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BALMORAL SOUTH IRON ORE PROJECT



SURFACE WATER MANAGEMENT PLAN



Prepared for: International Minerals Ltd

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SURFACE WATER MANAGEMENT PLAN

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EXECUTIVE SUMMARY

BACKGROUND

Project Background and Scope of Work

The project is based on three major magnetite orebodies, known as the Central, Southern and Northern Blocks near Cape Preston on the north-west Pilbara coast, 80km south-west of Karratha. This Surface Water Management Plan relates to the development of the Southern Block. Direct Reduced Iron/Hot Briquetted Iron will be produced and transported along a corridor to a port facility to be constructed at Cape Preston, with a shipping load-out facility constructed off Preston Island.

The scope of work includes:

- A flood assessment of the Fortescue River floodplain.
- A flood assessment of the Du Boulay Creek floodplain.
- An assessment of the mine site accommodation village with respect to the 100 year ARI flood in the Fortescue River.
- A surface water management plan.

Existing Fortescue River Hydrology

The mine site is located adjacent to the lower reaches of the Fortescue River and about 15km from the river mouth to the Indian Ocean. Above the project area, the Fortescue River has an effective catchment area of approximately 20,000km² and an estimated 100 year ARI peak flow of 9,570m³/s. The Fortescue River has a well defined main flow channel, typically 4-6m deep and around 100m wide adjacent to the project area. The main channel has a gravelly bed and typically gum trees along both banks. Vegetation over the floodplains varies from wide open grass areas to dense scrub. There appears to be a significant “break-out” area to the south of Coolangara Hill that redirects high level flood water north-west, away from the main Fortescue River system.

Existing Du Boulay Creek Hydrology

Du Boulay Creek flows in a north-westerly direction through the general project area, and joins the Fortescue River approximately 6km from the coast. The creek has a catchment area of about 200km², with an estimated 100 year ARI peak flow of 1,400m³/s. Du Boulay Creek typically has main flow channels with 5-10m width gravel beds and trees along the banks. Floodplains adjacent to the main channels typically comprise open grassed areas with scattered trees.

POTENTIAL IMPACTS

Waste Dump

The Balmoral South waste dump occupies the western extent of Leases MO8/126 & 129. It is located in the Fortescue River floodplain, west of the pit with the north end of the dump near Du Boulay Creek. It is currently sized at 3.1km long x 1.4km wide.

The proposed Balmoral South waste dump fully encroaches into the Fortescue River eastern floodplain, and a number of creeks and intertwining tributaries flow through the proposed dump area. Hydraulic modelling predicts that the construction of the Balmoral South waste dump in the Fortescue River floodplain will locally

increase 100 year ARI flood levels adjacent to and within about 3km upstream of the dump. The proposed Balmoral South waste dump is estimated to increase the river 100 year ARI peak flood level by up to 0.37m at its south end in combination with the Central Block waste dump. This rise in flood level could potentially cause more water to escape westwards from the Fortescue River main channel through the break-out channels. At its north end, flood levels are predicted to be unaffected by the development of the Balmoral South waste dump once the Central Block dump is in place.

The waste dump also has the potential to discharge sediment laden water to the environment.

Plant Site

The process and power station site is set around Du Boulay Creek. The proposed stockpile area, conveyor system, ROM pad and primary crushing area encroaches into the 100 year ARI floodplain but will be protected by bunding.

The bunds will restrict flow through the Du Boulay Creek in large flood events and cause water levels to rise. The most significant impact on water levels would occur adjacent to the plant site where 100 year ARI water levels are predicted to increase by about 1.0m after construction of the bunds. Average velocities in this area should decrease due to the increased flow depths causing flow areas to increase. However, the location of the bunds creates a meandering flow path and an increased potential for locally higher velocities and scouring.

Pit Area

The proposed open pit area is located between Du Boulay Creek and the Fortescue River at the north end of a domed hill. Several small ephemeral creeks drain the hill and will be disturbed by the open pit. The pit perimeter is located on down slopes, and therefore all creek drainage from the ridge is away from the open pit. However, the northern portion of the pit is located on the Du Boulay Creek floodplain and will be impacted by flood flows.

TSF

The tailings storage facility (TSF) occupies the eastern extent of Lease MO8/130, north of the mine village site. Most of the TSF occupies ground gently sloping towards the Fortescue River and no major watercourses are interrupted. However, the facility has the potential to discharge various chemicals, reagents and unrecovered metals to the environment, thus increasing the risk of surface water contamination.

Village Site

The proposed village site is located 8km south of the plant site in the south-east corner of Lease Area MO8/130. The village site gently slopes to the west towards the river and there are no significant water courses through the area. Hydraulic modelling shows the proposed village area has a 100 year ARI flood level of approximately RL30.8m and the ground level in the area of the village is about RL29.5m-32.5m. Therefore, the 100 year ARI flood level in the Fortescue River has the potential to inundate parts of the site nearer to the river.

Borefield

The project water supply borefield is proposed to be located on the western flank of the Fortescue River, upstream from the project area. Some of this borefield area would be susceptible to inundation during a 100 year ARI flood event. Inundation could locally be up to 2m depth during the 100 year ARI event, though peak flow velocities would typically be low at less than 1m/s.

SURFACE WATER MANAGEMENT

Waste Dump

The risk of erosion and sedimentation from the waste dumps is high. The waste dump area will be bunded to contain internal surface water runoff for treatment prior to discharge to the external environment, and to protect the dump from external river and wave attack. The waste dump surface may also be dished in the centre, to dissipate runoff by evaporation and seepage, and to reduce runoff and erosion down the face.

Around the perimeter bunding, vegetation would provide the best long term protection. Riprap (or rock armour) would be used as appropriate to protect against scouring and erosion. Armouring would be particularly required at the corners of the dump where eddies form or local velocities are high, to mitigate against erosion and scour holes.

A diversion channel will be required at the southern upstream edge of the waste dump to transport trapped water back towards the main river channel, although it is envisaged that some ponding would be acceptable.

Plant Site

Appropriate bunding will be required around the plant infrastructure to prevent runoff from flood events inundating the site. The proposed stockpile area, ROM pad and crusher encroaches into the Du Boulay Creek floodplain and should ideally be relocated to higher ground where they can be bunded off or raised above the flood level on a pad. The conveyor system crosses the Du Boulay Creek floodplain and would also need to withstand 100 year ARI floodwater depths and velocities. Runoff from the plant areas will be controlled to ensure it does not cause undue erosion and to guard against potential contamination of watercourses.

Pit Area

As the pit is centred on the top of the hill, there will be no requirement for external surface water management from the ridge area. However, the pit is proposed to extend over the Fortescue River and Du Boulay Creek floodplains and flood protection will be provided by the waste dump to the west linking to a flood bund to the north and east. Riprap will be placed against the flood bund for erosion protection in susceptible areas.

TSF

Most of the TSF occupies ground gently sloping towards the Fortescue River and no major watercourses are interrupted. Therefore, significant flood diversion works are not expected. However, the facility will require

external bunding to capture runoff from the external batters. Excess runoff will be treated via sediment traps prior to discharge to the environment.

Village Site

The proposed village site is at risk from flooding from the Fortescue River, and as such will require bunding to protect against large flood events. Drainage off the developed village site will also be self contained and controlled to ensure no undue erosion, and to guard against potential contamination to adjacent creeks and the Fortescue River.

Borefield

Where practical, production bores should be installed outside the Fortescue River flood prone areas. In flood prone areas, the bore headworks and control panels would be installed on elevated earth pads (or similar) above the design flood level. In all areas, the bore headworks and control panels would be mounted above ground level to provide protection from localised runoff.

TABLE OF CONTENTS

SECTION 1 - INTRODUCTION.....	1
1.1 Background.....	1
1.2 Surface Water Management Plan Requirements.....	1
1.3 Scope of Work.....	1
1.4 Fortescue River.....	2
1.5 Definitions.....	2
SECTION 2 - HYDROLOGY.....	4
2.1 General.....	4
2.2 Fortescue River.....	4
2.3 Fortescue River Break-Out.....	4
2.4 Other Creeks.....	5
SECTION 3 - FLOOD ASSESSMENT OF THE FORTESCUE RIVER FLOODPLAIN.....	6
3.1 General.....	6
3.2 Location of Waste Dump.....	6
3.3 Flood Study and HEC-RAS Model.....	6
3.4 Starting Water Levels / Storm Surge.....	7
3.5 Model Results – Pre-Development.....	8
3.6 Model Results – Post-Development.....	9
SECTION 4 - WASTE DUMP.....	10
4.1 General.....	10
4.2 Waste Material.....	10
4.3 Impact on Flood Levels.....	10
4.4 Bunding of Waste Dump.....	11
4.5 River Attack.....	12
4.6 Wave Attack on Waste Dump.....	12
SECTION 5 - ASSESSMENT OF THE MINE SITE ACCOMMODATION VILLAGE.....	13
SECTION 6 - FLOOD ASSESSMENT OF THE DU BOULAY CREEK FLOODPLAIN.....	14
6.1 General.....	14
6.2 Flood Study and HEC-RAS Model.....	14
6.3 Starting Water Levels / Storm Surge.....	14
6.4 Model Results – Pre-Development.....	14
6.5 Model Results – Post-Development.....	15
SECTION 7 - SITE INFRASTRUCTURE.....	17
7.1 Plant Site.....	17
7.2 Tailings Storage Facility.....	17
7.3 Open Pit Areas.....	18
7.4 Access Roads.....	18
7.5 Borefields.....	18
SECTION 8 - SURFACE WATER MANAGEMENT PLAN : FLOOD DIVERSION WORKS.....	19
8.1 General.....	19
8.2 Tailings Dam Diversion.....	19
8.3 Diversion at the Waste Dump.....	19
8.4 Diversion at the Open Pit.....	19
8.5 Diversion Channels.....	19

SECTION 9 - EROSION AND RUNOFF 21

9.1 General Principles 21

9.2 General Surface Water Impacts 21

9.3 Surface Water Impacts – During Construction 22

9.4 Surface Water Impacts – During Operations 22

9.5 Sediment Traps 23

9.6 Mine Waste Dump 24

SECTION 10 - CONCLUSIONS AND RECOMMENDATIONS 25

FIGURES

- Figure 1 Mine Site Development Layout
- Figure 2 Plant Site Layout

APPENDICES

- Appendix A HEC-RAS Modelling: Fortescue River Pre-Development Model
- Appendix B HEC-RAS Modelling: Fortescue River Post-Development Model
- Appendix C HEC-RAS Modelling: Du Boulay Creek Pre-Development Model
- Appendix D HEC-RAS Modelling: Du Boulay Creek Post Development Model

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

The project is based on three major magnetite orebodies, known as the Central, Southern and Northern Blocks near Cape Preston on the north-west Pilbara coast, 80km south-west of Karratha. This Surface Water Management Plan relates to the development of the Southern Block. Direct Reduced Iron/Hot Briquetted Iron will be produced and transported along a corridor to a port facility to be constructed at Cape Preston, with a shipping load-out facility constructed off Preston Island.

The mine site is adjacent to the lower reaches of the Fortescue River and about 15km from the river mouth in the Indian Ocean. This report presents the results of investigations and assessments of the surface water aspects of the project.

1.2 SURFACE WATER MANAGEMENT PLAN REQUIREMENTS

The objectives of the surface water study are as follows:

- Conduct a 100 year ARI flood assessment of the Fortescue River floodplain, adjacent to the Balmoral South project, proposed borefield and accommodation village.
- Conduct a 100 year ARI flood assessment of the Du Boulay Creek floodplain, adjacent to the Balmoral South process plant and pits.
- Conduct an assessment of the mine site accommodation village with respect to the 100 year ARI flood in the Fortescue River.
- Assess the Surface Water Management Plan of the proposed development areas including tailings dam, village site, plant site and waste dump.

1.3 SCOPE OF WORK

The scope of work includes:

Flood Assessment of the Fortescue River Floodplain

A detailed flood study of the Lower Fortescue River was undertaken for the Central Orebody Project, located to the north of this project. A similar study is required to determine the effects of locating the proposed waste dump in the floodplain.

Flood Assessment of the Du Boulay Creek Floodplain

The plant site is to be located either side of Du Boulay Creek. A flood study of the creek is required to determine the impact of the creek on the proposed plant site.

Assessment of the Mine Site Accommodation Village with Respect to the 100 Year ARI Flood in the Fortescue River

The proposed village location follows on the edge of the Fortescue River floodplain. An assessment is required of the site, in respect to flooding in the river.

Surface Water Management Plans

A Surface Water Management Plan is required to cover the proposed development areas.

1.4 FORTESCUE RIVER

The project area is located adjacent to the lower Fortescue River, which has an effective catchment area of approximately 20,000km². The total Fortescue River Basin has a catchment area of around 50,000km², however, the upper portion of this basin drains only as far as the Fortescue Marsh Area, approximately 350km from the coast, and does not drain into the lower Fortescue River (WRC, 2000).

Upstream from the North West Coastal Highway, the Fortescue River is generally contained between ridges. Downstream of the Highway, the topography becomes less pronounced and the river flow path less constrained. During large flood events, river flows will break away from the main flow channel and extend over the adjacent floodplains. Through the floodplains, numerous smaller flow channels have developed discharging in the same general direction as the main channel.

The Fortescue River adjacent to the project area has a well defined main flow channel, typically 4-6m deep and around 100m wide. The main channel has a gravelly bed and typically gum trees along both banks, except near the tidal river mouth where mangroves grow along the banks. Vegetation over the floodplains varies. Some sections contain wide open grass areas with scattered trees, while other sections comprise dense scrub. The Edward and Du Boulay Creeks flow in a north-westerly direction through the general project development area and discharge into the Fortescue River. These creeks, which drain ridges located to the east and south-east from the project area, have catchment areas of approximately 29km² and 200km² respectively. Near the project areas, both creeks typically have main flow channels with 5-10m width gravel beds and trees along the banks. Floodplains adjacent to the creeks typically comprise open grassed areas with scattered trees.

Rainfall runoff from the steep ridges located within the general project area would tend to be rapid and short lived. These steep and incised drainage lines typically link into lower energy flow channels located around the perimeter of the ridges and then drain to the main Fortescue, Du Boulay or Edward systems, or directly to the coast.

1.5 DEFINITIONS

- 100 year ARI flood - The flood having an average recurrence interval (ARI) of 100 years. It has a 1% chance of occurring or being exceeded in any one year, and at least a 50% chance of being experienced at least once in any average life span of a person. The 100 year ARI flood has been generally adopted in Australia and overseas as the basis for floodplain management planning.
- Floodplain - The portion of a river valley adjacent to the river channel which is covered with water when the river overflows its banks during floods. The term also applies to land adjacent to estuaries which is subject to inundation during floods.
- Flood prone area - The land which would be inundated as a result of the 100 year ARI flood.
- Floodway - The river channel and portion of the floodplain which forms the main flow path for floodwaters once the main channel has overflowed. If floodways are even partially blocked, upstream flood levels may be raised thereby affecting areas which may not have been affected previously.

- Flood fringe - The area of the floodplain, outside the floodway, which is affected by flooding but where development could be permitted providing appropriate measures are taken. These areas are generally covered by still or very slow moving waters during the 100 year ARI flood.

SECTION 2 - HYDROLOGY

2.1 GENERAL

WA has three broad climate divisions. The south-west corner has a Mediterranean climate, with long hot summers and wet winters. The northern part is dry tropical, receiving summer rainfall in a wet season lasting from December to March. Cyclones occur during this period, bringing heavy rain and potentially causing destruction to coastal towns. The remainder is mostly arid land or desert climates.

Cape Preston and the Pilbara lie in the dry tropical northern part of the State.

2.2 FORTESCUE RIVER

Stream flow data for the lower Fortescue River was obtained for Jimbegyinoo Pool gauging station (WRC (Water and Rivers Commission), site 708003) just upstream from the North West Coastal Highway Bridge. The Department of Water (then WRC) provided a 100 year ARI flood flow of 9,220m³/s. However, this station has not recorded flow information since 1998, and flow information for essentially the same catchment area is available for a gauging station at Bilanoo (WRC site 708015 at the road bridge) for the period since the Jimbegyinoo Pool gauge was closed. In Feb/Mar 2004 a large event (9,825m³/s), much in excess of the maximum recorded flow at the Jimbegyinoo Pool gauge, was observed on the Fortescue River. The reliability of this flow event is not considered high, as the rating curve has been extrapolated well above the highest measured flow (~2,800m³/s, some 4m lower in river level).

The Department of Water (DoW) provided summaries of the peak flows for the two gauging stations. Their standard approach to flood frequency analysis for the Pilbara is to use a partial series, and choose between an LP III (Log Pearson III) or GEV (Generalised Extreme Value) fitted distribution based on the "best-fit" to the recorded flows. An LP III flood frequency analysis was performed on the data provided by the DoW, and the 100 year ARI flood flow was estimated as 9,570m³/s.

The sensitivity of the estimate to the actual size of the 2004 event was then checked by varying the event by +/-20%, which resulted in the 100 year ARI flood flow being re-estimated as 10,690m³/s and 8,460m³/s respectively. Thus a 20% variation in the 2004 flood flow estimate produces a 12% variation in the 100 year ARI flood flow. For the purposes of this report, an estimated 100 year ARI flood flow of 9,570m³/s has been used, subject to sensitivity checks.

2.3 FORTESCUE RIVER BREAK-OUT

There appears to be a significant "break-out" area to the south of Coolangara Hill that redirects high level flood water away from the main Fortescue River channel system.

Upstream of Coolangara Hill and downstream of the North West Coastal Highway Bridge, on the west side of the main river channel, there is a noticeable north-south ridge line at about 30-40m elevation. The river floodplain at this point is generally 5km wide. Coolangara Hill is located approximately 10km downstream of the ridges at an elevation of about RL45m. The floodplain east of the hill reduces to about 4km wide.

In between the upstream ridge and Coolangara Hill, flow from large flood events appears to break out to the west from the main Fortescue River channel, and generally heads in a north-west direction towards the coast. Flows eventually exit at the sea, at anywhere up to 10km west of the main Fortescue River channels.

Based on the cross sections, it is clear that the western floodplain would overflow into the break-out region in large floods, and a significant volume of flow would be diverted away from the main Fortescue channels. However, as the main purpose of the modelling is to gauge relative water levels, and with the uncertainty as to the actual extent of the break-out, no flow reduction has been adopted for the analysis. Although the model assumes that the full flow of 9,570m³/s passes through the Fortescue River channel, sensitivity analyses will be conducted on this flow. This will assist in encompassing inaccuracies due to sensitivities to extreme rainfall events (for example the February 2004 storm) and loss of flows through the break-out channels.

2.4 OTHER CREEKS

The document "Australian Rainfall and Runoff" (ARR, revised 1998) is produced by the National Committee on Hydrology and Water Resources to provide the best available information on design flood estimation. ARR recommends the use of the Rational Method and Index Flood Method, as most appropriate for the area.

The Rational Method calculates the 10 year ARI flood discharge which can then be factored for larger or smaller flood events by "frequency factors". The Index Flood Method calculates the 5 year ARI flood discharge which can similarly be factored. Within the Pilbara Region, the accuracy of any flood estimate is low, and the SEE (standard estimate of error) for the methods is high. In this case, the actual flow off a catchment may reasonably be considered to lie within the wide range of 70-150% of the actual calculated estimate.

To improve the design flood discharge estimates, the "RORB" runoff routing software was used. This is a general runoff and stream flow routing program used to calculate flood hydrographs from rainfall and other channel inputs. ARR parameters such as the Kc factor, and initial and continuing rainfall losses were used, along with the calculated stream slope on several of the key catchments associated with Edwards Creek and a tributary to Edwards Creek (catchment areas 900ha and 2,900ha respectively). This showed broadly that the RORB results were similar to those for the Index Flood Method. The Index Flood Method was therefore adopted.

SECTION 3 - FLOOD ASSESSMENT OF THE FORTESCUE RIVER FLOODPLAIN

3.1 GENERAL

All proposed mine infrastructure, except for the waste dump site and borefield, will be located outside the Fortescue River (100 year ARI) floodplain. The locations of infrastructure are shown in Figure 1. The proposed waste dump lies along the western side of the lease area, which is inside the Fortescue River floodplain. As such, the waste dump will potentially impact the river flood levels adjacent to the site.

On the Central Orebody immediately to the north, the proposed waste dump also lies inside the Fortescue River floodplain. A number of studies have been carried out on the assessment of the waste dumps with respect to the 100 year ARI flood in the main Fortescue River, as follows:

- “Fortescue River Flood Study” (Aquaterra, March 2002)
- Letter Ref. 021b, Aquaterra - April 2005 (revised assessment)
- “Fortescue Iron Ore Project Surface Water Management Plan” (Report 012f, Aquaterra, April 2007)

These reports provided the predicted increase in flood levels adjacent to the Central Orebody waste dump.

3.2 LOCATION OF WASTE DUMP

The Balmoral South waste dump is shown on Figure 2 and occupies the western extent of Leases MO8/126 & 129. The north end of the dump is located near Du Boulay Creek. Initially the dump modelled was 1.8km long x 1.7km wide, but this was later revised to 3.1km long x 1.4km wide.

A number of creeks and intertwining tributaries flow through the proposed dump area. For modelling purposes, it was assumed that appropriate creek diversions were in place, as required.

3.3 FLOOD STUDY AND HEC-RAS MODEL

Background information comprised stream flow gauging data for the Fortescue River, aerial photography and published 1:50,000 topographical mapping. In addition, detailed survey cross sections of the river channel and floodplains were undertaken. The model for the previous Central Block studies utilised survey cross sections across the Fortescue River floodplain, being profiles RS1.5 RS2, RS3, RS4 and RS5 (Figure 1). A cross section RS1 was also developed at the coast to provide starting conditions.

Six additional cross-sections across the Fortescue River floodplain were obtained for the Balmoral South project being profiles RS70 to RS120. A total of 12 cross sections are therefore available for modelling purposes. These model cross sections are spaced about 2.5km apart on average and located from the river mouth to a point approximately 28km upstream.

A HEC-RAS computer model was used. This is a river backwater analysis model for open channel and floodplain flow with input data including flow cross sections, waterway roughness, discharge and starting water level. Waterway roughness values (Manning's n) were estimated from site observations, photographs (including aerial) and maps. A discharge rate of 9,570m³/s was adopted.

In running this model, two pre-development cases were considered for the Balmoral South Project:

- The natural river (i.e. assuming that waste dumps from the central block project were not installed)
- Waste dumps for the Central Block project already installed (thus effectively raising water levels just north of the Balmoral South project).

A post-development model was then run with the Balmoral South infrastructure included.

3.4 STARTING WATER LEVELS / STORM SURGE

Normal tidal variations cause inundation over the coastal flats. Mean spring tide levels vary from +/-1.8m, and mean neap tide levels from +/-0.5m, from mean sea level. The highest and lowest astronomical tides, which are the highest and lowest tidal levels which can be predicted to occur under average meteorological conditions, vary by approximately +/-2.5m from mean sea level. Under abnormal meteorological conditions, greater variations in the tidal range are possible.

The Pilbara coast cyclone season runs from December to April, peaking in February and March. Potentially the most destructive phenomenon associated with cyclones that make landfall, is the storm surge, a raised mound of seawater typically some 50km across, and up to several metres higher than the normal tide. The worst scenario arises when a severe cyclone crosses a coastline with a gently sloping seabed at or close to high tide. Actual sea levels are produced by the interaction of astronomical tides, storm surges and wave set-up.

On the 22 March 1999, Tropical Cyclone Vance, crossed the Pilbara coast near Exmouth, south-west of Cape Preston, and was one of the strongest cyclones ever to affect mainland Australia. The storm surge was about 3.6m at Exmouth, 4m at Onslow and >5m west of Onslow. Combined with a Highest Astronomical Tide (HAT) of RL2.43 m, the storm tide would have been RL7.5m.

A preliminary investigation was previously undertaken by Global Environmental Modelling Systems (GEMS). Modelling to simulate the effect of Cyclone Vance crossing the coast, at mid-tide (0.0m AHD), at the mouth of the Fortescue River, suggested storm surge flood levels of RL6.5m. This may translate to an inland flood level around RL7.0m AHD. If the cyclone coincided with a high tide, the storm surge flood level could increase to around RL8m.

The largest river floods in the Fortescue River and ocean storm surges at the mouth both occur as a result of tropical cyclone activity. However a cyclone related river flood would occur a number of days after the associated storm surge, due to the large size of the catchment, and a large storm surge occurring simultaneously with a river flood are not dependent. It is therefore not considered valid to use a "worst case" storm surge level as the starting water level together with (100 year ARI) river flood modelling in this case.

A starting downstream river water level of RL4m at the river mouth was adopted for the modelling based on observed debris levels. This is higher than the HAT and is therefore conservative.

3.5 MODEL RESULTS – PRE-DEVELOPMENT

The HEC-RAS model was run with the 100 year ARI flow, without the overlay of Balmoral South mine infrastructure. The estimated Fortescue River flood levels at the 8 cross sections between the north end of the project and the upper extent of the cross sections were:

- Fortescue River prior to Central Block waste dump being constructed - RL12.11m (junction with Du Boulay Creek at RS4), RL15.70m, RL20.06m, RL22.17m, RL25.90m, RL28.59m, RL32.32m and RL35.55m (furthest upstream cross section at RS120) as shown in Figure 1.
- Fortescue River with the Central Block waste dump constructed - RL12.47m, RL15.77m, RL20.06m, RL22.17m, RL25.90m, RL28.59m, RL32.32m and RL35.55m, as shown in Figure 1.

The results for the pre-development case with the Central Block waste dump included are shown in Appendix A.

At the north end of the Central Block waste dump, the floodplain is typically 8-9km wide. Heading upstream, the flow separates into individual flow paths (braids and anabranches), which combine and separate within the floodplain. Model cross sections show floodwaters flowing through several anabranches adjacent to the main Fortescue River. These reflect the various break-outs from Fortescue River as water spills over into adjacent creeks, with some flowing away from the Fortescue system and others rejoining again further downstream. For further details see Section 2.3 Fortescue River Break-Out.

The HEC-RAS results would be a conservative estimate of 100 year flood levels as the model forces all flow to be contained within the cross section when in reality water would spread out across the floodplain. In addition, the model does not account for the loss of volume that breaks out from the Fortescue River, as the actual extent of the break-out is uncertain.

Peak 100 year ARI flow depths in the main river channel are estimated to be 5m-6m adjacent to the project area, with average flow velocities around 2-3m/s. The estimated average flow velocity in the undeveloped flood plain is about 0.5-0.9m/s. The maximum floodplain velocities are likely to occur within small channels across the flood plain and to be in the order of 50% greater than average velocities.

The flood levels depend on model parameters assigned such as starting water levels, roughness coefficients, and peak flow rate. The section of the river of interest is non-tidal. Increasing the starting water level at the river mouth has no impact on levels near the project area.

The waterway roughness parameter (Manning's n) was varied \pm 20% to assess the sensitivity of the modelled water levels. Levels typically varied by \pm 0.2 to 0.4m in response to this roughness change.

The 100 year ARI flood flow was also varied \pm 20% to assess the sensitivity of the modelled water levels. Levels typically varied by \pm 0.2m to 0.4m in response to this flow change.

These variances should be considered for any design in the floodplain area in terms of freeboard.

3.6 MODEL RESULTS – POST-DEVELOPMENT

The proposed Balmoral South waste dump fully encroaches into the Fortescue River eastern floodplain. All other proposed mine infrastructure (e.g. power station, process plant, tailings storage facility, pit, etc) besides the borefield are located outside the 100 year ARI floodplain. Any encroachment onto the floodplain will restrict flow (in significant flood events) and cause water levels to rise upstream. The degree of encroachment into the floodplain may be effectively measured by the rise in flood levels adjacent to the site.

Existing channel bed levels at the north end of the dump are about RL5.8m (at profile RS4), with an estimated Central Block post-development 100 year ARI flood level of RL12.47m. This flood level estimate would not be affected with the development of the Balmoral South waste dump. Existing channel bed levels at the south end of the dump are about RL10.2m (at profile RS5), with an estimated post-development 100 year ARI flood level of RL16.07m. This is an estimated 0.30m increase in flood level due to the construction of the Balmoral South waste dump. Details of the HEC-RAS results are shown in Appendix B.

Thus the 100 year ARI flood water depths in the flow channels at the proposed Balmoral South waste dump are approximately 6.7m at the north end, and approximately 5.9m at the south end. Water depths over the overbank flow areas would be significantly less.

Adjacent to the proposed Balmoral South waste dump, peak 100 year ARI flood flow velocities in the main river channel are predicted to marginally increase by around 0.2m/s (14%) as a result of the dump construction. Average floodplain flow velocities are predicted to remain essentially unchanged.

The indicative potential peak storm surge level is RL8m, and is generally below the ground levels in the Balmoral South area.

SECTION 4 - WASTE DUMP

4.1 GENERAL

Waste will be generated in the mining process and moved to the waste dumps to be located west of the pit, within the mining lease. The waste dump will move along the pit as it develops and a number of haul roads are expected to be constructed on the western side of the pit to accommodate waste transport. The dump will be designed with 30m lifts with a 5m separating berm. Waste is expected to consist of material that is considered uneconomic for processing. Coarse tailings material from the magnetic separation process in the plant will also be incorporated into the waste dump. The height of the waste dump may be up to 80m.

The waste dump is shown on Figure 2 as 1.8km long x 1.7km wide (306ha) and occupies the western extent of Leases MO8/126 & 129. The revised position of the waste dump is also shown on Figure 2. Its location remains in the western side of Leases MO9/126 & 129 but is sized at 3.1km long x 1.4km wide (434ha).

4.2 WASTE MATERIAL

As a general rule, processing and storage of dangerous goods and substances should be sited away from flood-prone areas and be at least 500mm above a 100 year ARI floodplain (reference “Core Consultative Committee on Waste” and “Guidelines for Floodplain Management in Australia” (SCARM Technical Report Series)).

The “Core Consultative Committee on Waste” was established in WA in October 2002 due to stakeholder concerns regarding the management of hazardous waste. The committee facilitates a stakeholder involvement program to establish new and better hazardous waste treatment facilities in WA, within a broader framework of minimising hazardous waste generation and regulating hazardous waste more effectively; and advises the Waste Management Board on general waste management issues. Pyritic black shales, which give rise to acid mine drainage, were not found during extensive drilling on the site and are not evident in historic or current drilling of the Brockman Iron Formation. Pit waste is expected to be inert.

The Floodplain Management document aims to provide a set of best practice principles and guidelines for the management of the risks associated with flooding across the floodplains of Australia. The principles define the context of floodplain management and the guidelines develop the principles further and deal with practical issues that should be considered as part of the floodplain management process. Normally, floodplain management aims to retain natural drainage patterns as closely as possible, to allow the effective passage of floodwaters and the provision of sufficient floodplain storage areas to minimise flood risk upstream. As a principle, additional structures are placed in flood fringe areas, rather than floodway areas, to limit significant increases in either the height or velocity of the flood flow, and the impact on non-flood prone areas.

4.3 IMPACT ON FLOOD LEVELS

Hydraulic model predicts that the construction of the Balmoral South waste dump in the floodway area will locally increase the 100 year ARI flood levels and marginally increase flood widths within about 3km upstream of the waste dump. Minor changes to peak velocities in the main channel or floodway areas are expected. The proposed waste dump is estimated to increase the river 100 year ARI peak flood level adjacent to the site by up to 0.30m at the south end of the dump as compared to pre-development

conditions. In combination with the Central Block waste dump, the 100 year ARI peak flood level is predicted to increase by up to 0.37m as compared to pre-development conditions.

On the eastern side of the floodplain which abuts a high ridge, the impact of a flood level rise would be to marginally widen the Fortescue River floodplain further east against the higher ground.

The Mardie Station home stead is located 11km from the main Fortescue River channel and effectively lies outside the floodplain on the south-western side of the Fortescue River break-out.

On the western side, the edge of the floodplain is less well defined. In this area, the secondary flow channels are effectively break-out channels in that they eventually discharge to the ocean to the west of the main river mouth. It is thus possible that the flood level rises in the project area would be reduced somewhat, as additional flow is forced to the west and away from the main channel. It is not possible to quantify this effect.

At the north end of the Balmoral South waste dump, the cross section data (RS4) indicates that there would be widespread flooding across the floodplain, but with some western and intermediate areas of marginally higher ground. With construction of the Central Block waste dump, these low marginal areas would become marginally more prone to submergence. However, these flood levels would not be impacted from the construction of the Balmoral South waste dump once the Central Block dump is in place.

At the south end of the Balmoral South dump location, the cross section data (RS5) indicates widespread flooding across the floodplain. This area is only marginally impacted by the construction of the Central Block waste dump (100 year ARI increase of 0.07m) but construction of the Balmoral South waste dump would increase the water level by an estimated additional 0.30m. This rise in flood level could potentially cause more water to escape from the Fortescue River main channel and flow out north-west through the break-out channels. In the main Fortescue channel, water backwaters out from the Balmoral South waste dump such that water levels return to natural (pre-development) levels approximately 3km upstream from the south end of the dump.

4.4 BUNDING OF WASTE DUMP

The waste dump will remain as a permanent feature within the Fortescue River floodplain and as such is certain to be subject to extreme flood events. The dump will be enclosed in a bund, which effectively represents a levee within the river, behind which will contain and settle internal runoff before release onto the Fortescue River floodplain.

The bund will also protect the dump from external flood water attack. The minimum freeboard to the 100 year ARI flood in the main Fortescue River floodplain should be at least 1.5m. This freeboard allows for uncertainty in the flood level estimates, wave action, non-uniform flow patterns, plus minor settlement and erosion which may reduce the bund height.

4.5 RIVER ATTACK

The 100 year ARI average velocities in the floodplain are estimated at up to 0.9m/s, although velocities local to the bund may be up to twice this value depending on the local topographical features and local depth of flow.

Riprap (or rock armour) can be used to protect against scouring and erosion. The rock armour would be sourced from the coarser-sized mine overburden pre-strip. This material reduces water erosion by resisting hydraulic attack and dissipating the energy of flowing water or waves. The shape of rock is important, and coarse, angular rock (crushed or blasted) is more effective than round river rock. A correct mixture of aggregate size can also aid riprap's ability to create an interlocking structure.

Riprap is graded by size and a specified diameter (D50) will have fifty percent of the rock (by weight, W50) larger and fifty percent smaller. The velocity and direction of water flow is generally the determining factor for size of rock, as well as the embankment slope upon which it is laid – the steeper the slope, the less stable the material and the larger rock sizes required.

It is not considered necessary to armour an embankment against velocities of 1.5-2m/s. However, where flow patterns are altered appreciably, velocities will increase. At the south end of the dump, there will be a strong return flow towards the main channel, and local velocities will increase markedly (e.g. 2x). Appropriate armouring would be required at the corner of the dump to mitigate against erosion and scour holes.

At the north-west corner of the dump, eddies behind (i.e. north of) the dump will also warrant some additional protection near the corner. Upon final design for the waste dump, appropriate riprap will be selected.

For complete protection, the rock armour needs to be placed up to a freeboard of about 1.5m above the design flood, surge and wave attack levels.

4.6 WAVE ATTACK ON WASTE DUMP

It is unlikely that cyclonic winds, and broad scale flooding in the river, will coincide. The fetch will therefore be limited and it is anticipated that the wave height will remain low against the western side of the dump.

SECTION 5 - ASSESSMENT OF THE MINE SITE ACCOMMODATION VILLAGE

The proposed village site is 8km south of the plant site, and 7km west of North West Coastal Highway in the south-east corner of Lease Area MO8/130 as shown in Figure 1. It is understood that no detailed planning of the permanent village has been carried out.

The western edge of the village will lie within a few hundred metres of a significant anabranch channel of the Fortescue River. The village site gently slopes to the west towards the river. There are no significant water courses through the site, and only minor local drainage depressions or sheet runoff are anticipated. Drainage off the developed village site will be self contained and controlled to ensure no undue erosion and to guard against potential contamination of the creek to the south and the Fortescue River.

The proposed village area lies between profile RS100 and RS110, with an estimated 100 year ARI flood level of approximately RL30.8m. The ground level in the area of the village (south-east corner of Lease Area MO8/130) is approximately RL29.5m-32.5m. Therefore, the 100 year ARI flood level in the Fortescue River has the potential to inundate parts of the site nearer to the river, depending on the areal extent of the proposed site.

In addition, a significant creek (catchment ~ 45km², 100 year ARI flow 415m³/s) passes 800m south of the proposed village site before joining the Fortescue River. Flood levels from flooding in this creek cannot be ascertained at this stage, but are unlikely to impact the village at this distance.

On the basis of available information, it is concluded that the proposed village site is at risk from flooding in the Fortescue River, and as such will require bunding to protect against large floods.

SECTION 6 - FLOOD ASSESSMENT OF THE DU BOULAY CREEK FLOODPLAIN

6.1 GENERAL

All proposed mine infrastructure, except for the waste dump site, and borefield will be located outside the Fortescue River 100 year ARI floodplain. The proposed ROM pad, primary crusher, stockpiles, conveyor and the proposed process plant, all lie along the sides of Du Boulay Creek. As such, this infrastructure will potentially impact the creek flood levels adjacent to the site. The mine infrastructure is shown on Figure 2.

Du Boulay Creek flows in a north-westerly direction through the general project development area, and joins the Fortescue River approximately 6km from the coast. The creek has a catchment area of approximately 200km² at this point, with an estimated 100 year ARI flood flow of 1,400m³/s.

6.2 FLOOD STUDY AND HEC-RAS MODEL

Background information comprised stream flow gauging data, aerial photography and published 1:50,000 topographical mapping. In addition, detailed survey cross sections of the creek channel and floodplains were undertaken. Six cross sections across the Du Boulay Creek floodplain (profiles RS10 to RS60) were obtained for the Balmoral South project.

These cross sections are spaced about 750m apart and located from the creek junction with the Fortescue River to a point approximately 4km upstream. Waterway roughness values (Manning's n) were estimated from site observations, photographs (including aerial) and maps. A HEC-RAS hydraulic computer model was used for estimation of peak flood levels.

6.3 STARTING WATER LEVELS / STORM SURGE

Storm surge levels have no impact on Du Boulay Creek due to ground elevations. As a result of the size of the Fortescue River catchment, peak flooding in the Fortescue River and Du Boulay Creek will not coincide. As a "worst" case scenario, RL15.3m was used as the starting water level for the DuBoulay Creek model, and is therefore conservative. This level was the calculated 100 year ARI flood level in the Fortescue River after the construction of the Central Block waste dump and at a point between profiles RS4 and RS5. At this location, the ridge that separates the Fortescue River and Du Boulay Creek levels out into the general floodplain and floodwaters would be able to flow between the two channels.

6.4 MODEL RESULTS – PRE-DEVELOPMENT

The HEC-RAS model was run with the 100 year ARI flow. The estimated Du Boulay Creek flood levels at the 6 cross sections between the start and end chainages were RL15.3m (fixed starting water level at RS10, junction with Fortescue River), RL16.95m, RL18.35m, RL19.70m, RL21.25m and RL22.20m (furthest upstream cross section at RS60) as shown in Figure 2. The results are shown in Appendix C.

At the upstream end of the Du Boulay Creek model, the floodplain is estimated to be typically 1.5-2.0km wide. The floodplain then reduces to 0.5-1.0km wide as it passes between two small hills, before widening out again just upstream of its confluence with the Fortescue River.

Peak 100 year ARI flow depths in the main river channel are estimated to be 3-5m adjacent to the mine infrastructure, with average flow velocities around 0.7-1.3m/s. The estimated average flow velocity in the

undeveloped flood plain is about 0.5-1.0m/s. The maximum floodplain velocities are likely to occur within small channels across the flood plain and to be in the order of 50% greater than the average velocity.

The flood levels depend on model parameters assigned such as starting water levels, roughness coefficients, and peak flow rate. A water level of RL15.3m was used as a worse case scenario. However, the model is relatively insensitive to realistic variations to this level, and such changes have no impact on water levels at the proposed plant infrastructure.

The waterway roughness parameter (Manning's n) was varied \pm 20% to assess the sensitivity of the modelled water levels. Levels typically varied by \pm 0.2 to 0.3m in response to this roughness change. This variance should be considered for any design in the flood plain area in terms of freeboard.

The 100 year ARI flood flow was also varied \pm 20% to assess the sensitivity of the modelled water levels. Levels typically varied by \pm 0.2m to 0.3m in response to this flow change.

These variances should be considered for any design in the floodplain area in terms of freeboard.

6.5 MODEL RESULTS – POST-DEVELOPMENT

The creek's peak surface water level during the 100 year ARI event is greater than 1,500m wide in the vicinity of the plant area, before construction of the plant site. Therefore, parts of the proposed plant (indicative infrastructure layout only) are encompassed within the Du Boulay floodplain, as follows:

- The location of the proposed process plant is suitable provided the plant site is bunded or built up above the 100 year ARI flood level plus a freeboard
- The proposed stockpile area encroaches into the Du Boulay Creek floodplain and should ideally be moved from its current location near a main channel to higher ground to the north, either back into the hill, or into the flood fringe area of the floodplain where it can be bunded off or raised above the flood level on a pad.
- The conveyor system crosses the Du Boulay Creek floodplain and would need to withstand 100 year ARI floodwater depths and velocities.
- The ROM pad and the proposed primary crushing area currently lie across a main Du Boulay Creek channel. The ROM pad together with the crusher should ideally be moved west towards the hill, and either set on a pad above the 100 year ARI flood levels, or bunded off from the creek.
- The power station lies outside of the floodplain

A post-development HEC-RAS model was run with bunds around the proposed pit and plant site, as shown in Figure 2. By bunding off a proportion of the floodplain adjacent to the proposed pit and plant site, flow is restricted in large flood events and causes water levels to rise.

Downstream of the plant site at cross section RS20, existing channel bed levels are about RL11.5m. The predicted post-development 100 year ARI flood level reaches RL17.05m, representing a 0.1m increase from pre-development water levels and creating a peak water depth of 5.6m. At this cross section, peak channel velocities are predicted to increase from 1.8m/s to 2.1m/s due to the constriction by the pit bunds.

At cross section RS30, 100 year ARI water levels are predicted to increase by about 0.65m to RL19.0m. Flow through the confinement increases peak channel velocities, from 1.2m/s to 1.6m/s. Increases in localised velocities may be even greater.

At cross sections RS40 and RS50, a large proportion of the floodplain area is bunded off and 100 year ARI flow is constricted to almost half the pre-development surface width. It is at these locations that water levels increase the most significantly. An estimated increase of 1.0m and 1.05m occurs in the 100 year ARI flood levels at RS40 and RS50 respectively after the construction of the bunds around the plant site. Water depths in the main channel reach a maximum of about 5.8m at RS40, where the conveyor system crosses the Du Boulay Creek floodplain. However, the model shows that 100 year ARI peak channel velocities in this area should decrease slightly to 0.5-1.0m/s. This reduction is due to the increased flow depths causing flow areas to increase. However, the location of the bunds creates a meandering flow path and an increased potential for locally higher velocities and scouring.

At the upstream end of the plant site (RS60), existing channel bed levels are about RL19.4m. With an estimated post-development 100 year ARI flood level of RL22.65m, peak water levels are therefore about 3.25m deep and represent an increase of 0.45m compared to pre-development levels. Peak flow velocities in this area also decrease.

Details of the HEC-RAS results are shown in Appendix D.

SECTION 7 - SITE INFRASTRUCTURE

7.1 PLANT SITE

The process and power station site is a nominal area set around Du Boulay Creek and protected by bunding as shown in Figure 2. The plant site includes the process plant, power station, ROM pad, stockpile and crushing. The site slopes down to the creek on each side at (flat) grades of typically 0.5%. Parts of the plant site encroach into the 100 year ARI floodplain.

Away from water courses, surface water runoff in the development area will be predominately by sheet runoff. This will cause a localised increase in flow velocities around any mine infrastructure as water is concentrated in diversion channels, or alongside flood bunds or raised pads. This flow will be handled by the stormwater provisions for drainage off the developed areas.

The generally low slopes on the site, coupled with the defined flow paths through the site, indicate that effective site drainage can be readily achieved. Runoff from the plant areas will be controlled to ensure it does not cause undue erosion and to guard against potential contamination of watercourses.

7.2 TAILINGS STORAGE FACILITY

The tailings storage facility (TSF) is shown on Figure 1 and occupies the eastern extent of Lease MO8/130 away from the major watercourses. The TSF is located on land gently sloping towards the Fortescue River. Small watercourses are located near the perimeters of the TSF site, and minor diversions for these watercourses will be required. Additionally, diversion of sheet flows around the eastern boundary of the TSF may be required.

The proposed freeboard is to be in accordance with the 1998 Department of Minerals and Energy (DOIR) guidelines. For a TSF with a water pond normally located away from perimeter embankments, the freeboard provided against the risk of overtopping the embankments should be 500mm above the pond level after the design 1:100 year 72 hour duration rainfall event rain event (assuming no decant is operational) while the minimum freeboard to beach level is 300mm.

The consequences of TSF embankment failure by overtopping, particularly considering the location of the proposed accommodation village, are possible loss of life, direct economic loss and indirect loss due to the damage to the TSF. An emergency spillway is therefore proposed that would allow rainfall from a more extreme long return period cyclonic event to be discharged from the TSF into the Fortescue River.

The level of the emergency spillway would be maintained at the design minimum TSF embankment crest level but below the constructed TSF embankment crest level. The released water would have very low levels of contaminants and a low silt load. The excess water contained in the storage would be returned to the plant and used as make-up water. This, combined with the high evaporation rates, would bring the decant pond back to a more normal level.

Bunding will be required around the TSF to contain internal, potentially sediment laden runoff from the embankment batters. Excess runoff will be treated by sediment traps prior to discharging to the environment.

7.3 OPEN PIT AREAS

The proposed open pit area is located between Du Boulay Creek and the Fortescue River at the north end of a domed hill with a top elevation of RL38m. There are a number of small ephemeral creeks, which drain the hill and which will be disturbed by the open pit. The mine perimeter is all located on down slopes, and therefore all creek drainage is away from the open pit. If the pit at all stages is centred on the top of the hill, there will be no requirement for external surface water management from the ridge area.

However, the pit is proposed to extend over the Fortescue River and Du Boulay Creek floodplains with flood protection provided by the waste dump to the west linked to a flood bund to the north and east (Figure 2). These flood protection works will be constructed to provide a minimum 2.0m freeboard above the predicted 100 year ARI flood levels. As discussed for the waste dumps, riprap will be placed against the flood bunding for erosion protection, in susceptible areas.

7.4 ACCESS ROADS

Access roads will be constructed with a camber to drain water off the road surface. Table drains constructed alongside the road would collect and drain this water away. Approximately every 100m, the table drains would be turned out and discharged into the natural surrounds. Generally no sediment traps are required at these discharge points due to the small upstream catchment areas. This approach of discharging stormwater close to the source is consistent with water sensitive design principles.

7.5 BOREFIELDS

The project water supply borefield is proposed to be located on the western flank of the Fortescue River, upstream from the project area, as indicated in Figure 1. Some of this borefield area would be susceptible to inundation during a 100 year ARI flood event. Where practical, production bores would be installed outside of the flood prone areas, however some bores would be installed in flood prone areas. Inundation could be up to 2m depth during the 100 year ARI event, though peak flow velocities would typically be low at less than 1m/s.

In flood prone areas, the bore headworks and control panels would be installed above the design flood level. This would typically be achieved by constructing an earthpad at the bore site upon which to install the headworks and control panel. In all areas, the bore headworks and control panels would be mounted above ground level to provide protection from localised runoff.

SECTION 8 - SURFACE WATER MANAGEMENT PLAN: FLOOD DIVERSION WORKS

8.1 GENERAL

Surface water diversion results from interruption to existing surface water flow patterns. It requires a combination of bunding and excavated channels to carry flood waters via a flow path different from the natural water course. The diverted water is directed into a defined water course which may be the original water course at a point downstream, or another water course. The latter situation is less desirable and should be avoided if possible – it is possible that the water course would have limited capacity, insufficient to carry the now concentrated, diverted flows. Energy should be removed from the flow at the entry point e.g. a rip rap (rockfill) lining to match the channel shape.

8.2 TAILINGS DAM DIVERSION

The proposed TSF site occupies ground gently sloping towards the Fortescue River with no major watercourses interrupted. Diversion requirements around the TSF will be minimal.

8.3 DIVERSION AT THE WASTE DUMP

The waste dump is located in the Fortescue River floodplain between the higher ground (ore body) and the western lease boundary (Lease M08/126 & 127). The main Fortescue River channel is located to the west of this boundary. The proposed area contains various intertwining anabranches of the river, which will be covered by the waste dump. A diversion channel will be required at the southern upstream edge of the waste dump to transport any trapped water back towards the main river channel. The capacity of the diversion would depend somewhat on the floodplain levels at that location. It is envisaged that some ponding will be acceptable, but a lower capacity channel would direct low flows back towards the main channel.

8.4 DIVERSION AT THE OPEN PIT

The proposed open pit area is located between Du Boulay Creek and the Fortescue River. Several ephemeral streams will be disturbed by pit construction, but the pit perimeter is located on down slopes and therefore all creek drainage from the ridge is away from the pit. Flooding of the pit from the Fortescue River is intercepted by the Balmoral South waste dump to the pit's west. However, diversion of a Du Boulay Creek flow channel to the east of the pit would be required. Bunds would be constructed from the waste dump and continue around the north-east section of the pit perimeter, as shown in Figure 2. These diversion bunds would be constructed to provide a minimum 2.0m freeboard above the predicted 100 year ARI flood levels to prevent flooding of the pit.

8.5 DIVERSION CHANNELS

Diversion channels may be required at locations within the project area. The construction of the diversion channel would be determined by the terrain (longitudinal profile) and practical construction considerations, and the design flow chosen. Diversion channels need not have sufficient capacity to carry the full 100 year ARI flood event. The design capacity depends on the impacts of flooding. If flood flow in areas normally free of flooding may have potentially adverse impacts on other mine infrastructure or the environment, then diverted water needs to remain confined within its diversion channel (capacity 100 year ARI capacity).

The nominal design flow would be generally smaller (e.g. 2 or 5 year ARI capacity) to minimise earthworks and cost; and as such, low probability / high flow events would be partly carried in the excavated channel and partly as surface flow outside the channel.

Protection and armouring may be required if the diversion channel runs alongside other mine infrastructure e.g. a TSF embankment.

Earth bunding would typically consist of a minimum 3m wide crest with side batters of 1:3, and be built to an engineering specification using competent materials. Excavated open diversion channels would typically have side batters of 1:2.5. Flow paths formed by the construction of an earth bund will take on the cross section of the existing ground.

SECTION 9 - EROSION AND RUNOFF

9.1 GENERAL PRINCIPLES

The general objectives with regards to surface water are to:

- Maintain the integrity, functions and environmental values of watercourses and sheet flow; and
- Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected.

9.2 GENERAL SURFACE WATER IMPACTS

The Pilbara landscape is subject to extreme climatic events such as high rainfall intensities and storms associated with cyclonic activity. The risk of erosion and sedimentation can therefore be high, particularly on disturbed or degraded lands. As such the engineering design of the project will incorporate site-specific surface water controls including diversion and dispersion mechanisms, and erosion and sedimentation controls. Areas of major erosion hazard will be identified and avoided where practicable, or specific management measures implemented to reduce the erosion risk.

Potential surface water impacts include:

- Interruption to the existing surface water flow patterns.
- Reduction of surface water runoff volume and quality in the downstream environment.
- Impact on downstream vegetation communities that may be dependent on this drainage.
- Discharge of various chemicals, including hydrocarbons from the construction camp and accommodation village, sewage treatment plant, mine workshop, Tailings Storage Facility (TSF), etc.
- Impacts from haul roads and other infrastructure.

The following general strategies will be noted and implemented to minimise surface water impacts from the Project:

- Where feasible, upstream surface water flows will be diverted around structures with appropriate grades into adjacent or downstream defined surface water flow pathways.
- Construction on or near natural flow paths will be planned for the dry season where practicable. Temporary stabilisation measures will be used in high erosion risk zones.
- Where ecosystem sensitive sheet flow zones are located immediately downstream, diverted surface water will be discharged over spreader mechanisms to encourage the flows to slow and disperse. Where appropriate, riprap pads will be provided to slow and redistribute runoff.
- Surface water runoff from disturbed areas, waste dumps and stockpiles will typically be sediment laden and require treatment in sediment traps, prior to discharging to the downstream environment. Such areas will be bunded, as appropriate to contain surface water runoff for treatment prior to discharge to the external environment. Disturbance will be kept to the minimum to achieve the design function and necessary for safe working conditions. Vehicle movements will be kept to the minimum necessary, and existing tracks used where possible.
- Sediment or silt traps to control erosion and the deposition of sediment downstream, are generally more effective when they are located close to the source of sediment and the sediment laden water is not

allowed to mix with the “clean water”, so as to reduce the volume of water to be treated. The sedimentation basins will be sized appropriately for the rainfall events.

- Haul roads and other infrastructure that interrupt surface water flows will ensure major flow paths are not disrupted and runoff is kept local. Larger access tracks / roads may require culverts for the creek crossings.

9.3 SURFACE WATER IMPACTS – DURING CONSTRUCTION

The risk of erosion and sedimentation due to surface runoff is high, particularly on disturbed or degraded land. There is potential for the water quality of water courses downstream of the proposed infrastructure to deteriorate, if safeguard measures are not put in place. These sediments can reduce the capacity of water courses and impact water course ecology. The construction phase will be planned for the dry season where practicable and temporary stabilisation measures will be used in high erosion risk zones.

Soil erosion and sedimentation control measures will be applied where practical during construction activities such as clearing, drainage works, and removal and storage of topsoil and earthworks. Disturbance will be kept to the minimum to achieve the design function and necessary for safe working conditions. Areas of major erosion hazard will be identified and avoided where practicable, or specific management measures implemented to reduce the erosion risk.

The techniques and criteria which would be applied during construction operations will include:

- Clearing: Vegetation is the most effective method of minimising erosion and sedimentation. Initial clearing will be limited to areas of workable size actively being used for construction.
- Buffer Zones: Adequate buffer zones will be provided between the areas of disturbance and natural drainage lines where possible. These buffer zones will place a high priority on the protection of natural drainage lines from impacts resulting from construction activities.
- Drainage and Flooding: Flows from undisturbed areas should be separated from disturbed areas.
- Erosion and Sediment Controls: Use temporary erosion and sediment control structures such as diversion banks, drains, and sediment traps.
- Pollution Control: Potentially polluted runoff to drain to ponds fitted with outflow baffles, to prevent the discharge of oil and grease products.
- Topsoil Stockpiles: Stripping and storage of topsoil, protected by temporary vegetation or mulching, and be protected by diversion banks / catch drains from external surface flows and sediment damage, located away from drainage lines and upstream of sediment basins.

9.4 SURFACE WATER IMPACTS – DURING OPERATIONS

Surface runoff will typically be sediment laden but pollutant loads in water courses downstream of mine operations may also include oil and grease.

Waste dumps have the potential to discharge sediment laden water to the environment. Waste dump areas will be bunded, as appropriate to contain surface water runoff for treatment prior to discharge to the external

environment. Depending on the nature of the material, the waste dump area may be dished in the centre to be internally draining, thus reducing runoff and the potential for erosion down the face. If constructed in this manner, the collected runoff water on the top surface will dissipate by evaporation and seepage.

Stockpiles also have the potential to discharge sediment laden water to the environment and will be bunded, as appropriate, to contain surface water runoff for treatment prior to discharge.

Surface runoff from haul roads will be kept local to minimise downstream impact, and larger access tracks / roads may require culverts for the creek crossings.

Away from the main creek channels, surface water runoff in the development areas will be partially by sheet runoff. This will cause a localised increase in flow velocities around any mine infrastructure as water is concentrated in diversion channels, or alongside flood bunds or raised pads. This flow will be handled by the stormwater provisions for drainage off developed areas.

Where ecosystem sensitive flow zones are located immediately downstream, diverted surface water will be discharged to encourage the flows to rejoin the existing flow paths. Where appropriate, riprap pads will be provided to slow and redistribute runoff.

9.5 SEDIMENT TRAPS

Key issues associated with the surface water runoff are erosion and sediment control, particularly during initial pre-stripping and clearing for the dumps and pits. Sediment dams and erosion control structures will be constructed down slope of all waste dumps and pits (as appropriate) to manage these issues.

Local runoff will be collected and treated to remove sediments to acceptable levels prior to release to the natural environment. Bunds and drainage diversion works will be constructed around the perimeter of all infrastructure areas. These will be designed to effectively divert and prevent natural runoff waters originating outside the development sites from mixing with internal site runoff.

Concerns relating to the mine water management system focus on containment of runoff from the mining and waste dump areas and the potential effects on external surface water environment.

Sediment traps would be located at the low point and be constructed by forming earth bunds. Storage volume consists of the permanent pool settling zone and sediment storage zone. The trap size is calculated to match the settling velocity of the target sediment size with the design flow. For design of the sediment traps, a target of medium sized silt particles $> 0.02\text{mm}$ ($20\mu\text{m}$) will be adopted for the 10 year ARI 6hr design rainfall event. Hence, for the design event, the sediment trap is expected to be effective in removing sand and medium to coarse silt. However, the removal of fine silt and clay with sediment traps is generally not as effective.

For mine sites, the outlet structure will generally consist of a spillway only (no 'control' outlet such as an overflow pit / pipe system is generally provided). Thus smaller flow events would be fully contained within the trap, such that no sediment would be released downstream. Larger events up to the design storm would pass through the trap and over a 100 year ARI capacity spillway. Flow events larger than the design event

would still be treated by the trap prior to discharging downstream. During these large events, although the trap would have a lower trapping efficient, there is also a larger volume of water so the dilution of the silt would be greater.

After a storm event, the water in the trap would slowly infiltrate and evaporate until the trap was empty. Alternatively, water could be pumped from the trap following significant storm events. Prior to the commencement of the wet season, the sediment traps will be cleaned out. A ramp into the trap would be constructed so that sediment removal could be by front end loader (or similar). The sediments removed from the trap would be contained in an area such that the sediments would not be transported in the next storm event back into the sediment trap or to the downstream environment.

9.6 MINE WASTE DUMP

Waste dumps have the potential to discharge sediment laden water to the environment. Du Boulay Creek runs to the east of the proposed dump and currently collects water off the higher terrain to the east and west (i.e. the proposed pit and dump sites). A creek to the east of the proposed dump site carries drainage north and parallel to the dump on the eastern side before flowing into Du Boulay Creek.

The risk of erosion and sedimentation from the waste dumps is high, and the stability of these dumps and their response to water on slope length is an important factor in characterising their physical safety. The waste dump area may be dished in the centre, to dissipate runoff by evaporation and seepage, and to reduce runoff and erosion down the face. To minimise erosion on the outer faces of the waste dump, appropriate battering of the face and contour drains to provide effective water management will benefit vegetative growth. A berm should be installed between all changes of slope to minimise sheet water flows.

Waste dump areas will be bunded, as appropriate to contain internal surface water runoff for treatment prior to discharge to nearby water courses and the Fortescue River floodplain, and to protect the dump from external river and wave attack. Around the perimeter bunding, the formation of vegetation provides the best long term protection against erosion, river and wave attack in conjunction with appropriate armouring at key points.

SECTION 10 - CONCLUSIONS AND RECOMMENDATIONS

The proposed Balmoral South mine site is adjacent to the lower reaches of the Fortescue River and about 15km from the river mouth to the Indian Ocean. This report presents the results of investigations and assessments completed to date on surface water aspects of the Balmoral South project.

A detailed flood study of the Lower Fortescue River and Du Boulay Creek was undertaken using the HEC-RAS hydraulic backwater model. The Balmoral South waste dump is located in the Fortescue River 100 year floodplain and is estimated to increase the peak river flood levels adjacent to the site by up to 0.3m at the upstream end. The waste dump will be bunded to contain internal surface water runoff for treatment prior to discharge to the external environment, and to protect the dump from external river and wave attack. Diversion works may be required on the southern and eastern sides of the dump. Appropriate armouring would also need to be considered.

The Du Boulay Creek flows through the plant site. The proposed stockpile area, conveyor system, ROM pad and primary crushing area encroach into the 100 year ARI floodplain but will be protected by bunding. The proposed bunds restrict flow through the Du Boulay Creek in large flood events and cause water levels to rise. Modelling predicts the most significant impact on water levels would occur adjacent to the plant area where peak 100 year ARI flood levels increase by about 1.0m after construction of the plant site bunds.

It is likely that parts of the proposed village site are at risk from flooding from the Fortescue River. The 100 year ARI flood level has the potential to inundate parts of the village site nearer to the river, depending on the areal extent of the proposed site, and as such may require bunding to protect against large floods.

Most of the TSF occupies ground gently sloping towards the Fortescue River and no major watercourses are interrupted. Therefore, significant flood diversion works are not expected. However, the facility will require external bunding to capture runoff from the external batters. Excess runoff will be treated via sediment traps prior to discharge to the environment.

The proposed location of the water supply borefield is to the west of the Fortescue River, parts of which would be susceptible to inundation during a 100 year ARI flood event. To protect the headworks and control panels, production bores should be installed outside the Fortescue River flood prone areas or constructed on elevated earthpads.

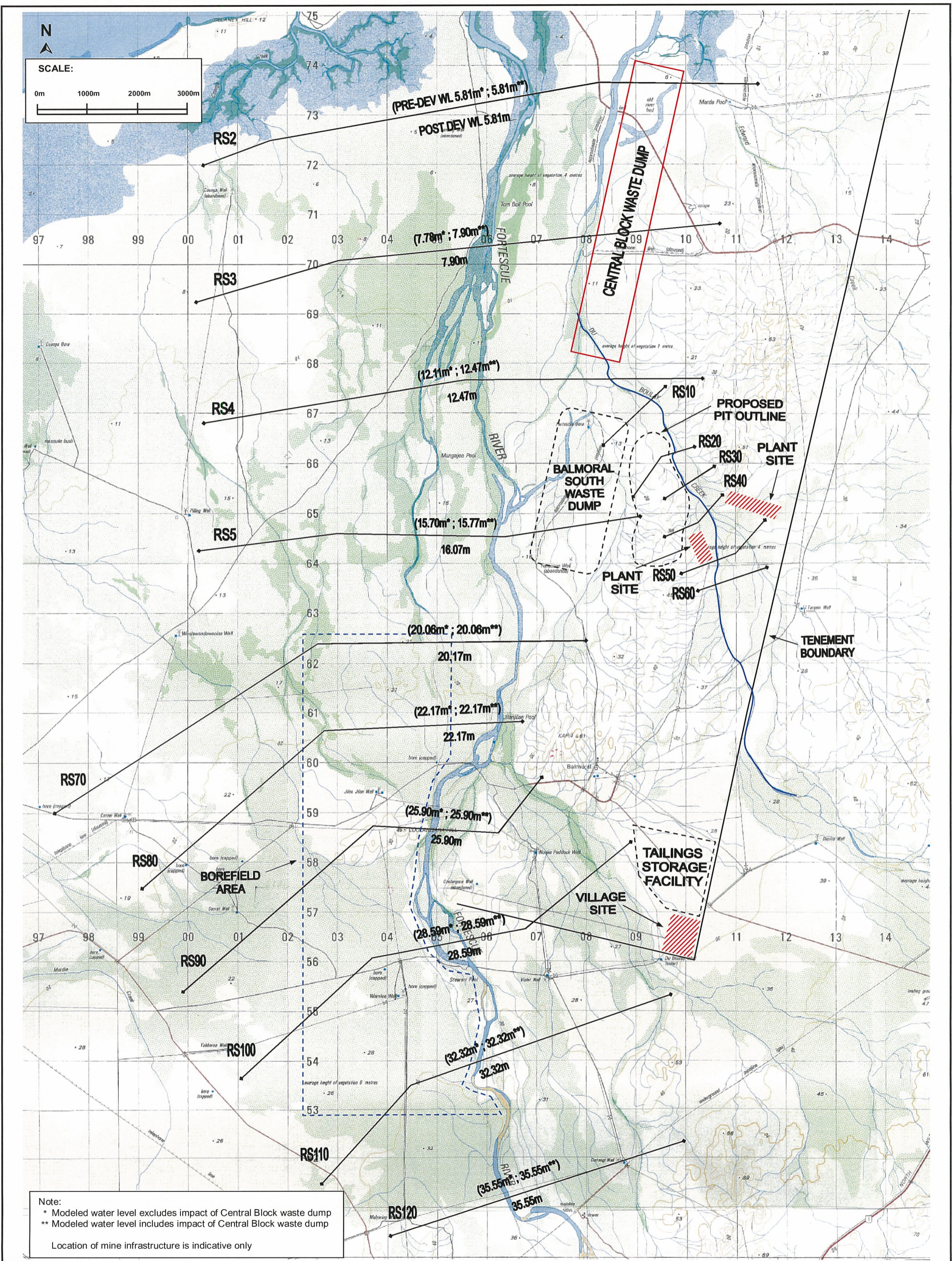
The proposed pit perimeter is located on down slopes and therefore surface water drainage will generally be away from the open pit. However, the northern portion of the pit is proposed to extend over the Fortescue River and Du Boulay Creek floodplains and flood protection bunding would be required. This bunding would link to the waste dump in the west, extend around the north and east areas of the pit perimeter and link into the proposed plant site bunding.

The general objectives with regards to surface water, erosion and runoff include the maintenance of the integrity, functions and environmental values of watercourses and sheet flow, and to maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected. As such the engineering design of the Balmoral South project will incorporate site-specific surface water controls including diversion and dispersion mechanisms, and erosion and sedimentation controls.

CONCLUSIONS AND RECOMMENDATIONS

Areas of major surface water flow and/or quality change will be identified and avoided where practicable, or specific management measures implemented to minimise its risk.

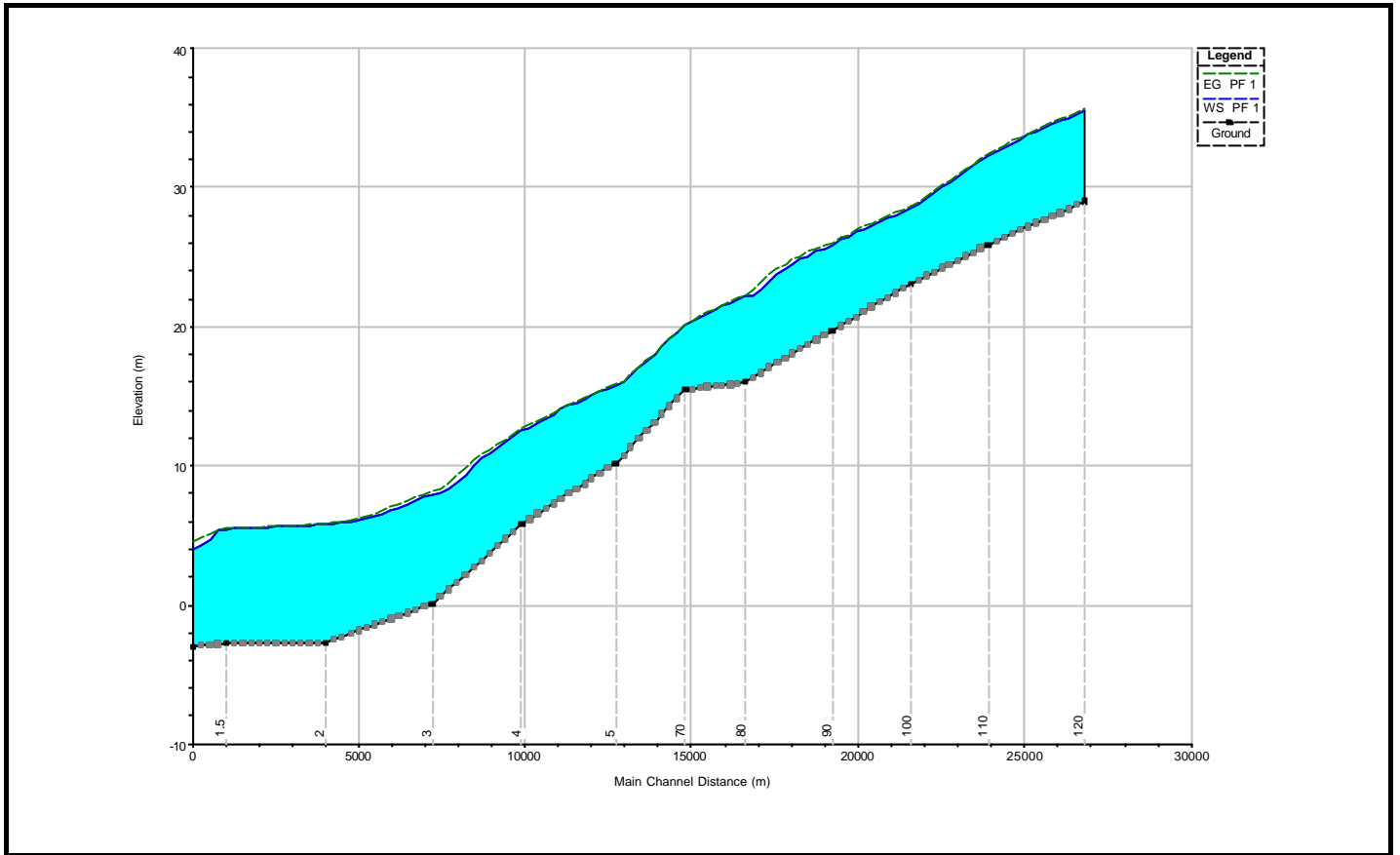
FIGURES



APPENDIX A

HEC-RAS MODELLING: FORTESCUE RIVER PRE-DEVELOPMENT MODEL

Fortescue River Pre-Development Model Water Level Profile

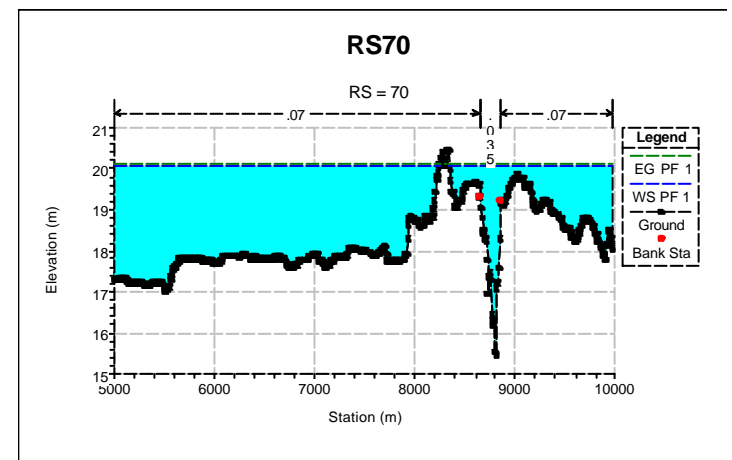
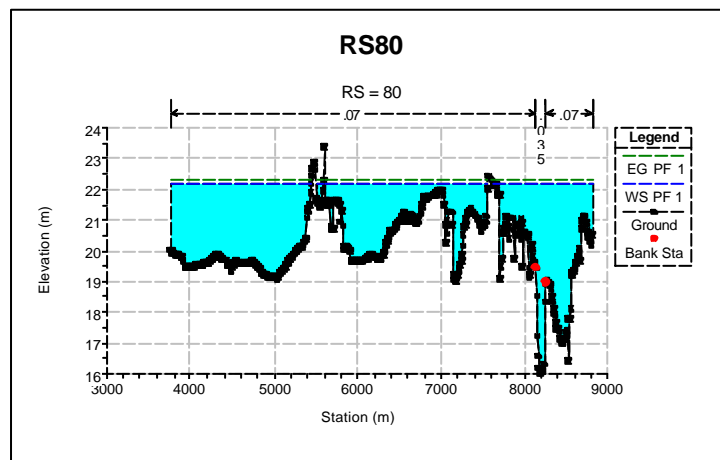
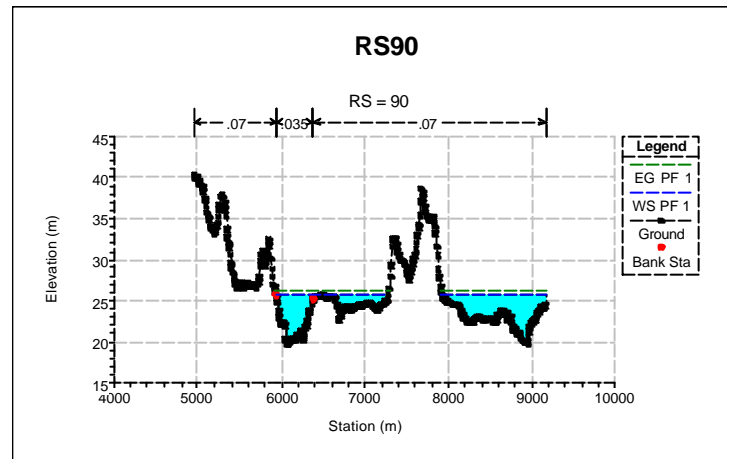
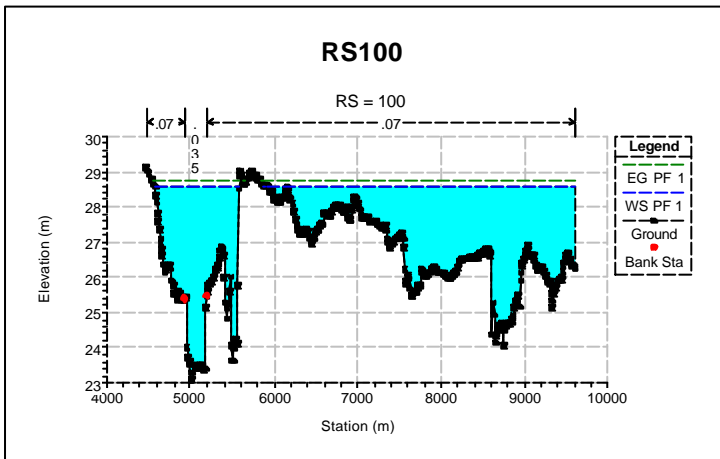
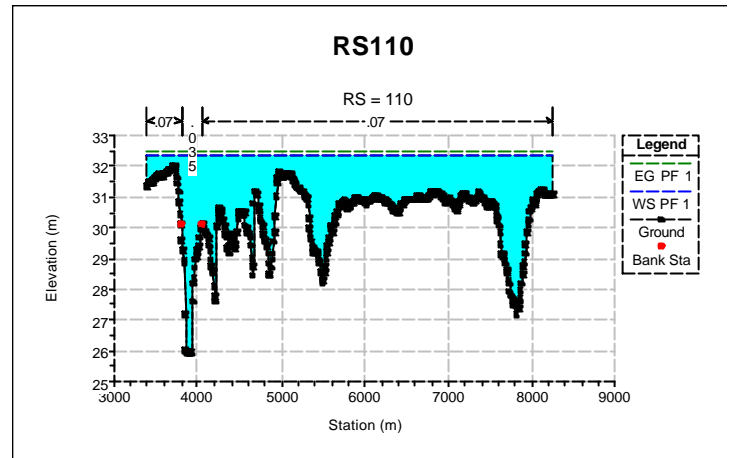
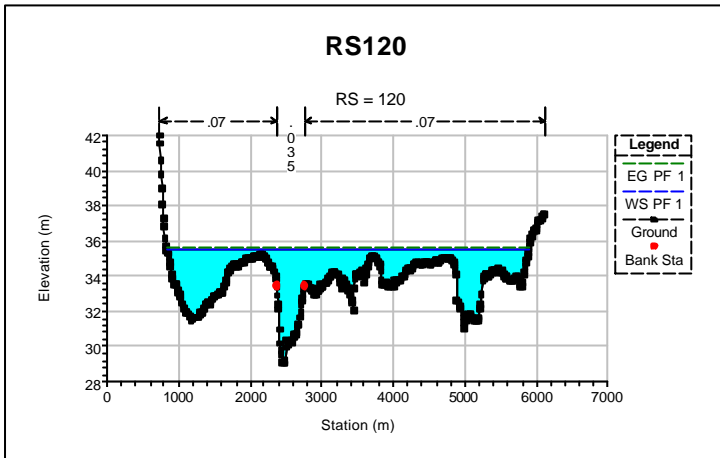


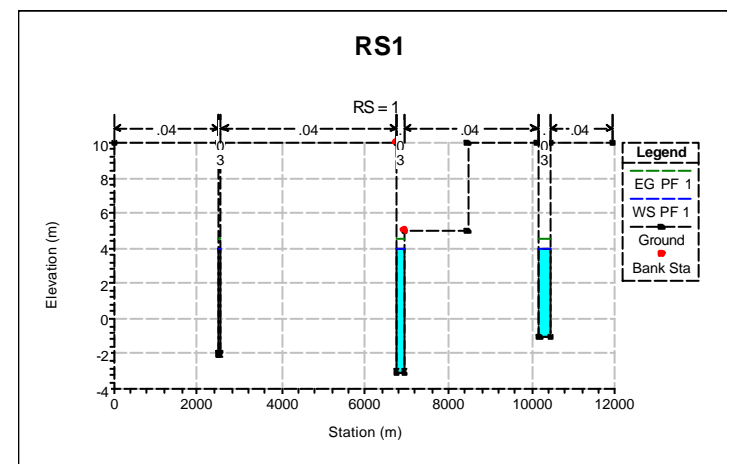
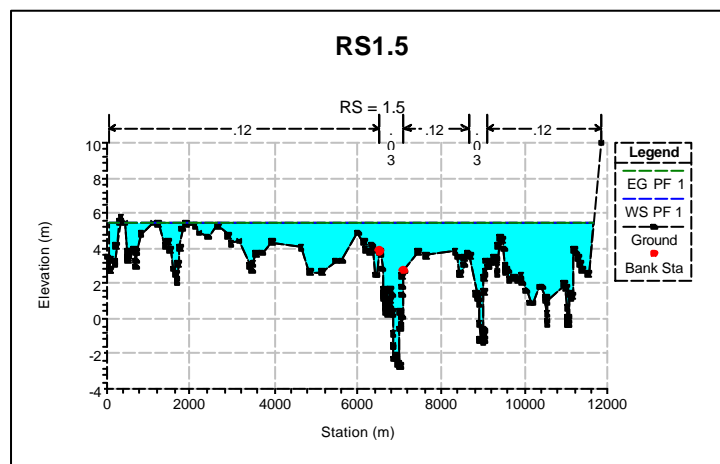
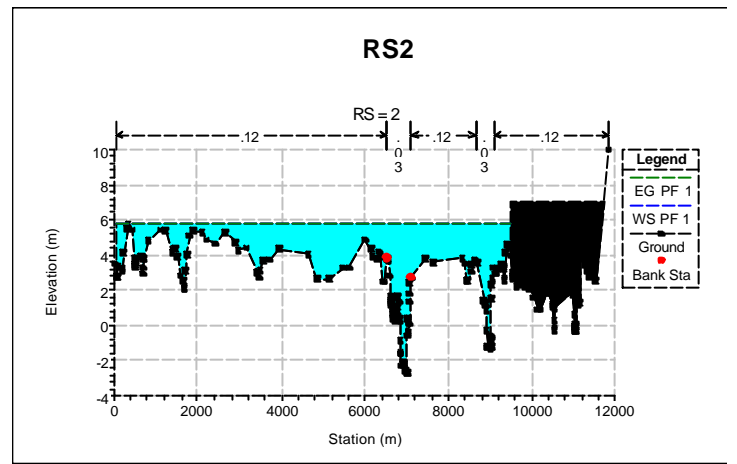
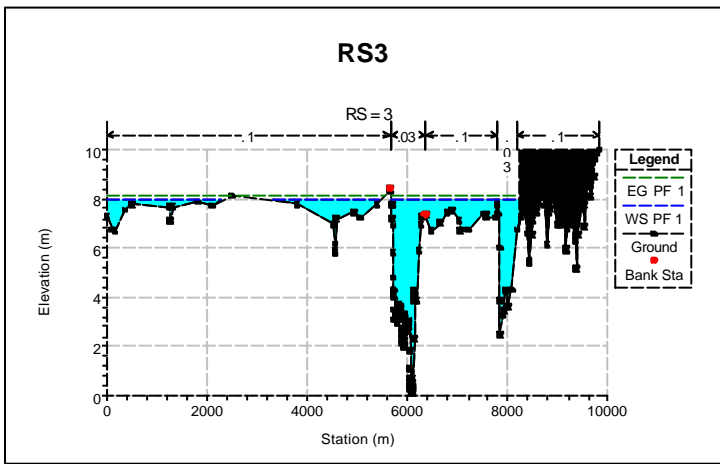
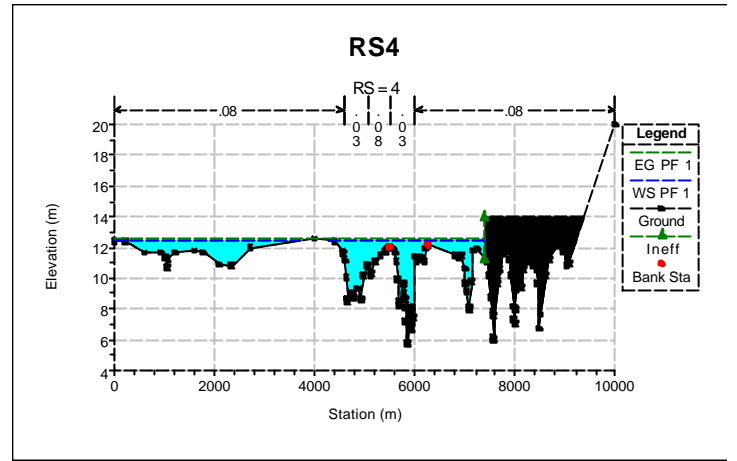
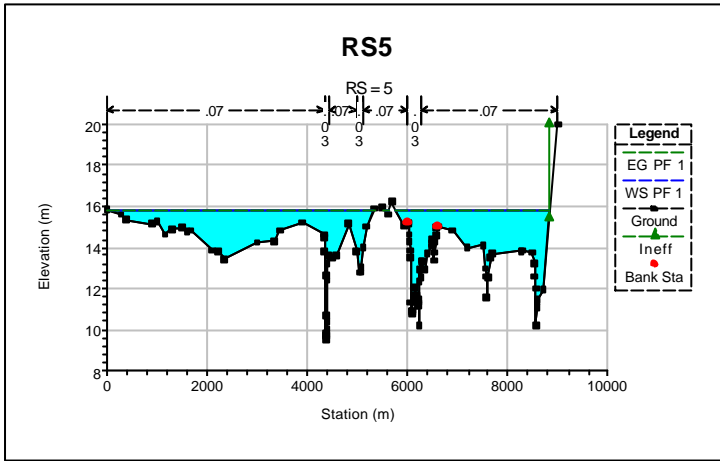
Fortescue River Pre-Development Model Summary Table

RS	Chainage (m)	Q Total (m ³ /s)	Min Ch Elev (mRL)	W.S. Elev (mRL)	Crit W.S. (mRL)	E.G. Elev (mRL)	E.G. Slope (m/m)	Ch Vel (m/s)	Overflow Vel (m/s)	Flow Area (m ²)	Top Width (m)	Channel Froude #
120	26789	9567	29.02	35.55		35.70	0.000913	2.41	0.64	10033	5063	0.36
110	23904	9567	25.93	32.32		32.45	0.001288	2.68	0.61	9524	4850	0.42
100	21581	9567	23.10	28.59		28.72	0.000991	2.55	0.75	10024	4685	0.37
90	19220	9567	19.76	25.90		26.11	0.001329	2.66	0.54	6658	2592	0.42
80	16597	9567	16.05	22.17		22.28	0.001068	2.84	0.88	10329	4919	0.39
70	14798	9567	15.44	20.06		20.14	0.001741	2.23	0.84	9304	4879	0.44
5 ⁽¹⁾	12700	9567	10.21	15.77	14.66	15.82	0.000862	1.61	0.64	12562	8406	0.31
4 ⁽¹⁾	9900	9567	5.79	12.47	11.50	12.62	0.001290	2.31	0.75	7745	6843	0.47
3 ⁽¹⁾	7200	9567	0.08	7.90		8.12	0.000780	2.34	0.68	6739	6935	0.37
2 ⁽¹⁾	4000	9567	-2.75	5.81		5.85	0.000187	1.43	0.34	20538	9472	0.19
1.5 ⁽¹⁾	1000	9567	-2.75	5.42		5.46	0.000179	1.34	0.25	24264	11446	0.19
1 ⁽¹⁾	0	9567	-3.00	4	1.71	4.56	0.000965	3.62	2.92	2942	523	0.45

⁽¹⁾ Cross sections from central block studies in Fortescue Iron Ore Project Surface Water Management Plan (Report 012e, Aquaterra, April 2007)

Fortescue River Pre-Development Model Cross Sections (Looking Downstream)

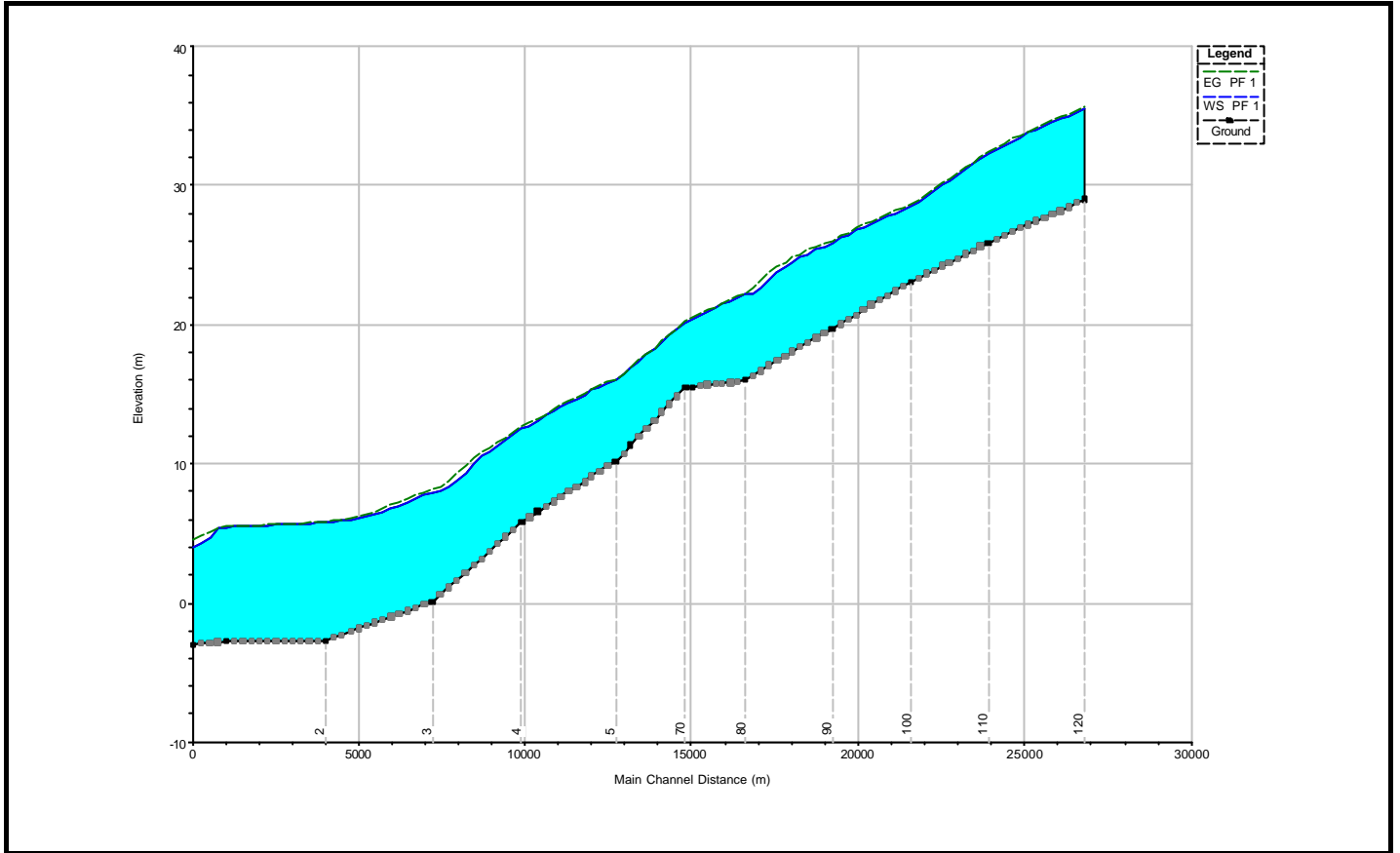




APPENDIX B

HEC-RAS MODELLING: FORTESCUE RIVER POST DEVELOPMENT MODEL

Fortescue River Post-Development Model Water Level Profile

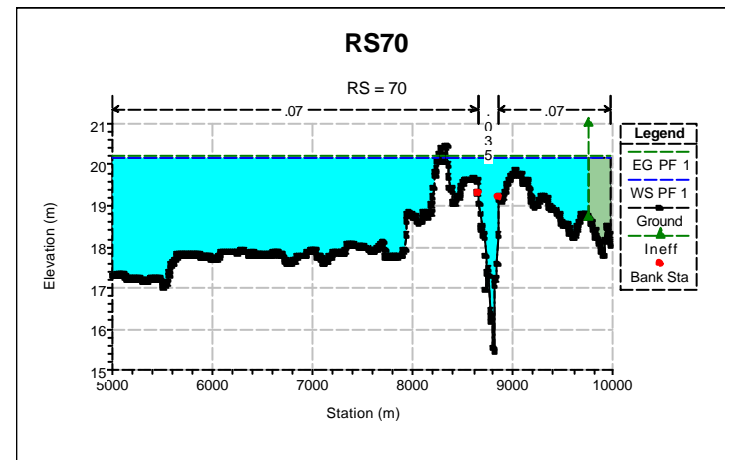
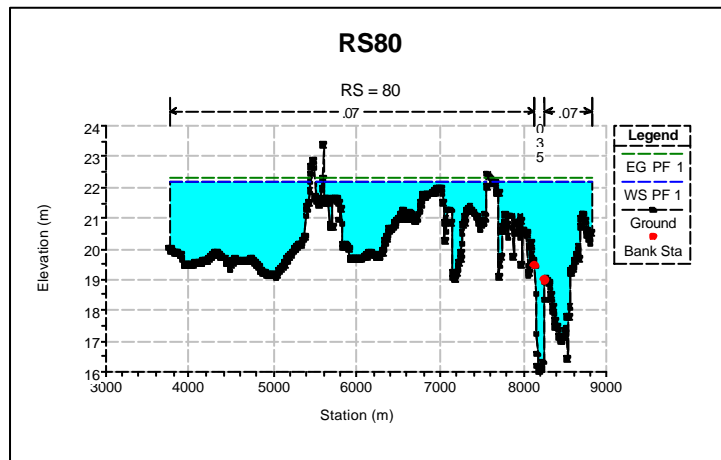
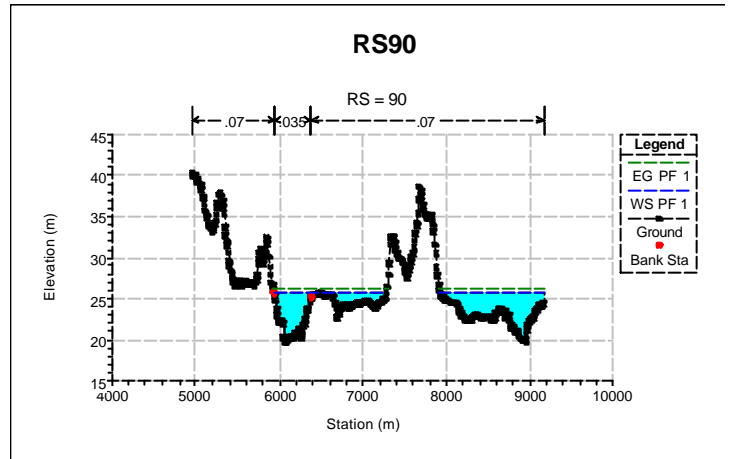
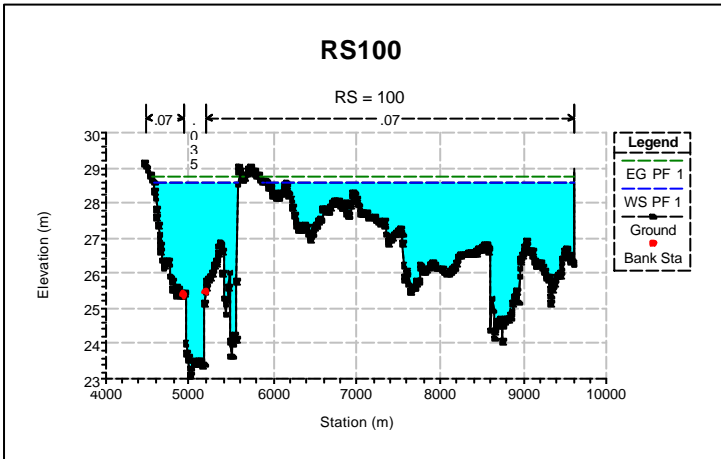
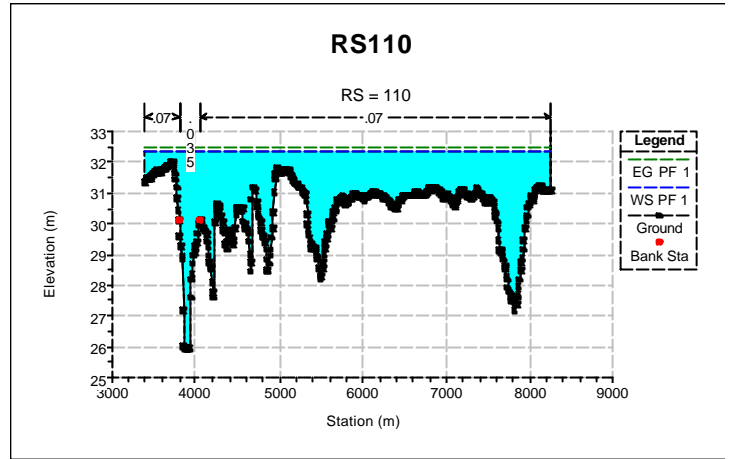
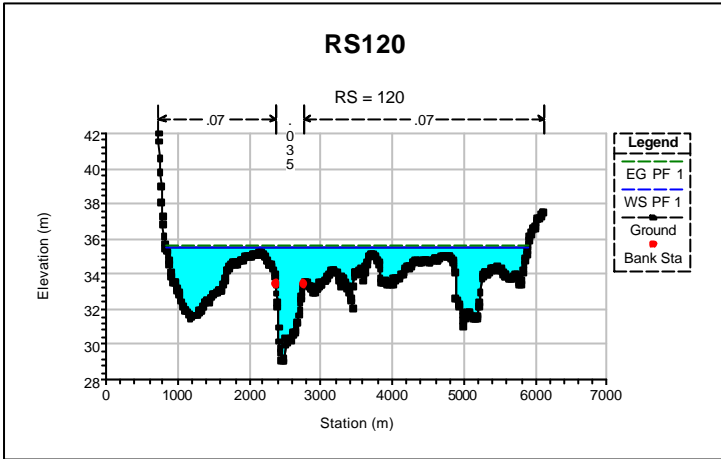


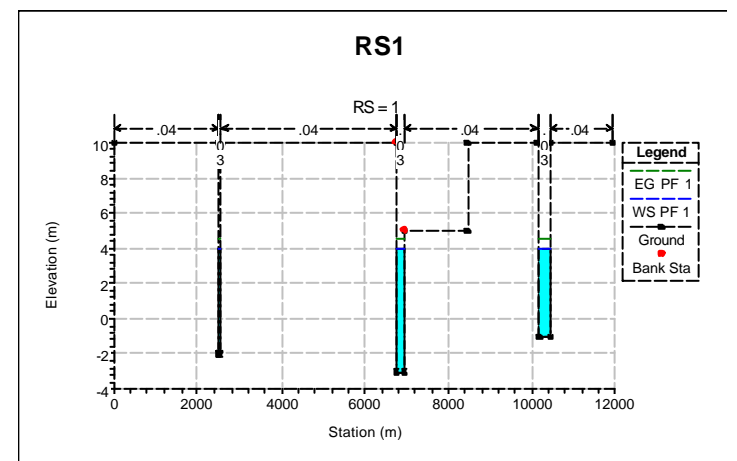
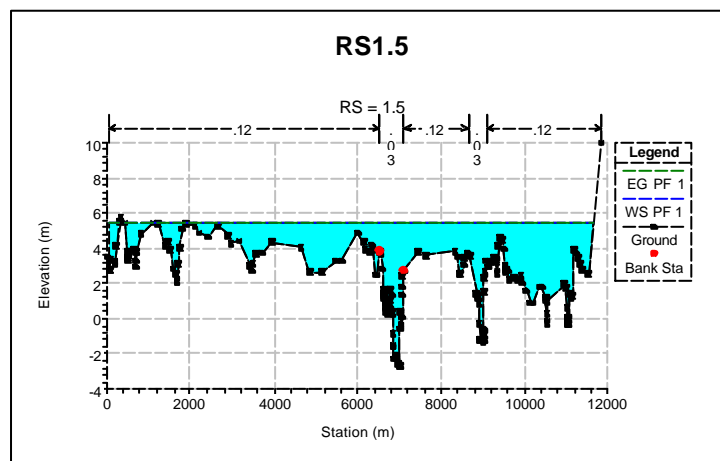
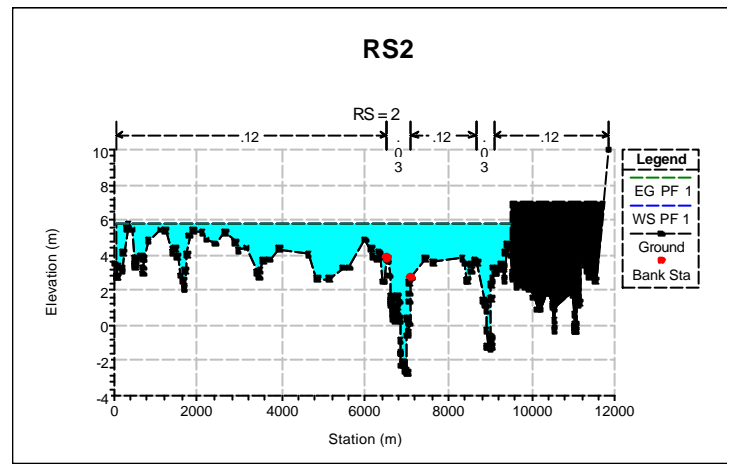
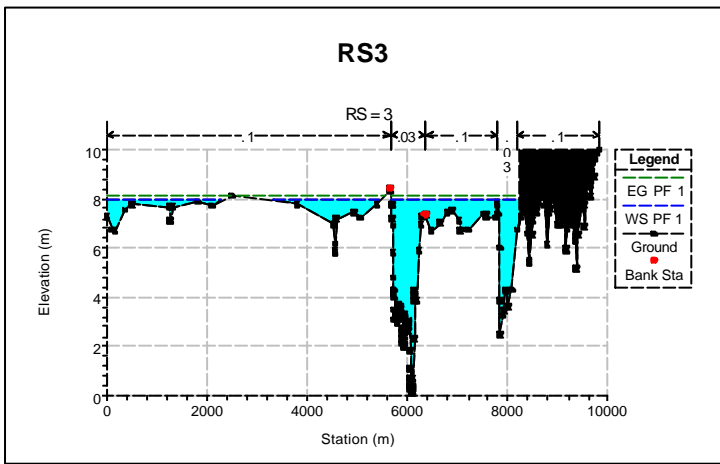
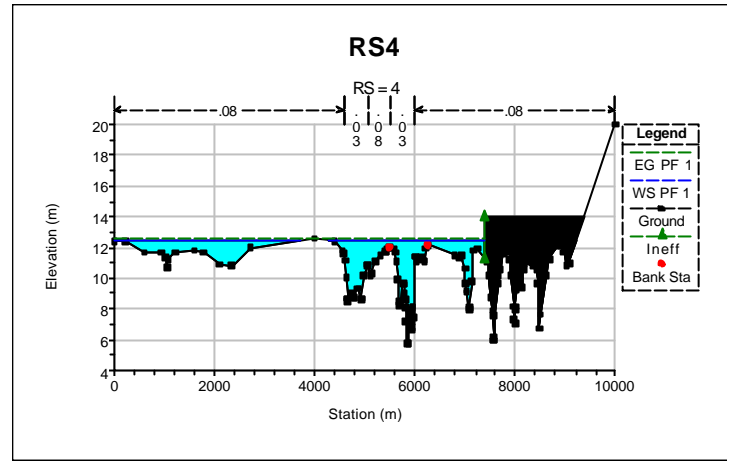
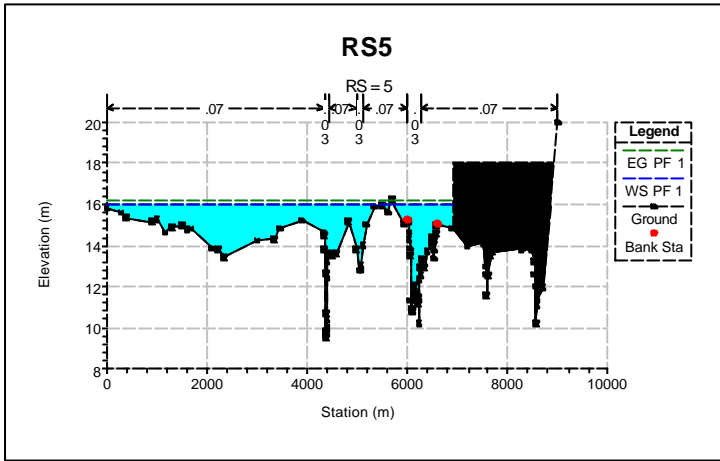
Fortescue River Post-Development Model Summary Table

RS	Chainage (m)	Q Total (m ³ /s)	Min Ch Elev (mRL)	W.S. Elev (mRL)	Crit W.S. (mRL)	E.G. Elev (mRL)	E.G. Slope (m/m)	Ch Vel (m/s)	Overflow Vel (m/s)	Flow Area (m ²)	Top Width (m)	Channel Froude #
120	26789	9567	29.02	35.55		35.70	0.000913	2.41	0.64	10033	5063	0.36
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100	21581	9567	23.10	28.59		28.72	0.000991	2.55	0.75	10024	4685	0.37
90	19220	9567	19.76	25.90		26.11	0.001329	2.66	0.54	6658	2592	0.42
80	16597	9567	16.05	22.17		22.28	0.001060	2.83	0.88	10356	4919	0.39
70	14798	9567	15.44	20.17	18.87	20.24	0.001576	2.18	0.80	9401	4916	0.43
5 ⁽¹⁾	12700	9567	10.21	16.07		16.15	0.001037	1.84	0.62	10427	6857	0.34
4 ⁽¹⁾	9900	9567	5.79	12.47		12.62	0.001290	2.31	0.75	7745	6843	0.47
3 ⁽¹⁾	7200	9567	0.08	7.90		8.12	0.000780	2.34	0.68	6739	6935	0.37
2 ⁽¹⁾	4000	9567	-2.75	5.81		5.85	0.000187	1.43	0.34	20538	9472	0.19
1.5 ⁽¹⁾	1000	9567	-2.75	5.42		5.46	0.000179	1.34	0.25	24264	11446	0.19
1 ⁽¹⁾		9567	-3	4	1.71	4.56	0.000965	3.62	2.92	2942	523	0.45

⁽¹⁾ Cross sections from central block studies in Fortescue Iron Ore Project Surface Water Management Plan (Report 012e, Aquaterra, April 2007)

Fortescue River Post-Development Model Cross Sections (Looking Downstream)

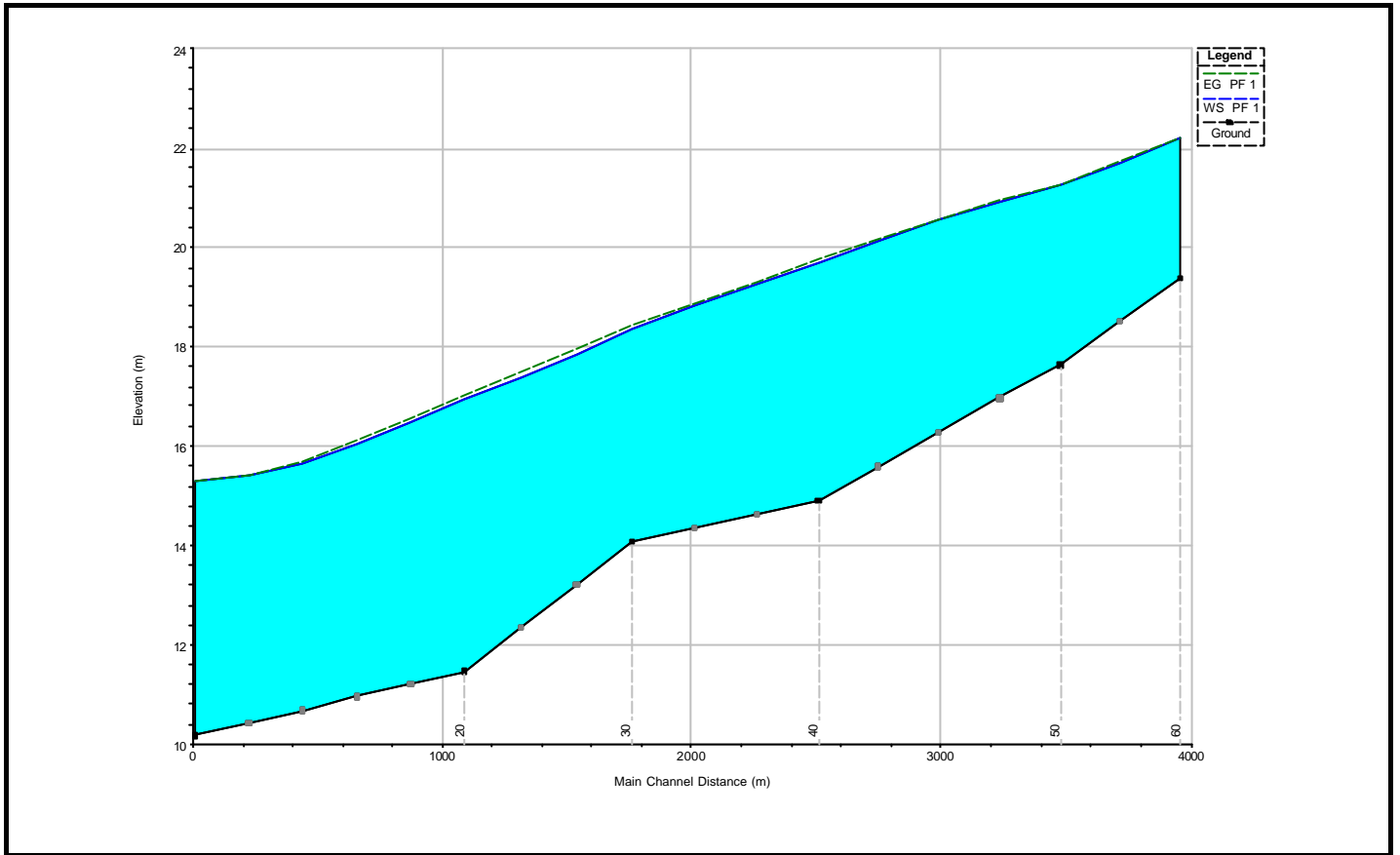




APPENDIX C

HEC-RAS MODELLING: DU BOULAY CREEK PRE-DEVELOPMENT MODEL

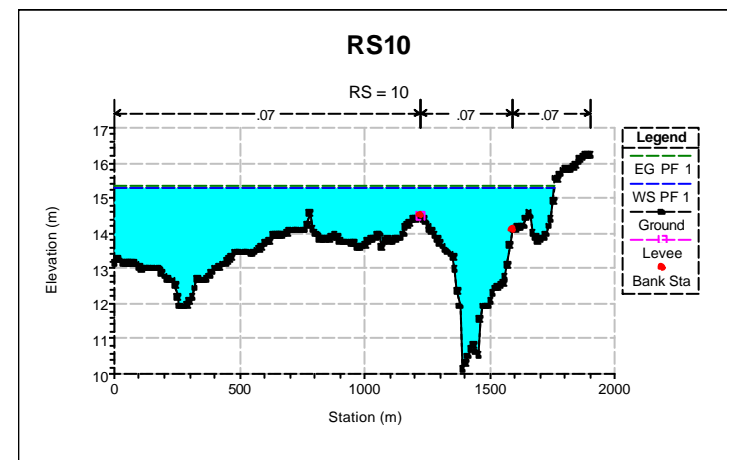
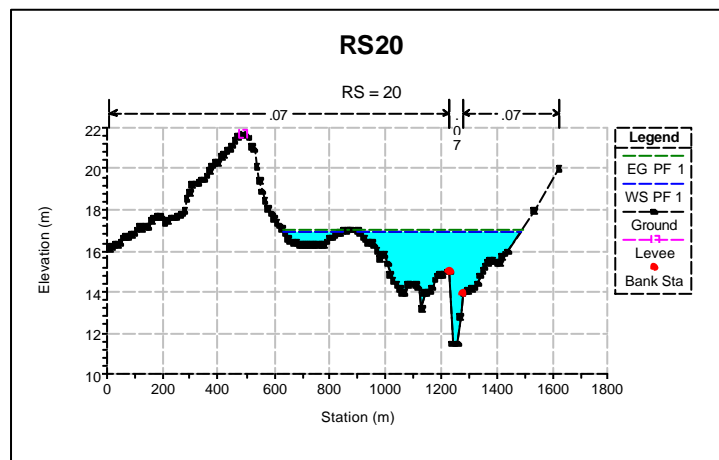
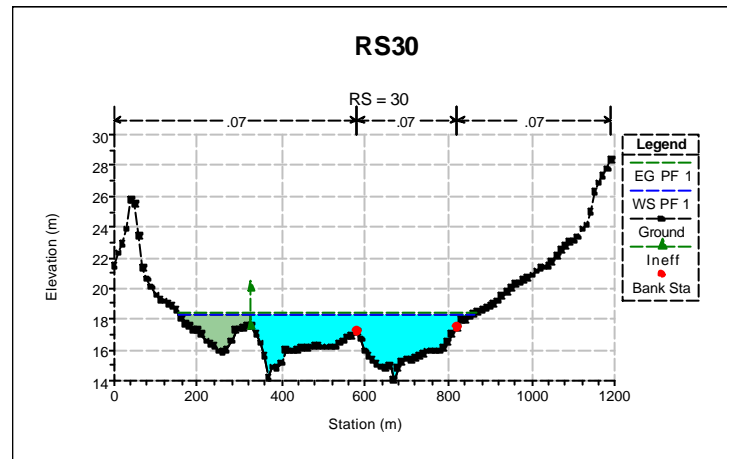
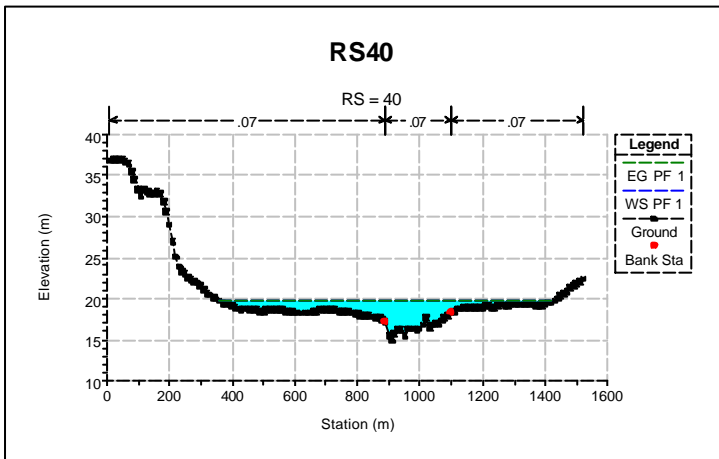
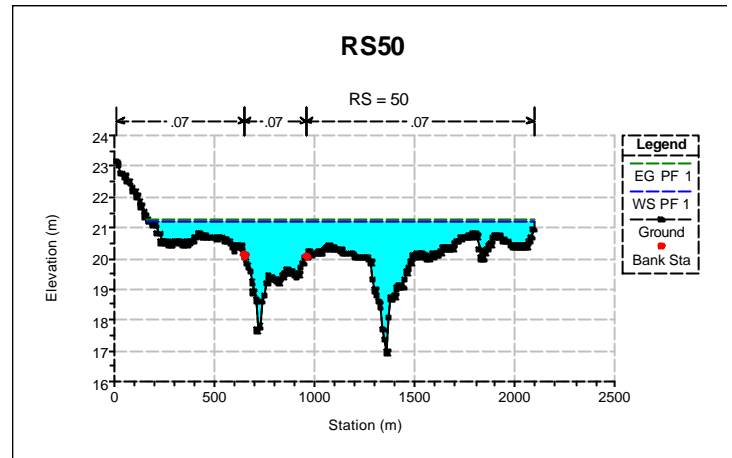
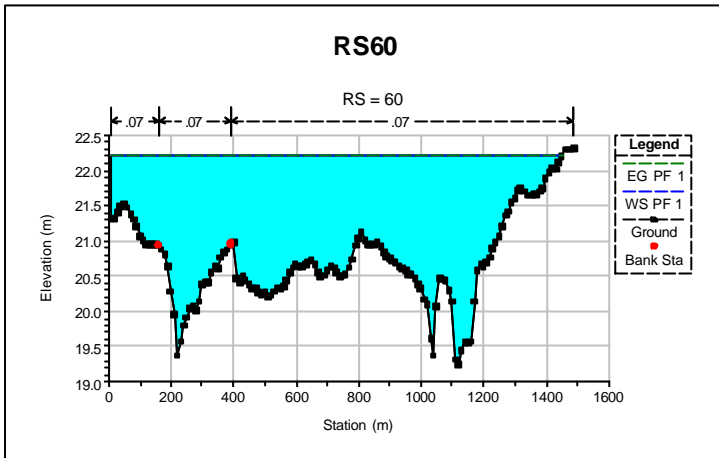
Du Boulay Creek Pre-Development Model Water Level Profile



Du Boulay Creek Pre-Development Model Summary Table

RS	Chainage (m)	Q Total (m ³ /s)	Min Ch Elev (mRL)	W.S. Elev (mRL)	Crit W.S. (mRL)	E.G. Elev (mRL)	E.G. Slope (m/m)	Ch Vel (m/s)	Overflow Vel (m/s)	Flow Area (m ²)	Top Width (m)	Channel Froude #
60	3949	1400	19.38	22.20		22.22	0.001175	0.74	0.56	2157	1439	0.17
50	3465	1400	17.64	21.25		21.28	0.001290	0.80	0.48	2281	1922	0.18
40	2496	1400	14.90	19.70		19.76	0.001823	1.30	0.58	1518	1068	0.23
30	1751	1400	14.07	18.37	16.78	18.44	0.001924	1.21	0.70	1227	708	0.24
20	1080	1400	11.46	16.94	15.49	17.02	0.002052	1.78	0.92	1308	799	0.26
10	0	1400	10.15	15.30	13.39	15.31	0.000321	0.49	0.33	3416	1756	0.10

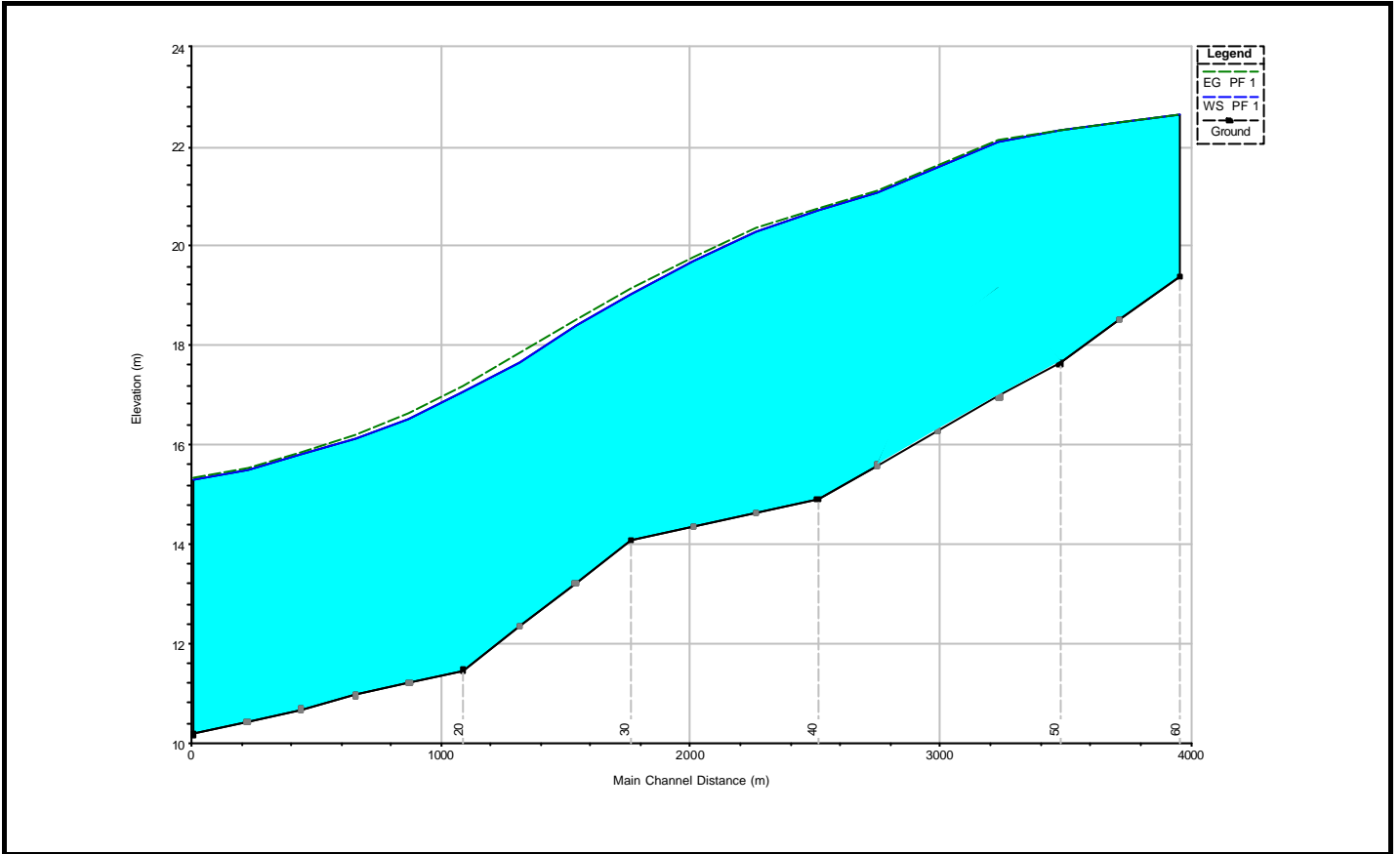
Du Boulay Creek Pre-Development Model Cross Sections (Looking Downstream)



APPENDIX D

HEC-RAS MODELLING: DU BOULAY CREEK POST DEVELOPMENT MODEL

Du Boulay Creek Post-Development Model Water Level Profile



Du Boulay Creek Post-Development Model Summary Table

RS	Chainage (m)	Q Total (m ³ /s)	Min Ch Elev (mRL)	W.S. Elev (mRL)	Crit W.S. (mRL)	E.G. Elev (mRL)	E.G. Slope (m/m)	Ch Vel (m/s)	Overflow Vel (m/s)	Flow Area (m ²)	Top Width (m)	Channel Froude #
60	3949	1400	19.38	22.65		22.66	0.000499	0.56	0.45	2830	1480	0.12
50	3465	1400	17.64	22.32		22.33	0.000572	0.55	0.47	2852	1120	0.10
40	2496	1400	14.90	20.72	18.33	20.77	0.001420	1.06	0.71	1517	560	0.17
30	1751	1400	14.07	19.02	17.19	19.14	0.002475	1.59	0.84	945	368	0.28
20	1080	1400	11.46	17.07	15.71	17.20	0.002623	2.05	1.23	981	402	0.30
10	0	1400	10.15	15.30	13.40	15.32	0.000764	0.76	0.47	2294	1306	0.15

Du Boulay Creek Post-Development Model Cross Sections (Looking Downstream)

