EVALUATION OF ALTERNATIVES FOR OPTIMIZATION OF THE UPPER BLACKFOOT MINING COMPLEX WATER TREATMENT SYSTEM

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LIST OF ACRONYMS

CMF	Ceramic Microfiltration
GPM	Gallons per Minute
HDPE	High-Density Polyethylene
HP	Horse Power
MDEQ	Montana Department of Environmental Quality
METG	Montana Environmental Trust Group LLC, Trustee of the Montana Environmental Custodial Trust
Mg/L	Milligrams per Liter
MPDES	Montana Pollutant Discharge Elimination System
NPV	Net Present Value
O&M	Operation and Maintenance
PVC	Polyvinyl Chloride
ROD	Record of Decision
S.U.	Standard Units
UBMC	Upper Blackfoot Mining Complex
UF	Ultrafiltration
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

The UBMC water treatment plant (WTP) treats mine drainage from two adits and multiple acidic seeps from a seepage capture trench and French drain collection system that was expanded in 2017. Recent developments including a July 2017 earthquake, the 2017 expansion of the seepage collection system, and exceptionally large 2017/18 snowpack and wet 2018 spring resulted in increased source flows to the WTP throughout 2018 and increased operation and maintenance (O&M) costs. The primary O&M challenges include management and handling of sludge generated through the pH adjustment/chemical precipitation water treatment process, and frequent plugging and required cleaning of the ceramic microfiltration (CMF) units. At the request of the Montana Environmental Trust Group (METG), Hydrometrics evaluated options for improving the WTP performance and efficiency with the goal of promoting long-term compliance with required WTP effluent limits while reducing O&M costs.

Based on screening of preliminary options, three alternatives for modifying the existing WTP are recommended for consideration, including:

- Alternative 1: Add a sludge thickener tank to the process to facilitate sludge handling;
- Alternative 2: Add a sludge thickener tank and lamellae clarifiers to facilitate sludge handling and reduce solids loading and plugging of the CMF; and
- Alternative 3: Additions proposed in Alternative 2 plus replacement of the CMF with a new ultrafiltration (UF) unit to reduce operational costs.

Although presented as three separate alternatives, the three alternatives are designed to allow for phased implementation if desired, so that the less expensive Alternative 1 can be implemented with Alternative 2 and/or 3 implemented at a later date if WTP performance warrants.

The evaluation included development of a water balance based on measured source flows recorded from 2009 through 2018. The water balance was used to determine an optimum WTP design flow capacity balancing the objective of promoting long-term compliance with the WTP effluent limits while minimizing capital and O&M costs. The water balance was also used to determine the optimum WTP operating schedule based on historic source flows and available water storage capacity. The results indicate that the optimum design flow capacity for the WTP with one or more of the recommend alternatives is 140 gallons per minute (gpm), and through efficient use of all currently available water storage options, the modified WTP could be shut down for three to four months each year. Seasonal shutdown of the WTP would significantly reduce O&M costs and eliminate safety-sensitive activities associated with winter operations.

As part of the evaluation, preliminary designs and cost estimates were developed for the three alternatives. Preliminary capital cost estimates for the three alternatives, considered to be +/-20%, are $638,800 for Alternative 1, $989,300 for Alternative 2, and $1,368,300 for Alternative 3. The estimated annual and long-term O&M costs were compared to the existing WTP O&M costs to determine the return on investment or breakeven year for each alternative where the savings resulting from the lower O&M costs would equal the capital expenditures. The cost-benefit analysis shows that savings from the reduced O&M costs would equal the capital costs in eight to nine years for all three alternatives. The cost-benefit analysis also estimates the 30-year savings resulting from reduced O&M costs for Alternatives 1, 2, and 3 compared to the existing WTP operations to be approximately \$2.4 million, \$3.7 million, and \$5.6 million, respectively. The capital and long-term O&M cost comparisons allow stakeholders to assess the alternatives based on short-term capital costs as well as long-term operating costs. Finally, the cost analysis shows that the currently available WTP O&M fund (≈\$3.4 million) will be depleted in 5 to 6 years with continued operation of the existing system or implementation of any of the three alternatives.

In addition to the water treatment alternatives, two water management alternatives are recommended for future consideration. Interception and diversion of clean groundwater that would otherwise recharge the mine workings and report to the WTP would reduce the volume of water requiring treatment. The second alternative, completing a well into and pumping from the deeper mine workings would increase the available storage capacity within the mine workings allowing for attenuation of higher seasonal peak flows and/or a longer winter shutdown period. The water management alternatives are considered preliminary at this time and would require further evaluation and field testing to better assess their feasibility and potential benefits.

Finally, the water treatment alternatives are scored against a suite of risk reduction/selection criteria such as capital and O&M costs, likelihood of future compliance with effluent limits, and ability to handle unanticipated future short-term or long-term increases in flow and/or contaminant loads. Water treatment alternatives 2 and 3 score highest for long-term performance and cost savings, with Alternative 3 having the highest capital cost but greatest long-term savings through reduced O&M costs. Therefore, final alternative selection may depend on the short-term availability of funds for capital expenditures. Pending a decision to proceed with a selected alternative, approximately nine months would be required for planning, design, equipment procurement and construction before the system modifications are operational. Thus, based on their current construction schedule, DEQ forecasts that any WTP modifications would occur after remedial activities are completed downstream of the WTP.

EVALUATION OF ALTERNATIVES FOR OPTIMIZATION OF THE UPPER BLACKFOOT MINING COMPLEX WATER TREATMENT SYSTEM

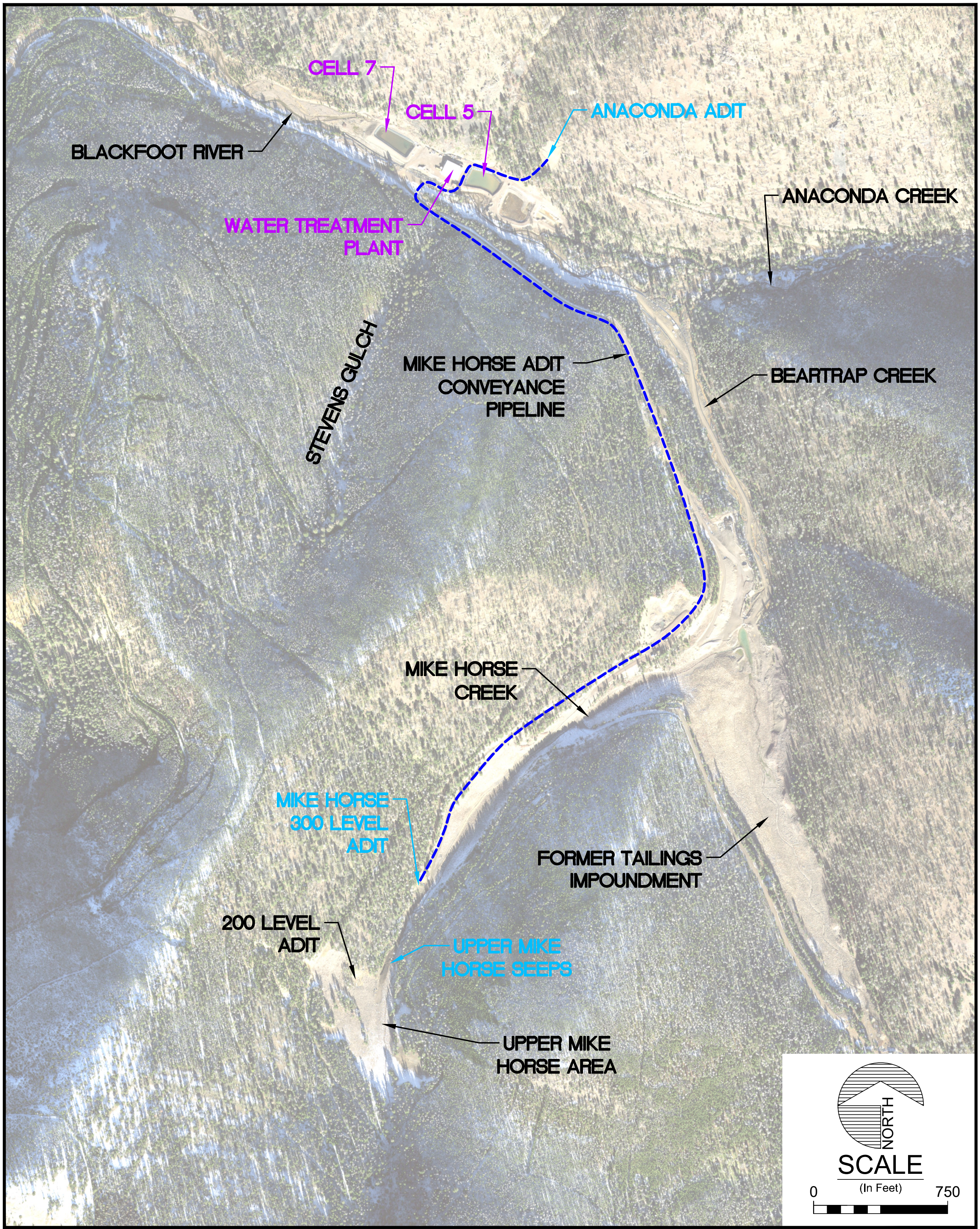
1.0 INTRODUCTION

At the request of the Montana Environmental Trust Group (METG), Hydrometrics, Inc. has conducted a streamlined evaluation of alternatives for optimizing performance of the Upper Blackfoot Mining Complex (UBMC) water treatment plant (WTP). This report presents results of the alternatives screening analysis including project background and objectives, development and screening of preliminary options, and recommended alternatives for optimizing the UBMC WTP operations.

1.1 PROJECT BACKGROUND

The UBMC WTP treats mine drainage from three primary sources; drainage from the inactive Mike Horse Mine underground workings, bedrock seepage in Upper Mike Horse Drainage (Upper Mike Horse Seeps), and discharge from the Anaconda Mine underground workings (Figure 1-1). All three sources contain high concentrations of some metals including, but not limited to, cadmium, copper, iron, manganese, lead and zinc, and are moderately to highly acidic. The Upper Mike Horse Seeps are captured and pumped back to the Mike Horse mine workings with the commingled seep/mine drainage discharged from the Mike Horse 300 Level Adit and conveyed approximately one mile through a high-density polyethylene (HDPE) pipeline to the WTP. The Anaconda Adit discharge is added to the Mike Horse Adit discharge in the WTP feed tank and the combined sources treated through chemical addition/metals precipitation and polishing through a series of ceramic microfilters (CMFs).

The water treatment system includes two lined ponds located near the WTP for water and sludge storage (Figure 1-1). The two lined ponds, referred to as Cell 5 and Cell 7, have storage capacities of 840,000 and 970,000 gallons, respectively. In addition, in 1995 a concrete plug or bulkhead was constructed within the Mike Horse Adit which allows water to be stored in the underground workings. The adit discharge conveyance line extends through the flow-through plug with a valve located downstream of the plug. By adjusting the valve, the adit discharge rate and the mine water level can be controlled. Thus, the mine workings can be used as an equalization reservoir with the water level drawn down during the low flow winter months to provide storage within the mine for the higher springtime mine inflow rates. A previous analysis by Hydrometrics (2013) indicates approximately seven million gallons of available storage between the 300 level and 200 level mine workings (Figure 1-2). The 200 level workings represent an upper limit for the mine water level before water would discharge from the open 200 Level Adit.



UPPER BLACKFOOT MINING COMPLEX	UBMC WATER TREATMENT PLANT AND RELATED FEATURES	FIGURE 1-1

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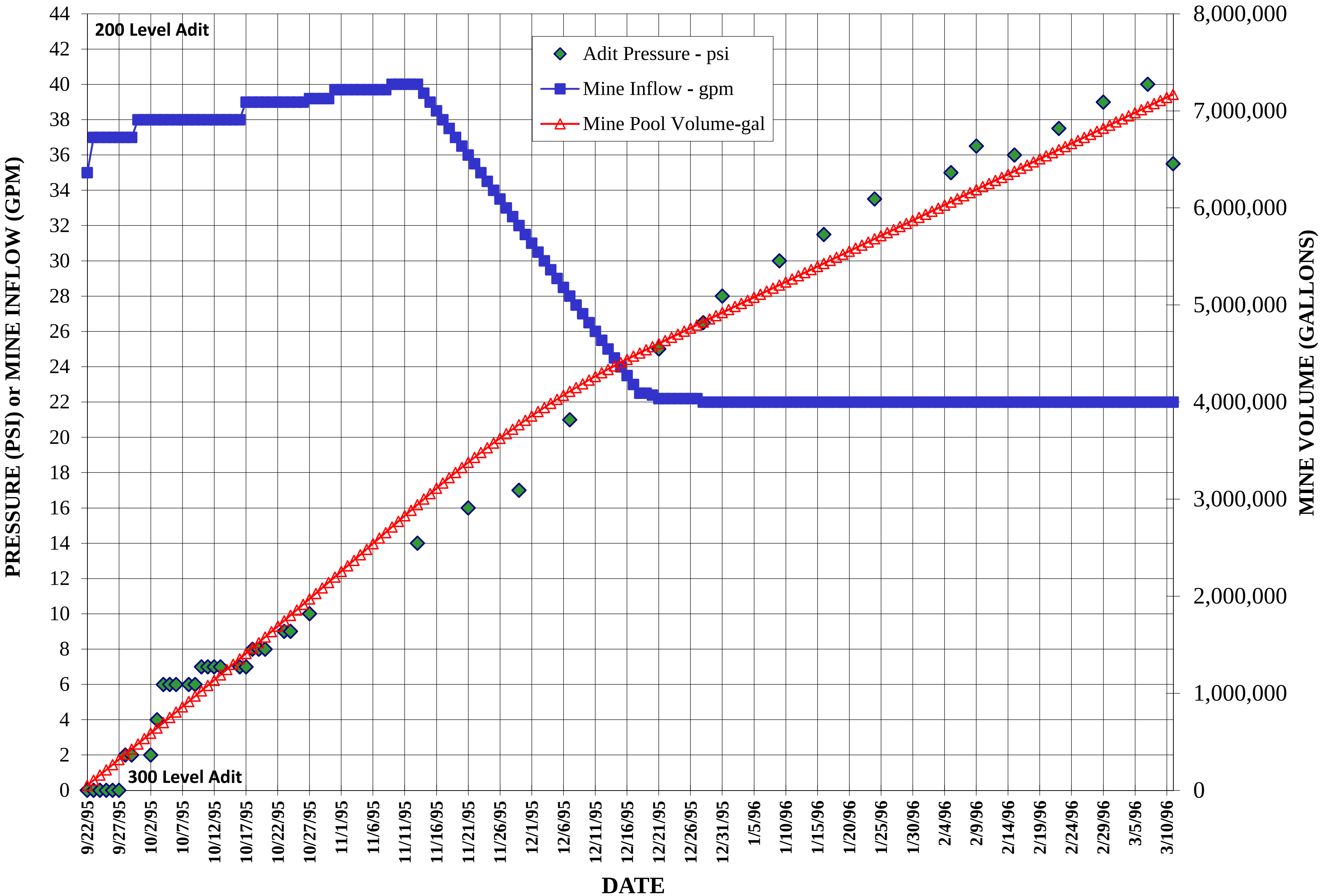
FIGURE 1-2. MIKE HORSE MINE WORKINGS PRESSURE/VOLUME CURVE



1.1.1 Source Flow Rates

The largest of the three source flows is the Mike Horse Adit discharge. Prior to 1995 when the concrete plug was placed in the Mike Horse Adit to control flows, the adit discharge rate varied from about 25 gpm during the late fall and winter, to 120 gpm or more during May and June. The large variation in seasonal flows and rapid response to the spring season snowmelt and rainfall indicates a close hydraulic connection between the mine workings and ground surface, either through mine workings in close proximity or directly connected to the ground surface or through geologic structures. The high May/June flows from the Mike Horse Adit result in increased operation and maintenance (O&M) costs during these periods.

Discharge from the Anaconda Adit is much less than the Mike Horse Adit with historic flows ranging from 0.2 to 9.0 gpm seasonally. Prior to the 2017 earthquake, the Anaconda Adit flow was normally around 1.0 gpm with higher flows corresponding to individual precipitation events and/or spring snowmelt. After the earthquake, the average flow of the Anaconda Adit increased to approximately 4.0 gpm. While the adit is still influenced by precipitation and snow melt, the average flow rate has steadily decreased since the earthquake with an average daily flow of 3.0 gpm as of May 20, 2019. The lower discharge rate for the Anaconda Adit is due primarily to the smaller extent of the Anaconda mine workings as compared to the Mike Horse workings.

The Upper Mike Horse Seep is an area of low pH, high metals concentration seepage water in Upper Mike Horse Drainage (Figure 1-1). In 2009 a seepage collection trench was constructed to capture the Upper Mike Horse Seep with the collected water pumped back to the Mike Horse mine workings through the 200 Level Adit. At that time, seepage flows ranged seasonally from a few gpm up to about 30 gpm. In 2017, the Upper Mike Horse seepage collection system was expanded to capture additional acidic seepage as part of the Upper Mike Horse Drainage remedial action. Flows to the expanded capture system in spring 2018 were reportedly as high as 175 gpm for a short duration, although a significant portion of that flow is believed to be snowmelt water due to the high winter 2017/2018 snowpack (discussed further below). The seepage collection system pump was replaced with a higher capacity pump in fall 2018 to handle increased flows from the expanded capture system.

Figure 1-3 shows monthly average flows for the Mike Horse Adit, Anaconda Adit, Upper Mike Horse Seep and the WTP discharge from May 2009, when the WTP was brought online, through November 2018. The relatively small contribution from the Anaconda Adit as compared to the Mike Horse Adit is evident from the figure, with the Mike Horse Adit discharge typically accounting for 80% or more of the total WTP inflow. It should be noted that the Mike Horse Adit flow includes the Upper Mike Horse Seep flow since the seep flow has been pumped back to the mine workings since 2009.

1.1.2 Source Water Chemistry and WTP Effluent Limits

Water quality data for the Mike Horse Adit and Anaconda Adit discharges from November 2018 is included in Table 1-1, along with recent WTP influent and effluent water quality and the WTP effluent limits. The Mike Horse Adit discharge is slightly acidic with a pH of 6.1 and high concentrations of sulfate, iron, manganese and zinc. The November 2018 sample results are typical

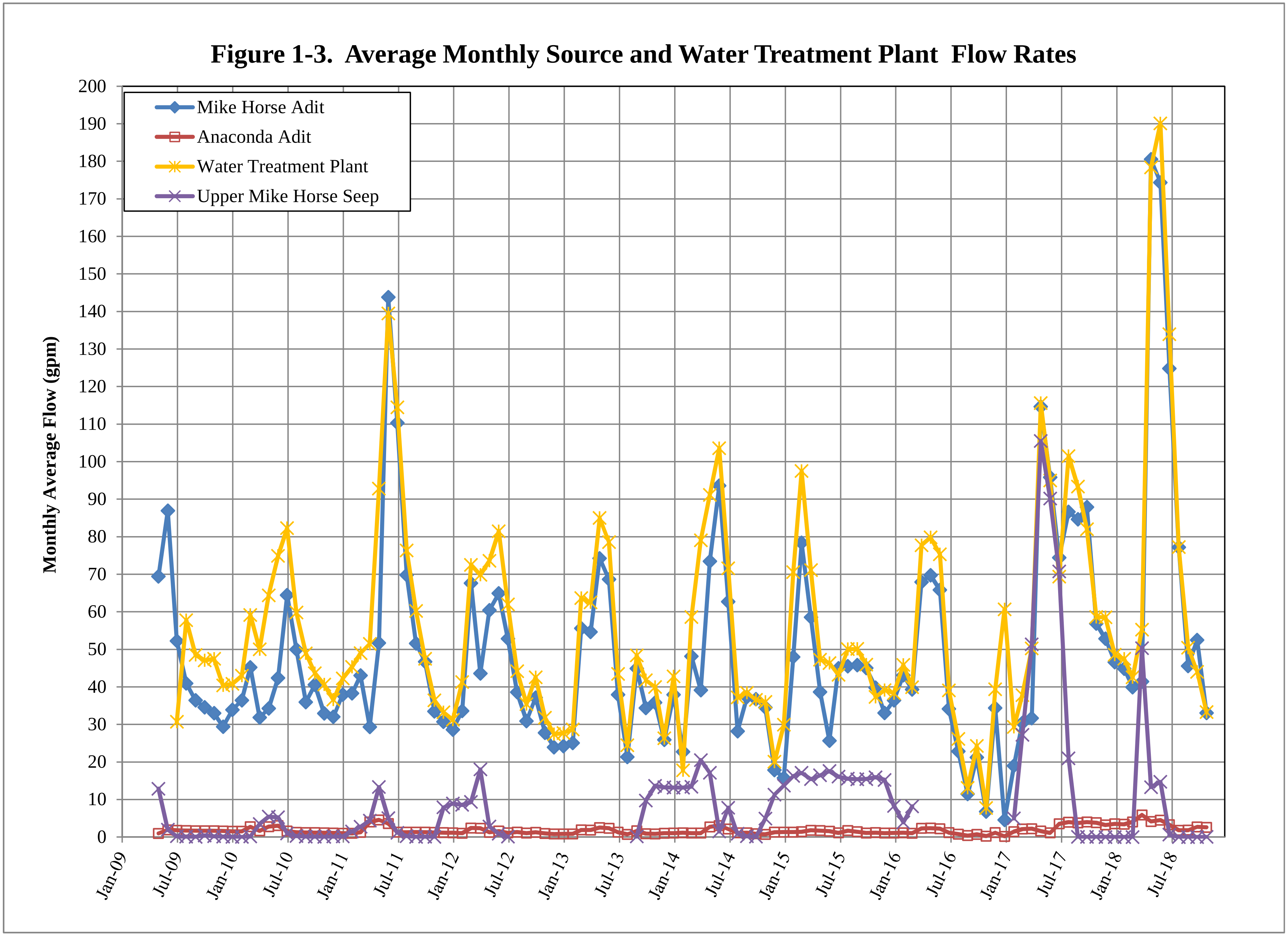


Figure 1-3. Average Monthly Source and Water Treatment Plant Flow Rates
Monthly Average Flow (gpm)
Mike Horse Adit
Anaconda Adit
Water Treatment Plant
Upper Mike Horse Seep
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
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Jan-16
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Jan-17
Jul-17
Jan-18
Jul-18

TABLE 1-1. WATER QUALITY DATA AND WATER TREATMENT PLANT EFFLUENT LIMITS

Parameter	Units	Mike Horse Adit Discharge	Anaconda Adit Discharge	Upper Mike Horse Seep	WTP		WTP Effluent Limits*	
					Influent	Effluent	Monthly Ave	Daily Max
Sample Date		*11/8/18*	*11/8/18*	*5/21/99*	*11/7/18*	*11/7/18*		
pH	S.U.	6.1	6.7	3.8	NM	7.74	6.0 to 9.0	
Total Dis. Solids	mg/L	1720	369	4000	NM	NM	NA	NA
Sulfate	mg/L	1030	179	2610	1050	NM	NA	NA
Hardness as CaCO3	mg/L	1110	232	1430	885	NM	NA	NA
Calcium	mg/L	220	63	156	NM	NM	NA	NA
Magnesium	mg/L	137	18	260	NM	NM	NA	NA
Sodium	mg/L	2	7	2	NM	NM	NA	NA
Potassium	mg/L	2	1	2	NM	NM	NA	NA
Aluminum	mg/L	0.155	0.027	128	<0.03	<0.03	NA	NA
Arsenic	mg/L	0.013	0.016	<0.003	0.01	<0.001	NA	NA
Cadmium	mg/L	0.0463	0.00043	1.16	0.0536	<0.00008	0.0002	0.0015
Copper	mg/L	0.356	0.005	66.2	0.466	<0.001	0.008	0.0103
Iron	mg/L	48.6	10.8	<0.02	46.1	<0.05	1.0	1.5
Lead	mg/L	0.0626	0.0065	2.04	0.0707	<0.0005	0.0025	0.0537
Manganese	mg/L	21.8	4.4	91.5	23.4	0.009	1.92	2.69
Zinc	mg/L	29.9	0.478	143	31.2	0.035	0.0907	0.0907

WTP - Water Treatment Plant
NM - Not Measured
NA - Not Applicable
* Additional effluent limits exist for total recoverable mercury and oil and grease.
All metals concentrations are total recoverable except aluminum in WTP effluent which is dissolved.

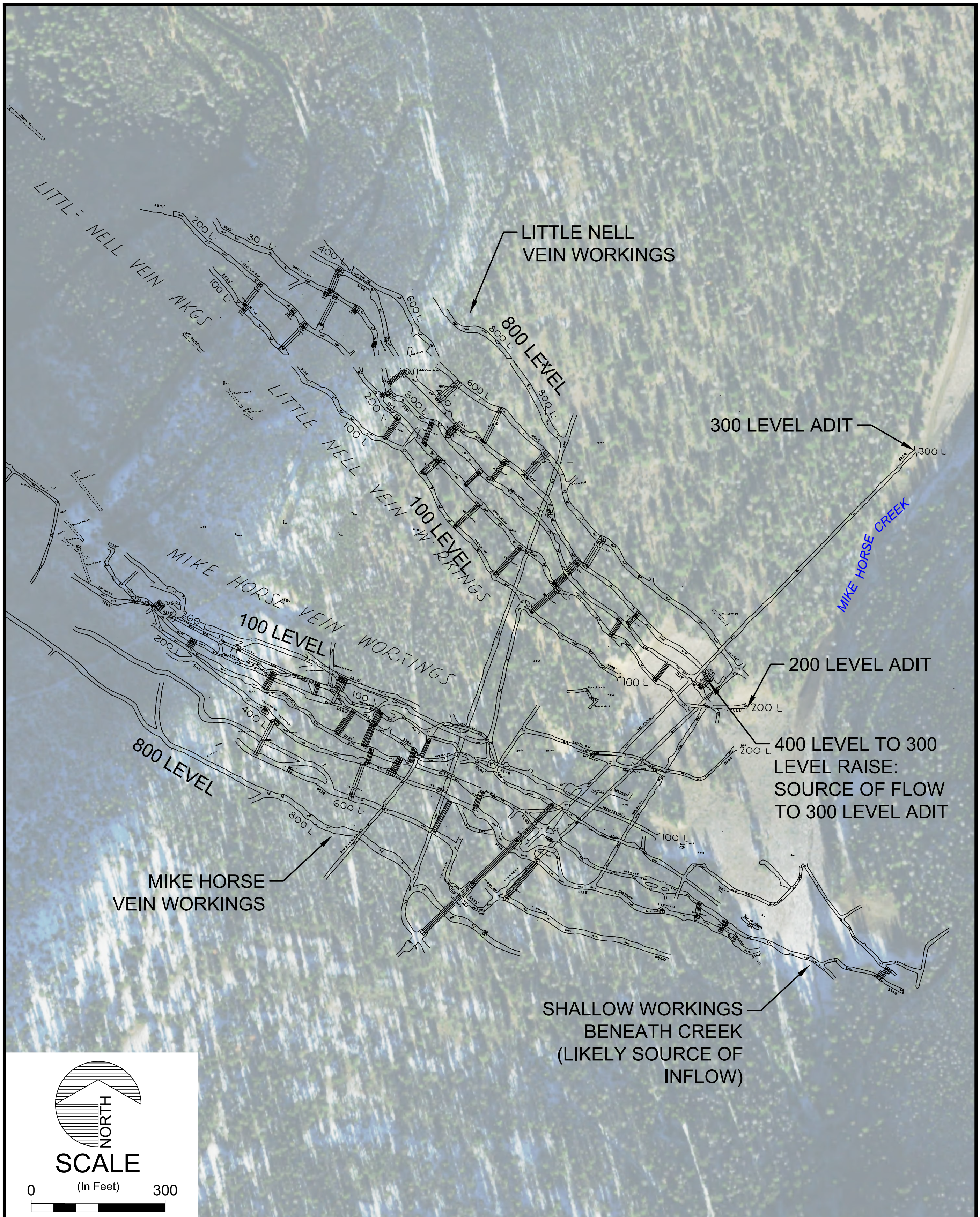
of the Mike Horse water quality for the majority of the year, although the adit discharge does experience a spike in acidity and metals concentrations during the May/June spring runoff period. The November 2018 sample from the Anaconda Adit is the first sample collected from that source in the past few years, and represents a significant improvement in water quality compared to data from the 1990s and 2000s. For example, sulfate, copper, lead, and zinc concentrations in a May 2, 2011 sample of the Anaconda Adit discharge were 830, 0.506, 0.030, and 19.0 milligrams per liter (mg/L), respectively, compared to 179, 0.005, 0.0065, and 0.478 mg/L in the November 11, 2018 sample. It is unclear if the November 2018 data represents a permanent improvement in water quality from this source or a short-term change. Additional sampling is proposed in 2019 to further assess the current Anaconda Adit discharge chemistry. Recent water quality data is not available for the Upper Mike Horse Seep but past sampling shows the seep water to be acidic with exceptionally high concentrations of aluminum, copper, manganese, and zinc (Table 1-1). Additional water quality monitoring from all three sources is recommended in 2019 (Section 4).

Discharge from the WTP was previously regulated through a Montana Pollutant Discharge Elimination System (MPDES) permit (Permit # MT0030031), with effluent limits or maximum allowable constituent concentrations prescribed by the permit. In 2011, the State of Montana issued an exemption for WTP operations from the MPDES permit to facilitate overall cleanup activities and oversight at the UBMC, although all substantive permit requirements, including the permit effluent limits remain. Despite the operational limitations and challenges described above, the WTP discharge has met the facility effluent limits (Table 1-1) the vast majority of the time. After experiencing a number of exceedances for cadmium, manganese, and zinc during the initial operational period (2010-2011), the effluent limits for these metals have consistently been met since then with the exception of a few exceedances for cadmium and zinc during the 2017 and 2018 high flow periods. There have been no exceedances of the copper, iron or lead effluent limits for the entire WTP operational period. As noted above, however, general compliance with the facility effluent limits has required extraordinary efforts on the part of the WTP operator and significant operational costs. It is the excessive efforts and costs that prompted this evaluation of treatment alternatives.

1.1.3 Mine Workings

As noted above, discharge from the Mike Horse mine workings is the largest source of flow to the WTP. The Mike Horse Mine was the largest and most productive of the individual mines comprising the UBMC, resulting in an extensive network of tunnels, shafts, stopes, and other underground workings (Figure 1-4). The Mike Horse workings were developed along two main vein systems, the Mike Horse Vein and Little Nell Vein, and include six levels. The six levels, from shallowest to deepest, include the 100 Level, 200 Level, 300 Level, 400 Level, 600 Level, and 800 Level. The designations refer to the approximate relative elevation of each level with the 800 Level approximately 700 feet below the 100 Level.

The Mike Horse workings discharge by gravity flow from the 300 Level Adit, meaning all workings below the 300 Level are fully flooded. Due to the flow-through plug inside the 300 Level Adit, the water level inside the mine can be raised by as much as 130 feet above the 300 Level at which point potential outflow from the 200 Level Adit precludes further flooding (Figure 1-2). Based on



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MIKE HORSE MINE UNDERGROUND WORKINGS

FIGURE **1-4**

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currently available data from August 2003 through August 2018, the water pressure behind the adit plug has ranged from 49.5 psi to 8.8 psi (114.3 feet to 20.3 feet) on 6/18/07 and 4/11/18, respectively. Over the last two years (2017-2018), the adit pressure has been maintained below 15 psi (except during spring high flow periods and immediately after the 2017 earthquake) in order to stabilize the chemistry of the adit discharge. Prior to that, the adit pressure was generally lowered before the anticipated spring runoff to provide additional storage capacity for the higher spring season mine inflow rates.

The Mike Horse Adit plug is located approximately 300 feet inside of the 300 Level portal in an area of hard, competent bedrock. The plug is constructed of type V concrete, compatible with the high sulfate content of the adit water, with a compressive strength of 2,500 psi and safe average shear stress of 50 psi. Based on these properties and a maximum design water level of 100 feet (43 psi) behind the plug, the required plug thickness is only 1.5 feet (Asarco, 1995). For the plug design and construction, a factor of safety of 4 was applied resulting for an actual plug length of six feet, meaning the plug is designed to withstand a hydrostatic pressure of about 170 psi or 400 feet of head. Following cement curing, the plug/bedrock interface was pressure grouted to provide a proper seal between the cement plug and bedrock.

The source and mechanism for groundwater inflow to the Mike Horse mine workings has previously been investigated to assess the potential for reducing groundwater inflow to the workings and outflow to the WTP (MSE, 1997; Spectrum Engineering, 2011). In 1994, the 300 Level mine workings were inspected in preparation of the mine plug construction. At that time, the inspectors noted that all of the water flowing out of the 300 Level Adit was upwelling from a raise connecting the 400 and 300 levels located about 750 feet south of the adit portal (Figure 1-4) and beyond that point the 300 Level main tunnel and the east-west drifts were dry with no leakage from the walls or ceiling. Further south, the Mike Horse Vein workings cross beneath Mike Horse Creek with the workings encroaching within 20 feet or less of the ground surface (Figure 1-4). It has been hypothesized that the main source of inflow to the mine workings occurs in this area due to the close proximity of shallow alluvial groundwater and Mike Horse Creek to the workings (MSE, 1997). A current conceptual model of inflow to the mine workings includes infiltration of shallow groundwater into the 200 and/or 300 Level Mike Horse Vein workings beneath Mike Horse Creek, northward flow through the deeper 400 Level workings, and upwelling from the 400 Level to the 300 Level through the connecting raise. This model accounts for the dry conditions noted in the 300 Level workings upgradient (south) of the connecting raise as observed in 1994, and is important when considering water management/source control options for the Mike Horse workings.

1.1.4 Clay-Based Grout Demonstration Project

MSE (1997) completed a detailed groundwater investigation and pilot grouting project in the Upper Mike Horse drainage area in the 1990s referred to as the Mike Horse Clay-Based Grouting Demonstration Project (MSE, 1994 and 1997). The project was funded by the U.S. EPA and U.S. DOE for the purpose of demonstrating the effectiveness of a clay-based grout at reducing or eliminating infiltration of surface and shallow groundwater into underground mine workings. The Mike Horse Mine was chosen as a demonstration project due to the occurrence of shallow mine workings underlying upper Mike Horse Creek as described above. The grouting project area is shown in Figure 1-5.

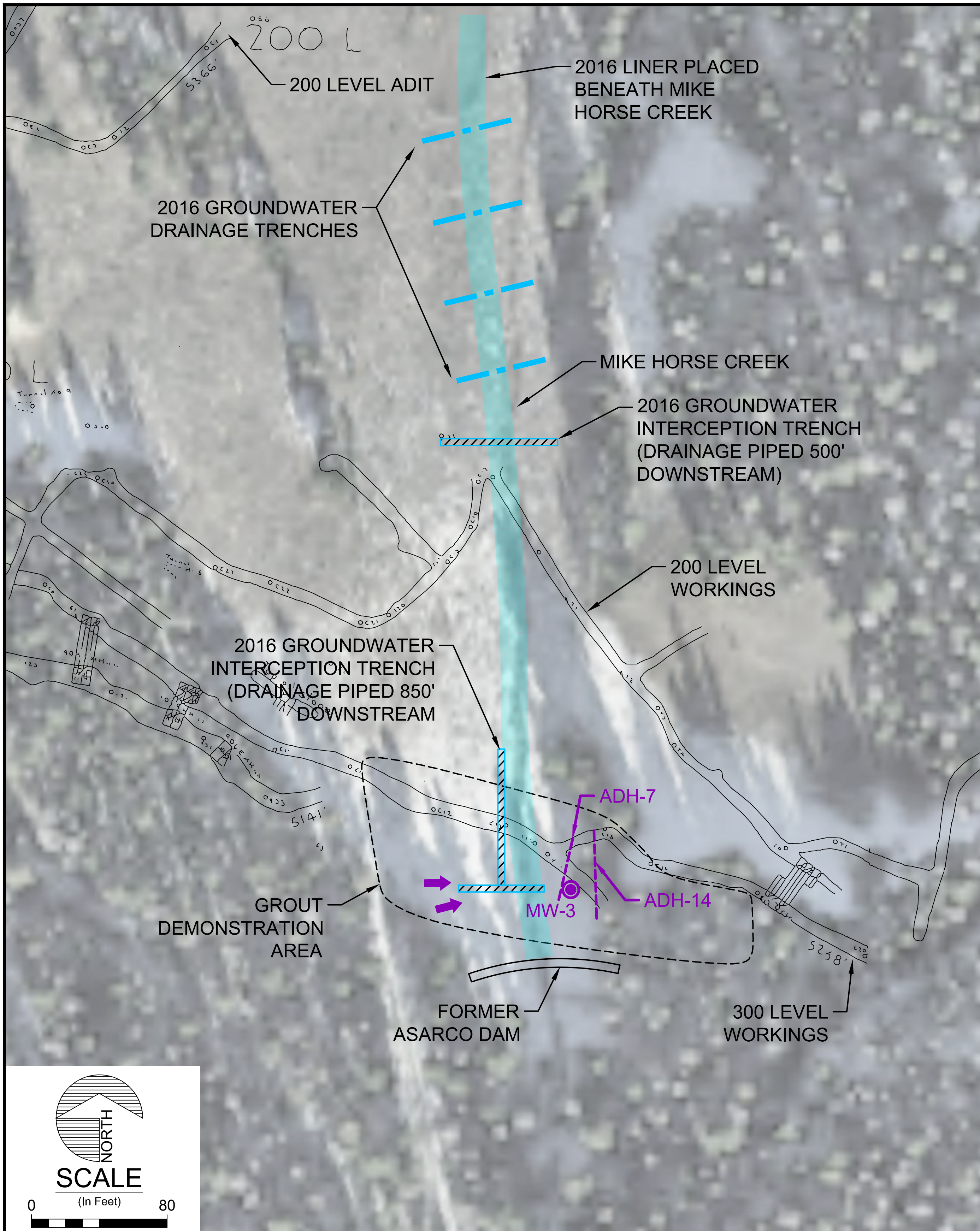
A groundwater/bedrock characterization program was completed in 1993/94 (prior to grouting) including bedrock core drilling (17 drill holes total), completion of seven monitoring wells, groundwater level monitoring and packer testing to determine bedrock transmissivity. The site characterization program identified a number of fracture zones within the shallow bedrock that could convey surface water and shallow groundwater into the underground workings, and concluded that a hydraulic connection existed between Mike Horse Creek and the underlying mine workings.

Between September and November 1994, approximately 1600 cubic yards of grout was injected through angled drill holes into the shallow bedrock to form a horizontal grout curtain between Mike Horse Creek and the shallow mine workings, with the majority of grout injected through drill holes ADH-7 and ADH-14 (Figure 1-5). An additional 1500 cubic yards of grout was scheduled for injection in 1995, however, due to changes in the Mike Horse Adit discharge, namely plugging and flooding of the mine workings, the Phase II program was canceled. Although the quantity of grout injected was estimated to be only 50% of the total amount required to complete the grout curtain, MSE concluded that the demonstration program was effective at reducing the bedrock permeability. Following grout injection, the water level in monitoring well MW-3 (Figure 1-5) rose from 111 to 17 feet below ground surface and a number of springs developed downstream of the injection site. Although a direct comparison of pre- and post-grouting adit discharge rates could not be made due mainly to flooding of the workings, MSE concluded that the grout injection likely was effective at reducing shallow infiltration to the mine workings based on the increased groundwater levels and spring development.

1.1.5 2016 Mike Horse Drainage Remediation Activities

The Montana Department of Environmental Quality (MDEQ) completed remediation activities in the Mike Horse drainage in 2016 including mine waste removal and revegetation in the drainage bottom and hillsides (Pioneer Technical Services, 2017). The remediation program incorporated a number of drainage control measures in the upper Mike Horse drainage (south of the 300 Level Adit) where Mike Horse Creek crosses the Mike Horse and Little Nell veins and associated underground workings. The drainage control measures are intended to reduce infiltration of surface water and shallow groundwater into the mine workings and associated 300 Level Adit discharge and therefore have potential implications for future WTP operations and the current alternatives evaluation.

In July 2016, a groundwater interception trench was excavated on the west side of upper Mike Horse drainage to a depth of 15 feet where competent bedrock was encountered. The trench was 100 feet long, oriented parallel (north-south) with the drainage, and headed in a “T” on the uphill (south) end (Figure 1-5). At the time of excavation, groundwater was observed entering the trench from the west side but not from the east (Pioneer, 2017). The trench was backfilled with coarse drain rock overlain with low permeability soil with the trench flow piped 850 feet downstream (north) through a 2-inch HDPE pipe where it discharges to Mike Horse Creek. This system was incorporated into the Upper Mike Horse remediation program as a permanent shallow groundwater drainage feature.



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UPPER MIKE HORSE DRAINAGE GROUT DEMONSTRATION PROJECT AND 2016 DRAINAGE CONTROLS

FIGURE 1-5

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A second shallow groundwater interception trench was constructed about 300 feet north of the first trench and is oriented perpendicular to the drainage (Figure 1-5). Similar to the upper trench, this trench was also backfilled with coarse drain rock overlain with low permeability soil, with the collected water piped about 500 feet downstream and discharged to Mike Horse Creek. In addition, four smaller drainage trenches were excavated immediately downstream of the second trench (Figure 1-5). These trenches are oriented diagonally (SW to NE) across the drainage bottom and backfilled with coarse drain rock but do not include outlet pipes like the two upstream trenches. These trenches are intended to move groundwater across the mineralized bedrock in this area to reduce contact time and potential metals leaching. As with the upper drainage trench, all of these features were incorporated into the 2016 Mike Horse drainage remediation program as permanent features (Pioneer, 2017).

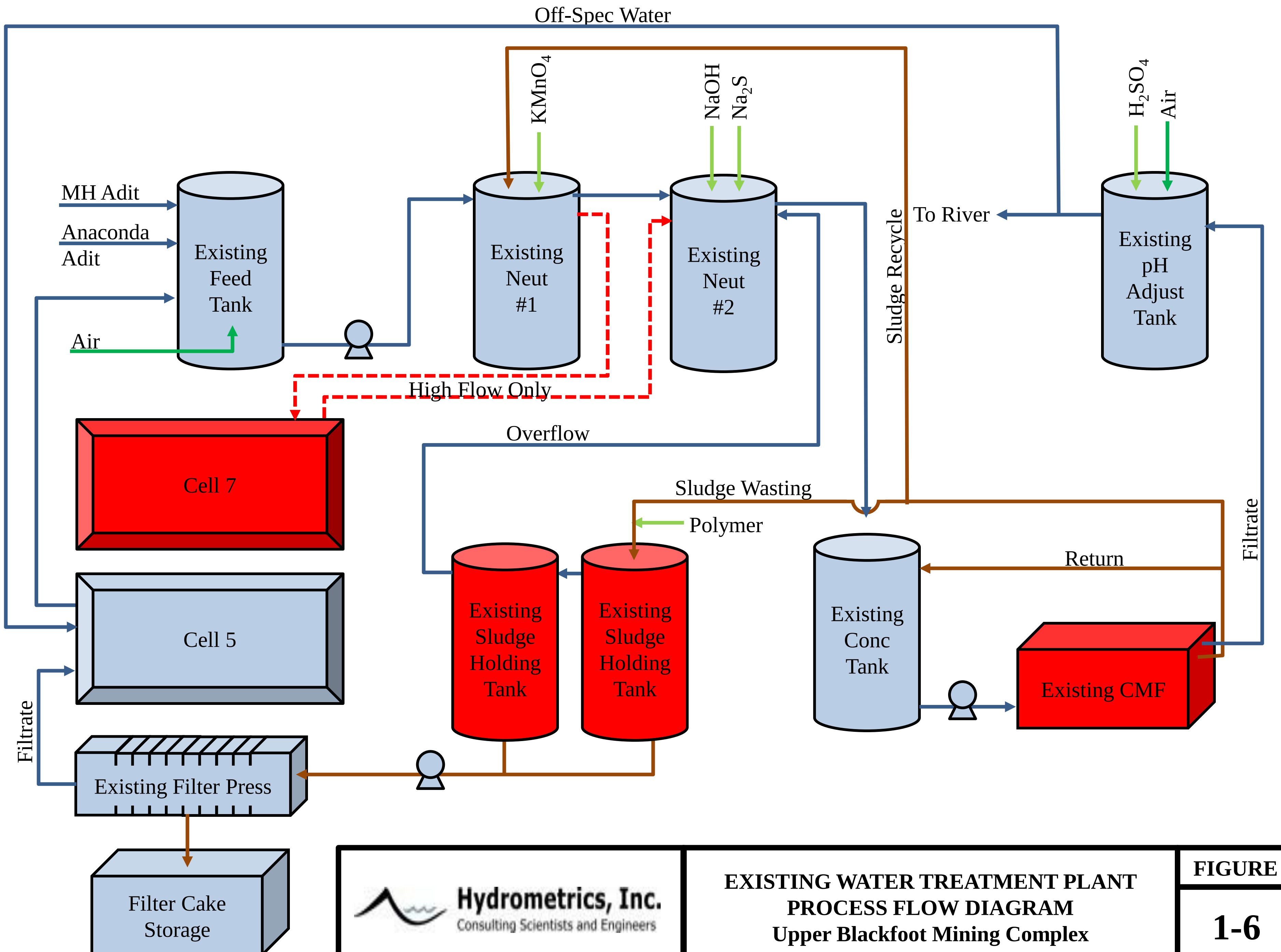
In addition to the interception/drainage trenches, the 2016 remediation program included placing a liner system beneath the reconstructed Mike Horse Creek channel. Following mine waste removal, the subsurface liner system was placed beneath the channel alignment starting near the former Asarco dam and extending downstream about 700 feet (Figure 1-5). The liner system includes, from bottom to top, 6 inches of low permeability soil, a geocomposite layer, a 40 mil plastic liner, a second geocomposite layer, and two feet of low permeability soil. The Mike Horse Creek channel was constructed on top of the upper soil layer. The purpose of the liner system is to prevent leakage of creek water into the underlying mine workings.

As outlined above, the 2016 remediation program included a number of elements designed to reduce potential seepage of surface water and shallow groundwater into the Mike Horse mine workings. A number of factors since 2016, including the July 2017 earthquake and the very wet 2018 spring temporarily altered hydrologic conditions in the area precluding detailed assessment of potential effects of the 2016 activities on adit discharge rates. The adit discharge rate will be evaluated during 2019 to determine possible benefits of the 2016 remediation activities.

1.2 EXISTING WATER TREATMENT PROCESS

The existing UBMC WTP utilizes a series of chemical and physical processes to remove metals from the collected adit waters. A process flow diagram of the existing WTP is included as Figure 1-6 and a general layout of the WTP in Figure 1-7. The raw source waters are collected and stored in the Feed Tank where the water is purged with low pressure air to strip carbon dioxide and reduce the water buffering capacity. This results in lower chemical costs for pH adjustment in the remaining process steps. From the Feed Tank, water is pumped to Neutralization Tanks #1 and #2 where the water is chemically treated to precipitate metals. Caustic soda (50% solution) is added to raise the pH to approximately 9.5; at this pH, target metals are converted to insoluble hydroxides which form precipitates. Following caustic addition, a sodium sulfide solution is added to precipitate any remaining cadmium as an insoluble sulfide, and lastly potassium permanganate solution is added to oxidize and precipitate any remaining manganese.

From the neutralization circuit, the water and solids are passed to the CMF system to separate the precipitated solids from the treated water. The Concentration Tank receives water from the



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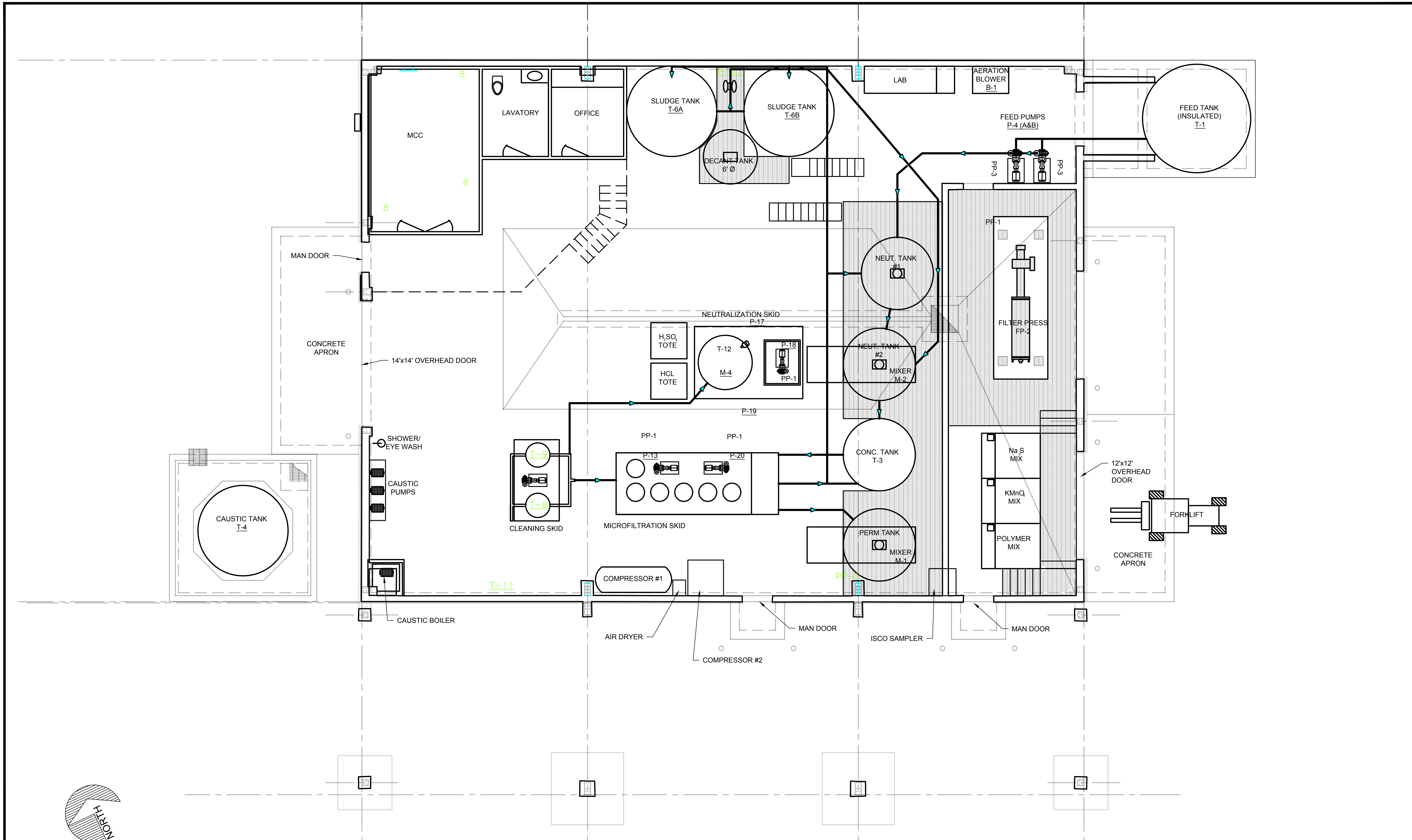
EXISTING WATER TREATMENT PLANT PROCESS FLOW DIAGRAM
Upper Blackfoot Mining Complex

FIGURE
1-6



UPPER BLACKFOOT MINING COMPLEX

WATER TREATMENT PLANT
GENERAL ARRANGEMENT

FIGURE
1-7

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Neutralization Tanks and a return stream from the CMF units. The CMF process circulates up to 2,100 gpm of water in a loop concentrating the solids content in the process stream. A sludge wasting stream from the CMF return loop is directed to the sludge holding tanks for ultimate solids removal in the filter press. Clear water which passes through the CMF reports to the pH Adjust Tank where sulfuric acid is added to lower the pH and air is added (as necessary) to raise the dissolved oxygen concentration prior to discharge to the Blackfoot River.

Although the existing WTP meets the discharge effluent limits the majority of time, high flows resulting from spring runoff and/or high precipitation events have caused upset conditions in the WTP resulting in increased O&M costs and occasional effluent exceedances. System limitations caused by high-flow events include short hydraulic retention times resulting in incomplete chemical reactions, increased required cleaning of the CMF units due to the elevated solids load in the CMF process loop, and increased maintenance of the CMF due to increased cleaning of the units. General system limitations include ineffective solids removal from the Concentration Tank, inefficient CMF operations, and long filter press loading times due to the low solids content of the settled sludge. These limitations result in increased operator time, chemical costs, and wear and tear on the CMF equipment.

During past high-flow events, WTP operators have diverted water from Neutralization Tank #1 to Cell 7 to increase residence times and provide preliminary solids settling before sending water back to Neutralization Tank #2 to finish processing. This was effective in decreasing the solids load to the CMF as well as extending CMF run times between cleanings, but resulted in the accumulation of sludge in Cell 7 which required significant labor and expense to process. Operators also used cartridge filters to filter the water and increase throughput in the WTP. Again, although this was effective, it was costly in terms of labor, equipment, and filters.

In summary, although the existing WTP has met the discharge effluent limits the majority of the time, current process limitations, including problems with sludge handling and management and frequent plugging of the CMF, have resulted in excessively high O&M costs and periodic effluent limit exceedances. Modifying the WTP infrastructure and operations as outlined in this report would reduce the potential for future effluent limit exceedances while reducing future labor and cost requirements associated with the WTP operations.

1.3 PROJECT GOALS AND OBJECTIVES

At the request of METG, Hydrometrics has evaluated options for addressing the operational limitations described above and improving overall WTP performance. Specific objectives of the evaluation include:

1. Evaluate and screen preliminary options for modifying the WTP and/or addressing source flows through water management/source control;
2. Reassess the required design flow capacity for the WTP based on source flow rates over the past several years and currently available water storage capacity;

3. Recommend one or more alternatives to enhance the WTP design and operations to promote long-term compliance with Facility effluent limits while minimizing O&M costs; and
4. Provide preliminary designs and cost estimates for implementing the recommended alternative(s) for consideration and use by project planners and stakeholders.

This report presents results of the UBMC WTP evaluation. The evaluation and reporting followed a streamlined approach, as compared to a formal feasibility study, to simplify the overall evaluation and review process and reduce associated costs. Section 2 presents a list of preliminary options for WTP modification and water management/sources control, and screening of selected options according to implementability, effectiveness and relative cost. Section 11 of the UBMC Record of Decision (ROD) identifies active mechanical treatment via the WTP as the selected remedy for treatment of adit discharge portions of groundwater. Therefore, as the selected remedy, water treatment meets the CECRA criteria stated in Section 75-10-721, MCA, including compliance with ERCLs, mitigation of risk, effectiveness and reliability, practicability, and cost-effectiveness. Based on the screening results, recommended alternatives are presented in Section 3. Supporting information is included in appendices.

2.0 SCREENING OF PRELIMINARY OPTIONS

As an initial step in the alternatives screening process, a preliminary list of options was developed. The preliminary list was intended to present all potential water treatment and management options for initial consideration by the project team. The preliminary list was reviewed by the project team during a site meeting on September 6th and follow-up meetings in Helena on September 7, 2018. Based on team review, a number of options were selected for more detailed evaluation under the alternatives screening process. The preliminary list of options is described below and summarized in Table 2-1 with the complete list included in Appendix A. It should be noted the preliminary water treatment options focus on approaches and technologies consistent with the existing WTP technology (chemical precipitation) to minimize overall costs. Although other water treatment technologies were briefly considered (i.e., reverse osmosis, ion exchange, electrocoagulation), these technologies were dismissed due to higher costs, uncertain effectiveness for the UBMC water chemistry and conditions, and limited compatibility with the existing WTP equipment and infrastructure.

2.1 PRELIMINARY LIST OF OPTIONS

2.1.1 Water Treatment Options

Water treatment options included in the preliminary options list fall under two general categories; modifying or replacing the existing water treatment system, or adding one or more pre- or post-treatment steps to augment the existing system. Five options for modifying the existing system were initially considered, including:

- Replacing the existing WTP with a new WTP capable of treating up to 300 gpm (a design capacity initially requested by the MDEQ project stakeholders);
- Replacing the existing WTP with a new WTP with adequate capacity (other than 300 gpm) to consistently meet effluent limits while reducing O&M costs;
- Constructing a second WTP to operate in parallel with the existing WTP to increase the combined capacity to 300 gpm (or other appropriate capacity);
- Modifying the existing WTP to handle up to 300 gpm; and
- Modifying existing WTP to increase capacity to a level (other than 300 gpm) necessary to ensure compliance with effluent limits and reduce O&M costs.

Of the five preliminary options, two options were retained for further evaluation including replacing the existing WTP with a new WTP with increased capacity and lower O&M costs (bullet 2), and modifying the existing WTP to increase plant capacity to an appropriate capacity and reduce O&M costs (bullet 5). After reviewing available flow data (discussed more in Section 3.1.1 and Appendix B), it was determined that increasing the WTP capacity to 300 gpm should not be necessary under all reasonably foreseeable flow conditions, and that construction of a second WTP to operate in parallel with the existing plant is not practical or desirable from a logistical or cost perspective (see comments in Table 2-1 and Appendix A). The two retained options are described and evaluated further in Section 2.2.

TABLE 2-1. SUMMARY OF PRELIMINARY WATER TREATMENT AND MANAGEMENT OPTIONS

Preliminary Options	Retain?	Comments
Water Treatment Options		
Modify Existing WTP to Increase Capacity/Reduce O&M Requirements		
Replace existing WTP with new 300 gpm capacity	No	Determined 300 gpm capacity not required.
Replace existing WTP with new WTP with increased capacity and lower O&M requirements	Yes	New appropriate designed WTP could attain project objectives.
Add second WTP to operate in parallel with existing WTP with combined 300 gpm capacity	No	Insufficient space and more efficient options available.
Modify existing WTP to increase capacity to 300 gpm	No	Determined 300 gpm capacity not required.
Modify existing WTP to appropriate capacity for effluent limit compliance & reduced O&M	Yes	Appropriately modified WTP could attain project objectives.
Add Pretreatment Step to Treatment System		
In-Situ Pretreatment of Upper Mike Horse Seeps through PRB or other passive technology	No	Short and long-term effectiveness questionable;space constraints.
In-Situ Treatment within the Mine Pool Through Lime/Caustic Addition	No	Effectiveness questionable; potential plugging/system disruptions.
Utilize Cell 5 and/or Cell 7 as a pretreatment pond or biotreatment cell	No	Effectiveness questionable; Cells better used for water storage.
Pre-treatment cell at another location between Mike Horse Adit and water treatment plant	No	Effectiveness questionable; No suitable locations.
Add Post-Treatment Polishing Step to Treatment System		
Convert WTP discharge to GW Discharge by directing through with infiltration gallery	No	Proximity to river results in direct connection to surface water.
Biotreatment/wetland cell at Shove (aka Shoue) Gulch	No	Landownership issues, pipeline costs, effectiveness questionable.
Convert all or a portion of Cell 7 to a polishing pond/biotreatment cell	No	Biotreatment effectiveness questionable; Cell 7 better used for water storage.
Water Management/Source Control Options		
Dewatering Wells in Bedrock Peripheral to Workings to Reduce Mine Inflow	Yes	Clean GW interception in Upper MH drainage feasible.
Gravity Drain Unimpacted Groundwater from the 100 Level Mine Workings to Mike Horse Ck	No	Interception of clean mine water for direct discharge unlikely.
Hydraulic diversion/isolation of highly mineralized 100 Level mine area	No	Limited effectiveness; poor access.
Identify Potential Conduits for Surface Flow Into Mine Workings	Yes	Plugging of surface conduits to mine could reduce adit discharge.
Increase Mine Pool Level	No	Potential for uncontrolled leakage; plug stability concerns.
Pump from Deeper Workings to Increase Mine Storage Capacity	Yes	Could significantly increase mine storage capacity.

Complete list and comments in Appendix A

A total of seven pretreatment/post-treatment options were included in the preliminary options list. The pretreatment/post-treatment options are intended to reduce operational requirements of the existing WTP by either reducing the chemical load in the WTP influent, or by polishing the WTP effluent to contribute to effluent limit attainment. The pretreatment options include:

- In-situ treatment of the Upper Mike Horse seeps through a permeable reactive barrier or other technology to reduce the significant seasonal contaminant load from the seeps;
- In-situ treatment of the Mike Horse mine pool through pH adjustment;
- Utilizing existing Cell 5 and or Cell 7 as a pretreatment pond or bio-treatment cell; and
- Constructing a pretreatment pond or cell at some other location between the Mike Horse Adit and the WTP.

Post-treatment options for polishing the WTP effluent include:

- Evaluating the technical and regulatory feasibility of changing the WTP effluent discharge from a surface water to a groundwater discharge in order to take advantage of differing discharge standards and potential effluent polishing through metals attenuation to soils;
- Converting all or a portion of Cell 7 to a polishing pond/bio-treatment cell; and
- Piping the WTP discharge to a bio-treatment cell/infiltration gallery near Shaue Gulch.

None of the seven pretreatment and post-treatment options are retained for further evaluation at this time for reasons listed in Table 2-1 and Appendix A. Basically, the pretreatment/post-treatment options were logistically impractical, deemed to be of questionable effectiveness, and/or not needed in light of the water treatment options retained. Although these options are not retained at this time, reevaluation of these and/or other options may be warranted in the future depending on future adit discharge rates and quality, post-remediation receiving water quality, and long-term WTP operating costs.

2.1.2 Water Management/Source Control Options

The water management and source control options are intended to reduce the total flow and/or contaminant load to the WTP. Due to the much greater flow, the options focus on the Mike Horse Adit discharge source. Of the six water management/source control options included in the preliminary list of options, four involve reducing the flow and/or contaminant load from the Mike Horse Adit through interception and diversion of groundwater or mine water, and two involve manipulation of the Mike Horse mine pool water level (Table 2-1, Appendix A). The preliminary options include:

- Placement of dewatering wells peripheral to the Mike Horse mine workings to intercept and divert clean groundwater from entering the mine workings;
- Pump or gravity drain clean water from within the upper mine workings;
- Isolate or eliminate shallow groundwater contact with an area of highly mineralized bedrock (the 100 Level Adit area);
- Identify and seal potential mine openings acting as recharge conduits from ground surface to the mine workings;

- Increase the allowable maximum water level within the Mike Horse mine workings to increase the mine storage capacity; and
- Lower the minimum achievable water level within the mine workings to increase storage capacity.

Of the six water management/source control options, three were retained for further evaluation including: capture and diversion of clean groundwater (Bullet 1); identify and seal potential conduits (Bullet 4); and lower the minimum achievable mine water level to increase mine storage capacity (Bullet 6). Each of these options is described and evaluated further in Section 2.2.

2.2 DESCRIPTION AND SCREENING OF RETAINED OPTIONS

Site conditions at the UBMC constrain the number of viable water treatment/water management options. The steep topography, land ownership patterns, extreme winter conditions, as well as financial considerations, limit available sites for constructing new water treatment components and infrastructure, as well as access for water management/source control measures in the Upper Mike Horse area. Although this limits the list of viable options, it also simplifies the screening process since the majority of preliminary options were quickly eliminated due to one or more of these constraints. For the remaining options, a semi-quantitative streamlined process was used to screen and select recommended alternatives. The screening process includes the following criteria in addition to any statutory criteria previously considered through inclusion of the WTP in the ROD-prescribed remedy:

- <u>Effectiveness</u>: Does the technology have the demonstrated potential to attain or significantly contribute to the attainment of project goals and objectives?
- <u>Implementability</u>: Can the technology be reliably constructed, installed, implemented, operated, and maintained?
- <u>Relative Cost</u>: What are the capital and O&M costs of the technologies? Estimated costs are intended to provide a relative comparison between alternatives, and are considered to be +50%/-30%.

Each of the retained options was evaluated for the three criteria and rated as Low, Moderate or High. For effectiveness and implementability, a numeric score of 1, 2, or 3 was applied to each option for a Low, Moderate or High rating, respectively. For relative cost, a low cost was scored a 3 and a high cost a 1.

2.2.1 Replace Existing WTP with New WTP

This option includes constructing a new WTP to replace the existing WTP. The new WTP would be located at the same location as the existing WTP to utilize existing infrastructure, allow for gravity drainage of source flows to the WTP, and due to a lack of other suitable locations. The new WTP would utilize appropriate technologies based on the source water chemistry and facility effluent limits, most likely centered on pH adjustment and chemical precipitation. Current operational limitations associated with sludge handling and CMF plugging would be addressed through appropriate design such as inclusion of a sludge thickener tank, one or more clarifiers for solids removal, and replacement of the CMF with a more efficient filtration system. Due to space limitations, construction of a new WTP would likely require the existing WTP to be demolished either concurrently with or prior to the new plant construction which could result in an extended period (a few months or more) with no means to treat water.

Replacing the existing WTP with a new WTP is rated high for effectiveness since construction of a new properly designed WTP could meet the goal of meeting the facility effluent limits while reducing O&M requirements on a consistent basis. Implementability is rated as low since there is insufficient land to build a new WTP without first demolishing the existing WTP, leaving no means to treat the source flows during the new WTP construction period. Relative cost is rated high since construction costs would be considerable (estimated at $3,000,000) including demolition of the existing WTP. The ratings result in an overall score of 5 out of a maximum potential score of 9 (Table 2-2).

2.2.2 Modify Existing WTP

This option includes modifying the existing WTP to address current operational difficulties and reduce O&M costs, while promoting long-term compliance with effluent limits. Potential modifications designed to address the current sludge handling and CMF plugging issues are similar to measures outlined for a new WTP and include: addition of a sludge thickener tank to facilitate sludge handling; addition of one or more clarifiers to improve solids removal, and/or replacement of the CMF skid with a more efficient, lower operating cost filter system. A modified WTP would be housed within the current WTP building and would utilize as much of the existing equipment and infrastructure as possible to reduce capital costs.

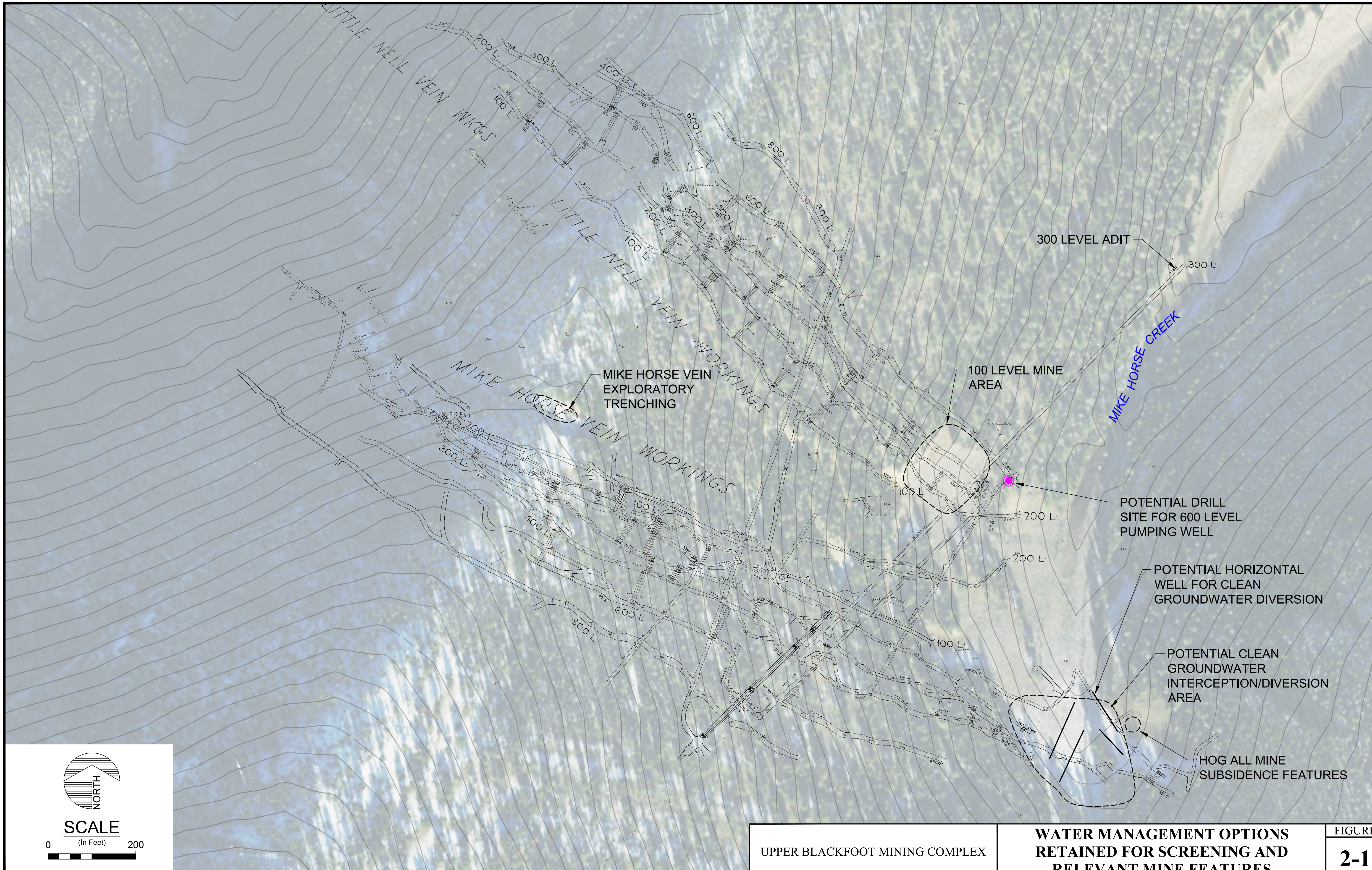
Modifying the existing WTP is rated high for effectiveness. Significant improvements can be made to the WTP performance utilizing the existing equipment and infrastructure with addition of a few new components. Implementability is rated as moderate since the modifications could be made with relatively minor or no disruption to the WTP operations. Relative cost is rated moderate ($600,000 to $1.36 million, depending on modification details), which is significantly less expensive than construction of a new WTP. The ratings result in an overall score of 7, but could be as high as 9 depending on specific details of the design as described in Section 3.

2.2.3 Dewatering Wells Peripheral to the Mine Workings

This option includes intercepting clean bedrock or alluvial groundwater in the Upper Mike Horse Drainage area to reduce inflow to the Mike Horse mine workings. As discussed in Section 1.1.3, inflow to the mine workings is believed to occur largely where the 200 Level workings cross beneath Mike Horse Creek in Upper Mike Horse drainage (Figure 1-4), and Section 1.1.5 describes shallow groundwater diversion measures implemented in the Upper Mike Horse Drainage in 2016 to reduce inflow to the mine workings. Further interception and diversion of clean groundwater currently recharging the mine workings would have a direct effect on the Mike Horse Adit discharge rate. The groundwater could be intercepted with vertical pumping wells completed in Upper Mike Horse drainage, or possibly by gravity drainage through one or more horizontal wells (Figure 2-1). The merits and potential costs from such actions are discussed further in Section 3.

TABLE 2-2. RETAINED OPTIONS SCREENING MATRIX

Option \ Screening Criteria		Effectiveness	Implementability	Relative Cost	Overall Score	Recommended Alternative?
Water Treatment Options						
1	Replace existing WTP with new WTP	High (3)	Low (1)	High (1)	5	No
3	Modify Existing WTP to increase capacity to design flow rate	High (3)	Moderate (2)	Moderate (2)	7	Yes
Water Management Options						
6	Dewatering Wells in Bedrock Peripheral to Workings	Moderate (2)	Moderate (2)	Moderate (2)	6	Yes
7	Identify Potential Conduits for Surface Flow Into Mine Workings	Low (1)	Low (1)	Moderate (2)	4	No
8	Pump from Deeper Workings to Increase Mine Storage Capacity	Moderate (2)	Moderate (2)	Low (3)	7	Yes



UPPER BLACKFOOT MINING COMPLEX

WATER MANAGEMENT OPTIONS RETAINED FOR SCREENING AND RELEVANT MINE FEATURES

FIGURE 2-1

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Interception and diversion of clean groundwater from outside of the mine workings is rated moderate for effectiveness and implementability. As with all of the water management/source control options, although the potential exists for reducing year-round or seasonal flows from the Mike Horse Adit, more testing and evaluation would be required to further assess both the effectiveness and implementability of these options. The relative cost is rated as moderate based on an estimated cost (+50/-30) of $100,000 for additional evaluation/field testing and $500,000 for implementation. The ratings result in an overall score of 6 for this option of a maximum potential score of 9 (Table 2-2).

2.2.4 Identify and Plug Potential Surface Conduits

Prior to the Mike Horse Adit discharge being controlled through construction of the flow-through plug in 1995, the adit discharge showed significant seasonal fluctuation with spring season flows of 120 gpm or more and winter rates of 30 gpm or less. The rapid and significant increase in springtime adit flows suggests a close hydrologic connection between the mine workings and the spring season rainfall/snowmelt. This option includes identifying and plugging potential conduits that could convey surficial rainfall and snowmelt directly into the mine workings.

A number of potential conduits have been identified in the past including two subsidence features on the Hog All mining claim in upper Mike Horse drainage, an exploration trench along the Mike Horse Vein on the ridge west of the Mike Horse Drainage, and the shallow 100 level workings uphill (west) of the 200 Level adits (Figure 2-1). Various field reconnaissance and evaluations have proven inconclusive regarding the role of these and other features on inflow to the Mike Horse mine workings. More detailed evaluations could be conducted such as geophysical testing and/or tracer testing to better assess the presence of potential direct flowpaths to the workings and the benefits of plugging such conduits.

The potential for surface (or shallow) conduits promoting recharge to the mine workings has been assessed in the past with little or no indication that such features contribute significantly to mine recharge. As discuss in Section 1.1.3, a 1994 inspection of the mine workings and other investigations suggest that the majority of inflow to the workings occurs in the extreme southern portion of the workings where the workings cross beneath Mike Horse Creek (Figure 1-4), and not from potential conduits as shown on Figure 2-1. For these reasons, identifying and plugging potential conduits is rated low for effectiveness. Implementability is also rated low due to difficult access to potential conduits due to the steep forested terrain. Although a reliable cost estimate cannot be presented at this time due to a lack of detail, the relative cost is rated moderate compared to the other retained options. The ratings result in an overall score of 4 for this option.

2.2.5 Pump from Deeper Mine Workings to Increase Storage Capacity

As described in Section 1.1, the Mike Horse mine workings include multiple vertical levels from the 100 Level (shallowest) to the 800 Level (deepest). The mine drainage discharges from the 300 Level Adit, with the discharge rate and mine water level controlled through a concrete flow-through plug. This allows for some attenuation of the peak seasonal discharge rate by raising the water level within the workings during the high flow season. Based on the vertical distance between the 300 Level and

200 Level adits, available storage within the mine is estimated at about seven million gallons (Figure 1-2).

This option involves drilling a well into and pumping from the deeper mine workings instead of discharging from the 300 Level Adit. By discharging from the deeper workings, the mine water level could be drawn down below the 300 Level on a seasonal basis to provide additional storage capacity within the workings. The additional storage capacity could be used to further attenuate the higher spring season flows and/or store water so the WTP can be shut down for extended periods if desired. There is potential that water pumped from the deeper mine workings may be of better quality than the current 300 Level Adit discharge, although the pumped water would still require treatment at the WTP. This option would provide the WTP with consistent flows and water quality which would greatly simplify operation of the WTP.

Figure 2-1 shows one potential drilling location to access the 600 Level workings with a vertical well. The depth to the 600 Level at this location is about 350 feet. Based on the estimated volume of 400 and 600 Level workings compared to the 300 Level workings, drawing the mine water level down to the 600 Level could provide an additional 10 to 15 million gallons of storage capacity.

Completing a well into and pumping from the deeper mine workings to increase the mine storage capacity is rated moderate for effectiveness and implementability. As previously noted, fully assessing the effectiveness of any water management option would require additional evaluation and detailed field testing. The relative cost for pumping from the deeper workings is rated low compared to other options with an estimated cost of $100,000 for field testing and evaluation, and $250,000 for implementation and long-term pumping costs (not including costs for continued WTP operations). The ratings result in an overall score of 7 for this option.

The two water treatment and three water management/source control options retained and described above are screened further in Section 3. All other options were excluded from further evaluation based on initial logistical, regulatory or cost considerations (Table 2-1, Appendix A).

2.3 SUMMARY OF ALTERNATIVES SCREENING

Based on the screening results, modifying the existing WTP is retained for inclusion as a recommended alternative. Replacement of the existing WTP with a new WTP is not retained due to the higher cost and extended period required for demolition/construction with no means to treat water. Capture and diversion of clean groundwater and pumping from the deeper mine workings are retained as recommended alternatives although additional testing and evaluation would be required to fully assess their effectiveness and implementability. Identification and plugging of potential recharge conduits is not retained due to the limited reductions in the Mike Horse Adit flow anticipated based on the current conceptual model of mine recharge and flow (Section 1.1.3), and difficult access to the potential conduits. In addition, further review of the construction completion report (CCR) documenting the 2016 construction activities in the Upper Mike Horse drainage (Section 1.1.5) and the 2019 adit discharge rates is required prior to considering other potential localized recharge sources. The recommended alternatives are discussed in Section 3.

3.0 RECOMMENDED ALTERNATIVES

Based on the screening evaluation results, it was apparent that most if not all of the evaluation goals can be attained solely through modifying the WTP equipment and operations, without any water management measures. However, implementation of some water management action(s) has the potential to reduce water treatment requirements and costs, resulting in long-term savings. Therefore, although the recommended alternatives presented below focus on modification of the WTP design and operations based on the current source characteristics, two potential water management options are retained from the screening evaluation for consideration of further evaluation and implementation if warranted.

3.1 WATER TREATMENT ALTERNATIVES

The recommended alternative for the WTP is Option 3 from Table 2-2, Modify Existing WTP. Based on the screening level evaluation, modifying the existing WTP represents the most cost effective and logistically practical option for increasing the WTP capacity and reducing O&M costs. Three versions of the recommended alternative are described. Alternative 1 includes addition of a sludge thickener tank and retains the CMF skid and other existing equipment and infrastructure. Alternative 2 includes addition of the sludge thickener plus addition of two lamellae plate clarifiers for improved solids removal. Alternative 3 includes the sludge thickener and clarifiers, and replaces the existing CMF with a new ultrafiltration (UF) unit. All three alternatives are designed to be implemented individually, or can be implemented in phases if desired. Following are descriptions of the design flow rate for the modified WTP; process descriptions for each alternative including discussions of kinetics, hydraulics, chemical consumption, equipment sizing and selection, sludge management; and cost estimates at a ±20% level. A comparison of operational costs for the three alternatives and the existing WTP are also presented to assess the return on investment period.

3.1.1 Design Flows Rates

The first step in designing any WTP modifications is to determine the optimum design flowrate to minimize capital and O&M costs, maximize operational flexibility, and ensure long-term compliance with effluent limits. Figure 3-1 shows historical recorded flows for the Mike Horse Adit, the Anaconda Adit, and WTP effluent with peak flows generally occurring April through June. As previously noted, the average monthly flow of 190 gpm recorded in June 2018 required extraordinary efforts to operate the WTP within the effluent limits and resulted in increased O&M costs. In order to support the preliminary alternatives designs, a water balance of the WTP and source flows was completed to determine the optimum WTP design flowrate that minimizes capital and long-term O&M costs, while ensuring long-term compliance with effluent limits. The water balance optimizes the use of all available storage including six million gallons in the Mike Horse Adit (less than the estimated seven million gallon capacity for conservatism) and 840,000 gallons in Cell 5. The 970,000 gallons of storage available in Cell 7 was included in the water balance but was only required

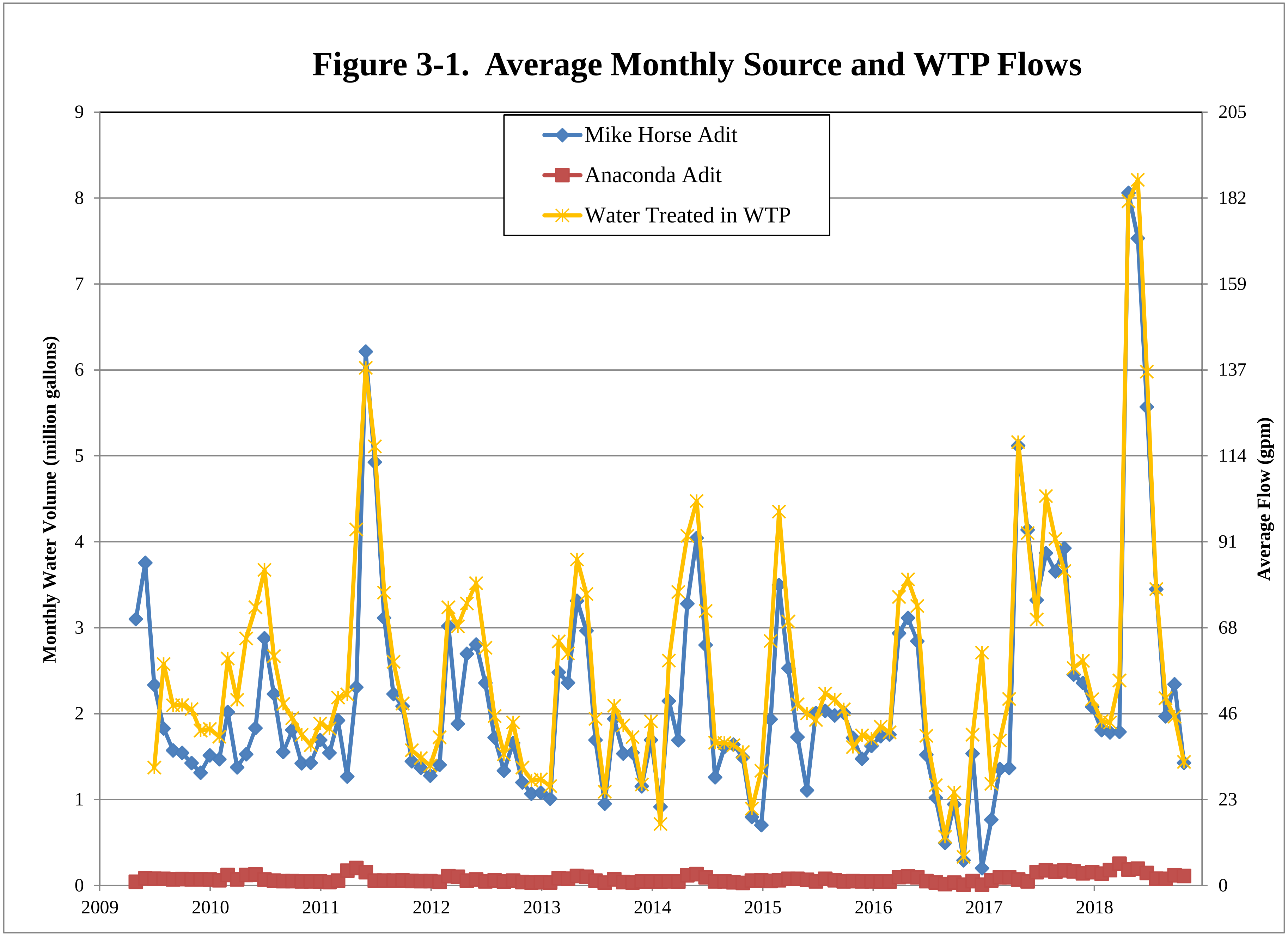
Figure 3-1. Average Monthly Source and WTP Flows
Mike Horse Adit
Anaconda Adit
Water Treated in WTP
Monthly Water Volume (million gallons)
Average Flow (gpm)
0
1
2
3
4
5
6
7
8
9
0
23
46
68
91
114
137
159
182
205
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

during extreme high flow events. The water balance consists of a spreadsheet model utilizing monthly average flows recorded for the Mike Horse Adit, Anaconda Adit, and WTP for the past ten years; the model spreadsheet and a description of the model design and calculations are included in Appendix B.

Based on the historic flow data and available storage capacity within the Mike Horse mine workings, Cell 5 and Cell 7, the water balance results show that the existing WTP with one or more of the modifications recommended in Section 3.1.2 can provide adequate retention time and treatment to consistently meet the required effluent limits at a design flow capacity of 140 gpm. Therefore, 140 gpm is used for the design capacity for the recommended alternatives preliminary designs and cost estimating.

Current WTP operations during the winter months include shutting down the WTP for two weeks while the Mike Horse Adit water is stored within the workings and the Anaconda Adit discharge diverted to Cell 5, and then operating the WTP for one week to process the stored water. This schedule requires maintaining access and WTP operations throughout the winter. Based on the water balance analysis, the modified WTP could be shut down for approximately four months (November through February) each year at the design capacity of 140 gpm and more efficient utilization of the available storage. Shutting down continuously during the winter would significantly reduce O&M costs since the need for heat, electricity, snow removal and labor would be minimal. Under this scenario, the WTP would be operated from March through October to treat the stored water plus the continuous source inflow rates. Monitoring of the winter snowpack and mine pool level could be used to help determine the appropriate spring startup date each year with earlier startups scheduled if high snowpack conditions warrant (see Hydrometrics, 2013).

Based on these evaluations, it was determined that a WTP flowrate of 140 gpm provides the optimum balance between capital costs and operational flexibility and costs while ensuring the ability of the WTP to consistently meet effluent limits. This flowrate was used to size the proposed equipment for the modified WTP. Under this scenario, all equipment used in the upstream half of the WTP including the pumps, tanks, mixers, controls, valves, piping, reagent feed systems, etc., as well as the final pH adjust tank with reagent feed systems and the filter press, can be reused in the modified WTP to reduce capital costs.

3.1.2 Water Treatment Plant (WTP) Modification Alternatives

As described in Section 3, modification of the existing WTP is recommended as the most cost effective means to attain the project goals; consistently meet effluent limits and reduce long-term O&M costs. Figure 1-7 shows the general arrangement of the existing WTP including major equipment locations and process flow paths for water and sludge processes. Based on past performance, two main factors are responsible for the majority of operational issues and costs; sludge handling and management, and required frequent cleaning of the CMF skid. To date, sludge resulting from the metals precipitation process accumulates either in two sludge storage tanks and/or in the lined Cell 7. Both options require considerable handling of the sludge prior to processing through the facility filter press and the low solids content of the settled sludge results in long filter press filling times (approximately 12 hours compared to the 2-3 hours typically required for properly settled sludge) further increasing the time and cost required for sludge processing. The second issue, frequent plugging of the CMF results from incomplete solids removal upstream of the CMF as well as other characteristics of the treatment stream chemistry. In response, the recommended WTP modifications focus on addressing these two operational issues, while retaining the majority of the existing WTP equipment and infrastructure to reduce costs.

Three alternatives for modifying the existing WTP are presented to address current operational issues. Each alternative includes incorporation of one or more new components to the WTP as follows:

- Alternative 1: Addition of a sludge thickener;
- Alternative 2: Addition of lamellae clarifiers and sludge thickener; and
- Alternative 3: Addition of lamellae clarifiers, sludge thickener and replacing the CMF with an ultrafiltration (UF) system.

The alternatives are prioritized from simplest and least expensive, to more complex and expensive. They are also arranged to allow for phased implementation where the sludge thickener alone can be added and lamellae clarifiers added at a later date, and finally the CMF replaced with a UF skid, if deemed necessary. This approach is intended to provide the most flexible and cost effective approach to the WTP modification. The proposed process modifications utilize the same chemical precipitation process used in the current system, and maximize reuse of existing equipment (i.e., the Feed Tank, Neutralization Tanks #1 and #2, Concentration Tank, pH Adjust Tank, filter press, etc.) to save on capital costs. Minor modifications would be required to one of the existing sludge handling tanks under all three alternatives to maintain the current 65-minute retention time in the existing tanks for complete precipitation reactions to occur at the increased WTP design capacity. The water treatment alternatives are described below.

3.1.2.1 Alternative 1 – Addition of Sludge Thickener

This alternative includes the addition of a sludge thickener to facilitate solids handling, increase the efficiency of the filter press, and reduce solids loading to the CMF, thereby reducing required cleaning and maintenance of the CMF. The thickener would be sited outside the main WTP building in a separate enclosed building to minimize disruptions to WTP operations during construction and to maximize available space within the main building for any potential future modifications. Figures C-1 and C-2, Appendix C, show the process flow diagram and general plant arrangement for this alternative.

As previously noted, one of the limiting factors in the current WTP operations is frequent plugging of the CMF due to excessive solids loading from insufficient hydraulic retention times at higher flow rates. To remedy this, one of the existing sludge holding tanks will be converted to an additional reaction tank to provide the reaction times required for chemical kinetics. The existing feed pumps will provide flow to this new reaction tank and also provide mixing within the tank. The tank will gravity overflow to the existing Neutralization Tank #1. Mixing within the tank will be by tangential jets located on the cone surface on the bottom of the tank. The water jets will impart sufficient energy to mix the tank contents without solids separation or deposition. The use of the sludge holding tank will increase the hydraulic retention time by approximately 40 minutes at 140 gpm process flow rate allowing for more complete chemical reactions and solids maturation.

Blowdown from the existing CMF unit will feed the thickener (Figure C-1). Operations have shown that reducing the concentrations of solids in the concentration tank circuit allows for higher throughputs and longer intervals between cleaning of the CMF units. Increasing the blowdown rate from 20 gpm up to 150 gpm (hydraulic capacity of thickener) from the CMF process return stream and sending it to the thickener will reduce the solids in the CMF system to a more manageable level. The volume of blowdown will be offset by the return of clarified overflow from the thickener. At these process rates, it is anticipated that the CMF units can operate at approximately 140 gpm with longer intervals between cleanings.

The sludge thickener selected is sized to accommodate up to 2,000 pounds per day of dry solids and a maximum hydraulic capacity of 150 gpm. Based on settling test results, a calculated 16-foot diameter thickener is needed for solids capture; however, a 20-foot diameter unit was selected to account for upsets and expansion. The design of the thickener assumes a feed rate of 40 gpm with less than 1% solids and a thickened sludge of 10% solids going to the filter press. Clarified overflow from the thickener will be routed back to the CMF Concentration Tank.

Siting of the thickener will be just north of the existing WTP building. Due to cold weather operations, the thickener will require housing within a building to prevent freezing and environmental effects on the unit. The building will have a 25-ft x 30-ft footprint and have a 30-foot roof peak. The additional height is necessary for constructability and maintenance of the internal components (rake, drive unit, and bridge).

The main advantages of this alternative are a reduction in operational manpower time due to passive thickener operations, as sludge tanks and Cell 7 will not be utilized for sludge handling, and continual checks on the tanks will not be necessary. Additionally, the time required to process sludge will be reduced considerably, from the current 12 hours to two to three hours with the thickener.

While there may be minor increases in WTP throughput by extending CMF operations between cleanings, the plant will operate at 140 gpm, well below the maximum 200 gpm seen in previous years' operations. In order to increase the CMF process rate, Alternative 1 includes adding an additional CMF unit to the existing skid (due to space constraints, only one unit can be added). The majority of parts required for the new unit are currently on site with only a new back pulse cylinder and some fittings needed. The additional CMF unit would increase the maximum WTP flow rate for Alternative 1 to about 165 gpm during higher flow periods.

3.1.2.2 <u>Alternative 2 – Addition of Sludge Thickener and Lamellae Clarifiers</u>

This alternative includes all the proposed aspects discussed in Alternative #1 as well as the addition of two horizontal plate clarifiers to the unit process. The clarifiers will further control suspended solids prior to the CMF filtration units. Two clarifiers are proposed to reduce the flow and solids loading through each unit thereby increasing solids removal, to facilitate handling of unanticipated higher short-term flows, and to provide a backup when one unit is taken off line for repairs or maintenance. Figures C-3 and C-4, Appendix C, present the process flow diagram and general WTP arrangement for this alternative.

The proposed clarifiers do not exceed the existing height requirements for hydraulic gradients and gravity flow within the process. The clarifiers are nominal 70 gpm units with a maximum hydraulic capacity for each unit is 200 gpm. Based on manufacturer's information, doubling the process flow rate to the units from the nominal 70 gpm rating decreases the capture efficiency by 20%.

The clarifiers would receive flow from the reaction tanks and pass clarified water to the existing CMF Concentration Tank. Sludge from the clarifiers would go to the sludge thickener which would operate as previously described with overflow reporting to the Concentration Tank and thickened solids being processed through the filter press. The rationale for this design is that if all or most of the solids are removed prior to the CMF unit, the return flow to the Concentration Tank will also contain virtually no solids. With fewer solids to plug the CMF filters, maximum throughput could be achieved. If solids are present in the CMF return flow a bleed stream (as described in Alternative #1) will be used to control the solids. With a reduced solids load feeding the CMF units, backpressure to the units could be increased resulting in increased flow rates through the units. However, careful considerations must be made to balance backpressure, process flow rates, and cleaning schedules to maximize the throughput of the units. With the installation of the clarifiers, a 10-20 gpm increase in total plant flow may be achieved through the existing CMF units. As with Alternative 1, Alternative 2 includes adding an additional unit to the CMF skid, giving Alternative 2 a maximum flow capacity of about 180 gpm during higher flow periods. Similar to Alternative 1, the additional CMF unit would be comprised primarily of spare parts currently available on site.

Benefits to this alternative include all the sludge handling improvements included in the previous alternative plus a slight increase in throughput. However, this alternative includes the continued use of existing CMF units. Although the CMF cleaning schedule should be extended with limited solids in the CMF feed stream, higher O&M costs for the CMF units remain and affect the overall costs for the WTP.

3.1.2.3 Alternative 3 – Addition of Sludge Thickener, Lamellae Clarifiers, and Ultrafiltration

This alternative includes all the proposed aspects discussed under Alternative #2, but would replace the existing CMF skid with a (UF) unit. Figures C-4 and C-5, Appendix C, show the process flow diagram and general arrangement of this alternative.

UF is a membrane filtration unit in contrast to the ceramic filters in the CMF unit. Filtrate from the UF goes to the final pH Adjustment Tank while blowdown from the UF unit strips solids from the membrane surface and is sent back to the first reaction vessel. The UF system is an efficient system that can process between 70 and 350 gpm, at 95% recovery rates. The UF system is completely automated and self-cleans without shutdown. The unit is modular which simplifies installation and is constructed from polyvinyl chloride (PVC) plastic so expensive stainless steel replacement parts are not necessary. The total horsepower requirement for the UF skid is 30 horse power (HP), a significant reduction when compared with the 75 HP required by the CMF skid. Chemical consumption is also reduced with the UF unit compared with the CMF unit due to the reduced need for chemical cleaning. In summary, the UF provides higher throughput and more efficient filtration while decreasing O&M costs when compared with the existing CMF system.

In evaluating Alternative 3, the expected lifespan of the current CMF skid and operational requirements of the CMF compared to the UF should be considered. With the four stainless steel housings and other spare parts currently on site, the CMF skid is expected to be operational for another 5 to 10 years before major replacement is required (minor equipment costs for maintaining the CMF for 5 to 10 years are included in the Alternative 1 and 2 costs in Section 3.1.3). At that time, replacement of the CMF skid is estimated to cost approximately $750k based on the initial CMF cost.

Regarding O&M requirements, various CMF components and operational issues, such as controlling filtrate turbidity and back pressure/throughput capacity, require near constant attention of a technical nature. These activities have to be balanced with scheduled cleaning and maintenance while maintaining WTP operations. Furthermore, the CMF piping and fittings are stainless steel meaning replacement and maintenance typically requires machining and/or welding. Routine maintenance and cleaning of the CMF requires the entire WTP to be shut down since the CMF cleaning is not automated. Conversely, the UF system is a compact skid with all components constructed of PVC materials eliminating the need for machining and welding of replacement parts, and system cleaning is automated. Therefore, replacing the CMF with the UF would not only reduce O&M costs, but would also simplify overall WTP operations reducing the required technical expertise and increasing the pool of perspective operators in the future.

Figure C-6, Appendix C, shows the hydraulic grade lines or water levels through the treatment circuit for each alternative. The optimum flow rate (200 gpm) accounts for internal recycle streams for use in hydraulic retention time calculations. The hydraulic grade shows that the process piping will convey the maximum flow rate without backup or overflowing of process tanks. This allows for gravity flow through the system without additional pumps, and a maximum flow rate of 200 gpm during higher flow periods.

3.1.3 Estimated Alternatives Costs

A cost analysis was performed to compare costs for the three alternatives. The analysis includes a comparison of capital expenditures (including equipment and installations costs) and operation expenditures (including labor, chemicals, replacement parts, maintenance, etc.). First, budgetary capital costs were developed for each alternative. These costs include equipment purchase prices and shipping, demolition, installation costs (concrete, steel, piping, valves, instrumentation, electrical, and labor costs), engineering costs and a 15% contingency. Contractor costs (mobilization / demobilization) have been included in these estimates as 10% of the project cost. These costs have been developed to provide an estimated ±20% range. Capital expenditures are summarized in Table 3-1 and a detailed cost breakdown is included in Appendix D. Costs to purchase and install equipment for Alternative 1 total $638,800, for Alternative 2 $989,300, and Alternative 3 $1,368,300.

TABLE 3-1. ESTIMATED CAPITAL COST OF PROPOSED ALTERNATIVES

	Alternative 1 Sludge Thickener	Alternative 2 Sludge Thickener and Clarifiers	Alternative 3 Sludge Thickener, Clarifiers and UF
Equipment Costs (including purchase, installation, and controls)	$489,500	$736,300	$1,008,000
Detailed Engineering, Bid Documents and Specifications	$17,800	$42,000	$67,500
Contractor Fees	$48,200	$75,300	$107,600
Rental Equipment (clarifier and filtration skids), if needed	$0	$6,700	$6,700
Subtotal	$555,500	$860,300	$1,189,800
Contingency (15%)	$83,300	$129,000	$178,500
Total	**$638,800**	**$989,300**	**$1,368,300**

Next, the O&M costs were estimated for the three alternatives. First, the average O&M costs for the existing system were calculated based on actual billing totals for the last four years (2015 through September 2018). A percent reduction in O&M costs for each alternative was then estimated. For Alternative 1 (sludge thickener), these reductions are a result of the reduced sludge handling and processing time requirements and some reduced solids loading to the CMF requiring less frequent CMF cleaning. Less frequent cleanings (every other day during high flow operation to biweekly) result in lower chemical and labor costs as well as reduced wear on the stainless steel components corroded by the acid wash. For the Alternative 2 (sludge thickener plus lamellae clarifiers), these reductions are the result of greatly reduced solids loading to the CMF resulting in a further reduction in cleaning costs. For Alternative 3 (sludge thickener, clarifiers, and UF), cost reductions are due to replacing expensive stainless steel components with PVC components and a fully automated cleaning system that reduces chemical and labor costs. Additionally, the lower horsepower pump required in Alternative 3 result in lower electrical costs. In all cases, there are also cost reductions due to winter shutdown as well as elimination of the cartridge filter system. Table 3-2 shows a summary of the projected annual O&M costs as described above. Detailed costs are included in Appendix D.

Once O&M costs were determined, a cost-benefit analysis was performed to show how capital expenditures can be balanced out with savings in operation expenditures over time (Table 3-3). First, O&M costs for the existing WTP were projected over 30 years with an average annual inflation rate of 2.5%. Next, total capital costs plus projected O&M costs for each recommended alternative were calculated over 30 years and compared to the projected operational costs for the existing WTP. As shown in the bottom row in Table 3-3, estimated projected cost savings over 30 years for each alternative include; $2,442,000 for Alternative 1, $3,698,000 for Alternative 2, and $5,652,000 for Alternative 3. Also shown in Table 3-3 is the breakeven point for each alternative where the cumulative annual O&M savings exceed the alternative capital cost. The breakeven points for Alternatives 1, 2, and 3 are year 9, year 9, and year 8, respectively. Thus, capital costs for all three alternatives would be recouped in less than 10 years through reduced operational costs.

TABLE 3-2. ESTIMATED ANNUAL O&M COST OF PROPOSED ALTERNATIVES

	Existing System	Alternative 1 Sludge Thickener	Alternative 2 Sludge Thickener/ Clarifiers	Alternative 3 Sludge Thickener/ Clarifiers/UF
MDEQ Expenses	$15,400	$15,400	$15,400	$15,400
Materials, Supplies & Chemicals	$115,800	$109,900	$104,000	$96,000
Operating Labor	$218,300	$202,000	$185,600	$161,100
Other Professional Services	$22,000	$22,000	$22,000	$22,000
Analytical Expenses	$14,800	$14,800	$14,800	$14,800
Utilities	$77,000	$66,200	$66,200	$63,800
Maintenance, Repairs and Special Projects	$144,500	$107,300	$92,900	$74,600
Total	**$607,800**	**$537,600**	**$500,900**	**$447,700**

As a final evaluation of relative costs, the net present value (NPV) of each alternative is shown in Table 3-4. The NPV shows the current equivalent cost assuming a 2% rate of return on current principal; in effect, the interest gained on principal offsets a portion of the future costs of WTP construction and operation. As shown in Table 3-4, the NPV for operating the existing WTP, Alternative 1, Alternative 2 and Alternative 3 over 30 years are $19.20 million, $17.61 million, $16.80 million and $15.49 million, respectively. These values represent the current funds required to construct and operate the various WTP alternatives at a 2% return on capital, and can be used for long-term budgeting purposes. Also shown in Table 3-4 is the year that the currently available WTP operating funds, approximately $3.4 million, will be depleted. The analysis shows that the current funds will be depleted in six years for the existing WTP and Alternative 1, and five years for Alternatives 2 and 3.

At the request of MDEQ, the effects of implementing Alternative 2 in Year 1 and delaying incorporation of the UF skid for 5 to 10 years was evaluated. Delaying full implementation of Alternative 3 (the UF skid) would result in increased costs over the 30 year evaluation period due to increase O&M costs as compared to full implementation of Alternative 3 in Year 1. As shown in Table 3-5, implementing Alternative 2 in Year 1 and delaying inclusion of the UF skid for 5 or 10 years would increase overall costs (capital and O&M costs) by about $270,000 and $550,000, respectively.

TABLE 3-3. WATER TREATMENT PLANT ALTERNATIVES COST-BENEFIT ANALYSIS

	Existing System O&M Costs		**Alternative 1 - Thickener Only**			**Alternative 2 - Thickener + Clarifiers**			**Alternative 3 - Thickener + Clarifiers + UF**		
	No capital expenditures		**Capital Expenditures:**		**$638,800**	**Capital Expenditures:**		**$989,300**	**Capital Expenditures:**		**$1,368,300**
Year	**Projected O&M Costs***	**Accumulated O&M Cost**	**Projected O&M Costs***	**Accumulated O&M Cost**	**Cost Savings**	**Projected O&M Costs***	**Accumulated O&M Cost**	**Cost Savings**	**Projected O&M Costs***	**Accumulated O&M Cost**	**Cost Savings**
1	$607,688	$607,688	$537,513	$537,513	$70,175	$500,914	$500,914	$106,774	$447,775	$447,775	$159,913
2	$622,880	$1,230,568	$550,951	$1,088,463	$142,105	$513,437	$1,014,350	$216,218	$458,969	$906,744	$323,824
3	$638,452	$1,869,020	$564,724	$1,653,188	$215,832	$526,273	$1,540,623	$328,397	$470,443	$1,377,188	$491,833
4	$654,413	$2,523,434	$578,843	$2,232,030	$291,403	$539,429	$2,080,052	$443,381	$482,205	$1,859,392	$664,042
5	$670,774	$3,194,208	$593,314	$2,825,344	$368,864	$552,915	$2,632,967	$561,240	$494,260	$2,353,652	$840,556
6	$687,543	$3,881,751	$608,146	$3,433,490	$448,260	$566,738	$3,199,705	$682,045	$506,616	$2,860,268	$1,021,483
7	$704,732	$4,586,482	$623,350	$4,056,840	$529,642	$580,906	$3,780,612	$805,871	$519,282	$3,379,550	$1,206,933
8	$722,350	$5,308,832	$638,934	$4,695,774	$613,058	$595,429	$4,376,041	$932,792	$532,264	$3,911,813	$1,397,019
9	$740,409	$6,049,241	$654,907	$5,350,681	$698,560	$610,315	$4,986,356	$1,062,886	$545,570	$4,457,383	$1,591,858
10	$758,919	$6,808,160	$671,280	$6,021,961	$786,199	$625,573	$5,611,928	$1,196,232	$559,209	$5,016,593	$1,791,568
11	$777,892	$7,586,052	$688,062	$6,710,023	$876,029	$641,212	$6,253,140	$1,332,912	$573,190	$5,589,782	$1,996,270
12	$797,339	$8,383,391	$705,263	$7,415,286	$968,105	$657,242	$6,910,383	$1,473,009	$587,519	$6,177,302	$2,206,090
13	$817,273	$9,200,664	$722,895	$8,138,181	$1,062,483	$673,673	$7,584,056	$1,616,608	$602,207	$6,779,509	$2,421,155
14	$837,705	$10,038,369	$740,967	$8,879,149	$1,159,220	$690,515	$8,274,571	$1,763,798	$617,263	$7,396,772	$2,641,597
15	$858,647	$10,897,016	$759,492	$9,638,640	$1,258,376	$707,778	$8,982,349	$1,914,667	$632,694	$8,029,466	$2,867,550
16	$880,113	$11,777,129	$778,479	$10,417,119	$1,360,010	$725,473	$9,707,822	$2,069,308	$648,512	$8,677,978	$3,099,152
17	$902,116	$12,679,246	$797,941	$11,215,060	$1,464,186	$743,609	$10,451,431	$2,227,815	$664,724	$9,342,702	$3,336,544
18	$924,669	$13,603,915	$817,889	$12,032,949	$1,570,966	$762,200	$11,213,630	$2,390,284	$681,342	$10,024,044	$3,579,870
19	$947,786	$14,551,700	$838,337	$12,871,286	$1,680,415	$781,255	$11,994,885	$2,556,815	$698,376	$10,722,420	$3,829,280
20	$971,480	$15,523,181	$859,295	$13,730,581	$1,792,600	$800,786	$12,795,671	$2,727,510	$715,835	$11,438,256	$4,084,925
21	$995,767	$16,518,948	$880,777	$14,611,358	$1,907,591	$820,806	$13,616,476	$2,902,472	$733,731	$12,171,987	$4,346,962
22	$1,020,662	$17,539,610	$902,797	$15,514,155	$2,025,455	$841,326	$14,457,802	$3,081,808	$752,075	$12,924,061	$4,615,549
23	$1,046,178	$18,585,788	$925,367	$16,439,521	$2,146,267	$862,359	$15,320,161	$3,265,627	$770,876	$13,694,938	$4,890,851
24	$1,072,333	$19,658,121	$948,501	$17,388,022	$2,270,099	$883,918	$16,204,079	$3,454,042	$790,148	$14,485,086	$5,173,035
25	$1,099,141	$20,757,262	$972,213	$18,360,236	$2,397,026	$906,016	$17,110,094	$3,647,168	$809,902	$15,294,988	$5,462,274
26	$1,126,620	$21,883,882	$996,519	$19,356,754	$2,527,127	$928,666	$18,038,761	$3,845,121	$830,150	$16,125,138	$5,758,744
27	$1,154,785	$23,038,667	$1,021,432	$20,378,186	$2,660,481	$951,883	$18,990,643	$4,048,023	$850,903	$16,976,041	$6,062,626
28	$1,183,655	$24,222,321	$1,046,967	$21,425,153	$2,797,168	$975,680	$19,966,323	$4,255,998	$872,176	$17,848,217	$6,374,104
29	$1,213,246	$25,435,567	$1,073,142	$22,498,295	$2,937,272	$1,000,072	$20,966,395	$4,469,172	$893,980	$18,742,197	$6,693,370
30	$1,243,577	$26,679,144	$1,099,970	$23,598,265	$3,080,879	$1,025,074	$21,991,469	$4,687,675	$916,330	$19,658,527	$7,020,617
30 Year Project Capital plus O&M Cost/Savings				$24,237,065	$2,442,079		$22,980,769	$3,698,375		$21,026,827	$5,652,317

*With 2.5% Annual Inflation: 2.5% (Average annual inflation rate over last 30 years per StatBureau.org)

[yellow box] Break Even Year

TABLE 3-4. WATER TREATMENT PLANT ALTERNATIVES
NET PRESENT VALUE COMPARISON

Year	Existing System	Alternative 1	Alternative 2	Alternative 3
1	$607,688	$1,176,313	$1,490,214	$1,816,075
2	$1,194,465	$1,682,804	$1,954,493	$2,221,612
3	$1,796,093	$2,214,957	$2,450,412	$2,664,922
4	$2,400,670	$2,749,718	$2,948,761	$3,110,404
5	$3,008,211	$3,287,100	$3,449,553	$3,558,071
6	$3,618,729	$3,827,117	$3,952,800	$4,007,931
7	$4,232,241	$4,369,781	$4,458,514	$4,459,997
8	$4,848,759	$4,915,104	$4,966,707	$4,914,279
9	$5,468,300	$5,463,101	$5,477,391	$5,370,788
10	$6,090,878	$6,013,785	$5,990,579	$5,829,534
11	$6,716,508	$6,567,167	$6,506,282	$6,290,529
12	$7,345,205	$7,123,263	$7,024,513	$6,753,784
13	$7,976,983	$7,682,084	$7,545,284	$7,219,310
14	$8,611,858	$8,243,645	$8,068,608	$7,687,118
15	$9,249,846	$8,807,958	$8,594,498	$8,157,219
16	$9,890,961	$9,375,038	$9,122,965	$8,629,625
17	$10,535,218	$9,944,897	$9,654,023	$9,104,346
18	$11,182,634	$10,517,550	$10,187,684	$9,581,394
19	$11,833,223	$11,093,010	$10,723,962	$10,060,781
20	$12,487,002	$11,671,291	$11,262,868	$10,542,518
21	$13,143,985	$12,252,406	$11,804,415	$11,026,616
22	$13,804,189	$12,836,371	$12,348,618	$11,513,087
23	$14,467,629	$13,423,197	$12,895,487	$12,001,943
24	$15,134,321	$14,012,901	$13,445,038	$12,493,195
25	$15,804,282	$14,605,495	$13,997,283	$12,986,855
26	$16,477,526	$15,200,994	$14,552,234	$13,482,936
27	$17,154,071	$15,799,412	$15,109,906	$13,981,448
28	$17,833,932	$16,400,763	$15,670,312	$14,482,403
29	$18,517,126	$17,005,062	$16,233,465	$14,985,814
30	$19,203,669	$17,612,324	$16,799,378	$15,491,693

NPV Return Rate: 2.0% (Source: METG)

(shaded) Year current funds ($3.4 million) depleted

TABLE 3-5. COMPARATIVE COST INCREASE FOR DELAYING REPLACEMENT OF CMF WITH UF

Year	Alternative 3: (Thickener, Clarifiers, UF)		Alternative 3 with UF Delayed 5 years		Alternative 3 with UF Delayed 10 years	
	Annual Project Cost	NPV	Annual Project Cost	NPV	Annual Project Cost	NPV
1	$1,816,075	$1,816,075	$1,490,214	$1,490,214	$1,490,214	$1,490,214
2	$458,969	$2,221,612	$513,437	$1,954,493	$513,437	$1,954,493
3	$470,443	$2,664,922	$526,273	$2,450,412	$526,273	$2,450,412
4	$482,205	$3,110,404	$539,429	$2,948,761	$539,429	$2,948,761
5	$494,260	$3,558,071	$971,260	$3,828,461	$552,915	$3,449,553
6	$506,616	$4,007,931	$506,616	$4,278,322	$566,738	$3,952,800
7	$519,282	$4,459,997	$519,282	$4,730,388	$580,906	$4,458,514
8	$532,264	$4,914,279	$532,264	$5,184,669	$595,429	$4,966,707
9	$545,570	$5,370,788	$545,570	$5,641,178	$610,315	$5,477,391
10	$559,209	$5,829,534	$559,209	$6,099,925	$1,098,892	$6,378,865
11	$573,190	$6,290,529	$573,190	$6,560,920	$573,190	$6,839,860
12	$587,519	$6,753,784	$587,519	$7,024,175	$587,519	$7,303,116
13	$602,207	$7,219,310	$602,207	$7,489,701	$602,207	$7,768,641
14	$617,263	$7,687,118	$617,263	$7,957,509	$617,263	$8,236,449
15	$632,694	$8,157,219	$632,694	$8,427,610	$632,694	$8,706,550
16	$648,512	$8,629,625	$648,512	$8,900,015	$648,512	$9,178,956
17	$664,724	$9,104,346	$664,724	$9,374,737	$664,724	$9,653,677
18	$681,342	$9,581,394	$681,342	$9,851,785	$681,342	$10,130,725
19	$698,376	$10,060,781	$698,376	$10,331,172	$698,376	$10,610,112
20	$715,835	$10,542,518	$715,835	$10,812,908	$715,835	$11,091,849
21	$733,731	$11,026,616	$733,731	$11,297,006	$733,731	$11,575,947
22	$752,075	$11,513,087	$752,075	$11,783,478	$752,075	$12,062,418
23	$770,876	$12,001,943	$770,876	$12,272,333	$770,876	$12,551,274
24	$790,148	$12,493,195	$790,148	$12,763,586	$790,148	$13,042,526
25	$809,902	$12,986,855	$809,902	$13,257,246	$809,902	$13,536,186
26	$830,150	$13,482,936	$830,150	$13,753,326	$830,150	$14,032,267
27	$850,903	$13,981,448	$850,903	$14,251,838	$850,903	$14,530,779
28	$872,176	$14,482,403	$872,176	$14,752,794	$872,176	$15,031,734
29	$893,980	$14,985,814	$893,980	$15,256,205	$893,980	$15,535,146
30	$916,330	**$15,491,693**	$916,330	**$15,762,084**	$916,330	**$16,041,025**
Additional Cost with UF Installation Delayed				**$270,391**		**$549,331**

Average Annual Inflation = 2.5% (average annual inflation rate last 30 years from StatBureau.org)

NPV Return Rate = 2.0% (Source: METG)

(blue)	Year current funds ($3.4 million) depleted
(green)	Year CMF replaced with UF

3.1.4 Water Treatment Alternatives Risk Reduction/Selection Criteria

The capital and O&M costs presented above for the water treatment alternatives are only two of the criteria important for alternative selection. Some of the other criteria include the likelihood for future effluent limit compliance, ability to handle unanticipated increases in flow and/or contaminant loads, and improvements to operator safety. Table 3-6 scores each of the alternatives against a suite of criteria related to risk reduction and other selection considerations. The criteria are weighted by relevance to the objectives of reducing O&M costs and promoting long-term compliance, with a weighting of 1 being the least and 3 being the most relevant. Each alternative is given a score of 1 to 3 for each criterion with 1 being the lowest and 3 being the highest score; the exception being capital and O&M costs where the scoring is reversed (1 being highest ranking (lowest cost) and 3 the lowest ranking (highest cost)). For each alternative, the individual criterion score are multiplied by the criterion weight and the individual scores summed to provide the total alternative score. The risk reduction/selection criteria and scoring are described below. As previously noted, the statutory criteria used in selecting a remedy were already met as they pertain to use of the WTP, as it was part of the selected remedy in the ROD.

<u>O&M Costs</u>: The O&M cost criterion is given the maximum weight (3) since reducing long-term O&M expenses is a direct objective of the alternatives evaluation. As shown in Table 3-2, all three alternatives would result in reduced O&M costs and provide long-term savings primarily due to the three to four month winter shutdown period achievable through improved sludge handling and water management. The addition of the lamellae plate clarifiers under Alternative 2 is expected to further reduce O&M costs due to decreased solids loading to and plugging of the CMF, while Alternative 3 would further reduce O&M costs and maximum long-term savings ($2.72 million over 30 years, Table 3-3) through replacement of the CMF with a more efficient UF system. As a result, Alternative 1 scores lowest (1.0) for O&M costs while Alternative 3 scores highest (3.0). Alternative 2 scores 2.0 based on the intermediate O&M costs and long-term savings.

<u>Capital Costs</u>: Short-term capital cost, including final design, planning, permitting, equipment procurement and construction, is weighted 2 in the scoring process. Although an important consideration for alternative selection, it is not directly related to the evaluation objectives. Similar to the O&M costs, scoring for the capital costs is relatively straight forward with the lowest cost Alternative 1 with a capital cost of $638,800 scored 3.0, Alternative 2 ($989,300) scored 2.0, and the highest capital cost Alternative 3 ($1.37 million) scored 1.0. Capital costs for each alternative are presented in Table 3-1.

<u>Future Effluent Limit Compliance</u>: The likelihood for future compliance with facility effluent limits is given a maximum weight of 3 since it is a direct objective of the alternatives evaluation. Although each alternative is expected to increase the likelihood of long-term compliance, the likelihood increases with the additional equipment and expenditures associated with each alternative. Alternative 1 would provide some increased potential for consistent compliance since the sludge thickener tank will provide some reduction in solids loading to the CMF (in addition to improving sludge handling), although Alternative 2 would provide much greater solids removal. Alternative 3

TABLE 3-6. WATER TREATMENT ALTERNATIVES RISK REDUCTION/SELECTION CRITERIA ANALYSIS

Alternative \ Criteria		Capital Cost		O&M Costs		Likelihood of Future Effluent Limit Compliance		Ability to Handle Unanticipated High Flows		Ability to Handle Increased Contaminant Loading		Potential for Process Upsets/Breakdowns		Minimize Operational Disruptions during Construction		Relative Future Equipment Replacement Needs		Safety Improvements		Overall Score
	Criteria Weight	**2**		**3**		**3**		**2**		**3**		**2**		**2**		**1**		**3**		
Alt 1	Add Sludge Thickener Tank	Low	3.0	High	1.0	Low to Med	1.5	Med	1.0	Med	1.0	Med	1.5	High	3.0	High	1.0	Med	2.0	**34.5**
Alt 2	Add Sludge Thickener and Lamellae Clarifiers	Med	2.0	Med	2.0	Med to High	2.5	Med to High	2.0	Med to High	2.5	Med to High	2.5	Med	2.0	Med	2.0	Med to High	2.5	**47.5**
Alt 3	Add Sludge Thickener, Lamellae Clarifiers and Ultrafiltration System	High	1.0	Low	3.0	High	3.0	High	3.0	High	3.0	Low	3.0	Med to Low	1.5	Low	3.0	High	3.0	**56.0**

Capital Cost - Estimated Capex as shown in Table 3-1. Higher cost results in lower score.

O&M Cost - Estimated Opex as shown in Table 3-2. Higher cost results in lower score.

Likelihood for Future Effluent Limit Compliance - Assumes existing limits. Higher assurance reflects overall confidence in process effectiveness. Higher assurance given higher score.

Ability to Handle Unanticipated High Flows - Reflects on ability of WTP to effectively manage short or long-term flows higher than design flow of 140 gpm. Better ability to manage unanticipated higher flows results in higher score.

Ability to Handle Increased Contaminant Loading - Reflects on ability of WTP to effectively treat increased contaminant load. Better ability to manage increased contaminant loading results in higher score.

Potential for Process Upsets/Breakdowns - Reflects on ability of WTP to manage process upsets such as equipment failure. Lower potential results in higher score.

Minimize Operational Disruption during Construction - Reflects on the disruption of WTP operations during the construction and implementation of the WTP improvements. Lower operational disruption results in higher score.

Future Equipment Replacement - Anticipates the need to replace process equipment in future. Lower potential to replace equipment results in higher score.

Safety Improvements - Reflects on overall operator safety environment, such as need to work on equipment and handle chemicals. Higher safety results in higher score.

would provide the greatest assurance of long-term compliance due to the greater solids removal afforded by the clarifiers, and the greater efficiency of the UF compared to the CMF. Inclusion of the UF would also reduce downtime associated with CMF cleaning further decreasing the potential for future noncompliance. Scoring for this critical criterion includes 1.5 for Alternative 1, 2.5 for Alternative 2, and 3.0 for Alternative 3.

Ability to Handle Unanticipated Increases in Future Flows and/or Contaminant Loads: The ability to handle potential future increases in source flows and/or contaminant loads, either short or long-term, is an important consideration in alternative selection. This is especially true in light of the recent operational issues and noncompliance events caused by the 2017 earthquake and the 2017/2018 high precipitation patterns. As a result, these criteria are both given a weight of 3. Although the lack of adequate sludge handling led to increased operational labor and costs, excessive flows and solids loading to the CMF is believed to be the primary cause of the sporadic zinc effluent limit exceedances during this period. Alternative 1 would provide some ability to handle short or long-term increases in flow or contaminant loads, although solids loading and CMF plugging could still impede continued operation and compliance. Due to the continued use of the CMF without major reductions in the solids loading to the CMF, Alternative 1 would be limited to a maximum sustain flow of about 165 gpm with the additional CMF unit added. The greater solids removal provided under Alternative 2 would improve the system's ability to meet unanticipated increases in flow or loads, providing a maximum sustainable flow of about 180 gpm with the additional CMF unit. Alternative 3 provides the greatest ability to handle long-term flow or load increases by replacing the flow-limiting CMF. Alternative 3 would be capable of handling a sustained flow rate of about 200 gpm. Scoring for both of the increased flow and contaminant load criteria include 1.0 for Alternative 1; 2.0 for Alternative 2; and 3.0 for Alternative 3 (Table 3-6).

Potential for Process Upsets/Breakdowns: System upsets or equipment breakdowns have the potential to limit the WTP capacity or operation, and could lead to noncompliance with the facility effluent limits and other operational problems resulting in a weighting of 2. With the WTP having operated since 2009, the potential for equipment failures and system upsets increases as the equipment ages. For this reason, Alternative 3 represents the lowest potential for major breakdowns and system upsets since it includes the addition or replacement the major system components. Likewise, elimination of the CMF reduces the potential for future upsets resulting from CMF cleaning and maintenance. For these reasons, Alternative 3 is given a score of 3.0 for this criterion. Alternative 2 is given a score of 2.5 since the lamellae clarifiers would eliminate much of the load and stress currently placed on the CMF. Alternative 1 is scored 1.5; the limited solids removal and continued loading to the CMF would present a greater potential for process upset and required shutdowns for equipment maintenance or replacement.

Operational Disruptions During Construction: Minimizing the need to shut down WTP operations during implementation of any WTP modifications is an important consideration since the available storage capacity must be capable of storing all source waters during the shutdown period. A shutdown period greater than the three or four months of current storage capacity, or an unanticipated increase in flow occurring during the shutdown, could result in the need for expensive emergency measures to avoid a noncompliance situation. Minimizing disruptions to WTP operations is given a weighting of 2.

Alternative 1 would have the least impact on WTP operations since the sludge thickener would be housed in an addition to the WTP building minimizing any construction related disturbance. A shutdown period of a few days or less would be required to bring the new thickener online. Retrofitting of the existing sludge tank to serve as an additional reaction vessel could largely be done while the WTP is operating. Therefore, Alternative 1 is given a score of 3.0. Alternative 2 would require three to four weeks of shutdown since the clarifiers would be located within the existing building and would require additional modifications to the plumbing, resulting in a score of 2.0. Alternative 3 would require a five to six week WTP shutdown due to the need to replace the CMF resulting in a score of 1.5. Although the required shutdown period is longer, implementation of Alternative 3 could easily be accomplished with appropriate planning and preparation.

Improved Operational Safety: Although not a specific objective of the alternatives evaluation, eliminating work hazards and improving overall safety is an important criteria in any project and is given the maximum weighting of 3. All three alternatives would result in reduced work-related hazards by allowing for complete winter shutdown and complete elimination of associated hazards (i.e., winter driving, snowplowing). All three alternatives would also simplify sludge handling thus eliminating the need to shovel sludge in Cell 7 and reducing filter press operations from approximately 12 hours to 2 or 3 hours. Alternative 2 would have the added benefit of reducing solids loading and required acid cleaning of the CMF, while Alternative 3 would fully eliminate the CMF and associated maintenance issues. The resulting scoring for the safety improvement criterion are 2.0 for Alternative 1, 2.5 for Alternative 2 and 3.0 for Alternative 3.

3.1.4.1 Alternatives Scoring Summary and Implementation Schedule

Based on the criteria weighting and scoring described above and listed in Table 3-6, total scores for each alternative are 34.5 for Alternative 1, 47.5 for Alternative 2 and 56.0 for Alternative 3. The increasing score with each alternative is not surprising given the larger scope of modifications and capital costs associated with each alternative. Based on the scoring, Alternative 1 would not be the recommended alternative, unless sufficient funding is not available for the Alternatives 2 or 3. All things considered, Alternative 3 would be the preferred alternative based on the higher score and greater long-term savings ($2.72 million over 30 years; Table 3-3) assuming adequate funds are available to cover the greater capital costs. Alternative 3 also provides the highest flow capacity of all three alternatives, up to 200 gpm, to handle unanticipated short or long-term increases in flows. If adequate funds are not available, Alternative 2 (or Alternative 1) could be implemented initially with the additional modifications made at a later date if funding is available and the WTP performance warrants.

Based on equipment lead times and typical construction periods, the term of the project from Notice-to-Proceed to commissioning of the modified WTP is estimated at nine months. The critical path for all alternatives is the ordering and manufacturing of the sludge thickener tank. The manufacturer estimates a 20 week lead time for the unit from issuance of the purchase order to delivery. This critical path affects all three alternatives equally. However, with the thickener sited outside the main building, construction can be ongoing during WTP operations. Once the thickener building is constructed, all further activities would be completed indoors out of the weather. Once the thickener is commissioned and the main piping installed, commissioning of Alternative 1 would require a few days of plant shut down to complete. Alternative 2 would require three to four weeks of plant shutdown to remove existing equipment and install the clarifiers and piping. Alternative 3 would require four to five weeks of shutdown to install the clarifiers and UF equipment and connect piping and instrumentation. If the plant modifications are to be commissioned prior to the 2020 high water flows, notice to proceed would be needed by June 2019.

3.2 WATER MANAGEMENT ALTERNATIVES

Based on the screening level evaluation, two water management options are recommended for further consideration; Options 6 and 8 from Table 2-2. Option 6 includes interception and diversion of clean bedrock groundwater upgradient of the mine workings to reduce inflow to the workings. Option 8 includes pumping from the deeper mine workings to provide additional water storage capacity within the workings. Each of these options is described in more detail below and would require further evaluation and field testing prior to determining if implementation is warranted.

3.2.1 Interception and Diversion of Bedrock Groundwater

Intercepting and diverting groundwater from entering the mine workings would result in a direct reduction in the Mike Horse Adit discharge rate and WTP influent flow. As discussed in Section 1.1, the majority of recharge to the Mike Horse workings may occur where the 200 and 300 Level workings cross beneath Mike Horse Creek at depths of 20 feet or less, and shallow groundwater was encountered in this area during the 2016 remediation program (Figure 1-5). The dry conditions noted in the 300 Level Tunnel several hundred feet inside the 300 Level Adit suggest little or no recharge to the 300 Level workings north of the Mike Horse Vein workings (Figure 1-4). The potential localized nature of recharge makes interception and diversion more practical and feasible.

Figure 2-1 shows a potential target area for intercepting clean bedrock groundwater for direct discharge to Mike Horse Creek. Groundwater seepage was observed from exposed bedrock along the west side of the drainage during the 2016 Upper Mike Horse drainage reclamation activities, indicating the presence of shallow groundwater adjacent to the shallow workings (Section 1.1.5). Clean groundwater in this area could be intercepted through one or more vertical pumping wells completed in bedrock and/or alluvium, or through one or more horizontal wells driven southward from the Mike Horse drainage bottom (Figure 2-1). Vertical wells would require power and long-term pumping costs while horizontal wells could divert groundwater through gravity drainage. Implementation (or testing) of this alternative would require some disturbance to the recently completed Upper Mike Horse remediation.

Prior to implementing any groundwater diversion actions, additional evaluation and field testing would be required. Further evaluation would include more detailed review of the Mike Horse workings maps, mining production records, details of the MSE 1990s drilling and testing program, and observations and findings from the 2016 remedial activities. Field testing would require completion of multiple vertical test wells in the target area and completion of long-term (one to three month) pumping tests to assess the mine discharge response to pumping and monitoring of pumping water quality to ensure its suitability for direct discharge to Mike Horse Creek, and possible tracer testing. Costs for the testing program, including additional review of existing information, establishing access for drilling, completion of three test wells, and long-term testing and monitoring are estimated at $70,000 to $100,000. If testing results warrant, alternative implementation, including completion of a horizontal well collared near the 200 Level Adit and driven southward approximately 500 feet to the target interception area would be approximately $500,000 additional. Assuming a direct correlation between the WTP flow rate and flow-related O&M costs (i.e., reagents, materials, operating labor), annual O&M costs could be reduced by approximately $25,000 for the existing WTP to $18,000 for WTP Alternative 3 for every 10 gpm reduction in adit flow (Alternative 1 and 2 savings would be about $22,000 and $21,000, respectively). Assuming a 10 gpm reduction in adit flow (selected for discussion purposes only), approximately 15 years for the existing WTP and 20 years for WTP Alternative 3 would be required to recoup the costs for this alternative.

3.2.2 Pumping from Deep Mine Workings

Completing a well into and pumping from the deeper mine workings could be used to lower the mine water level below the 300 Level and increase mine storage capacity seasonally. The additional storage capacity could be used to attenuate the higher spring season adit discharge rates resulting in more consistent year-round flow to the WTP, and/or provide for a longer seasonal WTP shutdown period (as discussed in Section 3.1.1, winter shutdown of 3 to 4 months is already achievable with the WTP modifications and efficient use of existing storage capacity).

Figure 2-1 shows one potential drilling location where the 600 Level workings could be intersected with a 350-foot deep vertical well. This location has the advantages of being relatively accessible and requiring less road construction and disturbance of remediated areas than other potential drilling sites. The Figure 2-1 site also targets an area where the 600 Level drift and tunnel intersect, increasing the potential for successfully intercepting the workings. This location is also close to existing infrastructure making electrical and plumbing hookups less expensive. Based on a comparison of the total length of workings between the 300 and 200 Levels (the portion of workings that provide the current storage capacity of about seven million gallons, Section 1.1), and the total length of workings between the 600 and 300 Level workings (additional storage area available if dewatered to the 600 Level), an additional 10 to 15 million gallons of storage may be available by pumping from the 600 Level. Based on an average adit discharge rate of 80 gpm for the 2018 water year (October 2017 through September 2018, a period of exceptionally high flows), drawing the mine water level down to the 600 Level would provide 3.0 to 4.5 months of additional storage (in addition to the 3 to 4 months of currently available storage, Section 3.1.1). Based on a more typical average annual flow rate of 50 gpm, pumping from the 600 Level could provide an additional 4.5 to seven months of storage. It should be noted however that the additional storage time does not necessarily equate to additional mine shutdown time since the shutdown period would have to be balanced with the ability of the WTP to treat all the stored water and mine inflows during the remaining WTP operational period. For the high flow (80 gpm average annual adit discharge rate) scenario, approximately eight months would be required to treat the stored water plus the continued mine inflow meaning the discharge could only be shut down for about four months, similar to the shutdown schedule achievable with the currently available storage capacity (Section 3.1.1). For the more typical average annual adit discharge of 50 gpm, approximately 5.5 months would be required to treat the stored water and continued mine inflow, meaning the adit could be shut down for about 6.5 months, or 3.5 months longer than estimated based on current available storage. It should be noted that lowering the mine water level by pumping from the deeper workings would also reduce or eliminate the hydraulic head behind the 300 Tunnel plug thus addressing any potential concerns with the long-term integrity of the adit plug.

Prior to implementation, additional evaluation and field testing would be required to further evaluate the feasibility and potential benefits of the deep pumping alternative. Similar to the groundwater interception and diversion alternative, testing for the deep pumping alternative would include further evaluation of the mine workings and feasibility of intersecting the workings with a well, road building and other logistical planning, completion of a test well targeting the 600 Level workings, and conducting a pumping test of adequate duration (approximately one month) to assess the mine water level response to pumping, the pumping discharge water quality, and potential effects on mine inflow rates (lowering the water level in the mine workings would most likely increase the mine inflow rate and total volume of water requiring treatment). Costs for the additional evaluation and field testing program are estimated to be about $100.000. Capital costs for full implementation of this alternative are estimated to be an additional $200,000. For each additional month of winter shutdown resulting from the increased storage capacity, annual O&M costs are estimated to decrease by $26,000 for the existing WTP scenario, and $20,000 for WTP Alternative 3 (WTP Alternatives 1 and 2 savings would be about $24,000 and $22,000, respectively). Assuming one additional month of shutdown, approximately nine years for the existing WTP and 11 years for WTP Alternative 3 would be required to recoup the costs for this alternative.

4.0 SUMMARY AND RECOMMENDATIONS

A number of water treatment and water management options were evaluated to optimize the performance of the UBMC WTP with the goal of ensuring long-term compliance with the Facility effluent limits and reducing O&M costs. The recommended water treatment alternatives center on modifying the existing WTP with three alternatives recommended for consideration by project stakeholders: addition of a sludge thickener tank to improve sludge management and handling procedures and increasing total flow capacity by expanding the CMF with an additional filter; addition of a sludge thickener tank and two lamellae plate clarifiers to facilitate sludge handling and reduce solids loading to and plugging of the CMF and increasing total flow capacity by expanding the CMF with an additional filter; and addition of the sludge thickener and clarifiers and replacement of the CMF with a UF filter system to further reduce O&M costs. Although presented as three separate alternatives, the alternatives are designed so that they can be implemented in phases or steps, starting with the lowest capital cost Alternative 1 with Alternative 2 and/or 3 added at a later date(s) if the WTP performance warrants. The main decision criteria in reviewing the alternatives is initial capital costs, long-term O&M costs and return-on-investment, and the modified WTP long-term and short-term flow capacities.

Two water management alternatives are also presented. The first alternative includes interception and diversion of clean groundwater to reduce inflow to and discharge from the mine workings, and the second includes pumping from the deeper mine workings to increase the mine storage capacity to allow for attenuation of peak seasonal flows and/or extend the optional winter shutdown period. However, both of these alternatives require additional investigation to determine the viability of each approach.

The information provided in this report is intended for review and consideration by the project stakeholders, with further discussions and evaluation anticipated to support selection of one or more recommended alternatives for implementation. Recommended actions to aid in alternatives selection and project planning are listed below.

Recommendation 1: Continue monitoring the WTP and source flows through 2019 to further evaluate current trends in the source flows and ongoing effects from the July 2017 earthquake, the exceptionally large 2017/2018 snowpack and wet 2018 spring, and potential effects of the 2016 Upper Mike Horse remedial actions on mine inflow. Seasonal samples should be collected from the individual source flows with samples collected on a quarterly schedule to reflect the varying seasonal conditions.

Recommendation 2: Consider merits for further evaluation of the water management alternatives. Section 3.2 includes estimated costs for further evaluation of the two recommended alternatives, including further review of existing information and field testing. Further review of existing information is recommended and possible preliminary testing (such as tracer testing) should be considered at this time with the merits of more involved field testing determined based on these results, and on review of the water treatment alternatives. A scope of work and budget for reviewing existing information (i.e., mine maps, production history, etc.) can be prepared for stakeholder review if requested.

Recommendation 3: Evaluate various regulatory issues that could affect future WTP effluent limits and operations. Potential ramifications for UBMC cleanup criteria and the WTP effluent limits should be assessed based on 2017 revisions to State of Montana water quality standards, and additional revisions currently proposed for Circular DEQ-7 (MDEQ, 2017). Existing and proposed changes to the water quality standards since the UBMC cleanup criteria were established, and/or changes in the receiving water quality, may have implications for future WTP effluent limits and should be considered when evaluating potential WTP modifications.

5.0 REFERENCES

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APPENDIX A

PRELIMINARY LIST OF WATER TREATMENT / WATER MANAGEMENT OPTIONS FOR THE UPPER BLACKFOOT MINING COMPLEX

APPENDIX A. PRELIMINARY LIST OF WATER TREATMENT/MANAGEMENT OPTIONS FOR THE UPPER BLACKFOOT MINING COMPLEX

PRELIMINARY OPTION	DESCRIPTION/COMMENTS
Water Treatment Alternatives	
Modify Existing WTP to Increase Capacity/Reduce O&M Requirements	
Add a parallel treatment process capable of treating increased flow of 170 gpm, modify existing WTP to ensure effluent requirements always met, reduce O&M	Build a parallel WTP to treat 170 gpm. Modify existing WTP with TBD changes that will also reduce O&M; however this may be difficult to do while at the same time keeping existing WTP on-line.
Add a new process capable of treating 300 gpm	Build a new WTP capable of 300 gpm meeting effluent limits. Use experience gained in existing WTP as input into design of new plant. Keep existing WTP on-line until new plant is commissioned.
Modify existing WTP to ensure effluent requirements always met, reduce O&M, including increasing throughput capacity to 300 gpm	Modify existing WTP with TBD changes that will also reduce O&M, also increase capacity up to 300 gpm; however this may be difficult to do while at the same time keeping existing WTP on-line.
Modify existing WTP to ensure effluent requirements always met, reduce O&M, but not increase throughput capacity	Modify existing WTP with TBD changes that will also reduce O&M; however this may be difficult to do while at the same time keeping existing WTP on-line. This will not increase throughput capacity.
Add Pretreatment Step to Treatment System	
In-Situ Pretreatment of Upper Mike Horse Seeps through PRB or other passive technology	The Upper Mike Horse Seeps are a relatively low average flow/high concentration source. Passive or semi-passive treatment at the source may be effective at removing a significant portion of the associated loads prior to pumping seeps back to mine pool and conveyance to the WTP. Pretreatment through a permeable reactive barrier, open limestone channel, precipitation basin would reduce loading to the WTP but would create its own treatment and sludge/waste handling issues.
In-Situ Treatment within the Mine Pool Through Lime/Caustic Addition	The Mike Horse Mine workings are partially flooded behind a concrete bulkhead constructed near the 300 Level Adit, with up to 7 mgal of storage available within the mine workings. Metals precipitation within the workings may be achieve through in-situ pH adjustment. Would need to do tracer tests within the mine workings to determine residence times and evaluate fate of precipitated sludge.
Utilize Cell 5, possibly in combination with a portion of Cell 4, as a pretreatment pond or biotreatment cell	This alternative involves converting existing Cell 5 (840,000 gal capacity), and possibly a portion of Cell 4 (currently scheduled for removal under site reclamation program), both located immediately upstream of the WTP, to a treatment pond and/or biotreatment cell for seasonal or year-round pretreatment. Cell 5 is currently used to store various waste streams/flows so need for this would have to be eliminated or alternatives identified.
Convert all or a portion of Cell 7 to a pretreatment pond/biotreatment cell	This alternative involves converting all or a portion of Cell 7, located immediately downstream of the water treatment plant, to a pretreatment pond and/or biotreatment cell. Cell 7 currently serves as a retention pond and is used for sludge storage, so alternatives for those uses would have to be identified or needs eliminated.
Pre-treatment cell at another location between Mike Horse Adit and water treatment plant	This alternative involves construction of a treatment pond or biotreatment cell at a location along the existing conveyance pipeline between the Mike Horse Adit discharge and the WTP. Options may be limited due to steep topography and land ownership patterns.
Add Post-Treatment Polishing Step to Treatment System	
Infiltration Gallery for GW Discharge and Soil Attenuation	These 2 alternatives would likely be combined. Alternative includes pipe effluent about 0.75 miles west to the Shoue Gulch area where an infiltration system could be built. This would result in a discharge to groundwater instead of surface water and take advantage of the higher GW effluent limits. If necessary, this could be combined with a biotreatment cell for effluent polishing. Would have to address potential direct connection between groundwater and surface water and other construction/permitting issues.
Biotreatment/wetland cell at Shoue (aka Shave) Gulch	
Convert all or a portion of Cell 7 to a polishing pond/biotreatment cell	This alternative involves converting all or a portion of Cell 7 (970,000 gallon capacity), located immediately downstream of the water treatment plant, to a post-treatment polishing pond or biotreatment cell. Cell 7 currently serves as a pre-treatment retention pond and sludge storage, so need for this would have to be eliminated or alternatives identified. Due to Cell 7 location adjacent to the Blackfoot River, infiltration at this location would likely be considered a surface water discharge. Effluent could be pipe to Shoue Gulch for possible conversion to a groundwater discharge if desired.

APPENDIX A. PRELIMINARY LIST OF WATER TREATMENT/MANAGEMENT OPTIONS FOR THE UPPER BLACKFOOT MINING COMPLEX

PRELIMINARY OPTION	DESCRIPTION/COMMENTS
Water Management/Source Control	
Groundwater/Mine Water Diversion	Past information suggests that much of the water flowing through the Mike Horse workings is relatively clean, and could be diverted around the area of highly mineralized bedrock reducing the volume of contaminated water. This could be achieved by pumping clean bedrock groundwater from wells for direct discharge to Mike Horse/Beartrap Creek to lower water table around the mine and reduce mine inflow rates, or intersecting the mine workings with a horizontal well and gravity draining clean water to Mike Horse Creek upstream of the mineralized bedrock zone. All of these alternatives would require considerable site characterization and testing to determine if they're feasible, so may only warrant conceptual evaluation at this time to determine if further evaluation is warranted.
Dewatering Wells in Bedrock Peripheral to Workings to Reduce Mine Inflow	
Gravity Drain Unimpacted Groundwater from the 100 Level Mine Workings to Mike Horse Ck	
Bedrock Capture Wells to Intercept Impacted Groundwater Upgradient of Mine Workings	
Shallow bedrock groundwater diversion trench, possibly with capping or grouting of high-grade mineralized bedrock.	Past information suggests the high concentration, acidic Upper Mike Horse Seep water is derived from infiltration into, and shallow groundwater flow through, an area of highly mineralized bedrock uphill (west) of the UMH Seeps and 200 level adit; in the vicinity of the 100 Level Shaft. Information suggests that this shallow bedrock groundwater may also be a significant contributor to the total load in the Mike Horse 300 Level Adit discharge. This alternative would attempt to reduce flow through the highly mineralized bedrock thus reducing loading to the UMH Seeps and possibly the mine workings. Considerable site investigation would be required to fully evaluate the merits of this alternative.
Increase Mine Pool Level	This alternative would increase the water level within the mine workings to decrease hydraulic gradients from the surrounding bedrock groundwater system to the mine pool, thereby reducing mine inflow rates, to further flood the mineralized bedrock and reduce sulfide oxidation, and increase the storage capacity within the mine workings. This would require placing additional bulkheads in the 200 Level Adit and other possible mine discharge points and possibly structurally enhancing the existing 300 Level bulkhead. This alternative would require further detailed evaluation to determine if feasible and identify potential leakage conduits, so may only warrant conceptual evaluation at this time to determine if further evaluation is warranted.
Identify Potential Conduits for Surface Flow Into Mine Workings	This would include a relatively cursory inspection of the ground and topography overlying the mine workings to see if here are any areas (such as old prospects) that may collect and funnel water into the workings. Prior to plugging, the Mike Horse Adit discharge rate was very sensitive to precipitation and snowmelt, indicating a close hydraulic connection to the surface.

APPENDIX B

WATER BALANCE SPREADSHEET

UPPER BLACKFOOT MINING COMPLEX WATER TREATMENT PLANT
WATER BALANCE DESCRIPTION

In order to support the UBMC water treatment alternatives evaluation, a water balance of the water treatment plant (WTP) and source flows was completed to determine the optimum WTP design flowrate that minimizes capital and long-term O&M costs, while facilitating long-term compliance with effluent limits. The water balance utilizes all available water storage including six million gallons in the Mike Horse Adit (less than the estimated seven million gallon capacity for conservatism), 840,000 gallons in Cell 5, and 970,000 gallons in Cell 7. The water balance consists of a spreadsheet model utilizing actual nearby precipitation data as well as monthly average flows recorded for the Mike Horse Adit, Anaconda Adit and WTP over the past ten years. Following is a description of the model inputs and calculations.

<u>Precipitation</u>
Monthly precipitation data was downloaded from the Copper Bottom Snotel site for the 10 year water balance period (2009 through 2018). The Copper Bottom site is located in the Copper Creek drainage about 11 miles northeast of the UBMC WTP and at a similar elevation (5200 feet). For the November through February winter period, half of the precipitation is stored as snow in the water balance model while the remainder is released as water to the storage cell (column F in the spreadsheet) and processed in the WTP. During the spring months of March and April, the stored water is released as water to the storage cell, 60% and 40% respectively.

<u>Mike Horse Adit Water</u>
The Mike Horse Adit is assumed to have 6 million gallons of available storage, a conservative value based on the seven million gallons of actual estimated storage. The mine inflow rate is estimated as the measured volume of water discharged from the Adit each month over the past ten years. This assumes no monthly change in storage (i.e., change in mine water level) over this period, a reasonable assumption over the 10 year period. The inflow water volume (Column I) is added to the volume of water stored in the adit during the previous month to calculate the total volume of Adit water to manage for that month (Column J). The managed water is sent to either the WTP for treatment (Column K) or the Adit (Column L) for storage. The managed water reports to the Adit for storage during the assumed winter WTP shutdown period or when the hydraulic capacity of the WTP is exceeded, with Cell 7 used for emergency overflow if the Adit storage capacity is exceeded. The storage volume is added to the previous month's storage volume to calculate the cumulative storage volume. Note that the Mike Horse Adit input includes the Upper Mike Horse Seep flow.

<u>Anaconda Adit Water</u>
The Anaconda Adit is assumed to have no available storage with water flowing directly to the WTP or to Cell 5 during winter shutdown of the WTP. Outflow from the Anaconda Adit is estimated as the actual measured volume of water collected from the Adit each month for the past ten years. The storage volume (Column Q) is added to the previous month's storage volume to calculate the cumulative storage volume in Cell 5.

<u>Storage Cell 5</u>
Cell 5 provides 840,000 gallons of available storage. Inputs to the Cell included precipitation, Anaconda Adit water, and wastewater from the WTP. Precipitation into Cell 5 is calculated using the effective precipitation depth as previously described and the total cell liner area; evaporation and sublimation are assumed to be zero for conservatism. The Anaconda Adit discharge all reports to Cell 5 as previously described. The average WTP wastewater flow to Cell 5 (wash water from the floor drain, off-spec effluent, feed tank overflow, filter press filtrate) is estimated to be 10 gpm based on current WTP operations. All inputs for the month are added to the volume of water stored in the Cell from the previous month to calculate the total Cell 5 monthly volume. The stored water is either directed to the WTP for

treatment or remains in the Cell for storage during the winter shutdown period or when source flows exceed the WTP capacity. For purposes of the water balance, it was assumed that a maximum of 40 gpm would be processed through the WTP from Cell 5 at any time.

Storage Cell 7

Cell 7 has a storage capacity of 970,000 gallons. Inputs to Cell 7 include precipitation and overflow from the Mike Horse Adit. Precipitation into Cell 7 is calculated using the effective precipitation depth as previously described and the total cell liner area; evaporation and sublimation are assumed to be zero for conservatism. Mike Horse Adit water is inputted to Cell 7 whenever storage within Mike Horse Adit exceeds the seven million gallon storage capacity. The total Cell 7 inflow for a month is added to the volume of stored water from the previous month to calculate the total volume of water in Cell 7 for that month. The Cell 7 stored water is sent to either the WTP for treatment or remains in the Cell for storage during winter WTP shutdown period or when the treatment capacity of the WTP is exceeded. For purposes of the water balance, it was assumed that a maximum of 50 gpm would be processed through the WTP from Cell 7.

Water Treatment Plant

The WTP is assumed to have an efficiency of 93% and the WTP hydraulic capacity is treated as a variable in the water balance that can be changed to model different design capacities. The maximum possible monthly treatment volume (Column AG) is calculated based on the WTP efficiency and selected design capacity.

Inputs to the WTP include the Mike Horse Adit discharge, Anaconda Adit discharge, Cell 5 and Cell 7. The volume of water sent to the WTP from the Anaconda Adit, Cell 5 and Cell 7 are inputted from their respective calculations as discussed above. The maximum volume of water sent to the WTP from the Mike Horse Adit is calculated by subtracting the Anaconda Adit, Cell 5 and Cell 7 inputs from the maximum possible treatment volume for the month. If the maximum possible Mike Horse Adit treatment volume is greater than the volume of water to be managed in the Mike Horse Adit for that month, then the volume of water to be managed is used as the input from the Mike Horse Adit to the WTP. If the maximum possible Mike Horse Adit treatment volume is less than the volume of water to be managed, then this possible treatment volume is used as the input from the Mike Horse Adit to the WTP with the remaining managed water stored in the Adit. The total volume of water treated is calculated by adding all the inputs to the WTP. Outputs from the WTP include wastewater or off-spec water sent to Cell 5 and treated on-spec water released to the Blackfoot River. An average of 10 gpm was sent to Cell 5 as previously discussed. The total discharged to the River is calculated by subtracting the volume of wastewater sent to Cell 5 from the total volume of water treated.

Water Balance Results

Ten years of calculations were performed in the water balance using measured inputs for precipitation, Mike Horse Adit flow data (which includes the Upper Mike Horse Seeps) and Anaconda Adit flow data. The treatment capacity of the plant was varied from the existing 120 gpm to a total of 200 gpm to evaluate the results of different treatment scenarios. Different simulations were also completed by turning off the WTP for different months during the year to evaluate how the storage capacity could be more effectively used to reduce operation and maintenance (O&M) costs.

Based on the historic flow data and available storage capacity within the Mike Horse mine workings, Cell 5 and Cell 7, the water balance results show that the existing WTP could consistently treat all input flows for the 10 year period of record at a design flow capacity of 140 gpm. Based on the water balance analysis, the WTP could also be shut down for approximately four months (November through February) most years using the WTP design capacity of 140 gpm and more efficient utilization of the available storage. A long-term shutdown during the winter would significantly reduce O&M costs since the need for heat, electricity, snow removal and labor would be minimal. Under this scenario, the WTP would be operated from March through October to treat the stored water plus the continuous source inflow rates.

Under the identified optimum operating scenario, a 140 gpm WTP design capacity and operating the WTP for only eight months a year, the water balance modeling results indicate the following:

- The water balance model shows only three months out of the 10 year period where the six million gallon Mike Horse Adit storage capacity is exceeded and flow is directed to Cell 7 for storage. Note that the six million gallon storage capacity utilized in the model is less than the seven million gallon actual estimated capacity. Neither Cell 5 nor Cell 7 exceeds their maximum storage capacities during the 10 year period. Also note that the three months in the 10 year period that flow was directed to Cell 7 could easily be eliminated by shortening the winter shutdown period.

- Of the 120 months simulated, the WTP had to run at the full 140 gpm design capacity for only 19 months with seven of those months occurring during the 2018 high flow year. The remainder of the months that the WTP operated (excluding shutdown periods), the average of the monthly WTP flows is 55% of the 140 gpm design capacity.

- In the 10 year period, the WTP is able to be shut down for four months (November through February) in nine of those years. The only exception is 2018 when the WTP could only be shuttered for three months due to the exceptionally high flows.

- In the three months out of a total of 120 months that the adit storage reaches six million gallons, the adit head can be maintained at a minimum of about 4 psi (about 750,000 gallons storage, Figure 1-2), and remain below the seven million gallon maximum adit storage capacity. During all other months, the adit storage volume is less than six million gallons, in most cases much less, and the adit head can be maintained at a higher minimum pressure. Thus, maximizing the adit storage to allow for seasonal shutdown should not affect mine water management procedures.

Time and Precipitaiton Data / Mike Horse Adit Water / Anaconda Adit Water / Cell 5 / Cell 7 / Water Treatment Plant

Assume Evap = 0, conservative estimate
Precip data from Copper Bottom Snotel Site
Assume 50% stored winter, released in spring

Mike Horse Adit Water: Total Available Storage = 6,000,000 gallons

Cell 5: Liner Area 20,117; WTP Waste/Off Spec Flow = 10 gpm; Max. Flow to WTP = 40 gpm; Total Available Storage = 840,000 gallons

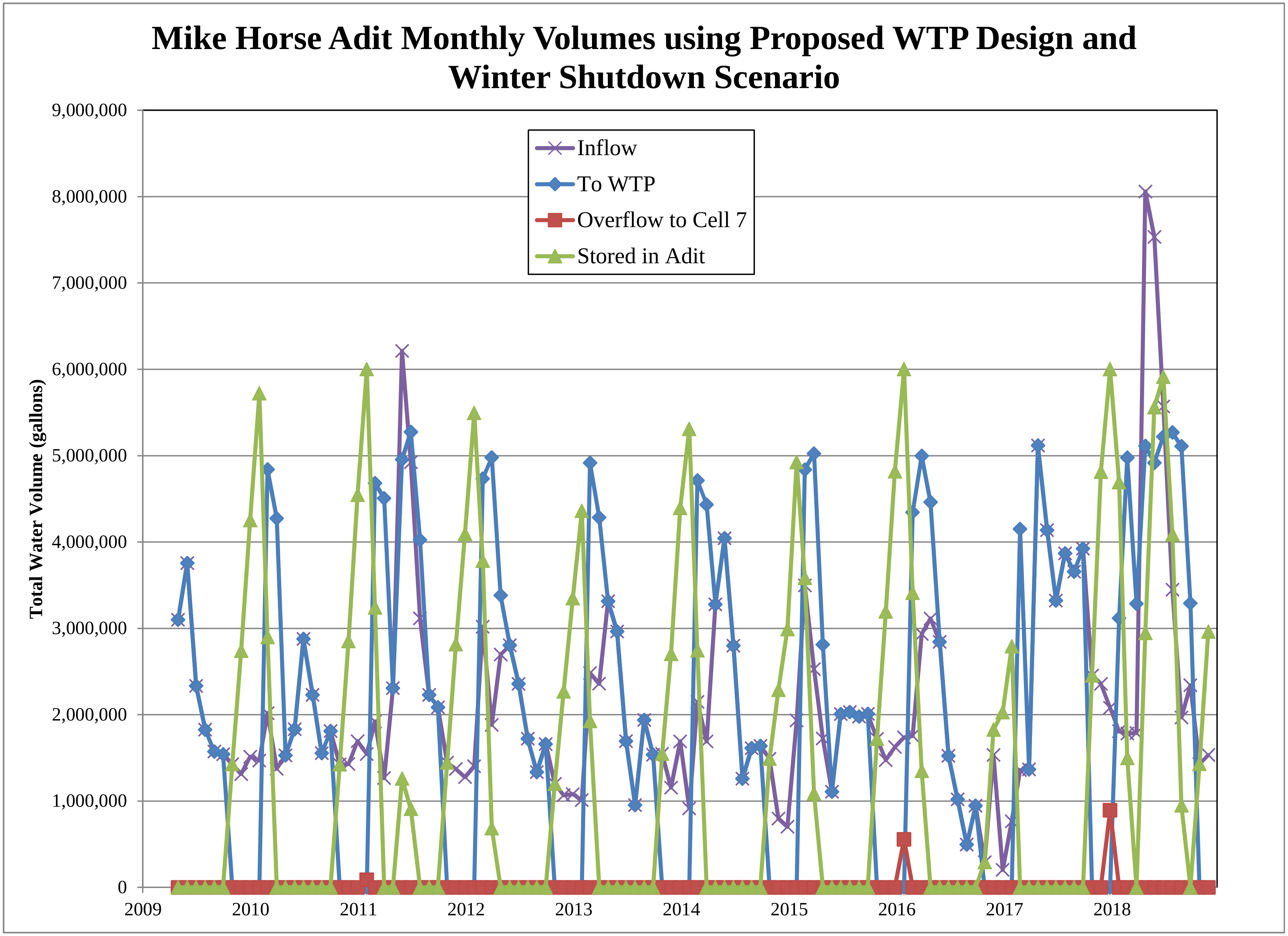
Cell 7: Liner Area = 22,886 sf; Max. Flow to WTP = 50 gpm; Total Available Storage = 970,000 gallons

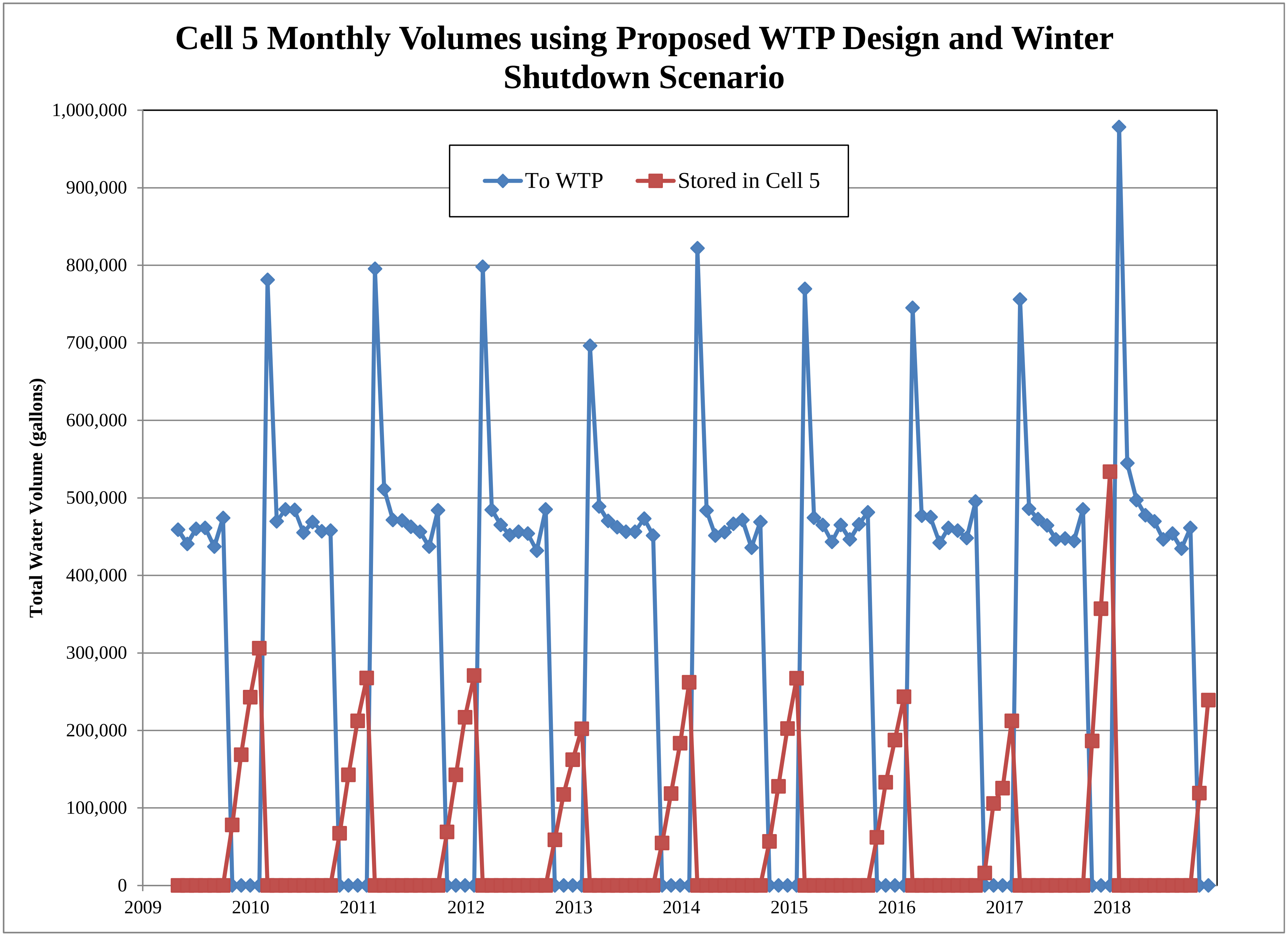
Water Treatment Plant: Treatment Plant Efficiency = 93%; Treatment Capacity of WTP = 140 gpm; Total Available Storage = 15,000 gallons

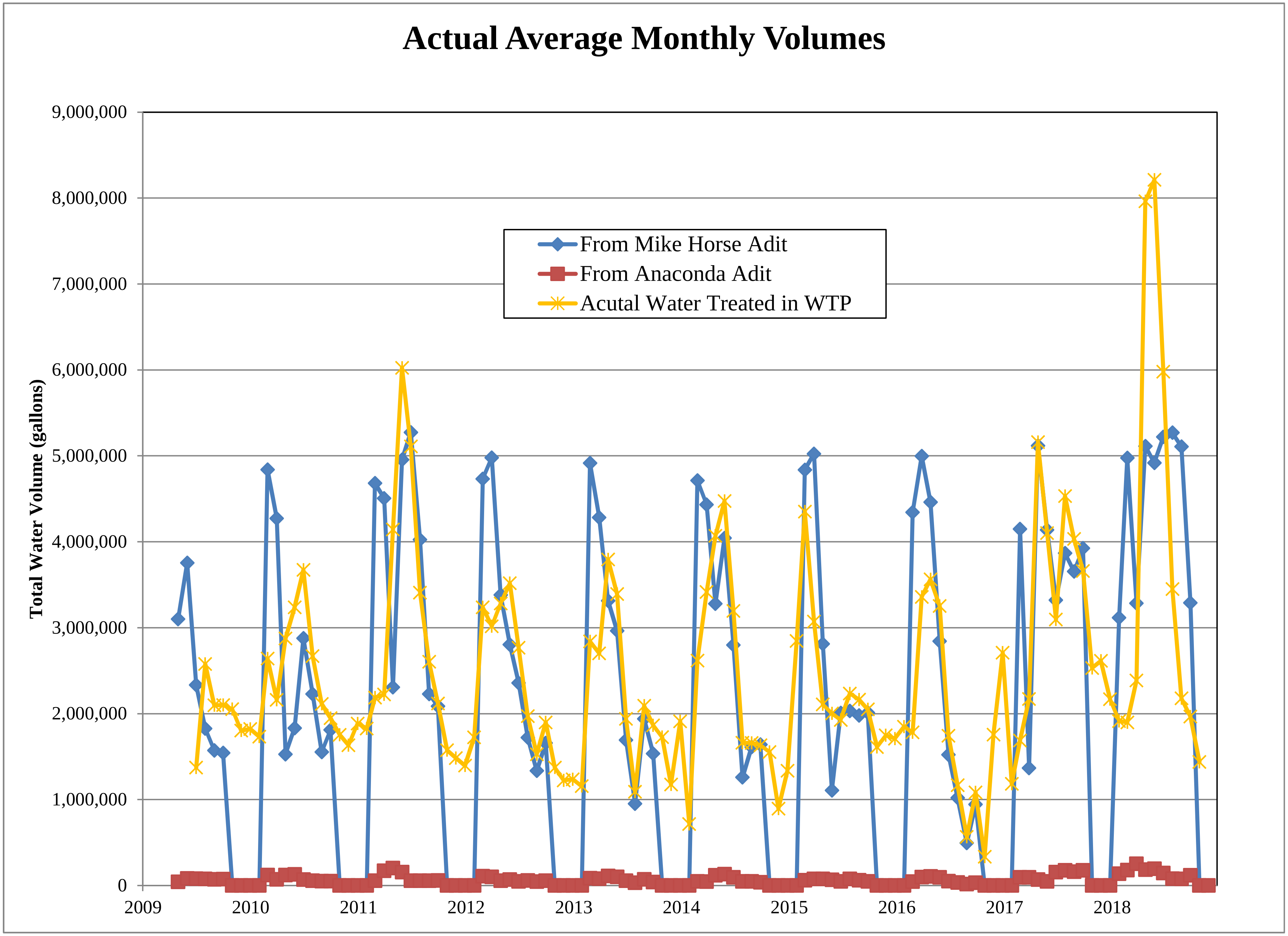
Time and Precipitaiton Data						Mike Horse Adit Water						Anaconda Adit Water		
Year	Date	Precipitation			WTP Operation	In		Out			Stored	In	Out	
		Snotel data	Percent stored/ released	Effective Precip		Inflow	Total to Manage	To WTP	To Storage	Overflow to Cell 7	Stored in Adit	Inflow	Outflow to WTP	Overflow to Cell 5
		inches		inches		gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons
1	Jan-09	3.6	-50%	1.8	off									
1	Feb-09	1.3	-50%	0.7	on									
1	Mar-09	2.3	60%	3.8	on									
1	Apr-09	1.2	40%	2.2	on					0	0			
1	May-09	1.0	0%	1.0	on	3,099,718	3,099,718	3,099,718	0	0	0	41,971	41,971	0
1	Jun-09	0.7	0%	0.7	on	3,755,828	3,755,828	3,755,828	0	0	0	82,770	82,770	0
1	Jul-09	1.1	0%	1.1	on	2,332,452	2,332,452	2,332,452	0	0	0	79,728	79,728	0
1	Aug-09	1.2	0%	1.2	on	1,827,376	1,827,376	1,827,376	0	0	0	77,039	77,039	0
1	Sep-09	0.4	0%	0.4	on	1,572,944	1,572,944	1,572,944	0	0	0	72,696	72,696	0
1	Oct-09	2.2	0%	2.2	on	1,542,260	1,542,260	1,542,260	0	0	0	73,973	73,973	0
1	Nov-09	0.9	-50%	0.5	off	1,425,778	1,425,778	0	1,425,778	0	1,425,778	72,469	0	72,469
1	Dec-09	3.0	-50%	1.5	off	1,312,493	2,738,271	0	2,738,271	0	2,738,271	71,877	0	71,877
2	Jan-10	0.9	-50%	0.5	off	1,513,085	4,251,356	0	4,251,356	0	4,251,356	68,477	0	68,477
2	Feb-10	0.2	-50%	0.1	off	1,469,282	5,720,638	0	5,720,638	0	5,720,638	61,993	0	61,993
2	Mar-10	0.8	60%	2.3	on	2,017,607	7,738,244	4,840,364	2,897,880	0	2,897,880	121,882	121,882	0
2	Apr-10	2.0	40%	3.0	on	1,375,531	4,273,411	4,273,411	0	0	0	71,526	71,526	0
2	May-10	3.1	0%	3.1	on	1,527,661	1,527,661	1,527,661	0	0	0	123,208	123,208	0
2	Jun-10	4.2	0%	4.2	on	1,831,476	1,831,476	1,831,476	0	0	0	131,104	131,104	0
2	Jul-10	0.7	0%	0.7	on	2,876,399	2,876,399	2,876,399	0	0	0	70,278	70,278	0
2	Aug-10	1.8	0%	1.8	on	2,229,647	2,229,647	2,229,647	0	0	0	55,756	55,756	0
2	Sep-10	2.0	0%	2.0	on	1,553,516	1,553,516	1,553,516	0	0	0	52,125	52,125	0
2	Oct-10	0.9	0%	0.9	on	1,810,113	1,810,113	1,810,113	0	0	0	51,363	51,363	0
2	Nov-10	3.0	-50%	1.5	off	1,423,036	1,423,036	0	1,423,036	0	1,423,036	48,498	0	48,498
2	Dec-10	4.4	-50%	2.2	off	1,428,321	2,851,357	0	2,851,357	0	2,851,357	47,834	0	47,834
3	Jan-11	3.8	-50%	1.9	off	1,693,538	4,544,894	0	4,544,894	0	4,544,894	45,802	0	45,802
3	Feb-11	2.5	-50%	1.3	off	1,543,050	6,087,944	0	6,087,944	87,944	6,000,000	39,581	0	39,581
3	Mar-11	2.4	60%	6.5	on	1,921,456	7,921,456	4,681,429	3,240,027	0	3,240,027	56,523	56,523	0
3	Apr-11	3.6	40%	6.3	on	1,266,813	4,506,840	4,506,840	0	0	0	172,965	172,965	0
3	May-11	2.0	0%	2.0	on	2,307,109	2,307,109	2,307,109	0	0	0	203,722	203,722	0
3	Jun-11	3.1	0%	3.1	on	6,213,219	6,213,219	4,954,755	1,258,464	0	1,258,464	154,789	154,789	0
3	Jul-11	1.3	0%	1.3	on	4,925,454	6,183,919	5,273,692	910,227	0	910,227	57,189	57,189	0
3	Aug-11	0.8	0%	0.8	on	3,114,575	4,024,801	4,024,801	0	0	0	57,165	57,165	0
3	Sep-11	0.4	0%	0.4	on	2,228,502	2,228,502	2,228,502	0	0	0	57,194	57,194	0
3	Oct-11	3.0	0%	3.0	on	2,085,467	2,085,467	2,085,467	0	0	0	57,934	57,934	0
3	Nov-11	2.5	-50%	1.3	off	1,444,705	1,444,705	0	1,444,705	0	1,444,705	53,437	0	53,437
3	Dec-11	3.4	-50%	1.7	off	1,370,752	2,815,456	0	2,815,456	0	2,815,456	52,245	0	52,245
4	Jan-12	3.8	-50%	1.9	off	1,276,942	4,092,398	0	4,092,398	0	4,092,398	50,479	0	50,479
4	Feb-12	1.8	-50%	0.9	off	1,402,789	5,495,188	0	5,495,188	0	5,495,188	42,676	0	42,676
4	Mar-12	3.0	60%	6.5	on	3,019,333	8,514,521	4,732,320	3,782,201	0	3,782,201	107,548	107,548	0
4	Apr-12	1.9	40%	4.2	on	1,881,831	5,664,032	4,979,221	684,811	0	684,811	100,837	100,837	0
4	May-12	1.5	0%	1.5	on	2,696,067	3,380,878	3,380,878	0	0	0	55,619	55,619	0
4	Jun-12	1.6	0%	1.6	on	2,804,228	2,804,228	2,804,228	0	0	0	68,856	68,856	0
4	Jul-12	0.8	0%	0.8	on	2,358,130	2,358,130	2,358,130	0	0	0	48,990	48,990	0
4	Aug-12	0.6	0%	0.6	on	1,722,101	1,722,101	1,722,101	0	0	0	58,350	58,350	0
4	Sep-12	0.0	0%	0.0	on	1,335,223	1,335,223	1,335,223	0	0	0	45,241	45,241	0
4	Oct-12	3.1	0%	3.1	on	1,658,267	1,658,267	1,658,267	0	0	0	56,187	56,187	0
4	Nov-12	2.9	-50%	1.5	off	1,199,881	1,199,881	0	1,199,881	0	1,199,881	40,655	0	40,655
4	Dec-12	3.6	-50%	1.8	off	1,068,104	2,267,984	0	2,267,984	0	2,267,984	36,190	0	36,190
5	Jan-13	1.3	-50%	0.7	off	1,080,169	3,348,153	0	3,348,153	0	3,348,153	36,599	0	36,599
5	Feb-13	0.9	-50%	0.5	off	1,010,405	4,358,558	0	4,358,558	0	4,358,558	34,235	0	34,235
5	Mar-13	1.2	60%	3.8	on	2,481,511	6,840,070	4,915,237	1,924,833	0	1,924,833	84,081	84,081	0
5	Apr-13	2.8	40%	4.5	on	2,358,876	4,283,708	4,283,708	0	0	0	79,925	79,925	0
5	May-13	1.9	0%	1.9	on	3,314,610	3,314,610	3,314,610	0	0	0	112,308	112,308	0
5	Jun-13	2.4	0%	2.4	on	2,964,425	2,964,425	2,964,425	0	0	0	100,443	100,443	0
5	Jul-13	0.8	0%	0.8	on	1,693,440	1,693,440	1,693,440	0	0	0	57,378	57,378	0
5	Aug-13	0.8	0%	0.8	on	952,467	952,467	952,467	0	0	0	32,272	32,272	0
5	Sep-13	3.3	0%	3.3	on	1,939,133	1,939,133	1,939,133	0	0	0	71,345	71,345	0
5	Oct-13	0.4	0%	0.4	on	1,535,650	1,535,650	1,535,650	0	0	0	39,883	39,883	0
5	Nov-13	3.0	-50%	1.5	off	1,546,179	1,546,179	0	1,546,179	0	1,546,179	36,136	0	36,136
5	Dec-13	2.9	-50%	1.5	off	1,155,522	2,701,701	0	2,701,701	0	2,701,701	45,441	0	45,441

		Cell 5						Cell 7					Water Treatment Plant							
Year	Date	In				Out	Stored	In			Out	Stored	In				Out			
		From WTP Waste/Off-Spec	From Anaconda Adit	Precip	Total to Manage	To WTP	Stored in Cell 5	Overflow from MH Adit	Precip	Total to Manage	To WTP	Total Volume Stored	From Mike Horse Adit	From Anaconda Adit	From Cell 5	From Cell 7	Maximum Possible Treated	Total Water Treated	Water Discharged to River	Waste/Off-Spec Water to Cell 5
		gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons
1	Jan-09																			
1	Feb-09																			
1	Mar-09																			
1	Apr-09						0					0								
1	May-09	446,400	0	12,540	458,940	458,940	0	0	14,266	14,266	14,266	0	3,099,718	41,971	458,940	14,266	5,812,128	3,614,895	3,168,495	446,400
1	Jun-09	432,000	0	8,778	440,778	440,778	0	0	9,986	9,986	9,986	0	3,755,828	82,770	440,778	9,986	5,624,640	4,289,362	3,857,362	432,000
1	Jul-09	446,400	0	13,794	460,194	460,194	0	0	15,692	15,692	15,692	0	2,332,452	79,728	460,194	15,692	5,812,128	2,888,065	2,441,665	446,400
1	Aug-09	446,400	0	15,048	461,448	461,448	0	0	17,119	17,119	17,119	0	1,827,376	77,039	461,448	17,119	5,812,128	2,382,981	1,936,581	446,400
1	Sep-09	432,000	0	5,016	437,016	437,016	0	0	5,706	5,706	5,706	0	1,572,944	72,696	437,016	5,706	5,624,640	2,088,361	1,656,361	432,000
1	Oct-09	446,400	0	27,587	473,987	473,987	0	0	31,384	31,384	31,384	0	1,542,260	73,973	473,987	31,384	5,812,128	2,121,604	1,675,204	446,400
1	Nov-09	0	72,469	5,643	78,111	0	78,111	0	6,420	6,420	0	6,420	0	0	0	0	0	0	0	0
1	Dec-09	0	71,877	18,809	168,798	0	168,798	0	21,398	27,818	0	27,818	0	0	0	0	0	0	0	0
2	Jan-10	0	68,477	5,643	242,918	0	242,918	0	6,420	34,237	0	34,237	0	0	0	0	0	0	0	0
2	Feb-10	0	61,993	1,254	306,165	0	306,165	0	1,427	35,664	0	35,664	0	0	0	0	0	0	0	0
2	Mar-10	446,400	0	28,841	781,406	781,406	0	0	32,811	68,475	68,475	0	4,840,364	121,882	781,406	68,475	5,812,128	5,812,128	5,365,728	446,400
2	Apr-10	432,000	0	37,619	469,619	469,619	0	0	42,797	42,797	42,797	0	4,273,411	71,526	469,619	42,797	5,624,640	4,857,353	4,425,353	432,000
2	May-10	446,400	0	38,873	485,273	485,273	0	0	44,223	44,223	44,223	0	1,527,661	123,208	485,273	44,223	5,812,128	2,180,365	1,733,965	446,400
2	Jun-10	432,000	0	52,666	484,666	484,666	0	0	59,916	59,916	59,916	0	1,831,476	131,104	484,666	59,916	5,624,640	2,507,162	2,075,162	432,000
2	Jul-10	446,400	0	8,778	455,178	455,178	0	0	9,986	9,986	9,986	0	2,876,399	70,278	455,178	9,986	5,812,128	3,411,840	2,965,440	446,400
2	Aug-10	446,400	0	22,571	468,971	468,971	0	0	25,678	25,678	25,678	0	2,229,647	55,756	468,971	25,678	5,812,128	2,780,053	2,333,653	446,400
2	Sep-10	432,000	0	25,079	457,079	457,079	0	0	28,531	28,531	28,531	0	1,553,516	52,125	457,079	28,531	5,624,640	2,091,252	1,659,252	432,000
2	Oct-10	446,400	0	11,286	457,686	457,686	0	0	12,839	12,839	12,839	0	1,810,113	51,363	457,686	12,839	5,812,128	2,332,000	1,885,600	446,400
2	Nov-10	0	48,498	18,809	67,307	0	67,307	0	21,398	21,398	0	21,398	0	0	0	0	0	0	0	0
2	Dec-10	0	47,834	27,587	142,728	0	142,728	0	31,384	52,783	0	52,783	0	0	0	0	0	0	0	0
3	Jan-11	0	45,802	23,825	212,356	0	212,356	0	27,105	79,887	0	79,887	0	0	0	0	0	0	0	0
3	Feb-11	0	39,581	15,674	267,612	0	267,612	0	17,832	97,719	0	97,719	0	0	0	0	0	0	0	0
3	Mar-11	446,400	0	81,633	795,644	795,644	0	87,944	92,869	278,532	278,532	0	4,681,429	56,523	795,644	278,532	5,812,128	5,812,128	5,365,728	446,400
3	Apr-11	432,000	0	79,501	511,501	511,501	0	0	90,444	90,444	90,444	0	4,506,840	172,965	511,501	90,444	5,624,640	5,281,750	4,849,750	432,000
3	May-11	446,400	0	25,079	471,479	471,479	0	0	28,531	28,531	28,531	0	2,307,109	203,722	471,479	28,531	5,812,128	3,010,841	2,564,441	446,400
3	Jun-11	432,000	0	38,873	470,873	470,873	0	0	44,223	44,223	44,223	0	4,954,755	154,789	470,873	44,223	5,624,640	5,624,640	5,192,640	432,000
3	Jul-11	446,400	0	16,301	462,701	462,701	0	0	18,545	18,545	18,545	0	5,273,692	57,189	462,701	18,545	5,812,128	5,812,128	5,365,728	446,400
3	Aug-11	446,400	0	10,032	456,432	456,432	0	0	11,412	11,412	11,412	0	4,024,801	57,165	456,432	11,412	5,812,128	4,549,810	4,103,410	446,400
3	Sep-11	432,000	0	5,016	437,016	437,016	0	0	5,706	5,706	5,706	0	2,228,502	57,194	437,016	5,706	5,624,640	2,728,418	2,296,418	432,000
3	Oct-11	446,400	0	37,619	484,019	484,019	0	0	42,797	42,797	42,797	0	2,085,467	57,934	484,019	42,797	5,812,128	2,670,217	2,223,817	446,400
3	Nov-11	0	53,437	15,674	69,112	0	69,112	0	17,832	17,832	0	17,832	0	0	0	0	0	0	0	0
3	Dec-11	0	52,245	21,317	142,674	0	142,674	0	24,252	42,084	0	42,084	0	0	0	0	0	0	0	0
4	Jan-12	0	50,479	23,825	216,978	0	216,978	0	27,105	69,188	0	69,188	0	0	0	0	0	0	0	0
4	Feb-12	0	42,676	11,286	270,940	0	270,940	0	12,839	82,027	0	82,027	0	0	0	0	0	0	0	0
4	Mar-12	446,400	0	80,880	798,220	798,220	0	0	92,013	174,040	174,040	0	4,732,320	107,548	798,220	174,040	5,812,128	5,812,128	5,365,728	446,400
4	Apr-12	432,000	0	52,666	484,666	484,666	0	0	59,916	59,916	59,916	0	4,979,221	100,837	484,666	59,916	5,624,640	5,624,640	5,192,640	432,000
4	May-12	446,400	0	18,809	465,209	465,209	0	0	21,398	21,398	21,398	0	3,380,878	55,619	465,209	21,398	5,812,128	3,923,105	3,476,705	446,400
4	Jun-12	432,000	0	20,063	452,063	452,063	0	0	22,825	22,825	22,825	0	2,804,228	68,856	452,063	22,825	5,624,640	3,347,972	2,915,972	432,000
4	Jul-12	446,400	0	10,032	456,432	456,432	0	0	11,412	11,412	11,412	0	2,358,130	48,990	456,432	11,412	5,812,128	2,874,964	2,428,564	446,400
4	Aug-12	446,400	0	7,524	453,924	453,924	0	0	8,559	8,559	8,559	0	1,722,101	58,350	453,924	8,559	5,812,128	2,242,933	1,796,533	446,400
4	Sep-12	432,000	0	0	432,000	432,000	0	0	0	0	0	0	1,335,223	45,241	432,000	0	5,624,640	1,812,464	1,380,464	432,000
4	Oct-12	446,400	0	38,873	485,273	485,273	0	0	44,223	44,223	44,223	0	1,658,267	56,187	485,273	44,223	5,812,128	2,243,949	1,797,549	446,400
4	Nov-12	0	40,655	18,182	58,838	0	58,838	0	20,685	20,685	0	20,685	0	0	0	0	0	0	0	0
4	Dec-12	0	36,190	22,571	117,599	0	117,599	0	25,678	46,363	0	46,363	0	0	0	0	0	0	0	0
5	Jan-13	0	36,599	8,151	162,349	0	162,349	0	9,273	55,636	0	55,636	0	0	0	0	0	0	0	0
5	Feb-13	0	34,235	5,643	202,227	0	202,227	0	6,420	62,055	0	62,055	0	0	0	0	0	0	0	0
5	Mar-13	446,400	0	47,776	696,403	696,403	0	0	54,352	116,407	116,407	0	4,915,237	84,081	696,403	116,407	5,812,128	5,812,128	5,365,728	446,400
5	Apr-13	432,000	0	56,930	488,930	488,930	0	0	64,766	64,766	64,766	0	4,283,708	79,925	488,930	64,766	5,624,640	4,917,329	4,485,329	432,000
5	May-13	446,400	0	23,825	470,225	470,225	0	0	27,105	27,105	27,105	0	3,314,610	112,308	470,225	27,105	5,812,128	3,924,248	3,477,848	446,400
5	Jun-13	432,000	0	30,095	462,095	462,095	0	0	34,237	34,237	34,237	0	2,964,425	100,443	462,095	34,237	5,624,640	3,561,201	3,129,201	432,000
5	Jul-13	446,400	0	10,032	456,432	456,432	0	0	11,412	11,412	11,412	0	1,693,440	57,378	456,432	11,412	5,812,128	2,218,662	1,772,262	446,400
5	Aug-13	446,400	0	10,032	456,432	456,432	0	0	11,412	11,412	11,412	0	952,467	32,272	456,432	11,412	5,812,128	1,452,583	1,006,183	446,400
5	Sep-13	432,000	0	41,381	473,381	473,381	0	0	47,077	47,077	47,077	0	1,939,133	71,345	473,381	47,077	5,624,640	2,530,935	2,098,935	432,000
5	Oct-13	446,400	0	5,016	451,416	451,416	0	0	5,706	5,706	5,706	0	1,535,650	39,883	451,416	5,706	5,812,128	2,032,655	1,586,255	446,400
5	Nov-13	0	36,136	18,809	54,945	0	54,945	0	21,398	21,398	0	21,398	0	0	0	0	0	0	0	0
5	Dec-13	0	45,441	18,182	118,569	0	118,569	0	20,685	42,084	0	42,084	0	0	0	0	0	0	0	0

Time and Precipitaiton Data						Mike Horse Adit Water						Anaconda Adit Water			Cell 5						Cell 7					Water Treatment Plant							
6	Jan-14	3.0	-50%	1.5	off	1,691,874	4,393,575	0	4,393,575	0	4,393,575	46,300	0	46,300	0	46,300	18,809	183,678	0	183,678	0	21,398	63,482	0	63,482	0	0	0	0	0	0	0	0
6	Feb-14	5.2	-50%	2.6	off	915,386	5,308,961	0	5,308,961	0	5,308,961	46,005	0	46,005	0	46,005	32,603	262,286	0	262,286	0	37,091	100,573	0	100,573	0	0	0	0	0	0	0	0
6	Mar-14	4.8	60%	9.0	on	2,147,826	7,456,787	4,713,674	2,743,113	0	2,743,113	47,144	47,144	0	446,400	0	113,233	821,919	821,919	0	0	128,818	229,391	229,391	0	4,713,674	47,144	821,919	229,391	5,812,128	5,812,128	5,365,728	446,400
6	Apr-14	1.3	40%	4.1	on	1,689,734	4,432,847	4,432,847	0	0	0	45,053	45,053	0	432,000	0	51,663	483,663	483,663	0	0	58,774	58,774	58,774	0	4,432,847	45,053	483,663	58,774	5,624,640	5,020,337	4,588,337	432,000
6	May-14	0.4	0%	0.4	on	3,278,251	3,278,251	3,278,251	0	0	0	120,450	120,450	0	446,400	0	5,016	451,416	451,416	0	0	5,706	5,706	5,706	0	3,278,251	120,450	451,416	5,706	5,812,128	3,855,823	3,409,423	446,400
6	Jun-14	1.9	0%	1.9	on	4,043,997	4,043,997	4,043,997	0	0	0	132,421	132,421	0	432,000	0	23,825	455,825	455,825	0	0	27,105	27,105	27,105	0	4,043,997	132,421	455,825	27,105	5,624,640	4,659,348	4,227,348	432,000
6	Jul-14	1.6	0%	1.6	on	2,799,568	2,799,568	2,799,568	0	0	0	94,576	94,576	0	446,400	0	20,063	466,463	466,463	0	0	22,825	22,825	22,825	0	2,799,568	94,576	466,463	22,825	5,812,128	3,383,432	2,937,032	446,400
6	Aug-14	2.0	0%	2.0	on	1,258,122	1,258,122	1,258,122	0	0	0	49,134	49,134	0	446,400	0	25,079	471,479	471,479	0	0	28,531	28,531	28,531	0	1,258,122	49,134	471,479	28,531	5,812,128	1,807,267	1,360,867	446,400
6	Sep-14	0.3	0%	0.3	on	1,610,975	1,610,975	1,610,975	0	0	0	49,109	49,109	0	432,000	0	3,762	435,762	435,762	0	0	4,280	4,280	4,280	0	1,610,975	49,109	435,762	4,280	5,624,640	2,100,125	1,668,125	432,000
6	Oct-14	1.8	0%	1.8	on	1,639,636	1,639,636	1,639,636	0	0	0	38,988	38,988	0	446,400	0	22,571	468,971	468,971	0	0	25,678	25,678	25,678	0	1,639,636	38,988	468,971	25,678	5,812,128	2,173,273	1,726,873	446,400
6	Nov-14	4.2	-50%	2.1	off	1,489,201	1,489,201	0	1,489,201	0	1,489,201	30,637	0	30,637	0	30,637	26,333	56,970	0	56,970	0	29,958	29,958	0	29,958	0	0	0	0	0	0	0	0
6	Dec-14	2.2	-50%	1.1	off	797,480	2,286,681	0	2,286,681	0	2,286,681	57,217	0	57,217	0	57,217	13,794	127,981	0	127,981	0	15,692	45,650	0	45,650	0	0	0	0	0	0	0	0
7	Jan-15	2.6	-50%	1.3	off	702,468	2,989,149	0	2,989,149	0	2,989,149	58,279	0	58,279	0	58,279	16,301	202,561	0	202,561	0	18,545	64,195	0	64,195	0	0	0	0	0	0	0	0
7	Feb-15	1.9	-50%	1.0	off	1,933,899	4,923,048	0	4,923,048	0	4,923,048	52,819	0	52,819	0	52,819	11,913	267,293	0	267,293	0	13,552	77,748	0	77,748	0	0	0	0	0	0	0	0
7	Mar-15	1.2	60%	4.5	on	3,498,015	8,421,063	4,838,032	3,583,031	0	3,583,031	62,836	62,836	0	446,400	0	56,052	769,745	769,745	0	0	63,767	141,515	141,515	0	4,838,032	62,836	769,745	141,515	5,812,128	5,812,128	5,365,728	446,400
7	Apr-15	1.2	40%	3.4	on	2,528,370	6,111,401	5,024,772	1,086,628	0	1,086,628	77,266	77,266	0	432,000	0	42,384	474,384	474,384	0	0	48,218	48,218	48,218	0	5,024,772	77,266	474,384	48,218	5,624,640	5,624,640	5,192,640	432,000
7	May-15	1.5	0%	1.5	on	1,725,793	2,812,421	2,812,421	0	0	0	76,725	76,725	0	446,400	0	18,809	465,209	465,209	0	0	21,398	21,398	21,398	0	2,812,421	76,725	465,209	21,398	5,812,128	3,375,754	2,929,354	446,400
7	Jun-15	0.9	0%	0.9	on	1,108,165	1,108,165	1,108,165	0	0	0	66,675	66,675	0	432,000	0	11,286	443,286	443,286	0	0	12,839	12,839	12,839	0	1,108,165	66,675	443,286	12,839	5,624,640	1,630,965	1,198,965	432,000
7	Jul-15	1.5	0%	1.5	on	2,006,982	2,006,982	2,006,982	0	0	0	49,029	49,029	0	446,400	0	18,809	465,209	465,209	0	0	21,398	21,398	21,398	0	2,006,982	49,029	465,209	21,398	5,812,128	2,542,619	2,096,219	446,400
7	Aug-15	0.0	0%	0.0	on	2,030,601	2,030,601	2,030,601	0	0	0	76,382	76,382	0	446,400	0	0	446,400	446,400	0	0	0	0	0	0	2,030,601	76,382	446,400	0	5,812,128	2,553,383	2,106,983	446,400
7	Sep-15	2.7	0%	2.7	on	1,979,426	1,979,426	1,979,426	0	0	0	60,791	60,791	0	432,000	0	33,857	465,857	465,857	0	0	38,517	38,517	38,517	0	1,979,426	60,791	465,857	38,517	5,624,640	2,544,591	2,112,591	432,000
7	Oct-15	2.8	0%	2.8	on	2,009,622	2,009,622	2,009,622	0	0	0	48,204	48,204	0	446,400	0	35,111	481,511	481,511	0	0	39,944	39,944	39,944	0	2,009,622	48,204	481,511	39,944	5,812,128	2,579,281	2,132,881	446,400
7	Nov-15	1.8	-50%	0.9	off	1,718,921	1,718,921	0	1,718,921	0	1,718,921	50,780	0	50,780	0	50,780	11,286	62,066	0	62,066	0	12,839	12,839	0	12,839	0	0	0	0	0	0	0	0
7	Dec-15	3.8	-50%	1.9	off	1,474,649	3,193,570	0	3,193,570	0	3,193,570	47,292	0	47,292	0	47,292	23,825	133,183	0	133,183	0	27,105	39,944	0	39,944	0	0	0	0	0	0	0	0
8	Jan-16	1.1	-50%	0.6	off	1,624,539	4,818,109	0	4,818,109	0	4,818,109	47,491	0	47,491	0	47,491	6,897	187,571	0	187,571	0	7,846	47,790	0	47,790	0	0	0	0	0	0	0	0
8	Feb-16	1.7	-50%	0.9	off	1,737,419	6,555,528	0	6,555,528	555,528	6,000,000	45,186	0	45,186	0	45,186	10,659	243,415	0	243,415	0	12,126	59,916	0	59,916	0	0	0	0	0	0	0	0
8	Mar-16	1.9	60%	4.4	on	1,754,709	7,754,709	4,343,629	3,411,080	0	3,411,080	44,761	44,761	0	446,400	0	55,425	745,240	745,240	0	555,528	63,054	678,498	678,498	0	4,343,629	44,761	745,240	678,498	5,812,128	5,812,128	5,365,728	446,400
8	Apr-16	1.9	40%	3.6	on	2,934,277	6,345,356	4,997,256	1,348,100	0	1,348,100	99,421	99,421	0	432,000	0	44,892	476,892	476,892	0	0	51,071	51,071	51,071	0	4,997,256	99,421	476,892	51,071	5,624,640	5,624,640	5,192,640	432,000
8	May-16	2.3	0%	2.3	on	3,112,832	4,460,932	4,460,932	0	0	0	105,471	105,471	0	446,400	0	28,841	475,241	475,241	0	0	32,811	32,811	32,811	0	4,460,932	105,471	475,241	32,811	5,812,128	5,074,455	4,628,055	446,400
8	Jun-16	0.8	0%	0.8	on	2,842,716	2,842,716	2,842,716	0	0	0	96,319	96,319	0	432,000	0	10,032	442,032	442,032	0	0	11,412	11,412	11,412	0	2,842,716	96,319	442,032	11,412	5,624,640	3,392,480	2,960,480	432,000
8	Jul-16	1.2	0%	1.2	on	1,523,009	1,523,009	1,523,009	0	0	0	51,604	51,604	0	446,400	0	15,048	461,448	461,448	0	0	17,119	17,119	17,119	0	1,523,009	51,604	461,448	17,119	5,812,128	2,053,179	1,606,779	446,400
8	Aug-16	0.9	0%	0.9	on	1,019,406	1,019,406	1,019,406	0	0	0	34,540	34,540	0	446,400	0	11,286	457,686	457,686	0	0	12,839	12,839	12,839	0	1,019,406	34,540	457,686	12,839	5,812,128	1,524,471	1,078,071	446,400
8	Sep-16	1.3	0%	1.3	on	494,759	494,759	494,759	0	0	0	16,764	16,764	0	432,000	0	16,301	448,301	448,301	0	0	18,545	18,545	18,545	0	494,759	16,764	448,301	18,545	5,624,640	978,370	546,370	432,000
8	Oct-16	3.9	0%	3.9	on	945,398	945,398	945,398	0	0	0	32,033	32,033	0	446,400	0	48,904	495,304	495,304	0	0	55,636	55,636	55,636	0	945,398	32,033	495,304	55,636	5,812,128	1,528,371	1,081,971	446,400
8	Nov-16	1.0	-50%	0.5	off	292,036	292,036	0	292,036	0	292,036	9,895	0	9,895	0	9,895	6,270	16,165	0	16,165	0	7,133	7,133	0	7,133	0	0	0	0	0	0	0	0
8	Dec-16	6.0	-50%	3.0	off	1,533,876	1,825,911	0	1,825,911	0	1,825,911	51,972	0	51,972	0	51,972	37,619	105,756	0	105,756	0	42,797	49,930	0	49,930	0	0	0	0	0	0	0	0
9	Jan-17	1.9	-50%	1.0	off	202,017	2,027,928	0	2,027,928	0	2,027,928	8,059	0	8,059	0	8,059	11,913	125,727	0	125,727	0	13,552	63,482	0	63,482	0	0	0	0	0	0	0	0
9	Feb-17	4.6	-50%	2.3	off	764,462	2,792,390	0	2,792,390	0	2,792,390	57,695	0	57,695	0	57,695	28,841	212,263	0	212,263	0	32,811	96,293	0	96,293	0	0	0	0	0	0	0	0
9	Mar-17	3.7	60%	7.8	on	1,357,634	4,150,024	4,150,024	0	0	0	95,484	95,484	0	446,400	0	97,182	755,845	755,845	0	0	110,558	206,851	206,851	0	4,150,024	95,484	755,845	206,851	5,812,128	5,208,205	4,761,805	446,400
9	Apr-17	1.6	40%	4.3	on	1,367,476	1,367,476	1,367,476	0	0	0	95,484	95,484	0	432,000	0	53,920	485,920	485,920	0	0	61,342	61,342	61,342	0	1,367,476	95,484	485,920	61,342	5,624,640	2,010,222	1,578,222	432,000
9	May-17	2.1	0%	2.1	on	5,116,820	5,116,820	5,116,820	0	0	0	70,430	70,430	0	446,400	0	26,333	472,733	472,733	0	0	29,958	29,958	29,958	0	5,116,820	70,430	472,733	29,958	5,812,128	5,689,941	5,243,541	446,400
9	Jun-17	2.6	0%	2.6	on	4,138,431	4,138,431	4,138,431	0	0	0	47,145	47,145	0	432,000	0	32,603	464,603	464,603	0	0	37,091	37,091	37,091	0	4,138,431	47,145	464,603	37,091	5,624,640	4,687,270	4,255,270	432,000
9	Jul-17	0.0	0%	0.0	on	3,321,984	3,321,984	3,321,984	0	0	0	156,691	156,691	0	446,400	0	0	446,400	446,400	0	0	0	0	0	0	3,321,984	156,691	446,400	0	5,812,128	3,925,075	3,478,675	446,400
9	Aug-17	0.1	0%	0.1	on	3,866,921	3,866,921	3,866,921	0	0	0	176,707	176,707	0	446,400	0	1,254	447,654	447,654	0	0	1,427	1,427	1,427	0	3,866,921	176,707	447,654	1,427	5,812,128	4,492,709	4,046,309	446,400
9	Sep-17	1.0	0%	1.0	on	3,655,385	3,655,385	3,655,385	0	0	0	162,322	162,322	0	432,000	0	12,540	444,540	444,540	0	0	14,266	14,266	14,266	0	3,655,385	162,322	444,540	14,266	5,624,640	4,276,512	3,844,512	432,000
9	Oct-17	3.1	0%	3.1	on	3,924,351	3,924,351	3,924,351	0	0	0	178,395	178,395	0	446,400	0	38,873	485,273	485,273	0	0	44,223	44,223	44,223	0	3,924,351	178,395	485,273	44,223	5,812,128	4,632,242	4,185,842	446,400
9	Nov-17	3.5	-50%	1.8	off	2,455,057	2,455,057	0	2,455,057	0	2,455,057	164,426	0	164,426	0	164,426	21,944	186,370	0	186,370	0	24,965	24,965	0	24,965	0	0	0	0	0	0	0	0
9	Dec-17	4.3	-50%	2.2	off	2,357,621	4,812,678	0	4,812,678	0	4,812,678	143,840	0	143,840	0	143,840	26,960	357,170	0	357,170	0	30,671	55,636	0	55,636	0	0	0	0	0	0	0	0
10	Jan-18	3.1	-50%	1.6	off	2,079,530	6,892,208	0	6,892,208	892,208	6,000,000	157,315	0	157,315	0	157,315	19,436	533,922	0	533,922	0	22,112	77,748	0	77,748	0	0	0	0	0	0	0	0
10	Feb-18	6.6	-50%	3.3	on	1,807,840	7,807,840	3,116,852	4,690,988	0	4,690,988	137,277	137,277	0	403,200	0	41,381	978,502	978,502	0	892,208	47,077	1,017,032	1,017,032	0	3,116,852	137,277	978,502	1,017,032	5,249,664	5,249,664	4,846,464	403,200
10	Mar-18	2.6	60%	7.9	on	1,782,011	6,472,999	4,975,916	1,497,082	0	1,497,082	179,391	179,391	0	446,400	0	98,436	544,836	544,836	0	0	111,985	111,985	111,985	0	4,975,916	179,391	544,836	111,985	5,812,128	5,812,128	5,365,728	446,400
10	Apr-18	1.7	40%	5.2	on	1,788,172	3,285,254	3,285,254	0	0	0	253,781	253,781	0	432,000	0	65,206	497,206	497,206	0	0	74,181	74,181	74,181	0	3,285,254	253,781	497,206	74,181	5,624,640	4,110,422	3,678,422	432,000
10	May-18	2.5	0%	2.5	on	8,058,869	8,058,869	5,113,388	2,945,481	0	2,945,481	185,327	185,327	0	446,400	0	31,349	477,749	477,749	0	0	35,664	35,664	35,664	0	5,113,388	185,327	477,749	35,664	5,812,128	5,812,128	5,365,728	446,400
10	Jun-18	3.0	0%	3.0	on	7,532,558	10,478,039	4,917,492	5,560,547	0	5,560,547	194,732	194,732	0	432,000	0	37,619	469,619	469,619	0	0	42,797	42,797	42,797	0	4,917,492	194,732	469,619	42,797	5,624,640	5,624,640	5,192,640	432,000
10	Jul-18	0.0	0%	0.0	on	5,570,568	11,131,115	5,219,471	5,911,644	0	5,911,644	146,257	146,257	0	446,400	0	0	446,400	446,400	0	0	0	0	0	0	5,219,471	146,257	446,400	0	5,812,128	5,812,128	5,365,728	446,400
10	Aug-18	0.6	0%	0.6	on	3,446,338	9,357,982	5,269,176	4,088,806	0	4,088,806	80,469	80,469	0	446,400	0	7,524	453,924	453,924	0	0	8,559	8,559	8,559	0	5,269,176	80,469	453,924	8,559	5,812,128	5,812,128	5,365,728	446,400
10	Sep-18	0.2	0%	0.2	on	1,968,929	6,057,735	5,108,799	948,936	0	948,936	78,480	78,480	0	432,000	0	2,508	434,508	434,508	0	0	2,853	2,853	2,853	0	5,108,799	78,480	434,508	2,853	5,624,640	5,624,640	5,192,640	432,000
10	Oct-18	1.2	0%	1.2	on	2,341,195	3,290,131	3,290,131	0	0	0	119,897	119,897	0	446,400	0	15,048	461,448	461,448	0	0	17,119	17,119	17,119	0	3,290,131	119,897	461,448	17,119	5,812,128	3,888,594	3,442,194	446,400
10	Nov-18	1.3	-50%	0.7	off	1,428,263	1,428,263	0	1,428,263	0	1,428,263	110,990	0	110,990	0	110,990	8,151	119,141	0	119,141	0	9,273	9,273	0	9,273	0	0	0	0	0	0	0	0
10	Dec-18	2.4	-50%	1.2	off	1,532,711	2,960,974	0	2,960,974	0	2,960,974	105,069	0	105,069	0	105,069	15,048	239,257	0	239,257	0	17,119	26,391	0	26,391	0	0	0	0	0	0	0	0
																														453,158,496	297,311,085	66%	


Mike Horse Adit Monthly Volumes using Proposed WTP Design and Winter Shutdown Scenario
Inflow
To WTP
Overflow to Cell 7
Stored in Adit
Total Water Volume (gallons)
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

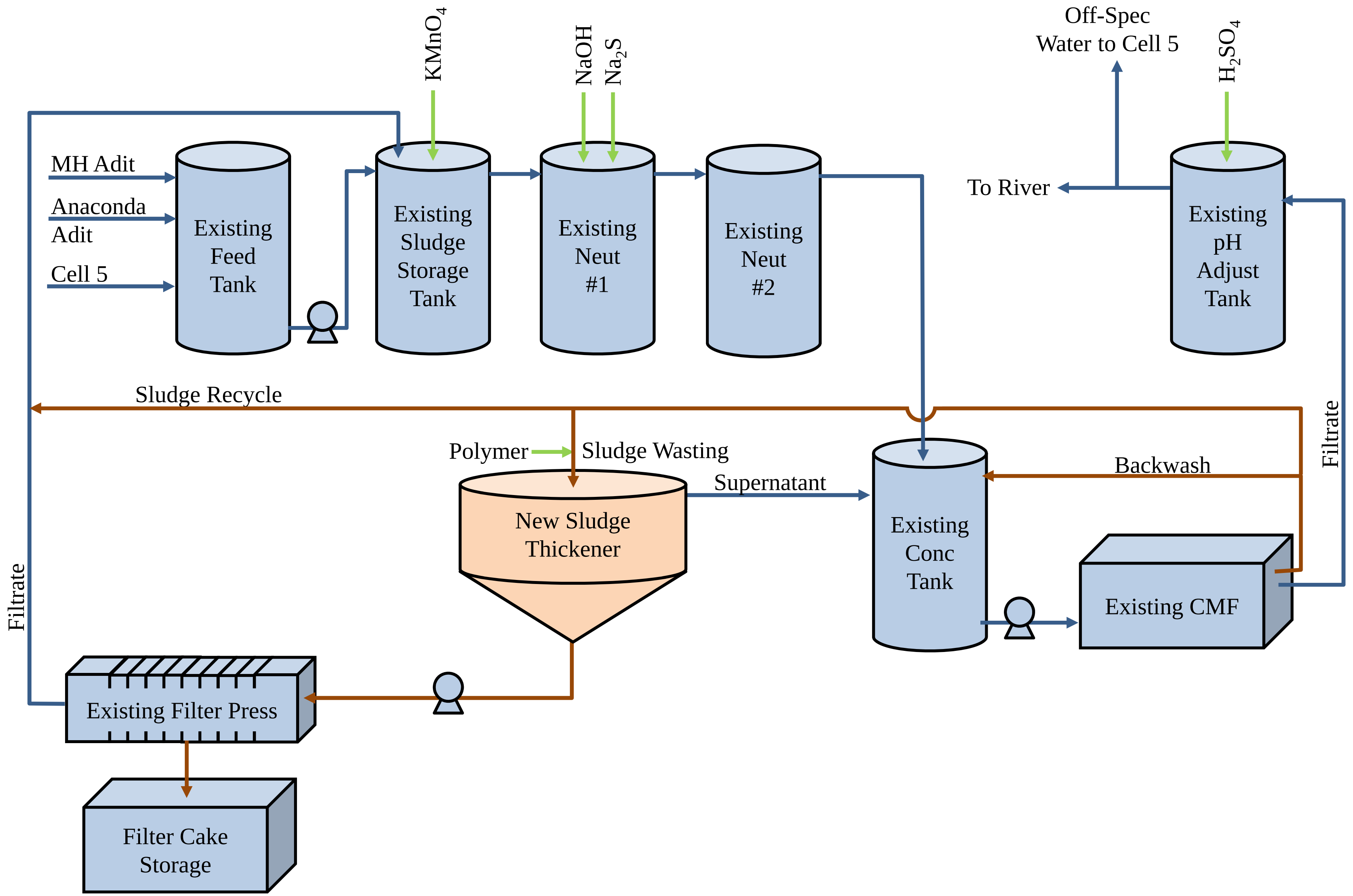

Cell 5 Monthly Volumes using Proposed WTP Design and Winter Shutdown Scenario
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Total Water Volume (gallons)
To WTP
Stored in Cell 5
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018



Actual Average Monthly Volumes
Total Water Volume (gallons)
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
From Mike Horse Adit
From Anaconda Adit
Acutal Water Treated in WTP

APPENDIX C

WATER TREATMENT PLANT
MODIFICATIONS DESIGN INFORMATION



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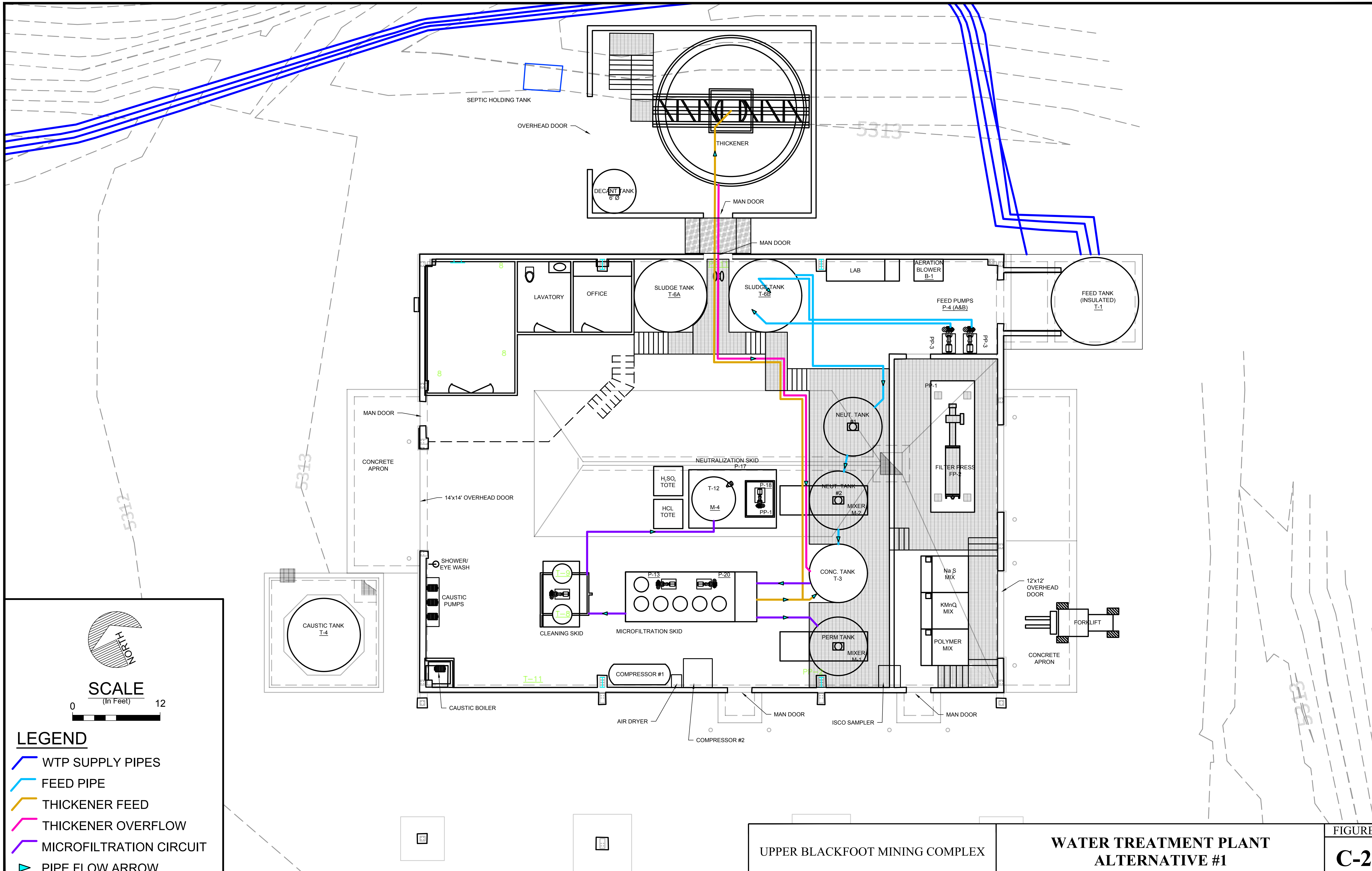
Consulting Scientists and Engineers

WATER TREATMENT ALTERNATIVE 1
PROCESS FLOW DIAGRAM
SLUDGE THICKENER TANK

FIGURE

C-1



UPPER BLACKFOOT MINING COMPLEX

WATER TREATMENT PLANT ALTERNATIVE #1

FIGURE

C-2

UPDATE TIME: 1:48 PM
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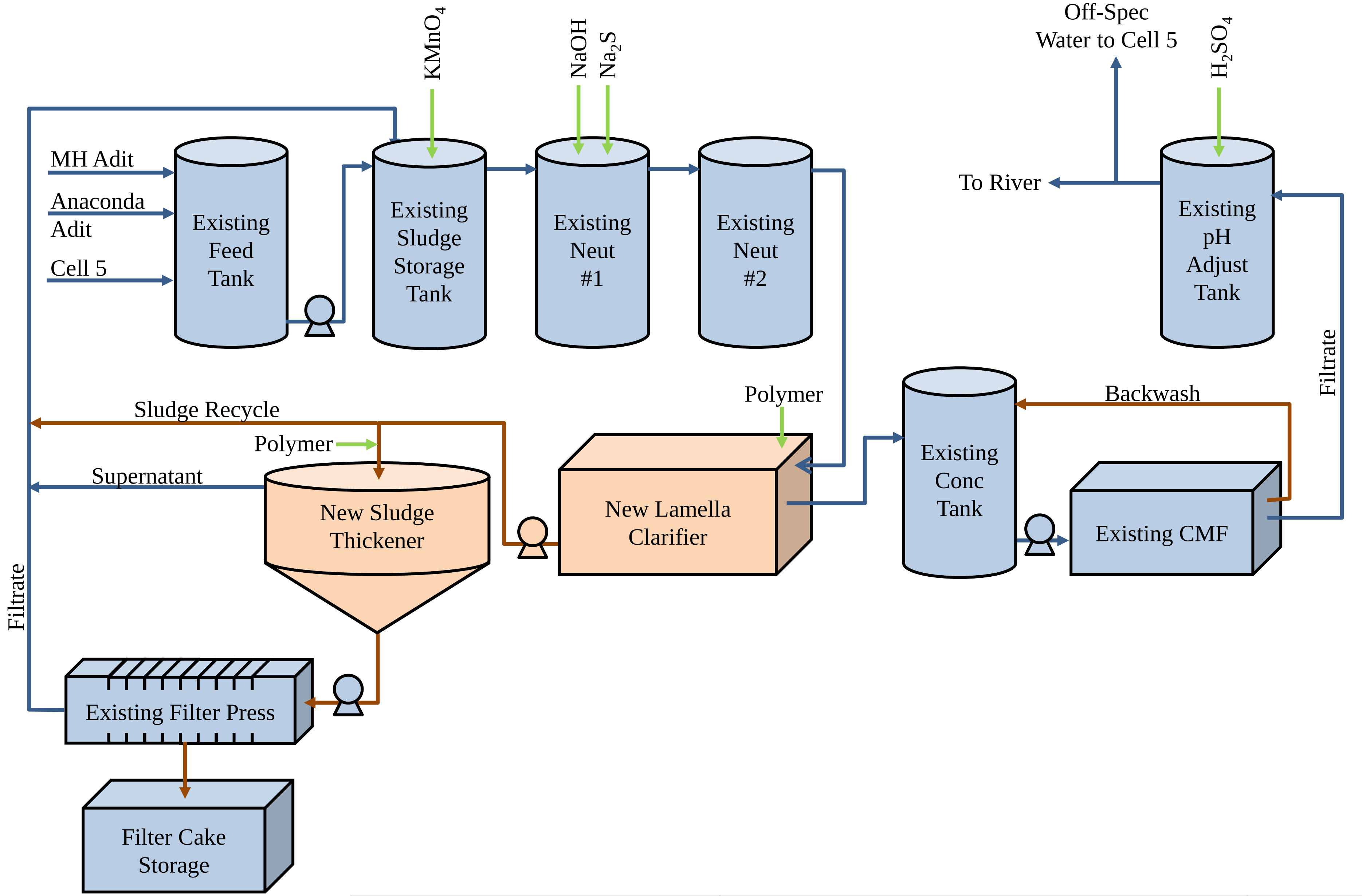
Consulting Scientists and Engineers



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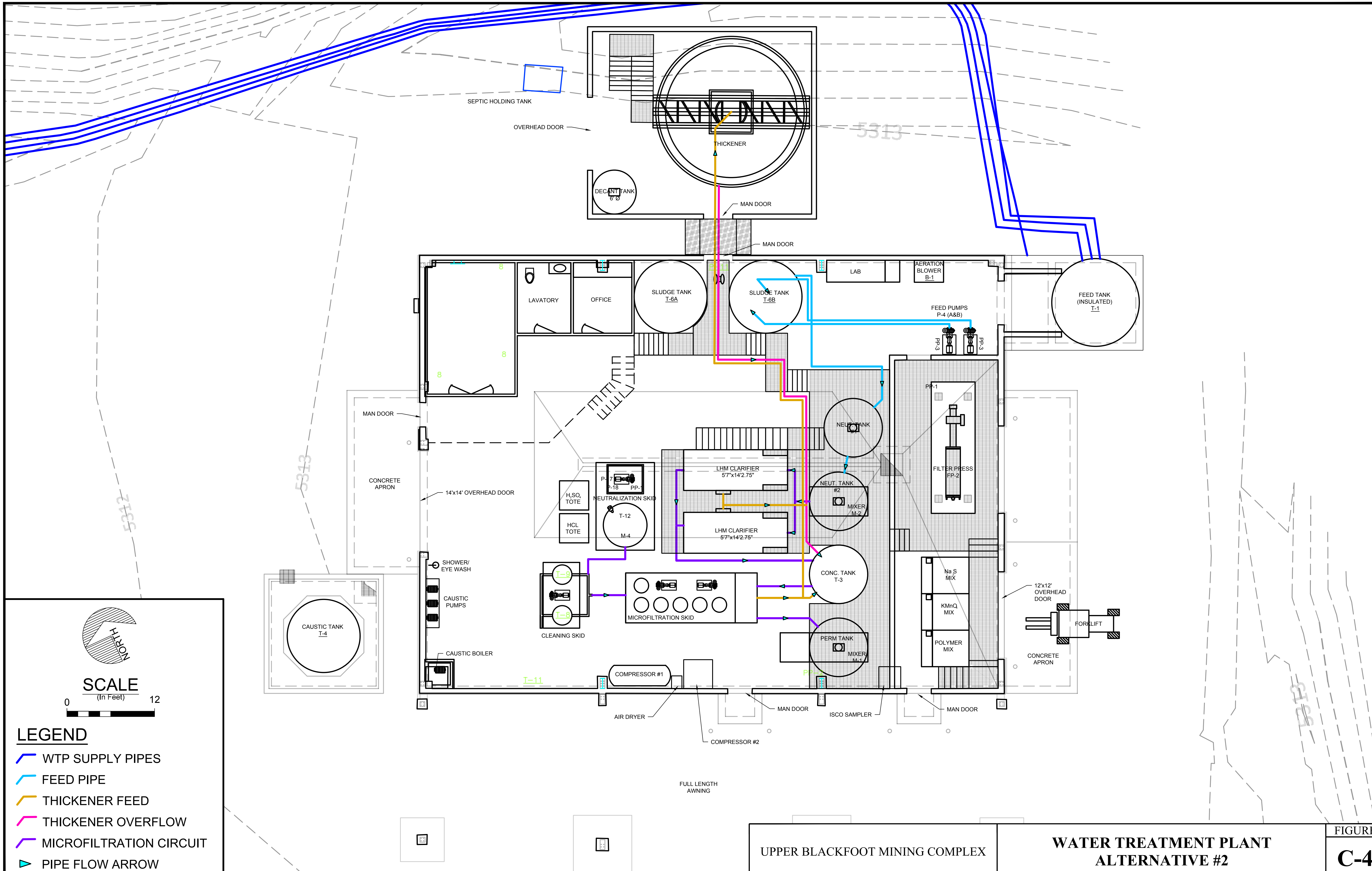
WATER TRREATMENT ALTERNATIVE 2 PROCESS FLOW DIAGRAM - SLUDGE THICKENER AND LAMAELLA CLARIFIER

FIGURE

C-3



UPPER BLACKFOOT MINING COMPLEX

WATER TREATMENT PLANT ALTERNATIVE #2

FIGURE

C-4

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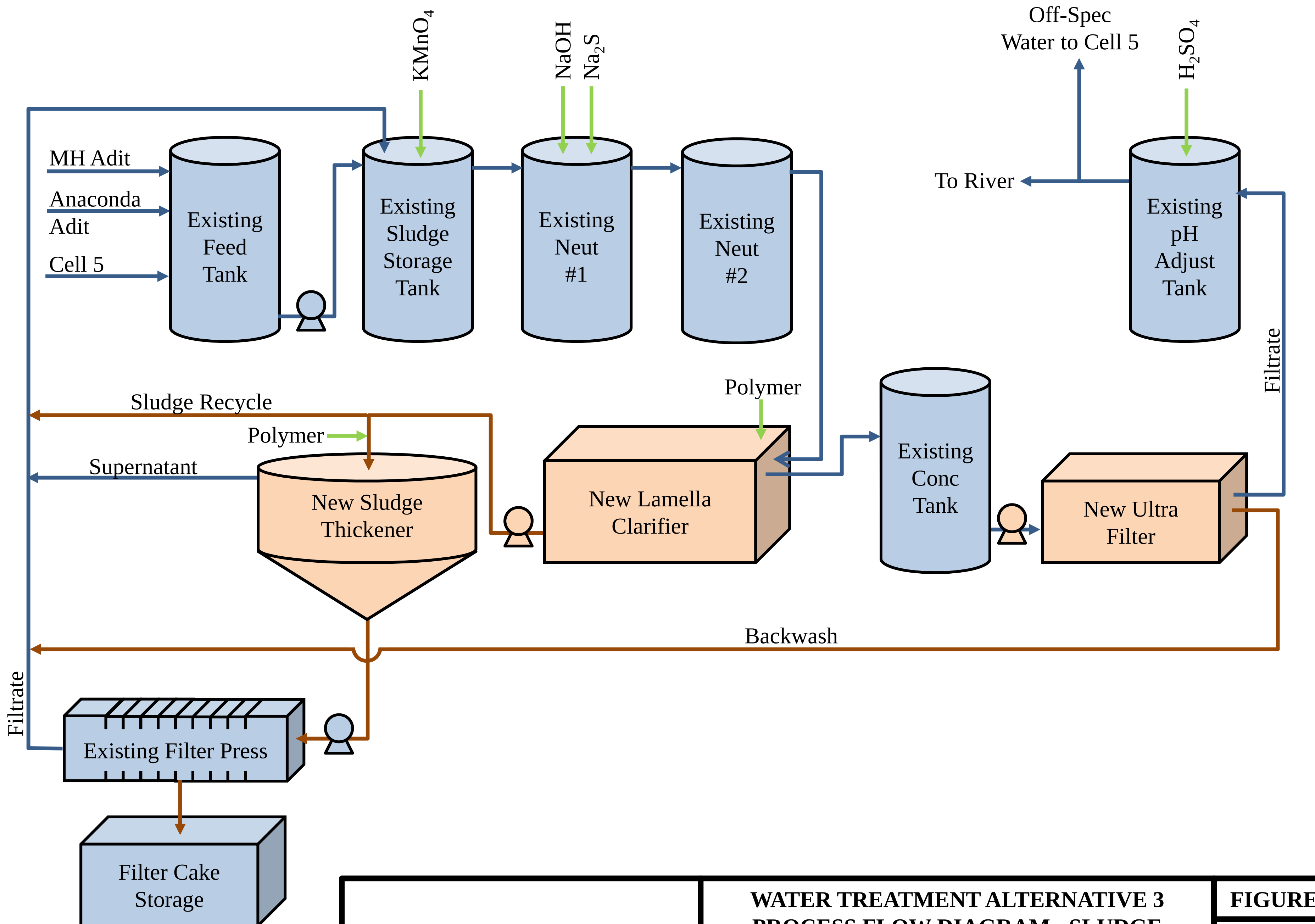

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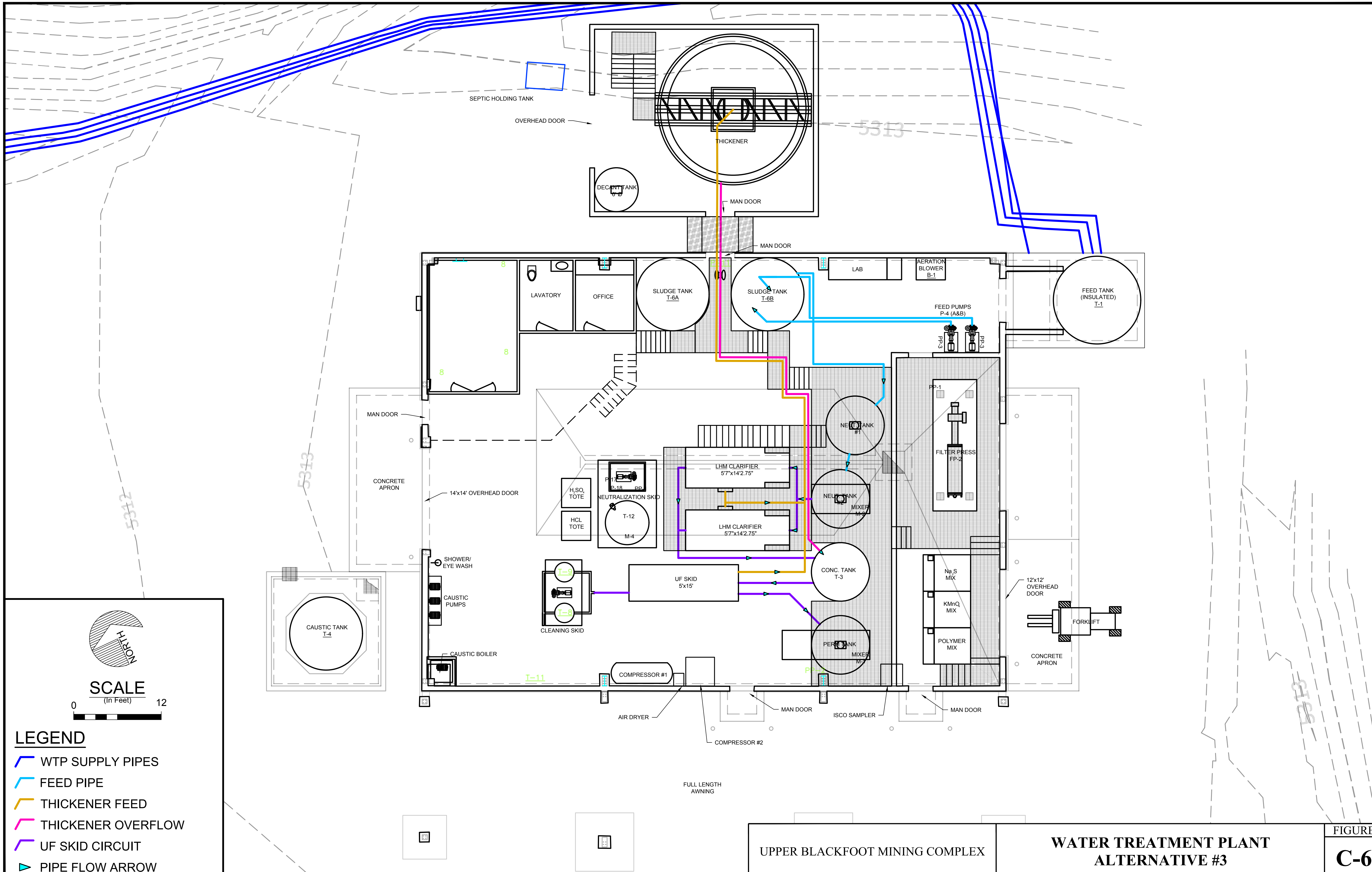
WATER TREATMENT ALTERNATIVE 3 PROCESS FLOW DIAGRAM - SLUDGE THICKENER, CLARIFER AND ULTRAFILTRATION SKID

FIGURE

C-5



UPDATE TIME: 1:43 PM
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Hydrometrics, Inc.
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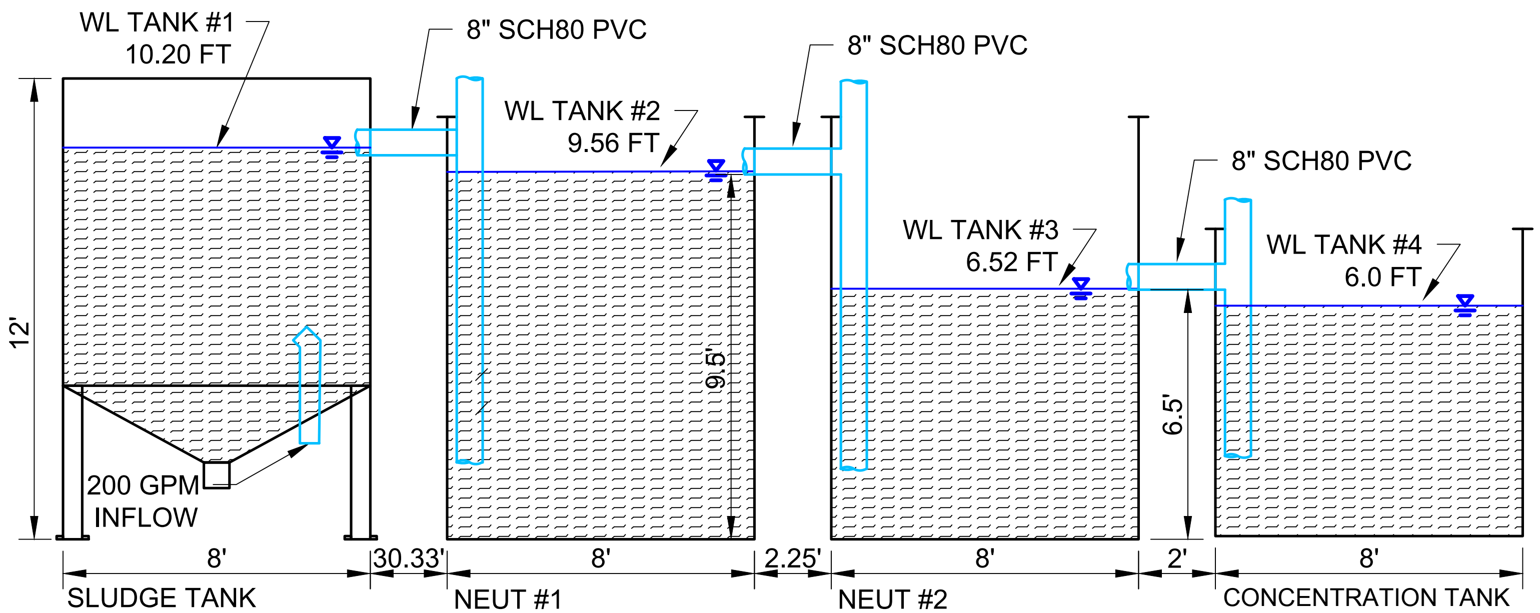
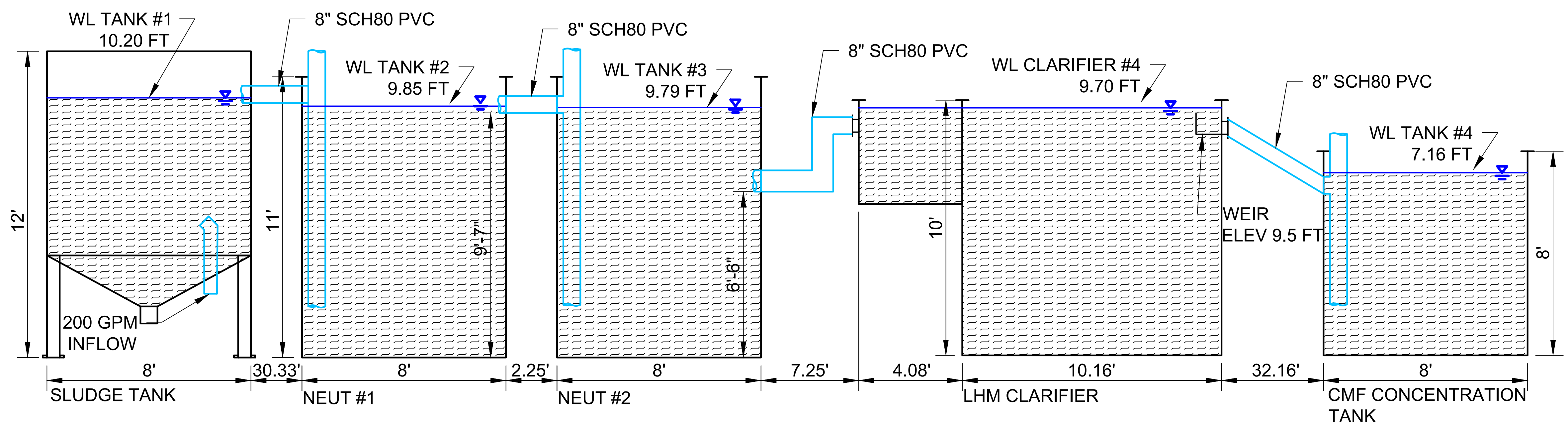
FEED
140 GPM RAW
0.68 GPM CHEMICALS
30 GPM SUPERNATANT THICKNER
10 GPM SLUDGE RECYCLE
20 GPM UF BACKWASH

ALTERNATIVE #1



ALTERNATIVE #2&3



SCALE
(In Feet)
0 5
NTS

PIPE LENGTHS HAVE BEEN SHORTENED TO FIT ON PAGE

UPPER BLACKFOOT WATER TREATMENT PLANT	**ALTERNATIVE 1,2&3 HYDRAULIC GRADE LINE**	FIGURE **C-7**

UPDATE TIME: 11:27 AM
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Hydrometrics, Inc.
Consulting Scientists and Engineers

MONROE ENVIRONMENTAL
Liquid Clarification & Air/Gas Cleaning Systems
810 West Front Street • Monroe, Michigan 48161 USA • Phone: 1-800-992-7707 or 734-242-7654
Registered ISO 9001 ISO 14001

Hydrometrics
3020 Bozeman Ave.
East Helena, MT 59601

November 13, 2018

Attention: Jim Lloyd

Reference: Request for Quotation
Monroe Environmental Horizontal Clarifier and Gravity Thickener
M.E.C. Quote #11565R1

Dear Mr. Lloyd,

Per your request, Monroe Environmental proposes to design and build (2) Monroe Horizontal Clarifiers and (1) Gravity Thickener to treat the Acid Mine Drainage (AMD) from the Mike Horse Mine workings.

The full scale units we are proposing have been sized and designed per the successful pilot testing conducted.

Benefits of Utilizing "The Monroe Method"

- In-House Engineering & Fabrication Capabilities
- Shop Assembly Capabilities & Fit-Up as Required
- Dedicated Parts & Service Departments for Ongoing Support
- Experienced & Responsive Project Management Team
- Registered ISO 9001 & ISO 14001 Quality Systems
- 40+ Years of Experience Manufacturing Pollution Control Systems

I. Monroe Horizontal Clarifiers (Each)

Design Criteria	
Design Flow Rate	Up to 70 GPM (200 GPM Hydraulic Max)
Monroe Model	HC-230
Approximate System Dimensions With Pretreatment Tanks	6'-0" W x 12'-6" L x 8'-7" H (Does Not Include Mixer Height)
Effective Settling Area	230 ft^2 *(< 0.32 GPM/ft^2; To mimic the pilot system at 20 GPM)*
Actual Settling Area	460 ft^2
Flocculation Tank Capacity	210 Gallons
Tank Construction	A36 Mild Steel (Option for 304 Stainless Steel)
Support Structure Construction	A992/A572 and/or A36 Mild Steel
Separator Plate Construction	304 Stainless Steel
Non Submerged Steel Finish	One (1) Coat of High Build Epoxy Primer; One (1) Coat of Polyurethane Enamel
Submerged Steel Finish	Sandblasted to SP-10; Two (2) Coats of High Solids Industrial Epoxy
Sludge Removal	Pyramid Hopper
Fastener Material	18-8 Stainless Steel (ASTM A325 for Structural)

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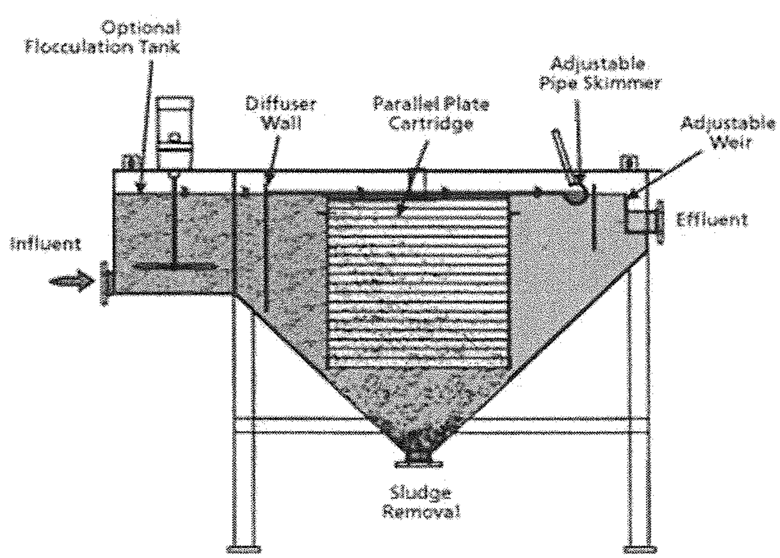
System Description

The Monroe Horizontal Clarifier is designed to remove solids from wastewater and other process liquids. The Flocculation Tank allows for the addition of chemicals that will aid in the settling process - enhancing the agglomeration of suspended particles into heavier, more settle-able floc. The liquid is fed from this tank into the clarifier through the inlet chamber, which directs flow into the separation section.

The separator section shall operate in a co-current mode with the process water flowing horizontally while solids settle. The incoming water shall be fed at the front end of the plates and collected directly at the end of the plates by means of an effluent trough. The still water channels formed by the plate framing provides the quiescent zone to allow solids to free fall without being re-entrained back into the liquid flow within the separation section. The plate packs shall be individually removable for inspection or repair and to ease initial installation.

Settled solids collect at the bottom of the pyramid sludge hopper and are able to be removed from the clarifier while floating oils, greases, and fats are collected in the slotted pipe skimmer.



For Ref. Only — May Not Depict Final Unit

Attention: Jim Lloyd

Reference: Request for Quotation
Monroe Environmental Horizontal Clarifier and Gravity Thickener
M.E.C. Quote #11565R1

Components and Features	
Flocculation Tank	- One (1) 6" flanged influent connection - Three (3) minute retention time at design flow - One (1) mixer with 316L stainless steel shaft and impeller - Up to 1/2 HP inverter duty motor with loose VFD (3/60/460v) *- Available upon request - 3 Phase local disconnect*
Influent Area	- Diffusion wall with slotted inlet orifices for flow distribution
Separation Section	- Provides required effective separation area at design flow - Separation plates are sloped 60° from horizontal - 2" spacing between each plate
Pyramid Sludge Hopper	- One (1) pyramid sludge hopper - One (1) 3" flanged connection for purging per hopper (purging equipment by others) - Three (3) sludge sampling ports - Hopper sides sloped for sludge shedding and concentration - Access port provided for ease of access
Slotted Pipe Skimmer	- Manually adjustable - Removes floating oils & solids - One (1) 4" flanged discharge connection - Constructed from 304 stainless steel
Effluent Chamber	- One (1) 6" flanged effluent connection - 304 stainless steel overflow weir
Optional On-site Supervision	*- On-site supervision, start-up supervision and/or operator training by a Monroe factory trained technician* *- Excludes all mechanical labor, tools, parts, and equipment*

Hydrometrics
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November 13, 2018

Attention: Jim Lloyd

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M.E.C. Quote #11565R1

II. Monroe Gravity Thickener

Design Criteria	
Clarifier Type	Gravity Thickener
Diameter	25'-0"
Side Water Depth	10'-0"
Freeboard	0'-6"
Floor Slope	3"/ 12"
AGMA Continuous Drive Torque Rating	10,000 ft-lbs.
Momentary Maximum Drive Torque Rating	20,000 ft-lbs.
Tank Shell Material	¼" A516 Grade 70 Steel
Submerged Material	Mild Steel (unless otherwise stated)
Effluent Weir Material	¼" FRP
Submerged Steel Finish	Sandblasted to SP-10; One (1) Coat of High Solids Industrial Epoxy; *Final Epoxy Top Coat (Provided & Applied in Field by Others)*
Non-Submerged Steel Finish	One (1) Coat of High Build Epoxy Primer; *Final Polyurethane Enamel Top Coat (Provided & Applied in Field by Others)*
Submerged Fastener Material	18-8 Stainless Steel (Mechanically Galvanized A325 for Structural)

Components and Features	
Tank	- Ø25'-0" x 10'-6" side wall tank shell - Self-supporting steel structure with integral leg set (Concrete anchors by others) - Includes 6" flanged influent connection - Sludge cone with 4" flanged connection (sludge pump by others) - Full circumference effluent launder sized for under 2 ft/sec with dropout box and 6" flanged effluent connection - **Tank and support structure will require field welding and final top coat by others** - **Foundation engineering and installation of thickener by others**

Bridge/Walkway	- Structural steel bridge spans the full diameter - 36" wide grated galvanized walkway spans half of diameter - Includes access platform with a minimum of 2'-0" clearance - Handrails, mid-rails, posts & kick plate provided - Dimensions conform to OSHA dimensional standards
Drive Unit	- Bridge mounted drive - Includes helical gear reduction, intermediate planetary gear reduction unit & final reduction unit - Output torque limited by torque overload protection device - One (1) visual torque indicator dial visible from the walkway provided - Drive: Up to 1/2 HP TEFC motor (3/60/460) *Available upon request:* *- 4-20 mA torque transducer for remote torque monitoring and process control* *- 3-phase local disconnect* *- Control panel/PLC*
Optional Drive Lift	*- Option for 24" 5-ton automatic drive lift* *- Drive: Up to 1/2 HP TEFC motor (3/60/460)*
Drive Shaft	- 6" schedule 80 drive shaft - Drive shaft to have a bolted connection to the main gear of the drive - Mounted to drive unit to support rake arms
Influent Piping	- 6" piping extends from tank shell to feedwell - Inlet diffusion system - Flanged inlet connection terminates at tank wall
Feedwell	- Dissipates influent velocities - Distributes flow into the separation zone - Supported from the bridge above
Sludge Rake Arms	- Two (2) rake arms fabricated from structural steel members - Continuously rakes bottom of clarifier floor to move sludge into the central sludge cone - Picket-style rakes symmetrically about the center for enhanced thickening - 14-gauge 304 stainless steel scraper blades and central sludge cone scraper

Effluent Weirs	- ¼" thick × 9" FRP weir plate - Full circumference & adjustable - 90° properly spaced V-notches - Bolted to effluent launder with gaskets and stainless-steel fasteners
Optional On-site Supervision	*- On-site supervision, start-up supervision and/or operator training by a Monroe factory trained technician* *- Excludes all mechanical labor, tools, parts, and equipment*

III. Exclusions

All equipment, components, services, testing, certifications, guarantees, and inspections not specifically called out or identified in this proposal are not included in Monroe Environmental's scope of supply. Storage of completed equipment is excluded. You will be contacted when your equipment is complete and ready for shipment. If your equipment has not shipped within two weeks of completion, it will be moved to storage and a monthly storage fee will be applied after notification to the purchaser. Please refer to the list below and the Terms & Conditions for a complete list of exclusions.

- Offloading
- Freight
- Installation
- Foundation engineering
- Field welding & painting
- Interconnecting piping outside of tank
- Local electrical disconnect
- Drive torque transducer
- Sludge pumps/valves
- Performance testing

IV. Assumptions

- Monroe assumes that the material and coating stated in this proposal are compatible with the influent and water characteristics (pH, Chlorides). Customer is responsible for verifying and/or recommending material of construction/coating.
- Clarifier drive torque sized for 64 lb/ft arm loading factor
- 10 ft/min rake tip speed.
- Drive alarm factory set to 100% and cutoff factory set to ≅ 120% of continuous torque
- Monroe reserves the right to revise pricing at time of order if necessary due to fluctuating steel prices.
- Site specific wind / seismic loads have not been considered in this proposal

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V. Cost Summary

Qty	Item #	Description	Unit Price	Line Total
2	HC-230	70 GPM Monroe Horizontal Clarifier *As Described Above*	$ 58,500.00	$ 117,000.00
2	*HC-230*	*Adder to Upgrade to 304 Stainless Steel Tank with Coated Mild Steel Supports*	*$ 6,700.00*	*$ 13,400.00*
1	*CIRT-25*	Ø25'-0" Monroe Gravity Thickener *As Described Above*	$ 162,100.00	$ 162,100.00
1	*ADDER*	*Optional Drive Lift*	*$ 25,900.00*	*$ 25,900.00*
--	*Option 1*	*Optional On-site Supervision*	*$ 100 / Hr. Portal to Portal + Expenses*	--

This Proposal is subject to Monroe Environmental's Terms & Conditions (See Below)

Please include quote number (11565R1) with any correspondence pertaining to the above information.

Thank you for the opportunity to quote this equipment to you. Please let us know if we may provide additional information regarding our proposal.

Sincerely,
Monroe Environmental

Alex Zychowicz
Sales & Applications
Phone: 734-342-2114
Email: azychowicz@mon-env.com

Hydrometrics
3020 Bozeman Ave.
East Helena, MT 59601

November 13, 2018

Attention: Jim Lloyd

Reference: Request for Quotation
Monroe Environmental Horizontal Clarifier and Gravity Thickener
M.E.C. Quote #11565R1

Monroe Environmental Terms & Conditions

This proposal is valid for thirty (30) days. We reserve the right to correct any typographical errors in our proposal.

Deliverables – Equipment Delivery, Approval Drawings, Schedules, IO&M Manuals, Etc.

Price quoted is Ex Works Factory and does not include freight to the jobsite.

Normal delivery is (16-18) weeks after receipt of approved submittal drawings. Approval drawings to be sent (2-4) weeks after receipt of acceptable purchase order. To be confirmed at time of purchase order.

Monroe Environmental is not including special provisions for expedited delivery. Normal delivery excludes holidays.

Delivery estimates exclude holidays and will be delayed according to the following holiday observance schedule:

- November 22nd & 23rd
- December 24th, 25th, & 31st
- January 1st

Shipment quoted is estimated in weeks after complete order information is received at Monroe Environmental. The delivery date is contingent on approved drawings being released for manufacturing. Delivery will be confirmed within two (2) weeks upon receipt of the approved drawings from the Purchaser.

Drawings will be sent electronically for approval.

Items called out in this proposal are to be supplied by the specified manufacturer or equal.

One (1) electronic and one (1) hard copy of the Operation and Maintenance manual will be included.

Warranty

Monroe Environmental warrants the equipment against defects in workmanship and material for a period of twelve (12) months after delivery. The twelve (12) month warranty is for parts only and does not include freight; if a technician were required it would be at an additional charge. Monroe is not liable for production, downtime or incidental(s) costs.

Payment Terms

Progressive Payments to be as follows:

50% Invoiced at time of order.
40% Invoiced after receipt of fabrication materials at Monroe.
10% Invoiced at shipment.

All payments are due net thirty (30) days with exception to the final 10%, which is due at equipment acceptance or thirty (30) days after shipment, whichever occurs first.

Purchasers shall be charged a 2% late fee per month based on total project price when invoices are not paid by the due date as agreed upon. Purchaser shall incur all of MEC's reasonable costs for legal fees to collect unpaid balances. MEC retains the right to withhold shipment of the equipment until all unpaid invoices are paid as agreed upon. All orders are subject to credit approval.

Purchaser will be charged a storage fee if completed equipment is not picked up from our facility within two (2) weeks of the date agreed upon by both parties— Due to either revised pick-up date by customer request or if payments are not received in a timely manner as agreed upon. Storage and handling fees determined by sole discretion of Monroe Environmental and may require an offsite storage facility. All liquidated damages / late delivery fees are negated if delay in shipment is caused by customer.

Purchase Order Revisions, Changes, & Cancellations

Purchase Order revisions made by the Purchaser shall be subject to the modifications in delivery timing and pricing.

Purchaser shall also be liable to pay the corresponding price of any items and materials which may already have been purchased or used for the manufacturing of the contract goods as specified on the order and which may have become unusable due to the order change requested by the Purchaser.

Hydrometrics
3020 Bozeman Ave.
East Helena, MT 59601

November 13, 2018

Attention: Jim Lloyd

Reference: Request for Quotation
Monroe Environmental Horizontal Clarifier and Gravity Thickener
M.E.C. Quote #11565R1

A cancellation fee will be applied to all cancelled orders. Cancellation fee will be based on cost incurred from Purchase Order Date to Cancellation Date.

Back-Charges, Delays, Disputes, & Damages

Monroe Environmental is not responsible for any damages, back-charges, or schedule delays that are the result of the Purchaser's failure to provide sufficient information in a timely fashion as outlined in MEC's proposal or RFIs (requests for information) relating to scope of supply, order confirmation, MEC approved drawings, or all other information that is requested by Monroe Environmental. All such delays will extend the project schedule and may result in late delivery of approval drawings, equipment, and any other related MEC deliverables.

Monroe Environmental does not anticipate problems with the erection of this equipment. However, due to the nature of fabricated equipment, a certain amount of field fit-up and adapting work may be required by the erector. This is considered to be a normal part of erection, as well as the use of such tools as come-alongs, welding and cutting torches, and drift pins. The AISC "Code of Standard Practice", latest edition, specifically states under "Correction of Errors" that cutting, reaming, and use of drift pins are a part of standard erection practice:

> "Normal erection operations include the correction of minor misfits by moderate amounts of reaming, chipping, welding or cutting, and the drawing of elements into line through the use of drift pins. Errors which cannot be corrected by the foregoing means or which require major changes in member configuration are reported immediately to the owner and fabricator by the erector, to enable whoever is responsible either to correct the error or to approve the most efficient method of correction to be used by others."

Monroe Environmental will not accept any charge for modification, servicing, adjustment, or for any other item without written authority in the form of a PURCHASE ORDER issued from the home office in Monroe, Michigan IN ADVANCE of doing the work. This authority will only be given when satisfactory proof is submitted and the authority will only then be issued providing the price is agreed upon and the authority is given as outlined above by a Monroe Environmental Project Manager.

Monroe Environmental is not responsible for any design, scheduling, performance, or installation back-charges that result from unknown, undocumented, unforeseen, or unverifiable dimensions, site-specific conditions, or schedule deviations. The Purchaser shall provide notification of such discrepancies, as well as satisfactory proof of their occurrences, in writing to Monroe Environmental within seven (7) days of the Purchaser's awareness of them. Monroe Environmental will not honor any back-charge submitted contrary to this agreement and any such back-charge will be rejected in total without consideration.

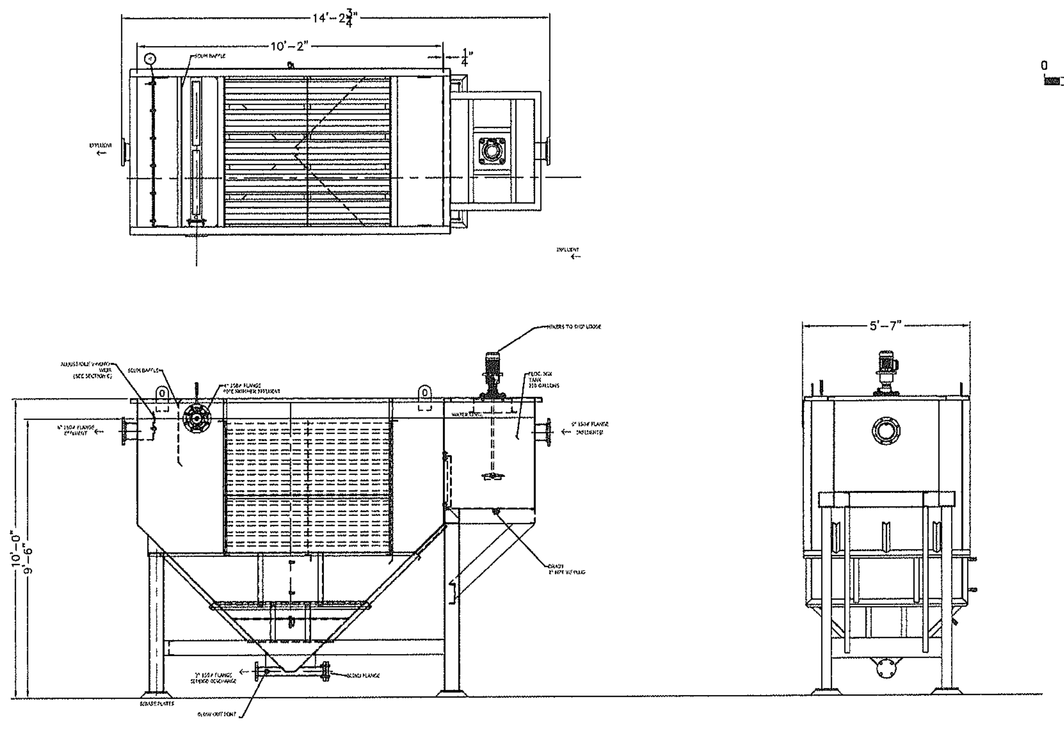
The terms of this proposal and dispute arising under the terms of this order or in connection with Monroe Environmental's work shall be governed in all respects by the laws of the State of Michigan. The federal and state courts of Michigan shall be the exclusive forum for adjudicating any claim, controversy, or dispute concerning a question of fact or law arising out of or relating to this proposal. Purchaser hereby consents to the jurisdiction and venue of such courts, and waives any objection it may have on the basis of lack of personal jurisdiction or forum non conveniens.

Exclusions

Additional Exclusions, unless otherwise noted in this proposal:

- Freight
- Offloading services
- Special packaging
- Sales Tax, Duties, Tariffs
- Installation
- Installation supervision
- Installation start-up
- Training
- Field service
- Non-Destructive testing
- On-site Running/Performance test
- CSA Inspection
- Pressure vessel stamp
- Process / Performance guarantees
- Liquidated damages
- Consequential damages
- Insulation / Freeze protection
- Heat tracing
- External piping
- Dampers
- Interconnection ductwork
- Explosion vents
- Sludge handling equipment
- Emergency pressure relief valves
- Explosion proof motors/ Inst.
- Chemical storage
- Chemical feed equipment
- On-site storage
- Polymer / Chemicals
- External Valves
- Field Paint
- Exhaust Stack(s)
- Drain Lines
- Anchor bolts

All materials and labor beyond the scope of this proposal are not included.



SCALE
(In Feet)
0 4

PRELIMINARY

--SUBJECT TO CHANGE--
– DIMENSIONS ARE APPROXIMATE –
– NOT TO SCALE –
– FOR REFERENCE ONLY –

REV	CHANGE	DRW	DATE	CKD	DATE	APP	DATE

FABRICATION TOLERANCES
MACHINING TOLERANCES
CAUTION

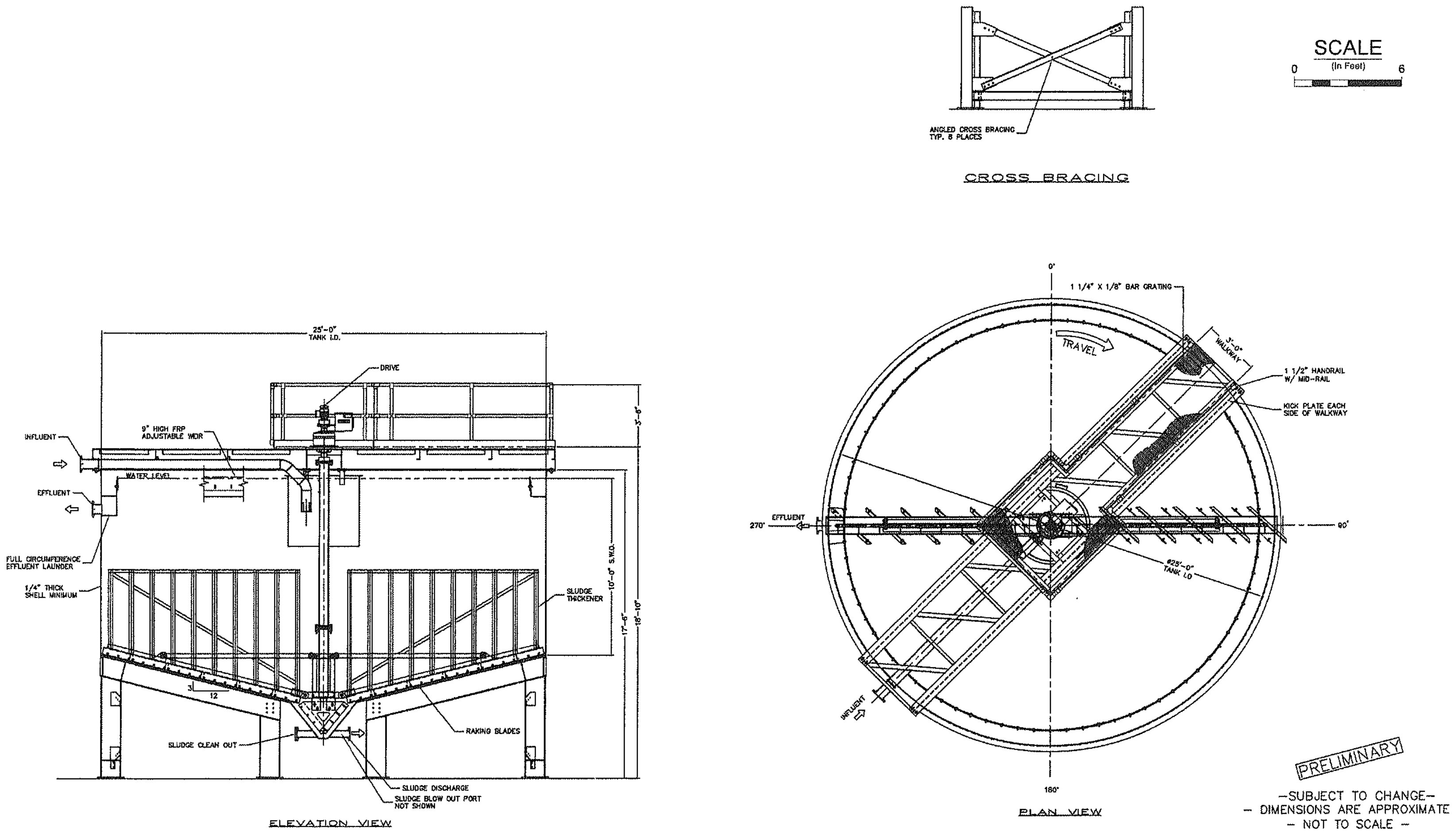
MONROE ENVIRONMENTAL
MONROE, MICHIGAN

TITLE
70 GPM HORIZONTAL CLARIFIER
GENERAL ARRANGEMENT

METG

SCALE NTS
PROJECT NO. 11565
DRAWING NO. 11565-2

11565-2



REV	CHANGE	DRW	DATE	CKD	DATE	APP	DATE

FABRICATION TOLERANCES
STRUCTURAL STEEL TOLERANCES PER AISC
MACHINING TOLERANCES
CAUTION
DO NOT SCALE USE DIMENSIONS ONLY
DO NOT USE FOR CONSTRUCTION UNLESS APPROVED ABOVE

MONROE ENVIRONMENTAL
MONROE, MICHIGAN

TITLE
ø25' CIRCULAR THICKENER
GENERAL ARRANGEMENT – ELEVATION VIEW

METG

SCALE	PROJECT NO.	DRAWING NO.
NTS	11565	11565-1

11565-1

www.sharpemixers.com
P.O. Box 3906 - Seattle, WA 98124 - (800) 237-8815 - FAX (800) 767-5670

QUOTATION

Customer: Montana Environmental Trust Group

Date : January 23, 2012
Proposal No. : K2008EPS
Shipment : 7-8 weeks
After Receipt of Purchase Order
Terms : NET 30 DAYS, OAC

Application : mix tank

ON-CENTER MOUNTING

Design conditions : Viscosity(cps): 1 , Sp.Grav: 1.00 Temp.: Ambient Pressure: Atmospheric

Tank dimensions : 96 Dia. Tank x 144.0 " overall height from mixer base to tank floor
Tank Volume (gallons)= 4200 Tank equipped with baffles 8" wide, " off wall

Liquid levels: Design max (from tank floor): 132"; Min. Liquid Level: 49"

Equipment : **N-SERIES HELICAL DRIVE TOP-ENTERING MIXER**
Quantity : 1 **Mixer Model # 2N2 -17**

Motor : 2.00 Horsepower, @ 1750 RPM, 3PH, 60Hz, 230/460 VOLTS TEFC
56C Frame, Motor Furnished by Sharpe , Mounted by Sharpe
TEFC- Inverter capable to minimum 4:1 turn-down

Mixer Drive : N2 Parallel Helical Gearbox 16.5:1 Ratio, Rated at 7.00 Horsepower

Mixer mounting : Mounting Plate Furnished

Wetted Parts : SS316

Shaft : 2.38 "Dia. X 116 " long from mounting base, turning @ 106 RPM ***CCW rotation***

18 " min. opening required to install impeller

Impellers : 34.0 "dia HYF-218 Hydrofoil Impeller reverse pitch
Split Cast Hub
pumping down CCW rotation

Net Price Each : ***$6,465***

F.O.B.: Seattle, WA *Ship Wt.,each=* *300* lbs

Q1QP-112111

Please address your order to:
Sharpe Mixers *Sharpe Mixers*
P.O.Box 3906
Seattle, WA 98124

Quotation prepared by: Kyle Sides
Sharpe Mixers

-

Note - This quote is valid for 30 days. Any order placed as a result of this proposal is subject to Sharpe Mixers Terms and Conditions.

1/23/12 3:04 PM

SHARPE MIXERS, INC. - STANDARD TERMS & CONDITIONS OF SALE

In consideration of the mutual promises and agreements contained herein, the buyer ("Buyer") and SHARPE MIXERS, INC. ("SHARPE" or "WE") hereby agree to the following terms and conditions; provided, that the terms and conditions (including the price quotations) shall only become binding on SHARPE upon the mailing or other transmission of SHARPE's Acknowledgment Form as described in Section 6 Below.

1. Warranty

We warrant that we shall repair or replace, without additional charge, or refund the price of, the products provided to the Buyer herewith (collectively "Mixer") if the Mixer (a) is defective in materials or workmanship, (b) fails to provide the process results specified in SHARPE's proposal ("Proposal"), or (c) if no process results are specified in SHARPE's proposal, Mixer fails to provide the process results described in Buyer's written specifications. While we warrant that the Mixer is made from the materials specified in the Proposal or its commercial equivalent, WE DO NOT GUARANTEE THE MIXER AGAINST CHEMICAL ATTACK OR OTHER DETERIORATION DUE TO EXPOSURE.

THE FOREGOING WARRANTIES EXTEND ONLY FOR TWELVE (12) MONTHS AFTER FIRST INSTALLATION OF THE MIXER AT BUYER'S FACILITY OR FOR EIGHTEEN (18) MONTHS AFTER ITS SHIPMENT FROM SHARPE'S FACILITY, WHICHEVER PERIOD IS SHORTER. ADDITIONALLY, SUCH WARRANTIES ARE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, ORAL OR WRITTEN, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND OF ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF SHARPE. THESE WARRANTIES SHALL NOT APPLY TO FAILURES RESULTING FROM (A) NORMAL WEAR AND TEAR, (B) ACCIDENT, NEGLIGENCE, ALTERATION, ABUSE, MISUSE OR USE INCONSISTENT WITH ANY INSTRUCTIONS PROVIDED AS TO STORAGE, HANDLING, MAINTENANCE, LUBRICATION, INSTALLATION, STARTUP, OPERATION AND SAFETY, (C) IMPROPER INSTALLATION AND/OR (D) INACCURATE AND/OR INCOMPLETE SPECIFICATIONS, DESIGN CONDITIONS OR OTHER DATA FURNISHED BY OR ON BEHALF OF BUYER. WE MAKE NO WARRANTY WHATSOEVER WITH RESPECT TO ACCESSORIES OR PARTS NOT SUPPLIED BY SHARPE.

2. LIMITATION OF REMEDIES

Buyer's remedy for breach of any of the foregoing warranties shall be limited to those set forth in Section 1 above; provided, WE will not be responsible for removal, loading, installation, freight or similar related expenses in connection with any replacement, repair or return. The determination of which such remedy shall be applicable shall be determined by SHARPE, in its sole discretion. THE ABOVE STATED REMEDIES ARE SHARPE'S ENTIRE AND EXCLUSIVE LIABILITIES AND BUYER'S EXCLUSIVE REMEDIES FOR ANY CLAIM FOR DAMAGES IN CONNECTION HEREWITH. By way of illustration and not limitation, in no event shall we be liable for any direct, indirect, special or consequential damages or delay whatsoever or loss of use, and SHARPE'S liability under no circumstance will exceed the contract price for the Mixer for which liability is claimed. All claims for breach of any of SHARPE'S warranties shall be barred unless Buyer notifies SHARPE in writing within 30 days of discovery of the breach. WE shall not be responsible for any repairs performed by third parties unless the extent, terms and costs of such repairs are authorized by SHARPE in writing in advance. Buyer shall be solely responsible for any agreement that Buyer makes with its customers which is contrary to the foregoing provisions.

3. DELIVERY / SHIPMENTS

Unless otherwise quoted, shipments are F.O.B. shipping point. Risk of loss and damage to the Mixer shall pass to Buyer upon delivery to the carrier and at such time, Buyer shall be solely responsible for the Mixer. We will make every effort to ship on the date specified in the contract; provided, that such dates are approximations only. We will not be liable for or penalized as a result of delays in shipment, for any cause, including but not limited to delays that are beyond our control.

Buyer may not defer shipments beyond the specified shipment date after commencement of manufacture without SHARPE's written consent. When shipping is deferred for Buyer's convenience, due to lack of shipping instructions, failure to complete credit arrangements satisfactory to SHARPE or late delivery of customer supplied material, Buyer agrees to pay reasonable storage charges, interest and any other expenses incurred by SHARPE due to the delay. Orders on which delivery is deferred shall be invoiced upon completion of manufacture and are subject to finance charges of 1.5% per month.

4. CHANGES

Any changes requested by Buyer and approved by SHARPE with respect to the Mixers shall be subject to adjustments to the delivery schedule and/or price of the Mixer, as shall be determined by SHARPE, in its sole discretion.

5. PRICES / PAYMENT

Price quotations set forth on any Proposals from SHARPE are for informational purposes only and represent an estimate of the prices that will be available to Buyer. Such price quotations are not binding upon SHARPE until an authorized representative of SHARPE (at SHARPE's home office in Seattle, Washington) accepts and confirms in writing any offer to purchase submitted by the Buyer by way of a Contract Acknowledgment. Prices set forth on SHARPE's Acknowledgment Form shall be binding with respect to the order described therein; provided, that orders placed "on-hold" or held over 3 months or more (i.e., awaiting Buyers approval) are subject to price adjustments.

Upon approval of Buyer's credit by SHARPE, unless stated otherwise on the face hereof (in which case such terms shall control), terms are net 30 days, F.O.B. Seattle, WA-Freight Collect; provided, that if, in the sole discretion of SHARPE, (a) the order is for a customized or otherwise unique Mixer or is of a substantial magnitude or for any other reason, or (b) Buyer's credit is not approved or the financial condition of Buyer becomes such that it does not justify continuance of production, shipment or delivery on the terms of payment specified, we may require full or partial payment in advance or payment upon delivery. Prices do not include customs, duties or taxes such as sales, use, excise, retailer's occupation or similar taxes, and if, in connection with this transaction, SHARPE is subject to any such customs, duties or taxes, the same will be added to the purchase price to be paid by Buyer. If payment is not made when due, Buyer shall pay SHARPE a finance charge of 1.5% per month and (ii) ALL WARRANTIES PROVIDED BY SHARPE HEREUNDER SHALL IMMEDIATELY BE NULL AND VOID. All price lists and discount schedules are subject to change without notice.

6. ACCEPTANCE

All orders by Buyer are subject to acceptance by SHARPE's authorized representative at SHARPE's main office; provided, that any terms or conditions which are additional or different to the terms and conditions set forth herein or which may have been included in any communication between Buyer and SHARPE, whether written or oral, are hereby objected to by SHARPE and shall not be effective or binding upon SHARPE unless specifically assented to by a duly authorized officer of SHARPE in Writing. No waiver, alteration or modification of any of the provisions hereof shall be binding on SHARPE unless made in writing and signed by a duly authorized officer of SHARPE. Buyer's acceptance of delivery of the Mixer shall constitute full acceptance of all of the terms and conditions set forth herein. The failure of either party to enforce any of its rights hereunder shall not constitute a waiver of such rights or of any other rights hereunder. The terms and conditions of the Acknowledgment contain the entire agreement of the parties. Clerical and typographical errors are subject to correction.

7. CANCELLATION CHARGES

Orders placed by Buyer may not be canceled without SHARPE's written consent. Buyer agrees to indemnify SHARPE against all loss, damage or expense incurred due to cancellation including, but not limited to the cost of special materials, non-resalable goods, completed or in process, labor, freight, engineering time, overhead and profit. A minimum charge of 20% will be applied in the event of a cancellation.

8. OCCUPATIONAL SAFETY AND HEALTH ACT OF 1970

WE do not warrant or represent that any of SHARPE's products by themselves or in a system or with other equipment will conform to or comply with the provisions of the Occupational Safety and Health Act of 1970 and the standards and regulations thereunder, or any other federal, state, or local law or regulation of the same or similar nature.

9. PATENTS

SHARPE certifies that to its knowledge the Mixer does not infringe upon any patents granted to others by the United States of America. WE do not assume any responsibility or liability for any claim of infringement brought against the Buyer, its successors, assigns, customers or users of the Mixer.

10. ATTORNEY FEES

In the event an arbitration, suit or action is brought by any party under this agreement to enforce or interpret any of its terms, or in any appeal therefrom, it is agreed that the prevailing party shall be entitled to reasonable attorneys fees to be fixed by the arbitrator, trial court, and/or appellate court. Buyer shall be responsible for any and all costs of collection incurred by SHARPE in connection herewith, including attorney's fees and costs.

11. JURISDICTION/VENUE

This agreement shall be binding upon the successors and assigns of SHARPE and Buyer, and shall be deemed entered into at Seattle, Washington, and shall be governed by and construed in accordance with the laws of the State of Washington. In the event of litigation between the parties to enforce any terms of the agreement, the parties agree that venue shall be the Superior Court of the State of Washington for King County. ---------------------------

Jim Lloyd

From:	Curtis SHARP <CSHARP@westech-inc.com>
Sent:	Friday, October 26, 2018 9:51 AM
To:	Jim Lloyd
Cc:	Tyler GLADWIN
Subject:	WesTech Water Treatment Options
Attachments:	LintonL_MTC16_MembraneFiltrationIndustrialMining.pdf; Reference_LimeSoftening_Questa.pdf; AltaPac Flyer.pdf; Contrafast_Brochure_05-17.pdf; SuperSettler Brochure_05-17.pdf

Mr. Lloyd,

Thank you for contacting WesTech for your water processing needs. Mr. Tyler Gladwin has contacted me regarding your desire to replace a ceramic membrane.

WesTech has a large portfolio of treating options; we understand that there are a few physical constraints (height, width or doorway, etc.) regarding the existing building. These constraints may reduce the number of options below. Please see the information below regarding the three (3) most likely technologies for this application; **each of the three configurations below would be followed by a UF system**, the information for which is also outlined below. The pricing figures below are for equipment only and do not include shipping, taxes, foundations, installation, etc. All of the sizing and pricing information should be considered preliminary and subject to evaluation of the solids. The pricing would increase for any units that would require insulation.

<u>1 Conventional Thickener (HDS Process) + SuperSand</u>

A conventional thickener has an estimated diameter of about 28 feet, which would require some on-site assembly. A bolted tank would be an option but would be slightly more expensive than a welded model but would have a lower installation cost. A 10' diameter SuperSand would be needed. The estimated purchase price for this configuration is $278,000.

<u>1 Concentric ContraFast + SuperSand</u>

WesTech offers a high-rate settler known as a ContraFast, please see the attached brochure. The ContraFast technology comes in both a concentric and rectangular configuration; in this instance a concentric model is recommended. The estimated diameter of a ContraFast unit for this application is about 10 feet. A ContraFast unit is shop assembled to minimize on-site assembly. The ContraFast would be followed by a 10' diameter SuperSand unit. The estimated purchase price for this configuration is $320,000.

<u>1 SuperSettler + SuperSand</u>

WesTech offers a high-rate plate separator known as a SuperSettler, please see the attached brochure. A SuperSettler is about 13' long x 4'-3" wide and 12'-6" tall. Likewise, a SuperSand unit would be followed by a 10' diameter Super Sand unit. The estimated purchase price for this configuration is $310,000.

<u>UF System</u> THIS UNIT

WesTech offers an ultrafiltration (UF) system known as AltaPac. AltaPac is a modular unit that is typically about 13' long x 5' wide x 11.5' tall and has minimal on-site installation. Please refer to the attached information on AltaPac and associated case studies on UF units from WesTech. The estimated purchase price for this configuration is $250,000.

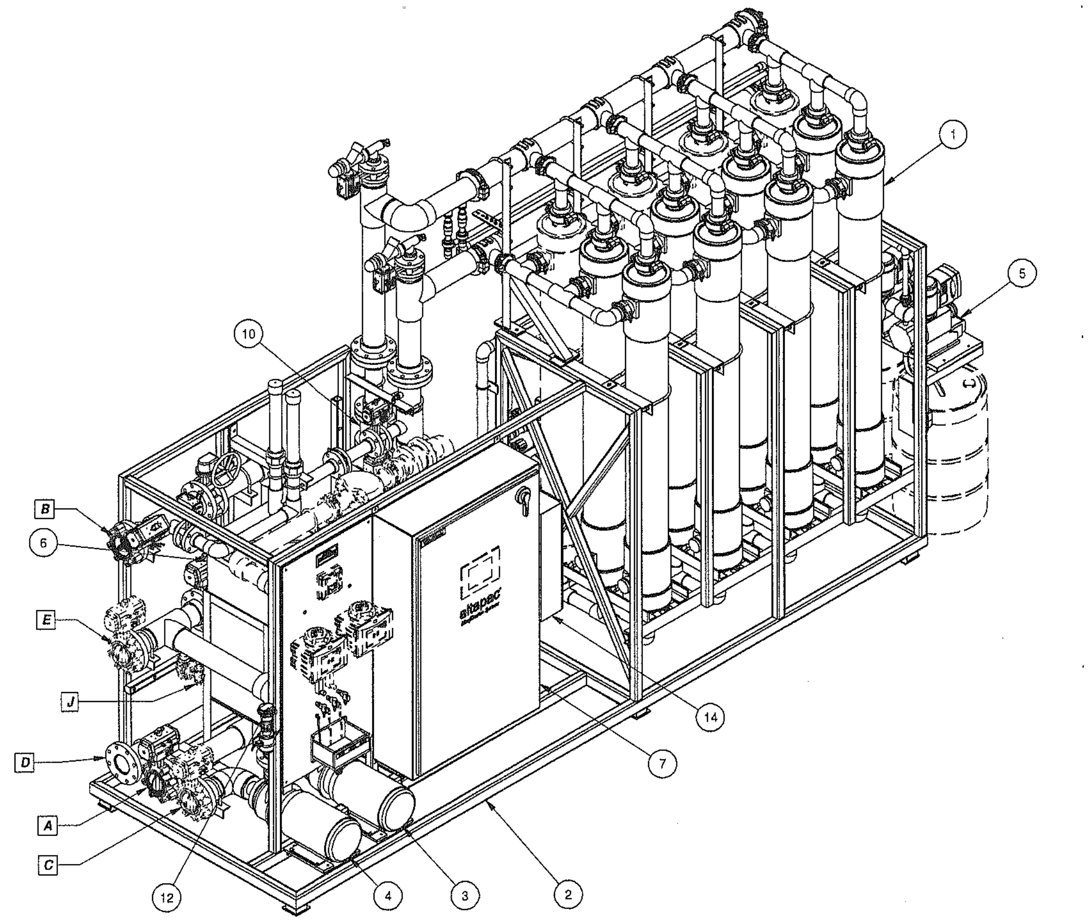
Please review this information at your convenience. Please contact Tyler Gladwin to set up a time when we can discuss these options.

Best Regards,

Curtis R. Sharp, PE
(registered in Ohio)

Industrial Sales | Applications Engineer **T:** 801.290.5742
csharp@westech-inc.com | westech-inc.com

WesTech
an employee-owned company
3665 South West Temple
Salt Lake City, UT 84115 USA



ITEM	EQUIPMENT DESCRIPTION	MATERIAL
1	(8-12) ULTRAFILTRATION MODULES	PVDF
2	SKID (POWDER COATED STEEL)	A36
3	PUMP - UF FEED	-
4	PUMP - BACKWASH SUPPLY / UF FILTRATE TRANSFER	-
5	(2) CHEMICAL METERING PUMPS	-
6	TANK - CIP 50 GALLONS	HDPE
7	CONTROL PANEL	-
8	(2) PRE-STRAINERS 200 MICRON (OPTIONAL)	-
9	HEATER	TI
10	FLOW METER 3" FLANGED	-
11	TEMPERATURE TRANSMITTER	-
12	pH TRANSMITTER	-
13	TURBIDIMETERS - UF FEED / UF FILTRATE (OPTIONAL)	-
14	CONTROL PANEL A/C UNIT	-

CONNECTION SUMMARY

NOZZLE	SIZE	TYPE	DESCRIPTION
A	4"	FLANGE	UF FEED
B	4"	FLANGE	UF FILTRATE
C	4"	FLANGE	BACKWASH SUPPLY
D	4"	FLANGE	BACKWASH WASTE / DRAIN DOWN TO GRAVITY DRAIN
E	4"	FLANGE	PRESSURIZED DISTRIBUTION LINE (OPTIONAL)
F	1"	NPT	AIR SUPPLY
G	1/2" ID	TUBING	TURBIDIMETER DRAIN
H	1" ID	TUBING	SAMPLE SINK DRAIN
J	1/2"	SOC	BLEED VALVE (OPTIONAL)

NOTES:

1. FOLLOW THE LISTED WESTECH REFERENCE DOCUMENTS EXCEPT AS NOTED ON THIS DRAWING.
2. AIR SUPPLY PIPING TO BE 304, ALL OTHER SKID PIPING TO BE PVC SCH 80.
3. ALL VALVE AIR SUPPLY, SAMPLE, AND INSTRUMENT TUBING TO BE POLYURETHANE.
4. ALL FLANGED CONNECTIONS TO BE 150#.
5. SKID CONNECTIONS ARE NOT DESIGNED TO BEAR PLANT PIPING LOADS. PLANT PIPING MUST BE PROPERLY SUPPORTED.
6. EQUIPMENT MUST BE LEVEL AFTER INSTALLATION.
7. CHEMICAL TANKS BY OTHERS. SHOWN FOR REFERENCE ONLY.
8. OPTIONAL ITEMS SHOWN AS HIDDEN LINES FOR REFERENCE ONLY. SEE THE PROJECT EQUIPMENT SUMMARY TO SEE WHICH OPTIONAL ITEMS ARE INCLUDED.

REV	REVISION DESCRIPTION	ECN	DESIGNER	APPROVER	DATE
B	ADD 6" HEATER SECTION	3060	VO00	ST00	06/28/2018
A	REMOVE ISOLATION VALVES, UPDATE INSTRUMENT PANEL & AIR PIPING	1813	GE50	ST00	12/04/2017

PROJECT EQUIPMENT SUMMARY

REFERENCE DOCUMENTS

altapac™

Ultrafiltration Systems

WESTECH

TITLE GENERAL ARRANGEMENT
ALTAPAC
AP-XII

DESIGNER	CHECKER	APPROVER	DATE
ST00	GE50	DY03	12/03/2013

DOCUMENT NUMBER	SHEET	REV
UF-00002	1 OF 4	

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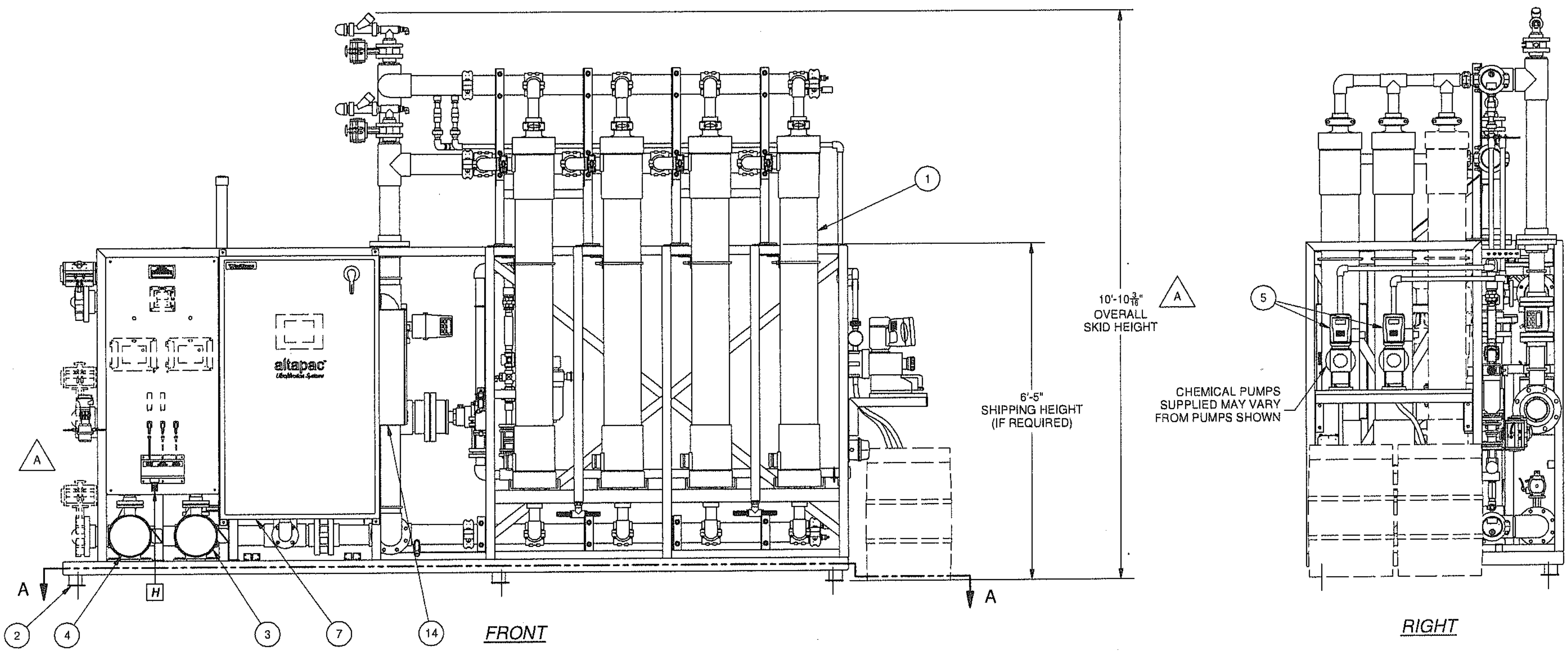

WESTECH

TITLE	GENERAL ARRANGEMENT ALTAPAC AP-XII		
DESIGNER	CHECKER	APPROVER	DATE
ST00	GE50	DY03	12/03/2013
DOCUMENT NUMBER		SHEET	REV
UF-00002		2 OF 4	B

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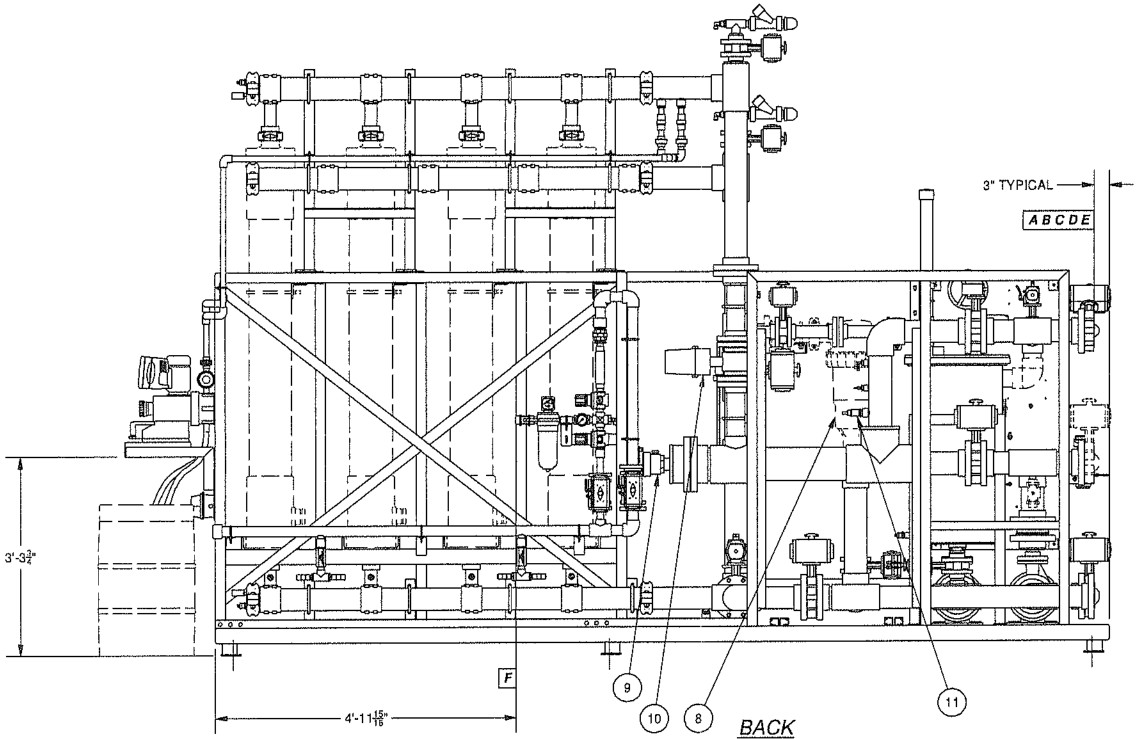

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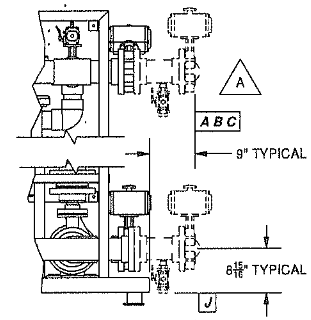
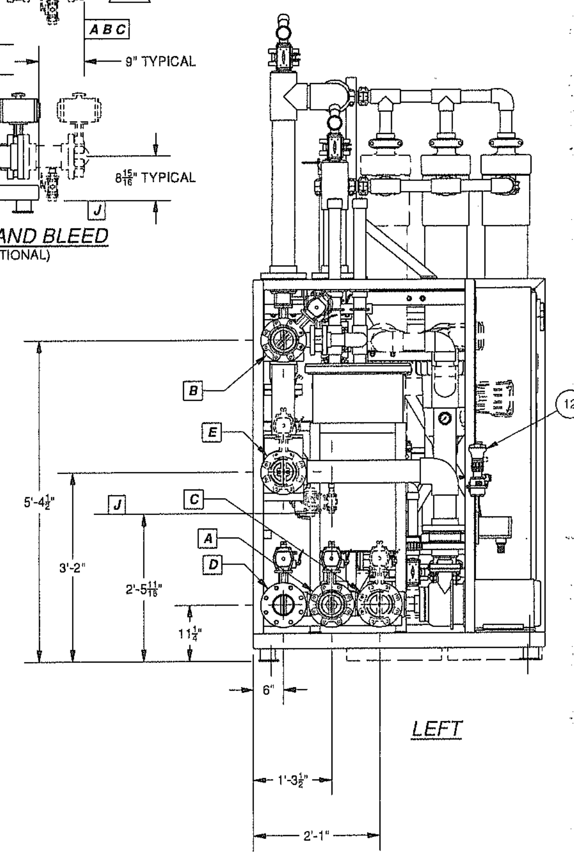


BLOCK AND BLEED
(OPTIONAL)



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WESTECH

TITLE	GENERAL ARRANGEMENT ALTAPAC AP-XII			
DESIGNER	CHECKER	APPROVER	DATE	
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	DOCUMENT NUMBER		SHEET	REV
	UF-00002		3 OF 4	

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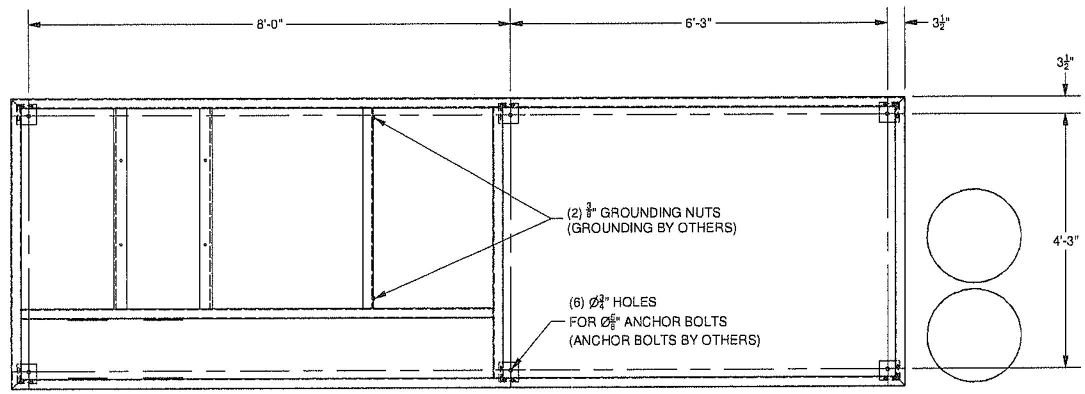
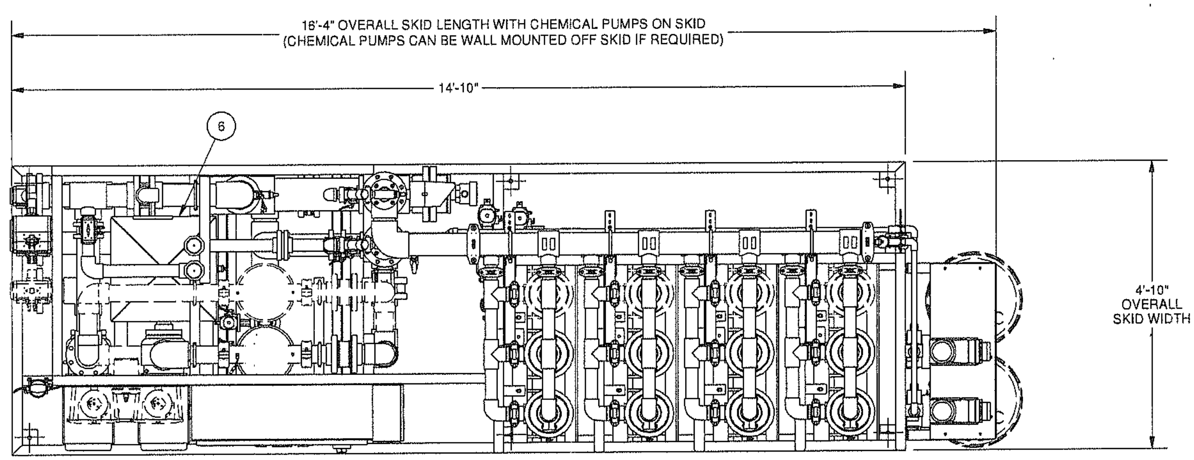


SECTION A-A - ANCHOR BOLT LAYOUT
(FROM SHEET 2)



PLAN

WESTECH

TITLE	GENERAL ARRANGEMENT ALTAPAC AP-XII			
DESIGNER	CHECKER	APPROVER	DATE	
ST00	GE50	DY03	12/03/2013	
DOCUMENT NUMBER			SHEET	REV
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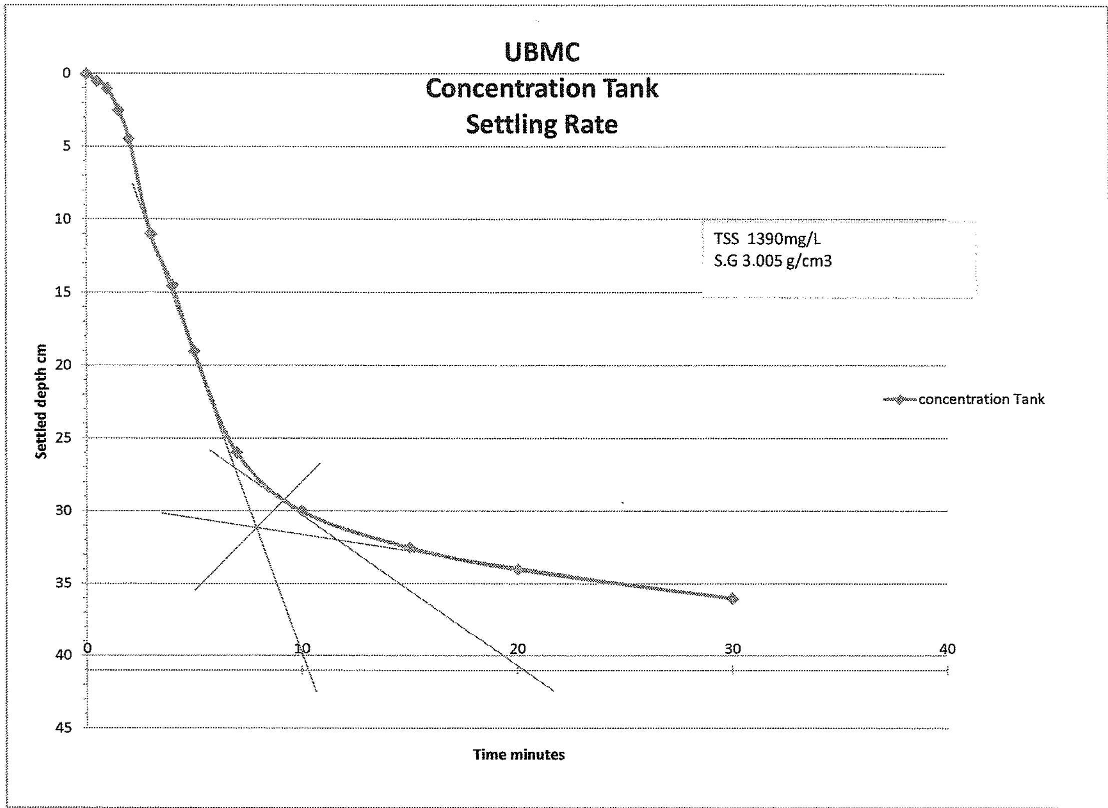
RESIDENCE TIMES (MIN) IN TANKS AT DIFFERENT FEED RATES

	Raw Water Feed Tank	**Neut. Tank #1**	**Neut. Tank #2**	**Conc. Tank**	**Rxn. Tanks Total**	**pH Adjust Tank**
Tank Volume (gal)	15,000	5,000	5,000	5,000		3,000
Diameter (ft.)	12	8	8	8		8
Invert Elev.	17.73	9.98	9.86	9.8		7.98
Volume (ft3)	2005.3	501.6	495.6	492.6		401.1
Volume (gal)	15,000	3,752	3,707	3,685		3,000
Additional Flows (gpm)		20 (a)	40 (b)	20 (c)		
Average Feed Rate (gpm)	Residence Time (min)	Residence Time (min)	Residence Time (min)	Residence Time (min)	Residence Time (min)	Residence Time (min)
50	300.0	53.6	41.2	52.6	147.4	60.0
60	250.0	46.9	37.1	46.1	130.0	50.0
70	214.3	41.7	33.7	40.9	116.3	42.9
80	187.5	37.5	30.9	36.8	105.3	37.5
90	166.7	34.1	28.5	33.5	96.1	33.3
100	150.0	31.3	26.5	30.7	88.5	30.0
110	136.4	28.9	24.7	28.3	81.9	27.3
120	125.0	26.8	23.2	26.3	76.3	25.0
130	115.4	25.0	21.8	24.6	71.4	23.1
140	107.1	23.5	20.6	23.0	67.1	21.4
150	100.0	22.1	19.5	21.7	63.3	20.0
160	93.7	20.8	18.5	20.5	59.9	18.8
170	88.2	19.7	17.7	19.4	56.8	17.6
180	83.3	18.8	16.9	18.4	54.0	16.7
190	78.9	17.9	16.1	17.5	51.5	15.8
200	75.0	17.1	15.4	16.7	49.3	15.0

(a) 20 gpm return from concentration tank.
(b) 20 gpm return from concentration tank + 20 gpm overflow from sludge tanks.
(c) 20 gpm overflow from sludge tanks.
Alternative #1 49.3 minutes @ 200 gpm
Alternative #2 49.3 minutes @ 200gpm



Hu g solids/gms water*total column height

Hu		0.057016							
Tu		21	minutes						
kynch procedure		A=	Tu/Co*Ho	tss					
	Tu	0.014583	day		12400				
	Co	0.00139	kg/l		8184				
	Ho	41	cm						
	A=	255.8928	cm2/kg-day						
		25.58928	m2/mt-d					dia	
	mT/d	0.7315		Area=	18.71856	radius=	2.440961	4.881921	meters
							8.006351	16.0127	feet

APPENDIX D

COST ESTIMATING SPREADSHEETS

UBMC WATER TREATMENT PLANT MODIFICATIONS

Alternative #1 - Thickener Only Projected Project Costs	Purchase Cost (includes shipping)	Demolition Cost	Installation Cost									Total
			concrete	steel	steel fabrication	piping/ fittings/ instrumentation	pumps	labor	PLC integration	electrical (SG, wire & labor)		
1- 20-ft Monroe above floor thickener w/bridge and rakes	$178,200	$14,300	$24,100	$8,000	$52,000	$5,500	--	$4,800	$1,500	$3,600		$292,000
Building - 25'x30'x30' peak	$115,000	--	--	--	$32,000	--	--	--	--	$3,500		$150,500
Conversion of SHT-Manways in main WTP building	--	--	--	$9,500	$3,200	$4,500	--	$4,800	--	--		$22,000
Detailed Engineering, Bid Documents,Specifications	$17,800											$17,800
Contractor Fees (Mob/Demob)	$48,200											$48,200
Add additional CMF Unit												$25,000
Subtotal	$359,200	$14,300	$24,100	$17,500	$87,200	$10,000	$00	$9,600	$1,500	$7,100		$555,500
									Contingency (15%)			$83,300
									TOTAL			**$638,800**

Equipment	Unit HP	Total HP
thickener drive	0.5	0.5
CMF feed	75	75
	Total	**75.5**

UBMC WATER TREATMENT PLANT MODIFICATIONS

Alternative #2 - Thickener + Clarifiers Projected Project Costs	Purchase Cost (includes shipping)	Demolition Cost	Installation Cost								Total
			concrete	steel	steel fabrication	piping/ fittings/ instrumentation	pumps	labor	PLC integration	electrical (SG, wire & labor)	
2- 70-gpm Monroe Lamella Plate Clarifiers	$122,000	$2,500	$2,500	$22,500	$6,200	$17,500	$10,700	$16,000	$2,500	$4,300	$206,700
1- 20-ft Monroe above floor thickener w/bridge and rakes	$178,200	$14,300	$24,100	$8,000	$52,000	$5,500	--	$4,800	$1,500	$3,400	$291,800
Building - 25'x30'x30' peak	$115,000	--	--	--	$32,000	--	--	--	--	$3,500	$150,500
Enclose awning for loader (one bay)	$5,200	--	--	$25,400	$8,000	--	--	--	--	$1,700	$40,300
Conversion of SHT-Manways in main WTP building	$00	--	--	$9,500	$3,200	$4,500	--	$4,800	--	--	$22,000
Detailed Engineering, Bid Documents,Specifications	$42,000										$42,000
Contractor Fees (Mob/Demob)	$75,300										$75,300
Add additional CMF Unit											$25,000
Rental Equipment(clarifier and filtration skids)	$6,700										$6,700
Subtotal	$544,400	$16,800	$26,600	$65,400	$101,400	$27,500	$10,700	$25,600	$4,000	$12,900	$860,300
									Contingency (15%)		$129,000
									TOTAL		**$989,300**

Equipment	Unit HP	Total HP
sludge pumps	3	6
thickener drive	0.5	0.5
clarifier mixers	0.5	1
Sharp Mixer	2	2
CMF feed	75	75
	Total	**84.5**

UBMC WATER TREATMENT PLANT MODIFICATIONS

Alternative #3 - Thickener + Clarifiers + UF Projected Project Costs	Purchase Cost (includes shipping)	Demolition Cost	Installation Cost								Total
			concrete	steel	steel fabrication	piping/ fittings/ instrumentation	pumps	labor	PLC integration	electrical (SG, wire & labor)	
2- 70-gpm Monroe Lamella Plate Clarifiers	$122,000	$10,000	$2,500	$22,500	$6,200	$18,500	$10,700	$16,000	$2,500	$4,300	$215,200
1- Westech Altrapac XII UF skid 70-350 gpm	$255,000	--	$2,500	$4,600	--	$8,300	--	$8,000	$3,800	$6,000	$288,200
Enclose awning for loader (one bay)	$5,200	--	--	$25,400	$8,000	--	--	--	--	$1,700	$40,300
1- 20-ft Monroe above floor thickener w/bridge and rakes	$178,200	$14,300	$24,100	$8,000	$52,000	$5,500	$00	$4,800	$1,500	$3,400	$291,800
Building - 25'x30'x30' peak	$115,000	--	--	--	$32,000	--	--	--	--	$3,500	$150,500
Conversion of SHT-Manways in main WTP building	$00	--	--	$9,500	$3,200	$4,500	$00	$4,800	--	--	$22,000
Detailed Engineering, Bid Documents,Specifications	$67,500										$67,500
Contractor Fees (Mob/Demob)	$107,600										$107,600
Rental Equipment(clarifier and filtration skids)	$6,700										$6,700
Subtotal	$857,200	$24,300	$29,100	$70,000	$101,400	$36,800	$10,700	$33,600	$7,800	$18,900	$1,189,800
									Contingency (15%)		$178,500
									TOTAL		**$1,368,300**

Equipment		Unit HP	Total HP
sludge pumps		3	6
thickener drive		0.5	0.5
clarifier mixers		0.5	1
Sharp Mixer		2	2
UF filter	feed	15	15
	backwash	15	15
		Total	**39.5**

UMBC ESTIMATED WTP OPERATION AND MAINTENANCE COSTS

PROJECTED UMBC WATER TREATMENT PLANT OPERATION AND MAINTENANCE EXPENSES	Historical O&M Costs				Existing Conditions	Alternative 1 - Thickener Only		Alternative 2 - Thickener + Clarifiers		Alternative 3 - Thickener + Clarifier + UF		
	2015 O&M Costs	2016 O&M Costs	2017 O&M Costs	2018 O&M Costs	Projected O&M Costs	Percent Reduction	Projected O&M Costs	Percent Reduction	Projected O&M Costs	Percent Reduction	Projected O&M Costs	Comments
MDEQ Expenses (Routine Operating Expense)												
MDEQ Direct Personnel Charges	$15,778	$13,134	$8,373	$11,698	$12,246	0%	$12,246	0%	$12,246	0%	$12,246	Remains the same
MDEQ Travel Charges	$0	$0	$40	$0	$10	0%	$10	0%	$10	0%	$10	Remains the same
MDEQ Indirect Charges (Personnel Services & Other Indirects)	$3,594	$3,077	$2,355	$3,170	$3,049	0%	$3,049	0%	$3,049	0%	$3,049	Remains the same
MDEQ Expenses	$130	$26	$4	$34	$48	0%	$48	0%	$48	0%	$48	Remains the same
MDEQ Hydro Solutions, Incl, Back-up/Emergency Operator			$1,836	$17,901	$0	100%	$0	100%	$0	100%	$0	No longer needed - provided by Hydrometrics
Total	**$19,502**	**$16,236**	**$12,608**	**$32,803**	**$15,353**	**0%**	**$15,353**	**0%**	**$15,353**	**0%**	**$15,353**	
Materials, Supplies & Chemicals (Routine Operating Expense)												
Laboratory Equipment & Supplies	$878	$1,854	$2,197	$42	$1,243	0%	$1,243	0%	$1,243	0%	$1,243	Remains the same
Shop Supplies & Tools	$1,873	$3,287	$2,577	$2,800	$2,634	0%	$2,634	0%	$2,634	0%	$2,634	Remains the same
Chemicals	$73,931	$73,346	$75,061	$110,096	$74,113	5%	$70,407	10%	$66,702	15%	$62,996	Average from '15-'17 only, less cleaning
Office Equipment & Supplies	$1,765	$412	$855	$412	$861	0%	$861	0%	$861	0%	$861	Remains the same
Safety Supplies/Minor Equipment	$2,767	$1,708	$452	$141	$1,267	0%	$1,267	0%	$1,267	0%	$1,267	Remains the same
Replacement Parts (all equipment, except ceramic filter components)	$22,422	$20,814	$15,618	$26,097	$21,238	0%	$21,238	0%	$21,238	0%	$21,238	Remains the same
Replacement Parts for CMF/UF Components (only)	$14,948	$13,876	$10,412	$18,403	$14,410	15%	$12,248	30%	$10,087	60%	$5,764	Less wear and tear due to acid cleaning
Total	**$118,584**	**$115,298**	**$107,171**	**$157,991**	**$115,765**	**5%**	**$109,898**	**10%**	**$104,031**	**17%**	**$96,003**	
Operating Labor (Routine Operating Expense)												
Hydrometrics Project Management					$43,979	0%	$43,979	0%	$43,979	0%	$43,979	
Water Treatment Services LLC (WTS) Trust Management/Oversight	$47,048	$69,204	$72,483	$54,875			$0		$0		$0	No longer needed - provided by Hydrometrics
Greenfield Environmental Trust Group, Inc. (GETG) Trust Oversight	$9,124	$13,851	$10,738	$10,440	$11,038	0%	$11,038	0%	$11,038	0%	$11,038	Remains the same
WTP Operator	$136,628	$104,962	$70,021	$61,582	$163,272	10%	$146,945	20%	$130,617	35%	$106,127	Averge cost/$40/hr old cost * $70/hr new cost, less O&M, winter shutdown
Total	**$192,799**	**$188,017**	**$153,241**	**$126,897**	**$218,289**	**7%**	**$201,962**	**15%**	**$185,635**	**26%**	**$161,144**	
Other Professional Services/Labor (Routine Operating Expense)												
PLC Instrumentation Service (MET)	$13,169	$10,036	$19,366	$8,706	$12,819	0%	$12,819	0%	$12,819	0%	$12,819	Remains the same
Handyman Charges	$7,491	$7,434	$4,380	$1,721	$5,256	0%	$5,256	0%	$5,256	0%	$5,256	Remains the same
Accounting Services (Wipfli)	$3,219	$4,305	$3,958	$1,875	$3,339	0%	$3,339	0%	$3,339	0%	$3,339	Remains the same
Weed Control	$1,200	$0	$0	$1,200	$600	0%	$600	0%	$600	0%	$600	Remains the same
Total	**$25,078**	**$21,776**	**$27,704**	**$13,502**	**$22,015**	**0%**	**$22,015**	**0%**	**$22,015**	**0%**	**$22,015**	
WTP Operations - Analytical (Routine Operating Expense)												
Energy Lab Testing (O&M Samples)	$10,000	$13,744	$13,483	$11,980	$12,302	0%	$12,302	0%	$12,302	0%	$12,302	Remains the same
Linda Tangen Data Validation (O&M Samples)	$3,288	$1,705	$2,722	$2,283	$2,500	0%	$2,500	0%	$2,500	0%	$2,500	Remains the same
Total	**$13,288**	**$15,449**	**$16,205**	**$14,263**	**$14,801**	**0%**	**$14,801**	**0%**	**$14,801**	**0%**	**$14,801**	
WTP Operations - Utilities (Routine Operating Expense)												
Waste Disposal (Sludge)	$10,984	$6,087	$7,607	$14,579	$8,226	0%	$8,226	0%	$8,226	0%	$8,226	Average from '15-'17 only
Telephone	$4,024	$3,808	$3,699	$2,015	$3,387	0%	$3,387	0%	$3,387	0%	$3,387	Remains the same
Electricity	$50,318	$48,953	$51,034	$36,902	$46,802	15%	$39,781	15%	$39,781	20%	$37,441	Winter shutdown, loss of 75 HP pump.
Water & Sewage	$1,000	$1,000	$600	$200	$700	25%	$525	25%	$525	25%	$525	Winter shutdown
Garbage & Trash Removal	$1,181	$1,521	$1,406	$1,371	$1,370	25%	$1,027	25%	$1,027	25%	$1,027	Winter shutdown
Propane	$27,405	$5,366	$15,826	$17,514	$16,528	20%	$13,222	20%	$13,222	20%	$13,222	Winter shutdown
Total	**$94,913**	**$66,735**	**$80,172**	**$72,581**	**$77,012**	**14%**	**$66,169**	**14%**	**$66,169**	**17%**	**$63,828**	
Projects & Construction (Non-Routine/Non-Recurring Expenses)												
Unforeseen Breakdowns and Repair Response Funds	$23,694	$20,000	$18,251	$2,608	$16,138	10%	$14,525	10%	$14,525	20%	$12,911	Less due to CMF removal/reduction
Health & Safety Compliance			$168	$926	$547	0%	$547	0%	$547	0%	$547	Remains the same
Spare Parts	$24,131	$79,883	$24,043	$17,579	$36,409	10%	$32,768	20%	$29,127	40%	$21,845	Less due to CMF removal/reduction
CMF/UF Related Spare Parts/Maintenance		$18,321	$36,878		$27,600	25%	$20,700	50%	$13,800	70%	$8,280	Less due to CMF removal/reduction
Planned Repairs/Maintenance	$55,088	$28,628	$52,510	$18,334	$38,640	10%	$34,776	20%	$30,912	30%	$27,048	Less due to CMF removal/reduction
Building Repairs	$0	$0	$0	$0	$4,000	0%	$4,000	0%	$4,000	0%	$4,000	Remains the same
Purchase and install cartridge filters				$21,119	$21,119	100%	$0	100%	$0	100%	$0	Will no longer need.
Total	**$102,913**	**$146,832**	**$131,850**	**$60,566**	**$144,453**	**26%**	**$107,315**	**36%**	**$92,910**	**48%**	**$74,631**	
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS	**$567,077**	**$570,342**	**$528,952**	**$478,603**	**$607,688**	**12%**	**$537,513**	**18%**	**$500,914**	**26%**	**$447,775**	