



# VISTA GOLD

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Mt Todd Gold Project  
50,000 tpd Feasibility Study  
Northern Territory, Australia

REFERENCE | APPENDIX O

## Stormwater Management Plan

PROJECT NO. 117-8348002

DATE: DECEMBER 2021



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## ATTACHMENTS

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ATTACHMENT 1: Surface Water Management Plans

## LIST OF UNITS

g	acceleration of gravity
cm/s	centimeters per second
km	kilometers
kN/m <sup>3</sup>	kilonewton per cubic meter
kPa	kilopascals
masl	meters above mean sea level
m/day	meters per day
m	meters
m <sup>3</sup>	cubic meters
m <sup>3</sup> /s	cubic meters per second
mm	millimeter
t/m <sup>3</sup>	tonnes per cubic meter
tpd	tonnes per day

## ACRONYMS, ABBREVIATIONS & SYMBOLS

AMD	Acid Mine Drainage
ARI	Average Return Interval
ha	hectares
HLP	Heap Leach Pad
IFD	Intensity-Frequency-Duration
LGOS	Low Grade Ore Stockpile
M	Meters
mm	millimeters
mAHD	Meters Relative to the Australian Height Datum
NAF	Non-Acid Forming
ROM	Run of Mine
PAF	Potentially Acid Forming
PP	Processing Plant
PRP	Process Plant Retention Pond
PWP	Process Water Pond
RWD	Raw Water Dam
TSF	Tailings Storage Facility
WRD	Waste Rock Dump
WTP	Water Treatment Plant

## 1. EXECUTIVE SUMMARY

Vista Gold Australia Pty Ltd (Vista Gold) proposes to re-establish and operate the Mt Todd Gold Mine (Project), located 55 km north of Katherine, NT (**Figure 1-1**) (GHD, 2013). Tetra Tech was commissioned by Vista Gold to develop a plan for the managing runoff during construction, production, closure, and post-closure in support of the Mt Todd Gold Project Feasibility Study.

The Project area is located in a historical mining district and is a brownfield/disturbed site. It was last mined in the 1990s, and mining operations reportedly ceased in July 2000. Mining infrastructure remaining on-site includes a tailings storage facility, a low-grade ore stockpile, a waste rock dump, waste rock dump retention pond, a heap leach pad, a raw water supply reservoir, runoff retention ponds, and other processing facilities in varying states of repair.

As reported in the Surface Water Assessment – Hydrology Appendix I (GHD, 2013a), the Mt Todd Mine is traversed by four creeks that drain into the Edith River, located to the south of the mine. Horseshoe and Batman Creeks feed Stow Creek, which borders the proposed TSF2 and then flows into the Edith River. Horseshoe Creek flows along the eastern boundary of the mine, Batman Creek flows through the center of the mine, and Burrell Creek flows along the southwestern corner of the mine (see Sheet 4520-DC-133C of attached plans). The following information has been excerpted from the Surface Water Assessment Appendix (GHD, 2013a) for completeness.

Flooding along these creeks has the potential to encroach on storage embankments, plant, pit and other infrastructure. Hydrologic modelling in conjunction with 1-D hydraulic models has been used to extend the existing flood outlines from previous studies and to assess flood immunity and impacts on existing and proposed mine infrastructure, particularly storage embankments. Channels were designed to route the storm runoff away from the mining facilities and to the Edith River. These channels are routed to limit the water interacting with mine facilities and needing treatment.

Previous flood modelling has shown that most of the existing mine infrastructure is located outside the 100-year ARI design flood extent of creeks passing through the mine area. The notable exceptions are the future TSF2, which encroaches on the area of flooding along Horseshoe Creek and Stow Creek, and the area of proposed Low-Grade Ore Stockpile (LGOS) and Run of Mine (ROM), which encroach on the flood extent of Batman Creek.

The design of TSF2 includes diversion channels and levees along Horseshoe Creek and Stow Creek to protect the embankment from flooding and erosion. Diversion channels have been designed for 100-year ARI flood events and comprise lined riprap channels with a width and length on Stow Creek of approximately 34m and 850m, respectively, and a nominal depth of 4.2m. The width and length of the diversion channel on Horseshoe Creek will be approximately 36m and 550m, respectively, with a nominal depth of 3.0m.

The existing TSF1 is protected from flooding along Horseshoe Creek by means of a creek diversion channel, which modelling shows has sufficient capacity to accommodate the 10-year ARI design flood event.

Batman Creek is proposed to be channelized to route the natural creek around the pit to the north and also from the LGOS until south of the plant facilities to reduce the risk of a major storm impacting the proposed pit or process plant.

Upgraded drainage channel designs have been made to route stormwater to the nearest creek to avoid contamination and interference with mining activities. Drainage across the processing plant site will be limited by the installation of cut-off drains to divert uncontaminated runoff from around the site and into Batman Creek via a settling pond. All stormwater runoff from within the site will be directed toward the existing drainage channel on the east side of the proposed process plant.

LGOS will require collection ditches to capture runoff and seepage from stockpiles for conveyance to retention ponds. WRD runoff will be collected in channels which are designed to contain the peak 100-year flow (during production, but just prior to closure). The channels are located east and west of the facility and discharge into a

retention pond (RP1). The storage requirements for the LGOS and WRD were determined using the water balance GoldSim model further discussed in Appendix I.

Mitigation includes diversion structures to limit the runoff from undisturbed areas of the mine and upstream catchments from reaching water containment and plant infrastructure. Diversions are also present around the LGOS and the HLP, with the purpose of collecting runoff from these disturbed areas of the mine and directing it into storage ponds for pumping into the wastewater treatment plant. Diversion channels have been constructed around the western and eastern margins of the WRD retention pond (GHD, Nov 2010) to divert uncontaminated runoff away from the pond and thereby reduce the risk of overtopping. Diverted water reports to local creeks downstream of the pond. With the increased size of the WRD, new diversion drains have been designed to divert runoff from retention pond RP1. Additional diversion channels have been designed east and west of TSF2 and east of TSF1 to avoid the unnecessary treatment of previously clean water.

Overtopping of cross drainage structures and haul roads is likely to be an infrequent occurrence, but upgrades to existing stormwater drainage, erosion and sediment controls, including the vegetation of verges, will be necessary to minimize damage and maintain access during less extreme but more frequent storm events.

Locations where flood peak velocities are expected to exceed 2m/s and thus have the potential to cause scouring of unlined channels have been identified. While the majority of these locations are sufficiently distant from mine infrastructure to be of no immediate risk, the section of Batman Creek adjacent to the processing plant is likely to experience high-velocity flows during extreme flood events. Riprap protection to earthwork embankments adjacent to the existing drainage channel on the east side of the proposed process plant will be installed for channel protection. Downstream sections of the Western WRD diversion channel will require riprap to avoid undue channel erosion. Sections of Horseshoe Creek, Eastern TSF2 diversion channel and Western TSF2 diversion channel in the vicinity of the proposed embankment of TSF2 are also expected to experience high-flow velocity during extreme flood events. Scour protection measures will include placement of riprap in association with proposed channel diversion works.

The following additional mitigation measures are proposed for the management of storm water runoff:

- Ensure flood immunity by siting mine infrastructure outside the 100-year ARI flood extent;
- The potential for contamination of receiving waters has been reduced by segregation of “clean” stormwater runoff from “dirty” stormwater runoff, and the collection and treatment of “dirty” stormwater runoff from areas within the mine site;
- The amount of pit water needing treatment has been reduced by minimizing the stormwater runoff entering the pit by construction of bunds around the pit perimeter;
- The amount of stormwater runoff from material stores has been minimized through appropriate design of batter slopes and drainage collection systems;
- During rainfall events that exceed the design capacity of water containment infrastructure, excess inflow may need to be redirected back into the active TSF up to the height of beached tailings or allowed to overflow to the environment. It is assumed that retention ponds have been designed to overflow while maintaining the safety of embankment structures.

An FS-level estimate of initial and sustaining capital expenses for the stormwater infrastructure was prepared. The estimated capital costs are summarized in **Table ES-1** and provided in United States Dollars (USD).

Table ES-1: Stormwater Capital Cost Estimate Summary

Cost Category	Capital Cost (USD000s)
Horseshoe Creek and Stow Creek Diversion Construction - cut and fill	2,670
Batman Creek Diversion - cut and fill	9,525
WRD Diversion Channel - cut and fill	614
TSF Diversion Channels - cut and fill	948
Rock armor channel as required	64
Geotextile	8
Engineering Design (15%)	2,074
General, Admin, Construction Observation (15%)	2,074
Contingency (10%)	1,383
<b>Total</b>	<b>19,361</b>

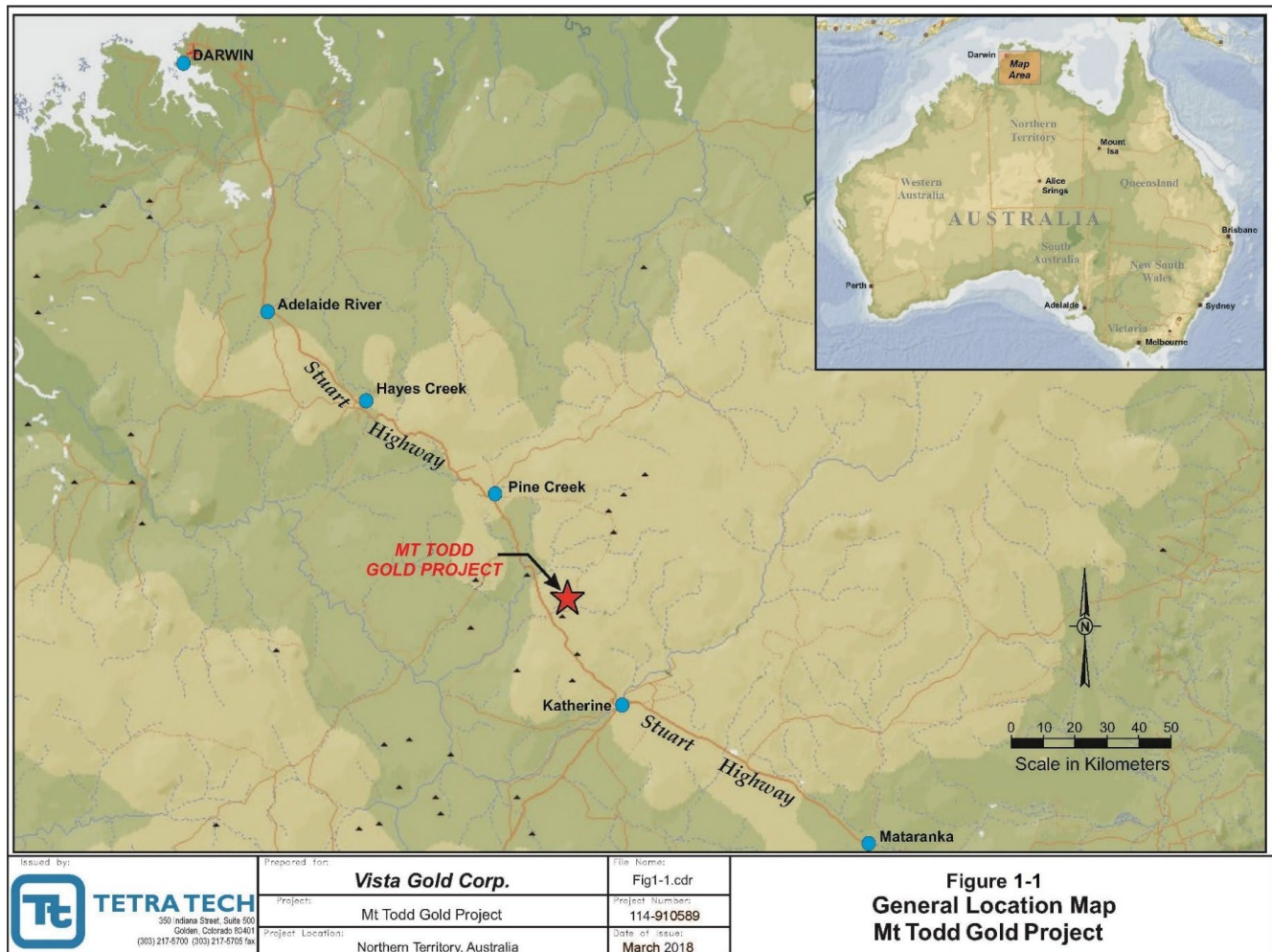


Figure 1-1: Project Location

## 2. INTRODUCTION

Vista Gold Corp. (Vista) retained Tetra Tech, Inc. (Tetra Tech) to prepare the feasibility study (FS) for its Mt Todd Gold Project (the Project) in Northern Territory, Australia. The FS evaluates a development scenario of a 50,000 tonne per day (tpd) gold processing facility. The FS is based on the results of a comprehensive review of each aspect of the Mt Todd Project and the re-design of various elements of the project.

The Mt Todd Project is located 56 kilometers (km) by road northwest of Katherine, and approximately 290 km southeast of Darwin in NT, Australia. Access to the property is via high quality, two-lane paved roads via the Stuart Highway, the main arterial within the territory and the site is well serviced by water, grid power, communication and natural gas spur lines.

Vista and its subsidiary, Vista Gold Australia Pty Ltd (Vista Australia) entered into an agreement to acquire an interest in the Project located in Northern Territory (NT), Australia on March 1, 2006. The acquisition was completed on June 16, 2006 when the mineral leases comprising the Project were transferred to Vista Australia and funds held in escrow were released. Vista Australia is the operator of the Mt Todd property.

The Mt Todd property contains a number of known occurrences of gold, which have been explored and/or exploited to various degrees. The largest and best-known deposits are the Batman and Quigleys deposits, both of which have had historic mining by prior operators. The Batman deposit has produced and been explored more extensively than the Quigleys deposit.

The mine plan contains 267.0 million tonnes of ore mined from the Batman open pit plus 13.4 million tonnes of ore from the existing heap leach pad that is processed through the mill at the end of the mine life. Together, 280.4 million tonnes of ore containing 6.98 million ounces of gold at an average grade of 0.84 g-Au/t are processed over the 16-year operating life. Total gold recovered is expected to be 6.39 million ounces. Average annual gold production over the life of mine is 428,000 ounces, averaging 479,000 ounces during the first seven years of operations. Commercial production would begin following two years of construction and commissioning.

The Project is designed to be a conventional, owner-operated, large open-pit mining operation that will use large-scale mining equipment in a blast/load/haul operation. Ore is planned to be processed in a large comminution circuit consisting of a gyratory crusher, cone crushers, HPGR crushers, and primary grinding by ball mills and secondary grinding by horizontal IsaMills. Vista plans to recover gold in a conventional carbon-in-pulp (“CIP”) recovery circuit.

The primary purpose of this Appendix is to provide documentation for the updated feasibility study, supporting the Technical Report developed in accordance with NI-43-101 and S-K 1300.

This Appendix describes the Stormwater Management Plan design assumptions, design analyses, and opinion of costs. The design for the Stormwater Management Plan is the same for the Base and Alternate Cases.

### 3. PREVIOUS STUDIES

Previous studies that were referenced during this work are discussed herein. Hydrology studies that were completed in the past include:

- AGC Woodward-Clyde (October, 1992) includes information regarding the inundation area of a 100-year rainfall event.
- Knight Piesold (July, 1995) includes information regarding the runoff flow rates, depths and velocity from a 10-, 20-, 100-year storm event on Horseshoe Creek.
- GHD (2010 and 2013) completed two studies, the first of which was to determine the capacity of the drains located around the WRD designed to reduce the runoff entering the WRD Retention Pond (RP1). The 2013 study was completed to determine the return flows for the natural creek catchment during 10-year and 100-year storm return period.
- Tetra Tech (2019) Preliminary Feasibility Study includes the preliminary design of many of the design elements discussed in this report, including the sizing of diversion channels to route storm runoff around mining infrastructure, the design of the landform runoff features, and design of drainage features for PAF landforms including the LGOS and Process Water Pond.

## 4. PROJECT DESCRIPTION

There are four creeks traverse the Mt Todd Mine Site (Horseshoe, Batman, West, Burrell, and Stow) and drain to the Edith River (**Figure 4-1**). The creeks are ephemeral, running solely during the wet season. Prior to discharging into the Edith River, Horseshoe Creek converges into Stow Creek; West Creek and Burrell Creek converge and flow into the Edith River.

### 4.1 Batman Creek

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Batman Creek originates to the north-west of Batman Pit before traversing the north and east edge of the pit near the proposed low grade ore stockpile (LGOS). Batman Creek flows underneath the access road to the processing plant via a culvert before draining south to the Edith River.

### 4.2 Horseshoe Creek

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Horseshoe Creek is comprised of two tributaries: Horseshoe Creek North-East and Horseshoe Creek North-West. Horseshoe Creek North-East is dammed and is shown as the Raw Water Supply Reservoir. Post-confluence Horseshoe Creek flows past the east toe of Tailing Storage Facility 1 (TSF1), before flowing south past Tailing Storage Facility 2 (TSF2) via a proposed diversion channel. Horseshoe Creek flows underneath the access road to raw water dam via a culvert before terminating at the confluence with Stow Creek.

### 4.3 Stow Creek

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Stow Creek collects water from the area east of site. Runoff from the area flows along the south toe of the proposed TSF2 via a proposed diversion channel near the south-east corner of the landform. At the southwest corner of TSF2 Stow Creek and Horseshow Creek join and flow southwest to the Edith River.

### 4.4 West and Burrell Creeks

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West and Burrell Creeks are located on the west side of the site. Burrell Creek will be partially buried by the new waste rock dump (WRD). West creek flows to the east near the southwest toe of the WRD, where it turns south and drains to the Edith River.

The Mt Todd Gold Project has several proposed aspects that are relevant to hydrology:

- Expansion of the existing waste rock dump (WRD) to a final elevation of approximately 450 mAHD and area of approximately 257 hectares (ha)
- Raising the existing TSF1 by 18 m to a final elevation of 158 mAHD
- Construction of TSF2 that will be approximately 60 m in height with an area of 220 ha
- Construction of LGOS between Batman Pit and TSF2 that will be approximately 51 hectares and have a maximum elevation of 160 mAHD
- Construction of a 750 m<sup>3</sup>/hr water treatment, and 126,000 m<sup>3</sup> process water pond to hold contaminated drainage during rain events
- The expansion of WRD encroaches on part of Burrell Creek. In addition, the re-alignment of the access road may also effect drainage of the mine site
- The Heap Leach Pad (HLP) will be removed and processed prior to closure of the mine site



## 5. REGULATORY REQUIREMENTS

### 5.1 Legislation

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The two main Northern Territory (NT) acts which relate to erosion and sediment control are (NRETA, 2012):

- Soil Conservation and Land Utilization Act, which assists in protecting sensitive areas and in reducing the impact of sediment on land downstream
- Water Act, which provides for the investigation, use, control, protection, management and administration of water resources within the Northern Territory

In addition, the *Mining Management Act* contains general provisions for the management of potential environmental effects emanating from mine sites including water and ground water management. The Act is administered by the Minerals and Energy Group of the Department of Primary Industry, Fisheries and Mines.

### 5.2 Conditions Specified in the EIS

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The analysis completed for this Plan was based on the conditions specified in the Environmental Impact Statement (EIS). The EIS states the compliance conditions for mine operation, and relevant items pertaining to stormwater management include:

- Diversion channels to isolate runoff from undisturbed areas to reduce the water entering the mine site water management system.
- Process Water Pond to manage the contaminated runoff and water in the retention ponds.
- Process Plant Retention Pond must be maintained to act as a sediment trap rather than a true retention pond.
- A maximum estimated seepage rate from the WRD (3,109 m<sup>3</sup>/day) must be treated post-closure until a passive-treatment wetland is constructed.
- Treated water from the WTP will be used for dust suppression and at the Processing Plant (PP).
- Diversion channels to convey Horseshoe Creek and Batman Creek around TSF2, as well as diversions upstream of LGOS and around the HLP.

## 6. LANDFORM HYDROLOGY

To determine the size of the diversion structures (i.e., channels, dikes) a hydrology study was undertaken for the landforms. The landforms studied were the LGOS, TSF1, TSF2, and the WRD. Tetra Tech was directed to design channels for a 10- and 100-year average return interval (ARI) storm event.

The Australian Rainfall and Runoff (ARR) method and the National Resources Conservation Service (NRCS) method was used for the hydrologic analysis (Ball et al., 2019 and NRCS, 1986). The design rainfall depths for the 5, 10, 50, and 100-year storm events were retrieved from the Australian Government Bureau of Meteorology (BoM)’s Design Rainfall Data System (2016) for durations ranging from 5 minutes to 72 hours (BoM 2006) (**Table 6-1**). The 24-hour storm durations were used to calculate peak discharge for the 10-year and 100-year events using a 3-hour duration temporal distribution produced by the BoM.

Table 6-1: IFD Rainfall Depth Data for Mt Todd Mine

Storm Duration	Average Recurrence Interval (mm)			
	5-years	10-years	50-years	100-years
5 minutes	14.5	16.1	19.3	20.4
10 minutes	24.2	27.2	33.1	35.4
15 minutes	31.5	35.4	43.2	46.2
30 minutes	46.1	51.6	62.3	66.3
1 hour	61.4	68.5	82	86.8
2 hours	75.8	84.8	102	109
3 hours	83.5	94	116	124
6 hours	96.7	111	143	157
12 hours	113	133	182	205
24 hours	137	165	237	273
48 hours	174	212	310	357
72 hours	204	247	356	405

The Initial and Constant Loss method was selected based off ARR methodology for a rural catchment. The median Initial Loss (IC) and Constant Loss (CL) values were selected from Tables 5.3.5. and 5.3.6 in ARR’s *A Guide to Flood Estimation, Book 5* for a catchment in Region 1 (Ball et al., 2019). The IC used was 41.5mm and CL was 5.4 mm/hour. Hydrology for drainage areas around the LGOS, expanded WRD, TSF1 and TSF2 were calculated using the Bransby-Williams formula to determine the time of concentration, where:

$$t_c = 0.605 \frac{L}{A^{0.1} S^{0.2}}$$

Where:

- L = Length of overland flow (Km)
- A = Catchment area (Km<sup>2</sup>)
- S = Average catchment slope (%)
- t<sub>c</sub> = time of concentration (hrs)

Once the time of concentration was calculated using the Bransby-Williams formula, the lag time was determined by multiplying the time of concentration by sixth tenths in accordance with Simas equations (Simas, 1996). The lag time was then used with a standard Soil Conservation Service (SCS) unit hydrograph, to estimate the peak

return flows from the design storm events (SCS, 1986). The basin parameters and inputs for the lag time and time of concentration are reported in **Table 6-2**.

**Table 6-2: HEC-HMS Inputs for Proposed Diversion Channel Estimations**

Parameter	LGOS Catchments	W. WRD Catchment	E. TSF2 Catchment	W. TSF2 Catchment	TSF1 Catchment
Area (km <sup>2</sup> )	0.51	2.01	0.47	1.44	0.52
Flow Path Length (km)	1.91	2.18	1.73	2.01	1.62
Flow Path Slope (m/km)	10	31.7	28	12	5
Time of Concentration (hrs.)	1.25	0.96	0.92	1.13	1.20
Lag Time (mins.)	45.0	58.5	54.9	68.0	72.1
Impervious (%)	100	48	71	52	65
Initial Loss (mm)/ Constant Loss (mm/hr.)	41.5/5.4	41.5/5.4	41.5/5.4	41.5/5.4	41.5/5.4

The previously discussed rainfall data and runoff parameters were used in conjunction with HEC-HMS 4.8 model, which was developed by United States Army Corps of Engineers (USACE) (USACE 2021). The 100-year return flows were calculated using the Rational Method and runoff coefficients in the previous studies for Batman, West/Burrell, Stow and Horseshoe Creek. The flow rates for all the instream realignment channels for 10-year and 100-year events under a 24 hour duration were computed using HEC-HMS 4.8 for W.WRD, E.TSF2, W.TSF2, TSF1 and LGOS. **Table 6-3** provides a summary of the adopted design flood peaks for each creek. The calculations from the previous studies are not included in this section; however, the peak flow estimates for Batman Creek, West/Burrell, Stow Creek and Horseshoe Creek are included in **Table 6-3**.

**Table 6-3: Drainage Channel Design Flood Peak Estimates**

Parameter	W. WRD Channel	E. TSF2 Channel	W. TSF2 Channel	TSF1 Channel	LGOS
100-year Peak (m <sup>3</sup> /s)	9.8	2.5	7.1	2.6	2.1
10-year Peak (m <sup>3</sup> /s)	5.2	1.4	3.8	1.5	0.51

Channel geometry was sized using 10-year peak flows. Drainage channel geometry and riprap sizes and thicknesses are included in **Table 6-4**. With the exception of the LGOS channel, where peak flows exceed 2 m/s channels are lined with riprap to prevent scour.

**Table 6-4: Drainage Channel Geometry**

Channel	Minimum Slope (m/m)	Base Width (m)	Depth (m)	Top of Channel Width (m)	Riprap D <sub>50</sub> /Layer Thickness (mm/m)
W. WRD Channel	0.002	1.5	2.09	8.61	500/0.75
E. TSF2 Channel	0.002	0.5	1.47	5.12	300/0.45
W. TSF2 Channel	0.002	0.75	2.01	7.54	133/0.2
TSF1 Channel	0.002	0.5	1.48	5.19	200/0.3
LGOS Channel	0.01	2.0	1.25	9.5	HDPE Liner
LGOS to PWP Channel	0.01	2.0	1.5	11	HDPE Liner

The runoff by bench for the WRD, TSF1 and TSF2 were calculated to size the drain down channels discussed in Section 8.2. **Table 6-5** through **Table 6-7** outline the 100-year flow values. These calculations were also performed using the Rational Method measuring the area for each bench or raise in the case of TSF1.

**Table 6-5: WRD Runoff Volume by Bench**

Bench	Footprint Area (ha)	Exposed Finished Area (ha)	Runoff Coefficient	100 Yr.-Rainfall Intensity (mm/hr.)	Runoff by Bench (m <sup>3</sup> /s)	Total Runoff (m <sup>3</sup> /s)
Base	70.24	3.68	0.33	95	0.32	6.12
1	66.55	6.16	0.33	95	0.54	5.80
2	60.40	5.54	0.33	95	0.48	5.26
3	54.85	5.18	0.33	95	0.45	4.78
4	49.68	4.58	0.33	95	0.40	4.33
5	45.09	3.49	0.33	95	0.30	3.93
Crown	41.60	41.60	0.33	95	3.63	3.63

**Table 6-6: TSF1 Runoff Volume by Bench**

Lifts	Footprint Area (ha)	Exposed Finished Area (ha)	Runoff Coefficient	100 Yr.-Rainfall Intensity (mm/hr.)	Runoff by Bench (m <sup>3</sup> /s)	Total Runoff (m <sup>3</sup> /s)
Crown	41.06	41.06	0.33	95	3.58	3.58

**Table 6-7: TSF2 Runoff Volume by Bench**

Lifts	Footprint Area (ha)	Exposed Finished Area (ha)	Runoff Coefficient	100 Yr.-Rainfall Intensity (mm/hr.)	Runoff by Bench (m <sup>3</sup> /s)	Total Runoff (m <sup>3</sup> /s)
Base	62.94	7.09	0.33	95	0.62	5.49
1	55.86	8.07	0.33	95	0.70	4.87
Crown	47.79	47.79	0.33	95	4.16	4.16

## 7. STREAM HYDROLOGY

There are four creeks traverse the Mt Todd Mine Site (Horseshoe, Batman, West, Burrell, and Stow) and drain to the Edith River. Tetra Tech was directed to design diversion channels for a 100-year average return interval (ARI) storm event around Batman Pit, the Processing Plant, and TSF2. To determine the size of the diversions updated the Rational Method analysis completed in previous analysis.

The time of concentration was calculated using the Bransby-Williams formula, presented in Section 6 of this report. The catchment areas for the streams are predominately low lying hills with land cover of scrub and long grass. The area is rural with very little development in the area. Site specific studies have been completed for runoff coefficient in the mine area, which determined a coefficient of 0.6. This runoff coefficient was assumed to be accurate for the stream catchments. In accordance with the 1987 ARR, a factor of 1.2 was applied to the runoff coefficient for the 100-year ARI event.

The design rainfall intensities for the 5, 10, 50 and 100-year storm events were retrieved from the Australian Government Bureau of Meteorology (BoM)'s Design Rainfall Data System (2016) for durations ranging from 5 minutes to 72 hours (BoM 2006) (**Table 7-1**). The inputs for the rational analysis are presented in **Table 7-2**.

Table 7-1: Design Rainfall Intensities

Storm Duration	Average Recurrence Interval (mm/hr.)			
	5-years	10-years	50-years	100-years
5 minutes	174	194	231	245
10 minutes	145	163	199	213
15 minutes	126	142	173	185
30 minutes	92.2	103	125	133
1 hour	61.4	68.5	82	86.8
2 hours	37.9	42.4	51.2	54.4
3 hours	27.8	31.3	38.5	41.3
6 hours	16.1	18.5	23.9	26.2
12 hours	9.41	11.1	15.1	17.1
24 hours	5.71	6.86	9.88	11.4
48 hours	3.63	4.42	6.45	7.43
72 hours	2.83	3.43	4.94	5.63

Table 7-2: Rational Method Inputs for Stream Peak Flow Estimations

Parameter	Batman Creek	West/Burrell Creek	Stow Creek	Horseshoe Creek (North West Tributary)	Horseshoe Creek (North East Tributary) <sup>1</sup>
Area (km <sup>2</sup> )	6.58	1.16	101.27	13.06	24.70
Flow Path Length (km)	5.59	1.34	24.68	8.25	12.01
Flow Path Slope (m/km)	11.56	13.56	6.45	5.72	2.68
Time of Concentration (hrs.)	2.72	0.76	10.27	4.32	6.86
Raw Runoff Coefficient	0.6	0.6	0.6	0.6	0.6
100-Year ARI Runoff Coefficient Frequency Factor	1.2	1.2	1.2	1.2	1.2

Parameter	Batman Creek	West/Burrell Creek	Stow Creek	Horseshoe Creek (North West Tributary)	Horseshoe Creek (North East Tributary) <sup>1</sup>
100-Year ARI Runoff Coefficient	0.72	0.72	0.72	0.72	0.72
100-Year ARI Rainfall Intensity (mm/h)	45.0	103.9	19.0	32.8	24.5

Design flood peak discharges for the creeks (Batman, West/Burrell, Stow and Horseshoe) were calculated using the same methodology as the previous studies (Knight Piesold, 1995 and GHD, 2013).

Table 7-3: Stream Peak Flow Estimation

Parameter	Batman Creek	West/Burrell Creek	Stow Creek	Horseshoe Creek (North West Tributary)	Horseshoe Creek (North East Tributary)
100-year Peak (m <sup>3</sup> /s)	58.7	23.9	381.7	84.9	120.2

Channel geometry was sized using 100-year peak flows. Drainage channel geometry and riprap sizes and thicknesses are included in **Table 7-4**. Where peak flows exceed 2 m/s channels are lined with riprap to prevent scour.

Table 7-4: Drainage Channel Geometry

Channel	Minimum Slope (m/m)	Base Width (m)	Depth (m)	Top of Channel Width (m)	Riprap D <sub>50</sub> /Layer Thickness (mm/m)
Batman Creek Channel (including northern section)	0.002	3.5	3.75	17.02	200/0.3
Stow Creek Channel	0.002	34	4.2	49.33	133/0.2
Horseshoe Creek Channel	0.002	36	3	46.64	133/0.2

## 8. SURFACE WATER MANAGEMENT DURING CONSTRUCTION

Increased sediment in runoff is expected throughout the site where areas are disturbed for construction. This section addresses the major sediment control devices that will be used for areas where significant sediment generation is expected (WRD, TSF1 and TSF2). Minor construction areas, which will also generate some sediment, will require sediment control management practices and devices to prevent sediment-laden runoff from entering the creek system. Sediment control devices for the minor areas will be field-installed, adjusted, and maintained by the Contractor with day-to-day control of the construction activities. Sediment control implementation must conform to requirements of the Northern Territory and Australian federal government as stated in the Erosion and Sediment Control Plan (NRETA, 2012).

Adherence to the Erosion and Sediment Control Plan will ensure that construction activities will minimize erosion generation over the sole reliance of sediment removal from construction site runoff. Erosion control management practices shall limit the amount and rate of erosion occurring on disturbed areas. Sediment control management practices should capture, to the greatest extent practicable, the soil that has been eroded before it is transported off the construction site. The contractor with day-to-day responsibility at the site should:

- Conduct land-disturbing activities in a manner that effectively reduces accelerated soil erosion and reduces sediment movement and deposition off site.
- Schedule construction activities to minimize the total amount of soil exposed at any given time.
- Establish temporary or permanent cover on areas that have been disturbed as soon as practical after grading is completed.
- Design and construct temporary facilities to limit the flow of water to non-erosive velocities for the conveyance of water around, through, and from the disturbed area.
- Remove sediment caused by accelerated soil erosion from surface runoff water before it leaves the site.
- Stabilize disturbed areas with permanent vegetative cover.

Sediment control for minor areas may be accomplished with devices such as silt fence, erosion control logs, diversion channels, sedimentation ponds, check dams, and other erosion control and treatment devices. Selection of the appropriate devices will be the responsibility of the contractor and shall consider field conditions and appropriateness of the device. Sediment that is trapped in any devices should be cleaned out once the capacity has been reduced by 50%.

RP1 and dam south of the WRD will supply the sediment control for water running off the feature. Velocities of the runoff will diminish and allow for the settling out of the sediment. Sediment left behind the dam can be removed via the construction equipment that is on-site.

Sediment control for the south section of TSF2 will be provided by the embankment of the access road to TSF2 and the Raw Water Dam. This embankment will act as a barrier, routing water to either Batman Creek or the sedimentation pond located at the south-east corner of TSF1. Sediment will be removed via the construction equipment that is on-site.

Check dams will be constructed at various points along the natural streams or channels where sedimentation ponds would not be feasible. These dams will be constructed out of rocks (amply available on site). Rock size distribution used in the dams should follow recommendations shown in **Figure 8-1**. The dams will be constructed to include a small weir capable of conveying the 10-year storm event. A typical detail for the check dams is shown on the Check Dam Detail sheet (4520-DC-131C) of the plans. A conceptual location of the check dams and sedimentation ponds are located on the Sediment Control Plan sheet (4520-DC-104C).

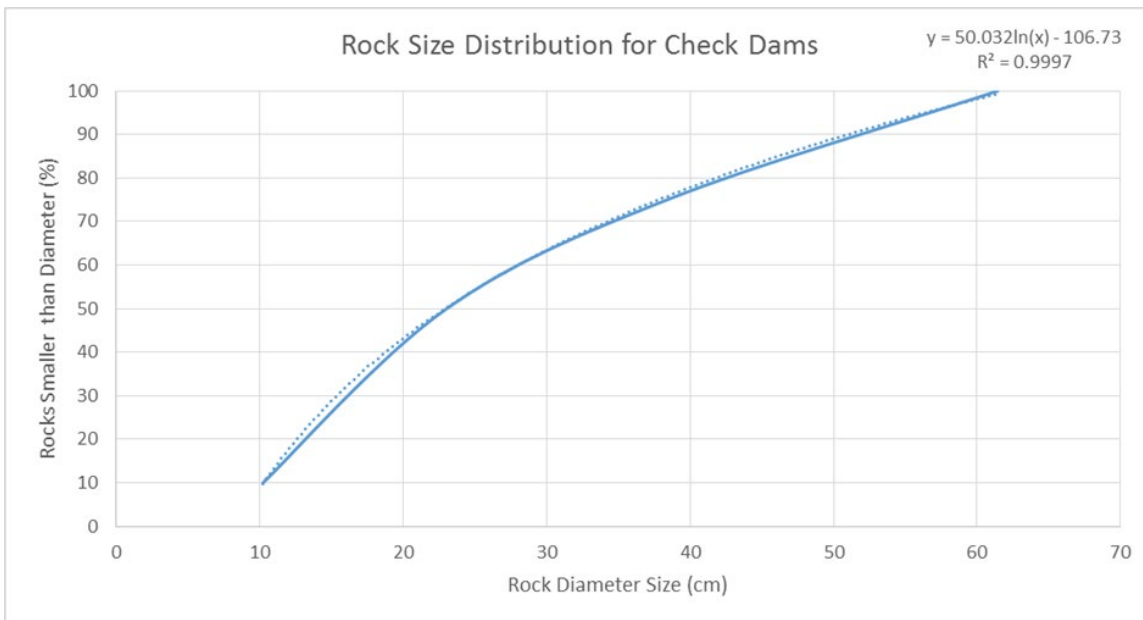


Figure 8-1: Check Dam Rock Diameter Distribution in cm

## 9. PRODUCTION AND CLOSURE SURFACE WATER MANAGEMENT

### 9.1 Approach

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Based on the hydrology performed for WRD, TSF1, TSF2 landforms, structures were designed to convey runoff down said landforms, then around mining facilities. All diversion structures were designed to convey the 10-year flow from each landform catchment. The PAF landform drainage structures and the Batman Creek re-alignment were designed to convey the 100-year flow.

Bench catchments, run-down channels and stilling basins were designed to allow runoff to be safely routed off and away from the landforms. Once the runoff has been conveyed from the stilling basins, it will naturally convey to either a diversion channel or to a natural stream, depending on the location.

In order to reduce the amount of water entering the TSFs and the WRD retention pond, and to avoid damage to mine equipment or facilities, diversion channels have been designed to convey the 10-year flood around the mine facilities. The 10-year peak flows were found using the Bransby-Williams and the rational method to stay consistent with previous studies. A list of the channel designs includes:

- The west WRD diversion Channel was designed to convey flows from the WRD and some offsite areas. This channel will replace the existing Burrell Creek diversion, which will eventually be buried under the WRD.
- TSF1 will have one diversion channel along the eastern side intercepting clean runoff and diverting it away from the TSF. This channel is proposed to terminate at a culvert, from which it will convey the re-aligned Batman Creek.
- TSF 2 will have two channels. The first channel originates directly downstream of the raw water saddle dam spillway and will run from the north side of TFS2 west to Horseshoe Creek. The second channel originates on the north-east side of TSF2 and will flow south until it terminates at Stow Creek.
- Batman Creek will be re-aligned by a channel in two places. One reach is a diversion around Batman Pit starting production year 4 and another diversion is from approximately 450 meters north of the process plant to approximately 700 meters south of the process plant.
- In order to avoid acid mine drainage (AMD) runoff contamination, a drainage channel is designed around the LGOS, as well as a sedimentation pond for the LGOS, referred to as the Low-Grade Ore Stockpile Retention Pond, LGRP (a.k.a. RP2). Due to the possibility of contamination, these channels are elevated to avoid comingling with the nearby Batman Creek channel and TFS1 drainage channel. The AMD water collected in the LGRP will then be pumped to the process water pond (PWP) for the water treatment plant (WTP) was also designed. Additionally, a drainage channel is designed around the WRD during mining production to reduce AMD runoff contamination. The runoff will be collected in Retention Pond 1, also known as RP1.

### 9.2 Landform Drainage

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The planned raise for the WRD is approximately 170 mAHD to elevation 450 mAHD with an accompanying area of approximately 257 ha. TSF1 is being raised 29 m to 169 mAHD. TSF2 will be constructed to approximately 60 m in height with an area of 220 ha.

These expanded and newly-proposed structures pose the issues of larger catchment areas, as well as steep slopes. In order to manage the runoff from these structures, a typical structure was designed that could be tailored in the future upon further analysis. The first drainage structure is a one-meter berm that will be placed at the end of each bench on the WRD and a 1.5 m berm that will be placed on TSF1 and TSF2. These will be used to route the water to the

run-down channels. Each bench requires a minimum slope of 0.1% to one direction. The berms should have a side slope of 2:1 horizontal to vertical. The berms on WRD can convey 5.27 m<sup>3</sup>/s with a berm height of 1 m and the berms on TSF2 and TSF1 can convey 4.36 m<sup>3</sup>/s with a berm height of 1.5 m. Based on runoff calculations by bench shown in **Table 9-1** through **Table 9-3** these berms will be able to convey from any one bench, with the exception of the crowns of the capped TSF1 and TSF2. However, with the rock armoring the runoff velocity should be slow enough to not overtop or severely scour the berms. A typical detail for the berm is show on in Detail 10 on Sheet 4520-DC-130C on the plans.

Design of a second structure included down-drain channels to convey approximately 6.12 m<sup>3</sup>/sec at various points along the WRD, TSF1 and TSF2. These channels were designed so that the 6.12 m<sup>3</sup>/sec could be conveyed even at the lower slope bench areas. The rundown channels are designed with a 2-m bottom width, a channel depth of 1.25 m, and a 2:1 horizontal to vertical (H:V) side slopes. Grouted Riprap will be placed at each bench and at the bottom of the WRD in order to reduce velocities from steep sections of the channels. The channels will be lined with grouted riprap to avoid scour damage during rain events. **Table 9-1** through **Table 9-3** have the results of HEC-RAS hydraulic models for the drain-down channels for the WRD, TSF1, and TSF2. These models were based on the topographic data of the proposed closure landforms, and manning coefficients for grouted riprap and floodplains (USDOT, 2005).

**Table 9-1: WRD Drain-Down Channel HEC-RAS Model Output**

Location	100-year flow (m <sup>3</sup> /s)	Depth (m)	Freeboard (m)	Channel Velocity (m/s)
Crown	3.63	0.57	0.68	2.04
Beginning of Draindown Channel	3.63	0.48	0.77	2.52
Beginning of Bench 7	3.63	0.66	0.59	1.64
End of Bench 7	3.63	0.57	0.68	2.04
Beginning of Bench 6	3.93	0.69	0.56	1.67
End of Bench 6	3.93	0.59	0.66	2.08
Beginning of Bench 5	4.33	0.73	0.52	1.71
End of Bench 5	4.33	0.63	0.62	2.12
Beginning of Bench 4	4.78	0.77	0.48	1.76
End of Bench 4	4.78	0.66	0.59	2.17
Beginning of Bench 3	5.26	0.8	0.45	1.81
End of Bench 3	5.26	0.7	0.55	2.22
Beginning of Bench 2	5.8	0.85	0.4	1.86
End of Bench 2	5.8	0.74	0.51	2.27
Beginning of Bench 1	6.12	0.87	0.38	1.89
End of Bench 1	6.12	0.76	0.49	2.3
Entering Stilling Basin	6.12	0.28	0.97	8.51
Edge of Stilling Basin	6.12	1.56	-0.31	0.78
Stilling basin	6.12	2.33	-1.08	0.46
Stilling basin	6.12	2.33	-1.08	0.46
Exiting to Environment	6.12	0.92	0.33	1.73

**Table 9-2: TSF1 Drain-Down Channel HEC-RAS Model Output**

Location	100-year flow (m <sup>3</sup> /s)	Depth (m)	Freeboard (m)	Channel Velocity (m/s)
Top of TSF1	3.58	0.66	0.59	1.63
Beginning of Drain-Down Channel	3.58	0.56	0.69	2.03
Entering Stilling Basin	3.58	0.77	0.48	1.32
Stilling basin	3.58	1.57	-0.32	0.46
Stilling basin	3.58	1.57	-0.32	0.46
Exiting to Environment	3.58	0.7	0.55	1.5

**Table 9-3: TSF2 Drain-Down Channel HEC-RAS Model Output**

Location	Flow-1/3 of 100 year flow (m <sup>3</sup> /s)	Depth (m)	Freeboard (m)	Channel Velocity (m/s)
Crown	4.16	0.71	0.54	1.71
Beginning of Drain-Down Channel	4.16	0.61	0.64	2.1
Beginning of Bench 4	4.16	0.19	1.06	9.41
End of Bench 4	4.16	0.35	0.9	4.35
Beginning of Bench 3	4.16	0.22	1.03	7.67
End of Bench 3	4.87	0.43	0.82	3.97
Beginning of Bench 2	4.87	0.89	0.36	1.45
End of Bench 2	4.87	0.67	0.58	2.18
Beginning of Bench 1	4.87	0.97	0.28	1.27
Entering Stilling Basin	5.49	1.51	-0.26	0.74
Stilling basin	5.49	2.27	-1.02	0.43
Stilling basin	5.49	2.27	-1.02	0.43
Exiting to Environment	5.49	0.87	0.38	1.68

At the end of the rundown channels the runoff will enter a stilling basin. The stilling basins are placed at the end of each rundown channel that dissipates energy before the water naturally drains to the nearest creek or diversion channel. The stilling basins are the same width as the channels. They have an entrance section at a 2:1 H:V for 2-foot vertical drop, then a 2-meter flat section, before a vertical incline at a 2:1 H:V slope. This should allow for proper energy dissipation before the water naturally drains to the nearest creek or diversion structure. Based on on-site staff observations, it is believed that post construction there will be little to no sediment loading. As such, the stilling basins were designed for energy dissipation and not sediment removal. A detail and section of the stilling basins are shown in Detail 12 and Section 14 on Sheet 4520-DC-130C.

### 9.3 Diversion Channel Design

As a part of this management plan seven channels were designed to divert water around mining facilities. These channels were designed to convey a 10-year event for around the mining facilities. The Manning’s ‘n’ roughness coefficient has been used to represent the effects of surface friction on the conveyance flood peak flows through channels and over floodplains. Estimates for roughness coefficients were determined by analysis of aerial photography and by reference to industry standard tables (Chow, 1959). A value of 0.04 was applied to the main

channel and a value of 0.08 was used for the floodplain. Channels are located on Sheet 4520-DC-128C (Proposed Typical Channel Details) on the attached plans.

### 9.3.1 Western WRD Diversion Channel Design

The expanded WRD is expected to cover much of the existing West Creek. To avoid unnecessary water contact with PAF material, a new channel was designed to catch the water draining off the hill to west and the clean water running off the western half of the WRD after closure. The 10-year flow was used to design the channel as described as above. The Hydraflow Express Extension of AutoCAD was used to determine the channel geometry to convey the 10-yr flow of 5.2 m<sup>3</sup>/sec at the minimum slope of 0.2% with freeboard. The resulting analysis shows that channel must have a base width of 1.5 meters, a depth of 2.1 meters, and a 2:1 H:V vertical side slope. In the case where it is necessary to construct the channel using fill, a one-meter channel crest width was added to the channel. Due to the steep slopes from Station 0+00 to 0+200, the channel will need to be lined with riprap protection to protect the channel against scouring. The riprap should have an average diameter of 500 mm and layered up to a thickness of 0.75 meters. Riprap can be sourced from NAF waste rock on the mining site.

The WRD being adjacent to this diversion, and a 10-yr rainfall event would likely occur during the life of mine, the western WRD diversion channel was also evaluated for the 100-yr flow. The 100-yr flow was calculated to be 9.7 m<sup>3</sup>/sec. When this flow was routed through the western WRD diversion channel, it was found that the channel could convey the flow with approximately 0.23 meters of freeboard. With the minimal freeboard, it is likely that the channel banks would be overtopped around bends and areas with increased turbulence. However the toe of the WRD is approximately 1 meter above the top of the channel on average, so a storm larger than a 100-year event would need to occur prior to the WRD being inundated.

A plan and profile view for this channel is located on Sheets 4520-DC-109C through 4520-DC-111C on the submitted plans.

### 9.3.2 TSF1 Diversion Channel Design

TSF1 will have one diversion channel along the eastern side intercepting clean runoff, diverting it away from the TSF. This channel is proposed to terminate at Horseshoe Creek. The 10-year flow was used to design the channel as described as above. The Hydraflow Express Extension of AutoCAD was used to determine the necessary geometry of the channel to convey 10-yr flow of 1.5 m<sup>3</sup>/sec at an approximate minimum slope of 0.2%. The results of the excel analysis found that the channel needs to have a base width of 0.5 meters, a depth of 1.5 meters, and a 2:1 H:V vertical side slope. In the case where it is necessary to make the channel using fill, a 1-meter channel crest width was added to the channel.

TFS1 being adjacent to this diversion, and a 10-yr rainfall event would likely occur during the life of mine, the TSF1 diversion channel was also evaluated for the 100-yr flow. The 100-yr flow was calculated to be 2.6 m<sup>3</sup>/sec. When this flow was routed through the diversion channel, it was found that the channel could convey the flow with approximately 0.33 meters of freeboard. With this freeboard, it is not expected that the channel overflows during the 100-year event.

A plan and profile view for this channel is located on Sheets 4520-DC-112C through 4520-DC-113C on the submitted plans.

### 9.3.3 Eastern TSF2 Diversion Channel Design

TSF2 will have two channels. This section will discuss the design of the Eastern TSF2 Channel, which originates on the northeast side of TSF2 and will flow south until it terminates at Stow Creek. This channel was designed to safely convey the 10-year flow of 1.4 m<sup>3</sup>/sec at a minimum slope of 0.2%. The diversion was designed using the Hydraflow Express Extension of AutoCAD, which found that the channel needs to have a base width of 0.5 meters, a depth of 1.5 meters, and a 2:1 H:V vertical side slope. Where it is necessary to make the channel using fill, a 1-meter wide

channel crest will be added to the channel. Due to the steep slopes from station 0+00 to 0+700, the channel will need to be lined with riprap protection to protect the channel against scouring. The riprap should have an average diameter of 300 mm and layered up to a thickness of 0.45 meters. Riprap can be sourced from NAF waste rock on the mining site.

TSF2 being adjacent to this diversion, and a 10-yr rainfall event would likely occur during the life of mine, the eastern TSF2 diversion channel was also evaluated for the 100-yr flow. The 100-yr flow was calculated to be 2.5 m<sup>3</sup>/sec. When this flow was routed through the diversion channel, it was found that the channel could convey the flow with approximately 0.34 meters of freeboard. With this freeboard, it is not expected that the channel overflows during the 100-year event.

A plan and profile view for this channel is located on Sheets 4520-DC-120C through 4520-DC-121C on the submitted plans.

#### 9.3.4 Western TSF2 Diversion Channel Design

The second diversion channel for TSF2 will run from the north side of TFS2 west to Horseshoe Creek, and originates directly downstream of the raw water saddle dam spillway. The channel runs west near north base of the TSF2 crossing the TSF2 access road before terminating at Horseshoe Creek. The Hydraflow Express Extension of AutoCAD was used to determine the necessary geometry of the channel to convey 10-yr flow of 3.8 m<sup>3</sup>/sec at an approximate minimum slope of 0.2%. The results of the iterative analysis of the channel geometry found that the channel needs to have a base width of 0.75 meters, a depth of 2.0 meters, and a 2:1 H:V vertical side slope. Where it is necessary to make the channel using fill, a 1-meter wide channel crest will be added to the channel. Due to the steep slopes from stations 8+50 to 11+50 and 13+50 to 15+00, the channel will need to be lined with riprap protection to protect the channel against scouring. The riprap should have an average diameter of 133 mm and layered up to a thickness of 0.2 meters. Riprap can be sourced from non-PAF waste rock on the mining site. This Channel will be re-evaluated in the future for alternative drainage structures due to the large amount of cut needed to excavate through the hill north of the proposed TSF2 known as “Mt Todd”.

As this diversion is adjacent to both TSF2 and the construction camp, and considering that a 10-yr rainfall event will likely occur during the life of mine, the diversion channel was also evaluated for the peak flow produced by a 100-yr rainfall event. The 100-yr peak flow for the diversion was calculated to be 7.1 m<sup>3</sup>/sec. When this flow was routed through the diversion channel, it was found that the channel could convey the flow with approximately 0.3 meters of freeboard. With this freeboard, it is possible that the channel banks would be overtopped around bends and areas with increased turbulence. However, the toe of TSF2 is approximately 1 meter above the top of the channel on average, so a storm larger than a 100-year event would be required to inundate TSF2.

A plan and profile view for this channel is located on Sheets 4520-DC-117C through 4520-DC-119C on the submitted plans.

#### 9.3.5 Batman Diversion Channel Design

As stated in the Introduction, Batman Creek passes the north and east edge of pre-production Batman Pit and runs adjacent to the proposed low-grade ore stockpile (LGOS), then flows by the processing plant before draining south to the Edith River. Due to its proximity to both critical facilities (the Pit and Processing Plant) as well as near a landform with PAF material (the LGOS), Tetra Tech designed a channel to transport the runoff from a 100-year event around the Pit and past the LGOS and processing plant. Due to Batman Pit extending into the natural Batman Creek (starting production year 4), the diversion will be constructed to go through the northern hills to prevent the water from inundating the pit. The Hydraflow Express Extension of AutoCAD was used to determine the necessary geometry of the channel to convey 100-yr flow of 58.3 m<sup>3</sup>/sec at an approximate minimum slope of 0.2%. The results of the iterative analysis of the channel geometry found that the channel needs to have a base width of 3.5 meters, a depth of 3.75 meters, and a 2:1 H:V side slope. Where it is necessary to construct the channel using fill, a 2-meter wide channel crest will be added to the channel. At the end of the proposed diversion channel it will be graded back

into Batman Creek's natural alignment. Due to the steep slopes in the northern diversion channel (North Batman Creek Re-Alignment) from stations 1+00 to 2+00 and 6+00 to 9+50, the channel will need to be lined with riprap protection to protect the channel against scouring. The riprap should have an average diameter of 200 mm and placed to a thickness of 0.3 meters.

A plan and profile view for this channel is located on Sheets 4520-DC-114C through 4520-DC-116C on the submitted plans. The northern diversion through the hills is located on Sheets 4520-DC-122C through 4520-DC-123C.

### 9.3.6 Stow Creek Diversion Channel Design

The current design of the TSF2 covers a section of the natural alignment of the Stow Creek. To route the natural stream flow around TSF2, a diversion channel will be constructed along the south-eastern edge of TSF2. The channel will be designed for a 100-year, 24-hour event. The Hydraflow Express Extension of AutoCAD was used to determine the necessary geometry of the channel to convey the 100-yr flow of approximately 382 m<sup>3</sup>/sec at a minimum slope of 0.2%. The results of the iterative analysis of the channel geometry found that the channel will be required to have a base width of 36-meters, a depth of 4.2 meters, and a 2:1 H:V side slope. Where it is necessary to construct the channel using fill, a 2-meter wide channel crest will added to the channel. At the end of the proposed diversion channel it will be graded back into Stow Creek's natural alignment.

A plan and profile view for this channel is located on Sheets 4520-DC-124C through 4520-DC-125C on the submitted plans.

### 9.3.7 Horseshoe Creek Diversion Channel Design

The current design of the TSF2 covers a section of the natural alignment of the Horseshoe Creek. To route the natural stream flow around TSF2, a diversion channel will be constructed along the western edge of TSF2. The channel will be designed for a 100-year, 24-hour event. The Hydraflow Express Extension of AutoCAD was used to determine the necessary geometry of the channel to convey 100-yr flow of approximately 214 m<sup>3</sup>/sec at a minimum slope of 0.2%. The results of the iterative analysis of the channel geometry found that the channel needs to have a base width of 34-meters, a depth of 3 meters, and a 2:1 H:V side slope. Where it is necessary to construct the channel using fill, a 2-meter wide channel crest will added to the channel. At the end of the proposed diversion channel it will be graded back into Horseshoe Creek's natural alignment. Due to the steep slopes from stations 0+50 to 2+00, the channel will need to be lined with riprap protection to protect the channel against scouring. The riprap should have an average diameter of 133 mm and layered up to a thickness of 0.2 meters.

A plan and profile view for this channel is located on Sheet 4520-DC-126C on the submitted plans.

### 9.3.8 Diversion Performance

Tetra Tech developed two site wide 2-dimensional HEC-RAS model, to evaluate the expected performance of the diversion channels during a 100-year event during closure versus the site pre-closure. The model was set using the topography data obtained from the most recent topographic survey and the landform and surface water diversion channels designed in this feasibility study.

Tetra Tech setup a 40-meter by 40-meter 2-dimensional flow grid with break lines distinguishing flow paths. Unsteady flow data was used to set up boundary conditions at the upstream point for each channel. One-minute interval hydrographs for a 100-year event for W.WRD, E.TSF2, W.TSF2, and TSF1 were developed using the SCS method in HEC-HMS. One-minute interval hydrographs for Batman Creek, Horseshoe Creek, Stow Creek, and West/Burrell Creek were developed using the Rational Method. A friction slope of 0.002 was set for all upstream boundary conditions and the most downstream boundary condition at Edith River. An unsteady flow analysis was conducted and resulted in an hourly-interval output timeseries for velocity.

**Figure 9-1** presents existing site conditions inundated under a 100-year flood event. The 100-year flood boundary is presented as maximum velocity (m/s), and its color key corresponds to ranges of velocity. Majority of the velocity is under 2 m/s, but Batman Creek and Horseshoe Creek have areas where velocity is over 2 m/s. The flood boundary does not impact existing infrastructure and landforms. To assess how current conditions might impact post-closure conditions, a polyline layer was overlaid to display the proposed landforms and infrastructure in post-closure conditions. Under current conditions, Batman Pit, LGOS, TSF2, and the WRD are partially submerged. Diversion channels and stormwater management infrastructure are needed to prevent water from inundating landforms and mine infrastructure.

The post-closure site conditions inundated under a 100-year flood event are presented in **Figure 9-2**. Most of the maximum velocity of the flow does not exceed 2 m/s, except for some areas in the proposed diversion channels. These areas will be lined with riprap to reduce the possibility of scour (described in more detail in Section 9.3). The post-closure site includes the stormwater diversion channels described in this report, which are designed to collect flow and prevent water from inundating landforms and mine infrastructure. Stow Creek diversion and Horseshoe Creek diversion channel banks both overtop under a 100-year event, and water flows toward TSF2 but does not inundate it. Batman Creek Diversions contains the 100-year flow until it begins to overtop in the downstream reaches but carries the flow away from LGOS and the WRD. TSF1 and E.TSF2 channel banks do not overtop. W.WRD and W.TSF2 diversions overtop the banks in sharp bends, but route water away from TSF2 and the WRD. Overall, the proposed channels can mitigate flood risk under a 100-year flood event.

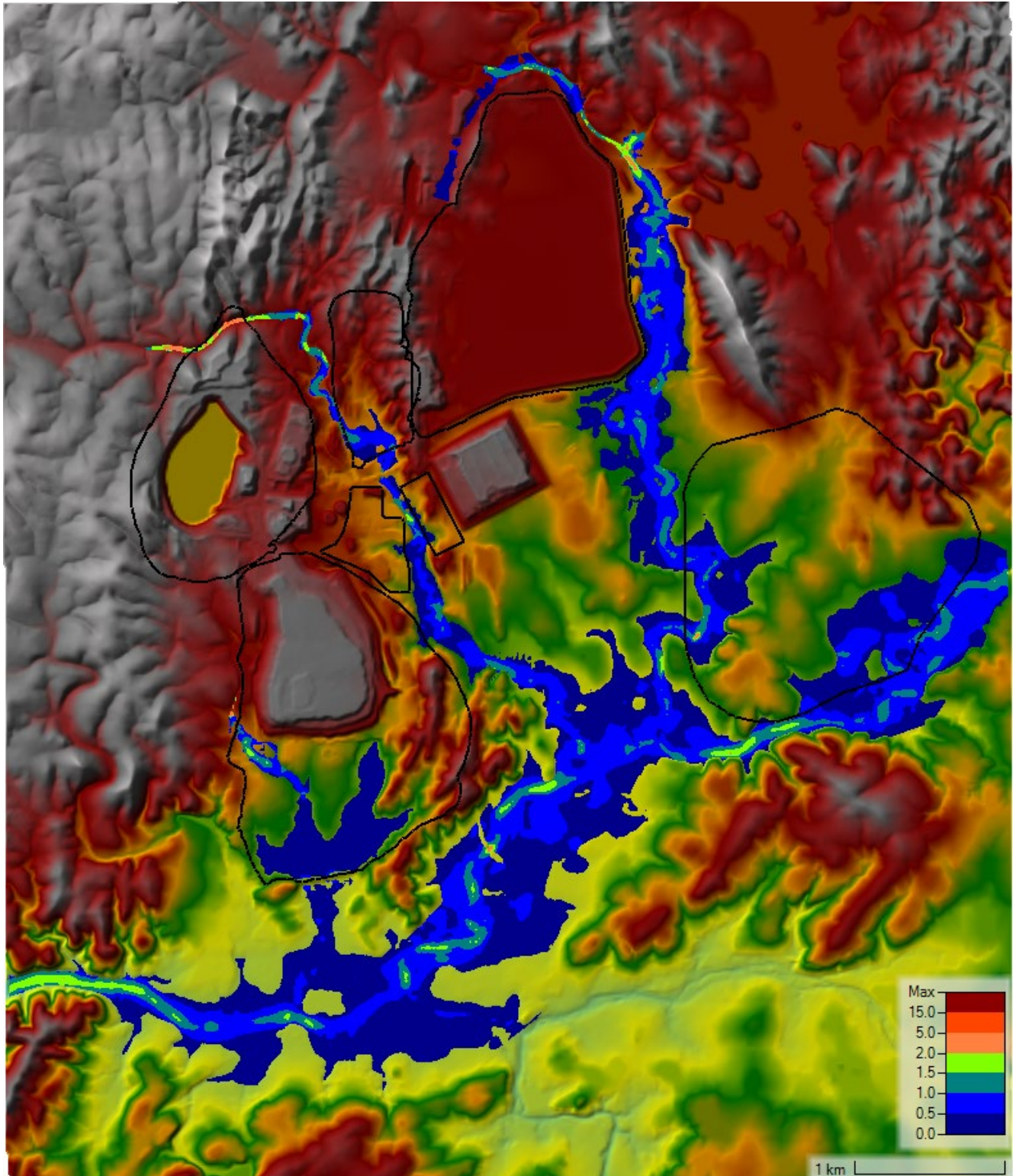
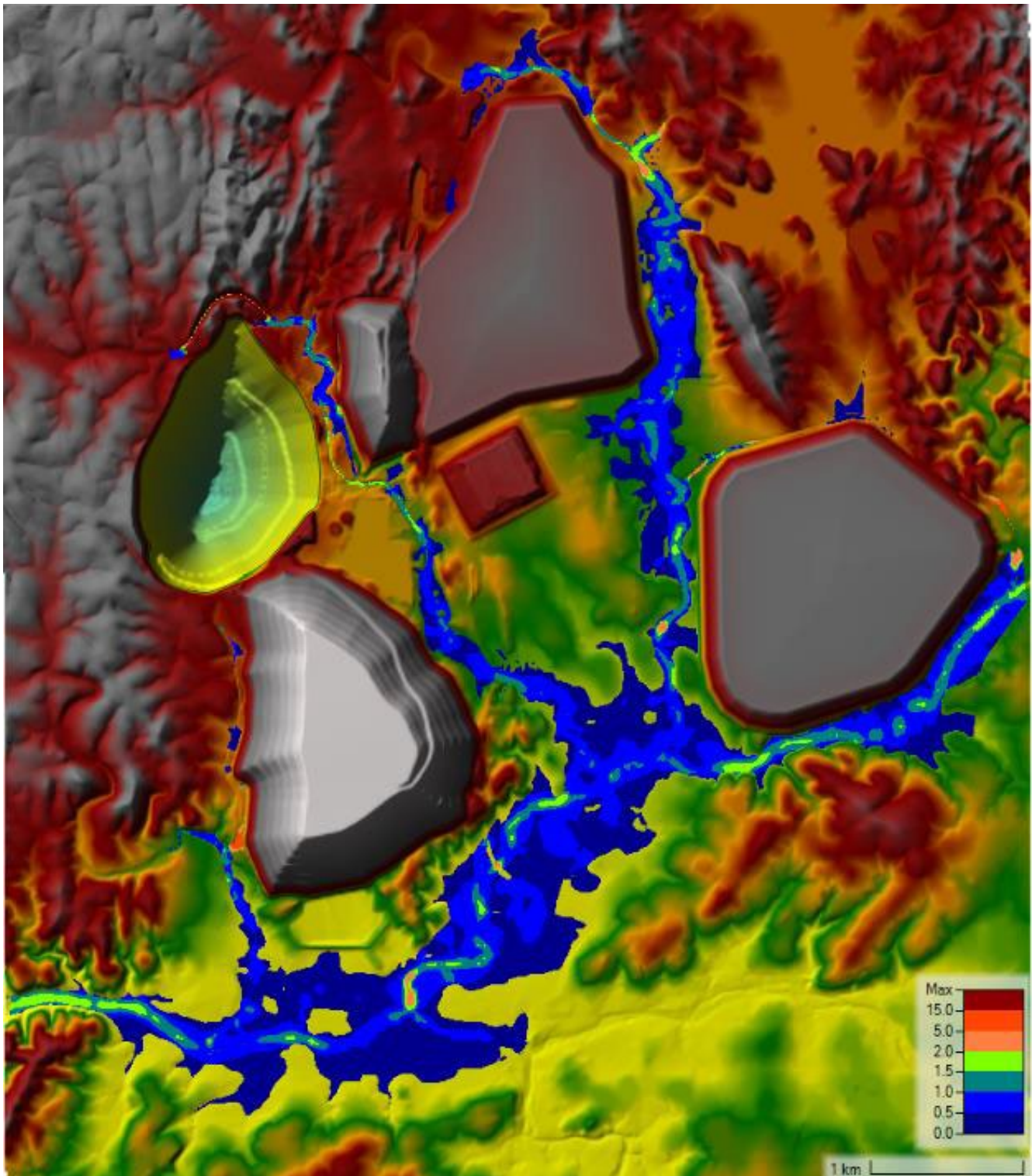


Figure 9-1: Existing Mt Todd Site during a 100-year Flood. Black boundaries are proposed landforms and infrastructure. Key represents Max Velocity (meter/second) during a 100-year Flood.



*Figure 9-2: Proposed Mt Todd Site during a 100-year Flood. Key represents Max Velocity (meter/second) during a 100-year Flood.*

## 9.4 PAF Landform Drainage

As a part of this management plan, water that passes through PAF rock must be conveyed to a retention pond and eventually to the Process Water Pond (PWP) prior to treatment at the Water Treatment Plant (WTP). The water contained in the TSFs will be pumped out to the PWP during large storm events. This section discusses the WRD, the LGOS, and PWP.

### 9.4.1 WRD PAF Contacted Water Drainage

As discussed in Section 8.2 and as detailed on the drawings (Attachment 1), care has been taken to divert as much water as practicable from potentially acid forming areas. Some rainwater is still expected to infiltrate into the PAF waste rock area of the WRD. In order to assist in the interception of clean water before contact with PAF, a waste rock and armoring rock layer will be placed as the top layer at each bench, underlain by a layer of fines. Below the fines layer a linear low density polyethylene liner be placed - this layer will stretch back into the WRD. Eight horizontal meters of NAF waste rock will be placed on the outside of each bench as well. Reference Detail 15 on Sheet 4520-DC-130C “Proposed Typical WRD Closure Design” of **Attachment 1**, for a depiction of this design.

Some runoff is still expected to infiltrate the WRD to the PAF material. When this occurs, the water will drain through the WRD and south towards the Waste Rock Dump Retention Pond (RP1). However, due to the WRD expansion, the WRD footprint will be in conflict with the existing RP1. A new dam will be constructed approximately 375 meters downstream of the existing RP1 dam. The new dam will have a maximum height of 10 meters which negates regulation from the Australian National Committee on Large Dams (ANCOLD). The dam crest is approximately 900 meters long, running between two hills downstream of the WRD. The proposed dam will have a crest width of 5 meters, and a downstream slope of 2:1 H:V and an upstream slope of 3H:1V. The normal water surface elevation would be approximately 1 meter below dam crest, and would be controlled using a 100-horsepower, self-priming pump. A 330-millimeter diameter HDPE pipe would be installed along the foundation of the dam, with a slide gate on the upstream end of the conduit to allow for the controlled release of the contaminated water to the passive treatment system post-closure. A bentonite cutoff wall would be installed at the maximum section of the dam to mitigate seepage through the embankment. Construction of the remainder of the dam would be constructed with the material in the vicinity of the proposed dam and from borrow in the bottom of the new RP1 to increase the total storage available in the pond.

The existing RP1 dam would be used as a cofferdam against WRD and existing conduits that run through the dam would be outfitted with flap valves at the discharge end to prevent the contact water from backflowing into WRD. Barring the existence of conduits through the existing embankment, subsequent to construction of the new dam (production year 3), the existing pond would be drained via pumping or a siphon to allow for a 330-millimeter diameter HDPE pipe with a one-way flap valve to be installed at the discharge end.

The revised configuration of RP1 could result in reduced storage. However, if the material inside the pond is suitable as borrow it will be used for the construction of the dam. This provides a required storage volume of approximately 1.4 million cubic meters with a meter of freeboard. The volume requirement is based on the GoldSim model developed as part of the feasibility study. As previously stated, the water level would be maintained via a 100-horsepower pump that would convey water to the PWP.

### 9.4.2 LGOS Drainage

During the first seven years of production of the mine a low-grade ore stockpile will be constructed and then processed. However, prior to processing the stockpile will be a source of acid runoff. In addition, the pile is located near Batman Creek. To avoid interaction with the environment, an elevated lined collected channel is proposed to encompass the LGOS. A similar design approach was taken for the diversion channels. The LGOS drainage channels commence at the north end of the LGOS and traverse east and west before a confluence at the LGRP pond on the south end of the LGOS. These channels are designed to convey approximately half of the 100-year flow rate for the

entire LGOS, 2.9 m<sup>3</sup>/sec per channel. The channel geometry was calculated using a design slope of 1% based on the site topography: a base width of 2 meters, a channel height of 1.25 meters, an outside berm width of 1.5 meters, and a side slope of 2:1 H:V. The LGOS side of the channel is the face of the LGOS to allow the runoff to enter the channel. The channel will be lined with HDPE to preclude the infiltration of acidic runoff in the channel.

The sedimentation pond was designed to impound a volume of 28,500 m<sup>3</sup> before overtopping. The volume requirement is based on the GoldSim model developed as part of the feasibility study. The spillway that will carry excess runoff from the sedimentation pond to the PWP was sized for a 100-year event (12.6 m<sup>3</sup>/sec). The water level would be maintained via a 40-horsepower, self-priming pump that would convey the water to the PWP. The spillway has a base width of 2 meters, a channel height of 1.5 meters, an outside berm width of 1.5 meters, and a side slope of 2:1 H:V. Both the Sedimentation pond as well as the spillway will be lined with HDPE. Reference Sheet 4520-DC-129C “Proposed Typical LGOS Drainage Details” of **Attachment 1** for details.

### 9.4.3 Process Water Pond

During extreme rain events, water will need to be pumped to the PWP and treated at the WTP. Additionally during the dry season, PWP water cannot be treated and discharged into the Edith River. Based on the water balance model completed as part of the feasibility study, the final storage volume of the PWP (also known as EQP) is proposed to be 126,000 m<sup>3</sup>. The current configuration is for construction of one pond at the beginning of production to serve through the life of the mine. The proposed base elevation of the PWP is 119 m AMSL, and has an average bottom width of approximately 148 m and an average bottom length of approximately 260 m. The geometry as well as cross-sections are detailed on Sheet 4520-DC-127C “Proposed Process Water Pond Plan and Profile” (**Attachment 1**). The pond is located adjacent to the water treatment plant for ease of access.

## 10. POST-CLOSURE SURFACE WATER MANAGEMENT

### 10.1 Design

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Post-closure water treatment will use a passive wetland treatment system. Benefits of the passive treatment system are:

- The wetland will dramatically reduce the operating cost of the mine associated with running the WTP
- Converting from a mechanical and chemical treatment WTP to passive wetland treatment reduces energy consumption, transportation and use of chemicals, and eliminates waste and sludge disposal
- The wetland will provide continuous collection and treatment of PAF-contacted water.

Per a recent study completed by the Interstate Technology and Regulatory Council (ITRC, 2010), these systems typically raise pH to above 6, and reduce acidity, iron aluminum, copper, zinc, and lead between 75 and 85%. These systems also reduce sulphate levels between 10 and 30%.

It was estimated in the EIS that approximately 10 ha of wetlands will be needed to treat the PAF-contacted water post-closure. Three wetlands are proposed: passive treatment wetland 1 will be constructed during closure or post closure and will treat flows from TSF1; passive treatment wetland 2 will be constructed following post-closure and treat flows from the WRD; and passive treatment wetland 3 will be constructed post-closure and treat flows from TSF2. Proposed locations of the wetland are shown on Sheet 4520-DC-102C “Proposed Closure Facilities Arrangement”. Conceptual cross sections for the passive treatment wetlands are presented and shall not be considered final. Issued for construction plans will be prepared once sufficient data are gathered and prior to mine closure.

## 11. SURFACE WATER MANAGEMENT CONCLUSION AND LIMITATIONS

The work presented herein provides a surface water management plan for the construction phase, production phase, and post-closure phase of the mine. Tetra Tech used previous studies at the site to design drainage facilities from the landforms and around key mining facilities. General drainage designs for the landforms (WRD, TSF1, and TSF2) is discussed in Section 9.2 and shown in Attachment 1. Channels will be conveyed to natural creeks via diversion channels as discussed in Sections 9.3.1–9.3.7 and as shown on the plans.

Details for the collection and conveyance of runoff from the LGOS to the PWP are on Sheet 4520-DC-129C of the attached plans. The sediment control system is provided for pre-production as well as a preliminary design of a passive treatment system (wetlands) for post-closure.

The plans are conceptual until final design of the landforms; however they provide a guideline for the management of the surface water runoff. Until final design of the mine, this information should be considered as preliminary in nature, and are not issued for construction.

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**ATTACHMENT 1:  
Surface Water Management Plans**