MWH

BUILDING A BETTER WORLD

HPPL - ROY HILL

PRELIMINARY INTEGRATED WATER MANAGEMENT PLAN

May 2009

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REVISION SCHEDULE

REV. NO.	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY	APPROVED BY
1.0	24/12/08	Initial document from MWH Perth	Holly Taylor	Jim Campbell	Jim Campbell
2.0	10/02/09	Incorporates Govt and Peer comments	Holly Taylor	Gary Clark	Jim Campbell
3.0	27/03/09	DMA comments and report updates	Holly Taylor	Gary Clark	Jim Campbell
4.0	08/05/09	10 year mining scenario	Holly Taylor	Gary Clark	Jim Campbell

EXECUTIVE SUMMARY

The technical and economic viability of the Roy Hill 1 Iron Ore project (the Project) is currently being evaluated by Roy Hill Iron Ore Pty Ltd (RHIO). The proposed location is within Roy Hill 1 tenements on the southern slopes of the Chichester Range, 1.5 km north-east of the Fortescue Marsh on the plains of the Fortescue Valley.

RHIO understands that effective water management is essential for a successful mining operation. Water risks and opportunities must be managed at both a corporate and site level to ensure operational value is maximised, production is secure and the community and environmental values associated with water are maintained or enhanced.

This document has been designed to provide an informative and succinct summary of the surface and ground water investigations which have been undertaken to date, and the proposed water processes and management strategies which will be used during operation and into the closure of the mine. The most up-to-date information has been input into this report, however it is acknowledged that aspects of the Project are subject to change, therefore, the plan will be updated and reviewed on an annual basis.

To date the key Project water management issues which have been identified are:

- Pit dewatering to maintain “dry” open–cut mining conditions
- Ensuring an adequate supply of water for mine operations
- Usage, storage and disposal of saline water from dewatering, as a small proportion of the ore body lies below the salt water interface that is associated with the Fortescue Marsh.
- On-going investigations in to the feasibility and engineering design of temporary and permanent surface water diversions
- Assessing and implementing management strategies which mitigate any potential risks to the surrounding area (including the Fortescue Marsh)

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1. INTRODUCTION

The technical and economic viability of the Roy Hill 1 Iron Ore project is currently being evaluated by Roy Hill Iron Ore Pty Ltd (RHIO).

1.1 PURPOSE OF THIS DOCUMENT

RHIO understands that effective water management is essential for a successful mining operation. Water risks and opportunities must be managed at both a corporate and site level to ensure operational value is maximised, production is secure and the community and environmental values associated with water are maintained or enhanced.

This Preliminary Integrated Water Management Plan (IWMP) brings together the water management elements of the Roy Hill project, so that they can be managed in a comprehensive and coordinated manner. The IWMP covers both surface and ground water, using a whole-of mine approach that encompasses: exploration, design and development, operation and decommissioning.

This document has been designed to provide an informative and succinct summary of the surface and ground water investigations which have been undertaken to date, and the proposed water processes and management issues which will occur during operation and into the closure of the mine. The most up-to-date information has been input into this report, however it is acknowledged that aspects of the Project are subject to change, therefore, the plan will be updated and reviewed on an annual basis.

1.2 RELATIONSHIP TO OTHER DOCUMENTS

A number of management plans have been developed for Roy Hill. The plans which are relevant to Integrated Water Management include:

- Project Environmental Risk Assessment
- Construction Environmental Management Plan
- Operation Environmental Management Plan
- Conceptual Mine Closure and Rehabilitation Plan
- Acid Mine Drainage Management Plan
- Stakeholder and Community Consultation Plan
- Fortescue Marsh Management Plan

2. BACKGROUND

2.1 CLIMATE

The climate in the eastern Pilbara is semi-arid, characterised by seasonal periodic rainfall and high evaporation rates. Rainfall occurs predominantly in summer with the largest events being associated with tropical cyclones which periodically cross the north tropical coast and track inland bringing heavy rainfall to the inland parts of the Pilbara. The area also experiences frequent thunderstorm activity during the summer wet season and is occasionally affected by the monsoon trough.

The rainfall gauge at Roy Hill[1] station has the longest record in the region. Average monthly rainfall and evaporation data for Roy Hill is summarised in Table 2-1.

Table 2-1: Average Rainfall and Point Potential Evapotranspiration at Roy Hill (mm)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL[1]	45	58	44	23	19	18	11	6	2	5	8	24
EVAPO-TRANSPIRATION[2]	390	310	290	205	138	100	110	165	230	315	380	405

Source: [1]Bureau of Meteorology Site No. 005023 (Roy Hill 1900-1990), [2]BoM Climate Atlas, Evapotranspiration

2.2 GEOLOGY

The Roy Hill Project consists of iron mineralisation associated with the lowermost unit of the Marra Mamba Formation (Nammuldi member) and the associated overlying detrital deposits occupying the basal part of the paleochannel associated with Kulbee Creek. The Marra Mamba Formation is generally dipping gently to the south-south west, with only the basal Nammuldi member present. The Marra Mamba Formation overlies the shale, chert and dolomite of the Jeerinah Formation. The sequence occupies the northern limb of a major syncline, with a series of gentle crosscutting folds. The sequence has been faulted by a series of generally north south trending faults.

The detrital deposits that overlie the Marra Mamba Formation generally consist of a sequence of clays and goethitic material occupying the paleochannel of the modern day Kulbee Creek. The Alluvial deposits occur on the lower slopes and in general their thickness increases in a south-westerly direction towards the main Fortescue valley.

2.3 GROUNDWATER

2.3.1 HYDROGEOLOGICAL INVESTIGATIONS

MWH Pty Ltd has performed hydrogeological investigations at Roy Hill since 2005. This work has characterised the hydrogeological environment of the proposed mine site and adjoining areas, and has included field investigations using test production bores and monitoring bores (see Appendix C). Investigations are currently being carried out to the south of Roy Hill towards Ethel Creek.

The information gathered from field investigations has been used to develop a hydrogeological computer model which simulates the potential impacts of the Project on groundwater resources (drawdown, quality, recovery) during the mine life and following mine closure.

2.3.2 AQUIFER CHARACTERISTICS

The primary aquifer in the area is associated with the secondary permeability of the mineralised Nammuldi Member of the Marra Mamba Formation. Local faulting may also provide local areas of enhanced permeability within the surrounding bedrock.

The Warri Dolomite is also thought to form a significant aquifer in the south and west of the area. It is separated from the Nammuldi Member by the Roy Hill Shale, which acts as an aquiclude. However, faulting can create hydraulic connections between these aquifers.

The alluvial deposits (ALL) are highly variable in nature, ranging from silty clays through to gravels and cobbles, and include older Tertiary pisolitic detritals. In places chemical deposits of calcrete and silcrete occur. The alluvials are absent from the high ground in the north east of the Roy Hill investigation area, but occur extensively on the lower ground in the modern day drainage systems of Kulbee Creek and the Fortescue Valley. Their thickness is generally in excess of 50m, with localised pockets over 80m thick

The next hydrogeological unit is the Nammuldi Member (NAM), which can comprise a) an upper, clayey weathered horizon, b) the mineralised main ore zone, and c) cherts and shales of unmineralised Banded Iron Formation (BIF). The main groundwater flows appear to be associated with the ore zone.

The underlying Jeerinah Formation (JER) acts as an aquiclude, and effectively forms the base of the modern groundwater system. However, in the south and west of the tenement area, the JER is thin or absent, such that the underlying Warri Dolomite is in hydraulic continuity with the NAM and ALL aquifers.

Recharge to the NAM occurs in the outcrop areas, from where the groundwater flows through the NAM and discharges into the ALL deposits. Rainfall recharge also enters the groundwater system via the ALL deposits, in particular along the streambeds of the creeks. The rainfall recharge flushes the shallower parts of the groundwater system and maintains fresh, low Electrical Conductivity (EC) water (<2500 uS/cm). The fresh water is thought to discharge into the ALL deposits and flow towards the Fortescue Marsh, where it mixes with the saline waters in the Marsh.

Further downgradient and below a level of some 370m AHD, the water is saline (EC >10,000 uS/cm). This probably represents old groundwater that has not been flushed by recent recharge, due to its depth or structural entrapment. Fresh recharge from the high ground to the east will tend to flow over the top of the pocket, leaving the deeper water isolated.

The WAR contains some highly saline water (>100,000 uS/cm), which probably represents very old, static groundwater. Although it is in hydraulic continuity with the ALL and NAM groundwater, there has been so little flow in these areas to date that the saline water has remained at depth.

In summary, the saline waters exist in the aquifer systems where they extend below a level of 370m AHD. Saline waters are also present at higher levels towards the Fortescue River in the south and towards the Fortescue Marsh to the west.

2.3.3 GROUND WATER LEVELS

A groundwater elevation contour map derived from water level data collected in all monitoring bores between 4th and 12th May 2007 is displayed in Figure 2-1: Groundwater Level Contour Map. The hydraulic gradient is generally north east to south west towards the Fortescue River. The highest levels are found in the outcrop areas in PZ10 (442.6m AHD) and PZ09 (429.7m AHD). Away from the outcrop areas, levels range from 412m AHD to ~409m AHD.

The groundwater gradient is steeper towards the outcrop areas of the Nammuldi Member and Jeerinah Formations, with the groundwater profile generally mimicking the topography. The general steepening of the gradient in the areas approaching the outcrop areas is considered to be a function of the general tight nature of the bedrock material, in particular the shale of the Jeerinah Formation.

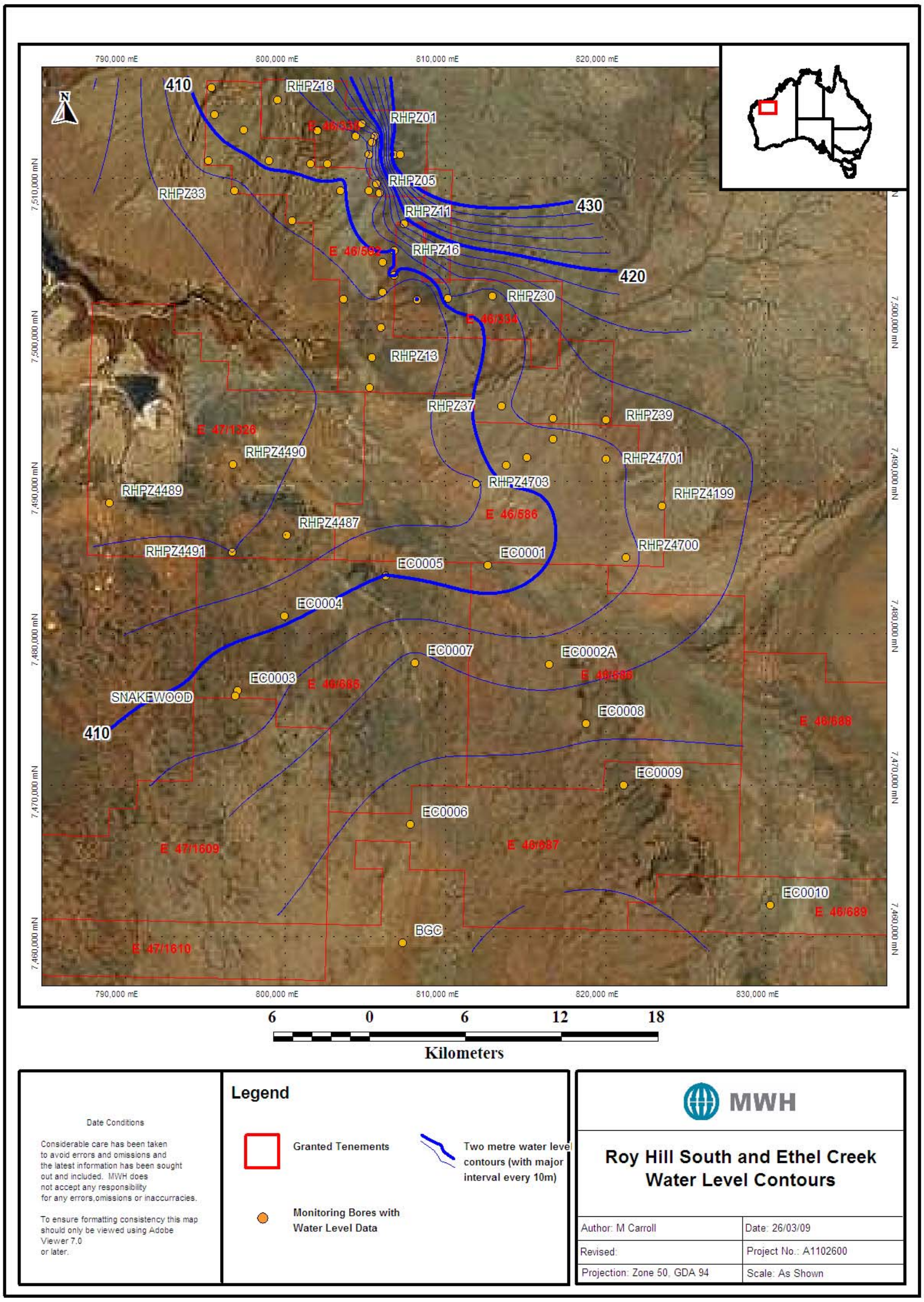

Figure 2-1: Groundwater Level Contour Map

2.3.4 GROUNDWATER QUALITY

The results of water quality analysis performed in 2007 from the production and monitoring bores are presented in Appendix A.

Only the sample from Production Bore 6 was "fresh" and met the National Health and Medical Research Council (NMRC) Guidelines for drinking water. The other samples exceed the drinking water criteria for various analytes including Total Dissolved Solids (TDS), sodium, iron, chloride and sulphate. The level of nitrate is anomalously high in PZ27S, while nitrate levels slightly exceed the guideline value of 50 mg/l in bores PB2 and PZ10.

The lowest concentrations of anions and cations was found in the samples from the new camp bore (referenced A), PZ10 (ref I) and PB6 (ref G). These lie adjacent to the higher ground where the Nammuldi member outcrops, and represent recharge waters. Further downgradient, the concentration of minerals in the groundwater increases, as indicated by the samples from bores PB3 (ref D), PZ27 (ref Q), PB2 (ref C) and PB5 (ref F).

2.3.5 ADDITIONAL INFORMATION

Additional baseline groundwater information is contained in MWH, 2007, *HPPL Roy Hill Hydrogeological Assessment Part A,* Interim Report prepared for HPPL.

2.4 SURFACE WATER

2.4.1 HYDROLOGICAL INVESTIGATIONS

Gilbert and Associates Pty Ltd's hydrological investigations have included catchment characterisation and water balance modelling. To increase understanding of hydrological processes occurring in the catchment, continuous river level and rainfall recorders have been installed on Kulbee Creek. Additionally, a conceptual stormwater management and diversion of runoff plan has been developed.

2.4.2 REGIONAL SETTING

The Roy Hill Project area is located in the Fortescue River catchment to the north of the Fortescue Marsh. It is naturally separated into upper and lower sections by the Fortescue Marsh which is a large intermittent wetland lying between the Chichester Ranges to the north and Hamersley Ranges to the south. The Marsh is a depositional feature lying upstream of the natural topographical barrier formed by the Goodiadarrie Hills crossing of the Fortescue River. When full it would occupy an area of some 1,000 square kilometres. It receives runoff from the 30,700 square kilometre upper Fortescue River catchment upstream as well as groundwater inflows and incident rainfall. It is a sink for regional groundwater which has resulted in salt accumulation and development of a hyper-saline groundwater system beneath the Marsh. In the event of extreme inflows, the Marsh could overtop into the lower Fortescue River downstream, however there are no recorded instances of this ever having occurred.

Rivers in the Pilbara are ephemeral and flow only occasionally (WRC, 2000). The rivers are dry most of the year, except for chains of large pools that may last for considerable periods. Annual stream flow volumes in the Pilbara region are highly variable, with flow typically only in response to large rainfall events (WRC, 2000). There is limited surface water data available for this region.

The following general regional rainfall - runoff characteristics are evident from the data recorded in the Pilbara (Gilbert 2008):

- Annual runoff is highly variable.

- There is typically little or no runoff in years when rainfall is less than about 150 to 200mm.
- In years with higher rainfall, runoff is typically a small percentage of rainfall (3-7%) in excess of “zero runoff” amount. In particular years however recorded runoff has been as high as 24% of rainfall.
- Averaged over all gauged catchments, average annual runoff is about 3% of rainfall.

2.4.3 LOCAL DRAINAGES

The Project area is drained by a series of ephemeral creeks and watercourses which flow predominantly in a northeast – southwest direction toward Fortescue Marsh. The catchment areas of the main Project area creek systems are summarised in Table 2-2 Project Area Catchments

Table 2-2 Project Area Catchments

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

2.4.4 FLOOD HYDROLOGY OF LOCAL CREEKS

Gilbert and Associates (2008) modeled flood peaks for Kulkinbah, Kulbee and No-name Creek; the results are tabulated below in Table 2-3 Estimated Peak Flood Discharges

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Table 2-3 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)
Kulkinbah	Marble Bar Road Crossing	273	674	1.270
Kulbee	Upstream diversion	30	76	146
No-name	At northern lease boundary	62	176	369

2.4.5 WATER QUALITY

Surface water quality data is not available for the Project area. The Proponent has instigated a baseline water quality sampling program, it is outlined in Section 8.3.

2.4.6 ADDITIONAL INFORMATION

Additional baseline surface water information is contained in Gilbert and Associates Pty Ltd, 2009, *Roy Hill Iron Ore Project – Surface Water Assessment.*

2.5 FORTESCUE MARSH

The Fortescue Marsh (the Marsh) is an extensive intermittent wetland located approximately 1.5 km to the south-west of Project operations (Figure 2). It is bound by the Chichester Range to the north and the Hamersley Range to the south, occupying an area of 1,000 km^2 when full (Department of Environment, Heritage, Water and the Arts (DEHWA), 2008). The Marsh is a depositional feature that receives runoff from the 30,700 km^2 upper Fortescue River catchments as well as many creeks and tributaries which drain the adjoining Chichester Ranges.

The Fortescue 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 Fortescue 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, 2008). The eastern margin of the proposed conservation estate will be located more than 15km west of the Project.

2.5.1 WATER QUALITY

There is relatively little baseline water quality data available for the region. Baseline data for local creeks is often difficult to collect due to the transient and short duration that creeks flow and access difficulties during wet weather. Water quality data for the Fortescue Marsh was provided by the Department of Environment and Conservation covering a period from August 2003 until August 2006. This data set included analysis results of eight separate samples collected over this period. The average (mean), minimum and maximum concentrations of the key analytical parameters are summarised in Table 2-4 below. Results indicate that water in the Marsh over this period was alkaline and moderately to highly saline. The dominant solutes were sodium chloride and calcium sulphate. Major nutrient (nitrogen and phosphorous) concentrations were high compared to default trigger values given in the ANZECC water quality guidelines for north Western Australia particularly total phosphorous. Iron concentrations were low.

Table 2-4 Summary of Water Quality Data—Fortescue Marsh 2003-2006

PARAMETER	UNITS	AVERAGE	MINIMUM	MAXIMUM
Field pH	pH	8.9	8.28	9.98
Total Dissolved Solids	g/L	4.1	0.3	12
Total Nitrogen	µg/L	1401.3	230	4,700
Total Phosphorus	µg/L	235.6	5	1,400
Alkalinity	mg/L	54.0	28	80
Hardness	mg/L	1,631	25	3,702
Silica	mg/L	92.7	1.3	420
Sodium	mg/L	933	130	3,640
Calcium	mg/L	484.9	1.4	1,200

PARAMETER	UNITS	AVERAGE	MINIMUM	MAXIMUM
Magnesium	mg/L	104.2	3.2	383
Potassium	mg/L	112.5	6.4	281
Manganese	mg/L	0.0011	0.0005	0.003
Chloride	mg/L	1,447	103	5,500
Bicarbonate	mg/L	91.6	20	256
Carbonate	mg/L	1.9	1	8
Nitrate	mg/L	1.0	0.005	5
Sulphate	mg/L	1,565	8.3	3,320
Iron	mg/L	0.2	0.00025	1.3

DEC, unpublished

2.5.2 ADDITIONAL INFORMATION

Additional information is contained in SMEC (2009) *Roy Hill 1 Iron Ore Mining Project: Fortescue Marsh Management Plan.*

3. GOVERNANCE

3.1 BEST PRACTICE

This Integrated Water Management Plan encompasses principles of sustainable development outlined in *Leading Practice Sustainable Development Program for The Mining Industry – Water Management developed by* Department of Resources Energy and Tourism, (2008).

3.2 CORPORATE

3.2.1 PROJECT ENVIRONMENTAL MANAGEMENT SYSTEMS

RHIO will oversee the development of an Environmental Management System (EMS) for the Project. The EMS will be consistent with the principles of ISO 14001, including provisions for monitoring and continuous improvement of environmental performance. The EMS forms a component of the broader Project management system that addresses the occupational health and safety and community and heritage aspects of The Project. A series of supporting environmental management plans (EMPs) will be developed to implement the environmental management and monitoring commitments adopted for The Project.

3.2.2 PROJECT ENVIRONMENTAL MANAGEMENT PLAN

A Project Environmental Management Plan (EMP) will be prepared as a component of the Project EMS. The EMP will detail policies, procedures and controls that will be implemented by RHIO to minimise potential environmental impacts during design, construction and operation of the Project. The objectives of the EMP are to:

- Define the management structure of the Project and the environmental roles and responsibilities of RHIO and contractors on the Project;
- Identify environmental legal requirements relevant to the Project;
- Identify the environmental risks associated with the major activities that will be undertaken during the Project;
- Document Project management controls, procedures and rules to manage the identified environmental risks and satisfy environmental requirements;
- Establish objectives and targets for environmental performance;
- Document monitoring, auditing and reporting requirements; and
- Capture commitments made in the EIS as specific and measurable actions.

Implementation of the Project EMP will ensure adequate protection and management of the environmental values which may be impacted upon by the construction and operation of the Project.

3.3 RELEVANT LEGISLATION

The water management at Roy Hill will be undertaken is accordance with the relevant legislation. Relevant water legislation, guidelines and strategies are briefly summarised below.

3.3.1 PILBARA WATER IN MINING GUIDELINE

The Department of Water (DoW) is the statutory authority that manages Western Australia's water resources. DoW released a draft version of the *Pilbara water in mining guideline* for public comment in February 2009. The document provides guidance to the proponents of mining projects on how to meet regulatory requirements and manage the complexities of water management.

3.3.2 ENVIRONMENTAL PROTECTION ACT, 1986

The *Environmental Protection Act 1986* (EP Act) is the main governing legislation relevant to environmental protection in WA. The EP Act provides for the establishment of the Environmental Protection Authority (EPA) and is the main statute under which the WA environmental approvals processes are conducted, and also provided for the establishment of the EPA, the body with overall responsibility for approving projects submitted under Part IV of the EP Act.

In July 2005 RHIO submitted a Referral Document to the EPA to enable the level of environmental impact assessment (EIA) for the Project under the EP Act to be determined. In August 2005, the EPA determined that the level of assessment for the Project will be set at Public Environmental Review (PER) in accordance with Section 38 of the EP Act.

The level of environment assessment for the Project is PER. A draft PER was submitted to the EPA in December 2008 and a subsequent second draft PER submitted in February 2009.

3.3.3 RIGHTS IN WATER AND IRRIGATION ACT, 1914

The Department of Water regulates the use of water in WA through the powers assigned to it under the *Rights in Water and Irrigation Act, 1914* (RIWI Act). Surface and groundwater resources in proclaimed areas have been divided up into Surface Water and Groundwater management areas. The Roy Hill site lies within the proclaimed "Pilbara" Groundwater Management and Surface Water Management areas.

The object of the RIWI Act is to:

(a) provide for the management of water resources in WA, and in particular
  (i) for their sustainable use and development to meet the needs of current and future users; and
  (ii) for the protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them;
(b) promote the orderly, equitable and efficient use of water resources;
(c) foster consultation with members of local communities in the local administration, and to enable them to participate in that administration; and
(d) assist the integration of the management of water resources with the management of other natural resources.

With particular emphasis on object (ii) above, the RIWI Act provides for:

- a statutory planning process which requires specific identification of environmental values and how the rights to water should be allocated including the needs of the environment;

- the need to obtain the approval of the Minister for Water Resources before implementation of plans;
- the establishment of local water resources management committees including, where practical, people with knowledge and experience in the conservation of ecosystems;
- a statutory framework for broad public consultation in plan development and, specifically, consultation with water resources management committees and stakeholder bodies; and
- the ability for the DoW to put conditions on licences or to amend licences to protect the environment as well as making directions for the same purpose.

Two types of licences and a permit make up the regulatory system that the DoW uses to administer the use of water in WA under the RIWI Act:

- **Well Licences** – are required under Section 26D of the RIWI Act, to construct or alter any artesian well or non-artesian wells in proclaimed areas. A 26D licence does not on its own give the right to take water from the well.
- **Permits** – are issued to allow the holder to construct or interfere with the bed or banks of a watercourse to which there is access by a public road or reserve, or to build or alter a dam on a proclaimed or prescribed watercourse or wetland. As with a 26D well licence, a permit does not give the right to take any water collected by the activity authorised by the permit.
- **Licences to Take Water 5C** – allow holders to take water in proclaimed or prescribed areas.

3.3.4 STATUS OF LICENCES AND PERMITS

The following Table 3-1 provides a summary of the water licences and permits that are relevant to operations at Roy Hill.

Table 3-1: Water Licences and Permits

TYPE	LOCATION	DURATION OF LICENCE	NUMBER
26D	E46/335, E46/334	exp. 30/09/2006	CAW159274(1)
26D	E46/334, E46/592, E46/586, E46/335 – Roy Hill	19/10/2006 – 31/10/2007	CAW161545(1)
26D	E47/1609, E46/586, E46/686, E47/1610, E46/592, E46/688, E46/689, E46/685	26/02/2009 – 25/2/2010	CAW167712(1)
5C	Camp Bore	22/6/2007 – 20/10/2010	GW164004(1)

3.3.5 ANZECC GUIDELINES

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have formulated the National Water Quality Management Strategy (NWQMS). The NWQMS published the National Water Quality Management Strategy series which aims to achieve the sustainable use of Australia's water resources by protecting and enhancing their quality, while maintaining their economic and social development. The Strategy consists of a series of policy documents and guidelines which will help water authorities, environment protection agencies, catchment managers and local communities to manage the quality of the nation's water resources in a sustainable way.

The policy documents and guidelines relevant to water management at Roy Hill include:

Paper No.1 Water Quality Management - An Outline of the Policies (1994)

Paper No.4 Aus. and N.Z. Guidelines for Fresh and Marine Water Quality (revised 2000)

Paper No.6 Australian Drinking Water Guidelines (1996 amended 2001)

Paper No.7 Australian Guidelines for Water Quality Monitoring and Reporting (2000)

Paper No.8 Guidelines for Groundwater Protection in Australia (1995 – currently under review)

3.3.6 STATE WATER STRATEGY

State Water Plan 2007 provides a strategic framework to plan and manage water resources in Western Australia. It reflects knowledge of resources, their intrinsic value to the environment, local and Indigenous communities and foundation for economic prosperity. Western Australia has unique challenges in management of water resources. The strategy highlights that WA uses significantly less water in agriculture and more in mining than most parts of Australia and that WA has greater access to and is more reliant on groundwater resources.

3.3.7 NATIONAL WATER INITIATIVE

The National Water Initiative (NWI) represents a shared commitment by governments to increase the efficiency of Australia's water use, leading to greater certainty for investment and productivity, for rural and urban communities, and for the environment. Through it, governments across Australia have agreed on actions to achieve a more cohesive national approach to the way Australia manages, measures, plans for, prices, and trades water.

RHIO is committed to contributing towards positive outcomes of National Water Initiative objectives.

3.4 COMMUNITY

To date, RHIO has enjoyed a reciprocal relationship with the pastoralists at Roy Hill Station, a relationship which will continue to be developed through the progression to mine operation.

Formal stakeholder consultation and liaison related to water management issues will be managed through the Stakeholder and Community Consultation Plan.

4. EXPLORATION/BASELINE STUDIES

Baselines surveys, studies and monitoring have been and will continue to be undertaken during the exploration/baseline monitoring phase of the project.

The key water management investigations in this phase of development have revolved around undertaking studies and putting in place processes to ensure there is a mine water supply which is compatible with community expectations and long term environmental sustainability. Due to the lack of permanent surface water in the Pilbara, investigations have focused on groundwater sources, including mine dewatering.

Details of the baseline monitoring program are contained in Section 8 of this document.

4.1 WATER MANAGEMENT STRATEGIES

4.1.1 GROUNDWATER

The following groundwater management strategies have been and continue to be implemented to limit the impacts of the Project:

- Groundwater assessment for each relevant component of the Project (mine dewatering, saline water disposal, water supply).
- Characterisation of the hydrogeological environment of the mine site, adjoining areas and associated borefield.
- Development of a 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.

4.1.2 SURFACE WATER

The following surface water management strategies have been and continue to be implemented:

- Detailed assessment of the hydrological processes occurring within and surrounding the Project area.
- Development of a conceptual plan for storm water diversion and flood management

4.2 STUDIES TO DATE

To date, the following groundwater and surface water studies have been undertaken to improve understanding of baseline hydrological characteristics:

1. Gilbert and Associates Pty Ltd, 2008, *Baseline Surface Water Sampling Manual 2008 - 2009 Wet Season,* Report prepared for HPPL

2. Gilbert and Associates Pty Ltd, 2009, *Roy Hill Iron Ore Project – Surface Water Assessment,* Report prepared for HPPL

3. MWH, 2009, *HPPL Dewatering Strategy Roy Hill Project,* Report prepared for HPPL

4. MWH, 2007, *HPPL Roy Hill Hydrogeological Assessment Part A,* Interim Report prepared for HPPL

5. PRE-MINING/CONSTRUCTION

The pre-mine development phase would include with construction of the main Project components needed to support mining, processing and transport. The key infrastructure that would be constructed during the pre-mine period would comprise:

- Construction and operation village, administration and workshop facilities
- Advance mine dewatering borefield
- Kulbee Creek diversion
- Marble Bar Road realignment (Main Road WA)
- Site access and haul roads
- Airstrip
- Site preparation for out-of-pit waste dump and pre-stripping of initial mine areas
- Waste Fines Storage Facility
- Ore processing plant (crushing and screening plant, and desanding plant) and conveyers
- Hydrocarbon, explosives and chemical storage facilities
- Water supply borefield and associated reticulation system
- Ore load-out facility

The key water management actions would be:

- Advance de-watering
- Temporary upslope diversions of storm water, including sediment and erosion controls (developed ahead of the main earthworks construction activities)

5.1 POTENTIAL WATER RISKS

Table 5-1: Construction- Potential Water Risks

	POTENTIAL RISK
GROUNDWATER	• Loss of groundwater-dependant flora/vegetation/fauna as a result of hydrogeological changes (i.e. lowering of the water table) • Contamination of groundwater by hydrocarbons, explosives, chemicals and ARD

	POTENTIAL RISK
SURFACE WATER	• Storm water management • Alteration of runoff volumes, flow paths, velocities and water quality due to construction of mine infrastructure and temporary diversions • Decrease in percentage of stream runoff flowing into the Fortescue Marsh due to interception by open pits or water containment structures • Increased erosion and sediment movement for soil exposure • Contamination of surface water by hydrocarbons, explosives, chemicals and ARD

5.2 WATER MANAGEMENT STRATEGIES

Water management during the pre-mine construction phase would focus on drainage control, sediment and erosion control and water supply for construction. Construction water would be supplied from existing (exploration) bores and from the advance mine dewatering borefield, which would, along with the construction camp, be constructed early in the initial project development phase.

A system of temporary upslope diversions and sediment and erosion controls would be developed ahead of the main earthworks construction activities. The objective of these works would be to minimise disturbance to runoff from areas upstream of construction sites and to control/limit the potential for erosion from active earthworks construction areas. Sediment and erosion control works would be designed in accordance with regulatory and industry best practice guidelines. The plan would be modified and updated periodically to reflect ongoing mine area disturbance activities during the construction and subsequent operational phases of the project.

5.2.1 GROUNDWATER

The following actions will be implemented to limit the impacts of the Project:

- Ongoing groundwater assessment for each relevant component of the Project (mine dewatering, saline water disposal, advance dewatering for water supply)
- Adherence to licence and permit requirements
- Dewatering in advance of the mining pits to avoid significant increases in dewatering rates over the life of Project
- Collection and treatment of groundwater that has potentially been contaminated
- Maximise water use efficiency
- Liaise with the Department of Water and other stakeholders to collectively develop a cumulative groundwater impact study
- Manage dewatering and discharge (fresh and saline) to ensure the protection of aquifers and downstream ecosystems, such as the Fortescue Marsh

5.2.2 SURFACE WATER

The following surface water management strategies will be implemented to limit the impacts of the Project:

- Continue detailed assessment of the hydrological processes occurring within and surrounding the Project area.
- Develop temporary upslope diversions and sediment and erosion controls (design in accordance with regulatory and industry best practice guidelines).
- Infrastructure disturbance areas designed to avoid, minimise and/or mitigate impacts on pre-mining surface water flows, in particular sheetflow.
- Minimise disturbance to creeks and sheetflow areas.
- Implement RHIO surface water monitoring plan
- Realignment of Marble Bar Road to be designed and constructed to minimise ponding of surface water upstream and minimise impacts on downstream environment
- Any contaminated runoff to be collected and treated.

5.2.3 MONITORING

Ground water and surface monitoring and reporting will be undertaken throughout the life of the project to monitor the impact of the Project on the surrounding environment and the effectiveness of management strategies designed to mitigate the impacts.

Details of groundwater and surface water monitoring during the pre-mining and construction phases is shown in Section 8.

6. MINE OPERATION

The operational phase covers the period of active mining and transport of ore from the Roy Hill site. The mine operation will involve:

- Conventional strip mining open-pits
- A process of progressive rehabilitation where mine voids will be progressively backfilled (see section 7 Closure)

This section includes details of groundwater and surface water related investigations which have been undertaken to understand and plan the water management during mine operation.

6.1 WATER MANAGEMENT ISSUES

From a water management perspective, the main issues during this operational phase are:

- Dewatering to allow "dry" mining operations to be undertaken.
- Management of saline water
- Stormwater and flood management including the diversion of runoff around active mine areas
- Containment and management of mine water, including the overall site water balance
- Water supply for mining and on site ore processing
- Reject water management

The water management system comprises the water infrastructure works, including water storages and drainage control structures; water reticulation systems, and the management and monitoring systems needed to manage water on site.

6.2 MINE WATER PROCESSES

The following different types of water would be produced from different areas/activities within the Project (Gilbert, 2009):

- Dewatering from the advance mine dewatering borefield and water recovered from in-pit sumps. Water reporting to pit sumps would comprise residual groundwater inflows, seepage from the upslope backfilled areas and rainfallrunoff from the active mine area. The water recovered from these combined mine dewatering activities is expected to have a wide range of salinities from moderately saline (during the first stage of the Project) to hypersaline (during the second stage of the Project). Management and reuse of mine water would therefore be dependent on salinity and water quality more generally. Ore quality requirements in regard to chloride content are expected to limit reuse of highly and hypersaline groundwater. Hypersaline water would also be unsuitable for use in dust suppression or for irrigation and would be disposed to on site evaporation basins constructed prior to the second stage of the Project.

- Water used in the desanding plant would be sourced from low to moderately saline groundwater extracted from the advance dewatering activities (during the first stage of the Project) and from a regional water supply borefield which would be developed to support the Project prior to Stage 2. Water would also be recovered from the WFSF;

- Dirty water comprising runoff and seepage from the out of pit overburden waste emplacement, and from ore stockpile and load out facility areas would be intercepted via bunded, contained catchment storage areas and used for dust suppression;.

- Clean water runoff from upslope and other undisturbed areas within the mine would, where practical, be diverted around the mine and associated disturbed areas and toward downstream drainage areas;

- Water generated from sediment control areas would either be opportunistically harvested for use in haul and access road watering or would be released to downstream drainage areas following settling;

- Potable water would be sourced from local bores tapping fresh water in upland alluvial and fractured rock aquifers; and

- Sewage from the camps and site ablution facilities would be treated on site with treated effluent being used on garden and landscape areas around the mine.

6.3 DEWATERING

The groundwater table lies approximately 8 to 46 m BGL with an average of 35 m BGL. Two groundwater quality systems exist within the proposed mining area; fresh to brackish groundwater associated with the saturated parts of the tertiary alluvial sequence and the upper parts of the Marra Mamba Formation, and saline to hypersaline groundwater associated with the Fortescue Marsh groundwater system. A significant proportion of the ore body lies below the groundwater table but a small proportion is also below the salt water interface with maximum pit excavations expected to be approximately 100 m BGL. Pit dewatering will be required to maintain “dry” open-cut mining conditions.

A brief outline of the dewatering strategy is below. The full description is contained in MWH (2009).

6.3.1 NUMERICAL MODELLING

A numerical groundwater model for the Roy Hill area was developed to evaluate abstraction volumes required to dewater the proposed mine site, as well as assess the potential impacts resulting from dewatering on groundwater levels (MWH, 2009).

Numerical simulations were conducted to estimate the volume of water to be extracted from the mining area over the Stage 1 mining period (see Table 6.1). Based on the numerical modelling results a total of 75 GL is required to be abstracted over a period of 10 years, this represents an average dewatering requirement of 20.46 ML/d.

Simulations were undertaken using a solute transport model to determine the percentage of fresh water (defined for the purpose of this investigation as being <10,000 μS/cm EC) in the dewatering discharge. The results are shown in Table 6-1 and indicate that in Years 8 and 9 only approximately 50% of the total water removed during dewatering will be fresh and suitable for use in the mineral processing. Similarly, in Year 10 the percentage of fresh water falls to 40%. The current results of the solute transport modelling should be considered as preliminary and will improve with further calibration and refinement.

Table 6-1 Modelled Dewatering Volumes and Estimated Percentage Fresh

MINING YEAR	DEWATERING VOLUME (ML)	DAILY AVERAGE (ML/D)	PREDICTED % FRESH
Year 1	5,640	15.45	100
Year 2	8,822	24.17	100
Year 3	13,301	36.44	75
Year 4	97	0.27	100
Year 5	1,085	2.97	100
Year 6	6,504	17.82	75
Year 7	10,958	30.02	75
Year 8	2,625	7.19	50
Year 9	18,750	51.37	50
Year10	6,886	18.87	40
Total Dewatering	**74,668**	**20.46**	

- Volumes derived from drains are based on starting dewatering 1 year in advance of mining to ensure dry mining.
- Actual dewatering will be smoothed over several years to reduce peaks and troughs.

6.3.2 DEWATERING STRATEGY

As discussed in Section 4, to achieve dewatering of the proposed pit(s), it is estimated that a total of 74,668 ML of groundwater, over a 10 year period will be required to be removed from the immediate mining area to maintain “dry” mining conditions.

It is further recognised that the rate of required dewatering varies from abstraction rates of 0.27 to 51.37 ML/day, throughout the 10 year mining period. The variability in dewatering requirements is a function of the location and migration of the mining areas throughout the mining schedule and the associated impact of the localised hydrogeology.

To manage the variability of the required dewatering abstraction rates throughout the project life and to assist in the overall water management and operating strategy of the dewatering and water demand of the project area, it is proposed to optimise the dewatering requirement for the first ten years of dewatering by establishing the dewatering borefield at or slightly above the 10 year average of 20.46 ML/d.

The benefit of the advanced dewatering strategy is to normalise the abstraction volume over the life of the Project and to remove the spikes in dewatering requirements as required from the numerical modelling results.

It is anticipated that yields in the bores established early in the mine life, particularly those in the northern part of the proposed ex-pit dewatering borefield will decline as dewatering desaturates the orebody aquifer. During the first 10 years, progressive movement of the centre of the operating borefield will be required to advance to the south as mining moves to the south. The existing northern bores will either be decommissioned or operated at reduced yield as mining migrates to the south.

6.3.3 DEWATERING LAYOUT

Due to the geometry of the ore body and the planned rate of advancement set out in the mining schedule, the proposed adopted dewatering strategy for the Roy Hill Project will consist of:

- A network of external to the pit dewatering bores down dip and along the western edge of the planned mining area
- A small network of internal to the pit dewatering bores (sacrificial) that would be established in areas to be mined later in the mine life and will ultimately be destroyed and lost during mining activities

6.4 WATER SUPPLY BOREHOLES

To meet the water demand of the processing plant, it is proposed to abstract groundwater from the production borefield to augment the flow from the dewatering boreholes. In adopting this strategy it is recognised that dewatering will be required to be undertaken over significant parts of the proposed mining area in advance of the mining activities. Figure 6-1 illustrates how the fresh dewatering supply and borefield supply can be used to meet the water demand of the mine over the whole of the Stage 1 period.

The production borefield will comprise some 16 boreholes, drilled at roughly 1km centres. The holes will be positioned along the southern edge of the proposed mine pits, so that they can be retained when mining commences in this area during Stage 2 and used as dewatering bores.

Bore construction of these production holes would be designed to be fully penetrating through the Tertiary alluvium and Nammuldi Formation and into the underlying dolomite, where it is present due to faulting. The anticipated yield of individual production bores is likely to be around 1.0 to 1.5 ML/d.

Another potential borefield is currently being investigated in the Roy Hill South/Ethel Creek area. Subject to regulatory approval, it is anticipated that water from this borefield will be used to meet the process water requirements of mining during Stage 2 of the Roy Hill Project. However this water may also be available to supplement supplies in the later years of Stage 1, if required.

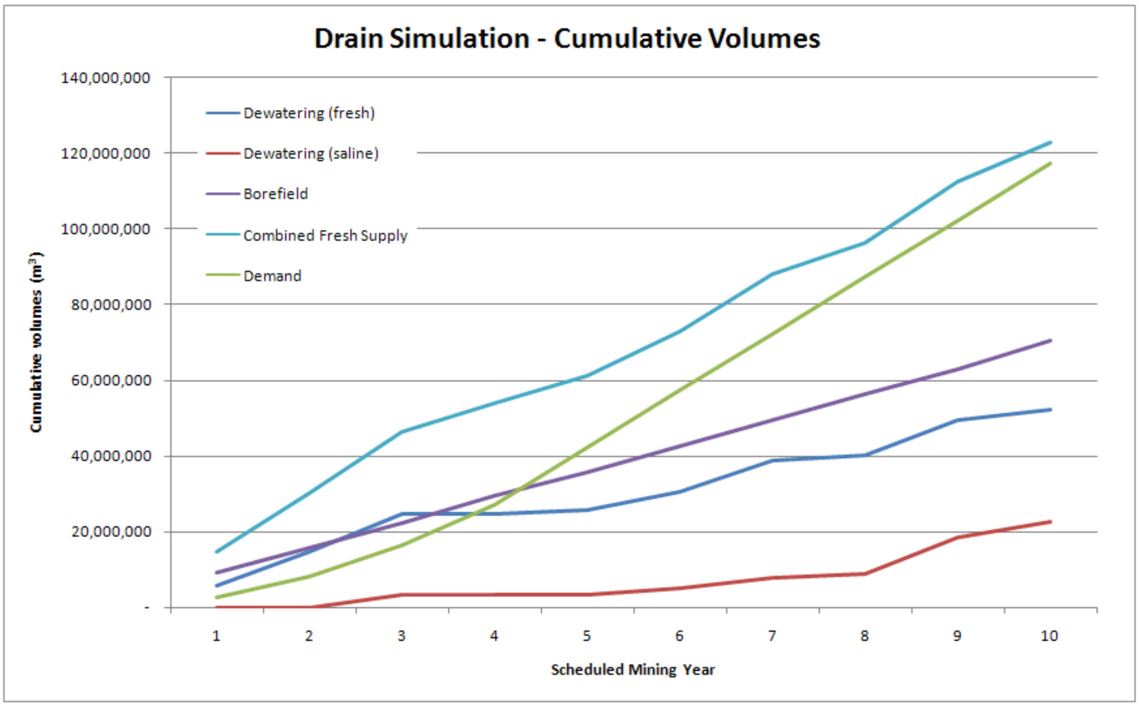

Figure 6-1: Predicted Water Supply and Demand Volumes

6.5 SALINE WATER MANAGEMENT AND SYSTEM DESIGN

6.5.1 SALINE WATER MANAGEMENT

The upper freshwater lenses of groundwater will be used for ore processing and dust suppression activities. The denser saline water above 10,000µS/cm EC will be unsuitable for use in iron ore processing.

The current base case for addressing saline water is to construct and manage a system to evaporate the water and encapsulate the salt.

The saline water management system will comprise 3 components:

- Evaporation Pond.
- Salt Production Facility
- In-pit Encapsulation Cell(s)

The evaporation pond is designed to evaporate surplus water from the project plus incident rainfall.

Concentrated brine will be pumped from the evaporation pond to the salt production facility where salt will be precipitated and dried before harvesting and placement in engineered cells constructed above the water table within the backfilled pits.

The facilities will be constructed and operated to maximise the area of water and thus the evaporation losses.

The facilities will consist of a number of individual cells lined with a low permeability liner. This liner can comprise a clay liner or a 1 mm smooth HDPE liner.

Pond construction will be staged to optimise the number of cells required. Depending upon the effectiveness of the first constructed cells and their performance versus that predicted, as well as the benefit realised through utilisation of evaporation enhancement techniques, the required number of cells will be reviewed to reflect operational experience. Additional cells will be constructed as required.

Encapsulation cell construction will also be staged and will depend on the quantities of salt produced and the mining and backfilling sequence.

The applicable design criteria and standards are summarised in Table 6-2.

Additional information on Saline water management and system design is contained in Lycopodium (2009).

Table 6-2: Summary of Design Criteria and Standards

OPERATIONS	
Design Component	Design Application
Production Throughput	• 6.1 GL/annum average, 23 GL/annum max
Production Hours/Year	• 8000 (91.3% availability)
Design Factor for Pipes and Pumps	• 120%
Water Characteristics	• SG water = 1.1 • TDS = 67,000 mg/L
STORMWATER MANAGEMENT	
Design Component	Design Application
1:25 yr	• Temporary diversion structures during construction.
1:10 yr	• Diversion channel erosion protection.
1:10 yr/1:100 yr	• Diversion channel capacity (minor / major).
1:100 yr/72 hr in addition to the maximum operating pond levels for average climatic conditions 1:1000 yr	• Evaporation pond capacity. • Evaporation ponds operating spillways
1:5000 yr, 6-, 18-, 72-hr intensity and 72-hr volume	• Evaporation structure at reclamation
SEDIMENTATION BASINS	
1:20 yr, 6hr duration	• Sedimentation basin sizing
SEISMICITY	
Acceleration Coefficients	• Operating Basis Earthquake (OBE), acceleration coefficient equivalent to a 1 in 475 year annual exceedance probability - 0.07g. • Maximum Design Earthquake (MDE), acceleration coefficient equivalent to a 1 in 10,000 year annual exceedance probability - 0.45g.
Stability	• Static loading stability FOS = 1.5 • Pseudo-static loading (OBE) stability FOS = 1.1.
EVAPORATION PONDS	
Design Component	Design Application
General	• Minimum water freeboard of 0.3 m plus 1 in 100 year 72 hr storm event (0.4 m). • Total freeboard approximately 0.7 m • Total area approximately 400 ha (2km by 2 Km) • Total height approximately 3 m.
Construction	• Pond embankments constructed using local borrow, low permeability embankment. • 6 m 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. • 1 mm smooth HDPE pond liner. • Erosion protection/rockfill 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 – 300 mm of 1 x 10^{-9} m/s compacted soil

Source: Lycopodium(2009)

6.6 GROUNDWATER DRAWDOWN

The dewatering activities will result in the drawdown of the aquifer, lowering the water table. The extent of the area predicted by modelling to be affected by a 2m drawdown at the end of each year in Stage 1 is shown in MWH (2009).

The extent of the area affected by drawdown is predicted to increase year on year, as the mining moves into new areas. By Year 10, the drawdown of the water table, resulting from the dewatering and production borefield, is predicted to be contained largely within the mining lease, except in the northwest and southeast corners.

The area affected by drawdown is predicted to remain some 4 kilometres away from the Fortescue Marsh, to such an extent that the abstraction of the groundwater will have no direct impact on the Marsh.

6.7 GROUNDWATER REBOUND

The groundwater model was used to simulate the rebound of the groundwater table when the dewatering is switched off on cessation of mining after Year 20. The model indicated that recovery to original levels will take some 40 years. This is based on the following assumptions;

- All pits will be backfilled with waste material to original ground level
- The backfill material has a porosity of 35% to allow for bulking
- Recharge occurs only by direct infiltration of rainfall, with no contribution from surface water runoff

The predicted duration of recovery of water levels after the cessation of dewatering and mining is in line with similar predictions of water levels in pit voids throughout the Pilbara region. The majority of the recovery process is dependent on recharge, with little contribution from the groundwater system occurring once water levels have risen above the water levels observed in the Fortescue Marsh.

In reality the recovery may occur sooner if the backfill material is compacted and has a lower porosity, and the diverted watercourses are reinstated such that they contribute surface runoff into the backfilled pits.

6.8 SURFACE WATER DIVERSION

A conceptual stormwater management scheme has been developed as part of the Project feasibility and environmental assessment studies (Gilbert and Associates, 2009). The objectives of the stormwater management works are:

- Limit stormwater inflows and the risks of flooding in active mine areas which would otherwise occur in the event of high rainfall.
- Reduce the volume of stormwater runoff which could potentially be contaminated as a result of contact with mining activities and associated mine infrastructure areas.
- Limit changes to the distribution of surface runoff flow in watercourses downstream of the mine area - both during and post mining.

The scheme would require the construction of a series of diversion structures to convey runoff around the mine and associated mine waste emplacement areas and around the main infrastructure areas. The diversions would convey these flows into existing downstream drainages that flow to the Fortescue Marsh. During active mining a combination of permanent and temporary diversions would be constructed.

As mining and overburden emplacement were completed in different areas temporary diversions would be replaced by permanent, reconstructed drainage features which would be constructed across previously mined and backfilled areas of the mine to recreate the original pattern of drainage. This would result in the re-connection of the upper sections of the main watercourses with their remnant sections downstream. The reconstruction works would aim to restore the geomorphic attributes and hydrological/ecological functions of these drainages in a similar manner to the original drainage system. The components of the system and its evolution over time are depicted in Appendix B. The conceptual design features of the proposed creek reconstruction works are described in more detail in Gilbert and Associates (2009).

6.8.1 DIVERSION DESIGN CRITERIA

The following peak design flows are proposed for temporary works:

- For service life of 5 years or less – 1 in 20 year ARI;
- For service life of between 5 and 10 years – 1 in 50 year ARI; and
- For service life of between 10 and 20 years – 1 in 100 year ARI.

Temporary diversion works would be designed to be stable against erosion during the proposed design event.

Permanent channel reconstruction works would involve controlled overburden placement within defined corridors. It is envisaged that a corridor of some 300 to 500m wide would be required to accommodate each re-constructed creek and associated flood plain area. Placement of mine waste within these corridor areas would be scheduled to create valleys within the generally more elevated waste dump surface and which are consistent with the valley contours upstream and downstream of the mine area. The reconstructed channel would comprise a low flow channel of similar dimensions as the original creek together with broad constructed flood plain areas. Investigations including exploration drilling confirm relatively thick, unconsolidated and permeable alluvial and colluvial deposits underlie the main drainage features. These materials would be preserved during the mining process for reuse in the creek reconstruction works where they would be used to form the final 3 to 5m thick surface layer in the drainage corridor. The alluvial layer would be supported on a zone of selected mine waste placed by paddock dumping methods which would be spread and compacted in lifts.

Permanent diversion channels and flood plain reconstruction works would be designed to have similar flow velocities, bed shear stresses and stream power characteristics as the natural drainage system that they would replace over a wide range of flows from a 1 in 1 year to an estimated 1 in 10,000 year event. This would necessitate the same or similar channel gradients and lengths and similar channel cross sectional profiles. The reconstructed creek channels which cross backfilled mine areas would be constructed along a similar alignment as the original creek channel such that the channel length and bed slope would be the same as the original.

Flow loss in the form of water infiltrating into the bed of local watercourses occurs as a natural process. Flows generated from the catchment seep into the bed sands and gravels until the bed materials become locally saturated and are able to sustain surface flows. In the aftermath of rainfall, flows recede rapidly and the bed sediment de-saturate as water drains downward through the coarse bed sediments to recharge the underlying groundwater. These same cycles would occur in the reconstructed creek lines which would be constructed using the same bed materials. Flow losses in the longer term are expected to be similar in the reconstructed creek line as they are under current, pre-mine conditions.

6.9 FORTESCUE MARSH

A network of observation boreholes has been installed along the western and southern boundary of the mining lease between the mining area and the Fortescue Marsh. The boreholes have been monitored regularly since 2007 to provide baseline information on groundwater levels and the level of the saline interface, and they will continue to be monitored during the life of the mine to measure any impact from the mining and dewatering activities. Data loggers are installed in some of the holes to capture water level data at 2 hourly intervals. This produces a continuous record of the water table and provides information on the extent to which water levels fluctuate in response to natural changes, such as seasonal rainfall events.

The potential impact of dewatering activities at the Roy Hill minesite on the Fortescue Marsh has been assessed using a numerical groundwater model (MWH, 2009). The model covers an area of 2000 square kilometres, and extends some 20km to the west of the minesite into the Fortescue Marsh, and some 30 km south of the Fortescue River. The area affected by drawdown is predicted to remain some 4 kilometres away from the Fortescue Marsh, to such an extent that the abstraction of the groundwater will have no direct impact on the Marsh.

The monitoring network and program will allow direct comparison between the actual and predicted impact throughout the life of mining.

6.10 MINE WATER BALANCE

The water balance model is a useful tool for providing a concise overview of water distribution and usage. Figure 6-2 shows the average annual water balance for the proposed operations. The information is the best that is available at the present time, and will be subject to change as the mining process is refined. As detailed engineering design continues, the water quality of process operations will be determined and incorporated in to a detailed annual water balance.

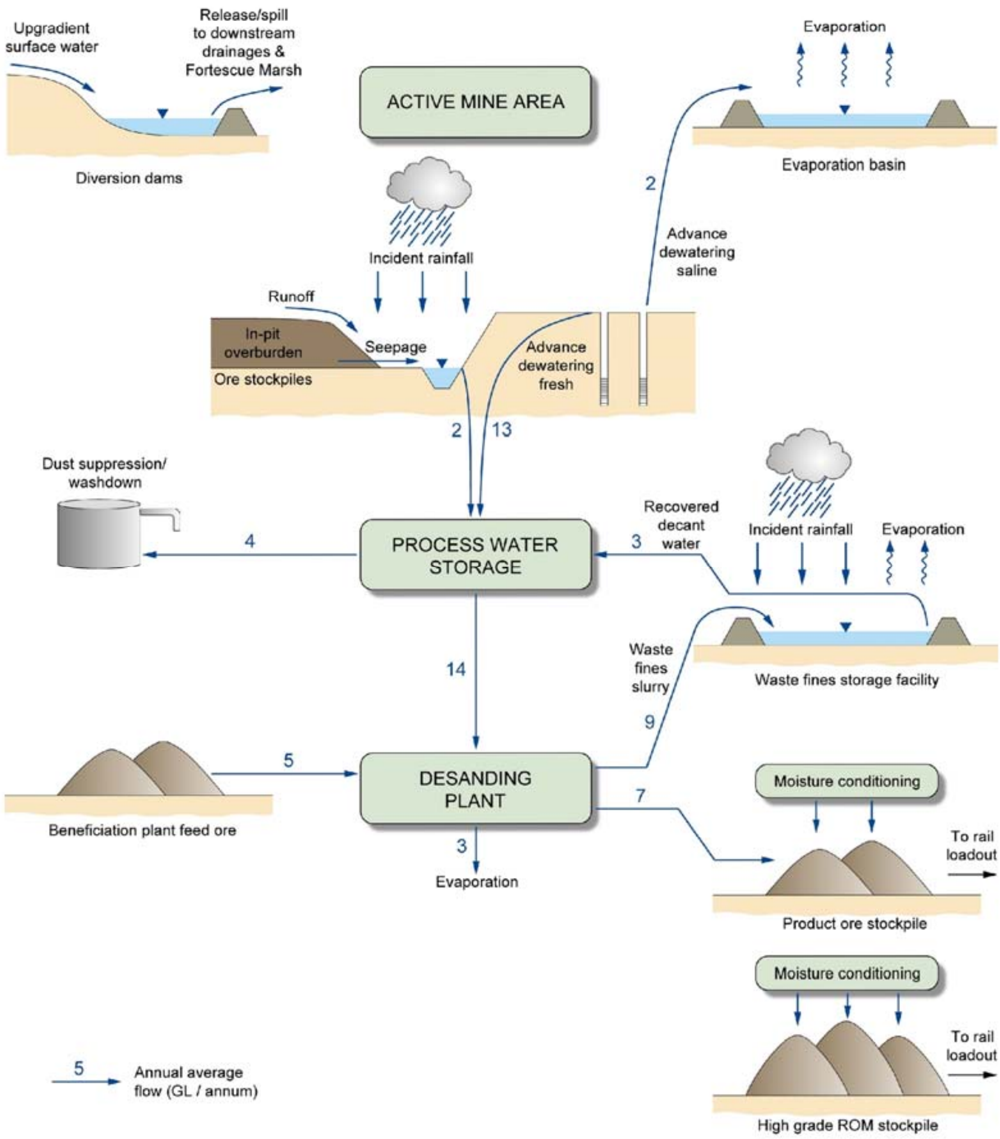

Figure 6-2 Indicative Water Balance

6.11 WATER USE EFFICIENCY

Wet processing of the Project ore will be relatively water efficient compared to the processing water requirements of other iron ore projects in the Pilbara per Mtpa of ore processed (Table 6-3).

Table 6-3: Comparative Water Use Efficiency at Iron Ore Projects

IRON ORE PROJECT	WATER REQUIREMENTS PER TONNE OF IRON ORE
Cloud Break Mine (FMG)	1.5ML/Mt
Marandoo (Rio Tinto)	1 ML/Mt
Roy Hill 1 (RHIO)	0.7 ML/Mt
Hope Downs (Rio Tinto)	0.24 ML/Mt

6.12 POTENTIAL WATER IMPACTS

The potential water impacts, which have been identified through comprehensive studies, including a wholistic environmental risk analysis SMEC (2008), are listed in Table 6-4.

Table 6-4: Mine Operation - Potential Water Impacts

	POTENTIAL IMPACT
GROUNDWATER	• Leaching or overtopping of hyper-saline water from evaporation ponds • Loss of groundwater-dependant flora/vegetation/fauna as a result of hydrogeological changes (drawdown) • Contamination of groundwater by hydrocarbons, explosives, chemicals and ARD
SURFACE WATER	• Storm water flooding mine infrastructure • Alteration of runoff volumes, flow paths, velocities and water quality due to construction of mine infrastructure and temporary diversions • Decrease in percentage of stream runoff flowing into the Fortescue Marsh due to interception by open pits or water containment structures • Increased erosion and sediment movement for soil exposure • Contamination of surface water by hydrocarbons, explosives, chemicals and ARD

6.13 WATER MANAGEMENT STRATEGIES

The following water management strategies will be implemented to limit the impacts of the Project.

6.13.1 GROUNDWATER

- Adhere to licence and permit requirements.
- Limit dewatering to the minimum required to safely dewater mine area.
- Collect, contain and treat groundwater that has potentially been contaminated.
- Liaise with the Department of Water and other stakeholders to collectively develop a cumulative groundwater impact study.
- Manage dewatering and discharge (fresh and saline) to ensure the protection of aquifers and downstream ecosystems, such as the Fortescue Marsh.

6.13.2 SURFACE WATER

- Implement a 500m buffer inside the western tenement boundary to ensure no shadow effects beyond the boundary of the Project impacting the downstream environment.
- Design and construct stormwater diversion drains and containment areas to reduce the flood risk to the Project and minimise the impact on stormwater flows into the Fortescue Marsh catchment area.
- Design, install and manage surface water diversion structures that enable runoff to be directed around disturbance areas.
- Design, install and manage surface water containment structures that will enable contaminated water to be collected and managed
- Redistribute diverted stormwater into remnant sections of the natural water courses downstream of the Project area.
- Engineer dispersion systems at the discharge point of diversion drains to reintroduce sheet flow minimising the impact on downstream environment.
- Dewatering in advance of the mining pits to avoid significant increases in dewatering rates over the life of Project.
- Minimise the amount of disturbance to creeks and areas of sheet flow, particularly through staged mining and rehabilitation activities for the life of the mine.
- Minimise disturbance to creeks and sheetflow areas.
- Implement a surface water monitoring plan.
- Any contaminated runoff to be harvested and treated/contained.
- Reinstate natural drainage channels (subject to engineering feasibility).

6.13.3 EROSION AND SEDIMENTATION:

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

- Delay vegetation removal in areas adjacent to surface water flows as long as practically possible to minimise increases in erosion and sedimentation.
- Stabilise disturbed areas and new drainage lines prior to “wet season”.
- Use rock armour in areas of potentially high erosion (steep gradients, bends).
- Stabilise the banks of the diversion channels with direct seeding of native vegetation species endemic to water courses of the region.

- Contour rehabilitated areas to minimise the velocity of stormwater reducing erosion potential.
- Use cleared vegetation material to stabilise rehabilitated surfaces.

6.13.4 WATER USE EFFICIENCY

To improve the water use efficiency, the following management strategies would be employed:

- Use water obtained from dewatering and surface water captured by diversion structures in preference to developing a borefield external to the Project area.
- Promote the importance of water use efficiency during induction training and corporate and environmental policies
- Quantify, monitor and report water use.
- Produce annual mine water balance.

7. CLOSURE

A process of progressive rehabilitation has been proposed to increase the overall rate of rehabilitation of the mine pit void this would involve the overburden material removed from mining areas being directly deposited in to previous voids, to a level above the original water table. Topsoil and vegetation from the new mining area would be directly reinstated to the backfilled areas.

The closure of the operation following the cessation of mining and processing operations will involve the complete demolition and rehabilitation of all redundant plant and infrastructure. The proposed progressive rehabilitation will minimise the total amount of rehabilitation required at closure.

At the completion of mining a Mine Closure Plan will be implemented. To date a conceptual plan has been developed.

7.1 MAJOR WATER MANAGEMENT ISSUES

The main post closure surface water issues are:

- The stability of drainage and erosion of post mine landform;
- The stability of diversions and creek reconstruction works and other constructed water management works left post mining;
- Restoration of overland flow regimes in areas affected by mining and subsequent closure/rehabilitation works;
- Disposal of hyper-saline residues from the evaporation ponds.

7.2 POTENTIAL RISKS

The potential water impacts, which have been identified through comprehensive studies, including a holistic environmental risk analysis SMEC(2008), are listed in Table 7-1.

Table 7-1: Mine Closure - Potential Water Impacts

	POTENTIAL IMPACT
GROUNDWATER	• Reduction in groundwater quality
SURFACE WATER	• Drainage stability and erosion of post mine land form • Increased erosion and sediment movement • Surface water quality

7.3 SURFACE DRAINAGE IMPACTS

Gilbert and Associates (2009) undertook a Surface Water Assessment, the results of that study are summarised below.

A preliminary analysis to assess the change in the area of catchment likely to report to the main site drainages leaving the Project disturbance area was undertaken and is summarised in Table 7-2. The largest changes can be seen to occur to the areas draining to the two western arms of Kulbee Creek. These changes will affect a relatively small area upstream of where these channels join. Other changes are relatively small and are unlikely to have much effect. The overall effect on the pattern of flows in the lower distributary flow area fringing the Fortescue Marsh is expected to be undetectable (Gilbert and Associates, 2009).

Table 7-2: Changes to surface water catchments Post Closure

HYDROLOGICAL IMPACT ASSESSMENT POINT		PRE-MINE CATCHMENT AREA (KM²)	POST CLOSURE CATCHMENT AREA (KM²)
1	Tributary of Christmas Creek	21	21
2	No-name Creek	88	91
3	Central Catchment Drainage	31.2	43
4	Far Western Arm of Kulbee Creek	2	16
5	Western Arm of Kulbee Creek	38	8
6	Main Arm of Kulbee Creek	28	30
7	Western Tributary of Eastern Catchment	4.9	5
8	Eastern Tributary of Eastern Catchment	11.3	12
9	Western Tributary of Kulkinbah Creek Catchment	21.5	23
10	Eastern Tributary of Kulkinbah Creek Catchment	5.6	3.2

Valley depressions will be formed within these landforms where major creek lines are reconstructed across them. As yet there has been no detailed assessment of the surface treatment or drainage management for the rehabilitation areas. In principle, however, the drainage and vegetation provisions would aim to mimic elements within the surrounding terrain with similar topography and aspect. The upper surfaces of the landform would be top-soiled and vegetated with native grass and spinifex species. The slopes would also be planted with shrubs and tree species which occur in the foothills of the Chichester Ranges.

A network of formal drainage lines would be provided for surface runoff. These features would be directed into the reconstructed creek lines either directly or via toe drains constructed around the upslope and downslope toe of the final mine landform. The toe drains would convey runoff to the reconstructed creeks and to existing down-slope drainage lines.

Drainage stability and erosion of post-mined landforms is a significant issue for most large mining projects. Whilst Roy Hill is located in an arid environment where rainfall is scarce, rainfall intensities can be high with attendant high potential for erosion. Providing erosional stability to post-mined landforms is a combination of establishing a sustainable and effective vegetation cover, providing adequate and stable drainage and undertaking ongoing monitoring and maintenance during the establishment phase. With adequate and detailed planning and adoption of best practice progressive rehabilitation methods there is nothing particular about the situation at Roy Hill which would prevent stable self-sustaining landforms being achieved.

7.4 WATER MANAGEMENT STRATEGIES

The following management strategies will be specifically adopted during closure:

- Constructing drainages to mimic natural forms (i.e. similar channel width and depth, similar bed gradients, similar bed sediment) and by propagating similar riparian vegetation, the reconstructed drainages should behave in a similar fashion to natural drainage lines; and
- Design and implement measures to restore creek systems and reduce changes in downstream sedimentation regimes after mining.
- Any residual brine in the evaporation cells will be transferred to the salt production facility for evaporation.
- Any residual salt that has deposited in the evaporation cells and production cells will be harvested using mechanical equipment and placed in the in-pit encapsulation cells.

There are two options to be considered for rehabilitation of the evaporation and production cells:

- Option 1 - Remove the bunds and HDPE liner, and return the land to its original condition by placing topsoil and seeding with native flora.
- Option 2 - Use the cells as the basis for an aquaculture production facility.

7.5 MONITORING

Groundwater and surface water monitoring will continue after mine closure (section 8).

8. WATER MONITORING PROGRAM

8.1 BACKGROUND

To date, water monitoring has focussed on the collection of baseline data, so that in the future as mining progresses, groundwater and surface water can be assessed in relation to baseline conditions.

The following section describes the details of the various aspects which are included in the water monitoring program. The location, frequency and measured parameters will be subject to review during the life of the Project and may be subject to change.

8.2 GROUND WATER

Groundwater monitoring will be undertaken to assess the impact of the Project (primarily dewatering and groundwater abstraction) on groundwater levels and water quality in the surrounding environment, in particular the Fortescue Marsh. The results of the groundwater monitoring program will be an input into other monitoring components including: water use efficiency and vegetation monitoring.

The frequency and details of the monitoring program at the progressive stages of mining is outlined in Table 8-1. The results of monitoring will be used to confirm the computer simulated results of groundwater impacts and for the refinement of future predicted impacts.

The location of the existing monitoring bores is shown in Appendix C. The location of monitoring bores has been selected to ensure coverage of the modelled drawdown area. Additional monitoring bores have been located to confirm that the Project drawdown will not extend to the Fortescue Marsh. Pending further hydrogeological investigations (particularly into the Project water supply borefield), the location of monitoring bores may be subject to change and additional monitoring bores may be installed.

Table 8-1: Groundwater Monitoring

ASPECT TO BE MONITORED	MONITORING PROGRAM
Baseline	• Conduct monthly monitoring of water levels in existing piezometers and production bores (Appendix C) • Download water level loggers every three months • Undertake down hole EC surveys of piezometers every four months

ASPECT TO BE MONITORED	MONITORING PROGRAM
Pre-Mining / Operation	• Monthly cumulative and instantaneous pumping volumes for each potable/dewatering /production bore • Monthly pH and EC measurement of each dewatering/production bore • Monthly pumping and test water level in production bores • Monthly measurement of water levels in piezometersMonthly reading of key water meters • Monthly download of water level data loggers • Monthly EC profiles of piezometers • Six monthly sampling of non potable production bores of pH, EC, TDS, hardness, Na, Ca, Mg, K, CL, SO_4, HCO_3, NO_3, Fe and alkalinity • Monthly potability sampling of potable water supply production bore(s) and nominated sampling points • Annual presentation of well field monitoring results in Annual Aquifer reports as per DoW licences
Closure	• Quarterly water level monitoring • Quarterly EC profiles • Monitoring will continue until subsequent sampling shows variability less than one standard deviation in all key parameters, but will not exceed three years
Reporting	• Annual presentation of well field monitoring results in Annual Aquifer reports as per DoW licences • Present summary of results to DoW, EPA and other relevant authorities

8.3 SURFACE WATER

A surface water monitoring program has begun prior to mining operations and will continue during mining, in order to quantify the impacts of the mine operation on water quantity and quality of surface water. The ephemeral hydrological regime and the variability of climatic conditions present challenges in establishing a representative “baseline” dataset; where required hydrological modeling and statistical analysis tools may be developed to improve understanding of the system.

A baseline hydrological monitoring Program has commenced on Kulbee Creek; three flow monitoring sites and three pluviometers were set up in November 2006. The locations of the monitoring stations and pluviometers are shown in Appendix D (KC1 – KC3). They correspond to the upper, mid and lower sections of the lease. The gauging stations record water level in a well installed within the creek bed alluvium, which is converted into equivalent flow rates using a rating relationship which has been developed using a hydraulic model of the creek in the vicinity of each gauging station site (Gilbert, 2008).

The on-going surface water monitoring program is shown in Table 8-2.

Table 8-2: Surface Water Monitoring

ASPECT TO BE MONITORED	MONITORING PROGRAM
Baseline	• Maintain continuous flow monitoring at three locations in Kulbee Creek to monitor baseline flow • Download in-stream loggers every three months. • Operate rainfall network at Roy Hill (download every three months)
Operation	• Extend monitoring network to include all major site drainages (locations upstream and downstream of the project disturbance areas) • Continue Kulbee Creek flow monitoring • Continue to operate rainfall network at Roy Hill
Closure	• Continue flow monitoring • Operate rainfall network at Roy Hill • Monitoring to continue for 2 years
Reporting	• Report flow and rainfall annually • Provide data relevant to the assessment of cumulative impacts • Present summary of results to DoW, EPA and other relevant authorities

The objective of the baseline water sampling program is determination of the water quality characteristics of the project site catchments prior to development. Water quality data will be used in conjunction with flow monitoring and rainfall data to enable informed prediction and assessment of potential project impacts and mitigation/management measures.

A comprehensive water quality monitoring program for Roy Hill is shown in Table 8-3. HPPL will collect at least one year of baseline water quality data before the diversion of any of the creeks, subject to accessibility to the sites being in compliance with HPPL's OH&S policy and the occurrence of sufficient runoff events to allow water samples to be taken.

The on-going surface water quality program is shown in Table 8-4.

Table 8-3 Baseline Surface Water Sampling Program

<table>
<tr><th colspan="5">ROY HILL BASELINE SURFACE WATER SAMPLING PROGRAM</th></tr>
<tr><th rowspan="2">Sampling Sites</th><th rowspan="2">Sampling Frequency</th><th colspan="3">Parameter Suite</th></tr>
<tr><th>Field Measured</th><th colspan="2">Laboratory Analysis</th></tr>
<tr><td>Kulbee Creek:
KC1
KC2
KC3
KC4</td><td>Between 3 and 5 sampling events at each site, to coincide with streamflow events:
early wet season ‘first flush’ event
late wet season receding flow event
high runoff event
two other events (at discretion of field personnel)</td><td rowspan="4">pH
Conductivity
Temperature
Total Suspended Solids (TSS)</td><td rowspan="4">Calcium
Magnesium
Sodium
Chloride
Sulphate
Nitrate
Alkalinity
Total nitrogen
Total phosphorus</td><td rowspan="4">Total arsenic
Total iron
Total manganese
Total copper
Total zinc
Total lead
Total selenium
Total molybdenum
Total aluminium
Total cobalt
Total chromium</td></tr>
<tr><td>No-Name Creek:
NN1
NN2</td><td>Maximum of 3 sampling events to coincide with receding flow following high flow event</td></tr>
<tr><td>Kulkinbah Creek:
KK</td><td>Maximum of 3 sampling events to coincide with receding flow following high flow event</td></tr>
<tr><td>Fortescue Marsh:
FM</td><td>Maximum of 3 sampling events to coincide with receding flow following high flow event</td></tr>
</table>

Table 8-4: Surface Water Quality

ASPECT TO BE MONITORED	MONITORING PROGRAM
Baseline	• Conduct baseline monitoring during wet season as outlined in Gilbert and Associates (2008) • Parameters: pH, Conductivity, Temp, TSS, Calcium, Magnesium, Sodium, Chloride, Sulphate, Nitrate, Alkalinity, Total nitrogen, Total phosphorus, Total arsenic, Total iron, Total manganese, Total copper, Total zinc, Total lead, Total selenium, Total molybdenum, Total aluminium, Total cobalt, Total chromium • Measure and record all parameters in mg/L (where appropriate) • Submit all samples to NATA accredited laboratory for analysis.
Operation	• Conduct monitoring 3 times (first flush, high flow, end of season) annually during runoff events • Parameters: *as above*
Closure	• Conduct monitoring 3 times (first flush, high flow, end of season) during runoff events for 2 years • Parameters: *as above*

ASPECT TO BE MONITORED	MONITORING PROGRAM
Reporting	• Report water quality annually • Provide data relevant to the assessment of cumulative impacts • Present summary of results to DoW, EPA and other relevant authorities

8.4 GEOMORPHIC CHANGE

Geomorphic change to creek lines is expected – particularly in creeks which receive additional runoff from diverted catchments. Whilst, these changes are expected to be moderate and localised to reaches subject to changed contributing catchment flows, a monitoring program to monitor geomorphic change is outlined below in Table 8-5.

Table 8-5: Geomorphic Change

ASPECT TO BE MONITORED	MONITORING PROGRAM
Baseline	• Survey reference cross sections and conduct photographic survey (1) reference "control" catchment and (2) catchments which will potentially be impacted during mine operation
Operation	• Monitor reference cross sections and conduct photographic survey of reference catchment and catchments impacted during mine operation.
Closure	• Monitor reference cross sections and conduct photographic survey of reference catchment, catchments impacted during mine operation and re-instated channel sections for 2 years
Reporting	• Report annually

8.5 VEGETATION

Prior to the commencement of mining, studies will be conducted to identify groundwater dependent ecosystems (GDE) which may be impacted by operations at Roy Hill. Where GDE are identified, an on-going monitoring program will be instigated.

The program will be refined as GDE are identified and site specific information becomes available.

Table 8-6: Phreatophytic Vegetation

ASPECT TO BE MONITORED	MONITORING PROGRAM
Pre-mining	• Assessment of conservation significance/ecological value and condition of GDEs; • Analysis of ecosystem groundwater dependency; • Assessment of hydrological regime in which dependency operates (input from results of groundwater and surface water monitoring program) • Determination of Ecological Water Requirements (EWRs) • Selection and establishment of monitoring and control sites (transects) in the groundwater drawdown zone. • Parameters to be measured may include: species, height, % alive canopy, health score, site conditions, photograph
Operation	• Ongoing monitoring at sites and parameters outlined above.

8.6 WATER USE EFFICIENCY

Table 8-7: Water Use Efficiency

ASPECT TO BE MONITORED	MONITORING PROGRAM
Operation	• Document monthly water abstraction rates on all production bores (dewatering and potable) • Update site water balance on an annual basis • Document water use efficiency annually (ML/Mt)

8.7 SALINE WATER MANAGEMENT SYSTEM

The monitoring plan for the saline water management system is contained in Lycopodium (2009).

9. PERFORMANCE CRITERIA

Table 9-1 outlines the performance criteria for the water monitoring program as described in the previous section. In some instances, quantifiable criteria are yet to be defined, however, they will be included in future revisions on the IWMP once sufficient information and baseline data are available.

Following the development of performance criteria, the results of all ground water and surface water monitoring programs will be cross referenced with these performance criteria. Should there be an occurrence where the performance criteria has been exceeded, the EPA, DoW and other relevant agencies will be advised, and consulted with regard to the implementation of remedial measures.

Table 9-1: Performance Criteria for Water Resources Monitoring Management

ASPECT		PERFORMANCE CRITERIA
MINE DEWATERING AND PROCESS WATER SUPPLY	Pre-mining /Operation	• Licensed abstraction volume is not exceeded • Saline water is treated on site. No discharge of saline water to the surrounding environment • Drawdown (extent and depth) is within levels of confidence of predictive modelling
POTABLE WELLFIELD	Exploration/ Pre-mining/ Operation	• Licenced abstraction volume is not exceeded • Meets ANZECC criteria for potability
SURFACE WATER FLOW DISTRIBUTION	Baseline	• Establish baseline information. Develop relationship between rainfall and catchment runoff (mm/km^2)
	Operation	• Flow regime will change as water is temporarily diverted and re-routed. • Response trigger would 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 [applied to significant rainfall events which result in peak flows generally exceeding the bank-full capacity of the monitored creeks]
	Closure	• Surface water flows (downstream of mining are within 20% of predicted value (using relationship established during baseline phase)
SURFACE WATER QUALITY	Baseline	• ANZECC[1] may be applied if no baseline criteria has been set • Continue to establish baseline data record • Once baseline has been established, response (investigation) triggers would be activated if any water quality parameter measured both upstream and downstream of the disturbance area increases by 20% or one standard deviation

ASPECT		PERFORMANCE CRITERIA
	Operation	• ANZECC[1] may be applied if no baseline criteria has been set • Release to environment no detriment to baseline
	Closure	• ANZECC[1] may be applied if no baseline criteria has been set • Water Quality no detriment to baseline
GEOMORPHIC CHANGE	Operation	• Bank or bed erosion occurs in a reach of a creek downstream of the impacted zone which is outside the range of natural variability (i.e. significantly larger than corresponding rates in control cross section)
	Closure	• Bank or bed erosion occurs in a reach of a creek downstream of the impacted zone which is outside the range of natural variability (i.e. significantly larger than corresponding rates in control cross section)
PHREATOPHYTIC VEGETATION	Ongoing	• Specific EWR triggers may be set in relation to statistical variations in parameters such as health ranking, growth, function and ground water levels
WATER USE EFFICIENCY	Operation	• No performance criteria but water use efficiency to be tracked by RHIO on a monthly basis and documented • Water use to be calculated monthly during operation: Total Volume of Water/Tonne of Product

ANZECC[1] : Not recommended due to ephemeral nature of water courses. Monitoring to establish baseline conditions and develop site specific trigger values is the preferred approach.

9.1 ANZECC GUIDELINES (2000)

The ANZECC 2000 Guidelines (the Guidelines), were developed to provide a framework for sustaining the environmental value of Australia’s rivers, lakes, estuaries and water resources. The Guidelines advocate an “issue-based’ approach to assessing the ambient water quality, rather that the application of rigid numerical criteria which do not consider context.

Adopting the trigger levels defined in the Guidelines, where there is a lack of sufficient site-specific data, is a reputable approach to water quality management on site. However, it should also be noted that the classification of ecosystems in the Guidelines is coarse and there is not sufficient information to characterise the water quality requirements of ephemeral rivers.

The wide range of geographic, climatic, physical and biological factors that can influence a particular river system makes it essential that site-specific information is incorporated whenever possible. Consequently the default trigger values should only be used as a guide until site-specific trigger values or alternative indicators can be generated for the Project.

As a reference, Appendix E contains the default trigger values for slightly disturbed ecosystems in tropical Australia (the region applicable to the Pilbara), as outlined in the ANZECC 2000 Guidelines.

10. REPORTING

The reporting requirements for the Project will be specified as a part of the EPA licence conditions.

Table 10-1 presents the proposed reporting framework for the surface water and groundwater related facets of the Project.

Table 10-1: Reporting Framework

IWMP	• Updated Integrated Water Management Plan produced annually with best available information
MINE DEWATERING AND PROCESS WATER SUPPLY	• Annual presentation of wellfield monitoring results in Annual Aquifer reports as per DoW licences • Present summary of results to DoW, EPA and other relevant authorities
POTABLE WATER WELLFIELD	• Annual presentation of potable wellfield monitoring results in Annual Aquifer reports as per DoW licences • Present summary of results to DoW, EPA and other relevant authorities
SURFACE WATER FLOW MONITORING	• Report flow and rainfall annually • Provide data relevant to the assessment of cumulative impacts • Present summary of results to DoW, EPA and other relevant authorities
SURFACE WATER QUALITY	• Report water quality annually • Provide data relevant to the assessment of cumulative impacts • Present summary of results to DoW, EPA and other relevant authorities
FORTESCUE MARSH IMPACTS	• Annual reporting to consider potential Project impacts on Fortescue Marsh (i.e. borehole levels along the western and southern boundary of the mining lease)
VEGETATION	• Annual reporting summarising and analysing the monitoring data (identification of spatial and temporal trends in vegetation, correlated with historical information, groundwater and surface water monitoring data)
WATER USE EFFICIENCY	• Present an annual summary of the water use efficiency • Submit results to DoW, EPA and other relevant authorities
COMMUNITY ENGAGEMENT	• Provide input of Integrated Water management issues into the Stakeholder Management Plan

11. REFERENCES

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APPENDIX A: GROUNDWATER QUALITY DATA

Groundwater Quality

Analyte	Units	Bore ID									NHMRC Drinking Water Guideline Values[1]	
		RHPB1	RHPB2	RHPB3	RHPB4	RHPB5	RHPB6	RHPZ10	RHPZ12	RHPZ13	Health[2]	Aesthetic[3]
Bore use	- -	Test Pump	Test Pump	Test Pump	Test Pump	Test Pump	Test Pump	Monitoring	Monitoring	Monitoring	- -	- -
Date Sample Collected	- -	17/04/07	13/08/07	01/05/07	22/04/07	05/05/07	09/05/07	11/05/07	10/05/07	10/05/07	- -	- -
pH	pH Units	7.8	7.8	7.5	7.9	8.2	7.9	7.9	7.9	7.8	- -	6.5-8.5
Electrical Conductivity @ 25ºC	µS/cm	10000	1700	1600	13000	2500	580	1500	73000	100000	- -	- -
Total Dissolved Solids (calculated as NaCl)	mg/L	6100	1000	990	8000	1600	370	920	47000	67000	- -	500[4]
Iron, Fe (soluble)	mg/L	<0.02	<0.02	<0.02	0.24	<0.02	<0.02	<0.02	<0.4	<2.0	- -	0.3
Sodium, Na	mg/L	1600	150	85	2600	260	20	48	16000	26000	- -	180
Potassium, K	mg/L	170	19	23	260	13	4.7	18	1800	2400	- -	- -
Calcium, Ca	mg/L	310	120	140	220	140	61	150	320	460	- -	- -
Magnesium, Mg	mg/L	330	69	92	300	73	18	70	1800	3300	- -	- -
Chloride, Cl	mg/L	2600	160	130	3500	350	54	130	21000	39000	- -	250
Carbonate, CO_3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	- -	- -
Bicarbonate, HCO_3	mg/L	180	220	130	200	230	110	260	810	260	- -	- -
Sulphate, SO_4	mg/L	2000	420	560	1900	380	93	310	12000	19000	500	250
Nitrate, NO_3	mg/L	<0.2	53	13	<0.2	11	17	51	<0.2	7.7	50	- -

µS/cm = microsiemens per centimetre
mg/L = milligrams per liter

"- -" = data not available or not applicable
"<" = less than the stated value

NH&MRC = National Health and Medical Research Council
= values above NH&MRC Guidelines

1. Australian Drinking Water Guidelines 6, NHMRC 2004; Endorsed by NHMRC 10-11 April 2003; Full document available online at http://www.nhmrc.gov.au
2. Health Guideline: Concentration that based on present knowledge does not result in any significant risk to the health of the consumer over a lifetime of consumption.
3. Aesthetic Guideline: Concentration that is associated with good quality water.
4. <500mg/L is regarded as good quality drinking water based on taste; 500-1,000 mg/L is acceptable based on taste.

Analyte	Units	Bore ID						NHMRC Drinking Water Guideline Values[1]	
		RHPZ14	RHPZ15B	RHPZ16 D	RHPZ22B	RHPZ26 D	RHPZ27 S	Health[2]	Aesthetic[3]
Bore use	- -	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	- -	- -
Date Sample Collected	- -	08/05/07	08/05/07	08/05/07	07/05/07	10/05/07	10/05/07	- -	- -
pH	pH Units	8.0	8.0	8.0	8.4	7.9	7.8	- -	6.5-8.5
Electrical Conductivity @ 25ºC	µS/cm	69000	76000	24000	2300	48000	8500	- -	- -
Total Dissolved Solids (calculated as NaCl)	mg/L	44000	49000	15000	1500	31000	5400	- -	500[4]
Iron, Fe (soluble)	mg/L	<0.4	<1	<0.4	<0.02	<0.4	<0.02	- -	0.3
Sodium, Na	mg/L	16000	17000	4300	330	9400	450	- -	180
Potassium, K	mg/L	1700	1700	310	27	720	120	- -	- -
Calcium, Ca	mg/L	470	340	390	83	690	700	- -	- -
Magnesium, Mg	mg/L	1800	1800	700	44	1400	410	- -	- -
Chloride, Cl	mg/L	23000	22000	5500	320	13000	2300	- -	250
Carbonate, CO_3	mg/L	<1	<1	<1	12	<1	<1	- -	- -
Bicarbonate, HCO_3	mg/L	290	280	210	300	200	170	- -	- -
Sulphate, SO_4	mg/L	9000	12000	3800	440	8300	1600	500	250
Nitrate, NO_3	mg/L	4.2	12	4.2	8.7	15	340	50	- -

µS/cm = microsiemens per centimetre
mg/L = milligrams per liter

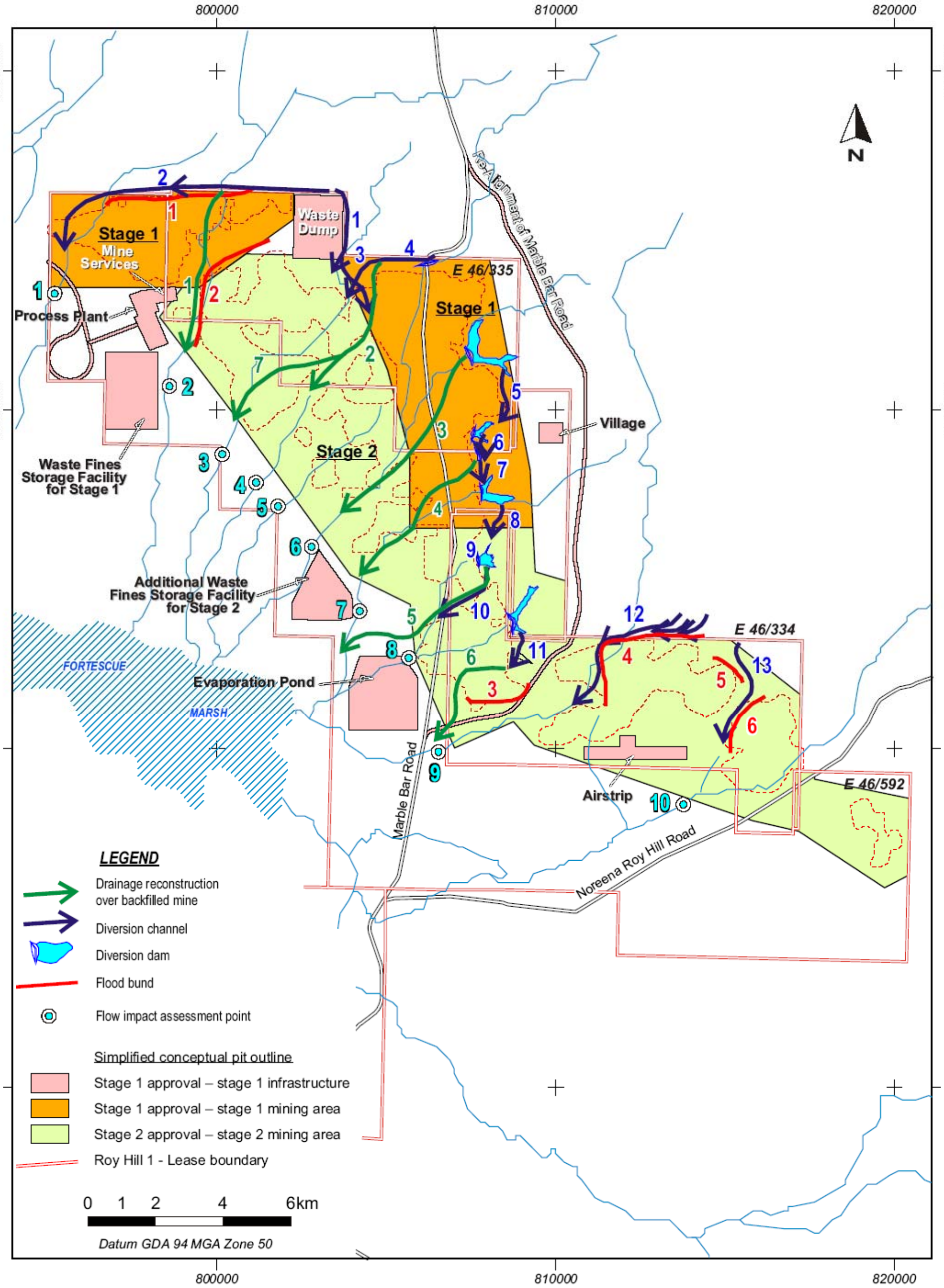
"- -" = data not available or not applicable
"<" = less than the stated value

NH&MRC = National Health and Medical Research Council
= values above NH&MRC Guidelines

1. Australian Drinking Water Guidelines 6, NHMRC 2004; Endorsed by NHMRC 10-11 April 2003; Full document available online at http://www.nhmrc.gov.au
2. Health Guideline: Concentration that based on present knowledge does not result in any significant risk to the health of the consumer over a lifetime of consumption.
3. Aesthetic Guideline: Concentration that is associated with good quality water.
4. <500 mg/L is regarded as good quality drinking water based on taste; 500-1,000 mg/L is acceptable based on taste

APPENDIX B: CONCEPTUAL STORMWATER DRAINAGE PLAN

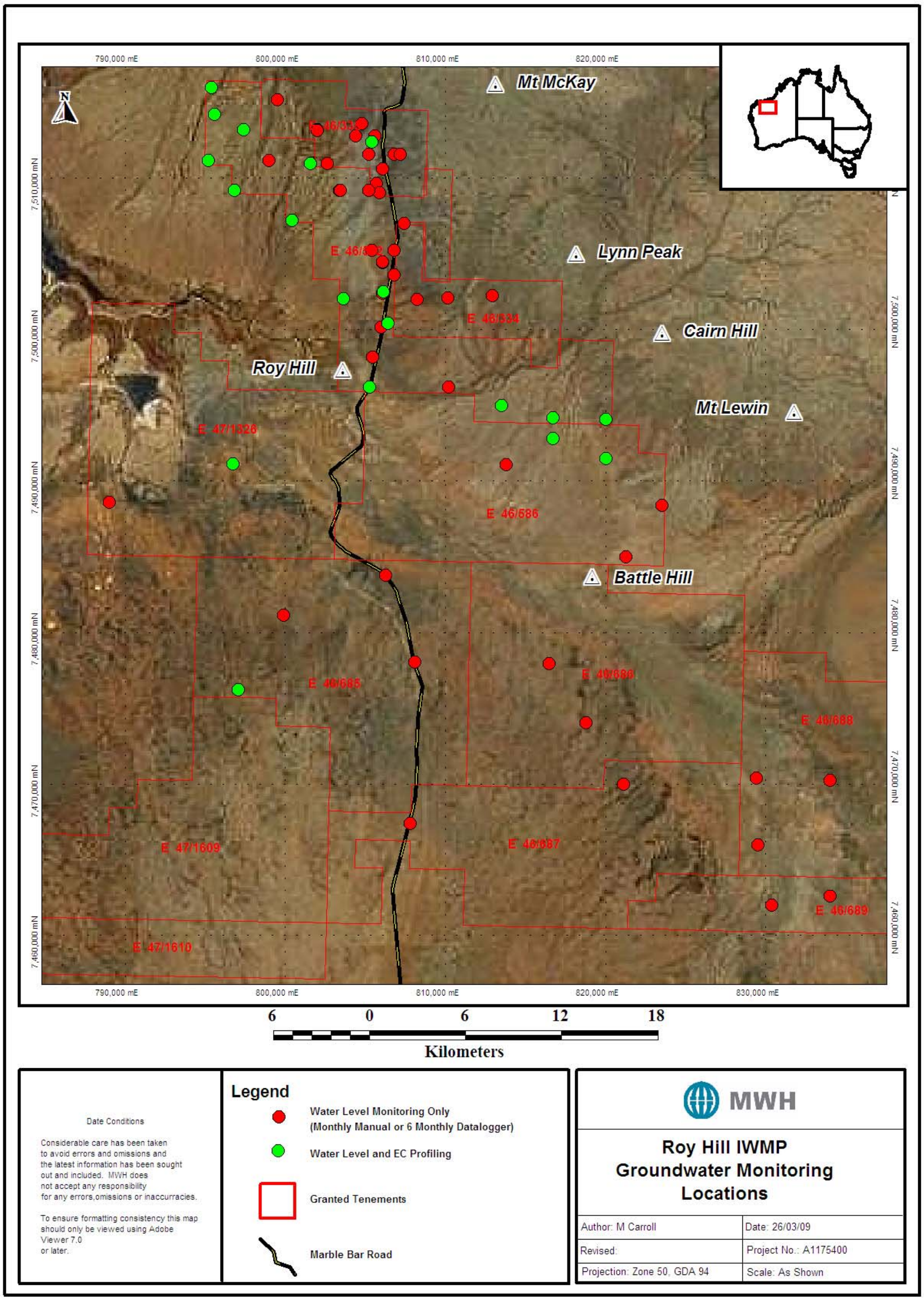
Source: Gilbert and Associates Pty Ltd, 2009, *Roy Hill Iron Ore Project – Surface Water Assessment,* Report prepared for HPPL



CLIENT:	HANCOCK PROSPECTING PTY LTD	SCALE:	As Shown	Gilbert & Associates Pty Ltd
		DRAWN:	P.L.	
PROJECT:	ROY HILL IRON ORE PROJECT SURFACE WATER ASSESSMENT	CHECKED:	Gilbert & Assoc.	STORMWATER DRAINAGE PLAN
		REV:	A	
		DATE:	April, 2008	DWG No: J0502-4-D-011 FIGURE: 11

APPENDIX C: GROUNDWATER MONITORING BOREHOLES

	Easting	Northing	Datalogger Download	Water Level	EC Profile
	MGA Zone 50 (GDA 94)				
Frequency			*6 Mo.*	*1 Mo.*	*3 Mo.*
RHPB1	806,058	7,504,421		X	X
RHPB2	803,410	7,509,151		X	
RHPB3	808,221	7,501,992		X	
RHPB4	812,908	7,502,208		X	X
RHPB5	795,401	7,515,951		X	
RHPB6	799,517	7,515,158		X	
RHPZ01	805,595	7,512,762		X	
RHPZ02S	805,382	7,512,353		X	X
RHPZ02D	805,382	7,512,362		X	X
RHPZ03	805,206	7,511,560		X	
RHPZ04	806,089	7,510,601		X	
RHPZ05	805,696	7,509,624	X	X	
RHPZ06	805,869	7,509,020		X	
RHPZ07	804,786	7,513,570		X	
RHPZ08	804,387	7,512,769	X	X	
RHPZ09	806,796	7,511,563		X	
RHPZ10	807,199	7,511,554	X	X	
RHPZ11	807,403	7,506,996		X	
RHPZ12	805,265	7,496,195	X	X	X
RHPZ13	805,434	7,498,173		X	
RHPZ14	805,976	7,500,156		X	
RHPZ15A	806,063	7,502,382		X	
RHPZ15B	806,100	7,502,469	X	X	X
RHPZ16S	806,066	7,504,432		X	
RHPZ16D	806,066	7,504,432		X	
RHPZ17A	801,984	7,513,150		X	
RHPZ17B	801,982	7,513,142		X	
RHPZ18S	799,517	7,515,160		X	
RHPZ18D	799,517	7,515,160		X	
RHPZ19S	795,390	7,515,937		X	
RHPZ19D	795,390	7,515,937	X	X	X
RHPZ20S	797,395	7,513,161		X	
RHPZ20D	797,395	7,513,161		X	X
RHPZ21A	798,985	7,511,155		X	
RHPZ21B	798,973	7,511,154		X	
RHPZ22A S	801,577	7,510,956		X	
RHPZ22A D	801,577	7,510,956		X	
RHPZ22B	801,591	7,510,955	X	X	X
RHPZ23A	802,609	7,510,958		X	
RHPZ23B	802,602	7,510,958		X	
RHPZ24S	805,215	7,509,164		X	
RHPZ24D	805,215	7,509,164		X	
RHPZ25S	803,426	7,509,152		X	
RHPZ25D	803,426	7,509,152		X	
RHPZ26S	805,404	7,505,194		X	
RHPZ26D	805,404	7,505,194	X	X	
RHPZ27S	806,798	7,505,188		X	
RHPZ27D	806,798	7,505,188		X	
RHPZ28S	806,796	7,503,600		X	
RHPZ28D	806,796	7,503,600		X	
RHPZ29	808,230	7,501,983		X	
RHPZ30	812,918	7,502,210	X	X	
RHPZ31	810,169	7,502,074		X	
RHPZ32	803,608	7,502,007		X	X
RHPZ33	796,803	7,509,158		X	X
RHPZ34	795,207	7,511,156	X	X	X
RHPZ35	795,566	7,514,169		X	X
RHPZ36	800,398	7,507,193		X	X
RHPZ37	813,501	7,494,999		X	X
RHPZ38	816,703	7,494,165		X	X
RHPZ39	819,999	7,494,059		X	X
RHPZ40	810,201	7,496,204			
RHPZ41	806,400	7,500,400		X	X
RH4700	821,275	7,484,997		X	
RH4701	819,997	7,491,454		X	X
RH4706	816,702	7,492,785		X	X
RH4489	788,999	7,488,612		X	
RH4490	796,718	7,491,138		X	X
RH4199	823,498	7,488,392		X	
RH4704	813,798	7,491,053		X	
EC0002	816,477	7,477,965		X	
EC0003	797,060	7,476,225		X	X
EC0004	799,900	7,481,140		X	
EC0005	806,250	7,483,775		X	
EC0006	807,790	7,467,400		X	
EC0007	808,090	7,478,060		X	
EC0008	818,765	7,474,050		X	
EC0009	821,118	7,470,005		X	
EC0010	830,384	7,461,989		X	
EC0011	834,015	7,462,590		X	
EC0012	829,512	7,466,007		X	
EC0013	834,031	7,470,255		X	
EC0014	829,436	7,470,391		X	


790,000 mE
800,000 mE
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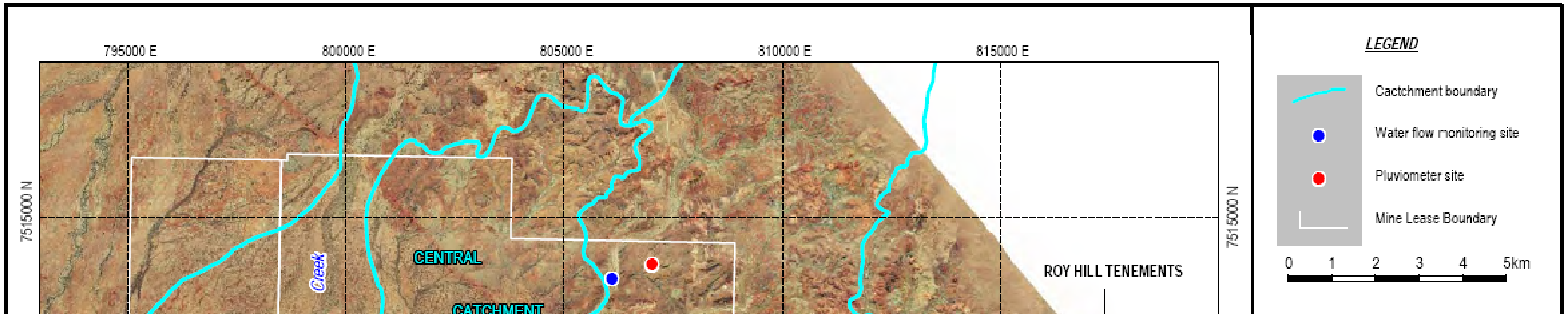
7,480,000 mN
7,470,000 mN
7,460,000 mN
N
Mt McKay
Lynn Peak
Cairn Hill
Mt Lewin
Roy Hill
Battle Hill
E 46/534
E 47/1326
E 46/686
E 46/685
E 46/688
E 47/1609
E 46/687
E 46/689
E 47/1610
6 0 6 12 18
Kilometers
Date Conditions
Considerable care has been taken to avoid errors and omissions and the latest information has been sought out and included. MWH does not accept any responsibility for any errors,omissions or inaccuracies.
To ensure formatting consistency this map should only be viewed using Adobe Viewer 7.0 or later.
Legend
Water Level Monitoring Only
(Monthly Manual or 6 Monthly Datalogger)
Water Level and EC Profiling
Granted Tenements
Marble Bar Road
MWH
Roy Hill IWMP
Groundwater Monitoring
Locations
Author: M Carroll
Date: 26/03/09
Revised:
Project No.: A1175400
Projection: Zone 50, GDA 94
Scale: As Shown

APPENDIX D: SURFACE WATER MONITORING LOCATIONS



DESIGNED	L.G.	SCALE	As Sown
DRAWN	P.L.	LEVEL DATUM	GDA 94
CHECKED	L.G.	SHEET SIZE	A4
APPROVED		CAD FILE	J0502-4-D-009
DATE	November 2008	ISSUE	November 2008

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CLIENT HANCOCK PROSPECTING PTY LTD

PROJECT ROY HILL IRON ORE PROJECT SURFACE WATER ASSESSMENT

TITLE

CATCHMENT PLAN & WATER MONITORING SITES

JOB NUMBER	J0502-4	
FIGURE	9	REV A

APPENDIX E: WATER QUALITY GUIDELINES

Source: ANZECC/ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management strategy paper No 4, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Table 3.3.5 Ranges of default trigger values for conductivity (EC, salinity), turbidity and suspended particulate matter (SPM) indicative of slightly disturbed ecosystems in tropical Australia. Ranges for turbidity and SPM are similar and only turbidity is reported here. Values reflect high site-specific and regional variability. Explanatory notes provide detail on specific variability issues for groupings of ecosystem type.

Ecosystem type	Salinity (µScm^{-1})	Explanatory notes
Upland & lowland rivers	20–250	Conductivity in upland streams will vary depending upon catchment geology. Values at the lower end of the range are typical of ephemeral flowing NT rivers. Catchment type may influence values for Qld lowland rivers (e.g. 150 µScm^{-1} for rivers draining rainforest catchments, 250 µScm^{-1} for savanna catchments). The first flush of water following early seasonal rains may result in temporarily high values.
Lakes, reservoirs & wetlands	90–900	Values at the lower end of the range are found in permanent billabongs in the NT. Higher conductivity values will occur during summer when water levels are reduced due to evaporation. WA wetlands can have values higher than 900 µScm^{-1}. Turbid freshwater lakes in Qld have reported conductivities of approx. 170 µScm^{-1}.
	Turbidity (NTU)	
Upland & lowland rivers	2–15	Low values for base flow conditions in NT rivers. QLD turbidity and SPM values highly variable and dependent on degree of catchment modification and seasonal rainfall runoff.
Lakes, reservoirs & wetlands	2–200	Most deep lakes and reservoirs have low turbidity. However, shallow lakes and reservoirs may have higher turbidity naturally due to wind-induced resuspension of sediments. Lakes and reservoirs in catchments with highly dispersible soils will have high turbidity. Wetlands vary greatly in turbidity depending upon the general condition of the catchment or river system draining into the wetland, recent flow events and the water level in the wetland.
Estuarine & marine	1–20	Low values indicative of offshore coral dominated waters. Higher values representative of estuarine waters. Turbidity is not a very useful indicator in estuarine and marine waters. A move towards the measurement of light attenuation in preference to turbidity is recommended. Typical light attenuation coefficients (log_{10}) in waters off north-west WA range from 0.17 for inshore waters to 0.07 for offshore waters.

Source: ANZECC/ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management strategy paper No 4, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Table 3.3.4 Default trigger values for physical and chemical stressors for tropical Australia for slightly disturbed ecosystems. Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types. Data derived from trigger values supplied by Australian states and territories, for the Northern Territory and regions north of Carnarvon in the west and Rockhampton in the east. Chl *a* = chlorophyll a, TP = total phosphorus, FRP = filterable reactive phosphate, TN = total nitrogen, NO_x = oxides of nitrogen, NH_4^+ = ammonium, DO = dissolved oxygen.

Ecosystem type		Chl *a* ($\mu g\ L^{-1}$)	TP ($\mu g\ P\ L^{-1}$)	FRP ($\mu g\ P\ L^{-1}$)	TN ($\mu g\ N\ L^{-1}$)	NO_x ($\mu g\ N\ L^{-1}$)	NH_4^+ ($\mu g\ N\ L^{-1}$)	DO (% saturation)[f]		pH	
								Lower limit	Upper limit	Lower limit	Upper limit
Upland river[e]		na[a]	10	5	150	30	6	90	120	6.0	7.5
Lowland river[e]		5	10	4	200– 300[h]	10[b]	10	85	120	6.0	8.0
Freshwater lakes & reservoirs		3	10	5	350[c]	10[b]	10	90	120	6.0	8.0
Wetlands		10	10–50[g]	5–25[g]	350–1200[g]	10	10	90[b]	120[b]	6.0	8.0
Estuaries[e]		2	20	5	250	30	15	80	120	7.0	8.5
Marine	Inshore	0.7–1.4[d]	15	5	100	2–8[d]	1–10[d]	90	no data	8.0	8.4
	Offshore	0.5–0.9[d]	10	2–5[d]	100	1–4[d]	1–6[d]	90	no data	8.2	8.2

na = not applicable

a = monitoring of periphyton and not phytoplankton biomass is recommended in upland rivers — values for periphyton biomass (mg Chl *a* m^{-2}) to be developed;

b = Northern Territory values are 5µgL^{-1} for NO_x, and <80 (lower limit) and >110% saturation (upper limit) for DO;

c = this value represents turbid lakes only. Clear lakes have much lower values;

d = the lower values are typical of clear coral dominated waters (e.g. Great Barrier Reef), while higher values typical of turbid macrotidal systems (eg. North-west Shelf of WA);

e = no data available for tropical WA estuaries or rivers. A precautionary approach should be adopted when applying default trigger values to these systems;

f = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability (see Section 3.3.3.2);

g = higher values are indicative of tropical WA river pools;

h = lower values from rivers draining rainforest catchments.

Source: ANZECC/ARMCANZ 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management strategy paper No 4, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Table 3.4.1 Trigger values for toxicants at alternative levels of protection. Values in grey shading are the trigger values applying to typical *slightly–moderately disturbed systems*; see table 3.4.2 and Section 3.4.2.4 for guidance on applying these levels to different ecosystem conditions.

Chemical		Trigger values for freshwater (μgL^{-1})				Trigger values for marine water (μgL^{-1})			
		Level of protection (% species)				Level of protection (% species)			
		99%	95%	90%	80%	99%	95%	90%	80%
METALS & METALLOIDS									
Aluminium	pH >6.5	27	55	80	150	ID	ID	ID	ID
Aluminium	pH <6.5	ID	ID	ID	ID	ID	ID	ID	ID
Antimony		ID	ID	ID	ID	ID	ID	ID	ID
Arsenic (As III)		1	24	94 [C]	360 [C]	ID	ID	ID	ID
Arsenic (AsV)		0.8	13	42	140 [C]	ID	ID	ID	ID
Beryllium		ID	ID	ID	ID	ID	ID	ID	ID
Bismuth		ID	ID	ID	ID	ID	ID	ID	ID
Boron		90	370 [C]	680 [C]	1300 [C]	ID	ID	ID	ID
Cadmium	H	0.06	0.2	0.4	0.8 [C]	0.7 [B]	5.5 [B, C]	14 [B, C]	36 [B, A]
Chromium (Cr III)	H	ID	ID	ID	ID	7.7	27.4	48.6	90.6
Chromium (CrVI)		0.01	1.0 [C]	6 [A]	40 [A]	0.14	4.4	20 [C]	85 [C]
Cobalt		ID	ID	ID	ID	0.005	1	14	150 [C]
Copper	H	1.0	1.4	1.8 [C]	2.5 [C]	0.3	1.3	3 [C]	8 [A]
Gallium		ID	ID	ID	ID	ID	ID	ID	ID
Iron		ID	ID	ID	ID	ID	ID	ID	ID
Lanthanum		ID	ID	ID	ID	ID	ID	ID	ID
Lead	H	1.0	3.4	5.6	9.4 [C]	2.2	4.4	6.6 [C]	12 [C]
Manganese		1200	1900 [C]	2500 [C]	3600 [C]	ID	ID	ID	ID
Mercury (inorganic)	B	0.06	0.6	1.9 [C]	5.4 [A]	0.1	0.4 [C]	0.7 [C]	1.4 [C]
Mercury (methyl)		ID	ID	ID	ID	ID	ID	ID	ID
Molybdenum		ID	ID	ID	ID	ID	ID	ID	ID
Nickel	H	8	11	13	17 [C]	7	70 [C]	200 [A]	560 [A]
Selenium (Total)	B	5	11	18	34	ID	ID	ID	ID
Selenium (SeIV)	B	ID	ID	ID	ID	ID	ID	ID	ID
Silver		0.02	0.05	0.1	0.2 [C]	0.8	1.4	1.8	2.6 [C]
Thallium		ID	ID	ID	ID	ID	ID	ID	ID
Tin (inorganic, SnIV)		ID	ID	ID	ID	ID	ID	ID	ID
Tributyltin (as µg/L Sn)		ID	ID	ID	ID	0.0004	0.006 [C]	0.02 [C]	0.05 [C]
Uranium		ID	ID	ID	ID	ID	ID	ID	ID
Vanadium		ID	ID	ID	ID	50	100	160	280
Zinc	H	2.4	8.0 [C]	15 [C]	31 [C]	7	15 [C]	23 [C]	43 [C]
NON-METALLIC INORGANICS									
Ammonia	D	320	900 [C]	1430 [C]	2300 [A]	500	910	1200	1700
Chlorine	E	0.4	3	6 [A]	13 [A]	ID	ID	ID	ID
Cyanide	F	4	7	11	18	2	4	7	14
Nitrate	J	17	700	3400 [C]	17000 [A]	ID	ID	ID	ID
Hydrogen sulfide	G	0.5	1.0	1.5	2.6	ID	ID	ID	ID
ORGANIC ALCOHOLS									