roy hill iron ore pty ltd | june 2009








roy hill 1 iron ore mining project

stage 1 public environmental review fortescue marsh management plan

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1 Introduction

1.1 Project overview

The Roy Hill 1 Project has a total operating life of approximately 20 years; however the operation will be divided into two stages. The scope of the two stages is described below:

- Stage 1: construction of all infrastructure to meet the full 20 year life of mine, plus mining and processing ore from the Stage 1 Mining Area. Dewatering to provide 'dry' mining conditions in the Stage 1 area and advanced dewatering from future mining areas in Stage 2 in the southeast of the project area will supply the majority of water for operations. Additional water from opportunistic capture of rainfall will also be used to make up any shortfall. This will mean that all water requirements for Stage 1 would be sourced entirely from within the Project area and an external water supply would not be required. Saline water produced from dewatering will be disposed in an evaporation pond.
- Stage 2: mining and processing ore from the Stage 2 Mining Area and an external water supply.

1.2 Purpose of this document

The purpose of the Fortescue Marsh Management Plan (FMMP) is to describe how Stage 1 activities will be managed during construction, operation and post-closure to:

- maintain conservation values associated with the Fortescue Marsh (the Marsh) and associated wetlands;
- manage surface water resources and quality to maintain environmental values;
- maintain beneficial uses of groundwater resources;
- minimise adverse impacts on the abundance, species diversity, geographic distribution and productivity of vegetation communities; and
- manage operations in a manner which minimises adverse impacts on the abundance, species diversity, geographic distribution and productivity of terrestrial fauna at species and ecosystems levels.

1.3 Objectives

The objective of the FMMP is to manage Project activities on site so that conservation values associated with the Marsh are maintained during construction, operations and post-closure.

1.4 Relevant legal and other requirements

The legal and other requirements of the FMMP are provided within the reference list of this document.

1.5 Implementation

The FMMP will be implemented prior to the commencement of construction and will be regularly updated throughout the life of mine. The management measures provided in this management plan will guide the Project's detailed mine design.

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2 Fortescue Marsh

The Fortescue Marsh is an extensive intermittent wetland located, at its nearest point, approximately 1.5 kilometres (km) to the southwest of the Project operations. It is bound by the Chichester Range to the north and the Hamersley Range to the south, occupying an area of 1,000 square kilometres (km^2) when in flood (Department of Environment, Heritage, Water and the Arts (DEHWA), 2008a). The Marsh is a depositional feature that receives runoff from the 30,700km^2 upper Fortescue River catchments as well as many creeks and tributaries which drain the adjoining Chichester Ranges. In major storm events sheetflow can become an important inflow source (Gilbert and Associates, 2009).

2.1 Conservation significance

The Marsh supports a rich diversity of migratory birds and is recognised by the Commonwealth under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA). The Marsh is also listed as an Indicative Place on the register of National Heritage Places for the conservation of waterbirds as it is important for periodic breeding by waterbirds, especially *Pelecanus conspicillatus* (Australian Pelican) and *Cygnus atratus* (Black Swan) (DEHWA, 2008b). Other species include the *Anas gracilis* (Grey Teal) and *Fulcia atra* (Eurasian Coot) which are seen within the Marsh.

The Marsh is also recognised by the DEC as having particular heritage and conservation values. On expiration of pastoral leases in 2015, the DEC plans to obtain reserve status for an area of 42,388 hectare (ha) covering sections of the Marsh and surrounds, referred to as a proposed conservation estate (DEWHA, 2008a). The eastern margin of the proposed conservation estate will be located more than 15km west of the Project.

2.2 Hydrology

Stream flows in the Pilbara Region tend to be a direct response to rainfall seasonality and variability. Most runoff periods occur during January to March, with least runoff occurring during the months of April to December. Other major tributaries contributing to the Marsh are Weeli Wolli, Yandicoogina, and Mindy Mindy Creeks with smaller tributaries including Kulbee, Kulkinbah and Christmas Creeks, draining the slopes of the Chichester Ranges near the Project area (DoW, 2000; Gilbert and Associates, 2009). Table 2-1 below identifies the drainage catchment within the Project area.

Table 2-1: Project area catchment.

DRAINAGE CATCHMENT	CATCHMENT AREA AT DOWNSTREAM LEASE BOUNDARY (km^2)
Kulkinbah Creek	703
Kulbee Creek	38
No-name Creek	88
Central catchment	31

The Marsh predominantly lies *between 400 metres (m) to 405m above sea level and the flood level in the Marsh would need to be 415m above sea level to overspill westwards into the Goodiadarrie Hills* (Fortescue Metals Group Pty Ltd (FMG), 2006a, P6). In the event of significant rainfall periods, sheetflow becomes an important inflow water source for the Marsh. During more localised rainfall events, *temporary pools form within the Marsh, near to the main inflow point, or in larger more-regional events such as major cyclones, a large proportion (or all) of the Marsh may become inundated* (FMG, 2006a, P6).

A surface water assessment conducted by Gilbert and Associates (2009) for the Project has provided the following results:

Baseline hydrological monitoring was conducted on Kulbee Creek; with three flow monitoring sites and three pluviometers being set up in November 2006. The sampling locations correspond to the upper, mid and lower sections of the Mining Lease Area (MLA). The gauging stations recorded water level in a well installed within the creek bed alluvium, which is converted into equivalent flow rates using a rating relationship which was developed using a hydraulic model of the creek in the vicinity of each gauging station site (Gilbert and Associates, 2009). The data collated from baseline hydrological sampling since 2006 indicates:

- hydrographs generated from larger rainfall events showed a rapid rise and recession;
- no evidence of any significant base flow contribution to runoff with recorded water levels falling below the stream bed soon after flow; and
- runoff generation being higher in the more elevated areas of the catchment, which dominate the catchment above the upstream gauging site, than in the lower flatter catchment areas which dominate the residual catchment between the middle and lower gauging stations.

Regional runoff is highly variable and on average, is a small proportion of annual rainfall, increasing with the higher and more prolonged rainfall events. Regional runoff is influenced by rainfall and typically there tends to be little or no runoff in years when rainfall is less than 150 millimetres (mm) to 200mm. In comparison, in years of higher rainfall events, runoff is approximately 3% of rainfall. Local knowledge also indicates that local drainages only flow during and for relatively short periods after significant rainfall and that under these conditions flow response and the subsequent recession is typically rapid (Gilbert and Associates, 2009).

2.2.1 Flood hydrology of local creeks

Inflows to the Marsh occur from the Fortescue River and other creeks within the region, along with sheet flow after storm events. The results of the estimated peak flood discharges for Kulkinbah, Kulbee and No-name Creek are listed in Table 2-2 (Gilbert and Associates, 2009).

Table 2-2: Estimated peak flood discharges.

CREEK	LOCATION	ANNUAL EXCEEDENCE PROBABILITY		
		20% (1 in 5 year ARI)	**5% (1 in 20 year ARI)**	**1% (1 in 100 year ARI)**
Kulbee	Upstream diversion	30 (m^3/s)	76 (m^3/s)	146 (m^3/s)
No Name	At northern lease boundary	62 (m^3/s)	176 (m^3/s)	369 (m^3/s)

ARI: Average Recurrence Interval

2.2.2 Water quality

Water quality data is limited for the Marsh. However, between August 2003 and August 2006 the DEC collected eight water samples for basic water quality analysis. The results provided a 'snapshot' of the water quality in the Marsh indicating:

- a moderate to high saline ecosystem dominated by sodium chloride and calcium sulphate (Pinder, 2006); and
- high concentrations of nitrogen and phosphorus in comparison to trigger levels of disturbed aquatic ecosystems provided in the Australia and New Zealand Environment and Conservation Council (ANZECC) *Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000).

2.3 Hydrogeology

Groundwater in the Pilbara Region is generally fresh except away from the main rivers on the coastal plain. Groundwater in the Fortescue Valley is fresh to brackish except in the Marsh where saline groundwater is dominant.

Saline waters exist in the aquifer systems where they extend below a level of 370m Australian Height Datum (AHD). Salinity increases in the direction of groundwater flow, in areas of low permeability and with increasing depth. Groundwater quality in the outcrop areas and in the upper levels of the alluvial deposits away from the Marsh is considered fresher (MWH, 2007).

On the flanks of the Marsh the groundwater is hypersaline due to concentrations of salt through evaporation (Van Vreeswyk *et al*, 2004). Freshwater recharge into alluvial deposits flows towards the Marsh, where it mixes with saline waters in the Marsh. Saline water depths are very shallow near the Marsh (MWH, 2007).

The following studies have been undertaken to improve the understanding of hydrogeological characteristics within the Project area:

- MWH (2007) *Roy Hill Hydrogeological Assessment Part A, Interim Report* prepared for Roy Hill Iron Ore Pty Ltd; and
- MWH (2009a) *Dewatering Strategy.* Report prepared for Roy Hill Iron Ore Pty Ltd.

2.4 Flora and vegetation

The flora and vegetation composition of the Marsh consists of *Atriplex cinerea* and *Halosarcia halocnemoides*, which occur together with grasses, (*Eragrostis, Panicum* and *Aristida* spp., and forbs, *Ptilotus* spp) and woodland species (*Eucalyptus victrix*, and *E. camaldulensis* and *Melaleuca* spp) occur along creeks entering the Marsh (Beard, 1975).

Mulga communities occur along the fringes of the Marsh and are dependent on surface water runoff and sheet flow. Mulga communities are considered significant because they:

- may support and/or provide refuge for other flora and fauna species;
- play an integral role in water and nutrient capture and are important to ecosystem function; and
- are susceptible to disturbance from impacts such as grazing, fire and weeds.

The majority of the mulga woodlands that occur within the tenement boundaries are found within the vicinity of drainage lines and on the southwest, outside boundary of the tenement towards the Marsh.

The vegetation within the Roy Hill Project area, in particular the riparian communities, are in relatively poor condition due to extensive historical and current pastoral activities that extend to the Marsh. This also applies to a lesser yet significant degree to mulga communities within the Project area (Ecologia, 2009).

2.5 Fauna

When in flood, the Marsh has the capacity to support a rich diversity of migratory birds. Within the entire Fortescue River Floodplains, 22 waterbird species are known to use the Marsh area. Within the Marsh, one fish species is known to occur, the spangled grunter (*Leiopotherapon unicolour*) (DEWHA, 2008b). No listed threatened fauna species occurs within the Marsh in accordance with *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) and *Wildlife Conservation Act 1950* (WA).

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3 Risk assessment

3.1 Methodology

As part of the Environmental Impact Assessment (EIA) a qualitative assessment was undertaken to assess the risk posed to the environment, including the Marsh, by the proposed Project. The environmental risk assessment was conducted by SMEC Australia Pty Ltd (SMEC), on behalf of RHIO. The risk assessment process followed the framework outlined in *AS/NZS 4360:2004 Risk Management* and the guidance material provided in *Leading Practice Sustainable Development Program for the Mining Industry—Risk Assessment and Management* published by the Commonwealth Department of Energy, Resources and Tourism (DERT, 2008).

3.2 Participants

The Risk Assessment workshop was conducted to provide expertise on potential environmental impacts of Project activities on the Marsh. The workshop involved representatives from the following organisations:

- Roy Hill Iron Ore Pty Ltd (Proponent);
- SMEC Pty Ltd (Environmental Impact Assessment);
- MWH Australia (Hydrogeology);
- Gilbert and Associates (Hydrology);
- Ecologia (Flora and fauna); and
- Heggies Pty Ltd (Noise and Dust).

3.3 Inherent risks

Each hazard was identified and assessed based on its environmental consequence and the likelihood of the unwanted event/outcome occurring. Each assessed hazard was assigned a severity rating from a qualitative risk matrix. The hazards were assessed for their inherent risk without any control measures in place. Planned control and mitigation measures (management plans, procedures, engineering controls, and similar) were then identified and the hazard reassessed. The resulting “residual risk” severity was calculated and the risks with a “residual risk” rating of extreme, high or moderate were classified as key issues requiring specific mitigation and management measures as provided in the following section.

Other impacts not rated as extreme, high or moderate have been assessed and summarised in section 3.4 (potential impacts).

3.3.1 Surface water flows

Indirect impacts on the Marsh from changes to surface water flows are considered an inherent risk with a “high” risk rating factor. The inherent risks are associated with Project activities that alter runoff volumes, flow paths, velocities and water quality due to construction of mine infrastructure and temporary diversions, (eg Waste Fines Storage Facility (WFSF), rail loop, salt evaporation pond etc). Mitigation measures consist of:

- engineering designs for surface water flow structures (eg culverts and sheet flow re-dispersion mechanisms);
- hydrological investigations (eg water balance assessments);
- stabilisation of disturbed areas; and
- stormwater management plan.

After implementation of mitigation measures and management strategies, the residual risk was considered moderate.

3.3.2 Groundwater

Dewatering for ‘dry’ mining will require management of the saline interface associated with the Marsh. Saline water, not suitable for processing, will require disposal. Disposal of saline water has the potential to cause a reduction in ground and surface water quality flowing to the Marsh. Dewatering and groundwater abstraction also has the potential to reverse the hydraulic gradients between the Marsh and the Project. The inherent risk rating factor for groundwater is classified as “high”. Proposed mitigation measures consist of:

- designing, constructing and operating a saline management system (eg lined evaporation pond, salt production facility and in-pit encapsulation cells);
- implementing and continually improving the dewatering strategy for the Project; and
- developing and implementing a Borefield Management Plan for the water supply borefield within the Project Area.

The residual risk to groundwater associated with the Marsh from Project activities is high. Monitoring within the Project area (up-gradient of the Marsh), will be ongoing throughout the Project. Further engineering of the evaporation pond and encapsulation cells will be conducted during detail design, with the aim of minimising risks to groundwater quality.

3.3.3 Erosion and sedimentation

Ground disturbance (land clearing from Project activities) has the potential to impact the Marsh indirectly, through increased erosion and sedimentation. Erosion and changes in sedimentation regimes through ground disturbance was considered an “extreme” inherent risk rating factor. Hazards associated with ground disturbance consist of habitat disruption/reduction that can lead to increased erosion and changes in sedimentation to the Marsh. Mitigation measures proposed to minimise the inherent risks included:

- undertaking progressive clearing and rehabilitation;
- minimising ecological footprint through mine planning;
- compliance with ground disturbance permits;
- locating infrastructure where practical to avoid priority flora and fauna habitat sites;
- providing a 500m buffer to contain and manage potential impacts within the Project boundaries; and
- implementation of surface water engineering designs (eg water storage and drainage control structures) and an integrated site sediment and erosion control plan to minimise impacts on downstream environments (the Marsh).

With the implementation of mitigation measures and proposed management plans, the residual risk was still considered extreme due to the scale of disturbance over the life of the project. To minimise these impacts, additional management strategies have been developed that consist of:

- minimising clearing of native terrestrial vegetation,
- use of markers/flagging to clearly delineate vegetated areas to be cleared; and
- use of vehicle hygiene and weed control measures.

3.4 Potential impacts

The Project has the potential to impact ecosystem and conservation values associated with the downstream environment and indirectly the Marsh. However, these impacts can be minimised and managed with the implementation of strategies described in section 4 (management strategies). Potential impacts on the Marsh from Project activities are summarised in Table 3-1:.

Table 3-1: Summary of potential impacts on the Marsh.

ENVIRONMENTAL FACTOR	PROJECT PHASE	POSSIBLE IMPACTS TO FORTESCUE MARSH
Surface Water	Construction and Operation	Impacts on downstream receptors from changes to runoff volumes, flow paths, velocities and water quality due to construction of mine infrastructure and temporary diversions. Increased erosion and sediment movement from land clearing. Contamination of surface water by hydrocarbons, explosives, chemicals and acid mine drainage. Contamination of surface water from leakage or rupture of evaporation cells and associated pipes.
	Closure	Drainage instability and erosion of post-mine land forms altering sedimentation regime. Increased sedimentation of surface water through increased erosion of inadequately rehabilitated landforms. Interruption of surface water flows contributing to loss of inflows into the Marsh.
Groundwater	Construction	Potential reversal of hydraulic gradients between Fortescue Marsh and pit dewatering activities. Drawdown of the groundwater table from pit dewatering impacting on groundwater dependant phreatophytic vegetation at or near the Marsh, eg *Eucalyptus victrix* and *Eucalyptus camaldulensis* as well as groundwater dwelling stygofauna.
	Operation	Leaching of hypersaline water from evaporation cells. Seepage from the WFSF and salt evaporation pond facility causing mounding and or changes in quality of groundwater beneath WFSF resulting in localised inundation of vegetation communities downstream of WFSF. Contamination of groundwater by hydrocarbons, explosives, chemicals and AMD.
	Closure	Reduction in groundwater quality from in-pit encapsulated salt.
Erosion and Sedimentation	Construction and Operation	Runoff or discharge of wastewater potentially contaminating or increasing sediment flow downstream into the Marsh. Ground disturbance, weed invasion and feral animals causing increased erosion and sedimentation of surface runoff into the Marsh.
Fauna	Construction and Operation	Changes in behavioural patterns to significant migratory avifauna species predating on insects attracted to Project lighting and avifauna attracted to artificial aquatic ecosystems (evaporation pond and WFSF).
Ecosystem Health	Construction and Operation	Degradation of surface water dependent environments (ecosystem health) from changes in surface and sheet flow (low mulga woodlands). Degradation of groundwater dependent environments from changes in groundwater levels from dewatering and abstraction (phreatophytic vegetation).
Cumulative Impacts	Construction and Operation	Cumulative impacts on the Marsh from surrounding operations from changes in surface water volumes, dewatering and quality, ecosystem health and (mulga woodlands) and regional hydrogeology.

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4 Management strategies

This section sets out the management strategies for the Project to minimise impacts on the downstream environment and indirectly the Marsh. In addition, the Integrated Water Management Plan and Conceptual Closure and Rehabilitation Plan provide management and monitoring of the downstream and Fortescue Marsh environment.

4.1 Surface water

The location of the Pits and infrastructure will intercept surface flows and run-off. Stormwater management will entail construction of a series of upstream creek diversions which would direct flows via linked spillways into adjacent catchment areas. The intention of the diversion structures is not to reduce flows downstream with only minor loss through evaporation and seepages. Assuming the complete loss of the combined capacity of the volume of the diversions, it is estimated that this would represent about 12% of the runoff from these catchments in a median year. When translated to the Marsh itself it would represent about 0.03% of average surface inflows which would have no measurable effect on water levels in the Marsh (Gilbert and Associates, 2009).

Large rainfall events with significant runoff will carry increased sediment load from disturbed areas and newly engineered diversions into the Marsh system. The sediment load is likely to be deposited in flats between the Project boundary and the Marsh creating “delta” like features in large events (Gilbert and Associates, 2009).

The Proponent’s consultant Gilbert and Associates has developed a conceptual stormwater management plan to divert surface flows during all phases of mining. This management plan, the Integrated Water Management Plan, as well as the Conceptual Closure and Rehabilitation Plan, will be implemented to minimise surface water impacts during all phases of mining.

The control systems discussed in Table 4-1 will be located within and upstream of the 500 metre drainage buffer zone to allow for treatment and distribution of surface flows prior to the Project boundaries. With the implementation of these control designs, impacts on the Marsh will be reduced (Gilbert and Associates, 2009).

All diversions and control systems for managing drainage, runoff and sediment and erosion will be designed so that any surface flows or sediment leaving the Project site is below agreed trigger levels. Response trigger levels will be activated if the ratio of peak flow to catchment area in an impacted creek exceeds the same ratio in non-impacted creeks by either 20% or one standard deviation. Appropriate trigger levels will be established and implemented upon collection of baseline data prior to construction. Refer to section 5 (monitoring) for a summary and the IWMP for detailed Baseline Water Quality Monitoring.

Management of surface water impacts is described in Table 4-1.

Table 4-1: Management of potential surface water impacts.

MANAGEMENT OF POTENTIAL SURFACE WATER IMPACTS	
Objectives	Maintain the quantity of the water to protect the values of downstream environments, including ecosystem maintenance. Maintain the integrity, ecological functions and environmental values of the Marsh. Manage surface water resources so that their beneficial uses are not compromised.
Targets	No significant changes in surface water quality. No change in ecological functions and environmental values of the Marsh as a result of mining operations.
Potential Surface Water Impacts	Refer to Table 3-1.

MANAGEMENT OF POTENTIAL SURFACE WATER IMPACTS	
Management Strategies	Avoiding where practical constructing infrastructure in locations blocking overland flow. Construct diversions and flow dispersion systems (culverts) around infrastructure to convey flows into existing downstream drainages. Design permanent diversion channels and flood plain reconstruction works with similar characteristics as the natural drainage system. Surface water diversion channels to be installed to divert upslope stormwater runoff around evaporation pond and sedimentation basins to control sediment load entering the natural drainage system. Water (not contaminated) comprising runoff and seepage from out of pit overburden waste emplacement (waste rock dump) and from ore stockpile and load out facility areas would be intercepted via bunding, contained in catchment storage areas and used to meet dust suppression demands. Construct flow re-dispersion devices down slope of culverts and diversion drains. Install culverts beneath roads to limit shadowing. Design and construct the realignment of Marble Bar Road to minimise ponding of surface water upstream. Implement a 500m drainage buffer zone along the western boundary to contain and manage impacts associated with changes in surface hydrology such as shadow effects, contaminated runoff, poor water quality and increased sedimentation within the tenement boundaries. Progressive rehabilitation of disturbed areas. Design and implement control and diversion systems for managing drainage, runoff, sediment and erosion. Undertake regular maintenance of an equipment washdown and oil recovery facility. All spills/leaks to be correctly cleaned up and disposed in accordance with the Chemical and Hydrocarbon Spill Procedure. All chemicals and hydrocarbons to be stored according to Australian Standards. Remediation and/or disposal of hydrocarbon contaminated soil at a soil remediation farm. Develop and implement an Integrated Water Management Plan. Develop and implement a Stormwater Drainage Plan. Implement the Conceptual Closure and Rehabilitation Plan.

4.2 Groundwater

4.2.1 Pit dewatering

Dewatering of mining pits will be required at the Project to allow mining under dry conditions and to supply water for ore processing. It is estimated that during Stage One of the Project the average dewatering rate will be approximately 7.5 gigalitres per annum (GL/a) or 20.5 megalitres per day (ML/d). Dewatering and abstraction activities associated with the Project will result in the drawdown of groundwater, increasing the depth to the water table.

Dewatering activities within the Project area have been assessed through development of a numerical groundwater model. Current geological and hydrological data has been used to form the basis of predicted impacts for the model which covers an area of 1,780km^2. This has been used to evaluate abstraction volumes required to dewater the proposed mine site and map expected groundwater drawdown contours and the zone of impact.

Modelling the maximum extent of groundwater drawdown associated with mine dewatering predicts that drawdown will remain some four kilometres away from the Marsh, to such an extent that dewatering will have no direct impact on the Marsh. The monitoring network will allow direct comparison between the actual and predicted impact throughout the life of mining.

Recovery of the groundwater table after cessation of pit dewatering is expected to take approximately 40 years, in line with predictions for other mining pit voids within the Pilbara region. Recovery is primarily dependant on recharge through precipitation with little contribution from the groundwater system occurring once water levels rise above water levels in the Marsh.

The Marsh groundwater system consists of saline to hypersaline water. The interface between this and fresher groundwater of the Project area has been identified and will be monitored during the life of the Project. Saline water abstracted from the groundwater table will be managed properly to minimise potential environmental impacts and implications. Management strategies for saline water abstraction include the construction of an evaporation pond, where saline water will be discharged into for evaporation. The residual salt brine will be pumped to salt production cells, where it will evaporate and be harvested to form a salt cake.

4.2.2 Evaporation pond

An evaporation pond is to be constructed on site for the evaporation of saline water. The evaporation pond will have sufficient capacity to retain and evaporate all of the saline flows generated over the mine life. The pond will consist of a number of individual cells which will be lined with low permeability liner. Cell construction will be staged to optimise the number of cells required. Based on the effectiveness of the first constructed cells and their performance versus that predicted, the required number of cells will be reviewed to reflect operational experience.

Each individual cell within the pond area is designed and will be constructed with a freeboard to ensure that unless a storm event in excess of the design event occurs, the storm capacity of the individual cells will not be exceeded. In the event that this capacity is exceeded, saline water will flow through the spillway to the cell directly downstream.

Harvested salt shall be placed within engineered encapsulation cells incorporated in the backfilled pit(s). The encapsulation cells will be located above the water table and constructed of suitable materials such as compacted clay. This encapsulation technique will be consistent with that used for containing other environmentally hazardous material (eg acid forming materials).

Extensive monitoring of all aspects of the operation will be undertaken. Monitoring bore stations will be installed around and downstream of the facility. These monitoring bores will be designed as de-watering bores to be activated if the groundwater downstream of the facility rises to within a trigger level relative to the ground surface. Section 5 (monitoring) presents a summary of monitoring requirements for the evaporation pond, with a full description of monitoring requirements in the Integrated Water Management Plan. The design components of the evaporation cells are listed in Table 4-2.

Table 4-2: Design components of evaporation cells.

DESIGN COMPONENT	DESIGN APPLICATION
General	Minimum water freeboard of 0.3m plus 1-in-100 year 72hr storm event.
Construction	Pond embankments constructed using local borrow, low permeability embankment. 6m crest width.
Materials	Undercut unsuitable foundation soils from entire embankment footprint for use as drainage material or embankment fill (if suitable). Embankment fill from local borrow. 1mm smooth HDPE pond liner to be placed inside embankment. Erosion protection/rock fill material from local quarry/rejects stockpile (if required).
Required Liner Permeability	HDPE–effective installed liner permeability of 10^{-10} to 10^{-11} m/s assumed, depending upon water depth. Soil liner–300mm of 1 x 10^{-9}m/s compacted soil.

4.2.3 Waste fines storage facility

A waste fines storage facilities (WFSF) will be constructed to contain the residual waste slurry of fine sediments from ore processing and desanding. Due to the size constraint placed upon the WFSF, a second WFSF is proposed for construction later in mine life.

The WFSF will be designed using best practice engineering techniques and following guidance material provided by the Department of Minerals and Petroleum (DMP) and the Commonwealth Department of Industry, Tourism and Resources (DTIR). The total area of the WFSF is approximately 572ha and will be operated to maintain a freeboard of 0.7m (Lycopodium, 2009), which is considered sufficient to store rainfall from a 1-in-100 year ARI rainfall event of 72 hours duration plus allowing 0.3m for waves (Gilbert and Associates, 2009). The risk of overflow or unintentional discharge from the facility is considered low.

Apart from a flocculant additive, no chemicals will be used in the desanding process. The slurry will otherwise consist only of fine sediment and water. As a result, the slurry is not considered to be acidic or potentially acid forming. A thickener will be used during the desanding process to lower water use and thus the amount of water entering the WFSF.

Detailed design of the WFSF will include geotechnical investigations into foundation conditions. Bores will be installed to monitor groundwater elevations, as well as to define and monitor baseline groundwater quality in the underlying system. If the monitoring bores show an increase in groundwater elevation or changes in groundwater quality during operation, it will trigger an immediate investigation into potential causes and impacts.

Management of potential groundwater impacts associated with Project activities are given below in Table 4-3.

Table 4-3: Management of potential groundwater impacts.

MANAGEMENT OF POTENTIAL GROUNDWATER IMPACTS	
Objectives	Manage Project activities so that the beneficial use of groundwater resources at the Project area and at the Marsh are not compromised during construction, operation and post-closure; Comply with all DoW Groundwater Licences; Minimise impact of groundwater abstraction on dependant flora, fauna and stock watering bores; and Ensure changes to groundwater quality and flows (hydrogeology) do not adversely impact on the Marsh.
Targets	Compliance with all DoW groundwater licences.
Potential Groundwater Impacts	Refer to Table 3-1.
Management Strategies	Implement dewatering strategy and maximise water efficiency. Continuous improvement of the hydrogeological model of the Project area to assist in the management of groundwater issues and model the changes in hydrogeology, groundwater quality and quantity resulting from groundwater drawdown. Implement groundwater monitoring program (monitoring bore stations). Dewatering in advance of the mining pits to avoid significant increases in dewatering rate. Mined out pits are to be backfilled with overburden material to above the pre-mining watertable. Implement Construction and Operation Environmental Management Plan and Integrated Water Management Plan. Implementation of engineering design (eg evaporation pond, WFSF). Collect and treat contaminated groundwater. Deep monitoring bores designed as de-watering bores which can be activated if the groundwater downstream of the evaporation pond or WFSF rises to within a trigger level relative to the ground surface. Water balance to be completed daily for salt evaporation pond to detect seepage or leaks.

4.3 Erosion and sedimentation

To minimise the potential for erosion of disturbed or rehabilitated areas, the following management strategies will be implemented:

Table 4-4: Management of potential erosion and sedimentation impacts.

MANAGEMENT OF POTENTIAL EROSION AND SEDIMENTATION IMPACTS	
Objectives	Minimise clearing of native vegetation. Ensure all approvals and licenses are satisfied prior to the commencement of any clearing. Maintain ecological integrity of the soil and maximise seed bank viability to contribute to regeneration of flora diversity. Final mine landforms are stable, revegetated and compatible with the surrounding natural topography.
Targets	No clearing to occur outside approved clearing areas. No significant erosion from soil stockpiles.
Potential Erosion and Sedimentation Impacts	Refer to Table 3-1.
Management Strategies	Implement Construction and Operation Environmental Management Plan. Develop and implement Weed Management Plan and Equipment Hygiene Procedure. Develop and implement a Feral Animal Management Program. Develop and implement erosion and sediment control plan to include: • constructing and stabilising control works during dry season, minimising disturbance work during the wet season; • where practical, directing run-off back into mine pits; • constructed diversion drainage lined with similar gradients to the natural drainage; • a 500m drainage buffer zone within the Project area and activities; • rock armouring areas with potentially high erosion (steep gradients and bends); • construct diversion drainage with similar gradients to the natural drainage systems in the Project area; • stabilise the banks of the diversion channels by direct seeding of native vegetation species endemic to water courses in the region; • contour rehabilitated area to minimise the velocity of stormwater, thereby reducing erosion potential; and • use vegetation debris from cleared areas to stabilise rehabilitated surfaces.

4.4 Fauna

Studies have been conducted to identify the effectiveness of various techniques and mechanisms for discouraging birds from mining project activities (Read, 1996). Design mechanisms to limit the number of large diurnally flying birds such as the black swan (*Cygnus atratus)*, may include:

- rotating beacon;
- intermittent sonic gun deterrent systems;
- hollow balls on surface of evaporation cells;
- multi laser beam reflectors;
- overhead flagging; and
- engineering steep, lined banks.

The Project will trial and implement methods to deter waterbirds from the Project area which will include a site specific management approach.

4.4.1 Lighting

Management strategies will be developed which will employ lighting measures that minimise unnecessary luminaires. In relation to minimising luminaires within the Project area, consideration needs to be made for it to comply with Occupational Health and Safety Standards for safety reasons. Proposed management measures to minimise impacts on avifauna will include:

- Installation of light shields at sensitive locations;
- Installation of amber filters and yellow lighting at sensitive locations;
- All migratory fauna sightings to be reported to the environmental personnel; and
- Luminaire observations to be recorded at sensitive receptors. Appropriate, site specific trigger values will be established in the Light Monitoring Program.

An Artificial Light Management Plan has been developed to minimise, and where possible eliminate adverse environmental impacts associated with unnecessary artificial illumination of the Project. Management strategies to address potential fauna impacts are listed in Table 4-5: Management of potential fauna impacts.

Table 4-5: Management of potential fauna impacts.

MANAGEMENT OF POTENTIAL FAUNA IMPACTS	
Objectives	Minimise the adverse impacts on priority and threatened terrestrial fauna; and Avoid the disturbance of any protected or listed fauna which use or are present within the Project area and infrastructure corridors, eg realignment of the Marble Bar Road.
Targets	No clearing to occur outside approved clearing areas. No net loss of threatened or priority fauna habitat.
Potential Fauna Impacts	Refer to Table 3-1.
Management Strategies	Implement structures and engineering designs to deter birds away from evaporation pond. Develop and implement Construction and Operation Environmental Management Plan. Decrease luminance to minimum safe operating levels to minimise impacts of fauna species. Install amber filters at sensitive locations.

4.5 Ecosystem health

Ecosystem health indicators provide a framework to evaluate collaborative management actions. Vegetation changes over time are important indicators of condition and ecosystem health. Vegetation changes are particularly important as targets and triggers for management. As part of the Project, ecosystem health with be monitored through methods summarised in Table 4-6. The major focus of monitoring of ecosystem health will consist of installing and monitoring eight survey points along the western boundary of the Project area, within the 500 metre buffer and upstream of the Marsh. The locations of the monitoring control sites will be negotiated with the DEC and other regulators (particularly if the control sites are to be located within the Marsh conservation estate). Table 4-6: Management of potential ecosystem health impacts lists the management strategies to implement to address impacts on ecosystem health.

Table 4-6: Management of potential ecosystem health impacts.

MANAGEMENT OF POTENTIAL ECOSYSTEM HEALTH IMPACTS	
Objectives	Minimise adverse impacts on the abundance, species diversity, geographic distribution and productivity of vegetation communities Avoid the disturbance of any protected or listed flora species or ecological communities identified within the Project Area.
Targets	No clearing to occur outside approved clearing areas; and Wherever possible, avoid Declared Rare Flora (DRF), Priority flora or Threatened Ecological Communities (TEC's).
Potential Ecosystem health Impacts	Refer to Table 3-1.
Management Strategies	Implement engineering designs to reduce erosion and minimise negative downstream impacts from Project activities. Implement Integrated Water Management Plan.

4.6 Cumulative impacts

Project activities will be managed to minimise cumulative impacts in the region and maintain beneficial uses of surface water quality, mulga woodlands and groundwater resources during construction, operation, and post-closure. Table 4-7 lists the management strategies to address potential cumulative impacts arising from the construction, operation and closure of the Project.

Table 4-7: Management of potential cumulative impacts.

MANAGEMENT OF POTENTIAL CUMULATIVE IMPACTS	
Objectives	Manage the Project activities to limit potential impacts on surrounding environment or users.
Targets	Minimised impact to the surrounding environment or users.
Potential Cumulative Impacts	Refer to Table 3-1.
Management Strategies	Implement the Integrated Water Management Plan, including the surface water monitoring program. Assess the engineering feasibility of reinstating drainage channels to minimise/limit downstream impacts. Redistribute diverted stormwater into remnant sections of the natural water courses downstream of the Project area. Minimise the disruption to surface water flows. Construct diversions and flow dispersion systems around infrastructure to convey flows into existing downstream drainages. Liaise with DoW and FMG to collectively develop cumulative groundwater management measures and assess cumulative impacts on groundwater aquifers.

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5 Monitoring

Results from monitoring and sampling activities can provide early indication about the impact of Project activities on the Marsh.

The monitoring and sampling will be in accordance with the applicable guidelines, including:

- surface water quality trigger levels will be developed upon conclusion of the baseline surface water monitoring program, prior to the diversion of any creeks. Trigger levels will be developed and implemented to ensure potential impacts are managed and reduced. In association with the development of trigger levels, targets will be established to identify contingency measures, in the event trigger levels are exceeded;
- determination of specific triggers which will be used as a benchmark to understand the health of the Marsh. These triggers will be obtained from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). It is proposed that ANZECC default trigger guidelines will be adopted initially as there is at present a lack of sufficient site-specific data and these guidelines are a reputable approach to water quality management within the Project area. These default trigger values will be used until site specific values can be obtained from the detailed monitoring programs. It is important to note that the classification of ecosystems in these Guidelines is coarse and there is not sufficient information to characterise the water quality requirements of ephemeral rivers;
- *AS/NZS 5667-1:1998 Water Quality Sampling - Part 1: Guidance on the design of sampling programs and sampling techniques;*
- *DoW Water Quality Protection Guidelines No.11 Mining and Mineral Processing: Mine Dewatering, 2000;*
- *DoW Water Quality Protection Guidelines No.4 Mining and Mineral Processing: Installation of Minesite groundwater monitoring bores, 2000;*
- *DoW Water Quality Protection Guidelines No.5 Mining and Mineral Processing: Minesite Water Quality Monitoring; and*
- *DoW Water Quality Protection Guidelines No.6 Mining and Mineral Processing: Acid Mine Drainage, 2000.*

The focus of monitoring activities will be on environmental aspects of the Marsh that have the potential to be impacted by Project activities. Hence, the main focus of monitoring will be on surface water and groundwater characteristics (eg water quality, surface runoff flow patterns), evaporation pond, erosion and sedimentation (geomorphic change) and vegetation communities, ecosystem health and water efficiency.

Table 5-1 summarises key monitoring aspects and strategies for the Marsh, with a full description given in the Integrated Water Management Plan. Performance criteria for monitoring data results have also been detailed in the Integrated Water Management Plan.

Table 5-1: Summary monitoring table for the Marsh.

ASPECT	OBJECTIVE	MONITORING
Surface Water	Determination of water quality characteristics of the Project site catchments prior to, during and after development.	Target is to conduct surface water sampling to develop water quality data prior to, during and after development. Baseline monitoring to be conducted during flow events in the wet season. In-situ water quality testing to include pH, electrical conductivity (EC), temperature and total suspended solids (TSS). All water quality samples for laboratory analysis to be submitted to a NATA accredited laboratory for testing of: calcium, magnesium, sodium, chloride, sulphate, nitrate, alkalinity, total nitrogen, total phosphorus, and total concentrations for a complete heavy metal suite. During operation and post-closure, conduct monitoring 3 times (first flush, high flow, end of season (where possible) during runoff events. During operation, monitoring will be conducted for the first two years. Post-closure monitoring will continue until subsequent sampling shows variability less than one standard deviation in all key parameters, but will not exceed three years. Reporting to be annually to relevant authorities (eg DoW, EPA) and provide data relevant to the assessment of cumulative impacts.
Groundwater	Determination of water quality characteristics of the Project site aquifers prior to, during and after development.	Target is not to exceed the licensed abstraction volume. Baseline water quality obtained through monthly monitoring of water levels in existing piezometers and production bores, as well as down hole electrical conductivity (EC) surveys of piezometers every four months. During pre-mining and operation, groundwater monitoring will consist of: • pumping volumes; • pH and EC measurements; • measurement of water levels; • key water meter readings; • biannual sampling of non-potable production bores of pH, EC, TDS, hardness, Soidum (Na), Calcium (Ca), Mercury (Hg), Magnesium (Mg), Potassium (K), Chlorine (Cl), Iron (Fe) and alkalinity; and • potability sampling potable water supply production bore(s). Post-closure, water levels and EC will be monitored quarterly until subsequent sampling shows variability less than one standard deviation in all key parameters, but will not exceed three years. Reporting to include monitoring results of the water supply borefield within the Project Area in the Annual Aquifer results as per DoW licence requirements and summarise results to DoW, EPA and other relevant authorities for cumulative impact assessments.
Evaporation Pond	Management of evaporation pond to operate in a manner which does not impact the environment.	Target is to for no adverse impacts to be caused to the environment from evaporation pond or the network of cells. Monitoring to focus on: • short term operation; • compliance; • long term performance; • encapsulated salt slurry; and • seepage.
Erosion and Sedimentation (Ground Disturbance causing Geomorphic Change)	Minimise adverse impacts on the abundance, species, diversity, geomorphic distribution and productivity of vegetation communities.	Target of no clearing outside of approved clearing areas. One reference cross section to be surveyed prior to construction, during operation and post-closure. Photographic survey and two catchment surveys in areas potentially impacted during mine operation. Report survey results annually for inclusion in cumulative impact assessments.

ASPECT	OBJECTIVE	MONITORING
Ecosystem Health	Minimise adverse impacts on the abundance, species, diversity, geomorphic distribution and productivity of vegetation communities.	Target of no clearing outside approved clearing areas. Monitoring prior to construction, during operation and post-closure to consist of vegetation surveys, visual observations and GIS imagery within the 500m drainage buffer zone. Consultation will be sought with DEC Pilbara Region regarding vegetation health monitoring and design/implementation of the monitoring program. Reporting to be biannual to include both wet and dry seasons.
Water Efficiency	Manage water resources so that their beneficial uses are not compromised.	Target of no significant changes in water quality and quantity during or after mine operation and closure. Monthly water abstraction rates on all production bores (dewatering and potable) to be monitored and reported, including an annual site water balance.

5.1 Contingency plans

Monitoring will be used to determine the effectiveness of the plan, identifying impacts within the Project and buffer zone and consequently the Marsh. In the event of non-compliance and exceedance of trigger levels, contingency actions will be implemented.

Table 5-2: Contingency plans.

ASPECT	CONTINGENCY PLAN
Objective	Manage the Project activities without adversely affecting the surrounding environment and other users.
Target	Minimise impacts to the environment or surrounding users.
Surface water trigger levels exceeded	Investigate likely causes. Reduce surface water runoff. Increase surface water monitoring.
Increase in erosion and sedimentation	Develop and implement structures to limit/divert surface water runoff along eroded creeks. Rehabilitate eroded creeks.
Contamination of surface water	Investigate likely causes of contamination. Contain and treat contaminated surface water. Increase surface water monitoring to identify point of contamination.
Reduced surface flow into the Marsh	Investigate likely causes. Divert surface water to increase flows into the Marsh.
Behavioural impacts to migratory bird species	Implement structures and measures to deter migratory birds from the Project area.
Hydrocarbon and/or chemical contamination of the Marsh	Investigate likely consequences of contamination. Contain and treat contaminated water.
Increased salinity in aquifers	Increase groundwater monitoring to identify source of contaminant. Suspension of groundwater abstraction.
Death and degradation to surface water dependent environments	Investigate likely consequences of degradation. If lack of surface water runoff into the environment, assess re-dispersion structures to increase surface water runoff.

5.2 Emergency response for evaporation pond

5.2.1 Ruptures of saline water pipelines

Emergency response procedures have been developed by the Proponent's Engineering Consultants Lycopodium (2009). In areas where a breech in the water delivery and brine pipelines would not drain into the evaporation facility, the pipelines will be contained within designated bunded corridors. This will reduce the likelihood and consequence of any emergency situation and will minimise the release of water from the facility or contamination of any local water systems. Regular inspection of the pipeline corridor will be carried out, noting moisture build up, vegetation distress and any visible signs of water seepage. All recorded signs of possible leakages must be investigated to determine the status of the pipeline. In particular, where the corridor crosses existing creeks, the pipeline will be inspected following adverse weather to ensure that the pipeline has not been exposed or damaged.

Should a minor leakage be detected the pipeline will be shut down, the cause of the leak recorded, and repairs carried out at the earliest practicable time. Any potentially contaminated soils surrounding the pipeline will be removed and disposed of into the in-pit co-disposal site. Clean soils will be used to reinstate the bunded corridor. This procedure will prevent major problems from developing.

Should a major rupture be detected the pipeline will be shutdown. A drop in pipeline pressure, local erosion around the pipeline and water are likely to be evident, and therefore detection of the rupture will be relatively easy. Any contaminated soils will be cleaned up and placed into the in-pit co-disposal site and, where possible, ponded water resulting from leakage will be pumped into the evaporation pond facility. Any damage to embankments / slopes, surrounding environment, etc., will be restored and made good.

5.2.2 Pipeline blockage

In the unlikely event that a blockage occurs in the pipelines the flow will be either transferred into another branch of the pipeline, or temporarily halted. The failure of a discharge point will be treated in a similar manner to the procedures for a blockage in the distribution line. The discharge point containing the blockage will then be removed and the new discharge point assembled. On replacement, deposition will be returned to its original position.

5.2.3 Water overflow

The water level in each cell will be closely monitored and deposition transferred to other cells when the water level reaches the designated maximum operating level, in order to maintain storm capacity and reduce the risk of overflow. To ensure maximum security it is essential that the most southerly pond within the cascade is operated at a relatively low level to accommodate extreme events and to provide additional buffering capacity. Under very extreme circumstances where the final pond in the cascade is nearing its maximum capacity operating the brine recycling system will reduce the water levels within the evaporation pond. However, the integrity of the in-pit co-disposal site will never be compromised by undertaking this action. Finally, the lowest pond in the evaporation system will have an emergency spillway in the event that discharge from the system becomes necessary.

5.2.4 Pond liner leakage

Monitoring of the evaporation pond will assist in both the technical and environmental management of the facility. Due to the potential environmental impact of liner leakage, it is essential that water balance assessments are carried out regularly to determine the inputs, outputs and storage of the evaporation pond facility. Through this procedure leakage from the pond may be identified thus allowing appropriate measures to be taken in order to reduce the potential for contamination to occur.

A cell is considered to be operating incorrectly if any of the following occur:

- significant quantities of water cannot be accounted for within the water balance assessment;
- a cell shows significant variation in operating parameters from other cells in use; and
- visual evidence of cell leakage is observed. This is considered unlikely because cell leakage is most likely to occur through the base of the pond and there may not be any visual evidence of such at ground surface.

It should be noted that the water balance is based on values which have been derived through methods that have inherent uncertainty, and therefore the review of water loss through pond leakage needs to be undertaken with care and by an appropriately skilled engineer.

Should the water balance assessment indicate that a pond is not operating correctly, the following actions should be undertaken:

- initiate brine recycling to reduce the pond water level. This reduces the hydraulic head and therefore the potential for seepage;
- review previous environmental water samples taken from monitoring boreholes near to the suspected leakage and take additional water monitoring samples from the appropriate boreholes (eg remembering the direction of water flow). This may indicate a leakage due to chemical composition; and
- undertake a detailed inspection of the pond (externally and internally) that is suspected to be leaking, documenting the inspection in writing and with photographs.

Should any defects be identified these should be repaired and appropriate validation testing be undertaken.

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6 Reporting

The reporting schedule is provided in Table 6-1. The reporting schedule will include the reporting of interim results which provide a means of reviewing the progress and continual improvement of the FMMP.

Table 6-1: Reporting schedule for key environmental impacts.

REPORTING ASPECT	REPORTING COMPONENT	TIMING	RESPONSIBILITIES
Surface Water Reporting	Engineering design methods to incorporate flow diversion systems in accordance with Integrated Water Management Plan.	Prior to operation and continual progress to be reported annually.	Project Manager and Project Director.
	Preventative engineering control in accordance with Surface Water Assessment.	Prior to construction with annual review.	Project Manager.
	Surface water quality monitoring to be undertaken in accordance with Integrated Water Management Plan.	Prior to construction and throughout life of Project.	Site Environmental Manager.
	Continual flow monitoring at three locations in Kulbee Creek to monitor baseline flow in accordance with Integrated Water Management Plan.	Prior to diversion of creeks and throughout life of Project.	Site Environmental Manager.
	Design infrastructure to minimise impacts to sheetflow in accordance with Construction Environmental Management Plan.	Prior to construction with annual review.	Project Manager and Hydrologist.
	Inspection of operation areas to ensure any chemical spills have been dealt with according to the Chemical Spill Procedures and Hydrocarbon Spill Procedures in accordance with Operation Environmental Management Plan.	Monthly.	Area Superintendent.
	Progressive rehabilitation to be conducted.	As required.	Site Environmental Manager.
	Evaporation pond monitoring to be conducted in accordance with Integrated Water Management Plan consisting of: • short term operation monitoring; • compliance monitoring; and • long term performance monitoring.	 Daily Monthly. Daily.	Site Environmental Manager.
	Encapsulated salt residue monitoring in accordance with Integrated Water Management Plan.	Monthly.	Site Environmental Manager.

REPORTING ASPECT	REPORTING COMPONENT	TIMING	RESPONSIBILITIES
Erosion and Sedimentation Reporting	Develop engineering control measures in accordance with Surface Water Assessment.	During Project design and prior to construction.	Site Environmental Manager and Hydrologist.
	Inspect erosion and sediment control structures to ensure that they function correctly in accordance with Construction Environmental Management Plan.	Monthly with annual review.	Site Environmental Manager and Hydrologist.
	All diversion structures to be inspected following heavy rainfall events to identify any damage in accordance with Construction environmental Management Plan.	Following heavy rainfall events.	Site Environmental Manager and Hydrologist.
	Inspect rehabilitation areas for erosion damage in accordance with Operation Environmental Management Plan.	Following heavy rainfall event.	Site Environmental Manager and Hydrologist.
Fauna Reporting	All migratory avifauna sightings to be reported to the Environmental Team in accordance with Fauna and Artificial Light Management Plans.	Ongoing with continual review.	All site personnel.
	Install light shields at sensitive locations and decrease luminance in accordance with Artificial Light Management Plan.	Implement prior to construction with continual monitoring.	Site Electrician.
	Install amber filters at sensitive locations in accordance with Artificial Light Management Plan.	Ongoing with continual review.	Site Electrician.
	Implement mechanisms to deter birds from evaporation cells in accordance with Integrated Water Management Plan and Fauna Management Plan.	Prior to operation with continual review.	Site Environmental Manager.
Ecosystem Health Reporting	Implement vegetation monitoring within 500m drainage buffer zone in accordance with Integrated Water Management Plan.	Prior to construction with biannual reporting.	Site Environmental Manager.
	Photographic surveys to be conducted to determine geomorphic change in accordance with the Integrated Water Management Plan.	Prior to operation with annual reporting.	Site Environmental Manager.
Cumulative Impacts	Implementation of Integrated Water Management Plan in accordance with Operation and Construction Environmental Management Plan.	Prior to construction with continual review.	Project Manager, Project Director, Hydrologist, Hydrogeologist and Site Environmental Manager.
	Review of drainage control mechanisms to determine feasibility of structures in accordance with Surface Water Assessment.	Ongoing with continual review.	Site Environmental Manager and Hydrologist.

7 Conclusion

The Marsh is an important wetland and its conservation significance is unique to the Pilbara region.

Various environmental management plans developed for the Project include strategies to protect the environmental values of the Marsh. These management plans include the Integrated Water Management Plan, Construction Environmental Management Plan, Operation Environmental Management Plan and Conceptual Closure and Rehabilitation Plan.

The FMMP (this document) has been developed to bring together the key management strategies to address potential impacts on the Marsh from Project activities during construction, operation and post-closure. Ongoing consultation will be undertaken with decision-making authorities to define further monitoring and assessment strategies, where required.

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