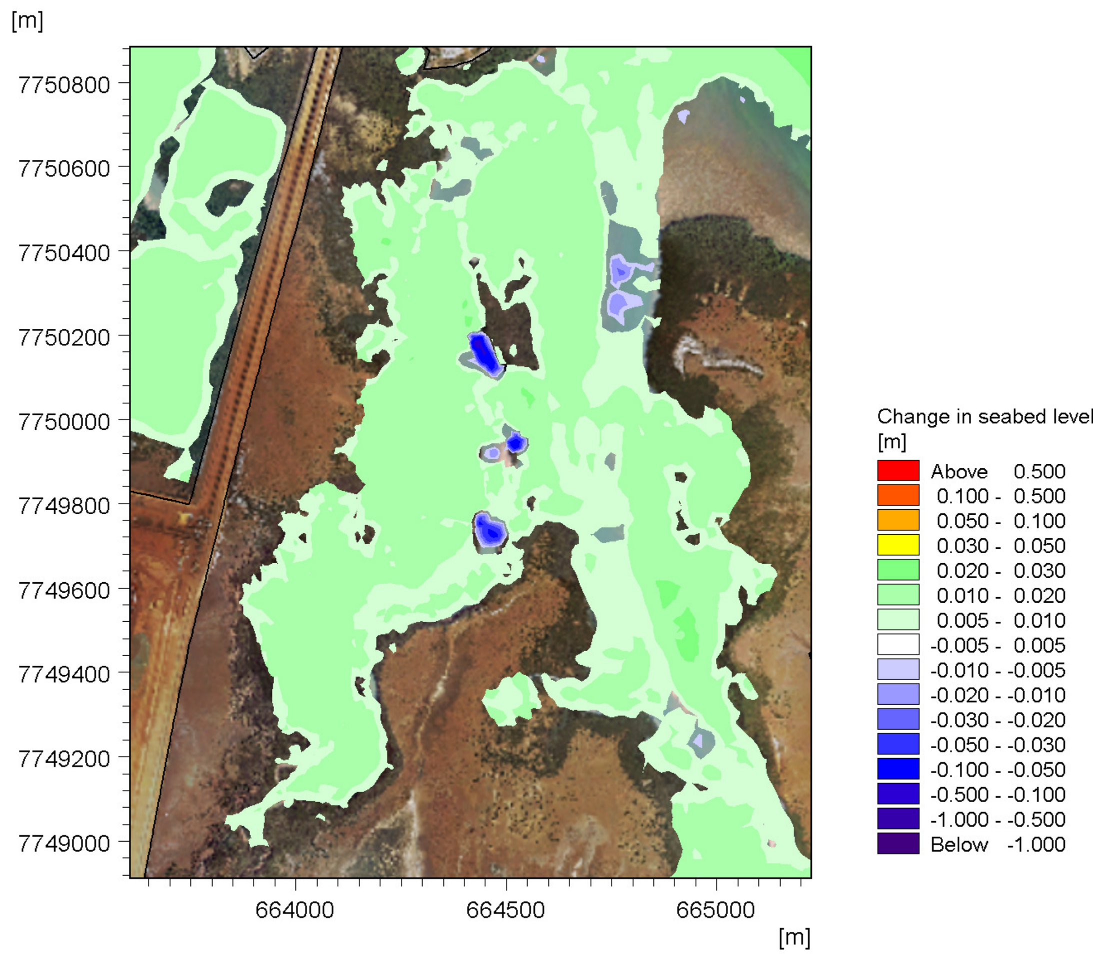

Figure 4-1: Predicted change in seabed level over the year of 2004 for Case 0 (positive is accretion, negative is erosion)

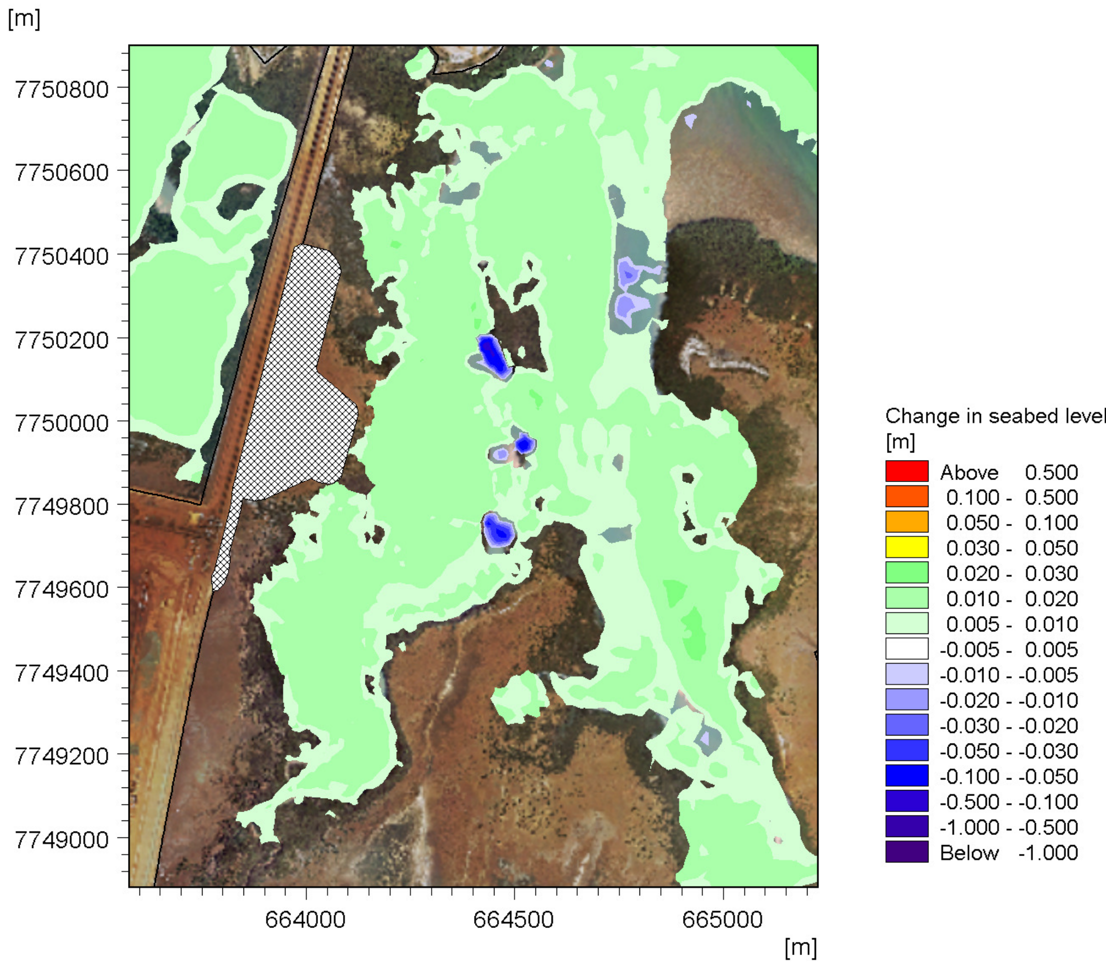

Figure 4-2: Predicted change in seabed level over the year of 2004 for Case 1 (positive is accretion, negative is erosion)

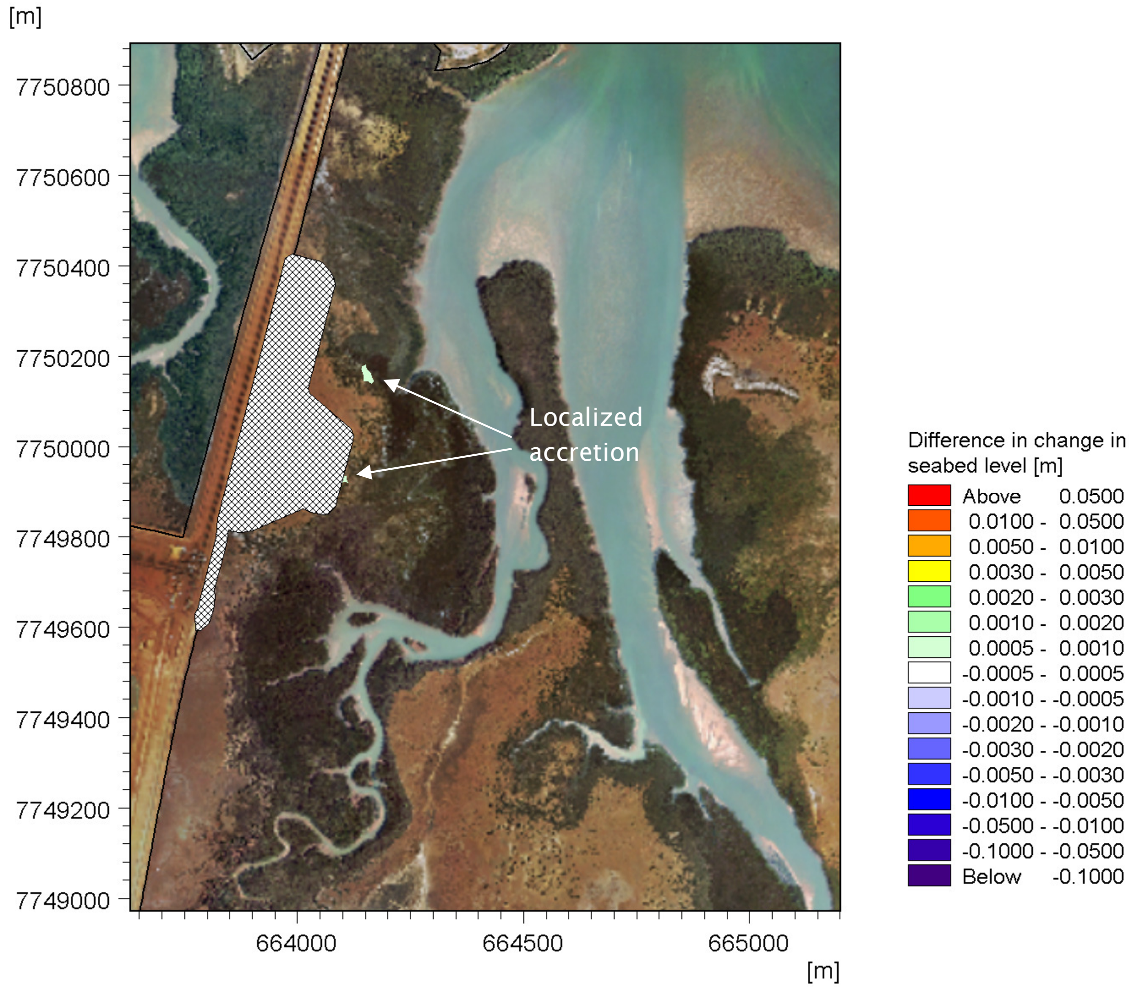

Figure 4-3: Difference in change of seabed level over the year of 2004 between Case 1 and Case 0

4.2 Expected seabed evolution at key output locations

A point location analysis was carried out to assess the impact of the development on morphology at locations near the development area. Five key output locations were specified by IBJV in consultation with WorleyParsons as shown in Figure 4-4.

Coordinates and sea bed levels of these points are presented in Table 4-1. Output point 5 is located adjacent to the dredged basin and output points 1, 2, 3, and 4 are located within the creek adjacent to the mangrove area.

At each key output location the seabed level in each time step for the simulated year was extracted. Time series showing the seabed level change for Cases 0 and Case 1are shown in Figure 4-5.

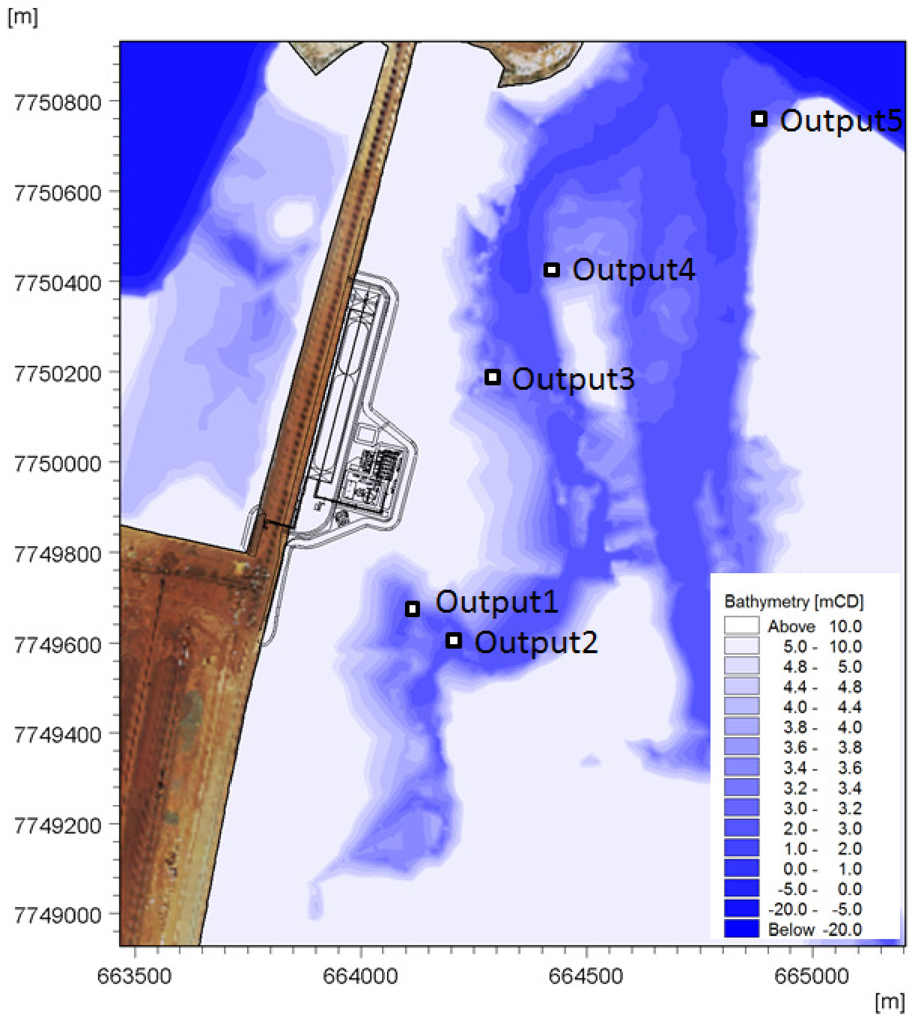

Figure 4-4: Five key output locations near the development area

Minor accretion of 0.005m to 0.02 m is expected to occur at all key output locations for both cases over the course of the modelled year.

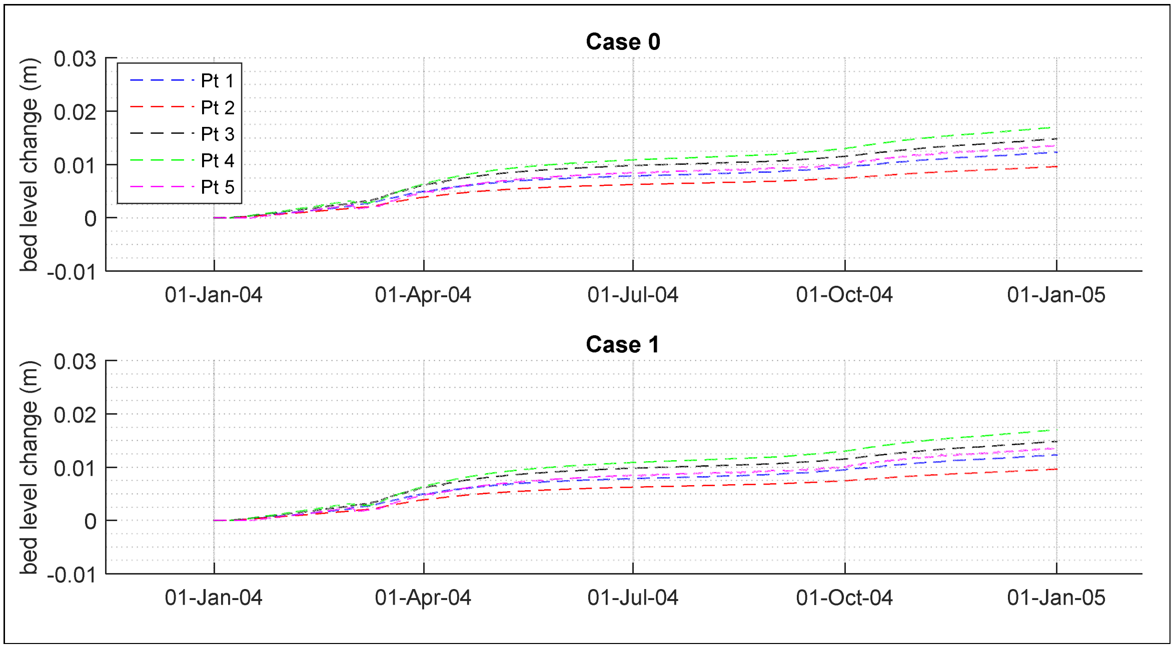

Figure 4-5: Evolution of bed thickness change at key output locations

The total predicted change in seabed level during the modelled period at the selected key output locations is presented in Table 4-1.

Table 4-1: Summary predicted seabed change at key output locations over average year

Site	Easting	Northing	Bed Level (mCD)	Case 0 seabed change (m)	Case 1 seabed change (m)	Difference in seabed change (Case1-Case0) (m)
1	664111	7749668	+3.1	0.012	0.012	0
2	664208	7749601	+2.6	0.010	0.010	0
3	664284	7750189	+3.6	0.015	0.015	0
4	664427	7750426	+3.5	0.017	0.017	0
5	664879	7750765	+3.0	0.014	0.014	0

5. CONCLUSIONS

The sediment transport modelling undertaken in this assessment has enabled the potential change in seabed level associated with the proposed development to be estimated and quantified. This was achieved using a sediment transport model that was used to simulate seabed level evolution associated with the pre-development (Case 0) and proposed post-development (Case 1).

Key findings are:

- accretion in the project area of generally less than 0.03m is expected during an average year in both simulated cases;
- the impact of the proposed development on the morphology in the project area is within predicted natural variation and is therefore, likely to be negligible.

REFERENCES

Australian Hydrographic Service (AHS) 2012, *Australian National Tide Tables 2013*, Australian Hydrographic Office, Commonwealth of Australia.

Danish Hydraulic Institute (DHI) 2011, *MIKE C-MAP*, release 2011 SP7.

Environmental Protection Authority (EPA), 2009, Environmental Assessment Guidelines No. 3

Koskela Group 2007, PHPA, Maintenance Dredging Campaign 2007, Sediment Sampling and Analysis Report, 2007-003-01-001

WorleyParsons 2009, FMGL, The Heng Shan Project, South West Creek Berths 1 and 2, Geotechnical Investigation, 00093-P-12044-RP-GE-0003

WorleyParsons 2010, PHPA, South West Creek Approvals, Offshore Sampling and Analysis Sediment Characterisation Report, 301012-01297-EN-REP-0002

WorleyParsons 2015, FMG NSS2 Marine Studies, Hydrodynamic Impact Assessment – Option E, 201012-00530-CS-REP-0003

Appendix 4: Surface Water Assessment (WorleyParsons, 2015d)

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WorleyParsons Consulting

EcoNomics™

FORTESCUE METALS GROUP

North Star Stage 2, Port Expansion Environmental Marine Studies

Surface Water Impact Assessment Option E

2012012-00530 – RP-HY-0002

27 August 2015

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NORTH STAR STAGE 2, PORT EXPANSION ENVIRONMENTAL MARINE STUDIES
SURFACE WATER IMPACT ASSESSMENT OPTION E

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PROJECT 2012012-00530 - NORTH STAR STAGE 2, PORT EXPANSION ENVIRONMENTAL MARINE STUDIES

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
0	Issued for use	S Ripley	I Weaver	S Atkinson	06-Aug-15		
B	Reissued for use	S Ripley	I Weaver	S Atkinson	27-Aug-15		

CONTENTS

1. EXECUTIVE SUMMARY

WorleyParsons was engaged by the Iron Bridge Joint Venture (IBJV) to undertake a surface water impact assessment for the proposed port facility at Anderson Point as part of the North Star Study 2 Project (NSS2).

This report presents the results of a surface water impact assessment, identifies the potential impacts associated with the proposed development and presents mitigation and management measures. The results suggest the following:

- There is a decrease in peak flow, and an increase in total volume of runoff from the site under post development conditions. The delivery of a higher volume of water to the tidal creeks under post development conditions is not considered to have a significant impact on the creeks or surrounding mangrove habitat;
- To protect site infrastructure from flooding, overland flood flow paths are provided in the port drainage and earthworks design to convey floodwater from the 100 year ARI design storm event to discharge to the tidal creek;
- The runoff is discharged to the same tidal creek system as under pre development conditions and the drainage system and site earthworks ensures there is no starvation of flow or ponding that would lead to detrimental impacts to mangrove vegetation; and
- A sedimentation pond has been designed to remove suspended sediment prior to discharge to the environment.

The concept drainage approach presented in this report has been shown to effectively manage the potential surface water related risks associated with the NSS2 port development (Figure 1), and to minimise impacts to the tidal creek and mangrove habitat. The management measures are also consistent with those presented in the Fortescue: Surface Water Management Plan, Environment (Fortescue, 2014) and drainage systems at Fortescue's existing port facility at Anderson Point.

2. INTRODUCTION

2.1 Background

WorleyParsons was engaged by the Iron Bridge Joint Venture (IBJV) to undertake a Surface Water Impact Assessment for the proposed port facility for export of magnetite, as part of the North Star Study 2 Project (NSS2).

The proposed port facility is located at Anderson Point in Port Hedland approx. (663979 E, 7750017 N, MGA Z50). The Dewatering Facility and Iron Bridge Stockyard are located outside the Anderson Point lease area (DRG No: 662PO-4200-DR-GN-0001) and will be referred to as the Project for the remainder of the report.

Figure 1: Location of Dewatering Facility and Iron Bridge Stockyard, Port Hedland

Following completion of the V3 study the preferred location of the Project changed to an area to the north of the TPI's stockyard, on the eastern side of the causeway. The presently undeveloped land will require removal of mangroves and placement of geofabric, bulk fill and extension of rock revetment. The stockpile area will be covered by a shed roof.

2.2 Objectives

The objective of this surface water impact assessment is to identify surface water risks associated with the proposed port development and to develop surface water management measures and associated designs to mitigate risk and minimise potential impacts on the environment.

The management measures will be consistent with those presented in the Fortescue: Surface Water Management Plan, Environment (Fortescue, 2014).

2.3 Scope of Work

The scope of work for this impact assessment includes:

- Identify surface water related risks associated with the proposed development;
- Identify surface water management measures to mitigate risk and potential impacts on the environment;
- Validate the performance of proposed mitigation measures, specifically:
  - Confirm that the drainage system design can capture and treat runoff from the site and mitigate the risk of flooding from rainfall runoff;
  - Confirm that sedimentation ponds can effectively remove suspended sediment prior to discharge to the environment; and
  - Confirm that the quantity and quality of flow conditions to downstream mangrove habitats, located in tidal creeks, are similar under pre and post development conditions.
- Complete an impact assessment with proposed surface water management measures in place.

3. METHODOLOGY

The following methodology was adopted for this surface water impact assessment:

- Literature review and gap analysis;
- Characterise the existing site conditions;
- Identify sensitive receptors in the project area and the surface water risks associated with the Project;
- Develop surface water management measures to mitigate risk;
- Utilise LiDAR data (2015), design earthworks levels and infrastructure layouts to delineate catchment areas under pre and post development conditions;
- Estimate peak flows, hydrographs and flow volumes under pre-development conditions using Regional Methods presented in Australian Rainfall and Runoff (AR&R, 1987) and XP-Storm modelling software (hydrological and hydraulic modelling software);
- Develop concept drainage and sedimentation pond designs to maintain the quantity and quality of flow to downstream tidal creeks and mangrove habitats under post development conditions;
- Test and confirm hydraulic performance of concept drainage and sedimentation pond designs using XP-Storm modelling software. Use the model to estimate peak flows, hydrographs and flow volumes under post-development conditions;
- Estimate and compare peak flows, hydrographs and flow volumes under pre and post development conditions; and
- Complete an impact assessment with proposed surface water management measures in place.

The hydrological analysis presented in this report has adopted methods consistent with those presented in Australian Rainfall and Runoff (AR&R, 1987).

4. LITERATURE REVIEW AND GAP ANALYSIS

4.1 Literature Review

A literature review was conducted to identify reference documents that are relevant to this study. The reference documents referred to when preparing this Surface Water Impact Assessment are listed in Table 1 along with their relevance.

Table 1: Reference Documents and Relevance to this Study

Reference	Relevance
Benthic Primary Producer Habitat Survey and Impact Assessment (201012-00530-EN-REP)	This report was used to identify significant sensitive surface water ecosystems within the NSS2 development. The study indicated the only significant sensitive ecosystem within the project area are the mangroves.
Mangrove Protection Management Plan (P-PL-EN-0012)	This report was used to understand the specific monitoring requirements needed for the protection of mangroves and minimisation of impacts to the mangroves during works
Fortescue: Surface Water Management Plan, Environment (Fortescue, 2014)	This document presents legislative requirements and objectives for surface water management at all Fortescue sites and also presents the potential direct and indirect environmental impacts to surface water arising from Fortescue's activities. The potential impacts relevant to this study include: • Alteration of surface water volume and flow regimes; • Reduction in water quality; • Fauna and habitat loss; • Increased turbidity and downstream sedimentation caused by excessive erosion; • Increased risk of storm surge and flooding. This Surface Water Impact Assessment Report addresses these risks and presents management measures and engineering designs that are consistent with Fortescue's Surface Water Management Plan.
Western Australian Water in Mining Guideline published by the Department of Water (DoW, 2013)	This guideline ensures the consideration of mining activities on surface water dependent ecosystems, including surface water dependent coastal vegetation such as mangroves. An objective from the guidelines that is particularly relevant to this Surface Water Impact Assessment is to: • Minimise the adverse effects of the discharge of

Reference	Relevance
	water from the site on environmental, social and cultural values. This Surface Water Impact Assessment Report achieves this objective.
T155: Port – Flood Risk Assessment and Drainage Design (515P-10029-RP-HY-0001)	The surface water management measures presented in this report were designed to: • Manage surface water runoff to minimise impacts on port operations and protect key infrastructure from flooding; and • Minimise surface water impacts on tidal creeks and mangrove habitats associated with the expansion of FMG's port facility. The objectives were therefore very similar to the objectives of this study. So a similar approach was adopted for the design of storm water drainage systems at the NSS2 site. The results of this study were used also to confirm the soil types and parameters for modelling, to identify the contributing catchment areas and to evaluate the risk posed by flooding in upstream catchment areas. The study showed that the FMG port development protects the proposed NSS2 site from floodwaters passing from upstream catchment areas and that floodwater levels in the vicinity of the NSS2 study area are influenced mostly by tide and storm surge levels (tailwater conditions).
T155: Port – Basis of Design for Earthworks, Roads and Drainage (510P-00000-BD-CI-0001)	This document assisted with the development of the Basis of Design for this study (Section 7.2).
The Heng Shan Project South West Creek Flood Study (00093-R-05029-RP-HY-0001)	The results of this study were used to characterise the existing hydrological conditions; to evaluate the risk that flooding in South West Creek poses to the NSS2 site. The study showed that the FMG port development protects the proposed NSS2 site from flooding as a result of upstream catchment areas.
Oceanic Storm Surge Study at Anderson Point, Port Hedland Harbour (07519-06010-EN-RP-0002)	The results of this study were used to set tail water conditions when developing the concept drainage design.
Pilbara Iron Ore and Infrastructure Project: South West Creek and Rail Loop Flood Study (11098-06100-	The results of these studies were used to characterise the existing hydrological conditions, to evaluate the risk that flooding in South West creek poses to the

Reference	Relevance
CI-RP-0002)	NSS2 site, and to confirm the contributing catchment areas.
Pilbara Iron and Infrastructure Project – Railway Stages A & B Waterways Report (300/07519-06010-CI-RP-0001)	

4.2 Gap Analysis

The literature review shows significant existing surface water and environmental information and data is available to support this impact assessment. This information is considered sufficient to characterise the existing site hydrology, to identify potential environmental risks and receptors and to develop appropriate mitigation and management measures for the Project.

No significant information gaps were identified.

5. EXISTING SITE CONDITIONS

5.1 Climatic Conditions

The Pilbara region is classified as arid to semi-arid with average annual rainfall between 200-350mm. The region is a climate of extremes with considerable variability controlled by the tropical cyclones during the summer months, predominantly January to March. Flooding is usually associated with cyclonic events, decreasing with distance from the coast.

Rainfall and evaporation data recorded from the Bureau of Meteorology (BoM) Port Hedland Airport monitoring station (4032) are shown in Figure 2 and Figure 3.

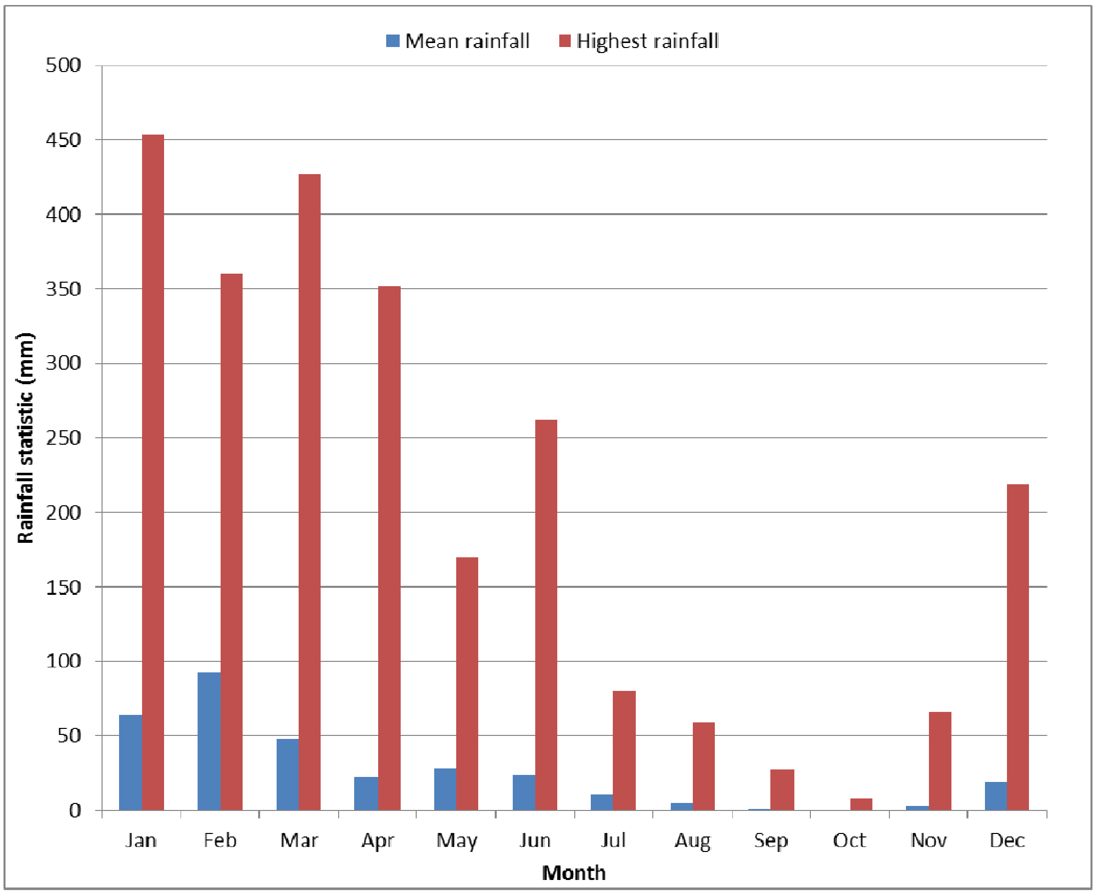

Figure 2: Average monthly rainfall statistics for Port Hedland Airport (BoM 2015)

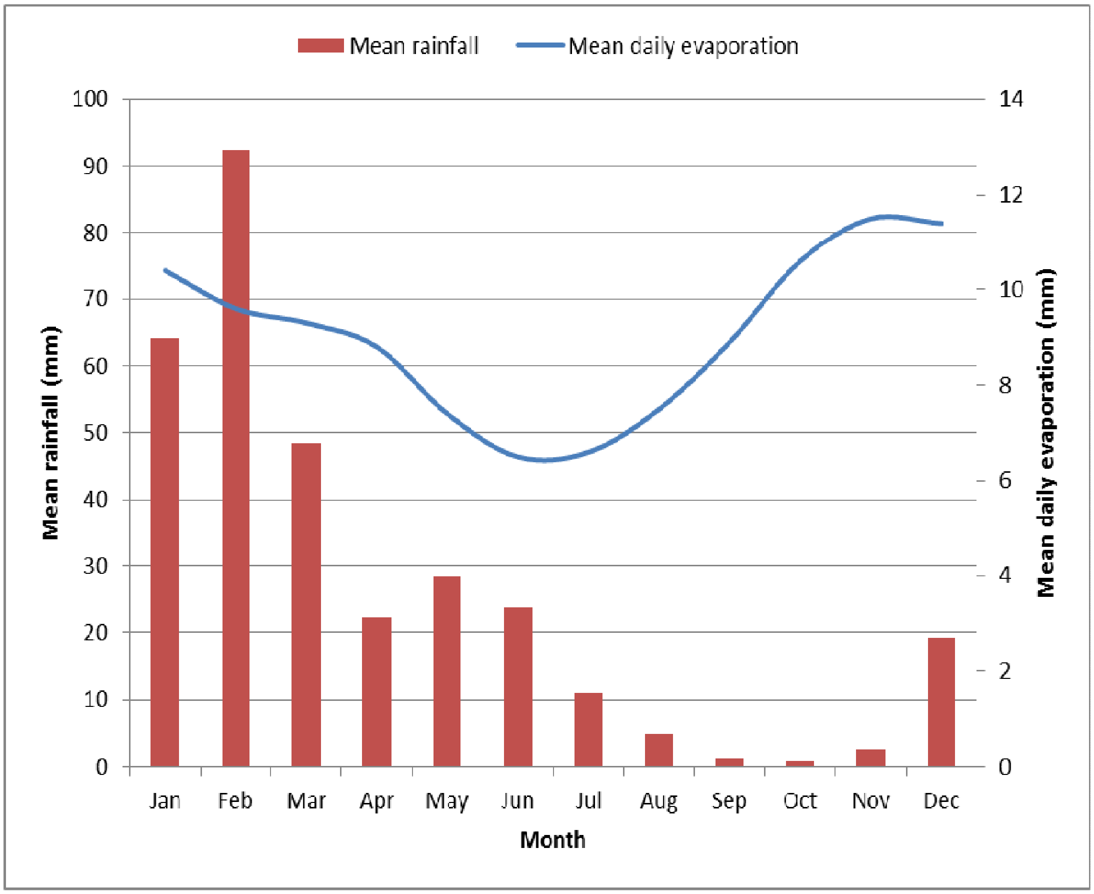

Figure 3: Mean monthly rainfall and daily evaporation statistics (BoM 2015)

5.2 Intensity-Frequency-Duration Curves

Design rainfall Intensity-Frequency-Duration (IFD) data for the Project was obtained from the BoM online IFD tool. IFD Data for the NSS2 Project (663979 E, 7750017 N, MGA Z50) are shown in Figure 4.

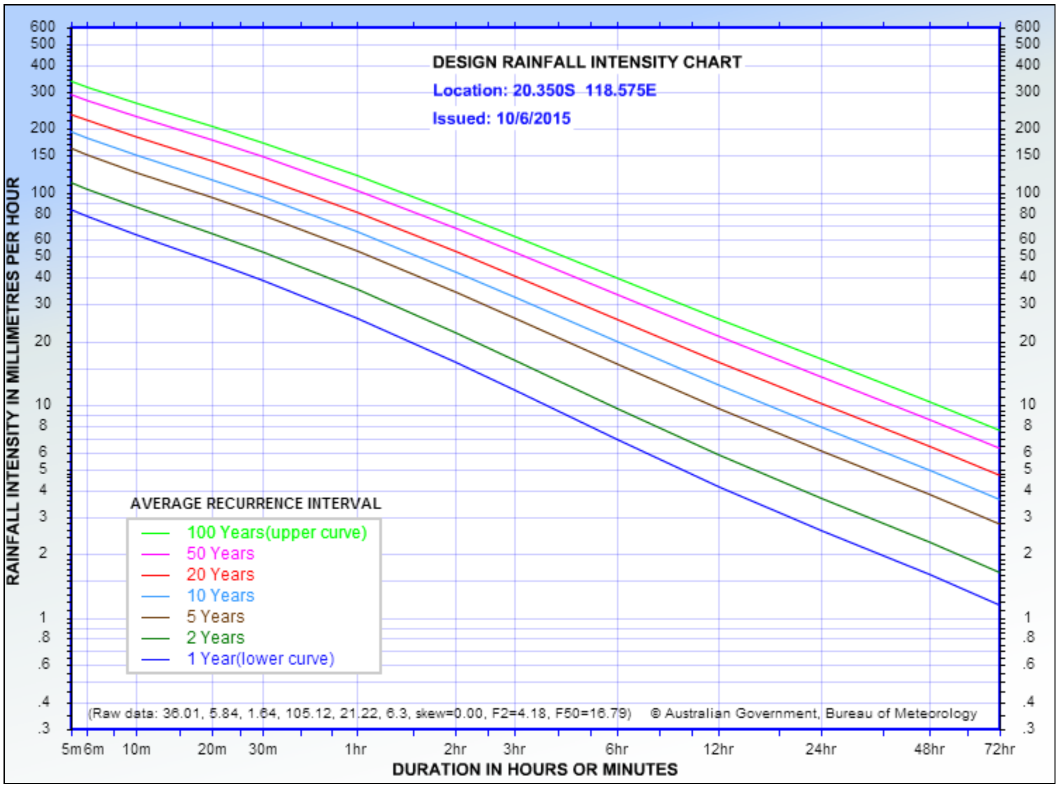

Figure 4: Design rainfall IFD chart for Port Hedland (BoM 2015)

5.3 Topography

The Project lies within the floodplain of South Creek and South West Creek, within the Port Hedland coastal zone. The Project footprint is located on tidal flats, characterised as flat, low lying terrain. Much of the surface water flow in the catchment is in the form of overland/sheet flow (WorleyParsons 2004) generated from rainfall runoff.

The aerial photography and contour data indicate the Project area is flat, with overland flow following natural pathways and discharging into the tidal creek to the east of the Project.

5.4 Hydrology

The Project area, lies immediately north of the existing Anderson Point Port development. It is protected from flood waters originating from South Creek and South West Creek, the two major watercourses in the area, by existing port infrastructure (WorleyParsons 2011 T155: Port – Flood Risk Assessment and Drainage Design). Runoff flows impacting on the project area therefore are limited to rainfall excess runoff, generated from the local catchment, which flows into the adjacent tidal creek. The catchment areas and flow paths contributing to the tidal creek under pre-development conditions are shown in Figure 5. Under the existing conditions, rainfall runoff is distributed across the catchment area with no single point source of discharge to the tidal creek.

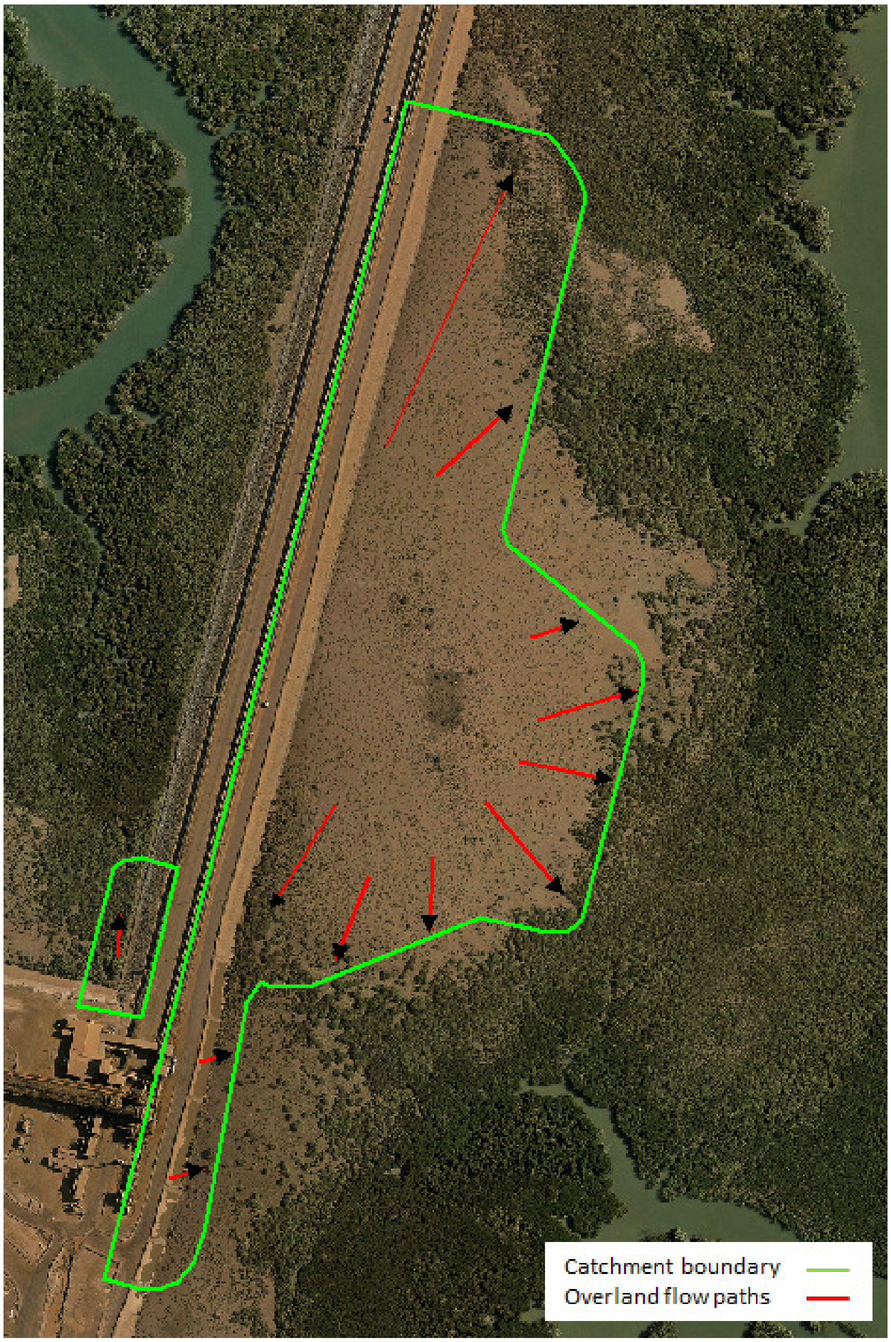

Figure 5: Pre-development hydrology and environmental receptors

5.5 Tides

Port Hedland experiences large tidal range as shown in Table 2 (from the Australian National Tide Tables, 2011).

Table 2: Standard Tide Levels from the 2011 National Tide Tables

Highest Astronomical Tide (HAT)	Mean High Water Springs (MHWS)	Mean High Water Neap (MHWN)	Mean Sea Level	Mean Low Water Neap	Mean Low Water Springs
7.5	6.7	4.6	4	3.3	1.2

Measurements are referenced in m CD. In Port Hedland the conversion between AHD and CD is based on the following equation: 0.0m AHD = +3.9m CD (WorleyParsons (BoD) 2011).

5.6 Storm Surge

Storm surge is a rise in normal sea water level along the shore as a result of strong onshore winds and/or low reduced atmospheric pressure. A storm surge accompanies a tropical cyclone as it comes ashore. Storm surges can also be formed by intense low-pressure systems in non-tropical areas.

A previous study of Oceanic Storm Surge at Anderson Point, Port Hedland Harbour by WorleyParsons (2004) concluded the following:

- 100 year ARI storm surge water level reaches +6.1m AHD (still water level) at Anderson Point; and
- 50 year ARI storm surge water level of 5.4m AHD.

The study showed the design peak flood levels developed by the modelling vary through the harbour area and are shown to be highest over the mudflats and sandy lowland areas where the high ground elevation tends to lift the storm surge water level.

5.7 Tailwater Levels

The modelling undertaken as part of the Greater Port Hedland Storm Surge Study (Global Environmental Modelling Systems 2000) provided catchment response times for South West Creek. For the 50 year and 100 year ARI peak design floods, the times to peak flood generally varied between 8 to 12 hours, depending on the rainfall pattern being modelled. The results demonstrate that the river flood peak discharge generally occurs well after any ocean storm surge such that the probability of the two events occurring at the same time is low. The joint probability of occurrence is less than 1% yielding an equivalent ARI in excess of 100 years.

In line with the above results and with the hydrological and hydraulic model simulations of previous studies, a high tailwater condition at the outlet of 3.6m AHD (Highest Astronomical Tide [HAT]) was adopted as a basis of the concept design.

6. SENSITIVE RECEPTORS, SURFACE WATER RISKS AND MANAGEMENT MEASURES

6.1 Sensitive Receptors

The Benthic Primary Producer Habitat Assessment indicated the disturbance footprint of the project consists mainly of bare saltflat and some sparse mangrove. Some of the area has already been disturbed and the saltflat areas are not considered to be BPPH (WorleyParsons 2015 BPPH Assessment).

Direct loss of mangrove will occur during the construction works primarily along the Project's eastern border and the development area portion located on the west side of the causeway Figure 5. The area of mangroves to be removed will be 1.85 ha, which includes 1.47 ha of open, sparse *Avicennia marina* species, and 0.38 ha of closed canopy mangrove. The location and extent of mangroves are presented in Figure 5. There is expected to be no major impact on the ecological integrity of the remaining mangrove stands as the existing tidal flushing regime will be maintained (WorleyParsons 2015 BPPH Assessment).

The remaining mangrove habitat must be protected from the Project surface water runoff through effective surface water management. Measures must be implemented to ensure the quantity and quality of surface water from the site under pre and post development conditions are similar. The Mangrove Management Plan will be utilised to monitor the health of mangroves and mangrove habitat during the construction and operation works.

The surface water management measures presented in this section have been developed to minimise impacts to the mangrove habitat.

6.2 Surface Water Risks

6.2.1 Sediment Loads

The main risk posed by the proposed development to the environmental receptors is the mobilization and transport of sediment laden runoff from the development area. Runoff from the existing (pre-development) site will transport sediment during significant flood events. However sediment loads in runoff from stockpile areas and disturbed port site areas are significantly higher than would occur under natural conditions.

The risk posed by sediment in runoff is also high during construction where the ground is disturbed and prone to erosion.

6.2.2 Hydrocarbon discharge

There is potential for adverse change to surface water quality due to the discharge of hydrocarbons stored, handled or transported on site, into tidal creeks.

6.2.3 Alteration of surface water volume and flow regimes

The development of the site has the potential to alter surface water runoff volumes and flow regimes to the tidal creek mangrove habitat.

Alterations to the runoff volumes and flow regimes can occur if the catchment areas contributing runoff and their characteristics are significantly changed.

6.2.4 Increased turbidity caused by erosion

Construction activities will disturb areas of the site which will potentially increase the risk of erosion by wind and rain and lead to increased turbidity in the receiving tidal creek and mangrove habitat.

6.2.5 Storm surge and flooding

The site is located in an area which is subject to the effects of storm surge during extreme storm events, which poses a flood risk to the site.

Rainfall runoff also poses a potential flood risk to the site. Previous investigations (Section 4), suggest that Fortescue's existing port facility provides adequate protection from floodwaters passing from South Creek and South West Creek. Flood levels in the vicinity of the NSS2 site are influenced most by tide and storm surge.

Direct rainfall runoff on the site must be managed to minimise the risk of flooding of infrastructure.

6.3 Surface Water Management Measures

The following surface water management measures are consistent with Fortescue's Surface Water Management Plan (Fortescue 2014) and drainage systems at Fortescue's existing port facility at Anderson Point.

6.3.1 Sediment Loads

Runoff from the site during operations will be captured in a surface drainage network and treated using a sedimentation pond or alternative sediment trapping methods to remove suspended sediment prior to discharge to the tidal creek and mangrove habitat.

Runoff generated during construction from disturbed areas on site will be managed to remove the sediment prior to discharge to the tidal creek.

6.3.2 Hydrocarbon discharge

Hydrocarbons will be managed to avoid leaks and spills. Fuel handling areas will be bunded to capture any spills for remediation and located outside of floodplains or appropriately elevated to avoid the risk of flood inundation. Bunded areas must be capable of containing the combined volume from runoff from a 20 year ARI 72 hour duration design flood event and 110% of the tank contents in accordance with the Water Quality Protection Guidelines No 6. (Water and Rivers Commission 1999).

6.3.3 Alteration of surface water volume and flow regimes

The drainage design developed for the site will collect runoff on the site, treat and discharge back to the same tidal creek as under natural conditions. The catchment areas contributing runoff to the tidal creek under pre and post development conditions will remain the same to minimise impacts on the volume of runoff and flow regime.

6.3.4 Increased turbidity caused by erosion

Runoff generated during construction from disturbed areas on site will be managed to remove sediment prior to discharge back to the tidal creek.

The drainage system presented in this report was designed to limit flow velocities generally to less than 2m/sec for the design event to minimise the risk of scour and erosion. Scour protection is recommended to prevent erosion in those areas where velocities exceed 2 m/sec.

The finished earthworks level is the same as the existing Anderson Point development, (nominally 7.0m AHD). For drainage purposes, the finished earthworks level was assumed to gently grade to trapezoidal drains at a nominal surface gradient of 0.5%, to limit overland flow velocities and to reduce risk of scour and erosion from rainfall runoff.

6.3.5 Storm surge and flooding

The civil design for the site has taken into consideration tide levels and storm surge to protect the site from flooding by storm surge.

The drainage system design has been designed to protect the site infrastructure from flooding caused by direct rainfall runoff. The drainage system has also been designed to prevent starvation of flow or ponding in mangrove areas.

7. DRAINAGE SYSTEM DESIGN

7.1 Rainfall Runoff Modelling

The pre and post development hydrological conditions at the site were examined using XP-STORM hydrologic and hydraulic modelling software. A conceptual drainage layout was adopted for the post-development condition. XP-STORM was used to estimate peak flows and hydrographs within the modelled drainage system. XP-STORM's modelling methods and parameters are consistent with those presented in AR&R (1987) and were adopted for the design of the FMG T155 port drainage systems (WorleyParsons 2011).

The model calculates rainfall runoff for delineated catchment areas and routes the runoff through the drainage network. The software can account for storage effects, infiltration losses based on soil type and is able to estimate runoff from both pervious and impervious areas.

For this project, infiltration losses were estimated using the Green Ampt Method. The representative soil parameters shown in Table 3 were adopted for the various pervious areas assigned to the modelled subcatchments.

Table 3: Adopted Green-Ampt Infiltration parameters (SWMM Runoff Variables)

Classification / Land Use *	Average Capillary Suction (mm)	Saturated Hydraulic Conductivity (mm/hr)	Initial Moisture Deficit
Bare Earth / Fill	218.5	3.0	0.250
Magnetite Stockpiles if exposed to rainfall	110.1	21.8	0.358

* Soil types selected from available list in XP-Storm, and considered representative of the materials at site.

Pre-development modelling involved estimating runoff from the existing catchment area shown in Figure 5 and routing the flows to the tidal creek.

Post development modelling required the development of concept drainage designs (including a sedimentation pond). The designs were incorporated into the model to demonstrate the effectiveness of a typical drainage network to convey flows to the tidal creek without significantly impacting on the quantity of flow. The post development modelling methodology and the Basis of Design are described below.

7.2 Basis of Design

All simulations adopted a high tailwater condition at the outlet from the XP-Storm model network, of 3.6m AHD (Highest Astronomical Tide [HAT]).

The Water Quality Protection Guidelines (DoW 2000) provides guidelines for stormwater management, with stormwater drainage to be designed in accordance with Australian Rainfall and Runoff (1987). Stormwater management on site shall provide for the collection, storage and disposal of water, with runoff carrying high sediment loads diverted to a sedimentation pond for treatment prior to discharge to the environment, in accordance with these guidelines.

The minor / major design approach recommended in AR&R (1987) was adopted for this Project. This approach requires all “minor” runoff from the 10 year ARI design storm event to be captured and treated by the stormwater drainage system at the site prior to discharge to the tidal creek. All “major” rainfall runoff on site, from the 100 year ARI design storm event, is assumed to report to the central area of the site before draining into the sedimentation pond for discharge to the tidal creek. Infrastructure designs should be developed with building pad levels set above the 100 year ARI flood levels of 6.1m AHD.

The conceptual site drainage network comprised trapezoidal drains designed to capture runoff from both pervious and impervious areas and to direct flows to a sedimentation pond located adjacent to the northern boundary of the site prior to discharge from the site.

A nominal finished earthworks level of 7.0m AHD was adopted, in line with the existing Anderson Point development. The finished surface was assumed to gently grade to trapezoidal drains and toward the sedimentation pond at an average gradient of 0.5%.

7.2.1 Open Drains

Trapezoidal open drains were adopted to control scouring and sedimentation and to minimize sudden changes in velocity. The designs had side slopes no steeper than 1V:3H, with base widths varying from 2m to 5m. The drains were generally unlined except where scour protection was required:

- where design velocities exceeded 2m/s;
- where drain materials had high scour potential;
- at all culvert inlets and outlets;
- at substantial changes in direction of open channels and drains; and
- at abrupt changes in invert levels at falls along any open drain alignment.

7.2.2 Sedimentation Pond

The runoff from the Project will be directed from a surface drainage system into an unlined sedimentation pond for treatment, prior to discharging, via a spillway and outlet drain, to the tidal creek. The pond will be designed to provide detention of the 10 year ARI storm event for sufficient time to settle out of suspension sediment particles of size greater than or equal to 75µm (fine sand/silt). Typical sedimentation pond sizing calculations are provided in Appendix 1.

The rock lined spillway will include a geosynthetic underlay to limit the erosion of fines from the underlying subgrade. For the 10 year ARI design event, a typical pond design is expected to provide a minimum freeboard of 500mm above the peak water level to the crown of the sedimentation pond bund.

8. PRE DEVELOPMENT HYDROLOGY

8.1 Catchment Delineation

The proposed development catchments contributing rainfall runoff to the tidal creeks under pre development conditions are depicted in Figure 5. The total catchment area is 12.09 Ha.

8.2 Hydrological Modelling

The catchment area was assumed to comprise undisturbed bare earth which was assumed to be 100% pervious. Runoff was estimated from rainfall excess after infiltration was assessed using the Green Ampt soil parameters in Table 3. No impervious areas were present within the catchment area.

A range of design storm durations were tested using the XP-Storm model to identify the critical duration (the duration producing the largest peak flow). The 10, 20, 30, 45, 60, 90 and 120 minute duration rainfall events were tested yielding a peak flow rate of 1.70 m^3/sec for the critical duration of 60 minutes. The resulting pre development hydrograph for the 10 year ARI design storm of 60 minutes duration is presented in Figure 6.

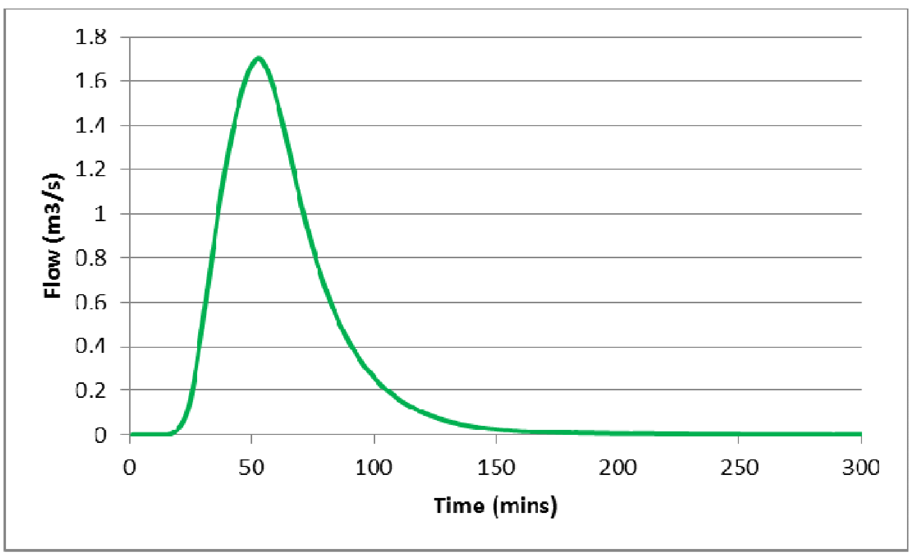

Figure 6: Pre-development hydrograph from the 10 year ARI design storm of 60 minutes duration.

9. POST DEVELOPMENT HYDROLOGY

9.1 Catchment Delineation

The existing TPI Port protects the proposed development area from flooding of South Creek and South-West Creek. Local rainfall-runoff from the NSS2 site drains south to the tidal creek as shown in Figure 7, with the site boundary defining the post-development catchment area.

A drainage network was developed based on the infrastructure layouts for the Project (DRG No. 662PO-4200-DR-GN-0001_D). Delineation of internal sub-catchments was completed to determine the areas contributing flow to the different sections of the drainage network. Subcatchment delineation for the development area and the proposed discharge location to the tidal creek are shown in Figure 7. The total catchment area was 12.09 ha. Subcatchment areas corresponding to Figure 7 are shown in Table 4.

Table 4: Areas of subcatchments in the Project area

Subcatchment Number	Area	Subcatchment Number	Area
sc1	1.61ha	sc7	0.72ha
sc2	1.32ha	sc8	1.14ha
sc3	1.68ha	sc9	1.17ha
sc4	0.77ha	sc10	0.84ha
sc5	0.44ha	sc11	0.71ha
sc6	0.61ha	sc12	1.08ha

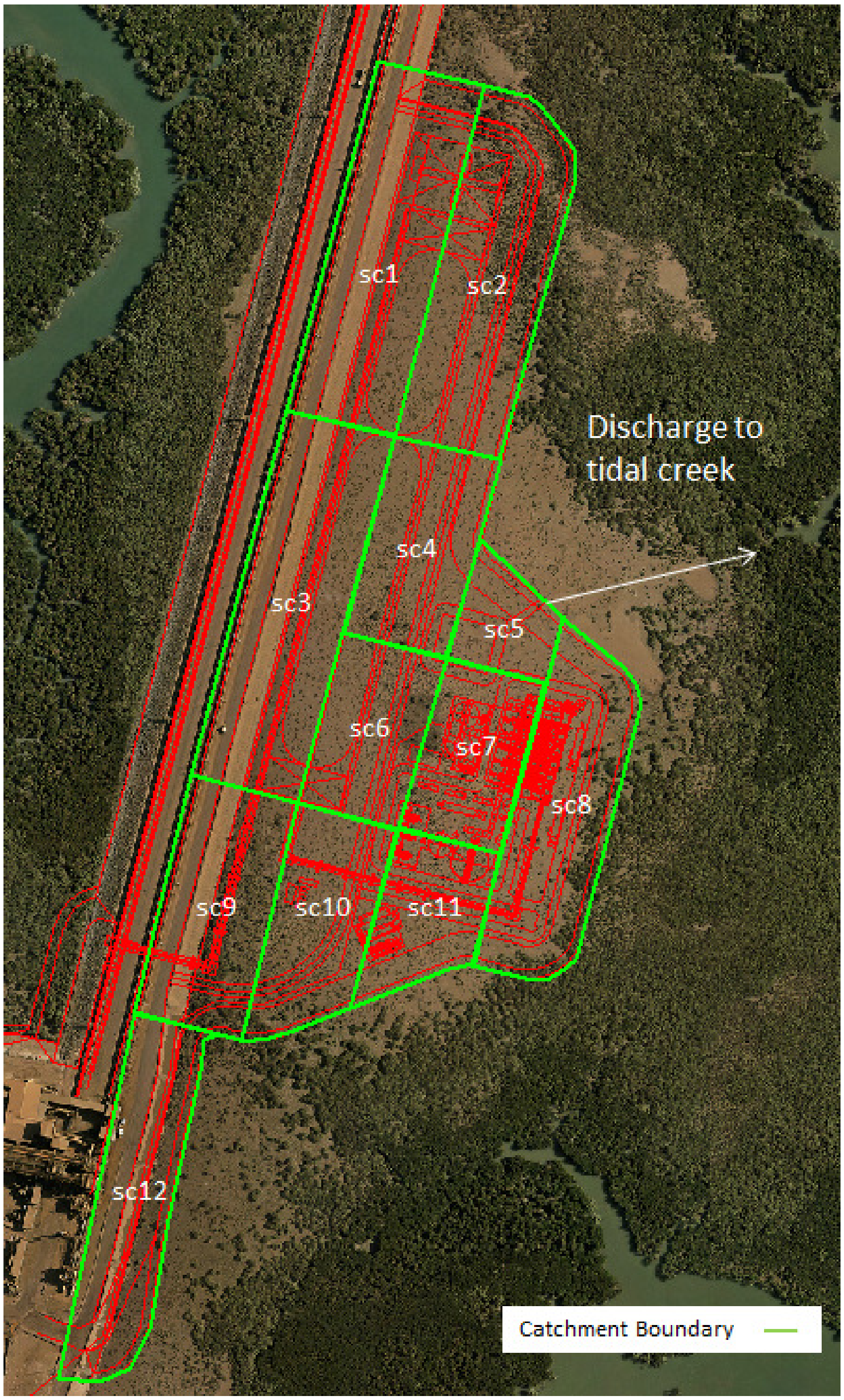

Figure 7: Delineated catchment areas discharging to tidal creek

9.2 Drainage Design

A conceptual drainage system was evaluated and the hydraulic performance tested using XP-Storm in accordance with the Basis of Design outlined in Section 7.2.

The following assumptions were adopted for evaluation of a conceptual drainage system using the XP-Storm model:

- Drain the NSS2 development area from the south and west towards the north east at an average grade of 0.5%. This grade was assumed sufficient to direct runoff to surface drains and to reduce risk of scour and uncontrolled discharge of surface water runoff to the tidal creek;
- Surface drains should be nominally 0.3 to 0.7 m deep with 1:3 (V:H) side slopes;
- Impervious fractions are assigned to catchment areas based on planned infrastructure;
- A high tide level tailwater condition of 3.6m AHD is considered at the outlet of the system (WorleyParsons 2011); and
- Runoff is collected and discharged to a sedimentation pond for removal of suspended sediment prior to discharging the treated water to the tidal creek.

Design levels for the concept drainage network were developed to minimize drain depths while providing adequate drain gradients for effective movement of flows to the sedimentation pond and outlet.

For the portion of the NSS2 project on the west of the causeway, it is assumed the area will tie into the existing drains.

9.3 Hydrological Modelling

Green Ampt soil parameters in Table 3 were used to estimate infiltration losses and hence runoff from bare earth areas.

A range of design storm durations were tested using the XP-Storm model to identify the critical duration. The 10, 20, 30, 45, 60, 90, 120 minute duration rainfall events were tested and again the critical duration was identified to be 60 minutes.

The resulting post development flow hydrographs are presented in Figure 8. Peak flows and volumes are also presented in Table 5.

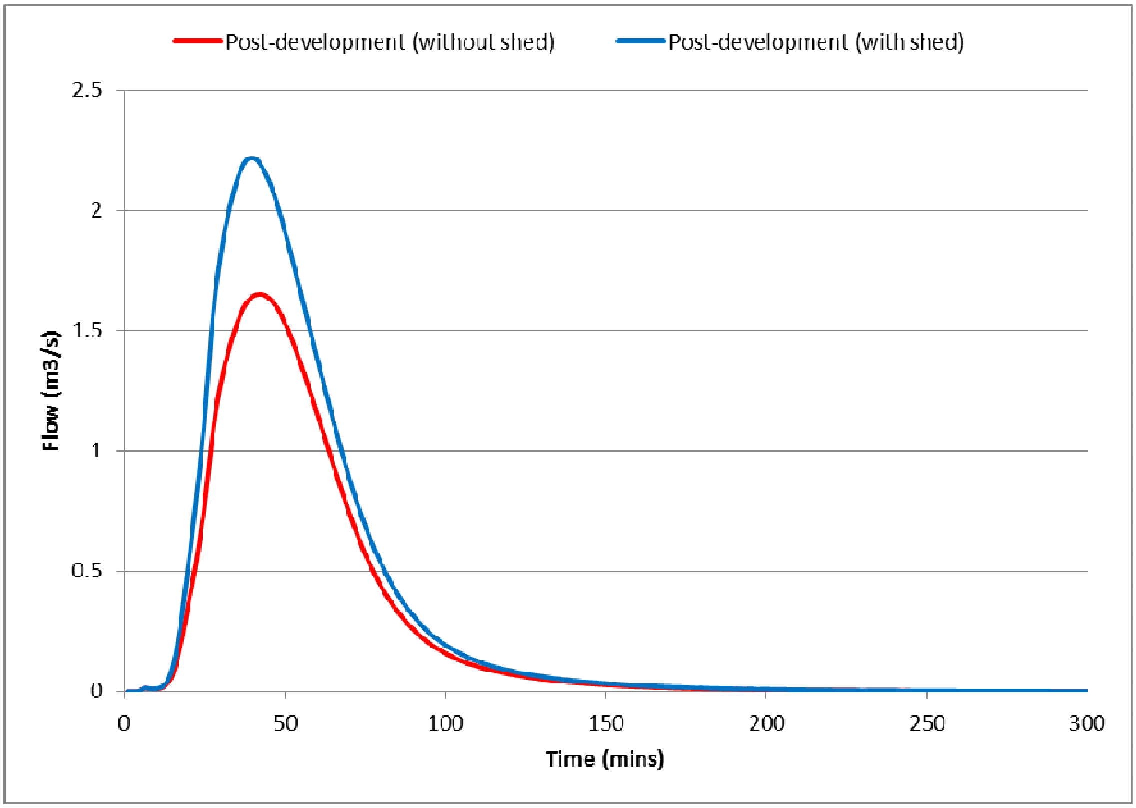

Figure 8: Post-development flow hydrographs (m^3/sec) for the 10 year ARI design event

Results from the XP-STORM modelling suggests the 10 year ARI design flows are contained within the drainage system. The peak flow for the post-development scenario with a shed is greater than without the shed cover. The runoff passed through the sedimentation pond for treatment prior to discharge to the tidal creek. At least 500 mm of freeboard was maintained above the pond maximum water level to the crown of the surrounding bunds.

Rational Method calculations were also performed to confirm the peak flow estimates generated by the XP-Storm model (AR&R1987). The results presented in Table 5 suggest that the peak flows estimated using the Rational Method are comparable to the XP-Storm model predictons.

Table 5: Comparison of peak flow and volume estimates for 10 year ARI design event

Model Scenario	Peak Flow (m^3/sec)	Volume of Runoff (m^3)
Pre-development conditions	1.70	4729
Post-development (without shed)	1.65	4760
Post-development (with shed)	2.21	6142
Rational Method calculation (AR&R, 1987)	1.65	5722

9.4 Sedimentation Pond

A sedimentation pond is proposed to remove sediment from collected runoff. It will be designed to manage sediment transported in runoff from storms up to the 10 year ARI design event. The dimensions of a typical sedimentation pond were determined using Stoke's Law and the Fair and Geyer (1954) method was used to calculate the fraction of initial solids removed. The resulting conceptual pond was 40 m long, 10 m wide and 1 m deep, which produced a 0.83 fraction of initial solids removed assuming a 75μm particle size. Sedimentation pond calculations are provided in Appendix 1. The calculations show that a significant proportion of particles of size less than 75μm can be removed and almost all particles greater than 75μm are removed. These sediment removal removal rates are based on the endemic soil types of the area (reflected in the materials likely to be used in the earthworks and unsealed pavements). Any transported magnetite particles, which have much higher density, will settle out even more readily.

Changes to pond size and shape will affect the fraction of sediment removed. A smaller sized pond is likely to be reflected in a lower removal fraction. Pond shape also affects removal efficiency. Circular or square ponds are least efficient shapes. Rectangular ponds, with the ratio of the long side length to short side length greater than three are substantially better, provided that the inlet and outlet positions are at opposite ends of the pond.

A typical sedimentation pond was also modelled using XP-Storm and showed that the hydraulic performance consistent with the Basis of Design could be readily achieved. For the modelling a conservative approach was adopted, by which the pond was assumed full to the weir crest prior to the design storm.

10. IMPACT ASSESSMENT

Comparison of the estimated pre and post development peak flows, volumes and hydrographs (Figure 9) and summarized in Table 5 suggest the following:

- While there is an increase total volume of runoff from the site under post development conditions its contribution is small compared to the runoff expected from the total catchment discharging to each of the affected creeks and insignificant when compared to the tidal flows to which the mangroves are subjected. The delivery from the site of a higher volume of water to the tidal creeks under post development conditions is not considered to have a significant impact on the tidal creeks or the surrounding mangrove habitat;
- Flood flow paths will be considered in the port drainage and earthworks design to convey floodwaters overland to the tidal creek to protect site infrastructure from flooding;
- Post development runoff is discharged to the same tidal creek systems as under pre development conditions and the drainage system and site earthworks are designed to avoid starvation of flow or ponding that would adversely impact the mangrove vegetation; and
- The sedimentation pond was designed to effectively remove suspended sediment prior to discharge to the environment.

By directing surface runoff flows to the proposed discharge area to the tidal creek via a sediment pond, it has been shown that management of the potential surface water related risks can be effectively achieved. Impacts to the tidal creek and mangrove habitat can be minimised.

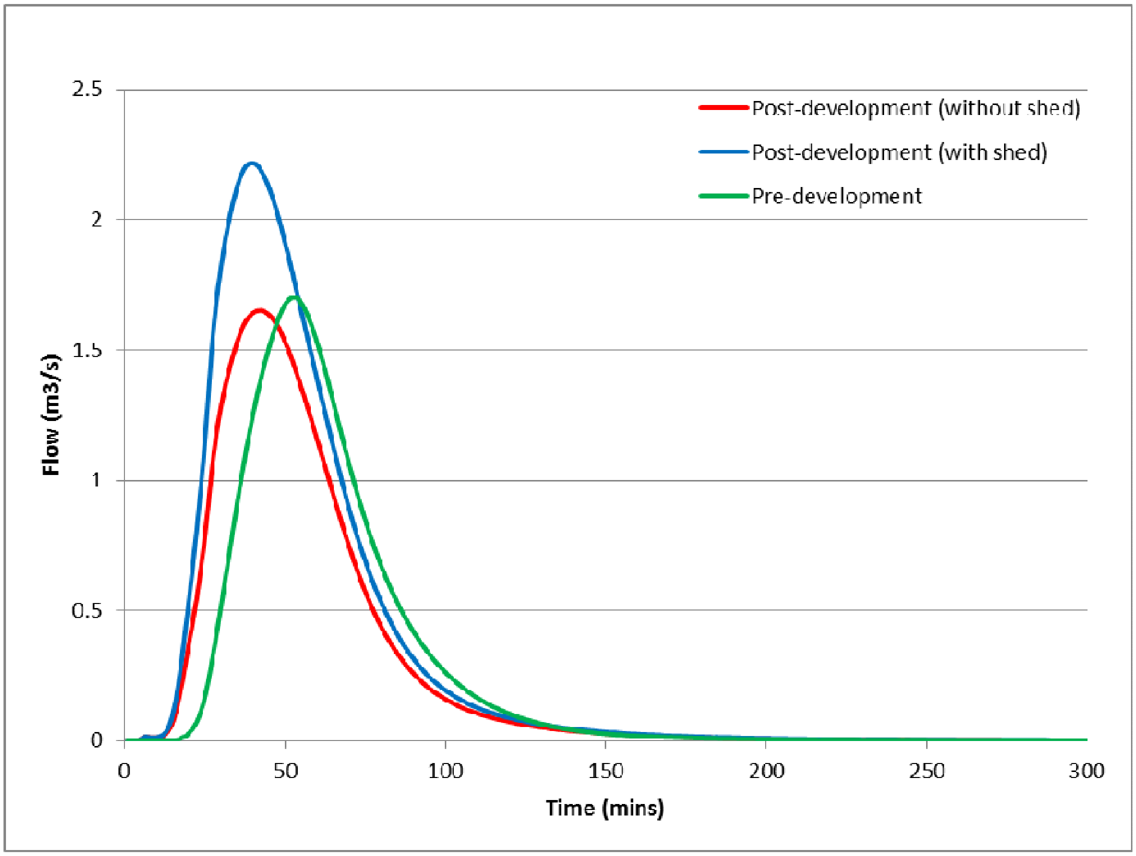

Figure 9 Comparison of pre and post development flow hydrographs for the 10 year ARI event

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Appendix 1 - Sedimentation Basin Calculations

Particle Diameter (D) (m)	Settling Velocity (Vs) (m/s)	Time to Settle 1 metre Vertically (secs)	Fraction Removed
1.00E-05	2.26E-04	4421	0.05
2.00E-05	9.05E-04	1105	0.19
5.00E-05	5.65E-03	177	0.63
7.50E-05	1.27E-02	79	0.83
1.00E-04	2.26E-02	44	0.91
2.00E-04	9.05E-02	11	0.99
5.00E-04	5.65E-01	2	1.00

Stokes Law:

$$V_s = \frac{(\rho_m - \rho_w) g D^2}{18\mu}$$

Fair and Geyer Theory:

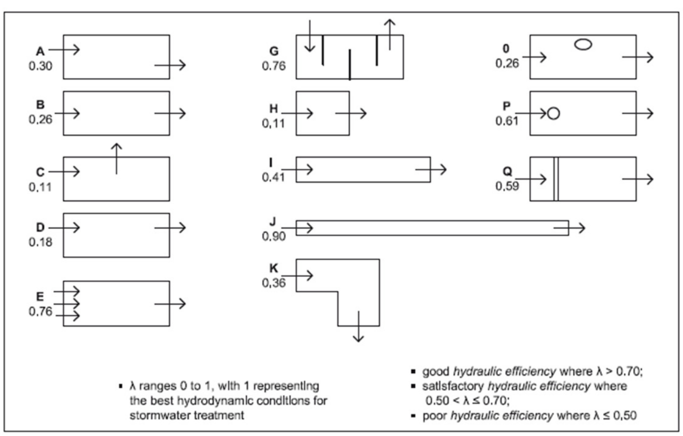
$$R = 1 - \left(1 + \frac{1}{n} \frac{V_s}{Q/A}\right)^{-n}$$

Basin Dimensions

Width	**10**
Length	**40**

Where:

ρ_m	**Density of Magnetite**	5150	kg/m3	
ρ_w	**Density of Water**	1000	kg/m3	at 20 degrees
m	**Viscosity of Water**	0.001	kg/ms	at 20 degrees
g	**Gravity**	9.81	m2/s	
A	**Basin Surface Area**	400	m2	
A	**Basin Cross Sectional Area**	10	m2	
Q	**10yr ARI Design Inflow**	1.65	m3/s	
V	**Ave Velocity of flow**	0.17	m/s	
d	**Depth of flow in pond (m)**	1.00	m	
l	**Hydraulic efficiency**	0.41		
n	**Turbulence parameter**	1.695		



Notes:

1. Settling velocities based on Stokes law for the settling of spherical particles - this applies only to small particles in non-turbulent systems with low Reynolds number.
2. 'Fraction Removed' based on Fair and Geyer theory recommended in Australian Runoff Quality (2006).

Appendix 5: Air Quality Assessment (PEL, 2015)

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Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Final Report

DUST ASSESSMENT – NORTH STAR STAGE TWO EXPORT FACILITY

FORTESCUE METALS GROUP LTD

Job ID. 20283

28 August 2015

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EXECUTIVE SUMMARY

Pacific Environment was commissioned by Iron Bridge Joint Venture (IBJV) to provide the dust assessment for the North Star Stage Two Export Facility (the Project). The purpose of the air quality assessment is to update the prediction of the potential impact on ambient air quality across Port Hedland, in particular the ground level concentration of particles (as PM_{10}), using the recently validated PHIC model (CALPUFF).

This report summarises the assessment of air quality impacts associated with the operation of the project at 176 Million tonnes per annum (Mtpa). The Project in this assessment includes FMG de-rated to 165 Mtpa with IBJV at 11 Mtpa.

OVERVIEW OF ASSESSMENT

For the purpose of the air quality assessment, the Project comprises FMG port facilities and associated infrastructure including the road network. The key pollutant assessed is particles (as PM_{10}).

Air quality assessment criteria provide the framework to assess the effects of existing and predicted emissions on human health, and the natural environment (i.e. environmental impact). Air quality assessment criteria are based on the published Port Hedland Dust Management Taskforce (Taskforce) criteria of 70 µg/m^3 for particles as PM_{10} (24-hour average) with no more than 10 exceedances per year) (DSD, 2010) at the Taplin Street monitor.

Modelled ground level concentrations for PM_{10} have been compared to ambient air quality assessment criteria in order to determine the potential impact on the environment. This assessment has considered the potential impact attributable to the Project, as well as the cumulative impact (i.e. the Project in conjunction with the existing emission sources in the Port Hedland area). The assessment has been made generally across the model domain, as well as at key sensitive receptor locations.

Air quality emissions were modelled using the Port Hedland Industry Council Cumulative Air Model (PHIC CAM). This model has been adopted by PHIC in order to provide industries with a consistent approach to the estimation and modelling of particle emissions in Port Hedland.

KEY FINDINGS OF ASSESSMENT

Particles (as PM_{10}) were modelled to represent the potential impact on the environment and human health, with an assessment being made at Taplin Street, considered to be the key sensitive receptor location. The following cases were modelled:

- Scenario 1: Project contribution in isolation of other emission sources;
- Scenario 2: Existing air quality being the baseline determined during the development of the PHIC Model (PEL, 2015);
- Scenario 3: Cumulative impact on Port Hedland with the inclusion of the project (existing air quality and the inclusion of the Project).

Scenario 1 - Project Impact in Isolation of Other Emission Sources

The modelling results for the Project (de-rated FMG at 165 Mtpa and IBJV at 11 Mtpa) in isolation of other emission sources indicate that the predicted ground level concentrations of PM_{10} at Taplin Street was 79 µg/m^3. This equated to a single excursion of the Taskforce criteria at Taplin Street. It is noted that this excursion is the result of a single high value and as the predicted 99th percentile concentration at this receptor is significantly lower indicates that the predicted maximum is an outlier.

When the PHIC 2013 Background file is incorporated into the model results for scenario 1 there was one additional excursion of the Taskforce criteria at Taplin Street. This excursion is a direct result of the background file of a single high concentration of 134 µg/m^3 which highlights the naturally high background concentrations of dust in the region.

Scenario 2 - Existing Air Quality

The modelling for scenario 2, which represents existing and proposed facilities including FMG operations at 175 Mtpa, predicts that there are nine potential excursions of the Taskforce criteria at Taplin Street. The existing air quality has been determined based on the assessment made during the development of the PHIC model (PEL, 2015). The modelling results indicate that at the key sensitive receptor (Taplin Street):

- The annual average PM_{10} concentration is 32.6 µg/m³
- The highest 24-hour maximum PM_{10} concentration is 144 µg/m³
- The maximum predicted concentration is representative of the high background dust concentrations that are encountered in this region

Scenario 3 - Cumulative Impact

This scenario represents the Project in conjunction with existing and proposed operations. The modelling results indicate that there are six potential excursions of the Taskforce criteria at Taplin Street which represents a reduction of three potential excursions of the Taskforce criteria at Taplin Street. This reduction is due to the emission characteristics of the IBJV magnetite product which have zero (or very low emissions) from stacking, reclaiming and shiploading.

The cumulative modelling results indicated that at the key sensitive receptor (Taplin Street):

- the annual average PM_{10} concentration is 31.8 µg/m³
- the highest 24-hour maximum PM_{10} concentration is 144 µg/m³
- As with scenario 2 the maximum predicted concentration is representative of the high background dust concentrations that are encountered in this region

Summary of Results

The presented results indicates that the Project will result in a reduction in ground level concentrations of PM_{10} throughout the region and reduce the number of excursions of the Taskforce criteria at the Taplin St monitor.

The modelling indicates that the introduction of the Project will result in a reduction in ground level concentrations of particulates (as PM_{10}) in the region. This is due to the emission characteristics of the magnetite product which has zero (or very low emissions) from stacking, reclaiming and shiploading.

The results of the modelled scenarios, in comparison to the relevant criteria, are shown in Table ES 6-1.

Table ES 6-1: Project Model Results Summary (Taplin St)

Reference	Criteria	Project In isolation			Project with 2013 Background			Existing with 2013 Background			Cumulative Impact (including Project) with 2013 Background		
		Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³
DSD, 2010	Maximum 10 Exceedances of 70 µg/m³ /year	78.5	6.8	1	134.0	22.8	2	143.6	32.6	9	143.7	31.8	6

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1 INTRODUCTION

1.1 Background

Fortescue Metals Group Ltd (FMG) is an Australian iron ore company, mining and exporting Direct Shipping Ore (DSO) from its operations in the Pilbara region through the Port of Port Hedland in Western Australia. FMG's Herb Elliott Port Facilities based at Anderson Point, Port Hedland, consist of processing, stockpiling and shiploading facilities, from four approved berths. These port facilities are in close proximity to the town of Port Hedland and other ore handling and export operations.

The North Star Magnetite Project is owned by the Iron Bridge Joint Venture (IBJV) an unincorporated joint venture between FMG Iron Bridge Pty Ltd and Formosa Steel IB Pty Ltd. IB Operations Pty Ltd, a subsidiary of the joint venture is the managing agent for the joint venture. The project is located approximately 110 kilometres (km) south-south east of Port Hedland in the Pilbara region of Western Australia.

The IBJV is exploring options to develop an export facility at the Port of Port Hedland, Anderson Point (herein referred to as the North Star Stage 2 export facility). The North Star Stage 2 (NSS2) export facility is located on land that is managed by the Pilbara Ports Authority (PPA) and will rely on the use of The Pilbara Infrastructure Pty Ltd (TPI) outloading infrastructure to enable loading onto a vessel. It is understood that the key infrastructure components of the NSS2 export facility includes:

- IBJV infrastructure:
  - Slurry pipeline from the Herb Elliott Port Boundary to filter plant,
  - Covered stockpiles with stacker and bridge reclaimer (stockyard)
  - Filtration plant; and
  - materials handling facility
- TPI infrastructure (a new outload circuit for magnetite product):
  - Conveyors;
  - Transfer points; and
  - Shiploader at Berth AP5

The project location relative to Port Hedland is shown in Figure 1-1

Figure 1-1 Project site location and existing third party operations

1.2 Scope of Work

Pacific Environment was commissioned by IBJV to undertake an air quality assessment for the NSS2 project (the Project). The purpose of the air quality assessment is to investigate the predicted potential impact on ambient air quality across Port Hedland that would result from the introduction of the Project, in particular the ground level concentration of particles (as PM_{10}). The assessment is to be carried out consistent with the agreed approach and methodology described for the Port Hedland Industries Council Cumulative Model (PHIC CAM).

The scope of work of this assessment includes:

- Undertake air dispersion modelling to predict the potential air quality impacts from the NSS2 magnetite export facility and the TPI 4th Outload Circuit at Herb Elliott Port, Anderson Point
- Dust impact assessment report preparation
- Attend stakeholder consultation meetings (meeting with regulators).

Ambient air quality and potential impacts are assessed in terms of Particles as PM_{10}. The background and existing air quality in the study area is the baseline determined by the PHIC CAM (PEL, 2015).

1.3 Structure of Report

This report describes the methods and findings of an assessment of the potential impacts to the air environment arising from the operation of the Project. The assessment includes:

- Study approach and methodology (Section 2)
- Quantification of emissions of particles (dust in the form of PM_{10}) from the Project (Section 3)
- Atmospheric dispersion modelling of the emissions, using the Port Hedland Industries Council Cumulative Model (PHIC CAM) (Section 4)
- An evaluation of the incremental change in air quality and impact to the air environment by the Project (Section 4)
- Conclusions (Section 5).

The Appendices contain relevant extracts from the PHIC CAM report (PEL, 2015).

2 STUDY APPROACH AND ASSESSMENT METHODOLOGY

This section outlines the approach applied in the assessment of ambient air quality. It includes the methodology applied to defining the meteorological characteristics of the project area important to the assessment, the emission estimation techniques, the dispersion model of choice, and the ambient assessment criteria selected for the purposes of determining the significance of the dispersion model results, and therefore the potential impact. Any deviations from the agreed PHIC Model methodology are identified and explained.

2.1 Climate assessment methodology

The climate and meteorological characteristics of the region control the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere (i.e. ambient air quality). For the purposes of understanding the local climatology, the development of the PHIC CAM included an assessment of the meteorological parameters recorded in the region during 2013 (calendar year data). The PHIC CAM analysis of climate and meteorological characteristics of the region (PEL, 2015) has been adopted in this assessment without change.

2.2 Emission Estimation Dispersion Modelling

2.2.1 Emissions model/inventory

Emissions from all key sources associated with the Project have been identified according to accepted methods. An emissions inventory has been developed for the Project. Emissions of particles from the Project have been estimated consistent with the PHIC CAM flow chart (Appendix A). Emissions have been estimated for one year of operations, and are based on operational activities when the IBJV Project and FMG's de-rated port are assumed to be at the maximum production and handling capacity of 175 Mtpa.

Emissions for all non-project key sources in the region are based on the PHIC CAM (PEL, 2015). To retain individual company confidentiality of this information, these specific details have not been disclosed to FMG, and are not reported.

2.2.2 Meteorological model

The meteorology applied within a dispersion model is a key factor for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling (or assumptions). For the purposes of this assessment, the meteorological model and configuration from the PHIC CAM (PEL, 2015) has been adopted without change.

2.2.3 Dispersion model

For this assessment, air dispersion modelling has been conducted using the PHIC CAM as configured for CALPUFF (PEL, 2015). The model has been used to predict ground level concentrations across the model domain and at nominated sensitive receptor locations (specifically Taplin Street). The air quality impacts associated with the Project were considered in isolation of other emission sources. The background PM_{10} concentration was based on the model configuration as defined for Port Hedland in the PHIC CAM (PEL, 2015). The existing air quality was based on the model configuration as defined for Port Hedland in the PHIC CAM (PEL, 2015). An assessment of the potential cumulative impact of emissions due to these other emissions sources in the region in conjunction with the Project was also undertaken to assess the potential cumulative impacts. The reported constraints and limitations of PHIC CAM were taken into account when interpreting the model results.

Particular considerations for the use of PHIC CAM when assessing hourly results is that PHIC CAM:

- may over-predict concentrations at Richardson Street

- may under-predict the maximum concentration at Kingsmill Street and Taplin Street, though the remaining concentrations may be slightly over predicted

Particular considerations for the use of PHIC CAM when assessing 24-hour results is that PHIC CAM:

- may over-predict concentrations at Richardson Street
- the modelled results at Kingsmill Street and Taplin Street are considered realistic reflections of actual monitored air quality
- the prediction of the number of excursions of the interim target is considered to be a practical reflection at Taplin Street.

The PHIC CAM was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined with the Southwest corner of the grid cell to be at Universal Transerce Mercator (UTM) coordinates: 647.4 km east and 7736.8 km north at 150m grid resolution, consistent with PEL, 2015.

2.2.4 Modelled Project Scenarios and Assumptions

The air quality assessment has taken into account only the operational phase impacts of the Project i.e. emissions associated with the construction phase of the Project are not considered.

2.2.1 Background Air Quality

The semi-arid landscape of the Pilbara is a naturally dusty environment with wind-blown dust a significant contributor to ambient dust levels within the region. This was highlighted by the aggregated emission study that was conducted by SKM in 2000 (SKM, 2003a). This study found that the Pilbara region emitted around 170,000 tonnes of windblown particulate matter in the 1998/1999 financial year.

For the purposes of this assessment, background air quality is defined as being the air quality that could be expected if the port-based industries were not there (i.e. no contribution from industry). The method for developing the background file for inclusion in the PHIC CAM is detailed in PEL, 2015. Constraints and limitations were also reported. This background file has been adopted in this current assessment without amendment, and the constraints and limitations taken into account when interpreting the model results.

Particular considerations for the use of PHIC CAM when assessing background results is that:

- there is a high probability that not all fugitive (non-industrial) sources have been accounted for in the background file,
- the 2013 model year has one of the lowest background concentrations in the previous 10-years of monitoring.
- the ambient monitoring data indicates large annual variations in the background air concentrations in the regions (PEL, 2015). Of particular note is the potential contribution of emissions from the spoil bank at the Taplin Street monitor not being accounted for in the background file. This may lead to an under-estimate of emissions at Taplin Street

2.3 Ambient Air Quality Assessment Criteria

Modelled ground level concentrations for particles (as PM_{10}) have been compared to ambient air quality assessment criteria in order to determine the potential impact on Port Hedland. This assessment has considered the potential impact attributable to the Project, as well as the cumulative impact (i.e. in conjunction with the existing emission sources in the area). The assessment has been made generally across the model domain, as well as at key sensitive receptor locations identified as being representative or important for assessment.

The National Environmental Protection Measure (NEPM) for Ambient Air Quality (NEPC, 1998; NEPC, 2003) specifies an ambient standard (based on the protection of human health) of 50 µg/m^3 for PM_{10}, (24-hour average) with exceedances not occurring more than 5 days per year.

The Port Hedland Dust Management Taskforce (Taskforce) has specified an interim guideline of 70 µg/m³ for PM_{10} (24-hour average) with 10 exceedances per year. This guideline is determined at the Taplin Street monitoring station (DSD, 2010).

A summary of the assessment criteria adopted in this study is shown in Table 2-1.

Table 2-1: Summary of Assessment Criteria Adopted

Air Quality Impact Assessment Criteria		
Parameter	Reference	Criteria
PM_{10}	Taskforce (DSD, 2010)	70µg/m³ (24-hour) Maximum 10 exceedances a year

2.4 Sensitive Receptors

The discrete receptor locations adopted are consistent with those of the PHIC CAM (PEL, 2015). These locations are listed in Table 2-2 and shown in Figure 2-1, and are used for interpreting the model results.

Table 2-2: Discrete Sensitive Receptor Locations

Location ID	Receptor Name	Easting (m0	Northing (m)
1	Harbour	664,350	7,753,240
2	Richardson St	664,763	7,753,402
3	BMX	665,281	7,753,352
4	Kingsmill St	665,508	7,753,450
5	Hospital	665,870	7,753,420
6	**Taplin St**	**667,030**	**7,753,435**
7	St Celia's	667,292	7,753,390
8	Holiday Inn	667,780	7,753,480
9	Shop	668,050	7,753,280
10	All Seasons	668,140	7,753,530
11	Council	668,450	7,753,640
12	Neptune Pl	669,441	7,754,077
13	Primary School	670,631	7,754,008
14	South Hedland	666,600	7,743,439
15	Wedgefield	665,526	7,747,107

Figure 2-1: Discrete Sensitive Receptor Locations

3 EMISSION ESTIMATION

This section outlines the emission estimation process used to develop the emission inventory for the Project. Emission estimates are sourced from this project specific inventory for inclusion in the dispersion model. It includes the emissions from port facilities and associated infrastructure including the road network. It is noted that the construction phase activities are expected to contribute particle (dust) emissions but will be not be present for the duration of the Project. The emphasis of the emission estimation and modelling is on the potential impact from the operating phase of the Project. Emission estimation of construction activities is excluded from the assessment.

The emission estimation process has followed the PHIC CAM Flowchart (PEL, 2015). An extract is provided in Appendix A.

3.1 Emission Sources

The key emission sources for the operating phase of the Project and FMG's de-rated facility are considered to be associated with:

- material loading from
  - reclaimers
- material unloading from
  - train unloading
  - stackers
- material transfer
  - by conveyors
  - transfer stations
- wheel generated dust from roads
- ship loaders
- wind erosion from stockpiles and open areas.

It is worth noting that sources spanning large distances (e.g. conveyors, reclaimers, stackers) are segmented to increase source accuracy.

Reductions to account for dust abatement controls have been assigned to emission sources based on site specific measurements and NPI. Reduction factors are implemented 90% of the time. Magnetite emission estimation is based on the assumption that the stockyard will be housed in a shed, i.e. no emissions coming from processes occurring in the transfer station. However a site assessment conducted at a trial concentrate handling facility (CHF) located adjacent to the Great Northern Highway, approximately 110km south east of Port Hedland, indicates that emissions associated with stacking, reclaiming and wind erosion will be negligible (PEL 2015).

An overview of the site operations, processes and emission sources is shown in Figure 3-1.

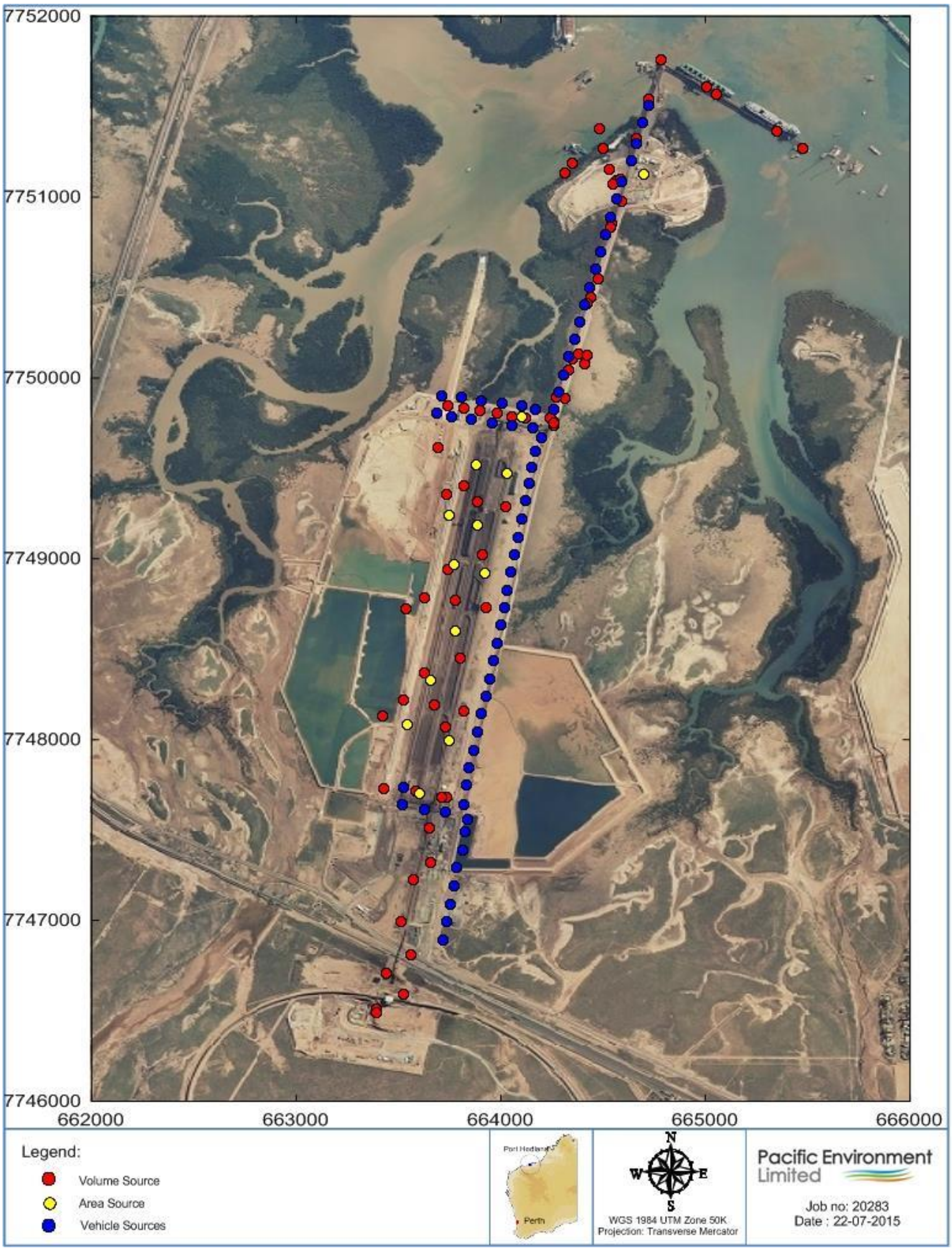

Figure 3-1: Project Process and Volume Emission Sources

3.1.1 Material Handling

The approach applied to estimate the Project's emissions from material handling for beneficiated ore is consistent with the method set out in the PHIC CAM Flowchart (PEL, 2015) shown in Appendix A.1.

3.1.2 Roads

The approach applied to estimate the Project's emissions from roads is consistent with the method set out in the PHIC CAM Flowchart (PEL, 2015) shown in Appendix A.1.

3.1.3 Wind Erosion

The approach applied to estimate the Project's emissions from wind erosion is consistent with the method set out in the PHIC CAM Flowchart (PEL, 2015) shown in Appendix A.1.

3.1.4 Dustiness Index

The Dustiness Index (DI) has not been applied in this assessment. The DI is only applicable for ore that has not undergone beneficiation and is therefore not applicable to either existing FMG or proposed IBJV operations.

3.1.5 Factor

Factor's (as defined in the PHIC CAM Flowchart for non-beneficiated ore) has not been applied in this assessment.

3.2 Emission Controls

Emissions controls were included in the emissions estimation based on information provided by FMG in regard to the dust abatement currently being installed or applied at their Port facility as shown in Table 3-1. The percentage reduction applied to various sources is consistent with the percentages outlined in the PHIC CAM report (PEL, 2015) and described in Appendix A. It should be noted that a 90% availability of the equipment was included in the estimations.

Table 3-1: Dust abatement at current FMG operations and proposed IBJV

Emission sources	Dust Abatement description
Train unloading	Enclosed with extraction
Stackers	Slewing and luffing units with boom sprays
Reclaimer	Sprays on boom
Transfer Stations	Fully enclosed chutes
Conveyors	Belt wash stations and moisture analysers
Wind erosion from stockpile	Water sprays to keep ore wet
Wheel generated dust	Water truck and chemical treatment

3.3 Emission Summary

A summary of the estimated annual emissions from the Project is shown in Table 3-2.

. Note that scenario 2 has a reduction in emissions associated with the replacement of haematite ore with magnetite concentrate.

Table 3-2: Estimate of Annual Particle Emissions from the Project

Project Activity	Base Case	FMG de-rated with IBJV	
	175 Mtpa Haematite PM_{10} (kg/year)	165 Mtpa Haematite PM_{10} (kg/year)	11 Mtpa Magnetite PM_{10} (kg/year)
Reclaimers (loading)	192,821	146,224	-
Train unloading (unloading)	3,578	3,361	-
Stackers (Unloading)	73,990	70,731	-
Conveyors (material transfer)	1,123,129	1,022,869	19,238
Transfer Stations (material transfer)	496,291	482,781	27,545
Ship Loaders	73,965	69,946	2,880
Wheel generated dust	39,715	39,715	-
Wind erosion from stockpiles and open areas	114,536	114,536	-
TOTAL	**2,003,488**	**1,835,627**	**49,662**
	2,003,488	**1,885,289**	

4 ATMOSPHERIC DISPERSION MODELLING RESULTS

This assessment has used the PHIC CAM to estimate the air quality impacts associated with the Project. Particles, as PM_{10} was modelled (24-hour average) with tabulated results presented for the listed sensitive receptor locations, and contours across the model domain.

The modelling results are presented within the following scenarios:

- Scenario 1 – The Project (FMG de-rated to 165 Mtpa and IBJV at 11 Mtpa) emissions in isolation of all other emission sources (both including and excluding the stated PHIC CAM 2013 measured ambient background air quality)
- Scenario 2 - Emissions from existing and proposed port operations (FMG, BHP Billiton Iron Ore(BHPB), Pilbara Port Authority (PPA), Roy Hill Iron Ore (RHIO) and North West Infrastructure (NWI)) (with the inclusion of the stated PHIC CAM 2013 measured ambient background air quality
- Scenario 3 - The Estimate Cumulative Emissions arising from the Project in conjunction with PHIC CAM third party sources and the PHIC CAM 2013 measured ambient background air quality.

It should be noted that this assessment is using the approved PHIC CAM and contains updated variable emissions files. This will result in variations to model outcomes and the results cannot be compared to the previous FMG modelling assessments.

The predicted ground level concentrations of particles as PM_{10} at the key sensitive receptor locations are presented for each case and scenario. The modelled concentration statistics (i.e. maximum, 99th percentile, 95th percentile, 90th percentile and 70th percentile) are tabulated for each case and scenario. Contour maps showing the modelled ground level concentration of PM_{10} are also presented.

4.1 Scenario 1 – The Project in isolation

The model results for PM_{10} from the Project (in isolation of all other sources and excluding 2013 background concentrations) based on FMG de-rated to 165 Mtpa haematite and IBJV at 11 Mtpa are summarised in Table 4-1 and shown in Figure 4-1. The results indicate that:

- The highest PM_{10} (24-hour) concentration of 227 µg/m^3 is predicted to occur at the Harbour receptor with the 99th percentile predicted concentration at 103 µg/m^3. The 95th percentile is predicted to be even lower at 60 µg/m^3, indicating that the maximum predicted concentration is primarily a single high event.
- The highest PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 79 µg/m^3.
- There is one modelled exceedance of the Taskforce criteria at Taplin Street under this scenario (maximum 10 exceedances per year).
- Exceedances of the Taskforce criteria are predicted to occur at Taplin St, St Celia's and Wedgefield.

The model results for PM_{10} from the Project (in isolation of all other sources and including the 2013 background concentrations) are summarised in Table 4-1 and shown in Figure 4-2. The results indicate that:

- The background dust contribution to the airshed is relatively high and the introduction of the IBJV operations is predicted to have relatively insignificant impact.
- The Taskforce criterion (Maximum 10 exceedances per year) is achieved under this scenario with only two exceedances predicted at Taplin Street.
- The highest PM_{10} (24-hour) concentration of 233.6 µg/m^3 is predicted to occur at the Harbour receptor, with the 99th percentile predicted concentration at 118 µg/m^3. The 95th percentile is predicted to be even lower at 78 µg/m^3, indicating that the maximum predicted concentration is primarily an isolated high event.
- The highest PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 134 µg/m^3.

- The 99th percentile PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 56 µg/m³.
- Scenario 2 will have a reduced impact at the sensitive receptors when compared to Scenario 1.

Note that as mentioned in Section 2.2.3 the model over-predicts the concentrations at Richardson Street and will therefore also over-predict the concentrations at the Harbour monitor, which is located immediately to the west (Figure 2-1).

Table 4-1: Project in Isolation (Excluding 2013 background) – PM_{10}

ID	Receptor Name	Modelled Concentration (µg/m³)						
		Maximum	99th percentile	95th percentile	90th percentile	70th percentile	Annual Average	Exceedances > 70 µg/m³
1	Harbour	227.0	103.3	59.9	46.1	15.7	15.3	N/A
2	Richardson St	109.3	85.6	49.3	35.0	13.8	12.2	N/A
3	BMX	115.2	69.2	45.3	31.4	13.2	11.4	N/A
4	Kingsmill St	104.2	62.2	39.2	27.5	11.4	10.0	N/A
5	Hospital	114.5	54.6	37.9	23.2	10.3	9.1	N/A
6	**Taplin St**	78.5	33.4	22.9	17.8	8.3	6.8	1
7	St Celia's	74.8	32.1	23.2	19.2	8.7	7.0	1
8	Holiday Inn	67.0	30.9	23.3	18.1	8.4	6.7	0
9	Shop	69.7	36.2	25.9	21.5	9.6	7.8	0
10	All Seasons	63.4	29.0	22.2	17.8	8.0	6.6	0
11	Council	60.8	29.8	21.2	17.8	7.8	6.4	0
12	Neptune Pl	53.4	27.9	19.8	15.0	7.0	5.6	0
13	Primary School	37.1	24.6	15.0	12.3	6.1	4.7	0
14	South Hedland	44.4	34.2	15.6	10.2	2.6	3.5	0
15	Wedgefield	129.4	123.0	66.7	52.8	27.9	22.6	17

Table 4-2: Project in Isolation (Including 2013 background) – PM_{10}

ID	Receptor Name	Modelled Concentration (µg/m³)						
		Maximum	99th percentile	95th percentile	90th percentile	70th percentile	Annual Average	Exceedances > 70 µg/m³
1	Harbour	233.6	117.5	78.1	60.5	34.2	31.3	N/A
2	Richardson St	134.5	107.8	67.4	51.9	33.0	28.3	N/A
3	BMX	134.3	84.5	62.6	50.6	31.6	27.4	N/A
4	Kingsmill St	134.3	76.4	58.6	46.2	29.9	26.0	N/A
5	Hospital	134.2	68.1	54.5	44.4	29.3	25.2	N/A
6	**Taplin St**	134.0	55.5	44.5	37.6	27.8	22.8	2
7	St Celia's	134.0	55.2	44.6	38.6	28.1	23.1	2
8	Holiday Inn	133.9	52.8	43.8	37.7	27.9	22.7	2
9	Shop	133.9	61.6	45.9	40.7	28.8	23.8	2
10	All Seasons	133.9	55.9	43.3	37.4	27.9	22.7	2
11	Council	133.9	54.4	43.1	36.6	27.6	22.4	2
12	Neptune Pl	133.9	53.4	40.4	35.6	26.5	21.7	1
13	Primary School	133.8	47.6	37.1	32.9	25.5	20.7	1
14	South Hedland	142.7	49.2	43.0	32.8	22.2	19.6	1
15	Wedgefield	184.5	135.8	89.7	72.4	45.5	38.7	41
	2013 background	133.8	42.5	29.7	27.1	19.1	16.1	1

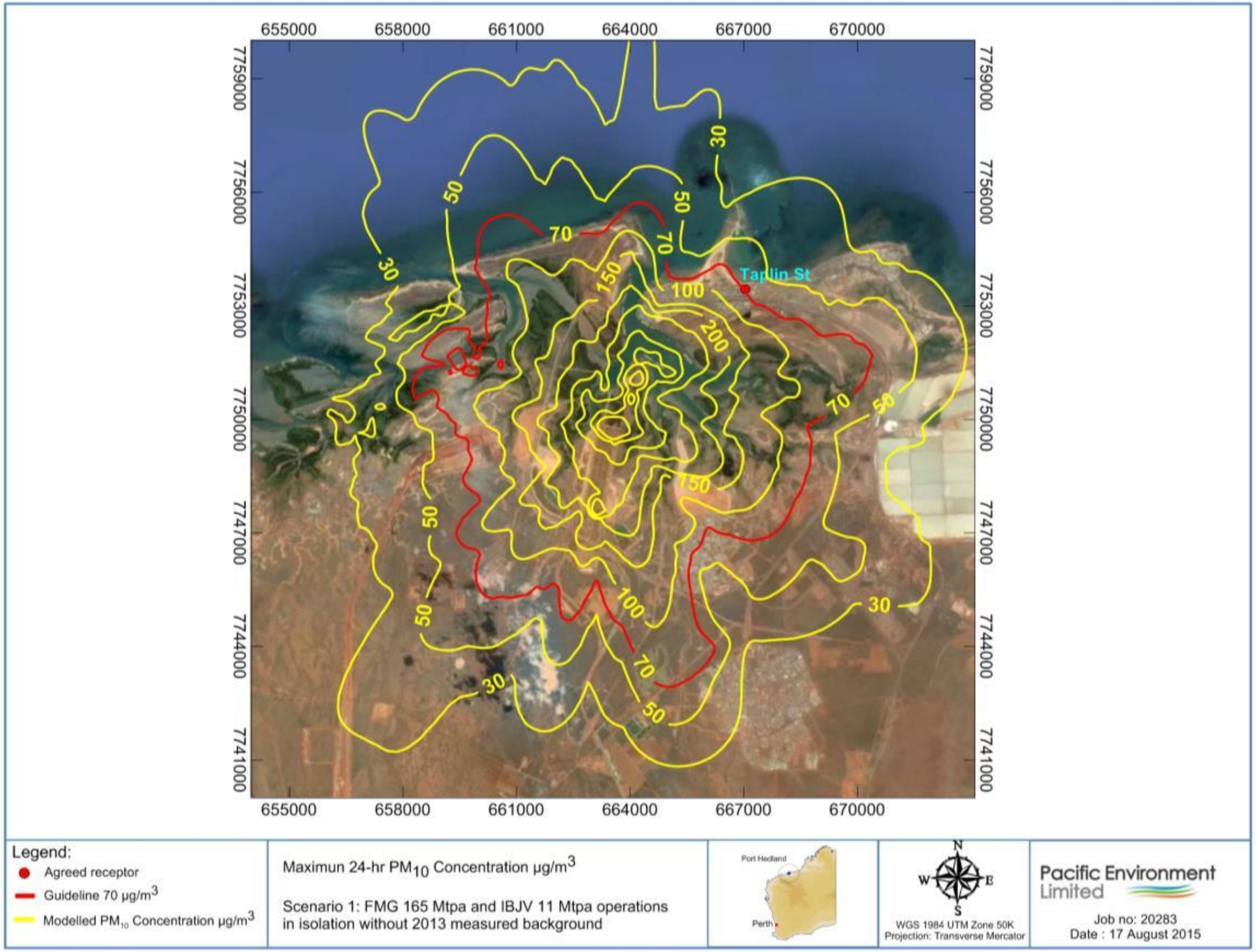

Figure 4-1 Maximum predicted 24-hour PM_{10} concentration from the Project (excluding background)

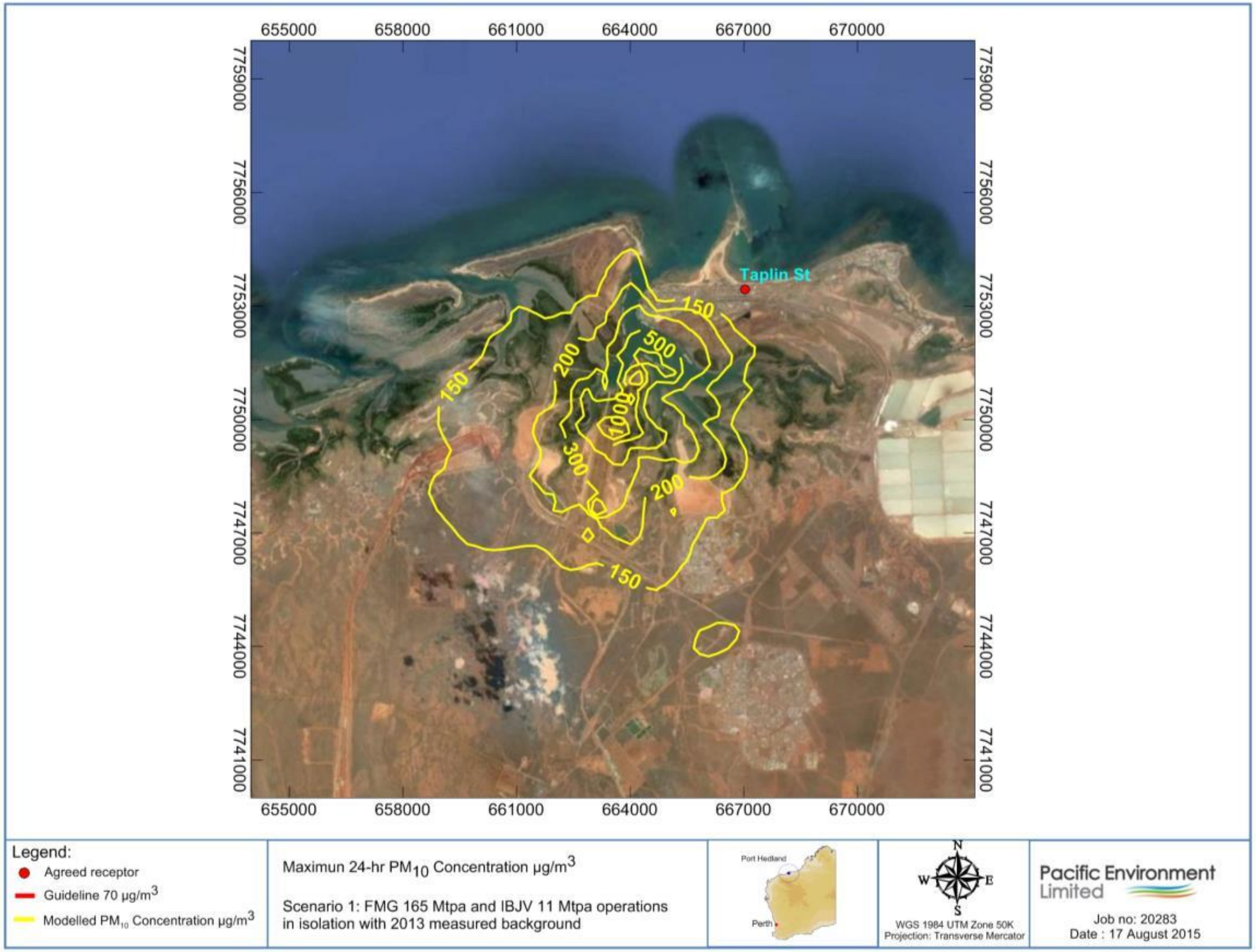

Figure 4-2 Maximum 24-hour PM_{10} concentration IBJV project impact (Project standalone-including background)

4.2 Scenario 2 – Existing and approved operations (including PHIC CAM background concentrations)

The model results for PM_{10} for the existing and proposed operation (including background concentrations) are summarised in Table 4-3 and shown in Figure 4-3 . The results indicate that:

- The highest PM_{10} (24-hour) concentration, estimated to be 279 µg/m³, is predicted to occur at the Harbour receptor.
- The highest PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 144 µg/m³.
- The 99th percentile PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 84 µg/m³.
- The Taskforce criterion (Maximum 10 exceedances per year) is achieved under this scenario with nine exceedances predicted at Taplin Street.

Table 4-3: Predicted Existing Impact – PM_{10}

ID	Receptor Name	Modelled Concentration (µg/m³)						
		Maximum	99th percentile	95th percentile	90th percentile	70th percentile	Annual Average	Exceedances > 70 µg/m³
1	Harbour	278.7	180.3	146.0	122.7	79.7	68.3	N/A
2	Richardson St	207.3	162.6	113.9	93.6	65.3	55.4	N/A
3	BMX	230.0	147.3	95.0	82.3	57.4	48.7	N/A
4	Kingsmill St	210.4	136.3	89.1	75.8	53.6	44.4	N/A
5	Hospital	216.3	123.5	81.8	72.0	50.0	41.6	N/A
6	**Taplin St**	143.6	83.5	61.4	55.6	40.8	32.6	9
7	St Celia's	142.2	82.7	61.2	56.5	41.0	32.6	8
8	Holiday Inn	137.1	78.9	57.8	52.2	39.9	31.0	6
9	Shop	139.3	88.9	61.7	56.2	43.4	33.0	10
10	All Seasons	137.1	80.7	55.8	50.9	38.7	30.4	7
11	Council	136.8	79.3	54.7	49.8	38.4	29.8	6
12	Neptune Pl	135.5	77.6	51.6	45.6	34.8	27.8	6
13	Primary School	135.0	63.7	47.6	42.0	32.5	26.0	3
14	South Hedland	149.0	58.3	45.1	39.5	24.7	21.9	1
15	Wedgefield	225.4	156.6	108.8	85.6	54.4	45.7	63
	2013 background	133.8	42.5	29.7	27.1	19.1	16.1	1

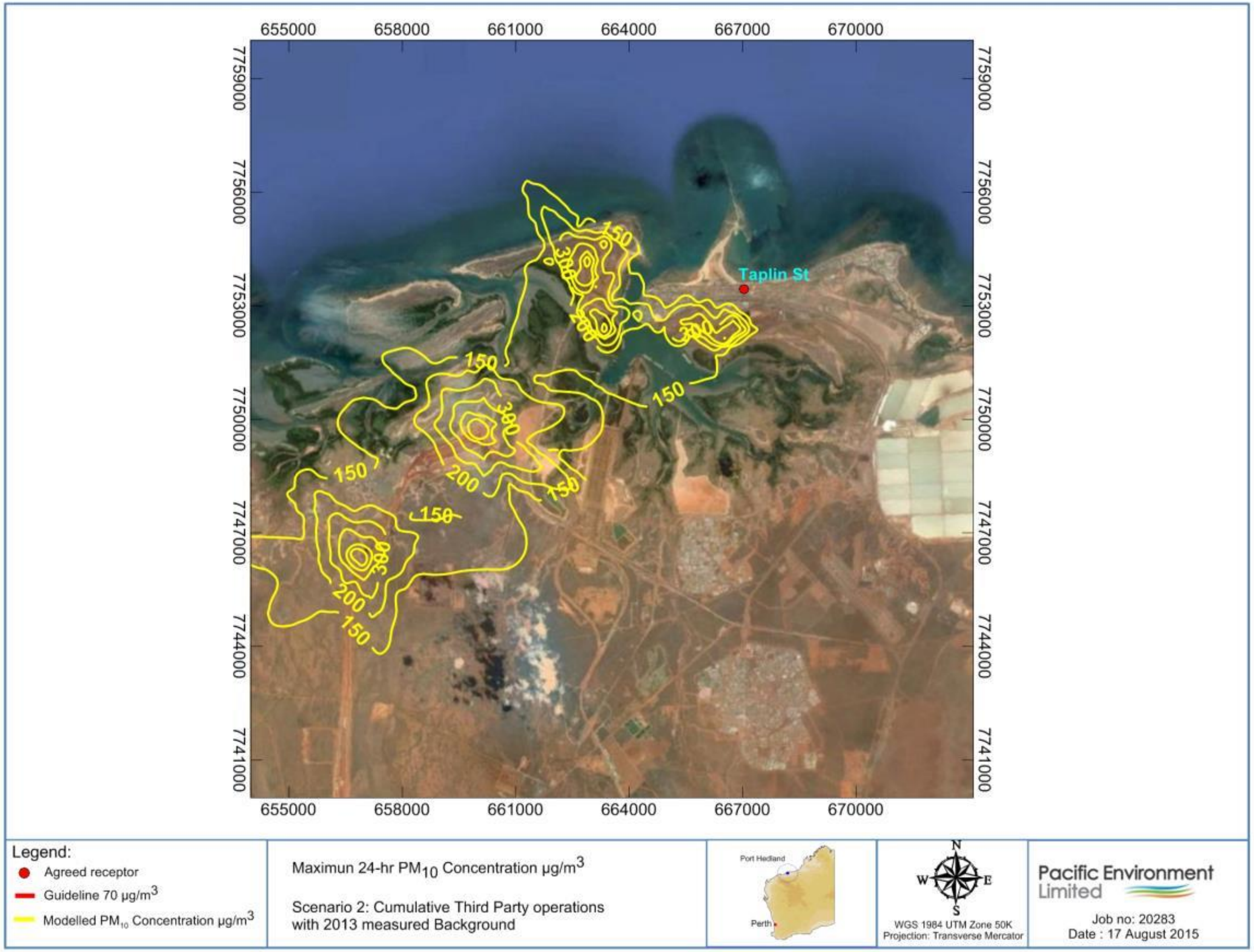

Figure 4-3 Maximum 24-hour PM_{10} concentration Third party impact (including background) – without IBJV operations

4.3 Scenario 3 - Cumulative Emissions including Project and PHIC CAM third party sources (with PHIC CAM background)

Based on the proposed Project (FMG de-rated to 165 Mtpa haematite and IBJV at 11 Mtpa), the model results for PM_{10} from the project in conjunction with all other sources (cumulative impact) are summarised in Table 4-4 and shown in Figure 4-4. The results indicate that:

- The highest PM_{10} (24-hour) concentration, estimated to be 262 µg/m^3, is predicted to occur at the Harbour receptor. This represents a predicted reduction of 16 µg/m^3 from the base scenario (Scenario 2)
- The highest PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 144 µg/m^3.
- The 99th percentile PM_{10} (24-hour) concentration predicted at Taplin Street is estimated to be 77 µg/m^3.
- The Taskforce criterion (Maximum 10 exceedances per year) is achieved under this scenario with six exceedances predicted at Taplin Street. This represents a potential reduction of 3 excursions of the criteria due to the implementation of the Project.

Table 4-4: Cumulative Impact – PM_{10}

ID	Receptor Name	Modelled Concentration (µg/m^3)						
		Maximum	99th percentile	95th percentile	90th percentile	70th percentile	Annual Average	Exceedances > 70 µg/m^3
1	Harbour	261.8	173.5	141.2	111.6	77.8	66.4	N/A
2	Richardson St	206.2	140.8	110.0	93.5	62.9	54.0	N/A
3	BMX	213.9	125.8	94.1	83.3	55.7	47.5	N/A
4	Kingsmill St	200.4	112.3	87.7	74.9	51.6	43.4	N/A
5	Hospital	212.9	105.5	80.0	69.9	49.2	40.6	N/A
6	**Taplin St**	143.7	77.4	59.9	54.1	40.3	31.8	6
7	St Celia's	141.4	81.4	60.6	55.5	40.0	31.9	5
8	Holiday Inn	136.5	76.4	55.9	51.5	38.5	30.2	6
9	Shop	138.7	86.9	61.8	54.8	41.3	32.1	9
10	All Seasons	136.6	78.3	55.4	49.1	38.1	29.7	7
11	Council	136.2	75.5	53.9	47.8	36.9	29.0	6
12	Neptune Pl	135.0	71.9	49.9	44.6	33.6	27.0	5
13	Primary School	134.7	58.2	45.9	40.7	32.0	25.2	3
14	South Hedland	144.3	56.5	45.4	38.0	24.5	21.4	1
15	Wedgefield	187.1	143.1	105.8	82.8	51.0	43.2	56
	2013 background	133.8	42.5	29.7	27.1	19.1	16.1	1

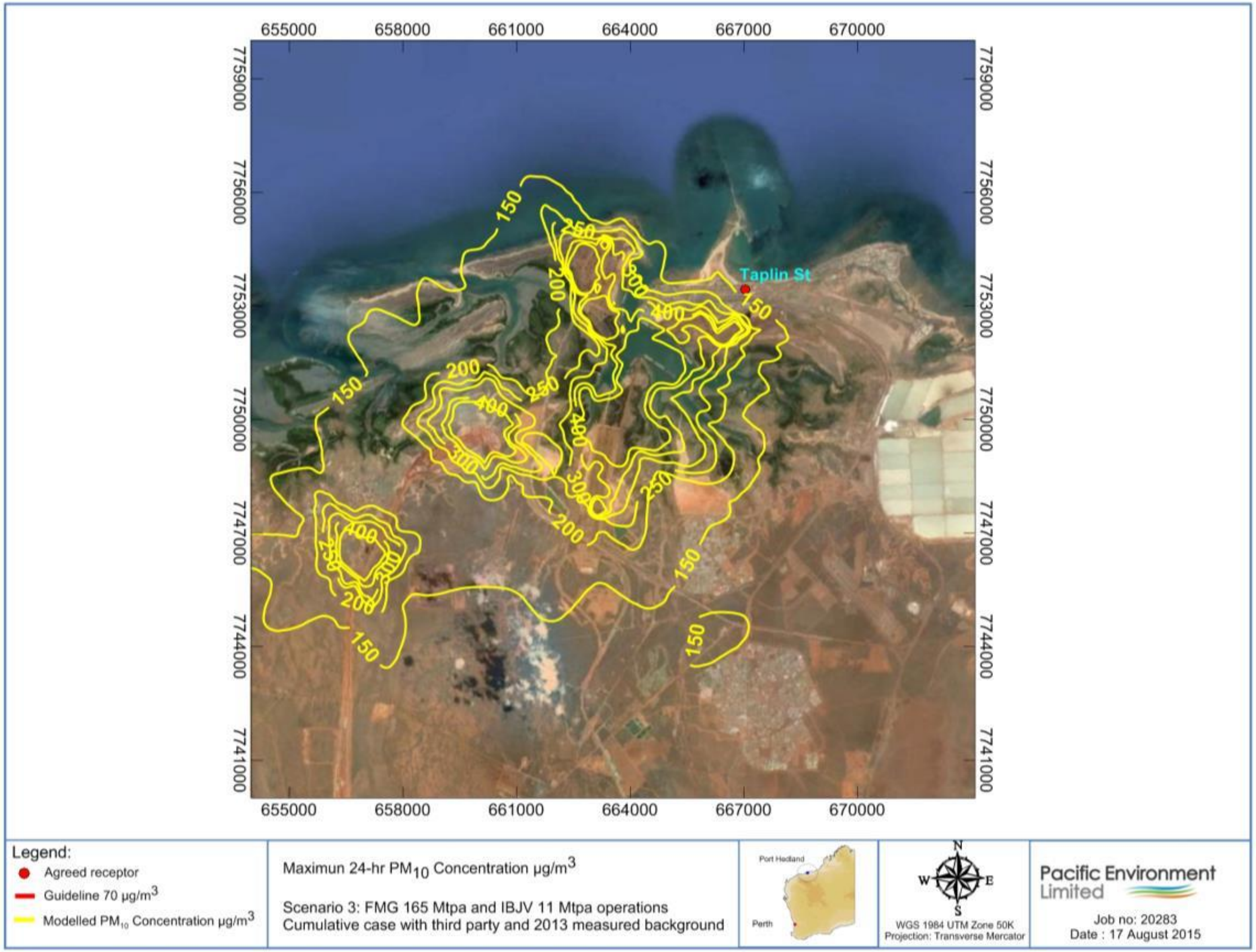

Figure 4-4: Maximum 24-hour PM_{10} concentration Cumulative Impact (All Sources)

4.4 Summary of Results

A consolidated summary of the modelling results at all sensitive receptors is presented in Table 4-5.

Table 4-5: Summary of results - PM_{10}

ID	Receptor	Project In isolation			Project with 2013 Background			Existing with 2013 Background			Cumulative Impact (including Project) with 2013 Background		
		Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³	Maximum 24-Hr	Annual average	Exceedances > 70 µg/m³
1	Harbour	227.0	15.3	N/A	233.6	31.3	N/A	278.7	68.3	N/A	261.8	66.4	N/A
2	Richardson St	109.3	12.2	N/A	134.5	28.3	N/A	207.3	55.4	N/A	206.2	54.0	N/A
3	BMX	115.2	11.4	N/A	134.3	27.4	N/A	230.0	48.7	N/A	213.9	47.5	N/A
4	Kingsmill St	104.2	10.0	N/A	134.3	26.0	N/A	210.4	44.4	N/A	200.4	43.4	N/A
5	Hospital	114.5	9.1	N/A	134.2	25.2	N/A	216.3	41.6	N/A	212.9	40.6	N/A
6	**Taplin St**	**78.5**	**6.8**	**1**	**134.0**	**22.8**	**2**	**143.6**	**32.6**	**9**	**143.7**	**31.8**	**6**
7	St Celia's	74.8	7.0	1	134.0	23.1	2	142.2	32.6	8	141.4	31.9	5
8	Holiday Inn	67.0	6.7	0	133.9	22.7	2	137.1	31.0	6	136.5	30.2	6
9	Shop	69.7	7.8	0	133.9	23.8	2	139.3	33.0	10	138.7	32.1	9
10	All Seasons	63.4	6.6	0	133.9	22.7	2	137.1	30.4	7	136.6	29.7	7
11	Council	60.8	6.4	0	133.9	22.4	2	136.8	29.8	6	136.2	29.0	6
12	Neptune Pl	53.4	5.6	0	133.9	21.7	1	135.5	27.8	6	135.0	27.0	5
13	Primary School	37.1	4.7	0	133.8	20.7	1	135.0	26.0	3	134.7	25.2	3
14	South Hedland	44.4	3.5	0	142.7	19.6	1	149.0	21.9	1	144.3	21.4	1
15	Wedgefield	129.4	22.6	17	184.5	38.7	41	225.4	45.7	63	187.1	43.2	56

5 CONCLUSIONS

FMG is an Australian iron ore company, mining and exporting Direct Shipping Ore (DSO) from its operations in the Pilbara region through the Port of Port Hedland in Western Australia. Currently FMG has approval to export 175 Mtpa of iron ore through the Herb Elliot facility. FMG are seeking to de-rate their throughput tonnage to 165 Mtpa to allow IBJV to export 11 Mtpa of magnetite through their port facility – this scenario has been stated as the 'Project' throughout the report.

The purpose of this assessment is to undertake an air quality assessment to investigate the potential impact on ambient air quality across Port Hedland that would result from the introduction of the Project, in particular the ground level concentration of particles (as PM_{10}). The assessment was conducted consistent with the agreed approach and methodology described for the PHIC CAM. This includes emission estimation and modelling.

As part of this assessment three modelling scenarios were undertaken:

- Scenario 1 – The Project (FMG de-rated to 165 Mtpa and IBJV at 11 Mtpa) emissions in isolation of all other emission sources (both including and excluding the stated PHIC CAM 2013 measured ambient background air quality)
- Scenario 2 - Emissions from existing and proposed port operations (FMG, BHP Billiton Iron Ore(BHPB), Pilbara Port Authority (PPA), Roy Hill Iron Ore (RHIO) and North West Infrastructure (NWI)) (with the inclusion of the stated PHIC CAM 2013 measured ambient background air quality
- Scenario 3 - The Estimate Cumulative Emissions arising from the Project in conjunction with PHIC CAM third party sources and the PHIC CAM 2013 measured ambient background air quality.

The results of the modelling indicate that in scenario 1 the Project (FMG de-rated to 165 Mtpa and IBJV at 11 Mtpa), excluding background, may result in one excursion of the Taskforce criteria at Taplin Street. However this excursion is the result of a single high value and as the predicted 99th percentile is significantly lower indicates that the predicted maximum is an outlier. When the PHIC 2013 Background file is incorporated into the model results for scenario 1 there was one additional excursion of the Taskforce criteria at Taplin Street. This excursion is a direct result of the background file of a single high concentration of 134 µg/m^3 – highlighting the dustiness of the region.

The modelling for scenario 2, which represents existing and proposed facilities including FMG operations at 175 Mtpa, predicts that there are nine potential excursions of the Taskforce criteria at Taplin Street. The maximum predicted concentration is representative of the high background dust concentrations that are encountered in this region.

Scenario 3, which incorporates the Project in conjunction with existing and proposed operations (with the removal of FMG at 175 Mtpa), indicates that there is six potential excursions of the Taskforce criteria at Taplin Street. This represents a reduction of three potential excursions of the Taskforce criteria at Taplin Street. This reduction is due to the emission characteristics of the IBJV magnetite product which have zero (or very low emissions) from stacking, reclaiming and shiploading.

The conclusion from this assessment is that the introduction of 11 Mtpa of magnetite from the IBJV project, which is achieved through a de-rating of the tonnage throughput by FMG will result in a reduction in ground level concentrations of particulates (as PM_{10}) throughout Port Hedland.

6 REFERENCES

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Appendix A EMISSION ESTIMATION

A.1 EMISSIONS ESTIMATION FLOWCHART (PHIC CAM APPENDIX G)

This section contains the flow chart for the calculation of the emissions along with additional information that was used in the emission estimation process. As stated in PHIC CAM report (PEL, 2015), this flowchart is to be used for all subsequent assessments in Port Hedland taking into account the following factors:

- All potential dust sources within the proposed facility should be modelled.
- Calculated emission file for a facility must be an hourly variable file. PHIC will not accept any modelling that assumes a constant emission rate for each source over an entire year.

Therefore, based on this requirement the flowchart process has been adhered to when determining the emission estimates for the Project.

Emission Estimation Process for Port Users in Port Hedland

Material handling

Beneficiated ore

Confirm that ore will arrive at port above DEM

Can use NPI equations for High Moisture Content Ores as specified in Table 3 in the Emission Estimation Technique Manual for Mining (Version 3.1). This emission rate (0.002 kg/t) is to be used for:

- Car Dumper
- Transfer Stations
- Stacking
- Reclaiming
- Shiploaders

Note that with beneficiated ore with a high moisture content there is a high potential for emissions associated with carryback along the entire length of the conveyor. This must be modelled and the emission estimation should use the 0.002 kg/t as specified for other sources.

The entire length of the conveyor should be modelled.

Non-beneficiated ore

Need to determine expected ore moisture. Components to consider are:

- Rotating Drum Testing to determine Dust Extinction Moisture (DEM)
- Conduct particle size distribution to determine percentage of ultrafines in the ore. Ultafines are classified as material below 100 microns. The greater the percentage of ultrafine material the less likely it is that DEM can be achieved.
- Mined tonnage: % above water table, % below water table

It is important to note that PHIC will not accept any assessment that assumes that all ore will be at or greater than DEM. There will always be a percentage of ore that arrives below specification. A best case scenario of 90% at/above DEM can be used only if all ore is sourced from below the water table.

Use the following equations on an hourly basis:

Equation 1: Part 1 (kg/tonne) = 0.001 x (Dustiness Index + 30) / Factor

Equation 2: PM10 emission (g/s) = Part 1 x tonnes/3.6 x (ws/2.2)^1.3

Dustiness Index: Determine, on an hourly basis, using the information from the rotating drum testing.

Factor: See guide below

Tonnes: Hourly tonnage

ws: Hourly wind speed

Roads

Roads should be sealed (as per PPA guidelines). However emissions will still occur as material will be deposited onto the road.

Estimate number of vehicles on each section of road (divide into day/night and week/weekend numbers). Note that vehicle numbers at night and during the weekend can be significantly lower than during the day (mon-fri)

Determine speed limit for each section of road. Nominally 40km/hr but some roads will have lower speed limits (20km/hr)

Undertake emission estimation as per USEPA AP-42 13.2.1 Paved roads

Wind Erosion

Must use Shao equation as detailed in Equation 5.14 in Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques (SKM 2005)

Active open areas must be modelled and include the following areas:

- Laydown yards
- areas underneath/adjacent to incoming transfer stations
- areas underneath/adjacent to outgoing transfer stations

The wind speed threshold should be estimated as 6.5m/s unless evidence proves otherwise.

Wind erosion from open areas in Port Hedland is expected to be significantly higher than the 0.2 kg/ha/hr specified in the NPI for Mining. So when using the Shao et al equation adjust the 'k' factor until an emission rate of 0.5 - 0.6 kg/ha/hr is obtained.

For stockpiles the following methodology can be utilised:

- Beneficiated ore: wind speed threshold of 9m/s
- Lump ore: No wind erosion
- Non beneficiated fines
  - Coarse fines (ultrafines < 5%): wind speed threshold of 8m/s
  - Fines (ultrafines < 15%): wind speed threshold of 7m/s
  - Very fines (ultrafines > 15%): wind speed threshold of 5.5m/s

Wind erosion must be modelled for both active open areas and stockpiles (except lump ore). PHIC will not accept any modelling that disregards these sources.

A.3 DUSTINESS INDEX

The Dustiness Index (DI) is classified as the dustiness of a particular ore at a given moisture concentration. It is taken directly from the results of the rotating drum testing (AS4156.6-2000). It is preferable that the DI number used in the equations be taken from the rotating drum testing for each particular ore type. However if that information is not available then the information in Table A-1 can be utilised. Note that to use this still requires that the particle size distribution of the ore be known.

Table A-2: Potential DI for different ore types

Moisture	Ultrafines <5%		Ultrafines <15%		Ultrafines >15%	
	Lump	Fine	Lump	Fine	Lump	Fine
1.25	280	270	620	350	750	650
1.75	280	270	610	310	720	650
2.25	150	230	480	280	580	650
2.75	70	180	310	250	400	440
3.25	30	140	130	240	270	230
3.75	10	70	25	220	140	105
4.25	5	20	5	200	70	90
4.75	2	5	2	170	30	55
5.25	2	5	2	50	5	45
5.75	2	5	2	10	2	35
6.25	2	2	2	2	2	29
6.75	2	2	2	2	2	20
7.25	2	2	2	2	2	15
7.75	2	2	2	2	2	8
8.25	2	2	2	2	2	2
8.75	2	2	2	2	2	2

A.4 FACTOR

Equation 1 in the flowsheet contains a component classified as a 'factor'. This allows the emission estimation process to differentiate between various emission sources within the proposed facility. For the purposes of sources from iron ore export facilities in Port Hedland there are only two separate factors as follows:

- 200: This factor is to be used for car dumpers, stackers and the lump rescreening plant (if proposed)
- 450: This factor is to be used for transfer stations, reclaimers and shiploader

A.5 EMISSION ABATEMENT

An important component of any assessment is the correct application of emission source abatement. To ensure consistency in dust abatement throughout the Port Hedland region it is essential that proponents refer to the PPA Dust Management Leading Practice Guidelines to determine the most appropriate abatement strategy for their facility. The percentage reduction that can be applied to the emissions from various sources is outlined in Table A-2. Any deviation from these reductions needs to be documented.

Table A-3: Abatement and applicable reduction factors for emission estimation

Source	Abatement	Percentage reduction
Car Dumpers	Should be fully enclosed with extraction	99%
Stackers	Luffing with water sprays	87%
Reclaimers	Water sprays	50%
Transfer Stations	Enclosed	70%
Conveyors	Belt wash stations	80%
Shiploader	Luffing with water sprays	87%
Stockpile Wind Erosion	Water sprays	50%
Open Area Wind Erosion	Water sprays	50%
Roads	Sealed and cleaned	

Note that dust abatement only occurs when the equipment used is well maintained and operational. As there will always be occurences of equipment being out of service the modelling should reflect this. For the purposes of modelling dust emissions from operations in Port Hedland an availability of 90% should be factored into the modelling. This means that for 10% of the year dust abatement is not available and no emission reductions should be applied.

Please note that Section A.3, A.4, A.5 are direct extracts from the PHIC CAM report (PEL, 2015).

Appendix B PROJECT SOURCE EMISSION ESTIMATION

B.1 VOLUME SOURCES

As mentioned in the main body of this report emission estimation was done following procedures as per the PHIC CAM report (PEL, 2015). A summary of the equations and procedures used for the emission estimation of volume sources is shown in this section.

Loading emission estimation technique was sourced from the *NPI EET Manual for Mining v3*. Emissions estimation factors used are listed in Table B-1.

Table B-1 Emissions factors used in assessment

Activity/Operation	EFPM10	Units	Reference
Car Dumping	0.002	kg/t	(NPI, 2012)
Transfer Station (Loading stockpiles)	0.002	kg/t	(NPI, 2012)
Stacking	0.002	kg/t	(NPI, 2012)
Reclaiming	0.002	kg/t	(NPI, 2012)
Transfer Station (Loading to ship)	0.002	kg/t	(NPI, 2012)
Conveying (misc transfer points)	0.002	kg/t	(NPI, 2012)
Shiploading	0.002	kg/t	(NPI, 2012)

Total emissions associated with loading, unloading, conveying, shiploading and transferring for PM_{10} were estimated using Equation 1.

Equation 1

$$E_i = M \times EF_i \times \left(\frac{100 - CE_i}{100}\right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/a)
M	=	Total amount of material loaded	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)
CE_i	=	Overall control efficiency for pollutant i	(%)

Equations used to calculate the emissions from wheel generated dust from unpaved roads are shown by Equation 2:

Equation 2

$$EF_{PM_{10}} = 0.51 \times \frac{\left(\frac{s_i}{12}\right)^{0.7} \times \left(\frac{S}{48}\right)^{0.5}}{\left(\frac{M_i}{0.5}\right)^{0.2}} - 0.0013$$

where:

$EF_{PM_{10}}$	=	Emissions factor for PM_{10} due to travel on unpaved roads	(kg/km)
s_i	=	Silt content of material i upon which operation is occurring	(%)
M_i	=	Moisture content of material i upon which operation is occurring	(%)
W_i	=	Vehicle gross mass operating on material i	(tonnes)
S	=	Mean vehicle speed	(km/h)

Data associated with vehicles travelling on unpaved roads are presented in Table B-2.

Table B-2 Data associated for dust generated on unpaved roads

Activity/Operation	Value	Units	Notes
Total length of main usage unpaved road	2,000	m	Determined on Google image
Total moderate usage unpaved road	0	m	Determined on Google image
Total light usage unpaved road	0	m	Determined on Google image
No. of car - main usage unpaved road	150	-	No. of cars on that section during photo was taken in Google image
No. of car - moderate usage unpaved road	0	-	No. of cars on that section during photo was taken in Google image
No. of car - light usage unpaved road	0	-	No. of cars on that section during photo was taken in Google image
Trips per day - main usage	365	Trips	Assumption
Trips per day - moderate usage	24	Trips	Assumption
Trips per day - light usage	2	Trips	Assumption
Weekday	0	ratio	Assumption
Weekend	0	ratio	Assumption
Day	1	ratio	Assumption
Night	0.5	ratio	Assumption
Peak	1	ratio	Assumption
Non-peak	0.5	ratio	Assumption
VKT - main usage unpaved road	1	km/day	Calculation
VKT - moderate usage unpaved road	0.5	km/day	Calculation
VKT- light usage unpaved road	600	km/day	Calculation
VKT - main usage unpaved road	0	km/hour	Calculation
VKT - moderate usage unpaved road	0	km/hour	Calculation
VKT- light usage unpaved road	25	km/hour	Calculation

B.2 AREA SOURCES

Equation 3 was used to calculate the rate of emission of PM_{10} from wind erosion.

Equation 3

$$EF_{PM10} = k\left[WS^3 \times \left(1 - \frac{{WS_0}^2}{WS^2}\right)\right] \qquad where\ \ WS > WS_0$$

$$EF_{PM10} = 0 \qquad where\ WS < WS_0$$

Where:

EF_{PM10}	=	Emission factor for PM_{10}	($g/m^2/s$)
WS	=	Wind speed	(m/s)
WS_0	=	Threshold for dust lift off	(m/s)
k	=	A constant	

B.3 SOURCE CHARACTERISTICS

B.3.1 Volume sources

A summary of the volume sources characteristics input into the model are shown in Table B-3 and Table B-4 for scenario 1.

Table B-3 Source characteristics- Volume sources- Scenario 1

Type of source	Description	Calpuff ID	Easting (m)	Northing (m)	Sigma Z (m)	Sigma Y (m)	Base elevation (m)	Effective height (m)
Volume	Train Unloading	TUL1	663046	7746562	2.8	0.7	9.0	1.8
Volume	Train Unloading	TUL2	662909	7746480	2.8	0.7	9.9	1.8
Volume	Train Unloading	TUL3	662910	7746458	2.8	0.7	9.9	1.8
Volume	Transfer station	TS901	663254	7747650	11.6	1.3	7.5	5.0
Volume	Transfer station	TS902	663101	7747683	11.6	1.3	7.2	5.0
Volume	Transfer station	TS906	663229	7747651	11.6	1.3	7.3	5.0
Volume	Transfer station	TS908	662948	7747700	11.6	1.3	6.3	5.0
Volume	Conveyor	CV901a	663082	7746781	2.8	0.7	8.0	1.5
Volume	Conveyor	CV901b	663175	7747289	2.8	0.7	8.2	1.5
Volume	Conveyor	CV905a	662960	7746680	2.8	0.7	8.8	1.5
Volume	Conveyor	CV905b	663170	7747477	2.8	0.7	6.9	1.5
Volume	Conveyor	CV906a	663034	7746962	2.8	0.7	8.4	1.5
Volume	Conveyor	CV906b	663094	7747193	2.8	0.7	8.7	1.5
Volume	Stacker	SK701a	663338	7748128	138.0	3.0	5.9	8.0
Volume	Stacker	SK701b	663447	7748702	138.0	3.0	4.9	8.0
Volume	Stacker	SK701c	663543	7749255	138.0	3.0	5.9	8.0
Volume	Stacker	SK702a	663193	7748160	138.0	3.0	6.3	8.0
Volume	Stacker	SK702b	663298	7748737	138.0	3.0	5.2	8.0
Volume	Stacker	SK702c	663403	7749282	138.0	3.0	6.1	8.0
Volume	Stacker	SK704a	663042	7748190	138.0	3.0	7.6	8.0
Volume	Stacker	SK704b	663147	7748755	138.0	3.0	5.2	8.0
Volume	Stacker	SK704c	663255	7749326	138.0	3.0	5.3	8.0
Volume	Ship-loader	SL701	664523	7751576	14.0	3.0	0.0	10.0
Volume	Ship	SL702	664868	7751336	14.0	3.0	0.0	10.0
Volume	Ship	SL703	664001	7751349	14.0	3.0	0.7	10.0
Volume	Reclaimer	RC701a	663245	7748036	138.0	3.0	6.8	8.0
Volume	Reclaimer	RC701b	663318	7748420	138.0	3.0	5.6	8.0
Volume	Reclaimer	RC701c	663427	7748995	138.0	3.0	7.8	8.0
Volume	Reclaimer	RC702a	663146	7748340	138.0	3.0	7.0	8.0
Volume	Reclaimer	RC702b	663261	7748910	138.0	3.0	6.9	8.0
Volume	Reclaimer	RC702c	663341	7749374	138.0	3.0	5.4	8.0
Volume	Reclaimer	RC703a	662939	7748097	138.0	3.0	7.0	8.0
Volume	Reclaimer	RC703b	663054	7748689	138.0	3.0	5.7	8.0
Volume	Reclaimer	RC703c	663212	7749587	138.0	3.0	5.0	8.0
Volume	Transfer station	TS903	663571	7749757	11.6	1.3	6.2	5.0
Volume	Transfer station	TS914	663419	7749787	11.6	1.3	5.5	5.0
Volume	Transfer station	TS917	663262	7749813	11.6	1.3	5.6	5.0
Volume	Transfer station	TS904	663776	7749724	11.6	1.3	5.7	5.0
Volume	Transfer station	TS944	663775	7749709	11.6	1.3	5.7	3.0
Volume	Transfer station	TS945	663759	7749747	11.6	1.3	5.5	3.0

Type of source	Description	Calpuff ID	Easting (m)	Northing (m)	Sigma Z (m)	Sigma Y (m)	Base elevation (m)	Effective height (m)
Volume	Transfer station	TS950	664088	7751063	11.6	1.3	5.4	3.0
Volume	Transfer station	TS905	664300	7751731	11.6	1.3	0.0	3.0
Volume	Conveyor	CV921a	663870	7750077	2.8	0.7	5.6	1.5
Volume	Conveyor	CV921b	663956	7750417	2.8	0.7	6.3	1.5
Volume	Conveyor	CV921c	664063	7750826	2.8	0.7	5.7	1.5
Volume	Conveyor	CV921d	664184	7751296	2.8	0.7	5.7	1.5
Volume	Conveyor	CV948a	663896	7750104	2.8	0.7	5.5	1.5
Volume	Conveyor	CV948b	663993	7750517	2.8	0.7	6.4	1.5
Volume	Conveyor	CV948c	664112	7750948	2.8	0.7	5.3	1.5
Volume	Conveyor	CV948d	664241	7751514	2.8	0.7	1.4	1.5
Volume	Conveyor	CV950a	664048	7751125	2.8	0.7	4.7	1.5
Volume	Conveyor	CV950b	664019	7751240	2.8	0.7	2.3	1.5
Volume	Conveyor	CV950c	664066	7751041	2.8	0.7	5.0	1.5
Volume	Conveyor	CV922	664997	7751241	2.8	0.7	0.0	1.5
Volume	Conveyor	CV927	664574	7751535	2.8	0.7	0.0	1.5
Volume	Conveyor	CV944	663339	7749805	2.8	0.7	5.4	1.5
Volume	Conveyor	CV945	663499	7749776	2.8	0.7	6.2	1.5
Volume	Conveyor	CV915	663637	7749747	2.8	0.7	5.9	1.5
Volume	Ship Loader	SL704	663869	7751157	14.0	3.0	1.3	10.0
Volume	Reclaimer	RCMag	663929	7750047	138.0	3.0	5.3	8.0
Volume	Stacker	SKMag	663942	7750092	138.0	3.0	5.1	8.0
Volume	Transfer station	TS973	663835	7749855	11.6	1.3	5.6	5.0
Volume	Transfer station	TS974	663789	7749863	11.6	1.3	5.6	5.0
Volume	Transfer station	BN949	664103	7751070	11.6	1.3	5.7	5.0
Volume	Transfer station	TS954	663831	7751105	11.6	1.3	1.7	5.0
Volume	Conveyor	CV949a	663850	7750016	2.8	0.7	5.7	1.5
Volume	Conveyor	CV949b	663943	7750379	2.8	0.7	6.4	1.5
Volume	Conveyor	CV949c	664055	7750805	2.8	0.7	5.7	1.5
Volume	Ship Loader	SL704	663869	7751157	14.0	3.0	1.3	10.0

Table B-4 Source characteristics- Volume sources (Vehicles)- Scenario 1

Type of source	Description	Calpuff ID	Easting (m)	Northing (m)	Sigma Z (m)	Sigma Y (m)	Base elevation (m)	Effective height (m)
Volume	Vehicle	V-MN1	663238	7746858	12.5	1.6	7.6	1.7
Volume	Vehicle	V-MN2	663252	7746964	12.5	1.6	7.6	1.7
Volume	Vehicle	V-MN3	663271	7747061	12.5	1.6	7.4	1.7
Volume	Vehicle	V-MN4	663290	7747160	12.5	1.6	7.8	1.7
Volume	Vehicle	V-MN5	663304	7747263	12.5	1.6	7.8	1.7
Volume	Vehicle	V-MN6	663333	7747358	12.5	1.6	7.8	1.7
Volume	Vehicle	V-MD1	663347	7747459	12.5	1.6	8.2	1.7
Volume	Vehicle	V-MD2	663356	7747530	12.5	1.6	8.6	1.7
Volume	Vehicle	V-MD3	663338	7747609	12.5	1.6	8.2	1.7
Volume	Vehicle	V-LG1	663246	7747570	12.5	1.6	6.9	1.7
Volume	Vehicle	V-LG2	663146	7747583	12.5	1.6	7.0	1.7
Volume	Vehicle	V-LG3	663035	7747609	12.5	1.6	7.1	1.7
Volume	Vehicle	V-LG4	663045	7747705	12.5	1.6	7.2	1.7
Volume	Vehicle	V-LG5	663353	7747718	12.5	1.6	8.6	1.7
Volume	Vehicle	V-LG6	663363	7747815	12.5	1.6	10.0	1.7
Volume	Vehicle	V-LG7	663385	7747911	12.5	1.6	8.5	1.7
Volume	Vehicle	V-LG8	663405	7748010	12.5	1.6	7.2	1.7
Volume	Vehicle	V-LG9	663425	7748111	12.5	1.6	6.8	1.7
Volume	Vehicle	V-LG10	663444	7748208	12.5	1.6	6.6	1.7
Volume	Vehicle	V-LG11	663465	7748306	12.5	1.6	6.8	1.7
Volume	Vehicle	V-LG12	663481	7748405	12.5	1.6	6.9	1.7
Volume	Vehicle	V-LG13	663502	7748499	12.5	1.6	5.9	1.7
Volume	Vehicle	V-LG14	663521	7748601	12.5	1.6	4.1	1.7
Volume	Vehicle	V-LG15	663536	7748698	12.5	1.6	4.0	1.7
Volume	Vehicle	V-LG16	663549	7748796	12.5	1.6	4.1	1.7
Volume	Vehicle	V-LG17	663566	7748895	12.5	1.6	4.6	1.7
Volume	Vehicle	V-LG18	663585	7748994	12.5	1.6	6.1	1.7
Volume	Vehicle	V-LG19	663602	7749089	12.5	1.6	6.2	1.7
Volume	Vehicle	V-LG20	663621	7749190	12.5	1.6	6.1	1.7
Volume	Vehicle	V-LG21	663638	7749289	12.5	1.6	6.4	1.7
Volume	Vehicle	V-LG22	663657	7749388	12.5	1.6	6.4	1.7
Volume	Vehicle	V-LG23	663672	7749476	12.5	1.6	6.5	1.7
Volume	Vehicle	V-LG24	663689	7749564	12.5	1.6	6.3	1.7
Volume	Vehicle	V-LG25	663718	7749641	12.5	1.6	6.1	1.7
Volume	Vehicle	V-LG26	663677	7749694	12.5	1.6	5.9	1.7
Volume	Vehicle	V-LG27	663687	7749796	12.5	1.6	5.5	1.7
Volume	Vehicle	V-LG28	663777	7749793	12.5	1.6	5.4	1.7
Volume	Vehicle	V-LG29	663802	7749892	12.5	1.6	5.8	1.7
Volume	Vehicle	V-LG30	663829	7749989	12.5	1.6	5.9	1.7
Volume	Vehicle	V-LG31	663852	7750087	12.5	1.6	5.7	1.7

Type of source	Description	Calpuff ID	Easting (m)	Northing (m)	Sigma Z (m)	Sigma Y (m)	Base elevation (m)	Effective height (m)
Volume	Vehicle	V-LG32	663881	7750181	12.5	1.6	6.0	1.7
Volume	Vehicle	V-LG33	663903	7750279	12.5	1.6	6.1	1.7
Volume	Vehicle	V-LG34	663929	7750376	12.5	1.6	6.6	1.7
Volume	Vehicle	V-LG35	663955	7750472	12.5	1.6	6.5	1.7
Volume	Vehicle	V-LG36	663982	7750569	12.5	1.6	6.3	1.7
Volume	Vehicle	V-LG37	664008	7750667	12.5	1.6	6.0	1.7
Volume	Vehicle	V-LG38	664032	7750765	12.5	1.6	5.8	1.7
Volume	Vehicle	V-LG39	664057	7750860	12.5	1.6	5.5	1.7
Volume	Vehicle	V-LG40	664088	7750956	12.5	1.6	5.1	1.7
Volume	Vehicle	V-LG41	664112	7751057	12.5	1.6	5.7	1.7
Volume	Vehicle	V-LG42	664159	7751168	12.5	1.6	6.4	1.7
Volume	Vehicle	V-LG43	664183	7751268	12.5	1.6	6.2	1.7
Volume	Vehicle	V-LG44	664214	7751383	12.5	1.6	3.9	1.7
Volume	Vehicle	V-LG45	664240	7751479	12.5	1.6	2.2	1.7
Volume	Vehicle	V-LG46	663573	7749704	12.5	1.6	6.4	1.7
Volume	Vehicle	V-LG47	663475	7749719	12.5	1.6	6.2	1.7
Volume	Vehicle	V-LG48	663375	7749741	12.5	1.6	5.3	1.7
Volume	Vehicle	V-LG49	663278	7749755	12.5	1.6	5.4	1.7
Volume	Vehicle	V-LG50	663204	7749776	12.5	1.6	5.5	1.7
Volume	Vehicle	V-LG51	663227	7749872	12.5	1.6	6.0	1.7
Volume	Vehicle	V-LG52	663328	7749860	12.5	1.6	5.9	1.7
Volume	Vehicle	V-LG53	663425	7749843	12.5	1.6	5.9	1.7
Volume	Vehicle	V-LG54	663524	7749827	12.5	1.6	6.5	1.7
Volume	Vehicle	V-LG55	663622	7749816	12.5	1.6	5.8	1.7

B.3.2 Area sources

A summary of the area sources characteristics input into the model are shown in Table B-5 and Table B-6.

Table B-5 Source characteristics- Area sources –Scenario 1

Type of source	Description	Calpuff ID	Sigma Z (m)	Sigma Y (m)	Base elevation (m)	Effective radius (m)
Area	Stockpile	StWE1	25.2	3.7	7.3	39.7
Area	Stockpile	StWE2	25.2	3.7	5.7	43.4
Area	Stockpile	StWE3	25.2	3.7	6.3	41.2
Area	Stockpile	StWE4	25.2	3.7	6.4	43.6
Area	Stockpile	StWE5	25.2	3.7	7.5	41.5
Area	Stockpile	StWE6	25.2	3.7	6.6	45.1
Area	Stockpile	StWE7	25.2	3.7	7.3	41.3
Area	Stockpile	StWE8	25.2	3.7	5.3	41.8
Area	Stockpile	StWE9	25.2	3.7	6.2	39.2
Area	Stockpile	StWE10	25.2	3.7	8.2	42.9
Area	Open area	OPA1	69.8	0.2	6.2	99.2
Area	Open area	OPA2	40.7	0.2	5.9	76.3
Area	Open area	OPA3	46.5	0.2	7.2	77.6

Table B-6 Source characteristics- Area sources (Coordinates)- Scenario 1

Type of source	Calpuff ID	X_1 (Km)	X_2 (Km)	X_3 (Km)	X_4 (Km)	Y_1 (Km)	Y_2 (Km)	Y_3 (Km)	Y_4 (Km)
Area	StWE1	663.2	663.3	663.3	663.3	7747.9	7748.0	7748.0	7747.9
Area	StWE2	663.4	663.4	663.5	663.5	7749.0	7748.8	7748.8	7748.9
Area	StWE3	663.5	663.6	663.6	663.5	7749.4	7749.4	7749.5	7749.5
Area	StWE4	663.4	663.4	663.4	663.4	7749.1	7749.2	7749.2	7749.1
Area	StWE5	663.3	663.3	663.3	663.3	7748.5	7748.6	7748.6	7748.5
Area	StWE6	663.1	663.2	663.2	663.2	7748.3	7748.4	7748.3	7748.2
Area	StWE7	663.3	663.3	663.3	663.3	7748.9	7749.0	7749.0	7748.9
Area	StWE8	663.4	663.4	663.4	663.4	7749.4	7749.5	7749.5	7749.4
Area	StWE9	663.2	663.3	663.3	663.3	7749.2	7749.3	7749.3	7749.2
Area	StWE10	663.0	663.0	663.1	663.1	7748.0	7748.1	7748.1	7748.0
Area	OPA1	664.1	664.2	664.3	664.2	7751.0	7751.3	7751.2	7751.0
Area	OPA2	663.5	663.5	663.7	663.7	7749.7	7749.8	7749.8	7749.7
Area	OPA3	663.0	663.0	663.2	663.2	7747.6	7747.7	7747.7	7747.6

Appendix C VARIABLE EMISSION FILES

C.1 PROJECT VARIABLE EMISSION FILES – VOLUME SOURCES

Table C.1: FMG and IBJV Project PM_{10} Emission Rate - Statistical summary (Scenario 1)

Source Id	Maximum (g/s)	99th Percentile (g/s)	95th Percentile (g/s)	90th Percentile (g/s)	70th Percentile (g/s)	Average (g/s)
TUL1	0.07	0.07	0.07	0.07	0.07	0.03
TUL2	0.07	0.07	0.07	0.07	0.07	0.03
TUL3	0.07	0.07	0.07	0.07	0.07	0.04
TS901	1.98	1.98	1.98	1.98	1.98	1.01
TS902	1.98	1.98	1.98	1.98	1.98	1.04
TS906	3.95	3.95	3.95	3.95	2.64	2.19
TS908	1.98	1.98	1.98	1.98	1.98	1.15
CV901a	3.29	3.29	3.29	3.29	3.29	1.68
CV901b	3.29	3.29	3.29	3.29	3.29	1.68
CV905a	3.29	3.29	3.29	3.29	3.29	1.92
CV905b	3.29	3.29	3.29	3.29	3.29	1.92
CV906a	3.29	3.29	3.29	3.29	3.29	1.73
CV906b	3.29	3.29	3.29	3.29	3.29	1.73
SK701a	4.94	4.94	0.82	0.82	0.82	0.45
SK701b	4.94	4.94	0.82	0.82	0.00	0.15
SK701c	4.94	4.94	0.82	0.82	0.00	0.15
SK702a	4.94	4.94	0.82	0.82	0.00	0.24
SK702b	4.94	4.94	0.82	0.82	0.00	0.24
SK702c	4.94	4.94	0.82	0.82	0.00	0.26
SK704a	4.94	4.94	0.82	0.82	0.00	0.25
SK704b	4.94	4.94	0.82	0.82	0.00	0.24
SK704c	4.94	4.94	0.82	0.82	0.00	0.26
SL701	5.78	5.78	5.78	0.72	0.72	0.72
SL702	5.78	5.78	5.78	0.72	0.72	0.73
SL703	6.33	6.33	0.79	0.79	0.79	0.43
SL704	7.67	7.67	0.96	0.96	0.00	0.34
RC701a	7.67	5.78	3.17	2.89	0.00	0.69
RC701b	7.67	5.78	3.17	2.89	0.00	0.68
RC701c	7.67	5.78	3.17	2.89	0.00	0.67
RC702a	7.67	5.78	3.17	2.89	0.00	0.69
RC702b	7.67	5.78	3.17	2.89	0.00	0.68
RC702c	7.67	5.78	3.17	2.89	0.00	0.71
RC703a	7.67	5.78	3.17	2.89	0.00	0.53
RC703b	7.67	5.78	2.89	2.89	0.00	0.56
RC703c	7.67	5.78	3.17	2.89	0.00	0.55
TS903	2.30	2.30	2.30	1.90	1.73	1.11
TS914	2.30	2.30	2.18	1.90	1.73	1.13
TS917	2.30	2.30	1.90	1.90	1.73	0.90
TS904	1.73	1.73	1.73	1.73	1.73	1.03
TS944	1.73	1.73	1.73	1.73	1.73	1.03
TS945	1.90	1.90	1.90	1.90	1.90	0.63
TS950	1.90	1.90	1.90	1.90	1.90	0.63

Source Id	Maximum (g/s)	99th Percentile (g/s)	95th Percentile (g/s)	90th Percentile (g/s)	70th Percentile (g/s)	Average (g/s)
TS905	3.47	3.47	3.47	3.47	2.40	2.06
BN949	2.30	2.30	2.30	2.30	0.00	0.47
TS954	2.30	2.30	2.30	2.30	0.00	0.47
TS949	2.30	2.30	2.30	2.30	0.00	0.47
CV921a	1.44	1.44	1.44	1.44	1.44	0.86
CV921b	1.44	1.44	1.44	1.44	1.44	0.86
CV921c	1.44	1.44	1.44	1.44	1.44	0.86
CV921d	1.44	1.44	1.44	1.44	1.44	0.86
CV948a	1.44	1.44	1.44	1.44	1.44	0.86
CV948b	1.44	1.44	1.44	1.44	1.44	0.86
CV948c	1.44	1.44	1.44	1.44	1.44	0.86
CV948d	1.44	1.44	1.44	1.44	1.44	0.86
CV950a	2.11	2.11	2.11	2.11	2.11	0.70
CV950b	2.11	2.11	2.11	2.11	2.11	0.70
CV950c	2.11	2.11	2.11	2.11	2.11	0.70
CV922	5.78	5.78	5.78	1.16	1.16	0.95
CV927	5.78	5.78	5.78	1.16	1.16	0.97
CV944	7.67	7.67	7.67	6.33	5.78	3.69
CV945	7.67	7.67	7.26	6.33	5.78	3.77
CV915	7.67	7.67	6.33	6.33	5.78	2.99
CV949a	2.56	2.56	0.51	0.51	0.00	0.15
CV949b	2.56	2.56	0.51	0.51	0.00	0.15
CV949c	2.56	2.56	0.51	0.51	0.00	0.15
SL704	0.96	0.96	0.96	0.28	0.00	0.09
RCMag	0.00	0.00	0.00	0.00	0.00	0.00
SKMag	0.00	0.00	0.00	0.00	0.00	0.00
TS973	2.30	2.30	2.30	0.67	0.00	0.22
TS974	2.30	2.30	2.30	0.67	0.00	0.22
BN949	2.30	2.30	2.30	0.67	0.00	0.22
TS954	2.30	2.30	2.30	0.67	0.00	0.22
CV949a	7.67	7.67	7.67	2.22	0.00	0.73
CV949b	7.67	7.67	7.67	2.22	0.00	0.73
CV949c	7.67	7.67	7.67	2.22	0.00	0.73

Table C.2: FMG and IBJV Project PM_{10} Emission Rate- Statistical Summary – Vehicles-(Scenario 1)

Source Id	Maximum (g/s)	99th Percentile (g/s)	95th Percentile (g/s)	90th Percentile (g/s)	70th Percentile (g/s)	Average (g/s)
V-MN1	0.06	0.06	0.06	0.05	0.05	0.03
V-MN2	0.06	0.06	0.06	0.05	0.05	0.03
V-MN3	0.06	0.06	0.06	0.05	0.05	0.03
V-MN4	0.06	0.06	0.06	0.05	0.05	0.03
V-MN5	0.06	0.06	0.06	0.05	0.05	0.03
V-MN6	0.06	0.06	0.06	0.05	0.05	0.03
V-MD1	0.10	0.10	0.10	0.08	0.08	0.05
V-MD2	0.10	0.10	0.10	0.08	0.08	0.05
V-MD3	0.10	0.10	0.10	0.08	0.08	0.05
V-LG1	0.04	0.04	0.04	0.03	0.03	0.02
V-LG2	0.04	0.04	0.04	0.03	0.03	0.02
V-LG3	0.04	0.04	0.04	0.03	0.03	0.02
V-LG4	0.04	0.04	0.04	0.03	0.03	0.02
V-LG5	0.04	0.04	0.04	0.03	0.03	0.02
V-LG6	0.04	0.04	0.04	0.03	0.03	0.02
V-LG7	0.04	0.04	0.04	0.03	0.03	0.02
V-LG8	0.04	0.04	0.04	0.03	0.03	0.02
V-LG9	0.04	0.04	0.04	0.03	0.03	0.02
V-LG10	0.04	0.04	0.04	0.03	0.03	0.02
V-LG11	0.04	0.04	0.04	0.03	0.03	0.02
V-LG12	0.04	0.04	0.04	0.03	0.03	0.02
V-LG13	0.04	0.04	0.04	0.03	0.03	0.02
V-LG14	0.04	0.04	0.04	0.03	0.03	0.02
V-LG15	0.04	0.04	0.04	0.03	0.03	0.02
V-LG16	0.04	0.04	0.04	0.03	0.03	0.02
V-LG17	0.04	0.04	0.04	0.03	0.03	0.02
V-LG18	0.04	0.04	0.04	0.03	0.03	0.02
V-LG19	0.04	0.04	0.04	0.03	0.03	0.02
V-LG20	0.04	0.04	0.04	0.03	0.03	0.02
V-LG21	0.04	0.04	0.04	0.03	0.03	0.02
V-LG22	0.04	0.04	0.04	0.03	0.03	0.02
V-LG23	0.04	0.04	0.04	0.03	0.03	0.02
V-LG24	0.04	0.04	0.04	0.03	0.03	0.02
V-LG25	0.04	0.04	0.04	0.03	0.03	0.02
V-LG26	0.04	0.04	0.04	0.03	0.03	0.02
V-LG27	0.04	0.04	0.04	0.03	0.03	0.02
V-LG28	0.04	0.04	0.04	0.03	0.03	0.02
V-LG29	0.04	0.04	0.04	0.03	0.03	0.02
V-LG30	0.04	0.04	0.04	0.03	0.03	0.02
V-LG31	0.04	0.04	0.04	0.03	0.03	0.02
V-LG32	0.04	0.04	0.04	0.03	0.03	0.02
V-LG33	0.04	0.04	0.04	0.03	0.03	0.02

Source Id	Maximum (g/s)	99th Percentile (g/s)	95th Percentile (g/s)	90th Percentile (g/s)	70th Percentile (g/s)	Average (g/s)
V-LG34	0.04	0.04	0.04	0.03	0.03	0.02
V-LG35	0.04	0.04	0.04	0.03	0.03	0.02
V-LG36	0.04	0.04	0.04	0.03	0.03	0.02
V-LG37	0.04	0.04	0.04	0.03	0.03	0.02
V-LG38	0.04	0.04	0.04	0.03	0.03	0.02
V-LG39	0.04	0.04	0.04	0.03	0.03	0.02
V-LG40	0.04	0.04	0.04	0.03	0.03	0.02
V-LG41	0.04	0.04	0.04	0.03	0.03	0.02
V-LG42	0.04	0.04	0.04	0.03	0.03	0.02
V-LG43	0.04	0.04	0.04	0.03	0.03	0.02
V-LG44	0.04	0.04	0.04	0.03	0.03	0.02
V-LG45	0.04	0.04	0.04	0.03	0.03	0.02
V-LG46	0.04	0.04	0.04	0.03	0.03	0.02
V-LG47	0.04	0.04	0.04	0.03	0.03	0.02
V-LG48	0.04	0.04	0.04	0.03	0.03	0.02
V-LG49	0.04	0.04	0.04	0.03	0.03	0.02
V-LG50	0.04	0.04	0.04	0.03	0.03	0.02
V-LG51	0.04	0.04	0.04	0.03	0.03	0.02
V-LG52	0.04	0.04	0.04	0.03	0.03	0.02
V-LG53	0.04	0.04	0.04	0.03	0.03	0.02
V-LG54	0.04	0.04	0.04	0.03	0.03	0.02
V-LG55	0.04	0.04	0.04	0.03	0.03	0.02
V-MN3	0.06	0.06	0.06	0.05	0.05	0.03
V-MN4	0.06	0.06	0.06	0.05	0.05	0.03
V-MN5	0.06	0.06	0.06	0.05	0.05	0.03
V-MN6	0.06	0.06	0.06	0.05	0.05	0.03
V-MD1	0.10	0.10	0.10	0.08	0.08	0.05
V-MD2	0.10	0.10	0.10	0.08	0.08	0.05
V-MD3	0.10	0.10	0.10	0.08	0.08	0.05
V-LG1	0.04	0.04	0.04	0.03	0.03	0.02

C.2 PROJECT VARIABLE EMISSION FILES – AREA SOURCES

Table C.3: FMG and IBJV Project PM_{10} Emission Rate - Statistical Summary (Scenario 1)

Source Id	Maximum ($g/m^2/s$)	99th Percentile ($g/m^2/s$)	95th Percentile ($g/m^2/s$)	90th Percentile ($g/m^2/s$)	70th Percentile ($g/m^2/s$)	Average ($g/m^2/s$)
StWE1	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE2	2E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE3	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE4	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE5	2E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE6	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE7	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE8	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE9	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
StWE10	3E-03	4E-04	7E-05	3E-05	0E+00	2E-05
OPA1	3E-03	8E-04	1E-04	6E-05	0E+00	4E-05
OPA2	3E-03	8E-04	1E-04	6E-05	0E+00	4E-05
OPA3	3E-03	8E-04	1E-04	6E-05	0E+00	4E-05

Appendix D PROJECT MODEL INPUT FILES

D.1 PHIC CAM (CALPUFF)

```
CALPUFF.INP     2.0             File version record
FMG volume Scenario 2 165MPTA
Calpuff contour run, 2013, Volume source
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input     * METDAT =             *
    or
ISCMET.DAT    input     * ISCDAT =             *
    or
PLMMET.DAT    input     * PLMDAT =             *
    or
PROFILE.DAT   input     ! PRFDAT =profile.DAT !
SURFACE.DAT   input     * SFCDAT =             *
RESTARTB.DAT  input     * RSTARTB=             *
--------------------------------------------------------------------------------
CALPUFF.LST   output    ! PUFLST =puff_FMG165_V01.LST !
CONC.DAT      output    ! CONDAT =FMG165_V01.CON     !
DFLX.DAT      output    ! DFDAT  =FMG165_V01.DRY     !
WFLX.DAT      output    ! WFDAT  =FMG165_V01.WET     !

VISB.DAT      output    * VISDAT =             *
TK2D.DAT      output    * T2DDAT =             *
RHO2D.DAT     output    * RHODAT =             *
RESTARTE.DAT  output    * RSTARTE=             *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input     * PTDAT  =             *
VOLEMARB.DAT  input     ! VOLDAT =FMG_165_1.src  !
BAEMARB.DAT   input     * ARDAT  =             *
LNEMARB.DAT   input     * LNDAT  =             *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input     * OZDAT  =             *
VD.DAT        input     * VDDAT  =             *
CHEM.DAT      input     * CHEMDAT=             *
AUX           input     ! AUXEXT =AUX      !
(Extension added to METDAT filename(s) for files
 with auxiliary 2D and 3D data)
H2O2.DAT      input     * H2O2DAT=             *
NH3Z.DAT      input     * NH3ZDAT=             *
HILL.DAT      input     * HILDAT=             *
HILLRCT.DAT   input     * RCTDAT=             *
COASTLN.DAT   input     * CSTDAT=             *
FLUXBDY.DAT   input     * BDYDAT=             *
BCON.DAT      input     * BCNDAT=             *
DEBUG.DAT     output    * DEBUG =             *
MASSFLX.DAT   output    * FLXDAT=             *
MASSBAL.DAT   output    * BALDAT=             *
FOG.DAT       output    * FOGDAT=             *
RISE.DAT      output    * RISDAT=             *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 132 characters in length


Provision for multiple input files
----------------------------------
```

```
     Number of Modeling Domains (NMETDOM)
                                  Default: 1       ! NMETDOM =   1   !

     Number of CALMET.DAT files for run (NMETDAT)
                                  Default: 1       ! NMETDAT =   13   !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                  Default: 0       ! NPTDAT =   0   !

     Number of BAEMARB.DAT files for run (NARDAT)
                                  Default: 0       ! NARDAT =   0   !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                  Default: 0       ! NVOLDAT =   0   !

!END!

-------------
Subgroup (0a)
-------------

  Provide a name for each CALMET domain if NMETDOM > 1
  Enter NMETDOM lines.
                                    a,b
Default Name              Domain Name
------------              ------------
 none                   * DOMAIN1=     *    *END*
 none                   * DOMAIN2=     *    *END*
 none                   * DOMAIN3=     *    *END*


  The following CALMET.DAT filenames are processed in sequence
  if NMETDAT > 1

  Enter NMETDAT lines, 1 line for each file name.

                                     a,c,d
Default Name  Type          File Name
------------  ----          ---------
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\janmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\febmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\marmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\aprmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\maymet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\junmet-2013a.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\junmet-2013b.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\julmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\augmet-2013.dat ! !END!
 none         input    ! METDAT1=  C:\Jobs\6866\CALMET\sepmet-2013.dat ! !END!
 none         input    ! METDAT1 = C:\Jobs\6866\CALMET\octmet-2013.dat ! !END!
 none         input    ! METDAT1 = C:\Jobs\6866\CALMET\novmet-2013.dat ! !END!
 none         input    ! METDAT1 = C:\Jobs\6866\CALMET\decmet-2013.dat ! !END!
-------------
    a
     The name for each CALMET domain and each CALMET.DAT file is treated
     as a separate input subgroup and therefore must end with an input
     group terminator.
    b
     Use DOMAIN1= to assign the name for the outermost CALMET domain.
     Use DOMAIN2= to assign the name for the next inner CALMET domain.
     Use DOMAIN3= to assign the name for the next inner CALMET domain, etc.
      --------------------------------------------------------------------
      |   When inner domains with equal resolution (grid-cell size)      |
      |   overlap, the data from the FIRST such domain in the list will  |
      |   be used if all other criteria for choosing the controlling     |
      |   grid domain are inconclusive.                                  |
      --------------------------------------------------------------------
    c
     Use METDAT1= to assign the file names for the outermost CALMET domain.
     Use METDAT2= to assign the file names for the next inner CALMET domain.
     Use METDAT3= to assign the file names for the next inner CALMET domain, etc.
    d
     The filenames for each domain must be provided in sequential order

-------------
Subgroup (0b)
```

```
-------------

  The following PTEMARB.DAT filenames are processed if NPTDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * PTDAT=     *   *END*


-------------
Subgroup (0c)
-------------

  The following BAEMARB.DAT filenames are processed if NARDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * ARDAT=     *   *END*


-------------
Subgroup (0d)
-------------

  The following VOLEMARB.DAT filenames are processed if NVOLDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * VOLDAT=     *   *END*

--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:    Year   (IBYR)  --    No default    ! IBYR  =  2013  !
                       Month  (IBMO)  --    No default    ! IBMO  =  1  !
                       Day    (IBDY)  --    No default    ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default    ! IBHR  =  1  !
                       Minute (IBMIN) --    No default    ! IBMIN =  0  !
                       Second (IBSEC) --    No default    ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default    ! IEYR  =  2014  !
                       Month  (IEMO)  --    No default    ! IEMO  =  1  !
                       Day    (IEDY)  --    No default    ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default    ! IEHR  =  1  !
                       Minute (IEMIN) --    No default    ! IEMIN =  0  !
                       Second (IESEC) --    No default    ! IESEC =  0  !

     (These are only used if METRUN = 0)

     Base time zone:          (ABTZ)  --    No default    ! ABTZ= UTC+0800 !
      (character*8)
     The modeling domain may span multiple time zones.  ABTZ defines the
     base time zone used for the entire simulation.  This must match the
     base time zone of the meteorological data.
     Examples:
         Los Angeles, USA          = UTC-0800
         New York, USA             = UTC-0500
         Santiago, Chile           = UTC-0400
         Greenwich Mean Time (GMT) = UTC+0000
         Rome, Italy               = UTC+0100
         Cape Town, S.Africa       = UTC+0200
         Sydney, Australia         = UTC+1000

     Length of modeling time-step (seconds)
```

```
Equal to update period in the primary
meteorological data files, or an
integer fraction of it (1/2, 1/3 ...)
Must be no larger than 1 hour
(NSECDT)                        Default:3600     ! NSECDT =  3600  !
                                Units: seconds

Number of chemical species (NSPEC)
                                Default: 5       ! NSPEC =  4   !

Number of chemical species
to be emitted  (NSE)            Default: 3       ! NSE =  0   !

Flag to stop run after
SETUP phase (ITEST)             Default: 2       ! ITEST =  2   !
(Used to allow checking
of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of program
                  after SETUP

Restart Configuration:

   Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

      0 = Do not read or write a restart file
      1 = Read a restart file at the beginning of
          the run
      2 = Write a restart file during run
      3 = Read a restart file at beginning of run
          and write a restart file during run

   Number of periods in Restart
   output cycle (NRESPD)        Default: 0       ! NRESPD =  0   !

      0 = File written only at last period
     >0 = File updated every NRESPD periods

Meteorological Data Format (METFM)
                                Default: 1       ! METFM =  1   !

      METFM = 1 - CALMET binary file (CALMET.MET)
      METFM = 2 - ISC ASCII file (ISCMET.MET)
      METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
      METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                  surface parameters file (SURFACE.DAT)
      METFM = 5 - AERMET tower file (PROFILE.DAT) and
                  surface parameters file (SURFACE.DAT)

Meteorological Profile Data Format (MPRFFM)
       (used only for METFM = 1, 2, 3)
                                Default: 1       ! MPRFFM =  1   !

      MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
      MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
Averaging Time (minutes) (AVET)
                                Default: 60.0    ! AVET = 60. !
PG Averaging Time (minutes) (PGTIME)
                                Default: 60.0    ! PGTIME = 60. !


Output units for binary concentration and flux files
written in Dataset v2.2 or later formats
(IOUTU)                         Default: 1       ! IOUTU =  1   !
    1 = mass      -  g/m3 (conc) or g/m2/s (dep)
    2 = odour     -  odour_units (conc)
    3 = radiation -  Bq/m3 (conc) or Bq/m2/s (dep)


Output Dataset format for binary concentration
and flux files (e.g., CONC.DAT)
(IOVERS)                        Default: 2       ! IOVERS =  2   !
    1 = Dataset Version 2.1
    2 = Dataset Version 2.2
```

```
!END!

-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated slugs? (MSLUG)              Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled?
     (MTRANS)                              Default: 1     ! MTRANS =  1   !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)

     Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
        0 = no  (i.e., no stack tip downwash)
        1 = yes (i.e., use stack tip downwash)

     Method used to compute plume rise for
     point sources not subject to building
     downwash? (MRISE)                     Default: 1     ! MRISE =  1  !
        1 = Briggs plume rise
        2 = Numerical plume rise

     Method used to simulate building
     downwash? (MBDW)                      Default: 1     ! MBDW =   2  !
        1 = ISC method
        2 = PRIME method

     Vertical wind shear modeled above
     stack top (modified Briggs plume rise)?
     (MSHEAR)                              Default: 0     ! MSHEAR =  0  !
        0 = no  (i.e., vertical wind shear not modeled)
        1 = yes (i.e., vertical wind shear modeled)

     Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  0  !
        0 = no (i.e., puffs not split)
        1 = yes (i.e., puffs are split)

     Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  0   !
        0 = chemical transformation not
            modeled
        1 = transformation rates computed
            internally (MESOPUFF II scheme)
        2 = user-specified transformation
            rates used
        3 = transformation rates computed
            internally (RIVAD/ARM3 scheme)
        4 = secondary organic aerosol formation
            computed (MESOPUFF II scheme for OH)
        5 = user-specified half-life with or
```

```
        without transfer to child species
    6 = transformation rates computed
        internally (Updated RIVAD scheme with
        ISORROPIA equilibrium)
    7 = transformation rates computed
        internally (Updated RIVAD scheme with
        ISORROPIA equilibrium and CalTech SOA)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 6, or 7)        Default: 0     ! MAQCHEM =  0   !
    0 = aqueous phase transformation
        not modeled
    1 = transformation rates and wet
        scavenging coefficients adjusted
        for in-cloud aqueous phase reactions
        (adapted from RADM cloud model
         implementation in CMAQ/SCICHEM)

Liquid Water Content flag (MLWC)
(Used only if MAQCHEM = 1)            Default: 1     ! MLWC =  1   !
    0 = water content estimated from cloud cover
        and presence of precipitation
    1 = gridded cloud water data read from CALMET
        water content output files (filenames are
        the CALMET.DAT names PLUS the extension
        AUXEXT provided in Input Group 0)

Wet removal modeled ? (MWET)          Default: 1     ! MWET =  1   !
    0 = no
    1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
    0 = no
    1 = yes
    (dry deposition method specified
     for each species in Input Group 3)


Gravitational settling (plume tilt)
modeled ? (MTILT)                     Default: 0     ! MTILT =  0   !
    0 = no
    1 = yes
    (puff center falls at the gravitational
     settling velocity for 1 particle species)

Restrictions:
     - MDRY  = 1
     - NSPEC = 1  (must be particle species as well)
     - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                  set to zero for a single particle diameter

Method used to compute dispersion
coefficients (MDISP)                  Default: 3     ! MDISP =  1   !

    1 = dispersion coefficients computed from measured values
        of turbulence, sigma v, sigma w
    2 = dispersion coefficients from internally calculated
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.
    5 = CTDM sigmas used for stable and neutral conditions.
        For unstable conditions, sigmas are computed as in
        MDISP = 3, described above.  MDISP = 5 assumes that
        measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)         Default: 3     ! MTURBVW =  1  !
    1 = use sigma-v or sigma-theta measurements
        from PROFILE.DAT to compute sigma-y
        (valid for METFM = 1, 2, 3, 4, 5)
    2 = use sigma-w measurements
        from PROFILE.DAT to compute sigma-z
```

```
        (valid for METFM = 1, 2, 3, 4, 5)
    3 = use both sigma-(v/theta) and sigma-w
        from PROFILE.DAT to compute sigma-y and sigma-z
        (valid for METFM = 1, 2, 3, 4, 5)
    4 = use sigma-theta measurements
        from PLMMET.DAT to compute sigma-y
        (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                      Default: 3     ! MDISP2 =  2  !
(used only if MDISP = 1 or 5)
    2 = dispersion coefficients from internally calculated
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.

[DIAGNOSTIC FEATURE]
Method used for Lagrangian timescale for Sigma-y
(used only if MDISP=1,2 or MDISP2=1,2)
(MTAULY)                              Default: 0     ! MTAULY =  0  !
    0 = Draxler default 617.284 (s)
    1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
   10 < Direct user input (s)             -- e.g., 306.9


[DIAGNOSTIC FEATURE]
Method used for Advective-Decay timescale for Turbulence
(used only if MDISP=2 or MDISP2=2)
(MTAUADV)                             Default: 0     ! MTAUADV =  0  !
    0 = No turbulence advection
    1 = Computed (OPTION NOT IMPLEMENTED)
   10 < Direct user input (s)   -- e.g., 800


Method used to compute turbulence sigma-v &
sigma-w using micrometeorological variables
(Used only if MDISP = 2 or MDISP2 = 2)
(MCTURB)                              Default: 1     ! MCTURB =  1  !
    1 = Standard CALPUFF subroutines
    2 = AERMOD subroutines

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
    0 = no
    1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion modeled for
point sources?
(MPARTL)
    0 = no
    1 = yes

Partial plume penetration of          Default: 1     ! MPARTLBA =  1  !
elevated inversion modeled for
buoyant area sources?
(MPARTLBA)
    0 = no
    1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
    0 = no (computed from measured/default gradients)
    1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF = 0  !
(MPDF)
    0 = no
    1 = yes
```

```
Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
   0 = no
   1 = yes

Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0  !
(MBCON)
   0 = no
   1 = yes, using formatted BCON.DAT file
   2 = yes, using unformatted CONC.DAT file

Note:  MBCON > 0 requires that the last species modeled
       be 'BCON'.  Mass is placed in species BCON when
       generating boundary condition puffs so that clean
       air entering the modeling domain can be simulated
       in the same way as polluted air.  Specify zero
       emission of species BCON for all regular sources.

Individual source contributions saved?
                                      Default: 0     ! MSOURCE = 0  !
(MSOURCE)
   0 = no
   1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
cell are computed for the current cell configuration and ambient
conditions by CTEMISS. CALPUFF models the dispersion of these
emissions and provides cloud information in a specialized format
for further analysis. Output to FOG.DAT is provided in either
'plume mode' or 'receptor mode' format.

Configure for FOG Model output?
                                      Default: 0     ! MFOG =  0   !
(MFOG)
   0 = no
   1 = yes  - report results in PLUME Mode format
   2 = yes  - report results in RECEPTOR Mode format


Test options specified to see if
they conform to regulatory
values? (MREG)                        Default: 1     ! MREG =  0   !

   0 = NO checks are made
   1 = Technical options must conform to USEPA
       Long Range Transport (LRT) guidance
                  METFM    1 or 2
                  AVET     60. (min)
                  PGTIME   60. (min)
                  MGAUSS   1
                  MCTADJ   3
                  MTRANS   1
                  MTIP     1
                  MRISE    1
                  MCHEM    1 or 3 (if modeling SOx, NOx)
                  MWET     1
                  MDRY     1
                  MDISP    2 or 3
                  MPDF     0 if MDISP=3
                           1 if MDISP=2
                  MROUGH   0
                  MPARTL   1
                  MPARTLBA 0
                  SYTDEP   550. (m)
                  MHFTSZ   0
                  SVMIN    0.5 (m/s)
```

```
!END!

--------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =          PM01 !         !END!
! CSPEC =          PM04 !         !END!
! CSPEC =          PM07 !         !END!
! CSPEC =          PM09 !         !END!

                                                         Dry                 OUTPUT GROUP
    SPECIES          MODELED          EMITTED         DEPOSITED                 NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)     (0=NO,                  (0=NONE,
   (Limit: 12                                         1=COMPUTED-GAS          1=1st CGRUP,
    Characters                                        2=COMPUTED-PARTICLE     2=2nd CGRUP,
    in length)                                        3=USER-SPECIFIED)       3= etc.)

!          PM01  =          1,               0,            2,                 1   !
!          PM04  =          1,               0,            2,                 1   !
!          PM07  =          1,               0,            2,                 1   !
!          PM09  =          1,               0,            2,                 1   !

!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.

! CGRUP =          PM10 !     !END!


--------------------------------------------------------------------------------


INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM     ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0      ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0      ! FNORTH = 0.000  !
```

```
     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  50   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  0N  !
     (RLON0)                    No Default      ! RLON0 =  0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  30S  !
     (XLAT2)                    No Default      ! XLAT2 =  60S  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84    ! DATUM = WGS-84  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  260   !
            No. Y grid cells (NY)      No default     ! NY =  220   !
         No. vertical layers (NZ)      No default     ! NZ =  11   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = .15 !
```

```
                                  Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE = .0, 20.0, 50.0, 80.0, 160.0, 320.0, 640.0, 1000.0, 1500.0, 2000.0,
              2500.0, 3500.0 !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 647.4 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 7736.8 !
                                      Units: km


COMPUTATIONAL Grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  40   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  24   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  175  !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  174  !
                  (1 <= JECOMP <= NY)



SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = T !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =  40   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  24   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  175   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  174   !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!


-------------------------------------------------------------------------------
```

```
INPUT GROUP: 5 -- Output Options
--------------
                                             *                            *
     FILE                          DEFAULT VALUE              VALUE THIS RUN
     ----                          -------------              --------------

   Concentrations (ICON)                 1                    !  ICON =  1   !
   Dry Fluxes (IDRY)                     1                    !  IDRY =  1   !
   Wet Fluxes (IWET)                     1                    !  IWET =  1   !
   2D Temperature (IT2D)                 0                    !  IT2D =  0   !
   2D Density (IRHO)                     0                    !  IRHO =  0   !
   Relative Humidity (IVIS)              1                    !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                              Default: T          ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                          Default: 1          !  IQAPLOT =  1   !
         0 = no
         1 = yes

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported?
       (IMFLX)                            Default: 0          ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported?
       (IMBAL)                            Default: 0          ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    NUMERICAL RISE OUTPUT OPTION:

       Create a file with plume properties for each rise
       increment, for each model timestep?
       This applies to sources modeled with numerical rise
       and is limited to ONE source in the run.
       (INRISE)                           Default: 0          ! INRISE =  0  !
         0 = no
         1 = yes (RISE.DAT filename is
                  specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)    Default: 0          ! ICPRT =  0   !
       Print dry fluxes (IDPRT)        Default: 0          ! IDPRT =  0   !
       Print wet fluxes (IWPRT)        Default: 0          ! IWPRT =  0   !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in timesteps            Default: 1          ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in timesteps            Default: 1          ! IDFRQ =  1   !
       Wet flux print interval
       (IWFRQ) in timesteps            Default: 1          ! IWFRQ =  1   !

       Units for Line Printer Output
```

```
       (IPRTU)                         Default: 1         ! IPRTU =  3   !
                   for              for
                Concentration    Deposition
           1 =      g/m**3         g/m**2/s
           2 =     mg/m**3        mg/m**2/s
           3 =     ug/m**3        ug/m**2/s
           4 =     ng/m**3        ng/m**2/s
           5 =     Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                         Default: 2         ! IMESG =  2   !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----   ------ DRY FLUXES ------   ------ WET FLUXES -----
-   -- MASS FLUX --
   SPECIES
   /GROUP        PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON
DISK?   SAVED ON DISK?
   -------       ------------------------   ------------------------   ------------------------
-   ---------------
!         PM10 =     0,           1,           0,           1,           0,           1,
0   !

  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                 Default: F     ! LDEBUG = F !

       First puff to track
       (IPFDEB)                                 Default: 1     ! IPFDEB =  1  !

       Number of puffs to track
       (NPFDEB)                                 Default: 1     ! NPFDEB =  1  !

       Met. period to start output
       (NN1)                                    Default: 1     ! NN1 =  1   !

       Met. period to end output
       (NN2)                                    Default: 10    ! NN2 =  10  !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

       Number of special complex terrain
       receptors  (NCTREC)                      Default: 0     ! NCTREC =  0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                  No Default     ! MHILL =  2   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)
```

```
       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1.0 !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1.0 !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL           XC        YC       THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2   SCALE 1    SCALE
2    AMAX1     AMAX2
 NO.          (km)      (km)      (deg.)   (m)      (m)      (m)       (m)       (m)         (m)
(m)        (m)
----          ----      ----      ------  -----  ------    ------    ------   -------    -----
--    -----     -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
                      (km)         (km)         (m)
                     ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                     (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES     DIFFUSIVITY      ALPHA STAR      REACTIVITY    MESOPHYLL RESISTANCE
HENRY'S LAW COEFFICIENT
       NAME        (cm**2/s)                                             (s/cm)
(dimensionless)
```

```
      -------     -----------      ----------      ----------    --------------------     ----
-------------------


!END!

-------------------------------------------------------------------------------


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME            DIAMETER                   DEVIATION
                       (microns)                  (microns)
      -------      -------------------        ------------------
!         PM01 =          1.0,                       .0    !
!         PM04 =          4.0,                       .0    !
!         PM07 =          7.0,                       .0    !
!         PM09 =          9.0,                       .0    !

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     !   NINT =  9   !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     !   IVEG =  1    !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
!         PM01 =         5.2E-05,             1.7E-05 !
!         PM04 =         1.0E-04,             3.0E-05 !
!         PM07 =         1.0E-04,             3.0E-05 !
!         PM09 =         1.0E-04,             3.0E-05 !
```

```
!END!


-------------------------------------------------------------------------------


INPUT GROUP: 11a, 11b -- Chemistry Parameters
---------------------

---------------
Subgroup (11a)
---------------

     Several parameters are needed for one or more of the chemical transformation
     mechanisms.  Those used for each mechanism are:
                                   M                 B
                                   A  B  R  R  R     C  B        N
                             B     V  C  N  N  N  M  K  C  O     D
                             C  M  G  K  I  I  I  H  H  K  F  V  E
                          M  K  N  N  N  T  T  T  2  2  P  R  C  C
                          O  O  H  H  H  E  E  E  O  O  M  A  N  A
     Mechanism (MCHEM)    Z  3  3  3  3  1  2  3  2  2  F  C  X  Y
     --------------------   ------------------------------------------
     0 None               .  .  .  .  .  .  .  .  .  .  .  .  .  .
     1 MESOPUFF II        X  X  .  .  X  X  X  X  .  .  .  .  .  .
     2 User Rates         .  .  .  .  .  .  .  .  .  .  .  .  .  .
     3 RIVAD              X  X  .  .  X  .  .  .  .  .  .  .  .  .
     4 SOA                X  X  .  .  .  .  .  .  .  .  X  X  X  .
     5 Radioactive Decay  .  .  .  .  .  .  .  .  .  .  .  .  .  X
     6 RIVAD/ISORRPIA     X  X  X  X  X  X  .  .  X  X  .  .  .  .
     7 RIVAD/ISORRPIA/SOA X  X  X  X  X  X  .  .  X  X  X  X  .  .


     Ozone data input option (MOZ)     Default: 1           ! MOZ =  0   !
     (Used only if MCHEM = 1, 3, 4, 6, or 7)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations in ppb (BCKO3)
     (Used only if MCHEM = 1,3,4,6, or 7 and either
        MOZ = 0, or
        MOZ = 1 and all hourly O3 data missing)
                                   Default: 12*80.
     !  BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00,
80.00 !

     Ammonia data option (MNH3)        Default: 0           ! MNH3 =  0   !
     (Used only if MCHEM = 6 or 7)
        0 = use monthly background ammonia values (BCKNH3) - no vertical variation
        1 = read monthly background ammonia values for each layer from
            the NH3Z.DAT data file

     Ammonia vertical averaging option (MAVGNH3)
     (Used only if MCHEM = 6 or 7, and MNH3 = 1)
        0 = use NH3 at puff center height (no averaging is done)
        1 = average NH3 values over vertical extent of puff
                                   Default: 1           ! MAVGNH3 =  1   !

     Monthly ammonia concentrations in ppb (BCKNH3)
     (Used only if MCHEM = 1 or 3, or
               if MCHEM = 6 or 7, and MNH3 = 0)
                                   Default: 12*10.
     !  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00,
10.00 !

     Nighttime SO2 loss rate in %/hour (RNITE1)
     (Used only if MCHEM = 1, 6 or 7)
     This rate is used only at night for MCHEM=1
     and is added to the computed rate both day
     and night for MCHEM=6,7 (heterogeneous reactions)
                                   Default: 0.2         ! RNITE1 = .2 !

     Nighttime NOx loss rate in %/hour (RNITE2)
     (Used only if MCHEM = 1)
                                   Default: 2.0         ! RNITE2 = 2.0 !
```

```
     Nighttime HNO3 formation rate in %/hour (RNITE3)
     (Used only if MCHEM = 1)
                                  Default: 2.0          ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1           ! MH2O2 =  1   !
     (Used only if MCHEM = 6 or 7, and MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations in ppb (BCKH2O2)
     (Used only if MQACHEM = 1 and either
        MH2O2 = 0 or
        MH2O2 = 1 and all hourly H2O2 data missing)
                                  Default: 12*1.
     !  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Options
     (used only if MCHEM = 4 or 7)

     The MCHEM = 4 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)

     The MCHEM = 7 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)

     These characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:

        Month    1    2    3    4    5    6    7    8    9   10   11   12
                Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

     Clean Continental
        BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
        OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Clean Marine (surface)
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
     !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
     !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
50.00 !

 --- End Data for SECONDARY ORGANIC AEROSOL (SOA) Option
```

```
     Number of half-life decay specification blocks provided in Subgroup 11b
     (Used only if MCHEM = 5)
     (NDECAY)                                   Default: 0      ! NDECAY =  0   !

!END!


--------------
Subgroup (11b)
--------------

     Each species modeled may be assigned a decay half-life (sec), and the associated
     mass lost may be assigned to one or more other modeled species using a mass yield
     factor. This information is used only for MCHEM=5.

     Provide NDECAY blocks assigning the half-life for a parent species and mass yield
     factors for each child species (if any) produced by the decay.
     Set HALF_LIFE=0.0 for NO decay (infinite half-life).


                              a            b
        SPECIES      Half-Life   Mass Yield
         NAME          (sec)       Factor
        -------      ---------   ----------

     *   SPEC1   =    3600.,        -1.0   *    (Parent)
     *   SPEC2   =     -1.0,         0.0   *    (Child)
   *END*

--------
    a
     Specify a half life that is greater than or equal to zero for 1 parent species
     in each block, and set the yield factor for this species to -1
    b
     Specify a yield factor that is greater than or equal to zero for 1 or more child
     species in each block, and set the half-life for each of these species to -1

     NOTE: Assignments in each block are treated as a separate input
           subgroup and therefore must end with an input group terminator.
           If NDECAY=0, no assignments and input group terminators should appear.

-------------------------------------------------------------------------------


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP = 5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ =  0   !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP =  5   !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point
```

```
Range of land use categories for which
urban dispersion is assumed
(IURB1, IURB2)                          Default: 10     ! IURB1 =  10  !
                                                 19     ! IURB2 =  19  !

Site characterization parameters for single-point Met data files ---------
(needed for METFM = 2,3,4,5)

   Land use category for modeling domain
   (ILANDUIN)                           Default: 20     ! ILANDUIN =  20  !

   Roughness length (m) for modeling domain
   (Z0IN)                               Default: 0.25   ! Z0IN = .25 !

   Leaf area index for modeling domain
   (XLAIIN)                             Default: 3.0    ! XLAIIN = 3.0 !

   Elevation above sea level (m)
   (ELEVIN)                             Default: 0.0    ! ELEVIN = .0 !

   Latitude (degrees) for met location
   (XLATIN)                             Default: -999.  ! XLATIN = -999.0 !

   Longitude (degrees) for met location
   (XLONIN)                             Default: -999.  ! XLONIN = -999.0 !

Specialized information for interpreting single-point Met data files -----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                             Default: 10.    ! ANEMHT = 10.0 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4,5 or MTURBVW = 1 or 3)
   (ISIGMAV)                            Default: 1      ! ISIGMAV =  0  !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                           Default: 0      ! IMIXCTDM =  0  !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                Default: 1.0    ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                               Default: 1.0    ! XSAMLEN = 1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                 Default: 99     ! MXNEW =  60   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                 Default: 99     ! MXSAM =  60   !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT)                                Default: 2      ! NCOUNT =  2   !

Minimum sigma y for a new puff/slug (m)
(SYMIN)                                 Default: 1.0    ! SYMIN = 1.0  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                 Default: 1.0    ! SZMIN = 1.0  !

Maximum sigma z (m) allowed to avoid
numerical problem in calculating virtual
time or distance.  Cap should be large
enough to have no influence on normal events.
Enter a negative cap to disable.
(SZCAP_M)                               Default: 5.0e06 ! SZCAP_M = 5.0E06 !
```

```
     Default minimum turbulence velocities sigma-v and sigma-w
     for each stability class over land and over water (m/s)
     (SVMIN(12) and SWMIN(12))

                     ----------  LAND  ----------       ---------  WATER  ----------
        Stab Class :  A    B    C    D    E    F         A    B    C    D    E    F
                     ---  ---  ---  ---  ---  ---       ---  ---  ---  ---  ---  ---
     Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37, .37, .37
     Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06, .03, .016

           ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370, 0.370,
0.370, 0.370!
           ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080, 0.060,
0.030, 0.016!

     Divergence criterion for dw/dz across puff
     used to initiate adjustment for horizontal
     convergence (1/s)
     Partial adjustment starts at CDIV(1), and
     full adjustment is reached at CDIV(2)
     (CDIV(2))                                  Default: 0.0,0.0  ! CDIV = .0, .0 !

     Search radius (number of cells) for nearest
     land and water cells used in the subgrid
     TIBL module
     (NLUTIBL)                                  Default: 4      ! NLUTIBL =  4  !

     Minimum wind speed (m/s) allowed for
     non-calm conditions. Also used as minimum
     speed returned when using power-law
     extrapolation toward surface
     (WSCALM)                                   Default: 0.5    ! WSCALM = .5 !

     Maximum mixing height (m)
     (XMAXZI)                                   Default: 3000.  ! XMAXZI = 3000.0 !

     Minimum mixing height (m)
     (XMINZI)                                   Default: 50.    ! XMINZI = 50.0 !

     Default wind speed classes --
     5 upper bounds (m/s) are entered;
     the 6th class has no upper limit
     (WSCAT(5))                      Default   :
                                     ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

                              Wind Speed Class :  1     2     3     4     5
                                                 ---   ---   ---   ---   ---
                                       ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

     Default wind speed profile power-law
     exponents for stabilities 1-6
     (PLX0(6))                       Default   : ISC RURAL values
                                     ISC RURAL : .07, .07, .10, .15, .35, .55
                                     ISC URBAN : .15, .15, .20, .25, .30, .30

                               Stability Class :  A     B     C     D     E     F
                                                 ---   ---   ---   ---   ---   ---
                                        ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !

     Default potential temperature gradient
     for stable classes E, F (degK/m)
     (PTG0(2))                       Default: 0.020, 0.035
                                        ! PTG0 = 0.020,   0.035 !

     Default plume path coefficients for
     each stability class (used when option
     for partial plume height terrain adjustment
     is selected -- MCTADJ=3)
     (PPC(6))                  Stability Class :  A     B     C     D     E     F
                                  Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                                 ---   ---   ---   ---   ---   ---
                                        !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !

     Slug-to-puff transition criterion factor
     equal to sigma-y/length of slug
     (SL2PF)                               Default: 10.       ! SL2PF = 10.0 !
```

```
Puff-splitting control variables ------------------------

  VERTICAL SPLIT
  --------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                           Default:   3        ! NSPLIT =  3  !

  Time(s) of a day when split puffs are eligible to
  be split once again; this is typically set once
  per day, around sunset before nocturnal shear develops.
  24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
  0=do not re-split    1=eligible for re-split
  (IRESPLIT(24))                     Default:  Hour 17 = 1
  !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                          Default: 100.       ! ZISPLIT = 100.0 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
  postpones a split until a nocturnal layer develops)
  (ROLDMAX)                          Default: 0.25       ! ROLDMAX = 0.25 !


  HORIZONTAL SPLIT
  ----------------

  Number of puffs that result every time a puff
  is split - nsplith=5 means that 1 puff splits
  into 5
  (NSPLITH)                          Default:   5        ! NSPLITH =  5  !

  Minimum sigma-y (Grid Cells Units) of puff
  before it may be split
  (SYSPLITH)                         Default:  1.0       ! SYSPLITH = 1.0 !

  Minimum puff elongation rate (SYSPLITH/hr) due to
  wind shear, before it may be split
  (SHSPLITH)                         Default:  2.        ! SHSPLITH = 2.0 !

  Minimum concentration (g/m^3) of each
  species in puff before it may be split
  Enter array of NSPEC values; if a single value is
  entered, it will be used for ALL species
  (CNSPLITH)                         Default:  1.0E-07   ! CNSPLITH = 1.0E-07 !

Integration control variables ------------------------

  Fractional convergence criterion for numerical SLUG
  sampling integration
  (EPSSLUG)                          Default:   1.0e-04  ! EPSSLUG = 1.0E-04 !

  Fractional convergence criterion for numerical AREA
  source integration
  (EPSAREA)                          Default:   1.0e-06  ! EPSAREA = 1.0E-06 !

  Trajectory step-length (m) used for numerical rise
  integration
  (DSRISE)                           Default:   1.0      ! DSRISE = 1.0 !

  Boundary Condition (BC) Puff control variables ------------------------

  Minimum height (m) to which BC puffs are mixed as they are emitted
  (MBCON=2 ONLY).  Actual height is reset to the current mixing height
  at the release point if greater than this minimum.
  (HTMINBC)                          Default:   500.     ! HTMINBC = 500.0 !

  Search radius (km) about a receptor for sampling nearest BC puff.
  BC puffs are typically emitted with a spacing of one grid cell
  length, so the search radius should be greater than DGRIDKM.
```

```
       (RSAMPBC)                          Default:   10.      ! RSAMPBC = 10.0 !

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                           Default:   1        ! MDEPBC =  1  !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  0  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                      a
          POINT SOURCE: CONSTANT DATA
          -----------------------------
                                                                                b          c
  Source       X          Y       Stack    Base     Stack    Exit  Exit     Bldg.  Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.    Dwash   Rates
              (km)       (km)      (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
     X       is an array holding the source data listed by the column headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
```

```
           the effect of rain-caps or other physical configurations that
           reduce momentum rise associated with the actual exit velocity.
           (Default: 1.0  -- full momentum used)
   ZPLTFM  is the platform height (m) for sources influenced by an isolated
           structure that has a significant open area between the surface
           and the bulk of the structure, such as an offshore oil platform.
           The Base Elevation is that of the surface (ground or ocean),
           and the Stack Height is the release height above the Base (not
           above the platform).  Building heights entered in Subgroup 13c
           must be those of the buildings on the platform, measured from
           the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
           downwash method) for sources with building downwash.
           (Default: 0.0)

    b
     0. = No building downwash modeled
     1. = Downwash modeled for buildings resting on the surface
     2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source                                                                a
 No.       Effective building height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------     --------------------------------------------------------------------


--------

    a
     Building height, width, length, and X/Y offset from the source are treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to the
     stack, of the center of the upwind face of the projected building, with the
     x-axis pointing along the flow direction.

---------------
Subgroup (13d)
---------------
                                               a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)
```

```
--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below            (IARU)       Default: 1  !  IARU =   1 !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr
           8 =     Bq/m**2/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 = 0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                     a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                         b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                               a
```

```
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                                     a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                              No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)        No default   ! NLINES =  0  !

     Units used for line source
     emissions below                (ILNU)          Default: 1  !  ILNU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr
```

```
     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)        (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                           Default: 7   ! MXNSEG =  7  !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which              Default: 6   ! NLRISE =  6  !
        transitional rise is computed

        Average building length (XL)              No default   ! XL = .0 !
                                                  (in meters)

        Average building height (HBL)             No default   ! HBL = .0 !
                                                  (in meters)

        Average building width (WBL)              No default   ! WBL = .0 !
                                                  (in meters)

        Average line source width (WML)           No default   ! WML = .0 !
                                                  (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = .0 !
                                                  (in meters)

        Average buoyancy parameter (FPRIMEL)      No default   ! FPRIMEL = .0 !
                                                  (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------
                                                                                     a
Source    Beg. X      Beg. Y      End. X     End. Y     Release    Base        Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation     Rates
           (km)        (km)        (km)       (km)       (m)        (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ---------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                        a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
```

```
          4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                   first group is Stability Class A,
                                   and the speed classes have upper
                                   bounds (m/s) defined in Group 12
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   11  !

      (If NVL2 > 0, ALL parameter data for
       these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ----------------------------
                                                                       b
         X           Y        Effect.    Base     Initial    Initial   Emission
     Coordinate  Coordinate   Height   Elevation  Sigma y    Sigma z    Rates
        (km)        (km)        (m)       (m)       (m)        (m)
     ----------  ----------   ------    ------    --------   --------   --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
```

```
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  0  !

!END!

---------------
Subgroup (17b)
---------------
                                               a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                   X            Y          Ground       Height   b
Receptor       Coordinate   Coordinate   Elevation   Above Ground
  No.             (km)         (km)         (m)          (m)
--------       ----------   ----------   ---------   ------------


-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

Appendix 6: Noise Assessment (SVT, 2015)

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SVT ENGINEERING CONSULTANTS

IRON BRIDGE PORT FACILITY ENVIRONMENTAL NOISE ASSESSMENT

1370422-8-100 Rev1-29 July 2015

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EXECUTIVE SUMMARY

SVT have been engaged by FMG Iron Bridge (FMGIB) to undertake an environmental noise assessment of the proposed North Star Magnetite Port Facility at the Herb Elliot Port, Anderson Point in Port Hedland. The expansion involves the installation of infrastructure at the Herb Elliot port facility to enable the processing of Magnetite.

The aim of this environmental noise assessment was to quantify the noise emissions associated with the proposed North Star Magnetite Facility and assess compliance with the *Environmental Protection (Noise) Regulations 1997* (the *Regulations*) at the nearest noise sensitive receivers.

Modelling Results

The predicted received noise levels for the Magnetite Facility are shown in Table E 1.

Table E 1 L_{A10} Predicted noise levels in dB(A)

Receivers	L_{A10} Assigned[1] Level	Magnetite Export Facility	
		Predicted Level	Exceedence
Brearley St	32	27.2	Nil
Crow St	33	32.8	Nil
Esplanade Hotel	44	37.4	Nil
Hospital	32	32.0	Nil
McKay Street	37	34.8	Nil
Parker Street	30	17.3	Nil
Police Station	47	36.2	Nil
Pretty Pool	30	18.0	Nil
South Hedland	30	14.6	Nil
Wedgefield	44	29.7	Nil
White Hill Estate	30	9.0	Nil

Conclusions and Recommendations

Based on the noise modelling predictions, the following has been concluded (see section 6.1 for details);

- The Magnetite Facility in-isolation is compliant with the Regulations.
- The Magnetite Facility does not increase PHIC[2] cumulative noise levels[3] .
- Based on these results, no noise mitigation is required for the new Magnetite Facility.

[1] A 5dB non-significant contributor reduction is included in the assigned level.

[2] Port Hedland Industries Council (PHIC) Cumulative noise levels.

[3] It is inevitable that adding additional noise sources will increase the cumulative noise levels. However, the Magnetite facility adds to the second decimal place only (i.e. 0.01 dB). This is negligible and therefore has not been noted as an increase.

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1. INTRODUCTION

SVT have been engaged by FMG Iron Bridge (FMGIB) to undertake an environmental noise assessment of the proposed North Star Magnetite Port Facility at the Herb Elliot Port, Anderson Point in Port Hedland.

The expansion involves the installation of additional infrastructure at the Herb Elliot port facility to enable the processing of Magnetite.

1.1 Objectives

The objectives of this environmental noise assessment are to:

- Quantify the noise emissions associated with the proposed North Star Magnetite Facility;
- Assess if the noise emissions from the proposed equipment comply with the *Environmental Protection (Noise) Regulations 1997* (the *Regulations*) at the nearest noise sensitive receivers in Port Hedland and South Hedland; and
- If applicable, determine noise control required to meet the *Regulations*.

1.2 Major Activities

To achieve these objectives the following activities have been undertaken:

- Review documentation provided by FMGIB including plot plans, equipment lists and drawings, topographical data, noise data;
- Calculate the overall noise source levels for the proposed activities;
- Develop a noise model for the proposed activities;
- Predict noise levels and generate noise contours at the nearest sensitive receivers under worst case meteorological conditions;
- Determine compliance with the noise limits imposed under the *Regulations*; and
- if applicable, recommend noise mitigation measures required to achieve compliance.

1.3 Applicable Documents

The following is a list of applicable documents:

1) Environmental Protection (Noise) Regulations 1997.
2) SVT Report 1253921-9-100 'Port Hedland Cumulative Environmental Noise Study'.
3) SVT Report 1370422-3-100 Rev1-10 June 2014 'Environmental Noise Assessment: Magnetite Processing'.

2. BACKGROUND

FMGIB is a joint venture (IBJV) consisting of FMG and Formosa Steel IB. IBJV have entered into an agreement with The Pilbara Infrastructure (TPI) for use of its port facilities at Anderson Point to export magnetite product received from the North Star Mine, owned and operated by the IBJV.

As part of the environmental approvals process for the project, an environmental noise assessment for the new Magnetite Facility is required.

The proposed facility, highlighted in Figure 2-1, is located adjacent to the existing FMG port infrastructure. A more detailed site layout drawing of the Magnetite export facility is presented in Figure 2-2.

The infrastructure required for the Magnetite export facility includes;

- Slurry pipeline from the Northstar minesite to the port facility
- Filtration Plant
- Water return pipeline from the port facility to the Northstar mine
- Stockpile and stockyard
- Conveyors, Conveyor Drives and Transfer Stations

The above list is a high level summary of the new major infrastructure required for the export facility. A detailed list of the equipment modelled and their associated noise source levels included in the noise modelling is presented in Appendix B.

Figure 2-1 Existing FMGIB Port Facility and new Magnetite Facility (yellow highlights)

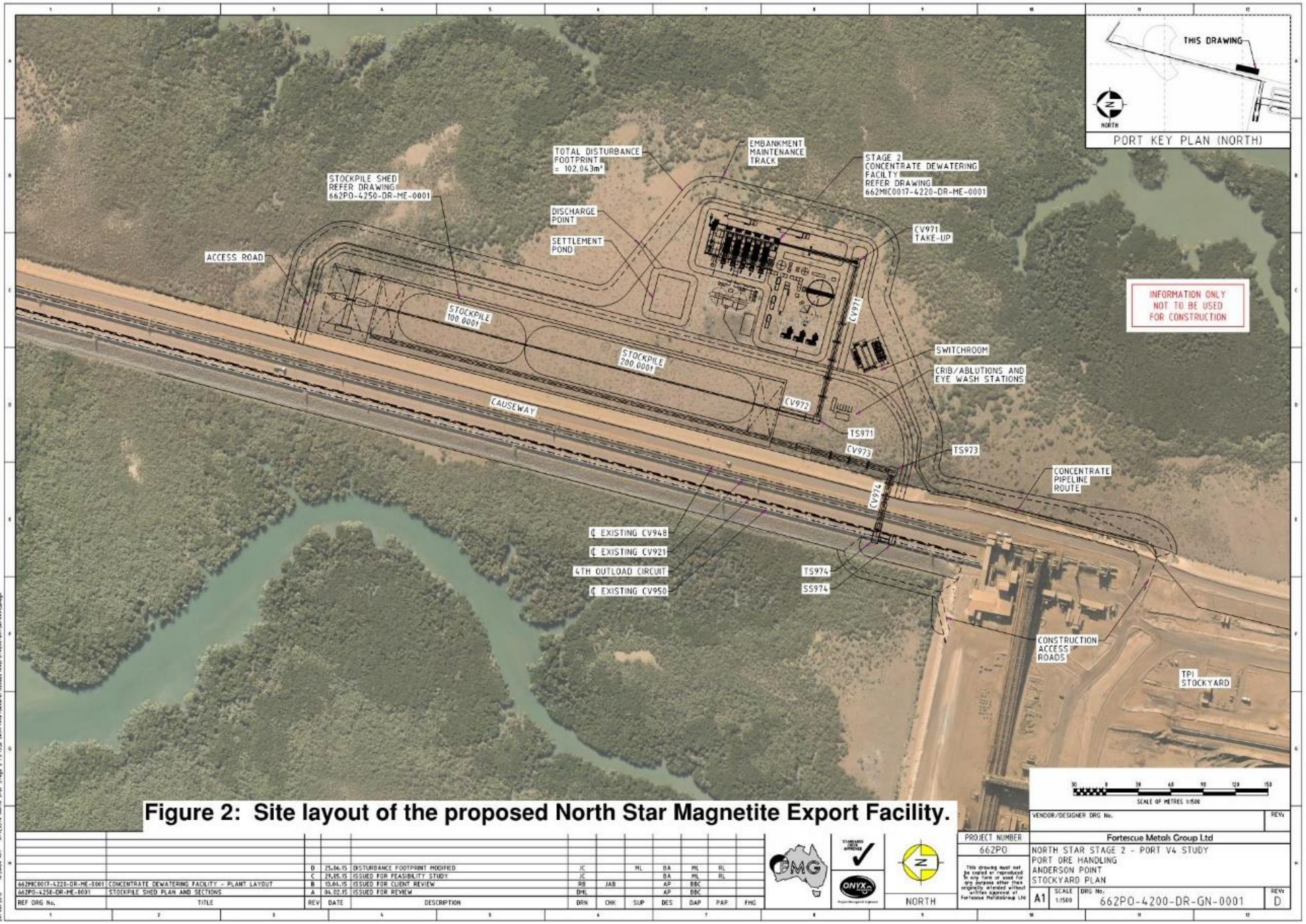

Figure 2: Site layout of the proposed North Star Magnetite Export Facility.

Figure 2-2 North Star Magnetite Facility Layout

3. APPLICABLE REGULATIONS AND ASSIGNED LEVELS

Noise management in Western Australia is implemented through the *Environmental Protection (Noise) Regulations 1997* [1], which operate under the *Environmental Protection Act 1986.* Further details about these Regulations are provided in Appendix A.

The *Regulations* specify maximum noise levels (assigned levels), which are the highest noise levels that can be received at noise-sensitive premises, commercial and industrial premises. The *Regulations* define three types of assigned noise level:

- L_{Amax} assigned noise level is a noise level which is not to be exceeded at any time;
- L_{A1} assigned noise level, which is not to be exceeded for more than 1% of the time; and
- L_{A10} assigned noise level, which is not to be exceeded for more than 10% of the time.

The L_{A10} assigned noise level is the most significant for this study because it is representative of continuous noise emissions from the facility.

The assigned noise level must also be "free" of annoying characteristics (Appendix A-1), namely tonality, modulation and impulsiveness. If the received level contains annoying characteristics, a penalty adjustment must be added to the assigned level. No penalty adjustment has been added to the noise-sensitive receivers for this project as all receivers are over 1 km from the facility and any tonality is expected to be absorbed into the atmosphere. In addition, it is assumed that the port facility will not produce any noise that has modulating or impulsive characteristics.

Noise-sensitive premises such as residences have an "influencing factor" incorporated into the assigned noise levels. The influencing factor depends on the land use zonings within a 100 metre circle and a 450 metre radius from the noise-sensitive receiver (for more information, see Appendix A-2). The higher the percentage of industrial and commercial zoning and vehicles per day within the 100 and 450 meters radii, the higher the influencing factors.

When checking the modelled results' compliance with the assigned noise levels set by the *Regulations*, the most relevant maximum to consider is the L_{A10} allowable noise levels in dB(A) at night. This is because the assigned noise levels are most stringent at night and, if this level is met, then it is assumed that the noise level will not exceed the restrictions during the day or evening.

The *Regulations* require that noise from a **new emitter**[4] must be 5 dB below the assigned noise level if noise levels at sensitive receivers already exceed the assigned noise levels. This is so that the new emitter is not a significant contributor to cumulative noise levels at the noise-sensitive receiver.

The assigned levels for the receivers used in the previous FMG study and for the Port Hedland Industrial Council (PHIC) are shown in Table 3-1. These assigned levels will be used for the current study.

[4] North Star Magnetite Export Facility is considered a new noise emitter.

Table 3-1 Assigned noise levels of receivers considered for FMGIB study

Location[5]	GPS co-ordinates (MGA94)		L_{A10} Night-time Assigned Levels, dB(A)	L_{A10} Night-time Assigned Levels, dB(A) less 5 dB[6]
	Eastings	Northings		
Esplanade Hotel, Port Hedland	664608	7752926	49	44
McKay Street, Port Hedland	664746	7753342	42	37
Crow Street, Port Hedland	665570	77530349	38	33
Wedgefield (Caretakers' Residences only)	665509	7746336	65	60
Parker Street (Lawson), South Hedland	667033	7743388	35	30
White Hill Estate	665758	7739062	35	30
Brearley St , Port Hedland	667699	7753338	37	32
Hospital , Port Hedland	665799	7753424	37	32
Police Station, Port Hedland	664652	7753117	52	47
Pretty Pool, Port Hedland	671261	7752609	35	30
South Hedland	667852	7742771	35	30

[5] Additional receivers have been added for comparison with noise assessment undertaken by the PHIC [2].

[6] This applies for receivers where there is, or is predicted to be, an exceedence of the assigned levels.

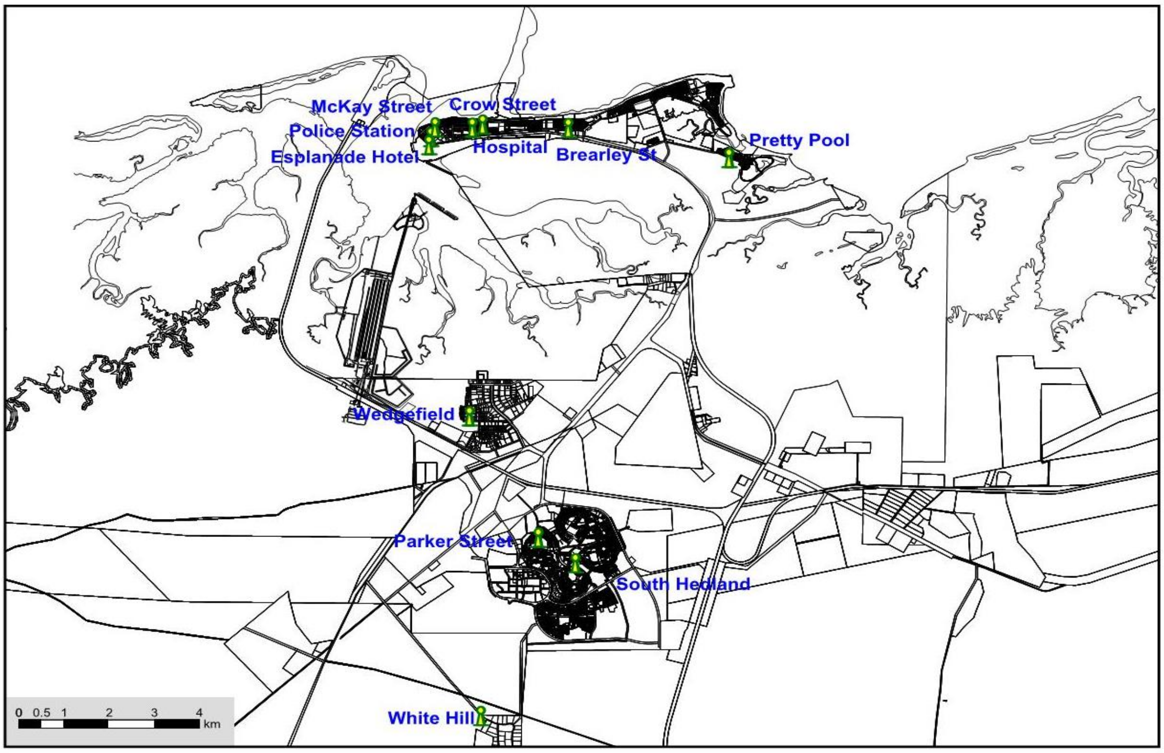

Figure 3-1 Noise Sensitive Receivers Used in this study

4. PORT HEDLAND INDUSTRY COUNCIL (PHIC) STRATEGIC NOISE GOALS

The PHIC cumulative noise assessment [2] has identified that cumulative noise emissions from industry in Port Hedland currently exceed the regulatory noise levels. At the time of this report, a *Regulation* 17 exemption process had not been initiated for Port Hedland. Until such an exemption has been approved it has been proposed that noise goals be set that will give guidance to plant operators and regulators for noise management and assessment in Port Hedland. The goals that are relevant to this assessment are:

During ongoing operations:

- Ensure plant and infrastructure equipment items are maintained and that their noise emissions are addressed in maintenance plans and activities.

During growth:

- As Low As Reasonably Practicable (ALARP) noise levels must be achieved and demonstrated.
- When assessed in isolation, i.e. excluding existing plant and infrastructure, any new plant equipment and infrastructure must comply with the *Regulations*.
- The overall noise emissions, i.e. those of new plant and existing plant, remain the same or improve.

The methodology used in this assessment has been adapted to ensure that the North Star Magnetite Export Facility achieves the goals proposed in the PHIC study.

5. NOISE MODELLING METHOD

In order to assess compliance against the Regulations and the PHIC noise goals (section 4), the following assessment method has been used;

- An in-isolation model scenario has been developed for the Northstar Magnetite Facility. The in-isolation scenario will assess the new Magnetite infrastructure[7] (see Appendix B).

- The in-isolation noise model will be combined with the PHIC cumulative noise model[8] to determine if the new Magnetite Facility will result in an increase in cumulative noise levels.

5.1 Noise Model Software

An acoustic model was created using the SoundPlan v7.0 program developed by SoundPlan LLC. The program calculates sound pressure levels at nominated receiver locations and produces noise contours over a defined area of interest. The inputs required in SoundPlan are noise source data, ground topographical data, meteorological data and receiver locations.

5.2 Input Data

5.2.1 Topography and Ground Types

Topographical information for the acoustic model was provided by FMGIB in dxf format, which were entered into the noise model. The ground absorption for the sea surface was set to zero (perfectly reflecting), representing a realistic worst-case condition at the frequencies of interest, and soft ground was used for land (ground absorption factor = 0.7).

The topographical data entered is consistent with previous FMG and PHIC modelling in the area.

5.2.2 Equipment List and Source Sound Power Levels

The proposed Magnetite Facility equipment list modelled and the noise source sound power levels (SWL's) associated with this equipment are presented in Appendix B.

The new equipment sound power levels were calculated using data provided by FMGIB. The existing facility noise source levels were determined using a combination of data provided and noise source levels from SVT's database of similar equipment.

5.2.3 Noise-Sensitive Receivers

Eleven (11) noise-sensitive receivers have been used for this assessment, which are consistent from the previous FMG [3] and PHIC assessment [2]. These receivers and their assigned noise levels are listed in Table 3-1, and their locations presented graphically in Figure 3-1

[7] The outloading circuit has not been included as this is part of the existing FMG facility.

[8] As the Magnetite Facility is being operated by a new entity (FMGIB), the Magnetite Facility will be considered as the first facility operated by the FMGIB entity.

5.2.4 Meteorology

Certain meteorological conditions can increase noise levels at a receiving location by a process known as refraction. When refraction occurs, sound waves that would normally propagate directly outwards from a source can be bent downwards, causing an increase in noise levels. Such refraction occurs during temperature inversions and where there is a wind gradient.

SoundPlan has a range of different algorithms which it can use to calculate noise levels for user-defined meteorological conditions. For this assessment, the CONCAWE[9] algorithm was used. The meteorological conditions assigned to the model were in accordance with the EPA's recommendations for worst-case weather conditions, as outlined in *Guidance for the Assessment of Environmental Factors, Draft No.8, May 2007*, namely:

- Day (07:00 – 19:00) wind speed – 4m/s; Pasquill Stability Class "E"; temperature – 20°C; and relative humidity – 50%.
- Night (19:00 – 07:00) wind speed – 3m/s; Pasquill Stability Class "F"; temperature – 15°C; and relative humidity – 50%.

As the operations are continuous and worst-case conditions occur during night-time, the night-time meteorological conditions were used in the model.

5.3 Noise Model Configuration

The noise model was configured, as per Figure 2-2, and to include the new Magnetite equipment listed in Appendix B. Detailed equipment layout drawings and noise source heights were provided by FMGIB.

To represent worst-case operational conditions, all equipment modelled was assumed to be operating simultaneously.

5.4 Modelling Assumptions

The modelling assumptions used were as follows:

1. Worst-case weather conditions were applied, as outlined in *Guidance for the Assessment of Environmental Factors, Draft No.8, May 2007* (see section 5.2.4).
2. All items of equipment except conveyor belts (i.e. line stands with rollers) were modelled as point sources. Conveyor belts were modelled as line sources.
3. No barrier effect of physical structures and noise emission directivities were considered.
4. Sea surface is perfectly reflective and land is soft ground (ground absorption factor = 0.7). This assumption was made in the previous model.
5. All items of equipment are assumed to operate simultaneously.
6. It is assumed that once the product has been extracted from the slurry it will be 'fines' and not lump.

[9] CONCAWE (Conservation of Clean Air and Water in Europe) was established in 1963 by a group of oil companies to carry out research on environmental issues relevant to the oil industry.

6. NOISE MODELLING RESULTS AND ASSESSMENT

6.1 Point Calculations

Table 6-1 presents the noise model predictions at the noise sensitive receiver locations, run under worst case conditions[10].

Table 6-1 Noise Model Results Summary

Receivers	L_{A10} Assigned Level	Magnetite Export Facility	
		Predicted L_{A10} Level	Exceedence
Brearley St	32	27.2	Nil
Crow St	33	32.8	Nil
Esplanade Hotel	44	37.4	Nil
Hospital	32	32.0	Nil
McKay Street	37	34.8	Nil
Parker Street	30	17.3	Nil
Police Station	47	36.2	Nil
Pretty Pool	30	18.0	Nil
South Hedland	30	14.6	Nil
Wedgefield	44	29.7	Nil
White Hill Estate	30	9.0	Nil

Based on the noise modelling predictions in Table 6-1, the following has been concluded;

- The Magnetite Facility in-isolation is compliant with the Regulations.
- The Magnetite Facility does not increase PHIC cumulative noise levels[11].
- Based on these results, no noise mitigation is required for the new Magnetite Facility.

6.2 Noise Contours

Figure 6-1 presents a noise contour map of the results presented in Table 6-1.

[10] Worst case night-time meteorological conditions defined in section 5.2.4 and worst case operational conditions (i.e. all equipment operational simultaneously).

[11] It is inevitable that adding additional noise sources will increase the cumulative noise levels. However, the Magnetite facility adds to the second decimal place only (i.e. 0.01 dB). This is negligible and therefore has not been noted as an increase.

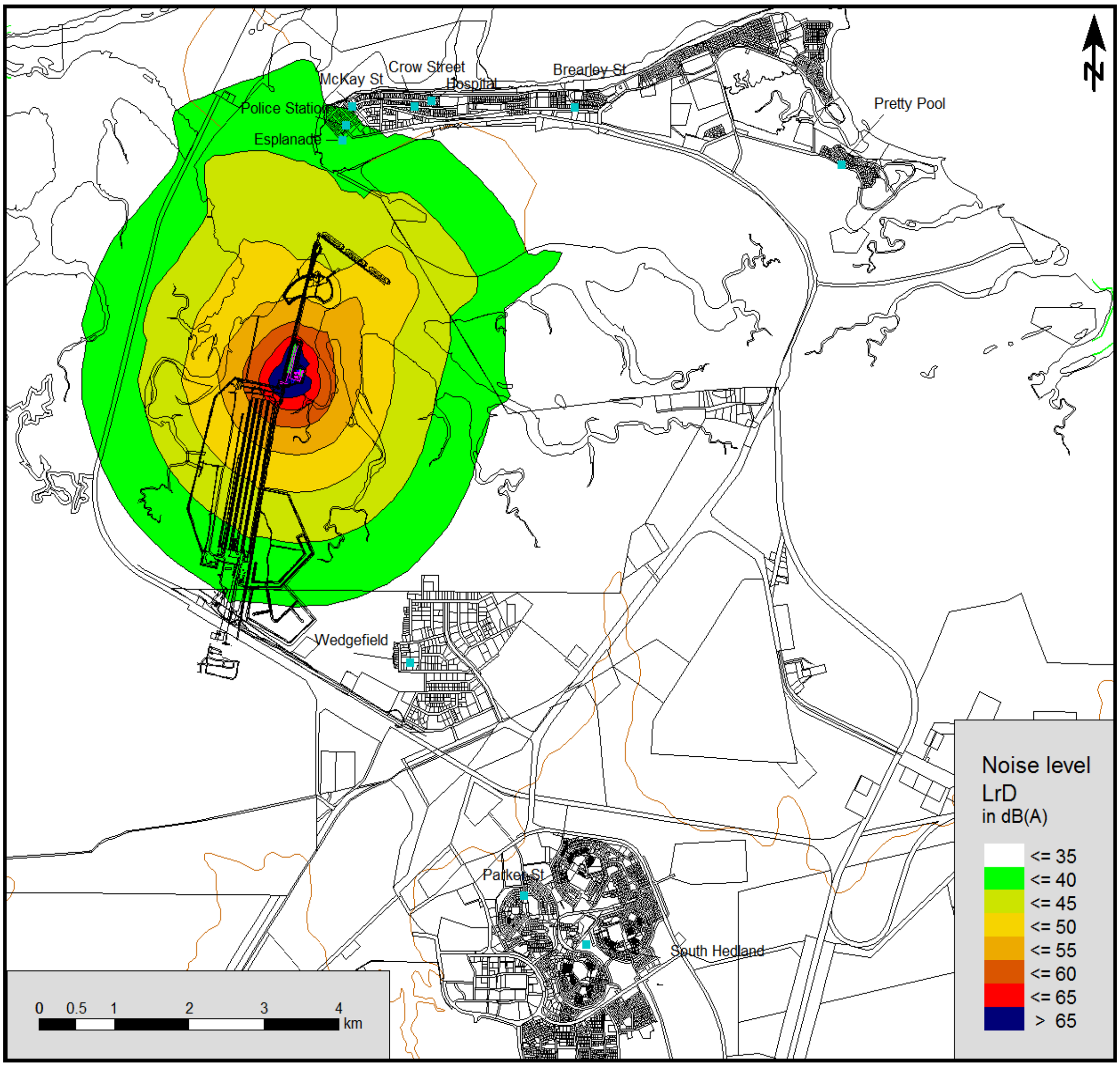

Figure 6-1 Noise Contour Map – Magnetite Facility

7. CONCLUSIONS

In order to comply with the Regulations and PHIC noise goals, the proposed expansion needs to satisfy the following requirements:

- Requirement 1 – New additional equipment, operating in-isolation, shall comply with the *Regulations*.
- Requirement 2 – Combined noise levels from the new expansion plus the existing facilities will not result in a noise increase at any of the receivers.

Based on the results of noise modelling, the following conclusions have been made;

- Requirement 1 is achieved with no noise controls as the Magnetite Facility expansion is compliant with the Regulations.
- Requirement 2 is achieved with no noise controls as the Magnetite Facility expansion does not increase PHIC cumulative noise levels[12].

[12] It is inevitable that adding additional noise sources will increase the cumulative noise levels. However, the Magnetite facility adds to the second decimal place only (i.e. 0.01 dB). This is negligible and therefore has not been noted as an increase.

APPENDIX A SUMMARY OF THE ENVIRONMENTAL PROTECTION (NOISE) REGULATIONS 1997

Table A1 shows the assigned noise levels for noise-sensitive premises according to the *Environmental Protection (Noise) Regulations 1997*. As can be seen from the table, the time of day also affects the assigned levels for noise-sensitive, commercial and industrial premises.

Table A1 Assigned Noise Levels

Type of premises receiving noise	Time of day	Assigned Noise Levels dB(A)		
		$L_{A\ 10}$	$L_{A\ 1}$	$L_{A\ max}$
Noise sensitive premises: highly sensitive area	0700 to 1900 hours Monday to Saturday	45+ influencing factor	55+ influencing factor	65+ influencing factor
	0900 to 1900 hours Sundays and public holidays	40+ influencing factor	50+ influencing factor	65+ influencing factor
	1900 to 2200 hours all days	40+ influencing factor	50+ influencing factor	55+ influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35+ influencing factor	45+ influencing factor	55+ influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

Note that the *Regulations* do not deal with:

- Noise within one premises, for example in a workplace;
- Noise from traffic on roads or trains;
- Noise from aircraft; and
- Noise from safety warning devices (e.g. reverse beepers).

Appendix A-1 Noise Characteristics

Received noise levels are subject to penalty corrections if the noise exhibits intrusive or dominant characteristics, i.e. if the noise is impulsive, tonal, or modulated (see Table A2). That is, the measured or predicted noise levels are increased by the applicable penalties, and the adjusted noise levels must comply with the assigned noise levels. Regulation 9 sets out objective tests to assess whether the noise is free of these characteristics.

Table A2 Penalties for intrusive or dominant noise characteristics

Adjustment where noise emission is not music these adjustments are cumulative to a maximum of 15 dB		
Where tonality is present	Where modulation is present	Where impulsiveness is present
+5 dB	+5 dB	+10 dB

Appendix A-2 Influencing Factors

As shown in Table A3, the influencing factor is calculated at the noise-sensitive premises and the calculated value is added to the assigned noise levels. The influencing factor depends on the land use zonings within 100 metre and 450 metres circles from the noise receiver. This factor's value depends on:

- the proportion of industrial land use zonings;
- the proportion of commercial zonings; and
- the presence of major roads within the circles.

The influencing factors used in the previous FMG study are shown in Table A3.

Table A3 Influencing factors used in previous FMG study

Location	Influencing Factor
Esplanade Hotel, Port Hedland	14 dB
McKay Street, Port Hedland	7 dB
Crowe Street, Port Hedland	3 dB
Wedgefield	N/A
Parker Street (Lawson), South Hedland	0 dB
White Hill Estate	0 dB

The influencing factors used in PHIC are shown in Table A4 and Figure A1.

Table A4 Influencing factors used in PHIC

Residential Area	Influencing Factor
Police Station	17 dB
Hospital	2 dB
Brearley Avenue	1 to 2 dB
Pretty Pool	0
South Hedland	0

Figure A1 Influencing factors that can be applied to different areas of Port Hedland

APPENDIX B EQUIPMENT MODELLED AND SOUND POWER LEVELS

Equipment	Octave Frequency Band Sound Power Levels in dB(lin)									Overall dB(A)
	31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Air Compressor 1.Dewatering Facility	103.6	103.4	101.3	93.1	90.6	88.3	87.1	83.2	80.3	**94.6**
Air Compressor 2.Dewatering Facility	103.6	103.4	101.3	93.1	90.6	88.3	87.1	83.2	80.3	**94.6**
Air Compressor 3.Dewatering Facility	103.6	103.4	101.3	93.1	90.6	88.3	87.1	83.2	80.3	**94.6**
Air Compressor 4.Dewatering Facility	103.6	103.4	101.3	93.1	90.6	88.3	87.1	83.2	80.3	**94.6**
Clarifier. Dewatering Facility					105.1					**101.9**
Clarifier Underflow Pump. Additional Pumps	78.6	71.6	78.5	79	80.6	80.4	77.2	73.4	40.3	**84.4**
CV970.Inload Conveyors	78.7	82	83.4	82.5	82.8	81.8	76.7	71	66	**85.5**
CV970 Drive. Inload Conveyors	100	104.2	105.6	103.1	107.8	110.2	103	94.1	86.6	**112.2**
CV971.Inload Conveyors	78.7	82	83.4	82.5	82.8	81.8	76.7	71	66	**85.5**
CV971 drive. Inload Conveyors	97.4	103.2	101.3	100.4	103.4	108	100.1	91.1	85.4	**109.6**
CV972.Inload Conveyors	78.7	82	83.4	82.5	82.8	81.8	76.7	71	66	**85.5**
CV972 Drive. Inload Conveyors	97.4	103.2	101.3	100.4	103.4	108	100.1	91.1	85.4	**109.6**
CV973.Inload Conveyors	88.4	91.5	89.4	88.2	88.2	83.8	79.8	74.2	67.3	**89.2**
CV973 Drive. Inload Conveyors	107.2	104.9	100.7	101.2	106.6	103.4	102.3	89	82.9	**108.4**
CV974.Inload Conveyors	88.4	91.5	89.4	88.2	88.2	83.8	79.8	74.2	67.3	**89.2**

Equipment	Octave Frequency Band Sound Power Levels in dB(lin)									Overall dB(A)
	31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
CV974 Drive. Inload Conveyors	97.4	103.2	101.3	100.4	103.4	108	100.1	91.1	85.4	**109.6**
Filter Feed Tank Agitator 1.Dewatering Facility	101.4	99.4	101.8	103.4	104.6	101.1	97.7	88.1	81.1	**105.9**
Filter Feed Tank Agitator 2.Dewatering Facility	101.4	99.4	101.8	103.4	104.6	101.1	97.7	88.1	81.1	**105.9**
Filtrate Pump 1.Additional Pumps	83	76	82.9	83.4	85	84.8	81.6	77.8	44.7	**88.8**
Filtrate Pump 2.Additional Pumps	83	76	82.9	83.4	85	84.8	81.6	77.8	44.7	**88.8**
Filtrate Pump 3.Additional Pumps	83	76	82.9	83.4	85	84.8	81.6	77.8	44.7	**88.8**
Filtrate Pump 4.Additional Pumps	83	76	82.9	83.4	85	84.8	81.6	77.8	44.7	**88.8**
Filtrate Pump 5.Additional Pumps	83	76	82.9	83.4	85	84.8	81.6	77.8	44.7	**88.8**
Gland Water Pump 1.Additional Pumps	80.9	73.9	80.8	81.3	82.9	82.7	79.5	75.7	42.6	**86.7**
Gland Water Pump 2.Additional Pumps	80.9	73.9	80.8	81.3	82.9	82.7	79.5	75.7	42.6	**86.7**
Instrument Air Compressor 1.Dewatering Facility	105.8	105.6	103.5	95.3	92.8	90.5	89.3	85.4	82.5	**96.8**
Instrument Air Compressor 2.Dewatering Facility	105.8	105.6	103.5	95.3	92.8	90.5	89.3	85.4	82.5	**96.8**
Instrument Air Compressor 3.Dewatering Facility	105.8	105.6	103.5	95.3	92.8	90.5	89.3	85.4	82.5	**96.8**
Instrument Air Compressor 4.Dewatering Facility	105.8	105.6	103.5	95.3	92.8	90.5	89.3	85.4	82.5	**96.8**

Equipment	Octave Frequency Band Sound Power Levels in dB(lin)									Overall dB(A)
	31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Pressure Filter 1.Dewatering Facility [13]	97.3	97.7	97.8	97.8	95.5	93.5	88.6	84.3	81.0	**98.0**
Pressure Filter 2.Dewatering Facility [13]	97.3	97.7	97.8	97.8	95.5	93.5	88.6	84.3	81.0	**98.0**
Pressure Filter 3.Dewatering Facility [13]	97.3	97.7	97.8	97.8	95.5	93.5	88.6	84.3	81.0	**98.0**
Pressure Filter 4.Dewatering Facility [13]	97.3	97.7	97.8	97.8	95.5	93.5	88.6	84.3	81.0	**98.0**
Pressure Filter 5.Dewatering Facility [13]	97.3	97.7	97.8	97.8	95.5	93.5	88.6	84.3	81.0	**98.0**
Process Water Pump 1.Additional Pumps	89.4	82.4	89.3	89.8	91.4	91.2	88	84.2	51.1	**95.2**
Process Water Pump 2.Additional Pumps	89.4	82.4	89.3	89.8	91.4	91.2	88	84.2	51.1	**95.2**
Product Belt Feeder 1.Dewatering Facility	98.7	97.9	105.8	98.2	94.3	90.6	89	86.5	81.5	**97.8**
Product Belt Feeder 2.Dewatering Facility	98.7	97.9	105.8	98.2	94.3	90.6	89	86.5	81.5	**97.8**
Product Belt Feeder 3.Dewatering Facility	98.7	97.9	105.8	98.2	94.3	90.6	89	86.5	81.5	**97.8**
Product Belt Feeder 4.Dewatering Facility	98.7	97.9	105.8	98.2	94.3	90.6	89	86.5	81.5	**97.8**
Product Belt Feeder 5.Dewatering Facility	98.7	97.9	105.8	98.2	94.3	90.6	89	86.5	81.5	**97.8**
Product Chute 1.Dewatering Facility	107	113.1	110.2	106.9	105.6	100.2	94.7	88.7	85.2	**106.3**
Product Chute 2.Dewatering Facility	107	113.1	110.2	106.9	105.6	100.2	94.7	88.7	85.2	**106.3**

[13] There is a level of uncertainty regarding the SWL for the Pressure Filters. The SWL has been based on the air vent only, located on the Western side of the Dewatering Plant. It has been assumed that the Hydraulic Power pack will be acoustically enclosed, reducing noise levels in the appropriate frequency bands between 15 dB and 20 dB.

Equipment	Octave Frequency Band Sound Power Levels in dB(lin)									Overall dB(A)
	31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Product Chute 3.Dewatering Facility	107	113.1	110.2	106.9	105.6	100.2	94.7	88.7	85.2	**106.3**
Product Chute 4.Dewatering Facility	107	113.1	110.2	106.9	105.6	100.2	94.7	88.7	85.2	**106.3**
Product Chute 5.Dewatering Facility	107	113.1	110.2	106.9	105.6	100.2	94.7	88.7	85.2	**106.3**
RC770.Inload Conveyors	88.4	91.5	89.4	88.2	88.2	83.8	79.8	74.2	67.3	**89.2**
Return Water Charge Pump 1.Additional Pumps	81.7	85.3	86.8	83.8	84.7	84	94.1	87.4	82.6	**96.7**
Return Water Charge Pump 2.Additional Pumps	81.7	85.3	86.8	83.8	84.7	84	94.1	87.4	82.6	**96.7**
Return Water Pump 1.Dewatering Facility	91.6	95.2	96.7	93.7	94.6	93.9	104	97.3	92.5	**106.6**
Return Water Pump 2.Dewatering Facility	91.6	95.2	96.7	93.7	94.6	93.9	104	97.3	92.5	**106.6**
Return Water Pump 3.Dewatering Facility	91.6	95.2	96.7	93.7	94.6	93.9	104	97.3	92.5	**106.6**
SS974.Inload Conveyors	104.8	110.3	107.7	107.5	107.6	107.2	107.9	105.9	99.2	**113.5**
Wash Water Pump 1.Additional Pumps	92.2	85.2	92.1	92.6	94.2	94	90.8	87	53.9	**98**
Wash Water Pump 2.Additional Pumps	92.2	85.2	92.1	92.6	94.2	94	90.8	87	53.9	**98**
Wash Water Pump 3.Additional Pumps	92.2	85.2	92.1	92.6	94.2	94	90.8	87	53.9	**98**
Wash Water Pump 4.Additional Pumps	92.2	85.2	92.1	92.6	94.2	94	90.8	87	53.9	**98**

Appendix 7: Mangrove Protection Management Plan

Iron Bridge

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Iron Bridge

Iron Bridge Port Facility

Mangrove Protection Management Plan

September 2015

662PO-4000-PL-EN-0002

Iron Bridge

	Mangrove Protection Management Plan		**662PO-4000-PL-EN-0002**
Revision Number	**A**		**15/09/2015**
Status	**IFU - ISSUED FOR USE**		
Author	Anthony Bougher /Andrew Winzer	Signature	19/08/2015
Checked	Clayton Brandwood	Signature	27/08/2015
Checked	Ken Wilyman		
Approved	Simon Carter	Signature	17/9/15 Click here to enter a date.
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**N/A**		

Revision History *(to be completed for each version retained by Document Control)*

Author	**Checker**	**Approver**	**Rev No.**	**Status**	**Issued Date**
Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.
Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.

Iron Bridge

	Mangrove Protection Management Plan		**662PO-4000-PL-EN-0002**
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1. INTRODUCTION

IB Operations Pty Ltd proposes to develop the Iron Bridge Port Facility (the Port Facility), located in the Port Hedland Port Precinct, in the Pilbara Region of Western Australia. The Port Facility will accept magnetite concentrate slurry from the North Star Magnetite Mine, located approximately 110 km South of Port Hedland, whereupon it will be dewatered and stockpiled prior to export.

1.1 Requirement for Management Plan

This *Mangrove Protection Management Plan (this Plan)* is required by the Minister as part of development approval for the Iron Bridge Port Facility.

1.2 Objectives and Scope

The objectives of this Plan are to:

- Monitor the health of mangroves and mangrove habitat condition in order to provide information to Fortescue and construction / dredging managers that can assist them in protecting mangroves and minimising impacts during works; and
- Identify management strategies and actions which should be implemented to minimise adverse impacts to mangroves.

The scope of this Plan is limited to management issues relevant to the North Star Stage 2 (NSS2) project which have the potential to impact upon mangroves and mangrove health. The key activities to be undertaken during the NSS2 project that have the potential to impact on mangroves include:

- Direct loss of mangroves due to construction of the port facility
- Dust effects from construction and operations
- Lack of containment of sediment within bunded areas during earthworks (slippage of fill)
- Hydrocarbon spill or leakages from construction and operation activities
- Acid Sulphate soils issues due to disturbance from construction.

1.3 Definitions and Acronyms

The following definitions have been used throughout this Plan and are defined in Table 1.

Table 1: Definitions

Term	Definition
Activity	Refers to 'Environmental Aspects' as defined in ISO14001.
NSS2	North Star Stage Two
PPA	Pilbara Port Authority

1.4 Legislation and Regulatory Framework

Fortescue employees and contractors are obliged to comply with all relevant Commonwealth and State legislation. Legislation directly relevant to the management of mangrove protection throughout the proposed expansion works in Western Australia is provided in Table 2.

Table 2: Relevant Commonwealth and State Legislation.

Legislation	Application
Environmental Protection Act 1986	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 the foregoing.
Environment Protection and Biodiversity Conservation Act 1999	Provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as 'matters of national environmental significance'.
National Environment Protection Council Act 1994	The object of this Act is to ensure that, by means of the establishment and operation of the National Environment Protection Council: a) people enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia.
Wildlife Conservation Act 1950	Provides for the listing of threatened native plants and threatened native animals that need to be specially protected because they are under identifiable threat of extinction, are rare, or otherwise in need of special protection.

The following standards and guideline are also of relevance to this Plan:

- Environmental Assessment Guideline 3 (EAG3): Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment, and
- Environmental Protection Bulletin No.14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland.

1.5 Internal Management Plans and Procedures

Iron Bridge Operations will be required to incorporate a port area rehabilitation management strategies for the NSS2 project into its Port Area Rehabilitation Plan. The plan will be drafted on completion of the construction works with options for the re-establishment of mangrove vegetation.

The following Fortescue documents should be read in conjunction with this plan:

- *Chemical and Hydrocarbon Management Plan (100-PL-EN-0011)*

- *Acid Sulfate Soils Management Plan (100-PL-EN-1016)*
- *Port Facility Dust Environmental Management Plan (P-PL-EN-0010)*
- *Port Area Rehabilitation Management Plan (P-PL-EN-0002)*.

2. ROLES AND RESPONSIBILITIES

All Iron Bridge Operations employees and contractors are required to comply with the requirements of this Plan.

Accountability for fulfilling the requirements of this Plan is dependent on the stage of project development (construction, operations, decommissioning) and the project type (rail or mine).

During construction stages, whether activities are undertaken by an external service provider or internal Fortescue personnel, the Port General Manager will be accountable for ensuring the requirements of this Plan are met.

During operational, decommissioning and closure stages, the Port General Manager will be accountable for ensuring the requirements of this Plan are met.

Where responsibilities are delegated, this must be clearly recorded and communicated.

In Section 6.3 specific management actions have been attributed to the appropriate personnel.

When site specific management programs are developed to support this Plan, the RASCI framework should be utilised to delegate roles, responsibilities, and review and approval levels. RASCI is used to denote:

R-Responsible Those who do the work to achieve the task.

A-Accountable Those who are ultimately accountable for the completion of the deliverable or task and the one to whom the Responsible person is accountable.

S-Supportive Resources allocated to the Responsible person and who will also assist in completing the task.

C-Consulted Those whose opinions are sought, two-way communication.

I-Informed Those whom are kept informed, one-way communication.

3. STAKEHOLDER CONSULTATION

In 2006, the Department of Conservation and Land Management and the Department of Environment were consulted regarding the content of the draft Plan with a workshop held in early 2006 to discuss various aspects of the Plan. A mangrove specialist from Murdoch University (Dr Eric Paling) was also consulted with his comments taken into account in the preparation of the final document (URS 2006a). The Plan was updated to reflect the comments received.

There have been no changes to the environmental factors and no substantial modification of this Plan in the interim, and therefore further consultation specific to the North Star Port Facility has not been considered to be warranted. However Fortescue has consulted with key stakeholders regarding the proposed expansion of the port such as the proposed NSS2 works. This consultation included discussions of potential impacts associated with the clearing of further mangrove areas. Further works proposed by Iron Bridge Operations will also include stakeholder consultation as warranted. A summary of consultation with key stakeholders in provided below in Table 3.

Table 3: Stakeholder Consultation

Stakeholder	Comment(s)
Office of the Environmental Protection Authority	Refer to Environmental Assessment Guideline No. 8 Environmental factors and objectives (EAG No. 8) (January 2015);
Pilbara Ports Authority	Refer to PPA Sustainability Plan (July 2013 – June 2014)

The Plan will be submitted to the Office of the Environmental Protection Authority for their comment and approval.

4. KEY ENVIRONMENTAL ACTIVITIES

Fortescue's Port Hedland port facility is located on the south side of Port Hedland Harbour with the proposed NSS2 Port Facility located adjacent to the Herb Elliott Port Facility (Figure 1). The existing port infrastructure consists of a stockyard and a conveyer system that transfers iron ore from the stockyard to the wharf and shiploader located at Anderson Point.

As far as practicable, the existing port facilities and associated infrastructure have been designed to minimise impacts to mangroves through the placement of facilities and use of culverts and other structures to maintain tidal flows and adequate flushing. This has included significant redesign of the reclamation areas to minimise loss to core mangrove areas and avoid tidal creek areas where possible.

The key activities to be undertaken by Iron Bridge Operations Facility for the NSS2 Port Facility that have the potential to impact on mangroves include:

- Direct loss of mangroves due to construction of the port facility
- Dust effects from construction and operations
- Lack of containment of sediment within bunded areas during earthworks (slippage of fill)
- Hydrocarbon spill or leakages from construction and operation activities
- Acid Sulphate soils issues due to disturbance from construction.

Further information is provided below on Fortescue's port facilities.

4.1 Works Undertaken to Date

This proposal is yet to vbe referred to the OEPA. This management plan is intented to be submitted with the referral supporting document.

4.2 Proposed Works

Proposed works for the NSS2 Port Facility which are to be assessed are shown in Figure 1 and include:

- A dewatering facility and a magnetite stockyard to be located outside the Anderson Point lease areas on undeveloped land directly to the north east of the existing hematite stockyard, on the eastern side of the existing causeway to Anderson Point. This land is mainly comprised of saltflat habitat with scattered samphires and some mangroves, which will be removed during construction.
- An outload conveyor onto the Herb Elliott Port Facility.
- Concentrate slurry and return water pipeline from the Herb Elliott Port Boundary to dewatering facility

The proposed area will be formed to the same AHD of the existing causeway with the perimeter slopes stabilised by geofabric overlaid by rock armor. The development area will contain any surface water runoff with the area draining from the perimeters to trapezoidal drains. Runoff collected will be discharged to a sedimentation basin for removal of sediment prior to discharging the treated water to the tidal creek at the north west corner of the development area.

The dewatering facility will receive magnetite slurry from the mine via a concentrate slurry pipeline and is discharged into filter feed tanks prior to being pumped to the product filters for filtration. Filtered concentrate product from the dewatering facility is transferred by conveyors to a product stockpile with the excess water pumped back to the mine via a return water pipeline. The magnetite concentrate product is reclaimed from the product stockpile and loaded onto ships via a new fourth outload circuit and shiploader on AP5 berth.

No dredging or spoil disposal will be required for this proposed construction works. Wastewater discharges will also not be required.

Figure 1 Proposed NSS2 Port Facility

5. POTENTIAL ENVIRONMENTAL IMPACTS

The potential direct and indirect environmental impacts on mangroves or changes to mangrove habitat condition arising from Iron Bridge Operations activities are presented in Table 4.

Table 4: Potential Environmental Impacts Arising from Iron Bridge Operation's Activities

Potential Environmental Impacts	Details
Direct habitat loss	Clearing of mangroves and incidental damage will result in loss of vegetation.
Dust effects	Deposition of dust may cause loss of condition.
Slippage of fill	Deposition of sediment amongst mangroves and smothering of aerial root structures (pneumatophores) that may causes tree stress
Hydrocarbon spills	Mangroves are highly susceptive to exposure both by acute toxic effects and physical smothering
Disturbance of ASS	Disturbance of ASS can lower the local pH over time, mobilising heavy metals and impacting water quality in the surrounding waterways
Release of stormwater at discharge point	Partial dilution of existing hypersaline groundwater/soilwater conditions on tidal flats immediately downslope of discharge point (note: this change may enhance mangrove growth)

To assist with defining the requirements of this Plan an assessment was made of the potential impacts to mangroves that may arise from the construction and operation of the port facilities. Similar assessments were made previously during preparation of the existing Fortescue site Mangrove Protection Plan (MPP) (URS 2006 & 2009) and is updated here for NSS2 project.

A benthic habitat survey was conducted for the NSS2 development, adjacent to the existing Fortescue facilities at Anderson Point, in January 2015 to map the benthic habitat within the proposed disturbance footprint (Aurecon 2015). The assessment of potential impacts on mangroves has been updated below to account for this mapping and the proposed works described in Section 5.1 for the NSS2 Port Facility.

5.1 Direct Habitat Loss

Previous construction works within the Fortescue controlled areas in the Port of Port Hedland was approved under Ministerial Statement 690 and included direct loss of mangrove habitat. Future construction, such as the proposed NSS2 construction works, may also lead to the direct loss of additional mangrove habitat, subject to OEPA approval.

The NSS2 construction works proposed will result in the direct loss of 2.01 ha of mangrove habitat in addition to that previously approved under Ministerial Statement 690 (EPA 2014).

All additional vegetation disturbance will occur at Herb Elliott Point, adjacent to existing disturbance areas and is located outside the approved ground disturbance footprint for the original proposal in Ministerial Statement 690.

It is unlikely that significant indirect impacts to BPPH will occur as a result of the proposed NSS2 Port development. Key findings from the NSS2 Port Facility environmental assessment can be summarised as follows:

- No change to the marine environment or tidal flushing is proposed to occur; therefore the Proposal is unlikely to contribute to changes in erosion or accretion, affecting fringing mangroves
- Concept drainage designs developed for the NSS2 Port Facility indicated the Proposal is unlikely to have any significant impact on the quantity and quality of surface water and is therefore unlikely to impact on BPPH health
- The additional disturbance area is unlikely to significantly contribute to dust emissions from the overall port operations.

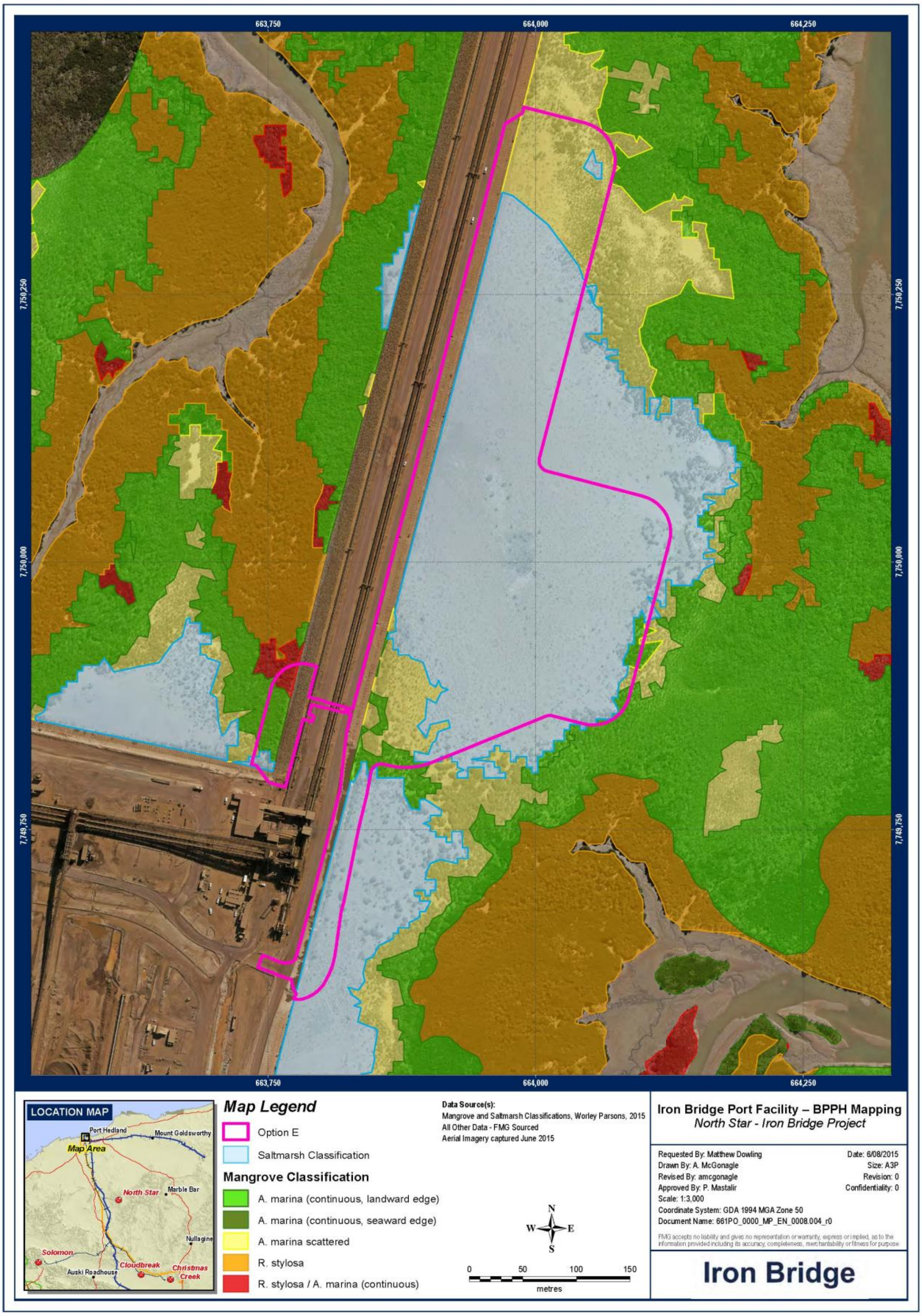
The following associations of mangroves will be disturbed during the proposed NSS2 project:

- *Rhizophora stylosa* / *A.marina* (closed canopy)– 0.04 ha
- Closed-canopy *Avicennia marina* – 0.37 ha
- Open scattered *Avicennia marina* – 1.6 ha

An area of 8.14 ha of saltpan habitat will also be removed, however this is not considered to be BPPH by the EPA, and therefore is not discussed in this MPMP.

The NSS2 Port Facility project area mangrove associations are shown in Figure 2.

Figure 2 **Mangrove associations and areas of mangrove loss at the NSS2 project site**



5.1.1 Port Hedland Local Assessment Unit

At the time of the original proposal, the ‘Port Hedland Industrial Area’ management unit was defined for the purpose of considering cumulative loss of mangrove habitat in accordance with Environmental Guidance Statement No. 29 Benthic Primary Producer Habitat Protection for Western Australia’s Marine Environment (EPA 2004). This document has since been superseded by the EPA Assessment Guideline No. 3, Benthic Primary Producer Habitat Protection for Western Australia’s Marine Environment (EAG 3) (EPA 2009b).

*Avicennia marina (*open scattered).

Avicennia marina / Rhizophora stylosa (closed-canopy).

Avicennia marina (closed-canopy, landward)

Rhizophora stylosa (closed canopy).

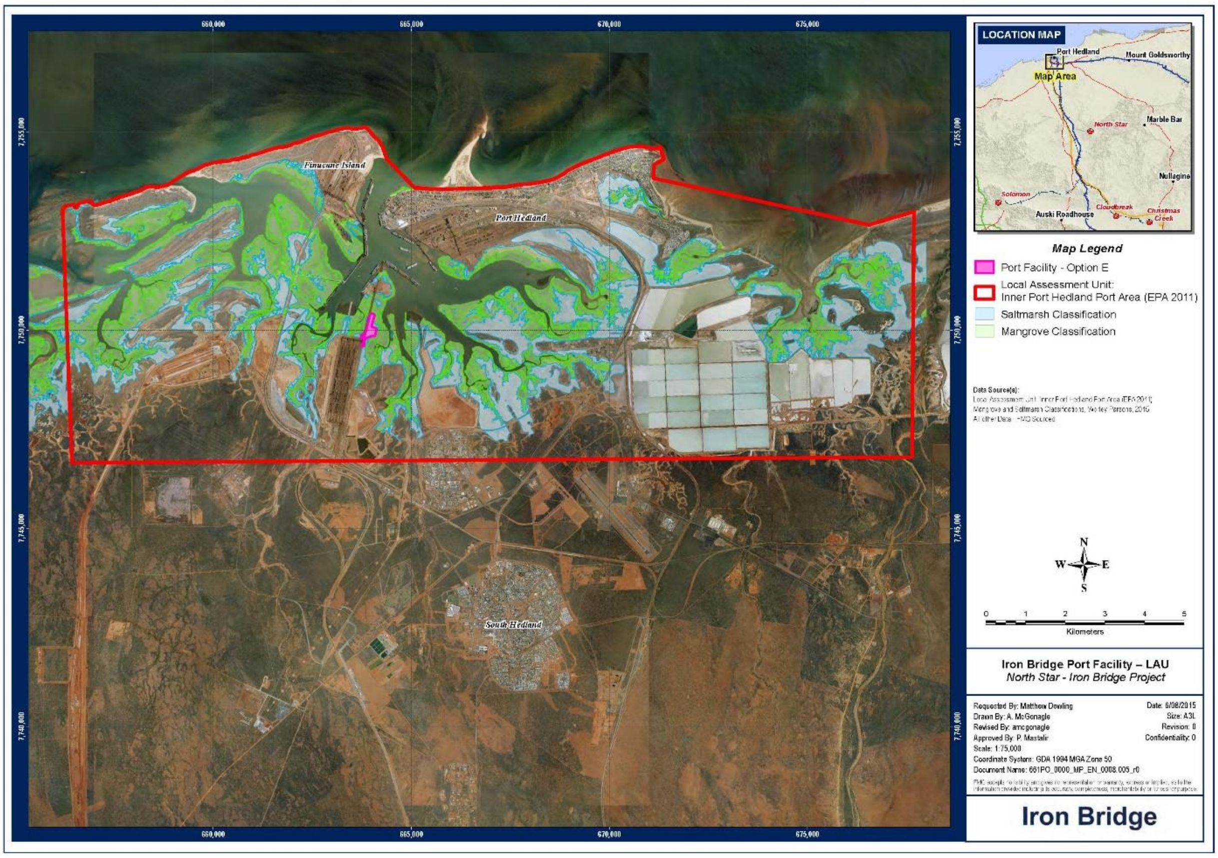
Avicennia marina
(Top view)
(closed-canopy, landward)

Avicennia marina
(closed-canopy, seaward).

Plate 1: Mangrove association photograph

In August 2011, the EPA released the Environmental Protection Bulletin No. 14 Guidance for the Assessment of Benthic Primary Producer Habitat loss in and around Port Hedland. This bulletin provided the EPA established boundaries for the Local Assessment Unit (LAU) to be used for the assessment of future BPPH losses within Port Hedland. The Port Hedland LAU is presented in Figure 3.

Figure 3 Port Hedland LAU



WorleyParsons (2015) conducted a cumulative loss assessment based on the Port Hedland LAU from Environmental Protection Bulletin No. 14. The additional disturbance of 2.01 ha is approximately 0.08% of the mangroves within the LAU and will bring the cumulative loss of mangroves to approximately 14.53%. The EPA have previously described the Port Hedland LAU as a category F area (EPA Report No: 1337: EPA 2009b) where cumulative loss has been significantly exceeded (beyond 10%). The estimates of cumulative loss do however include losses accruing to projects which have been approved but have not yet been constructed.

5.1.2 Offsets

Iron Bridge Operations will investigate the potential to offset its impacts on mangroves by developing new mangrove habitat, rehabilitating previously impacted mangroves, funding research or similar. The offsets related work undertaken by Iron Bridge Operations to date has comprised of:

- A literature and data review on mangrove biodiversity, cause-and-effect pathways, mangrove habitat and impacts on ecological integrity (Pedretti and Paling 2010). The review meets the first requirement for a biodiversity survey in fulfilment of the conditions placed on Fortescue for operation within Port Hedland Harbour under Ministerial Statement 690.

- Annual assessments of new mangrove habitat that has developed at the Fortescue site and monitoring of seedling recruitment within areas of new habitat.

Iron Bridge Operations proposes to continue this work in order to offset the impacts and also assess options for additional offsets related to the NSS2 project.

In addition, PPA is committed to offsetting mangrove losses within Port Hedland Harbour. Offsets for past and future degradation and/or loss of mangrove habitat within the Port Hedland Harbour are being investigated as part of the PHPA Development Plan 2012-2016 (PHPA 2011).

5.2 Dust Effects

Dust generated from construction earthworks and road traffic on unsealed roads may settle on nearby mangrove canopies and cause temporary debility in mangroves.

During the operation phase the presence of iron ore stockpiles, materials handling (e.g. conveyer/load out operations), vehicle movement and other Project activities all have the potential to generate dust within the port area. Studies have demonstrated that iron ore dust in particular does not appear to cause any significant structural damage to mangrove leaf structures (Paling et al. 2001). Dust deposition may still cause other loss of condition in mangroves through effects relating to increased heat or reductions in gas exchange. Issues relating to dust monitoring and management area addressed in the *Port Facility Dust Environmental Management Plan.* It is understood this document will be updated during the NSS2 EIA process.

5.3 Sediment Spillage

During the earthworks stage there is the potential for fill material to slip or be washed down slope and spread out in a fan over adjacent tidal flat and mangrove areas. Slippage is most likely to occur along the outer edge or perimeter bund prior to the slope being stabilised by concrete revetment or rock armour and would be confined to localised areas.

The dominant mangrove species in the area (*Avicennia marina*) develops a system of aerial roots (pneumatophores) that protrude above the mud flat surface. Pneumatophores are breathing roots that allow for the exchange of gas between the atmosphere and the internal root structure. Excess input of sediment can cause tree stress owing to the smothering or burial of the aerial root systems. Impacts can range from reduced vigour to death depending on the rate, amount and type of sediment deposition.

5.4 Hydrocarbon Spills or Leakages

Mangroves are sensitive to direct contact from hydrocarbons. Hydrocarbons can also indirectly affect mangroves through depletion or loss of the associated benthic fauna community. Spills and leaks may occur from a range of earthmoving and construction equipment. Issues relating to hydrocarbon management are addressed in the *Chemical and Hydrocarbon Management Plan.*

5.5 Acid Sulphate Soils

An *Acid Sulfate Soil Management Plan* (ASSMP) (URS 2009) was established to take into account the outcomes of ASS investigations undertaken as part of the environmental assessment of sediment quality for the Project. A number of ASS investigations have been conducted within the Port Hedland region, it is generally acknowledged that mangrove environments contain potentially acid-generating soils. In its natural environment, some disturbance of ASS in mangroves may be considered low risk due to the surrounding high alkaline environment and the continual neutralizing effect of tidal flushing. However, large-scale excavation, and dredging activities if not properly executed, may play its part in the generation of a highly acid environment and the mobilisation of iron, aluminium and other heavy metals such as chromium and nickel, which may then flush into surrounding waterways. Issues regarding the management and monitoring of ASS are addressed in the ASSMP.

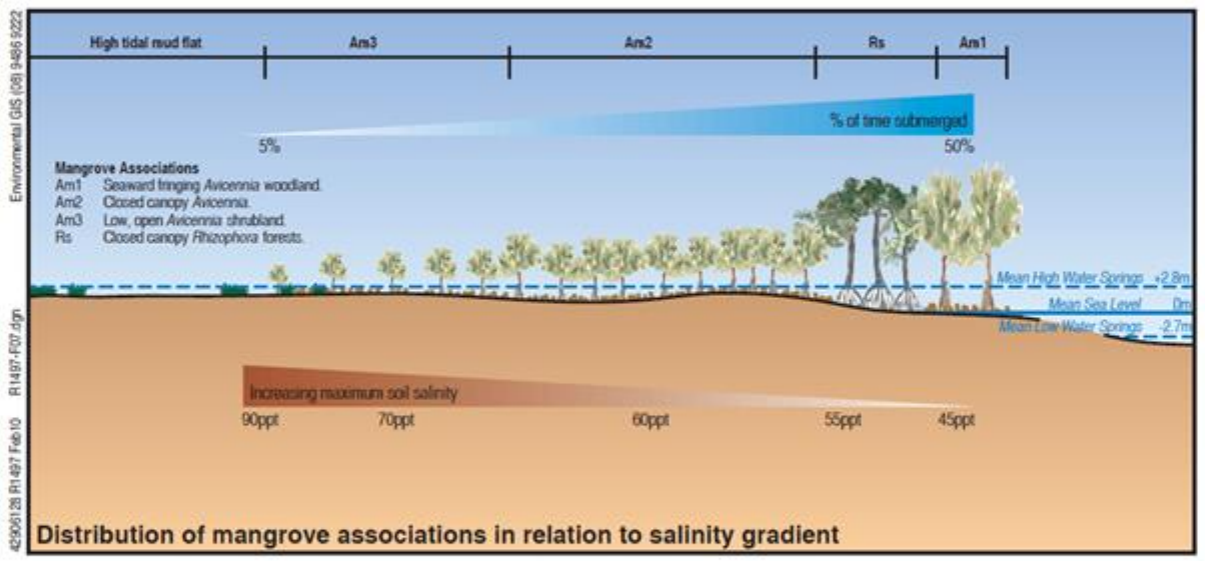
5.6 Release of Stormwater at Discharge Point

While not considered to be a potential indirect impact to mangroves, the release of stormwater (with salinities approaching freshwater) on to the salt flat habitat downslope from the discharge point has the potential to modify habitat conditions by reducing the existing hypersalinity on the salt flat, thereby providing conditions that may be conducive to mangrove recruitment and growth.

Salinity and surveyed ground level data collected since 2006 for the Fortescue Mangrove Monitoring Programme data demonstrates the salinity gradients that occur through the mangrove zone at Port Hedland (URS 2010). Salinities increases from approximately 40-55‰ (ppt TDS) at the more seaward areas (e.g. seaward and taller *Avicennia* zone and *Rhizophora* zone) to approximately 70-90‰ in the more landward sections of the mangrove zone where low open *Avicennia* shrubland occurs (Figure 4).

The dominant species in the study area (*Avicennia marina*) has the greatest salinity tolerance of the Pilbara mangrove species and occurs in areas where groundwater salinity reaches up to 90‰ (approximately 2.5 times seawater). With increasing tidal elevation through landward sections of the mangrove zone, the reduction in tidal inundation in combination with high evaporation rates results in groundwater and soilwater conditions (including salinity) that are beyond the threshold tolerated by mangroves (>90‰). In these areas the mud flats are devoid of mangrove vegetation and the habitat becomes a high tidal mud flat with scattered patches of samphire, algal mats or salt flats. It is into this type of habitat to which the release of freshwater from the NSS2 discharge point will occur and potentially lower salinities to provide conditions conducive to mangroves (depending on the rate, volume and frequency of water release).

Figure 4 Schematic profile showing the relationship between tidal elevation, salinity gradients and mangrove zonation at Port Hedland



6. ENVIRONMENTAL MANAGEMENT

A key component of the management plan is to outline a series of management actions aimed at minimising the impacts to mangrove from construction and operation of the NSS2 facilities.

These are:

1. All personnel understand obligations relating to environmental protection and relevant systems on site.

2. No unauthorised vegetation disturbance and no disturbance to tidal flats outside of the approved boundary.
3. Controlled levels of fugitive dust emissions.
4. Ensure no indirect losses to mangroves outside of the approved project footprint.

For each objective, management actions have been developed to ensure the impacts from Iron Bridge's operations are managed, and that appropriate monitoring, reporting and corrective action functions are implemented to support the successful implementation of the management actions.

The key elements of the environmental management process associated with each objective are described in Table 5.

Table 5: Description of Key Elements of Environmental Management Process to Achieve Identified Objectives

Element	Definition/Description
Objective	What is intended to be achieved.
Management Action	Tasks undertaken to enable the objective to be met.
Performance Indicators	Metrics for evaluating the outcomes achieved by Management Actions.
Reporting Evidence	Demonstrates that the Management Action has been applied and the outcome evaluated.
Timing	Period during which the Management Action should be undertaken.
Responsibility	Accountability for ensuring the Management Action is completed.

The key management actions, performance indicators, evidence, timing and responsibilities for each objective are provided in Table 6.

6.1 Construction Phase

The following management actions will be undertaken to reduce impacts to mangroves from construction activities.

6.1.1 Workforce Management

Iron Bridge Operations is committed to the philosophy of planning, designing, constructing and operating the port facilities in an environmentally acceptable manner. This includes monitoring of potential impacts to ensure that applicable standards are not compromised or violated, and that mitigation and management efforts are effective.

Training of construction personnel will help to ensure that all environmental requirements are understood and followed. Environmental awareness training will be undertaken for all personnel and subcontractors during their initial Induction at Iron Bridge Port facility.

The environmental awareness training will include information on the ecological importance of sensitive mangrove habitats and the measures undertaken to protect mangrove areas as identified in this document. Access into mangrove areas outside the immediate disturbance area will be prohibited.

6.1.2 Reporting of Incidents

A system for reporting incidents that have the potential to affect mangroves has been established. Such incidents would include, but not be limited to, oil/fuel spills from earthworks machinery, fires, disturbance to mangroves outside the disturbance boundary, unauthorised people gaining access though the site, etc.

6.1.3 Vegetation Clearing and Management

Fortescue will ensure that only areas that are necessary for access, construction purposes and associated purposes will be cleared or disturbed. Key management measures for significant vegetation such as mangroves are:

- No clearing outside the required disturbance envelope and minimisation of disturbance to soil surface as much as possible. Where practical a buffer area (10 m) between the infrastructure edge and the approved disturbance boundary will be included in site plans to minimise the potentail for impacts to mangroves outside of the approved area. Prior to site clearing activities, there will be delineation of clearance boundaries through use of flagging, taping, signage as appropriate to avoid unnecessary disturbance to mangroves.
- Mangrove areas outside of the required disturbance envelope are designated as exclusion areas and access into these areas by workers and machinery will be prohibited so that ecological integrity is maintained.
- Where possible, mangroves should be scrub-rolled or cut at (or close to) ground level rrather than removed to provide the maximum opportunity for vegetative recovery of mangroves along the boundary of cleared areas and minimse soil disturbance. The main Pilbara mangrove (*Avicennia marina*) has a great ability to re-sprout or coppice when under stress. Therefore by scrub-rolling or cutting trees there is the maximum chance of the rolled trees re-sprouting and providing more stability for additional rehabilitation via seedlings. Plate 1 provides an example of vegetative recovery (coppicing) in *Avicennia marina* trees that were cut during the 2006 clearing works at the FMG site.

Plate 2 Vegetative recovery of cut *Avicennia* mangroves at the base of perimeter bund

6.1.4 Dust Control

Construction-phase fugitive dust emissions are generated during site clearing, grading, material re-screening, loading/transport of bulk materials and other general construction operations (e.g. construction traffic, equipment operation). In addition construction material storage piles may result in fugitive dust through wind erosion.

To minimise the spread of dust into mangrove areas the following mitigation measures will be implemented:

- Water will be applied at regular intervals to control dust. During dry and windy weather conditions, the application of water will occur more frequently;
- Daily monitoring, through environmental inspections and real time monitoring will be conducted to ensure dust control measures are implemented and effective;
- Water will be routinely applied to road surfaces and all construction vehicles will adhere to signed speed limits to minimise dust generation and ensure safety; and
- When dumping material that has the potential to generate dust (e.g. into haul trucks or onto ground surface) drop heights will be minimised.

Further details regarding dust management during the construction phase can be found within the *Construction Dust Management Plan.*

6.1.5 Sediment Containment

To minimise the potential for the deposition of sediment into adjacent mangrove areas from sediment spillage or erosion of fill material sediment containment measures will be implemented. These may include the use of geofabric (or similar) to contain sediment and stabilize the perimeter bund slopes prior to the placement of concrete revetment or rock armour.

6.1.6 Mangrove Monitoring Programme

Since 2006 Fortescue have implemented a Mangrove Monitoring Program (MMP) undertaken mangrove monitoring at the network of sites shown the Figure 4 below. The MMP has been designed to link mangrove community health to the potential site changes associated with the construction of the port facilities and, in particular, focus on how those physical site changes may modify the key physical processes responsible for mangrove ecosystem function. Monitoring components include mangrove health, sedimentation/erosion, groundwater/soilwater salinity and depth and the collection of other qualitative data.

The proposed Mangrove Monitoring Programme for the NSS2 Port proposal will be aligned to the existing Fortescue programme (i.e. same methodologies) however monitoring is only required at the sites immediately adjacent to the NSS2 project area (Figure 4).

Figure 4 **Port Layout and Location of Existing Fortescue Monitoring Sites**

Prior to clearing and site works commencing for the NSS2 project, three sites will be established in mangroves adjacent to the site and monitoring methodologies employed during a baseline survey that are consistent with the existing Fortescue MMP (see Section 7 for methodologies and location of the three NSS2 monitoring sites). Bi-annual monitoring of these sites will occur during the construction phase.

6.1.7 Mangrove Offsets

Fortescue will prepare and implement a mangrove offsets plan for the NSS2 project. This will include an assessment of potential offset options based on site conditions and case studies where offsets or the development of new mangrove habitat has occurred in the Port Hedland area (including new mangrove habitat that has developed at the Fortescue site since 2006).

The Mangrove Offsets Plan will be linked to the data and outcomes of the existing Fortescue MMP where relevant to maximise the potential for rehabilitation or new habitat development success. Information collected during the Fortescue mangrove monitoring surveys indicates that the development of areas of new mangrove habitat has been initiated as a result of port construction activities (URS 2010, 2014).

Since 2007, substantial recruitment of mangrove seedlings has been observed around the Anderson Point Island where potentially suitable mangrove habitat has been developed between the perimeter bund and the current mangrove zone. Mangroves are colonising new habitat that has been created by construction phase earthworks undertaken in this area where mangroves did not previously occur.

Mangrove recruitment has also occurred on tidal flats at the base of the perimeter bund concrete revetment in several areas next around the Fortescue site where localised seepage expressed at the base of the revetment is providing suitable conditions for mangrove growth in an area (high tidal flats) where normally salinities would be too high. In addition the perimeter bunds form a structure (barrier or deposition zone) were mangrove seeds (propagules) are deposited during spring tides.

Mangrove (*Avicennia marina*) seedlings are also colonising the sides of the two discharge channels at South-West Creek and the channel (in between the two discharge channels) excavated to access seawater for dust suppression.

Mangrove seedling recruitment areas have been monitored adjacent to the Anderson Point Island reclamation areas since 2008 (URS 2014), to delineate areas where new mangrove habitat has developed as a result of Fortescue port construction activities and also where mangrove recruitment has occurred within the new habitat (URS 2014). The seedling recruitment area has increased from 0.19 ha in 2008 to 1.7 ha in 2014 (URS 2014).

6.2 Operations Phase

Following completion of the NSS2 construction the MMP will be reviewed to determine the scope and frequency of monitoring required during the operations phase. It is envisaged that future mangrove monitoring for the NSS2 project would be aligned to the scope undertaken for the overall Fortescue site which is currently:

- annual monitoring of core monitoring parameters to confirm that the health status of mangroves and key habitat condition factors are maintained; and
- annual monitoring of the development of new mangrove habitat around the Fortescue port site and the recruitment/growth of mangrove seedlings within these areas.

Fortescue has committed to ongoing mangrove monitoring during the operations phase until two years following decommissioning. The frequency and scope of monitoring will be reviewed in consultation with relevant government agencies through the annual environmental reporting process.

6.3 Reporting Schedule

The methodology, results and findings of the mangrove monitoring program and any related management actions will be documented as per the following reporting schedule:

- Baseline (pre-construction) report and brief reports after each bi-annual survey during construction phase; and
- Post-construction phase report that summarises the construction phase monitoring results and identifies the operations phase monitoring and management requirements.

Table 6: Key Management Actions for Management of Mangroves for the Iron Bridge Port Facility

Objective No.1	All personnel understand obligations relating to environmental protection and relevant systems on site.				
Reference	**Management Action**	**Performance Indicators**	**Reporting/Evidence**	**Timing**	**Responsibility**
1.1	Environmental awareness training will be undertaken for by personnel and subcontractors during their initial Induction at Fortescue's Anderson Point facility.	100% of workforce completes induction.	Induction records.	Construction / Operation	Port Environmental Superintendent
1.2	A system for reporting incidents that have the potential to affect mangroves has been established.	100% of incidents and near-misses reported.	Incident reports.	Construction / Operation	Port Environmental Superintendent
Objective No.2	No unauthorised vegetation clearing.				
Reference	**Management Action**	**Performance Indicators**	**Reporting/Evidence**	**Timing**	**Responsibility**
2.1	No clearing outside the required disturbance envelope and minimisation of disturbance to soil surface as much as possible. Undertake clearing in accordance with *Ground Disturbance Permit Procedure* (100-PR-EN-0004) and *Vegetation Clearing and Topsoil Management Procedure* (45-PR-EN-0013).	100% of clearing authorised through clearance management procedures.	Clearance management documentation (checklist/signed approval etc.)	Construction / Operation	Port Environmental Superintendent
2.2	Mangrove areas outside of the required disturbance envelope are designated as exclusion areas and access into these areas by workers and machinery will be prohibited so that ecological integrity is maintained.	100% of clearing within designated boundaries.	Clearance management documentation.	Construction / Operation	Port Environmental Superintendent
2.3	Where reasonably practicable, mangroves should be scrub-rolled rather than removed to provide the maximum opportunity for vegetative recovery of mangroves along the boundary of cleared areas.	100% of clearing authorised through clearance management procedures.	Clearing permit documentation.	Construction / Operation	Port Environmental Superintendent
Objective No.3	Control fugitive dust emissions.				
Reference	**Management Action**	**Performance Indicators**	**Reporting/Evidence**	**Timing**	**Responsibility**
3.1	Water will be applied as required to control dust. During dry and windy weather conditions, the application of water will occur more frequently;	Mangrove dust deposition levels within acceptable limits.	Monitoring and reporting as per MMP.	Construction / Operation	Port Environmental Superintendent
3.2	Environmental inspections and real time monitoring will be conducted to ensure dust control measures are implemented and effective.	Environmental workplace inspections conducted weekly.	Workplace inspection checklist.	Construction / Operation	Port Environmental Superintendent
3.3	All construction vehicles will adhere to signed speed limits to minimise dust generation and ensure safety.	Mangrove dust deposition levels within acceptable limits.	Monitoring and reporting as per MMP.	Construction / Operation	Port Environmental Superintendent
3.4	When dumping material that has the potential to generate dust (e.g. into haul trucks or onto ground surface) drop heights will be minimized.	Mangrove dust deposition levels within acceptable limits.	Monitoring and reporting as per MMP.	Construction / Operation	Port Environmental Superintendent
Objective No.4	Sediment containment				
Reference	**Management Action**	**Performance Indicators**	**Reporting/Evidence**	**Timing**	**Responsibility**
4.1	Minimise sediment spillage into tidal flat and mangrove areas by use of geofabric (or similar) to contain sediment and stabilize the perimeter bund slopes prior to the placement of concrete revetment or rock armour	Project related sediment deposition in mangroves outside the approved boundary to be < 10 cm over a 12 month period	Monitoring and reporting as per MMP.	Monitor at biannual frequency during construction phase	Port Environmental Superintendent
4.2	Implement erosion control features to minimise the flow of sediment site, downslope and into adjacent tidal flats and mangrove areas.	Project related sediment deposition in mangroves outside the approved boundary to be < 10 cm over a 12 month period	Monitoring and reporting as per MMP.	Monitor at biannual frequency during construction phase	Port Environmental Superintendent

Objective No.5	Ensure no indirect losses to mangroves outside of the approved project footprint				
Reference	**Management Action**	**Performance Indicators**	**Reporting/Evidence**	**Timing**	**Responsibility**
5.1	Monitor mangrove health to detect short term and localised changes in tree condition, extent of canopy cover and other factors. Rapid assessment enables sufficient spatial coverage to be achieved at sites where potential localised impacts may occur. Monitoring data to be collected are: • canopy density - an indicator of environmental stress as leaf defoliation and leaf growth are sensitive to a wide range of environmental indicators (English et al. 1997); • species composition and density (once only baseline data collection to characterise mangrove communities that occur at the surveillance sites); • health of individual trees classified into three categories of tree condition: (healthy, unhealthy, dead) as per the criteria outlined in Duke et al. (2005). Percentage survivorship and mortality rates can be subsequently calculated; • photographs from standard reference points to characterise mangrove condition.	Biannual to annual monitoring	Monitoring Report	Monitor at biannual frequency during construction phase. Operations phase frequency to be determined at end of construction phase (most likely annual frequency)	Port Environmental Superintendent
5.2	Monitor groundwater to ensure that suitable groundwater / soilwater conditions required for mangrove growth and survival are maintained. Shallow groundwater monitoring bores will be installed manually and monitored by collecting field data (water table depth and salinity). Groundwater is to be monitored during periods of neap tides to determine the maximum salinities experienced by mangroves. Groundwater sites at be located within the same monitoring plots use for rapid assessment mangrove health.	Biannual to annual monitoring	Monitoring Report	Monitor at biannual frequency during construction phase. Operations phase frequency to be determined at end of construction phase (most likely annual frequency)	Port Environmental Superintendent
5.3	Monitor for potential sedimentation and erosion effects by use of two techniques: • RTK GPS surveying of ground levels along transects that extend through the mangrove zone. Each transect consists of a series of points where the horizontal position coordinates and ground surface levels (AHD RL). Transects will be re-surveyed to determine if any significant changes to ground surface levels have occurred. • measuring of relative ground levels or sediment heights using fixed reference markers (sedimentation stake method) at same monitoring plots use for rapid assessment mangrove health.	Biannual to annual monitoring	Monitoring Report	Once only during baseline survey (prior to construction phase) for the RTK surveying of ground levels along transects. Biannual frequency for measuring relative sediment heights at reference markers during construction phase. Operations phase frequency to be determined at end of construction phase (most likely annual frequency for sediment stake method only).	Port Environmental Superintendent

	Management Action	Performance Indicators	Reporting/Evidence	Timing	Responsibility
5.4	If trigger values are exceeded or otherwise not met then Fortescue will assess the significance of the exceedance matter and liaise with relevant stakeholders as necessary. Following this assessment the need for management options or contingency measures to mitigate impacts or prevent future potential impacts will be determined. Implement contingency measures as appropriate and monitor effectiveness. Monitor groundwater to ensure that suitable groundwater / soilwater conditions required for mangrove growth and survival are maintained. Shallow groundwater monitoring bores will be installed manually and monitored by collecting field data (water table depth and salinity). Groundwater is to be monitored during periods of neap tides to determine the maximum salinities experienced by mangroves. Groundwater sites at be located within the same monitoring plots use for rapid assessment mangrove health.	Biannual to annual monitoring	Monitoring Report	As required (i.e. only if trigger values exceedances occur).	Port Environmental Superintendent

7. MONITORING PROGRAMME

The Mangrove Monitoring Programme for the NSS2 project will be aligned to the existing Fortescue programme (i.e. same methodologies) however monitoring is only required at the sites immediately adjacent to the NSS2 project area, the existing sites T2 and T3 and the three proposed new sites to be established on the eastern side of the project areas as shown in Figure 5.

The Mangrove Monitoring Program (the Monitoring Program) aims to measure the success of management measures identified in this Plan to inform an adaptive management approach.

The Program is focused on parameters that are readily detectable (to provide early warning) and these are linked to the main processes responsible for maintenance of mangrove systems and survival of mangroves (e.g. tidal inundation, sedimentation/erosion and ground/soil water conditions, in particular salinity).

7.1 Objectives and Scope

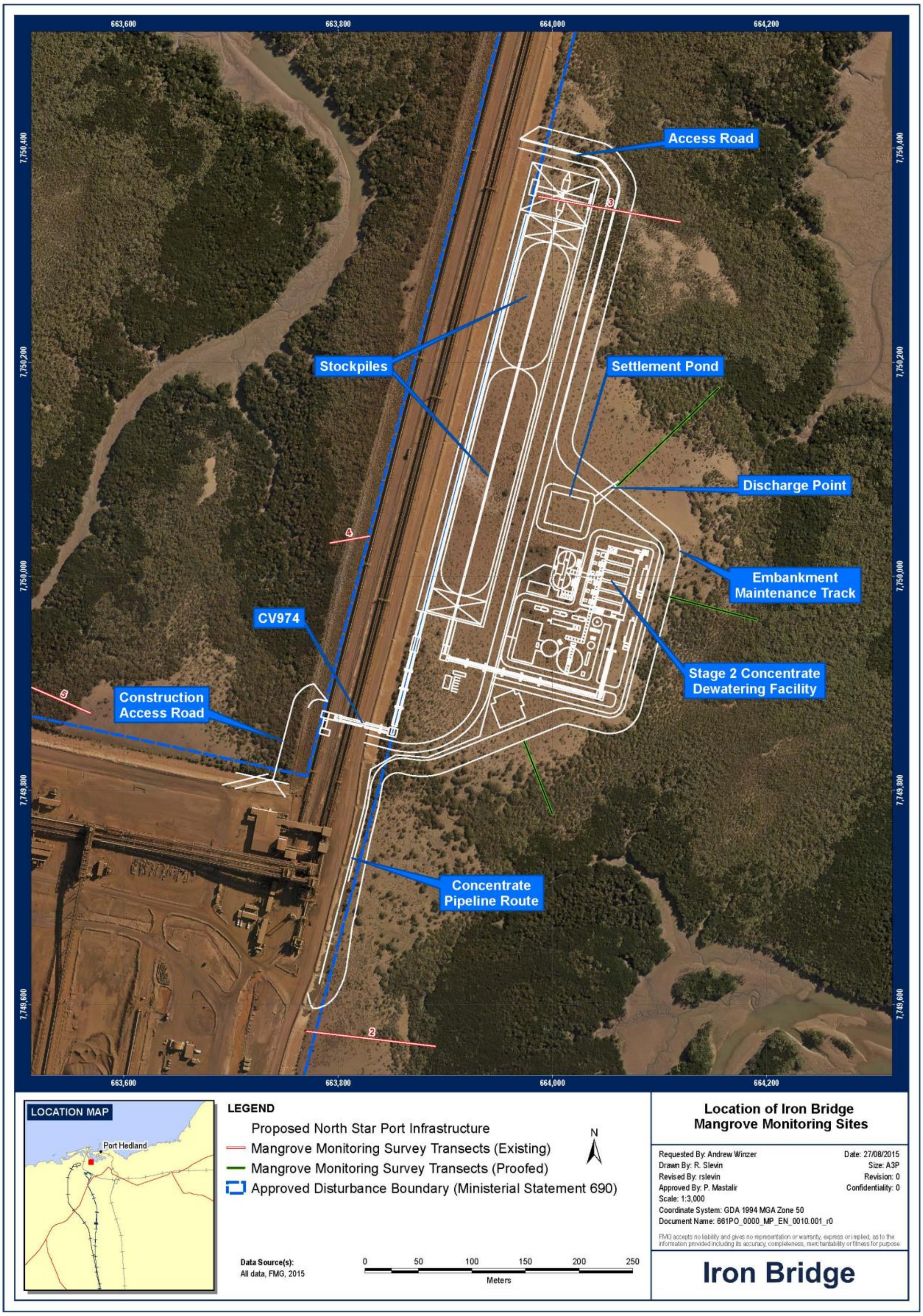
Monitoring objectives and requirements of the Monitoring Program include:

1. Assessment of monitoring parameters to confirm the health status of mangroves and maintenance of key habitat condition factors.
2. Link mangrove community health to the potential impacts associated with construction and operation activities.

The scope of the Monitoring Program includes mangrove areas affected by direct or indirect impacts from construction and operational activities.

Prior to construction commencing, monitoring sites would be established in mangroves adjacent to the NSS2 project areas prior at the indicative site locations shown in Figure 5.

Figure 5 Location of Iron Bridge Mangrove Monitoring Sites



7.2 Monitoring Aspects and Methodology

A set of monitoring aspects and associated methodology (Table 7) have been identified to provide a broad coverage of changes to mangrove health and distribution that can be expected from construction and operational impacts.

The methodologies are consistent with those employed since 2006 at the network of monitoring sites established for the Fortescue MMP.

Table 7: Monitoring aspects and methodology

Aspect	Method	Frequency
Mapping mangrove distribution and condition	Map changes to mangrove distribution that result from the construction of the NSS2 project and update baseline mapping to depict areas affected by direct and indirect. Overlay the actual disturbed mangroves areas onto the baseline map of mangrove assemblages (contained within GIS) to calculate the area of mangrove loss and accretion.	Annually
Mangrove health monitoring	Rapid assessment of mangrove health to detect short term and localised changes in tree condition and extent of canopy cover. Rapid assessment enables sufficient spatial coverage to be achieved at numerous sites where potential localised impacts may occur.	Pre-construction phase – once (baseline survey) Construction phase - biannually Operations phase – annually
Groundwater monitoring	Mangroves are sensitive to changing groundwater conditions and are dependent on tidal inundation patterns to maintain suitable groundwater/soilwater salinities for mangrove growth and survival. Shallow groundwater monitoring bores will be installed manually and monitored by collecting field data (water table depth and salinity). Groundwater sites will be linked closely to surveillance monitoring sites so that the response of vegetation to changes in groundwater and surface water conditions can be determined.	Pre-construction phase – once (baseline survey) Construction phase - biannually Operations phase - annually
Sedimentation / erosion	Monitor for potential sedimentation and erosion effects by two techniques. 1. RTK DGPS surveying of ground levels profiles (transects) through tidal flat and mangroves areas 2. Monitoring of relative sediment heights from within the monitoring sites using reference markers (sedimentation stakes). Additional mini-cores would be undertaken on site to determine the extent of foreign sediment veneers (only if required). Sedimentation/erosion monitoring sites will be linked to the monitoring of mangrove health so that the response of vegetation to changes in ground levels/sediment heights and the presence of foreign sediment veneers/can be determined.	**RTK surveying of ground level profiles** Pre-construction phase – once (baseline survey) **Sedimentation Stakes** Pre-construction phase – once (baseline survey) Construction phase - biannually Operations phase - annually

7.2.1 Mangrove Health Monitoring

A series of mangrove surveillance monitoring sites will be established to allow for rapid assessment of mangrove health and detect short-term and/or localised changes in tree condition, extent of canopy cover and other factors. Surveillance sites have been integrated with surveyed transects (for sedimentation/erosion monitoring) and groundwater sites to provide monitoring information that links potential changes in site conditions to corresponding effects on mangrove health. The following data will be collected from each surveillance site:

- Canopy density - is a quantitative measure indicating the percentage of the site occupied by the mid and upper vegetation strata (i.e. foliage cover comprised of leaves and branches). This parameter is considered to be a useful indicator of environmental stress as leaf defoliation and leaf growth are sensitive to a wide range of environmental indicators (English et al. 1997). Changes in canopy density can therefore provide a measure of mangrove health/condition and associated factors causing changes.
- Canopy density is determined using a spherical forestry densiometer to provide estimates of the foliage cover (leaf cover/branch cover) within each of the four subplots formed by the four plot corner markers (1, 2, 3, 4) and the plot centre point. The technique employed follows that used for the Department of Infrastructure, Planning and Environment (DIPE) Darwin Harbour Mangrove Monitoring as described in Moritz-Zimmerman, Comley and Lewis (2002). At each of the four subplots, four readings of foliage cover are taken, facing north, east, south and west (total of 16 readings per plot). To convert these values to foliage cover (FC), counts are multiplied by 1.04. The overall canopy density at each site is calculated as the mean of the readings of foliage cover recorded from each subplot.
- Species composition and density (once only baseline data collection to characterise mangrove communities that occur at the surveillance sites).
- Health of individual trees classified into three categories of tree condition (healthy, unhealthy, dead) as per the criteria outlined in Duke et al. (2005). Percentage survivorship and mortality rates can be subsequently calculated. The categories are classified as ‘healthy’ - leaves green, no visible sings of sickness; ‘unhealthy’ – yellowing, wilting leaves, low foliage cover; and ‘dead’ - plant dead. When considering these categories it should be noted that *Avicennia* mangroves, which are the most abundant species in the study area, are well known to defoliate their canopies in response to some form of stress (giving the appearance of being dead) and then subsequently trigger the production of epicormic shoots and new leaves (i.e. coppicing effect).
- Photographs from standard reference points to characterise mangrove condition.

7.2.2 Groundwater Monitoring

The monitoring of groundwater conditions is undertaken to provide leading data on some of the main processes responsible for maintenance of mangrove systems and survival of mangroves (e.g. tidal inundation, ground/soil water conditions, in particular salinity). Tidal exchange and flows are the dominant and prevailing processes that maintain the Pilbara mangroves as they regulate many of the physical, chemical and biological functions. Groundwater salinity gradients are established across the tidal flats in response to decreasing frequencies of seawater (tidal) recharge with increasing tidal flat elevation and these gradients have produced recognisable structural and physiognomic zones within the mangroves. Changes to these gradients and the groundwater conditions they create can have corresponding effects on mangroves.

Groundwater monitoring bores will be established at all the surveillance monitoring sites so that the response of vegetation to changes in groundwater and surface water conditions can be determined. Groundwater is monitored during periods of neap tides to determine the range of maximum salinities experienced by mangroves. The following basic environmental parameters are recorded onsite:

- depth BGL to the water table; and
- groundwater salinity [Total Dissolved Salts (TDS) in parts per thousand ($^{0}/_{00}$)].

7.2.3 Monitoring of sedimentation/erosion effects

To monitor for potential sediment deposition and erosion effects, two complementary techniques are used that are based on determining if changes to ground level occur that may be related to sedimentation/erosion effects or ground disturbance. These two techniques are:

- surveying of ground levels along transects through the mangroves (i.e. surveyed ground levels related to the AHD).
- measuring of relative ground levels or sediment heights using fixed reference markers (sedimentation stake method)

During the construction phase, observational data will also be collected during the biannual surveys on the presence of foreign sediment veneers that may be deposited over the existing mangrove muds (i.e. sediment potentially eroded from the NSS2 sites and deposited in to mangroves). Evidence for this occurring would be the deposition of silt/clay veneers (possibly of a different colour) over existing mangrove substrates, or increases in sediment heights/ground levels. Should such veneers be evident then a series of mini-cores (i.e. top 5 cm of substrate) will be undertaken on site to characterise the nature and depth of the veneers.

Surveying of ground levels along transects

Monitoring consists of RTK Global Positioning System (GPS) surveying of ground levels along transects that extend through the mangrove zone. Each transect comprises a series of points where the horizontal position coordinates and ground surface levels [AHD relative level (RL)] were obtained within each of the main habitats present along a transect (e.g. landward edge, /salt flat, mangrove zones). The transects include survey points at each mangrove plot where both the ground level at each corner marker and the AHD of the top of the corner markers are determined so that potential changes in ground level derived from the two techniques can be correlated if required.

It is proposed that surveying of ground levels along the transects only be undertaken during the baseline survey (pre-construction) when the NSS2 monitoring sites are established, however it can be repeated in the future should it be required.

Measurement of relative sediment heights within monitoring plots

At each monitoring site, the plot corner markers (PVC pipes firmly entrenched in the ground) serve as sediment height reference markers, and sediment heights are recorded relative to each corner marker by measuring the vertical distance between the top of the corner marker and the ground with a tape measure. The overall ground level for a site/plot during a sampling event is calculated as the mean of the readings recorded from each corner.

7.2.4 Remote sensing

Fortescue is investigating the potential to use remote sensing data such as Digital Multi-Spectral Imagery (DMSI) to provide for future assessment of mangrove health decline (or increase) at the Fortescue port sites and to help provide a broader or regional context to changes detected in areas adjacent to the project site. The application of the DMSI data could also be of relevance to the NSS2 site.

8. CORRECTIVE ACTIONS

Exceedance of criteria may not have immediate, readily identified impacts. As required, additional monitoring may be undertaken to ascertain deleterious impacts (if any) of non-conforming data. This monitoring will inform future management options.

Key considerations for development of a response are:

- nature of non-conformance (e.g. human error, system failure, *force majeure*)
- Significance of the changes detected and potential causes (both project related and natural)
- Scale of impacts to mangroves (if this has occurred) and/or potential for impacts to occur
- Adequacy of the monitoring programme and the existing criteria
- Need for further investigation or additional monitoring.

The mangrove monitoring response framework shown in Table 4 outlines a step-by-step process that will guide such a monitoring program and subsequent management measures.

9. COMPLIANCE

Internal auditing of activities associated with this Plan will be carried out in accordance with Fortescue's internal audit schedule.

Audit reports will describe the status of compliance with environmental obligations at the time of the audit and identify areas of non-conformance and no compliance relative (but not limited) to the following:

- Management actions within this document;
- Implementation of monitoring program; and
- Applicable conditions and commitments within Ministerial Statements.

Where non-conformance issues or opportunities for improvement are identified, these will be documented and tracked via the Business Management System (BMS).

10. REPORTING

The methodology, results and findings of the Mangrove Monitoring Programme and any related management actions will be documented as per the following reporting schedule:

- Baseline monitoring report;
- Brief reports after each biannual survey during construction phase; and
- Post-construction phase report that summarises the construction phase monitoring results and identifies the operations phase monitoring and management requirements.

11. REVIEW

It is important that plans and procedures are frequently reviewed and updated as Fortescue's operations change and opportunities for improved management practices are identified.

This Management Plan will be reviewed at least every five years, or when significant additional information comes to hand. The review will be based on achieving approval requirements, Fortescue commitments, and progress in implementing the Management Plan and will incorporate any new investigations, information, techniques and advice from experts and regulatory authorities.

Upon review, the document revision status will be updated in accordance with Fortescue's document control procedures.

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Appendix 1: Mangrove Offsets Plan

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Iron Bridge

Iron Bridge Port Facility

Mangrove Offsets Plan

September 2015

662PO-4000-PL-EN-0003

	Iron Bridge Port Facility - Mangrove Offsets Plan		662PO-4000-PL-EN-0003
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Status	**IFU - ISSUED FOR USE**		
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Checked	Clayton Brandwood	Signature	9/09/2015
Checked	Ken Wilyman		
Approved	Simon Carter	Signature	17/9/15 Click here to enter a date.
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**N/A**		

Revision History *(to be completed for each version retained by Document Control)*

Author	**Checker**	**Approver**	**Rev No.**	**Status**	**Issued Date**
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1. INTRODUCTION

1.1 Project Background

IB Operations Pty Ltd (IBO) proposes to develop the Iron Bridge Port Facility (the Port Facility), located in the Port Hedland Port Precinct, in the Pilbara Region of Western Australia. The Port Facility will accept magnetite concentrate slurry from the North Star Magnetite Mine, located approximately 110 km South of Port Hedland, whereupon it will be dewatered and stockpiled prior to export.

The Port Facility is located within Fortescue Metals Group Ltd.'s (Fortescue) Herb Elliott Port Precinct at Anderson Point, located within the Town of Port Hedland in the Pilbara Region of Western Australia. The location of all infrastructure associated with the Port Facility is depicted in Figure 1. Anderson Point is approximately 1.7 km south of the western end of Port Hedland.

Magnetite concentrate produced by the North Star Mine will be mixed with water and pumped via a slurry pipeline to the proposed Port Facility. Upon arrival at the Port, the slurry will be dewatered and stacked in a covered stockpile until sufficient material is available for export. The concentrate is then reclaimed and loaded onto Panamax sized vessels via Fortescue's existing out loading facilities for delivery to customers. The entire footprint of the Port Facility is 10.2 hectares (ha), of which 0.05 ha is already cleared.

1.2 Relationship to Other Projects

North Star

The Iron Bridge Joint Venture Project is being implemented in two stages.

Stage 1 of the Project is the construction and operation of the North Star Hematite Project, so called because the mine targets an oxide (mag-hematite) zone which overlies a larger magnetite ore body. Stage 1 is a 10 Mtpa iron ore mine producing 2 Mtpa of magnetite concentrate. Magnetite produced by the mine is dewatered on site and will be trucked to Port Hedland for export. The Hematite Project was referred to the EPA in July 2012 and was not formally assessed. IBO has subsequently obtained secondary environmental approvals to allow for construction and operation of the mine. Stage 1 is currently fully constructed and is in the commissioning phase. Magnetite concentrate produced by the mine will be exported using existing infrastructure at Fortescue's Herb Elliott Port. The stockpile, handling and export of 2 Mtpa of magnetite concentrate at Fortescue's Port facility is approved under Part V of the EP Act (W5749/2014/1). The export of the magnetite concentrate produced by Stage 1 of the Project is not dependent on the construction of this Port Facility and is not subject to this referral.

Stage 2 of the Project is a larger, 30 Mtpa mine (the North Star Magnetite Project). This Project was referred to the EPA in October 2012 and formally assessed through a Public Environmental Review (Assessment No. 1947). The EPA released its report on the Magnetite Project (Report No. 1514) in June 2014 and the Minister released the Ministerial Statement (MS 993) on 9 January 2015.

The Magnetite Project was also assessed by the Commonwealth Department of Environment under the EPBC Act (EPBC 2012/6689). The Federal Minister authorised the controlled action on 6 February 2015.

It is the magnetite concentrate produced by the North Star Stage 2 Mine that will be handled and stockpiled by the Port Facility subject to this referral. Note, construction and operation of the North Star Magnetite Project has not yet commenced.

Herb Elliott Port Facility

Fortescue, through its wholly owned subsidiary The Pilbara Infrastructure Pty Ltd (TPI) own and operate the Herb Elliott Port Facility. TPI and IBO have reached agreement with regards to port services provided by TPI. This will enable IBO to access TPI's Port facilities and additional infrastructure which operate under the TPI Agreement on land governed by the existing leases and licences from the Pilbara Ports Authority (PPA).

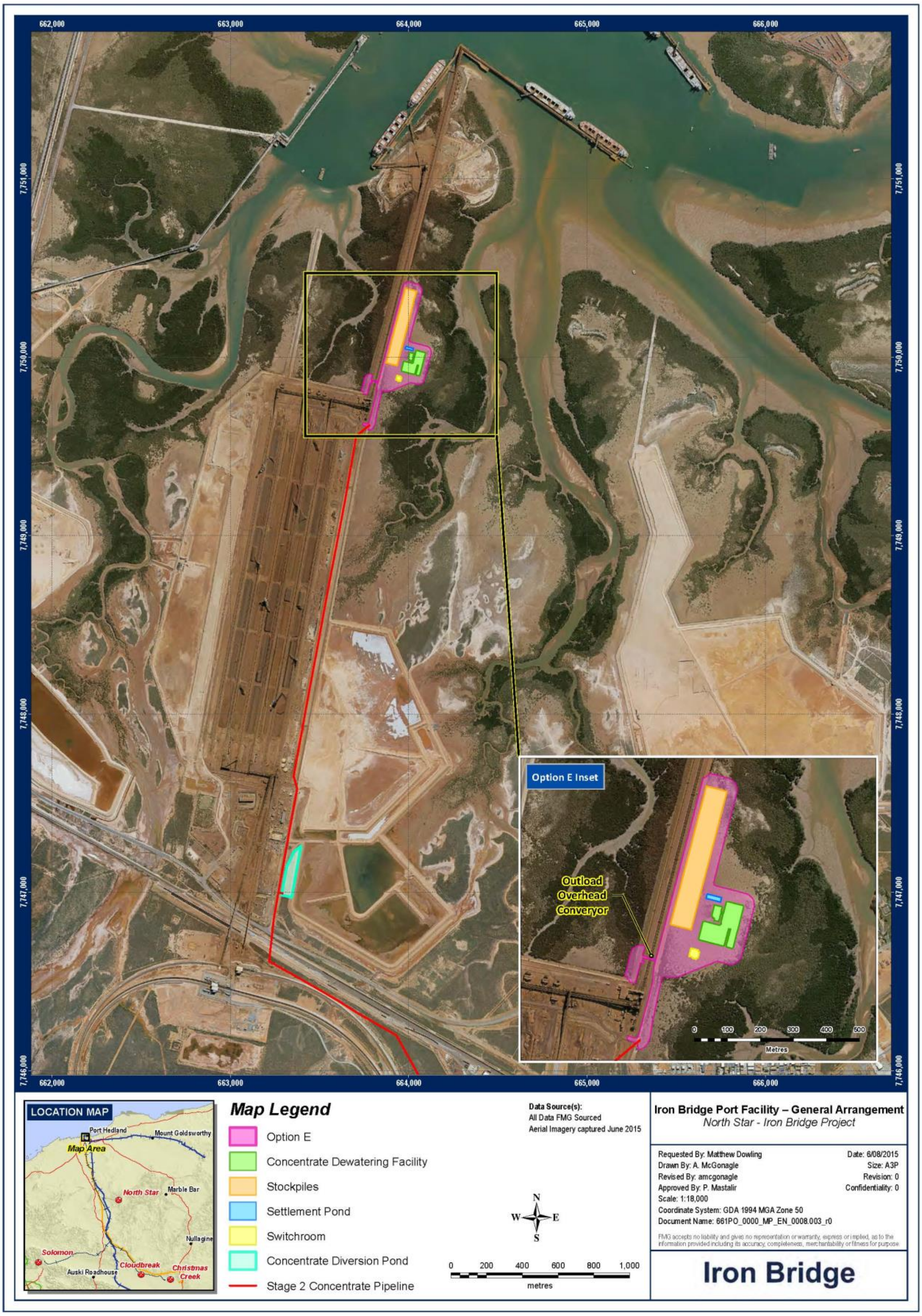
1.3 Mangrove Offsets

Due to the predicted loss of mangrove habitat from the IBO project and EPA's objectives and guidance regarding cumulative loss of mangroves within the Port Hedland Loss Assessment Unit (LAU) there is the requirement for the IBO project to assess options for mangrove offsets.

The approach taken to develop the mangrove offsets outlined in this report has been to:

- Provide background information on the extent of impact to mangroves from project, existing mangrove environment and the dominant processes maintaining mangroves (and resulting salinity gradients and mangrove zonation)
- Consider mangrove offsets already achieved at the Fortescue site and from elsewhere in the Port Hedland area as the basis to assess potential offsets appropriate for the IBO project
- Outline potential options for mangrove offsets related to the IBO project

Figure 1 Location Map



2. EXISTING ENVIRONMENT AND EXTENT OF IMPACTS

2.1 Mangrove Communities

The marine habitats found in Port Hedland are typical of those found along the arid coastlines of the Pilbara. The BPPH present in the Port Hedland LAU includes mangroves, corals, seagrass, turfing algae, macroalgae, reef habitat and sandy (benthic micro-algal) habitat. The most dominant habitat in terms of areal extent was identified as bare sediments. Mangrove species include the locally dominant species *Avicennia marina*, *Rhizophora stylosa*, and a small proportion of *Ceriops australis* (WorleyParsons, 2015c).

All of these species are found elsewhere in the Port Hedland area and Pilbara region. None are listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 or the Wildlife Conservation Act 1950.

Paling, Humphreys and McCardle (2003) developed a mapping scheme for mangrove associations that has been accepted for general usage and is described as follows:

a) *Avicennia marina* (closed canopy, seaward edge) – a forest comprising large, mature, multi-stemmed *Avicennia marina* on the seaward edge of the main channels and sheltered small bays

b) *Rhizophora stylosa* (closed canopy) – a forest/scrub comprising a relatively narrow zone, often only a few trees wide, behind the seaward *Avicennia marina* fringe and lining steep banks on small channels

c) *Avicennia marina/Rhizophora stylosa* (closed canopy) – a forest/scrub comprising a transitional zone between closed canopy forest close to the seaward edge of main channels and extending to landward along small channel banks

d) *Avicennia marina* (closed canopy, landward edge) – a forest/scrub comprising the typical zone of mangroves immediately behind the mixed association of *Avicennia marina* and *Rhizophora stylosa* and often up to 100 m or more in width and characterised by a decrease in vegetation height with increasing height on the shore

e) *Avicennia marina* (scattered) – comprising scattered landward individuals of the mangrove *Avicennia marina*, often with scattered samphires, but without high densities.

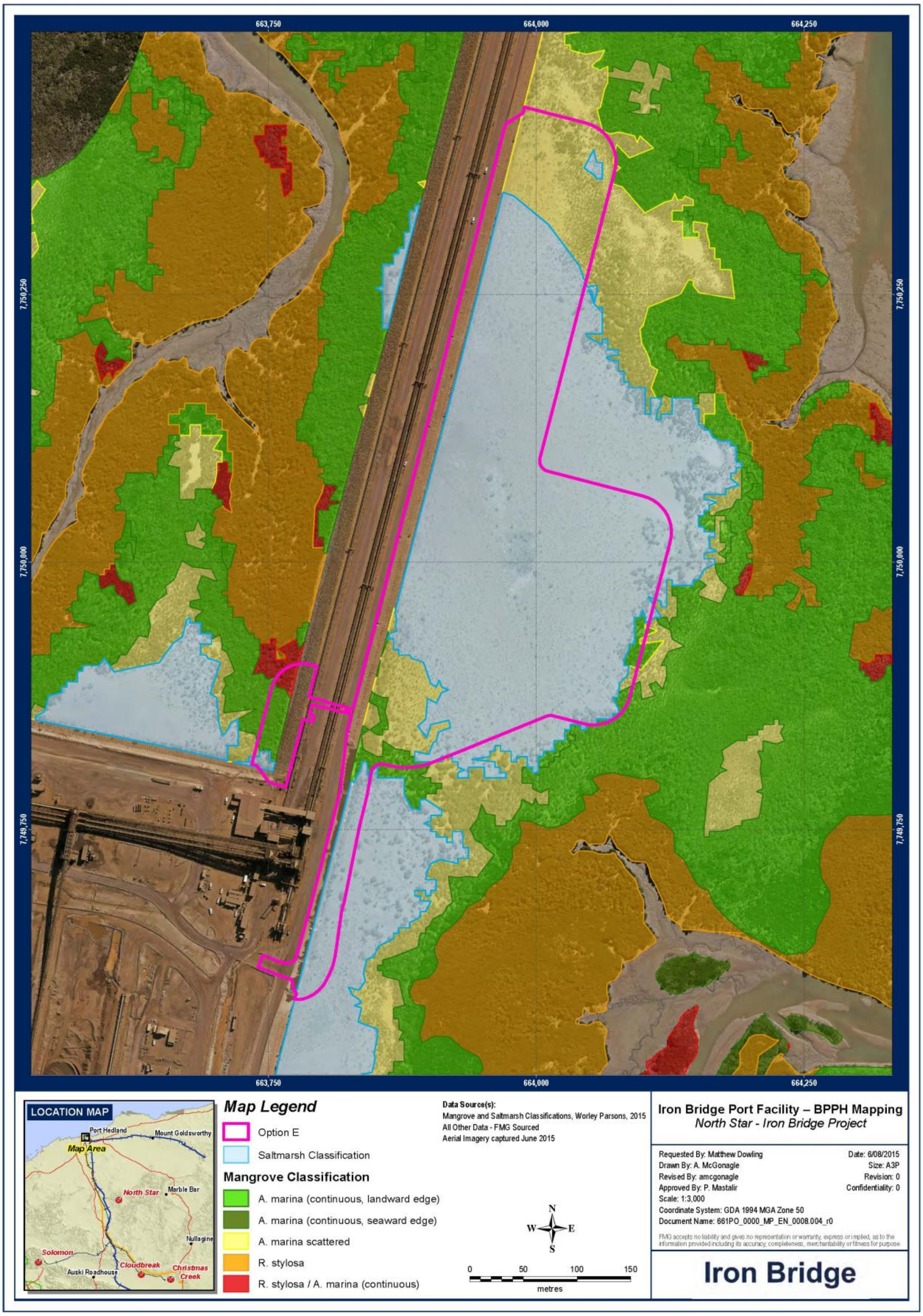
BPPH mapping exists over the area subject to this proposal. Table 1 describes the mangrove communities found within the disturbance footprint, displayed in Figure 2.

Table 1 Mangrove communities within the Port Facility footprint

Description	Area m^2
Avicennia marina closed canopy, seaward edge	0.37
A. marina scattered	1.6
Rhizophora stylosa/A. marina closed canopy	0.04

Therefore, a total of 2.01 ha of mangrove vegetation occurs within the proposal footprint. The density of the mangroves varies from scattered to closed canopy. The vegetation is considered to be in excellent condition on the Trudgen scale (GHD, 2012).

Figure 2 Mapping of mangrove communities within the disturbance footprint



2.1.1 Samphire Saltmarsh

A total of 8.14 ha of samphire saltmarsh occur within the proposal footprint, forming the vast majority of the total disturbance area (Figure 2). This vegetation is described as Tecticornia Open Samphire: *Tecticornia indica subsp. leiostachya, Tecticornia halocnemoides, Muellerolimon salicorniaceum* and *Hemichroa diandra* with some scattered mangroves approximately 1.5m high. These areas are episodically inundated and have developed into a distinct zone between the estuarine environments and terrestrial environments. The samphire vegetation is considered to be in excellent condition on the Trudgen scale (GHD, 2012).

2.2 Impact Assessment

2.2.1 Direct Disturbance to Mangroves

The EPA Guidance Statement No. 1 (EPA, 2001) describes four types of management areas for tropical arid mangroves, habitats and dependent habitats along the Pilbara coastline. These are:

Guideline 1: Regionally significant mangroves – Outside designated industrial areas and associated port areas

Guideline 2: Other mangrove areas – outside designated industrial areas and associated port areas

Guideline 3: Regionally significant mangroves – inside designated industrial areas and associated port areas

Guideline 4: Other mangrove areas – inside designated industrial areas and associated port areas.

The area subject to this proposal does not contain regionally significant mangroves and is located inside an industrial area or port. Therefore, the management of mangroves is guided by Guideline 4. The EPA's objective for Guideline 4 areas is that the impacts of development on mangrove habitat and ecological function of the mangroves in these areas should be reduced to the minimum practicable level (EPA, 2001).

To provide a consistent basis for assessment of cumulative impacts to BPPH in and around Port Hedland, the EPA have released spatial data for the Port Hedland Local Assessment Unit (LAU) (EPA , 2011).

WorleyParsons developed a dataset for mangrove communities within the LAU from the EPA report and recommendations for the BHP Billiton Outer Harbour Development, Lumsden Point Cargo Facility and mapping undertaken by GHD in 2012 (WorleyParsons, 2015c). This dataset was utilised to determine the cumulative impact on mangrove communities within the LAU from this and other proposals, either constructed or approved.

It is estimated that of the 2,676 ha of mangrove community present within the LAU prior to 1964, approximately 386.7 ha have been either lost as a result of development or are planned to be disturbed by future approved projects (WorleyParsons, 2015c). This represents a cumulative loss of 14.45%. When the loss of 2 ha of mangrove communities proposed by this proposal is added to the estimated cumulative loss, the percentage loss within the LAU increases to 14.53%. Considering the marginal increase in disturbance and the potential loss of mangroves if IBO had pursued other options for development which represented a greater risk to mangroves, IBO do not consider that this proposal will have a significant impact on BPPH.

In addition, this represents the gross loss of mangrove habitat. Some areas of mangrove habitat within the Port Hedland LAU are accreting (WorleyParsons, 2015c), and the total net loss is more likely to represent approximately 5%.

The EPA consider that the cumulative loss of mangroves within the Port Hedland LAU has exceeded cumulative loss guidelines (EPA, 2009). The EPA's objective in this area is to ensure no net loss of BPPH and where possible to generate a net gain in the area of BPPH. In its report and recommendations for BHP Billiton's Outer Harbour Development, the EPA suggested that cumulative loss of mangrove habitat from the LAU may be less than 10%.

2.2.2 Direct to Disturbance to Samphire Saltmarsh

The proposed Port Facility will result in the loss of 8.14 ha of Samphire saltmarsh. It is estimated that there may have been 628 ha of saltmarsh habitat within the LAU prior to 1964. Of this approximately half of this habitat (52% in total) has been lost through development of the inner harbour. The removal of 8.14 ha of samphire saltmarsh will increase the cumulative loss of this habitat type to approximately 53.4%. This minor increase in the cumulative loss of samphire habitat is not considered to be a significant impact.

3. TIDAL HYDROLOGY, SALINITY GRADIENTS AND MANGROVE ZONATION

The relationship between tidal elevation (as a surrogate measure for tidal hydrological patterns), mangrove zonation and the groundwater salinity conditions is crucial for understanding both mangrove rehabilitation requirements and potential offset options.

Tidal exchange and flows are the dominant and prevailing processes that maintain the Pilbara mangroves as they regulate many of the physical, chemical and biological functions. Inundation by seawater during flood tides is the main recharge mechanism that regulates the intertidal zone with lower salinities occurring in mangrove areas of lower tidal elevation (e.g. lower reaches of tidal creeks and more seaward locations) where tidal inundation is frequent (daily) and higher salinities are recorded from the more landward closed canopy and open shrubland zones that receive less frequent tidal inundation. The salinity gradients influence both the occurrence of the different mangrove species (due to differing salinity tolerance limits) and the mangrove community structure.

Groundwater and sediment salinity gradients established across the tidal flats have produced recognisable structural and physiognomic zones or associations within the mangroves. Mapping of mangrove communities at Port Hedland Harbour undertaken by Paling, Humphreys and McCardle (2003) shows the characteristic zonation patterns described previously for the Pilbara coast by Semeniuk (1983 & 1993). This zonation pattern is repeated in the mangrove communities at the Fortescue site.

Survey data on ground levels collected for the Fortescue Mangrove Monitoring Programme show that mangroves occupy the section of the intertidal gradient approximately between Mean Sea Level [0 m Australian Height Datum (AHD)] and an elevation of approximately 2.2 m AHD, a level between Mean High Water Neaps (0.7 m AHD) and Mean High Water Springs (2.8 m AHD). As the survey data include numerous survey points (i.e. ground levels) from within each of the main mangrove zones, they can be correlated with salinity data also collected from these locations (URS 2010a) - see Table 2.

The data provided in Table 1, and shown schematically in Figure 3, demonstrate the salinity gradients that occur through the mangrove zones at Port Hedland. Data obtained from similar mangrove habitats on the Pilbara coast show similar salinity increases from approximately 40-55‰ [parts per thousand (ppt)] at the more seaward areas (e.g. seaward and taller *Avicennia* zone and *Rhizophora* zone) to approximately 70-90‰ in the more landward sections of the mangrove zone where low open *Avicennia* shrubland occurs (Semeniuk 1983; Biota 2005; URS 2010b). The dominant species in the study area (*Avicennia marina*) has the greatest salinity tolerance of the Pilbara mangrove species and occurs in areas where groundwater salinity reaches up to 90‰ (approximately 2.5 times seawater) (Gordon 1998). With increasing tidal elevation from the seaward to landward mangrove zones, the reduction in tidal inundation in combination with high evaporation rates results in groundwater and soilwater conditions (including salinity) that are beyond the threshold tolerated by mangroves. In these areas the mud flats are devoid of mangrove vegetation and the habitat becomes a high tidal mud flat with scattered patches of samphire, algal mats or salt flats (Figure 3).

Table 2 Relationship between ground levels and salinity in mangrove zones at Port Hedland

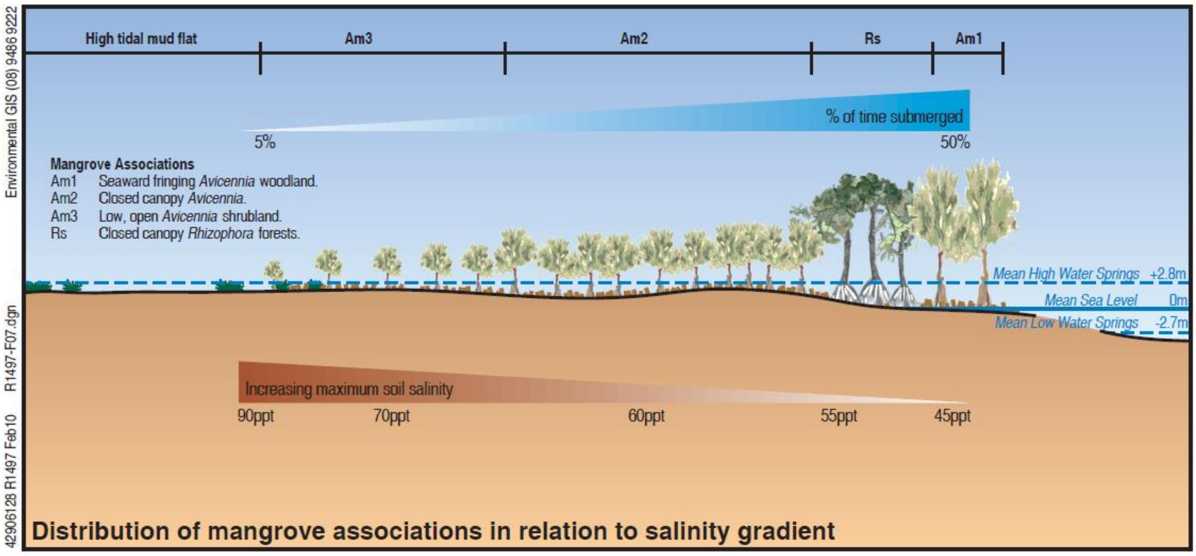
Mangrove Zone	Ground Levels (m AHD) Mean and Range	Groundwater Salinity (TDS)
Avicennia marina closed canopy, seaward edge	Mean = 0.64 m Range = -0.25 m to 1.36 m	Mean = $47^{0}/_{00}$ Range = $39\text{-}59^{0}/_{00}$
Rhizophora stylosa low forest	Mean = 1.47 m Range = 0.89 to 1.93 m	Mean = $54^{0}/_{00}$ Range = $43\text{-}67^{0}/_{00}$
Avicennia marina closed scrub	Mean = 2.08 m Range = 1.44 m to 2.56 m	Mean = $58^{0}/_{00}$ Range = $44\text{-}75^{0}/_{00}$
Avicennia marina open heath/shrubland	Mean = 2.21 m Range = 1.88 m to 2.54 m	Mean = $72^{0}/_{00}$ Range = $60\text{-}86^{0}/_{00}$
Salt flat with samphire patches and scattered low *Avicennia marina*	Mean = 2.47 m Range = 2.19 to 2.70 m	No data available

Note: Height relationship between Port Hedland Harbour Tidal Datum and Australian Height Datum (AHD) is summarised below.

Lowest Astronomical Tide (LAT) = -3.9m AHD
Mean Low Water Springs (MLWS) = -2.7m AHD
Mean Low Water Neaps (MLWN) = - 0.60 m AHD
Mean Sea Level (MSL) = 0.00 m AHD
Mean High Water Neaps (MHWN) = 0.70 m AHD
Mean High Water Springs (MHWS) = 2.80 m AHD
Highest Astronomical Tide (HAT) = 3.60 m AHD

Note: Groundwater salinity data has been derived from sampling undertaken on neap tides. Salinity measure is Total Dissolved Salts (TDS) $^{0}/_{00}$ or ppt.

Figure 3 Schematic profile showing the relationship between tidal elevation, salinity and mangrove zonation at Port Hedland



4. MANGROVE OFFSETS AND MANGROVE HABITAT DEVELOPMENT IN THE PORT HEDLAND AREA

4.1 Case Studies

A review of mangrove rehabilitation literature yields many examples of rehabilitation or attempted mangrove offset projects in tropical locations (i.e. South East Asia). Many of these projects have failed despite substantial resources being provided, while there is an increasing number of examples where mangrove rehabilitation has been successful or mangroves recovered naturally after a period of degradation.

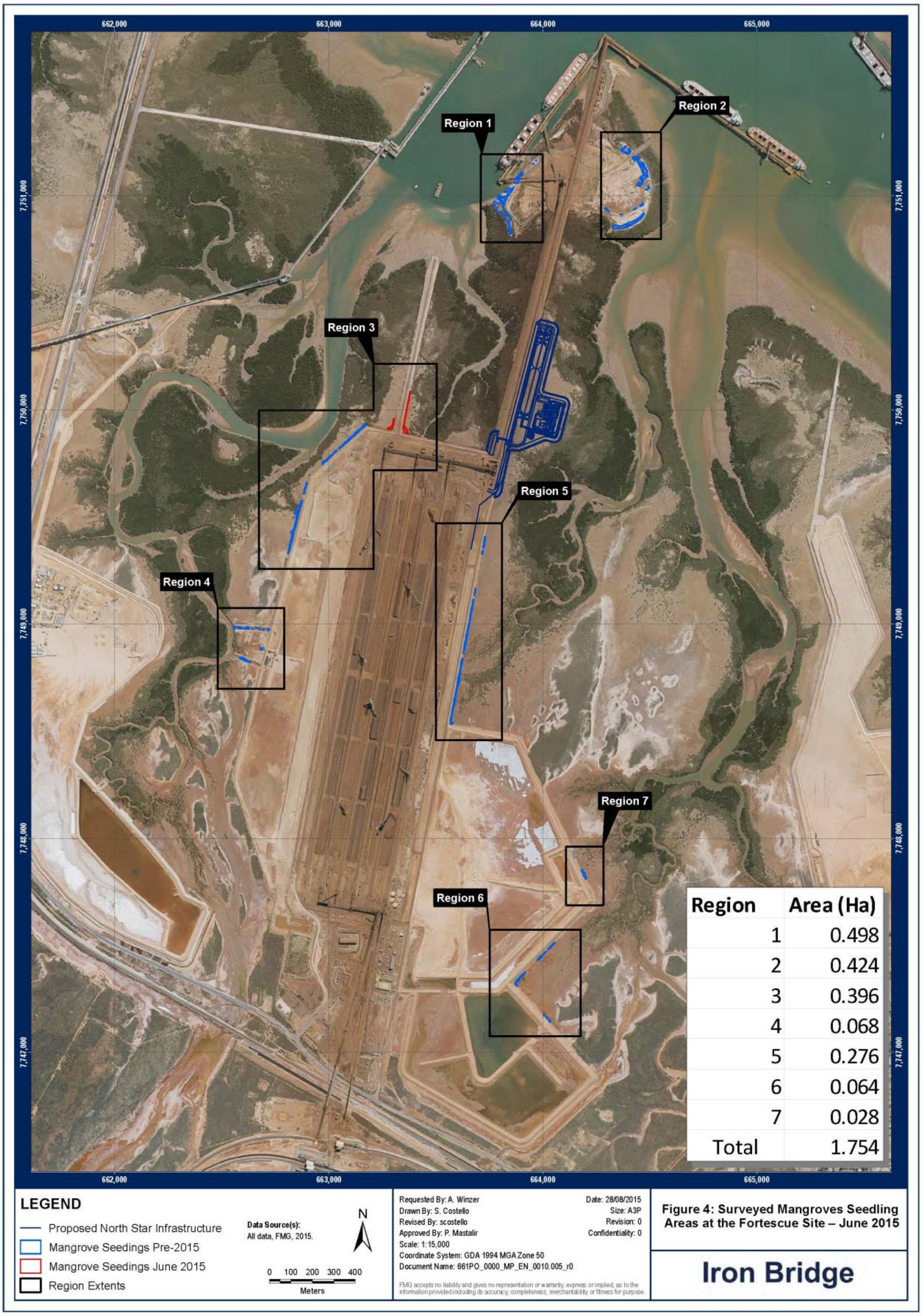
Due to the arid and high salinity conditions experienced within Pilbara mangrove systems it is unlikely that many of the tropical zone mangrove rehabilitation examples are of direct relevance to potential offsets from the IBO project. Of greater value to developing the Plan is to assess case studies in the Port Hedland area where natural mangrove recruitment and revegetation has occurred as a result of human activities.

The information below provides this assessment and identifies which aspects of the case studies are of relevance to potential mangrove offsets for the IBO project, thus providing the rationale for some of the offset options proposed in Section 5.

4.2 Fortescue Site

Monitoring undertaken since 2008 has documented the development of new mangrove habitat that has occurred as a result of port construction activities and the recruitment of mangrove seedlings within the new habitat. Annual surveying of the mangrove seedling recruitment areas was repeated in June 2015 and the mapping was updated to show the distribution and extent of new mangrove habitat and mangrove seedling areas (see Figure 4). The area estimates determined from the June 2015 survey confirm that the process of mangrove recruitment has continued within the new mangrove habitat and further in-filling of the new habitat with seedlings is expected in the future. The seedling recruitment area has increased from 0.19 ha in 2008 to 0.86 ha in 2011 and to 1.75 ha in 2015.

Figure 4 Surveyed mangrove seedling recruitment areas at the Fortescue site in June 2015



Region	Area (Ha)
1	0.498
2	0.424
3	0.396
4	0.068
5	0.276
6	0.064
7	0.028
Total	1.754

New mangrove habitat around the Fortescue site has developed via three scenarios or types of new habitat (URS 2014).

Anderson Point – excavation of sand chenier

New mangrove habitat is developing around the Anderson Point island between the perimeter bund and the current mangrove zone. Mangroves are colonising new habitat that has been created by construction phase earthworks (in 2006) which excavated a chenier (low sand dune/shell deposit) to form a perimeter bund, leaving an area of sand and mud flat with suitable conditions (e.g. substrate type, soil salinities, tidal inundation regime) for mangrove recruitment. Figure 4 shows the location of mangrove recruitment areas at Anderson Point (i.e. Regions 1 and 2).

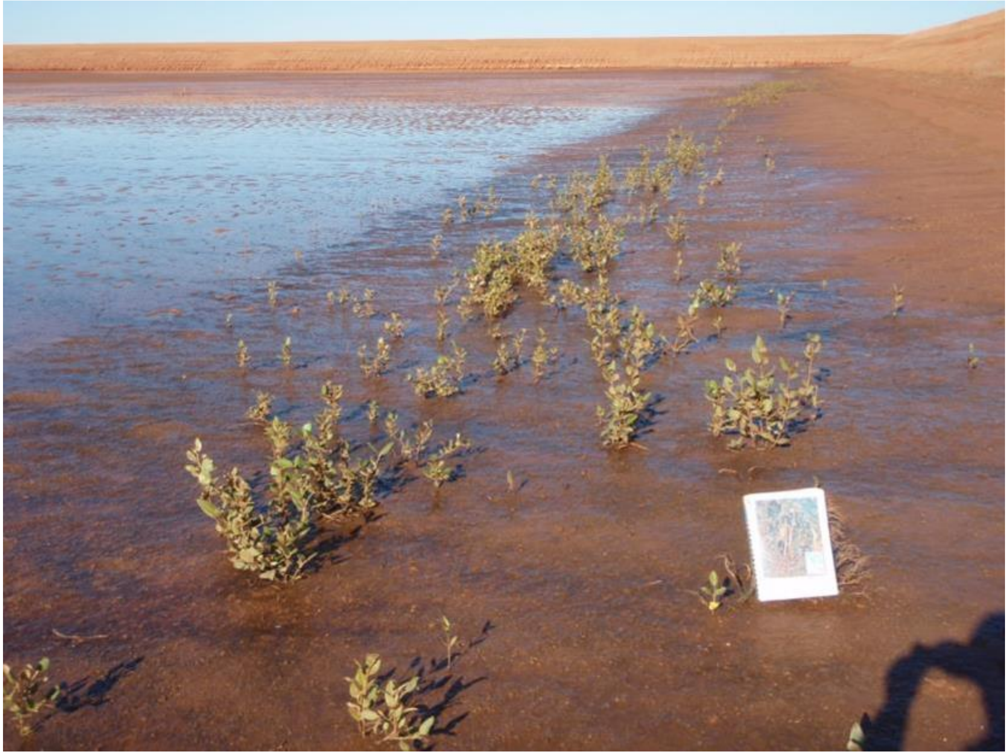
Seed (propagule) deposition zone along base of perimeter bunds

Mangrove recruitment has also occurred on tidal flats at the base of the perimeter bunds (concrete revetment) in several areas (see Regions 3, 5, 6 and 7 in Figure 4). The perimeter bunds constructed on high tidal mud flats provide a physical barrier and seed (propagule) deposition zone. Mangrove propagules floating in tidal waters are deposited along the barrier (bund) edge during spring tides. Increased water retention, localised seepage and intermittent surface flow of lower salinity water into the deposition zone assists the survival of mangrove seedlings in an area (high tidal flats) where normally salinities would be too high (as described in Section 3).

Plates 1 and 2 provide examples of both older (2007) and more recent (2014) areas of seedling recruitment along the base of perimeter bunds.

Plate 1 *Avicennia marina* saplings on tidal flats at the base of the northern settlement area perimeter bund (May 2014). Seedling recruitment in this area commenced in 2007.

Plate 2 Mangrove seedlings along the base of the South East Settlement area bund (May 2014). Seedling recruitment in this area commenced in 2011.



Excavation of artificial tidal creek channels

Mangrove (*Avicennia marina*) seedlings are also colonising the sides of the two discharge channels at South West Creek and the channel (in between the two discharge channels) excavated to access seawater for dust suppression during the early part of the construction phase. During the first dredging campaign in 2006 two discharge channels were excavated to a depth 1-2 m below the level of surrounding mudflats and this has provided a habitat at suitable elevation to receive sufficient tidal wetting, thereby developing the substrate and salinity conditions conducive to mangrove seedling recruitment (see Plate 3). In effect the discharge channels are serving as small artificial tidal creeks connected to the larger South West Creek.

Plate 3 Mangrove seedlings colonising the slopes of an excavated discharge channel, South West Creek

4.3 PPA Seedling Propagation, Mangrove Offsets Study and Redbank Trial Area

The Port Hedland Port Authority (now Pilbara Ports Authority – PPA) has undertaken mangrove propagation trials in purpose-built nurseries. Intensive seed collection occurs throughout summer, resulting in a mangrove nursery housing mangrove seedlings from the seven species of mangroves found in Port Hedland. A second mangrove nursery has been constructed, in which fresh seeds are propagated using new, more efficient methods.

The concept of creating artificial tidal creeks as a method of developing new mangrove habitat was recommended by a “mangrove offsets” study commissioned by the PPA to examine how best to create mangrove habitats (VCSRG 2008). This study concluded that the easiest and most appropriate habitat to re-create would be the tidal creek habitat, that it could be achievable from an engineering perspective and it would be the option most likely to function ecologically.

In 2013 PPA undertook a trial in the Redbank area involving the construction of a channel and small embayment connected to the upper reaches of South East Creek and planted mangrove seedlings that had been propagated in glasshouse conditions (see Plates 4 and 5). Monitoring of the seedling survival at the Redbank trial area is providing data on the survival of planted seedlings and also the natural recruitment of mangrove propagules into the excavated channel/embayment.

Plate 4 PPA artificial tidal creek habitat at Redbank, Port Hedland (May 2013)

Plate 5 Redbank mangrove rehabilitation area (November 2013)

4.4 Other Port Hedland Examples

4.4.1 Utah Point Road – mangrove seedling deposition area

A substantial number of mangrove seedlings (several hundred) have become established on high tidal flats along the base of the Utah Point Road (see Plate 6). The road, constructed approximately four years ago, has provided a barrier and mangrove propagule deposition zone. Mangrove propagules floating in tidal waters have been deposited on tidal flats next to the road and have become established. In some areas this has occurred on largely bare mud flats (previously devoid of mangroves) and this probably indicates that increased water retention and seepage of lower salinity water along the base of the road may be assisting with seedling recruitment/survival.

Plate 6 Mangrove seedling recruitment (*Avicennia marina*) on high tidal mud flats next to the Utah Point Road

4.4.2 Finucane Island Road Causeway

A road causeway providing public access to Finucane Island branches off the large road and rail causeway across West Creek. The smaller causeway (Finucane Island Road) curves away from the BHPBIO rail causeway and cuts off a pocket of mangrove habitats between the road and rail causeways. The flora and fauna of mangrove habitat in this pocket were surveyed in December 2007. This area has an altered hydrological regime as a result of the physical barrier created by the road embankment. There are two culverts through which all tidal inflows and outflows are channelled. High tides flood the area and at low tide the substrate is exposed, however the constraint of water movement through the culverts on both flood and ebb tides apparently reduces flow speeds through the mangrove stands and increases the residence time of tidal water in the area. There are numerous mangrove pneumatophores, which are indicative of waterlogged substrate, and greater amounts of leaf litter and fine sediments when compared to similar mangrove habitats elsewhere in the harbour. There may also be some seepage of freshwater (which is used to control dust on the nearby stockpiles) into this area (SKM 2009a).

Mangroves at this site comprised a stand of *Avicennia marina* ranging in height from 1–2.5 m and extending east to the railway embankment. At the time of the field survey, the substrate was very wet and heavily bioturbated. Five species of mud whelks were abundant here, at densities of approximately 5–10 individuals per square metre. The combination of fine sediments, surface water, and possibly more nutrients (from decomposing leaf litter) appear to have created favourable conditions for benthic molluscs such as mud whelks, hence their high abundance in this area (SKM 2009a).

The benthic fauna at was considerably more diverse when compared with other areas of the harbour at similar shore heights during field surveys in 2007. In particular, a high diversity of molluscs (mud whelks and other molluscs) and crabs were observed, generally in large numbers. Many benthic fauna species recorded at this site were not recorded in mangrove habitat during surveys conducted elsewhere in the harbour in 2007. Elsewhere in the harbour at similar shore heights the diversity of benthic fauna recorded ranged from 4-8 species but at this site 21 species were observed. The fauna assemblage recorded was found to extend right to the seaward edge of the mangrove habitat that is bounded by the existing road and rail lines, and was comprised of species typically associated with mangroves in tropical Australia (SKM 2009a).

4.4.3 Finucane Island – West Creek

During a comparison of aerial photographs from 1963 with more recent satellite imagery from 2008 the area of mangroves lying between Harriet and Utah Points has increased with colonisation of formerly bare areas of substrate by mangrove species (SKM 2009b). The area appears to be a site of active sediment accretion although it is not clear whether the construction of ports infrastructure has promoted colonisation of this area by mangroves.

Examination of the same aerial imagery supplemented by field survey has shown that the tidal channel of West Creek has been gradually infilling with fine sediments since the construction of the causeway across to Finucane Island (SKM 2009b). On both the west and east sides of the causeway fine sediments now support a completely different fauna from that typically associated with the tidal channel substrates elsewhere in the harbour. Some mangrove colonisation has occurred on both sides of the causeway and the area of mangrove is likely to expand as accreting sediments create suitable substrates.

4.4.4 BHP Iron Ore – East Creek, Port Hedland

East Creek was a mangrove lined tidal creek that connected to the Port Hedland harbour system. Between 1967 and 1970, during the development of the Nelson Point iron ore port facility, the mouth of the creek was reclaimed. Successive infrastructure developments compounded losses of mangroves on the remnant channel of the creek and a rehabilitation program began in 1994 which included construction of tidal channels linking high tidal mud flats (mostly bare at the time) and remnant areas of mangroves (i.e. in the remnant section of East Creek), to the upper reaches of Stingray Creek (BHPIO 1998). These areas had experienced modification to tidal flows from the truncation of East Creek and development of the area for stockpiles and rail facilities. Limiting factors to rehabilitation were identified as being insufficient tidal flushing and high salinities.

In an attempt to provide greater tidal flushing a swamp dozer/excavator was used to excavate a series of long narrow tidal channels that were connected to the upper reaches of existing tidal channels in the north east section of Stingray Creek. The existing tidal channels were orientated in a direction towards the rehabilitation area and the excavated channels (up to approximately 600 m long) extended this alignment across mostly bare tidal mud flats. Within one year BHPBIO environmental personnel noted that mangrove propagules had been deposited amongst the excavated channels and adjacent areas of high tidal mud flats located south of the BHPIO railway line (southern branch). Mangrove recruitment and growth has continued since that time with several hectares of mangroves now occurring in the area (Mark Piggott, BHPBIO pers. comm.).

The remnant section of the East Creek tidal channel has been used as a tailings area for deposition of sediment and also traps storm water runoff, reclamation water from stockpiles, and tidal water which reaches this area on high spring tides via the tidal channels connecting to Stingray Creek that were constructed during the rehabilitation program. Water ponds in the remnant channel and apparently cannot completely drain down the constructed channels because of a mound of sediment (tailings) which lies to the east of the ponded water. This area was briefly surveyed in 2008 (SKM 2008) and was found to support an extensive freshwater wetland with extensive algal growth and some areas of sedges. Fine sediments and high levels of decaying organic material were observed. Some stands of the mangrove *Avicennia marina* were also present and exhibit a size and growth form atypical for this species in the harbour but typical for this species when growing in a low salinity environment with waterlogged muddy substrates.

4.4.5 Dampier Salt – Port Hedland Operations

In the early 1990s Cargill Salt (now Dampier Salt - Port Hedland Operations) expanded the solar salt pond system by including the construction of a new concentration pond (Pond 0) and intake pumps on intertidal flats next to existing ponds located 30 km east of Port Hedland. A Mangrove Monitoring Program and Rehabilitation Plan was prepared and, in 1993, a mangrove rehabilitation plan was initiated to gather information on the potential for rehabilitation, both within the pond system and in mangrove habitats adjacent, but external, to the pond levees.

The main findings of this work (LDM 1998 & 2000) are:

- There has been considerable recruitment and establishment of mangroves in deltas within the pond system. Fine sediments contained in tidal waters pumped into the pond system are deposited as the velocity of the pumped water is reduced upon entering the pond. The accumulation of silts and muds by this process has formed mud banks which have been colonised by mangroves after seeds were also transported into the ponds via pumped tidal water.

- Seedling recruitment has occurred within seepage zones on tidal flats immediately next to the Pond 0 levee, where seepage of lower salinity Pond 0 water has diluted high groundwater salinities and accumulated water on the tidal flats. In several areas, this has occurred as a narrow band approximately 20 m wide out from the toe of the levee. The combined effect of a dispersal barrier or mangrove propagule deposition zone (due to presence of the levee) and the low salinity conditions have provided the habitats conducive to seedling recruitment and growth (see Plate 7).
- Within mangrove systems existing in the high tidal flat settings near the ponds (but outside of the ponds and seepage zone described above), there is naturally low in situ establishment and survival of mangrove seedlings. A large proportion of the propagules produced in these mangroves stands each year is presumably killed off, dispersed off site and/or consumed by crabs.
- Trial transplanting of seedlings has indicated that the potential for successful re-vegetation by planting is likely to be confined to areas where considerable natural or unassisted seedling recruitment is already occurring or is anticipated to occur (e.g. seepage zones next to Pond 0 levee, in the pond deltas and within sheltered embayments inside Pond 0).

Plate 7 Recruitment and growth of mangrove seedlings in the seepage zone on tidal flats next to the Pond 0 levee (May 1999)

Historic changes due to tidal creek truncation

During the construction of salt ponds by Cargill Salt a bund on the eastern end of the pond complex cut off the upper section of a large tidal creek. The loss of this upper section appears to have changed the depositional environment downstream of the bund as tidal water no longer runs off the flats of the creek catchment which is now a series of ponds that retain water. Examination of aerial photography from 1963 and satellite images from 1993 and 2008 show continuing colonisation of formerly bare areas of substrate in the channel of the tidal creek by high value closed canopy forest of both *Avicennia marina* and *Rhizophora stylosa* with the formation of a new mangrove island and extension of mangroves areas on other tidal islands in this creek system (SKM 2009b).

An assessment of creek modification and mangrove distribution (LSC 1990) undertaken prior to the major pond expansion in 1992 at the Cargill Salt concentration pond system showed that historical changes to creek morphology were initiated in 1978 when a tidal dam was constructed across the southern arm of Ridley Creek. This resulted in:

- Siltation next to and downstream from the dam (as described above) that resulted in tidal mud flats replacing previous channel areas and approximately 6 ha of mangrove habitat becoming established between 1978 and 1987; and
- An expansion of the north-eastern arm of Ridley Creek as tidal waters that previously flowed into both the southern and north-eastern arms were directed solely into the north-eastern arm. This resulted in erosion and the extension of the upper reaches of the north-eastern arm to expand its channel length from 2 km to 6 km during the years 1978 to 1987. Mangroves subsequently colonised the extended reaches of the north-eastern arm.

5. OPTIONS FOR MANGROVE OFFSETS FOR THE IBO PROJECT

Based on the experienced gained from the types of mangrove offsets achieved since 2006 at the Fortescue site and from other relevant case studies from the broader Port Hedland area, offset options using the following scenarios to develop new mangrove habitat are suggested for consideration:

- Physical barrier on high tidal mud flats - seedling deposition zone along the base of bunds
- Dilution of high groundwater/soilwater salinities on high tidal mud flats (salt flats) by the discharge of lower salinity water
- Excavation of tidal channels
- Trial planting of propagules and seedlings

The overall objectives guiding the mangrove offset options would be to:

- develop new mangrove habitat in areas that are largely devoid of mangroves (e.g. high tidal mud flats) without the need for physical disturbance to those areas.
- enhance the process of new mangrove habitat development that is already occurring in previously disturbed areas (this may involve physical disturbance such as channel excavation however it would be confined to areas that have already been subject to considerable physical disturbance and landform modification).

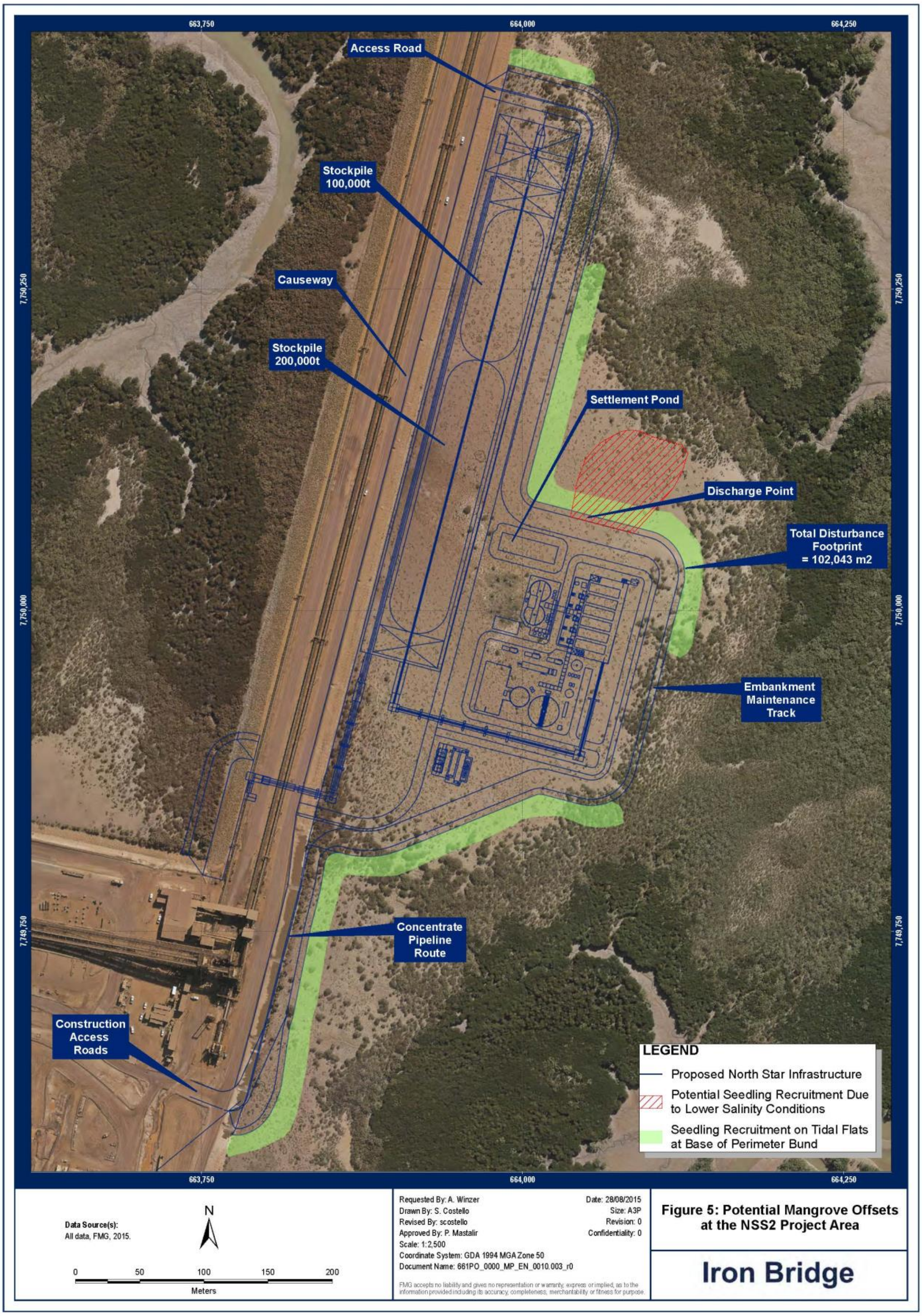
Details are provided below on how these scenarios may occur (or be implemented) in areas immediately adjacent to the IBO site and at other locations around the overall Fortescue site.

5.1 Seedling Colonisation on Tidal Flats Along Base of Perimeter Bund

As observed in several areas around the FMG site and elsewhere in the Port Hedland area it is anticipated that mangrove recruitment will occurred on tidal flats at the base of the perimeter adjacent to the IBO site. The perimeter bunds constructed on high tidal mud flats will provide a physical barrier and seed (propagule) deposition zone. Mangrove propagules floating in tidal waters are likely to be deposited along the barrier (bund) edge during spring tides. Increased water retention, localised seepage and intermittent flow of lower salinity water into the deposition zone will assist with the survival of mangrove seedlings in an area (high tidal flats) where normally salinities would be too high.

The approximate area where this may potentially occur on tidal flats adjacent to the IBO site is shown in Figure 5. If it assumed that a band 5 m wide of out from the toe of the perimeter bund becomes colonised by mangrove seedlings then this would represent an area of approximately 0.46 ha.

Figure 5 Potential mangrove offsets at the NSS2 project area



5.2 Provision of Lower Salinity Conditions by Discharge of Water onto Tidal Flats

The release of stormwater (with salinities approaching freshwater) onto the salt flat habitat downslope from the discharge point at the IBO site has the potential to modify habitat conditions by reducing the existing hypersalinity on the salt flat, thereby providing conditions that may be conducive to mangrove recruitment and growth. This scenario could be similar to that observed at the Dampier Salt (Port Hedland Operations) Pond 0 levee, where seepage of lower salinity Pond 0 water diluted the existing high groundwater salinities on salt flats, thereby providing conditions conducive to seedling recruitment and growth that subsequently developed as a band approximately 20 m wide out from the toe of the levee.

Salinity and surveyed ground level data collected since 2006 for the FMG Mangrove Monitoring Programme data demonstrates the salinity gradients that occur through the mangrove zone at Port Hedland (URS 2010a). Salinities increases from approximately 40-55‰ (ppt TDS) at the more seaward areas (e.g. seaward and taller *Avicennia* zone and *Rhizophora* zone) to approximately 70-90‰ in the more landward sections of the mangrove zone where low open *Avicennia* shrubland occurs (see Section 3).

The dominant species in the study area (Avicennia marina) has the greatest salinity tolerance of the Pilbara mangrove species and occurs in areas where groundwater salinity reaches up to 90‰ (approximately 2.5 times seawater). With increasing tidal elevation through landward sections of the mangrove zone, the reduction in tidal inundation in combination with high evaporation rates results in groundwater and soilwater conditions (including salinity) that are beyond the threshold tolerated by mangroves (>90‰). In these areas the mud flats are devoid of mangrove vegetation and the habitat becomes a high tidal mud flat with scattered patches of samphire, algal mats or salt flats. It is into this type of habitat to which the release of freshwater from the NSS2 discharge point will occur and potentially lower salinities to provide conditions conducive to mangroves (depending on the rate, volume and frequency of water release).

The approximate area where this may occur at the IBO site is shown in Figure 5.

5.3 Excavation of Tidal Channels on East Side of Anderson Point

During earthworks undertaken in 2006 and 2007 for the Fortescue project the large chenier (low sand/shell deposit formed to a level just above high tide mark) and dune system at Anderson Point was substantially modified by excavation works to source material for the perimeter bund. These works left an area of sand and mud flat that is at suitable elevation (relative to the tidal regime) and provide suitable conditions (e.g. substrate type, soil salinities) for mangroves to recruit into. Annual surveying has documented this seedling recruitment (see Section 4.2).

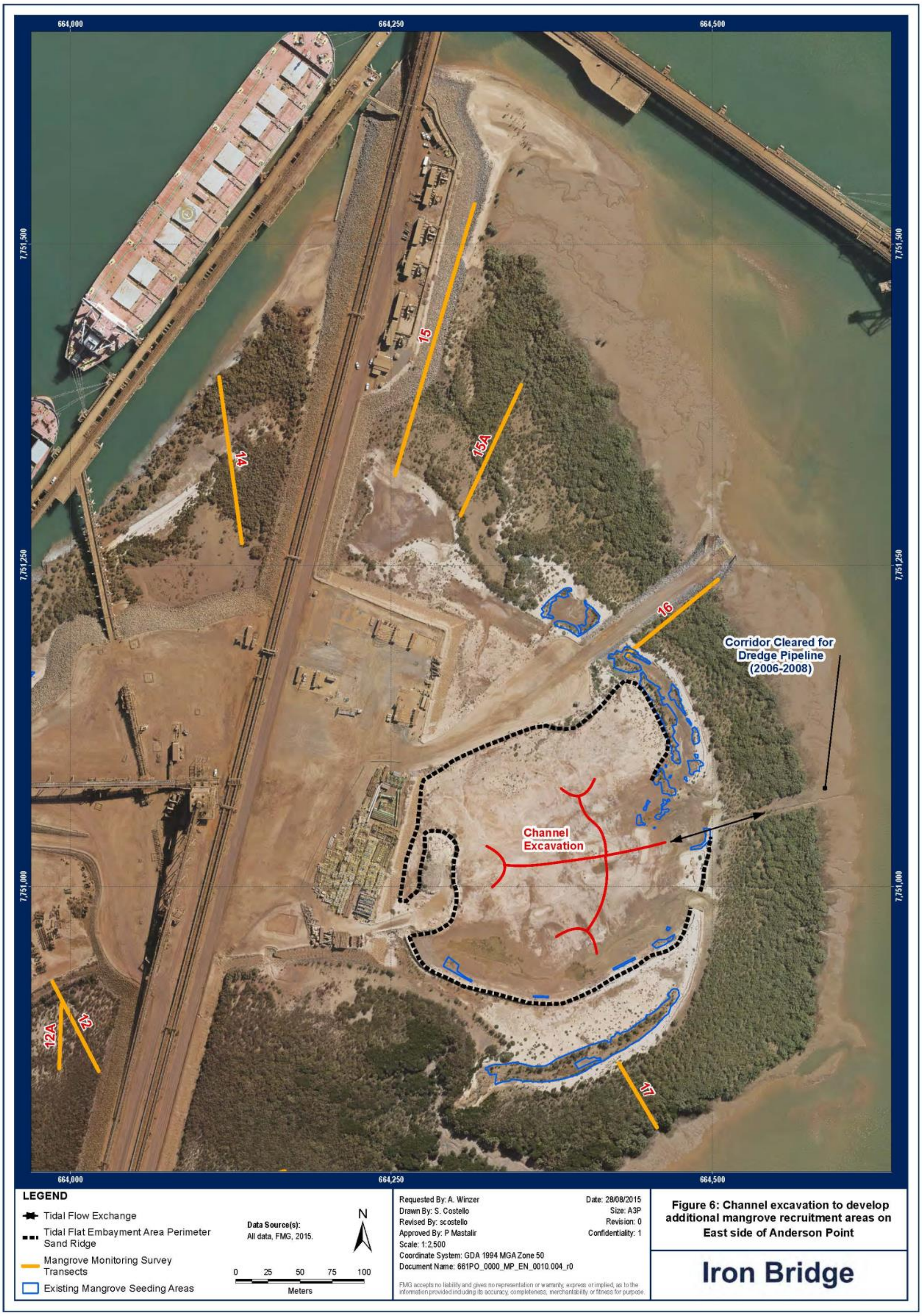
On the east side of Anderson Point the earthworks resulted in the formation of an embayment shaped area partly surrounded by a narrow sand ridge (i.e. remnant of the former chenier) and the perimeter levee. This embayment base is a mud/sand substrate and the area is inundated by spring tides with tidal flows occurring through a gap in the sand ridge and through a corridor cleared to support a pipeline used to pump dredge spoil from AP1-3 berth pockets to the settlement areas.

Figure 6 shows the location of this embayment and the small amount of mangrove recruitment that has occurred within it. Using a similar channel excavation scenario observed elsewhere to be successful in developing new mangrove habitat, it is proposed that tidal channels be excavated within the embayment area to provide:

- Increased tidal exchange flows throughout the embayment area thereby enhancing the seedling recruitment process that has already been initiated (albeit on small scale).
- Provide additional mangrove habitat structure (i.e. channel banks/slopes) for seedlings to colonise (similar to that observed at the South West Creek discharge channel (see Section 4.2).

The location of the proposed channels shown in Figure 6 are only indicative at this stage and any final alignment and channel morphology would need to consider machinery access and other factors such as the experience gained from previous channel excavation trails undertaken at Port Hedland (e.g. PPA Redbank and BHPIO East Creek). The intention of the excavation works would be to limit physical disturbance to the embayment (itself a substantially modified area by the 2006-2007 earthworks) and avoid any areas of undisturbed mangrove habitat.

Figure 6 **Channel excavation to develop additional mangrove habitat on the east side of Anderson Point**



5.4 Experimental Planting of Mangrove Propagules and Seedlings next to MOF Road

In addition to the offset options discussed above, consideration will be also be given to augmenting the natural recruitment observed on tidal flats along the base of perimeter bunds at the Fortescue site with experimental planting of mangrove propagules (seeds) and/or seedlings. One potential area for such a trial is on the western side of the MOF access road (i.e. section of the road that traverses salt flats areas, closest to the stockpiles).

During periods when propagules are abundant (e.g. February to March for *Avicennia marina*) it would be a relatively simple exercise to collect propagules and scatter them over the ground surface on tidal flats along the base of the MOF access road. This would provide for the seeding of a site with a large number of propagules. If *Rhizophora stylosa* propagules were to be included within the trial they would need to be partly pushed into the substrate due to their long pod like shape.

Experimental plantings could either be done by obtaining propagated seedlings from the PPA (if available) or by transplanting *Avicennia marina* seedlings (wildings) from nearby areas where abundant supplies of seedlings suitable for transplanting occur (and within close proximity to the Fortescue site). Several areas of high seedling abundance are likely to exist where roads or other barriers to seed dispersal have been constructed within mangroves and tidal flats (e.g. along the edge of the Finucane Island and Utah Point Roads). Given that the majority of seedlings in these seedling source areas will ultimately not survive, the removal of some for the above purpose will not affect the longer-term viability of the mangrove populations. To maximise the potential for survival, seedlings should be quite small (ideally 10 to 18 leaves) and up to approximately 20-30 cm in height. Transplants should be removed using a trowel or small spade and have an intact root ball.

6. MONITORING

Monitoring of seedling recruitment achieved by the mangrove offset options will be aligned with similar monitoring undertaken for the Fortescue project. Annual estimates of mangrove seedling recruitment and distribution will be determined by surveying boundaries of mangrove seedlings areas and overlaying surveyed polygons onto aerial photography - these being identified as areas where the minimum seedling density is approximately five seedlings per m^2. It is noted that scattered seedlings at lower densities may also be observed elsewhere within the new mangrove habitat area, thus indicating the potential for further mangrove recruitment.

Natural recruitment of *Avicennia marina* seedlings (the dominant species) peaks during the annual fruiting and seed/propagule dispersal period (February to April) and hence annual monitoring should be just after this period to capture the annual infusion of propagules/seedlings (e.g. May-June).

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Iron Bridge

Appendix 8: Dust Management Plan

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Iron Bridge

Iron Bridge Port Facility

Dust Monitoring and Management Plan

September 2015

662PO-4000-PL-EN-0001

	Iron Bridge Port Facility – Dust Monitoring and Management Plan		**662PO-4000-PL-EN-0001**
Revision Number	**A**		**15/09/2015**
Status	**IFU - ISSUED FOR USE**		
Author	Andrew Winzer	Signature	13/08/2015
Checked	Clayton Brandwood	Signature	7/09/2015
Checked	Ken Wilyman		
Approved	Simon Carter	Signature	17/9/15 Click here to enter a date.
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**N/A**		

Revision History *(to be completed for each version retained by Document Control)*

Author	**Checker**	**Approver**	**Rev No.**	**Status**	**Issued Date**
Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.
Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.

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1. INTRODUCTION

The IBJV is developing an export facility at Anderson Point in Port Hedland (herein referred to as the Export Facility). The Export Facility is located on land that is managed by the Pilbara Ports Authority (PPA) and will rely on the use of The Pilbara Infrastructure Pty Ltd (TPI) outloading infrastructure to enable loading onto a vessel. The key infrastructure components of the Export Facility will include:

- IBJV infrastructure:
    - Slurry pipeline from the Herb Elliott Port Boundary to dewatering facility
    - Covered stockpiles with stacker and bridge reclaimer (stockyard)
    - Filtration plant
    - Outload conveyor onto TPI outload circuit

This Dust Monitoring and Management Plan (DMMP) outlines the program to be put in place for the operation of the Export Facility. It includes the dust management controls to be used at the site, provisions for ambient monitoring including access to the existing ambient air quality monitoring data (from the existing TPI boundary dust monitoring network), roles and responsibilities for dust management at the site, complaints management protocol, dust event investigation, and reporting. The DMMP is relevant during the pre-operational (construction and commissioning) and operational phases of the Export Facility, and is subject to periodic review and updating as necessary.

The dust management performance of the IBJV operations will be determined by two key factors:

- Design features that have been built into the Export Facility (operations and infrastructure) that control the generation and emission of dust.
- Operational practices (during both pre-operational and operational phases) that control the emission of dust.

This DMMP therefore:

- Defines the measures adopted to manage dust emissions.
- Defines the criteria against which performance is to be assessed, in turn determining if the environmental objectives and environmental outcomes of the DMMP are achieved.
- Outlines the process for investigating dust complaints, dust incidents and events, and for implementing solutions.

2. ENVIRONMENTAL OBJECTIVE AND ENVIRONMENTAL OUTCOME

A risk-based approach has been applied to the assessment of potential air quality (dust) emission sources, and the potential impact from the IBJV operations. This approach has taken into account the potential cumulative impact to current air quality (dust) in Port Hedland.

2.1 Environmental Objective

The EPA's Environmental Objective for the environmental factor of Air states: *Air Quality and Atmospheric Gases - 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* (EPA, 2015).

For the IBJV Export Facility, this key aspect is in relation to Dust only. Activities/areas of dust generation during the pre-operations phase of the Export Facility (i.e. construction and commissioning) are considered to be:

- wheel generated dust from roads (both sealed and unsealed)
- bulk earthworks
- wind erosion from open areas.

Activities/areas of dust generation during the operations phase of the project are considered to be:

- material loading from reclaimers
- material transfer by conveyors and transfer stations
- wheel generated dust from roads (both sealed and unsealed)
- wind erosion from stockpiles and open areas.

This assessment of potential impact is summarised in Table 1.

Table 1 Air: Description of Factor, Impact Assessment and Management (Risk Framework)

Context	Potential Impact (without mitigation)	Environmental Aspect	Management Actions (Mitigation)	Regulation	Meets EPA Objective?
EPA Environmental Objective: Air Quality and Atmospheric Gases - 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 (EPA, 2015)					
Assessment and management of Cumulative Impact to air quality (dust emissions) subject to Port Hedland Dust Management Taskforce report and recommendations. High background concentrations due to Pilbara environment and existing sources in the Port Hedland airshed. Dust generated during construction due mainly to mechanical disturbances such as earthmoving (new road construction) and vehicle movements on unsealed surfaces. Dust generation from operations mainly due to material handling activities and vehicle movements on unsealed surfaces. During dry, windy periods dust lift-off from open and disturbed areas. Due to close proximity of operations to other third party dust sources and proximity to Port Hedland, any IBJV contribution to the cumulative load of dust is likely to be considered a significant and unacceptable impact.	Construction Activities: • Existing cleared site. • Road construction activities lead to temporary dust emission. • Unsealed roads will receive additional traffic and lead to temporary dust emission Operation Activities – materials handling leads to dust emissions from stockpiling, stacking, reclaiming, loading (in-loading and outloading), transferring, and conveyoring. Magnetite ore has DEM of 1.5%. Based on dispersion modelling • in-isolation scenario shows no significant impact • cumulative scenario shows no significant impact (in conjunction with TPI de-rating) Based on field analysis of magnetite ore, minimal emissions observed from stacking, stockpile surfaces, and conveyoring, with exception of accumulated material on return side.	Dust lift-off from cleared and / or open areas Dust lift-off from roads and trafficked (sealed and unsealed) Fugitive dust emissions from plant and infrastructure area • stockpiling • stacking • reclaiming • loading (in-loading and outloading) • transferring • conveyoring	Seal priority roads and routine surface cleaning. Unsealed roads subject to watering and temporary surface treatment (surfactant) Enclosed stockyard will reduce potential for emissions from: • stockpiling • stacking • reclaiming • loading (in-loading and outloading) Addition of belt scrapers and belt wash stations on the IBJV conveyors will reduce potential for emissions. DMMP is not a static document and will be reviewed throughout life of the project to ensure the objectives and outcomes remain relevant and aligned to Taskforce expectations.	Ministerial Statement – Pending under Part IV of EP Act Works approval and Licence – Pending under Part V of EPA Act	Potential contribution to cumulative dust impact on Port Hedland. Dust Monitoring and Management Plan to include: • targets • triggers • actions

2.2 Conditioned Environmental Outcome

The EPA's Conditioned Environmental Outcome from the Part IV environmental impact assessment (Ministerial Statement Number pending) is: *Dust generated by the IBJV Export Facility will not lead to an increase in the cumulative air quality impact in Port Hedland (as determined by ambient monitoring results at Taplin Street and Wedgefield receptors).*

3. DUST MANAGEMENT STRATEGY

The IBJV is adopting an integrated and outcomes-based approach to dust management for the project, with management actions targeting the key emission sources on site. The approach includes:

- Baseline air quality assessments being undertaken (atmospheric dispersion modelling and source emission estimation for magnetite ore handling).
- Dust control measures incorporated into the design of the operations.
- Ambient monitoring of air quality (dust as PM_{10}) and meteorology (includes access to data from an existing boundary network by agreement with TPI, and additional monitors).
- Definition of management action trigger values and associated management action and reporting responses.
- Reporting requirements, both internally within IBJV and externally to the Environmental Protection Authority (EPA) and the Department of Environment Regulation (DER).
- The key components of the dust management strategy are summarised in the following subsections (Section 0 to Section 3.5).

3.1 Baseline Air Quality Assessment

An air quality impact assessment for the IBJV was undertaken (PEL, 2015a) as part of the environmental impact assessment process. The assessment used computer-based atmospheric dispersion modelling to predict the ground level concentration of particulate matter (PM_{10}) from activities associated with the operation of the Export Facility. The key finding from this study is that the introduction of the IBJV 11 Mtpa magnetite product, with a de-rating of the existing TPI facility from 175 Mtpa down to 164 Mtpa, will result in a reduction in dust emissions to the Port Hedland air shed.

A field analysis was also completed to directly measure the dust emissions associated specifically with the magnetite ore, and its dust generation potential during material handling processes (PEL, 2015b). The behaviour of the magnetite ore during conveyoring, stacking, and high wind speeds, was observed and measured.

The Dust Extinction Moisture (DEM) for magnetite, is approximately 1.5%. During the field analysis, the magnetite being handled had a moisture concentration around 8.5%, and ranged between 6.6% and 6.8% within the stockpile. During stacking operations minimal emissions were observed. Wind erosion of stockpile surfaces was not evident. Conveyors were observed to be a potential key source of dust emission where the concentrate has adhered to the conveyor belt with emissions occurring on the return side of the belt, and material accumulating in the vicinity of belt pulleys and return idlers.

The combined findings of these baseline assessments was used as a basis for identifying suitable management strategies to mitigate fugitive dust emissions associated with the site and operations.

The key emission sources likely to impact ambient air quality are significantly reduced with the planned addition of belt scrapers and belt wash stations on the IBJV conveyors.

3.2 Dust Control Measures

A series of dust control measures have been adopted to address potential dust generation and impacts. These measures are supported by procedures and systems for managing onsite actions, monitoring and compliance. The key control measures aligned to various components of the project is summarised in Table 2 for the Pre-operations Phase of the project (i.e. construction and commissioning), and for the Operations Phase. The table also identifies the key site personnel accountable for ensuring the control measure is implemented as intended.

Table 2 Summary of Dust Control and Management Actions

Activity	Phase	Dust Control Measure	Responsibility
Induction	Pre-operations Operations	Deliver a site induction for all site personnel (employees and contractors) – Potential dust sources – Dust management plan, monitoring program, regulatory conditions – Reporting dust issues – Implementing actions Prestart and toolbox sessions	IBJV General Manager Operations
Daily Operations Planning	Pre-operations	Review Daily Dust Risk Forecast from Air Quality Management System (AQMS)	IBJV General Manager Operations
	Operations	Review Daily Dust Risk Forecast from AQMS: – Distribute to key site personnel – Include in daily toolbox meeting – When forecast dust risk is high or extreme i.e. yellow or red, then initiate management action hierarchy when outloading is planned Utilise Water trucks and water sources available on site for dust suppression	IBJV General Manager Operations

Activity	Phase	Dust Control Measure	Responsibility
Minimising emissions from plant and infrastructure area activities • stockpiling • stacking • reclaiming • loading (inloading and outloading) • conveyoring	Pre-operations	Construct enclosure to house stockpile Install sprinkler systems around plant and infrastructure area (e.g. conveyor boom sprays) Install belt wash station and scrapers on conveyors where required	IBJV General Manager Operations
	Operations	Clean-up spillages in stockpile areas and return to main product stockpile on regular basis Use sprinkler systems around plant and infrastructure area (e.g. conveyor boom sprays) Inspect regular IBJV • infrastructure sprinklers and dust suppressant systems to ensure operational • belt scrapers to ensure they are correctly aligned • belt wash station to ensure it is operational All plant regularly serviced and maintained	IBJV General Manager Operations
Minimising emissions from cleared and open areas	Pre-operations Operations	Apply water (via water trucks) on cleared areas as necessary within IBJV footprint. Dust suppressant chemicals to be applied to long-term open and cleared areas.	IBJV General Manager Operations
Minimising emissions from trafficable areas	Pre-operations Operations	Apply dust suppressant (water and / or chemical) to unsealed internal roads Site speed limits assigned and enforced All vehicles regularly serviced and maintained	IBJV General Manager Operations

3.3 Ambient Monitoring

IBJV has an agreement in place with Fortescue/TPI to access the monitored data from the TPI real-time Air Quality Monitoring System (AQMS). IBJV will supplement this network with additional monitors (two maximum). Due to the terrain immediately surrounding the proposed location (primarily tidal mud flats) the additional monitors will be a nepholometer (similar to the E-Samplers currently utilised by Fortescue).

3.3.1 Existing Dust Monitors and Locations

The TPI boundary dust network consists of nine BAM 1020 monitors, two E-Sampler monitors and one E-BAM monitor, all measuring PM_{10}. There is also a meteorological station recording wind speed and wind direction at 10 metres above ground level.

The BAM1020 has USEPA Federal Equivalent Method (FEM) designation for continuous monitoring of PM_{10} and will be operated according to *AS 3580.9.11:2008 - Methods for sampling and analysis of ambient air - Determination of suspended particulate matter -* PM_{10} *beta attenuation monitors (BAM).*

3.3.2 Additional Dust Monitors and Locations

A maximum of two new PM_{10} monitors (E-samplers) are proposed by IBJV. The intent of these additional monitors is to assist with the delineation of emission sources (i.e. IBJV operations and third party operations). The equipment selection and locations are pending finalisation, taking into account site selection criteria and site access constraints. The new monitor(s) would be in place and functional for the operations phase of the Export Facility.

3.3.3 Ambient Monitoring Data and AQMS

All ambient monitoring data (dust and meteorology) is relayed into the AQMS and displayed live. This system was put in place by Fortescue Metals Group at the Herb Elliott Port to further improve its management of dust. IBJV has an agreement in place with Fortescue/TPI to access the AQMS, the data stored, and the analysis tools available. The purpose of the *EnviroSuite* AQMS is to:

- assess potential impacts and evaluate dust risk in advance
- provide recommendations for potential issues, based on system outputs
- develop a log of alerts for predicted dust incidents and events
- evaluate dust events and determine if which port activities may have caused an impact.

EnviroSuite has been used successfully at other facilities in Port Hedland and includes air quality monitoring, weather forecasting and real-time and forecast air quality modelling modules.

Forecast mode - *EnviroSuite* uses data from a high resolution site-specific weather forecast and dust dispersion model to assess potential dust impacts ahead of time. The system sends a daily forecast dust risk report to an email distribution list (including site environmental and operations staff) that provides forecasted daily dust risk data up to 3 days in advance. Operators use the forecast risk report to act with sufficient lead time to control dust emissions or conduct preparatory measures to plan for adverse weather conditions to avoid impacts, should the forecast weather conditions eventuate. A sample is shown in Figure 1.

Night Shift - Tuesday

11/08/2015 6:00:00 PM - 12/08/2015 6:00:00 AM

Hours:	18 - 19	19 - 20	20 - 21	21 - 22	22 - 23	23 - 00	00 - 01	01 - 02	02 - 03	03 - 04	04 - 05	05 - 06
Dust Risk:	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE
Inversion Strength:	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Very Weak	Very Weak
Temperature (°C):	23.8	22.6	21.7	21.1	20.2	19	18.7	17.9	17.1	16.7	16.1	15.3
Rain (mm):	0	0	0	0	0	0	0	0	0	0	0	0
Wind Speed (m/s):	3.2	3.4	3.8	4.5	4.7	4.3	4.1	4.3	4.4	4.9	5.1	5.1
Wind Gust (m/s):	4.4	4.5	5	5.8	6	5.6	5.3	5.5	5.6	6.2	6.5	6.4
Relative Humidity (%):	20.7	21.1	20.3	17.3	16.9	20.8	26.2	30.7	34.6	36.5	39.3	44
Inversion (°C/100 m):	0.8	1.5	2	1.8	1.7	1.7	1.4	1.3	1.4	1	0.5	0.4

Day Shift - Wednesday

12/08/2015 6:00:00 AM - 12/08/2015 6:00:00 PM

Hours:	06 - 07	07 - 08	08 - 09	09 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18
Dust Risk:	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE
Inversion Strength:	Very Weak	None	None	None	None	None	None	None	None	None	None	None
Temperature (°C):	14.8	17.9	19.5	21.2	22.8	24.2	25.3	26.1	26.7	26.9	26.2	23.1
Rain (mm):	0	0	0	0	0	0	0	0	0	0	0	0
Wind Speed (m/s):	5.1	9	10.1	9.9	9.4	8.9	8.3	7.7	7.2	7.1	6.8	3.7
Wind Gust (m/s):	6.4	11.4	13	12.6	11.9	11.3	10.5	9.7	9.1	8.9	8.5	4.9
Relative Humidity (%):	47.1	36.1	30.9	27.7	24.5	21.5	18.9	17.3	15.8	14.6	15.2	18.6
Inversion (°C/100 m):	0.4	0	0	0	0	0	0	0	0	0	0	0

Figure 1 A forecast meteorological conditions and forecast dust risk (sample)

Real-time mode – *EnviroSuite* receives and displays real-time dust and weather data on the user's screen (see Figure 2). The system generates alerts based on logic that interrogates the data to determine whether site activities are causing elevated dust concentrations at the site boundary. The alerts are linked to dust management responses that are used to mitigate dust emissions from operations, where necessary.

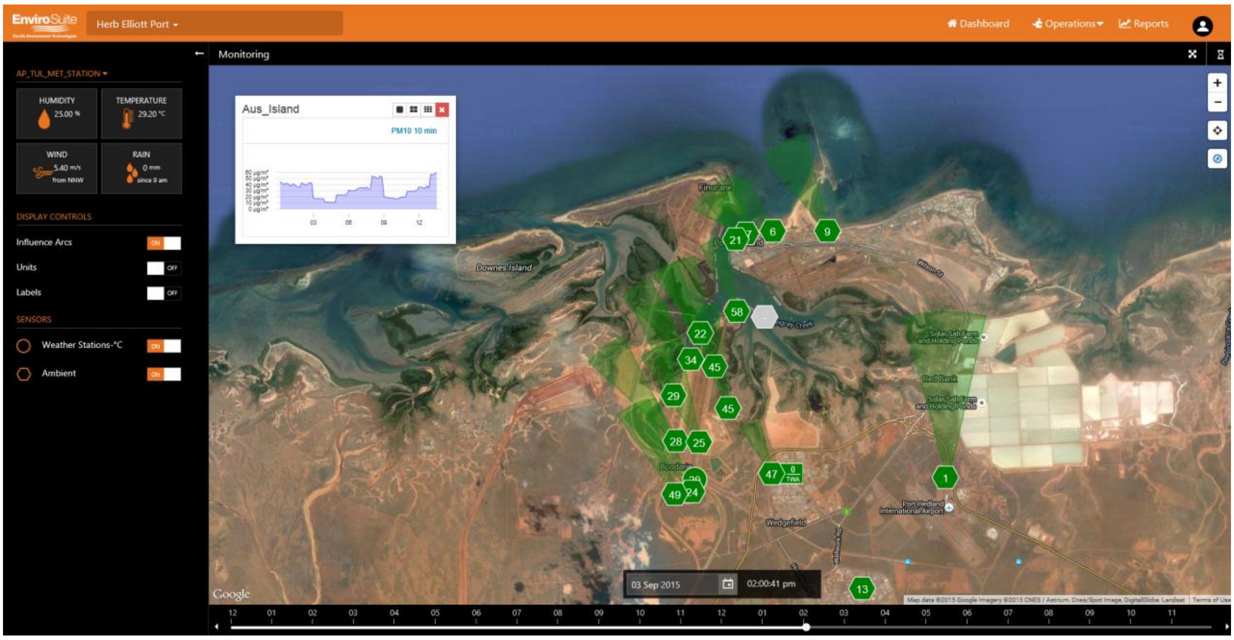

Figure 2 AQMS display of live ambient monitoring date, and “pop-up” time series (sample)

In addition, *EnviroSuite* runs a dust dispersion model in real-time (using data from the real-time weather station and validated emission rates for onsite dust sources) to provide an indication of airborne dust movements.

Analysis mode – *EnviroSuite* provides features for quantifying the extent to which elevated PM_{10} concentrations are attributable to site operations, or if it was more likely to be from a neighbouring facility, or due to elevated background dust concentrations. A sample is shown in Figure 3.

Figure 3 AQMS forecast meteorological conditions and forecast dust risk (sample)

The system does this by generating real-time pollution rose and wind scatter charts (based on monitoring data) and back trajectory modelling (using on-site weather data). *EnviroSuite's* analysis tools can:

- apportion the contribution of total dust measured at each monitor to each wind direction over a set period of time (e.g. past 24 hours);
- identify the time that each upwind area has influenced each dust monitor; and
- show the path that dust has travelled to arrive at a complainant's location or monitoring location.

The combination of forecast, real-time and analysis features provided by the *EnviroSuite AQMS* provides Fortescue (and IBJV) with a leading practice proactive dust management system.

The key monitoring actions for the project is summarised in Table 3 for the Pre-operations Phase of the project (i.e. construction and commissioning), and for the Operations Phase. The table also identifies the key site personnel accountable for ensuring the control measure is implemented as intended.

Table 3 Summary of Dust Monitoring Actions

Activity	Project Phase	Dust Control Measure	Responsibility
Monitoring	Pre-operations Operations	Maintain access to FMG's ambient monitoring network data Install additional monitors (maximum 2) to supplement existing FMG network. Maintain access to FMGs meteorological and dust risk forecast Identify and configure FMG Air Quality Management System (AQMS) for high dust alerts relevant to the IBJV operations – High wind alert within specified wind arc – Internal early warning alert Regularly review monitoring data (AQMS) Respond to dust complaints Respond to internal early alerts from the AQMS – Investigate results indicating high dust levels from IBJV operations Respond to High Alerts requiring management actions – Investigate results indicating high dust levels from IBJV operations – Implement corrective actions to eliminate causal factors Report monitoring results in – Monthly Reports – As required by environmental regulators Respond to Exceedance Alert requiring immediate dust abatement action	IBJV General Manager Operations

Activity	Project Phase	Dust Control Measure	Responsibility
		– Investigate results indicating high dust levels – Implement corrective actions to eliminate causal factors	

3.4 Management Action Trigger Values

Dust management action trigger values (against which monitored dust levels will be referenced) have been defined for the IBJV for the Port Facility using a tiered approach. This approach supports a proactive approach to dust management, as well as a reactive mechanism to respond to dust events.

The following management framework is used:

- **Internal management triggers (alert levels)** – these are a short term value (e.g. 10-minute, 1-hour) set as an early warning for managing impacts proactively. The values may be assigned to one or more boundary monitor. The values are set initially and are refined over time, with changes being made to the alert levels in the AQMS (*EnviroSuite*). Due to the dynamic nature of these internal management triggers, the values are not reported externally.
- **Reactive Management Triggers (Trigger Criteria)** – these are a 24-hour value, that when the level is reached or exceeded, indicates that further (contingency) dust management actions are required to be implemented, consistent with IBJV procedures. This action is intended to avert (where possible) the situation of the Threshold Criteria being reached. A 24-hour rolling average is used for the Trigger Criteria.
- **Corrective Action Management Trigger (Threshold Criteria)** – this is a 24-hour value, that when the level is reached or exceeded, indicates that a potential non-compliance incident has occurred and requires investigation and reporting. The intent of the investigation is to ascertain if IBJV is responsible for the dust event. From a Part V perspective, this value may also be adopted as the limit at a specified monitor.

The Trigger Criteria and Threshold Criteria are shown in Table 5.

Table 5 Dust Management Action Trigger and Threshold Criteria

Parameter	Trigger Criteria	Threshold Criteria*
PM_{10}	**Proposed (interim) Trigger Criteria** Monitor: Wedgefield Wind arc: 320º - 340º Level: 35 µg/m³ Timeframe: 24-hour rolling average **Proposed (interim) Trigger Criteria** Monitor: Taplin Street Wind arc: 210º - 230º Level: 60 µg/m³ Timeframe: 24-hour rolling average	**Proposed Threshold Criteria** Monitor: Wedgefield Level: 50µg/m³ Timeframe: 24-hour average

3.5 Contingencies

If the need arises, contingency management actions will be initiated. There are three identified key areas of contingencies, these being:

- **Complaints** – receiving, recording, investigating and responding to complaints received from third parties (i.e. made by persons not associated with IBJV operations).
- **Reactive management** –responding to a potential dust incident / event where the Trigger Criteria is reached and management decisions and actions are required to be implemented to mitigate before the Threshold Criteria is reached.
- **Non-compliance corrective action** – responding to dust incident / event investigation findings where the Threshold Criteria is reached, and where the investigation finding confirms that IBJV site is a contributing source (partial or sole-source) and therefore confirmed responsible for a dust event.

These contingency events, the required actions, and responsibilities are outlined in the following subsections.

3.5.1 Dust Complaints Management

A summary of the key actions to be taken in response to a dust complaint is provided in Table 7.

Table 4 Summary of Dust Complaint Action

Dust Impact requiring Contingency Action	Contingency Action	Responsibility
Complaint received from third party – and registered	When a complaint is received, the following actions will be undertaken: – log details of complaint and commence enquiry – cross reference with the forecast weather conditions, actual weather conditions and air quality monitoring data – identify the activities that were occurring at the time of the complaint, including dust management measures – determine the potential activity that may have caused the complaint – prepare a report and notify the appropriate parties of the corrective action to prevent recurrence – resolve the complaint within 72 hours and provide feedback to complainant	IBJV General Manager Operations

3.5.2 Reactive Dust Management

Where the Trigger Criteria value is exceeded (see Table 6), management decisions and actions will be implemented to mitigate the dust event before the Threshold Criteria is reached. The necessary action will be determined in accordance with the IBJV internal procedure. The decision process will take into account the operations and dust management actions underway at the time, as well as the meteorological conditions leading up to that time, and as predicted to continue.

A summary of the key actions to be taken in response to a dust complaint is provided in Table 8.

Table 5 Summary of Reactive Dust Management Action

Dust Impact requiring Contingency Action	Contingency Action	Responsibility
Monitored Level indicates Trigger Criteria reached – Reactive Management Required	When a monitored level reaches the Trigger Criteria value at the nominated monitor(s), the following actions will be undertaken: – log details of high recorded measurement commence enquiry – cross reference 24 rolling average with projected 24 hour average for the day – cross reference with the forecast weather conditions, actual weather conditions and air quality monitoring data – identify the activities that were occurring during 24-hour rolling period of concern, including dust management measures – determine the potential activity that may have caused the concern – prepare a short summary and notify the appropriate parties of the need for immediate reactive management and the corrective action to take – continue to review 24-hour rolling average for the remainder of the day	IBJV General Manager Operations

3.5.3 Incident Investigation and Response

Where the Threshold Criteria value is exceeded (see Table), an investigation will be undertaken to determine the cause of the high dust concentrations and to prevent any reoccurrences where IBJV is responsible or accountable for the event.

A summary of the action to be taken in response to monitored levels above the Threshold Trigger Value, is provided in Table 9.

Table 6 Summary of Dust Incident / Event Investigation (Threshold Trigger Value)

Dust Impact requiring Contingency Action	Contingency Action	Responsibility
Monitored Level indicates incident / event and possible exceedance of Threshold Criteria (i.e. possible non-compliance)	When a monitored level is recorded above the Threshold Trigger Value, the following actions will be take: – log details of high recorded measurement in BMS and commence investigation – cross reference with the forecast weather conditions, actual weather conditions and air quality monitoring data – identify the IBJV activities that were occurring at the time of the exceedance, including dust management measures – determine the IBJV activities that were most likely contributing to the exceedance – review the IBJV operational process and environmental management controls in place for these activities – Implement post-event corrective action i.e. an agreed alternative to more adequately control dust emissions in future – Detail the incident, the investigation, and the resolution in BMS	IBJV General Manager Operations

Corrective action may also involve revising the internal monitoring alerts, or revising existing operational practices.

4. REPORTING

Dust monitoring results will be reported to the DER in accordance with relevant licence conditions. A summary of results will be provided in Annual Environmental Reports.

5. REVIEW

The DMMP will be reviewed every 5-years by IBJV. Reviews will take into account the following:

- Any changes to the Export Facility design or operation that require modifications to the environmental management procedure outlined in this DMMP.

- Any dust management issues identified as a result of internal or external audits, and management reviews of audit outcomes.
- Corrective or improvement actions developed in response to dust incidents or non-compliant dust events.

6. REFERENCES

DER (2015). Environmental Protection Act 1986 – Amendment to Licence L8194/2007/3 Anderson Point Materials Handling Facility, Port Hedland WA 6721. Department of Environment Regulation, Government of Western Australia, 11 June 2015.

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EPA (2015). Environmental Assessment Guideline for Environmental principles, factors and objectives. (EAG 8). Environmental Protection Authority, Western Australia, January 2015.

PEL (2015a). Draft Report: Dust Assessment – North Star Stage Two Export Facility. Unpublished report prepared by Pacific Environment Limited for Fortescue Metals Group Ltd. 9 August 2015.

PEL (2015b). North Star Magnetite Project – Point Source Emission Estimation. Unpublished report prepared by Pacific Environment Limited for Fortescue Metals Group Ltd. 29 July 2015.

Appendix 1: Draft Report – Dust Assessment – North Star Stage Two Export Facility (PEL, 2015a)

Appendix 2: North Star Magnetite Project – Point Source Emission Estimation (PEL, 2015b)

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Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Final Report

NORTH STAR MAGNETITE PROJECT - POINT SOURCE EMISSION ESTIMATION

FORTESCUE METALS GROUP LTD

Job ID. 20049

28 August 2015

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EXECUTIVE SUMMARY

Fortescue Metals Group Ltd (FMG) operates the North Star Magnetite Project (NSMP) located approximately 110 kilometres (km) south-south east of Port Hedland. The magnetite product from this facility will be transported to Port Hedland via a slurry pipeline. The slurry will be de-watered at a concentrate handling facility at the FMG Herb Elliot facility with the concentrate then being stacked before being reclaimed and exported.

To determine the potential emissions from the stacking/reclaiming/export operations at the Herb Elliot facility Pacific Environment Limited was commissioned to undertake a point source emissions sampling program at the temporary concentrate handling facility located along the Great Northern Highway approximately 110km south of Port Hedland.

This survey focussed on emissions from the following activities:

- Stockpile stacking
- Conveyors
- Wind erosion or windblown dust from stockpiles.

The results of this monitoring program are as follows:

Conveyors: The high moisture content of the concentrate results in material adhering to the conveyor. This results in emissions along the return side, particularly at belt pulleys and some return idlers.

Stacking: Minimal emissions were observed from stacking of the magnetite concentrate primarily due to the high moisture content of the ore.

Wind Erosion: No wind erosion emissions were observed during the site investigation, even during wind speeds of up to 9.5 m/s. This was determined to be resulting from:

- The formation of a crust on the surface of the stockpile
- Lack of large particles within the concentrate which removes two of the main causes of wind erosion – saltation and creep.

Based on the results of this field investigation the only potential fugitive emission associated with operating a concentrate handling facility at Port Hedland are from conveyors. It is therefore recommended that a belt wash station be fitted at the head end of all conveyors over 60-80m to supplement the belt scrapers.

CONTENTS

List of Figures

1 INTRODUCTION

1.1 Background

Fortescue Metals Group Ltd (FMG) is an Australian iron ore company, mining and exporting Direct Shipping Ore (DSO) from its operations in the Pilbara region of Western Australia. One of these operations include the North Star Magnetite Project (NSMP) located approximately 110 kilometres (km) south-south east of Port Hedland. The NSMP is an open-cut iron ore mine with associated infrastructure to produce up to 15 million tonnes per annum of magnetite concentrate product over a mine life of 45 years.

The mined ore at the NSMP will be processed on site (as slurry), and then transported to Port Hedland for export via a slurry pipeline. At the commencement of the project, the product will be processed at the concentrate handling facility (CHF) at NSMP. The concentrate product will then be loaded into road trains using front end loaders (FELs) and then trucked to FMG's Herb Elliot port in Port Hedland where it will be stockpiled. This practice will only be conducted until such time that a slurry pipeline can be constructed between the facility and the port.

1.2 Objectives of the Study

As set out in correspondence from FMG, Pacific Environment undertook the following scope of work for this project:

- Undertake point source emissions sampling of stockpile activities of magnetite concentrate at the NSMP concentrate handling facility (CHF) focussing on:
  - Conveyor emissions (ie. conveyor CV07)
  - Stacking of concentrate
  - Front end loader activity at concentrate loading zone
  - Wind erosion from stockpile at concentrate loading zone

1.3 Report Structure

This report describes the methods and findings of the site investigation. The assessment includes:

- Study approach and methodology (Section 2)
- Monitoring results (Section 3)
- Conclusion (Section 4).

2 STUDY APPROACH AND METHODOLOGY

This section provides an overview of the study approach and methodology applied to derive the site specific emission rates, and to confirm their validity for inclusion in the site's dispersion model.

2.1 Overview

The purpose of this study to determine the potential emissions of magnetite concentrate when it is exported from the Herb Elliot port facility. Estimation of emissions requires a combination of suitable algorithms (emission factors), reliable data on activity levels and site conditions. Site-specific estimates are preferable as generic methods, such as the National Pollutant Inventory (NPI) emission estimation techniques, may not be relevant to actual conditions at a site.

Site specific measurements of dust sources and emissions were undertaken and site specific emission equations can be determined taking into account the characteristics and moisture of magnetite. A major benefit of this study is that it will provide FMG with detailed information to assist in determining suitable, and cost effective, dust abatement strategies.

2.2 Emission of Concern - Particulate Matter

Suspended solids or liquids in air are referred to as particulate matter (PM). Concentrations of particles suspended in air can be classified by an aerodynamic diameter, which describes the behaviour of the particle in the air based on its size and shape. The classification is described as:

- Total Suspended Particulate (TSP) – refers to the total amount of the PM suspended in air (regardless of size). Particles in air are subject to gravitational settling; particles larger than about 30 µm in aerodynamic diameter are likely to be removed by gravitational settling within a short time of being emitted (i.e. they settle to the ground or other surfaces fairly quickly). These larger particles are primarily associated with amenity or visibility issues.
- PM_{10} refers to the total of suspended particulate matter less than 10 µm in aerodynamic diameter. Particles in this size range can enter bronchial and pulmonary regions of the respiratory tract and can impact human health. Particles in this size range can remain suspended for many days in the atmosphere.
- $PM_{2.5}$ refers to the total of suspended particulate matter less than 2.5 µm in aerodynamic diameter. Epidemiological studies have shown that particles in this size range are associated with greater health impacts on humans than other particle sizes. These particles can remain suspended for months to years.

2.3 Key Emissions Sources for FMGL Operations

Emission sources (activities) identified for inclusion in the study are:

- Stockpile stacking
- Transfer stations
- Conveyors
- Wind erosion or windblown dust from stockpiles.

2.4 Field Measurement Methodology

A series of site measurements (traverses) were taken during a field trip specifically targeting the emission sources listed in Section 2.3.

In order to determine the dust emissions from various on-site sources, dust measurements were taken along a traverse downwind of the source using portable DustTrak monitors.

Measurements were undertaken at distances of 2 to 50 metres (m) downwind of the source and as close to right angles to the wind as possible. Depending on conditions, approximately eight traverses were undertaken by passing through the plume with the portable DustTrak monitors. The following conditions influence the quality of traverses, and therefore the estimation of emissions and subsequent trends and model validation:

- Operating conditions at the time of measurements (eg. conveyor may shut down)
- Increased dust emissions upwind of the source (eg. reclaimer may move location on a stockpile)
- Wind speed may increase/decrease during monitoring
- Wind direction may change during monitoring
- Traverse can become blocked by machinery.

The resultant profiles were analysed to generate horizontally integrated measures of the dust mass. Measured emission rates were then back calculated using the horizontal emission profiles, the vertical height of the plume, atmospheric stability and wind speed. The methodology used to back calculate the emission rates is presented in Appendix A.

This measurement methodology is consistent with that applied to other operations / premises in Port Hedland including the BHP Billiton Iron Ore operations in Port Hedland along with the Pilbara Port Authority (PPA) Utah Point operations and the Rio Tinto Cape Lambert, East Intercourse Island and Parker Point operations.

2.4.1 DustTrak Monitors

Dust measurements were taken using the TSI 8520 DustTrak aerosol monitoring unit. These instruments are mobile (portable) and can continuously monitor the concentration of suspended particulate matter less than 10 µm in aerodynamic diameter (PM_{10}). The DustTrak uses a laser to count the number of particles less than 10 µm in diameter.

These instruments provide sufficiently accurate, high-frequency data in field conditions. PM_{10} data was gathered in one second time intervals and logged internally by the DustTrak. This data was downloaded and analysed after completing monitoring at all sampling locations. Wind speeds were also be measured and recorded at the time of sampling using a hand held weather meter.

2.4.2 DustTrak Calibration

The DustTrak instrument (as supplied) is calibrated using Arizona road dust in order to convert these particle counts into a concentration estimate. Therefore, the instrument does not measure the actual concentration and for accurate results must be calibrated against another standard for the particulate of interest. For this study the DustTrak calibration obtained from the Herb Elliot Facility was used (PEL 2015).

2.4.3 Accuracy of Emission Estimation and Measurements - Limitations

While every effort is made to ensure dust sampling and emission calculations are as accurate as possible, there are sources of potential error associated with this methodology and sampling conditions. These errors may be associated with either the physical sampling of the dust, or those associated with emission estimation calculations.

Errors associated with physical sampling of dust may include the following:

- The plume sampled may be affected by another dust sources ie. show an elevated reading due to another dust source.
- Wind speed is taken as an average value, which may not reflect peaks in dust concentrations associated with wind gusts.
- Calibration of DustTrak to specific ore types.
- Distances of traverse to source may be difficult to measure due to various obstacles (ie infrastructure) between the source and traverse.

Errors may also be associated with source emission calculations. The main error is associated with an "idealised" method of calculating an emission rate, where by an empirical equation has been used to provide hourly average emission rate, however, in reality emissions would vary on a smaller time scale due to wind gusts, ore moisture and ore throughput.

3 MONITORING RESULTS

This section outlines the results of the 2015 dust emission source measurements undertaken at the CHF, located adjacent to the Great Northern Highway, approximately 110 kilometres (km) south of Port Hedland.

3.1 Field Measurements, Observations and Analysis

3.1.1 Conveyor

At the existing CHF there is a single conveyor which transports the concentrate to the stacker. This conveyor is fitted with scrappers at the head end (Figure 3-1). While these scrappers are effective at removing most of the concentrate which adheres to the conveyor they do not remove all of the material. As can be seen from Figure 3-2 the return side of the conveyor still has material adhering to it which has the potential to result in fugitive dust emissions.

Figure 3-1: Scrappers on head end of conveyor

Figure 3-2: Material adhering to return conveyor

At certain sections along the return conveyor there are fugitive emissions, particularly at belt pulleys and some return idlers. This is evident in Figure 3-3 where it can be seen that there is significant build-up of concentrate material around the pulleys. The area around this location was associated with the highest fugitive emissions observed at the site (Table 3-1).

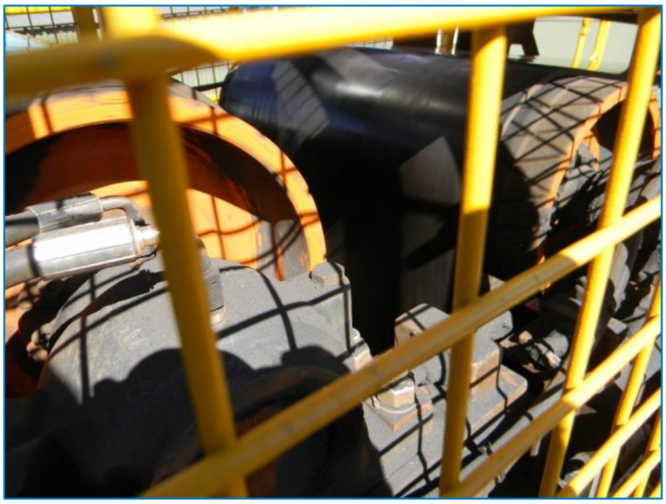

Figure 3-3: Fugitive emissions and build up of material around pulleys

A series of samples were taken at various points along the stacker conveyor at the CHF. The results of this sampling as presented in Table 3-1. From this table it can be determined that the average emission rate from the return idlers is 0.1 g/s though this varied from a maximum of 0.4 g/s to a minimum of 0.01 g/s.

The average emission rate from the pulley system at the belt take up point is 0.78 g/s which is significantly higher than that recorded at the return idlers. The impact from these elevated emissions is evident in Figure 3-3 and is evidence that further dust abatement is required beyond the installation of belt scrappers.

Table 3-1: Monitoring Results for Conveyor Emissions

Date	Sample Number	Wind Speed (m/s)	Location	Emission Rate (g/s)
23/6/2015	15NS002S	3.2	Return idler	0.16
23/6/2015	15NS003S	3.3	Pulleys (Belt take up)	0.53
23/6/2015	15NS004Sa	4.5	Return idler	0.40
23/6/2015	15NS004Sb	6.6	Return idler	0.01
23/6/2015	15NS004Sc	5.8	Pulleys (Belt take up)	0.47
23/6/2015	15NS005Sa	5.2	Return idler	0.07
23/6/2015	15NS005Sb	5.9	Return idler	0.09
23/6/2015	15NS005Sc	3.2	Pulleys (Belt take up)	1.56
24/6/2015	15NS006sa	2.3	Return idler	0.06
24/6/2015	15NS006sb	3.2	Return idler	0.05
24/6/2015	15NS006sc	3.1	Pulleys (Belt take up)	0.66
24/6/2015	15NS008sa	1.5	Return idler	0.04
24/6/2015	15NS008sb	4.5	Return idler	0.02
24/6/2015	15NS008sc	2.9	Pulleys (Belt take up)	0.70

It is therefore recommended that any conveyor belt longer than 60-80m be fitted with a belt washer at the head end. This minimum length ensures that the return conveyor belt has sufficient time to dry before additional product is loaded on it.

3.1.2 Stacking

The moisture of the concentrate being stacked is approximately 8.5% which is significantly higher the Dust Extinction Moisture (DEM) for magnetite which, according to information supplied by FMG, is 1.5%. With such a high moisture concentration emissions from the stacking were expected to be low and this was confirmed during the site investigation. The stacking of the concentrate can be observed in Figure 3-4.

Figure 3-4: Stacking of material

To further confirm that the stacking of magnetite concentrate would result in low emissions the operation of a front end loader (FEL) moving the stacked ore was observed. During this process no fugitive emissions were observed to be emanating from the dumping ore onto the final stockpile. It is important to note that the operation of a FEL only occurs at this pilot CHF as the proposed facility for the port will have an automated stacker/reclaimer system.

Figure 3-5: Front end loader dumping magnetite ore

A single emission sample was undertaken at the stacker and the calculated emission rate is presented in Table 3-2. From this table it is apparent that the emission rate from the stacking process is very low, primarily due to the very high moisture of the concentrate product.

Table 3-2: Monitoring Results for Stacking

Date	Sample Number	Wind Speed (m/s)	Emission Rate (g/s)
21/6/2015	15NS001S	3.1	0.03

3.1.3 Wind Erosion

During the site investigation wind speeds of up to 9.5 m/s were encountered however during these events no wind erosion emissions were evident from the concentrate stockpiles. The cause of this lack of emissions was investigated and it was determined that there were two main components. The first component is that the magnetite concentrate very quickly forms a crust on the surface of the stockpile. The formation of this crust on a stockpile that is actively being stacked is evident in Figure 3-6.

Figure 3-6: Crust forming on recently stacked stockpile

The second component is the lack of larger particles within the concentrate which removes two of the main causes of wind erosion – saltation and creep. Saltation occurs when the wind speed exceeds a threshold velocity resulting in particles, nominally 70 – 1000 µm in size, becoming airborne. Once airborne these particles are brought back to the surface by gravitational force with enough energy to result in finer particles (<70 µm) becoming airborne. These finer particles normally have significantly low gravitational settling velocities, particularly particles below 20 µm, and hence become suspended particles. Creep occurs when particles above 1000 µm in size are pushed along the surface by the wind (or saltating particles) resulting in lift off of finer particles.

As the concentrate material lacks the presence of large particles, especially above 100 µm, there is minimal opportunity for saltation or creep to occur and hence there is no suspension of material from the magnetite concentrate stockpiles.

3.2 Ore Moisture

Ore moisture is a critical factor for controlling fugitive dust emissions from haematite ore (such as that processed by Rio Tinto and BHP Billiton Iron Ore) and this is assumed to also be the case with magnetite concentrate. To verify this assumption investigations were conducted into the moisture concentrations at the surface and within the stockpile.

Field observations of a magnetite stockpile highlighted the appearance of wet and dry spots which are evident in Figure 3-7. The stockpile in this figure has been gradually constructed over 5 days with the oldest component being the section furthest away. A closer inspection of the stockpile (Figure 3-8) determined that the wet/dry components appear to be random with no relationship between either the age of the stockpile or the height. The formation of a crust on the surface of the stockpile also does not appear to be related to the surface moisture.

Figure 3-7: Wet/dry spots on stockpile

Figure 3-8: Crust and wet/dry spots on stockpile

To determine the moisture concentration of the magnetite on the surface of the stockpile a series of surface skim samples were taken over the course of two days. The results of these samples are presented in Figure 3-9. From this figure it is evident that the surface of the stockpile, with an average moisture concentration of 0.8%, is significantly drier than the stacked material (8.5%). However, unlike what occurs with haematite ore, this decrease in moisture does not equate to an increase in the potential for wind erosion (Section 3.1.3).

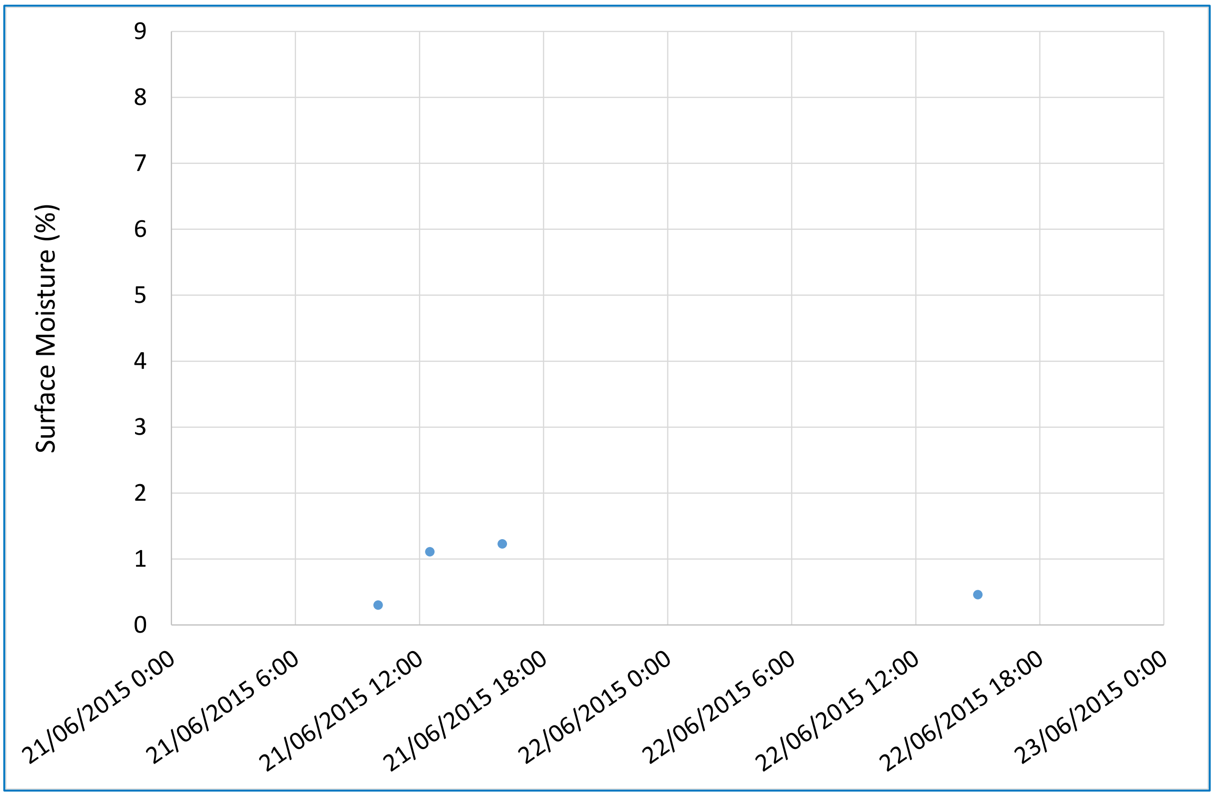

Figure 3-9: Surface moisture on stockpile

To gain a further understanding of the moisture concentration in a magnetite stockpile a series of spear samples were taken at two different heights from the base of the stockpile (1m and 2.5m) to a depth of approximately 15cm. These samples were taken over a single day and the moisture concentrations from this sampling are presented in Figure 3-10. The average moisture at 1m from the base of the stockpile is 6.6% while the average moisture at 2.5m from the base is 6.8%. These moisture concentrations, which are effectively the same, are approximately 22% lower than the stacked concentration (8.5%). This indicates that there is movement of moisture within the stockpile and further testing may be warranted to determine if the moisture is moving downwards under a gravitation effect or is being lost due to evaporation.

Given that the moisture concentration within the stockpile is significantly higher than the DEM for magnetite (1.5%) and that wind erosion does not appear to be a cause for concern any further investigations regarding ore moisture would have to be warranted on an engineering basis.

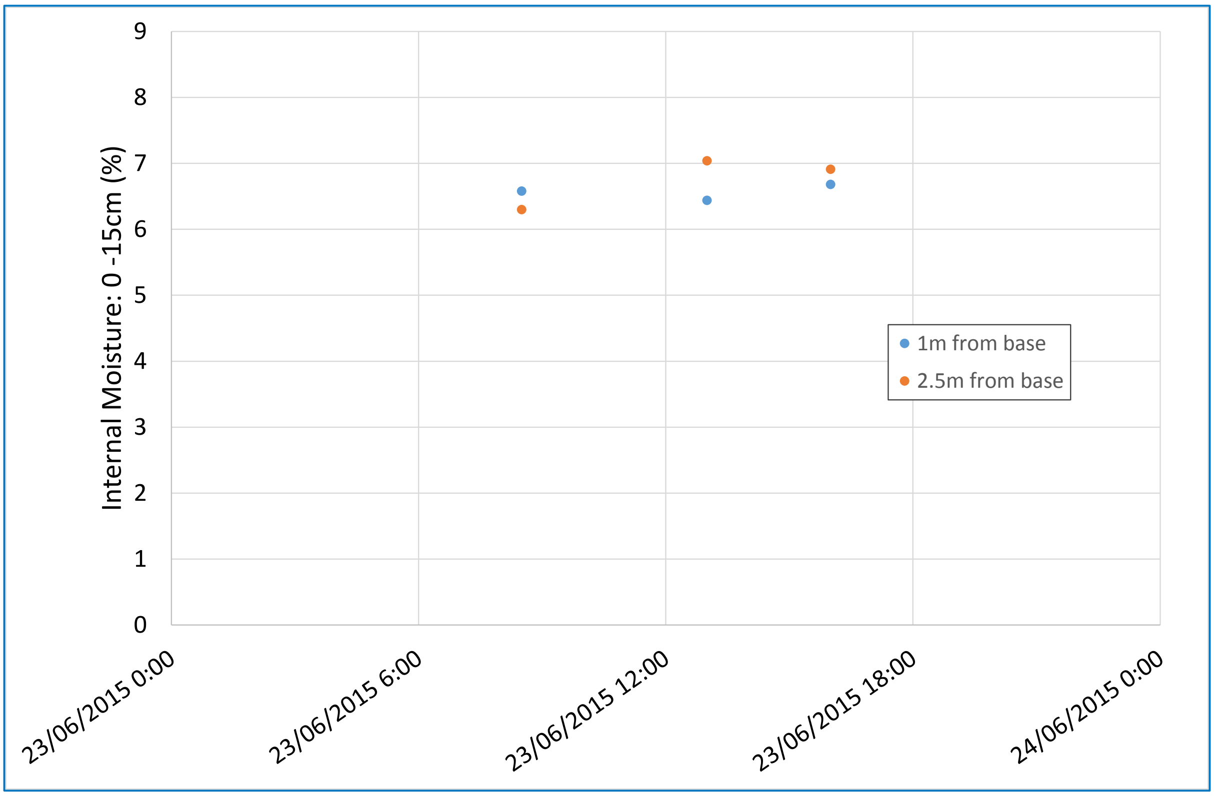

Figure 3-10: Moisture concentrations from 0-15cm deep into magnetite stockpile

4 CONCLUSION

Fortescue Metals Group Ltd (FMG) operates the North Star Magnetite Project (NSMP) located approximately 110 kilometres (km) south-south east of Port Hedland. The magnetite product from this facility will be transported to Port Hedland via a slurry pipeline. The slurry will be de-watered at a concentrate handling facility at the FMG Herb Elliot facility with the concentrate then being stacked before being reclaimed and exported.

To determine the potential emissions from the stacking/reclaiming/export operations at the Herb Elliot facility, Pacific Environment Limited was commissioned to undertake a point source emissions sampling program at the temporary concentrate handling facility located along the Great Northern Highway approximately 110km south of Port Hedland.

This survey focussed on emissions from the following activities:

- Stockpile stacking
- Conveyors
- Wind erosion or windblown dust from stockpiles.

The results of this monitoring program are as follows:

Conveyors: The high moisture content of the concentrate results in material adhering to the conveyor, resulting in emissions along the return side, particularly at belt pulleys and some return idlers.

Stacking: Minimal emissions were observed from stacking of the magnetite concentrate primarily due to the high moisture content of the ore.

Wind Erosion: No wind erosion emissions were observed during the site investigation, even during wind speeds of up to 9.5 m/s. This was determined to be resulting from:

- The formation of a crust on the surface of the stockpile
- Lack of large particles within the concentrate which removes two of the main causes of wind erosion – saltation and creep.

Based on the results of this field investigation the only potential fugitive emission associated with operating a concentrate handling facility at Port Hedland are from conveyors. It is therefore recommended that a belt wash station be fitted at the head end of all conveyors over 60-80m to supplement the belt scrapers.

Appendix A DETERMINATION OF DUST EMISSION RATES

The emission rates were calculated using the relationship between concentration, emission rate and the volume of air into which the pollutant is dispersed. The concentration can be calculated using Equation 1.

Equation 1

$$\chi = \frac{Q}{\Delta y \times \Delta z \times U}$$

Where:

χ	=	Concentration	(g/m³)
Q	=	Emission rate of substance	(g/s)
Δy	=	Distance perpendicular to wind	(m)
Δz	=	Distance in the vertical	(m)
U	=	Wind speed	(m/s)

Instead of assuming constant concentrations in the horizontal and vertical, for concentrations on the plume centreline a more realistic Gaussian shape must be assumed. This is achieved by replacing Δy in Equation 1 by $\sqrt{2\pi} \times \sigma_y$ and can be seen in Equation 2.

Equation 2

$$\chi = \frac{Q}{2\pi \times \sigma_y \times \sigma_z \times U}$$

Where:

χ	=	Concentration	(g/m³)
Q	=	Emission rate of substance	(g/s)
U	=	Wind speed	(m/s)
σ_y	=	Plume width standard deviation	(m)
σ_z	=	Vertical plume spread standard deviation	(m)

For ground level concentrations, from ground level sources, Equation 2 becomes Equation 3 where a factor of 2 has been introduced to account for particle reflection at the ground.

Equation 3

$$\chi = \frac{Q}{\pi \times \sigma_y \times \sigma_z \times U}$$

Where:

χ	=	Concentration	(g/m³)
Q	=	Emission rate of substance	(g/s)
U	=	Wind speed	(m/s)
σ_y	=	Plume width standard deviation	(m)
σ_z	=	Vertical plume spread standard deviation	(m)

Equation 3 will be approximately valid for the sources sampled in the trials, as they are all near ground level, with relatively large initial plume spreads.

In order to determine line sources, such as vehicular traffic or long conveyor belts, the concentration can be calculated using Equation 4.

Equation 4

$$\chi = \frac{2q}{sin(\phi) \times (\sqrt{2\pi}) \times \sigma_z \times U}$$

Where:

χ	=	Concentration	(g/m³)
q	=	Line source strength	(g/s/m)
ϕ	=	The angle between wind direction and line source	(°)
U	=	Wind Speed	(m/s)
σ_z	=	Vertical plume spread standard deviation	(m)

To determine the line source strength, the concentration downwind of the line source is measured, along with the wind speed and angle between wind direction and line source. The vertical plume spread standard deviation is then estimated from Equation 5.

Equation 5

$$\sigma_z = a(x + x_0)^b$$

Where:

σ_z	=	Vertical plume spread standard deviation	(m)
x	=	Down wind distance	(m)
x_0	=	Virtual distance	(m)
a	=	Dimensionless empirical parameter	(-)
b	=	Dimensionless empirical parameter	(-)

The dimensionless empirical parameters used to calculate the plume spread parameters can be found in Table A.1.

Table A.1: Dimensionless Constants Used to Calculate Plume Spread Parameters

Stability Class	Parameter a	Parameter b
A	0.180	0.945
B	0.145	0.932
C	0.110	0.915
D	0.085	0.870

The virtual distance is used to simulate the effect of the initial vertical plume size (σ_{z_0}) at the source. Equation 3 is determined by estimating the initial "size" of the dust cloud at the point of generation, dividing by 2.15 (Turner, 1970) and then inverting Equation 6.

Equation 6

$$\chi_0 = \left(\frac{\sigma_{z_0}}{a}\right)^{\frac{1}{b}}$$

Where:

χ_0	=	Concentration	(g/m³)
σ_{z_0}	=	Initial vertical plume size	(m)

a	=	Dimensionless empirical parameter	(-)
b	=	Dimensionless empirical parameter	(-)

The stability class was determined using the Pasquill Gifford stability classification based on wind speed and solar radiation (Hanna et al, 1982).

Inverting Equation 4, the line emission rate is determined by Equation 7.

Equation 7

$$q = \frac{sin(\phi) \times (\sqrt{2\pi}) \times \sigma_z \times U \times \chi}{2}$$

Where:

q	=	Line source strength	(g/s/m)
χ	=	Concentration	(g/m³)
ϕ	=	The angle between wind direction and line source	(°)
U	=	Wind Speed	(m/s)
σ_z	=	Vertical plume spread standard deviation	(m)

For point sources, such as stacking or from area sources, the emission rate was determined by rearranging Equation 3 to generate Equation 8.

Equation 8

$$Q = \pi \times \sigma_y \times \sigma_z \times U \times \chi$$

Where:

Q	=	Emission rate of substance	(g/s)
σ_y	=	Plume Width Standard Deviation	(m)
σ_z	=	Vertical plume spread standard deviation	(m)
U	=	Wind Speed	(m/s)
χ	=	Concentration	(g/m³)

By measuring the integrated horizontal flux of dust equal to $\int \chi \, dy$ or $\chi_{ave}\Delta_y$ or $\chi_{ave}\sqrt{2\pi} \times \Delta_y$, the emission rate can be determined by Equation 9.

Equation 9

$$Q = \frac{(\sqrt{2\pi})}{2} \times \sigma_z \times U \times \chi_{int}$$

Where:

Q	=	Emission rate of substance	(g/s)
σ_z	=	Vertical plume spread standard deviation	(m)
U	=	Wind Speed	(m/s)
χ_{int}	=	Integrated horizontal flux of dust	(g/m²)

For measurements which are not at the plume centreline, the reduction in concentration was determined assuming a reduction term (R) which is presented in Equation 10.

Equation 10

$$R = \exp\left(\left(-\frac{1}{2}\right) \times \left(\frac{\Delta z}{\sigma_z}\right) \times 2\right)$$

Where:

R	=	Reduction Term	(-)
σ_z	=	Vertical plume spread standard deviation	(m)
Δz	=	Vertical Distance	(m)

Equations 9 and 10 are combined to form Equation 11, which determines the reduction in concentration.

Equation 11

$$Q = \frac{(\sqrt{2\pi})}{2} \times \sigma_z \times U \times \chi_{\mathrm{int}} \times \left(\exp\left(\left(-\frac{1}{2}\right) \times \left(\frac{\Delta z}{\sigma_z}\right) \times 2\right)\right)$$

Where:

Q	=	Emission rate of substance	(g/s)
σ_z	=	Vertical plume spread standard deviation	(m)
U	=	Wind Speed	(m/s)
χ_{int}	=	Integrated horizontal flux of dust	(g/m²)
Δz	=	Vertical Distance	(m)

Appendix 9: Noise Management Plan

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Iron Bridge

Iron Bridge Port Facility

Noise Monitoring and Management Plan

September 2015

662PO-4000-PL-EN-0004

	Iron Bridge Port Facility – Noise Monitoring and Management Plan		**662PO-4000-PL-EN-0004**
Revision Number	**A**		**15/09/2015**
Status	**IFU - ISSUED FOR USE**		
Author	Andrew Winzer	Signature	17/08/2015
Checked	Clayton Brandwood	Signature	20/08/2015
Checked	Ken Wilyman		
Approved	Simon Carter	Signature	Click here to enter a date. 17/9/15
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	**N/A**		

Revision History *(to be completed for each version retained by Document Control)*

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Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.
Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.

	Iron Bridge Port Facility – Noise Monitoring and Management Plan		**662PO-4000-PL-EN-0004**
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Status	**IFU - ISSUED FOR USE**		
Author	Andrew Winzer	Signature	17/08/2015
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Checked	Ken Wilyman		
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Initial/Surname	Initial/Surname	Initial/Surname		Choose an item.	Click here to enter a date.

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1. INTRODUCTION

IB Operations Pty Ltd proposes to construct the Iron Bridge Port Facility within Fortescue Metals Group Ltd's Herb Elliot Port Precinct, located within the Port Hedland Inner Harbour in the Pilbara Region of Western Australia. IB Operations Pty Ltd is the managing entity for the Iron Bridge Joint Venture, a joint venture partnership between FMG Iron Bridge Pty Ltd and Formosa Steel IB Pty Ltd. IB Operations Pty Ltd is the proponent for this Proposal.

The Port Facility will accept magnetite concentrate as a slurry from the North Star Mine, located approximately 110km south of Port Hedland. Upon arrival at the Port Facility, water will be extracted from the slurry and returned back to the North Star Mine. The North Star Mine is also part of the Iron Bridge Joint Venture.

The extracted magnetite concentrate will then be stacked within a covered stockpile until a suitable volume has been received for export. Magnetite concentrate will then be reclaimed from the stockpile and loaded into bulk carrier ships for export via Fortescue Metals Group Ltd's existing port infrastructure. This 'outload circuit', consisting of Fortescue Metals Group Ltd's existing port infrastructure, does not form part of this Proposal.

2. NOISE MANAGEMENT STRATEGY

The objectives for noise management on the Iron Bridge Operations (IBOps) site and this NMMP are to:

1. Define environmental noise management measures that, if followed, will ensure IBOps noise emissions continue to comply with the Environmental Protection (Noise) Regulations 1997.
2. Define the measures to be adopted to manage and minimise noise emissions.
3. Outline the process for investigating noise complaints and implementing noise control solutions.

The intended environmental outcome from the implementation of the NMMP is that noise generated by IBOps will not lead to an increase in the cumulative noise impact in Port Hedland (as determined by the PHIC cumulative noise model).

The scope of this NMMP is limited to environmental noise from the IBO infrastructure and to definition of processes and noise management items required to achieve the objectives.

2.1 Baseline Noise Assessment: Summary

A noise impact assessment for IBOPS has been completed in 2015 (see SVT doc 1370422-8-100) as part of an assessment of the environmental impact of the project.

The aim of the environmental noise assessment was to quantify the noise emissions associated with the proposed North Star Magnetite Facility and assess compliance with the Environmental Protection (Noise) Regulations 1997 (the Regulations) at the nearest noise sensitive receivers. The noise impact assessment made the following conclusions:

- The Magnetite Facility in-isolation is compliant with the Regulations.
- The Magnetite Facility does not increase PHIC[1] cumulative noise levels[2] .
- Based on these results, no noise mitigation is required for the new Magnetite Facility.

2.2 Summary of Noise Management Actions

Table 1 summarises the noise management actions required by IBOps to ensure that the facility continues to comply with the objectives. Sections 3 to 5 provide detailed information for each of these noise management items.

Table 1 Summary - Noise Management Actions

Section of this plan	Item	Actions
3.1	**Annual Noise Monitoring and Reporting**	Annual noise monitoring, at locations agreed by IB during commissioning of the plant, will be undertaken to verify the equipment noise source levels (i.e. Sound Power Levels) and validate the noise model. The first round of noise monitoring will take place during commissioning or up to 1 month after commissioning. Subsequent monitoring will take place yearly. The results of the monitoring and model updates will be consolidated into an annual report. The monitoring results will be used to update the IBOps noise model. The model will be re-run after each update to determine compliance with the Regulations, and if applicable, the need for noise control.
3.2	**Noise Control**	If applicable (based on the results of item 3.1), noise control options will be defined and selected to achieve compliance with the Regulations, or to an ALARP[3] position.

[1] Port Hedland Industries Council (PHIC) Cumulative noise levels.

[2] It is inevitable that adding additional noise sources will increase the cumulative noise levels. However, the Magnetite facility adds to the second decimal place only (i.e. 0.01 dB). This is negligible and therefore has not been noted as an increase.

[3] As Low as Reasonably Practicable

Section of this plan	Item	Actions
		IBOps's noise model will be used to assist in determining ALARP and the selection of appropriate noise controls.
3.3	**Education and Training**	Undertake toolbox training sessions on environmental noise as required.
3.4	**New Equipment Purchasing**	Ensure that new equipment purchased has noise specifications defined and these are achieved. IBOps's and the PHIC noise model will be used to determine noise specifications. Install low noise idlers on all covneyors
3.5	**Equipment Maintenance**	All machinery and plant used on site will be maintained and serviced as per maintenance program. • Maintenance will include the following:mobile equipment fleet which will be regularly serviced to maintain the efficiency of equipment and prevent increases in emitted noise levels; • Regular maintenance of the conveyor belt drives and rollers will take place to reduce emitted noise levels • Regular inspection of machinery covers and insulation in order to ensure that they maintain their noise specification.
4.0	**Consultation and Complaints Process**	Noise complaints are to be directed to Iron Bridge Operations Community Office. The complainant will be notified of the progress of the investigation or the outcome of the investigation, where possible within 7 days
5.0	**Review of the noise management plan**	The NMMP will be reviewed every 5 years or earlier if deemed necessary by IBOps

3. NOISE MANAGEMENT: ACTIONS, GOALS AND RESPONSIBILITIES

3.1 Annual Noise Monitoring, Modelling and Reporting

Table 2 outlines the noise monitoring and reporting that will be undertaken to ensure IBOps continued compliance with the noise regulations.

Table 2: Annual Noise Monitoring, Modelling and Reporting

Objective/Target	To ensure that the IBOps noise model reflects current operations and the facility continues to be compliant with the Regulations.
Management Actions	Undertake annual noise monitoring to verify equipment noise source levels, validate the noise model, determine compliance with the Regulations and (if applicable) determine noise control actions required to achieve compliance. The first round of noise monitoring will take place during commissioning or up to 1 month after commissioning. Subsequent monitoring will take place annually. Preferred monitoring locations will be determined by IB during commissioninge plant. Provide the necessary resources to undertake the activities listed above.
Performance Indicators	Compliance with the Environmental Protection (Noise) Regulations 1997.
Monitoring	Annually.
Reporting	A report is to be developed, summarising results of annual monitoring.
Corrective Action	Where the noise report identifies non-compliance, noise control analysis and implementation will be undertaken as per section 3.2.
Term	For the life of the project.
Responsibility	Site Environmental Superintendent

3.2 Noise Control

Table 3 outlines the approach IBOps will take when the requirement for noise control is identified in monitoring and modelling (section 3.1).

Table 3: Noise Control

Objective/Target	Reduce received noise levels at noise sensitive receivers to be compliant with the Regulations.
Management Actions	If applicable (based on the results of item 3.1, a noise ALARP process in line with the regulations will be developed by IBOps after commissioning of the plant. In the event that noise control is triggered by a non-compliance event the following process will be followed: • Determine noise control options. • Select noise control measure, undertake detailed design and implement. • Measure and verify success of noise control implementation.
Performance Indicators	All identified noise non-compliance undergoes the noise control process as defined in the management actions (Table 2)
Monitoring	Undertake annual noise monitoring and reporting and the effectiveness of any control measures that were required as a result of a non-compliance.
Reporting	A report is to be developed, summarising results of annual monitoring.
Corrective Action	Where noise reports or audits determine non-compliance, noise control processes are to be initiated.
Term	Life of the project.
Responsibility	Engineering Superintendent

3.3 Education and training

Table 4 outlines the approach IBOps will take towards ensuring employees and contractors are aware of their obligations.

Table 4: Management Strategies for Noise Awareness and Training

Objective/Target	To ensure that personnel are aware of their responsibilities in reference to noise management.
Management Actions	Include and deliver an awareness of noise issues in site inductions for all site personnel after commissioning. Undertake toolbox training sessions on environmental noise as required.
Performance Indicators	Proportion of personnel that have received environmental noise awareness training (>90%).
Monitoring	Monthly review of training numbers.
Reporting	Annual Environmental Report.
Corrective Action	Where internal audits demonstrate that appropriate training and education has not been undertaken, additional targeted training programs will be undertaken.
Term	Life of the project.
Responsibility	Site Environmental Superintendent

3.4 New Equipment Purchasing

The approach IBOps will take towards ensuring noise emissions are considered when plant and equipment are being acquired is outlined in Table 5.

Table 5: Equipment Acquisition

Objective/Target	Ensure new equipment noise specifications are defined and achieved.
Management Actions	Ensure that new equipment purchased has noise specifications defined and these are achieved.
Performance Indicators	Evidence of the implementation of noise specifications in purchasing.
Monitoring	Annual noise monitoring.
Reporting	Annual noise report.
Corrective Action	Instances where purchasing has not included noise specifications for mobile and rotating equipment will be reported as an incident and investigated accordingly.
Term	Life of the project.
Responsibility	Procurement Manager

3.5 Equipment Maintenance

The IBOps approach to equipment maintenance to minimise noise emissions is outlined in Table 6.

Table 6: Equipment Maintenance

Objective/Target	Ensure that all plant items are maintained within noise specification and acceptable noise emissions are met.
Management Actions	All machinery and plant used on site will be maintained and serviced as per maintenance program. Regular maintenance of the conveyor belt drives and rollers to reduce emitted noise levels. Regular inspection of machinery covers and insulation will be built into the maintenance regime in order to ensure that they maintain their noise specification.
Performance Indicators	Maintenance records.
Monitoring	Annual noise monitoring.
Reporting	Annual noise report.
Corrective Action	All machinery and plant that show deterioration in noise level or do not pass the noise measurements taken by maintenance will follow the noise control process.
Term	Life of the project.
Responsibility	Operations Manager

4COMPLAINT RESPONSE PROCEDURE

Should a complaint be received during the operation of Iron Bridge Port FacilityS, the complaint will be investigated with the following procedure and outcomes documented:

- Noise complaints are to be directed to Iron Bridge Operations Community Office.
- The nature of the noise complaint will be determined. IBOps will determine if the complaint is attributable to IBOps and what noise sources were contributing at the complainant's residence.
- If attributable to IBOps, the identified equipment will be subjected to additional noise source measurements in order to determine if there have been any significant changes since the last set of measurements.
- If necessary, IBOps will implement the noise control process (Section 3.2).
- The complainant will be notified of the progress of the investigation or the outcome of the investigation, where possible within 7 days.

5. REVIEW OF THE NOISE MANAGEMENT PLAN

The NMMP will be reviewed every 5 years or earlier if deemed necessary by IBOps. Reviews will take into account the following;

- Any changes to the IBOps design or operations that require modifications to the environmental management procedure outlined in this plan.
- Any noise management issues and outcomes identified from internal or external audits.
- Corrective or improvement actions developed in response to operational experience, complaints or changes to IBOps environmental management systems.

Appendix A: Applicable Legislation and References

APPLICABLE LEGISLATION

IBOps will comply with all Commonwealth and State legislation that applies to the management of the development and operation with regard to noise.

REFERENCES

[1] Environmental Protection Act 1986.

[2] Environmental Protection (Noise) Regulations 1997.

[3] SVT Report 1253921-9-100 'Port Hedland Cumulative Environmental Noise Study'.

[4] SVT Report 1370422-3-100 'Environmental Noise Assessment: Magnetite Processing'.

[5] SVT Report 1370422-8-100 'Magnetite Facility Stage 2 Environmental Noise Assessment'.

RELEVANT DOCUMENTS

This Management Plan is to be read in conjunction with the following:

- AS2436:1981 Guideline to Noise Control on Construction, Maintenance and Demolition Sites.
- AS1055:1997 Acoustics- Description and Measurement of Environmental Noise.
- Guideline: Noise Control in Mines (2005), DOCEP, WA.

APPENDIX B: NOISE CRITERIA

Noise management in Western Australia is implemented through the *Environmental Protection (Noise) Regulations 1997* [2], which operate under the *Environmental Protection Act 1986 [1].*

The *Regulations* specify maximum noise levels (assigned levels), which are the highest noise levels that can be received at noise-sensitive premises, commercial and industrial premises. The assigned noise levels used in the Port Hedland Industrial Council (PHIC) have been adopted for this study and are presented in Table B-1. The locations of sensitive receivers are graphically presented in Figure B-1.

Table B-1 Assigned noise levels of receivers considered for IBJV study

Location[4]	GPS co-ordinates (MGA94)		L_{A10} Night-time Assigned Levels, dB(A)	L_{A10} Night-time Assigned Levels, dB(A) less 5 dB[5]
	Eastings	Northings		
Esplanade Hotel, Port Hedland	664608	7752926	49	44
McKay Street, Port Hedland	664746	7753342	42	37
Crow Street, Port Hedland	665570	77530349	38	33
Wedgefield (Caretakers' Residences only)	665509	7746336	65	60
Parker Street (Lawson), South Hedland	667033	7743388	35	30
White Hill Estate	665758	7739062	35	30
Brearley St , Port Hedland	667699	7753338	37	32
Hospital , Port Hedland	665799	7753424	37	32
Police Station, Port Hedland	664652	7753117	52	47
Pretty Pool, Port Hedland	671261	7752609	35	30
South Hedland	667852	7742771	35	30

[4] Additional receivers have been added for comparison with noise assessment undertaken by the PHIC [3].

[5] This applies for receivers where there is, or is predicted to be, an exceedence of the assigned levels.

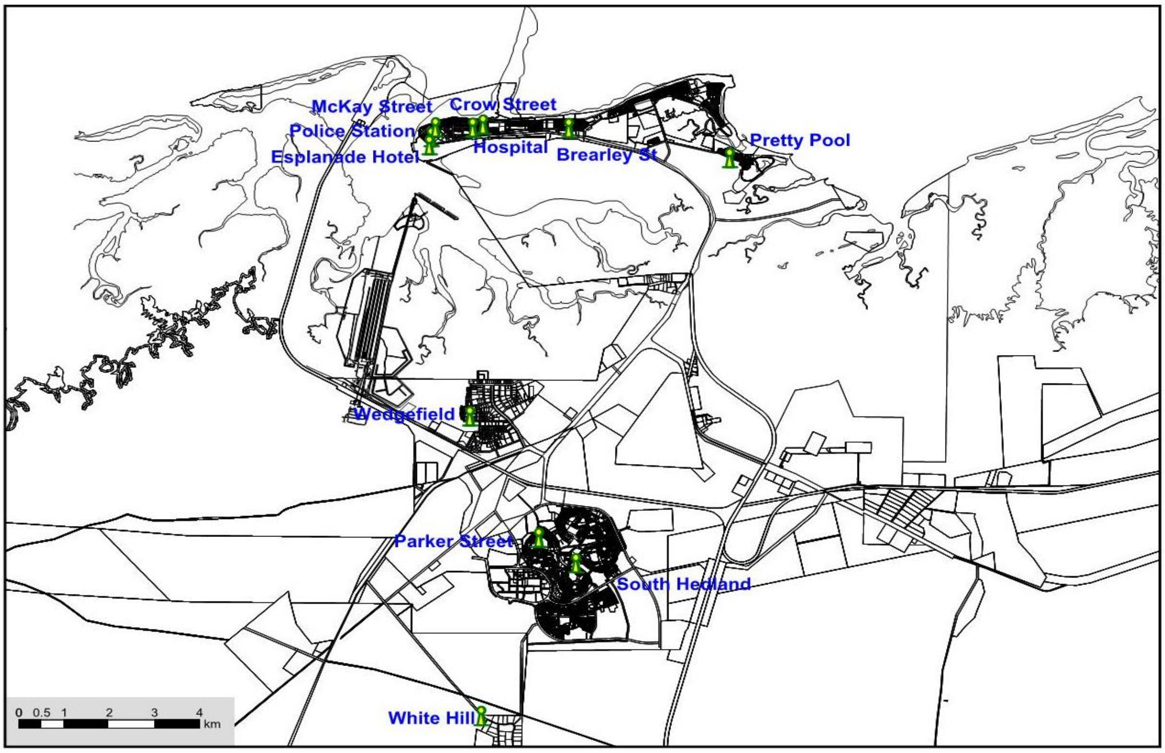

Figure B-1 Key Noise Sensitive Receivers