Fortescue Metals Group Ltd (FMG) is undertaking Feasibility Studies and Public Environmental Reviews (PERs) for the proposed Pilbara Iron Ore Project. Aquaterra Consulting Pty Ltd (Aquaterra) has been engaged by FMG to carry out a surface hydrology study to examine the natural surface water drainage patterns of the proposed port facilities and rail corridor to assist in appropriate design of infrastructure and of surface water control measures.

Proposed FMG Development within the Existing Port Environment

The proposed FMG port development area is located in the southwest sector of Port Hedland harbour between the existing BHPBIO Port Hedland-Shay Gap Railway and Anderson Point. The proposed development comprises a railway loop, dredge spoil deposition areas, stockyard area, a berth on Anderson Point, loadout causeway, rail car dumper facility and conveyors with associated material transfer facilities.

The existing topography of Port Hedland port area varies from the open harbour to tidal creeks, intertidal mudflats, bare coastal mudflats and sandy lowlands. Typically, mangroves populate the banks of the intertidal creeks and salt-tolerant open low shrublands and hummock grasslands populate the sandy lowlands. The bare coastal mudflats, being highly saline, do not support vegetation. The harbour is subjected to a tidal range of up to approximately 6m during spring tides.

Two main surface water drainage pathways outflow through the sector of the Port Hedland harbour in the vicinity of the proposed development, namely the South West Creek and the South Creek. The drainage pathway for South West Creek passes through the proposed FMG development area and discharges on the western side of Anderson Point. The drainage pathway for South Creek, passes outside the proposed FMG development area and discharges on the eastern side of Anderson Point. Natural drainage within the proposed port development area flows via the bare mudflats to the intertidal creeks.

At low flows, floodwaters from both of the major creek systems pass under the BHPBIO railway embankment into the Port Hedland harbour area through a series of culverts. During large flood events, these culverts would have insufficient capacity to accommodate peak discharges and surface water would pond on the upstream side of the railway embankment. A large capacity drainage channel has been excavated along the upstream side of the BHPBIO railway embankment to discharge excess flood flows from South West Creek to the west. No design information for this drainage channel was available during the study and it is possible that floodwater could also discharge over the railway embankment, at peak times.

The Wedgefield town site is located adjacent to South Creek downstream from the BHPBIO railway embankment. South Hedland town site is also located adjacent to South Creek, but 2 to 4 km upstream from the BHPBIO railway embankment. Both town sites have a history of flooding from river flood events on the South and South West Creek systems and from cyclone induced ocean storm surge events. River flood levels at South Hedland are compounded by the blocking effect of the Port Hedland-Shay Gap Railway embankment. However this railway embankment also gives the benefit of blocking the inland penetration of ocean flooding during storm surge events (GEMS, 2000).
Potential Surface Water Impacts of FMG Port Facilities and Proposed Management Measures

The proposed port facilities and infrastructure, located in the southwest sector of Port Hedland harbour, will potentially impact on the movement of surface water through the area. To reduce disturbance to surface water movements, intertidal creeks and associated mangrove communities, the facilities will be predominantly located over the bare mudflat areas away from the main intertidal zones and appropriate drainages structures provided.

Dredge Spoil Deposition Areas

Two dredge spoil deposition areas are proposed to be constructed using material dredged from the harbour. The main deposition area will be located under the stockyard area and the second smaller deposition area on Anderson Point. The spoil deposition areas will predominantly be located over the low-lying and vegetation bare mudflats and final boundaries have been shaped to avoid clearing and hydraulic impact in the mangrove communities.

Around the proposed deposition areas, the flow areas available for surface water drainage in South West Creek and South Creek will remain essentially unaltered. As such, the existing surface water flood levels in these creeks will not be impacted. The existing surface water flooding levels will also not be affected in the Wedgefield town site located around 1.5 km to the east of the stockyard spoil deposition area.

Other potential impacts of the dredge deposition areas will be managed through:

- Constructing elevated perimeter embankments 0.5m above the adopted design 100 year ARI average storm surge level;
- Seeding the finished surfaces to reduce the potential for surface erosion and dust generation;
- Managing internal surface drainage to harvest runoff for use in dust control with the excess treated via an oil separator and a sediment interceptor basin, prior to discharging to the harbour under favourable tidal conditions.

Railway Loop

The proposed railway loop runs westwards and northwards parallel to the existing BHPBIO Port Hedland-Shay Gap Railway. Through the South West Creek floodplain, the proposed railway will be installed on an embankment at a similar level to the existing Port Hedland-Shay Gap Railway and will cross the main flow channel twice.

Where parallel to the existing BHPBIO railway embankment, drainage culverts will be installed through the proposed embankment with at least a similar hydraulic capacity to those in the existing embankment. Some additional culverts may be installed where local drainage conditions warrant.

The existing BHPBIO railway embankment essentially blocks the larger flood discharges in the South West Creek channel from entering the proposed railway loop area. River flood levels in South West Creek immediately upstream from the existing BHPBIO railway embankment are currently controlled by the existing BHPBIO embankment, culverts and bypass channel arrangements. The proposed FMG railway embankment with equal to or greater capacity culverts will be constructed downstream from the existing BHPBIO embankment and as such will not adversely impact on the existing upstream flood levels.
The northern side of the proposed FMG railway loop embankment crosses South West Creek in the tidal creek zone. During the detailed design process, design flood levels through the railway loop area will be assessed such that the hydraulic capacity of the upstream culverts will not be impacted. At the detailed design stage, riprap or similar erosion protection blankets will be specified to reduce the potential for scouring around the culvert inlet and outlet zones.

**Loadout Causeway**
A proposed access causeway supporting the loadout conveyor and a roadway will be constructed from the proposed stockyard area to the proposed Anderson Point shiploading facilities. Culverts will be provided through the embankment to enable tidal flushing of the mangrove areas and local drainage. These culverts will be designed for discharges derived by hydrodynamic modelling of tidal movements such that adequate tidal flushing occurs through the mangrove areas. The construction of this causeway will not have an impact on the existing flood levels in South West Creek or South Creek and will not impact on drainage from the project development area.

**Stockyard Area**
The proposed stockyard area is located on the relatively higher level dredge spoil deposition area and natural sandy lowlands. The stockyard area will be protected from ocean storm surge flood events by the slightly raised perimeter road constructed around the dredge spoil deposition area. The road will also contain local stormwater runoff within the spoil deposition area, which will be harvested and used for dust control. Excess surface runoff water will be treated via an oil separator and a sediment interceptor basin, prior to discharging to the environment.

**Other Infrastructure**
The proposed rail car dumper facility located on the rail embankment at the western side of the railway loop will not impact on surface water drainage in the area. All facilities will be constructed to withstand the design 100 year ARI ocean storm surge and river flood conditions. Conveyors linking the car dumper to the primary screen house in the stockyard area will be installed on trestles and will not impact on surface water movements in the area. The proposed Anderson Point facilities will also be installed on trestle type structures that allow free surface water movement thus not impacting on the existing surface water regime.

**Ocean Storm Surge Estimates**
Design storm surge conditions have been assessed in the Port Hedland harbour area (GEMS, 2000) based on the port layout prior to construction of the proposed FMG port development works. With construction of these works, the ocean storm surges will potentially have restricted access to the low-lying tidal flats in the railway loop area, thus locally reducing the risk from ocean storm surge flooding. Whereas, in the Anderson Point area, the risk from flooding due to ocean storm surge levels is believed not to have changed. However, FMG propose to reassess this risk during the detailed design phase for the project to determine appropriate freeboard above the design 100 year ARI average storm surge level. The effect of storm waves above the design ocean surge level will also be considered.
Proposed FMG Rail Corridor Development within the Existing Environment

The proposed FMG North-South Rail corridor connects the proposed Port Facilities located in Port Hedland harbour to the proposed Mindy Mindy Mine Site located around 300km to the south. The rail corridor essentially runs parallel to the existing BHPBIO rail corridor connecting Port Hedland to Newman.

The initial 50km of rail corridor in the Port Hedland area passes through the South West Creek catchment where it is typically aligned parallel to and away from the main surface drainages, except where it crosses over the main South West Creek flow channel near to the MRD North West Coastal Highway road bridge. Further south of the Port Hedland area, the rail corridor passes through the Turner River and Yule River catchments crossing several major rivers and creek systems. All drainage channels are ephemeral responding to rainfall events. Following significant rainfall, the channels typically carry large discharges, possibly for a few days, then retreat back to isolated pools. In the main channels, smaller discharges may persist for a few weeks. During the large flood events, floodwater would over flow the main river channels into the surrounding floodplains. The rail corridor has typically been aligned to cross perpendicular to the main drainage channels.

The FMG rail corridor winds through the Chichester Plateau, to achieve a uniform gradient and to avoid the rugged peaks rising steeply some 100 to 150m above the plain. Through this plateau area, the corridor initially crosses the upper portions of the Yule and Shaw Rivers, which discharge northwards to the coast, and then crosses smaller drainages discharging southwards to the Fortescue River. Drainage pathways through the plateau area are characterised by typically smaller catchments, steeper gradients and steep sided valleys which respond and flow rapidly following rainfall, but typically for a comparatively short duration.

The Fortescue Valley occupies a trough between the Chichester and Hamersley Plateaux (Beard, 1975). The Goodiadarrie Hills, located on the valley floor around 7km west from the existing BHPBIO railway, effectively cuts the Fortescue River into two separate river systems. West from the Goodiadarrie Hills, the Lower Fortescue River Catchment drains to the coast, whereas east from the hills the Fortescue Marshes receives drainage from the Upper Fortescue River Catchment. The Fortescue Marshes is an extensive intermittent wetland occupying an area around 100km long by typically 10km wide. The FMG rail corridor crosses through the Fortescue Marsh area upstream from the Goodiadarrie Hills adjacent to the existing BHPBIO railway. Large floods in the early 1970’s are reported to have caused inundation up to the existing BHPBIO railway track level.

After crossing the marshes, the FMG rail corridor follows the route of the existing BHPBIO railway around the southern edge of the Fortescue Valley crossing Weeli Wolli Creek and terminating at the base of the Hamersley Ranges at Mindy Mindy mine site. On the southern and northern flanks of the Fortescue Valley, numerous creeks discharge to the marshes. On the lower less steep valley flanks, rainfall runoff tends to flow overland rather than along defined creek courses.

Potential Surface Water Impacts of FMG Rail Corridor and Proposed Management Measures

The FMG North-South Railway will be around 345km in length and comprise a continuous railway formation supported by cut and fill earthworks. Construction of the railway formation could potentially interrupt surface
water drainage features that naturally occur along the rail corridor. Where feasible the FMG rail corridor has generally been located adjacent the existing BHPBIO railway embankment, to reduce the potential for additional surface water impacts. However, in some areas, due to topography, it has been necessary to deviate the FMG corridor from the BHPBIO route, to reduce impacts on the natural drainage systems or on the existing BHPBIO railway drainage structures (eg: at the Turner River and Turner River East crossings).

Appropriate surface water management strategies need to be adopted to reduce the potential environmental impacts including altered flooding characteristics; scour, erosion and siltation of the drainage channels; inundation of upstream areas and water starvation to downstream areas. The following strategies are recommended to reduce potential impacts along the proposed rail corridor:

- Locate and size bridges and culverts so as not to hydraulically impact the corresponding existing BHPBIO railway bridges and culverts and not to adversely impact the surface water environment.
- Align the rail corridor such that the bridges cross perpendicular to the main drainage channels in order to reduce the disturbance to the existing surface water flow patterns and directions.
- Assess the waterway requirements for the proposed South West Creek bridge/culvert crossing in conjunction with the flood flow patterns through the upstream White Hill area.
- Install bridges over the major river channels and culverts at all other drainage crossings.
- Build bridges to safely pass the 50 year Average Recurrence Interval (ARI) flood and culverts to safely pass the 20 year ARI flood.
- Adopt “best practice” engineering to neutralise adverse water flow impacts from bridge and culvert constructions, such as provision of guide banks, hydraulically streamline flow areas and riprap or similar scour protection blankets.
- Install culverts and small interceptor embankments, where appropriate, to prevent long drainage pathways developing adjacent to the railway formation.
- Identify sheetflow areas with dependent downstream vegetation along the FMG rail corridor and assess if the BHPBIO railway already impacts these areas. If not, assess if the FMG railway would impact these areas. If significant impact is possible, install drainage culverts at regular intervals together with earthworks to redistribute the sheetflow on the downstream side.
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SECTION 1 - INTRODUCTION

1.1 BACKGROUND

Fortescue Metals Group Ltd (FMG) is undertaking Feasibility Studies and Public Environmental Reviews (PERs) for their East Pilbara Iron Ore Project. Aquaterra Consulting Pty Ltd (Aquaterra) has been engaged by FMG to carry out the surface hydrology study for these investigations.

The Project comprises the following:

- four mining areas and a number of potential satellite ore bodies;
- two railway lines;
- loading facilities at Port Hedland.

Three of the mining areas, Mt Nicholas, Mt Lewin and Christmas Creek, are located in the eastern Chichester Ranges. These deposits comprise mineralised Mara Mamba Formation, which outcrop northeast and east of the Fortescue River valley. The fourth area, located within the Mindy Mindy Creek valley approximately 25 km east of Hope Downs, comprises enriched Channel Iron Deposits (CID).

The two proposed railway lines connect the Mindy Mindy and Chichester Range mining areas to the Port Hedland loading facility, and comprise a north-south railway and east-west railway respectively. The loading facility at Port Hedland includes a rail loop, stockyard area, conveyor and berthing facilities.

The project development has been divided into two stages. Stage A includes the north-south railway line and port facility, and Stage B the east-west railway line and mining areas.

This report presents the results of the surface hydrology study for the Stage A Port and North-South Rail Corridor.

1.2 STUDY OBJECTIVES

The objectives of the study are to examine the natural surface water drainage patterns of the proposed port facilities and rail corridor to assist in appropriate design of infrastructure and surface water control measures. This study will:

- Identify watercourses and types of surface water flow including sheetflow;
- Undertake a study to investigate topography, catchment areas and surface water runoff patterns;
- Assess the potential impacts on surface water flow rates, drainage patterns, sediment transport, riparian vegetation, pools and dependent vegetation as a result of development activities; and
- Provide advice to the engineering team with regards to location and design of drainage structures and creek and river crossings.
SECTION 2 - METHODOLOGY

2.1 GENERAL
The approach to the surface hydrology study comprised:

Port Area
- Review proposed Port Area development plans.
- Liaise with the Marine Impact consultant.
- Liaise with DRD to gather flood study reports for the area
- Review existing design data on flood levels, tidal movements and storm surge levels.
- Provide advice on flood/surge protection, surface water management and erosion/sediment control.
- Liaise with the FMG designers to mitigate surface water impacts.

North-South Rail Corridor
- Review published maps, air photos and proposed railway alignment plans.
- Liaise with the Railway Design consultant on adopted hydrology design methodology and issues.
- Gather reports and data on the adjacent railway corridors.
- Define surface water drainage patterns and characteristics.
- Review existing maps and reports for surface water and groundwater interaction issues.
- Provide advice for flood protection, surface water management, environmental flows and erosion control.
- Liaise with FMG designers on methods to mitigate surface water impacts.

2.2 DATA REVIEW
Mapping data sources used for the study included:
- FMG supplied orthophoto plan of the port development area
- FMG supplied aerial photos of the Port Hedland port area
- FMG supplied detailed contour plans of the port development area
- FMG supplied 1:50,000 topography plans covering the rail corridor
- FMG supplied 1:75,000 photo mosaic of the rail corridor
- WRC plan titled “Surface Hydrology of the Pilbara Region”

In addition, we have drawn on Aquaterra’s expertise and previous experience on surface hydrology in the Pilbara Region and the reports referenced in Section 5.

2.3 PREVIOUS EXPERIENCE
Aquaterra has specific expertise in the investigation, environmental assessment, design and implementation of surface water flood control and diversion works for the mining industry. Projects undertaken by Aquaterra have largely related to the diversion of floodwaters around mine pits, minerals processing facilities and transport infrastructure in the Pilbara and Goldfields.
Relevant previous surface hydrology projects undertaken by our study team in the Pilbara Region include:

- **Sherlock Bay NOI**: Flood study and impact assessment for mine and process plant development in the Sherlock River floodplain (2004).
- **Robe River Bungaroo Creek Deposit**: Flood study and layout designs for pit development in a major floodplain (2003).
- **BHPBIO Area C, Pilbara**: Hydrological and environmental assessment of flows at Weeli Wolli Springs (2003).

### 2.4 FIELD INSPECTION

A field visit to inspect the proposed port development area and railway routes was undertaken by Vince Piper on the 30-31 March 2004. The full length of the rail corridor was viewed from the air using a low flying aircraft and the port area was viewed from both the ground and from the aircraft.

### 2.5 ASSESSMENT OF IMPACTS

Plans and mapping for the proposed port development area and railway routes were examined in detail and their proposed locations were viewed during the field visit. Based on this review and Aquaterra’s expertise and experience with surface water projects in the Pilbara Region, the potential impacts arising from the project development were identified and assessed.
SECTION 3 - PORT ASSESSMENT

3.1 EXISTING PORT ENVIRONMENT

3.1.1 Introduction

The existing Port Hedland port area topography varies from the open harbour to tidal creeks, intertidal mudflats, bare coastal mudflats and sandy lowlands. Typically, mangroves populate the banks of the intertidal creeks and salt-tolerant open low shrublands and hummock grasslands populate the sandy lowlands. The bare coastal mudflats, being highly saline, do not support vegetation.

The harbour is subjected to semi-diurnal tides with a spring tidal range of around 6m and a neap tidal range around 1.5m. The neap tides are confined to the tidal creeks and the lower lying intertidal mudflats, whereas the spring tides extend into the higher mudflat areas up to around RL 2.53.0m AHD. The sandy lowlands containing low shrublands and grasslands are typically above RL 4m AHD and above the normally experienced tidal range.

The proposed FMG port development area is located in the southwest sector of Port Hedland harbour between the existing BHPBIO Port Hedland-Shay Gap Railway and Anderson Point, as shown in Figure 1. Two main surface water drainage pathways flow through this sector, namely the South West Creek and the South Creek. Both these creeks flow northwards and cross under the Port Hedland-Shay Gap Railway to enter the harbour area. The drainage pathway for South West Creek passes through the proposed FMG development area and discharges on the western side of Anderson Point. Whereas, the drainage pathway for South Creek, which discharges on the eastern side of Anderson Point, passes outside the proposed FMG development area. Natural drainage within the proposed port development area flows via the bare mudflats to the intertidal creeks.

3.1.2 Storm Surge

During a cyclone, due to the combination of low atmospheric pressure and waves, the harbour area could be subjected to ocean storm surge. When accompanied by a high tide, the effects of a storm surge could inundate a significant area. Design 50 year and 100 year Average Recurrence Interval (ARI) peak flood levels in the Port Hedland area have been assessed in the “Greater Port Hedland Storm-Surge Study” (GEMS, 2000). This study employed a probabilistic approach to define return period levels for the coincidence of storm surge and rainfall generated flooding due to cyclones. The effects of varying tides and wave set-up were included in the modelling process.

The design peak flood levels developed by the modelling vary through the harbour area and are shown to be higher over the mudflats and sandy lowlands areas where the higher ground elevation tends to lift the storm surge water level. In the proposed FMG port development area, the design 100 year ARI storm surge levels vary from RL 5.0m AHD at Anderson Point to around RL 6.0m AHD at the Port Hedland-Shay Gap Railway. A design 100 year ARI average storm surge level of RL 5.5m AHD has been adopted by FMG for the port development area. The storm surge study reports that the Port Hedland-Shay Gap Railway acts as a barrier to the inland penetration of ocean flooding during storm surge events (GEMS, 2000).
3.1.3 South West Creek

South West Creek passes through the proposed FMG development area and discharges on the western side of Anderson Point (Figure 1). Upstream from the proposed FMG development area, the South West Creek main flow channel and floodplains are crossed by the existing Port Hedland-Shay Gap Railway embankment. Drainage culverts have been installed through this embankment.

In 2000, a detailed flood study was undertaken on the Port Hedland creek systems including South West Creek and South Creek. This study report, the “Greater Port Hedland Storm-Surge Study” (GEMS, 2000), describes the South West Creek as having a relatively flat catchment with poorly defined stream systems, making catchment boundaries and flowpaths in the lower reaches difficult to define. Typical of the smaller catchments in the area, the main flow channels have discontinuities linked by overland flowpaths. These overland flowpath areas experience relatively shallow slow moving sheet flow and act as water storages in the catchment slowing the catchment response time to rainfall.

South West Creek has an estimated main stream length of 53km and an estimated catchment area of 395km$^2$, upstream from the BHPBIO Port Hedland-Shay Gap Railway. Design 50 year and 100 year ARI peak discharge estimates at the railway are 1,233 m$^3$/s and 1,902 m$^3$/s respectively (GEMS, 2000). At low flows, floodwaters from South West Creek pass under the BHPBIO railway embankment into the Port Hedland harbour area via 12 steel pipe culverts, each with an approximately diameter of 600mm. During large flood events, these culverts would have insufficient hydraulic capacity for the peak catchment discharges and surface water would pond on the upstream side of the railway embankment. Based on flood maps (GEMS, 2000), this ponded water discharges westwards along the upstream side of the Port Hedland-Shay Gap Railway to alternative natural drainage pathways.

A large capacity drainage channel has been excavated along the upstream side of the BHPBIO railway embankment to discharge excess flood flows from South West Creek to the west. At this stage, the study team has found no reports on the hydraulic capacity for this bypass channel. However, it is possible that this bypass route has a limited capacity and during peak flood events floodwater would also discharge over the railway embankment. In March 1988, floodwaters are reported to have overtopped the railway in the region of South West Creek and South Creek causing considerable disruption (Chapple Research, 1995).

During the modelling undertaken for the “Greater Port Hedland Storm-Surge Study” (GEMS, 2000), the South West Creek catchment response times were assessed for major rainfall events. For the peak 50 year and 100 year ARI design floods, the times to flood peak generally varied between 8 to 12 hours, depending upon the rainfall pattern being modelled. This demonstrates that the river flood peak discharge generally occurs well after any ocean storm surge peak such that the direct combination of the two peak events is unrealistic.

3.1.4 South Creek

The drainage pathway for South Creek discharges on the eastern side of Anderson Point, thus passing outside the proposed FMG development area (Figure 1). As with the South West Creek, the existing Port Hedland-Shay Gap Railway embankment crosses the South Creek main flow channel and floodplains
around 4km southeast from the proposed FMG stockyard area. Drainage culverts have been installed through this railway embankment. The Wedgefield town site is located adjacent to South Creek downstream from the railway embankment. South Hedland town site is also located adjacent to South Creek, but 2 to 4 km upstream from the railway embankment. During peak flood events in South Creek, both town sites are potentially subjected to inundation.

The “Greater Port Hedland Storm-Surge Study” (GEMS, 2000) included a detailed flood assessment for South Creek. Upstream from the Port Hedland-Shay Gap Railway, South Creek has an estimated main stream length of 8.5km and an estimated catchment area of 23km² (GEMS, 2000). This is significantly smaller than the adjacent 395km² South West Creek catchment. The study report describes South Creek catchment as being complex with the upper reaches lacking a defined stream system and its mid-section draining developed land in the western portion of South Hedland. During major flood events on the neighbouring South West Creek, overflow into the South Creek upper catchment occurs in the White Hill area around 6km upstream from the Port Hedland-Shay Gap Railway (GEMS, 2000).

Design 50 year and 100 year ARI peak discharge estimates for South Creek at the railway are 234 m³/s and 383 m³/s respectively, however these discharges could possibly be under estimated due to the overflows from South West Creek not being reliably defined (GEMS, 2000). At low flows, floodwaters from South Creek pass under the railway embankment via steel pipe culverts into the Port Hedland harbour area. As at South West Creek, during large flood events these culverts would have insufficient hydraulic capacity for the peak catchment discharges and surface water would pond on the upstream side of the railway embankment. At peak times, floodwater would discharge over the railway embankment, as indicated in the GEMS 2000 study. As previously described, in March 1988, floodwaters are reported to have overtopped the railway in the region of South Creek and South West Creek causing considerable disruption (Chapple Research, 1995).

The “Greater Port Hedland Storm-Surge Study” (GEMS, 2000) concludes that portions of Wedgefield town site are subject to ocean storm surge and river flood inundation risk from South Creek, with the lower lying parts of town within the estimated 50 year ARI flood zone. Additionally, the southwestern fringe of South Hedland town site is subject to river flood inundation risk from South Creek and falls within the estimated 50 year ARI flood zone. The 100 year ARI flood zone encompasses a marginally larger area in both town sites.

3.1.5 Existing Flooding Issues

The town sites of Wedgefield and South Hedland have a history of flooding from river flood events on the South and South West Creek systems and from cyclone induced ocean storm surge events. River flood levels at South Hedland are compounded by the blocking effect of the Port Hedland-Shay Gap Railway embankment. However this railway embankment also gives the benefit of blocking the inland penetration of ocean flooding during storm surge events (GEMS, 2000).

Recent developments in the Boodarie Resource Processing Estate on the South West Creek floodplain will locally alter flooding behaviour and flood levels in South West Creek. The impacts of these changes were assessed in the report “Boodarie Resource Processing Estate: Drainage and Flood management Study”
This report concluded that flood levels on South West Creek local to the development would be raised, but this increase would not extend to impact on the adjacent South Creek, or effect flooding in South Hedland town site.

The local community would be concerned about any development in the South and South West Creek floodplains that may potentially adversely impact on the existing flood risks at the Wedgefield and South Hedland town sites.

3.2 POTENTIAL SURFACE WATER IMPACTS

3.2.1 Introduction

The main infrastructure layout for the proposed FMG port development is shown in Figure 1 attached. This infrastructure comprises the railway loop, the stockyard area, the berth on Anderson Point, a loadout causeway from the stockyard to Anderson Point, a rail car dumper facility and conveyors with associated material transfer facilities. Two dredge spoil deposition areas are also proposed which will form the foundation pad supporting some of the main infrastructure.

These proposed facilities, located in the southwest sector of Port Hedland harbour, will potentially impact on the movement of surface water through the area. To reduce disturbance to surface water movements, intertidal creeks and associated mangrove communities, the facilities will be predominantly located over the bare mudflat areas away from the main intertidal zones and appropriate drainages structures provided.

3.2.2 Dredge Spoil Areas

Two dredge spoil deposition areas are proposed to be constructed using material dredged from the harbour, to form foundation pads for stockpiles and working areas. The main deposition area will be located under the stockyard area and the second smaller deposition area on Anderson Point (Figure 1). A perimeter embankment will be constructed around the proposed spoil deposition areas, to contain the dredged spoil. These embankments will initially be constructed using borrow from beneath the dredge spoil deposition area and/or imported fill, however later they will likely be raised, using upstream construction, with selected reclaimed spoil material. The finished level of the perimeter embankment will be at a minimum level of RL 6.0m AHD, being 0.5m above the adopted design 100 year ARI average storm surge level of RL 5.5m AHD.

The spoil deposition areas will predominantly be located over the low-lying and vegetation bare mudflats, as shown in Figure 1. In the stockyard area, the deposited material will surround some existing areas of the relatively higher level sandy lowlands. Under the stockyards, the depositions will block some existing east-west linking mudflat channels, however these channels do not have a significant drainage function. The final boundaries to the spoil deposition areas have been shaped to avoid clearing and hydraulic impact in the mangrove communities. With these boundary considerations, the spoil deposition areas will not impact the mangrove areas, except possibly in the upper extremities of some flowpaths were some minor vegetation loss may occur.

Around the proposed deposition areas, the flow areas available for surface water drainage in South West Creek and South Creek will remain essentially unaltered. As such, the existing surface water flood levels in
these creeks will not be impacted by their construction. The existing surface water flooding levels will also not be affected in the Wedgefield town site located around 1.5 km east from the eastern boundary of the spoil deposition area.

Within the spoil deposition areas, deposition will be managed to settle the solids and decant the free water for discharge back into the harbour. The free water will be processed via sediment interception basins prior to disposal. This water will be discharged to the harbour at locations and under favourable tidal conditions such that the potential for impact to the mangrove populations is minimised. Upon completion of the dredging, the spoil deposition areas will be drained and levelled. The finished surface will be seeded to reduce the potential for surface erosion from rainfall and dust generation. The perimeter bund will be slightly elevated to contain internal stormwater runoff, which will be harvested and used for dust control. Excess surface runoff water will be treated via an oil separator and a sediment interceptor basin, prior to discharging to the environment.

3.2.3 Railway Loop

The proposed railway loop, in a clockwise direction, runs westwards and northwards parallel to the existing BHPBIO Port Hedland-Shay Gap Railway (Figure 1). The loop then curves eastwards over the low-lying South West Creek area before curving southwards over the relatively higher level dredge spoil deposition area and sandy lowlands to rejoin the main railway. The proposed railway will be installed on an embankment constructed using imported fill material to a similar level as the existing Port Hedland-Shay Gap Railway. Where parallel to the existing BHPBIO railway embankment, drainage culverts will be installed through the proposed embankment with at least a similar hydraulic capacity to those in the existing embankment. Some additional culverts may be installed where local drainage conditions warrant.

The northern portion of the proposed railway loop embankment will potentially be over 4m high through the lower lying South West Creek area and have a base footprint over 20m wide. Through this South West Creek area, a strip of vegetation, predominantly comprising mangrove communities, will be cleared for construction of the railway embankment. Whereas, the majority of the proposed southern, eastern and western railway embankments will be constructed on the relatively higher level sandy lowlands and dredged spoil deposition area. Through these higher areas, the required embankment heights will typically be between 0 to 2m and the base footprint less than 10m wide. On the sandy lowlands, a strip of vegetation, predominantly comprising low shrublands and hummock grasslands will be cleared for the embankment construction. Through the lower lying bare mudflat areas, the required embankment heights will typically be between 2 to 4m, and with the absence of vegetation, no clearing will be required.

The proposed FMG railway loop will be constructed through the South West Creek floodplain and will twice cross the main flow channel (Figure 1). The upstream crossing will be where the railway loop is located adjacent to the existing BHPBIO Port Hedland-Shay Gap Railway and the downstream crossing will be in the tidal creek zone at the northern side of the loop. As outlined in Section 3.1.3, the existing BHPBIO railway embankment only has low capacity culverts in the South West Creek channel and essentially blocks the larger flood discharges from entering the proposed railway loop area. During large flood events, surface water would pond on the upstream side of the BHPBIO railway embankment then overspill westwards along
the upstream side of the Port Hedland-Shay Gap Railway to alternative natural drainage pathways. A large capacity drainage channel has been excavated along the upstream side of the BHPBIO railway to carry these excess discharges, however, at this stage the study team has not found a report detailing the hydraulic capacity of this channel. It is possible that this bypass route has a limited capacity and during peak flood events floodwater would also discharge over the BHPBIO railway embankment.

In the South West Creek main flow channel, culverts are proposed to be installed through the FMG railway embankment, immediately downstream from the existing BHPBIO railway embankment low capacity culverts. The capacity of these FMG culverts will be determined during the detailed design stage for the project, however it is anticipated that they would be equal to or larger than the capacity of the existing BHPBIO culverts. During the detailed design stage, it is recommended that an assessment of the South West Creek upstream bypass channel hydraulics be undertaken, in conjunction with BHPBIO. This assessment will determine the required peak design flow to be discharged via the railway culverts or alternative options to manage the risk of embankment overtopping during peak flood events. The FMG railway culverts should then be selected for the required peak design discharge. River flood levels in South West Creek immediately upstream from the existing BHPBIO railway embankment are currently controlled by the existing BHPBIO embankment, culverts and bypass channel arrangements. The proposed FMG railway embankment with equal or greater capacity culverts will be constructed downstream from the existing BHPBIO embankment and as such will not adversely impact on the existing upstream flood levels. Regardless of potentially small variations in South West Creek flood levels upstream from the BHPBIO railway embankment, river flood levels in South Creek adjacent to South Hedland town site would not be affected.

The northern side of the proposed FMG railway loop embankment crosses South West Creek in the tidal creek zone. As with the upstream crossing, large capacity culverts are proposed to be installed in the main flow channel and in the main tributary channel located around 700m to the east (Figure 1). As a minimum, these culverts combined will be designed to have the same discharge capacity as the upstream FMG culvert crossing that controls river flood discharges entering the railway loop. These culverts will also be designed for discharges derived by hydrodynamic modelling of tidal movements such that adequate tidal flushing occurs through the mangrove areas. During the detailed design process, design flood levels through the railway loop area will be assessed such that the hydraulic capacity of the upstream culverts will not be impacted. River flood levels in South West Creek upstream from the existing BHPBIO railway embankment will not be affected by the downstream culverts.

In proximity to the culvert installations, localised higher flow velocities would occur with the potential for scouring. Using appropriate erosion protection works in these high flow transition zones, these potentially adverse scouring effects can be managed to acceptable levels. At the detailed design stage, riprap or similar erosion protection blankets will be specified around the culvert inlet and outlet zones.

### 3.2.4 Loadout Causeway

A proposed access causeway supporting the loadout conveyor and a roadway will be constructed from the proposed stockyard area to the proposed Anderson Point shiploading facilities. This embankment,
constructed using imported fill material, will be finished to a minimum level of RL 6.0m AHD, being 0.5m above the adopted design 100 year ARI average storm surge level of RL 5.5m AHD. The embankment will link the dredge spoil deposition area at the stockyard to that at Anderson Point and will be constructed over mudflats and a small tidal creek with the portion into the harbour itself constructed on an elevated truss forming a jetty.

Through the lower lying tributary creek area, the proposed embankment will potentially be over 4m high and have a base footprint over 20m wide. A strip of vegetation, predominantly comprising mangrove communities, will be cleared for the embankment construction. Culverts will be provided through the embankment to enable tidal flushing of the mangrove areas and local drainage. These culverts will be designed for discharges derived by hydrodynamic modelling of tidal movements such that adequate tidal flushing occurs through the mangrove areas. The construction of this causeway will not have an impact on the existing flood levels in South West Creek or South Creek and will not impact on drainage from the project development area.

3.2.5 Stockyard Area

The proposed stockyard area is located on the relatively higher level dredge spoil deposition area and natural sandy lowlands (Figure 1). The stockyard area will be protected from ocean storm surge flood events by the slightly raised perimeter road constructed around the dredge spoil deposition area. This road will be constructed to a minimum level of RL 6.0m AHD, being 0.5m above the adopted design 100 year ARI average storm surge level of RL 5.5m AHD. The road will also contain local stormwater runoff within the spoil deposition area, which will be harvested and used for dust control. Excess surface runoff water will be treated via an oil separator and a sediment interceptor basin, prior to discharging to the environment. Where necessary, vegetation on the sandy lowland area, predominantly comprising low shrublands and hummock grasslands, will be cleared and ground levelling and filling will be undertaken.

3.2.6 Other Infrastructure

The proposed rail car dumper facility located on the rail embankment at the western side of the railway loop will not impact on surface water drainage in the area. All facilities will be constructed to withstand the design 100 year ARI ocean storm surge and river flood conditions. Conveyors linking the car dumper to the primary screen house in the stockyard area will be installed on trestles and will not impact on surface water movements in the area. Conveyors linking the stockyard area to the shiploading facilities at Anderson Point will be located above the design 100 year ARI ocean storm surge level. The proposed Anderson Point facilities will be installed on trestle type structures that allow free surface water movement thus not impacting on the existing surface water regime.

3.2.7 Ocean Storm Surge Estimates

Design storm surge conditions have been assessed in the Port Hedland harbour area (GEMS, 2000) based on the port layout prior to construction of the proposed FMG port development works. With construction of the railway loop, the dredge spoil deposition areas and the Anderson Point access causeway, the local topography will be altered. These works will potentially restrict access of the ocean storm surge to the low-
lying tidal flats in the railway loop area, thus locally reducing the risk of flooding from the ocean storm surge. Whereas, in the Anderson Point area, with construction of these new works, the risk from flooding due to ocean storm surge levels is believed not to have changed. However, FMG propose to reassess this risk during the detailed design phase for the project. If appropriate, an enhanced freeboard above the design 100 year ARI average storm surge level of RL 5.5m AHD will be adopted in this area. The effect of storm waves above the design ocean surge level will also be considered.

3.3 SURFACE WATER MANAGEMENT

Construction of the proposed FMG port development infrastructure, located in the southwest sector of Port Hedland harbour, will potentially impact on the movement of surface water through the area. This development comprising the railway loop, dredge spoil deposition areas, the stockyard area, the berth on Anderson Point, a loadout causeway, a rail car dumper facility and conveyors with associated material transfer facilities is shown in Figure 1. To reduce disturbance to surface water movements, intertidal creeks and associated mangrove communities, the facilities will be predominantly located over the bare mudflat areas away from the main intertidal zones and appropriate drainages structures provided. The proposed surface water management strategies needed to reduce the potential for surface water impacts are as follows:

**Dredge Spoil Deposition Areas**

- Shape the final boundaries to the spoil deposition areas to avoid clearing and hydraulic impact in the mangrove communities.
- Manage the dredge spoil deposition areas such that the dredged solids are settled and the free water is decanted via sediment interception basins back into the harbour under favourable tidal conditions.
- Construct slightly elevated perimeter embankments around spoil deposition areas with a minimum finished level of RL 6.0m AHD, being 0.5m above the adopted design 100 year ARI average storm surge level of RL 5.5m AHD.
- Seed the finished surfaces of the dredge spoil deposition areas to reduce the potential for surface erosion and dust generation.
- Harvest internal surface runoff from the spoil deposition areas and use for dust control with the excess treated via an oil separator and a sediment interceptor basin, prior to discharging to the harbour.

**Railway Loop**

- Install drainage culverts through the proposed FMG railway embankment with at least a similar hydraulic capacity to those in the adjacent existing BHPBIO railway embankment.
- Assess the South West Creek upstream bypass channel hydraulics, to determine the peak design flow to be discharged via the FMG railway loop culverts or alternative management options to reduce the risk of embankment overtopping, then select appropriate culverts for this area.
- Undertake hydrodynamic modelling of tidal movements in the railway loop area and select culverts such that adequate tidal flushing occurs through the mangrove communities.
• Install erosion protection works on the culvert inlet and outlet zones, to manage potential adverse scouring effects.

Loadout Causeway
• Construct the loadout causeway to a minimum level of RL 6.0m AHD, being 0.5m above the adopted design 100 year ARI average storm surge level of RL 5.5m AHD.
• Undertake hydrodynamic modelling of tidal movements in the loadout causeway area and select culverts such that adequate tidal flushing occurs through the mangrove communities.

Stockyard Area
• Harvest local stormwater runoff within the spoil deposition area and used for dust control with the excess treated via an oil separator and a sediment interceptor basin, prior to discharging to the harbour.

Ocean Storm Surge Estimates
• Reassess the ocean storm surge risk adjacent to the port development area and adjust the freeboard requirements for the adopted design 100 year ARI average storm surge level, as appropriate.
SECTION 4 - NORTH SOUTH RAIL ASSESSMENT

4.1. EXISTING SURFACE WATER ENVIRONMENT

4.1.1. Introduction

The FMG North-South Rail corridor connects the proposed FMG Port Facilities located in Port Hedland harbour to the proposed Mindy Mindy Mine Site located around 300km to the south. The rail corridor, as shown in Figure 2, essentially runs parallel to the existing BHP Billiton Iron Ore (BHPBIO) rail corridor connecting Port Hedland to Newman.

The northern terminal for the FMG North-South Rail corridor is located on the sandy lowlands in the southwest sector of Port Hedland harbour adjacent to the BHPBIO Port Hedland-Shay Gap Railway. Whereas the southern terminal for the rail corridor is located on the southern flank of the Fortescue Valley adjacent to the Mindy Mindy Mine Site. On its route southwards to Mindy Mindy, the rail corridor crosses three major physiographic units, which have been described by Beard (1975) as the Abydos Plain, the Chichester Plateau and the Fortescue Valley. The mine site however is located in the lower levels of the Hamersley Plateau physiographic unit.

The Abydos Plain extends from the coast south to the Chichester Range and includes alluvial plains, low stony hills and granite outcrops (Beard, 1975). Topographically, along the rail corridor, the plain rises from the coastal lowlands to around 300 - 400m above mean sea level adjacent to the Chichester Range. On the Abydos Plain, the rail corridor crosses three main catchments (Figure 2), namely the Port Hedland Area Catchment, the Turner River Catchment and the Yule River Catchment. In common with most all Pilbara catchments, these catchments contain ephemeral drainages that only flow following rainfall events, with the exception of isolated springs and pools.

4.1.2 Port Hedland Area Catchment

The Port Hedland Area Catchment contains several creeks draining to the coast between the Turner River Catchment and the De Grey River Catchment. These creeks from west to east are the South West Creek, South Creek, Beebingarra Creek, Petermarer Creek and Tabba Creek. Over this initial 50km, the rail corridor passes solely through the South West Creek catchment the general characteristics of which have been described in Section 3.1.3. Through this area, the rail corridor is typically aligned parallel to and away from the main surface drainages except where it crosses over the main South West Creek flow channel near to the MRD North West Coastal Highway road bridge. This MRD road bridge waterway has been designed to pass the 20 year ARI flood event (Main Roads Department, 1975) and floodwaters from floods in excess of this level discharge over the highway embankment.

4.1.3 Turner and Yule River Catchments

South from the Port Headland Area Catchment, the rail corridor passes through the Turner River and Yule River Catchments (Figure 2). In the Turner River Catchment, the corridor crosses the Turner River East, Chinnamon Pool, Gillam Creek, Turner River and numerous smaller drainage channels. Whereas in the Yule River Catchment, the corridor crosses Coorong Creek, Yule River and several branches of Coonarrie Creek. The rail corridor has typically been aligned to cross perpendicular to the main drainage channels and floodplains. These main drainages support eucalypt woodland in their floodplains and have alluvial gravel-sandy beds that may become mobile during flood events.
All drainage channels are ephemeral responding to rainfall events. Following significant rainfall, the channels typically carry large discharges, possibly for a few days, then retreat back to isolated pools. In the main channels, smaller discharges may persist for a few weeks. During the large flood events, floodwater would overflow the main river channels into the surrounding floodplains.

4.1.4 Chichester Plateau

The Chichester Plateau, located along the southern edge of the Abydos Plain, steeply rises some 100 to 150m above the plain. This plateau comprises an elevated zone of mainly basalts with included siltstone, mudstone, shale, dolomite and jaspilite (Beard, 1975). The plateau forms the catchment divide between drainages discharging northwards across the Abydos Plain to the coast and those discharging southwards to the Fortescue River Valley.

The FMG rail corridor winds through the plateau, to achieve a uniform gradient and to avoid the rugged peaks. Through this plateau area, the corridor initially crosses the upper portions of the Yule and Shaw Rivers, which discharge northwards to the coast, and then crosses smaller drainages discharging southwards to the Fortescue River. Drainage pathways through the plateau area are characterised by typically smaller catchments, steeper gradients and steep sided valleys, as compared with drainages on the plain. Following rainfall, these steeper drainage pathways would respond and flow rapidly, but typically for a comparatively short duration. On the southern flanks of the Chichester Plateau, where the drainages discharge southwards to the Fortescue River Valley, the drainage pathways become less steep.

4.1.5 Fortescue Valley

The Fortescue Valley occupies a trough between the Chichester and Hamersley Plateaux (Beard, 1975). The Goodiadarrie Hills, located on the valley floor around 7km west from the existing BHPBIO railway, effectively cuts the Fortescue River into two separate river systems (Figure 2). West from the Goodiadarrie Hills, the Lower Fortescue River Catchment drains to the coast, whereas east from the hills the Fortescue Marshes receives drainage from the Upper Fortescue River Catchment. The FMG rail corridor crosses through the Fortescue Marsh area upstream from the Goodiadarrie Hills adjacent to the existing BHPBIO railway.

The Fortescue Marshes is an extensive intermittent wetland occupying an area around 100km long by typically 10km wide located on the floor of the Fortescue Valley. The marsh has an elevation around 400m above sea level. To the north, the Chichester Plateau rises to over 500m above sea level, whereas to the south the Hamersley Range rises to over 1000m above sea level. Following significant rainfall events, runoff from the approx 31,000 km$^2$ Upper Fortescue River Catchment drains to the marshes. For the smaller runoff events, isolated pools form on the marshes opposite the main drainage inlets, whereas for the larger events the whole marsh area floods. Large floods in the early 1970’s are reported to have caused inundation up to the existing BHPBIO railway track level (pers. com. Geoff Liddell, BHPBIO).

On the southern and northern flanks of the Fortescue Valley, numerous creeks discharge to the marshes. On the lower less steep valley flanks, rainfall runoff tends to flow overland rather than along defined creek courses. These water courses and sheetflow areas frequently support scrub and mulga woodlands,
particularly in the lower lying areas. The Fortescue River, Weeli Wolli Creek and other main channels entering the marshes typically support eucalypt woodland in their floodplains. After crossing the marshes, the FMG rail corridor follows the route of the existing BHPBIO railway around the southern edge of the Fortescue Valley crossing Weeli Wolli Creek and terminating at the base of the Hamersley Ranges at Mindy Mindy mine site around 450m above sea level (Figure 2).

4.2 POTENTIAL SURFACE WATER IMPACTS

4.2.1 Introduction

The FMG North-South Railway will be around 345km in length and comprise a continuous railway formation supported by cut and fill earthworks. Construction of the railway formation could potentially interrupt surface water drainage features that naturally occur along the rail corridor. These natural drainage features include major rivers and their tributaries, creeks, floodplains, sheet flow areas, marshes and springs. Inappropriate management of these features could potentially alter existing natural drainage patterns including flooding characteristics; scour, erosion and siltation of the drainage channels; inundation of upstream areas and water starvation to downstream areas.

The FMG rail corridor essentially runs parallel to the existing BHPBIO rail corridor connecting Port Hedland to Newman. As the existing BHPBIO railway embankment already causes some interruption to the existing surface water environment, where feasible the FMG rail corridor has generally been located adjacent to the existing BHPBIO railway to reduce the potential for additional surface water impacts. However, in some areas, due to topography, it has been necessary to deviate the FMG corridor from the BHPBIO route, to reduce impacts on the natural drainage systems or on the existing BHPBIO railway drainage structures.

Bridges will be installed over the major river channels and culverts installed at all other drainage crossings. Bridges will be built to safely pass the 50 year Average Recurrence Interval (ARI) flood and culverts built to safely pass the 20 year ARI flood. All bridge and culvert constructions will be to “best practice” engineering to neutralise adverse water flow impacts and will include erosion protection works as appropriate. Bridges and culverts will be located and sized so as not to adversely impact on the corresponding existing BHPBIO railway bridges and culverts.

4.2.2 Port Hedland Area

In the Port Hedland Area Catchment (Figure 2), the FMG rail corridor is typically aligned parallel to and on the western side of the natural surface drainages in South West Creek. This route has been selected to avoid the main flow channels, except where it crosses over the main South West Creek flow channel near to the MRD North West Coastal Highway road bridge. As described in Section 4.1.2, the existing MRD road bridge waterway has been designed to pass the 20 year ARI flood event (Main Roads Department, 1975) and floodwaters from floods in excess of this level discharge over the highway embankment. As the proposed FMG railway embankment will be constructed to similar levels as the highway formation, floodwaters from these rare floods will also discharge over the railway. At the South West Creek crossing, the FMG bridge/culvert layout will be determined at the project detailed design stage such that any potential adverse impacts to existing flood levels will be managed to acceptable levels. Guide banks and erosion protection works will be provided, as appropriate, to reduce potential local impacts to the creek system.
Upstream from the MRD road crossing, in the White Hill area, the South West Creek overspills into South Creek during major flood events, as described in Section 3.1.4. The existing flood flow distribution patterns through this area are complex and the FMG railway embankment has been located to avoid passing through this overspill zone and disturbing the existing flood flow patterns. At the project detailed design stage, FMG will assess the flood flow patterns through this area, in conjunction with their assessment for the proposed South West Creek bridge/culvert crossing. The results from this study will be used to finalise the preferred layout for the works such that any potential adverse impacts to existing flood flow patterns will be managed to acceptable levels.

4.2.3 Major River Systems

The rail corridor crosses several major rivers and their floodplains in the Turner River, Yule River and Upper Fortescue River Catchments (Figure 2). In the Turner River Catchment bridges will be constructed over the river channels at Turner River East, Chinnamon Pool, Gillam Creek and Turner River, whereas in the Yule River Catchment bridges will be constructed at Coorong Creek, Yule River and several branches of Coonarrie Creek. Bridges will also be constructed over three main channel crossings of the Weeli Wolli Creek, located in the Upper Fortescue River Catchment. To reduce disturbance to the surface water flow patterns and flow directions, where possible the rail corridor has been aligned such that the bridges cross perpendicular to the main drainage channels and floodplains.

Bridges with their approach embankments present a constriction to flood flow. The approach embankments divert upstream flow from the river floodplains into the main channel zone to pass the constriction, then downstream from the bridge, flows spread back into the floodplains. At bridge sites, confining the river flow results in channel flow velocities being locally increased with the potential for scour on the bridge abutments and channel beds. Flood water levels upstream from bridges also become elevated above natural levels, whereas downstream from the bridges flood levels are not affected. Using “best practice” engineering, these potentially adverse factors can be managed to acceptable levels. These measures include the provision of guide banks, hydraulically streamline flow areas and riprap or similar scour protection blankets. The open bridge waterways proposed for the FMG railway will allow flood discharges to pass with minimal obstruction together with any natural debris, sediment and bed load.

4.2.4 Smaller Flow Channels

The railway formation also crosses numerous smaller flow channels where culverts will be installed to allow drainage to pass. As with bridges, the culverts constrict flood flows. During a flood event, upstream water levels become elevated and pressurise the flow through the culverts generating a higher velocity discharge stream. Downstream from the culverts, the discharging water slows and reverts to natural flow conditions and water levels are not affected. In proximity to the culverts, localise higher flow velocities occur with the potential for scouring and appropriate erosion protection works are required. Using “best practice” engineering, these potentially adverse factors can be managed to acceptable levels. These measures include limiting the upstream water levels, the provision of riprap or similar scour protection blankets and at some locations the provision of additional support earthworks.
Where the railway formation is located such that topography would cause intercepted drainage pathways to flow along the upstream side of the formation for long distances, there is potential that large and erosive drainage discharges could develop. In these areas, culverts need to be installed under the railway formation at regular intervals together with small interceptor embankments to direct runoff into the culverts.

4.2.5 Sheetflow Areas and Dependant Vegetation

Runoff from rainfall initially drains down gradient as overland flow before concentrating in a defined flow channel. In this process surface detention, vegetation, seepage and other mechanisms absorb water from the runoff stream. In steep areas, the runoff processes are rather rapid with relatively low losses and defined drainage channels are typically in close proximity. Whereas in the lower slope areas, the runoff processes are rather slow with relatively higher losses and a greater distance between defined drainage channels. In some of these lower slope areas, vegetation communities have developed which have become dependent on seepage water provided by the overland flow process. In the lower slope areas the overland flow process has been termed sheetflow. To reduce environmental impacts, provision for drainage also needs to be provided where the railway formation crosses sheetflow areas.

Along the FMG rail corridor, sheetflow areas with dependent downstream vegetation (eg: mulga woodlands) occur in places along the flanks of the Fortescue Valley. Through these areas, where the railway formation effectively runs along the contour (ie: perpendicular to the drainage flowpaths) the formation will block the sheetflow pathways causing water to collect along the upstream side. With inappropriate management, areas with dependent downstream vegetation will potentially be impacted by the blocking action from the railway formation. In these areas, drainage culverts need to be installed at regular intervals under the railway formation together with earthworks to redistribute the sheetflow on the downstream side of the culverts. However, where the FMG railway will be adjacent to the existing BHPBIO railway and sheetflow culverts have not been installed under the BHPBIO railway, there is no advantage to installing such culverts under the FMG railway, unless BHPBIO plan to retrofit culverts.

4.2.6 Fortescue Marshes

The FMG rail corridor crosses through the Fortescue Marsh area upstream from the Goodiadarrrie Hills adjacent to the existing BHPBIO railway. At this location, slightly elevated terrain locally reduces the width of the marshes from a typical width around 10km to less than 500m. The marsh bed at this crossing location is also higher than the adjacent upstream and downstream bed areas. Drainage culverts will be installed under the railway formation at the lowest levels of the marsh crossing. These culverts will be sized to match those in the adjacent BHPBIO railway.

Being an extensive intermittent wetland, the marshes act as flood storage area receiving runoff from the surrounding catchments. Installation of the FMG railway embankment will not reduce the volume of storage available in the marshes and will not effect the existing surface water drainage patterns. As such the railway crossing of the marsh will have a negligible effect on the surface water drainage system.
4.3 SURFACE WATER MANAGEMENT

Construction of the FMG railway could potentially alter the existing natural drainage patterns along the route including flooding characteristics; scour, erosion and siltation of the drainage channels; inundation of upstream areas and water starvation to downstream areas. Appropriate surface water management strategies need to be adopted to reduce the potential for environmental impact. The recommended strategies are as follows:

1. Locate the FMG railway formation adjacent to the existing BHPBIO Port Hedland to Newman railway, to reduce the potential for additional surface water interruptions above that already caused by the BHPBIO railway embankment.

2. Locate and size bridges and culverts so as not to hydraulically impact the corresponding existing railway and road bridges and culverts and not to adversely impact the surface water environment.

3. Align the rail corridor such that the bridges cross perpendicular to the main drainage channels in order to reduce the disturbance to the existing surface water flow patterns and directions.

4. Where necessary due to topography, deviate the FMG railway formation away from the BHPBIO route, to reduce impacts on the existing BHPBIO railway drainage structures or on the natural drainage systems (e.g. at the Turner River and Turner River East crossings).

5. Assess the waterway requirements for the proposed South West Creek bridge/culvert crossing in conjunction with the flood flow patterns through the upstream White Hill area, then finalise the preferred layout for the works such that any potential adverse impacts to existing flood flow levels will be managed to acceptable levels.

6. Install bridges over the major river channels and culverts at all other drainage crossings.

7. Build bridges to safely pass the 50 year Average Recurrence Interval (ARI) flood and culverts to safely pass the 20 year ARI flood.

8. Adopt “best practice” engineering to neutralise adverse water flow impacts from bridge and culvert constructions, such as provision of guide banks, hydraulically streamline flow areas and riprap or similar scour protection blankets.

9. Install culverts and small interceptor embankments, where appropriate, to prevent long drainage pathways developing adjacent to the railway formation.

10. Identify sheetflow areas with dependent downstream vegetation along the FMG rail corridor and assess if the BHPBIO railway already impacts these areas. If not, assess if the FMG railway would impact these areas. If significant impact is possible, install drainage culverts at regular intervals together with earthworks to redistribute the sheetflow on the downstream side.
SECTION 5 - REFERENCES


Main Roads Department, 1975: South Hedland Flood Study Technical Report No. 4.


FIGURES
Figure 1.
Indicative Port Layout