VISTA GOLD
7961 Shaffer Parkway, Suite 5 | Littleton, CO 80127
Phone: +1 (720) 981-1185

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

REFERENCE | **Attachment R9**

Water Treatment Plant

PROJECT NO. 117-8348002

DATE: DECEMBER 31, 2021

TETRA TECH
1560 Broadway, Suite 1400 | Denver, CO 80202
Phone: +1 (303) 825-9999 | www.tetratech.com

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g	acceleration of gravity
g/cm^3	grams per cubic centimeter
GPa	gigapascals
Ha-m	hectare-meters
Hz	Hertz
in	inches
km	kilometers
kN/m3	kilonewton per cubic meter
kPa	kilopascals
kWh	kilowatt hour
kWh/day	kilowatt hour per day
m/s	meters per second
m	meter
m^3	cubic meters
m^3/hr	cubic meters per hour
m^3/day	cubic meters per day
m^3/day/m	cubic meters per day per unit meter
mil	1/1000 inch
mm	millimeter
MPa	megapascals
Mtpy	Million tonnes per year
PN	Pressure Number
t/m^3	tonnes per cubic meter
tpd	tonnes per day

ACRONYMS, ABBREVIATIONS AND SYMBOLS

ANZECC	Australian and New Zealand Environment and Conservation Council
CaO	Quicklime
$Ca(OH)_2$	Hydrated Lime
CIP	Clean-In-Place
Cr(III)	Trivalent Chromium
Cr(VI)	Hexavalent Chromium
FRP	Fiberglass Reinforced Plastic
HRT	Hydraulic Retention Time
kW	Kilowatts
$L/m^2/hr$	Liters per Square Meter per Hour
L/min	Liters per Minute
m^2	Square Meters
m^3	Cubic Meters
m^3/hr	Cubic Meters per Hour
m^3/m^2 *day	Cubic Meters per Square Meter per Day
Mg/L	Milligrams per liter
NaSH	Sodium Hydrosulfide
SOR	Surface Overflow Rate
Su	Standard pH units
TDH	Total Dynamic Head
TSF	Tailings Storage Facility
TV	Trigger Value
UF	Ultrafilter
µg/L	Micrograms per liter
µS/cm	Micro Siemens per centimeter
USD	United States Dollar
WDL	Waste Discharge Licence 178-05
WTP	Water Treatment Plant

1. INTRODUCTION

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

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

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

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

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

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

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

The primary purpose of this Appendix is to provide documentation for the feasibility study, supporting the Technical Report developed in accordance with NI 43-101. This appendix describes the Water Treatment Plant (WTP), a key component of the water management plan at the Mt Todd mine. The WTP will treat excess water collected at several areas of the mine so that the water can be discharged to the environment or used elsewhere on the site. This document will develop the design of the WTP and present opinions of capital and operations costs.

1.1 Climate and Hydrology

The project site is in a sub-tropical climate with a defined wet season (December to April) and dry season (May to November) (MWH, 2006). The wet season occurs approximately from November to April and dry season occurs from May to October. The Project receives most of its rainfall during the heavy wet season between January and early March. Average annual rainfall in the project area is between 973 millimeters (mm) and 1,146 mm, as recorded at Pine Creek and Katherine, respectively (NSR, 1992).

1.2 Site-Wide Water Management

A site wide water balance model was developed using the GoldSim software to simulate the site at the Mt Todd mine. The model is based on a 17-year Life of Mine (LOM), assuming 15 active mining years and 2 years for stockpile processing, with a processing rate of 50,000 tonnes per day (tpd). The water treatment plant will begin operations one year prior to start of production to draw down the Tailings Storage Facility 1 and the Batman Pit.

A description of the site landforms and impoundments is included in **Table 1-1**.

Table 1-1: Description of Landforms and Impoundments

Landform/Impoundment	Short Name
Tailings Storage Facility 1	TSF1
Tailings Storage Facility 2	TSF2
Raw Water Dam	RWD
Low Grade Ore Stockpile	LGOS
Low Grade Ore Stockpile Retention Pond	LGRP
Heap Leach Pad Moat	HLP
Batman Pit	RP3
Process Plant Retention Pond	PRP
Waste Rock Dump	WRD
Waste Rock Dump Retention Pond	RP1
Process Water Pond	PWP
Water Treatment Plant	WTP
Process Plant	PP

Water enters the site as precipitation onto the site, as makeup water pumped from the Raw Water Dam (RWD), or as groundwater inflow into the Batman Pit. Contact stormwater and groundwater are pumped from retention ponds around the site to the Process Water Pond (PWP). A process water bleed stream is also sent to the PWP from the TSF decant to maintain proper chemistry in the process circuit during the dry season. The PWP acts as a storage and equalization pond for the water treatment plant (WTP). Water leaves the site via evaporation from ponds, though use for dust suppression, or as discharge to the Edith River from the WTP. **Figure 1-1** depicts the flow of water around the Mt Todd site. **Table 1-2** lists typical flows between the facilities during the wet and dry seasons.

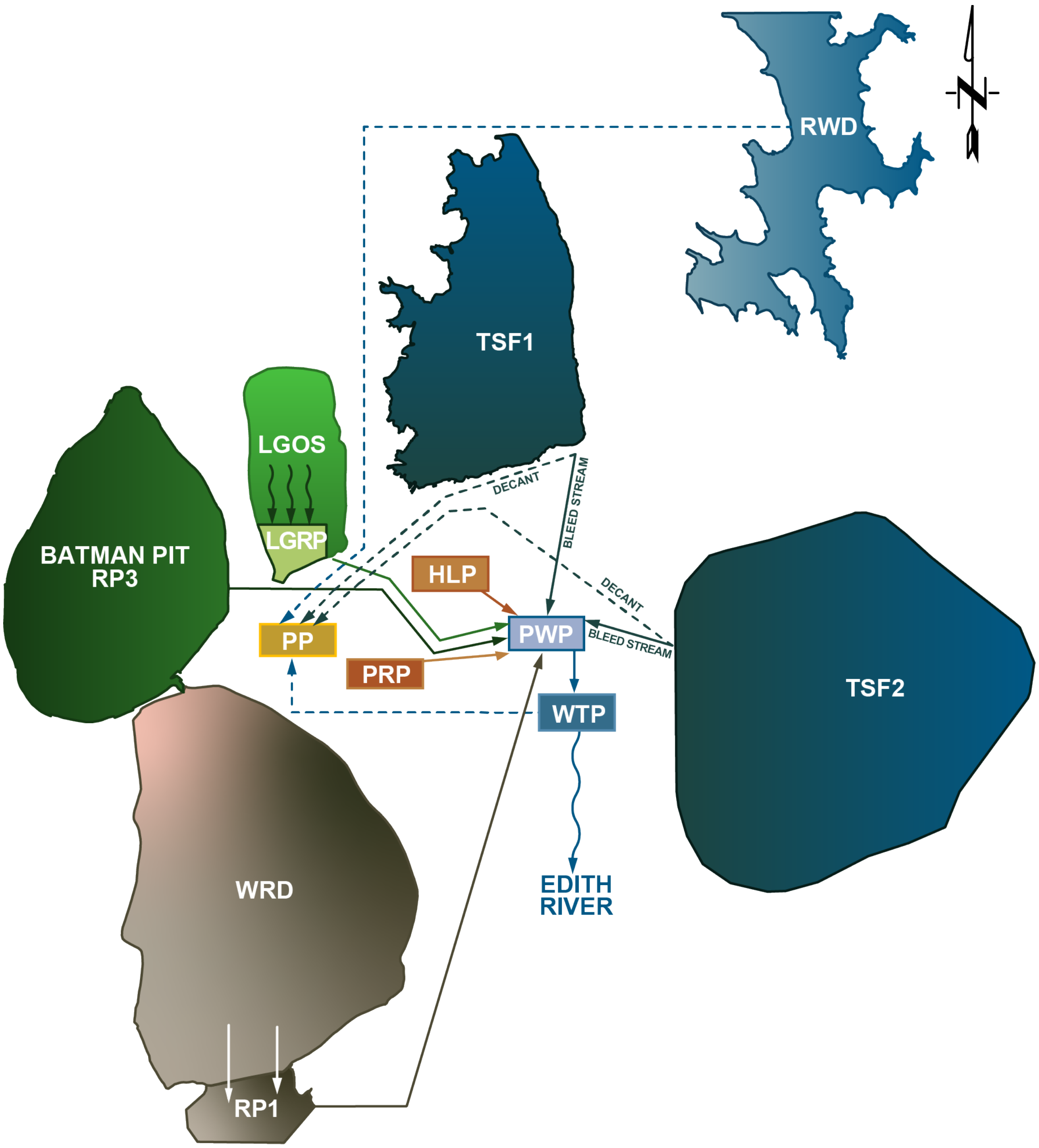


Figure 1-1: Site-Wide Water Management Flow Diagram

Table 1-2: Site-Wide Water Management Flow Summary

Landforms/Impoundments	Modeled Volume (m^3)	Maximum Pump Rate (m^3/hr)	Pump/Report to Location(s)	Years when Maximum Pump Rate Observed	Wet Season Estimated Average Flow (m^3/hr) 1/	Dry Season Estimated Average Flow (m^3/hr) 1/
Tailings Storage Facility 1 (TSF1)	4,156,231	2,270 250	PP PWP	1-14	933 0	972 125
Tailings Storage Facility 1 Seepage Pond	NA	75	TSF1	2-8	43	43
Tailings Storage Facility 2 (TSF2)	4,945,772	2,270 250	PP PWP	3-17	1,144 0	1,150 125
Tailings Storage Facility 2 Seepage Pond	NA	160	TSF2	17-19	68	69
Raw Water Dam (RWD)	18,325,000	750	PP	1-17	181	266
Low Grade Ore Stockpile (LGOS)	NA	No Pump	Seepage/runoff reports to LGRP	NA	NA	NA
Low Grade Ore Stockpile Retention Pond (LGRP)	17,072	450	PWP	1-17	105	14
Heap Leach Pad Moat (HLP)	45,030	194	PWP	1-17	102	15
Batman Pit (RP3)	11,970,286 - 327,656,639	750 50	PWP Dust Suppression	1-15	182 9	37 10
Process Plant Retention Pond (PRP)	9,536	70	PWP	1-17	16	10
Waste Rock Dump (WRD)	NA	No Pump	Seepage/runoff reports to RP1	NA	NA	NA
Waste Rock Dump Retention Pond (RP1)	1,200,196	600	PMP	1-18	236	97
Process Water Pond (PWP)	185,394	600	WTP	1-17	566	397
Water Treatment Plant (WTP)	NA	600 600 50	Edith River Process Plant Dust Suppression	1-17	302 61 3	33 156 19
Process Plant (PP)	NA	2,547	TSF1 TSF2	1-17	1,274 1,274	1,274 1,274

NOTE: 1/ Monthly average flow

2. WATER QUALITY GOALS

The process employed at the WTP will be capable of providing water for multiple uses at the Mt Todd site. The system must be capable of meeting regulatory requirements for discharge to the environment and for use as a dust suppressant. The third option for disposal of treated water is reuse in the process plant for process water. This section sets the goals for the WTP process.

2.1 Site-Specific Trigger Values

Discharges from the site are currently regulated by Waste Discharge Licence 178-08 (WDL), issued by the Northern Territory Government on November 30, 2020. The Mt Todd Mining Management Plan Section 6.14 (Vista Gold Australia, 2021) indicates that after the WTP is operational, the WDL will be revised to implement 95% species protection trigger values, as defined in the Australian and New Zealand Guidelines (ANZG) for Fresh & Marine Water Quality (ANZG 2018 Guidelines). This change will be reflected in a revision to WDL 178.

The purpose of the 95% species protection trigger value (TV) is to protect water quality in the Edith River downstream of the discharge from the WTP. The WTP will discharge effluent into Batman Creek, a tributary to the Edith River. Concentrations of contaminants measured in the Edith River shall not exceed the TV during discharge events. For the constituents of concern at the Mt Todd Mine (discussed further in Section 3.1), the TV are presented in **Table 2-1**.

Table 2-1: Site-Specific Trigger Values, Edith River Downstream of WTP Discharge

Analyte	Unit	Trigger Value	Source
pH	SU	6-8	ANZG 2018 Guidelines
Dissolved Oxygen	% Saturation	85-120	ANZG 2018 Guidelines
Conductivity	µS/cm	20-250	ANZG 2018 Guidelines
Magnesium	mg/L	2.5	Van Dam, et. Al 2010 Environ Toxicol Chem 29(2):410-421
Sulfate	mg/L	129	Elphick et al 2011 Environ Toxicol Chem 30(1):247-253
Aluminum	µg/L	55	ANZG 2018 Guidelines
Cadmium	µg/L	0.2	ANZG 2018 Guidelines
Cobalt	µg/L	13	Canadian guideline adopted by ANZG 2018 Guidelines
Chromium (III)	µg/L	3.3	ANZG 2018 Guidelines
Chromium (VI)	µg/L	1.0	ANZG 2018 Guidelines
Copper	µg/L	1.4	ANZG 2018 Guidelines
Manganese	µg/L	1900	ANZG 2018 Guidelines
Nickel	µg/L	11	ANZG 2018 Guidelines
Lead	µg/L	3.4	ANZG 2018 Guidelines
Iron	µg/L	300	ANZG 2018 Guidelines
Mercury	µg/L	0.6	ANZG 2018 Guidelines
Zinc	µg/L	8.0	ANZG 2018 Guidelines

The TVs for magnesium and sulfate have been held over from previous work, and are not referenced in the ANZG 2018 Guidelines.

2.2 Effluent Limits and Goals

To determine the allowable level of water quality constituents in the discharge of the WTP, a mass balance was performed on the Edith River system. First, an analysis was performed to evaluate the minimum dilution ratio required to meet the TV for sulfate at SW4 on the Edith River. Then upstream water quality values at sampling location SW2 on the Edith River and the minimum dilution ratio for sampling location SW4 downstream of the WTP discharge were used to calculate effluent limits at the WTP that maintain the site-specific trigger value at site SW4. The equation used to determine the effluent limits is:

$$Q_{WTP}C_{WTP} + Q_{SW2}C_{SW2} = Q_{SW4}C_{SW4}$$

Where:

Q_{WTP} is the WTP flow rate
C_{WTP} is the allowable concentration of a given analyte in the WTP effluent
Q_{SW2} is the flow in the Edith River upstream of the WTP
C_{SW2} is the background concentration of a given analyte in the Edith River upstream of the WTP
Q_{SW4} is the flow in the Edith River downstream of the WTP
C_{SW4} is the background concentration of a given analyte in the Edith River downstream of the WTP

A minimum dilution ratio of 1:19 WTP flow rate to Edith river flow rate (Q_{WTP}:Q_{SW4}) is required to consistently achieve the sulfate TV at SW4. At a maximum WTP flow rate of 600 m^3/hr, the Edith river must have a minimum flow rate of 11,400 m^3/hr to discharge from the WTP to the Edith River. These conditions are typically met December through March and discharges to the environment will primarily occur between December and March. **Table 2-2** presents Edith River flows at field monitoring location SW4.

Table 2-2: Edith River Flow at SW4 (m^3/h), February 2013- June 2021

Month	Mean	Median	5th Percentile	95th Percentile	Maximum Day	Minimum Day
January	136,048	99,924	32,556	352,965	2,209,457	0
February	148,972	77,544	36,016	431,235	1,430,188	608
March	57,083	39,589	15,260	155,611	524,238	437
April	9,378	5,657	2,462	25,008	6,7106	0
May	2,602	1,516	0	8,666	16,801	0
June	706	87	0	3,388	6,557	0
July	577	0	0	2,893	4,720	0
August	2,365	0	0	12,280	110,348	0
September	1,690	0	0	8,779	79,007	0
October	2,176	0	0	11,313	101,972	0
November	5,733	3,050	119	17,102	180,450	0
December	24,824	9,352	1,006	93,294	764,616	0

Table 2-3 provides a summary of field data showing background water quality concentrations of constituents of concern at sampling site SW2, upstream of the WTP on the Edith River. For this assessment, it was assumed that non-detectable sampling events were equal to one half the detection limit of the analytical method.

Table 2-3: Water Quality Data at Sampling Site SW2, Edith River upstream of WTP Discharge, Jan 2015- March 2020

Analyte	Unit	No. of Samples	Minimum Value	Maximum Value	5th Percentile Value	95th Percentile Value	Average Value
Magnesium	mg/L	92	0.5	1	<0.5	1	0.68
Sulfate	mg/L	252	<1	19	<1	1	0.65
Aluminum	µg/L	252	30	3300	50	764	275
Cadmium	µg/L	251	<0.1	0.1	<0.1	<0.1	<0.1
Cobalt	µg/L	114	<1	1	<1	<1	<1
Chromium	µg/L	105	<1	2	<1	<1	<1
Copper	µg/L	245	0.23	20	<1	2	0.88
Manganese	µg/L	105	7	51	8	24.8	14.6
Nickel	µg/L	105	0.5	2	0.5	0.9	0.56
Lead	µg/L	88	<1	<1	<1	<1	<1
Iron	µg/L	251	400	4440	450	1355	829
Mercury	µg/L	105	0.05	<0.05	<0.05	<0.05	<0.05
Zinc	µg/L	105	1	16	1	7.95	3.48

Using the TVs presented in **Table 2-1,** the minimum dilution ratio, and the background water quality in **Table 2-3**, the mass balance was calculated for the allowable discharge concentrations at the WTP. **Table 2-4** summarizes the allowable effluent concentrations and the WTP effluent goals, which are set at 80% of the allowable concentration to allow for a margin of safety.

Table 2-4: Mt Todd WTP Effluent Goals

Analyte	Unit	C_{SW2}	TV	C_{WTP}	Effluent Goal
Magnesium	mg/L	1	2.5	31	25
Sulfate	mg/L	1	129	2,561	Refer to Section 3.1
Aluminum	µg/L	764	55	55	44
Cadmium	µg/L	0.1	0.2	2.1	1.7
Cobalt	µg/L	1	13	241	193
Chromium	µg/L	1	1.0	1.0	0.8
Copper	µg/L	2	1.4	1.4	1.1
Manganese	mg/L	0.025	1.9	37.5	30.0
Nickel	µg/L	0.9	11	203	162
Lead	µg/L	1	3.4	49	39
Iron	mg/L	1.4	0.3	0.3	0.24
Mercury	µg/L	0.05	0.6	11	8.8
Zinc	µg/L	7.95	8	8.9	8.0

The background water quality concentration at SW2 for aluminum, copper, and iron may exceed the site-specific TV, and is equal to the site-specific TV for chromium. In these cases, the WTP will remove the constituent to the TV prior to discharge. WTP effluent may also be used in the process plant for process water and around the site as dust suppression. It is assumed that the water quality requirements for environmental discharge will be satisfactory for these other uses as well.

3. WATER TREATMENT PROCESS

The water treatment process was designed specifically to treat the expected influent water quality to the discharge requirements. This section introduces the expected influent water quality and the water treatment process.

3.1 Influent Water Quality

The geochemistry report presents expected water quality at the equalization/Process Water Pond upstream of the WTP in the wet season and dry season for each of the operating years of the mine as well as post-closure. The geochemistry model includes inputs from various sources on the mine site, and considers potential chemical reactions between the various inputs prior to entering the WTP. **Table 3-1** presents the average and maximum values for each chemical constituent of concern, and compares it to the WTP effluent goal.

Table 3-1: Anticipated Average and Maximum Influent Water Quality at the WTP

Analyte	Unit	Average WTP Influent	Maximum WTP Influent	Effluent Goal	Average % Reduction Required	Maximum % Reduction Required
Magnesium	mg/L	47	249	25	47.2%	90.0%
Sulfate	mg/L	1201	2134	1/	-	-
Aluminum	µg/L	3,395	31,644	55	98.4%	99.8%
Cadmium	µg/L	12	98	1.7	85.8%	98.3%
Cobalt	µg/L	153	1,117	193	0%	82.7%
Chromium	µg/L	1.6	2.5	0.8	50.0%	68.0%
Copper	µg/L	1,518	7,471	1.1	99.9%	100.0%
Manganese	mg/L	0.32	1,752	30	0%	98.3%
Nickel	µg/L	154	1,107	162	0%	85.4%
Lead	µg/L	11	41	39	0%	4.9%
Iron	mg/L	0.15	0.28	0.24	0%	14.3%
Mercury	µg/L			8.8	-	-
Zinc	µg/L	2,469	21,564	8.0	99.7%	100.0%

NOTE: 1/ The WTP will not remove sulfate. The TV for sulfate at SW4 will be achieved by dilution in the Edith River.

The water treatment process is designed to meet the reductions as shown in **Table 3-1**. Chromium and sulfate are further discussed below.

3.1.1 Chromium

The field data does not differentiate between the species of chromium present in the Edith River, nor does the geochemical report detail the species present in the water treatment plant influent. If chromium (III) is present, there should not be an issue, as the TV and the allowable discharge concentration exceed the anticipated influent concentration. However, if chromium (VI) is present, some modest removal would be required. The treatment process anticipates some need to remove chromium (VI) by including the provision to add ferrous sulfate to reduce Cr(VI) to Cr(III) and precipitate the reduced chromium at pH 7. This provision was not included at this time, and further study of the species of chromium is recommended.

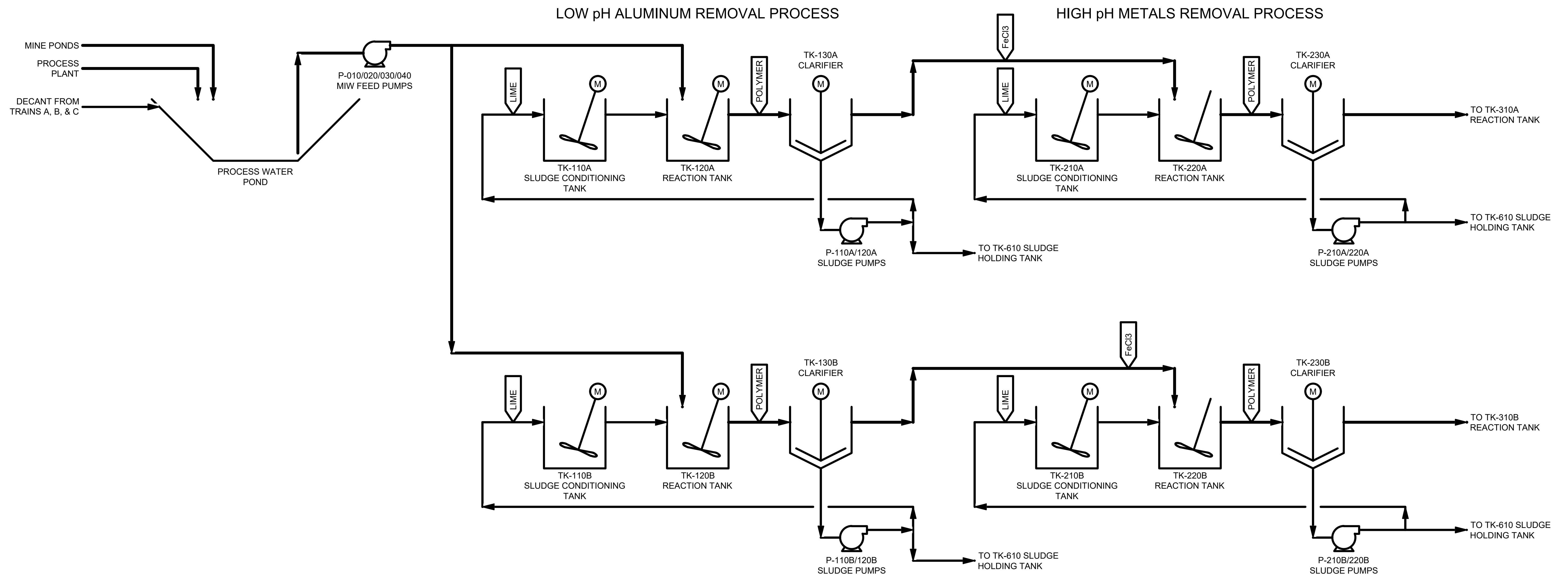
3.1.2 Sulfate

Sulfate is very difficult to remove from a water matrix. The generally recommended approach to removing sulfate is via reverse osmosis, which is very expensive to install, energy consuming to operate, and it generates a waste product (brine) that is difficult to dispose of.

The site wide water balance model was prepared to meet sulfate concentrations in the Edith River using dilution based on maximum projected sulfate concentrations for the site. A minimum dilution ratio of 1:19 WTP flow rate to Edith river flow rate was calculated to consistently achieve the sulfate TV at SW4.

3.2 Treatment Process Description

Water to be treated at the site will be collected in the process water pond (PWP). Collected wastewater will flow by gravity from the PWP to the Feed Pump Station. The pump station is adjacent to the PWP and houses three self-priming centrifugal pumps in a duty/duty/standby configuration. The Feed Pump Station pumps the collected water to the WTP building for treatment. The WTP process will consist of two-stage lime treatment and chemical precipitation with high-rate sedimentation, followed by filtration to remove remaining solids to meet effluent goals. The treatment processes and overall flow path are presented on the general process flow diagram in **Figure 3-1**. Two identical treatment trains will provide full redundancy of the WTP at 300 m^3/hr, with a maximum available treatment capacity at 600 m^3/hr.



LEGEND AND ABBREVIATIONS

- CHEMICAL ADDITION
- CLARIFIER RAKE
- MIXER
- (M) MOTOR
- PUMP

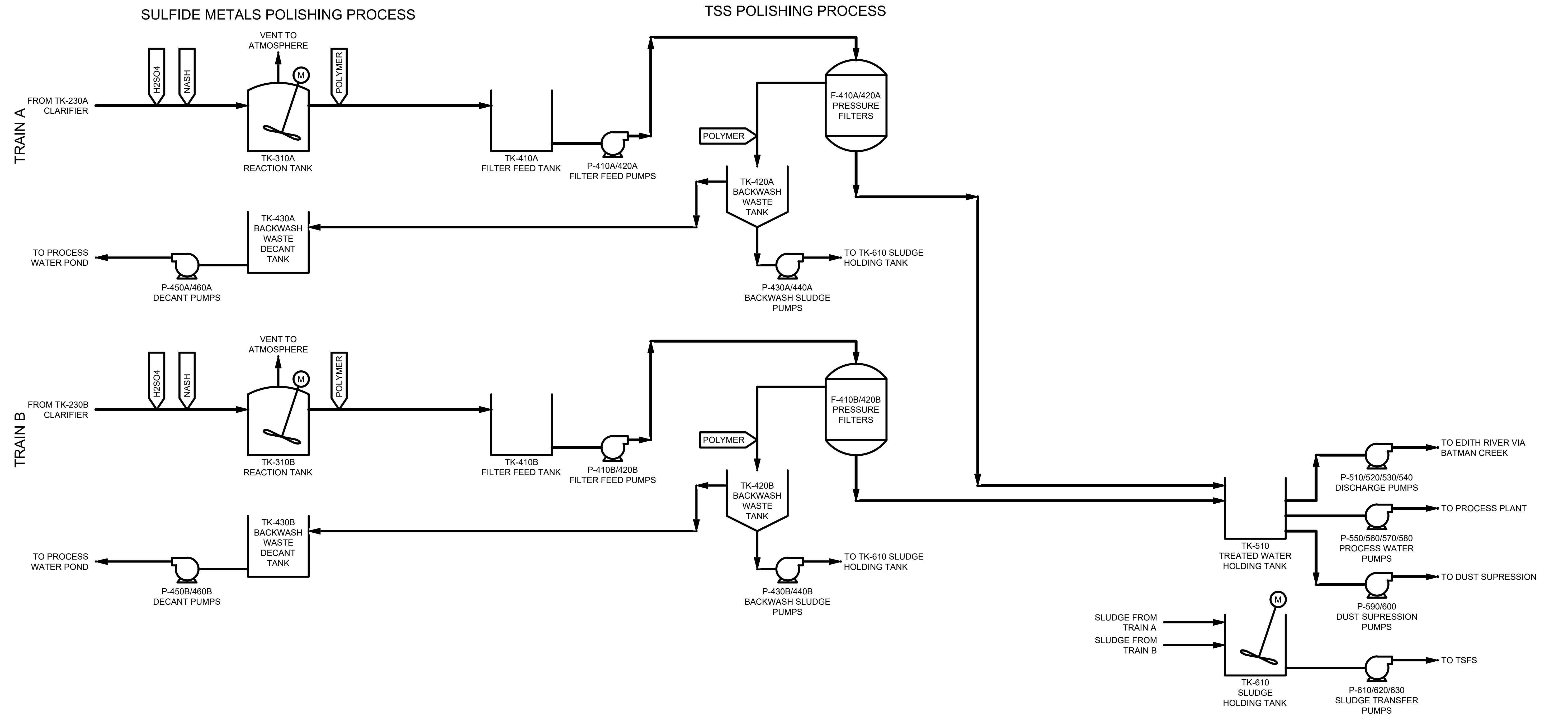
F	FILTER
FeCl3	IRON (III) CHLORIDE
HS204	SULFURIC ACID
MIW	MINING IMPACTED WATER
NASH	SODIUM HYDROSULFIDE
P	PUMP
TK	TANK
TSFS	TAILING STORAGE FACILITIES

TETRA TECH
www.tetratech.com
1560 Broadway, Ste. 1400
Denver CO 80202
Ph (303) 825-5999 Fax (303) 825-0642

MT TODD GOLD PROJECT
WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

Project No.:	200-01299-21007
Date:	01/27/22
Designed By:	REH
Figure	3-1

Bar Measures 1 inch



TETRA TECH

www.tetratech.com

1560 Broadway, Ste. 1400
Denver CO 80202
Ph (303) 825-5999 Fax (303) 825-0642

MT TODD GOLD PROJECT

WATER TREATMENT PLANT

PROCESS FLOW DIAGRAM

Project No.:	200-01299-21007
Date:	01/27/22
Designed By:	REH

Figure
3-2

Bar Measures 1 inch

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3.2.1 Low pH Lime Treatment Process

The first step of the treatment process is a low pH lime precipitation. The wastewater will be dosed with lime to raise the pH to approximately 6.5 to allow for the precipitation and removal of aluminum, which is most insoluble as a metal hydroxide at a significantly lower pH than most other metals. To reduce the footprint of the treatment process, solids are recycled to promote the precipitation reactions.

The low pH high-density lime system consists of three tanks in series.

- The first chamber in this process is a sludge conditioning tank where lime is dosed and blended with recycled solids.
- The second chamber is a reaction tank, where conditioned sludge reacts with process water to precipitate aluminum.
- The third basin is a clarifier unit. Solids are conditioned with polymer in the clarifier clearwell to enhance settling. Solids are collected and thickened in the unit by the rake mechanism.
- Clarified water flows through the effluent launders and on to the next chemical reaction process.
- Solids from the clarifier underflow are continuously recycled back to the sludge conditioning tank. Periodically, a portion of the solids are wasted from the system and will be pumped to the TSF for disposal.

3.2.2 High pH Lime Treatment Process

During the second stage of treatment, wastewater will be dosed with both ferric chloride and lime. The addition of lime will raise the pH to approximately 11 to allow for the precipitation and removal of constituents of concern including magnesium, cadmium, copper, nickel, and zinc. Ferric chloride will be added to promote coagulation and assist in the co-precipitation and adsorption of other metal species, specifically cadmium and zinc. To reduce the footprint of the treatment process, solids are recycled to promote the precipitation reactions.

The high pH high-density lime system consists of three tanks in series.

- The first chamber in this process is a sludge conditioning tank where lime is dosed and blended with recycled solids.
- The second chamber is a reaction tank, where conditioned sludge reacts with process water to precipitate constituents of concerns.
- The third basin is a clarifier unit. Solids are conditioned with polymer in the clarifier clearwell to enhance settling. Solids are collected and thickened in the unit by the rake mechanism.
- Clarified water flows through the effluent launders and on to the next chemical reaction process.
- Solids from the clarifier underflow are continuously recycled back to the sludge conditioning tank. Periodically, a portion of the solids are wasted from the system and will be pumped to the TSF for disposal.

3.2.3 NaSH Process

Overflow from the high pH high-density lime clarifier will be dosed with sulfuric acid and sodium hydrosulfide (NaSH) upstream of a reaction tank. The sulfuric acid will be used to adjust the pH to 8 to optimize the NaSH reaction. The NaSH process will further remove trace metals including zinc, cadmium, and others to meet the effluent discharge limits by promoting the precipitation of metal sulfides. The reaction tank, mixed using a vertical shaft mixer, will provide a minimum hydraulic retention time (HRT) of 30 minutes to allow chemical precipitation reactions to occur. The tank will be vented outside to prevent exposure to hydrogen sulfide in case of formation and off-gassing, which can occur if sulfuric acid is overdosed.

3.2.4 Filtration

Water from the NaSH reaction tank containing precipitate is directed to a dual media pressure filter system. Should water quality values and pilot plant performance indicate a need, a tighter membrane filter, in the form of a skid-mounted ultrafilter may be needed instead of the dual media pressure filters. Filtered water is directed to the treated water holding tank for storage prior to use for process water or discharge to Batman Creek. Water used to backwash the filters will be directed to a waste tank clarifier and ultimately back to the Process Water Pond.

3.2.5 Residuals Handling

Solids produced in this water treatment facility will be pumped to the tailings storage facility (TSF).

3.2.6 Chemical Feed Systems

The following sections outline the recommended chemicals for use in the WTP.

3.2.6.1 Ferric Chloride

Ferric chloride will be provided as a 42% liquid solution by weight and will be stored in a fiberglass reinforced plastic (FRP) storage tank. The storage tank will be capable of receiving liquid deliveries from bulk storage trucks. The feed system consists of the bulk storage tank and the metering pumps. Ferric chloride is a coagulant used to help settle and remove solids. The iron will form ferric oxyhydroxides at high pH, which can co-precipitate cadmium and other dissolved metals, increasing the removal of several constituents. Ferric chloride will be added to the reaction tanks in the high pH high-density lime system using peristaltic pumps.

3.2.6.2 Lime

Lime will be supplied as quicklime (CaO) because large quantities of quicklime are needed for other areas of the site. Hydrated lime ($Ca(OH)_2$) is preferred for use in the process because it disperses and reacts much faster. A combination quicklime storage silo and slaking unit will be installed to produce hydrated lime from quicklime. The lime feed system consists of the silo, a slaker, a slurry tank, and metering pumps. The lime system is a self-contained package system that will be located near the WTP building. Lime will be used to increase pH to promote the precipitation of dissolved constituents of concern.

3.2.6.3 Sodium Hydrosulfide (NaSH)

Sodium Hydrosulfide will be supplied as a 35% liquid solution and will be stored in a covered FRP storage tank that is vented outside. NaSH is used to promote the precipitation of metal sulfides in the process. The NaSH will be pumped to the process using peristaltic metering pumps.

3.2.6.4 Sulfuric Acid

Dilute sulfuric acid is injected upstream of Reaction Tank 310 to lower the pH to 8. Sulfuric acid will be shipped to the site as a 98% solution and will be pumped to a dilution tank. The storage tank will be capable of receiving liquid deliveries from bulk storage trucks. The acid will be diluted with treated water for use. The feed system consists of two tanks, transfer pumps, and metering pumps. Other acids may be considered during the design phase of this project to prevent the use of sulfuric acid.

3.2.6.5 Polymer

Polymer will be provided as an emulsion polymer. Polymer is a coagulant aid that will facilitate floc formation and will be added to the clearwells in the high-density clarifiers. Polymer will be delivered to the site in 1000-liter totes. A polymer blending unit with integral mixing chamber, solution tank, and metering pumps will be used to activate the polymer and prepare it for use. Treated water will be used as dilution water. The polymer feed system will be located in the WTP building. There are varying molecular weight anionic, cationic, and nonionic polymers to choose from for this use. Bench-scale jar testing is required to confirm and optimize the type and strength of polymer used in the treatment process.

4. DESIGN CRITERIA

The following sections outline the design criteria for the WTP and are separated into three categories: liquids, solids, and chemicals.

4.1 Liquid Treatment Process

Table 4-1 below summarizes the design criteria for the liquid stream components in the WTP.

Table 4-1: Liquid Treatment Process Design Criteria

Parameter	Criteria
WTP Capacity	
Minimum Flow Rate, m^3/hr	85
Maximum Flow Rate per Train, m^3/hr	300
Maximum Flow Rate, m^3/hr	600
Process Water Pond	
Quantity	1
Volume, m^3	185,394
Feed Pumps	
Quantity	3 (2 Duty, 1 Standby)
Type	Self-priming centrifugal with VFDs
Flow Rate, L/s	83
Total Dynamic Head (TDH), m	23
Motor Power, kW	31
High Density Lime System	
Quantity	4 (2 per train)
Sludge Conditioning Tank HRT, min	5
Reaction Tank HRT, min	22
Clarifier Rise Rate, m/hr	1.2
Clarifier Diameter, m	18
Sludge Recycle Rate	10x
Total Power, kW	63
NaSH Reaction Tank	
Quantity	2 (1 per train)
Volume, m^3	150
Diameter, m	6.0
Height, m	6.0
HRT, min	30
Backwash Waste Clarifier	
Quantity	1
Diameter, m	9.1
Side Water Depth, m	3.7

Parameter	Criteria
Treated Water Holding Tank	
Quantity	1
Volume, m^3	720
HRT, min	60
Treated Water Pumps	
Quantity	3 (2 Duty, 1 Standby)
Type	Centrifugal with VFDs
Flow Rate, L/s	83
TDH, m	21
Motor Power, kW	28.6
Dust Suppression Water Pumps	
Quantity	2
Type	Centrifugal
Flow Rate, L/s	4.5
TDH, m	2
Motor Power, kW	0.75

4.2 Filtration System

This report recommends using dual media pressure filters as a means of removing fine particles from the wastewater following the neutral pH treatment process. The design criteria for the pressure filtration system is presented in **Table 4-2** below.

Table 4-2: Pressure Filtration System Design Criteria

Parameter	Criteria
Quantity	6, 2 duty per train with 1 standby to allow for backwashing
Feed Pump Quantity	3 (2 Duty, 1 Standby)
Feed Pump Flow Rate, L/s	83
Feed Pump Motor Power, kW	3.5
Filtration Rate, m/h	18.6
Total Duty Filter Area, m^2	32
Area per Filter, m^2	8.0
Backwash Frequency, h	24
Volume per backwash, m^3	50

This report also acknowledges the possibility, based on the results of pilot testing, that a tighter membrane filter may be required to meet discharge limits.

4.3 Solids Generation and Handling

Table 4-3 below summarizes the design criteria for the solids stream components in the WTP.

Table 4-3: Solids Generation and Handling Design Criteria

Parameter	Criteria
Estimated Sludge Generation	
Average Sludge, kg /d (dry weight)	1,870
Max Sludge, kg /d (dry weight)	10,700
Low pH Sludge Pumps	
Quantity	2 (1 per train)
Type	Progressive Cavity
Flow Rate, L/s	0.4
TDH, m	3
Motor Power, kW	0.05
High pH Sludge Pumps	
Quantity	2 (1 per train)
Type	Progressive Cavity
Flow Rate, L/s	1.5
TDH, m	3
Motor Power, kW	0.24

4.4 Chemical Feed Systems

Table 4-4 below summarizes the design criteria for the chemical feed components in the WTP.

Table 4-4: Chemical Feed Design Criteria

Parameter	Criteria
Ferric Chloride	
Storage Tank Capacity, m^3	45
Average Dose, mg/L	119
Solution Concentration, %	42
Metering Pumps Quantity	3 (1 duty per train, 1 common standby)
Pump Capacity, L/min	0.4
Lime Storage and Feed System	
Delivered Form	Quicklime CaO
Feed Form	Calcium Hydroxide $Ca(OH)_2$ Solution
Average Dose, mg/L $Ca(OH)_2$	500
Silo, type	Vertical Welded Silo, Carbon Steel
Silo Volume, m^3	279
Storage Time, days	60
Slaker Capacity, tonnes/day	5.5
Slurry Concentration, %	14

Parameter	Criteria
Metering Pumps Quantity	2 (1 duty, 1 standby on continuous loop)
Pump Capacity, L/s	3
Sodium Hydrosulfide	
Storage Tank Capacity, m^3	20
Average Dose, mg/L	28.5
Solution Concentration, %	35
Metering Pumps Quantity	3 (1 duty per train, 1 common standby)
Pump Capacity, L/min	0.12
Sulfuric Acid	
Storage Tank Capacity, m^3	9.5
Average Dose, mg/L	26
Solution Concentration, %	98
Dilute Solution Concentration, %	10
Transfer Pumps Quantity	2 (1 duty, 1 standby)
Transfer Pump Capacity, L/min	0.28
Metering Pumps Quantity	3 (1 duty per train, 1 common standby)
Pump Capacity, L/min	1.4
Polymer	
Blending Units Quantity	1
Blending Unit Capacity, L/s	0.01-0.1
Average Dose, mg/L	5
Metering Pumps Quantity	6 (4 duty per train, 2 common standby)

5. COST ESTIMATING

Both capital costs and operating costs provided in this report are representative of Class 4 estimates as described by AACE. Data is based on vendor quotes and chemical costs acquired in United States Dollars (USD).

5.1 Opinion of Probable Capital Costs

Table 5-1 presents the capital cost opinions for the Mt Todd WTP. Prices are given in USD unless otherwise noted. Costs in the table include the equipment cost and an installation cost of approximately 30% of the capital cost of the equipment.

Table 5-1: Opinion of Probable Capital Costs

Parameter	Cost (USD)
Feed Pumps	$163,000
HDS Sludge Conditioning Tanks and Mixers	$195,000
HDS Reaction Tanks	$1,560,000
NaSH Reaction Tank & Clarifiers	$3,640,000
Pressure Filters	$2,048,000
Backwash Waste Clarifier	$328,000
Treated Water Holding Tank	$312,000
Ferric Chloride Feed System	$111,000
Lime Silo, Slaker, and Feed System	$1,300,000
Process Plant Return Pumps	$163,000
Polymer System	$133,000
Sodium Hydrosulfide Feed System	$104,000
Sulfuric Acid Feed System	$79,000
Treated Water Pumps	$163,000
Dust Suppression Pumps	$7,200
Lime Sludge Pumps	$182,000
Backwash Waste Sludge Pumps	$39,000
Concrete	$1,174,000
Pre-engineered Building	$2,352,000
Electrical and Instrumentation	$3,166,000
Piping, Pipe Supports, and Valves	$2,638,000
Engineering, Procurement, Construction	$3,552,000
Contingency	$2,575,000
Cyanide Probes	$9,100
HCN Gas Alarms	$18,000
Total	**$26,011,000**

5.2 Opinion of Probable Operating Costs

The estimated electrical use at the site is 2,827,000 kWh annually. The estimated labor use at the site includes one and a half (1.5) supervisor/certified operators and two and a half (2.5) maintenance personnel.

Table 5-2 presents the probable annual chemical consumption for the Mt Todd WTP during average flow conditions.

Table 5-2: Opinion of Probable Annual Chemical Consumption

Date: Month & Season		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chemical		Wet	Wet	Wet	Wet	Dry	Dry	Dry	Dry	Dry	Wet	Wet	Wet
Ferric Chloride, 42% (liquid)	tonne	61	55	58	51	46	31	27	27	30	33	58	61
Lime, 100% as CaO (solid)	tonne	169	153	162	142	127	85	75	75	83	91	157	169
Sodium Hydrosulfide, 35% (liquid)	tonne	15	13	14	12	11	7.4	6.5	6.5	7.2	7.9	14	15
Sulfuric Acid, 98% (liquid)	tonne	13	12	13	11	9.8	6.6	5.8	5.8	6.4	7.0	12	13

6. CONCLUSIONS AND RECOMMENDATIONS

The following sections describe the conclusions of the study and present recommendations for further evaluation.

6.1 Interpretations and Conclusions

In review of the SWWB, geochemical modeling and the Water Discharge Licence, conclusions reached for the Water Treatment Plant include the following:

- Two stage lime treatment at pH 6.5 and pH 10.0, followed by chemical precipitation and filtration is required to meet water quality goals based on the SWWB model results for treatment flow variations between wet season and dry season.
- The WTP water quality goals are based on a 1:19 flow dilution (WTP: Edith River) to maintain sulfate levels below the TV at SW4 in the Edith River.
- Influent water quality will not be known until mine operations commence and is expected to change over the life of the mine.

6.2 Recommendations

Items recommended for further study include:

- Bench- or pilot-scale testing to confirm design configuration, removal efficiency, estimates of chemical use and to collect design and operating parameters to further refine estimated treatment costs.
- Bench- or pilot-scale testing of filtration systems to determine the type of filters (dual media or membrane) required to meet discharge standards, and to establish operating parameters to perform life-cycle cost estimates.
- Water quality testing on water from TSF 1, which is expected to fall within the range of water quality expected at the PWP. Further testing is not required from Batman Pit, as it has already been treated.
- Expansion of the sampling program to include analyses for both Cr(III) and Cr(VI) at SW2, SW4, and TSF1. This data should be incorporated into the geochemical model to project the WTP influent concentrations for each constituent.
- Develop a detailed test plan that describes the testing protocol and sampling and analysis plan.

The estimated budget for this work is US$350,000.

7. REFERENCES

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