6.3 Water Management Design

This subsection summarizes the design basis and the design of the water management structures listed in **Table 6.2-1.**

6.3.1 Design Peak Flow Estimates

A hydrologic modelling system designed to simulate the precipitation-runoff processes of dendritic drainage basins HEC-HMS model (U.S. Army Corps of Engineers [USACE] 2015) was developed to evaluate design peak flows and flood volumes. Model inputs were calibrated to match unit peak flows developed for the Goathorn Creek near Telkwa Water Survey of Canada station (08EE008), which consists of 60 years of daily flow records, using a frequency pairing approach between rainfall-depth return periods and flood event return periods.

The Soil Conservation Service (SCS) curve number (CN) method was used to estimate precipitation excess (i.e., runoff). The Clark Unit Hydrograph method was used to transform precipitation excess into an outflow hydrograph (USACE 2015). The Clark Unit Hydrograph method uses a storage coefficient and time of concentration (Tc). Tc was estimated using the empirical equation developed by Watt and Chow (1985) and the storage coefficient was determined as a fraction of Tc (Sabol 1988).

The alternating block method and climate change adjusted DDF datasets were used to define the storm hyetographs for a range of return periods. The alternating block method is a simple way of developing a design hyetograph using precipitation depths from a corresponding storm duration (Chow 1959).

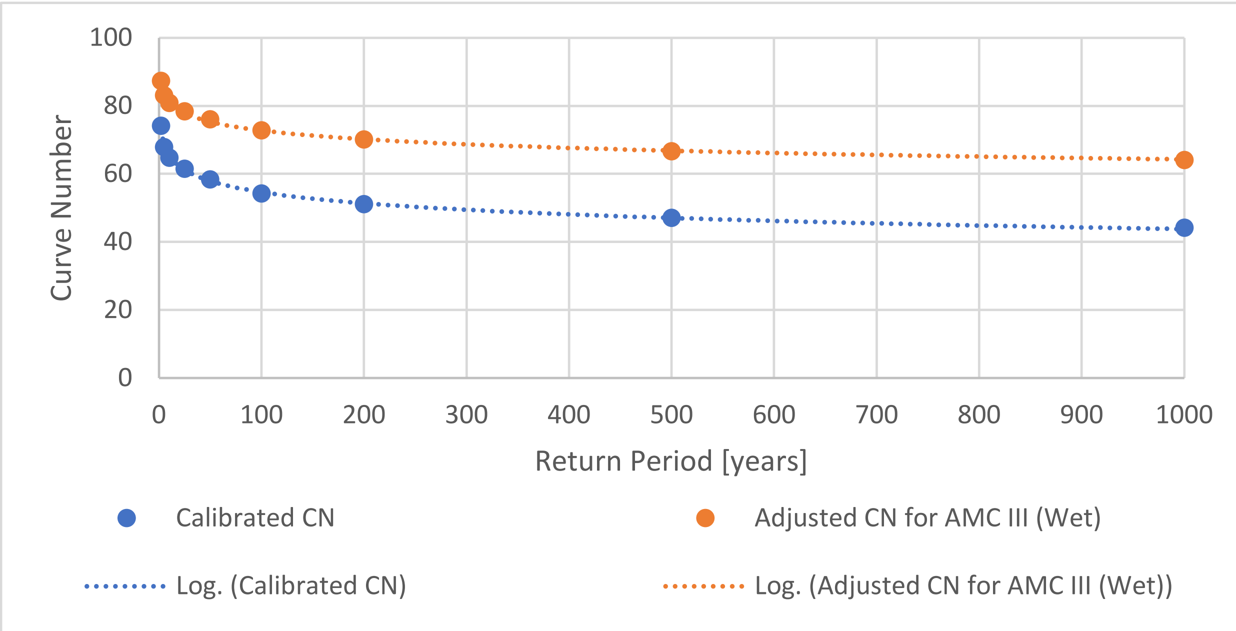
Table 6.3-1 summarizes unit peak flows developed for Goathorn Creek (08EE008, area=125 square km^2) and calibrated CN number for a range of return periods. Unit peak flows for Goathorn Creek were developed based on the Water Survey of Canada streamflow record. In addition, calibrated CNs were adjusted to simulate wet antecedent moisture conditions (AMC **III**), assuming that the calibrated results were representative of typical antecedent moisture conditions (AMC **II**). The adjusted CNs are also presented in **Table 6.3-1.**

Table 6.3-1: Goathorn Creek near Telkwa (WSC 08EE008) Curve Number (CN) Calibration Results

Return Period	Unit Peak Flow (L/s/km^2)	Peak Flow (m^3/s)	Calibrated CN	Adjusted CN for AMC III
2	100	12.5	74.2	87.3
5	145	18.1	67.9	83.1
10	180	22.5	64.7	80.8
25	227	28.4	61.5	78.4
50	263	32.9	58.4	76.1
100	298	37.3	54.2	72.8
200	334	41.8	51.1	70.1
500	382	47.8	47.1	66.6
1000	418	52.3	44.2	64.0

Source: *SRK 2021j*
Notes: *AMC=antecedent moisture conditions; CN=curve number; L/s/km^2=litres per metre per square kilometre; m^3/s=cubic metres per second*

Figure 6.3-1 illustrates a decreasing trend in CN numbers for larger return periods. Decreasing CN with increasing storm size is an observed hydrological behaviour, where results below represent a standard behaviour output with a near-constant CN for higher return periods (Hawkins 1993).



Source: *SRK 2021j*

Figure 6.3-1: Calibrated curve number (CN) values and CN values after adjustments for AMC III saturated conditions for return periods

Snowmelt is expected to govern the peak flows in this region and was therefore incorporated in addition to the rainfall distribution in hydrologic modelling for all infrastructure designs. For storm events up to the 200-year return period, the average year maximum 24-hour snowmelt depth was included. For calculations related to the Inflow Design Flood and spillway routing, the return period for snowmelt depth was selected based on Canadian Dam Association (CDA) (2007) recommendations. The shape of the snowmelt inflow hydrograph was developed using a sinusoidal distribution over a 13-hour period based on the average daylight hours for Smithers during April (National Research Council Canada [NRC] 2020). The snowmelt depths presented in **Table 6.1-7** were distributed, providing a peak snowmelt at mid-day.

Probable Maximum Flood (PMF) conditions were also modelled in HEC-HMS. Two (2) PMF cases were compared, as per CDA (2007) recommendations:

1. Spring rainfall-dominated flood: spring PMP rainfall event (**Table 6.1-5**) with a one in (1 in) 100-year snowmelt event (**Table 6.1-7**); and
2. Summer rainfall-dominated flood: summer PMP rainfall event (**Table 6.1-5**).

CDA also recommends comparing the spring snowmelt-dominated event, which includes the probable maximum snow accumulation, often estimated as twice the 1 in 100-year snowpack (Alberta Transportation 2004) with a 1 in 100-year rainfall event. In this case, the sum of the 1 in 100-year rainfall event and two

(2) times the 1 in 100-year snowmelt is less than the spring PMP rainfall depth on its own and was therefore assumed to not be as critical as the rainfall-dominated flood.

Like other rainfall events, the spring and summer PMP's were distributed using the alternating block method, where duration factors from the 1 in 1,000-year event in the depth-duration-frequency analysis were applied to each PMP.

6.3.2 Diversion and Collection Channels

This subsection summarizes the design of all channels and associated erosion protection for the Project. Culverts and road crossings are described separately in **6.3.9**.

6.3.2.1 Engineered Channels

Channels that operate throughout the LOM but are decommissioned during the Decommissioning and Reclamation Phase were designed to meet the following conditions:

- Convey the peak flow from the 1 in 10-year 24-hour return period flood event without destabilizing erosion protection;
- Contain the 1 in 25-year 24-hour return period flood event while maintaining minimum freeboard conditions; and
- Contain the 1 in 100-year 24-hour return period flood event without overtopping.

Channels that are expected to continue operating in the Post-closure Phase were designed to meet the following conditions:

- Convey the 1 in 200-year 24-hour return period flood event without destabilizing erosion protection and maintaining minimum freeboard; and
- All peak flows incorporate climate change and contributions from snowmelt. The hydraulic analysis and sizing of channels were determined using Manning's equation under a steady state normal depth condition.

Given that riprap is not readily available at the Project, channel geometry incorporates the use of turf reinforcement mat (TRM) as erosion protection for channels, where feasible. Channels with relatively steep grades and higher velocities or that are required post-closure will be lined with riprap sourced offsite. All channels that are breached in closure are expected to be operated within the design lifespan of the TRM.

Over time, vegetation is expected to become established within the channels. Therefore, channels were sized to convey the design peak flow with the addition of vegetation growth. Both TRM and riprap can promote vegetation growth.

Channels were also designed with typical geometry that reflect the size and capability of the anticipated construction equipment. All channels were designed to have a minimum base width of 2.0 m, side slopes of 2H:1V and a minimum freeboard of 0.3 m.

Channel excavated depths vary due to channel grade and type of erosion protection, and each channel is divided into segments of different grades. Minimum channel depths were designed to convey the design peak flow with the greater of the riprap Manning's roughness or the roughness value after vegetation is established.

Riprap sizing and Manning's roughness values were derived through model iterations. The Manning's equation was evaluated using initial roughness values and evaluated for each channel segment of different longitudinal slope. Where the Manning's roughness for the specified riprap was greater than the Manning's specified for vegetation, the riprap roughness was used for design depth calculations.

Riprap sizing for the closure conveyance channels was estimated using three (3) expressions: Isbash (USACE 1991), Robinson et al. (1998), and Khan and Ahmad (2011) and the riprap thickness was specified as two (2) times the D50. Given a riprap size estimate, a Manning's roughness value was then calculated based on three relationships by Strickler, Anderson, and Abt et al. (Abt. et al. 1988).

Alignments of channels were developed to maintain the target minimum design slope or reduce slopes overall. A minimum bend radius equal to 10 times the channel width should be considered as part of detailed engineering, along with additional erosion protection (i.e., larger riprap) in localized areas on the outer extents of any large bends.

A summary of the design criteria for engineered channels are presented in **Table 6.3-2**.

Table 6.3-2: Design Criteria for Engineered Channels

Parameter	Value	Reference and Justification
Capacity and Design Floods for Operations only Channels		
Design flood for erosion protection	1 in 10-year 24-hour event	SRK engineering judgement. Regular maintenance and repair will be conducted and consequence of failure during operations is low.
Design flood for channel capacity	Maximum of 1 in 25-year 24-hour event with freeboard or 1 in 100-year 24-hour event without freeboard	SRK engineering judgement
Capacity and Design Floods for Closure Channels		
Design flood for erosion protection	1 in 200-year 24-hour event	SRK engineering judgement
Design flood for channel capacity	1 in 200-year 24-hour event with freeboard	SRK engineering judgement
Geometry		
Minimum Freeboard	0.3 m	Best practices
Minimum Base Width	2.0 m	Constructability constraint
Minimum channel grade	0.5%	Constructability constraint
Channel side slopes	2:1 H:V	SRK engineering judgement
Thickness of topsoil layer below turf reinforcement mat	0.3 m	SRK engineering judgement
Erosion Protection		
Manning's roughness for Turf Reinforcement Mat	0.026	(Nilex 2018)
Manning's roughness for vegetation	0.040	(Chow 1959)

Parameter	Value	Reference and Justification
Manning's roughness for riprap	Varies, based on riprap size (0.030 to 0.046)	(Abt. et al. 1988)
Maximum permissible velocity for Turf Reinforcement Mat	2.9 m/s	(Nilex 2018)
Riprap thickness	2 x D_{50}	(British Columbia Ministry of Environment BC MOE 2000)
Geotextile	Non-woven, for riprap sections only	SRK engineering judgement

Source: *SRK 2021j*

Notes: *%=percent; D_{50}=mean rock size for which 50% of rocks are smaller; H:V=slope ratio horizontal to vertical; m=metre; m/s=metre per second*

The mine plan for each year of operations was analyzed to determine the most critical condition in terms of catchment area contribution to each channel. **Table 6.3-3** summarizes the various collection and diversion channels for the Project along with the most critical period in the mine life in terms of catchment contributions and the associated consequence of failure.

Table 6.3-3: Summary of Tenas Project Collection and Diversion Channels

Channel	Critical Phase	Description and Consequence of Failure	Figure Reference[1]
C-01	End of Year (EOY)2	Collects seepage and runoff from the eastern extents of the Project, including East Management Pond and North Management Pond dams and buttresses, discharging water to Tenas Control Pond. If overtopped, potentially high-sediment water would report to Four Creek. May result in short-term violation of discharge permit. Design assumes C-02 is discharging into C-01 towards Tenas Control Pond. This channel will be breached at closure, after buttresses are vegetated.	02, 03. 04, 05, 06
C-02	EOY5	Collects natural runoff upgradient of the East Management Pond and discharges to Four Creek, C01 and the East Management Pond through a series of overflow weirs and culverts (see **6.3.2.2).** If overtopped, undisturbed runoff would report to East Management Pond or increased flows to Four Creek. May result in local erosion on East Management Pond rock cover once the facility is closed or local erosion in Four Creek. This channel will remain in-place after closure, discharging permanently towards Four Creek and the East Management Pond. Channel includes a storage cell for potable water (see Potable Water Storage Pond design in **6.3.7.1**).	07, 08, 09, 10, 11
C-03	EOY0	Collects runoff along the southern portion of the western mine access road, as well as seepage and runoff from the West Management Pond and North Management Pond dams and buttresses, discharging water to Tenas Control Pond. If overtopped during larger flood events than the design storm, potentially high-sediment water would report to Tenas Creek. This channel will be breached at closure, after buttresses are vegetated. Runoff along the northern portion of the western mine access road will be collected in roadside ditches, designed by others.	13, 14, 15, 16, 17
C-04	EOY10	Collects runoff and seepage along the toe of the Tenas Control Pond dam and will provide sediment control during the construction period. Consists of two (2) channels, along the east and west portions of the	18, 19,20, 21

Channel	Critical Phase	Description and Consequence of Failure	Figure Reference[1]
		dam, which meet near the outlet of the Tenas Control Pond spillway. Discharge back to Tenas Control Pond via a pump or directly to Goathorn Creek tributary. This channel will be breached at closure or during progressive reclamation in operations, after buttresses are vegetated.	
C-05	EOY10	Collects natural runoff upgradient of the southeastern portion of the open pit, discharging into Four Creek. If overtopped, non-contact water would report to open pit. This channel will continue to operate post-closure, diverting runoff to Four Creek.	22, 23

Source: *SRK 2021j*
Note: *Appendix 13.11-E Minesite Water Monitoring Program*

Catchment characteristics such as catchment areas, flow path and time of concentration were determined using available 2017 Light Detection and Ranging (LIDAR) and were generated in Global Mapper (developed by Blue Marble Geographic). Calibrated CN values (**6.3.1**) were applied to natural catchment areas for the 10 and 25-year return period flood analyses, and the adjusted AMC III (saturated soils) CN values were applied for the 100-year and 200-year return period flood analysis. The climate change adjusted DDF precipitation data were incorporated into the HEC-HMS hydrologic model using the Alternating Block distribution method in addition to the snowmelt distribution for an average year maximum snowmelt event, as described in **6.3.1**.

The Muskingum-Cunge routing method was used to transform a storm hydrograph within a catchment area along a channel reach. The input parameters for routing reaches of collection channels were based on standard channel geometries, as well as channel length, slope, and Manning's roughness.

Table 6.3-4 presents design peak flows for engineered channels.

Table 6.3-4: Engineered Channel Peak Flow Results

Channel	Catchment Area [km^2]	Outlet	Peak Flows[m^3/s]			
			1 in 10-year event	1 in 25-year event	1 in 100-year event	1 in 200-year event(5)
C-01	3.9(1)	Tenas Control Pond	7.0	7.8	20.5	n/a
C-02	3.2	C-01 or Four Creek(2)	5.8	6.4	17.0	19.4
C-03	3.3	Tenas Control Pond	4.4	4.8	12.3	n/a
C-04	1.2(3)	Goathorn Creek Tributary or Tenas Control Pond	2.0	2.2	5.8	n/a
C-05	0.5	Four Creek	1.1	1.3	3.4	6.6

Source: *SRK 2021j*
Notes: *km^2=square kilometre; n/a=not applicable*
1. C-01 catchment area presented above is the combined area into the channel, including area contributions from C-02
2. C-02 is a collection channel that will operate with a flow control valve which will enable discharge to either the C-01 towards Tenas Control Pond or directly into Four Creek through a series of overflow weirs.
3. C-04 catchment area presented above represents the combined area to the toe drainage ditches C-04a and C-04b along Tenas Control Pond Dam during construction of the dam. Discharge during dam construction will be to Goathorn Creek tributary, while discharge after Tenas Control Pond is constructed may be into the Tenas Control Pond via a trash pump.
4. The 200-year peak flow is applied to channels in place beyond mine closure , which includes C-02 and C-05.
5. All channel alignments were selected to minimize water diverted towards Project infrastructure to reduce the downstream effects on natural watercourses. The alignment, profile and typical cross sections are illustrated in the design drawings.

Hydraulic results are summarized in **Table 6.3-5** for each channel section.

Table 6.3-5: Engineered Channel Design Results

Channel	Section	Grade [%]	1 in 10-year Velocity (m/s)	1 in 200-year Velocity (m/s)	Erosion Protection	Riprap D_{50} [m]	Base Width (m)	10-year Flow Depth [m]	25-year Flow Depth [m]	100-year Flow Depth [m]	200-year Flow Depth [m]	Design Depth [m]
C-01	1	3.50	2.7	n/a	Riprap(2)	0.15	5	0.44	0.50	0.86	n/a	0.90
	2	0.50	1.3	n/a	TRM	n/a	5	0.82	0.86	1.46	n/a	1.50
C-02	***1***	***0.50***	***1.5***	***1.7***	***Riprap***	***0.10***	***5***	***0.63***	***0.77***	***1.32***	***1.42***	***1.80***
C-03	1	9.20	3.2	n/a	Riprap	0.30	2	0.47	0.49	0.79	n/a	0.80
	2	1.00	2.2	n/a	TRM	n/a	2	0.63	0.81	1.29	n/a	1.30
C-04	1	3.40	2.6	n/a	TRM	n/a	2	0.36	n/a	n/a	n/a	0.70
C-05	***1***	***1.0-15***	***1.3***	***2.1***	***Riprap***	***0.10-0.30[4]***	***2***	***0.34***	***0.41***	***0.69***	***0.84***	***1.20***

Source: *SRK 2021j*

Notes: *%=percent; D_{50}=mean rock size for which 50% of rocks are smaller; m=metre; m/s=metres per second; n/a=not available*

1. *Rows highlighted in* ***bold italic*** *identify channels that will be in-place after mine closure. Riprap and channel design depth for closure channels were developed based on the 1 in 200-year return period event, as outlined in Table 6.3-2.*
2. *Riprap was selected for section 1 of C-01 and reflects a Manning's roughness of 0.035. The expected velocities with the lower Manning's roughness for turf reinforcement mat (TRM) prior to establishment of vegetation exceeded the TRM threshold of 2.9 m/s.*
3. *Riprap varies based on longitudinal slope. For slopes less than 10%, 0.10m D_{50} can be used. For slopes greater than 10%, riprap D_{50} of 0.30 m required.*

6.3.2.2 Protection at Project Discharge Locations

Erosion protection was also specified for natural flow pathways downstream of the major Project discharges, including the discharge from channel C-02 into Four Creek and the discharge from Tenas Control Pond into Goathorn Creek tributary. Both systems will remain in place during the Post-closure Phase, and therefore the 200-year return period event with climate change was selected along with riprap and geotextile lining for erosion protection.

Discharge from the Explosives Magazine and Explosives Facility sedimentation ponds will primarily occur through a low-flow pumped pipeline. A riprap apron will be extended from the emergency spillway to the nearest natural drainage. Note that streamflow rates in these drainages are not expected to increase beyond pre-mining conditions due to the relatively small catchment areas of each facility.

6.3.2.2.1 Channel C-02 and Four Creek

The alignment and discharge location of the C-02 diversion channel into Four Creek will result in a net increase to the existing catchment area in a portion of Four Creek (see SRK 2021b for details). As a result, the flow rates in this portion of the stream will increase, resulting in potential for increased erosion along the natural stream.

A control structure was designed for the outlet of C-02 channel to limit the inflows to Four Creek and thereby reduce the potential for increased erosion rates. A threshold velocity was estimated based on assumptions around the bedding material and vegetation in the creek. Based on United States Department of Agriculture guidance documentation, the permissible maximum velocity for gravel-based streams with moderate sediment transport and grasses, and a slope ranging from 5 to 10%, is 2.1 metre per second (m/s) (United States Department of Agriculture [USDA] 2007). The objective of the control structure is to limit the discharge rate from C-02 into Four Creek such that the combined flow rate during the design storm event from the natural catchment and the structure outflow produce an average channel velocity that is less than or equal to the threshold velocity of 2.1 m/s. The design storm event for this structure was selected to be the 1 in 10-year event.

The 1 in 10-year historical peak flow was calculated based on the existing catchment area at the proposed C-02 channel outlet, equal to 5.17 km^2, using the design peak flow methodology outlined in **6.3.1**. Cross-sectional geometry, including longitudinal slope, channel side slopes and base width, were estimated from the available LIDAR data. The Manning's equation was used to estimate average velocity, based on a roughness value back-calculated from manual flow measurements near the Four-Hydro station, calculated to be 0.09. This value corresponds to a stream with weedy reaches, deep pools, and underbrush, which is consistent with observations in baseline monitoring reports (ERM 2020). The acceptable combined peak flow was back calculated to produce an average velocity equal to the threshold value. The additional flow rate from the control structure was calculated as the difference between the acceptable combined peak flow and the historical peak flow during the design event. All flows greater than the calculated maximum flow rate during the 10-year event will be conveyed to an alternate location to reduce the effect on Four Creek. Design criteria and assumptions are summarized in **Table 6.3-6** and results are presented in **Table 6.3-7**.

Table 6.3-6: Four Creek Erosion Protection Design Criteria

Parameter	Unit	Value	Comment
Design Event for Control Structure	years	1 in 10-year, 24-hour storm	
Design Event for Overflow Structure	years	1 in 200-year, 24-hour storm	Consistent with closure infrastructure
Manning's n	unitless	0.09	Back calculated based on eight manual flow measurements and stream surveys (ERM trip reports, 2020 to 2021)
Channel Threshold Velocity	m/s	2.1	Grass lined channels with 5 to 10% slope with coarse bedding (USDA 2007)

Source: *SRK 2021j*
Note: *%=percent; m/s=metre per second; n=roughness value; USDA=United States Department of Agriculture*

Table 6.3-7: C-02 Channel Discharge to Four Creek Design Flow Results

Parameter	Unit	Value	Comment
Natural Channel			
Catchment Area	km^2	5.15	Pre-mining catchment at the outlet of C-02 into Four Creek
10-year Peak Flow	m^3/s	6.99	Based on calculated time of concentration 1 hour, CN of 80.8
Average Velocity during Design Event	m/s	1.97	n/a
Combined Conditions with Engineered Control Structure and Natural Channel			
Maximum Acceptable Velocity	m/s	2.1	Based on threshold velocity in **Table 6.3-6**
Combined Design Flow	m^3/s	8.50	Back calculated using Manning's equation and maximum acceptable velocity
Design Flow from Control Structure to Four Creek	m^3/s	1.51	Difference between combined design flow and natural channel peak flow

Source: *SRK 2021j*
Note: *CN=curve number; km^2=square kilometres; m/s=metre per second; m^3/s=cubic metre per second; n/a=not applicable*

The control structure includes culverts to discharge flow from C-02 into Four Creek. Any flow from C-02 more than the design flow rate (1.51 cubic metres per second [m^3/s]) will be conveyed to C-01 during the Construction, and Operation phases until the East Management Pond dam is constructed, at which point overflows will flow into the East Management Pond directly. The overflow structure will consist of an overflow weir which will convey flows up to the 200-year return period event, consistent with design criteria for Post-closure Phase infrastructure. After culvert placement, backfill (non-PAG and overburden) will be placed across culverts, forming an access road between channels C-02 and C-01. Erosion protection downstream of the culverts into Four Creek includes riprap since the structure will remain in-place through the Post-closure Phase.

The Potable Water Storage Pond will be in the downstream extents of C-02 and will provide attenuation capacity during storm events. The culvert diameter and slope for the control structure were optimized along with geometry and elevation of the overflow weir such that the design flow of 1.51 m^3/s is not exceeded during the 10-year event, and that all events more than the 10-year event are safely conveyed to the appropriate downstream structure (C-01 in early operations and East Management Pond for remaining operations and Post-closure Phase). Culvert performance curves were developed in HY-8 and inflow hydrographs were developed in HEC-HMS. Overflow weir geometry (i.e., base width and spillway invert elevation) was adjusted to reduce velocities and associated riprap requirements. Erosion protection and design of the channel downstream of the control structure into Four Creek was also prepared based on the slopes of the valley.

The resultant configuration is presented in **Table 6.3-8**. Designs are presented in **Figures 9** through **12** of **Appendix 13.11-A Engineering Drawings.**

Table 6.3-8: C-02 Control Structure and Overflow Weir Design Results

Parameter	Unit	Value	Comment
Control Structure to Four Creek			
Culvert Diameter	mm	400	
Number of Culverts	-	2	Provides contingency discharge during pipe maintenance or in case of blockage.
Culvert Slope	%	2%	Selected to optimize discharge rate
Invert Elevation Relative to Base of Potable Water Storage Pond	m	5.0	At top of Potable Water Storage Pond
Peak Outflow During Design Event (1 In 10-Year 24-Hour Event)	m^3/s	1.50	Less than threshold combined flow rate of 1.51 m^3/s
Overflow Weir To C-01 / East Management Pond			
Base Width	m	15	Selected to reduce riprap requirements
Side Slopes	H:V	10:1	For trafficability
Invert Elevation Relative to Base of Potable Water Storage Pond	m	6.0	1.0 m above top of Potable Water Storage Pond. Note top of C-02 channel is 6.8 m, providing ample freeboard.
Peak Outflow During Design Event (1 in 200-Year 24-Hour Event)	m^3/s	14.5	Consistent with closure design criteria
Riprap D_{50}	m	0.10	
Riprap Layer Thickness	m	0.20	2xD_{50}, (BC MOE 2000)
Channel from Control Structure to Four Creek			
Base Width	m	5	
Side Slopes	H:V	2:1	
Maximum Slope	%	11%	Ranges from 1% to 11% along edge of valley
Riprap D_{50}	m	0.15	
Riprap Layer Thickness	m	0.30	2xD_{50}, (BC MOE 2000)

Source: *SRK 2021j*
Notes: *%=percent; BC MOE= British Columbia Ministry of Environment; D_{50}=mean rock size for which 50% of rocks are smaller; H:V=slope ratio horizontal to vertical; km^2=square kilometres; m=metre; m^3/s=cubic metre per second; mm=millimetre*

Detailed alignment selection of the channel extension from the control structure to Four Creek and appropriate energy dissipation systems will be required to reduce effects on the in-stream fish population. A field survey will be completed as part of detailed engineering.

6.3.2.2.1.1 Goathorn Tributary

The Goathorn Creek tributary erosion protection analysis included a review of historical flow conditions, and an evaluation of the expected Project discharge from Tenas Control Pond.

Two (2) components were evaluated for the erosion protection along the Goathorn Creek tributary:

1. The extent along the tributary that erosion protection is required; and
2. The type and size of erosion protection.

The extent to which erosion protection will be required along the tributary was reviewed based on the peak flows that would reasonably have been expected from the tributary's natural watershed in comparison to the peak flows discharging from the Project. Based on the magnitude of the Project catchment, the natural watershed area would be increased by up to 20 times the natural area at the upstream extents, and as high as 4 times at the confluence with Goathorn Creek. This change could result in increased rates of erosion of the natural creek bed, and increased sediment loading in Goathorn Creek. For this reason, erosion protection was included along the full length of the Goathorn Tributary to its outlet at Goathorn Creek (approximately 2.1 kilometre [km] length).

Since Project discharge will continue throughout closure, riprap was selected as the type of erosion protection for the Goathorn tributary. The riprap sizing was developed based on the expected Project discharge rates during a 1 in 200-year return period peak flow event.

The most critical period for discharge will be at closure of North Management Pond, once the Tenas Control Pond has been decommissioned and removing the attenuation capacity within the pond. HEC-HMS was used to simulate the 200-year peak discharge, along with catchment characterisation of the site at closure, like channel designs. The AMC **III** CN values were applied to natural catchment areas (5.1 square kilometre [km^2]) for the 200-year return period flood, which was routed through the East Management Pond, and West Management Pond spillways. The channel dimensions and slope were obtained from the site topography. Erosion protection works at Goathorn tributary are summarized in **Table 6.3-9**.

Table 6.3-9: Summary of Erosion Protection Design at Goathorn Creek Discharge Location

Parameter	Goathorn Creek Tributary
200-year event design peak flow (m^3/s)	5.2(1)
Average slope (%)	3.8%
Design event velocity (m/s)	2.45
Riprap D_{50} (m)	0.20
Riprap thickness (m)	0.40
Length (m)	2,100

Source: *SRK 2021j*
Notes: *%=percent; D_{50}=mean rock size for which 50% of rocks are smaller; m=metre; m^3/s=cubic metre per second*
Discharge from North Management Pond at closure, attenuated by the East and West Management Ponds.
*A road crossing will be installed along the tributary for the access road to the Explosive Magazine area (CU-05) and is described in **4.9.***

6.3.3 Dam Classification and Design

All water containing structures were evaluated according to CDA Dam Safety Guidelines (2013) and Dam Safety Regulations, BC Reg 40/2016 (Government of British Columbia [GovBC] 2016) and supported by the Global Industry Standards on Tailings Management (GISTM) (International Council on Mining & Metals [ICMM] 2020) and Technical Guidance 7 in Environmental Management: Assessing the Design, Size, and Operation of Sediment Ponds Used in Mining (BC MOE 2015).

The following subsections summarize the dam classifications and methodologies for spillway design, as well as the freeboard calculations.

6.3.3.1 Classification

The consequence of failure was evaluated for each facility, including water storage ponds which will be constructed entirely in excavation and will not rely on a dam or embankment. All ponds are designed with an emergency spillway sized based on the associated dam classification, following guidance from CDA (2013).

A detailed dam break model was prepared for the major containment structures, including the Management Pond dams and the Tenas Control Pond dam (**Appendix 13.11-B Dam Breach Assessment**). Consequence classification for the remaining five ponds were evaluated qualitatively.

Table 6.3-10 is a reproduction of the CDA-recommended consequence classification criteria. The classification systems are based on the incremental consequences of a dam failure. The incremental consequences of failure are defined as the total impacts of a dam failure, above and beyond the impacts that would have resulted from the condition that caused the failure (e.g., a large earthquake or a large flood event) had the dam not failed. During the dam classification process, each of the four (4) hazard rating components in **Table 6.3-10** are considered individually, and the overall dam hazard rating is defined by the component with the highest (i.e., most severe) rating.

Table 6.3-10: Canadian Dam Association (CDA) (2013) Dam Classifications

Dam Class	Population at Risk[1]	Incremental Losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No long-term loss	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	No significant loss or deterioration of fish or wildlife habitat	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Loss of marginal habitat only	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial

Dam Class	Population at Risk[1]	Incremental Losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
				facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Restoration or compensation in kind highly possible	Extreme losses affecting critical infrastructure or service (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Source*: CDA 2013*

Notes:

1. Definitions for population at risk:

None: There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary: People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent: The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); Three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

2. Implications for loss of life:

Unspecified: The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 6.3-11 presents the consequence classifications for excavated water storage ponds that do not rely on embankments for containment. In the case of each pond, overtopping is the only credible failure mode, which is expected to occur by design for events more than the 1 in 10-year return period inflow event, according to BC MOE 2015. A detailed dam break model was prepared for the major containment structures, including the management pond dams and the Tenas Control Pond dam (**Appendix 13.11-B Dam Breach Assessment**). During these events, some sediment may be released to the environment, and erosion may occur in the downstream receiving environment. For this reason, a low consequence classification was assigned to all excavated water storage ponds.

Table 6.3-12 summarizes consequence classification for all embankments, as described in **Appendix 13.11-B Dam Breach Assessment**.

Table 6.3-11: Consequence Classification for Excavated Water Storage Ponds

Pond	Description of Failure Effect / Comments	Population at Risk	Incremental Losses			Recommended Consequence Classification
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economic Loss	
Coal Processing Plant (CPP) Sedimentation Pond	Overtopping scenario would result in water from the pond flowing into Four Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e. repairs to and rebuild the dam if required) and are expected to be low (Low)	Low
East Tenas Access Corridor (TAC) Sedimentation Pond	Overtopping scenario would result in water from pond flowing into Goathorn Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to sedimentation pond and delay in gravel removal) and are expected to be low (Low)	Low
Explosive Magazine Sedimentation Pond	Overtopping scenario would result in water from the pond flowing into Tenas Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the berm and pad if required) and are expected to be low (Low)	Low
Explosives Facility Sedimentation Pond	Overtopping scenario would result in water from the pond flowing into Tenas Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the berm and pad if required) and are expected to be low (Low)	Low
Gravel Quarry Sedimentation Pond for Pits 1 and 2	Overtopping scenario would result in water from pond into the quarry and with enough water into Goathorn Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to sedimentation pond and delay in gravel removal) and are expected to be low (Low)	Low

Pond	Description of Failure Effect / Comments	Population at Risk	Incremental Losses			Recommended Consequence Classification
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economic Loss	
Potable Water Storage Pond	Overtopping scenario would result in water from the pond flowing into the East Management Pond, C-01 or into Four Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the pond and channel if required) and are expected to be low (Low)	Low
Rail Infrastructure Sedimentation Pond	Overtopping scenario would result in water from the pond flowing into the Bulkley River	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the dam if required) and are expected to be low (Low)	Low
Rock Quarry Sedimentation Pond	Overtopping scenario would result in water from pond into Helps Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to sedimentation pond and delay in gravel removal) and are expected to be low (Low)	Low
Soil Treatment Facility Pond	Overtopping scenario would result in water from the pond flowing over the CPP and ultimately into the CPP Sedimentation Pond	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the pond and channel if required or clean-out of the CPP Sedimentation Pond downstream) and are expected to be low (Low)	Low
Wastewater Storage Pond	Overtopping scenario would result in water from the pond flowing over the CPP and ultimately into the CPP Sedimentation Pond	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to and rebuild the pond and channel if required or clean-out of the CPP Sedimentation Pond downstream) and are expected to be low (Low)	Low

Pond	Description of Failure Effect / Comments	Population at Risk	Incremental Losses			Recommended Consequence Classification
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economic Loss	
West TAC Sedimentation Pond	Overtopping scenario would result in water from pond flowing into Goathorn Creek	None (Low)	0 (Low)	Anticipate some minimal short-term loss and no permanent loss (Low)	Economic losses may include some limited infrastructure (i.e., repairs to sedimentation pond and delay in gravel removal) and are expected to be low (Low)	Low

Source: *SRK 2021j*

Table 6.3-12: Consequence Classification for Management Ponds and Tenas Control Pond

Dam	Description of Failure Effect / Comments	Population at Risk	Incremental Losses			Recommended Consequence Classification
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economic Loss	
Tenas Control Pond	A dam failure scenario would result in water from the pond flowing into Tenas Creek and Goathorn Creek, creating a flood wave towards the Town of Telkwa.	Permanent – likely to affect population inhabiting inundation zone. **(Very High)**	100 or fewer **(Very High)**	The Tenas Control Pond breach will likely cause downstream erosion with temporary deterioration of aquatic and terrestrial habitat. Restoration or compensation in kind is highly possible. **(Very High)**	Economic losses may include infrastructure (i.e., repairs to bridges, buildings, and roadways) and dam rebuilding if required. **(High)**	**Very High**
North Management Pond	A failure of the dam could cause a cascading failure of the Tenas Control Pond. A dam failure scenario would result in water from the ponds to flow into Tenas Creek and Goathorn Creek.	Permanent – likely to affect population inhabiting inundation zone. **(Very High)**	100 or fewer **(Very High)**	The breach will likely contribute to downstream erosion with some loss or deterioration of aquatic and terrestrial habitat. Restoration or compensation in kind is highly possible. **(High)**	Economic losses may include infrastructure (i.e., repairs to bridges, buildings, and roadways) and dam rebuilding if required. **(High)**	**Very High**

Dam	Description of Failure Effect / Comments	Population at Risk	Incremental Losses			Recommended Consequence Classification
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economic Loss	
East Management Pond	A failure of the dam could cause a cascading failure of the North Management Pond and Tenas Control Pond. A dam failure scenario would result in water from the ponds to flow into Tenas Creek.	Permanent – likely to affect population inhabiting inundation zone and mine personnel occupying mine infrastructure complex. **(Very High)**	100 or fewer **(Very High)**	The breach will likely contribute to downstream erosion with some loss or deterioration of aquatic and terrestrial habitat. Restoration or compensation in kind is highly possible. **(High)**	Economic losses may include infrastructure (i.e., repairs to bridges, buildings, and roadways) and dam rebuilding if required. **(High)**	**Very High**
West Management Pond	Depending on the location of the dam failure, the breached water could flow into Tenas Creek, Four Creek and Goathorn Creek. A failure of the dam may also cause a cascading failure of the North Management Pond and Tenas Control Pond.	Permanent – likely to affect population inhabiting inundation zone **(Very High)**	100 or fewer **(Very High)**	The breach will likely contribute to downstream erosion with some loss or deterioration of aquatic and terrestrial habitat. Restoration or compensation in kind is highly possible. **(High)**	Economic losses may include infrastructure (i.e., repairs to bridges, buildings, and roadways) and dam rebuilding if required. **(High)**	**Very High**

6.3.3.2 Selection of Inflow Design Flood (IDF)

Given the above dam classifications, the recommended inflow design flood events for the spillways are summarized in **Table 6.3-13**. Both the wastewater storage pond and the soil treatment facility pond are located upstream of the CPP Sedimentation Pond, which includes these facilities as part of its catchment area. Spillway designs for the Wastewater Storage Pond are described in presented in **S1.0-C1 Description of Project** in the **EAC Application** while the Soil Treatment Facility is described in SRK 2021c.

Table 6.3-13: Inflow Design Flood (IDF) based on Consequence Classification

Facility	Dam Classification	Minimum Design Flood	Selected Design Flood
Tenas Control Pond	Very High	2/3 between 1 in 1,000-year event and PMF	2/3 between 1 in 1,000-year event and PMF
North Management Pond	Very High	2/3 between 1 in 1,000-year event and PMF	2/3 between 1 in 1,000-year event and PMF
East Management Pond	Very High	2/3 between 1 in 1,000-year event and PMF	2/3 between 1 in 1,000-year event and PMF
West Management Pond	Very High	2/3 between 1 in 1,000-year event and PMF	2/3 between 1 in 1,000-year event and PMF
CPP Sedimentation Pond	Low	between 1 in 100 and 1 in 1,000-year event	1 in 200-year event
Rail Infrastructure Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event
Explosive Facility Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event
Explosive Magazine Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event
Potable Water Storage Pond	Low	1 in 100-year event	1 in 200-year event
Wastewater (Sanitary) Storage Pond	Low	1 in 100-year event	1 in 200-year event
Gravel Quarry Sedimentation Pond for Pits 1 and 2	Low	1 in 100-year event	1 in 200-year event
Rock Quarry Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event
East TAC Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event
West TAC Sedimentation Pond	Low	1 in 100-year event	1 in 200-year event

Source: *SRK 2021j*
Notes: *CPP=Coal Processing Plant; PMF=probable maximum flood; TAC=Tenas Access Corridor*

For sedimentation ponds, the minimum design flood for overflow spillways is the 1 in 200-year design flood (BC MOE 2015) which governs in the case of the Low consequence control ponds. All management pond spillways as well as the spillway for the Tenas Control Pond were designed to convey the partial PMF.

6.3.3.3 Spillway Design

Each spillway channel was designed with trapezoidal cross-section and a minimum spillway width of 2 m with minimum side slopes of 2H:1V. The spillways will be lined with riprap for erosion protection. Spillway inverts and base widths were defined to provide sufficient minimum freeboard during the inflow design flood (IDF) as per CDA guidelines (CDA 2013). Spillway designs are presented with associated pond designs in the following subsections.

Spillway sizing was performed by routing the IDF through respective ponds using the available pond capacity upstream of the spillway inlet (i.e., stage-storage curve) and the following trapezoidal spillway equation (Smith 1985):

$$Q=1.70BH^{3/2}+1.27H^{5/2}\tan(\phi/2) \qquad \textit{Equation 1}$$

Where B is the width of the spillway, H is the height of water over the spillway invert and $\phi/2$ is the angle of the side slope relative to the vertical, for which a channel with side slopes of 2:1, tan($\phi/2$) will have a value of 2.

Spillway designs are discussed in subsequent sections in relation to the associated structures.

6.3.3.4 Freeboard Evaluation

A wind set-up and wave run-up analysis was performed to establish minimum freeboard requirements for the management pond dams and Tenas Control Pond dam during normal operating conditions and during the passage of the IDF (CDA 2013).

For a Very High dam consequence, CDA (2013) recommends:

- no overtopping by 95% of the waves generated by a 1:1,000-year sustained wind when the pond is at its maximum normal elevation (normal freeboard); and
- no overtopping by 95% of waves generated by a 1:2-year sustained wind when the pond is at its maximum extreme level during the passage of the IDF.

Wind-generated wave heights were evaluated for hourly winds recorded at the Environment Canada Smithers Airport station. A correction factor of 1.2 was applied to wind data to account for the difference between overland and overwater conditions (CDA 2007). Wave generation and wave run-up were calculated following procedures presented in USACE (2003) and CDA (2007).

Table 6.3-14 summarizes the input parameters and calculated normal and minimum freeboard heights for each facility. Freeboard depths are applied to the maximum operating level and water level during routing of the IDF in **6.3.3** and **6.3.6** for management pond dams and in **6.3.5** for the Tenas Control Pond dam.

Table 6.3-14: Tenas Project Dam's Freeboard Summary

Pond	Scenario	Design Wind Speed (m/s)	Maximum Fetch Length (m)	Average Pond Depth (m)	Wave Runup (m)	Wind Setup (m)	Wind Freeboard (m)
Tenas Control Pond	1 in 1,000 Wind at Max Operating Level	30.5	1,000	3.5	0.74	0.05	0.79
	1 in 2 Wind During Passage of the IDF	15.1			0.36	0.02	0.38
West Management Pond	1 in 1,000 Wind at Max Operating Level	30.5	1,440	3.5	0.91	0.08	0.99
	1 in 2 Wind During Passage of the IDF	15.1			0.45	0.02	0.47
East Management Pond	1 in 1,000 Wind at Max Operating Level	30.5	1,860	2.7	1.1	0.1	1.2
	1 in 2 Wind During Passage of the IDF	15.1			0.52	0.03	0.56
North Management Pond	1 in 1,000 Wind at Max Operating Level	30.5	720	2.6	0.61	0.05	0.66
	1 in 2 Wind During Passage of the IDF	15.1			0.3	0.01	0.31

Source: *SRK 2021j*
Notes: *IDF=inflow design flood; m=metre; m/s=metre per second*

6.3.3.5 Dam Slope Stability

Slope stability for each water containment dam was evaluated in the Tenas Project Slope Stability Assessment Report (SRK 2021e), including each of the management pond dams and the Tenas Control Pond dam.

The results of the analyses showed that the Tenas Control Pond, North Management Pond, East Management Pond and West Management Pond configurations meet or exceed Telkwa´s internal requirement and CDA (2013) design criteria for dam stability factors of safety.

6.3.4 Sedimentation Ponds

There are 10 sedimentation ponds at the Project. Each pond was designed in accordance with the Technical Guidance in BC MOE 2015 to settle total suspended sediments and thereby improve water quality at the discharge point.

Table 6.3-15 presents the objectives for each pond and the routine and emergency discharge approach. Consequence classifications are summarized in **6.3.3.1**.

Table 6.3-15: Sediment Control Pond Objective and Discharge Summary

Pond	Objective	Discharge Approach
Tenas Control Pond	Provides sediment retention for Project footprint from early mining to closure. Provides water supply to CPP and to the management ponds year-round	▪ Pumped discharge to Goathorn Creek tributary (PMP_SYS-01). ▪ Overflow via spillway to channel that connects to Goathorn Creek tributary. ▪ Pumping systems to CPP (designed by others) and to management ponds (PMP_SYS_02)
CPP Sedimentation Pond	Provides sediment retention for runoff from CPP area	▪ Discharge via pumped pipeline or emergency spillway to unnamed tributary of Four Creek. ▪ Optional pumping system to Tenas Control Pond (PMP_SYS-04)
Rail Infrastructure Sedimentation Pond	Provides sediment retention for runoff from Rail Infrastructure area, which includes processed coal stockpiles and a topsoil stockpile on a pad	Discharge via pumped pipeline or emergency spillway to unnamed tributary of Bulkley River.
Explosive Facility Sedimentation Sump	Provides sediment retention for runoff from Explosive Facility pad. The pad itself will be a 100 m x 100 m raised rock area.	Discharge via pumped pipeline or emergency spillway to unnamed tributary of Tenas Creek.
Explosive Magazine Sedimentation Sump	Provides sediment retention for runoff from Explosive Magazine pad. The pad itself will be of a 100 m x 50 m raised rock area	Discharge via pumped pipeline or emergency spillway to unnamed tributary of Tenas Creek.
Rock Quarry Sedimentation Pond	Provides sediment retention for runoff from the Gravel Quarry. During heavy rain events, quarry operation will cease.	Discharge via a pumped pipeline or emergency spillway to Helps Creek
Gravel Quarry 1 Sedimentation Pond	Provides sediment retention for runoff from Gravel Quarry 1. During heavy rain events, quarry operation will cease.	Discharge via a pumped pipeline to Goathorn Creek
Gravel Quarry 2 Sedimentation Pond	Provides sediment retention for runoff from the Gravel Quarry 2. During heavy rain events, quarry operation will cease.	Discharge via a pumped pipeline to Goathorn Creek
East TAC Sedimentation Pond	Provides sediment retention for runoff from the TAC between Goathorn Creek Bridge and top of valley on the east side	Discharge via a discharge spillway to Goathorn Creek

Pond	Objective	Discharge Approach
West TAC Sedimentation Pond	Provides sediment retention for runoff from the TAC between Goathorn Creek Bridge and top of valley on the west side	Discharge via a discharge spillway to Goathorn Creek

Source: *SRK 2021j*
Notes: *CPP=Coal Processing Plant; PMF=probable maximum flood; TAC=Tenas Access Corridor*

All rock pads are to be constructed with non-PAG rock or overburden, and further treatment of discharge beyond TSS is not anticipated. Based on geochemical characterisations presented in the geochemistry report (SRK 2021d), the temporary coal stockpiles are not expected to oxidize and produce acidic and/or water with elevated metal concentrations. Water quality predictions from ponds are presented in the Water and Load Balance Modeling Report (SRK 2021b). This SRK report is provided in the **DMP** as **Appendix 13.5-B Water and Load Balance Modeling Report.**

TSS is removed by gravity settling and/or addition of flocculent, if required. Flocculent addition is a contingency measure and has not been included in the design. Sediment will accumulate within the pond and will be removed periodically so that the ponds maintain full design capacity for effective treatment. Each pond includes a maintenance access ramp for regular sediment removal.

All sediment control ponds will discharge to the environment via an engineered spillway and a pumping system. The CPP Sedimentation Pond will also be equipped with a pumping system to route collected runoff to the Tenas Control Pond in case water quality is not suitable for direct discharge because of spills around the CPP. All excavated ponds will be lined with coarse gravel to isolate the moving water from exposed soils and reduce erosion and mobilization of sediment during operations.

Design criteria for pond design are summarized in **Table 6.3-16**.

Table 6.3-16: Design Criteria for Sediment Control Ponds

Parameter	Value
Minimum Inflow Design Flood (IDF) for Ponds	24-hour duration 1 in 200-year flood event (rain + snowmelt)
Minimum Particle for Pond Retention	10 micron
Minimum Pond Retention Capacity	1 in 10-year 24-hour flood event
Particle Settling Velocity	2×10^{-5} m/s
Correction Factor for Non-ideal Settling	1.2
Target Length to Width Ratio	5:1
Minimum Pond Depth Below Orifice Outflow	0.5 m
Minimum Spillway Base Width	2.0 m
Spillway Side Slopes	2:1 H:V
Excavation Side Slopes	2:1 H:V
Minimum Freeboard	0.5 m during IDF
Minimum Pond Depth	1.5 m

Source: *SRK 2021j*
Notes: *H:V=slope ratio horizontal to vertical; DF=inflow design flood; m=metre; m/s=metre per second*

The following subsections outline the design details for the sediment control ponds. The Tenas Control Pond is discussed separately in **6.3.5**.

6.3.4.1 Sedimentation Pond Design Methodology

BC MOE 2015 recommends sedimentation ponds should be able to provide sufficient retention time to settle a 10-micron particle. The required retention time to settle a 10-micron particle with a settling velocity of 2 x 10-5 m/s can be evaluated given the following equation:

Tr=d/(3600V) Equation 2

Where Tr is the retention time in hours, d is the pond depth in metres and V is the settling velocity in m/s.

A settling velocity of 2 x 10-5 m/s was selected which coincides with a fine silt and is based on BC MOE recommendations where particle size information is not available. The minimum pond surface area was calculated based on Equation 3 below, which incorporates a correction factor of 1.2 (BC MOE 2015):

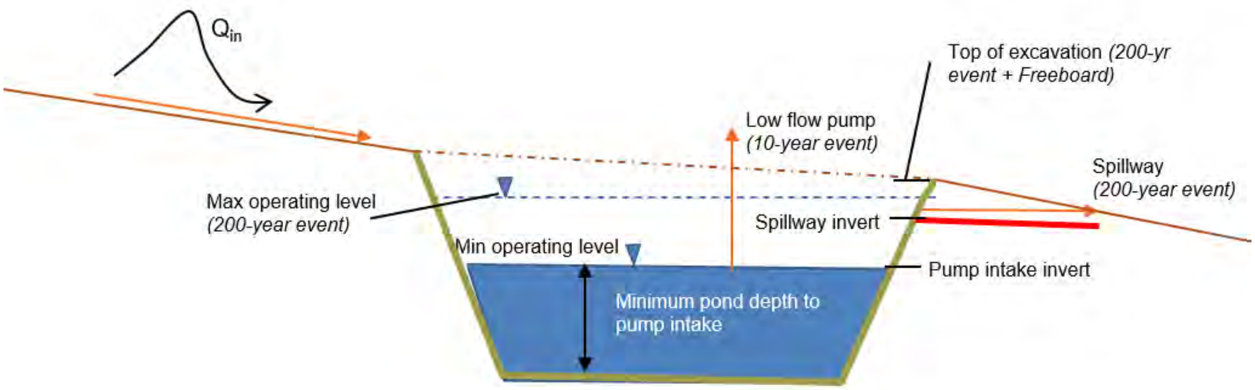
Min Surface Area =(Q_peak^(10-year event))/(1.2)(V) Equation 3

All sedimentation ponds will operate with a pumping system for normal operation and an emergency spillway. The pumping system will manage the discharge of water from the pond for events up to and including the 1 in 10-year event. The emergency spillway will convey events greater than the 1 in 10-year event up to the IDF, with a return period of 1 in 200-years. (**Figure 6.3-2**)

Additional assumptions for sedimentation pond design are as follows:

- The 1 in 10-year flood event and the 1 in 200-year flood event were modelled in HEC-HMS using peak flow inputs defined in **6.3.1** with climate change-adjusted precipitation depths and snowmelt contributions. A CN of 98 was applied for all Minesite facility pads, including the CPP area upstream of the CPP Sedimentation Pond, the Rail Infrastructure pad, the Explosive Magazine pad, and the Explosive Facility pad. Natural catchments incorporate CN values calibrated for each return period (**6.3.1**) and account for AMC III ground conditions during the IDF;
- Initial conditions during the 1 in 10-year flood event assume that the pond water level is equal to the pump invert elevation, which is set above a minimum depth of 0.5 m above the base of the pond for sediment accumulation;
- All ponds are excavated in natural ground for containment without ponding water against a berm or dam;
- The pond width is a fifth (1/5) of the length;
- The pond base length was adjusted to make the pond surface at the pump intake elevation greater than the minimum pond surface area for particle settling, as dictated by Equation 3;
- Two (2) baffles were included in the CPP Sedimentation Pond to better fit the topography and increase the flow length for particle settling;
- The pumping rate and pond volume were established to meet the minimum retention time value from Equation 2, while reducing the total pond volume based on routing of the 1 in 10-year event. The spillway invert was set at the peak water level during the 1 in 10-year event. Initial conditions for emergency spillway design assumed that the pond water level is at the spillway invert elevation at the onset of the IDF;

- The top of excavation (or top of pond) elevation was selected based on the maximum water level through the spillway during the IDF plus the minimum freeboard of 0.5 m; and
- Each pond includes an 8H:1V access ramp to the base of the pond for maintenance access and may be drained as needed using the pumping system.



Source: *SRK 2021j*

Figure 6.3-2: Typical sediment control pond geometry

6.3.4.2 Sedimentation Pond Design Results

The hydrologic analysis, pond geometry and sedimentation calculations and results are summarized in **Table 6.3-17, Table 6.3-18,** and **Table 6.3-19,** respectively. Catchment areas showing maximum areas contributing to each pond are presented in **Figure 6.3-3**.

Table 6.3-17: Sedimentation Pond Hydrologic Analysis Summary

Pond	CPP Sedimentation Pond	Rail Infrastructure Sedimentation Pond	Explosive Facility Sedimentation Pond	Explosive Magazine Sedimentation Pond	Rock Quarry Sedimentation Pond	Gravel Quarry 1 Sedimentation Pond	Gravel Quarry 2 Sedimentation Pond	East TAC Sedimentation Pond	West TAC Sedimentation Pond
Maximum Catchment Area (m^2)	203,500	77,900	10,000	5,000	50,000	15,000	80,000	20,000	10,000
1 in 10-year Peak Inflow (m^3/s)	1.8	0.5	0.1	0.1	0.7	0.2	1.1	0.3	0.1
1 in 10-year 24-hour Storm Volume (m^3)	19,550	7,440	960	480	4,820	1,450	7,720	1,930	960
1 in 10-year Max water level (m)	2.5	2.6	2.5	2.4	2.5	1.2	2.4	1.6	0.9
1 in 10-year Peak Outflow (m^3/s)	0.090	0.030	0.008	0.006	0.010	0.010	0.010	0.010	0.010
1 in 200-year Peak Inflow (m^3/s)	2.9	0.8	0.2	0.1	1.2	0.4	2.0	0.5	0.2
1 in 200-year 24-hour Storm Volume (m^3)	29,000	10,960	1,440	720	7,190	2,160	11,510	2,880	1,440
1 in 200-year Max water level (m)	2.8	2.7	2.6	2.5	2.7	2.5	2.6	2.5	2.5
1 in 200-year Peak Outflow (m^3/s)	2.6	0.8	0.2	0.1	1.0	0.2	1.9	0.4	0.0

Source: *SRK 2021j*
Notes: *CPP=Coal Processing Plant; m=metre; m^3=cubic metre; m^3/s=cubic metre per second; TAC=Tenas Access Corridor*

Table 6.3-18: Sediment Control Pond Geometry and Design Summary

Pond	CPP Sedimentation Pond	Rail Infrastructure Sedimentation Pond	Explosive Facility Sedimentation Pond	Explosive Magazine Sedimentation Pond	Rock Quarry Sedimentation Pond	Gravel Quarry 1 Sedimentation Pond	Gravel Quarry 2 Sedimentation Pond	East TAC Sedimentation Pond	West TAC Sedimentation Pond
Base length (m)	43	100	50	30	80	50	115	50	50
Number of baffles	2	0	0	0	0	0	0	0	0
Base width (m)	78	20	10	6	16	10	23	10	10
Depth from base of pond to pump intake (m)	0.5	0.5	2	2	0.5	0.5	0.5	0.5	0.5
Depth from base of pond to spillway (m)	2.6	2.7	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Depth from base of pond to top of excavation (m)	3.3	3.3	3.1	3.1	3.3	3.0	3.1	3.0	3.0
Spillway base width (m)	10	10	2	2	2	10	10	10	10
Spillway side slopes (H:V)	2	2	2	2	2	2	2	2	2
Pumping rate (m^3/s)	0.090	0.030	0.008	0.006	0.010	0.010	0.010	0.010	0.010
Pond volume below pump intake (m^3)	2,570	870	1,510	680	690	280	1,390	280	280
Pond volume below spillway (m^3)	16,780	6,550	2,060	970	4,460	2,060	8,390	2,060	2,060
Total pond volume (m^3)	22,290	8,400	2,800	1,330	6,310	2,690	10,910	2,690	2,690

Source: *SRK 2021j*
Notes: *CPP=Coal Processing Plant; H:V=slope ratio horizontal to vertical; m=metre; m^3=cubic metre; m^3/s=cubic metre per second; TAC=Tenas Access Corridor*

Table 6.3-19: Sediment Control Pond Sedimentation Calculation Summary

Pond	CPP Sedimentation Pond	Rail Infrastructure Sedimentation Pond	Explosive Facility Sedimentation Pond	Explosive Magazine Sedimentation Pond	Rock Quarry Sedimentation Pond	Gravel Quarry 1 Sedimentation Pond	Gravel Quarry 2 Sedimentation Pond	East TAC Sedimentation Pond	West TAC Sedimentation Pond
Minimum pond surface area for settling [m^2]	5,400	1,800	480	360	600	600	600	600	600
Design pond surface area at orifice level [m^2]	5,450	1,940	1,040	530	1,480	620	2,930	620	620
Minimum retention time [hr]	7	7	28	28	7	7	7	7	7
Design retention time during 1 in 10-year event [hr]	8	8	52	32	19	8	39	8	8

Source: *SRK 2021j*
Notes: *hr=hour; m= metre; m^2=square metre*

Sedimentation pond operation and monitoring requirements are described in **Appendix 13.11-E Minesite Water Monitoring Program** and includes:

- daily water level readings in all ponds;
- pumping rates should be measured and recorded with a totalizer. Pump controls may be manual or automatic, depending on the selected configuration and pump design;
- monthly water quality sampling in all ponds for full suite of water quality parameters, with more frequent measurements of TSS concentrations proceeding storm events to ensure ponds are working as intended;
- annual sediment accumulation measurements; and
- plan view and typical sections of the ponds are presented in **Drawings 14, 15** and **16** in **Appendix 13.11-A Engineering Drawings**.

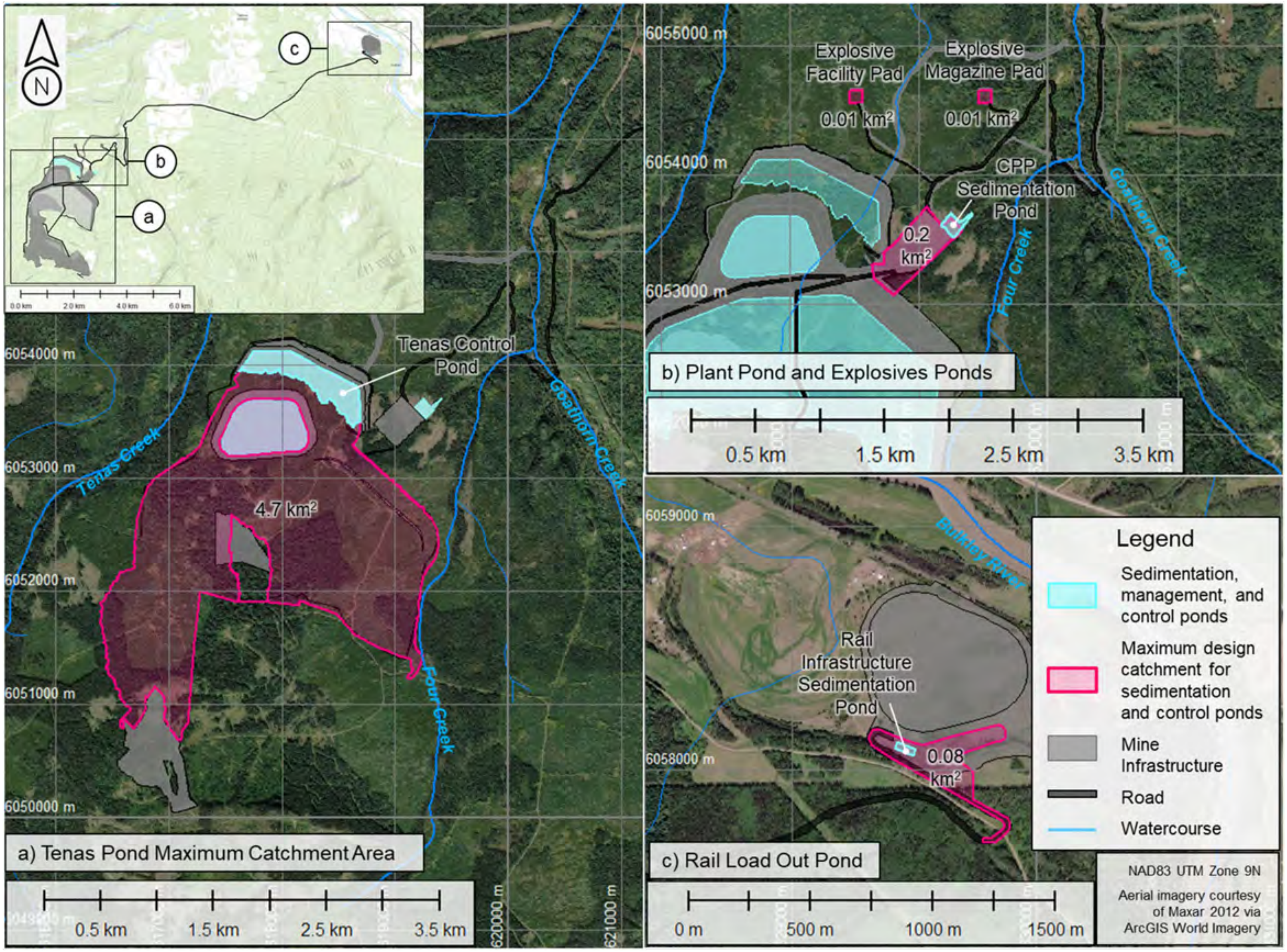


Figure 6.3-3: Sedimentation pond catchment area map for (a) Tenas Control Pond, (b) Coal Processing Plant (CPP) and Explosive Infrastructure area sedimentation ponds and (c) Rail Infrastructure Sedimentation Pond

6.3.5 Tenas Control Pond

The Tenas Control Pond will operate from the Construction Phase through the Decommissioning and Reclamation Phase, and for a period in the Post-closure Phase, providing sediment control and water supply to the Project. During the Construction Phase, best management practices (BMPs) coupled with a seepage collection channel along the toe of the final dam will be in-place to manage sediment. Once reclamation of the site is complete, the Tenas Control Pond will be dewatered to Goathorn Creek and the dam will be breached. The erosion protection at the toe of the dam will be extended south towards the outlet of the North Management Pond spillway to convey Project discharge during the Post-closure Phase through the former Tenas Control Pond area and towards Goathorn Creek (see **6.3.2.2**).

Tenas Control Pond could also be used to provide temporary water storage in the event water quality is unacceptable for direct discharge, while a response is being mounted. The stage-storage relationship for the pond is presented in **Appendix 13.11-C Stage-Storage Relationships**.

The following subsections summarize the design of the Tenas Control Pond.

6.3.5.1 Conceptual Model and Design Criteria

In addition to sedimentation control, the Tenas Control Pond has the following design objectives:

- Provide water supply to the CPP, including maintaining a contingency storage volume equivalent to 7 months' operational demand during a 1 in 10-year dry year;
- Provide water supply to the management ponds to maintain water covers over PAG materials, conservatively assuming there is no other source of flow to the ponds; and
- Maintain minimum discharge during the months of May through October to mix with treated effluent from the Sewage Treatment Plant.

The conceptual model and design criteria for the Tenas Control Pond are presented in **Figure 6.3-4** and **Table 6.3-20**. Parameters were developed iteratively using a monthly water balance, flood routing and sedimentation design. The following subsections describe the Tenas Control Pond water balance and associated designs.

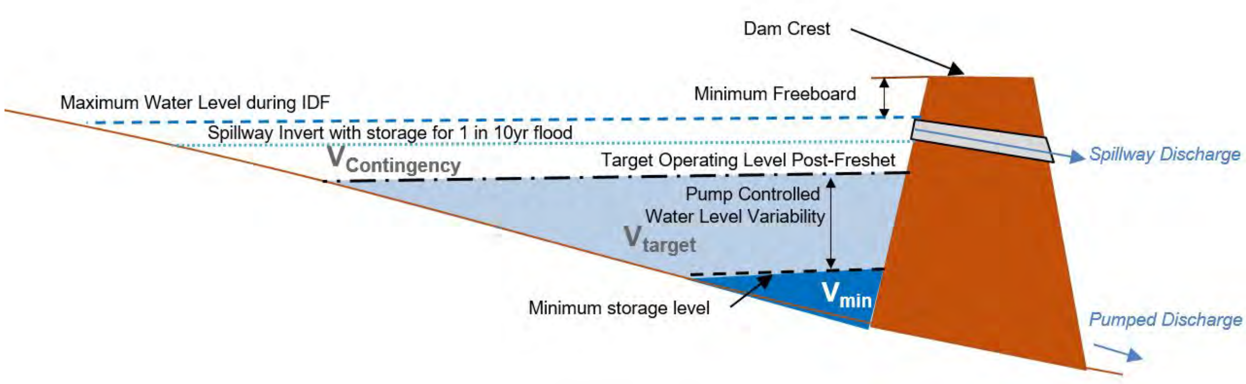


Figure 6.3-4: Tenas Control Pond conceptual design schematic

Table 6.3-20: Tenas Control Pond Design Criteria

Criteria	Description
Minimum Storage Volume (V_{min})	Seven (7) months of process water supply + 2.5 metres (m) of storage for sediment accumulation (see **6.3.5.3**)
Maximum Target Operating Volume Post-Freshet (V_{Target})	Required water inventory as of July 1, as determined by 1 in 10-year dry year water balance (see **6.3.5.4**)
Contingency Storage ($V_{Contingency}$)	Contingency storage capacity for 1 in 10-year 24-hour storm event above the normal maximum operating water level (see **6.3.5.6**) to provide operational flexibility in terms of discharge rates to Goathorn Creek
Pumping Rate	Mean annual runoff inflows – Annual process water demand, discharged over 5-month open-water period (see **6.3.5.5**). Considers flood recovery for 1:10-year inflow over 7-days (using backup pump system)
Spillway Invert	Based on stage-storage curve, providing storage volume greater than the sum of V_{target} and V_{10yr} (see **6.3.5.7**)
Inflow Design Flood (IDF) Maximum Water Level	Based on routing of the IDF through the spillway (see **6.3.5.8**)
Minimum Freeboard	Based on freeboard evaluation (see **6.3.3.4**)
Dam Crest	Selected based on the minimum freeboard and IDF maximum water level
Sediment Removal	Calculated based on the retention time during the 1 in 10-year inflow and expected pond volume and compared against the minimum retention time based on pond depth and particle settling velocity (Equation 2 in **6.3.4.1**)
Pond Surface Area at V_{min}	Calculated from stage-storage curve and compared against minimum pond surface area for settling (Equation 3 in **6.3.4.1**)

6.3.5.2 Operational Water Demand

The CPP water demand is approximately 15,000 m^3/month based on the processing rate of 1.05 million tonnes per annum and a water demand of 130 litres per tonne, and an allowance of 3,625 m^3/month for wash bays and dust suppression (all rates provided to SRK by TCL).

A minimum discharge rate is required to mix with Sewage Treatment Plant effluent from May through September, equal to 8,300 m^3/month (50,000 m^3/year).

Management ponds are required to maintain a minimum water cover above stored PAG material to reduce the risk of oxidation. Water supply requirements for the management ponds vary throughout the life-of-mine and are expected to increase with increasing PAG material volumes. The management ponds collect flows from active open pit mining and natural runoff from undisturbed catchment areas. Any deficits are made up by pumping from the Tenas Control Pond.

The Tenas Control Pond design includes sufficient water supply to maintain submergence of PAG materials at the maximum projected placement rate, assuming no other sources of water are available. The maximum PAG placement rate coincides with Year 5 from the mine plan, which is expected to produce 1.98 million cubic metres (Mm^3) of PAG material and 0.18 Mm^3 of processed rock, resulting in a total of 2.16 Mm^3 of material into the East Management Pond. A void ratio of 0.3 is assumed for all mine rock, which would require a volume of water equal to 0.65 Mm^3 to saturate the added material. A factor of safety of 1.1 was applied to this volume, and this water volume was assumed to be required evenly throughout the year, resulting in a monthly water demand of approximately 60,000 m^3/month.

6.3.5.3 Minimum Process Water Storage Volume

The minimum storage volume for the Tenas Control Pond was selected to provide contingency water supply to the CPP for a seven (7)-month period, calculated as 105,000 m^3 assuming no other sources of inflow are available to the CPP, in addition to an allowance of 2.5 m (approximately 5,000 m^3) for sediment accumulation (**Appendix 13.11-C**). The total minimum storage volume (V_{min}) selected for the Tenas Control Pond is 110,000 m^3.

If sediment accumulation exceeds the volume threshold, floating dredge infrastructure would be acquired for sediment removal. Additional measures to reduce sediment accumulation at the upstream toe of the Tenas Control Pond dam include check dams at the outlets of C-03a and C-01 as they discharge towards Tenas Control Pond from the west and east Project extents respectively, acting as primary settling ponds for coarse sediment removal.

6.3.5.4 Monthly Water Balance for Target Operating Level

A monthly water balance was prepared for the Tenas Control Pond to establish the target operating post-freshet water level required to maintain the minimum process water storage volume throughout the year during a 1 in 10-year dry year. The water balance is based on the critical period with maximum management pond water demand (Year 5, see **6.3.5.2**).

Monthly inflow rates to the Tenas Control Pond were calculated based on the Project monthly runoff distribution, as presented in **6.1.4**, and a Year 5 catchment area of 5.92 km^2 which includes runoff from the management pond dams and buttresses, runoff into the management ponds themselves, runoff to the CPP pad and flows pumped from the CPP Sedimentation Pond and portions of the active open pit, as shown in **Figure 6.3-5**.

In addition to the operational water demands outlined in **6.3.5.2**, additional losses from the system include evaporation and seepage. Project runoff rates account for losses to natural surfaces including evapotranspiration and groundwater infiltration. Additional evaporation losses were not included in the Tenas Control Pond water balance. However, the added head from management ponds and the Tenas Control Pond will increase groundwater infiltration losses over natural conditions. Seepage losses were included based on results from the groundwater model and expected liner performance, which result in a maximum seepage loss of 1,600 m^3/day (SRK 2021b).

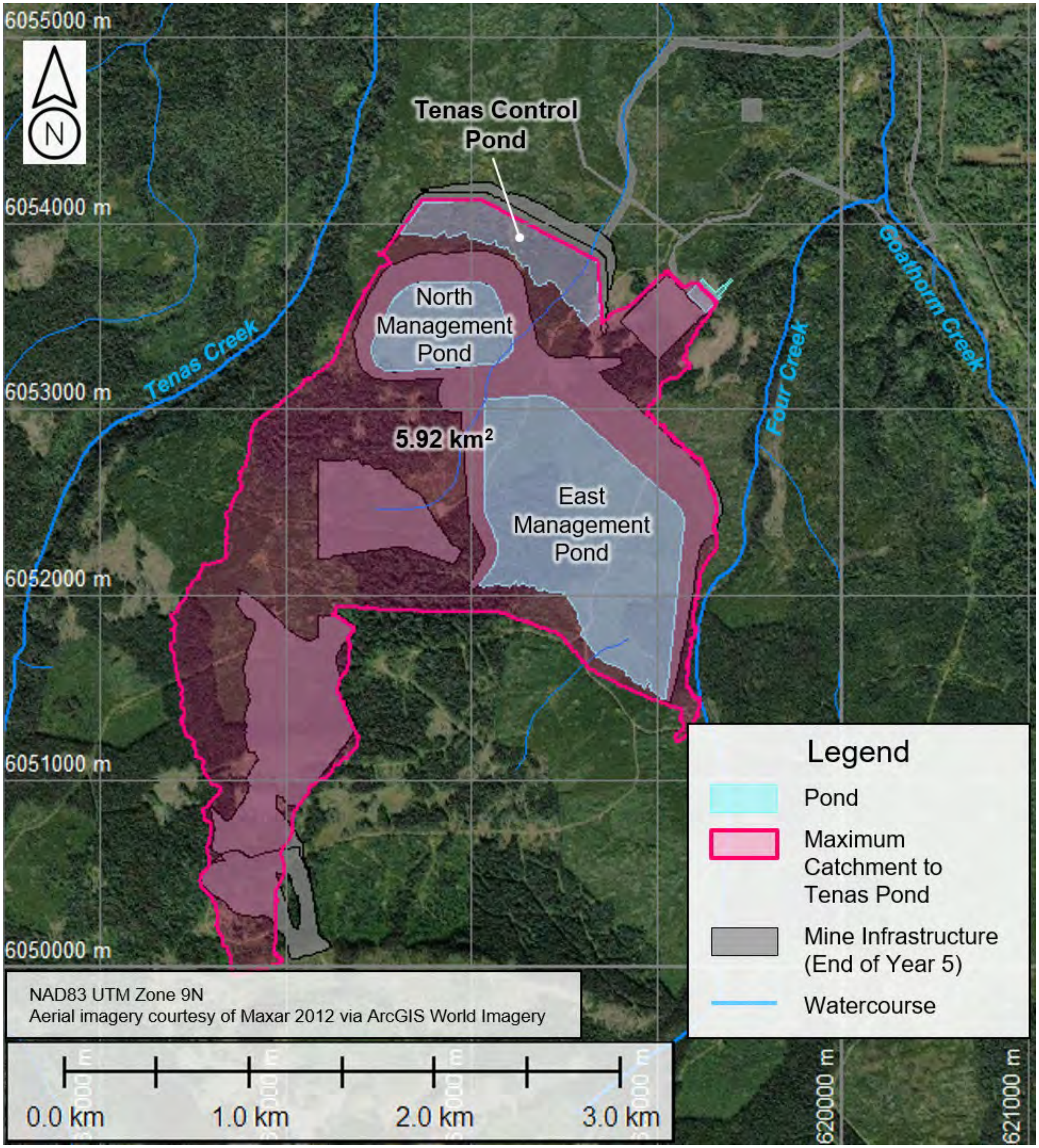
Monthly water balance results are presented in **Table 6.3-21**. A minimum post-freshet pond volume of 850,000 m^3 at the beginning of July is required to maintain a minimum volume of 110,000 m^3 throughout the 1 in 10-year dry condition. This volume becomes the target maximum operating volume after freshet each year, corresponding to a water level of 797.1 masl, to provide adequate water supply in the case of a dry year (maximum target operating volume post-freshet [V_{target}]).

Since the minimum pond volume provides sufficient water to maintain process water demand for an additional seven (7) months, the water balance results and target operating conditions for the Tenas Control Pond are conservative, allowing for uncertainty in evaporation rates, seepage rates, or more extreme dry conditions. Any excess water will be discharged to the environment, mimicking the natural hydrograph where possible. A detailed Operation, Maintenance and Surveillance (OMS) plan will be developed for the Tenas Control Pond in the detailed engineering phase, which will test the system under a wider range of conditions and look for opportunities to optimize the pond storage requirements.

Table 6.3-21: Tenas Control Pond Monthly Water Balance for one (1) in 10-year Dry Condition in Mine Year Five (5), during Critical Potentially Acid Generating (PAG) Placement Period

Month	Monthly Runoff (mm)	Pond Flow Rates [m^3/month]						End of Month Pond Volume (m^3)
		Runoff Inflow volume	CPP Water Demand	Management Pond Demand	Minimum Discharge	Seepage Loss	Net Inflow	
Jul[1]	12	69,200	-15,000	-62,000	-8,300	-49,600	-67,400	782,600
Aug	9	52,400	-15,000	-62,000	-8,300	-49,600	-84,200	698,300
Sep	10	58,000	-15,000	-60,000	-8,300	-48,000	-75,000	623,300
Oct	14	81,800	-15,000	-62,000	-8,300	-49,600	-44,800	578,500
Nov	10	58,800	-15,000	-60,000	0	-48,000	-64,200	514,300
Dec	4	24,400	-15,000	-62,000	0	-49,600	-102,200	412,100
Jan	3	20,300	-15,000	-62,000	0	-49,600	-106,300	305,800
Feb	4	21,700	-15,000	-56,000	0	-44,800	-94,100	211,700
Mar	6	32,900	-15,000	-62,000	0	-49,600	-93,700	118,000
Apr	27	159,600	-15,000	-60,000	0	-48,000	36,600	154,500
May	60	355,600	-15,000	-62,000	-8,300	-49,600	219,000	373,600
Jun	19	112,700	-15,000	-60,000	-8,300	-48,000	-20,300	353,300

Source: *SRK 2021j*
Notes: *CPP=Coal Processing Plant; m^3=cubic metre; mm=millimetre*
1. *initial pond volume at start of July is 850,000 m^3*



Source: *SRK 2021j*

Figure 6.3-5: Tenas Control Pond catchment area, Year 5, during critical potentially acid generating (PAG) placement period

6.3.5.5 Pumping Rate

The Tenas Control Pond includes two (2) pumping systems to discharge water either to Goathorn Creek tributary (PMP_SYS-01) or to the upstream management ponds (PMP_SYS-02). Pumping systems are described in **6.3.8**. The design flow rate for both systems was selected to discharge the mean annual runoff inflow over a five (5)-month period (May through September). This flow rate was calculated based on Equation 4:

Q_(Pumping Rate)=(MAR x Area-Annual CPP Water Demand)/(5 months) - Equation 4

*Where the pond catchment area is presented in **Figure 6.3-6**, MAR is the mean annual runoff depth of 219 mm presented in **Table 6.1-9**, and the annual CPP water demand is 180,000 m^3 based on the water balance in **Table 6.3-20**. The average pumping rate was calculated to be 267,350 m^3/month, or 0.1 m^3/s (including a factor of safety of 1.2). This discharge rate also meets the minimum discharge requirement stipulated by sewage treatment plant of 8,300 m^3/month, as described in **6.3.5.2** and in (Radloff 2021).*

The pumping system must also meet the selected performance standard in relation to recovery after a flood event. A flood recovery target of seven (7) days was selected, during which sufficient pump capacity is required from the Tenas Control Pond to discharge the 1 in 10-year event inflow volume. Based on the event volume of 119,000 m^3 and the pump capacity of 0.1 m^3/s, two (2) parallel pumping systems will be required to dewater the inflow volume with 7 days. Since two (2) systems will be in-place throughout operations to send water to both the management ponds and to Goathorn Creek, the flood recovery performance standard will be achieved. In the event of a flood, the pumping system from the Tenas Control Pond to the management pond (PMP_SYS-02) would be temporarily directed to discharge to Goathorn Creek in parallel to PMP_SYS-01. It is recommended that a back-up system from Tenas Control Pond to Goathorn Creek (PMP_SYS-01) be available onsite throughout operations in case of pump malfunction. This pumping rate excludes CPP water demand, which will operate on a separate system.

6.3.5.6 Sedimentation Capacity

The minimum available retention time in the Tenas Control Pond for sedimentation was estimated as 302 hours based on the minimum pond volume and typical pumped discharge rate (110,000 m^3 and 0.1 m^3/s, see **6.3.5.3** and **6.3.5.5**), which exceeds the minimum time required based on the criteria described in **6.3.4.1** (Equation 1) of 84 hours, calculated using a depth of 6.1 m corresponding to the minimum storage volume. If the minimum storage volume is depleted, sedimentation criteria will still be met up to a minimum operating elevation of 789.2 masl (equivalent to approximately 20,000 m^3 of storage).

6.3.5.7 Contingency Storage and Pond Spillway Invert

A contingency storage volume was selected to provide operational flexibility to control the rate of discharge to Goathorn Creek. The contingency storage volume was selected to be the volume associated with the one (1) in 10-year flood event.

The inflow volume is based on the maximum direct pond catchment area of 4.69 km^2, which occurs in Year 1 during the Operation Phase of the North Management Pond and construction of the East Management Pond (**Figure 6.3-3**). At this time, the C-02 channel will be constructed, diverting upstream runoff towards Four Creek, which was designed to convey up to the 200-year return period flows. This area is smaller than the catchment used for the water balance since it does not include runoff contributing to upstream management ponds or the open pit areas, which would attenuate flows during a short-duration runoff event but contribute to monthly inflow volumes with pumps in place.

Based on the maximum direct pond catchment area and the hydrology assumptions described in **6.3.1**, the 1 in 10-year flood volume was calculated to be 119,000 m^3.

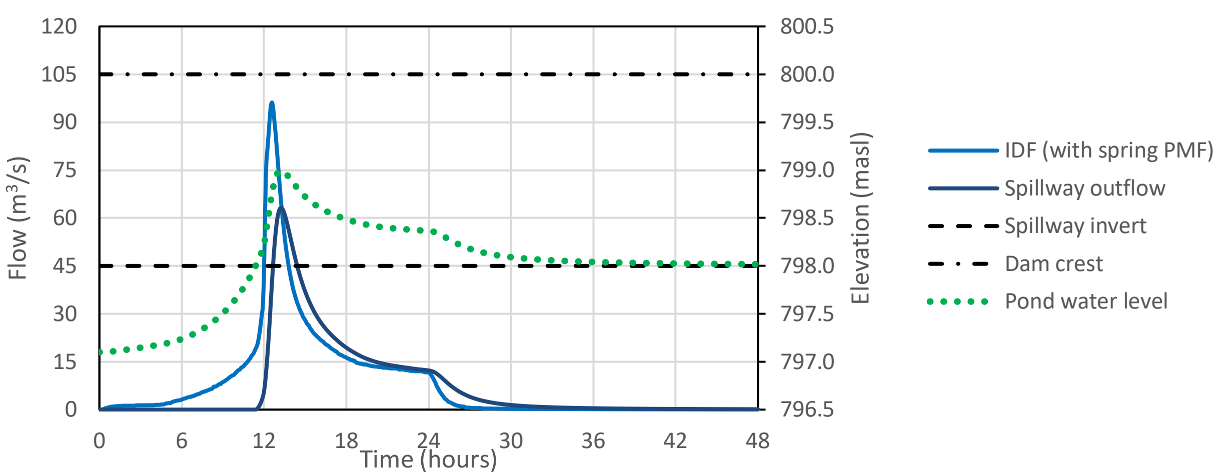
The spillway invert elevation was selected as the sum of the 1 in 10-year flood volume and the target operating post-freshet volume, calculated to be 850,000 m^3 (**6.3.5.4**). Based on the combined storage volume of 969,000 m^3, the corresponding water level from the stage-storage curve in **Appendix 13.11-C Stage-Storage Relationships** is 797.6 masl. A spillway invert of 798 masl was selected, which increases the contingency storage to 210,000 m^3 and providing a combined total storage capacity of 1,060,300 m^3.

6.3.5.8 Spillway Sizing and Freeboard

The emergency spillway was designed to convey the IDF based on the Tenas Control Pond dam classification while maintaining the minimum freeboard requirements defined in **6.3.3.4**. The IDF was selected to be 2/3 between the 1,000-year flood and the PMF, based on a CDA (2013) dam consequence classification of Very High. Both the spring snowmelt-dominated PMF and the summer rainfall-dominated PMF events were modelled in HEC-HMS, as described in **6.3.1**. It was assumed that all upstream infrastructure, including the C-02 channel, have failed in the event of the IDF. The 200-year return period calibrated CN value of 70.1, for AMC III conditions, was applied to natural catchments (**Table 6.3-1**), and a CN of 99 was applied any potentially ponded area and a CN of 98 for pads.

Two (2) scenarios were considered to estimate the IDF – End of Year (E0Y) 1 and End of Mining (EOM) (EOY21), as shown in **Figure 6.2-2** and **Figure 6.2-6** respectively. The catchment area for the EOY01 phase during operations is 8.25 km^2 (including North Management Pond), which assumes C-02 has failed, where direct runoff occurs from the sub-catchments except the North Management Pond area which is attenuated by the pond itself. This phase resulted in higher peak flow results compared to EOM and was considered the critical phase for the Tenas Control Pond spillway sizing. The resulting IDF was routed assuming that the initial water level is at the target maximum operating level of the Tenas Control Pond (797.1 masl).

Figure 6.3-6 presents the inflow hydrograph with the spring IDF, which produces a marginally higher peak and volume than summer IDF, as well as the outflow hydrograph through the spillway and water level of the Tenas Control Pond.



Source: *SRK 2021j*

Figure 6.3-6: Routing of the inflow design flood (IDF) through the Tenas Control Pond spillway

A spillway base width of 30 m was selected to achieve the minimum freeboard requirements with a dam crest elevation of 800 masl.

Erosion protection for the spillway was evaluated with a 1% longitudinal slope through the dam, and a 33% (3:1 slope ratio horizontal to vertical [H:V]) slope along the downstream face of the embankment. Channel velocities were calculated iteratively based on calculated Manning's roughness values and the selected riprap size, as described in **6.3.2.1** for engineered channels.

Results for spillway design, including riprap, along with freeboard evaluation are shown in **Table 6.3-22**.

Table 6.3-22: Tenas Control Pond Spillway and Freeboard Results

Parameter	Result
IDF Peak Inflow [m^3/s]	96.2
IDF Peak Outflow through spillway [m^3/s]	63.2
Spillway Base Width [m]	30
IDF Maximum Water Level [masl]	799.0
Minimum Freeboard [m]	0.38
Available Freeboard during IDF [m]	1.0
Velocity during IDF through Spillway [m/s]	2.22
Spillway Riprap D_{50} [m]	0.15
Velocity during IDF along Embankment Channel [m/s]	5.30
Embankment Channel Riprap D_{50} [m]	0.65

Source: *SRK 2021j*
Notes: *D_{50}=mean rock size for which 50% of rocks are smaller; IDF=inflow design flood; m=metre; masl=metres above sea level; m^3/s=cubic metre per second*

6.3.5.9 Summary of Tenas Control Pond Design

Table 6.3-23 summarizes design for the Tenas Control Pond.

Table 6.3-23: Summary Tenas Control Pond Design

Design Details			
Hydrologic Design			
1 in 10-year Peak Inflow (m^3/s)	6.4	IDF Peak Inflow (m^3/s)	97.0
1 in 10-year Storm Volume (m^3)	118,890	IDF Storm Volume (m^3)	1,448,730
1 in 10-year Max Water Level (m)	793.0	IDF Max Water Level (m)	798.8
1 in 10-year Peak Outflow (m^3/s)	0.10	IDF Peak Outflow (m^3/s)	74.2
Sedimentation Design			
Required Retention Time (hrs)	84	Available Retention Time (hrs)	302
Required Pond Surface Area[(1)] (m^2)	6,067	Available Pond Surface Area (m^2)	61,400

Design Details			
Pond Operating Volumes			
Minimum Storage Volume (V_{min}) (m^3)	110,000	Maximum Target Operating Volume, (V_{Target}) (m^3)	850,000
Contingency Storage Volume (V_{10yr}) [m^3]	210,300	Maximum Target Operating Level, (masl)	797.1
Pump Intake Elevation (masl)	792	Pumping Rate (m^3/s)	0.10
Spillway Invert (masl)	798	Total Storage Capacity to Spillway (m^3)	1,060,300
Dam Crest Elevation (masl)	800	Total Capacity to Dam Crest (m^3)	1,611,100
Spillway Design			
Spillway Base Width (m)	30.0	Spillway Side Slopes (H:V)	10:1
Spillway Riprap D_{50} (m)	0.15	Embankment Channel Riprap D_{50} (m)	0.65
Minimum Required Freeboard during IDF (m)	0.38	Available Freeboard during IDF (m)	1.0

Notes: *D_{50}=mean rock size for which 50% of rocks are smaller; H:V=slope ratio horizontal to vertical; IDF=inflow design flood; m=metre; masl=metres above sea level; m^3/s=cubic metre per second*
1. Minimum and available pond surface areas are based on the lowest expected pond levels, which coincide to the minimum pond volume of 110,000 m^3 at the pump intake elevation of 792 masl

6.3.6 Management Ponds

6.3.6.1 Design and Objectives

The purpose of the management ponds is to mitigate ML/ARD at the Project by maintaining a water cover above the impounded processed and unprocessed mine rock elevation, reducing the potential for oxidation of PAG materials. The effectiveness of sub-aqueous disposal of the PAG material is described in the water quality model (SRK 2021b) and the ML/ARD management plan (SRK 2021i).

There are three (3) management ponds for the Tenas Project: North Management Pond, East Management Pond and West Management Pond. Stage-storage relationships are presented in **Appendix 13.11-C Stage-Storage Relationships**.

The management ponds are partially lined storage facilities impounded by rockfill and overburden embankments (**6.3.3.5**). The base of each facility along with the upstream dam face will be lined, reducing seepage loss to groundwater. Buttresses will be constructed along the toe of each dam over time as suitable mine rock becomes available (**S1.0-C1 Description of Project** in the **EAC Application**).

Management ponds are constructed in stages, beginning with the North Management Pond in Year 0, providing containment for PAG material during Year One (1) and Year Two (2) of the Operation Phase. The North Management Pond dam will be a ring-dyke, located directly south of the Tenas Control Pond and north of the subsequent management ponds. As placement of PAG material proceeds in the North Management Pond, the East Management Pond dam is constructed, which will provide containment on three (3) sides, with a separation dam from the final management pond to the west. PAG placement will continue in the East Management Pond from Year 2 through 7. The West Management Pond will consist of both an excavated cell and an embankment, encompassing the northern extents of the open pit. Staging of open pit mining will be developed such that PAG backfill and flooding in the northern area may begin without impacting mining sequence farther south. PAG placement will continue in the West Management Pond from Year Seven (7) through 21 (end of mining).

Processed rock consists of all material that has gone through the CPP but is not processed coal. All processed rock will follow the deposition schedule of PAG material into the management ponds, designed to maintain water cover over PAG materials.

Once PAG placement is complete within each management pond, a minimum of 1.0 m layer of non-PAG rock will be placed, followed by a minimum of 0.3 m of overburden and topsoil. The non-PAG rock, overburden, and soil covers are intended to reduce evaporative losses from the facilities, while initiating progressive closure by returning the covered area to a similarly forested land use to pre-mining conditions. Soil covers will be graded towards the spillway locations, with engineered infiltration channels designed to maximize water flowing through the mine rock and soil, promoting long-term PAG saturation. **Appendix 13.11-D Soil Cover Memo** provides additional details on the soil cover design and objectives.

Spillways were designed for all management ponds based on the dam classifications presented in **6.3.3.1** and described in **Appendix 13.11-B Dam Breach Assessment.** In all cases, the IDF was selected to be 2/3 between the 1,000-year return period flood and the PMF. Normal and minimum freeboards were calculated for each facility an accordance with CDA guidelines (see **6.3.3.4**).

During the Operation Phase, the spillway alignments of the East Management Pond and West Management Ponds will intersect the main haul road from the open pit to the CPP. Based on the design of the management ponds, it is intended that water levels reach the spillway inverts and discharge by gravity instead of relying on pumps to facilitate drainage towards Tenas Control Pond. As such, a series of culverts will be required beneath the haul road to maintain access during normal flow conditions. Culverts are described in **6.3.9**.

Once saturated, both PAG and NAG rock are assumed to be 30% water by volume while processed rock is assumed to be 15% water by volume. **Table 6.3-24** presents the deposition schedule for PAG and processed rock, and **Table 6.3-25** presents the deposition volumes and associated elevations for each management pond.

Table 6.3-24: Management Pond Deposition Schedule

Management Pond	PAG and Processed Rock Deposition (start/end)
North Management Pond	Q3 Year -1 to Q2 Year 2
East Management Pond	Q2 Year 2 to Q1 Year 7
West Management Pond	Q1 Year 7 to Q4 Year 21

Source: *SRK 2021j*
Notes: *PAG=potentially acid generating; Q=quarter*

Table 6.3-25: Management Pond Design Volumes and Elevations

Parameter	North Management Pond	East Management Pond	West Management Pond
Total Saturated PAG Material Volume (m^3)	2,386,000	11,561,000	27,432,000
Total Saturated Processed Rock Volume (m^3)	344,000	986,000	3,006,000
Top of PAG Elevation (masl)	825.3	847.4	847.4

Parameter	North Management Pond	East Management Pond	West Management Pond
Non-PAG Cover Thickness (m)	1.5	1.5	1.5
Non-PAG Cover Volume (m^3)	427,000	1,580,000	1,441,000
Top of Non-PAG Elevation (masl)	826.8	848.9	848.9
Overburden Cover Thickness (m)	1.2	1.1	1.1
Overburden Cover Volume (m^3)	338,000	1,222,000	1,138,000
Dam Crest Elevation (masl)	830.0	852.0	852.0

Source: *SRK 2021j*
Notes: *masl=metres above sea level; m=metres; m^3/s=cubic metre per second; non-PAG=non potentially acid generating; PAG=potentially acid generating*

6.3.6.2 Spillway Sizing and Freeboard

All management ponds will operate with an emergency spillway throughout operations and post-closure, designed in accordance with CDA requirements (see **6.3.3.3**). Spillway alignments were selected to facilitate water conveyance from south to north across the Project footprint, routing water towards the Tenas Control Pond. The North Management Pond spillway discharges directly into the Tenas Control Pond, while the East and West management pond spillways discharge into the North Management Pond.

Culverts will convey overflows from the East Management Pond and West Management Pond towards the North Management Pond, crossing the haul road. Flood events more than the capacity of the culverts and up to the IDF will be conveyed via open-channel spillways, which will result in water flowing over the haul roads under extreme conditions. Riprap will be placed across the length of the spillway channels, with additional compacted gravel along the haul road sections to allow vehicle access. After extreme flood events, some re-grading may be required along the spillway sections over the haul road, however any mobilized material will be captured in either the North Management Pond or the Tenas Control Pond downstream.

The management pond spillways were designed for both operational and closure conditions. Freeboard was evaluated based on CDA (2013) recommendations, as described in **6.3.3.4.**

The operational spillway configuration for the East Management Pond and West Management Pond will consist of culverts (see **6.3.9**) and an overflow channel to convey the IDF (**Drawings 17** and **18** of **Appendix 13.11-A Engineering Drawings**). Overflow channel inverts were selected to maintain the minimum freeboard requirements while maximizing depth of flow through the culverts.

At the end of the Operation Phase, the management ponds will be reclaimed with soil covers and vegetated. The haul road will be decommissioned, and all culverts removed, and spillway invert elevations for both East Management Pond and West Management Pond will be lowered to the top of overburden. A Post-closure Phase condition IDF analysis was prepared based on final catchment contributions and final spillway requirements were evaluated.

A summary of the spillway designs is presented in **Table 6.3-26**.

Table 6.3-26: Design Criteria for Management Pond Spillways

Parameter	North Management Pond	East Management Pond	West Management Pond	Reference
Dam Classification	Very High			**Appendix 13.1-B Dam Breach Assessment**
Inflow Design Flood	2/3 between 1,000 return period event and PMF.			CDA (2007)
Freeboard	1 in 1,000 wind at max operating level, and 1 in 2 wind during passage of the IDF			CDA (2007)
Operational Spillway				
Minimum Overburden Thickness between non-PAG Cover and Culverts	n/a	0.5	0.5	SRK and TCL judgement
Minimum Spillway Base Width	2.0 m	2.0 m	2.0 m	SRK judgement and for ease of construction and maintenance
Spillway Side Slopes	10:1 H:V	10:1 H:V	10:1 H:V	SRK judgement and to allow traffic during dry conditions
Longitudinal Slope Through Dam	1%	1%	1%	SRK judgement
Longitudinal Slope of Embankment Channel	33%	33%	33%	Initial dam configuration, prior to buttress construction
Closure Spillway				
Minimum Spillway Base Width	2.0 m	2.0 m	2.0 m	SRK judgement and for ease of construction and maintenance
Spillway Side Slopes	10:1 H:V	10:1 H:V	10:1 H:V	SRK judgement and to allow traffic during dry conditions
Longitudinal Slope Through Dam	1%	1%	1%	SRK judgement
Longitudinal Slope of Embankment Channel	33%	33%	33%	Initial dam configuration, prior to buttress construction
Erosion Protection				
Manning's Roughness for Riprap	Varies, based on riprap gradation (0.03 to 0.05)			(Abt. et al. 1988)
Riprap Thickness	2 x D_{50}			(BC MOE 2000)
Geotextile	Non-woven, for riprap sections only			SRK judgement

Source: *SRK 2021j*
Notes: *%=percent; BC MOE=British Columbia Ministry of Environment; CDA=Canadian Dam Association; H:V=slope ratio horizontal to vertical; IDF=inflow design flood; m=metre; PMF=Probable Maximum Flood; TCL=Telkwa Coal Limited*

A HEC-HMS model was developed in accordance with inputs and assumptions outlined in **6.3.3.2** for the Operation, and Post-closure phase IDF as well as the lower return period culvert design floods for the East Management Pond and West Management Pond. Both an operational critical catchment condition and a closure catchment condition were simulated. The CN selected for the IDF assume AMC III conditions and conservatively use the calibrated results for the 200-year flood instead of higher return periods (**Table 6.3-1**). Time of concentration for each natural catchment was calculated and a minimum time of concentration of 10 minutes was applied to any ponded area. Catchment areas are presented in **Figure 6.3-7**. Note that all upstream diversion or collection infrastructure are assumed to fail in the event of the IDF, which exceeds the structures' design criteria.

During passage of the IDF in operations, it was assumed that all culverts were not functional (e.g., because of blockage). Both the spring and summer PMF cases were considered for operational and closure conditions. The inflow hydrograph is presented in **Figure 6.3-8, Figure 6.3-9** and **Figure 6.3-10** for the North Management Pond, East Management Pond and West Management Pond, respectively, along with the final outflow hydrograph based on selected spillway configuration. In the case of the North Management Pond, the operational spillway is more critical in terms of the IDF, and no changes will be required at closure. Spillway and freeboard results for operational conditions are presented in **Table 6.3-27** while closure conditions are presented in **Table 6.3-28**.

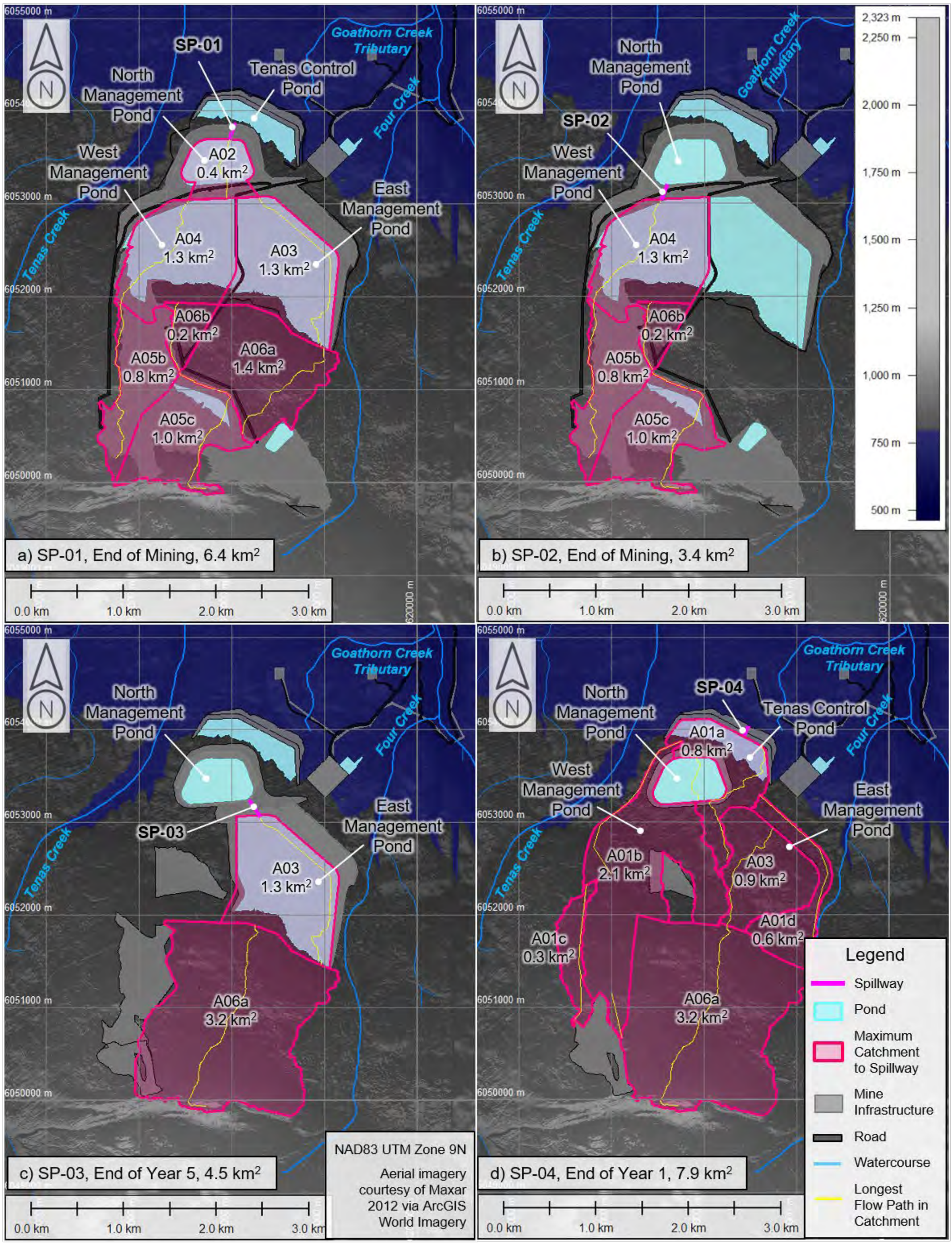


Figure 6.3-7: Management pond spillway catchment map

Table 6.3-27: Management Pond Operational Spillway and Freeboard Results

Parameter	North Management Pond	East Management Pond	West Management Pond
Spillway ID	SP-01	SP-03	SP-02
Critical Catchment Area (km^2)	6.4	4.5	3.4
Average Catchment time of Concentration (hour)	3.8	0.8	1.5
25-year Peak Inflow (m^3/s)	n/a	21.9	23.9
Diameter and Number (n) of Culverts Required	n/a	1.0 m diameter, n=14	1.0 m diameter, n=14
Culvert Invert Elevation (masl)	n/a	849.4	849.4
25-year Maximum Water Level (masl)	n/a	850.75	850.86
Overflow Channel Invert Elevation (masl)	828.0	850.8	851.0
IDF Peak Inflow (m^3/s)	22.8(1)	73.7	70.6
IDF Peak Outflow through Overflow Channel (m^3/s)	18.6	12.5	6.2
Spillway Base Width (m)	19.0	26.0	11.5
IDF Maximum Water Level (m)	828.6	851.2	851.4
Minimum Freeboard (m)	0.31	0.56	0.47
Available Freeboard during IDF (m)	1.40	0.80	0.60
Velocity during IDF through Spillway (m/s)	1.71	1.38	1.32
Spillway Riprap D_{50} (m)	0.10	0.10	0.10
Velocity During IDF along Embankment Channel (m/s)	4.12	3.36	3.34
Embankment Channel Riprap D_{50} (m)	0.40	0.25	0.25

Source: *SRK 2021j*
Notes: *D_{50}=mean rock size for which 50% of rocks are smaller; IDF=inflow design flood; km^2=square kilometre; m=metre; masl=metres above sea level; m^3/s=metres per second*
1 includes attenuated flow from East Management Pond and East Management Pond

Table 6.3-28: Management Pond Post-Closure Spillway and Freeboard Results

Parameter	North Management Pond	East Management Pond	West Management Pond
Spillway ID	SP-01	SP-03	SP-02
Critical Catchment Area (km^2)	6.4	3.0(1)	3.4
Average Catchment Time of Concentration (hr)	3.7	0.7	1.5
IDF Peak Inflow (m^3/s)	23.5	67.5	70.6
IDF Peak Outflow Through Spillway (m^3/s)	17.2	7.9	8.8
Spillway Base Width (m)	25.0	26.0	22.5
IDF Maximum Water Level (m)	828.50	850.30	850.35
Minimum Freeboard (m)	0.31	0.56	0.47

Parameter	North Management Pond	East Management Pond	West Management Pond
Available Freeboard During IDF (m)	1.50	1.70	1.65
Velocity During IDF Through Spillway (m/s)	1.56	1.17	1.27
Spillway Riprap D_{50} (m)	0.10	0.10	0.10
Velocity During IDF Along Embankment Channel (m/s)	3.73	2.82	3.09
Embankment Channel Riprap D_{50} (m)	0.35	0.25	0.25

Source: *SRK 2021j*

Notes: *D_{50}=mean rock size for which 50% of rocks are smaller; IDF=inflow design flood; km^2=square kilometre; m=metre; masl=metres above sea level; m^3/s=metres per second*

1 corresponds to End of Mining (EOM) catchment area

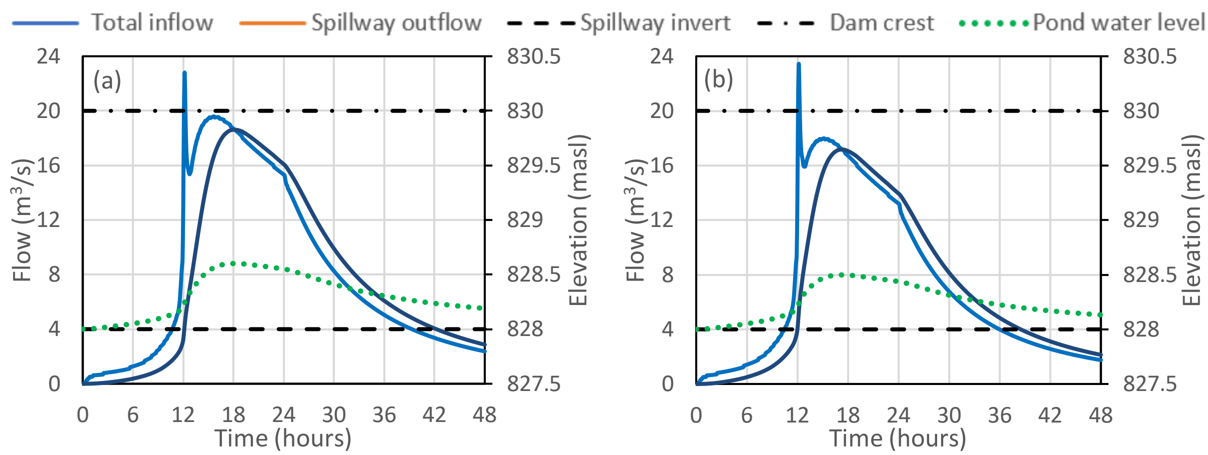


Figure 6.3-8: North Management Pond inflow design flood (IDF) hydrographs. (a) Operation Phase conditions hydrographs (b) Post-closure Phase conditions hydrographs

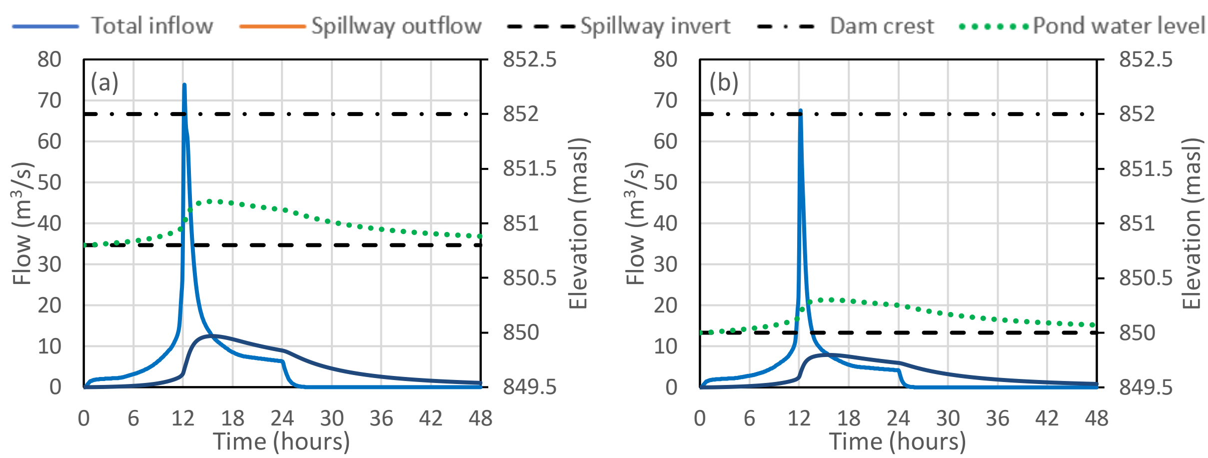


Figure 6.3-9: East Management Pond inflow design flood (IDF) hydrographs. (a) Operation Phase conditions hydrographs (b) Post-closure Phase conditions hydrographs

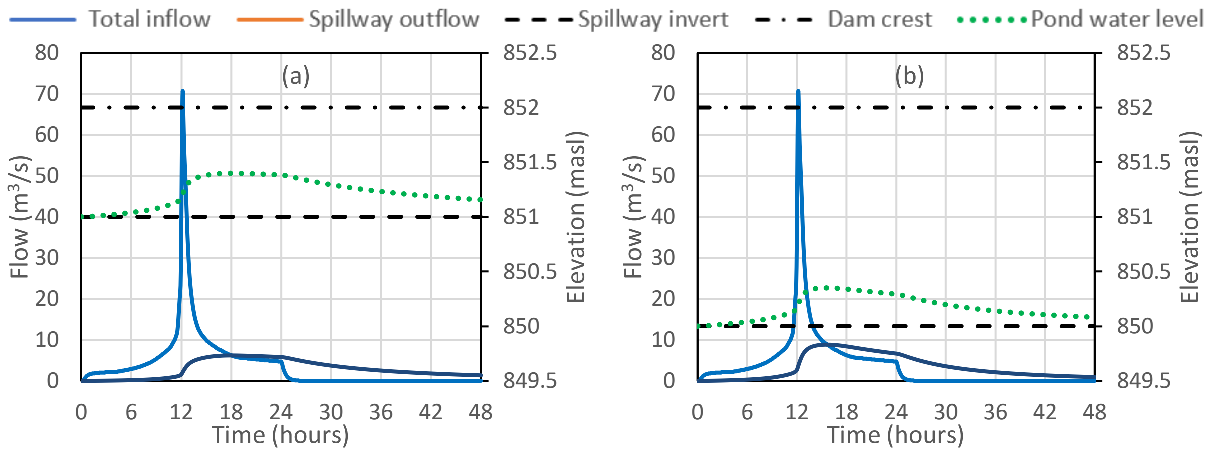


Figure 6.3-10: West Management Pond inflow design flood (IDF) hydrographs. (a) Operation Phase conditions hydrographs (b) Post-closure Phase conditions hydrographs

6.3.6.3 Management Pond Operations

Management ponds will require a minimum water cover thickness above placed PAG and processed rock to prevent oxidation and risk of ML/ARD. However, an excess of stored water may pose an increased consequence of dam failure and may also impede mine rock deposition. For this reason, operating criteria for the management ponds have been developed to control water levels in each facility.

Objectives of the management pond controls are as follows:

- Achieve and maintain the minimum 1.0 m water cover on top of all PAG material within 1-year of rock exposure from the open pit;
- Minimize potential dam breach failure consequence and enable PAG deposition by discharging excess water via the Tenas Control Pond;
- Pumping systems will be in-place throughout operations to control water levels within each management pond. Pump controls will be dictated by regular surveys of PAG levels and daily water level readings. Pumping systems will operate as follows:
  - Activate pump from Tenas Control Pond to any given management pond when that ponds' water cover depth is less than 1.0 m; and
  - Activate pump from any given management pond to the Tenas Control Pond when water cover depth exceeds 1.2 m.

During snowmelt, or extreme precipitation events, it is expected that water cover depths in any given management pond may temporarily exceed the pump activation level of 1.2 m above top of PAG. For dam breach modelling, it was assumed that 2.0 m of water depth would be in-place, with additional assumptions for conservative modelling.

PAG deposition and placement strategies are detailed in **S1.0-C1 Description of Project** in the **EAC Application**.

6.3.7 Other Project Infrastructure

The Project will consist of three (3) additional water storage facilities: the Potable Water Storage Pond; Wastewater Storage Pond; and Soil Treatment Facility Pond. Water management in the quarry areas is also discussed in the following subsections.

6.3.7.1 Potable Water Storage Pond

The Potable Water Storage Pond will serve as an intake to the Potable Water Treatment Plant for Minesite operations. The Potable Water Treatment Plant will require 17.3 m^3/day year-round, from a source with reliable water quality. Potable water plant design was prepared by Radloff (2021), including the pump intake and pipeline design from the Potable Water Storage Pond to the Potable Water Treatment Plant, which will be located near the CPP.

The Potable Water Storage Pond will be constructed along the alignment of channel C-02 and will consist of an over-excavated cell, starting at the southeast extent of C-02. During winter months, it was assumed that up to 1.0 m of water in the cell could freeze (British Columbia Ministry of Agriculture and Lands [BC MAL] 2006), reducing the available capacity and available water to meet potable water demand. The geometry was selected to maintain a minimum of 8 months of potable water demand (approximately 4,250 m^3 of water) beneath the maximum ice cover in the cell.

Cell geometry is presented in Figure 9 of **Appendix 13.11-A Engineering Drawings**. Total capacity to the spill point (i.e., invert of C-02) in the cell, without ice, will be approximately 7,200 m^3, sufficient to provide 415 days of Potable Water Treatment Plant operations.

The Potable Water Storage Pond cell will discharge into the C-02 channel, which is designed for the one (1) in 200-year event. An overflow weir will also be constructed as part of the Potable Water Storage Pond to convey excess flows to the East Management Pond. Design criteria and objectives of the overflow weir are described in **6.3.2.2**.

It is anticipated that the cell will remain near full during the open water season based on the expected average runoff yield of 600 to 3,300 m^3/day. Inflows are based on the water balance outputs (SRK 2021b) for channel catchment area, which ranges from 3.2 km^2 at the beginning of the Operation Phase to a final value of 1.6 km^2 towards the end of the Operation Phase as the open pit footprint expands farther east.

6.3.7.2 Wastewater Storage Pond

The Wastewater Storage Pond is a 5,000 m^3 storage facility located within the MIC pad, within the catchment of the CPP Sedimentation Pond. The design of the Wastewater Storage Pond is described in **S1.0-C1 Description of Project** in the **EAC Application**. In summary, it has been designed to hold 12 months of effluent from the Wastewater Treatment Plant or 5,000 m^3 to allow discharge to only occur in the open water season. Discharge occurs via a pumped pipeline to the tributary of Goathorn Creek and mixes with pumped outflows from the Tenas Control Pond (refer to Tenas Control Pond water demand in **6.3.5.2**).

6.3.7.3 Soil Treatment Facility Pond

A Soil Treatment Facility is required for treatment of petroleum hydrocarbon contaminated soil. Soil Treatment Facility design is described in SRK 2021c. BC MOE guidance does not specify criteria for minimum storage capacity for stormwater and snowmelt. The design of the Soil Treatment Facility Pond adopted the criterion based on Northwest Territory guidelines (Land and Water Boards of the Mackenzie

Valley [LWBMV] 2020): The facility is designed to contain the 24-hour, 1 in 10-year return period event plus the snowmelt equivalent to the average annual snow accumulation.

The area is situated between the Wastewater Treatment Plant and the run-of-mine (ROM) stockpiles, within the catchment area of the CPP Sedimentation Pond. Any overflows from the Soil Treatment Facility Pond will therefore be captured by the CPP Sedimentation Pond and managed up to the one (1) in 200-year event.

6.3.7.4 Quarry Development

BMPs will be included during quarry development to control sediment and runoff. Upstream runoff will be diverted around working areas to reduce water into the quarry using temporary diversion berms. The base of the quarry floor will include a low point to capture runoff from the working area. Overflows from the low point will be discharged to the environment when acceptable. A minimum storage volume will be maintained to facilitate sedimentation up to the 1 in 10-year event. Storage details and discharge options will be developed in the detailed engineering stage.

6.3.8 Pumping Systems and Pipelines

The water management design includes six (6) types of pump and pipeline systems to circulate water throughout the life-of-mine. **Table 6.3-29** summarizes the pumping systems for the Project.

Table 6.3-29: Tenas Project Pumping System Description

Pumping System	Description
PMP_SYS-01	Tenas Control Pond discharge to environment (Goathorn tributary). Activated when Tenas Control Pond exceeds maximum target operating level of 797.1 metres above sea level (masl)
PMP_SYS-02	Tenas Control Pond discharge to Management Ponds to maintain minimum water cover. Activated when water cover in any given pond is less than 1.0 metre (m).
PMP_SYS-03	Management Ponds discharge to Tenas Control Pond to maintain maximum target water cover depth. Activated when water cover in any given pond exceeds 1.2 m.
PMP_SYS-04	CPP Sedimentation Pond discharge to Tenas Control Pond
PMP_SYS-05	Sedimentation Pond discharges to environment
PMP_SYS-06	Open pit to the active management pond, designed to dewater the 1 in 2-year flood over a 24 hour duration in 2 days from the open pit area at the time of the flood

Pumping systems from the Tenas Control Pond to the CPP, and pumping infrastructure associated with water treatment plants for potable water and sewage treatment are not included in the SRK design scope.

The following subsections summarize conveyance requirements and pump and pipeline sizing for each system outlined in **Table 6.3-29**.

6.3.8.1 Pump Design Details

The design flow rate for each pumping system is summarized in the following bullet points:

- PMP_SYS-01 and PMP_SYS-02 have the same design capacity, developed based on the annual average inflows to the Tenas Control Pond minus the CPP demand (see **6.3.5.5**). The flow rate represents the expected discharge volume over a five (5)-month open water season, and was calculated to be 0.1 m^3/s, or approximately 9,000 m^3/day

- PMP_SYS-03 represents a mobile system that will be situated in the active management pond, as dictated by the current PAG deposition location. While each management pond is active, water more than the maximum target water cover depth (1.2 m) will be pumped to Tenas Control Pond for discharge offsite. This rate is selected to be the same as the flow rate from PMP_SYS-01, or 9,000 m^3/day, which was validated through the Water and Load Balance Modeling Report (SRK 2021b), also provided as **Appendix 13.5-B** of the **DMP**;
- PMP_SYS-04 is a contingency system to discharge water collected in the CPP Sedimentation Pond to the Tenas Control Pond. The CPP Sedimentation Pond was designed to provide sufficient retention time to remove 10-micron particles up to the 1 in 10-year inflow event, however based on the proximity of the CPP Sedimentation Pond to CPP and the Soil Treatment Facility, there is a risk that this water may be in contact with other contaminants. The PMP_SYS-04, therefore, provides a back-up solution to route all runoff from the CPP area towards the Tenas Control Pond, and controls the Project discharge towards Goathorn Creek instead of flowing by gravity into the smaller Four Creek (downstream of the CPP Sedimentation Pond). The pumping rate was sized to be 0.09 m^3/s, or approximately 7,800 m^3/day, based on sedimentation requirements outlined in **6.3.4.1**;
- PMP_SYS-05 will be in-place at each sedimentation pond, including the Explosives Magazine Sedimentation Pond, the Explosives Facility Sedimentation Pond, and the Rail Infrastructure Sedimentation Pond, enabling discharge to the downstream environment. The minimum pumping rates for each pond vary from 0.006 m^3/s to 0.03 m^3/s. Based on the low head requirements (less than 3.0 m of static head), all systems were designed equally, providing versatility and redundancy to operators, and enabling purchase of standard back-up pumps. The design rate for this system was selected to be 2,600 m^3/day based on the maximum of the three sedimentation ponds (Rail Infrastructure Sedimentation Pond) design rate; and
- PMP_SYS-06 will be a mobile pumping station that follows the active mining location during operations. Mining methods will result in natural depressions and low points throughout pit floor, providing temporary storage for rainfall events. Progressive backfilling of the pit will also alter the flow of runoff. The worst-case period for pump flow rate design was identified to be in the deepest portion of the open pit, in the footprint of the West Management Pond, when backfill in this area is minimized. The flow rate was calculated based on a 1 in 2-year return period 24-hour rainfall event, assuming 80% of precipitation is collected at the pit floor, and is dewatered in a 2-day period, which resulted in a flow rate of 10,900 m^3/day (0.13 m^3/s).

For pump characterisation, the following additional assumptions and calculations were completed for each system:

- Proposed pipeline alignments were selected to follow planned mine or haul roads, where possible, and reduce corners and bends;
- Static head was calculated based on the maximum elevation difference along the proposed pipeline alignment;
- Pipeline length was selected based on the selected alignment with an additional 20% contingency;
- Pipeline diameter was selected to facilitate a maximum expected velocity of 2 m/s based on the design flow rate;
- Head losses in the system were calculated based on Hazen Williams, with an assumed Hazen Williams roughness value of 120, representative of high-density polyethylene (HDPE) pipelines.

Additional singular losses value of five (5) was selected, which accounts for entrance/exit losses and bends in the pipeline;

- Pump efficiency was assumed to be 70%; and
- The number of stages along the pumped line were selected based on calculated pressure during the design flow, where an additional stage was incorporated when calculated pressure exceeded the pressure rating, assuming DR17 pipes.

Pump characterisation results are summarized in **Table 6.3-30**, including the design flow rate, pipeline length, and the calculated total head and power requirements. Detailed design of pumping systems and pipelines will be developed by a third party.

Table 6.3-30: Pump Design Summary

Pump ID	Intake Location	Discharge Location	Design Flow Rate [m^3/day]	Total Head [m]	No. of Stages	Power [HP]	Pipe Length [m]
PMP_SYS-01	Tenas Control Pond	Goathorn Tributary	9,000	25	1	50	340
PMP_SYS-02	Tenas Control Pond	Management Ponds	9,000	76	2	75	1650
PMP_SYS-03	Management Pond	Tenas Control Pond	9,000	75	2	100	1650
PMP_SYS-04	CPP Sedimentation Pond	Tenas Control Pond	7,800	14	1	25	880
PMP_SYS-05	Sedimentation Pond	Downstream Environment	2,600	5	1	1	30
PMP_SYS-06	Open Pit	Management Ponds	10,900	114	2	150	1200

Source: *SRK 2021j*
Notes: *HP=horsepower; m=metre; m^3/day=cubic metre per day; No.=number*

6.3.9 Road Crossings Design

During the Construction, and Operation phases of the project, haul roads and access roads will be constructed over low-lying points and collection channels. To facilitate traffic and allow drainage, conveyance culverts are proposed beneath service roads. Two (2) types of culverts were considered for the road crossing:

1. Channel culverts including a culvert crossing at the C-01 channel and the C-02 channel as well as crossing Goathorn Creek Tributary; and
2. Spillway culverts from East and West management ponds to the North Management Pond.

Figure 1 and 19 in **Appendix 13.11-A Engineering Drawings** illustrate the location of required road crossings along access roads which were positioned to maintain required drainage patterns, and the typical section for road crossings.

The Code specifies that all road crossings over stream be designed to convey the 1 in 100-year return period peak flow event. Only the crossing at the Goathorn Creek tributary is considered a natural stream. Design criteria were selected based on consequence of failure of each system.

The channel C-01 will cross the main haul road from the CPP to the management ponds and open pit. This crossing, identified as culvert CU-01, is not expected to be overtopped, due to the elevation of the haul road, however backwater could result in overtopping of the C-01 channel towards the CPP. This could result in uncontrolled discharge to the environment, and for this reason, the 100-year return period peak flow was used for CU-01 design.

The channel C-02 will cross the mine road upstream (south) of the intersection dam between the East Management Pond and West Management Pond (CU-02). An undersized culvert would result in overflows from C-02 into the open pit or into the West Management Pond, depending on the timing within the mine life. Local erosion could occur, but water would be controlled within downstream infrastructure. For this reason, a 25-year return period peak flow was used for sizing of the CU-02 culvert.

Both the East Management Pond and West Management Pond are expected to discharge excess water, once they have reached their maximum operating levels, towards the North Management Pond. This flow pathway will cross the haul road connecting the CPP to the open pit. If the discharge rate exceeds the capacity of these culverts (CU-03 from East Management Pond and CU-04 from West Management Pond), water would be conveyed within the emergency spillways designed for the IDF (refer to **6.3.6.2**). Minor erosion may be expected across the emergency spillway; however, the riprap will ensure structural stability is maintained. Since overflows will be controlled, the design event for these two (2) road crossings were selected to be the 25-year return period event.

The access road to the Explosive Facility will cross the Goathorn Creek Tributary which functions as the discharge conveyance channel from the Tenas Control Pond. Discharge more than the culvert capacity could result in erosion or potential wash-out of the Explosive Facility access road, which could result in loss of access for a temporary period and release of associated material sediment into Goathorn Creek. A 100-year return period was selected for the CU-05 design event. At closure, this road will no longer be required, and the culvert and road may be removed and replaced by a riprap swale.

All culverts were sized to maintain the maximum headwater depth to culvert diameter ratio (HW/D) below 1.5 (Federal Highway Administration 2019) during the design flood event.

The BC MFLNRO Engineering Manual requires that roads at 6-9% grade and with a slight erosion hazard have culverts placed every 250 metres (m) (BC MFLNRO 2018). Additional culverts can be included as needed along access roads within the Project footprint.

A summary of the design criteria culvert designs is presented in **Table 6.3-31**.

Table 6.3-31: Design Criteria for Road Crossings

Parameter	Description	Reference
CU-01, CU-05 Culvert Conveyance Capacity	1 in 100-year flood	SRK judgement
CU-02, CU-03 and CU-04 Culvert Conveyance Capacity	1 in 25-year flood	SRK judgement
Culvert slope	Variable, based on inlet and outlet conditions	SRK judgement
Maximum headwater depth to culvert diameter ratio	1.5	U.S. Department of Transportation (Federal Highway Administration, 2019)

Culvert crossings beneath service roads within the Project were sized using HY-8 software developed by U.S. Department of Transportation (Federal Highway Administration 2019). Inputs to the culvert hydraulics model includes the slope of the culvert, the dimensions, type of material, design inflow, and expected tailwater conditions. Circular culverts were optimized with a headwater constraint such that maximum headwater depth to culvert diameter ratio does not exceed 1.5 and the flow regime is governed by inlet control. The design flood was obtained using HEC-HMS with calibrated CN values (AMC II conditions) for associated return periods, assuming functional upstream diversion and collection channels. Description of the culvert inputs and design are detailed in **6.3.9**.

The CU-01, CU-02 and CU-05 culverts were sized as straight culverts using corrugated steel pipes (CSP). The diameter for these culverts were 1,600 mm, 1,400 mm, and 1,200 mm respectively. The slope and length of the culvert was based on available topography. The upstream water surface elevation and the inlet geometry represent the major flow control, i.e., inlet control. Critical depth occurs near the inlet and the flow regime immediately downstream is supercritical.

The East Management Pond and West Management Pond spillway culverts (CU-03 and CU-04 respectively) were analyzed as broken-back culverts as an alternative to steeply sloped culvert towards the North Management Pond. Double breaks were considered where the upper section (1% slope) collects flow, the steep section (33% slope) conveys flow across the embankment buttress and the runout section (1% slope) discharges water into North Management Pond (**Figure 19** in **Appendix 13.11-A Engineering Drawings**). The flow was inlet controlled for this configuration, but flat upstream slope with limited head resulted in large number of barrel requirements for 1,000 mm diameter culverts. Inlet elevations for both culverts were selected to provide a minimum of 0.5 m above the top of non-PAG cover to reduce water level fluctuations within non-PAG material and potential release of loading from drying and re-wetting of rock.

In addition, culverts will be placed through the division berm between East and West management ponds. These culverts would not be required to convey storm flows, which would be routed through the main discharge culverts, but would serve as a gravity flow mechanism between management ponds to facilitate water cover. Culverts would be controlled by a valve that would be left closed during large flood events to prevent erosion of downstream covers.

The culverts within the Project footprint are required during the Construction and Operation phases and are decommissioned for the Post-closure Phase. Given that roads will be kept through the Post-closure Phase to provide permanent access to the Project for monitoring purposes, CU-01, CU-02 and CU-05 culverts will be replaced with armoured swale crossings. All swales were designed to allow light-vehicle access with a minimum base width of 3 m, side slopes of 5H:1V and a maximum longitudinal slope of 0.5% to allow for road surfacing material to be stable post closure. Culverts CU-03 and CU-04 from East and West management ponds, respectively, will be removed at closure and replaced with trapezoidal channel spillways, as described in **6.3.6.2**.

The outlet velocities for both straight and broken-back culverts are high and erosion protection at the culvert outlet will be needed to avoid scour. In addition, the broken-back culvert on steep slopes can develop sections of sub-atmospheric (negative) and excess positive internal pressure that can affect structural condition and joints. Concrete boxes can be an alternative to this and require consideration in the detailed engineering design phase. **Table 6.3-32** summarizes the culvert details for the road crossings.

Table 6.3-32: Road Crossings Culvert Details

Parameter	CU-01	CU-02	CU-03	CU-04	CU-05
Upstream Structure	Channel C01	Channel C02	East Management Pond	West Management Pond	Goathorn Creek Tributary
Design Flood (Return Period)	100-year	25-year	25-year	25-year	100-year
Design Peak Flow (m^3/s)	20.5	6.4	21.9	23.9	3.7
Culvert Type	Straight	Straight	Broken-back	Broken-back	Straight
Culvert Inlet Invert Elevation (masl)	803.6	870.1	849.4	849.4	778.14
Culvert Outlet Elevation (masl)	801.4(1)	869.8	828.0(2)	828.0(2)	777.23
Longitudinal Slope (m/m)	1.8%	1.0%	1%, 33%, 1%(3)	1%, 33%, 1%(3)	3.0%
Diameter of Circular Culvert (mm)	1,600	1,400	1,000	1,000	1,200
Number of Culvert Barrels Required	4	2	14	14	2
Flow Control	Inlet control	Inlet control	Inlet control	Inlet control	Inlet control
Maximum Headwater Elevation (masl)	805.77	871.77	850.75	850.86	779.38
Maximum Headwater Depth to Culvert Diameter Ratio	1.35	1.19	1.27	1.40	1.03
Tailwater Depth (m)	1.46	0.57	n/a	n/a	0.17
Outlet Velocity	2.66	2.88	2.58	2.69	3.25
Maximum Velocity at Steep Section	n/a	n/a	7.56	7.75	n/a
Culvert Length (m)	120	30.0	135	135	30.0

Source: *SRK 2021j*

Notes: *%=percent; m=metre; m^3=cubic metre; masl=metres above sea level; n/a=not applicable*

1. Corresponds to downstream channel invert

2. Corresponds to overburden layer elevation of North Management Pond

3. Indicates slopes for upper, steep and runout sections respectively

6.3.10 Care and Maintenance (C&M)

Should the Project go into temporary care and maintenance (C&M), water monitoring and regular maintenance will continue as in regular operations. The following measures related to water management will continue:

- Active monitoring of management ponds and available water covers will continue throughout C&M, to control water levels;
- Keep pumping systems in-place at the open pit;
- Continue to discharge off-site to reduce total stored water;
- Regular dam and channel inspections; and
- Channel and spillway maintenance after large storm events.

6.3.11 Closure and Reclamation

Progressive reclamation of water management features will occur throughout the life-of-mine where possible, including:

- Installation of covers across each management pond upon completion of PAG material placement which will consist of variable thicknesses of non-PAG rock, overburden, and soil. The covers will be graded and vegetated, maximizing infiltration into the saturated PAG and non-PAG rock zones, and enabling gravity drainage towards the water management infrastructure inverts;
- Vegetation will be established within permanent engineered channels that are lined with turf reinforcement mats;
- Buttresses and dams will be vegetated after completion of mine rock placement at each facility. Forestry will not be established on dam portions of the management ponds;
- Toe drainage channels along each dam will remain in-place until monitoring shows that water quality is acceptable for direct discharge to the environment. It is expected that channel C-04 along the toe of the Tenas Control Pond may be decommissioned prior to end of operations after the dam slopes have been sufficiently vegetated to control erosion; and
- Open pit walls will be progressively covered with non-PAG rock backfill and overburden material. At the end of operations, a defined pit lake area will remain in the southwest portion of the open pit, however all original pit walls will be covered with non-PAG rock and overburden material to prevent ARD.

Once mining is complete, decommissioning and reclamation will continue for approximately four (4) years, as described in (SRK 2021f). The following decommissioning activities are related to water management features:

- The operational spillways at the East Management Pond and West Management Pond will be decommissioned and replaced by the Post-closure water management infrastructure (see **6.3.6.2**). Armoring will be extended into the downstream North Management Pond and across the North Management Pond soil cover to the North Management Pond water management infrastructure;
- Channels C-01 and C-03 along the toe of the East and West management ponds will be breached once monitoring shows that erosion and sediment migration from vegetated slopes has been controlled. Downgradient berms will be breached at regular intervals, preventing channelized flow,

and reducing risk of erosion on the natural slopes towards Tenas Creek and Four Creek. Associated road crossings will be removed;

- The Tenas Control Pond will be dewatered to the Goathorn tributary during open water season months of May through October. Dewatering rates will be dictated based on pond water quality at the end of operations which will support a detailed decommissioning plan. Once dewatered, sediment collected throughout operations in the TCP will be allowed to drain and dry out and will be form the basis of the wetland. The dam will be breached, and an armoured channel section will be constructed from the outlet of the North Management Pond spillway embankment channel to the former outlet of the Tenas Control Pond spillway embankment channel, which will tie-into the erosion protection along the Goathorn Creek tributary;
- All other sedimentation ponds will be dewatered and backfilled or the dams breached to allow these ponds to naturally drain. Backfill surfaces will be covered with overburden and vegetated, returning to pre-development conditions where possible; and
- Pumping systems will be decommissioned and removed from site.

The following water management systems will remain in-place in the Post-closure Phase which is approximately 25 years and beyond:

- The potable water pond cells within the C-02 channel will remain in-place, along with the C-02 channel. Water from the catchment between the East Management Pond and the final open pit extents will continue to be diverted towards Four Creek;
- The C-05 channel south of the open pit will remain in-place to continue diverting water around the pit lake and towards Four Creek; and
- Each management pond will discharge surface runoff and excess water from the soil covers through the closure spillways. Long-term monitoring and inspections of dams will be required.

7. MONITORING

Monitoring programs will be used to gauge the performance of the Project's water management system and mitigation measures against model results and regulatory commitments. When changes are observed, solutions will be developed using adaptive management to determine appropriate response.

Monitoring of Parameters of Potential Concern/Contaminants of Potential Concern (POPC/COPC) and Parameters of Concern/Contaminants of Concern (POC/COC) identified for aquatic life, wildlife, terrestrial vegetation, human health, and land uses will be conducted for soils, vegetation, sediment, and surface and groundwater

Please see **Appendix 13.11-E Minesite Water Monitoring Program** which the provides details of the monitoring program. Monitoring results will be summarized as described in the subsections to follow.

7.1 Monitoring Summaries

7.1.1 Flow Monitoring Results

Flow monitoring results will be presented in the annual report and will include:

- monthly and annual project discharge volumes from the Tenas Control Pond, management ponds, sedimentation ponds (CPP, Rail Infrastructure, Explosive Magazine and Explosive Facility sedimentation ponds), and the Potable Water Storage Pond;
- any exceedance of permitted discharge flow limits identified, including summary of cause for exceedance, the potential environmental risks, and any corrective and/or preventative measures taken to ensure the cause of the non-compliance is not ongoing;
- receiving environment: annual hydrograph plots prepared for Tenas Creek, Four Creek, Goathorn Creek and Telkwa River, including the average annual hydrograph pre-mining;
- an appendix including plots of spot-flow measurements and converted water level readings based on the rating curve for each hydrometric station; and
- comment on data gaps, quality assurance checks of raw data.

7.1.2 Water Quality Monitoring Results

Water quality monitoring results for effluent, seepage, surface water and groundwater will be presented in the annual report, including toxicity testing results. Monitoring of Parameters of Potential Concern/Contaminants of Potential Concern (POPC/COPC) and Parameters of Concern/Contaminants of Concern (POC/COC) identified for aquatic life, wildlife, terrestrial vegetation, human health, and land uses will be conducted for soils, vegetation, sediment, and surface and groundwater.

Specifically, water quality monitoring will focus on identified POPCs from the Initial Dilution Zone mixing model (SRK 2021k), which include dissolved and total aluminum, total antimony, total arsenic, dissolved cadmium, total chromium, total copper, total iron, total manganese, nitrate, nitrite, total selenium, total strontium, sulphate, total thallium, total uranium and total zinc. All annual results will be provided in an appendix, along with a compilation of historical data for trend analysis and modelled data to identify any deviations from expected conditions.

Summary statistics will be provided in a table or graph, highlighting non-compliance, exceedances of water quality guidelines or site performance objectives, or changes relative to modelled conditions, for parameters that:

- show a trend over time and space;
- exceed permit limits; and
- approach or exceed water quality guidelines in the receiving water.

Summary statistics will include minimum, maximum, mean, median, standard deviation, standard error, method detection limit and sample size and percent non-detects. Statistics will be calculated using 0.5 of the method detection limit.

Parameter concentrations will be plotted such that current calendar year is clearly compared against the last five (5) years of measurements along with modelled results. Trend lines and associated regression values will be added to show trends, where applicable. Plots will also include applicable permit limits.

Monitoring will take place through all Project phases.

7.1.3 Data Interpretation

The annual report will include discussion of any permit limit exceedances, information on why exceedances occurred, what environmental risk the non-compliance posted, and what was done (or planned) to deal with non-compliance.

The text will identify effects of the Minesite activities and discharges on the receiving water based on temporal and spatial trends as well as a comparison to baseline conditions and changes in discharges volumes or concentrations.

Parameter concentrations in receiving water that are above 80% of the guideline or exceed safe management levels or any permitted levels will be identified.

A comparison of receiving water parameter concentrations to impact predictions from the environmental assessment (EA) water quality modelling will be included to verify predictions and identify potential unforeseen issues.

7.2 Performance Objectives

Table 7.2-1 below highlights the Performance Objectives and targets required to ensure the proper implementation of this MWMP:

Table 7.2-1: Performance Objectives

Objective	Target
Total Suspended Solid (TSS) levels in discharge from sedimentation and Tenas Control Ponds	Meet regulatory requirements for discharges from all structures and if needed, assess flocculant and/or coagulant effectiveness and quantities used.
Effects on fish from flocculant and/or coagulant use	Target zero, no measurable effects on fish and/or fish habitat due to the use of flocculants and/or coagulants

Objective	Target
Water levels in the management ponds	Meet minimum cover requirement of 0.5 metre (m) and target 1 m if practical
Water levels in the management ponds	Meet minimum cover requirement of 2 meters in Post-closure Phase
Channels including discharge	Complete an as built report for channels and any modifications completed
Channels including discharge	Complete two (2) annual inspections for all channels, to check effectiveness of erosion and sediment control features are in good working order
Channels including discharge	Complete annual maintenance requirements and documentation for all structures
Channels including discharge	Track flows in structures to confirm effectiveness and seepage losses
Sedimentation, management, Tenas Control Ponds, Potable Water Storage Pond	▪ Complete an as built report for all structures and any modifications completed ▪ Complete geotechnical inspections annually by the Engineer of Record for all structures that require this type of inspection and complete repairs noted ▪ Complete annual maintenance requirements and documentation for all structures ▪ Track flows through all structures and water levels ▪ Complete water quality and quantity monitoring for all structures ▪ Complete a third-party geotechnical review of embankments every three (3) years or as required based on Regulatory requirements and/or inspections performed by TCL personnel. ▪ Complete a third-party geotechnical review of embankments every three (3) years or as required based on Regulatory requirements and/or inspections performed by TCL personnel. ▪ Complete seepage monitoring and compare to target levels and make any changes in future management pond liner construction requirements
Pumping Systems	▪ Complete two (2) annual inspections for all structure ▪ Ensure all systems have critical spares on site to ensure sufficient redundancy ▪ Complete as built report for pumping systems ▪ Ensure all systems are as similar as possible
Monitoring	Monitoring detailed in **Appendix 13.11-E Minesite Water Monitoring Program**, was completed as required and reporting provided to regulators as per permits requirements.
Monitoring	Monitoring of Parameters of Potential Concern/Contaminants of Potential Concern (POPC/COPC) and Parameters of Concern/Contaminants of Concern (POC/COC) concentrations downstream of the Project discharge in Goathorn, Tenas and Four Creeks and in the Telkwa and Bulkley rivers, meets benchmarks.
Annual review of the Minesite Water Management Plan (MWMP)	Annual review of the MWMP is conducted and MWMP is update as needed.

8. REPORTING

8.1 General Reporting

Reporting completed by TCL will confirm consistent implementation of the MWMP. Summary reports of monitoring activities and results will be compiled and reviewed annually.

8.2 Compliance Reporting

Compliance reporting will be subject to the EAC, and Mines Act, RSBC 1996, c 293, and Environmental Management Act, SBC 2003, c 53 (*MA/EMA)* permit conditions. The information gathered during monitoring practices will be summarized with information from other management plans into an Annual Environmental Management Summary Report and upon permitting completion, the Annual Environmental Reports as required by *MA/EMA* permits. Community engagement activities will be an aspect of the **Socio-economic Management Plan (S13.0-C16) (SEMP)**. The **SEMP** will have requirements related to reporting on community engagement programs**.**

8.3 Internal Reporting

Details of the monitoring will be reported internally on an annual basis according to the adaptive management framework of the EMS. The report will provide results of monitoring, assessment of performance objectives where applicable, and any other pertinent information.

TCL staff or contractors will be strongly encouraged to report any inefficiencies to management for evaluation consideration

8.4 Annual Reporting Requirements

TCL will prepare an annual report to the BC MOE summarizing the results of all monitoring required under the *MA*/*EMA* permits.

Key information requirements in the annual report will include:

- Compliance: effluent and process monitoring results will be compared to the applicable permit requirements and limits. All non-compliance events should be highlighted;
- Spills and other incidents: include dates, times, descriptions, and a chronology of measures taken for all incidents over the year that resulted in the release of unauthorized effluent emissions;
- Management plan summaries: summary of activities that occurred during the year related to applicable management plans in place onsite;
- Environmental effects: monitoring results need to be summarized and effects assessed; and
- Recommendations: about how existing impacts will be resolved or minimized, how non-compliance or effects will be avoided in the future, whether the monitoring programs are still sufficient and effective, and how to enhance the monitoring program, if required.

Annual report outline:

- executive summary;

- description of Minesite operation and discharges;
- chemical reagents and waste storage;
- incidents;
- monitoring:
  - summarize, interpret and discuss the results of all environmental monitoring as required in the associated discharge permit. This includes:
    - monitoring program description;
    - sampling methodology and equipment used, noting any variations in data collection;
    - description of QA measures and procedures used;
    - hydrological and flow monitoring results;
    - water quality monitoring results;
    - data interpretation;
    - summary and conclusion; and
    - appendices.

A summary of the MWMP monitoring program is provided in **7. Monitoring**, with details provided in **Appendix 13.11-E Minesite Water Monitoring Program.**

9. Roles and Responsibilities

9.1 Mine Manager

The Mine Manager bears overall responsibility for all phases of the Project, and responsibility for onsite environmental monitoring and compliance. The Mine Manager reports to the executive steering committee for TCL and will coordinate with this group to ensure that Project objectives are being met.

Specifically, the Mine Manager will:

- implement the MWMP;
- provide the necessary budget and resources to allocate sufficient resources to carry out the MWMP;
- complete an annual inspection of all water management infrastructure;
- participate in periodic risk assessments associated with MWMP; and
- facilitate the annual review of the MWMP.

9.2 Mine Superintendent

The Mine Superintendent will:

- complete an annual review of the MWMP;
- complete quarterly inspections of all water management infrastructure; and
- provide equipment and personnel to carry out maintenance of water management infrastructure when requested.

9.3 Environmental Coordinator

The Environmental Coordinator will:

- complete an annual review of the MWMP;
- complete reporting for regulatory agencies and for the **EMS** Annual Environmental Management Summary Report related to the MWMP; and
- complete quarterly inspections of all water management infrastructure.

9.4 Environmental Technician

The Environmental Technician will:

- provide vacation cover for the Environmental Coordinator;
- assist Environmental Coordinator as required with the Annual Environmental Management Summary Report; and
- assist the Environmental Coordinator with monitoring related to the MWMP.

9.5 Quality Assurance/Quality Control (QA/QC) Technician

The QA/QC Technician reports to the Environmental Coordinator and will:

- assist with all water, sediment, surface soil, overburden, dust samples and ML/ARD samples of mine rock, processed rock, ROM coal, and open pit surfaces, using standard industry BMPs and QA/QC methodologies;
- assist Environmental Coordinator as required with the Annual Environmental Management Summary Report;
- assist the Environmental Coordinator with monitoring related to the MWMP;
- provide vacation coverage for the Environmental Technician; and
- complete monthly inspections of all water management infrastructure.

9.6 Employees and Contractors

Employees and contractors will:

- complete a site-specific environmental induction and training appropriate to their role; and
- understand and implement the MWMP as appropriate to their role.

10. COMMUNICATION

Communication of the MWMP at TCL will be based on internal requirements and will primarily take place through this MWMP and relevant SPPs. Any significant change to the MWMP will be communicated to the Project's employees and contractors through a site-wide email, announcements over all radio channels by Minesite supervision and bulletins posted around the Project's Minesite. When effective to do so, maps will be marked with changes. Change management is detailed in **12**.

10.1 Training and Awareness

All employees and contractors will have training and awareness of the Project responsibilities to meet the objectives of the MWMP for all Project phases. Training will include an overview of the MWMP objectives, mitigation measures, monitoring, and reporting requirements to meet MWMP targets.

10.2 Employee Training

All employees and contractors will receive training on the MWMP during a general-site safety orientation. MWMP training will occur before individuals begin work on the Project and for new personnel arriving on the Project.

Employees are required to review all relevant management plans and/or SPP and their associated training modules at the start of employment and on annual basis. Employee training is tracked by the Health, Safety, and Human Resources Department using an industry standard software application.

10.3 Contractor and Visitor Training

Additional training will be provided to employees and contractors delegated to specific work tasks (e.g., clearing, reclamation or herbicide application) and will occur through site-specific orientation and/or in-person communication with the Environmental Coordinator.

Contractors will review the relevant management plans and/or SPP at the start of their contract and on an annual basis if contracts are longer than 13 months in duration to ensure their compliance with these requirements. Visitors will receive an overview of the relevant SPPs during their visitor induction session prior to accessing the Minesite or from their Contract Manager. Visitors are generally restricted to being under the direction of TCL employees and are unlikely to need to be familiar with the details of the MWMP.

11. Evaluation and Adaptive Management

11.1 Evaluation

A review of the MWMP will be completed by the Environmental Coordinator on an annual basis to compare data, trends, and implementation of the management plans and their objectives. This process will include a review of the management plan deliverables and input received from Indigenous groups through the **SEMP.**

11.2 Adaptive Management

A philosophy of adaptive management will be adopted to verify that management plans and mitigation measures are consistently meeting or exceeding performance targets. This will be achieved through periodic reviews of the MWMP and the results of monitoring programs.

The MWMP is a living document that should be reviewed and improved as site conditions change and following the evaluation of monitoring and sampling data collected through the life of the Project.

11.3 Continual Improvement

TCL will work towards continual improvement at the Project. The Mine Manager or their delegate will investigate improvements in any trend and assess whether the practices responsible for the improvements can be applied to other areas of the Project. Deteriorating trends will be studied to determine the root cause.

When the cause is identified, the Mine Manager or their delegate will implement a suitable corrective action. Examples of corrective actions could include:

- finding alternate flocculant and addition rates to improve TSS;
- additional training of employees and contractors on procedures;
- enhancement of maintenance or monitoring measures;
- construction of additional water management infrastructure; and/or
- additional supervisory oversight.

TCL will amend the MWMP as required based on annual evaluations and feedback from stakeholders and the Indigenous groups. Any proposed changes will be sent out for review by regulators, stakeholders, Indigenous groups, and community before being finalized and implemented into the MWMP.

12. CHANGE MANAGEMENT

Changing any part of the MWMP requires the use of a formalized process. If significant changes are being planned to objectives, management plan structure, operational milestones, communication and/or information management, it is required that the Management of Change (MOC) procedure in the **EMS** be followed. Minor edits and/or updates to this MWMP will be controlled through version control and content approval functions.

13. CONCLUSION

Management of surface and groundwater at the Project is important. Through implementation of the MWMP and relevant SPPs developed during the Construction Phase, TCL will ensure the protection of water resources through the minimizing of potential Project effects and mitigations of any identified effects.

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