

MARTHUR RIVER MINE PHASE 3 DEVELOPMENT PROJECT SURFACE WATER ASSESSMENT

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For and on behalf of
WRM Water & Environment Pty Ltd



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EXECUTIVE SUMMARY

Overview

The McArthur River Mine (MRM) Phase 3 development is proposed to occur in stages over a 26 year mine life from 2012 to 2036. The operational requirements of Phase 3 mining operations will have some impact on the surface water quantity and quality and flooding characteristics at the mine site. Changes are proposed to the existing mine site surface water management system to accommodate the proposed changes to the mine site layout, and to mitigate potential surface water and flooding impacts.

Surface Water Management Strategy

The proposed Phase 3 surface water management strategy will use a number of existing surface water management measures, as well as a number of additional surface water management measures that will be implemented during both construction and operational phases.

For surface water management purposes, the surface runoff generated at MRM is divided into three types based on water quality:

- 'Clean' – surface runoff from areas of the Project Site where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas.
- 'Dirty' – surface runoff water and seepage from the Project Site areas that are disturbed by mining operations such as NAF waste rock dumps and roads. This runoff may contain silt and sediment, but is unlikely to contain contaminant concentrations in excess of ANZECC (2000) guidelines. However, this runoff must be of suitable quality if discharge into receiving waters is required.
- 'Contaminated' – surface runoff water and seepage from areas affected by mining operations and potentially containing chemicals of various types generated by mining operations. Areas where hazardous waste can potentially be generated include where ore is stockpiled, areas where PAF waste rock is encapsulated in NAF waste rock in a waste rock dump, the open pit and underground mine voids, and process areas. Runoff from these areas must be managed to avoid discharge of potentially contaminated water into the natural watercourses. There are restrictions on the use and release of this water.

The surface water management system proposed for Phase 3 mining operations includes a number of 'clean' runoff drains to divert runoff from undisturbed areas away from disturbed areas; 'dirty' runoff drains and sediment ponds to capture and treat runoff from disturbed areas; and containment storages to capture 'contaminated' runoff on-site. The proposed surface water management system will ensure that:

- The 'clean' runoff within the mine site is separated to the fullest extent and diverted away from disturbed areas;
- The 'dirty' and 'contaminated' surface water is segregated to the fullest extent, and then collected within the disturbed area of the mine site via adequately sized sediment ponds and containment storages;
- 'Contaminated' water is stored in appropriately designed containment storages and is not released out of the mine site, except in a controlled manner in compliance with MRM Waste Discharge License (WDL) conditions;
- Controlled releases of 'dirty' runoff treated in proposed sediment ponds only takes place if water quality in the sediment ponds is within the MRM WDL water quality release limits;

- The 'raw' water consumption is minimised and reuse of 'contaminated' water within the mine site (e.g. for ore processing) is maximised;
- The evaporation of on-site 'contaminated' water is maximised from MRM dams to minimise the need for off-site releases; and
- There is adequate permanent pumping infrastructure to allow transfer of 'contaminated' runoff between containment storages to minimise the risk of uncontrolled overflows.

No further diversions of the McArthur River, Barney Creek or Surprise Creek channels are proposed as part of Phase 3 mine development.

It is proposed to intercept groundwater that would otherwise flow into the open pit and underground workings by constructing dewatering bores and spears around the open pit perimeter. This is expected to maintain the quality of the water at much cleaner levels than water that has contacted the open pit and underground workings. The 'intercepted' water will be pumped to the Tailings Storage Facility Cell 3 Water Management Dam (TSF Cell 3 WMD). Excess 'intercepted' water within the MRM water management system will be either disposed to the McArthur River under an appropriate 'controlled' release strategy during high flows in the river or pumped off-site for irrigation use at the McArthur River Pastoral Lease (MRPL). A WDL would be required from Department of Natural Resources, Environment, The Arts & Sport (NRETAS) to allow controlled releases of 'intercepted' water stored in the TSF Cell 3 WMD to the McArthur River or off-site to MRPL.

Potential Surface Water Impacts and Mitigation Measures

The potential surface water impacts at the MRM site include:

- Potential change in surface runoff quality from disturbed catchments;
- Additional runoff from areas disturbed by mining (including OEFs and TSFs) to be managed within the mine site water management system;
- Additional open pit water (including surface runoff and groundwater inflow) to be managed within the mine site water management system, due to the increased size of the open pit and its catchment;
- Potential reduction in flows in receiving waters due to the need to contain 'contaminated' water on-site; and
- Potential erosion impacts in the McArthur River channel and other local mine site streams.

The total area of land disturbance at the existing MRM site and the additional impact of proposed Phase 3 mining operations on surface water quantity and quality with the proposed water management system are considered minor. The current mining operations disturb an area of approximately 940 ha. The proposed Phase 3 mining operations would increase the disturbed area by approximately 700 ha, to a total of approximately 1,640 ha. The total disturbed area after Phase 3 development would be only about 0.12% of the McArthur River catchment area (1,292,000 ha) to the downstream end of the mine. The areas of disturbance within the local stream catchments caused by Phase 3 mining operations are also small.

With appropriate control measures in place, the impact of the Phase 3 mining operations on surface flows and water quality in downstream receiving waters will be insignificant.

Periodic releases of 'dirty' water from sediment ponds will occur. However, any release of 'dirty' water from the sediment ponds is likely to occur only during significant flow events in the McArthur River. Further, these release volumes are expected to be insignificant when compared to expected flow volumes in the receiving waters during such flow events.

Due to the expected non-toxic nature of the sediment pond releases and the potential for significant dilution of any releases from these storages, the periodic release of 'dirty' water (after

treatment) is not considered likely to have any significant environmental impact on receiving waters.

Potential Flood Impacts and Mitigation Measures

Most of the existing and proposed Phase 3 mining infrastructure are located within the McArthur River floodplain and are potentially affected by McArthur River, Barney Creek and/or Surprise Creek floodwaters. Further, the proposed Phase 3 mining operations would potentially increase flood levels, depths, velocities and extents within and in the vicinity of the mine site due to a reduction of floodplain storage and obstructions to flow caused by the mining infrastructure.

The existing flood mitigation measures at the MRM site will remain during Phase 3 mining operations. In addition, a number of additional measures are proposed to minimise the impact of flooding on Phase 3 mine infrastructure. The additional measures include:

- Constructing a new erosion protection bund to protect South and East OEFs from erosion up to the 1% AEP (100 year ARI) flood level;
- Continuing to place North OEF PAF material and North OEF PAF Runoff Dam spillway levels above the 1% AEP (100 year ARI) flood level.
- Undertaking a regular erosion monitoring program along channel reaches and floodplain areas where potentially elevated velocities and velocity increases have been identified. If any evidence of erosion is found at these locations following major flow events, appropriate erosion protection works at these affected locations would be undertaken.

Water Balance

The MRM site is a net producer of water due to the substantial amounts of groundwater inflows to the open pit and underground mine void, and high rainfall and runoff during the wet season. Almost all of the direct rainfall and surface runoff inflows to the MRM water management system are generated during the wet season between October and April. During the dry season, the only significant inflows to the MRM water management system are generated from groundwater sources. A major component of the proposed water management system is enhancement of evaporation losses via the use of evaporation fans, sprinklers and water fountains. The following is of note:

- Releases to the McArthur River would generally occur only between the months of January and April during high flows in the river. Most releases to the river would occur in February and March.
- Release of 'intercepted' groundwater to MRPL for irrigation use would generally occur between the months of April and July. During other months of the year, MRM can generally manage on-site water either within the water management system or by releasing to the McArthur River.
- Between July and December the mine site water management system is generally able to manage water stored on-site without off-site releases.

The water balance modelling results indicate that the proposed water management system is robust and has adequate storage capacity to manage surface water runoff generated within the MRM site for a wide range of possible climatic conditions, including extended wet and dry periods. The water balance modelling results also indicate the potential for 'contaminated' water at the MRM site overflowing into receiving waters is very low.

Surface Water Monitoring

MRM currently operates a comprehensive surface water monitoring network and data collection program within and in the vicinity of the mine site. Currently, surface water is monitored at 24 stream locations within and in the vicinity of the mine site, and 13 water storages and sumps.

The aims and objectives of the surface water monitoring program at MRM during Phase 3 mining operations will remain the same as under current operations. Therefore, the current

surface water monitoring network will remain largely unchanged. A number of minor changes to improve and expand the current surface water monitoring program are proposed to account for changes in site layout. No changes to the existing suite of parameters monitored or the monitoring frequency are proposed.

Changes to the surface water monitoring program include:

- The removal of the existing stream gauging station on Barney Creek (SW19) and replacing it with two new stations - one on Barney Creek approximately 5 km upstream of the removed station at the Carpentaria Highway crossing (SW4) and the other on Surprise Creek at the at the Carpentaria Highway Crossing (SW2);
- The installation of three (3) new surface water quality monitoring stations to monitor the impact of the North Overburden Emplacement Facility (NOEF) runoff on Emu Creek receiving waters; and
- The installation of six (6) new stations to monitor water quality in the new 'contaminated' storages proposed for the site. These are the two new storages in the TSF area (TSF Cell 3 WMD and TSF Cell 4 WMD) and the four new storages in the NOEF area, namely South-East PAF Runoff Dam (SEPROD), East PAF Runoff Dam (EPROD), North-East PAF Runoff Dam (NEPROD) and North-West PAF Runoff Dam (NWPROD).

During Phase 3 mining operations, it is proposed to direct runoff from NAF areas in the North, South and East OEFs towards sediment ponds. This is based on the assumption that runoff and seepage from the North, South and East OEF areas can be considered 'dirty' and can be released to the receiving waters after treatment in a sediment pond. Monitoring of water quality in these sediment ponds would be required to demonstrate that the water quality is within the limits specified in MRM's WDL prior to release into receiving waters. If runoff and/or seepage from North, South and East OEF areas is found to be 'contaminated', active management measures and/or additional storage volume would be required to fully contain the 'contaminated' water on site.

Limitations and Uncertainties

The proposed water management system for the MRM Phase 3 mining operations has been prepared based on the best available data and information at the time of preparing the report. It is noted however, due to data limitations a number of significant assumptions have been made when designing the proposed water management system. As a consequence, there is a degree of uncertainty in the design, operation and performance of the water management system components associated with the adopted assumptions. Further data acquisition will be required in the coming years to confirm the assumptions that have been made in this study and to make refinements to the proposed water management system as required.

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ACRONYMS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment & Conservation Council
APP	Anti-Pollution Pond
ARI	Average Recurrence Interval
As	Arsenic
BBPF	Bing Bong Port Facility
BCGS	Barney Creek Gauging Station
BoM	Bureau of Meteorology
Ca	Calcium
CaCO₃	Calcium Carbonate
Cd	Cadmium
Cl	Chlorine
CRP	Concentrator Runoff Pond
Cu	Copper
D/S	Downstream
DSGS	Downstream Gauging Station
DWT	Decant Water Tank
EC	Electrical Conductivity
EIS	Environmental Impact Statement
ELS	Eastern Levee Storage
EPROD	East PAF Runoff Dam
EWFS	Early Warning Flood System
Fe	Iron
FFA	Flood Frequency Analysis
FSL	Full Supply Level
GL	Gigalitre
GL/yr	Gigalitre per Year
GRGS	Glyde River Gauging Station
GTSMR	Generalised Tropical Storm Method (Revised)
ha	Hectares
HMTV	Harness Modified Trigger Value
km	Kilometre
LA	Lake Archer
m	Metre
m²	Square metre
m³	Cubic metres
mAHD	Metres Australian Height Datum
MOL	Maximum Operating Level

mg	Milligram
mg/L	Milligrams per litre
mGH	Metres Gauge Height
Mill	Concentrator Preparation Plant
MIM	Mount Isa Mine
ML	Megalitre
ML/d	Megalitres per Day
mLMD	Metres Local Mine Datum (AHD + 10,000)
MRM	McArthur River Mine
MRPL	McArthur River Pastoral Lease
Mtpa	Million tonnes per annum
NAF	Non-Acid Forming
No.	Number
NEPROD	North-East PAF Runoff Dam
NWPROD	North-West PAF Runoff Dam
NOEF	Northern Overburden Emplacement Facility
NRETAS	Department of Natural Resources, Environmental, The Arts and Sport
OEF	Overburden Emplacement Facility
OC	Open Pit
OMR	Old McArthur River
OOL	Optimum Operating Level
OPSIM	Operational Simulation Model
PAF	Potentially Acid Forming
Pb	Lead
pH	Power of Hydrogen
PP	Pete's Pond
PS	Pit Sump
QCCCE	Queensland Climate Change Centre of Excellence
ROM	Run Of Mine
RWT	Raw Water Tank
SDWMP	Sustainable Development Water Management Plan
SEPROD	South-East PAF Runoff Dam
SPROD	Southern PAF Runoff Dam
SPSD	Southern PAF Sediment Dam
SO₄	Sulphate ion
SW	Surface Water
SWPROD	South-West PAF Runoff Dam
tpa	Tonnes per annum
TSF	Tailings Storage Facility
TV	Trigger Value

µg/L	Micrograms per litre
µm	Microns
µS/cm	Microsiemens per centimetre
UG	Underground Mine Void
USGS	Upstream Gauging Station
U/S	Upstream
WDL	Waste Discharge Licence
WMD	Water Management Dam
WMP	Water Management Plan
WPSD	West PAF Sediment Dam
WRM	WRM Water and Environment Pty Ltd
VDD	Van Duncans Dam
V:H	Vertical : Horizontal
Zn	Zinc

1 INTRODUCTION

The McArthur River Mine (MRM) is located in the Northern Territory approximately 70 km south-west of the township of Borroloola and approximately 740 km south-east of Darwin. Xstrata Zinc's MRM Phase 3 Development Project proposes to expand its current open pit zinc/lead/silver mining and bulk concentrate processing operation commencing in 2012. The proposal is to increase bulk concentrate production using ore extracted from an expanded open pit operation, with the expanded pit developed in stages over a period of 26 years (2011-2036) to extract 5 Million tonnes per annum (Mtpa) of ore and produce 800,000 tonnes per annum (tpa) of bulk zinc/silver/lead concentrate. The concentrate from MRM will be trucked to Xstrata's Bing Bong Port Facility (BBPF) for distribution worldwide. A locality plan of the MRM and BBPF sites is shown in Figure 1.1.

Full details of the project background and proposed mining operations at MRM are contained in the Project Description chapter of the Environmental Impact Statement (EIS) (MET Serve, 2012). The Project will result in little change to the existing approved water management system at the BBPF. Therefore, this surface water assessment focuses on the required changes to surface water management at MRM.

As part of the EIS for the proposed MRM Phase 3 development project, Mining and Energy Technical Services Pty Ltd (MET Serve) (on behalf of Xstrata Zinc) requested WRM Water & Environment Pty Ltd (WRM) to undertake a surface water assessment for the MRM Site. This report has been prepared in response to that request.

This report is structured as follows.

- Section 2 describes the regional and local catchment and drainage characteristics in and around the MRM site.
- Section 3 describes the available rainfall, evaporation and streamflow data for the MRM site.
- Section 4 presents a summary of available surface water quality data for the MRM site.
- Section 5 describes the objectives of the surface water management strategy at the MRM site. The potential constraints to the proposed mining activities with respect to surface water management are also discussed.
- Section 6 describes the existing surface water management system at the MRM site.
- Section 7 presents the proposed surface water management measures for the MRM site.
- Section 8 presents details of the water balance modelling undertaken for the MRM site.
- Section 9 presents an assessment of flooding at the MRM site.
- Section 10 presents an assessment of the potential impacts of proposed mining activities on surface water and flooding at the MRM site. The proposed mitigation measures to minimise or mitigate potential impacts are also discussed.
- Section 11 reviews the surface water monitoring requirements for the MRM site.
- Section 12 is a list of references.

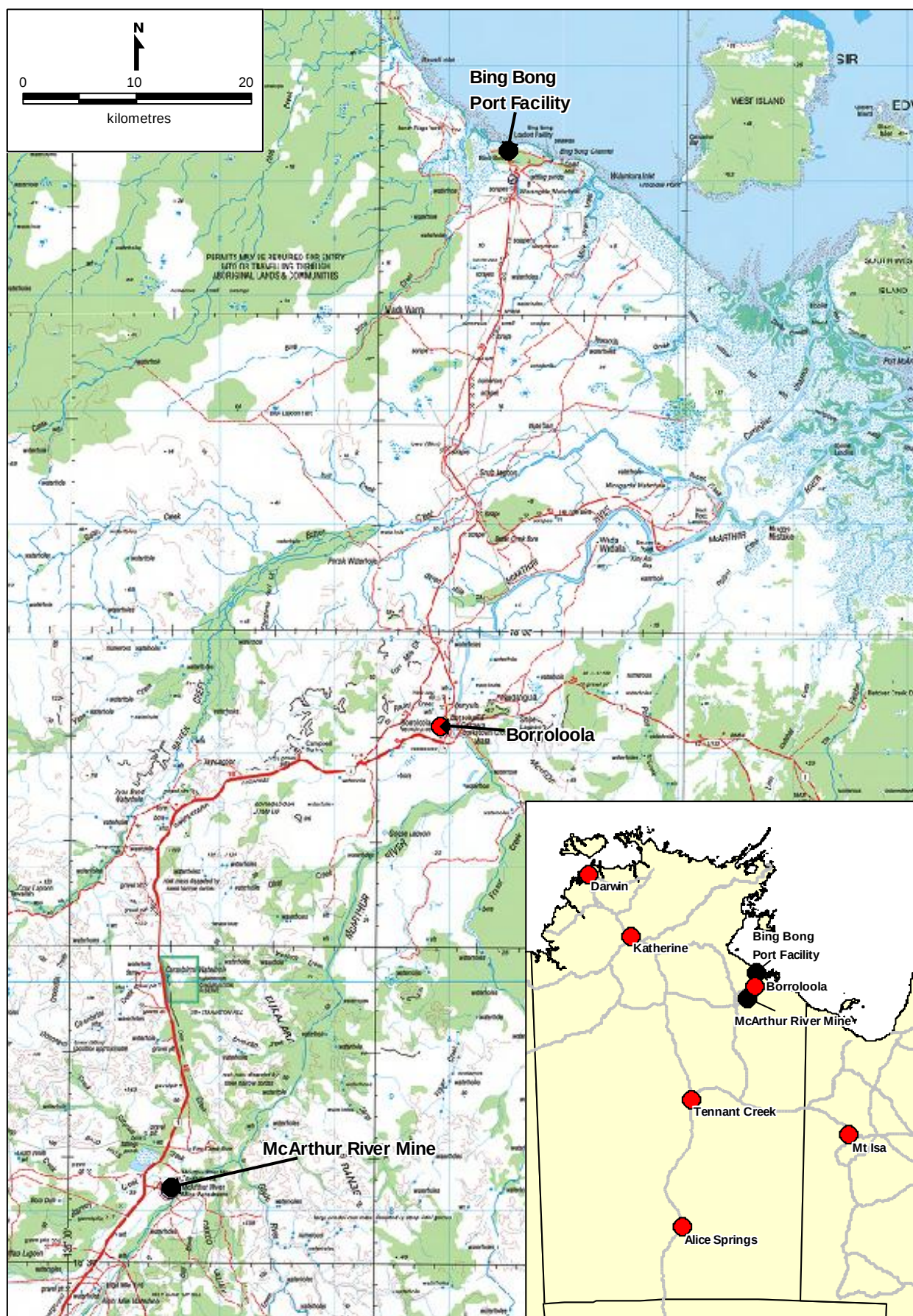


Figure 1.1 Locality Plan, McArthur River Mine and Bing Bong Port Facility

2 EXISTING ENVIRONMENT

2.1 REGIONAL CATCHMENTS

The McArthur River is the major surface water feature in the region. The McArthur River originates in the Barkly Ranges and flows in a north-easterly direction before discharging into the Gulf of Carpentaria near the Sir Edward Pellew Group Islands. The river falls more than 250 m over its 330 km length. The total catchment area of the McArthur River is approximately 18,000 km².

Figure 2.1 shows the drainage network of the McArthur River catchment and its major tributaries, including Batten Creek, Scrubby Creek, Tooganginie Creek, the Kilgour River, the Glyde River, Barney Creek and Rocky Creek. The catchment is bounded by the Limmen Bight River and Rosie River catchments to the west and north-west, the Wiso and Barkly Basins to the south and the Robinson River catchment to the east.

The catchment is sparsely populated with isolated communities, including the township of Borroloola. Land use is typically rural throughout the catchment.

The MRM is located adjacent to the McArthur River between its confluences with the Glyde and Kilgour rivers in the middle reaches of the catchment. The Glyde River, which has a catchment area of approximately 2,440 km², originates 95 km south-east of MRM and joins the McArthur River approximately 6.9 km downstream of the mine site. The Kilgour River, which originates approximately 112 km south of MRM, has a catchment area of approximately 3,100 km² and joins the McArthur River approximately 20.7 km upstream of the mine site. The McArthur River bed level in the reach adjacent to the mine site is between 16 and 21 mAHd.

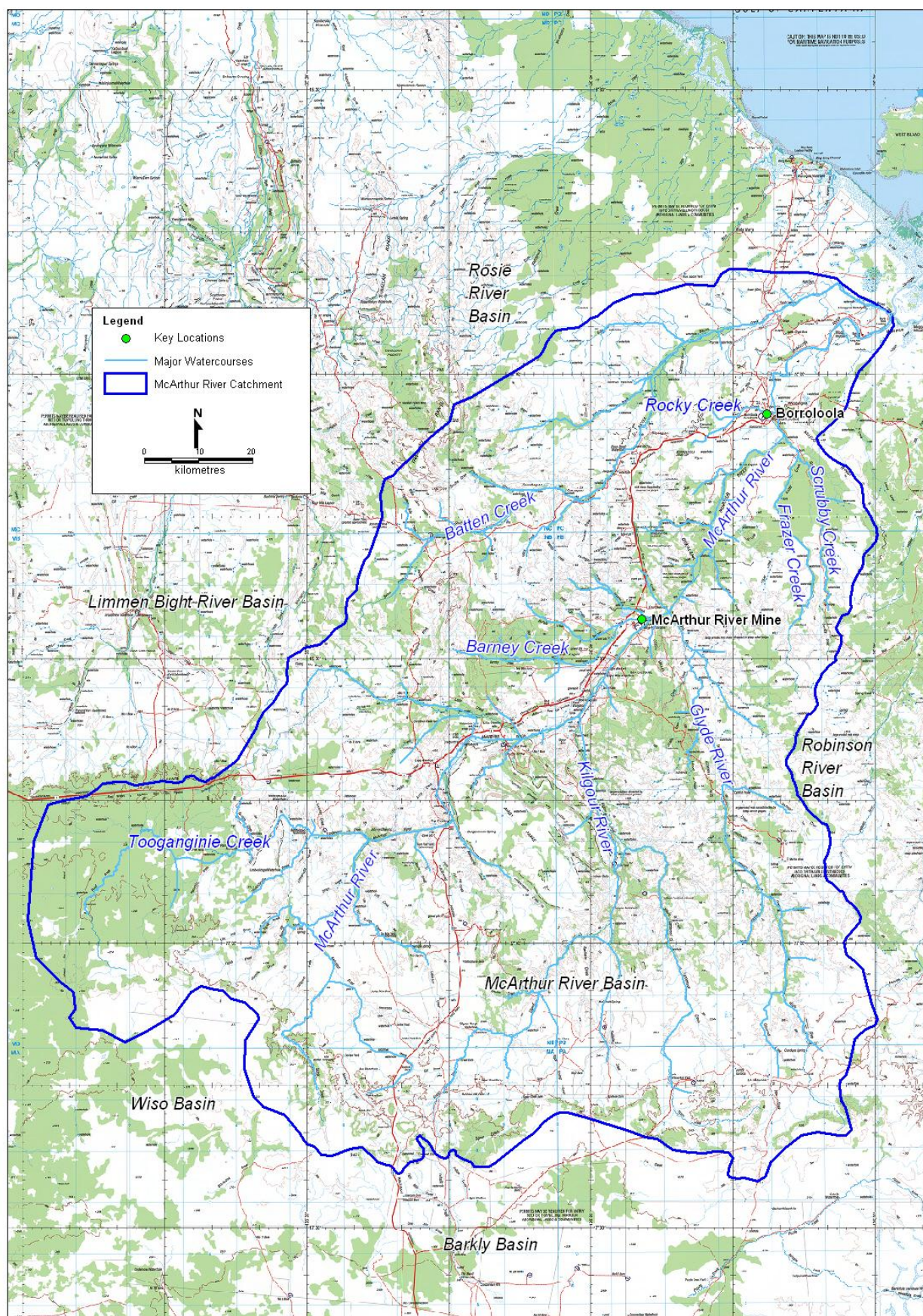


Figure 2.1 McArthur River Drainage Network

2.2 LOCAL CATCHMENTS

Figure 2.2 shows the local drainage network in the vicinity of the MRM site. Most of the mine site is within the McArthur River floodplain. The Glyde River joins the McArthur River from the south-eastern side downstream of the mine. Bull Creek and Emu Creek join the McArthur River from the east and north-west respectively in the vicinity of the mine upstream of the Glyde River confluence. Barney Creek and Surprise Creek join the McArthur River from the western side through the mine site.

The mine occupies a small portion of the catchments of Barney and Surprise Creeks. Most of the existing mine infrastructure is located on a low hill (Barney Hill) between the confluences of Barney Creek, Surprise Creek and McArthur River.

The McArthur River, Barney Creek and Little Barney Creek have been realigned within the mine site to allow for mining activities. In addition, a flood protection levee has been constructed to protect the open pit and mine infrastructure from McArthur River flooding. Bull Creek is intercepted by the McArthur River diversion channel. Surprise Creek is intercepted by the Barney Creek diversion channel. The above stream realignments and the alignment of the flood protection levee are shown in Figure 2.2.

Table 2.1 shows the catchment areas of the various watercourses in the vicinity of MRM.

Table 2.1 Catchment Areas of Watercourses in the Vicinity of the McArthur River Mine

Watercourse	Catchment Area (km ²)
McArthur River at upstream of the mine	9,600
Glyde River at the McArthur River junction	2,440
Barney Creek at the McArthur River junction	700
Surprise Creek at Barney Creek junction	120
Emu Creek at the McArthur River junction	65
Bull Creek at the McArthur River junction	105
McArthur River downstream of the Glyde River junction	12,920

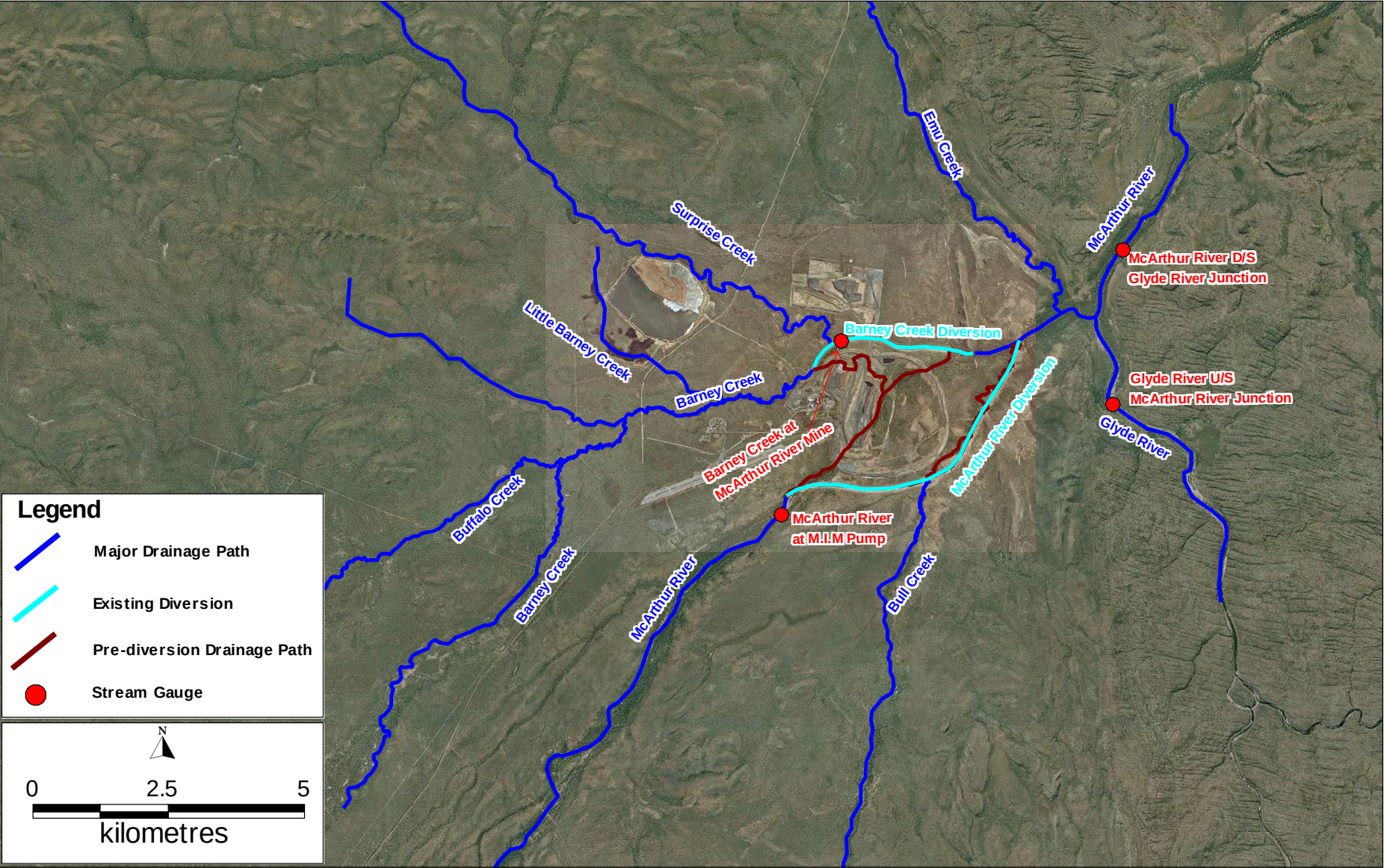


Figure 2.2 Local Drainage Network in the Vicinity of McArthur River Mine (include mine infrastructure, river/creek diversions, levees)

3 CLIMATIC AND STREAMFLOW DATA

3.1 CLIMATE

The McArthur River catchment experiences a monsoonal climate regime, which is strongly seasonal with distinct wet and dry seasons. The average daily minimum and maximum temperatures at MRM range between 12°C (in July) and 39°C (in November). The rainfall and evaporation variations at MRM are described in Section 3.2.

3.2 RAINFALL AND EVAPORATION

3.2.1 Available data

Table 3.1 shows summary details of rainfall recording stations located within and close to the McArthur River catchment, and in the vicinity of the MRM site. The locations of the various stations are shown in Figure 3.1. Rainfall data for the respective periods of record at stations listed in Table 3.1 was available from the Commonwealth Bureau of Meteorology (BoM) and the Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS). In addition, synthetic rainfall data was also obtained for the MRM site from the Queensland Climate Change Centre of Excellence (QCCCE) SILO Data Drill Service. The MRM site Data Drill data have been derived by interpolation of recorded rainfall data between regional stations as described by Jeffreys et al. (2001). The Data Drill provides a continuous daily data set over the 122 years between 1889 and 2011.

Recorded Class A pan evaporation data was available for the MRM site from the BoM evaporation station at the McArthur River Mine (Station No. 14704), as well as from the SILO Data Drill Service.

3.2.2 Rainfall

Table 3.2 compares mean monthly and annual rainfalls recorded at the McArthur River Mine rainfall station (No. 14704) with the Data Drill data for the 40 year period of record at the MRM station (1968-2011). Annual values are shown for “water years”, commencing in October.

The recorded mean monthly and annual rainfalls at MRM correlate well with the Data Drill data for the common period of data. The average monthly rainfalls at MRM exhibit distinct wet (November to April) and dry (May to October) seasons during the year, with a dry season low of 0-1 mm in August to a wet season high of 208 mm in January. The wet season average monthly rainfalls (34 mm to 208 mm) are significantly higher than the equivalent dry season monthly rainfalls (0 mm to 22 mm). The recorded mean annual rainfall at the MRM site over the period 1968 to 2011 is approximately 785 mm.

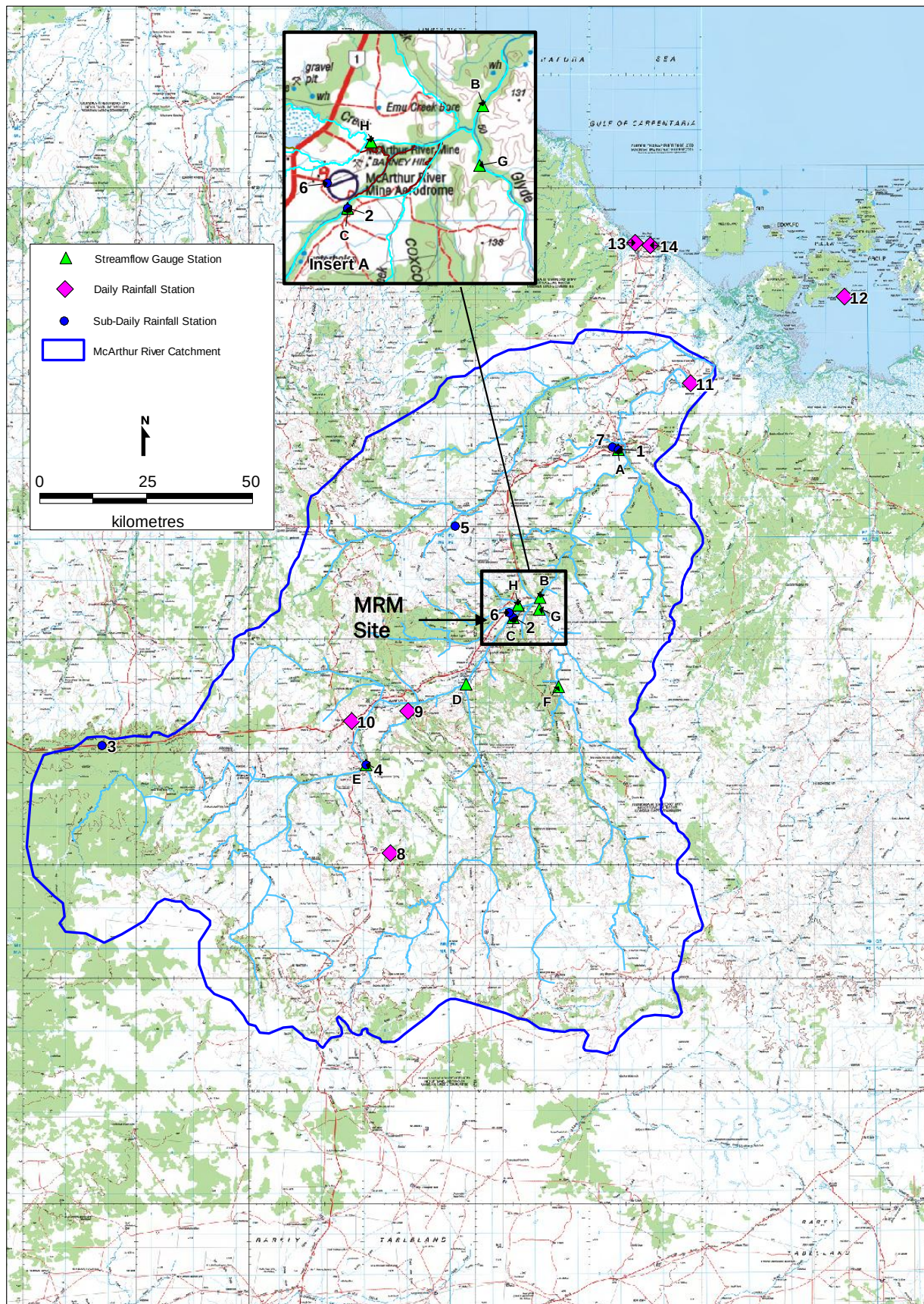


Figure 3.1 Location of Rainfall and Stream Gauging Stations

Table 3.1 Summary Details of Rainfall Stations

Station ID in Figure 3.1	Station Number	Station Name	Station Type	Period Of Record
1	R070121	McArthur R. at Borroloola Crossing	Continuous	2001 - 2010
2	R9070132	McArthur R. at MIM Pump	Continuous	1992 - Present
3	R9070135	Favenc Range	Continuous	1992 - Present
4	R9070142	McArthur R. at Baileys Grave	Continuous	1991 - Present
5	R9070146	Looking Glass Ck. At Skipping Stones	Continuous	1992 - 1993
6	14704	McArthur R. Mine	Continuous	1968 - Present
7	14723	Borroloola	Continuous	1993 - Present
8	14702	Mallapunyah	Daily	1963 - Present
9	14715	McArthur R. Station	Daily	1970 - 2007
10	14722	Cape Crawford	Daily	1986 - 2006
11	14732	King Ash Bay	Daily	2000 - 2011
12	14703	Centre Island	Daily	1968 - Present
13	014708	Bing Bong	Daily	1965 - Present
14	014729	Bing Bong Port	Daily	1996 - Present

3.2.3 Evaporation

Table 3.2 also shows a comparison of mean monthly and annual (Class A pan) evaporation data recorded at the McArthur River Mine station (No. 14704) with Data Drill data for the 26 year period of record at the MRM station (1975-2011).

The recorded mean monthly and annual evaporation at MRM correlate well with the Data Drill data for the common period. The average annual pan evaporation at the MRM site is estimated to be approximately 2700 mm, which is approximately 3.4 times the average annual rainfall. The evaporation rate is high throughout the year, with highest evaporation rates occurring in the months between August and January are generally much higher than rainfall in all months, except January and February.

Figure 3.2 shows the variation of mean monthly rainfall and pan evaporation at the MRM site.

Table 3.2 Mean Monthly and Annual Rainfall and Evaporation at the MRM Site

Month	Mean Monthly Rainfall (mm)		Mean Monthly Pan Evaporation (mm)	
	McArthur River Mine (14704) [1968 - 2011]	Data Drill Data [1968 - 2011]	McArthur River Mine (14704) [1975 - 2011]	Data Drill Data [1975 - 2011]
October	21	22	304	294
November	49	49	297	285
December	122	122	276	266
January	208	208	233	223
February	187	187	189	185
March	144	151	208	204
April	34	36	204	205
May	7	7	198	194
June	2	6	174	172
July	2	2	183	186
August	0	1	223	220
September	5	4	267	257
Annual	785	795	2739	2690

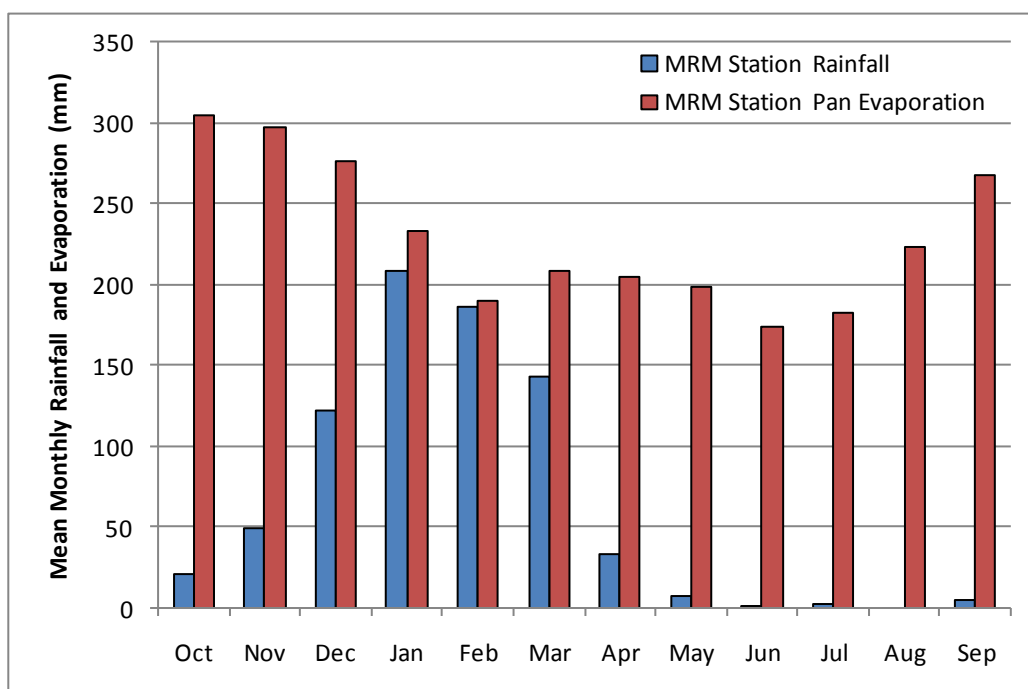


Figure 3.2 Variation in Monthly Rainfall and Evaporation at the MRM Site

3.2.4 Recorded vs Data Drill Rainfall and Evaporation Data

Figure 3.3 shows a comparison between recorded daily data at the McArthur River Mine (Station No. 14704) and the Data Drill data for the MRM site for the common periods of record. The SILO data is available for 122 years (1889-2011) and is considered to be more reliable and easier to use for long-term computer modelling than raw recorded rainfall data. Therefore, the SILO data has been used for this surface water assessment.

Figure 3.4 compares the mean monthly rainfalls and pan evaporation recorded at the McArthur River Mine (Station No. 14704) with the Data Drill data for the MRM site for the common period of record at the McArthur River Mine station (1968 to 2011).

Figure 3.3 and Figure 3.4 demonstrate that the Data Drill data provides a good long-term representation of rainfall and evaporation at the MRM site.

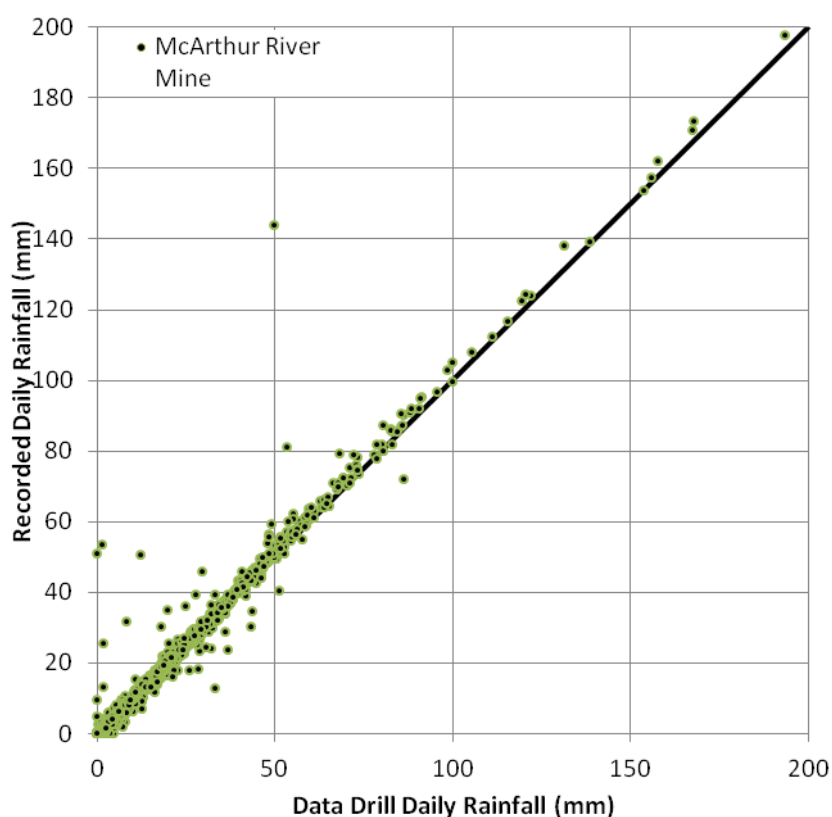


Figure 3.3 Comparison of Recorded and Data Drill Daily Rainfalls at MRM

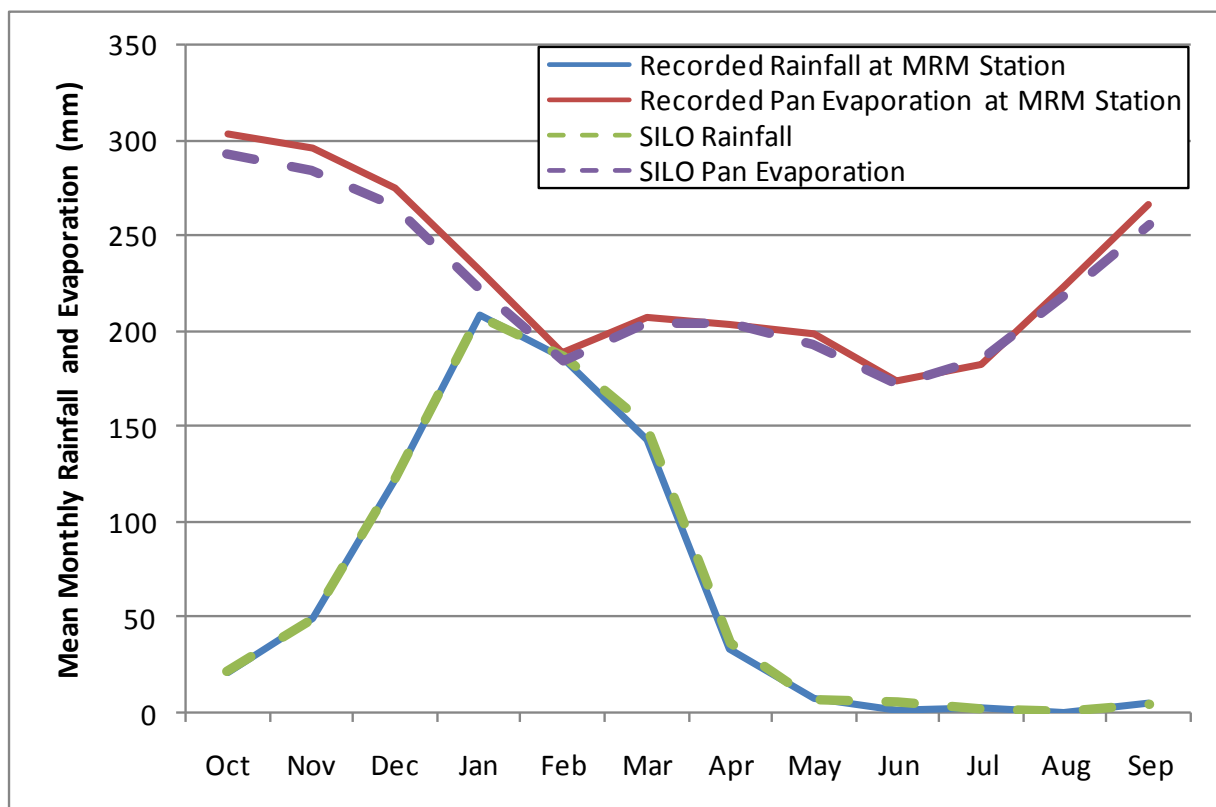


Figure 3.4 Comparison of Recorded and Data Drill Mean Monthly Rainfalls and Evaporation at MRM

3.3 STREAMFLOW

3.3.1 Available Data

There are five stream gauging stations in the McArthur River Catchment in the vicinity of the MRM site:

- The NRETAS's McArthur River at MIM Pump Station (No. G9070132) located just upstream of the MRM site;
- The MRM's McArthur River Flood Early Warning Station located on the McArthur River 21 km south-west of the mine site just downstream of the Kilgour River confluence;
- The MRM's McArthur River Downstream Station located just downstream of its confluence with the Glyde River;
- The MRM's Glyde River Station located approximately 1.8 km upstream of its confluence with the McArthur River; and
- The MRM's Barney Creek station located within the MRM site.

Only the MIM Pump Station has a reliable data record. The other four stations have a history of equipment malfunctions and/or recording problems. There are three other stations in the McArthur River catchment, two on the McArthur River itself (at Borrooloola and Baileys Grave) and one on the Glyde River (upstream of Amelia Yards). Table 3.3 shows summary details of the stream gauging stations within the McArthur River catchment including data availability

for the different stations. Figure 3.1 shows the location of these stations. Recorded water level data available for the stream gauging stations was obtained from NRETAS and McArthur River Mine.

Table 3.3 Summary Details of Stream Gauging Stations in the McArthur River Catchment

Station ID in Figure 3.1	Station Number	Station Name	Stream Name	Catchment Area (km ²)	Period of Record
A	G9070121	McArthur River at Borrooloola Crossing	McArthur River	14,565	1975 - Present
B	SW11	McArthur River D/S Glyde River Junction	McArthur River	12,920	2006 - Present
C	G9070132 / SW10	McArthur River at MIM Pump	McArthur River	9,600	1969 - Present
D	EWFS	McArthur River Flood Warning Station	McArthur River	9,350	2008 - Present
E	G9070142	McArthur River at Baileys Grave	McArthur River	4,560	1965 - Present
F	G9070229	Glyde R. U/S Amelia Yards	Glyde River	1,960	1973 - 1987
G	GRGS	Glyde River U/S McArthur River Junction	Glyde River	2,400	2008 - Present
H	BCGS	Barney Creek at McArthur River Mine	Barney Creek	700	2009 - Present

3.3.2 McArthur River Flows at MRM

McArthur River flows at MRM are highly variable. High levels of streamflow are generally recorded during the 'wet season' which typically occurs from November to April. During the dry season, streamflow is much lower and long periods of little to no flow can occur. During major floods, the main channel of the McArthur River overflows and spreads floodwater laterally across the floodplain for several kilometres.

Figure 3.5 shows daily flow duration curves for the McArthur River at the MIM Pump station for the full period of record, and also for the wet (November to April) and dry (May to October) seasons during the period of record. The river flows are important in understanding the site water management strategy, as the site can discharge water into the river subject to compliance with water quality and flow conditions that are stipulated on a Waste Discharge License (WDL), which is issued by the Department of Natural Resources, Environment, The Arts & Sport (NRETAS). MRM's WDL (No 174-1) allows waste water discharge from the mine when the river height at the McArthur River at MIM Pump station is greater than 2 mGH (which is equivalent to approximately 200 ML/d). With respect to McArthur River flow characteristics at MRM, the following is of note:

- The McArthur River flows for approximately 84% of the time.
- The McArthur River flows are greater than the WDL trigger flow of 200 ML/d only for approximately 29% of the time.
- The McArthur River flows exceed the trigger flow more frequently during the wet season from November to April (47% of the time) than during the dry season from May to October (12% of the time).

Figure 3.6 shows the variation in McArthur River water levels at the MIM Pump Station between February 2006 and April 2011. Based on the available data, Table 3.4 shows a statistical summary of the monthly, seasonal and annual flows (in GL) in the McArthur River

at MIM Pump station for days when flows exceed 200 ML/d. Minimum, 90th percentile, median, 10th percentile and maximum flows for the period of record are shown. Table 3.5 shows the equivalent results for the number of days in each month and seasons that the mine could potentially discharge water into the river in accordance with their WDL conditions. The following is of note:

- Daily data was available for 43 years. However, there are significant gaps in the data set. Months with 5 or more days of missing data were excluded from the analysis. A total of 366 months out of the 504 months were included in the analysis. Only 9 of the 43 years had data available for the entire year.
- It was assumed that the wet season is the 6-month period between November and April (inclusive) and the dry season is the 6-month period between May and October (inclusive).
- There is significantly more opportunity to discharge water in the wet season than in the dry season. During a median year, the McArthur River flows approximately 290 GL past MRM in 6 months during the wet season compared to no flows in excess of 200 ML/d during the dry season. Generally, there is very little or no opportunity to discharge mine water off-site during the dry season based on current WDL limits.
- January, February and March are the most viable months for discharging mine water. Potential number of discharge days in January range from 3 to 19 for 90th to 50th percentile months. Potential number of discharge days in February range from 7 to 28 days for 90th to 50th percentile months. Potential number of discharge days in March range from 7 to 21 days for 90th to 50th percentile months. Potential number of discharge days between April and December are insignificant.

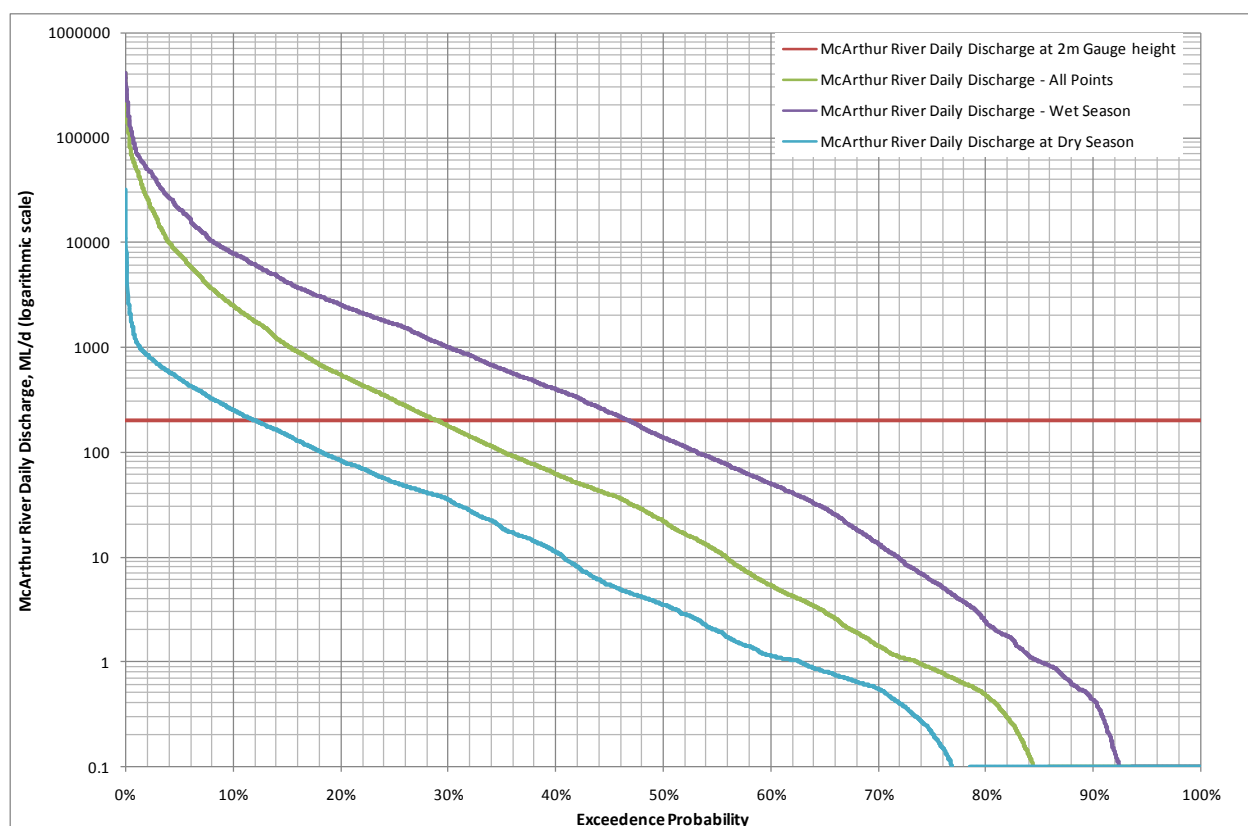


Figure 3.5 Daily Flow Frequency Curves for the McArthur River at MIM Pump Station, 1969-2011

Table 3.4 Monthly, Seasonal and Annual Statistics for McArthur River flows (in GL) during days when flows exceed 200 ML/d

	McArthur River Monthly Flows during days when flows exceed 200ML/d (GL/period)														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry	Annual
Minimum (Driest)	0	1	0	0	0	0	0	0	0	0	0	0	26	0	27
90 th %ile (Dry)	3	7	7	0	0	0	0	0	0	0	0	2	41	0	29
50 th %ile (Median)	55	79	103	2	0	0	0	0	0	0	1	12	289	0	289
10 th %ile (Wet)	582	548	356	96	23	13	6	0	0	1	16	70	1578	38	1509
Maximum (Wettest)	1433	1254	1204	684	77	24	13	4	2	23	63	982	2474	95	2569
Years of available data *	31	28	28	30	35	35	34	31	28	30	28	28	13	25	9

*43 Years of Data

Table 3.5 Monthly, Seasonal and Annual Statistics for the Number of days when McArthur River flows exceed 200 ML/d

	No. of Days where Flows in the McArthur River exceeds flow trigger level of 200ML/d (days)														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry	Annual
Minimum (Driest)	0	4	0	0	0	0	0	0	0	0	0	0	25	0	26
90 th %ile (Dry)	3	7	7	0	0	0	0	0	0	0	0	3	35	0	33
50 th %ile (Median)	19	28	21	4	0	0	0	0	0	0	2	9	69	0	69
10 th %ile (Wet)	31	28	31	30	31	30	23	0	0	1	9	19	122	83	176
Maximum (Wettest)	31	29	31	30	31	30	31	17	5	11	19	31	141	109	250
Years of available data *	31	28	28	30	35	35	34	31	28	30	28	28	13	25	9

*43 Years of Data

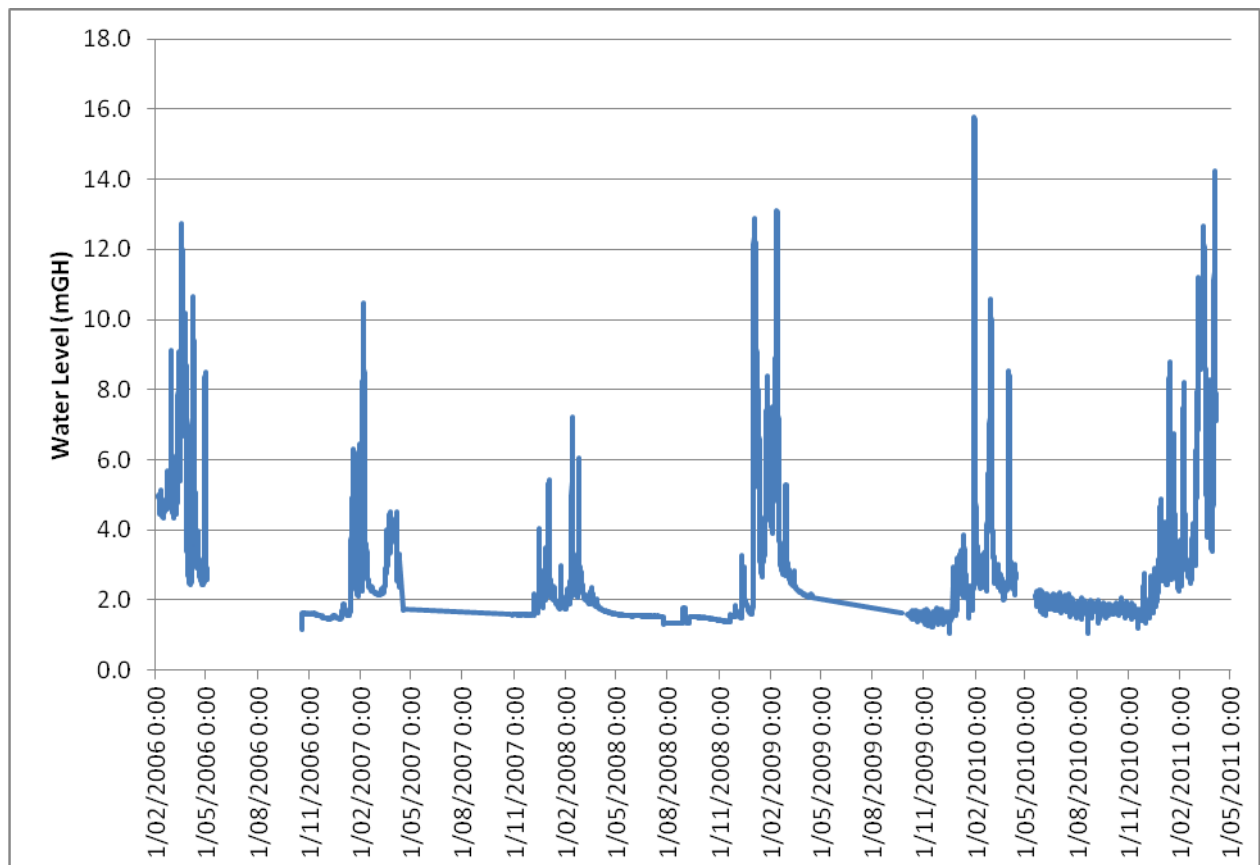


Figure 3.6 Water Level Variation at McArthur River at MIM Pump Station between February 2006 and April 2011

3.3.3 McArthur River Downstream of Glyde River Junction

Data available for the McArthur River stream gauging station downstream of the Glyde River is limited and unreliable. Further, no rating curve is available for this station to estimate discharges from recorded water levels. However, Figure 3.7 shows the variation in McArthur River water levels downstream of the Glyde River junction for the period between February 2006 and September 2008. The figure indicates that the McArthur River flows at MRM are highly variable. High flows are generally recorded only during the wet season. During the dry season, flows are much lower and long periods of little to no flow can occur.

3.3.4 Barney Creek at MRM Site

Data available for the Barney Creek stream gauging station is limited and unreliable. During McArthur River high flow events, water levels at this station are affected by backwater from the McArthur River. The stage-discharge relationship (i.e. rating curve) available for this station does not take into account the McArthur River backwater effects and therefore is considered unreliable. Figure 3.8 shows the variation in Barney Creek water levels at the MRM site between October 2009 and May 2010. Available data shows that Barney Creek at MRM flows only for short periods and high flows are generally recorded only during the wet season. During the dry season there is little or no flow in Barney Creek.

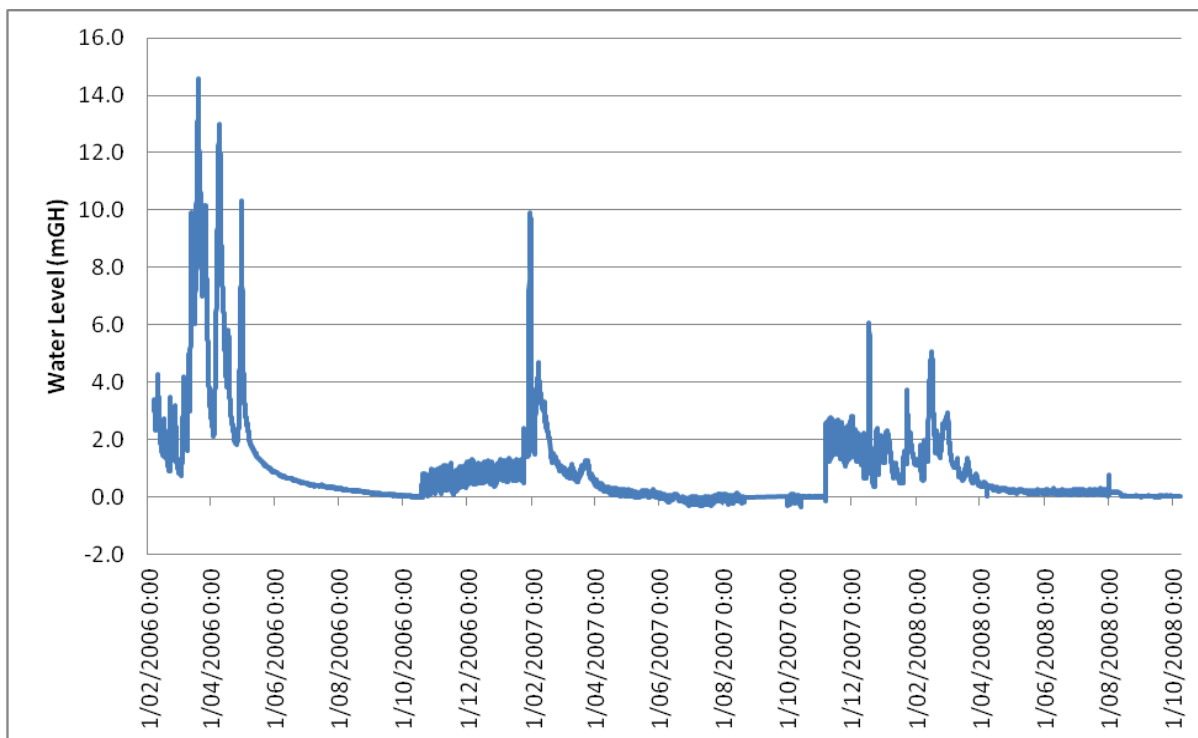


Figure 3.7 Water Level Variation in the McArthur River Downstream of Glyde River between February 2006 and September 2008

3.3.5 Glyde River Upstream of McArthur River Junction

Figure 3.9 shows the variation in the Glyde River water levels upstream of the McArthur River junction between November 2008 and March 2010. Data available for the Glyde River stream gauging station is limited. Further, no rating curve is available for this station. It is possible that water levels at this station are affected by backwater from the McArthur River during high flow events in the McArthur River. Available data suggests that significant flows occur in the Glyde River only for short periods and high flows are generally recorded only during the wet season. During the dry season there is little flow in the Glyde River.

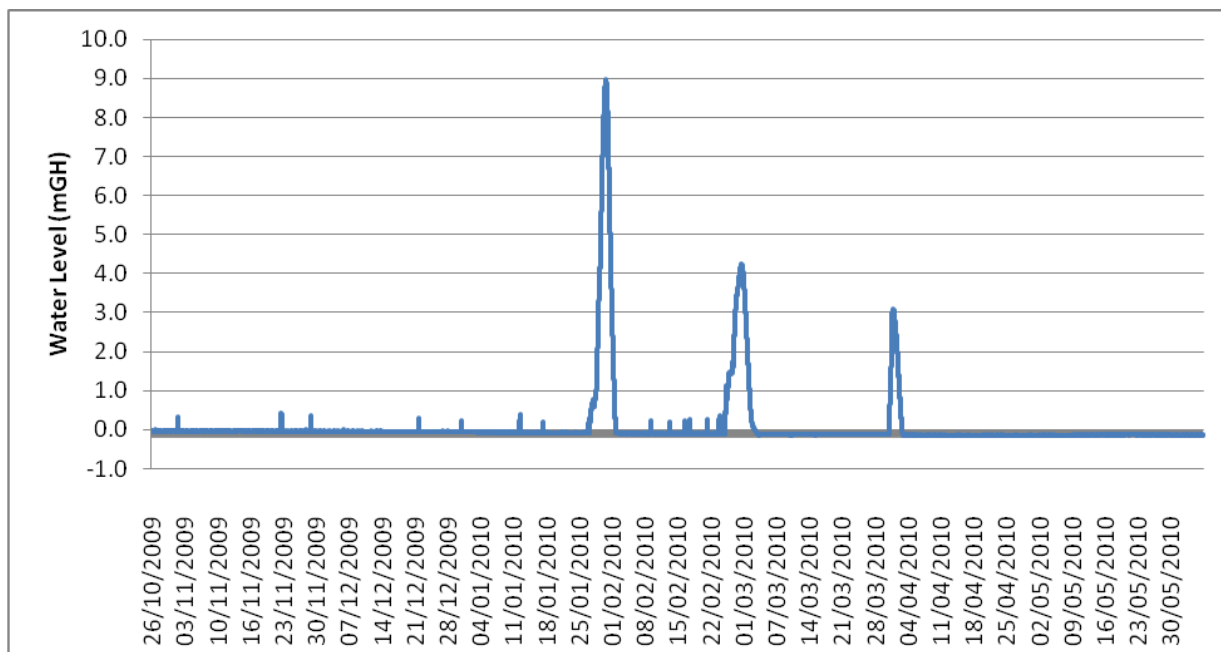


Figure 3.8 Water Level Variation at Barney Creek Gauging Station at MRM between October 2009 and May 2010

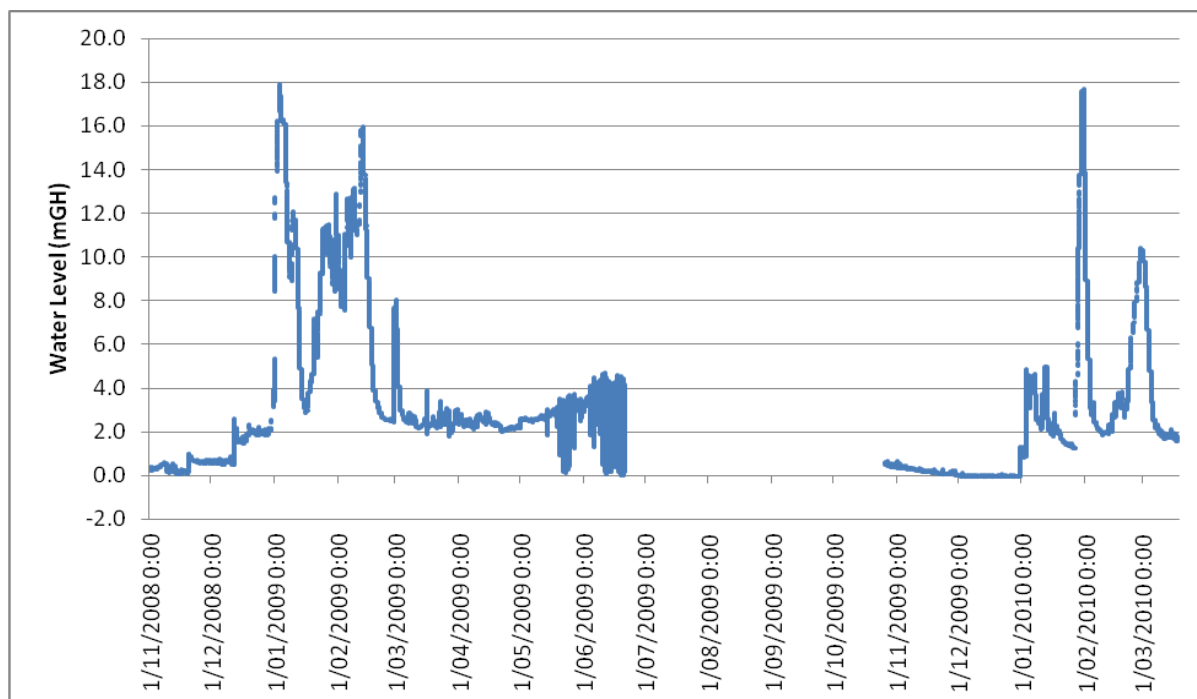


Figure 3.9 Water Level Variation in the Glyde River Upstream of the McArthur River Junction between November 2008 and March 2010

3.3.6 McArthur River MRM Flood Warning Station

The flood warning station in the McArthur River, operated by MRM, is located just downstream of the confluence of Kilgour and McArthur rivers. Although this station has been operational since August 2008, data for the station is only available from July 2010. Figure 3.10 shows the available data for the water level variation in the McArthur River at the flood warning station for the 2010/2011 wet season.

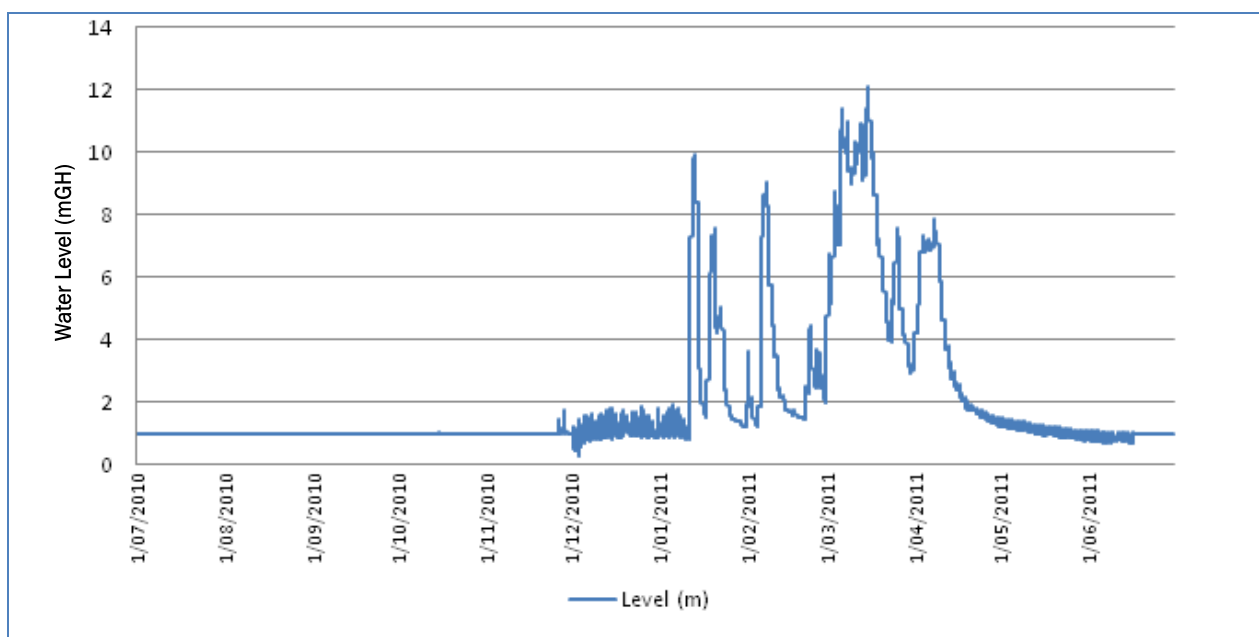


Figure 3.10 Water Level Variation at the McArthur River Flood Warning Station during the 2010/2011 Wet Season

4 SURFACE WATER QUALITY

4.1 AVAILABLE DATA

MRM has been operating a comprehensive surface and groundwater quality monitoring network within and in the vicinity of the mine site to assess background water quality and measure the impact of mining activities on water quality. Details of MRM's water quality monitoring network, its objectives, and the data collected at all stations over the reliable period of record dating back to 2007 are presented in the MRM Sustainable Development Water Management Plan - SDWMP (MRM, 2011). Currently water quality is monitored at 24 surface water sampling stations, 31 groundwater bores, and all major on-site storages, including the Tailings Storage Facility (TSF).

Figure 4.1 shows the location of the surface water monitoring sites in and around the MRM site. The surface water monitoring station SW11, located on the McArthur River immediately downstream of the mine site, is considered to represent the quality of water leaving the mining lease. Therefore, in conditions specified in MRM's Waste Discharge License (WDL 174-1) SW11 is the compliance point for external reporting and compliance, in conjunction with the surface water monitoring station SW21, which is located on the McArthur River upstream of the mine site.

4.2 WATER QUALITY COMPLIANCE CRITERIA

The streams in the vicinity of MRM are considered to be '*slightly to moderately disturbed*'. Accordingly, surface water quality for monitoring MRM's environmental performance is assessed as per the applicable Australian and New Zealand Guidelines for Fresh and Marine Waters (ANZECC, 2000), in particular the following water quality trigger values:

- Freshwater (95% level of ecosystem protection)
- Marine water (95% level of ecosystem protection)
- Livestock drinking water
- Irrigation water

ANZECC (2000) default trigger values are used for most surface water parameters, with the exception of sulphate for which interim site specific values are used in consultation with the Department of Resources (MRM, 2011). The influence of hardness on natural surface waters in the vicinity of MRM is taken into account through the use of Hardness Modified Trigger Values (HMTV's). As described in the SDWMP, the HMTV's have been calculated according to the methodology given in Table 3.4.3 of ANZECC (2000). Note that the recorded hardness in the McArthur River, Barney Creek and Surprise Creek are different. Therefore, the HMTVs vary for each stream.

Table 4.1 shows the ecosystem protection trigger values specified in MRM's WDL 174-1 as per ANZECC (2000) guidelines for key water quality parameters for freshwater, marine water, livestock water and irrigation water. It is of note that the trigger values for freshwater and marine water are several orders of magnitude lower than the equivalent values for livestock and irrigation watering.

4.3 EXISTING SURFACE WATER QUALITY

All surface water quality data collected by MRM to date and results from detailed analyses of the available data are presented in the SDWMP (MRM, 2011). A brief summary assessment of data relevant to surface water management at the mine site is presented below.

Figure 4.2 to Figure 4.4 compares recorded data with the HMTV for key water quality parameters (pH, As, Cd, Cu, Pb, Zn and SO₄) at the key monitoring sites in the McArthur River, Barney Creek and Surprise Creek. Data are shown for the following monitoring sites (see Figure 4.1 for locations):

- The McArthur River - SW21 and SW10, located upstream of MRM, and SW11, located downstream of MRM;
- Barney Creek - SW4 and SW22, located upstream of MRM; and
- Surprise Creek - SW23 and SW1, located upstream of the TSF.

Full interpretation of the background and existing mine site surface water quality data is given in the SDWMP. Based on data and results provided in the SDWMP:

- Surface water quality in the vicinity of MRM is affected by strong seasonal stream flows and generally high background levels of heavy metals, in particular Cu, Pb and Zn, in the water and stream sediments.
- Background levels of heavy metals in McArthur River flows in the vicinity of MRM are naturally elevated due to the close proximity of mineralised zones to the surface.
- Salinity, pH and SO₄ levels are also strongly related to stream flows. Salts tend to accumulate during the dry season as a result of evaporation in pools, and then salt concentrations drop dramatically during the wet season due to dilution and flushing from high flows.
- The metals Cu, Pb and Zn show the opposite trend to salt. Concentrations tend to increase during the wet season when turbidity levels are highest, consistent with strong metal-sediment attachment properties.

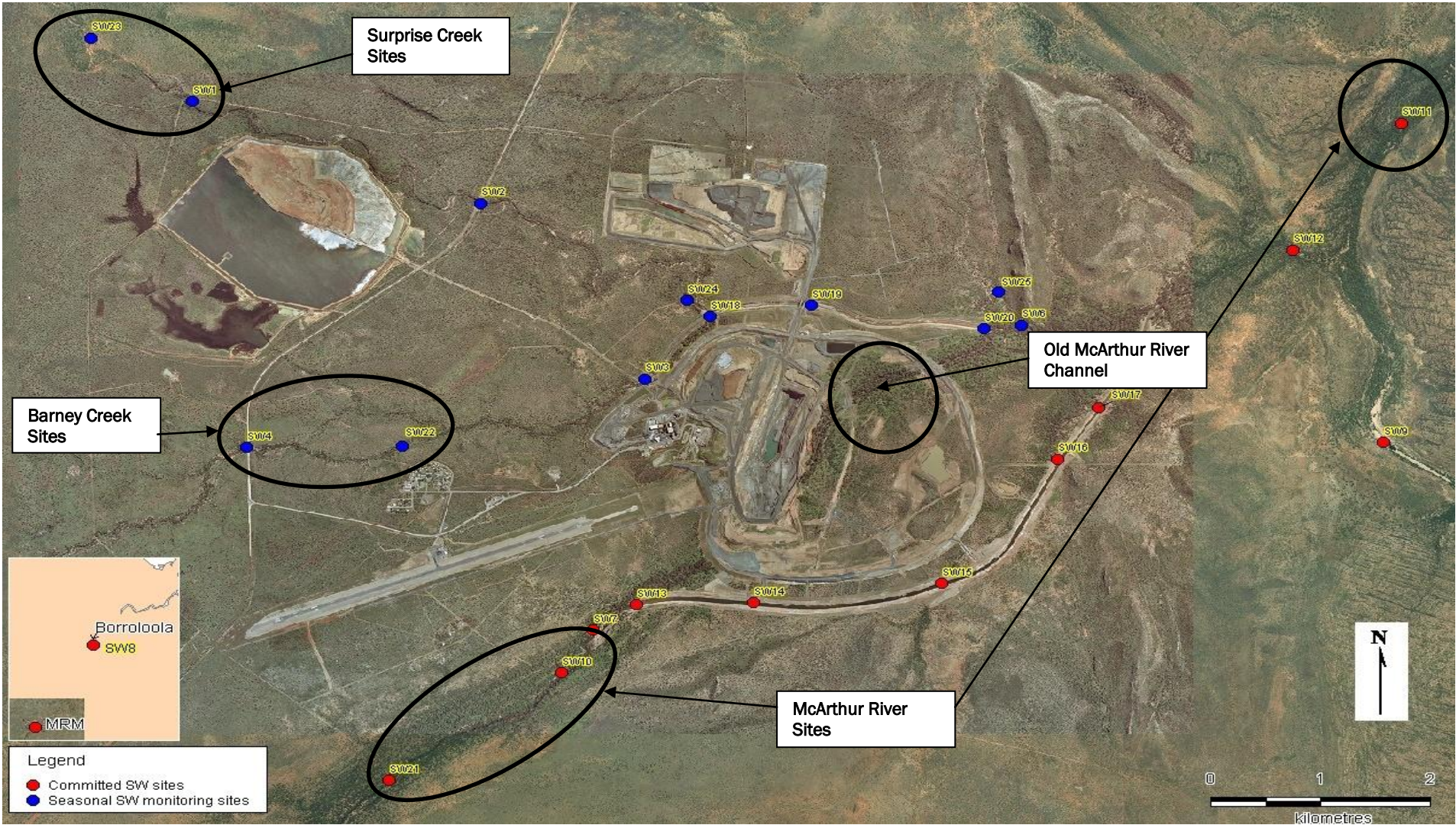


Figure 4.1 MRM Natural Surface Water Monitoring Sites

Table 4.1 Key Water Quality Trigger Values for MRM WDL 174-1 for Freshwater, Marine Water, Livestock Water and Irrigation Water

Parameter	Trigger Value				
	MRM WDL174-1 adjusted for Hardness ^f	ANZECC (2000) for Freshwater (95%)	ANZECC (2000) for Marine Water (95%)	ANZECC (2000) for livestock	ANZECC (2000) for irrigation
pH	<6.0 and >8.5	<6.0 and >8.0	<8.0 and >8.4	n/a	<6.0 and >8.5 ^d
Arsenic (As) in µg/L	ANZECC (2000)	13	2.3 ^g	500	100 to 2,000 ^c
Cadmium (Cd) in µg/L	1.79	0.2	5.5 (0.7) ^h	10	10 to 50 ^c
Copper (Cu) in µg/L	11.33	1.4	1.3	400-5,000 ^a	200 to 5,000 ^c
Lead (Pb) in µg/L	77.28	3.4	4.4	100	2,000 to 5,000 ^c
Zinc (Zn) in µg/L	64.72	8	15	20,000	2,000 to 5,000 ^c
Sulphate (SO ₄) in mg/L	15.8 ^e	n/a	n/a	1,000	n/a
Electrical Conductivity (EC) in µS/cm	n/a	150 to 250	n/a	2,985 to 7,463 ^a	600 to 4,200 ^b
Hardness in mg/L	n/a	n/a	n/a	n/a	60,000 CaCO ₃ for corrosion 350,000 CaCO ₃ for fouling

^a dependant on the type of livestock

^b dependant on the type of crop. Range given for clay soils

^c depends on the life of operations. High value for short term use (<20 years). Low value for long term use (<100 years).

^d limits to prevent corrosion, encrustation and fouling of irrigation systems

^e Interim Site Specific Trigger Value

^f We believe the adjusted values are based on a CaCO₃ concentration of approximately 350 mg/L

^g Should be used as an indicative interim working value only due to insufficient data to produce a reliable trigger level

^h Guidelines recommend that possible bioaccumulation and secondary poisoning effects should be considered. It is recommended the 99% value (in brackets) be adopted

n/a - not available

Note that the indicators above are not the only considering factors. Indicators were chosen based on availability of recorded data.

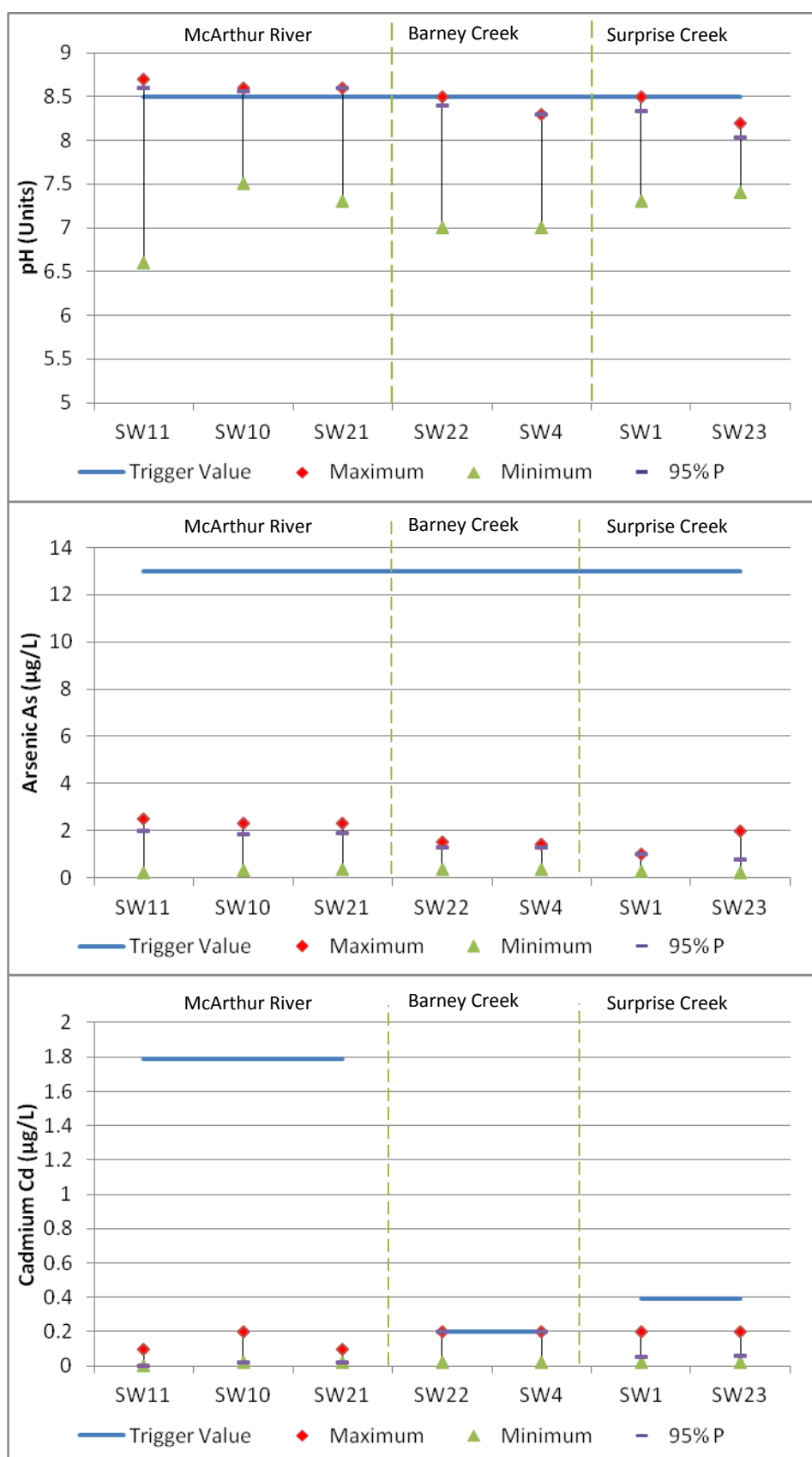


Figure 4.2 McArthur River, Barney Creek and Surprise Creek Water Quality (pH, As & Cd)

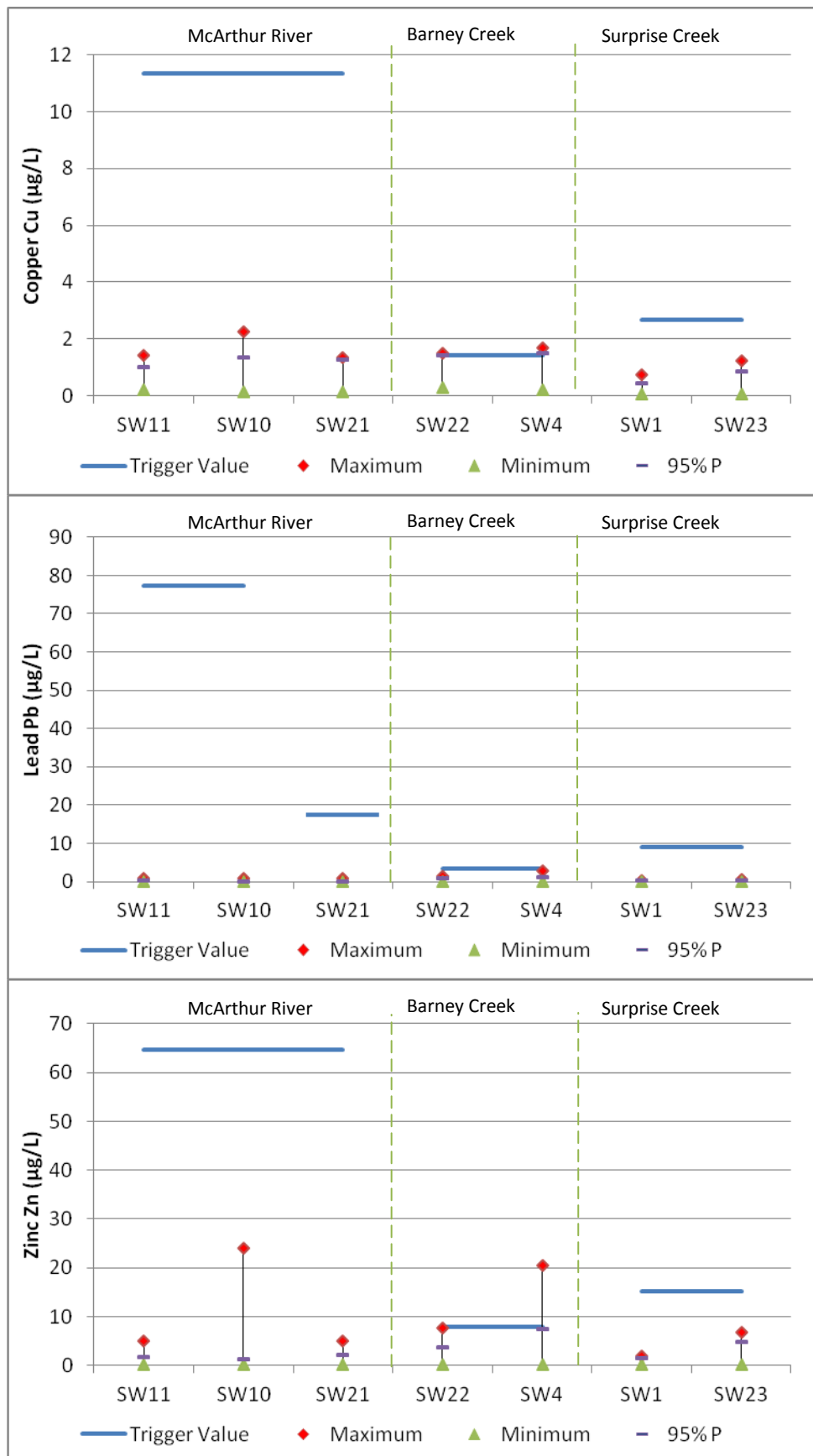


Figure 4.3 McArthur River, Barney Creek and Surprise Creek Water Quality (Cu, Pb & Zn)

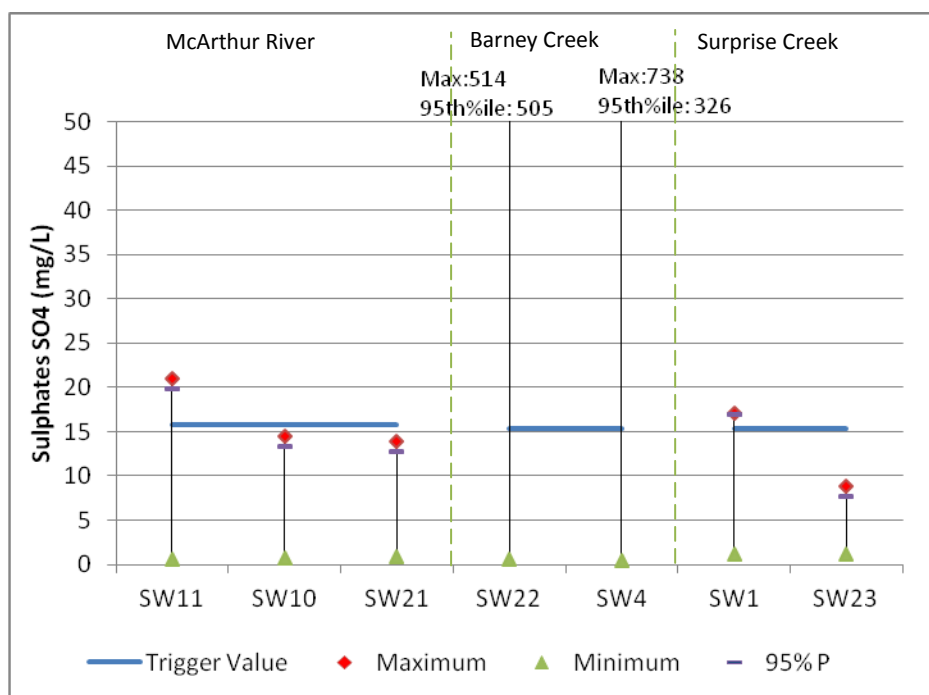


Figure 4.4 McArthur River, Barney Creek and Surprise Creek Water Quality (SO₄)

Table 4.2 shows the surface water quality summary statistics for McArthur River, Barney Creek, Surprise Creek and the Old McArthur River channel (see Figure 4.1 for monitoring sites) for a range of key water quality parameters (i.e. minimum, maximum, median and 90th percentile concentrations) including pH, electrical conductivity (EC), arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn) and sulphates (SO₄). Table 4.3 shows the water quality summary statistics for Lake Archer and the Open pit sump. Lake Archer and the Pit Sump data is considered to best represent the quality of Open pit water. The location of MRM site storages and a schematic of current site water circuit are shown in Figures 6.1 and 6.2 respectively. The following are of note:

- Recorded data that exceeds the MRM WDL174-1 water quality trigger values are shaded green in Tables 4.2 and 4.3.
- Recorded natural surface water concentrations of water quality parameters are generally within the limits specified in the MRM WDL174-1. The natural surface water is slightly more alkaline than the trigger value for pH, and sulphate levels are slightly above the trigger values at the downstream reporting location of the McArthur River (SW11).
- For the Old McArthur River channel, the water quality is generally within limits specified in the MRM WDL174-1 except for sulphates, which are approximately 15 times greater than the trigger value. Note that it appears that this high value is based on a single sample.
- For Lake Archer and the Pit Sump water, the concentrations for arsenic, cadmium, lead, zinc and sulphates exceed the MRM WDL174-1 trigger values. The Pit Sump has zinc and sulphate concentrations up to 255 and 135 times respectively greater than the trigger values, whilst Lake Archer has values that are 57 and 61 times greater respectively.

Further details on the artificial surface water quality data, including an interpretation of that data, are presented in the SDWMP (MRM, 2011).

Table 4.2 Summary Surface Water Quality Data, McArthur River

Parameter	Units	MRM WDL174-1 Trigger Value	SW11				SW10				SW21				Old McArthur River
			Median	95 th ile	Min	Max	Median	95 th ile	Min	Max	Median	95 th ile	Min	Max	
pH		<6 and >8.5	8.3	8.6	6.6	8.7	8.3	8.56	7.5	8.6	8.4	8.6	7.3	8.6	7.4
EC	µS/cm	n/a	662	751.6	21	783	679	724.2	79	741	662	713	66	735	565
Arsenic (As)	µg/L	13	1.1	2	0.2	2.5	1	1.86	0.3	2.3	1	1.9	0.35	2.3	1.08
Cadmium (Cd)	µg/L	1.79	0	0	0	0.1	0.02	0.02	0.02	0.2	0.02	0.02	0.02	1	0.02
Copper (Cu)	µg/L	11.33	0.5	1	0.2	1.4	0.42	1.33	0.14	2.25	0.49	1.26	0.13	1.35	0.97
Lead (Pb)	µg/L	77.28	0	0.2	0	1	0.01	0.14	0.01	0.79	0.02	0.15	0.01	1	<0.1
Zinc (Zn)	µg/L	64.72	0.5	1.7	0.2	5	0.5	1.36	0.2	24.1	0.5	2.14	0.2	5	33.1
Sulphates (SO ₄)	mg/L	15.8	12.2	19.8	0.6	21	8.2	13.26	0.8	14.5	7.4	12.72	0.9	13.9	248

Table 4.3 Summary Water Quality Data, Lake Archer and Open Pit Sump

Parameter	Units	MRM WDL174-1 Trigger Value	Lake Archer				Pit Sump			
			Median	95 th ile	Min	Max	Median	95 th ile	Min	Max
pH		<6 and >8.5	8.2	8.2	7.5	8.2	7.7	7.9	6.8	8.0
EC	µS/cm	n/a	1210	1594	1200	1650	3320	3730	2830	3760
Arsenic_As	µg/L	13	31.0	40.4	1.5	41.0	1.1	15.9	0.5	16.5
Cadmium_Cd	µg/L	1.79	2.1	18.0	0.2	20.4	8.5	14.7	2.8	15.6
Copper_Cu	µg/L	11.33	0.9	2.1	0.4	2.3	0.7	1.8	0.4	1.9
Lead_Pb	µg/L	77.28	6.0	31.2	0.3	36.6	58.2	77.5	49.9	77.9
Zinc_Zn	µg/L	64.72	488	3974	48	4560	13500	16610	1770	16700
Sulphates (SO ₄)	mg/L	15.8	250	895	167	928	2000	2140	1600	2170

5

SURFACE WATER MANAGEMENT OBJECTIVES

5.1 GENERAL

For surface water management purposes, the surface runoff generated in the McArthur River Mine Phase 3 Project Site is divided into three types based on water quality:

- **'Clean'** – surface runoff from areas of the Project Site where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas.
- **'Dirty'** – surface runoff water and seepage from the Project Site areas that are disturbed by mining operations such as NAF waste rock dumps and roads. This runoff may contain silt and sediment, but is unlikely to contain contaminant concentrations in excess of ANZECC (2000) guidelines for a 95% level of protection in freshwater ecosystems for key water quality parameters (adjusted for water hardness). However, this runoff must be of suitable quality if discharge into natural watercourses is required.
- **'Contaminated'** – surface runoff water and seepage from areas affected by mining operations and potentially containing chemicals of various types generated by mining operations. Areas where hazardous waste can potentially be generated include where ore is stockpiled, areas where PAF waste rock is encapsulated in NAF waste rock in a waste rock dump, the open pit and underground mine voids, and process areas. Runoff from these areas must be managed to avoid discharge of potentially contaminated water into the natural watercourses. There are restrictions on the use and release of this water.

The following type of groundwater generated at the McArthur River Mine Phase 3 Project Site is also of relevance to the proposed surface water management system based on its water quality:

- **'Intercepted Groundwater'** – groundwater that is intercepted by proposed dewatering bores and spears before it enters the open pit (i.e. before it is contaminated by mixing with water in the open pit and underground mine). Based on available groundwater water quality monitoring data (see MRM, 2011), the intercepted groundwater would have moderately elevated levels of Zn and SO₄, but is unlikely to contain contaminants at concentrations in excess of ANZECC (2000) guideline trigger levels for a 95% level of protection in freshwater ecosystems for other key water quality parameters (when adjusted for water hardness).

5.2 MANAGEMENT OBJECTIVES

The general surface water management objectives for the various construction and Phase 3 mining phases at MRM are as follows:

- Separate 'clean', 'dirty' and 'contaminated' water runoff as much as possible;
- Minimise the area of surface disturbance, thus minimising the volume of 'dirty' and/or 'contaminated' runoff;
- Treat all 'dirty' water on site via containment storages or sediment ponds dependant on the toxicity of contaminants likely to be generated;
- Controlled release of 'dirty' water treated in proposed sediment ponds, provided water quality is within the MRM WDL water quality release limits. (Proposed release and design criteria for sediment ponds are discussed in detail in section 7.6);
- Segregate, collect and contain all 'contaminated' runoff on site via adequately sized containment storages;
- The provision of permanent pumping infrastructure to allow transfer of 'contaminated' runoff between containment storages as required, minimising the potential for overflows;
- Minimise 'raw' water consumption and maximise reuse of 'contaminated' water within the mine site (e.g. for ore processing) without releasing it off-site;
- Maximise evaporation of on-site excess 'contaminated' water in MRM dams in order to minimise the need for off-site releases and/or reliance on external water demands; and
- Further excess 'contaminated' water would then be treated to adopted water quality compliance criteria prior to release into the surrounding environment and/or supply for external water use (such as off-site irrigation).

5.3 POTENTIAL CONSTRAINTS TO PROPOSED PHASE 3 MINING ACTIVITIES

The potential constraints to the MRM Phase 3 mine project, in relation to surface water management, are identified as follows:

- Significant groundwater inflows to the open pit and underground mine void may be encountered as mining progress. Groundwater modelling undertaken by URS (2011) predicts average annual groundwater inflows of up to approximately 6200 ML (17 ML/d) with daily inflow rates varying from approximately 13 ML/d during the dry season to approximately 23 ML/d during the wet season.
- Potential flooding from the McArthur River, Barney Creek and Surprise Creek. Most of the existing mine infrastructure, the TSF, the open pit and the North Overburden Emplacement Facility (OEF) are located within the McArthur River floodplain and without appropriate management, could potentially be affected by McArthur River, Barney Creek and/or Surprise Creek floodwaters.
- The quality of 'intercepted' groundwater. The available groundwater quality data is insufficient to accurately assess whether the quality of intercepted groundwater (a significant volume of which is proposed for use in off-site irrigation) is suitable for off-site irrigation purposes without treatment.

6

EXISTING SURFACE WATER MANAGEMENT SYSTEM

6.1 OVERVIEW

The water management system (strategies, operational procedures, infrastructure, etc) at MRM is continuously reviewed and updated as required. The improvements made to the water management system and performance of the water management system are documented in detail and presented annually to the Northern Territory Government in a report entitled 'Sustainable Development Management Water Management Plan'. The current water management system is described in 'Sustainable Development Water Management Plan, 2011/2012', a report prepared in August 2011 (MRM, 2011). This report includes:

- A description of the existing water management infrastructure, controls and issues at MRM;
- Justification for and details of new water management infrastructure and controls proposed for the next 12 months and beyond;
- Details of surface water and groundwater monitoring undertaken during the previous year and a review of water quality results; and
- Details of water balance modelling undertaken to assess the current water management system performance and to assess the impact of proposed changes to the water management system.

The water management system at MRM has to cope with pronounced wet and dry seasons, in addition to significant variations from year-to-year. This means that the water management system should be capable of accommodating distinct seasonal fluctuations and severe shortages and surpluses of water over the life of the mine.

6.2 EXISTING WATER MANAGEMENT INFRASTRUCTURE

Figure 6.1 shows the current configuration of the MRM site, including the existing water management infrastructure. Figure 6.2 shows a schematic of the existing water circuit at MRM. The existing water management infrastructure consists of the following:

- Contaminated Water Management:
 - A Tailings Storage Facility (**TSF Cell2**) to store fine rejects (tailings) from the Concentrator Product Plant (Mill), as well as seepage water pumped from the base of the TSF.
 - A Water Management Dam (**TSF Cell3 WMD**) (future TSF Cell 3) that also collects overflows from TSF Cell 2 during extreme runoff events.

- An inactive tailings storage facility (**TSF Cell1**) that is currently being capped with clay and NAF material and rehabilitated. Seepage sumps and borrow pits are located around the TSF Cell 1 to collect seepage reporting at the base of the TSF Cell 1. Seepage water is pumped to the pond in TSF Cell2.
 - An out-of-pit mine water dam (Pete's Pond (**PP**)) to collect water pumped out from the open pit and underground mine void. It is also a distribution point for contaminated water.
 - A concentrator runoff dam (Concentrator Runoff Pond (**CRP**)) to collect overflows from the Mill and Decant Water Tank (**DWT**).
 - A contaminated runoff dam (Anti-Pollution Pond (**APP**)) to collect runoff from the mine infrastructure area as well as pumped inflows from the CRP and return water from the TSF Cell 2. The APP supplies the Mill process water demands (via the DWT).
 - A West Overburden Emplacement Facility (OEF) runoff dam (Van-Duncan's Dam (**VDD**)) to collect NAF runoff from the West OEF. The VDD supplies the road watering demands.
 - An out-of-pit mine water dam (Lake Archer (**LA**)) to collect runoff from part of the West OEF and infrastructure area to the north-west as well as pumped inflows from interception bores along the McArthur River palaeo-channel.
 - An open pit (**OC**) that collects runoff from the open pit, groundwater inflows as well as residual moisture from the pit evaporative fans.
 - A decommissioned underground mine void (**UG**) to collect runoff from the open mine as well as groundwater inflow.
 - A temporary out-of-pit mine water dam (Eastern Levee Storage (**ELS**)) to collect water pumped out from the open pit and underground mine void.
 - A clean water dam (Old-McArthur River (**OMR**) channel to collect runoff from the natural catchment area within the mine levied area.
 - Two containment dams at North OEF (Southern PAF Sediment Dam (**SPSD**) and Southern PAF Run-Off Dam (**SPROD**)) to collect runoff from Potentially Acid Forming (PAF) runoff from the North OEF as well as water pumped out from PP to maximise evaporation.
 - A Raw Water Tank (**RWT**) to receive production bore water pumped from the MIMEX, Emu and Donkey production bores.
 - A Mill supply tank (Decant Water Tank (**DWT**)) to receive water pumped from the RWT and APP.
 - Evaporative Fans to enhance water losses from TSF Cell 2 and PP.
 - Sprinklers and water fountains at storages to enhance evaporation losses.
- Dirty Water Management
 - Numerous silt traps/sediment ponds located strategically across the mine site to prevent dirty on-site water directly flowing into the natural waterways.
 - Clean Water Management:
 - McArthur River diversion around the southern boundary of the open pit.
 - Bunds, drains and re-contouring within the flood protection levee wall area to direct clean water away from the open pit.

- Barney Creek diversion around the northern boundary of the open pit.
 - Little Barney Creek diversion around the western boundary of the TSF.
 - Flood protection levee around the perimeter of the open pit.
- Waste Discharge Licence Release Points:
 - WMD into Little Barney Creek.
 - OMR into the McArthur River.

Table 6.1 shows a list of existing mine water storages and their storage capacities at Full Storage Level (FSL). Further and more detailed information on the existing water management system and infrastructure can be found in the SDWMP (MRM, 2011).

Table 6.1 Storage Capacities of Existing Dams

Dam Name	Storage Capacity at FSL (ML)
Anti Pollution Pond (APP)	23
Concentrator Runoff Pond (CRP)	27
Van-Duncans Dam (VDD)	25
Pete's Pond (PP)	100
Cell 3 Water Management Dam (Cell 3 WMD)	1834
Lake Archer (LA)	20
Eastern Levee Storage (ELS)	850
Old McArthur River (OMR) Channel	600
North Overburden Emplacement Facility (North OEF) Southern PAF Sediment Dam (SPSD)	250
Northern Overburden Emplacement Facility (North OEF) Southern PAF Runoff Dam (SPROD)	810

6.3 WASTE DISCHARGE LICENCE (NO. 174-1)

Controlled releases from the WMD and OMR are permitted in accordance with the MRM's waste discharge licence (WDL No. 174-1). Controlled releases from these storages are permitted only when the following water quantity and water quality objectives can be met:

- The river height at the McArthur River upstream gauging station (SW10 on Figure 4.1) is greater than 2 mGH (which is equivalent to approximately 200 ML/d);
- The water quality at the downstream compliance point (SW11 on Figure 4.1) (downstream of the mixing zone) is within specified water quality trigger levels; and
- A dilution ratio of at least 1 part mine water to 160 parts McArthur River water is achieved for the discharge of mine water to the McArthur River (this dilution limit has been set based on MRM (2011) eco-toxicity test results).

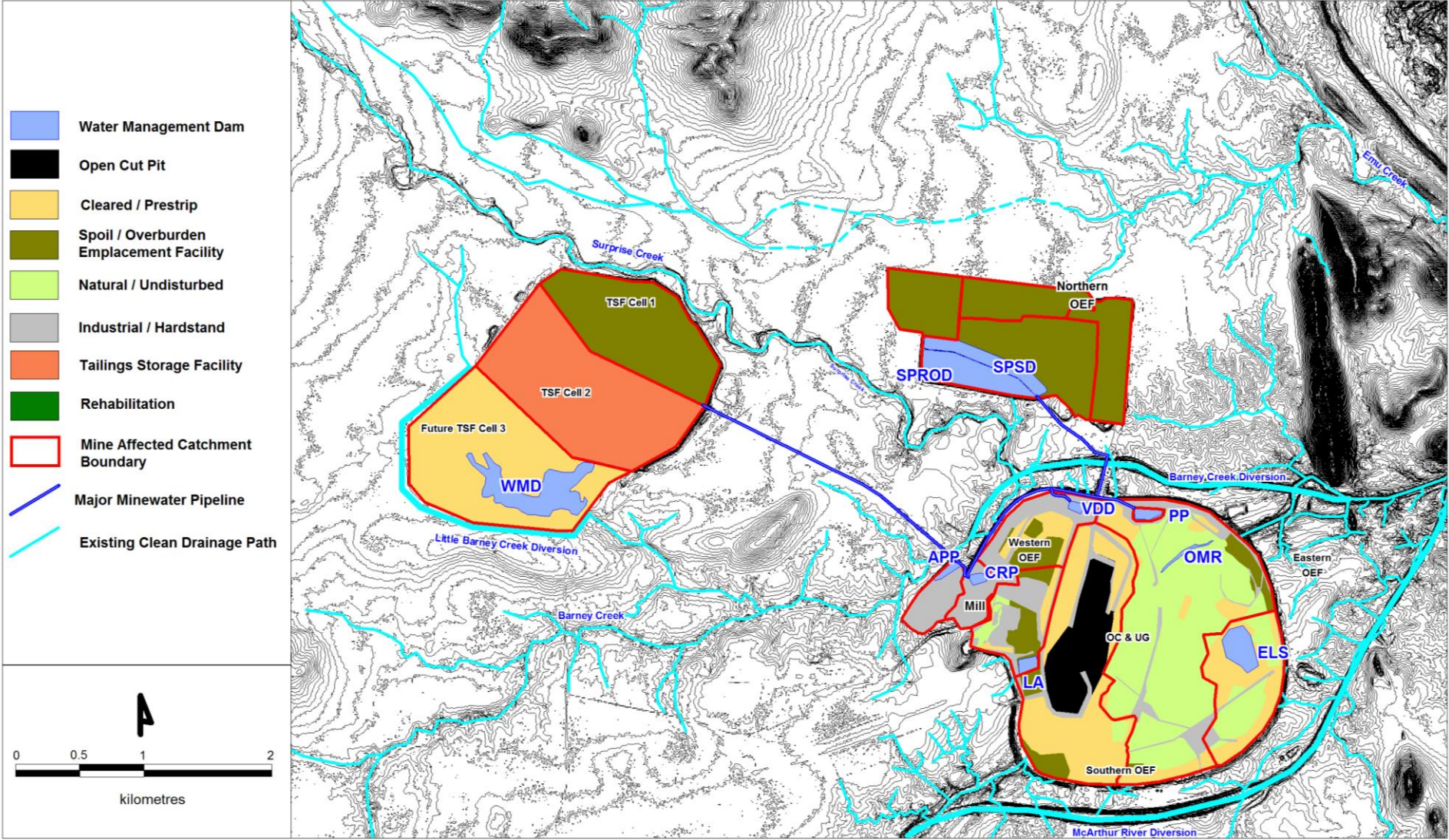


Figure 6.1 Current McArthur River Mine Water Management Infrastructure and Land Use Plan



7

PROPOSED SURFACE WATER MANAGEMENT MEASURES

7.1 GENERAL

7.1.1 Overview

The MRM Phase 3 mining operations require changes to the existing surface water management measures to accommodate the proposed changes to the mine site layout (e.g. increased open pit area and extended overburden emplacement areas). The TSF will also be expanded in 2012, separate to the MRM Phase 3 development. The proposed Phase 3 surface water management strategy will use a number of existing surface water management measures as well as a number of additional surface water management measures that will be implemented during both construction and operational phases. The overall philosophy and objectives of the MRM surface water management system will remain the same as outlined in Section 5.

This section details the proposed water management measures to separate 'clean' runoff from the 'dirty' and 'contaminated' runoff areas and the management measures proposed to manage 'dirty' and 'contaminated' water at the MRM mine site during Phase 3 operations.

Figure 7.1 to Figure 7.5 show the locations of the existing and proposed water storages, and contributing catchment areas and land uses during Phase 3 mining operations at five progressive stages of mining (2015, 2020, 2025, 2030 and 2035). Figure 7.6 shows a schematic of the proposed water circuit for the Phase 3 mining operations. For the purposes of reporting, the MRM site surface water drainage system has been divided into 3 separate areas as follows:

1. The open pit area (including the South and East OEFs);
2. The Tailings Storage Facility (TSF) area; and
3. The North Overburden Emplacement Facility (North OEF) area.

Note that surface water management in the above three areas is integrated and will be managed as a single site-wide water management system. Appendices A, B and C provide further details on the locations of surface water controls for the open pit area, TSF area and North OEF area respectively.

It is of note that no further diversions of the McArthur River, Barney Creek or Surprise Creek channels are proposed as part of Phase 3 mine development.

7.1.2 Surface Water Management Strategies

The diversion of 'clean' runoff away from disturbed areas will reduce erosion and the potential for contamination of 'clean' runoff. A series of diversion bunds and 'clean' runoff drains are proposed to divert clean water away from disturbed areas of the mine site.

'Dirty' runoff at the Project site will be managed by constructing several sediment ponds around the perimeter of the North, South and East OEF's as well as the rehabilitated surface areas of the TSF. 'Dirty' runoff drains will be constructed to capture and direct 'dirty' runoff into the proposed sediment ponds. The sediment pond and drain locations have been selected taking into account the topography of the mine site and to provide the most sustainable locations for the life of Phase 3 mining operations.

'Contaminated' water at the expanded mine site will be managed by using the existing containment storages (PP, APP, CRP, VDD, LA, WMD, SPROD and SPSP) as well as TSF Cells 2 and 3. In addition, the following new water storages are proposed:

- Four (4) PAF Runoff dams around the perimeter of North OEF; and
- The TSF Cell 4 WMD.

'Contaminated' runoff systems will be configured to limit the mixing of 'dirty' and 'contaminated' water. The following is of note:

- Within the North OEF, 'contaminated' runoff will be collected in drains in areas where PAF material is exposed and directed into the PAF Runoff dams;
- TSF Cell 4, will collect tailings only towards the end of the mine life (from 2032 to 2036), which will be built in 2012 separate to the Phase 3 mining activities for use as a 'contaminated' water storage and evaporation pond for the open pit and underground mine void;
- An additional 'contaminated' water storage may be required to manage water dewatered from the open pit when TSF Cell 4 is used for tailings deposition after 2032. The additional post-2032 storage requirement will be assessed in the future when more Phase 3 operational data becomes available; and
- Sprinklers and/or sprays will be installed in all 'contaminated' water storages to maximise evaporation losses. In addition, six (6) evaporation fans have been installed at the open pit and a further six (6) at the TSF to maximise evaporative losses from Pete's Pond and the TSF. Full details of the operation and performance of the installed sprinklers, sprays and evaporation fans are given in the SDWMP (MRM, 2011).

The 'intercepted' groundwater at the mine site will be managed using the existing WMD (TSF Cell3 WMD). Groundwater flowing into the open pit is to be intercepted by constructing dewatering bores and spears around the open pit perimeter. The 'intercepted' water will be pumped to the TSF Cell 3 WMD. Excess 'intercepted' water within the MRM water management system will be either released to the McArthur River under an appropriate 'controlled' release strategy during high flows in the river or if quality allows pumped off-site for irrigation use at the McArthur River Pastoral Lease (MRPL). A waste discharge licence would be required from NRETAS to allow controlled releases of 'intercepted' water stored in the TSF Cell 3 WMD to the McArthur River or off-site to MRPL.

The following sub-sections describe the various components of the MRM surface water management system proposed for the Phase 3 mining operations. The behaviour and performance of the proposed water management system (including existing and proposed water storages) over the mine life have been investigated using a long-term historical simulation water balance model, as described in Section 8 of this report.

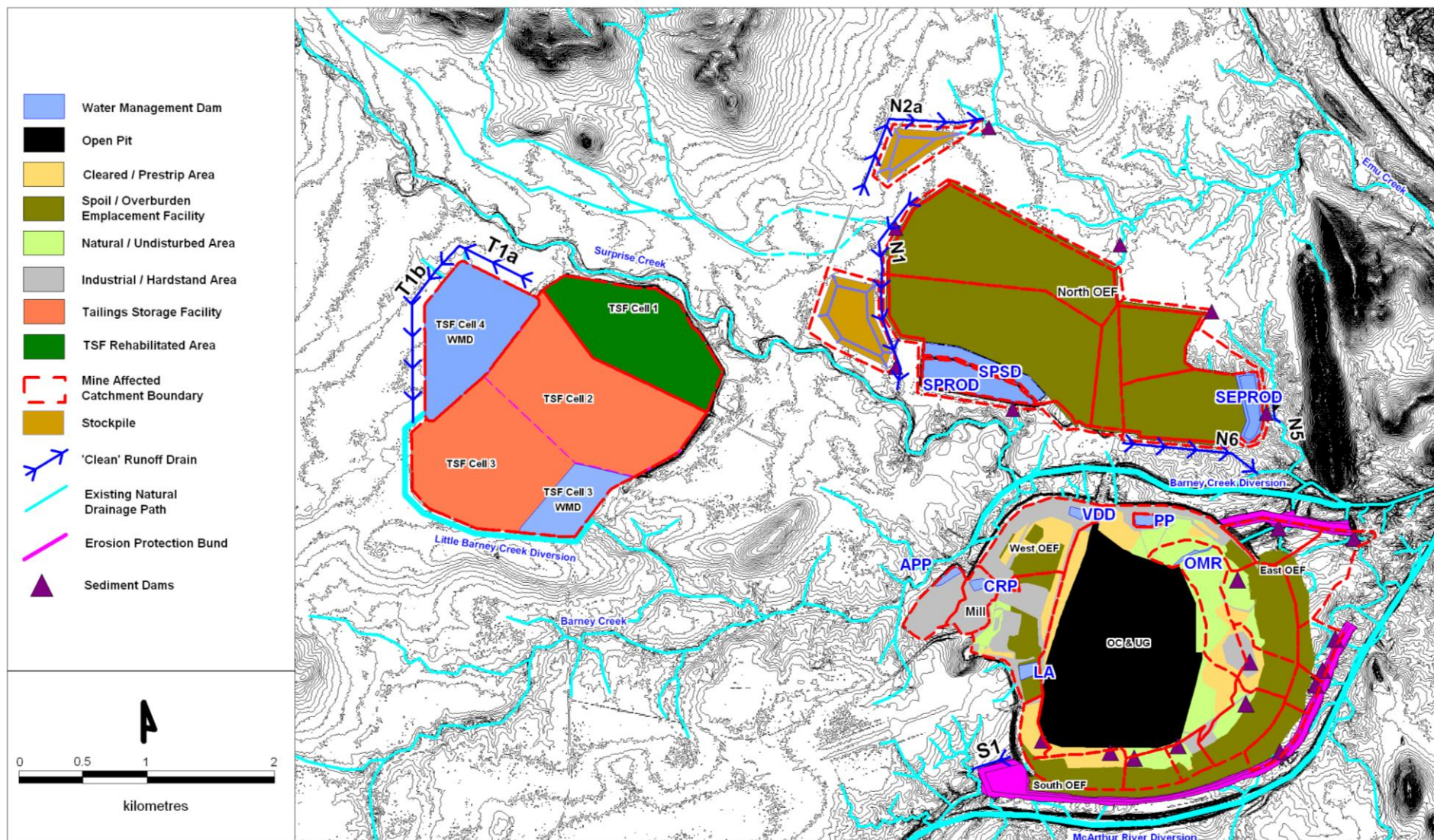


Figure 7.1 Proposed Water Management System, McArthur River Mine Phase 3 Project Site, Year 2015

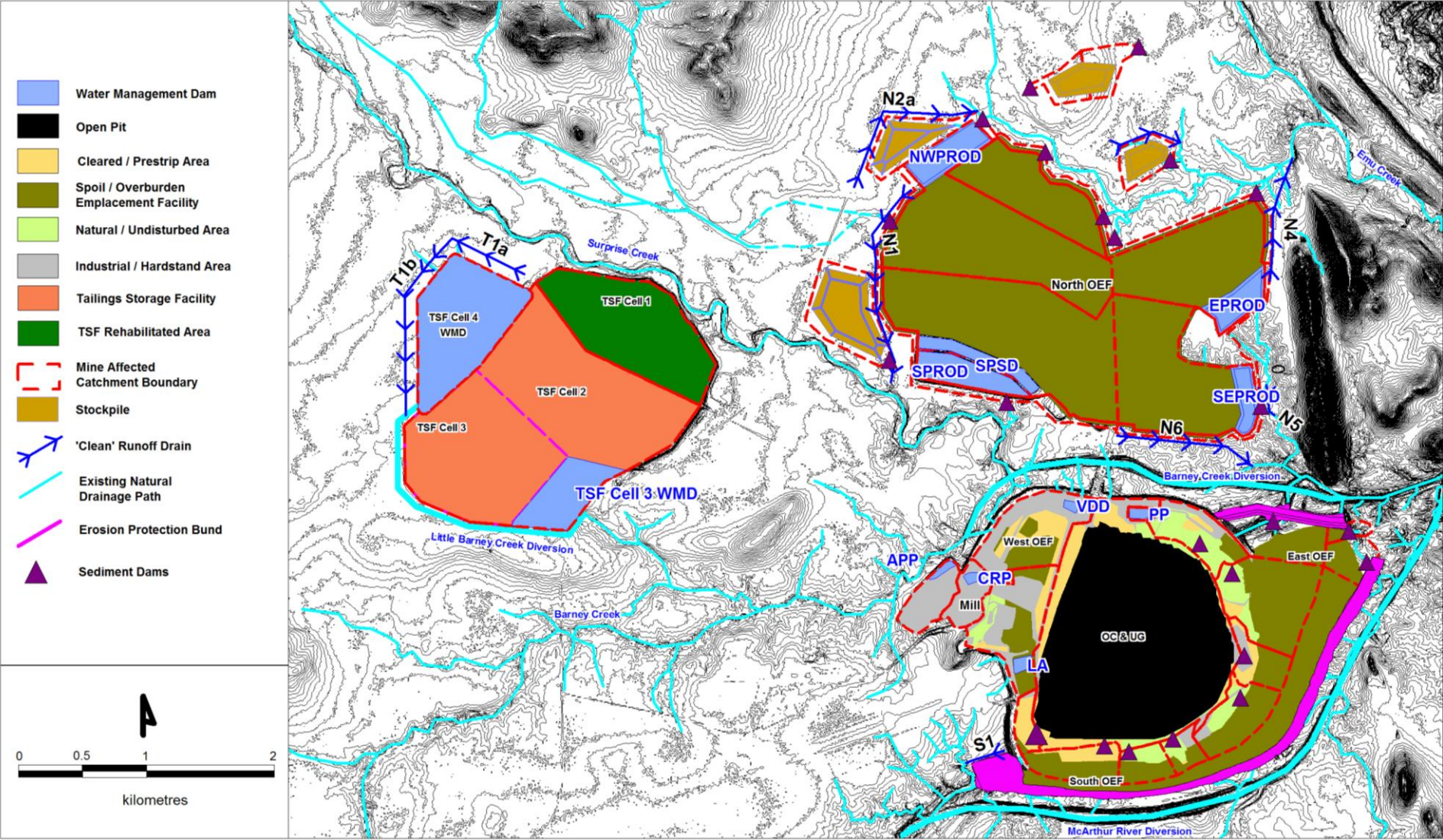


Figure 7.2 Proposed Water Management System, McArthur River Mine Phase 3 Project Site, Year 2020

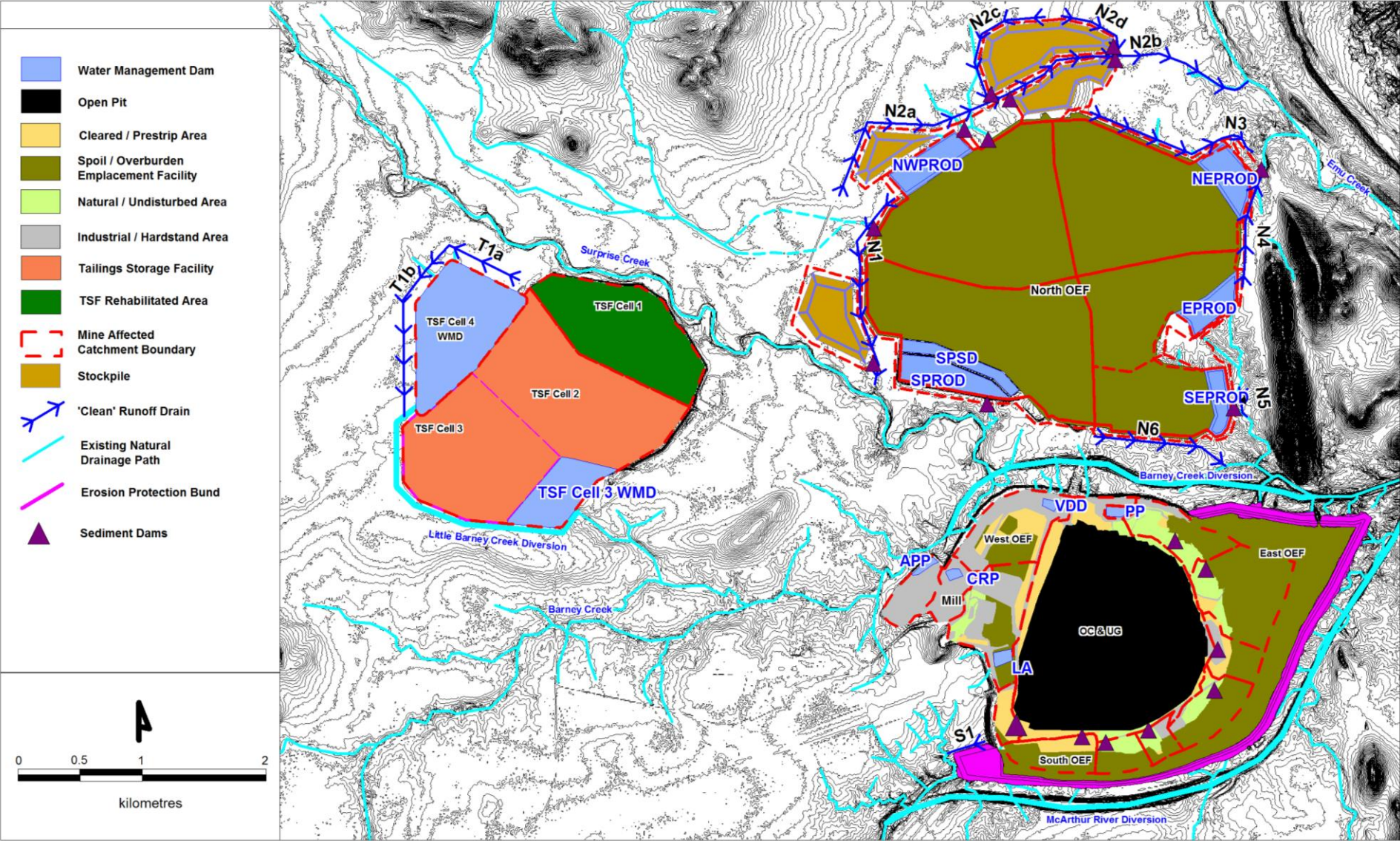


Figure 7.3 Proposed Water Management System, McArthur River Mine Phase 3 Project Site, Year 2025

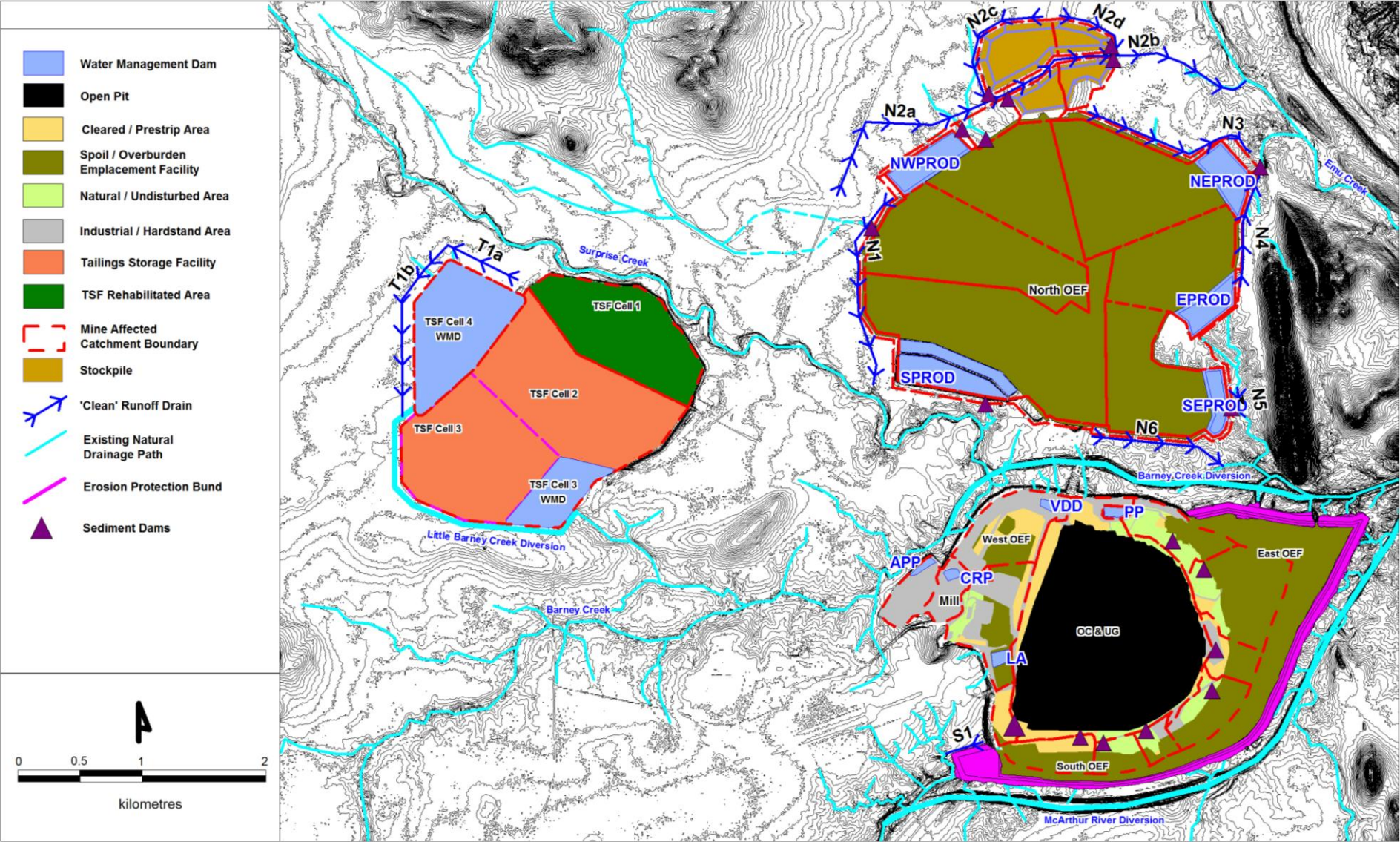


Figure 7.4 Proposed Water Management System, McArthur River Mine Phase 3 Project Site, Year 2030

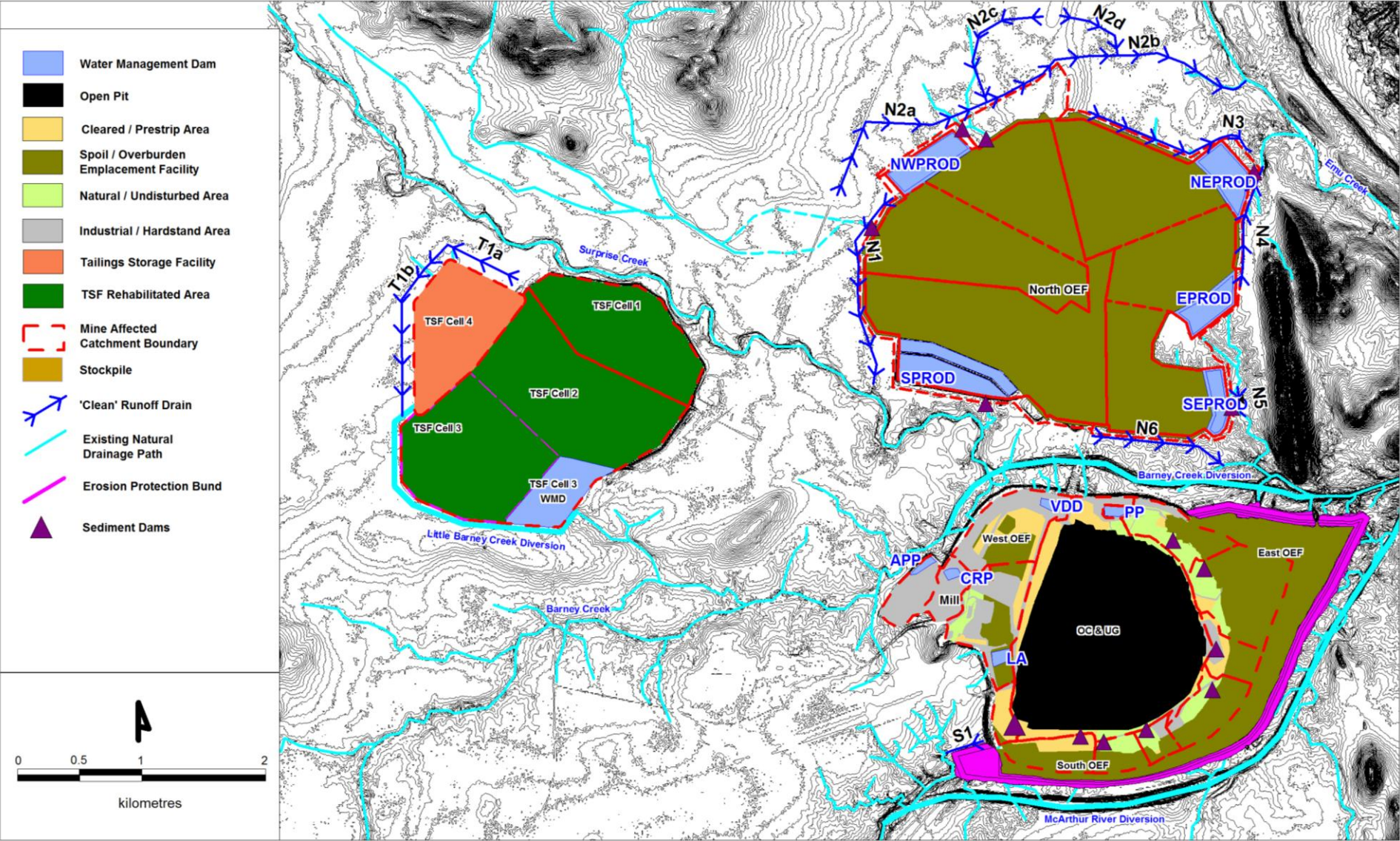


Figure 7.5 Proposed Water Management System, McArthur River Mine Phase 3 Project Site, Year 2035

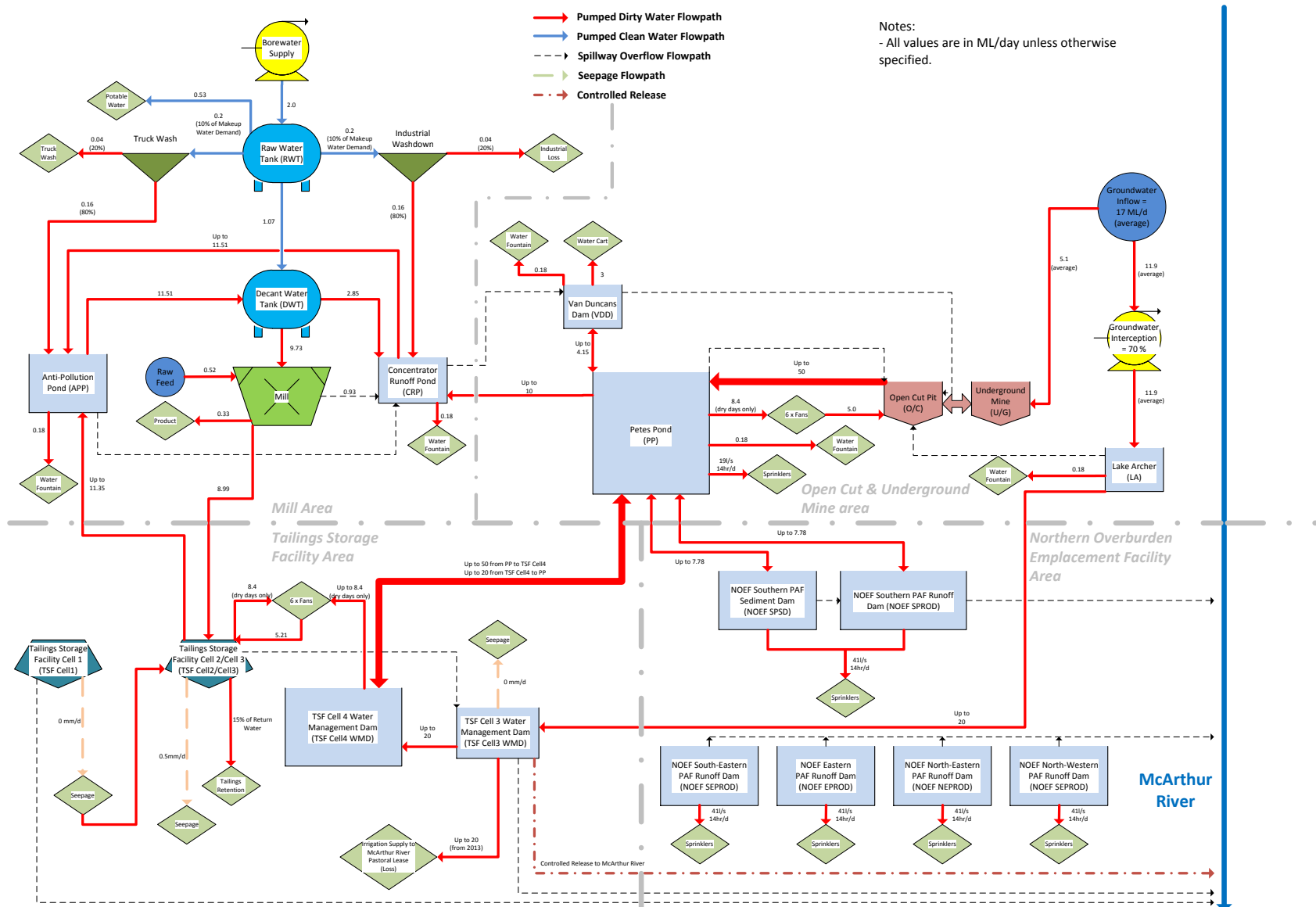


Figure 7.6 Schematic of Proposed McArthur River Mine Water Management System

7.2 OPEN PIT AREA WATER MANAGEMENT

7.2.1 General

Figures 7.1 to 7.5 provide an overview of the surface water management measures proposed for the open pit area, including the South and East OEF areas. Figures A1 to A3 in Appendix A show the locations and further detail on the proposed 'clean', 'dirty' and 'contaminated' surface water management measures in the open pit and South and East OEF areas for different stages of mining during Phase 3 operations (2015, 2020 and 2025-2035 respectively). Figure 7.6 shows a schematic of the proposed water circuit in the open pit area. Surface water management measures for the open pit area include the following:

- An existing flood protection levee around the perimeter of the open pit;
- An erosion protection bund around the South and East OEFs;
- Two (2) existing 'clean' runoff diversions:
 - The McArthur River Channel around the southern boundary of the open pit.
 - The Barney Creek Channel around the northern boundary of the open pit.
- One new 'clean' runoff drain (S1);
- Several 'dirty' runoff drains;
- Several sediment ponds;
- Five (5) existing storages (APP, CRP, VDD, PP and LA);

The existing Eastern Levee Storage (ELS) and Old McArthur River (OMR) channel will be decommissioned during the Phase 3 operations because they are located within the proposed expanded open pit and East OEF footprints.

7.2.2 Open Pit Flood Protection levee

The open pit area is located on the floodplain of the McArthur River and is protected from McArthur River floodwaters by a flood protection levee. This levee has been constructed to provide the open pit immunity from a McArthur River flood event of up to 0.2% annual exceedance probability (AEP) (500 year average recurrence interval (ARI)). The crest level of the existing flood protection levee is approximately 44 m AHD. The proposed Phase 3 mining works will maintain the current level of flood protection (0.2% AEP) to the open pit from McArthur River flooding.

7.2.3 Erosion Protection Bund around South and East OEFs

Figure A3 in Appendix A shows the alignment of the proposed erosion protection bund around South and East OEFs. The following is of note:

- The proposed bund will be constructed to protect the NAF dump from erosion from McArthur River and Barney Creek floodwaters for floods.
- The average height of the bund wall will vary from approximately 5m to 13m, to place the crest level at least above the 1% AEP (100 year ARI) level. The bund would be constructed with rocks from selected NAF material. The rocks will be sized to withstand erosive forces generated by floodwaters from the McArthur River and Barney Creek.

- The bund will be made out of permeable rock material to prevent NAF seepage water from building up within the South and East OEFs behind the bund wall. Rock will be adequately sized to protect against velocities in the McArthur River and Barney Creek for events greater than the 1% AEP (100 year ARI) flood;
- The proposed bund will be set back at least 75 m from the closest top of bank of the McArthur River and Barney Creek diversion channels;
- The bund will be constructed in advance of the South and East OEFs dumping schedule during the dry season to protect the dump and 'dirty' runoff drainage system ('dirty' runoff drains and sediment ponds) from potential erosion damage;
- It is expected that parts wall of the proposed bund will be affected by McArthur River floodwaters every 2 to 5 years (on average).

Table 7.1 shows the crest levels of the erosion protection bund required to protect the dump up to a 1% AEP flood event in the McArthur River. The crest elevation of the proposed bund varies from approximately 40.8 m AHD at the western end to 39.0 m AHD at the eastern end to due varying McArthur River flood levels.

Table 7.1 Proposed Erosion Protection Bund Crest Elevations

Reporting Location (see Figure A3, App A)	Crest Elevation (m AHD)	Easting In AMG 84 Zone 53 (m)	Northing In AMG 84 Zone 53 (m)
A	40.77	616420	8181278
B	40.67	617215	8181176
C	40.34	618505	8181326
D	39.75	619056	8181675
E	39.63	619221	8182003
F	39.17	619497	8182548
G	39.04	619893	8183306
H	39.04	619536	8183510
I	39.18	618989	8183558
J	39.19	618688	8183607
K	39.27	618327	8183539

7.2.4 The McArthur River and Barney Creek Diversions

The McArthur River and Barney Creek were diverted in 2009 to allow for the progression of the existing MRM open pit operations. The diverted channels are currently monitored regularly by mine staff for siltation and erosion within the channels and reported in the annual SDWMP (MRM, 2011). No changes are proposed to these existing diversions as part of the Phase 3 mining operations.

The proposed North, South and East OEFs will constrict the McArthur River and Barney Creek floodplains adjacent to the dumps. The dumps could increase velocities in some sections of the McArthur and Barney Creek channels and floodplain during large flood events. Areas where there is potential for elevated velocities due to the proposed Phase 3 works will be inspected after major flow events for any evidence of erosion. The key locations where velocities would be

elevated and therefore should be monitored are identified as part of the flood impact assessment (see Section 9). If it is found that erosion is taking place along the diversions, additional rock protection may be required along the affected reaches. The monitoring schedules for the above diversions have been documented in the SDWMP (MRM, 2011).

7.2.5 'Clean' Water Management Measures

A new 'clean' runoff drain approximately 0.3 km long (S1) will be constructed around the western end of the South OEF to collect and divert 'clean' runoff into an abandoned portion of the McArthur River channel. The catchment area, adopted design standard and configuration of this 'clean' runoff drain are given in Section 7.5.

Temporary 'clean' runoff management measures including bunds, drains and re-contouring within the flood protection levee wall will be constructed as required to prevent 'clean' runoff from flowing into the open pit. Note that some of these 'clean' runoff management measures will be mined through as the open pit progresses to the east.

7.2.6 'Dirty' Water Management Measures

The proposed 'dirty' runoff drains will direct runoff from the South and East OEFs towards sediment ponds. Based on available advice, runoff and seepage from the South and East OEF area is anticipated to be 'dirty' and of a quality that can be released to the receiving waters after treatment in a sediment pond. If runoff and/or seepage from South and East OEF areas is found to be 'contaminated', active management measures and/or additional storage volume would be required to fully contain the contaminated water on site.

It is expected that 'dirty' runoff drains and sediment ponds located within the open pit flood protection levee will be operational (once constructed) for the full duration of the Phase 3 operations. Overflows from sediment ponds within the flood protection levee will be directed into the old McArthur River until it is filled as part of the East OEF, at which time the overflow will be directed into the open pit dewatering system.

'Dirty' runoff drains constructed on the outer perimeter of the dump (which is exposed to McArthur River and Barney Creek floodwaters) will be located on the inside toe of the proposed erosion protection bund. Runoff from the contributing areas will be directed to temporary sediment ponds located at the inside toe of the erosion protection bund. Overflows from the sediment ponds will either seep through the erosion protection bund or flow through a spillway (overflow) pipe through the erosion protection bund. The final design of the sediment pond spillways will depend on the permeability of the erosion protection bund. One-way flap gates may be required on the end of the sediment pond pipe spillway to prevent McArthur River water from back-flowing into the sediment pond during periods of high flow. The proposed drainage system would be protected from the McArthur River and Barney Creek flooding by the erosion protection bund. However, the proposed drainage system would be inundated by McArthur River floodwater seeping through the erosion protection bund on average every 2 to 5 years. Note that the 'dirty' runoff management controls located along the erosion protection bund will be progressively covered over by NAF material as the OEF dumps progress towards the erosion protection bund. Rehabilitating the OEF close behind the advancing face will be important in managing erosion once the ground level sediment controls are buried. Adequate erosion protection would be provided along the final South and East OEF batter facing the McArthur River and Barney Creek.

The adopted design standards and configurations of 'dirty' runoff drains and sediment ponds are given in Section 7.6.

7.2.7 Water Storages

The 'dirty' and 'contaminated' water collected in the open pit and the infrastructure area located on the western side of the open pit will be managed using the five existing water storages in the open pit area. Figures A1 to A3, Appendix A show the locations of these storages, together with contributing catchment areas and expected land uses within the contributing catchments. Table 7.2 shows the adopted catchment areas, proposed storage capacity to the Full Storage Level (FSL), maximum operating level (MOL) and optimal operating level (OOL) for each storage. All storages in the open pit area are located within the existing flood protection levee and any spills would eventually flow into the open pit. Hence, the expected environmental harm in the event of spills from these storages would be negligible. It is proposed that all storages within the open pit area have adequate storage capacity during the wet season to contain at least the runoff from a 20% AEP (5 year ARI) 24-hour rainfall event. Spillways of these storages should be sized to convey the peak discharge during a 0.05% AEP (2,000 year ARI) rainfall event. Evaporation from each storage will be enhanced by using sprinklers and sprays within the storage. The characteristics and operating protocols of each storage is discussed below.

The adopted design standards and configurations of 'contaminated' water storages are given in Section 7.7.

Table 7.2 Open Pit Area Water Storage Capacities

Storage Name	Contributing Catchment Area (ha)	Stored Volume at FSL (ML)	Stored Volume at MOL (ML) ^c	Stored Volume at OOL (ML)
Pete's Pond (PP)	2.1	100	98	10
Anti Pollution Pond (APP)	14.5	23	12	10
Concentrator Runoff Pond (CRP)	13	27	17	17
Van Duncan's Dam (VDD)	38	35 ^a	6	6
Lake Archer (LA)	36	40 ^b	13	4

^a It is proposed to increase the FSL of VDD to contain the 20% AEP 24 hour runoff event

^b The FSL of Lake Archer will be increased to accommodate 'intercepted' groundwater inflows

^c FSL - 20% AEP (5 year ARI) 24 hour rainfall depth (0.152 m) x the catchment area x volumetric runoff co-efficient of 0.5

Pete's Pond

Pete's Pond (PP) is a turkey's nest dam with no external catchment area. 'Contaminated' water will be pumped into PP from the open pit and underground mine void at a rate of up to 50 ML/d and from the TSF Cell 4 WMD as required at a rate of up to 20 ML/d. PP will be the distribution point for pit water and will supply water to the following locations in order of priority (from highest to lowest):

- Concentrator Runoff Pond (CRP) for use in the Mill at a rate of up to 10 ML/d
- Van-Duncan's Dam (VDD) for water cart use at a rate up to 4.15 ML/d
- Evaporation Fans at the open pit to enhance evaporation at a rate of up to 8.4 ML/d
- TSF Cell 4 WMD for containment and evaporation at a rate of up to 50 ML/d
- North OEF SPSP and SPROD to enhance evaporation at a rate of up to 7.8 ML/d each

The storage capacity of PP to the FSL is approximately 100 ML. This will allow for storage of up to approximately 2 days of continuously pumped inflows during periods of peak pit dewatering. Overflows from PP will be directed into the open pit.

Anti Pollution Pond

The Anti Pollution Pond (APP) has a catchment area that could potentially generate 'contaminated' runoff from the ROM pad and associated lay down areas. 'Contaminated' water will be transferred to APP from CRP at an estimated rate of up to approximately 11.5 ML/d and return water from the TSF at an estimated rate of approximately 11.4 ML/d. The APP will supply process water to the Mill via the decant water tank (DWT) at an estimated rate of approximately 11.5 ML/d. The storage capacity of the APP to the FSL is approximately 23 ML. Overflows from APP will be directed overland via a constructed drain to the CRP.

Concentrator Runoff Pond

The Concentrator Runoff Pond (CRP) has a catchment area that could potentially generate 'contaminated' runoff from the processing area including the Mill. 'Contaminated' water overflowing from the Mill and DWT as well as used water from the industrial and vehicle wheel wash down areas will be directed overland to the CRP. 'Contaminated' water will also be transferred to the CRP from PP as required. The CRP will supply process water to the APP at an estimated rate of up to approximately 11.5 ML/d. The storage capacity of CRP to the FSL is approximately 27 ML. Overflows from CRP will be directed overland via a constructed drain to VDD.

Van Duncan's Dam

Van-Duncan's Dam (VDD) has a catchment area that could potentially generate 'dirty' runoff from NAF material in the West OEF. 'Contaminated' water will be transferred to VDD from PP, as required, at a rate of up to 4.2 ML/d. It is proposed to increase the VDD FSL from 25 ML to 35 ML to allow for containment of the 20% AEP (5 year ARI) 24-hour rainfall event. VDD will supply water to water carts to be used for dust suppression around the mine site at an estimated rate of 3 ML/d over the life of the mine. Overflows from VDD will be directed into the open pit.

Lake Archer

Lake Archer (LA) has a catchment area that could potentially generate 'dirty' runoff from part of the West OEF and infrastructure area to the north-west of the storage. LA will collect and transfer 'intercepted' groundwater from dewatering bores and spears around the open pit to TSF Cell 3 WMD at a maximum rate of 20 ML/d. Overflows from LA will be directed into the open pit. The capacity of LA will be increased from 20 ML to 40 ML to allow for storage of up to approximately 2 days of 'intercepted' groundwater inflows during the wet season.

7.2.8 Underground Mine Void

The runoff generated by rainfall onto the pit catchment area is potentially 'contaminated' water. Groundwater is also collected in the open pit. The open pit will be dewatered to PP at a maximum rate of 50 ML/d until the water level in the open pit drops below the open pit invert. Some of the 'contaminated' water pumped out of the open pit from PP will be sent back to the open pit via evaporation fans at an estimated rate of 5.0 ML/d (based on a 60% return rate from the evaporation fans). The underground mine void will collect groundwater that flows into the void as well as 'contaminated' runoff draining from the open pit.

During the proposed Phase 3 mining operations, the open pit will excavate down into the existing underground mine void. Hence, as the open pit progresses deeper, the available storage volume in the underground mine void will be reduced. Table 7.3 shows the adopted open pit invert (the deepest operating bench level), open pit surface area and the underground mine void storage volume for current, 2015, 2020, 2025, 2030 and 2035 mining stages. The underground mine void dewatering bores are currently located at an elevation of 9730 m Local

Mine datum (LMD) (approximately -270 m Australian Height Datum (AHD)). The underground mine void dewatering bores will be replaced with new deeper bores around year 2018 when the expanding pit is expected to mine out the collar of the shaft. It is understood the lowest level of the underground mine void is at an elevation of 9615 m LMD (-385 m AHD).

Table 7.3 Adopted Open Pit Invert and Surface Area and Underground Mine Void Storage Volume for Different Stages of Mining

Mine Year	Open Pit Invert (mLMD)	Open Pit Surface Area (ha)	Underground Mine Void Volume (ML)
Current	9920 (-80 mAHD)	38	4575
2015	9885 (-115 mAHD)	161	4425
2020	9790 (-210m AHD)	195	3075
2025	9740 (-260 mAHD)	195	1950
2030	9705 (-295 mAHD)	195	1275
2035	9630 (-370 mAHD)	195	175

7.3 TAILINGS STORAGE FACILITY AREA WATER MANAGEMENT

7.3.1 General

Figures 7.1 to 7.5 show an overview of the surface water management measures proposed for the TSF area. Figures B1 and B2 in Appendix B show the locations and further detail on the proposed 'clean', 'dirty' and 'contaminated' surface water management measures in the TSF area for 2015-2030 and 2035 stages respectively during Phase 3 mining operations. Figure 7.6 shows a schematic of the proposed water circuit in the TSF area. Surface water management measures for the TSF area include the following:

- One 'clean' runoff drain (T1- a&b);
- Several 'dirty' runoff drains;
- Several sediment ponds;
- Potential seepage controls (sumps and trenches);
- TSF Cell 2, TSF Cell 3 and TSF Cell 4;
- Two (2) TSF water management dams:
 - TSF Cell 3 WMD.
 - TSF Cell 4 WMD.

7.3.2 'Clean' Water Management Measures

'Clean' runoff drains approximately 0.9 km and 1.3 km long (T1 a&b) will be constructed around the outside wall of the TSF Cell 4 wall to collect and divert 'clean' runoff from Little Barney Creek around the perimeter of the proposed TSF Cell 4 into the existing Little Barney Creek diversion. The catchment area, adopted design standard and configuration of this 'clean' runoff drain are given in Section 7.5.

7.3.3 'Dirty' Water Management Measures

The proposed 'dirty' runoff management controls will consist of 'dirty' runoff drains that direct runoff from catchment areas that generate 'dirty' runoff (such as rehabilitated TSF cells) to sediment ponds for treatment before releasing the water to the receiving waters including Surprise Creek and Barney Creek. It is understood that rehabilitated TSF cells will be capped with clay, topped with NAF material and rehabilitated. It is expected that runoff from rehabilitated sections of the TSF will be of a suitable quality to discharge to the receiving environment after appropriate treatment via a sediment pond.

The adopted design standards and configurations of 'dirty' runoff drains and sediment ponds are given in Section 7.6.

Note that until it can be demonstrated (via appropriate water quality monitoring) that runoff from rehabilitated tailings areas is of acceptable quality to be released to the receiving waters, runoff from rehabilitated areas will be considered 'contaminated' and will be directed or pumped to an active TSF cell for containment.

7.3.4 'Contaminated' Water Management Measures

The 'contaminated' water management controls at the TSF area will include two water management dams (TSF Cell 3 WMD and TSF Cell 4 WMD) and active TSF cells (for collection of concentrator tailings slurry from the Mill). Figures C1 to C5 in Appendix C show the locations of the WMDs and TSF cells, associated catchment areas and expected land uses within the catchment area for different stages of Phase 3 mining operations. Existing seepage trenches and sumps will be maintained around TSF Cell 2 & TSF Cell 3. Additional seepage trenches and sumps will be installed around the perimeter of the TSF as required to collect seepage runoff from the TSF. Seepage water collected in the sumps will be pumped to an active TSF Cell. Table 7.4 shows the adopted catchment areas, storage capacity to the FSL, MOL and OOL for each of the TSF area storages. It is proposed that storages in the TSF area have adequate capacity between the MOL and the FSL to contain runoff from a 1% AEP (100 year ARI) 24-hour rainfall event. WMD spillways will be sized to convey the peak discharge during a 0.05% AEP (2,000 year ARI) rainfall event. The operating strategy for each storage is discussed below.

The adopted design standards and configurations of 'contaminated' water storages are given in Section 7.7.

Table 7.4 TSF Area Water Storage Capacities

Storage Name	Contributing Catchment Area (ha)	Stored Volume at FSL (ML)	Stored Volume at MOL (ML)	Stored Volume at OOL (ML)
TSF Cell 3 WMD	25 ^a	532	457	457
TSF Cell 4 WMD	65	4300	4100	500

^a After 2015

TSF Cell 3 WMD

The capacity of the existing TSF Cell 3 WMD will be reduced from approximately 1830 ML to 532 ML to allow for the construction of the tailings storage component of Cell 3 in 2015. TSF Cell 3 WMD is a turkeys nest dam with a surface area of approximately 129 ha prior to 2015 and 25 ha after 2015. The TSF Cell 2 and Cell 3 spillways report to the TSF Cell 3 WMD. However, these Cells will be designed to contain water up to a 0.5% AEP (200 year ARI) rainfall event before water would spill into the TSF Cell 3 WMD. The TSF Cell 3 WMD will be used to contain 'intercepted' groundwater from the groundwater dewatering bores and spears in the

mining area (via Lake Archer). The priority of use for water stored in the TSF Cell 3 WMD is as follows (from highest to lowest priority):

- Mine site process uses such as makeup water to the mill and dust suppression as well as enhanced evaporation infrastructure;
- Controlled releases to the McArthur River, when conditions permit; and
- Irrigation supply to the McArthur River Pastoral Lease.

The following is of note with respect to the operation of the TSF Cell 3 WMD:

- Permanent pumping infrastructure with a capacity of approximately 20 ML/d will be provided to link the 'intercepted' groundwater dewatering system with the TSF Cell 3 WMD (via Lake Archer);
- Pumping infrastructure with a capacity of approximately 20 ML/d will be provided to the TSF Cell 4 WMD to maintain the TSF Cell 4 WMD's OOL storage volume of 500 ML (to maximise evaporation) and use within the MRM water management system;
- The water storage will be maintained at an optimum volume of 457 ML during the wet season. When flows in the McArthur River allow, controlled releases will be made from the TSF Cell 3 WMD of up to 60 ML/d to the McArthur River via a pipeline. Discharges would be carried out in accordance with a discharge licence to be negotiated with the NRETRAS. The proposed controlled release strategy is further discussed in Section 7.8; and
- Pumping infrastructure with a capacity of approximately 20 ML/d will be provided to link the TSF Cell 3 WMD to the proposed irrigation water supply dam on the McArthur River Pastoral Lease. The design and operation protocols of the irrigation water supply dam are discussed elsewhere (TCT, 2011; TCT, 2012).

Based on available advice, the quality of 'intercepted' groundwater is assumed to be acceptable for irrigation activities and for controlled release to the McArthur River. If this assumption is incorrect, water in the TSF Cell 3 WMD would have to be evaporated, or treated to an acceptable quality before reuse or discharged off-site. Possible water treatment options are discussed elsewhere (TCT, 2012 and Chapter 10 of MET Serve, 2012).

TSF Cell 4 WMD

The TSF Cell 4 WMD will be a turkey's nest dam approximately 65 ha in surface area with no external catchment area. The TSF Cell 4 wall will be constructed during 2012, separate to the Phase 3 development and used for 'contaminated' water storage until it is scheduled to collect concentrator tailings from the Mill in 2032. The TSF Cell 4 WMD will contain potentially 'contaminated' water pumped from the open pit and underground mine void (via PP). The following is of note with respect to the TSF Cell 4 WMD:

- The storage capacity to FSL is approximately 4300 ML;
- Permanent pumping infrastructure with a capacity of approximately 50 ML/d will be provided to link the open pit with TSF Cell 4 WMD (via PP);
- The stored volume will be maintained at an OOL storage of 500 ML (when possible) to maximise evaporation from the surface of the dam, as well as providing emergency storage during wet periods. This will be achieved by pumping water from the TSF Cell 3 WMD during dry periods to maximise evaporation and reuse for operational purposes such as process water in the Mill and dust suppression;

- The MOL is 4100 ML. If the MOL in the TSF Cell 4 WMD is exceeded, excess pit water will be held in the open pit without pumping to PP;
- Evaporation will be enhanced using the existing evaporation fans at the TSF. However, evaporating supernatant water from the active TSF cells will have a higher priority than evaporating water in the TSF Cell 4 WMD; and
- During dry periods, water will be transferred to PP at a maximum rate of 20 ML/d for process uses on-site including the Mill and dust suppression, as required.

In year 2032, when TSF Cell 4 is expected to begin collecting concentrator tailings from the Mill, an alternate on-site water management storage may be required to draw down the remaining water in the TSF Cell 4 WMD and collect and store pit water for the final four years of mine life. It is possible that some of the proposed PAF Runoff Dams around North OEF may be available at this time. The additional post-2032 storage requirement will be assessed in the future when more Phase 3 operational data becomes available.

TSF Cell 2, TSF Cell 3 and TSF Cell 4

TSF Cell 2, Cell 3 and Cell 4 will collect concentrator tailings from the mill throughout the life of mining operations, in addition to direct rainfall onto the surface of the cells. Table 7.5 shows the adopted surface area and years when concentrator tailings are deposited from the Mill. The following is of note with respect to the TSF water management system:

- Available water quality monitoring data shows that tailings slurry water contained within the TSF substantially exceeds the ANZECC (2000) water quality guidelines for a 95% level of protection in freshwater ecosystems. This water is considered 'contaminated' and management measures will be implemented to contain and reuse this water within the Phase 3 mining water management system. This water will be used for makeup water in the concentrator Mill, dust suppression and disposal using enhanced evaporation measures such as evaporation fans, sprinklers and sprays;
- The TSF will be operated with a perimeter spigot arrangement with a central pond so that tailings slurry gravitates towards the centre of the cell to create a dry beach around the edges of the cell. It is intended that this arrangement will minimise the peizometric head at the walls of the cell and hence minimise the seepage under the walls;
- An underdrainage network will be considered beneath the TSF cell 4 that will collect seepage from the TSF to a sump. Any seepage runoff collected in these sumps will be pumped back into the pond within an active TSF cell;
- TSF Cell 4 will be appropriately sealed or lined to control seepage through the base and wall of the Cell; and
- Active TSF cells will be designed to capture and retain rainfall falling directly onto the cell for rainfall events up to the 0.05% AEP (200 year ARI).

Further details on the design and operation of the TSF are given elsewhere (Appendix E1 of MET Serve, 2012).

Table 7.5 TSF Surface Area and Years of Operation for Cell 1, Cell 2, Cell 3 and Cell 4

TSF Cell ID	Adopted Surface Area (ha)	Years of Active Tailings Deposition
Cell 1 (decommissioned)	78	N/A
Cell 2	116	Current - 2030
Cell 3	98	2015 - 2032
Cell 4	65	2032 - 2036

7.4 NORTH OVERBURDEN EMPLACEMENT FACILITY AREA WATER MANAGEMENT

7.4.1 General

Figures 7.1 to 7.5 show an overview of the surface water management measures proposed for the North OEF area. Figures C1 to C5 in Appendix C show the locations and further detail on the proposed 'clean', 'dirty' and 'contaminated' surface water management measures in the North OEF area for different stages of mining during Phase 3 operations (2015, 2020, 2025, 2030 and 2035 respectively). Figure 7.6 shows a schematic of the proposed water circuit in the North OEF area. Surface water management measures for the North OEF area include the following:

- Six (6) 'Clean' runoff drains (N1 to N6);
- Several 'dirty' runoff drains;
- Several sediment ponds;
- The existing SPSP and SPROD dams;
- Four (4) additional PAF runoff dams including:
 - South-East PAF Runoff Dam (SEPROD);
 - East PAF Runoff Dam (EPROD);
 - North-East PAF Runoff Dam (NEPROD); and
 - North-West PAF Runoff Dam (NWPROD).

A description of the North OEF NAF/PAF encapsulation and drainage system within the North OEF dump is described elsewhere (Appendix E2 of MET Serve, 2012). In summary, the management of 'dirty' and 'contaminated' runoff from the North OEF will be staged and vary as the material dumped on the North OEF switches from NAF to PAF and back to the final layer of NAF. The type of measures required to manage runoff from various sub-catchment areas within the dump will depend on the type of material being placed on the dump at a given point in time. Based on available advice, it is expected that areas of the North OEF that contain NAF material will generate 'dirty' runoff and seepage (both before PAF material is placed on the NAF material and after all PAF material in the contributing catchment area is encapsulated by clay capping and topped with NAF material) and will require only a sediment pond for treatment before release to the receiving waters. Areas of the North OEF that contain exposed PAF material could generate 'contaminated' runoff and seepage and is likely to require a water storage appropriately sized for containment of all runoff generated from the contributing catchment area.

The years where PAF is exposed in the contributing catchment areas of the proposed PAF runoff storages is shown in Table 7.6. Table D1, Appendix D shows the proposed annual staging of catchments draining to each of the storages around the North OEF over the life of Phase 3 mining operations. The years when NAF material drains to the designated storage is shaded light blue and the years when PAF material drains to the designated storage is shaded in brown. Note that the Western PAF sediment dam (WPSD) has not been sized for containment of PAF runoff because the proposed dump drainage has been designed so that this storage only collects runoff from catchment areas containing NAF material.

Figure C6, Appendix C shows the proposed mine closure plan for the North OEF. The mine closure plan for the North OEF is discussed elsewhere (Appendix E4 of MET Serve, 2012).

Table 7.6 Estimated Storage Volumes Required for 5% Probability of Exceedance When Exposed to PAF Material

Storage Name	Years Exposed to Rainfall Runoff from PAF	Maximum Contributing Catchment Area (ha)		5% Probability of Exceedance of Storage Volume When Exposed to PAF Material (ML)	Adopted Minimum Spillway Elevation (m AHD)
		When Exposed to PAF Material	All Years		
SPROD + SPSD	26 (2011-2037)	166.6	166.5	810	40.2
NWPROD	12 (2022-2027)	85.8	108.5	805	40.2
SEPROD	4 (2013-2016)	51.0	85.0	343	39.3
EPROD	8 (2015-2022)	75.6	75.6	500	39.2
NEPROD	3 (2024-2026)	94.0	121.8	698	38.9

7.4.2 'Clean' Water Management Measures

Six 'clean' runoff drains are proposed around the North OEF to collect and divert 'clean' runoff away from areas disturbed by mining. The proposed 'clean' runoff drains include:

- A 1.6 km long drain (N1) located around the western side of the North OEF that will direct 'clean' runoff to Surprise Creek;
- Four drains, 1.4 km, 2.5 km, 1.1 km and 0.6 km long (N2–a,b,c&d) located around the north-western side of the North OEF that will direct 'clean' runoff to a tributary of Emu Creek;
- A 1.5 km long drain (N3) located around the northern side of the North OEF that will direct 'clean' runoff to a tributary of Emu Creek;
- A 1.0 km long drain (N4) located around the north-eastern side of the North OEF that will direct 'clean' runoff to a tributary of Emu Creek;
- A 0.3 km long drain (N5) located around the south-eastern side of the North OEF that will direct 'clean' runoff around a proposed PAF Runoff Dam into a tributary of Barney Creek; and
- A 1.1 km long drain (N6) located around the south side of the North OEF that will direct 'clean' runoff to Barney Creek.

The catchment area, adopted design standard and configuration of these 'clean' runoff drains are given in Section 7.5.

7.4.3 'Dirty' Water Management Measures

The proposed 'dirty' runoff management measures will consist of 'dirty' runoff drains that direct runoff from catchment areas that generate 'dirty' runoff to sediment ponds for treatment before releasing the water to the receiving waters including Surprise Creek, Barney Creek and Emu Creek. The North OEF sediment ponds will collect runoff from catchment areas that may potentially generate 'dirty' runoff including NAF waste dumps and topsoil stockpiles. Sediment ponds around the perimeter of the North OEF will collect runoff both before PAF material is placed on the NAF material and after all PAF material in the contributing catchment area is encapsulated in clay and topped with NAF material. 'Dirty' runoff drains around the base of the North OEF will direct runoff to the sediment ponds. Areas that generate 'dirty' runoff include NAF dumps and NAF material that is below the PAF runoff drainage system (such as dump batters below the McArthur River 1% AEP (100 year ARI) flood level) and top-soil stockpiles. Sizing and design of the North OEF sediment ponds will be undertaken during detailed design of the North OEF. The adopted design standards and configurations of 'dirty' runoff drains and sediment ponds are given in Section 7.6.

Permanent sumps will be installed immediately upstream of the connected sediment ponds in locations where seepage runoff from the North OEF reports to the 'dirty' runoff drains. During dry days, any seepage reporting to the sumps will be pumped to a PAF Runoff pond. During wet days, seepage together with surface runoff will flow down the 'dirty' runoff drain, fill up the sump storage and overflow into to a sediment pond for treatment. After treatment, water will be pumped out of the sediment pond to the receiving waters, provided the water quality is within the trigger limits specified in the waste discharge licence. Any surface runoff water collected in the seepage sump will be pumped to a PAF runoff pond.

The runoff collected in sediment ponds from NAF material surfaces on top of encapsulated and capped PAF material is assumed to be of acceptable quality for release to the receiving waters. Monitoring of water quality in these sediment ponds would be required to demonstrate that the water quality is within the limits specified in the waste discharge licence prior to release into receiving waters.

7.4.4 PAF Runoff Storages

PAF runoff storages have contributing catchment areas that would potentially generate 'contaminated' runoff such as areas within the North OEF that contain exposed (uncapped) PAF material. Table 7.6 shows the maximum catchment area, storage volume at FSL and years where PAF is exposed in the contributing catchment area for the proposed PAF runoff dams. The PAF runoff dam walls will be built up above the natural ground surface so that the PAF runoff dam spillway levels will be elevated above the McArthur River 1% AEP (100 year ARI) flood level. The required PAF dam spillway elevation is also shown in Table 7.6.

The PAF runoff storages have been sized to fully contain potentially 'contaminated' runoff during periods when PAF material is exposed within the contributing catchment areas. Once all PAF material within the contributing catchment area is capped with clay and NAF material placed on top of the sealed PAF material, the storages will then be allowed to spill. This assumes that runoff from contributing catchment areas after the PAF material has been capped is 'dirty' runoff and can be released to the receiving waters after treatment in a sediment pond. If proposed water quality monitoring shows that this assumption is incorrect, active management measures and/or additional storage volume will be required to fully contain the 'contaminated' water running off the North OEF surfaces until it can be demonstrated that all PAF material within the catchment area has been adequately encapsulated and the surface runoff is of a suitable quality to discharge to the receiving environment (after treatment via sediment ponds).

For the EIS, it was assumed that the new North OEF containment water storages would operate in isolation from the existing mine process water system, except for SPROD and SPSP. Pit water will be pumped at 7.78 ML/d from PP to SPROD and SPSP to a MOL volume of 200 ML and 50 ML, respectively, to maximise evaporation of 'contaminated' water at the mine site.

The PAF Runoff storage volumes at FSL have been determined from the results of the water balance modelling described in Section 8 of this report. The water balance model was run over 26 years (2011-2036) to simulate the performance of the proposed PAF runoff storages during the various mine stages when PAF area runoff is collected. The model was run for 86 separate sequences of rainfall and evaporation generated from 112 years (1900-2011) of synthetic (Data Drill) data.

Evaporation from the PAF runoff storages will be enhanced using sprinklers and sprays on the storage embankments similar to the sprinkler system currently used at SPSP and SPROD storages. Based on model results described in Section 8, the use of evaporation sprinklers and sprays would reduce the required size of the PAF storages by approximately 40%.

The adopted FSL for the PAF runoff storages are based on the 95th percentile volume of water predicted to accumulate in the PAF runoff storage during the period of time that PAF material is expected to be exposed in the contributing catchment area. That is, there is a 5% probability of exceedance that the adopted storage would overflow whilst PAF material is exposed in the contributing catchment area.

North OEF PAF runoff storages will be designed and maintained as described in Section 7.7.

7.5 'CLEAN' RUNOFF DRAINS

7.5.1 Overview

The proposed 'clean' runoff drains will be used to direct 'clean' runoff from undisturbed upstream catchments around potentially disturbed and/or contaminated areas. Figure 7.7 shows the locations of the key 'clean' runoff drains proposed for the MRM Phase 3 site. The 'clean' runoff drains would be required for both construction and operational phases of the proposed expansion. The following key 'clean' runoff drains are proposed:

- Six (6) clean runoff drains (N1 to N6) around the North OEF;
- One (1) clean water drain (T1a, T1b and T1c) around the western side of the TSF; and
- One (1) 'clean' runoff drain (S1) around the western end of the South OEF.

A number of other minor drains and bunds would be required to separate 'clean' surface water from areas around borrow pits, local roads and mine operations. These drainage works will be designed to suit local topographic conditions during the detail design phase of the project.

7.5.2 Drain Design and Configuration

The following is of note with respect to the proposed new 'clean' runoff drains:

- All 'clean' runoff drains will be constructed to contain the 1% AEP (100 year ARI) design discharge;
- Where possible, 'clean' runoff drain structures will be designed to limit flow velocities to 1.8 m/s or less for the 1% AEP (100 year ARI) design event. However, in 'clean' runoff

drains with steep channel grades, rock check dams and other energy dissipation and sediment trapping structures may be required at regular intervals to limit erosion;

- All drainage structures should be inspected following significant storm events to ensure the structures have been able to sustain flow velocities without causing significant scour;
- 'Clean' runoff drains have been located based on existing topographic data and the proposed mine layout. If necessary, diversion drain locations may be adjusted during detailed design to accommodate finished site levels and grades; and
- 'Clean' runoff drains will be designed and configured as part of detailed designs for the open pit, North OEF, South OEF and TSF.

Table 7.7 shows the contributing catchment area and the required year of construction for each of the proposed 'clean' runoff drains. The configuration (dimensions) of each 'clean' runoff drain would be dependent on the upslope catchment area and slope. Each 'clean' runoff drain will exhibit the features identified below and shown in Figure 7.8:

- Trapezoidal channel;
- Bank batters between 1:3 to 1:6 (V:H);
- Channel batters 1:4 (V:H);
- Where necessary rock check dams will be used to maintain specified channel grades;
- Bank bottom widths (f) will vary depending on the adopted bank batters;
- Diversion banks will be constructed to appropriate engineering standards.
- The channel outlet will be flared out to a minimum width of 1.5 x channel base width. Ground slopes below the channel outlet shall be less than or equal to the channel grade; and
- Stable grass cover to be maintained in the bed and banks of the channel and below the channel outlets (as much as possible).

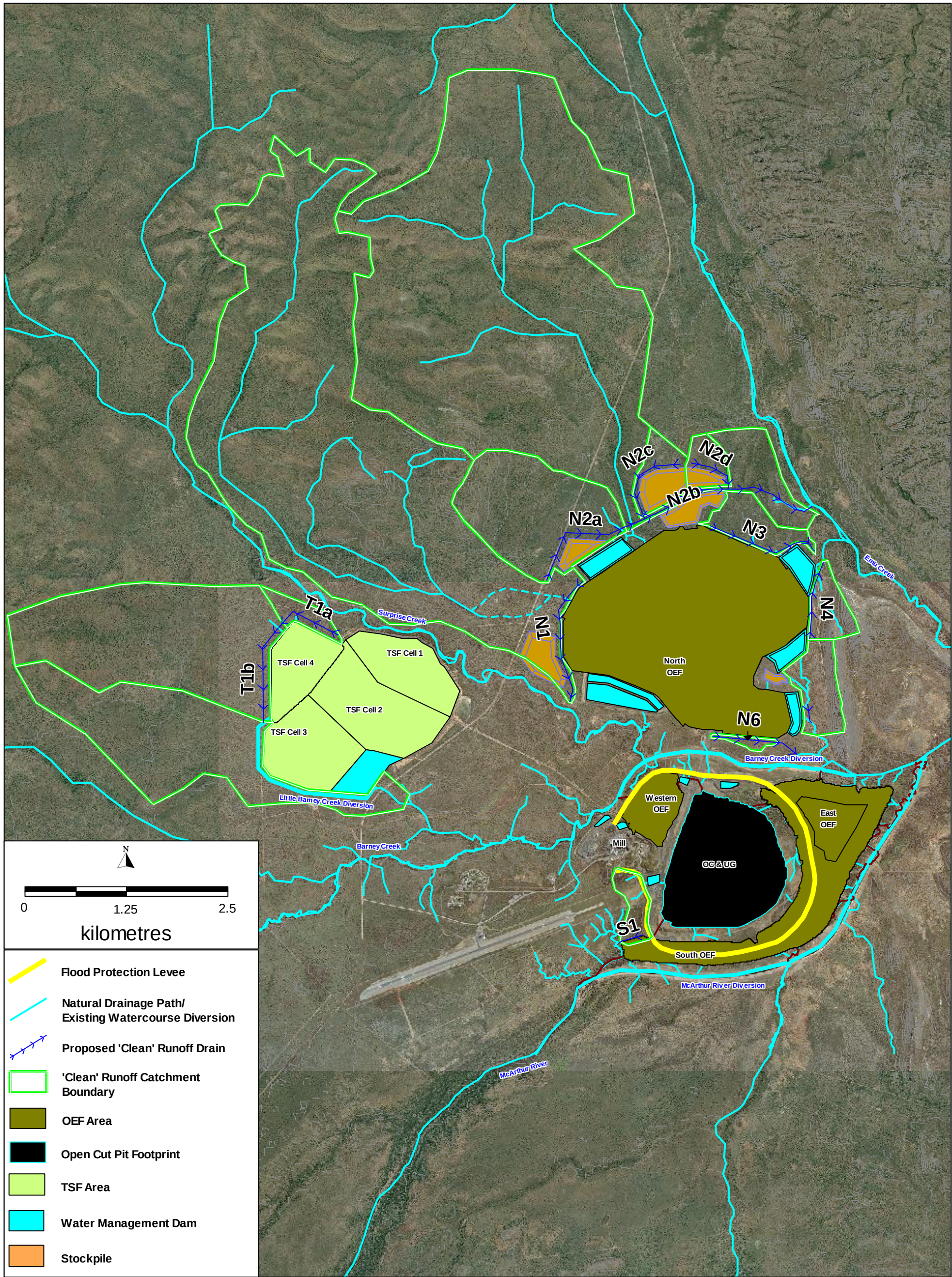


Figure 7.7 Locations of Proposed 'Clean' Runoff Drains, McArthur River Mine Site

Table 7.7 Adopted 'Clean' Runoff Drain Catchment Areas and Year of Construction

Drain ID	Catchment Area (ha)	Commissioning Year
T1a	23	2012
T1b	419	2012
N1	1317	2015
N2a	221	2015
N2b	1760	2025
N2c	47	2025
N2d	29	2025
N3	50	2025
N4	37	2020
N5	57	2015
N6	8	2015
S1	29	2012

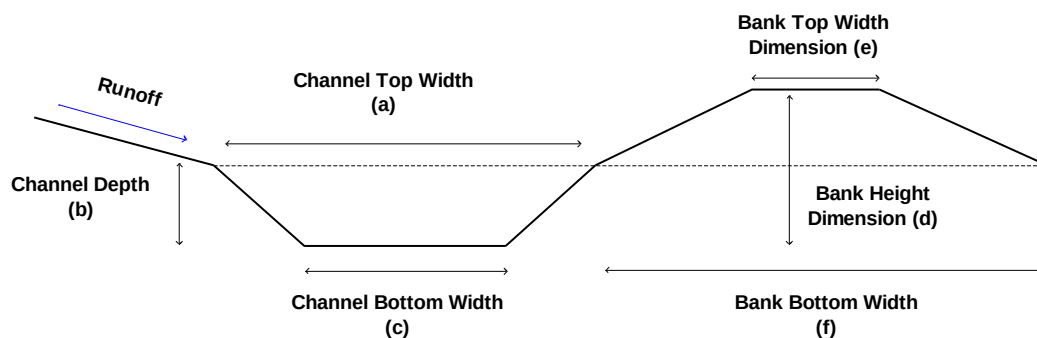


Figure 7.8 'Clean' Runoff Drain Configuration

7.6 'DIRTY' RUNOFF DRAINS AND SEDIMENT PONDS

7.6.1 Overview

'Dirty' runoff generated at the expanded MRM site will be managed by constructing a number of new 'dirty' runoff drains that collect and direct runoff from disturbed catchment areas to sediment ponds for treatment and release to receiving waters. Required diversion banks will be constructed to appropriate engineering standards. The locations and specific features of 'dirty' runoff drains and sediment ponds in the open pit area, TSF area and North OEF area are discussed in Sections 7.2 to 7.4. The following sub-sections provide further details on the adopted design criteria and configurations for new 'dirty' runoff drains and sediment ponds.

7.6.2 Drain Design and Configuration

The following is of note with respect to the proposed new 'dirty' runoff drains:

- Long-term 'dirty' runoff drains that will be active for longer than 2 wet seasons will be constructed to contain the 1% AEP (100 year ARI) design discharge;
- Temporary 'dirty' runoff drains that will be active for 2 wet seasons or shorter will be constructed to contain the 10% AEP design discharge;

- Where possible, 'dirty' runoff drain structures will be designed to limit flow velocities to 2.5 m/s or less for the 1% AEP (100 year ARI) design event. However, in 'dirty' runoff drains with steep channel grades, rock check dams and other energy dissipation and sediment trapping structures may be required at regular intervals to limit erosion;
- Banks will be constructed on the edge of the 'dirty' runoff drains to prevent 'clean' runoff entering the 'dirty' surface water management system. Where possible, 'clean' runoff will be directed to the nearest natural water course or 'clean' runoff drain so that 'clean' runoff does not pond against the banks of 'dirty' runoff drains;
- All drainage structures should be inspected following significant storm events to ensure the structures have been able to sustain flow velocities without causing significant scour or siltation; and
- 'Dirty' runoff drains have been conceptually located based on existing topographic data and the proposed mine layout. The actual location and sizes of 'dirty' runoff drains will be determined during detailed design to accommodate the progression of the OEFs and TSF rehabilitation schedule.

Each 'dirty' runoff drain will exhibit the features identified below and shown in Figure 7.8:

- Trapezoidal channel;
- Bank batters between 1:3 to 1:6 (V:H);
- Channel batters 1:4 (V:H);
- Where necessary rock check dams will be used to maintain specified channel grades;
- Bank bottom widths (f) will vary depending on the adopted bank batters; and
- Stable grass cover to be maintained in the bed and banks of the channel and below sill outlets (as much as possible).

7.6.3 Sediment Ponds

Sediment ponds will have contributing catchment areas that are expected to generate 'dirty' runoff such as disturbed catchment areas containing top-soil dumps and NAF areas of the OEFs. Sediment ponds will be sized and configured during the detailed design phase of the OEFs and the TSF in accordance with the Best Practice Erosion and Sediment Control guidelines (IECA, 2008). Sediment ponds will be designed as 'Type F' sediment basins (see IECA, 2008).

Figure 7.9 shows a typical cross-section of a 'Type F' sediment pond to be used on the site. The following is of note:

- The sediment ponds will have two zones: a settling zone to treat the sediment laden water; and a sediment storage zone for the collection of sediment that drops out of the water;
- The settling zone of the sediment ponds will be sized to capture the required 63% AEP (1 year ARI) 5-day rainfall event from the contributing catchment area. The size of the sediment storage zone of the sediment pond will be 50% of the settling zone. Note that the adopted sediment pond volumes mean that the capacity of the sediment ponds will be exceeded regularly and water will spill to the receiving waters at least once in most years;
- Where possible, sediment ponds will be located in old drainage channels such as old or abandoned creek channels that have been isolated due to mining activities to minimise the amount of excavation required for the storage and allow water to overflow/be pumped into a natural downstream channel after treatment;

- The sediment ponds will be designed for a 5-day cycle where by the sediment laden water fills the sediment pond, is treated and then pumped out to the receiving environment within a maximum of five days. The water will be then pumped down to the sediment storage zone in preparation for the next runoff event;
- De-silting of the sediment pond should be undertaken as required when the sediment storage zone is close to full;
- Long-term sediment ponds that will be active for longer than 2 wet seasons, will be constructed with spillways designed to convey the 1% AEP (100 year ARI) discharge plus a 300 mm freeboard to the crest of the dam wall;
- Short-term sediment ponds that will be active for 2 wet seasons or shorter, will be constructed with spillways designed to convey the 10% AEP (10 year ARI) discharge plus a 300 mm freeboard to the crest of the dam wall; and
- Adequate erosion protection will be required at and downstream of the spillway of the sediment pond.

The settling zone of the sediment ponds will be sized using the following formula:

$$V_s = 10 \times R_{(85\%,5\text{day})} \times C_v \times A$$

where:

V_s = volume of the settling volume (m^3);

$R_{(85\%,5\text{day})}$ = 85%, 5-day rainfall depth (36.0mm);

C_v = Volumetric runoff co-efficient (0.6 for clay); and

A = Catchment area connected to the sediment basin/trap in hectares (ha).

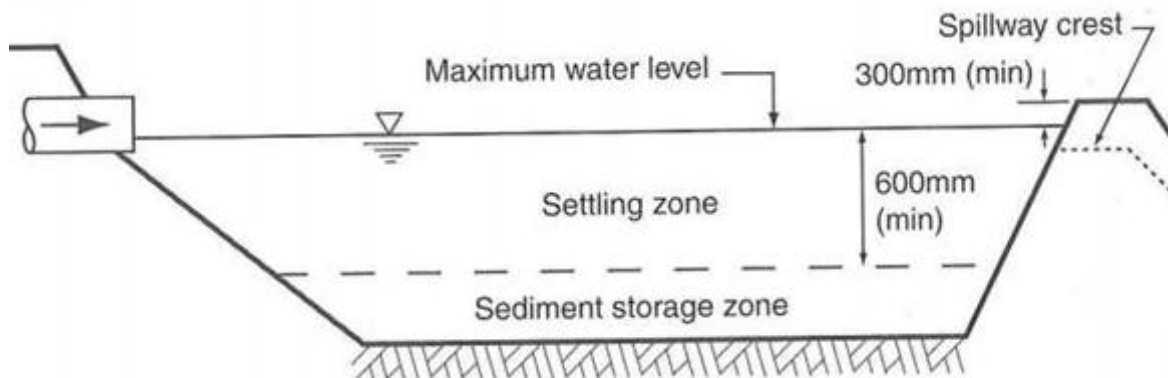


Figure 7.9 Typical Sediment Pond Cross-Section

7.7 'CONTAMINATED' WATER STORAGE

7.7.1 Overview

'Contaminated' water from the expanded MRM site will be managed by constructing a number of new water storages in addition to the existing storages that are used for the current operations at the MRM site. The proposed new storages containing 'contaminated' water include four additional PAF runoff dams around the North OEF and the future TSF Cell 4 that will be

constructed as part of the tailings storage facility. The location, staging and design of the TSF Cells 3 and 4 for tailings deposition are discussed elsewhere (Appendix E1 of MET Serve, 2012). The following is of note:

- All 'contaminated' water storages will be sized to capture and retain runoff from the contributing catchments;
- All 'contaminated' water storages will have appropriately sized emergency spillways designed to convey up to the 0.05% AEP (2,000 year ARI) discharges. Potential erosion issues will be considered when constructing these emergency spillways; and
- All 'contaminated' water storages will be appropriately sealed or lined to prevent leakage through the base and wall of the dam.

7.7.2 Storage Configuration

Figure 7.10 shows the adopted design configuration for 'contaminated' water storages. The following is of note:

- FSL volume is the capacity of the storage from the base to the spillway of the dam;
- MOL volume is the maximum volume of water that is allowed in the storage. No water would be pumped into a storage that exceeds the MOL volume. The required airspace volume between the MOL volume and the FSL volume should be calculated based on the following:
 - For storages contained within the open pit area (i.e. storages that overflow into the open pit): 20% AEP (5 year ARI) 24-hour rainfall depth (152 mm) multiplied by the contributing catchment area multiplied by the volumetric runoff co-efficient of 0.5 (based on rainfall runoff modelling).
 - For storages that overflow into the receiving environment: 1% AEP (100 year ARI) 24-hour rainfall depth (300 mm) multiplied by the contributing catchment area.
- OOL volume is the preferred (target) water level in the water storage. This volume is particularly important for storages that are utilised to maximise water disposal through evaporation and/or releases to the receiving environment. It is also important for storages that will receive continuous inflows from the open pit and groundwater sources.

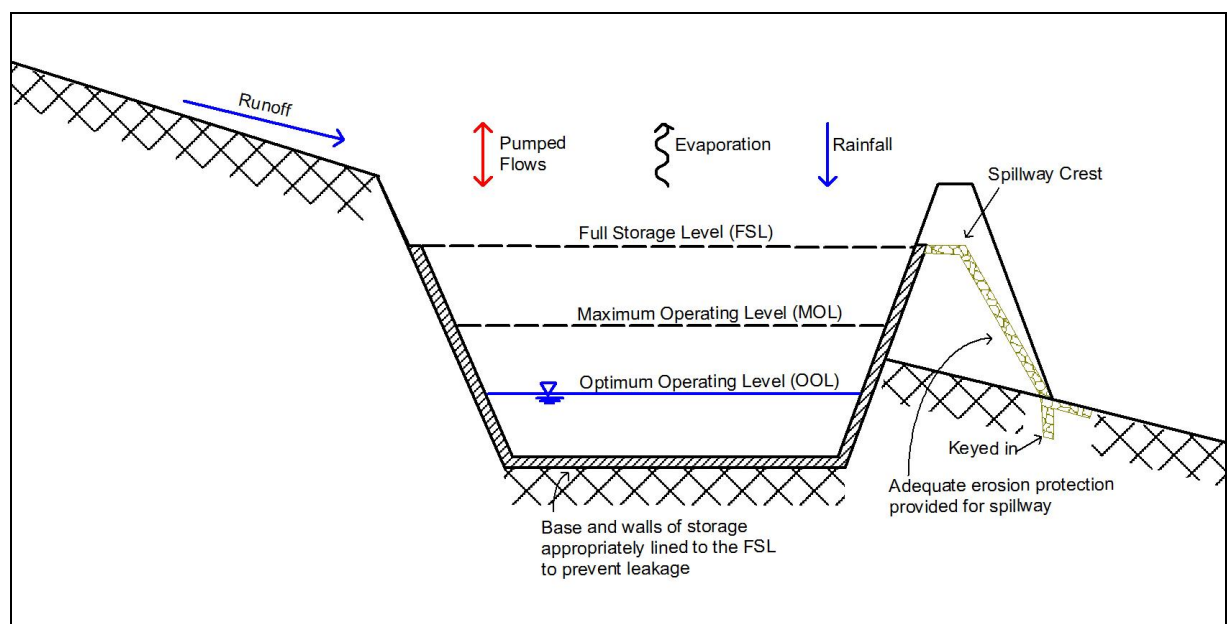


Figure 7.10 Typical Water Management Dam Cross-Section

7.8 'INTERCEPTED' GROUNDWATER MANAGEMENT

7.8.1 Overview

It is proposed to 'intercept' groundwater at the MRM site by constructing dewatering bores and spears around the perimeter of the open pit before it enters the open pit and underground mine void. Based on limited monitoring of water quality in the groundwater bores (up to 30 m deep) in the McArthur River palaeo-channel and the open pit area, it is understood that this 'intercepted' groundwater may be of acceptable quality for irrigation use at the MRPL and for controlled releases to the McArthur River (when appropriately diluted with river water).

Based on advice received from MET Serve, it is proposed to intercept 70% of the groundwater that would otherwise flow into the open pit and the underground mine void to ensure that adequate volumes of water of acceptable quality can be disposed off-site in accordance with the objectives of the MRM water management strategy. 'Intercepted' groundwater will be transferred to TSF Cell 3 WMD (via Lake Archer) and used in the following order of priority (from highest to lowest):

- Transfer to TSF Cell 4 WMD for on-site water demands such as makeup water to the mill, dust suppression and evaporation at a maximum rate of up to 20 ML/d;
- Controlled releases to the McArthur River up to a maximum rate of 60 ML/d (when conditions permit); and
- Irrigation supply to the MRPL up to a maximum rate of 20 ML/d.

7.8.2 Controlled Releases to the McArthur River

It is proposed to dispose 'intercepted' groundwater under the MRM WDL174-1 conditions outlined in Section 6.3. Controlled releases of up to 60 ML/d will be made via a proposed pipeline approximately 4 km long from TSF Cell 3 WMD to the McArthur River, when conditions permit.

The MRM WDL174-1 water quality trigger values for discharges from the mine are based on the quality of mine levee water and the limiting factor for determining the dilution rate appears to be based on the eco-toxicology factors rather than water quality trigger levels. The most recent eco-toxicology testing (Appendix 8 of MRM, 2011) found that existing mine levee water from OMR should be diluted by a factor of 25 with McArthur River water to ensure adequate protection of the downstream ecosystem. The eco-toxicology report also found that the concentration of zinc, which was 33 µg/L was adequate to explain the toxicity of the mine water. The relationship between metal concentrations and toxicity to aquatic organisms is complex and it is likely to be non-linear in nature. However, assuming that the relationship is linear, and that zinc is the limiting parameter, the dilution factor required for the discharge of 'intercepted' groundwater at the mine site (based on available palaeo-channel groundwater quality data given in SDWMP (MRM, 2011)) would be in the order of 333.

Based on a dilution factor of 333, an analysis of the McArthur River flow record at the MIM Pump station (43 years of data) shows that the potential rate of discharge of 'intercepted' groundwater to the McArthur River will be in the order of 0.1 GL/yr, 0.9 GL/yr and 4.8 GL/yr for a 90th percentile (dry) year, 50th percentile (median) year and 10th percentile (wet) year respectively.

7.8.3 Off-Site Irrigation Supply

It is also proposed to reuse 'intercepted' groundwater off-site to MRPL for irrigation activities. It is understood that an additional water storage will be constructed at the MRPL to store and

manage the water transferred from MRM. The MRM water management system has been configured to only send irrigation water to MRPL if there is no capacity within the MRM on-site water management system and controlled releases cannot be made to the McArthur River. Pumping infrastructure with a capacity of approximately 20 ML/d will be provided to link TSF Cell 3 WMD to the proposed irrigation supply dam on MRPL.

Details on the proposed use, storage and management of MRM water supplied to MRPL for irrigation (including the sizing of the proposed irrigation supply dam) are discussed elsewhere (TCT, 2012).

7.9 DATA LIMITATIONS AND ASSOCIATED UNCERTAINTIES

The proposed Water Management Plan (WMP) for the MRM Phase 3 operations has been prepared based on the best available data and information at the time of preparing the report. The data and information used have been obtained from reports prepared and modelling undertaken by other consultants, and verbal and written advice received from MRM staff, MET Serve and other consultants.

Notwithstanding the above, due to data limitations, a number of significant assumptions had to be made when designing the proposed WMP (described in the preceding sections). Therefore, there is a degree of uncertainty in the design, operation and performance of the WMP components associated with the adopted assumptions. If any of the assumptions made are found to be inaccurate, in order to meet the water management objectives stated in Section 5, it is likely that the WMP will require some refinements and changes as more representative data and information comes to hand during the Phase 3 mining operations.

Some of the potential uncertainties associated with key assumptions, and their implications, are discussed below (not in a particular order of importance):

- It is proposed to use 'dirty' runoff drains to direct runoff from the South and East OEFs towards sediment ponds. This is based on the assumption that runoff and seepage from the South and East OEF areas can be considered 'dirty' and can be released to the receiving waters after treatment in a sediment pond. Monitoring of water quality in these sediment ponds would be required to demonstrate that the water quality is within the limits specified in the waste discharge licence prior to release into receiving waters. If runoff and/or seepage from South and East OEF areas is found to be 'contaminated', active management measures and/or additional storage volume would be required to fully contain the contaminated water on site.
- The runoff collected in sediment ponds in the North OEF area from NAF material surfaces on top of encapsulated and capped PAF material is assumed to be of acceptable quality for release to the receiving waters. It is also assumed that the capping of the PAF areas would be effective in preventing infiltration through the cap. Monitoring of water quality in these sediment ponds would be required to demonstrate that the water quality is within the limits specified in the waste discharge licence prior to release into receiving waters. If not, active management measures and/or additional storage volume would be required to fully contain the contaminated water on site.
- The predicted groundwater inflow rates to the open pit and the underground mining void are quite significant. It is understood that there is significant uncertainty in the accuracy of the predicted inflow rates. Significant differences in groundwater inflows would require redesign of the water management system.
- It is assumed that 70% of the groundwater that would otherwise flow into the open pit and the underground mine void can be 'intercepted' to ensure that adequate volumes of

water of acceptable quality can be disposed off-site in accordance with the objectives of the MRM water management strategy. If it is not possible to 'intercept' the assumed volumes of groundwater a significantly larger on-site storage capacity would be required to meet MRM's water management objectives for the mine site.

- It is proposed that excess 'intercepted' groundwater will be either discharged to the McArthur River under an appropriate 'controlled' release strategy during high flows in the river or pumped off-site for irrigation use at the MRPL. This strategy assumes that a waste discharge licence from NRETRAS can be obtained to allow controlled releases of 'intercepted' water stored in the TSF Cell 3 WMD to the McArthur River or off-site to MRPL.
- It is assumed that the quality of 'intercepted' groundwater is acceptable for irrigation activities and for controlled release to the McArthur River. If this assumption is incorrect, water in TSF Cell 3 WMD would have to be treated to an acceptable quality before disposal off-site. Monitoring of 'intercepted' groundwater quality would be required to demonstrate that the water quality is within the limits specified in the waste discharge licence prior to release to the McArthur River or off-site irrigation use.
- A dilution ratio of 333 has been assumed for the release of 'intercepted' groundwater into the McArthur River. If proposed monitoring indicates that a much higher dilution ratio is required, the ability to release excess water to the McArthur River would be reduced. If it is not possible to release the assumed volume of 'intercepted' groundwater to the McArthur River more water would have to be released for irrigation use at MRPL or else a significantly larger on-site storage capacity would be required to meet MRM's water management objectives for the mine site.

It is recommended that further water quality monitoring and investigation of the issues identified above be undertaken. If the adopted assumptions are found to be inaccurate, the potential impacts and required modifications to the proposed WMP should be investigated and appropriate modifications be made to the WMP to ensure that the objectives stated in section 5 are met.

8 MINE SITE WATER BALANCE

8.1 GENERAL

8.1.1 Overview

A GoldSim model (GoldSim Technology Group, 2011) was developed to simulate the long-term behaviour of the water management system at MRM and determine the mine site water balance for existing and proposed Phase 3 mining operations.

The model was used to determine:

- The long-term behaviour of the various on-site storages;
- The ability and reliability of the various on-site storages to supply the mine site water requirements;
- The sizes of proposed new storages at the MRM site;
- The frequency and volume of potentially 'dirty' and/or 'contaminated' water overflows from various on-site storages;
- The ability to dewater the open pit within acceptable time frames;
- The frequency and volume of 'intercepted' groundwater released to the McArthur River and MRPL for irrigation supply; and
- The overall site water balance.

8.1.2 Modelling Methodology

The water balance model (GoldSim) represents the movements of water within the MRM surface water management system over time based on inputs and operating rules. It includes all inflows (e.g. rainfall, surface runoff, pumped inflows, groundwater inflows) and outflows (e.g. evaporation, seepage, storage overflows, pumped outflows, site water usage, off-site releases) affecting the on-site storages.

A daily (time-step) simulation model was first developed based on the schematisation of the existing water management system for the mine site as shown in Figure 6.2 and calibrated against data available for the 12 month period ending June 2011. The calibrated model was then expanded to include the proposed Phase 3 development water management system (as shown in Figure 7.6) to assess the performance of the proposed water management system and determine its ability to manage a range of climatic conditions during the proposed MRM Phase 3 mining operations.

An AWBM model (Boughton, 2003) for the McArthur River was calibrated to recorded flows at the MIM Pump stream gauging station. The AWBM model was then used to extend the McArthur River flow record at the MIM Pump station and use within the water balance model for the assessment of off-site water release opportunities from the MRM site.

A detailed water balance of the TSF was not undertaken as part of this study because the tailings dams have no external catchment and only the active cells receive pumped inflows from the Mill. The active cells within the TSF were included in the water balance model as a static storage (i.e. ignoring tailings deposition) to account for rainfall into and evaporation from the TSF. The design and operation of the TSF are discussed elsewhere (Appendix E1, METSERVE, 2012).

8.2 RAINFALL AND EVAPORATION

The SILO Data Drill rainfall and evaporation data obtained for the MRM site for the 122 year period 1889 to 2011 was used in the mine site AWBM and Goldsim models. This data is reviewed and discussed in Section 3.2 of this report.

8.3 CATCHMENT RUNOFF

8.3.1 Mine Site Catchments

The AWBM model was used to represent the runoff characteristics of different land use types within local mine site catchments. AWBM uses a group of connected conceptual storages (3 surface storages and 1 groundwater storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and reduced by evapotranspiration. Simulated surface runoff occurs when these storages fill and overflow. The model parameters define the depth and relative area of each of the storages, as well as the rate of water flux between storages.

To accurately simulate the site water balance it is necessary to define the runoff characteristics of the various catchment surface (land use) types. The following land use classifications were used:

- Natural - representing undisturbed area as well as rehabilitated areas;
- Disturbed/compacted - representing areas disturbed by mining such as, haul roads and plant areas (including industrial and cleared areas);
- Spoil - representing uncompacted dumped overburden material; and
- Pit - representing the open pit area.

Table 8.1 shows the adopted catchment areas of on-site storages for different stages of mining over the period of the mine life: 2011 (existing), 2015, 2020, 2025, 2030 and 2035. The annual variations in catchment areas for the proposed North OEF PAF dams are shown in Table D1, Appendix D. North OEF catchment areas were classified as spoil areas. Table 8.2 shows the adopted AWBM parameters and calculated volumetric runoff coefficients for the various catchment types at the mine site. The AWBM model parameters were determined on the basis of the Goldsim model calibration results and previous experience with similar catchments.

Table 8.1 MRM Storage Catchment Areas for Different Stages of Mining Operations

Catchment	Catchment Area (ha)			
	Existing (2011)	2015	2020	2025 to 2035
McArthur River	960,220	960,220	960,220	960,220
TSF				
- Industrial (Disturbed)	129.4	229.4	229.4	229.4
APP				
- Industrial(Disturbed)	14.5	14.5	14.5	14.5
CRP				
- Spoil	0.1	0.1	0.1	0.1
- Industrial (Disturbed)	12.9	12.9	12.9	12.9
TSF Cell 3 WMD				
- Industrial (Disturbed)	129	25	25	25
VDD				
- Industrial (Disturbed)	20.1	20.1	20.1	20.1
- Spoil	9.6	9.6	9.6	9.6
- Cleared (Disturbed)	8.2	8.2	8.2	8.2
TSF Cell 4 WMD				
- Industrial (Disturbed)	65	65	65	65
PP				
- Industrial (Disturbed)	2.1	2.1	2.1	2.1
OMR ^a				
- Natural	131.4	0	0	0
- Spoil	6.3	0	0	0
- Industrial (Disturbed)	22	0	0	0
- Cleared (Disturbed)	20.3	0	0	0
LA				
- Industrial (Disturbed)	18.2	18.2	18.2	18.2
- Spoil	13.9	13.9	13.9	13.9
- Natural	3.4	3.4	3.4	3.4
- Cleared (Disturbed)	3.6	3.6	3.6	3.6
OC&UG				
- Natural	2.1	63.5	37.5	35.1
- Spoil	5.7	69.8	81.4	91.5
- Pit Floor	36.9	161.5	198.2	198.2
- Industrial (Disturbed)	12.4	25.0	22.3	20.3
- Cleared (Disturbed)	64	47.5	38.8	37.9
ELS ^a				
- Natural	18.2	0	0	0
- Industrial (Disturbed)	10.2	0	0	0
- Cleared (Disturbed)	25.6	0	0	0

^a ELS and OMR Removed for Stages 2015 to 2035 due to progression of the open pit

Table 8.2 Adopted AWBM Parameters

Parameter	Parameter ID	McArthur River	Site Natural	Site Industrial	Site Spoil	Site Pit
Surface Store Depth (mm)	C1	30	17.6	6.0	15.0	10.0
	C2	120	73.8	18.0	90.0	30.0
	C3	400	400	0	0	0
Partial Areas	A1	0.06	0.07	0.10	0.10	0.10
	A2	0.40	0.40	0.90	0.90	0.90
Base flow index	BFI	0.12	0.10	0	0	0
Base flow recession constant	Kb	0.963	0.99	0	0	0
Surface flow recession constant	Ks	0.40	0	0	0	0
Long-term Average Runoff Coefficient	RC	0.082	0.22	0.50	0.32	0.45

8.3.2 McArthur River

The AWBM model was calibrated to the recorded daily McArthur River flows at MIM Pump station between October 1969 and August 2011, using the Rainfall Runoff Library (RRL) developed by the CRC for Catchment Hydrology (Podger, 2004). Daily rainfalls recorded at Mallapunyah station and MRM were averaged to provide an estimate of catchment average rainfalls. The model was calibrated to achieve a daily flow duration curve similar to the recorded data. Table 8.2 shows the adopted AWBM parameters and calculated volumetric runoff coefficient. Figure 8.1 shows a comparison of the recorded and predicted daily flow duration curves (in ML/d) at the McArthur River MIM Pump station.

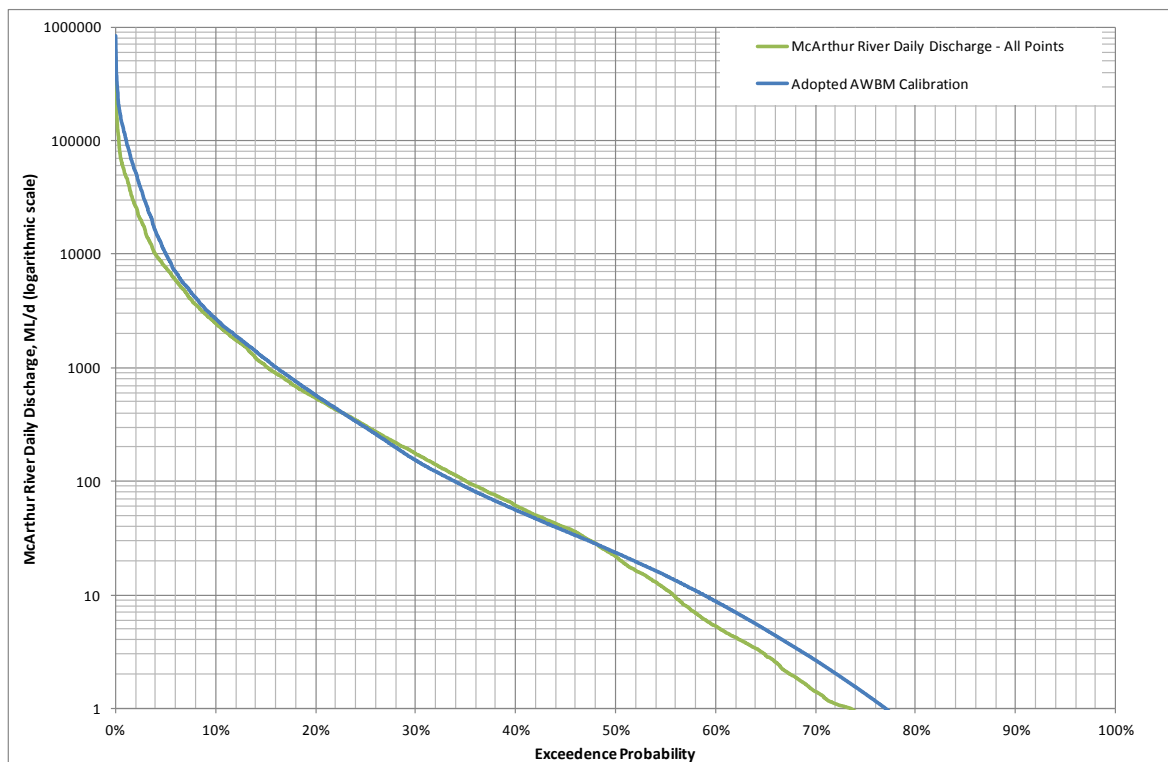


Figure 8.1 Recorded Vs Predicted Daily Flow Duration Curve, McArthur River at MIM Pump Station

8.4 SITE WATER DEMANDS

The major water demands at the MRM site are for:

- Concentrator Mill processing;
- Dust suppression on haul roads and OEFs;
- Potable water and power generation;
- Industrial and Infrastructure use (such as vehicle wash-down); and
- Evaporation enhancement (evaporative fans, sprinklers and water fountains).

Water demands were provided by MRM based on ROM production rates, OEF development schedules and concentrator Mill throughput. Table 8.3 shows the adopted daily water demands for the MRM site for existing and proposed MRM Phase 3 mining conditions. Note that potable water used at the MRM camp has not been included as a demand.

8.4.1 Concentrator Mill

The proposed MRM Phase 3 mining operations will double the ore processing rate from approximately 2.56 Mtpa in 2010/2011 to 5.25 Mtpa (averaged over the 26-year life of the mine). As a result, the expected concentrate produced will be increased to 0.8 Mtpa.

Table 8.4 shows the adopted throughput of raw ore feed into the Mill and product and tailings concentrate out of the Mill for existing and proposed conditions. Table 8.5 shows the existing and proposed Phase 3 operation daily water balances for the Mill, including an estimate of the required makeup water supply. Assuming an overflow rate of 10% from the Mill to the CRP, the required average makeup water requirement to the mill will increase from the current 5.17 ML/d to 9.73 ML/d for Phase 3 mining operations.

Table 8.3 Daily Water Demands at MRM Site

Water Use	Demand (ML/d)	
	Existing (2.56 Mtpa)	Phase 3 (5.25 Mtpa)
Concentrator Mill (make up water)	5.17	9.73
Dust suppression	2	3
Evaporative Fans	3.40 ^a	6.55 ^b
Sprinklers and Water Fountains	3.75 ^c	3.93 ^d + 8.28 ^e
Industrial Losses	0.03	0.04
Truck Wash	0.03	0.04
Potable Water and Power	0.53	0.53
Total Water Usage	14.91	23.86 + 8.28^e

^a 6 fans at 40% efficiency

^b 12 fans at 39% efficiency

^c 3 sprinklers (PP, SPSP, SPROD) at a loss rate of 3.03 ML/d and 4 water fountains (PP, VDD, CRP, LA) at a loss rate of 0.18 ML/d/storage

^d 3 sprinklers (PP, SPSP, SPROD) at a loss rate of 3.03 ML/d and 5 water fountains (PP, VDD, CRP, LA, APP) at a loss rate of 0.18 ML/d/storage

^e 4 PAF Runoff Dam sprinklers (SEPROD, EPROD, NEPROD, SEPROD) at a loss rate of 2.07 ML/d/storage

Table 8.4 Adopted Throughputs to the Concentrator Mill, Existing and Proposed Conditions

Description	Raw Ore Feed	Product Concentrate	Tailings Concentrate
<u>Current (2010/2011)</u>			
Tonnage (tonnes/d)	7000	1200	5800
Water Fraction (%)	3.5	13	45
Water Content (ML/d)	0.25	0.18	4.75
<u>Proposed (MRM Phase 3)</u>			
Tonnage (tonnes/d)	14380	2190	10970
Water Fraction (%)	3.5	13	45
Water Content (ML/d)	0.52	0.33	8.98

Table 8.5 Adopted Concentrator Mill Daily Water Balance, Existing and Proposed Conditions

Description	Flow (ML/d)	
	Current (2.56 Mtpa)	Phase 3 (5.25 Mtpa)
Raw Feed	+0.25	+0.52
Concentrator Product	-0.18	-0.33
Concentrator Tailings	-4.75	-8.99
Thickener Overflows	-0.49	-0.93
Mill Makeup Water	5.17	9.73

8.5 WATER SUPPLIES

8.5.1 Bore Water

Water from the MIMEX, Emu and Donkey bore fields is supplied to the existing MRM site. Water is currently pumped to the Raw Water Tank (RWT) from the bore fields at an estimated rate of up to about 1.5 ML/d. The bore water demand is estimated to increase to 2.0 ML/d during Phase 3 conditions to meet gland water requirements for return water to the Mill. Water stored in the RWT will be used for potable water supply, truck wash areas, industrial washdown areas and as a source of makeup water to the Mill (via the DWT).

Table 8.6 shows the uses for bore water for current and Phase 3 mining conditions. Note that additional bore water supplied to the MRM camp was not explicitly modelled.

Table 8.6 Bore Water Usage, Existing and Proposed Conditions

Bore Water User	Existing (ML/d)	Phase 3 (ML/d)
Potable Water Supply (constant)	0.53	0.53
Truck Wash (10% of bore water supply)	0.15	0.2
Industrial Washdown (10% of bore water supply)	0.15	0.2
Mill (via DWT) (15% of DWT demand)	0.67	1.07
Total	1.5	2

8.5.2 Groundwater Inflows

The predicted groundwater inflows over the next 26-year period of mine life into the open pit and underground mine void at MRM during Phase 3 mining operations were provided by URS (URS, 2012). Figure 8.2 shows the predicted daily groundwater inflows over the life of the mine. Based on these predicted inflows, the proposed mine site water management system has to accommodate significant groundwater inflows to the open pit and underground mine void for the full duration of the Phase 3 mining operations. URS (2012) predict average annual groundwater inflows of up to about 6200 ML (17 ML/d) with daily inflow rates varying from about 13 ML/d during the dry season to about 23 ML/d during the wet season. The groundwater inflows will be the most significant component of the water inventory at the mine.

Estimates of groundwater inflows to the open pit and underground mine void in 2010/2011 (for existing conditions) are provided in Connell Hatch (2011) and were used for the calibration of the Goldsim model. For existing conditions, it has been estimated that the groundwater inflows to the open pit and underground mine void ranged from about 4 ML/d in the dry season to 12 ML/d in the wet season. Figure 8.3 shows the variation in daily groundwater inflows adopted in the model for the period July 2010 to June 2011.

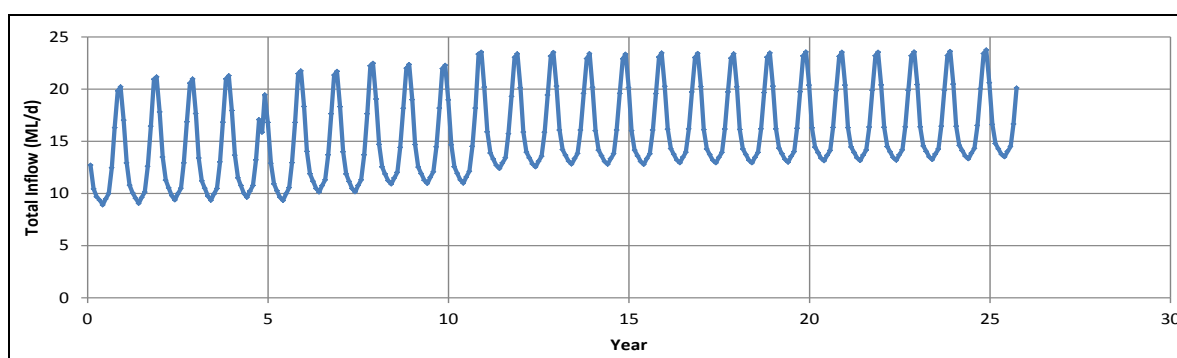


Figure 8.2 Predicted Total Groundwater Inflow Rates to the Open Pit and Underground Mine Void during Phase 3 Mining Operations

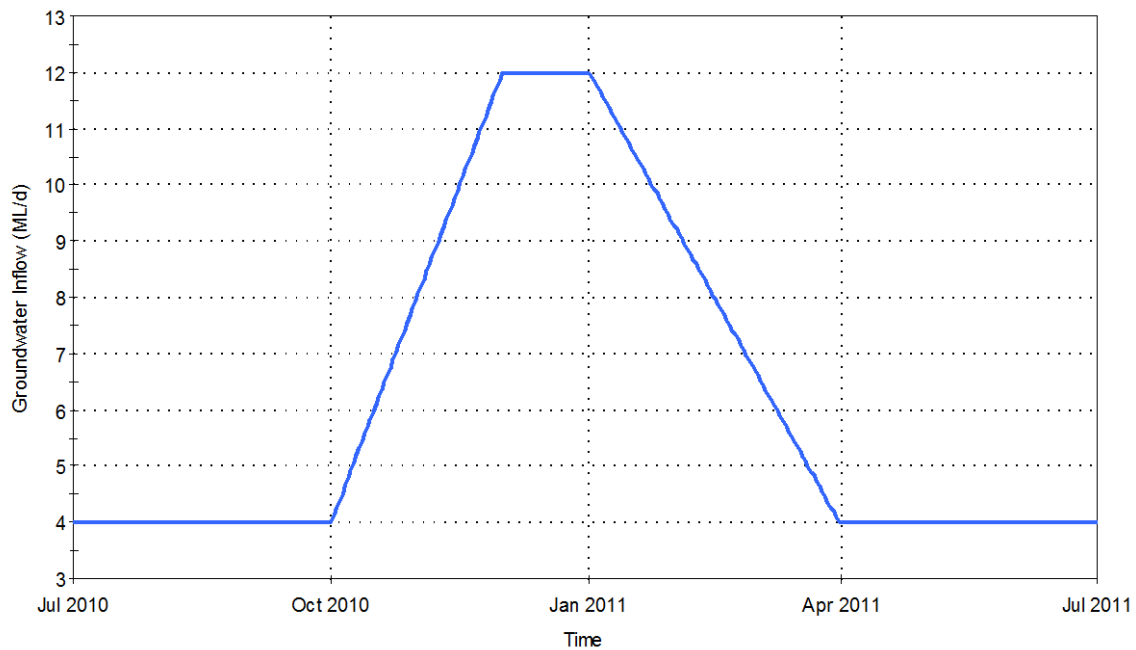


Figure 8.3 Predicted Total Groundwater Inflow Rates to the Open Pit and Underground Mine Void during, July 2010 to June 2011

8.6 CONTROLLED RELEASES

Under existing conditions, controlled releases to the McArthur River from the MRM site are made from the OMR channel and the TSF Cell3 WMD in accordance with conditions specified in MRM's WDL 174-1. Releases are made from the OMR at a maximum rate of 20.7 ML/d and from the TSF Cell 3 WMD at a maximum rate of 56.7 ML/d.

During MRM Phase 3 mining operations, it is proposed to continue controlled releases from the TSF Cell 3 WMD under the conditions specified in MRM's WDL. Based on recent ecotoxicology testing results given in MRM (2011) and the expected quality of 'intercepted' groundwater, a dilution ratio of 333 has been adopted for these releases at a maximum rate of up to 60 ML/d (see Section 7.8 for further discussion). The McArthur River AWBM model results were used to determine potential release opportunities and estimate release volumes from the mine site.

8.7 WATER BALANCE MODEL CONFIGURATION

8.7.1 Existing Conditions

Table E1, Appendix E shows the inflows to and outflows from each of the on-site storages incorporated in the existing conditions water balance model. Figure 6.2 shows a schematic of the existing conditions (2010/2011) model. The following is of note with regards to the configuration of the existing conditions water balance model:

- Daily rainfall and evaporation data are as described in Section 3.2;
- The configuration and operating rules of each storage are as detailed in Section 6;
- The open pit and underground mine void (OC&UG) were modelled as a combined (single) storage;

- Groundwater inflows to the OC&UG range from 4 ML/d in the dry season (April to September) to 12 ML/d during December as described in Section 8.5.2;
- Water collected in the OC is pumped to ELS at a rate of 4.15 ML/d, PP at a rate 4.15 ML/d and to PP (via LA) at a rate of 7.34 ML/d;
- Water collected in the UG is pumped to ELS at a rate of 10.0 ML/d and PP at a rate 8.99 ML/d;
- PP distributes (i.e. transfers) water to VDD at a rate of 4.15 ML/d, the NOEF SPSP and NOEF SPROD at a rate 7.78 ML/d and the CRP at a rate of 6 ML/d. PP also supplies water to six (6) evaporator fans at a rate of 8.4 ML/d;
- VDD supplies water tanks for dust suppression at a rate of 2.0 ML/d;
- Water in the APP and RWT is pumped to the DWT at a rate of 7.2 ML/d and 0.67 ML/d respectively. DWT supplies return water to the Mill at a rate of 5.17 ML/d;
- Water from the Mill is pumped to the TSF Cell 2 at a rate of 4.75 ML/d. 15% of water from the Mill is retained (lost) in the TSF matrix. Water from the TSF Cell 2 is returned to the APP at a rate of up to 7.2 ML/d;
- Overflows from the Mill and DWT are directed to the CRP at a rate of 2.70 ML/d and 0.49 ML/d, respectively. Water is returned from the CRP to the APP at a rate of up to 7.2 ML/d;
- The OMR and the TSF Cell 3 WMD release stored water to the McArthur River in accordance with conditions specified in MRM's WDL 174-1 at maximum rates of up to 20.74 ML/d and 56.68 ML/d, respectively; and
- DWT and RWT do not receive direct rainfall or catchment runoff nor have evaporation losses. That is, they are modelled as closed tanks.

8.7.2 MRM Phase 3 Mining Conditions

Table E2, Appendix E shows the inflows to and outflows from each of the on-site storages incorporated in the proposed Phase 3 mining conditions water balance model. Figure 7.6 shows a schematic of the proposed conditions model. The following is of note with respect to the proposed conditions water balance model:

- The operation of APP, CRP, RWT, DWT, RWT and Mill remains the same as for the existing conditions model except for modified flow rates associated with the proposed increase in production rates;
- The OMR and ELS water storages are removed in 2015;
- The TSF Cell4 WMD is added to the model in 2012;
- The FSL volume of TSF Cell 3 WMD is reduced from 1834 ML to 538 ML in 2015;
- The FSL volume of LA is increased from 20 ML to 40 ML in 2012;
- The FSL volume of VDD is increased from 25 ML to 35 ML in 2012;
- Long-term groundwater inflows to the OC&UG are as per URS (2012) predictions;
- The groundwater inflows to the OC&UG are intercepted at a rate of 70%. The 'Intercepted' ground water is pumped to TSF Cell 3 WMD (via LA) at a rate of up to 20 ML/d;
- OC&UG is dewatered to PP at a rate of up to 50 ML/d. PP in turn is dewatered to TSF Cell 4 WMD;

- Water in TSF Cell 3 WMD is be pumped to TSF Cell 4 WMD for reuse in the mine site water management system, released to the McArthur River or pumped to MRPL for irrigation use. The management of TSF Cell 3 WMD is discussed in Section 7.3.4; and
- Six (6) additional evaporation fans will be installed at the TSF to enhance evaporation losses from the active TSF Cells as well as water stored in TSF Cell 4 WMD.

The following is of note with respect to the North OEF component of the water balance model:

- All storages are operated in isolation to the rest of the mine site water management system except for the existing SPSP and SPROD. The SPSP and SPROD receive pumped inflows from PP up to maximum volumes of 50 ML and 150 ML respectively to enhance evaporation losses. The bottoms of these storages up to the above volumes were assumed to be unavailable when determining the size requirements for the North OEF storages;
- The construction schedule for the proposed new NOEF storages is as follows:
 - SEPROD will be constructed in 2012. It will receive potentially 'contaminated' runoff from PAF catchments from 2013 to 2016 (4 years);
 - EPROD will be constructed in 2012. It will receive potentially 'contaminated' runoff from PAF catchments from 2015 to 2022 (8 years);
 - NEPROD will be constructed in 2015. It will receive potentially 'contaminated' runoff from PAF catchments from 2024 to 2026 (3 years);
 - NWPROD will be constructed in 2016. It will receive potentially 'contaminated' runoff from PAF catchments from 2022 to 2027 (12 years); and
 - WPSD will be constructed in 2012. However, this storage will only receive 'dirty' runoff for the full duration of proposed Phase 3 mining operations. Hence, it is sized as a sediment pond.
- All PAF runoff dams will have sprinklers to enhance evaporation losses. A sprinkler loss rate of 41 litres/second for 14 hours/day has been adopted. This loss rate is the same as the estimated loss rate from the existing North OEF sprinkler system installed in SPROD and SPSP.

8.8 WATER BALANCE MODEL CALIBRATION

8.8.1 Overview

The GoldSim model was calibrated against the recorded stored volumes and water levels in TSF Cell 3 WMD, TSF Cell 2 and OC&UG between 1 July 2010 and 21 June 2011. The recorded water level and stored volume data was provided by MRM.

8.8.2 Calibration Results

Taking into account the gaps in available water management data for the MRM site, the GoldSim model was satisfactorily calibrated for the above period. Figure 8.4 shows a comparison of the recorded and predicted stored volumes in the open pit and underground mine void (combined) for the calibration period. Figure 8.5 and Figure 8.6 show comparisons of the recorded and predicted water levels in the TSF Cell 2 and TSF Cell 3 WMD, respectively. The predicted water levels in all three storages match reasonably well with the recorded volumes/levels. On this basis, the adopted AWBM parameters are also considered to adequately represent rainfall-runoff characteristics at the MRM site.

Table 8.7 shows the overall mine site water balance for the calibrated period. It is noted that over the calibration period, which was one of the wettest periods on record, the mine site water inventory increased by about 2900 ML.

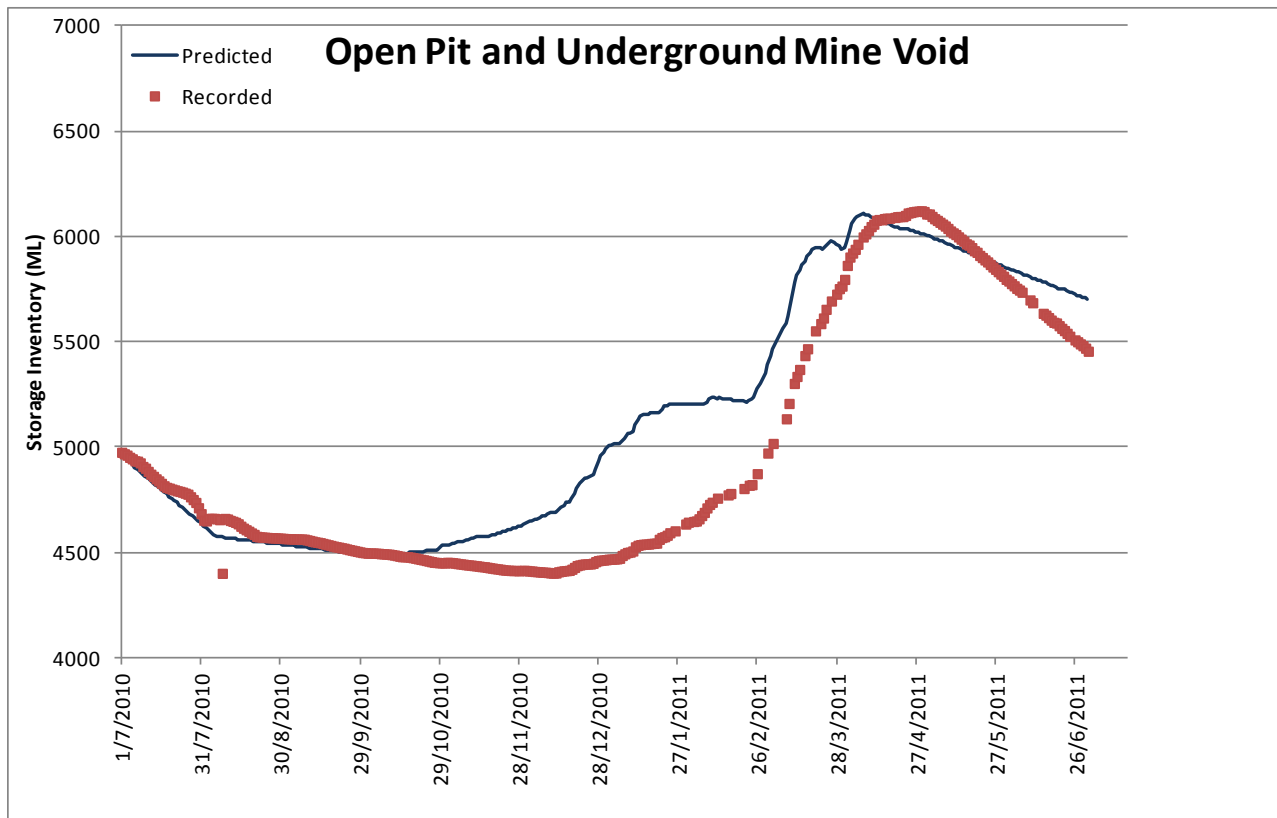


Figure 8.4 Comparison of Recorded and Predicted Stored Water Volumes, Open Pit and Underground Mine Void, July 2010 - June 2011

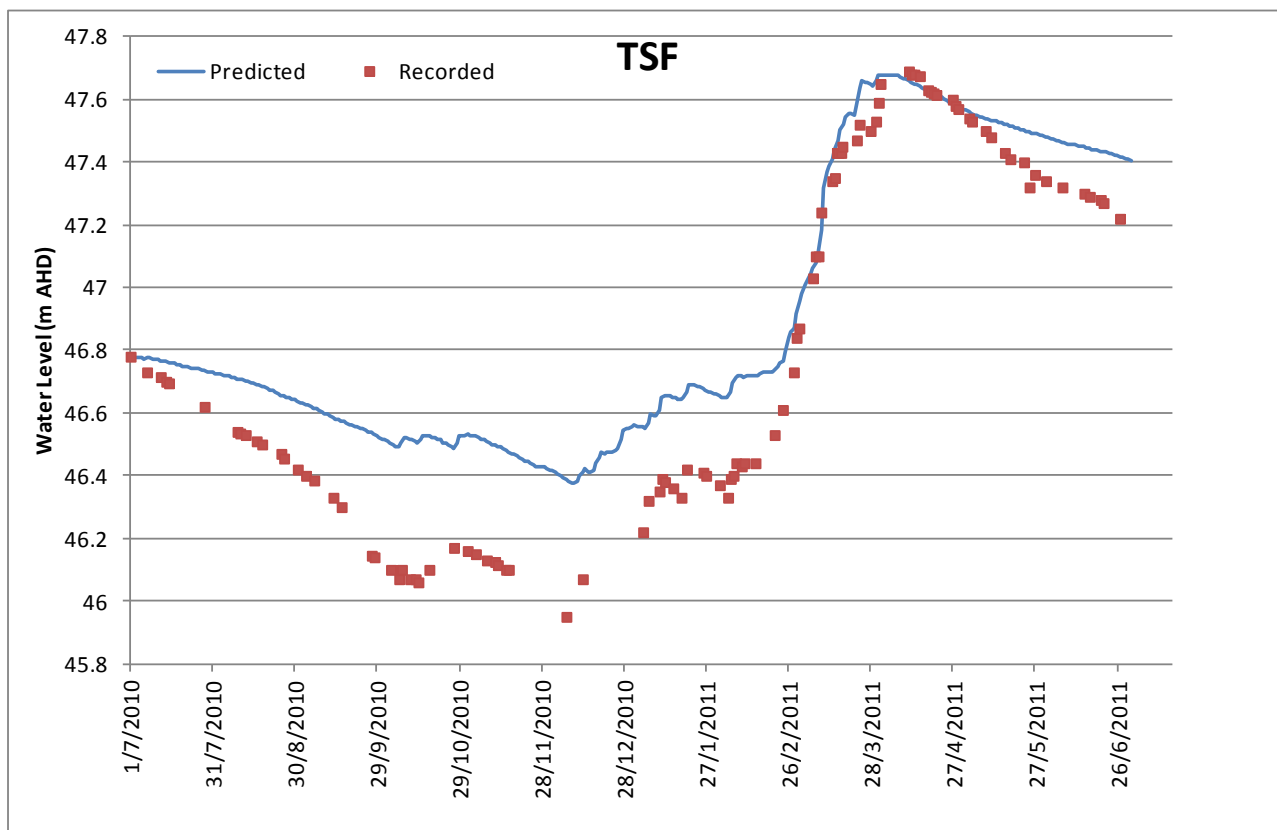


Figure 8.5 Comparison of Recorded and Predicted Water Levels, TSF Cell 2, July 2010 - June 2011

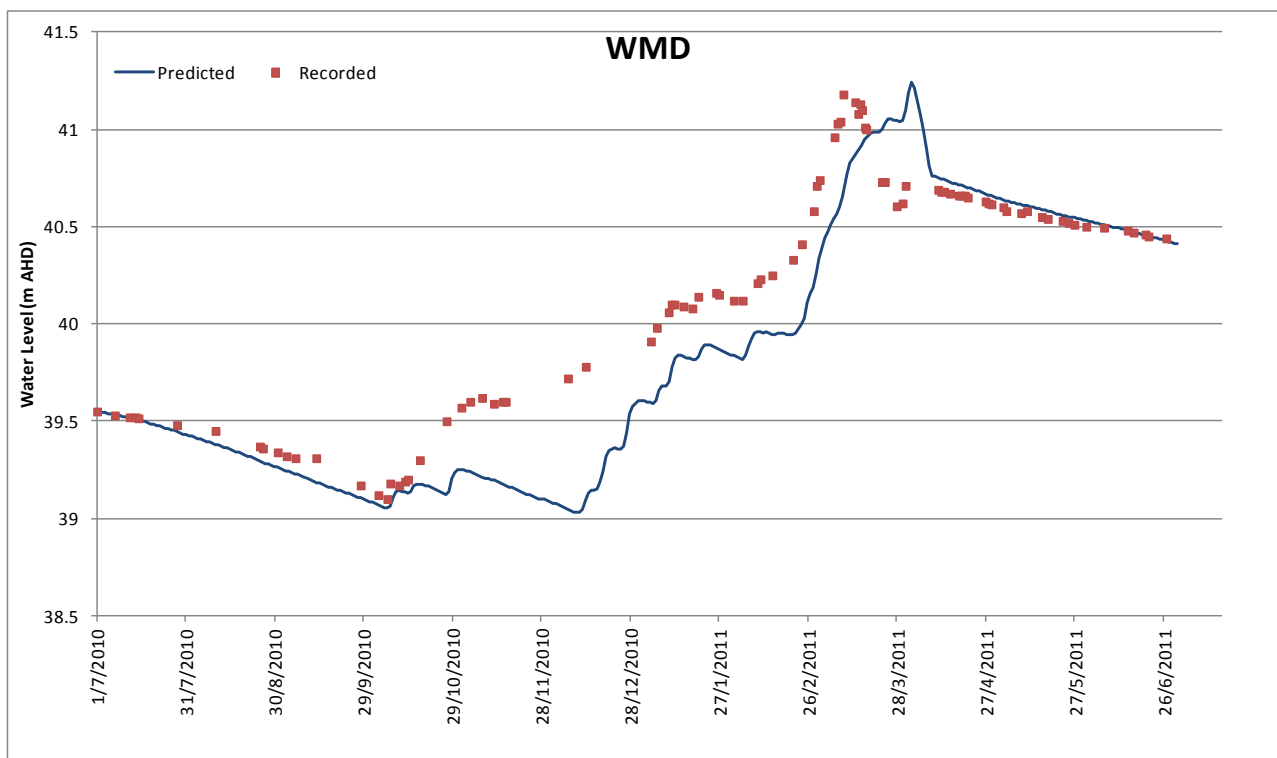


Figure 8.6 Comparison of Recorded and Predicted Water Levels, TSF Cell 3 WMD, July 2010 - June 2011

Table 8.7 MRM Site Water Balance for the Period 1 July 2010 to 30 June 2011

Component	Process	Volume (ML)	Data Source/Comments
Inflows	Direct Rainfall	2858.2	Based on Data Drill data
	Surface Runoff	4534.0	Based on AWBM results
	Groundwater	2308.0	Based on Hatch (2011) report
	Borefields	547.5	Based on advice from mine personnel
	Raw Feed Moisture	92.9	Based on advice from mine personnel
	Solid Accumulation in TSF	1176.1	Based on advice from mine personnel
	Total	11,516.7	
Outflows	Evaporation	3562.0	Based on 6 Fans @ 40% loss rate, Operated on dry days only (days with less than 5mm recorded rainfall)
	Spray Fans	705.8	
	Sprinklers	1036.7	
	Water Fountain	242.7	Based on advice from mine personnel
	Water Cart Usage	730.0	Based on advice from mine personnel
	Truck Wash	11.0	Based on advice from mine personnel
	Potable Use	193.5	Based on advice from mine personnel
	Industrial Use	11.0	Based on advice from mine personnel
	Product Moisture	65.6	Based on advice from mine personnel
	TSF Moisture Retention	260.3	Based on 15% moisture retention within the Concentrator rejects
	Seepage losses	309.1	Uncaptured losses from TSF based on water balance model results
	Off-site Uncontrolled Releases	0	Based on water balance model results
	Off-site Controlled Releases	1489.2	From WMD and Old McArthur River based on water balance model results
	Total	8,616.9	
Change in Site Water Inventory		2899.8	Based on water balance model results

8.9 PROPOSED PHASE 3 MINE SITE WATER BALANCE

8.9.1 Overview

The Phase 3 mine site GoldSim model was run on a daily time step over 26 years (2011-2036) to simulate the performance of the proposed water management system during the various mine stages. The model was configured for 6 stages of mining operations to represent the open pit progression over the mine life.

1. Stage 2011 - applies for the 2011-2013 period (2 years);
2. Stage 2015 - applies for the 2013-2017 period (4 years);
3. Stage 2020 - applies for the 2017-2022 period (5 years);
4. Stage 2025 - applies for the 2022-2027 period (5 years);
5. Stage 2030 - applies for the 2027-2032 period (5 years); and
6. Stage 2035 - applies for the 2032-2036 period (5 years).

The water management system performance was assessed for the dry (10th percentile), median (50th percentile) and wet (90th percentile) 26-year simulations based on historical rainfall records.

A second GoldSim model was used to better simulate the performance of the proposed North OEF PAF Runoff dams as configuration of the North OEF dump areas draining to the PAF runoff dams change over the 26 years of mine life.

Both models were run for 86 separate sequences of rainfall and evaporation generated from 121 years (1889-2011) of SILO data (see Section 3.2). The use of such a long period of continual data would provide a good indication of the behaviour of the various on-site storages at MRM over extended dry and wet periods.

8.9.2 Mine Site Water Balance

Table 8.8, Table 8.9 and Table 8.10 present representative long-term mine site water balance results for different stages of mining based on simulation results for the dry (90th percentile), median (50th percentile) and wet (10th percentile) 26-year rainfall sequences. It should be recognised that rainfall, runoff, evaporation and controlled release components of the water balance are highly variable from year to year because they are subject to climatic variability.

The MRM site is a net producer of water due to the substantial amounts of groundwater inflows to the open pit and underground mine void and high rainfall and runoff during the wet season. The excess would be either evaporated or disposed of to the McArthur River or used for off-site irrigation. Almost all of the direct rainfall and surface runoff inflows to the MRM water management system are generated during the wet season between October and April. During the dry season, the only significant inflows to the MRM water management system are generated from groundwater sources. A major component of the proposed water management system is enhancement of evaporation losses via the use of evaporation fans, sprinklers and water fountains.

Table 8.8 Summary Annual Average Water Balance, Dry Rainfall Sequence

Component	Process	Average Volume (ML/y)						Total (26 years)
		2012 (2 years)	2015 (4 years)	2020 (5 years)	2025 (5 years)	2030 (5 years)	2035 (5 years)	
Inflows	Direct Rainfall	857	823	680	505	645	471	635
	Surface Runoff	1329	2434	1885	1533	1894	1213	1732
	Groundwater	4660	4750	5293	5922	6015	6112	5578
	Borefields	731	731	730	730	731	730	731
	Raw Feed Moisture	191	191	191	191	191	191	191
	TOTAL	7769	8928	8779	8882	9476	8717	8866
Outflows	Evaporation	2896	1922	1907	1751	1980	1507	1892
	Spray Fans	2171	2101	2131	2203	2179	2148	2156
	Sprinklers/Water Fountain	1361	1355	1360	1360	1361	1360	1359
	Irrigation	5	387	699	1184	1377	1007	881
	Water Cart Usage	1096	1096	1096	1096	1096	1096	1096
	Truck Wash	15	15	15	15	15	15	15
	Potable Use	194	194	194	194	194	194	194
	Industrial Use	15	15	15	15	15	15	15
	Product Moisture	120	120	120	120	120	120	120
	TSF Moisture Retention	493	493	492	492	493	492	493
	Seepage losses	64	63	48	33	46	9	41
	Off-site Releases	1144	1198	1001	579	889	719	885
	TOTAL	9573	8956	9077	9041	9764	8679	9145
Change in Site Water Inventory		-1799	-28	-298	-159	-288	38	-279

Table 8.9 Summary Annual Average Water Balance, Median Rainfall Sequence

Component	Process	Average Volume (ML/y)						Total (26 years)
		2012 (2 years)	2015 (4 years)	2020 (5 years)	2025 (5 years)	2030 (5 years)	2035 (5 years)	
Inflows	Direct Rainfall	876	1071	792	693	585	570	740
	Surface Runoff	1715	3289	2017	1951	1710	1648	2047
	Groundwater	4660	4750	5293	5922	6015	6112	5578
	Borefields	731	731	730	730	731	730	731
	Raw Feed Moisture	191	191	191	191	191	191	191
	TOTAL	8173	10031	9023	9488	9232	9251	9286
Outflows	Evaporation	3142	2117	2224	1952	1839	1590	2030
	Spray Fans	2250	2123	2139	2139	2187	2162	2159
	Sprinklers/Water Fountain	1361	1360	1360	1360	1361	1360	1360
	Irrigation Supply	5	421	1245	1008	1366	1166	985
	Water Cart Usage	1096	1096	1096	1096	1096	1096	1096
	Truck Wash	15	15	15	15	15	15	15
	Potable Use	194	194	194	194	194	194	194
	Industrial Use	15	15	15	15	15	15	15
	Product Moisture	120	120	120	120	120	120	120
	TSF Moisture Retention	493	493	492	492	493	492	493
	Seepage losses	63	64	69	49	40	13	48
	Off-site Releases	942	1237	1040	1181	818	950	1030
	TOTAL	9694	9253	10007	9620	9543	9172	9543
Change in Site Water Inventory		-1516	778	-984	-132	-311	78	-256

Table 8.10 Summary Annual Average Water Balance, Wet Rainfall Sequence

Component	Process	Average Volume (ML/y)						
		2012 (2 years)	2015 (4 years)	2020 (5 years)	2025 (5 years)	2030 (5 years)	2035 (5 years)	Total (26 years)
Inflows	Direct Rainfall	1289	895	728	1037	682	518	807
	Surface Runoff	2859	2347	2257	2691	1950	1468	2190
	Groundwater	4660	4750	5293	5922	6015	6112	5578
	Borefields	731	731	730	730	731	730	731
	Raw Feed Moisture	191	191	191	191	191	191	191
	TOTAL	9730	8913	9199	10571	9569	9019	9496
Outflows	Evaporation	2821	2247	2023	2345	1986	1541	2081
	Spray Fans	2171	2129	2187	2125	2153	2168	2155
	Sprinklers/Water Fountain	1361	1360	1360	1360	1361	1360	1360
	Irrigation	5	1210	870	1444	1410	952	1086
	Water Cart Usage	1096	1096	1096	1096	1096	1096	1096
	Truck Wash	15	15	15	15	15	15	15
	Potable Use	194	194	194	194	194	194	194
	Industrial Use	15	15	15	15	15	15	15
	Product Moisture	120	120	120	120	120	120	120
	TSF Moisture Retention	493	493	492	492	493	492	493
	Seepage losses	63	71	53	70	53	12	52
	Off-site Releases	1833	857	936	1263	1099	1086	1116
	TOTAL	10187	9805	9360	10538	9994	9050	9781
Change in Site Water Inventory		-452	-892	-162	34	-425	-32	-284

8.9.3 Open Pit and TSF Cell 4 WMD Storage Behaviour

As discussed in Section 7, the TSF Cell 4 WMD will be constructed in 2012 to store pit water until 2032. Figure 8.7 shows the storage performance of TSF Cell 4 WMD for the dry (90th Percentile), median (50th percentile) and wet (10th percentile) rainfall sequence. The results show that the open pit could be fully pumped to TSF Cell 4 WMD at an uninterrupted dewatering rate of up to 50 ML/d, providing minimum disruption to mining in the open pit. It is noted that should the capacity of the TSF Cell 4 WMD be reached, excess water would have to be held in the pit until spare storage becomes available in TSF Cell 4 and this would disrupt mining in the open pit. It is also noted that for wetter rainfall sequences a higher dewatering rate and/or additional storage capacity may be required to maintain a dry open pit floor to minimise disruption to mining. Note that the capacity of the TSF Cell 4 is 4300 ML.

Figure 8.8 shows the expected storage duration curves for the open pit for the dry (10th percentile), median (50th percentile) and wet (90th percentile) rainfall sequences. The results show that the stored volume in the open pit would exceed 200 ML for approximately 0.4%, 0.7% and 1.7% of the time respectively during the dry, median and wet rainfall sequences. Based on the results for the wet rainfall sequence, the pit could be pumped 'dry' within 1 week for a median period of pit inundation, 4 weeks for a 90th percentile (wet) period of pit inundation and within a maximum of 10 weeks after a major rainfall event.

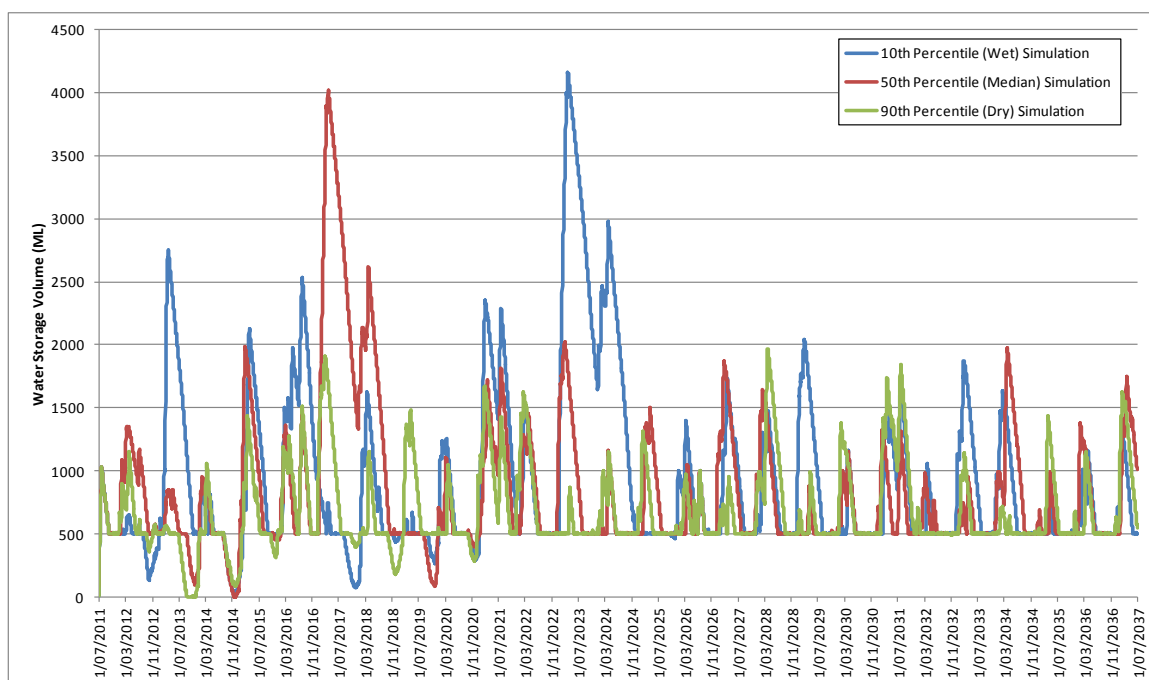


Figure 8.7 Simulated Storage Performance of TSF Cell 4 WMD Inventory - Dry, Median and Wet Rainfall Sequences

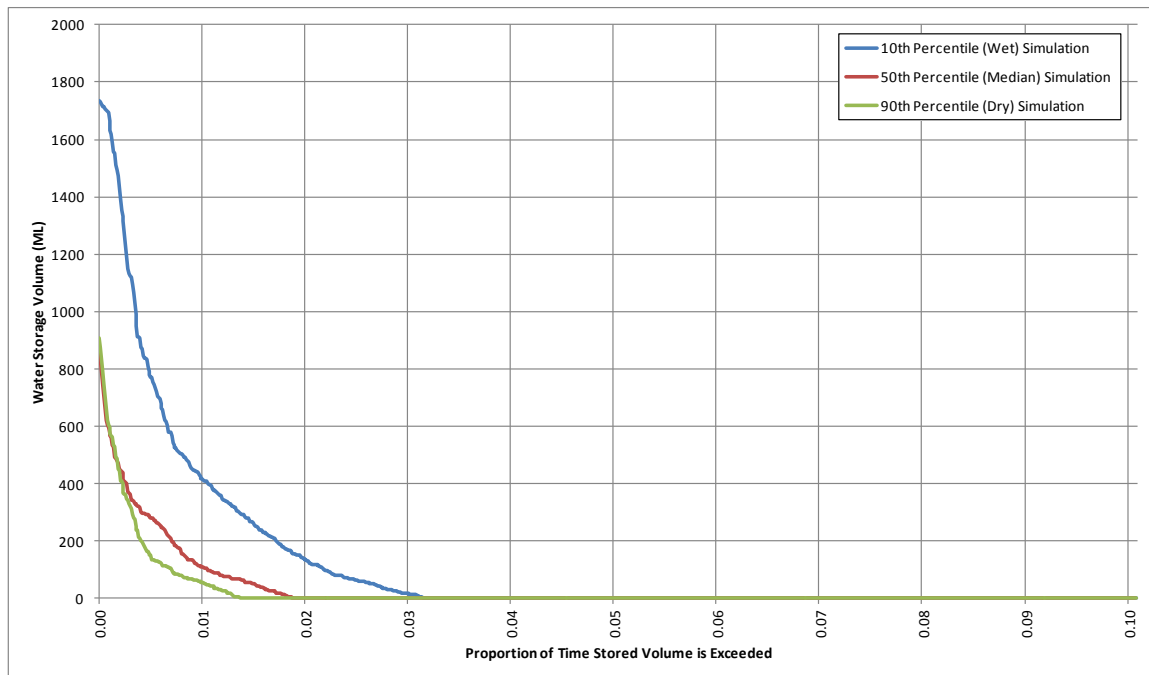


Figure 8.8 Open Pit Storage Duration Curve - Dry, Median and Wet Rainfall Sequences

8.9.4 Off-Site Releases

Figure 8.9, Figure 8.10 and Figure 8.11 show the predicted average monthly volumes (in ML/d) of total groundwater inflows to the open pit (prior to interception), combined total groundwater and surface runoff inflows into the open pit (after interception), off-site release to MRPL for irrigation use and releases to the McArthur River for the dry, median and wet rainfall sequences. The following is of note:

- Releases to the McArthur River would generally occur only between the months of January and April during high flows in the river. Most releases to the river would occur in February and March. The results show that over the 26-year life of the mine approximately 22,910ML, 25,630ML and 28,230ML respectively could potentially be released in dry, median and wet rainfall sequences.
- Release of 'intercepted' groundwater to MRPL for irrigation use would generally occur between the months of April and July. During other months of the year, MRM can generally manage on-site water either within the water management system or by releasing to the McArthur River. The results show that over the 26 year life of the mine approximately 22,460ML, 26,070ML and 27,830ML respectively could potentially be pumped to MRPL in dry, median and wet rainfall sequences.
- Between July and December the mine site water management system is generally able to manage water stored on-site without off-site releases.

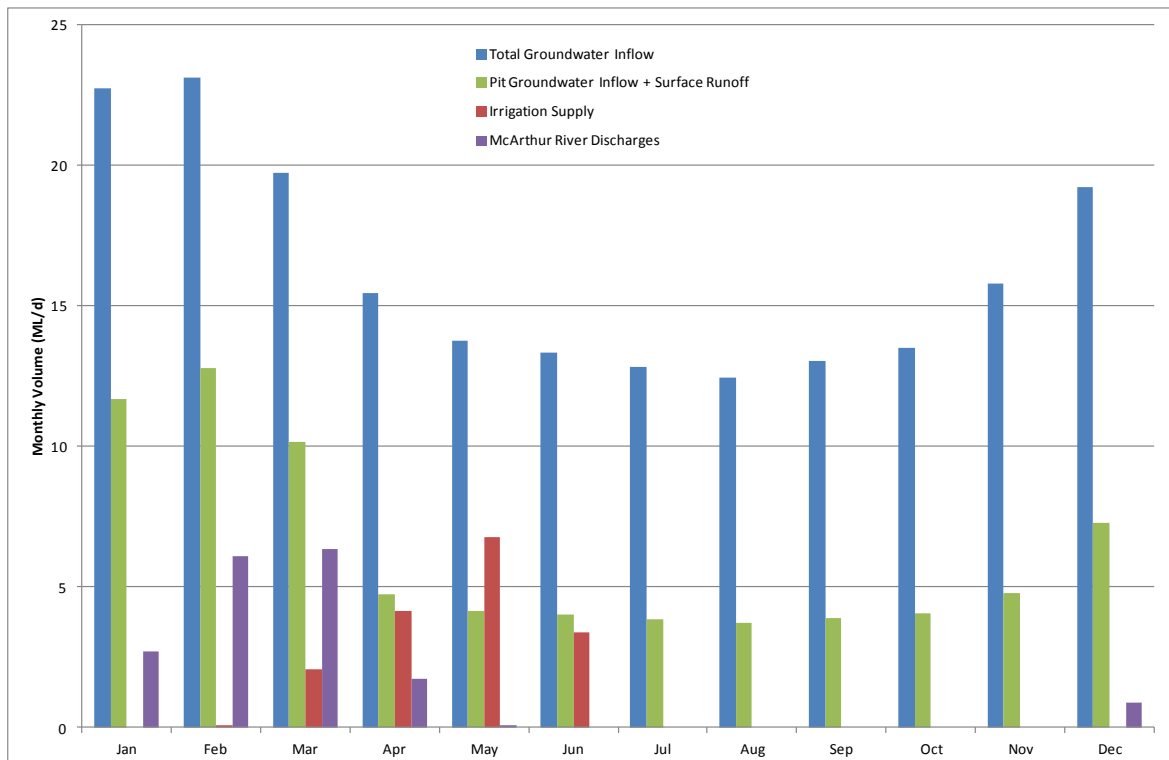


Figure 8.9 Expected Median Monthly Volumes of Total Groundwater Inflows, Combined Groundwater and Surface Runoff Inflows into the Pit (after interception), Irrigation Releases and McArthur River Releases for the Dry Rainfall Sequence

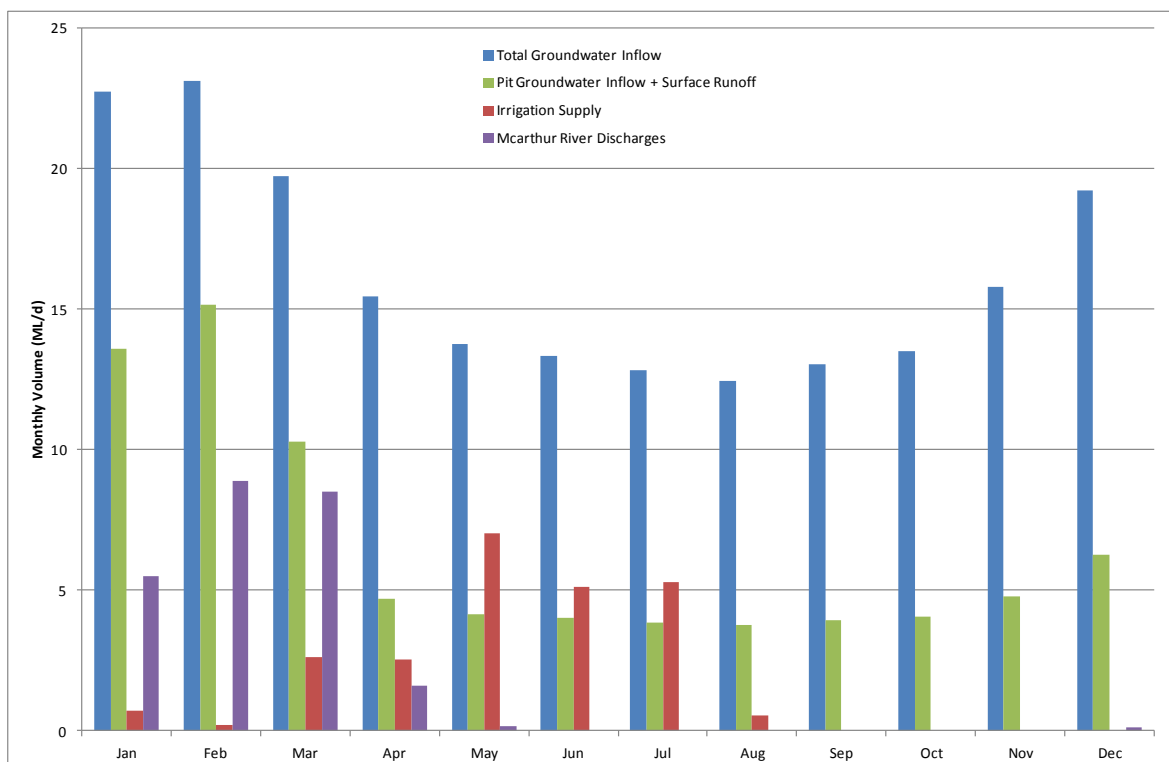


Figure 8.10 Expected Median Monthly Volumes of Total Groundwater Inflows, Combined Groundwater and Surface Runoff Inflows into the Pit (after interception), Irrigation Releases and McArthur River Releases for the Median Rainfall Sequence

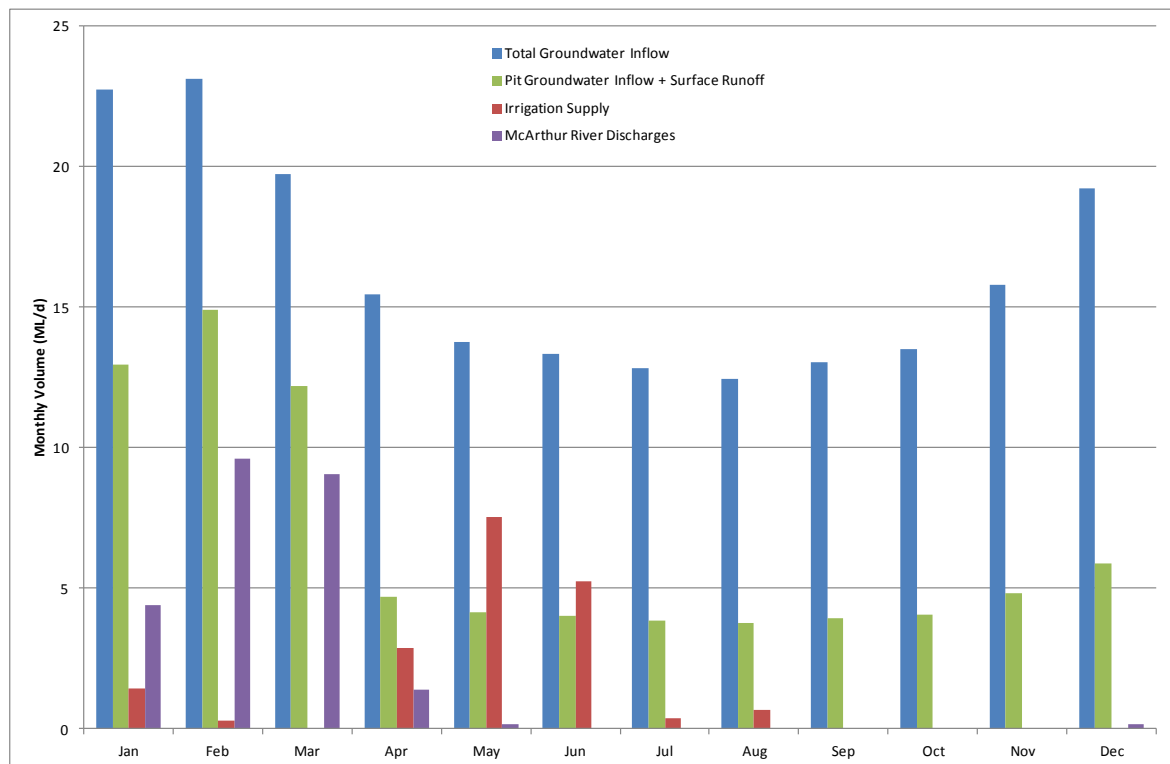


Figure 8.11 Expected Median Monthly Volumes of Total Groundwater Inflows, Combined Groundwater and Surface Runoff Inflows into the Pit (after interception), Irrigation Releases and McArthur River Releases for the Wet Rainfall Sequence

8.9.5 North OEF PAF Runoff Dam Storage Behaviour

Figure 8.12 to Figure 8.16 show plots of simulated maximum stored volumes vs. probability of exceedance during the 26 year (2011-2036) period of mine life when runoff from PAF areas drain to the particular storage. The results indicate that the use of evaporation sprinklers could significantly reduce the required size of the storages, with reductions of the order of 40%. Based on these results, Table 7.4 shows the estimated storage volumes required for 5% probability of exceedance if evaporation sprinklers are installed at each of the storages. Note that SPSP overflows into SPROD once it reaches its FSL of 250 ML. Hence the required volume shown in Table 7.4 of 810 ML includes the calculated SPROD volume requirement of 560 ML + 250 ML.

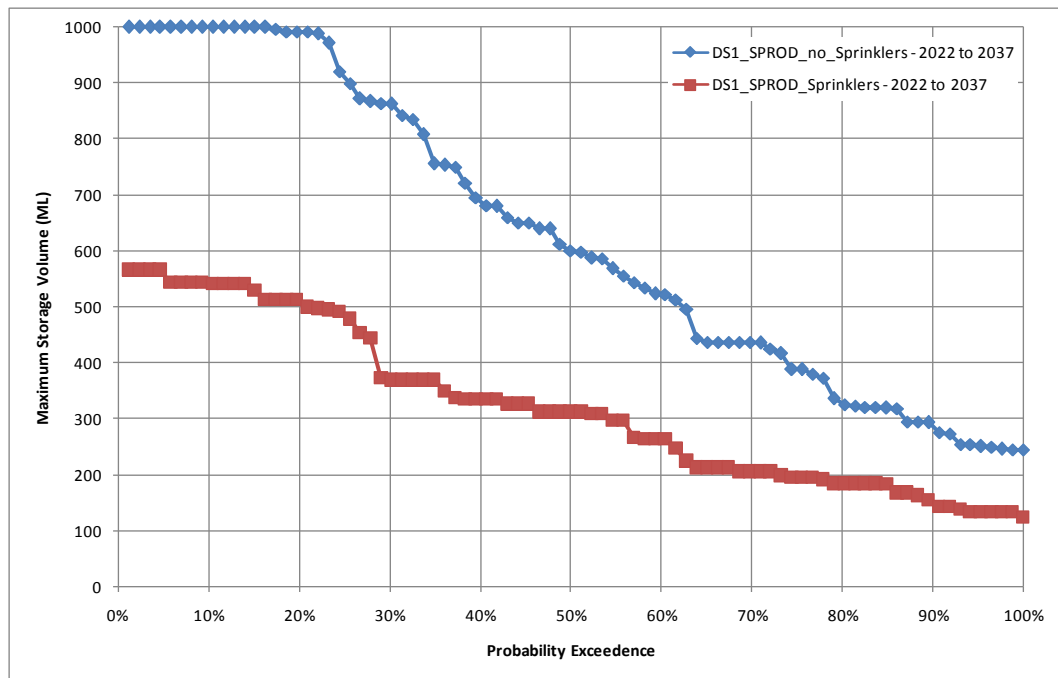


Figure 8.12 Maximum Stored Volume vs. Probability of Exceedance for SPROD during Years When PAF Material is Exposed - With and Without Sprinklers

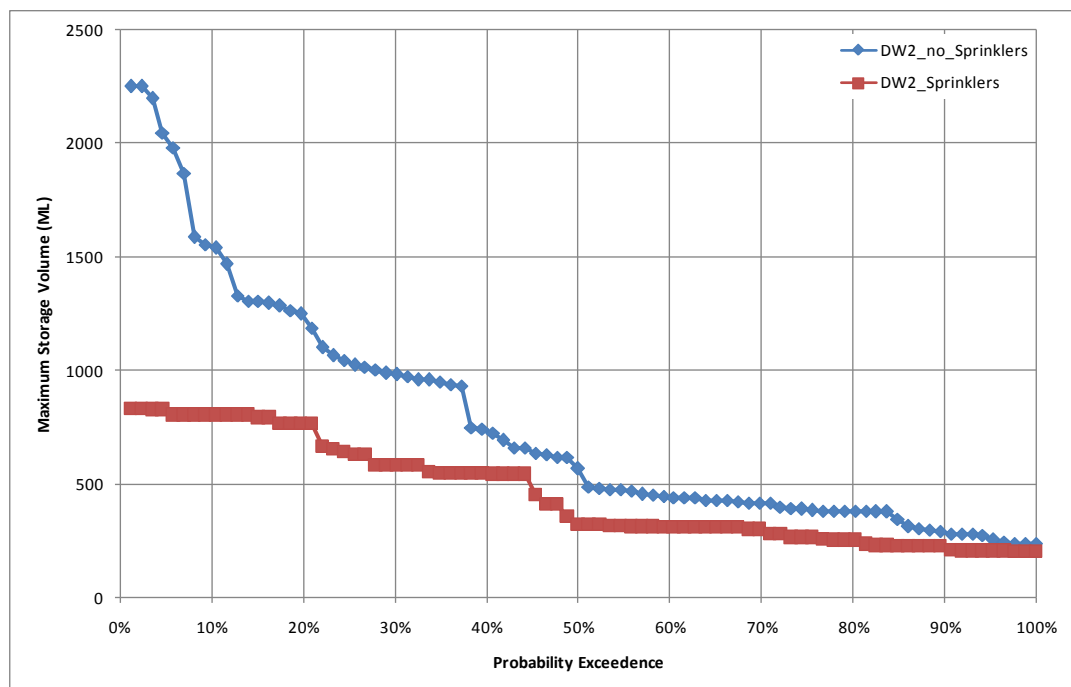


Figure 8.13 Maximum Stored Volume vs. Probability of Exceedance for NWPROD during Years When PAF Material is Exposed - With and Without Sprinklers

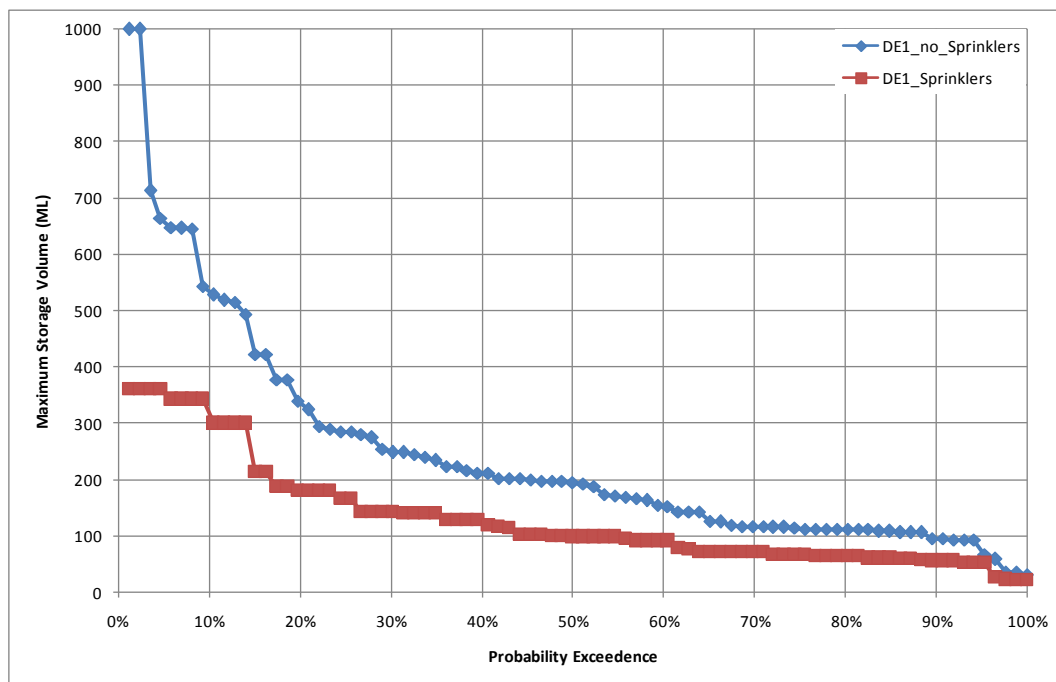


Figure 8.14 Maximum Stored Volume vs. Probability of Exceedance for SEPROD during Years When PAF Material is Exposed - With and Without Sprinklers

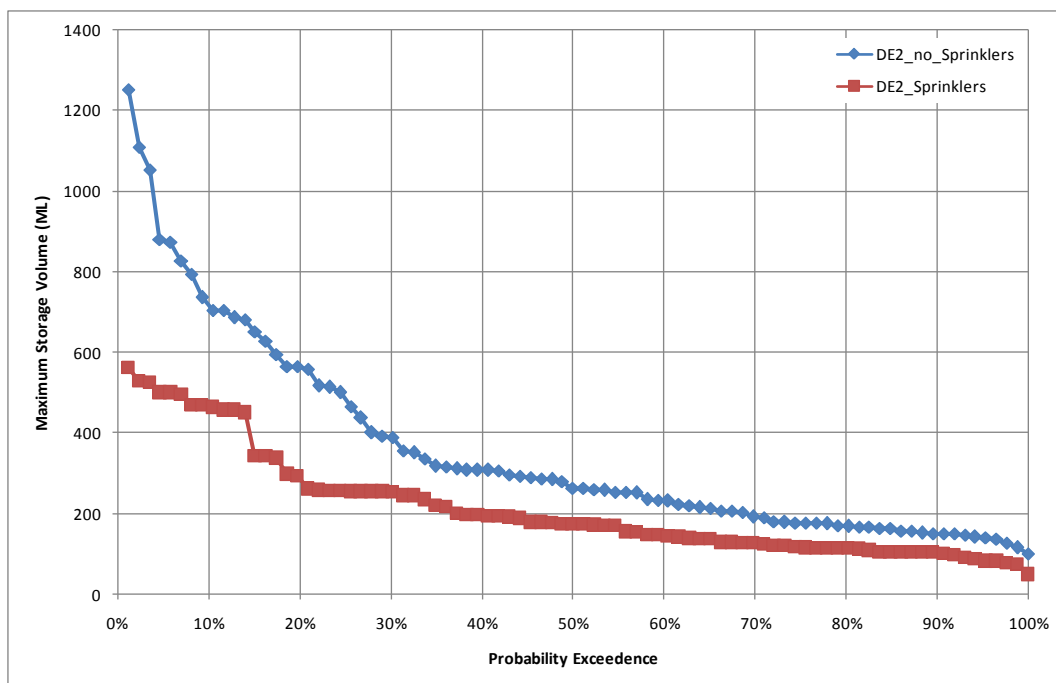


Figure 8.15 Maximum Stored Volume vs. Probability of Exceedance for EPROD during Years When PAF Material is Exposed - With and Without Sprinklers

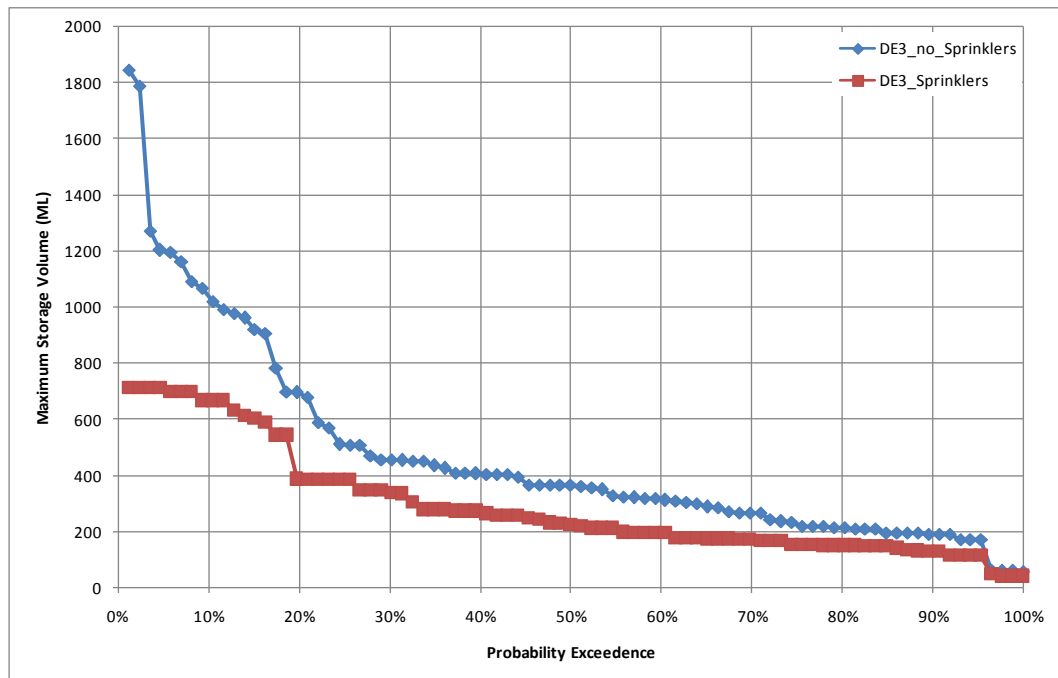


Figure 8.16 Maximum Stored Volume vs. Probability of Exceedance for NEPROD during Years When PAF Material is Exposed - With and Without Sprinklers

9 ESTIMATION OF DESIGN FLOOD LEVELS, VELOCITIES AND FLOOD EXTENTS

9.1 ADOPTED METHODOLOGY

The URBS runoff-routing model (Carroll, 2004) was used to estimate design flood discharges in the McArthur River and its tributaries in the vicinity of MRM. This model was developed by WRM for the Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS) in November 2011 for use in the Borroloola Floodplain Mapping Study. The URBS model was calibrated to recorded flood discharges at three stream gauging stations at Bailey's Grave (No G9070142), MIM Pump (No G9070132) and Borroloola Crossing (No G9070121) for 9 historical flood events, including the four recent events in January 2009, January 2010, February 2011 and March 2011. The locations of stream gauging stations and rainfall stations within the McArthur River catchment are shown in Figure 3.1. Details of the URBS model development and calibration and its use for design flood estimation are given in WRM (2011).

Due to the flat topography of the McArthur River floodplain in the vicinity of MRM, a two-dimensional hydraulic model (TUFLOW) was used to predict the movement of floodwater across the floodplain. The TUFLOW model was developed and calibrated to recorded data for the 2001, 2003, 2009 and 2010 flood events.

The calibrated URBS and TUFLOW models were used to estimate design discharges, flood levels, velocities and extents in the McArthur River and its tributaries at MRM for the 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) design flood events for current and proposed Phase 3 mine conditions. The design discharges estimated by the URBS model were reconciled with discharges estimated from flood frequency analysis (FFA) of recorded peak annual flood discharges at the MIM Pump stream gauging station. Design flood hydrographs predicted by the URBS model were used as inflows into the TUFLOW model. The model results were used to assess the potential impacts of the proposed MRM Phase 3 operations on flood levels, depths, velocities and extents of the McArthur River and its tributaries.

9.2 DESIGN FLOOD DISCHARGES

The URBS model of the McArthur River catchment was used to estimate design flood discharges in the vicinity of MRM for the McArthur River, Barney Creek, Surprise Creek, Emu Creek, the Glyde River, Bull Creek and Buffalo Creek. Table 9.1 shows the estimated McArthur River design discharges at MIM Pump station for 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) design events.

Figure 9.1 shows the results from WRM (2011) of a FFA at the MIM Pump stream gauging station. The FFA was undertaken using the method described in Book 4, Section 2 of ARR

(1998). Figure 9.1 also compares the results of the FFA with design discharges estimated from the URBS model for various AEPs and shows that the FFA and URBS model results are in good agreement.

A FFA has been previously undertaken for the McArthur River at MIM Pump Station by KBR (2005) as part of the hydraulic modelling study undertaken to estimate design flood levels during design of the MRM flood protection levee and diversions of the McArthur River and Barney Creek. Table 9.1 also shows a comparison of the 1% AEP and 0.2% AEP design discharges estimated by the URBS model, WRM (2011) FFA and KBR (2005) FFA. The following is of note:

- WRM (2011) used a rainfall-runoff model as well as a FFA to estimate and validate design discharge estimates. KBR (2005) used only a FFA and their results were not validated against results from any other method.
- WRM (2011) had access to 6 more years of recorded discharge data for the MIM Pump stream gauging station. WRM (2011) used 36 years of data at the MIM Pump station for their FFA compared to 32 years used by KBR (2005).
- The 1% AEP (100 year ARI) design discharge estimated in WRM (2011) is 1,500-1,800 m³/s higher than the KBR (2005) estimate.
- The 0.2% AEP (500 year ARI) design discharge estimated in WRM (2011) is 2,400 m³/s lower than the KBR (2005) estimate. The KBR (2005) estimate has been obtained by extrapolating their FFA results. WRM (2011) estimate has been obtained by using the calibrated URBS model with design rainfall depths obtained from the Generalised Tropical Storm Method Revised (GTSMR) outlined in BoM (2003).
- The design discharges estimated using the WRM (2011) URBS model was adopted for this study.

Table 9.1 Comparison of the McArthur River Design Discharge Estimates at MIM Pump Station

Annual Exceedance Probability (%)	Average Recurrence Interval (Years)	Design Discharge (m ³ /s)		
		WRM (2011) URBS Estimate	WRM (2011) FFA Estimate	KBR (2005) FFA Estimate
1	100	11,100	10,800	9,300
0.2	500	16,600	N/A	19,000

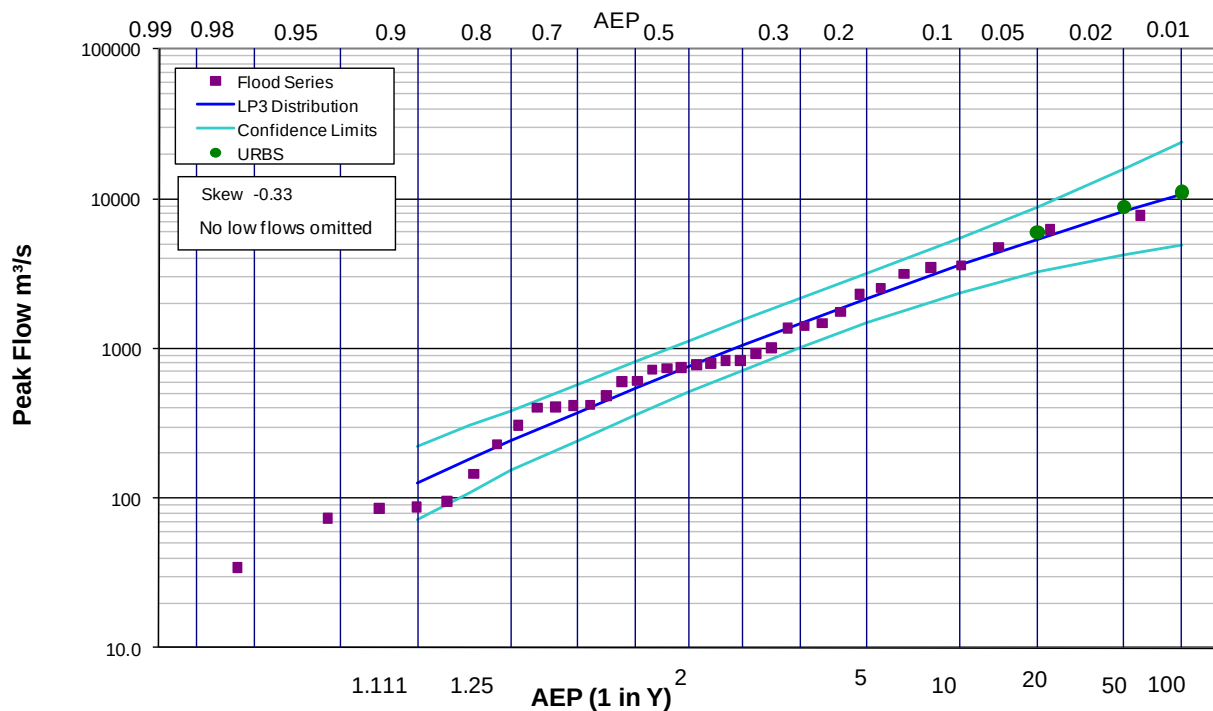


Figure 9.1 Flood Frequency Analysis Results, the McArthur River at MIM Pump Gauging Station

9.3 ESTIMATION OF DESIGN FLOOD LEVELS, VELOCITIES AND EXTENTS

9.3.1 Overview

Figure 9.2 shows the extent of the MRM TUFLOW model. The model extends approximately 11 km upstream of the existing MRM open pit to ensure that the locations of any McArthur River breakouts into the floodplain upstream of the MRM site are correctly identified. In order to accurately calibrate the model to selected historical flood events, the model was developed for three mine scenarios:

1. Pre open pit mine conditions (pre 2006)
2. Existing MRM open pit mine conditions (2009)
3. Proposed MRM Phase 3 open pit mine conditions

The calibrated TUFLOW model was used to assess the potential impacts of the proposed MRM Phase 3 mining operations on McArthur River flood levels, velocities and extents for the 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) events.

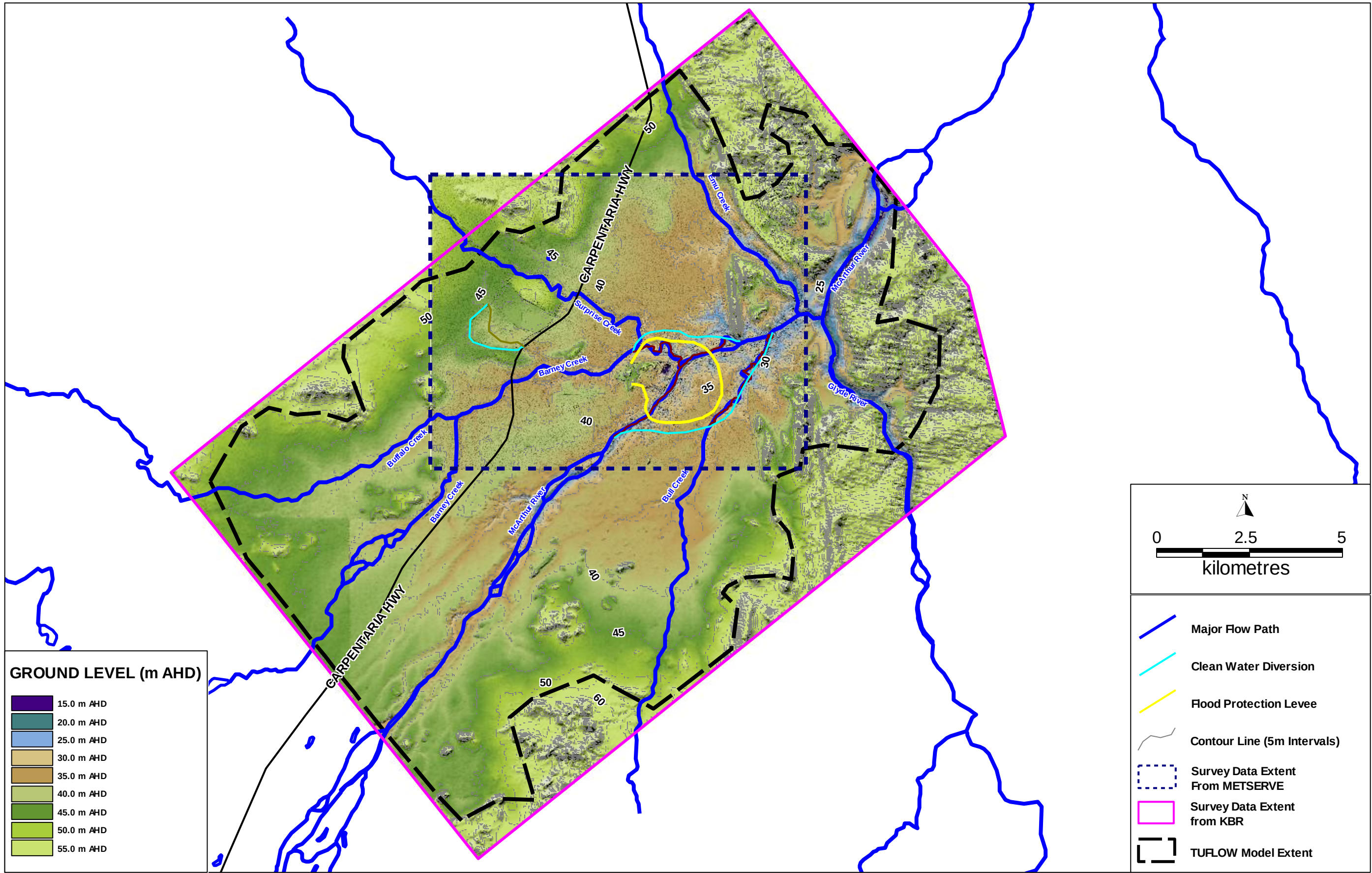


Figure 9.2 Available Survey Data and the McArthur River TUFLOW Model Extent

9.4 TUFLOW MODEL DEVELOPMENT

9.4.1 Model Configuration

Figure 9.3 shows the extent of the pre-mine TUFLOW model, the location of the major flow paths, vegetated overbank areas and the location of the one-dimensional (1D) and two-dimensional (2D) inflow and outflow boundaries. The modelled area covers approximately 210km², extending some 11 km upstream and 8 km downstream respectively of the existing MRM open pit. A 20 m grid size and a 5 second time step were adopted for the 2D model areas.

9.4.2 Topographic Data

Figure 9.2 shows the location and extent of the available survey data used for the TUFLOW model. Topographic aerial survey data for the study area was provided by MET Serve Pty Ltd and Kellogg Brown and Root Pty Ltd (KBR). The following is of note:

- The data supplied by MET Serve Pty Ltd included aerial survey undertaken in 2006, 2009 and 2010 and covers an area of approximately 80 km². The survey has been conducted using airborne laser survey (ALS) and surveyed points were supplied as a digital elevation model (DEM) spaced at 1m intervals. The 2006 survey included the MRM mine test pit. The 2009 and 2010 survey included the existing MRM mine including the completed open pit flood protection levee and channel diversions. This survey information was used to represent the ground surface in TUFLOW in the vicinity of the mine site.
- The data provided by KBR was extracted from their DELFT hydraulic model developed in 2002 (KBR, 2002) and covers an area of approximately 260 km². The surveyed points were supplied as a digital elevation model (DEM) spaced at 50 m intervals. The survey has been undertaken prior to the construction of the MRM test pit. This survey information was used to represent the ground surface in TUFLOW model in areas not covered by the ALS survey data supplied by MET Serve.

9.4.3 Adopted Manning's 'n' Values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). An ortho-photograph of the area was used to determine the spatial changes in vegetation characteristics along the creek banks and the overbank areas. Figure 9.3 shows the adopted vegetated overbank areas in the TUFLOW modelled area. Based on the calibration for the hydraulic model, the following Manning's 'n' values were adopted:

- Unvegetated overbank areas: 'n' = 0.06
- Vegetated overbank areas: 'n' = 0.09
- Channel areas: 'n' = 0.05
- Diverted channel (unvegetated) 'n' = 0.045
- Diverted channel (vegetated) 'n' = 0.06

9.4.4 Inflow and Outflow Boundaries

Figure 9.3 also shows the locations of the inflow and outflow boundaries used in the TUFLOW model. Table 9.2 shows the adopted 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) peak discharge at each inflow location. Note that the number at the beginning of the boundary name corresponds to the URBS model sub-catchment ID from the WRM (2011) study.

Table 9.2 TUFLOW Inflow Boundaries

Boundary Name	Peak Inflow (m ³ /s)	
	1% AEP (100 year ARI)	0.2% AEP (500 year ARI)
37 - McArthur River	11100	16600
38 - Bull Creek	410	610
43 - Barney Creek	920	1400
47 - Buffalo Creek	420	630
52 Surprise Creek	390	570
53 - Emu Creek	280	410
65 - Glyde River	3300	5000

A uniform 1D-channel with a cross-section shape equivalent to the channel shape at the 2D boundary was extended 4 km downstream at a slope of 0.05%. A hydraulic gradient of 0.05% was used at the downstream boundary of the 1D-channel. Sensitivity analyses showed that the flood levels within the mine area are sensitive to changes at the downstream boundary.

9.4.5 Existing Mining Infrastructure

Figure 9.4 shows existing mining infrastructure that affects flooding within the mine lease area. Key features include:

- A flood protection levee around the perimeter of the open pit. The crest level of the levee is approximately 44 m AHD and has been designed to protect the open pit from the McArthur River floodwaters up to a 0.2% AEP (500 year ARI) flood event;
- The McArthur River diversion around the southern boundary of the open pit and the Barney Creek diversion around the northern boundary of the open pit. Details on the design and construction of the existing river and creek diversions are given in Connell Hatch (2009);
- The North OEF;
- The TSF Cell 1, Cell 2 and Cell 3 located along the north-western fringe of the McArthur River floodplain;
- A haul road crossing of the Barney Creek Diversion from the open pit area to the North OEF. Design drawings for the haul road are provided in Connell Hatch (2009). The existing haul road was modelled as 2D layered flow construction in the TUFLOW model;
- The Carpentaria Highway crossings of Barney Creek and Surprise Creek bridges which span the respective main channels and will have minimal impact on flood discharge behaviour. Hence, these crossings were not explicitly represented in the TUFLOW model.

9.4.6 Proposed Mining Infrastructure

Figure 9.4 also shows proposed mining infrastructure that will affect flooding within the mine lease area. Proposed mining infrastructure includes the expanded North, South and East OEFs as well as TSF Cell 4. Note that no additional flood protection levees or river/creek diversions are proposed.

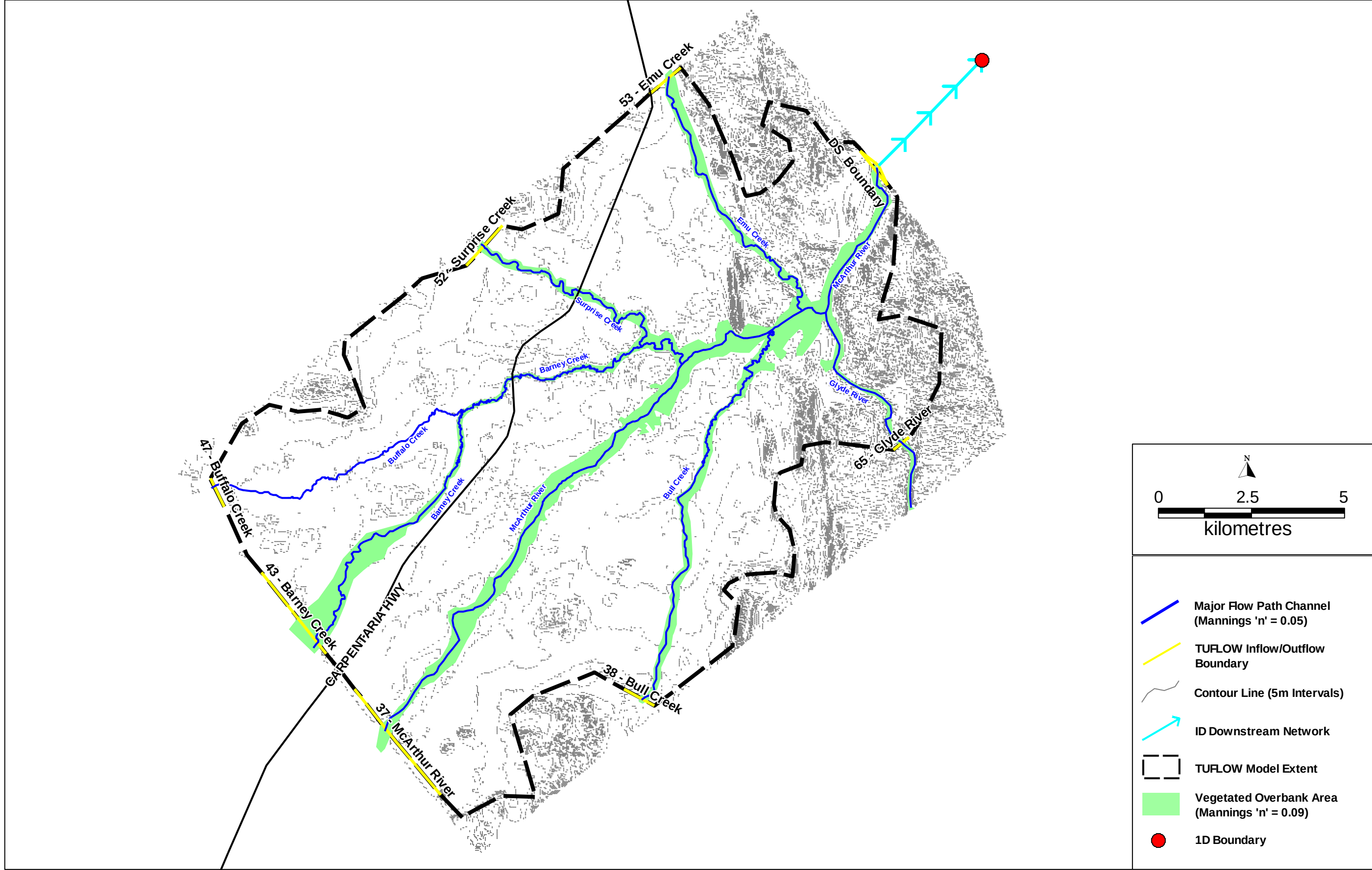


Figure 9.3 The McArthur River TUFLOW Model Configuration (Pre-mine Conditions)

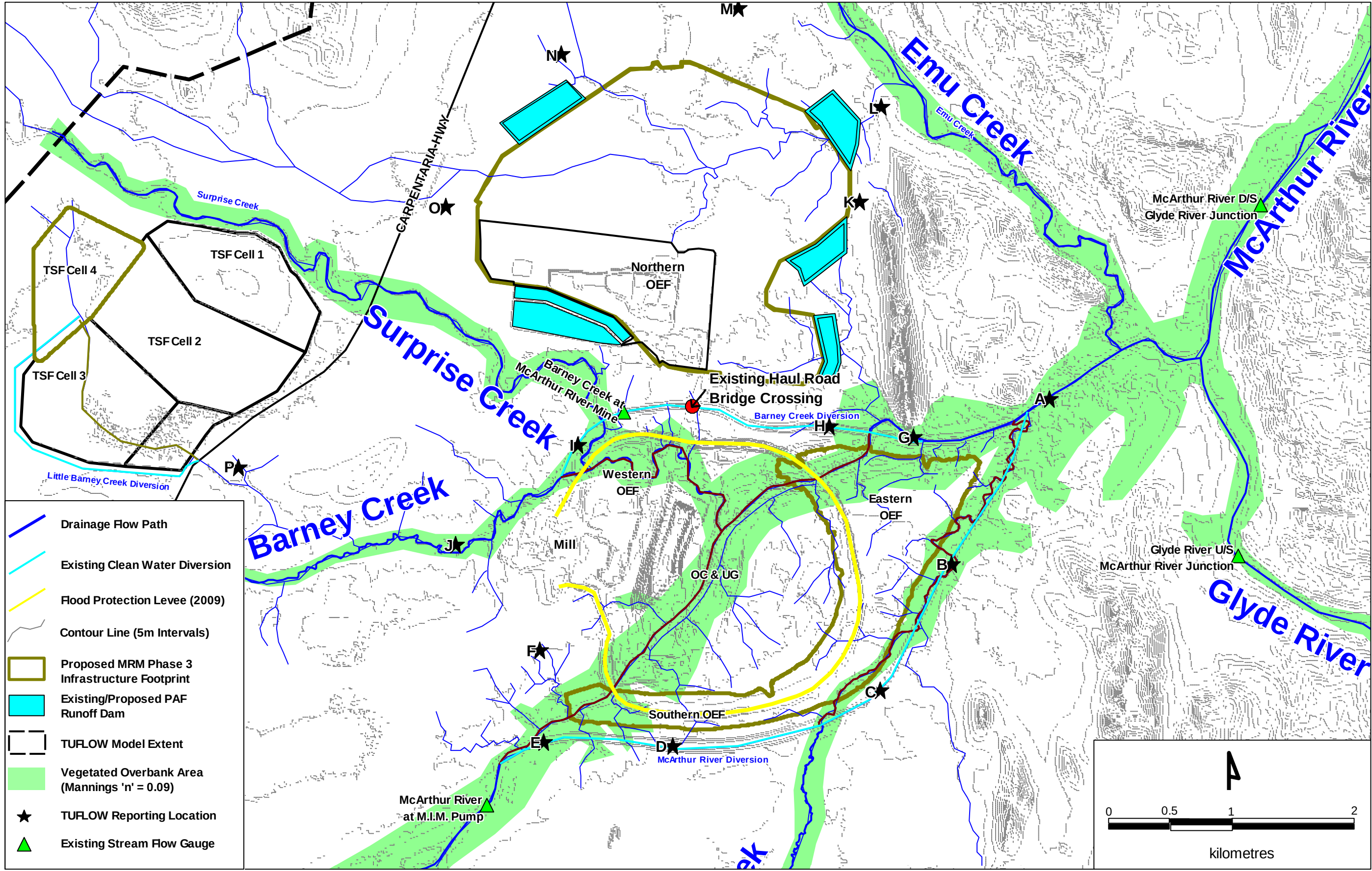


Figure 9.4 The McArthur River TUFLOW Model Configuration for Existing Mine Conditions and Proposed MRM Phase 3 Mining Conditions

9.5 MODEL CALIBRATION

9.5.1 Overview

The TUFLOW model was calibrated against the recorded McArthur River water level hydrographs at the MIM Pump stream gauge (SW10) for the February 2001, January 2003, January 2009 and January/February 2010 flood events. Peak water levels recorded at the Glyde River station upstream of the McArthur River junction (SW9), Barney Creek station (SW19) and the McArthur River station downstream of the Glyde River Junction (SW11) during the 2003 flood event were also used in the TUFLOW model calibration. The model was calibrated to flood events both before and after the McArthur River diversion to assess and incorporate the impact of the McArthur River diversion to the rating curve at the McArthur River MIM Pump stream gauging station.

Table 9.3 shows the recorded peak discharges at the MIM Pump Station during the 2001, 2003, 2009 and 2010 McArthur River flood events and the estimated AEPs of each event at MRM.

Table 9.3 Recorded Peak Discharges and Estimated AEPs of the 2001, 2003, 2009 and 2010 Flood Events

Event	Peak Discharge (m ³ /s)	Approximate AEP of Flood Event (%)	Approximate ARI of Flood Event (year)
February 2001	7610	5 to 2	20 to 50
January 2003	4804	10 to 5	10 to 20
January 2009	1679	39 to 18	2 to 5
January/February 2010	3171	18 to 10	5 to 10

9.5.2 Calibration Results

Table 9.4 shows the recorded and predicted peak water levels at the MIM Pump station during the February 2001, January 2003, January 2009 and January/February 2010 flood events. Figure 9.5 to Figure 9.8 show a comparison of the recorded and predicted water level hydrographs at the MIM Pump station for each calibration event. The gauge zero level at this station is 20.939 mAHD. The following is of note.

- For the February 2001 flood event, the predicted peak flood level is about 0.20 m higher than the recorded peak flood level. The maximum recorded flood depth above gauge zero for the 2001 event is approximately 16.7 m.
- For the February 2003 flood event, the predicted peak flood level is about 0.30 m higher than the recorded peak flood level. The maximum recorded flood depth above gauge zero for the 2003 event is approximately 15.5 m.
- For the January 2009 flood event, the predicted peak flood level is about 0.09 m higher than the recorded peak flood level. The maximum recorded flood depth above gauge zero for the 2009 event is approximately 12.9 m.
- For the January/February 2011 flood event, the predicted peak flood level is about 0.31 m lower than the recorded peak flood level. The maximum recorded flood depth above gauge zero for the 2010 event is approximately 15.8 m.

Table 9.5 shows a comparison of predicted and recorded peak water levels at the Glyde River (SW9), Barney Creek (SW19) Mine, the McArthur River MIM Pump (SW10) and McArthur River Downstream (SW11) stream gauging stations during the 2003 flood event. The predicted peak flood levels at all stream gauging stations, except the Barney Creek station, are in good agreement with the recorded peak water levels. There is considerable doubt about the accuracy of the Barney Creek recorded peak level due to a potentially faulty gauge and the inaccurate conversion of gauge heights to m AHD (KBR, 2005). Hence, no weight was given in the calibration to the recorded data at the Barney Creek station.

Overall, the calibration of TUFLOW is considered acceptable and it is expected that the McArthur River TUFLOW model will provide reasonable estimates of the McArthur River design flood levels, depths, velocities, etc across the MRM site.

Table 9.4 Recorded and Predicted Peak Water Levels at MIM Pump Station, 2001, 2003, 2009 and 2010 Flood Events.

Flood Event	Recorded Peak Level (m AHD)	Predicted Peak Level (m AHD)	Difference (m)
February 2001	37.67	37.87	+0.20
January 2003	36.21	36.51	+0.30
January 2009	33.81	33.90	+0.09
January/February 2010	36.72	36.41	-0.31

Table 9.5 Recorded and Predicted Peak Water Levels at MRM Stream Gauges, January 2003 Flood Event

Stream Gauge Location	Recorded Peak Level (m AHD)	Predicted Peak Level (m AHD)	Difference (m)
McArthur River at MIM Pump (SW10)	36.21	36.51	+0.30
Barney Creek at MRM (SW19)	35.86	34.60	-1.26
Glyde River U/S McArthur River (SW9)	33.77	33.72	-0.05
McArthur River D/S Glyde River Junction (SW11)	33.70	33.36	-0.34

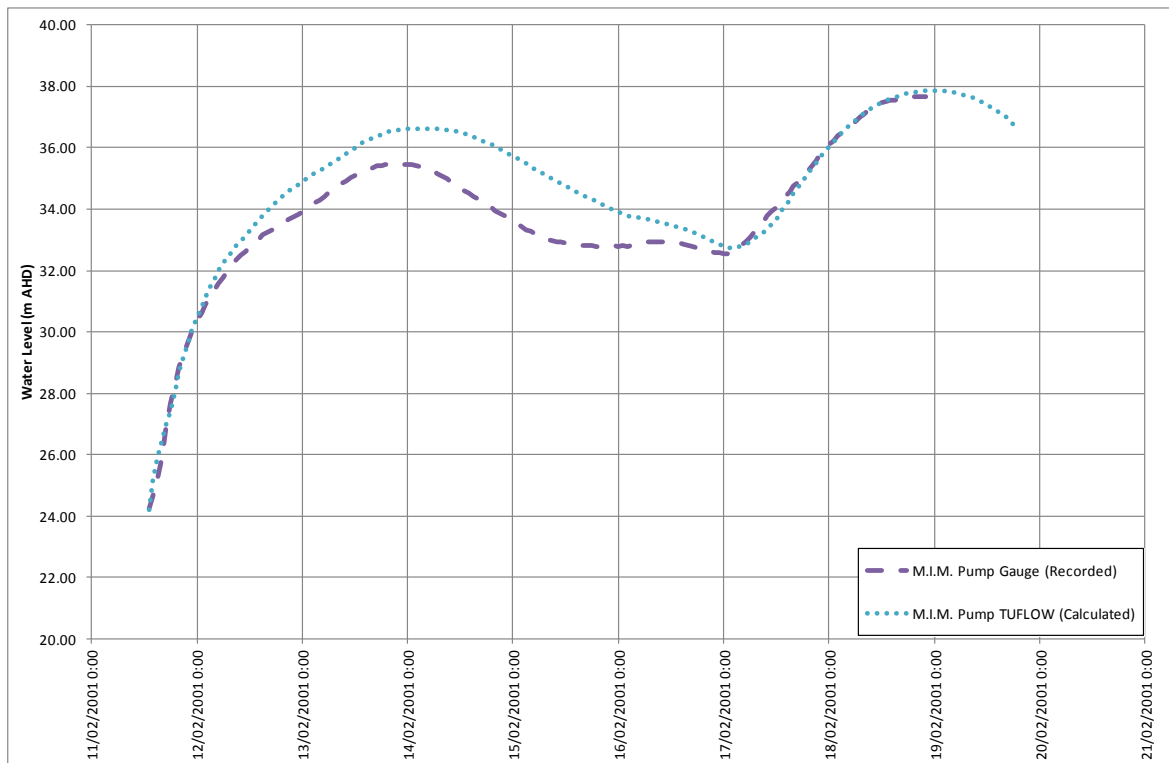


Figure 9.5 Comparison of Recorded and Predicted Water Level Hydrographs, McArthur River at MIM Pump Station, February 2001 Event

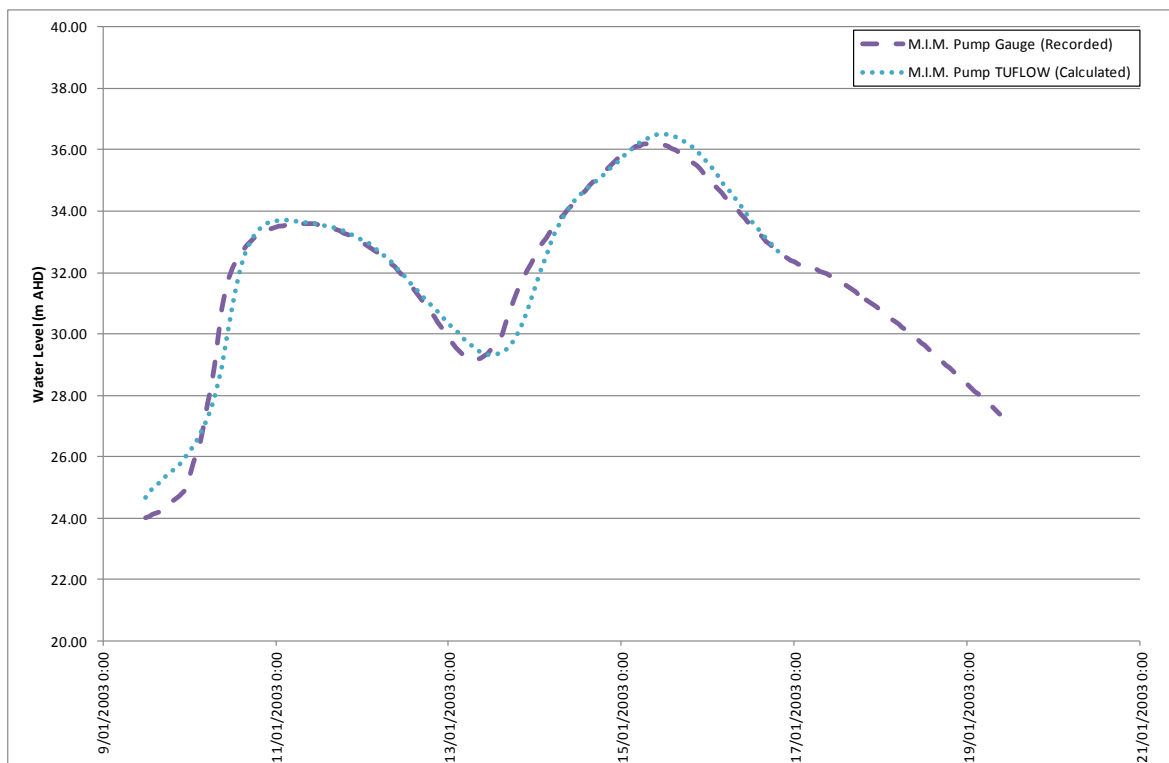


Figure 9.6 Comparison of Recorded and Predicted Water Level Hydrographs, McArthur River at MIM Pump Station, January 2003 Event

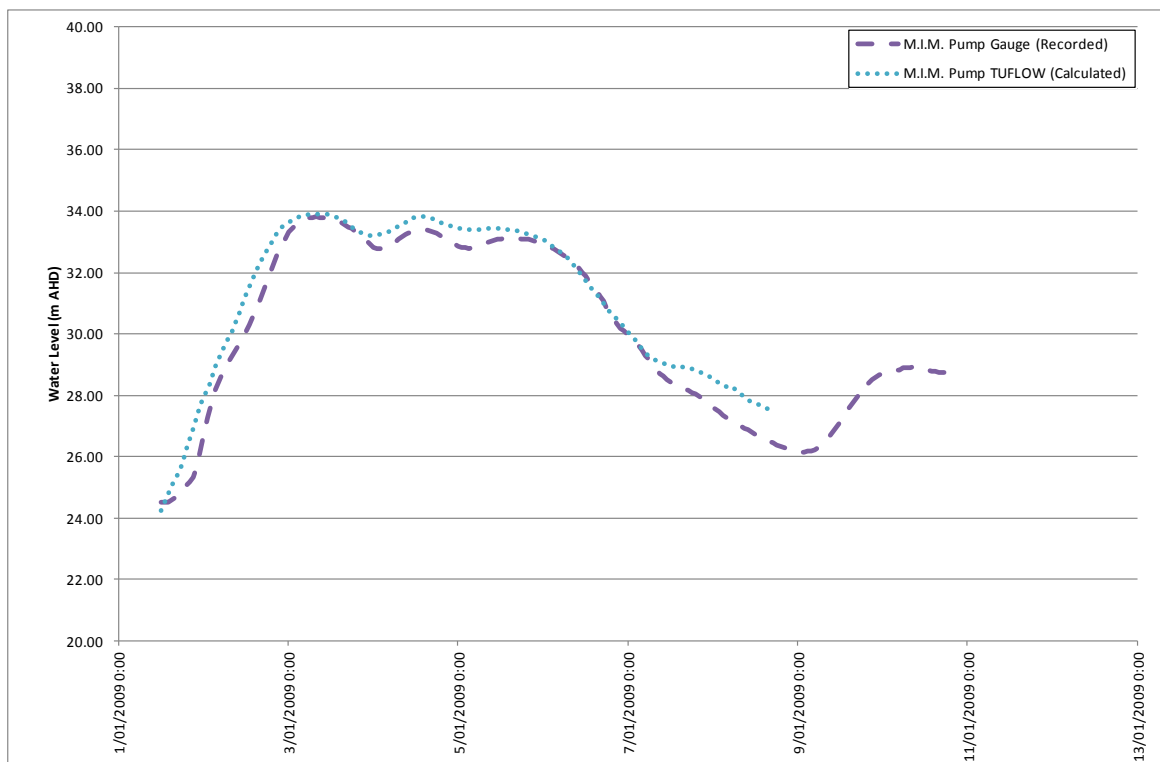


Figure 9.7 Comparison of Recorded and Predicted Water Level Hydrographs, McArthur River at MIM Pump Station, January 2009 Event

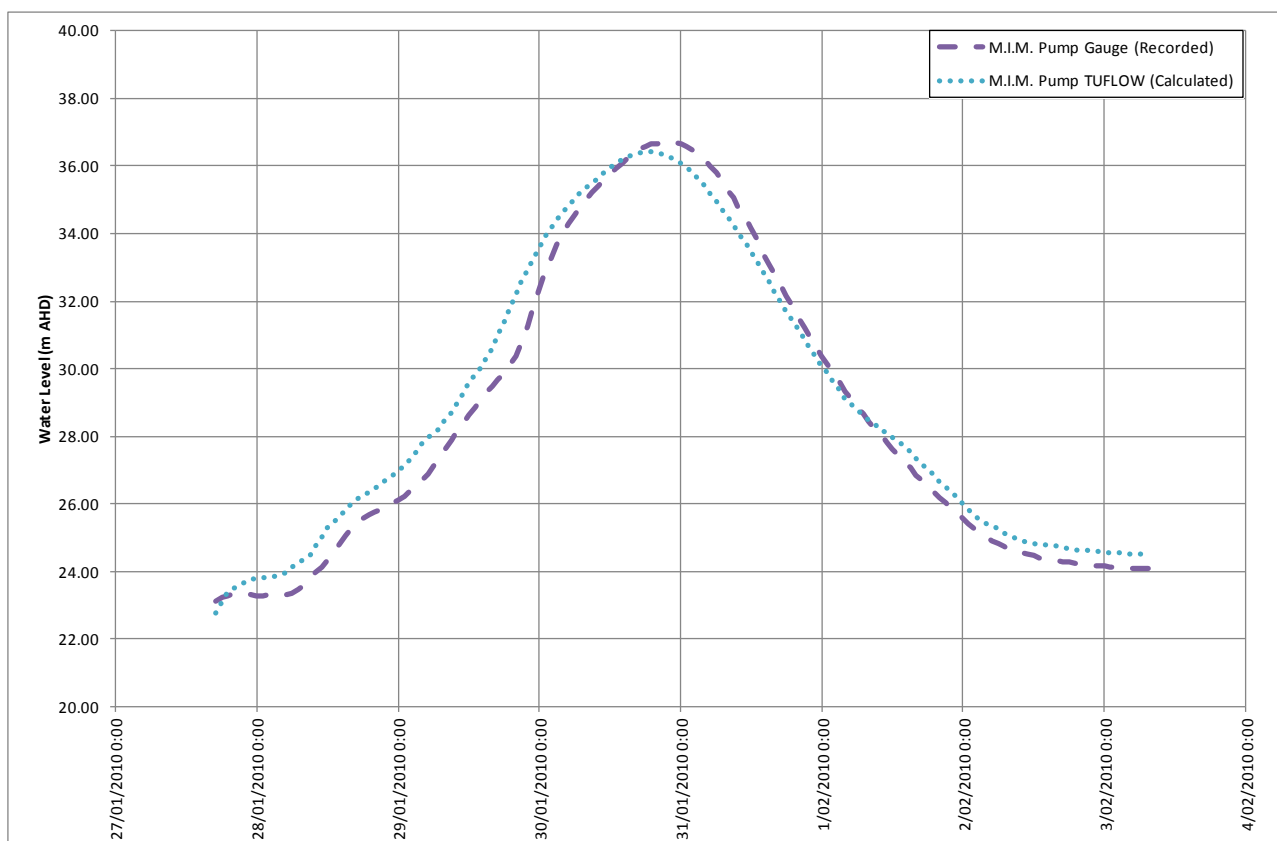


Figure 9.8 Comparison of Recorded and Predicted Water Level Hydrographs, McArthur River at MIM Pump Station, January/February 2010 Event

9.5.3 Revised MIM Pump Station Rating Curve

The rating (stage-discharge) curve at the MIM Pump station has changed due to the construction of the McArthur River diversion channel approximately 1 km downstream of the gauge. Figure 9.9 shows a comparison of the MIM Pump station rating curve for pre-diversion (the original NRETRAS rating curve) and post-diversion (calculated from TUFLOW results) conditions. The diversion has resulted in lower water levels at the gauge (by up to approximately 0.5 m) for discharges smaller than 1,100 m³/s and higher water levels (by up to 2.0 m AHD) for discharges greater than 1,100 m³/s. The post-diversion rating curve was adopted for river flows after 2006. The pre-diversion rating curve has been verified by actual stream gaugings undertaken before the diversion up to a discharge of 3,000 m³/s but the adopted post-diversion rating curve is yet to be verified against manual gaugings.

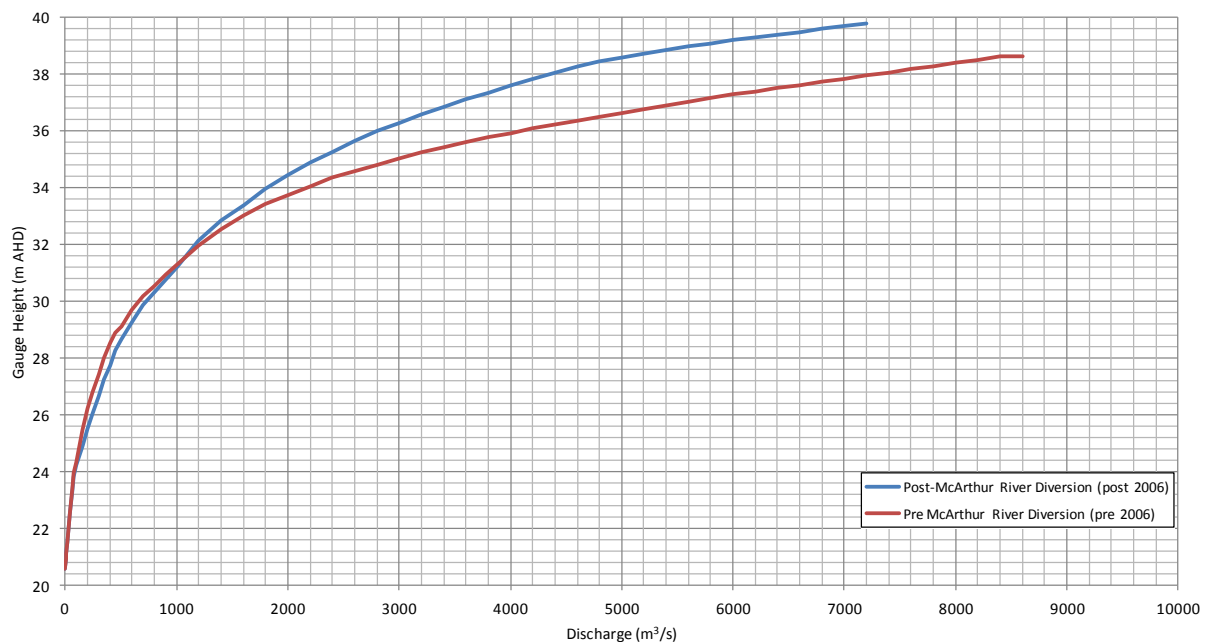


Figure 9.9 McArthur River Rating Curve at the MIM Pump Stream Gauging Station, Pre and Post McArthur River Channel Diversion Conditions

9.6 IMPACT OF PROPOSED MINE INFRASTRUCTURE

9.6.1 General

The TUFLOW model was used to determine impacts of the proposed Phase 3 mining operations on flood levels, velocities and extents for the 1% AEP (100 year ARI), and 0.2% (500 year ARI) flood events. In addition to flood level, flood velocity and extent maps, flood modelling and flood impact results are reported for a number of representative locations identified in Table 9.6. These representative reporting locations are shown in Figure 9.4.

The flood model shows that during major flood events substantial breakouts occur from the main McArthur River channel upstream of the mine site and flow into Barney Creek. The largest impacts on flood levels occur at four locations:

- On the floodplain on the western side (upstream) of the open pit. The impacts on flood levels at this location are due to the obstruction of flow across the floodplain caused by the proposed North, South and East OEFs.

- Along the McArthur River diversion channel adjacent to the proposed South and East OEFs upstream of Emu Creek and the Glyde River confluences. The impacts on flood levels and velocities along this reach are due to the constriction of flow along the McArthur River corridor caused by the obstruction of the floodplain by the South and East OEFs.
- Along the Barney Creek diversion channel adjacent to the existing flood protection levee and the Proposed North and East OEFs. The obstruction of the floodplain adjacent to the McArthur River forces more water around the western (upstream) side of the pit into Barney Creek. This would lead to increased flood levels and velocities along the Barney Creek channel.
- Along the sections of the Carpentaria Highway in the vicinity of MRM within the McArthur River floodplain.

Table 9.6 TUFLOW Model Results Reporting Locations

TUFLOW Reporting Location ID	Surface Level (m AHD)	Location and Description
A	38.87	McArthur River downstream of the Barney Creek diversion junction
B	39.00	McArthur River adjacent to the proposed East OEF
C	39.63	McArthur River adjacent to the proposed South OEF (east)
D	40.12	McArthur River adjacent to the proposed South OEF (mid)
E	40.31	McArthur River upstream of the proposed South OEF
F	40.28	Overbank area upstream of the western end of the flood protection levee
G	38.98	Barney Creek adjacent to the East OEF (mid)
H	39.01	Barney Creek adjacent to the East OEF (west)
I	39.45	Barney Creek adjacent to the western end of the flood protection levee
J	39.69	Barney Creek upstream of the flood protection levee
K	38.99	Overbank area adjacent to the eastern side of the North OEF
L	38.89	Overbank area adjacent to the north-eastern side of the North OEF
M	38.93	Overbank area adjacent to the northern side of the North OEF
N	38.96	Overbank area adjacent to the north-western side of the North OEF
O	39.35	Overbank area adjacent to the western side of the North OEF
P	39.75	Overbank area adjacent to TSF Cell 3 WMD spillway

9.6.2 Flood Level Impacts

Figure 9.10 and Figure 9.11 show the predicted flood level impacts in the vicinity of the mine for the 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood events. Table 9.7 shows the impact of the proposed mine infrastructure on peak flood levels at the 16 reporting locations for the 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) events. For the proposed Phase 3 mining conditions, the following is of note:

- The 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood levels along the McArthur River diversion channel range from 38.9 mAHd at location A to 40.8 mAHd at location F and from 41.7 mAHd at location A to 42.9 mAHd at location F respectively.
- The 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood levels along the Barney Creek diversion channel range from 39.0 mAHd at location G to 40.3 mAHd at location J and from 41.8 mAHd at location G to 42.8 mAHd at location J respectively.
- The 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood levels around the perimeter of the Northern OEF range from 37.2 mAHd at location N to 40.2 mAHd at location O and from 41.5 mAHd at location M to 42.7 mAHd at location O respectively.
- The 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood level in the vicinity of the Water Management Dam spillway (location P) is 40.4 mAHd and 42.9 mAHd respectively.
- The estimated 0.2% AEP (500 year ARI) flood levels around the existing open pit flood protection levee are between 41.7 mAHd (location A) on the eastern side of the pit and 42.9 mAHd (location F) on the western side of the pit. The potential flood level impact due to the proposed OEFs around the pit levee is up to 0.7 m. It is understood that the flood protection levee around the open pit is designed to withstand flooding from the McArthur River up to a level of at least 44 mAHd. Therefore, the protection of the open pit from a 0.2% AEP (500 year ARI) event is not compromised by the proposed changes.
- The potential 1% AEP (100 year ARI) flood level impact around the perimeter of the North OEF is up to 0.8 m on the western side of the dump.
- The potential 1% AEP (100 year ARI) flood level impact at the Carpentaria Highway in the vicinity of the TSF Cell 3 spillway is up to 0.6 m. It is understood that the Carpentaria Highway would be inundated for flood events greater than 5 year ARI (KBR, 2005). The proposed Phase 3 mining works would result in a small increase in the duration of inundation of the highway during the modelled events.
- The spillway level of the TSF Cell3 WMD is approximately 42.7 mAHd. The predicted 0.2% AEP (500 year ARI) flood level is 42.9 mAHd. It is noted that the TSF Cell3 WMD spillway is above the 1% AEP (100 year ARI) flood level of 40.5 mAHd but 0.2 m lower than the predicted 0.2% AEP (500 year ARI) flood level. The adopted 1% AEP (100 year ARI) flood immunity level requirement for 'contaminated' water storages would be maintained during Phase 3 operations.
- The model results indicate that the existing haul road crossing of Barney Creek has very little impact on flood levels because it is drowned out during the modelled flood events.

9.6.3 Flood Velocity Impacts

Figure 9.12 and Figure 9.13 show the predicted Phase 3 mine peak flood velocities for the 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood events respectively. Table 9.8 shows the impact of proposed Phase 3 mining operations on peak flood velocities at the 16 reporting locations for 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood events. For the proposed Phase 3 mining conditions, the following potential impacts are of note:

- The velocities along the McArthur River diversion channel could potentially be increased by up to 1.0 m/s at location B and up to 0.7 m/s at location C.
- The velocities along the Barney Creek diversion channel could potentially be increased by up to 0.2 m/s at location G.
- The velocities along the Barney Creek diversion overbank area along the northern side of the pit flood protection levee and southern side of the North OEF could potentially be increased by up to 1 m/s.

- The velocities around the North OEF could potentially be increased by up to 1.1 m/s at location K and up to 0.5 m/s at location O.

Two potential issues with respect to significant flood velocities include velocities between 4 m/s and 7m/s along the Barney Creek diversion between reporting locations H and I in the vicinity of the Haul Road and velocities between 3 m/s to 4 m/s along the McArthur River diversion channel between reporting locations B & D.

The predicted flood velocities may have an impact on in-stream erosion for flood events greater than about 18% AEP (20 year ARI) once significant flood breakouts from the McArthur River channel start to occur. The proposed works are unlikely to impact on stream erosion for more frequent events less than 18% AEP (20 year ARI).

Table 9.7 Peak Flood Levels and Flood Level Impacts for the 1% and 0.2% AEP (100 & 500 year ARI) Events, Existing and Proposed Mine Conditions

Reporting Location	Peak Flood Level (mAHD)				Peak Flood Level Impact (m)	
	Existing		Phase 3 EIS			
	1% AEP	0.2% AEP	1% AEP	0.2% AEP	1% AEP	0.2% AEP
McArthur River Diversion						
A	38.87	41.61	38.92	41.66	0.05	0.05
B	39.00	41.72	39.16	41.85	0.16	0.13
C	39.63	42.03	39.86	42.29	0.23	0.25
D	40.12	42.26	40.63	42.79	0.51	0.53
E	40.31	42.34	40.77	42.87	0.47	0.53
F	40.28	42.33	40.76	42.87	0.47	0.54
Barney Creek Diversion						
G	38.98	41.70	39.05	41.76	0.07	0.06
H	39.01	41.75	39.21	41.92	0.20	0.17
I	39.45	42.03	40.10	42.65	0.65	0.62
J	39.69	42.21	40.32	42.80	0.63	0.59
North OEF						
K	38.99	41.74	38.98	41.68	-0.01	-0.06
L	38.89	41.69	38.71	41.52	-0.18	-0.16
M	38.93	41.72	38.71	41.53	-0.21	-0.19
N	38.96	41.75	37.21	41.84	-1.75	0.08
O	39.35	41.95	40.17	42.65	0.82	0.70
Water Management Dam Spillway						
P	39.75	42.29	40.39	42.85	0.63	0.57

Table 9.8 Maximum Flood Velocities and Velocity Impacts for the 1% and 0.2% AEP (100 & 500 year ARI) Events, Existing and Proposed Mine Conditions

Reporting Location	Maximum Flood Velocity (m/s)				Velocity Impacts (m/s)	
	Existing		Phase 3 EIS			
	1% AEP	0.2% AEP	1% AEP	0.2% AEP	1% AEP	0.2% AEP
McArthur River Diversion						
A	1.3	1.1	1.4	1.3	0.1	0.2
B	1.9	1.8	2.9	2.8	1.0	1.0
C	3.1	3.0	3.8	3.6	0.7	0.6
D	2.8	2.8	2.6	2.5	-0.2	-0.3
E	1.5	1.7	1.5	1.7	0.0	0.0
F	0.5	0.5	0.5	0.5	0.0	0.0
Barney Creek Diversion						
G	1.6	1.6	1.8	1.8	0.2	0.2
H	2.0	2.0	2.0	2.0	0.0	0.0
I	0.9	0.9	0.9	0.9	0.0	0.0
J	0.6	0.6	0.6	0.5	0.0	-0.1
North OEF						
K	0.3	0.3	1.2	1.4	0.9	1.1
L	0.7	0.7	0.3	0.5	-0.4	-0.2
M	0.1	0.1	0.1	0.2	0.0	0.1
N	0.0	0.1	0.0	0.2	0.0	0.1
O	0.1	0.4	0.6	0.6	0.5	0.2
Water Management Dam Spillway						
P	0.0	0.2	0.0	0.2	0.0	0.0

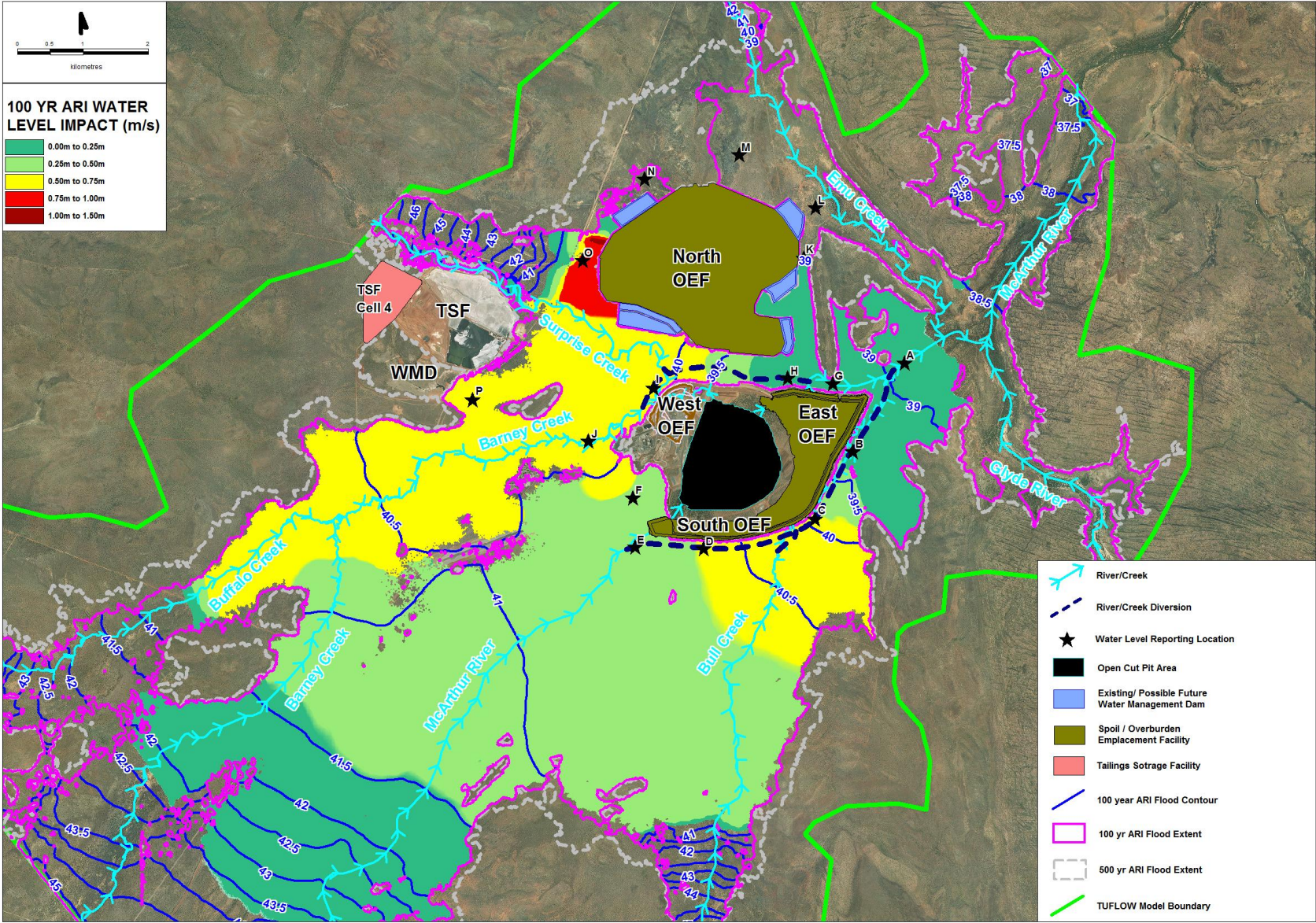


Figure 9.10 MRM Phase 3 Peak Flood Levels, Extents and Impacts, 1% AEP (100 year ARI) Event

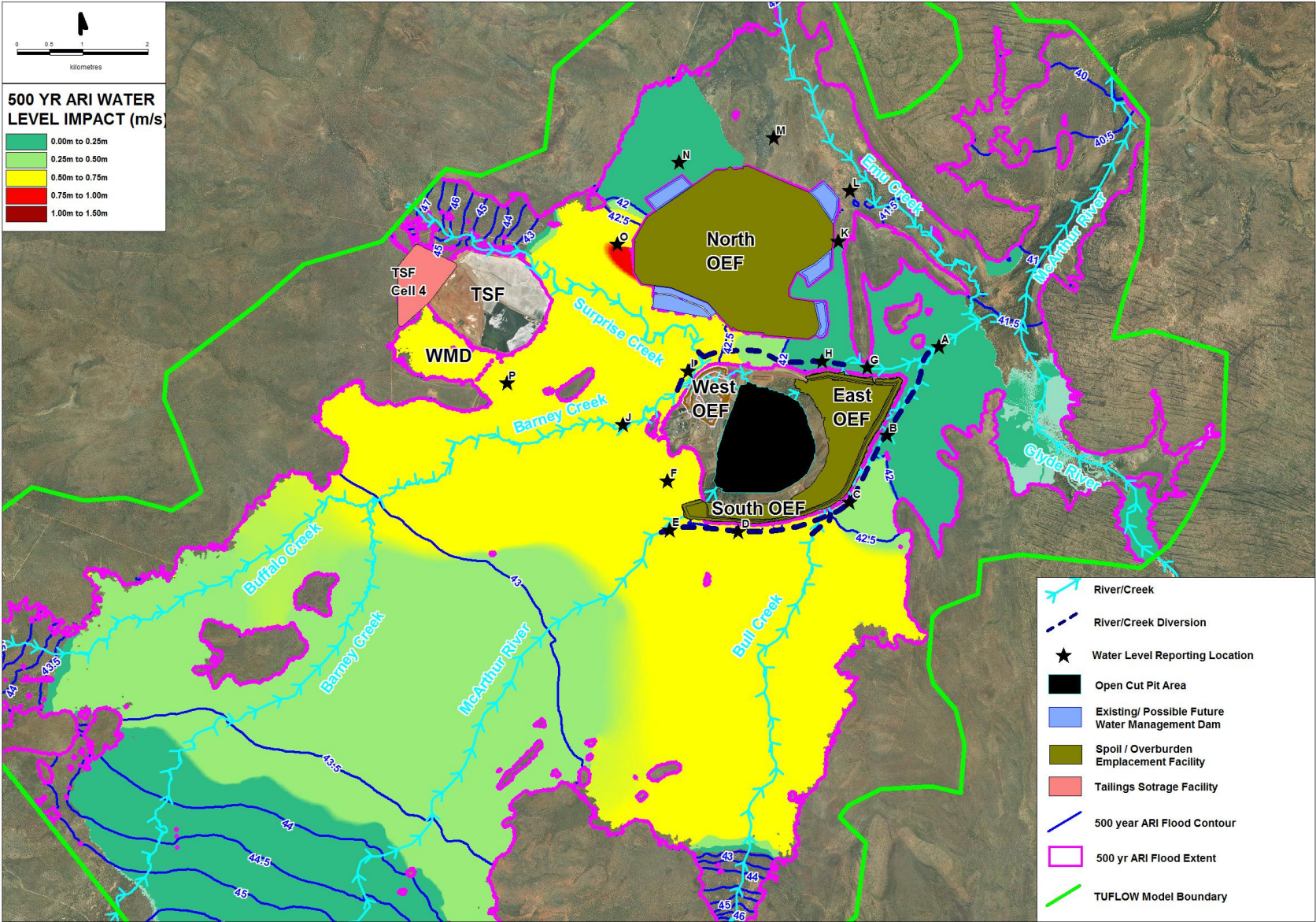


Figure 9.11 MRM Phase 3 Peak Flood Levels, Extents and Impacts, 0.2% AEP (500 year ARI) Event

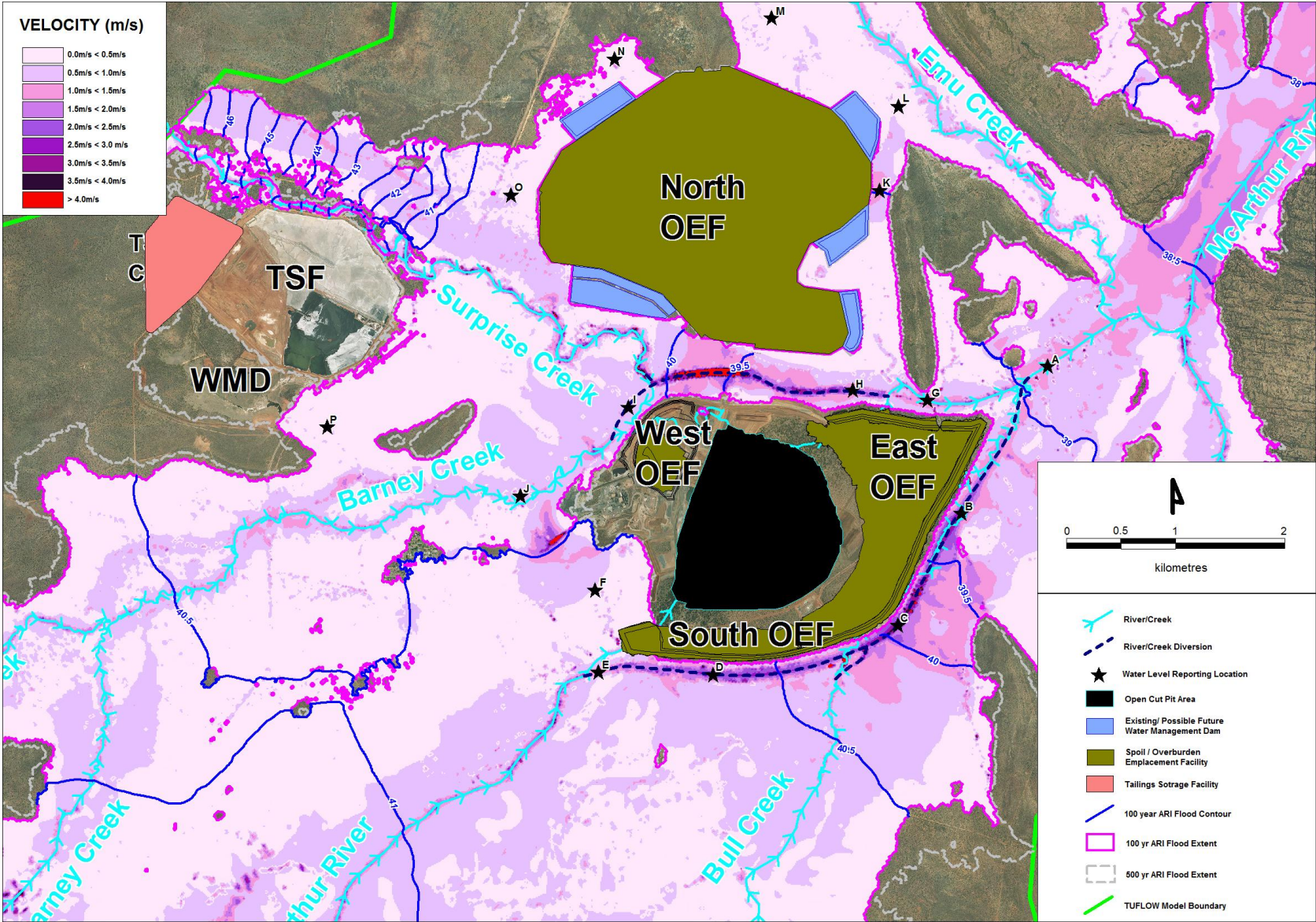


Figure 9.12 MRM Phase 3 Maximum Flood Velocities and Velocity Impacts, 1% AEP (100 year ARI) Event

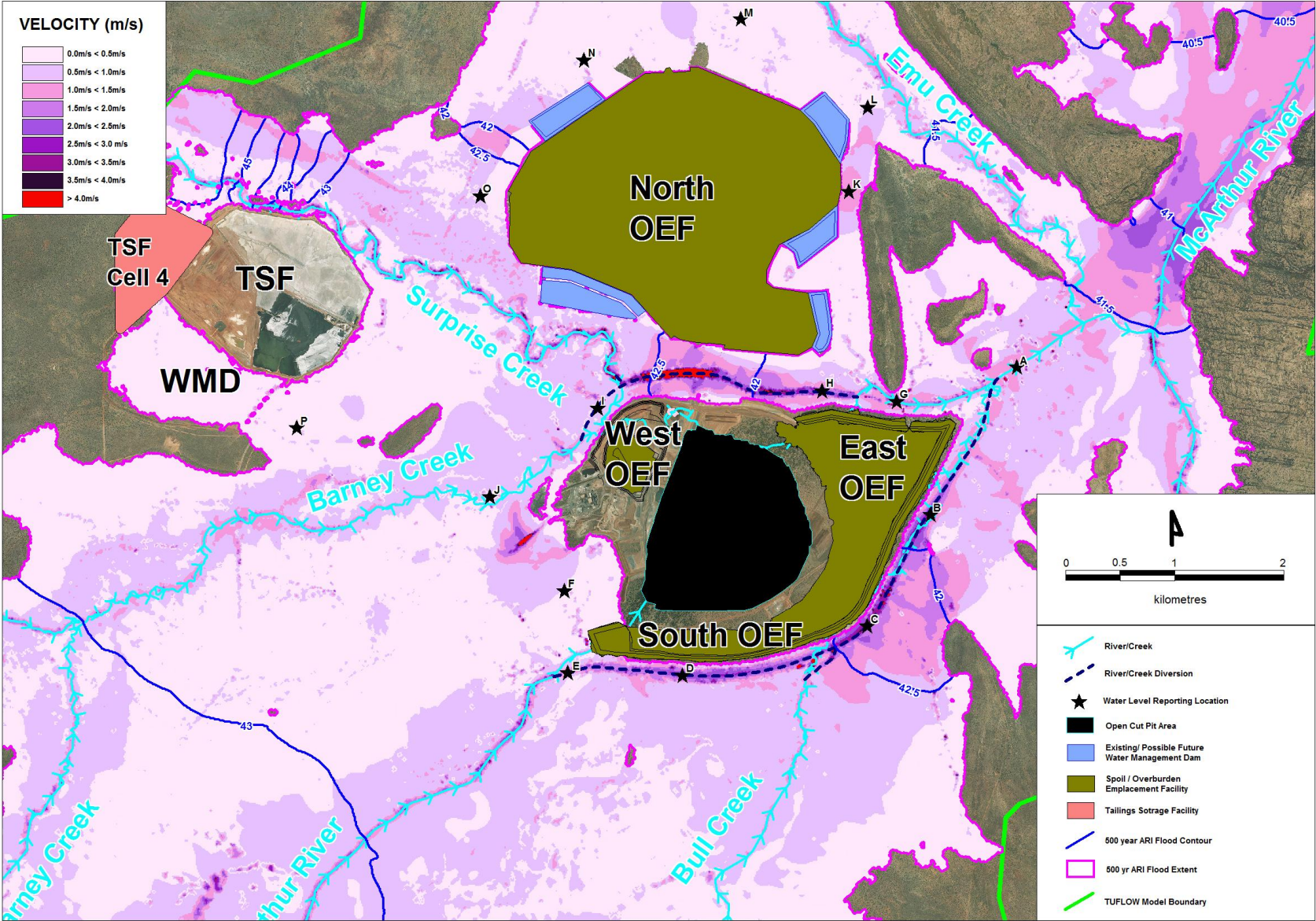


Figure 9.13 MRM Phase 3 Maximum Flood Velocities and Velocity Impacts, 0.2% AEP (500 year ARI) Event

9.7 FLOOD MITIGATION INFRASTRUCTURE

9.7.1 South and East OEF Erosion Protection Bund

It is proposed to construct the South and East OEF erosion protection bund to provide flood protection up to the 1% AEP (100 year ARI) flood level. Figure A3, Appendix A shows the location the proposed bund as well as 11 reporting locations, labelled A to K, used to specify design levels along the bund. Table 7.1 shows the 1% AEP (100 year ARI) peak flood level at each reporting location. It is recommended that this erosion protection bund be designed and constructed to appropriate engineering standards.

9.7.2 North OEF PAF Material

It is proposed that the placement of North OEF PAF material and the North OEF PAF Runoff Dam spillway levels will be above the 1% AEP (100 year ARI) flood level at the specific locations. This indicates a design level of between 38.7 mAHD (locations L and M) and 40.3 mAHD (location J). The minimum North OEF PAF Runoff dam spillway levels are shown in Table 7.6. The minimum levels of PAF material placement required to achieve the flood immunity requirements around the North OEF would be determined at the detailed design phase of the North OEF.

9.7.3 Existing Flood Protection Levee

The proposed mine infrastructure would potentially increase peak flood levels adjacent to the flood protection levee by up to 0.7 m to 42.9 mAHD. This level is lower than the minimum crest level (44 mAHD) of the flood protection levee. Although a significant increase in the peak flood levels along the McArthur River is predicted due to the proposed mine infrastructure, the downward revision of the design discharge for the 0.2% AEP (500 year ARI) flood event when compared with previous KBR (2005) estimates has resulted in up to 0.5 m lower predicted peak levels along the levee for existing conditions (see Section 9.2). On this basis, no additional open pit flood protection works are required because the existing flood protection levee would be adequate to protect the open pit up to a 0.2% AEP (500 year ARI) during the Phase 3 mining operations.

9.7.4 Erosion Protection along the diverted McArthur River and Barney Creek Channels

During large flood events, velocities between 4 m/s and 7m/s would potentially occur along the Barney Creek diversion between reporting locations H and I in the vicinity of the Haul Road and velocities between 3 m/s to 4 m/s would potentially occur along the McArthur River diversion channel between reporting locations B & D (see Figure 9.12 for locations). It is recommended that a regular erosion monitoring program be undertaken along these high velocity reaches. Additional erosion protection works should be undertaken in areas where visible erosion is evident at present.

9.7.5 Erosion Protection at North, South and East OEFs

The proposed North, South and East OEFs will constrict the McArthur River and Barney Creek floodplains adjacent to the OEFs. The flood modelling results indicate that the OEFs could increase flood velocities in some sections of the McArthur and Barney Creek channels and floodplain during large flood events. It is recommended that areas where there is a risk of elevated velocities due to the proposed Phase 3 works be inspected after major flow events for any evidence of erosion. If it is found that erosion is taking

place along the diversions or OEFs, additional rock protection may be required along the affected reaches.

10

POTENTIAL IMPACTS AND MITIGATION MEASURES

10.1 OVERVIEW

The MRM Phase 3 mine development is proposed to occur in stages over a 26 year mine life from 2012 to 2036. During this period, the operational requirements of Phase 3 mining include the following major works:

- Expanding and deepening the open pit;
- Additional overburden emplacement facilities (OEFs);
- Expanding the tailings storage facility (TSF);
- Constructing an erosion protection bund around East and South OEFs;
- Expanding the processing plant and associated infrastructure; and
- Enhancing the surface water management system.

The above works proposed for Phase 3 mining operations will have some impact on the surface water quantity and quality and flooding characteristics at the mine site. Therefore, changes are proposed to the existing mine site surface water management system to accommodate the proposed changes to the mine site layout and mitigate potential surface water and flooding impacts.

It is of note that no further diversions of the McArthur River or Barney Creek channels are proposed as part of Phase 3 mine development.

10.2 SURFACE WATER IMPACTS

The potential surface water impacts at the MRM site include:

- Potential change in surface runoff quality from disturbed catchments;
- Additional open pit water (including surface runoff and groundwater inflow) to be managed within the mine site water management system, due to the increased size of the open pit and its catchment;
- Additional runoff from areas disturbed by mining (including OEFs and TSFs) to be managed within the mine site water management system;
- Potential reduction in flows in receiving waters due to the need to contain 'contaminated' water on-site;
- Potential erosion impacts in the McArthur River channel and other local mine site streams.

The total area of land disturbance at the existing MRM site and the additional impact of proposed Phase 3 mining operations on surface water quantity and quality are considered minor. The following is of note:

- The current mining operations disturb an area of approximately 940 ha. The proposed Phase 3 mining operations would increase the disturbed area by approximately 700 ha, to a total of approximately 1,610 ha. The total disturbed area after Phase 3 development would be only about 0.12% of the McArthur River catchment area (1,292,000 ha) to the downstream end of the mine;
- The areas of disturbance within the local stream catchments caused by Phase 3 mining operations are small. The biggest impact will be on Little Barney Creek flows, however this is a minor tributary to the system. Phase 3 mining operations and associated infrastructure would increase the disturbed areas within each stream catchment when compared to the existing conditions as follows:
 - In the Little Barney Creek catchment the area of disturbance would increase from approximately 244 ha to 301 ha, which is about 25.2% of the Little Barney Creek catchment area (1,200 ha);
 - In the Barney Creek catchment the area of disturbance would increase from approximately 363 ha to 420 ha, which is only about 0.6% of the Barney Creek catchment area (70,000 ha);
 - In the Surprise Creek catchment the area of disturbance would increase from approximately 153 ha to 158 ha, which is only about 1.3% of the Surprise Creek catchment area (12,000 ha); and
 - In the Emu Creek catchment the area of disturbance would increase from approximately 52 ha to 418 ha, which is about 6.4% of the Emu Creek catchment area (6,500 ha).

With appropriate control measures in place, the impact of the Phase 3 mining operations on surface flows and water quality in downstream receiving waters will be insignificant. The surface water management system proposed for Phase 3 mining operations includes a number of 'clean' runoff drains to divert runoff from undisturbed areas away from disturbed areas, 'dirty' runoff drains and sediment ponds to capture and treat runoff from disturbed areas and containment storages to capture 'contaminated' runoff on-site. The proposed surface water management system will ensure that:

- The 'clean' runoff within the mine site is separated to the fullest extent and diverted away from disturbed areas;
- The 'dirty' and 'contaminated' surface water is segregated to the fullest extent, and then collected within the disturbed area of the mine site via adequately sized sediment ponds and containment storages;
- 'Contaminated' water is stored in appropriately designed containment storages and is not released out of the mine site, except in a controlled manner in compliance with the MRM WDL conditions;
- Controlled releases of 'dirty' runoff treated in proposed sediment ponds only takes place if water quality in the sediment ponds is within the MRM WDL water quality release limits;
- The 'raw' water consumption is minimised and reuse of 'contaminated' water within the mine site (e.g. for ore processing) is maximised;
- The evaporation of on-site 'contaminated' water is maximised to minimise the need for off-site releases and/or reliance on external water reuse;

- There is adequate permanent pumping infrastructure to allow transfer of 'contaminated' runoff between containment storages to minimise the risk of uncontrolled overflows.

Full details of the proposed changes to the MRM surface water management system, including measures to mitigate potential surface water impacts, are described in Section 7 of this report.

Long term water balance modelling, described in Section 8 of this report has been used to size and investigate the behaviour of the storages proposed as part of the Phase 3 water management system. Based on a 120 year period of simulation, the water balance modelling indicates the potential for 'contaminated' water at the MRM site overflowing into receiving waters is very low.

Periodic releases of 'dirty' water from sediment ponds will occur. However, any release of 'dirty' water from the sediment ponds is likely to occur only during significant flow events in the McArthur River. Further, these release volumes are expected to be insignificant when compared to expected flow volumes in the receiving waters during such flow events. Due to the expected non-toxic nature of the sediment pond releases and the potential for significant dilution of any releases from these storages, the periodic release of dirty water is not considered likely to have any significant environmental impact on receiving waters.

Based on 112 years of historical rainfall data, the water balance modelling results indicate that the proposed water management system is robust and has adequate storage capacity to manage surface water runoff generated within the MRM site for a wide range of possible climatic conditions, including extended wet and dry periods.

The proposed water management system for the MRM Phase 3 mining operations has been prepared based on the best available data and information at the time of preparing the report. It is noted however, due to data limitations a number of significant assumptions have been made when designing the proposed water management system (see Section 7.9). As a consequence, there is a degree of uncertainty in the design, operation and performance of the water management system components associated with the adopted assumptions. Further data acquisition will be required in the coming years to confirm the validity of the assumptions that have been made in this study and to make refinements to the proposed water management system as required.

10.3 FLOOD IMPACTS

Most of the existing and proposed Phase 3 mining infrastructure are located within the McArthur River floodplain and are potentially affected by McArthur River, Barney Creek and/or Surprise Creek floodwaters. Further, the proposed Phase 3 mining operations would potentially increase flood levels, depths, velocities and extents within and in the vicinity of the mine site due to a reduction of floodplain storage and obstructions to flow caused by the mining infrastructure.

For the McArthur River 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood events, flood modelling results indicate that the potential impacts of Phase 3 mining operations on flood levels are most significant at the following four locations (see Figure 9.10):

- On the floodplain on the western side (upstream) of the open cut pit due to the obstruction of flow across the floodplain caused by the proposed North, South and East OEFs.

- Along the McArthur River diversion channel adjacent to the proposed South and East OEFs upstream of Emu Creek and the Glyde River due to the constriction of flow along the McArthur River corridor caused by the obstruction of the floodplain by the South and East OEFs.
- Along the Barney Creek diversion channel adjacent to the existing flood protection levee and the Proposed North and East OEFs due to the obstruction of the floodplain adjacent to the McArthur River.
- Along sections of the Carpentaria Highway in the vicinity of MRM within the McArthur River floodplain causing a small increase in the duration of flood inundation during major flood events.

The existing flood mitigation measures at the MRM site will remain during Phase 3 mining operations. In addition, a number of additional measures are proposed to minimise the impact of flooding on Phase 3 mine infrastructure. The additional measures include:

- Constructing a new erosion protection bund to protect South and East OEFs from erosion up to the 1% AEP (100 year ARI) flood level; and
- Placing North OEF PAF material and North OEF PAF Runoff Dam spillway levels above the 1% AEP (100 year ARI) flood level.

For the McArthur River 1% AEP (100 year ARI) and 0.2% AEP (500 year ARI) flood events, flood modelling results indicate that the potential impacts of Phase 3 mining operations on flood velocities are most significant at the following four locations (see Figure 9.12):

- Along the McArthur River diversion channel velocities could potentially be increased by up to 1.0 m/s at location B and up to 0.7 m/s at location C.
- Along the Barney Creek diversion channel velocities could potentially be increased by up to 0.2 m/s at location G.
- Along the Barney Creek diversion overbank area along the northern side of the pit flood protection levee and southern side of the North OEF velocities could potentially be increased by up to 1 m/s.
- Around the North OEF velocities could potentially be increased by up to 1.1 m/s at location K and up to 0.5 m/s at location O.

In addition, during large flood events, velocities between 4 m/s and 7m/s would potentially occur along the Barney Creek diversion between reporting locations H and I in the vicinity of the Haul Road and velocities between 3 m/s to 4 m/s would potentially occur along the McArthur River diversion channel between reporting locations B & D (see Figure 9.12 for locations). It is recommended that a regular erosion monitoring program be undertaken along these high velocity reaches. If any evidence of erosion is found following major flow events erosion protection works should be undertaken.

The proposed North, South and East OEFs will constrict the McArthur River and Barney Creek floodplains adjacent to the OEFs. The flood modelling results also indicate that the OEFs could increase flood velocities in some sections of the McArthur and Barney Creek channels and floodplain during large flood events. It is recommended that areas where there is a risk of elevated velocities due to the proposed Phase 3 works (identified in Section 9) be inspected after major flow events for any evidence of erosion. If it is found that erosion is taking place along the diversions or OEFs, additional rock protection may be required along the affected reaches.

11

SURFACE WATER MONITORING

11.1 OVERVIEW

In addition to collecting site rainfall and meteorological data, MRM currently operates a comprehensive surface water monitoring network and data collection program within and in the vicinity of the mine site to collect:

- Water level (stream flow) data in the McArthur River, Barney Creek and the Glyde River;
- Water quality data in the natural streams upstream and downstream of the mine site, and through the mine site; and
- Water quality in 'contaminated' water storages and sumps on the mine site.

Currently, surface water is monitored at 24 stream locations within and in the vicinity of the mine site and 13 water storages and sumps. Figures 11.1 and 11.2 show the location of the 'natural' and 'artificial' surface water monitoring sites in and around the MRM site.

Data from the monitoring stations are used to assess the impact of mining activities on water quality in receiving waters and to demonstrate compliance with MRM's waste discharge license conditions. Details of MRM's surface water monitoring network and its objectives are presented in the SDWMP (MRM, 2011). Details of the parameters monitored at each station, together with the monitoring procedure and frequency for each of the parameters tested are also described in the SDWMP (MRM, 2011).

11.2 CURRENT MONITORING LOCATIONS

11.2.1 Natural Surface Water

Table 11.1 provides a summary of the 24 natural surface water monitoring sites shown in Figure 11.1. The monitoring sites cover the catchments of the McArthur River, Barney Creek, Surprise Creek and the Glyde River. There is an additional station labelled Early Warning Flood System (EWFS) Station on the McArthur River approximately 21 km upstream of the mine (just downstream of the confluence with the Kilgour River) that records river levels for early flood warning for the mine. Station SW8 is located approximately 60 km downstream of the MRM site at the Borroloola Township (see Figure 1.1).

Water quality is monitored at all stations listed in Table 11.1, except EWFS. The natural surface water quality parameters monitored by MRM include pH, EC, TDS, Cd, Cu, Pb, Zn, Al and SO₄. In addition, stream gauging is undertaken in the McArthur River at EWFS, SW10 and SW11, in Barney Creek at SW19, and in the Glyde River at SW9. Station SW11 is the compliance point for conditions specified in MRM's Waste Discharge License (WDL 174-1).

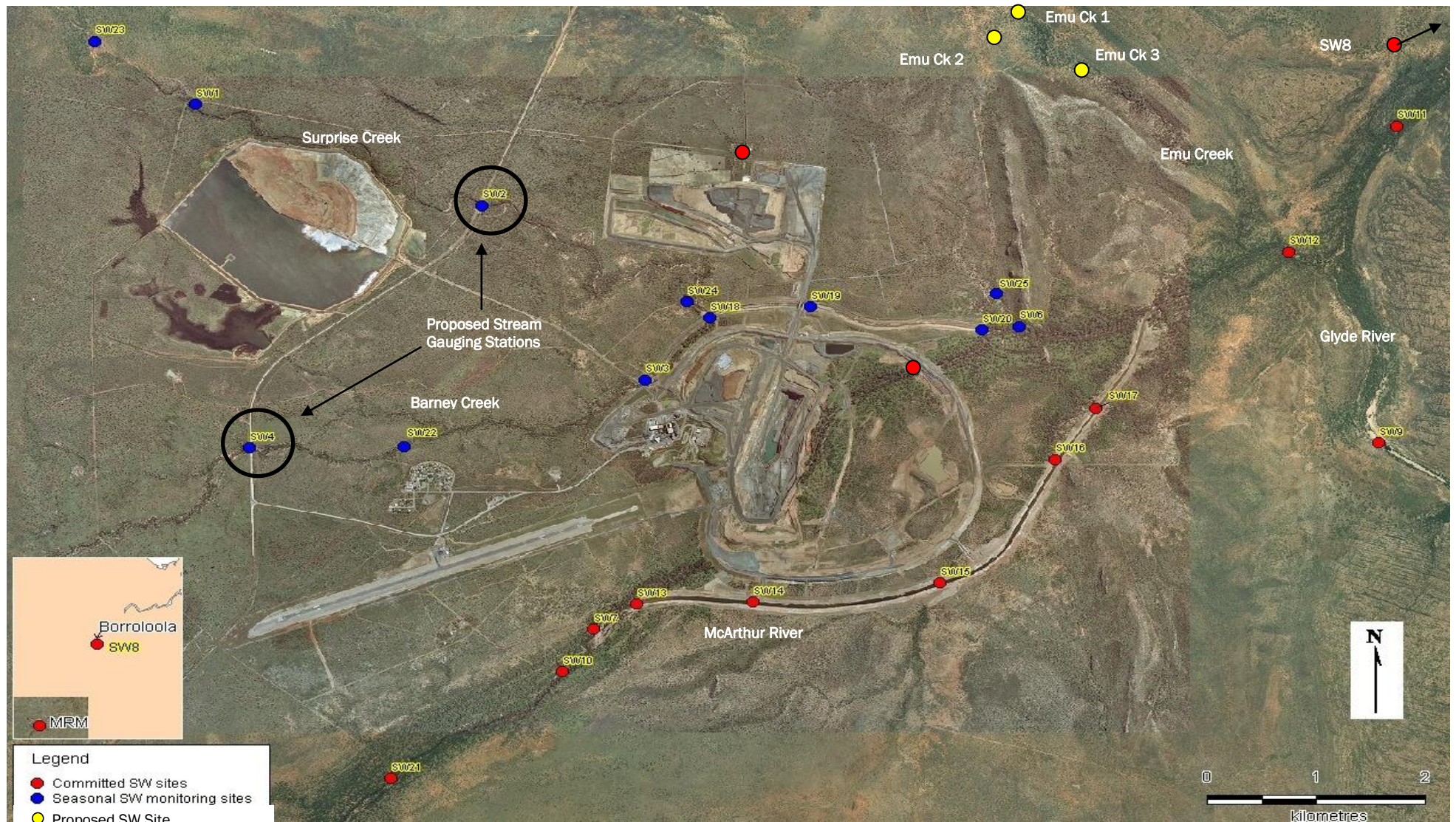


Figure 11.1 Natural Surface Water Monitoring Locations, MRM Site



Figure 11.2 Artificial Surface Water Monitoring Locations, MRM Site

Table 11.1 Current Natural Surface Water Monitoring Stations

Catchment	Station ID	Comments
McArthur River	EWFS	McArthur River at Kilgour River junction
	SW21	Upstream control location
	SW10	Upstream control location
	SW7	Upstream of mine
	SW13	McArthur River diversion channel
	SW14	Along McArthur River diversion channel
	SW15	McArthur River diversion channel
	SW16	McArthur River diversion channel
	SW17	McArthur River diversion channel
	SW12	Downstream of mine
	SW11	WDL 174-1 Compliance point
	SW8	Borrooloola (at Burketown Crossing)
Barney Creek	SW4	Mid/lower reach
	SW22	Mid/lower reach
	SW3	Mid/lower reach
	SW18	Barney Creek diversion channel
	SW19	Barney Creek diversion channel
	SW20	Barney Creek diversion channel
	SW6	Barney Creek/McArthur River junction
	SW25	Downstream of North OEF drainage
Surprise Creek	SW23	Mid reach
	SW1	Mid reach
	SW2	Mid/lower reach
	SW24	Lower reach
Glyde River	SW9	Lower reach

11.2.2 Artificial Surface Water

Water stored in mine site storages and sumps is referred to as ‘artificial’ water. These storages are designed to contain ‘contaminated’ water generated within the mine site. Artificial water is not released to the natural receiving waters unless it complies with MRM’s waste discharge licence conditions.

Table 11.2 provides a summary of the 13 current artificial surface water monitoring sites within the MRM site shown in Figure 11.2. Water quality is monitored at all stations listed in Table 10.2. Artificial surface water quality parameters monitored by MRM include pH, EC, TDS, Cd, Cu, Pb, Zn, Al and SO₄. In addition, water levels are monitored at sites Pit Sump (PS), TSF (including Cell 2 and WMD), and North OEFSPRD as well as the underground mine void dewatering vent shaft.

Table 11.2 Current Artificial Surface Water Monitoring Stations

Area	Station ID	Comments
Mill & Open Cut Pit Area	APP	Anti Pollution Pond
	CRP	Concentrator Runoff Pond
	RPS	ROM Pad Sump
	VDD	Van Duncan's Dam
	PP	Pete's Pond
	LA	Lake Archer
	PS	Pit Sump
TSF Area	TDBP	Tailings Dam Borrow Pit
	Cell 2	TSF Cell 2
	ID	Seepage Interceptor Drain
	WMD	Water management Dam
North OEF Area	NOEFSPD	North OEF South PAF Sediment Dam
	NOEFSPRD	North OEF South PAF Runoff Dam

11.3 MRM PHASE 3 DEVELOPMENT MONITORING LOCATIONS

The aims and objectives of the surface water monitoring program at MRM during Phase 3 mining operations will remain the same as under current operations. Therefore, the current surface water monitoring network will remain largely unchanged. A number of minor changes to improve and expand the current surface water monitoring program are proposed to account for the proposed changes in site layout.

11.3.1 Natural Surface Water

The stream gauging records at the current Barney Creek monitoring station (SW19) are unreliable and water levels at this station are affected by backwater from the McArthur River levels during high flow events. It is proposed to remove SW19 from the surface water monitoring network and replace this station with two new stations - one on Barney Creek approximately 5 km upstream of the removed station at the Carpentaria Highway crossing (SW4) and the other on Surprise Creek at the at the Carpentaria Highway Crossing (SW2). The two new stations are expected to provide more accurate streamflow data for both Barney Creek and Surprise Creek. The proposed locations of the above two stations are shown in Figure 11.1.

Three new surface water quality monitoring stations are proposed to monitor the impact of the North OEF runoff on Emu Creek receiving waters. These stations will monitor the background (upstream) water quality in Emu Creek, the quality of surface runoff entering Emu Creek from the North OEF area and the impact of the North OEF on Emu Creek receiving water quality. The proposed locations of the above three stations are shown in Figure 11.1 and Appendix C. No changes to the existing suite of parameters monitored or the monitoring frequency are proposed.

Table 11.3 shows the approximate eastings and northings of the proposed natural surface water monitoring sites discussed above.

Table 11.3 Proposed Natural Surface Water Monitoring Locations

Location	Easting in AMG84 Zone 53 (m)	Northing in AMG84 Zone 53 (m)	Station Type
Emu_Ck_1	618,645	8,187,253	Water Quality
Emu_Ck_2	618,996	8,186,438	Water Quality
Emu_Ck_3	619,946	8,185,846	Water Quality
SW2	615,040	8,184,770	Water Quality/ Stream Gauge
SW4	613,267	8,182,523	Water Quality/ Stream Gauge

11.3.2 Artificial Surface Water

It is proposed to expand the artificial surface water monitoring network to include the monitoring of the six (6) new 'contaminated' storages proposed for the site. These are the two new storages in the TSF area (TSF Cell 3 WMD and TSF Cell 4 WMD) and the four new storages in the North OEF area, namely South-East PAF Runoff Dam (SEPROD), East PAF Runoff Dam (EPROD), North-East PAF Runoff Dam (NEPROD) and North-West PAF Runoff Dam (NWPROD). Table 11.4 shows the easting and northing of the proposed artificial surface water monitoring sites discussed above. The locations of these storages are shown in Appendix B (for TSF storages) and Appendix C (for North OEF storages). No changes to the existing suite of parameters monitored or the monitoring frequency are proposed.

Table 11.4 Proposed Artificial Surface Water Monitoring Locations

Location	Easting in AMG84 Zone 53 (m)	Northing in AMG84 Zone 53 (m)	Station Type
North OEF Area			
NWPROD	616,084	8,185,970	Water Quality/ Water Level
SEPROD	618,518	8,184,086	Water Quality/ Water Level
EPROD	618,247	8,185,033	Water Quality/ Water Level
NEPROD	618,777	8,185,759	Water Quality/ Water Level
TSF Area			
TSF Cell 3	613,440	8,183,470	Water Quality/ Water Level
TSF Cell 4	612,159	8,184,234	Water Quality/ Water Level

During Phase 3 mining operations, it is proposed to direct runoff from NAF areas in the South and East OEFs towards sediment ponds. This is based on the assumption that runoff and seepage from the North, South and East OEF areas can be considered 'dirty' and can be released to the receiving waters after treatment in a sediment pond. Monitoring of water quality in these sediment ponds would be required to demonstrate that the water quality is within the limits specified in MRM's WDL prior to release into receiving waters. If runoff and/or seepage from North, South and East OEF areas is found to be 'contaminated', active management measures and/or additional storage volume would be required to fully contain the contaminated water on site.

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